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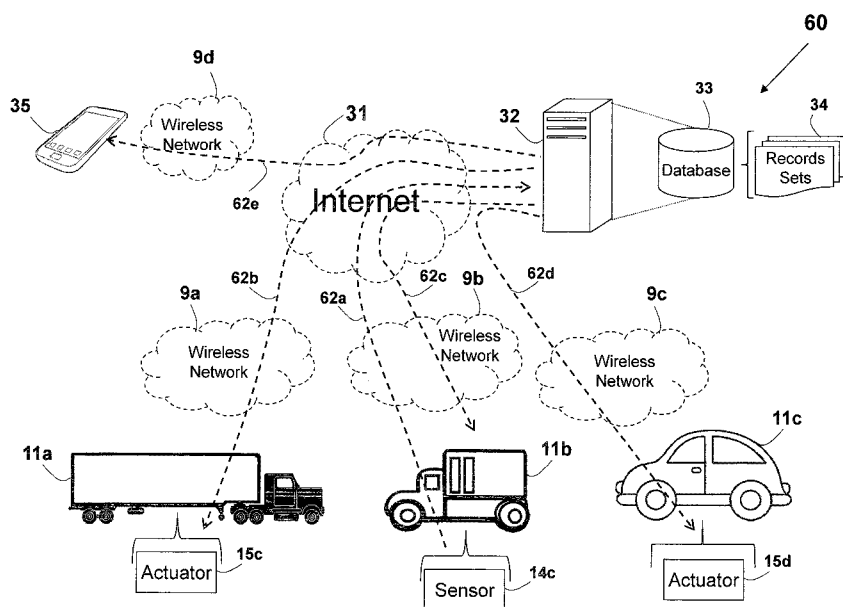


FIG. 6

(57) **Abstract:** A road hazard, such as a traffic collision, traffic regulation violation, road surface damage, or any other traffic obstruction, is detected by a sensor in a vehicle. The sensor data is sent periodically, or upon detecting the anomaly, to a server over the Internet via a first wireless network, together with a vehicle identifier (Vehicle Identification Number (VIN) or the license plate number) and its GNSS or GPS geographic location. The server analyzes the sensor data, and in response sends a notification message to a client device, such as a smartphone, or to a group of vehicles in close vicinity to the first vehicle, via a wireless network over the Internet. The received message may be used by each of the vehicles in the group for controlling, limiting, activating, or otherwise affecting an actuator operation, or may be used for notifying the driver using a dashboard display.



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A Method and Apparatus for Collecting and Using Sensor Data from a Vehicle

TECHNICAL FIELD

This disclosure relates generally to an apparatus and method for collecting and
5 analyzing data from a vehicle or from a group of vehicles in an area, and in particular
using the data for affecting the operation of other vehicles in the area.

BACKGROUND

Unless otherwise indicated herein, the materials described in this section are not
prior art to the claims in this application and are not admitted to be prior art by inclusion
10 in this section.

Vehicle. A vehicle is a mobile machine that transports people or cargo. Most
often, vehicles are manufactured, such as wagons, bicycles, motor vehicles (motorcycles,
cars, trucks, buses), railed vehicles (trains, trams), watercraft (ships, boats), aircraft and
spacecraft. The vehicle may be designed for use on land, in fluids, or be airborne, such
15 as bicycle, car, automobile, motorcycle, train, ship, boat, submarine, airplane, scooter,
bus, subway, train, or spacecraft. A vehicle may consist of, or may comprise, a bicycle, a
car, a motorcycle, a train, a ship, an aircraft, a boat, a spacecraft, a boat, a submarine, a
dirigible, an electric scooter, a subway, a train, a trolleybus, a tram, a sailboat, a yacht, or
an airplane. Further, a vehicle may be a bicycle, a car, a motorcycle, a train, a ship, an
20 aircraft, a boat, a spacecraft, a boat, a submarine, a dirigible, an electric scooter, a
subway, a train, a trolleybus, a tram, a sailboat, a yacht, or an airplane.

A vehicle may be a land vehicle typically moving on the ground, using wheels,
tracks, rails, or skies. The vehicle may be locomotion-based where the vehicle is towed
by another vehicle or an animal. Propellers (as well as screws, fans, nozzles, or rotors)
25 are used to move on or through a fluid or air, such as in watercrafts and aircrafts. The
system described herein may be used to control, monitor or otherwise be part of, or
communicate with, the vehicle motion system. Similarly, the system described herein
may be used to control, monitor or otherwise be part of, or communicate with, the
vehicle steering system. Commonly, wheeled vehicles steer by angling their front or rear
30 (or both) wheels, while ships, boats, submarines, dirigibles, airplanes and other vehicles
moving in or on fluid or air usually have a rudder for steering. The vehicle may be an

automobile, defined as a wheeled passenger vehicle that carries its own motor, and primarily designed to run on roads, and have seating for one to six people. Typically automobiles have four wheels, and are constructed to principally transport of people.

Human power may be used as a source of energy for the vehicle, such as in non-motorized bicycles. Further, energy may be extracted from the surrounding environment, such as solar powered car or aircraft, a street car, as well as by sailboats and land yachts using the wind energy. Alternatively or in addition, the vehicle may include energy storage, and the energy is converted to generate the vehicle motion. A common type of energy source is a fuel, and external or internal combustion engines are used to burn the fuel (such as gasoline, diesel, or ethanol) and create a pressure that is converted to a motion. Another common medium for storing energy are batteries or fuel cells, which store chemical energy used to power an electric motor, such as in motor vehicles, electric bicycles, electric scooters, small boats, subways, trains, trolleybuses, and trams.

Aircraft. An aircraft is a machine that is able to fly by gaining support from the air. It counters the force of gravity by using either static lift or by using the dynamic lift of an airfoil, or in a few cases, the downward thrust from jet engines. The human activity that surrounds aircraft is called aviation. Crewed aircraft are flown by an onboard pilot, but unmanned aerial vehicles may be remotely controlled or self-controlled by onboard computers. Aircraft may be classified by different criteria, such as lift type, aircraft propulsion, usage and others.

Aerostats are lighter than air aircrafts that use buoyancy to float in the air in much the same way that ships float on the water. They are characterized by one or more large gasbags or canopies filled with a relatively low-density gas such as helium, hydrogen, or hot air, which is less dense than the surrounding air. When the weight of this is added to the weight of the aircraft structure, it adds up to the same weight as the air that the craft displaces. Heavier-than-air aircraft, such as airplanes, must find some way to push air or gas downwards, so that a reaction occurs (by Newton's laws of motion) to push the aircraft upwards. This dynamic movement through the air is the origin of the term aerodyne. There are two ways to produce dynamic upthrust: aerodynamic lift and powered lift in the form of engine thrust.

Aerodynamic lift involving wings is the most common, with fixed-wing aircraft being kept in the air by the forward movement of wings, and rotorcraft by spinning wing-shaped rotors sometimes called rotary wings. A wing is a flat, horizontal surface, usually shaped in cross-section as an aerofoil. To fly, air must flow over the wing and

generate lift. A flexible wing is a wing made of fabric or thin sheet material, often stretched over a rigid frame. A kite is tethered to the ground and relies on the speed of the wind over its wings, which may be flexible or rigid, fixed, or rotary.

Gliders are heavier-than-air aircraft that do not employ propulsion once airborne.

5 Take-off may be by launching forward and downward from a high location, or by pulling into the air on a tow-line, either by a ground-based winch or vehicle, or by a powered "tug" aircraft. For a glider to maintain its forward air speed and lift, it must descend in relation to the air (but not necessarily in relation to the ground). Many gliders can 'soar' – gain height from updrafts such as thermal currents. Common examples of
10 gliders are sailplanes, hang gliders and paragliders. Powered aircraft have one or more onboard sources of mechanical power, typically aircraft engines although rubber and manpower have also been used. Most aircraft engines are either lightweight piston engines or gas turbines. Engine fuel is stored in tanks, usually in the wings but larger aircraft also have additional fuel tanks in the fuselage.

15 A propeller aircraft use one or more propellers (airscrews) to create thrust in a forward direction. The propeller is usually mounted in front of the power source in tractor configuration but can be mounted behind in pusher configuration. Variations of propeller layout include contra-rotating propellers and ducted fans. A Jet aircraft use airbreathing jet engines, which take in air, burn fuel with it in a combustion chamber,
20 and accelerate the exhaust rearwards to provide thrust. Turbojet and turbofan engines use a spinning turbine to drive one or more fans, which provide additional thrust. An afterburner may be used to inject extra fuel into the hot exhaust, especially on military "fast jets". Use of a turbine is not absolutely necessary: other designs include the pulse jet and ramjet. These mechanically simple designs cannot work when stationary, so the
25 aircraft must be launched to flying speed by some other method. Some rotorcrafts, such as helicopters, have a powered rotary wing or rotor, where the rotor disc can be angled slightly forward so that a proportion of its lift is directed forwards. The rotor may, similar to a propeller, be powered by a variety of methods such as a piston engine or turbine. Experiments have also used jet nozzles at the rotor blade tips.

30 A vehicle may include a hood (a.k.a. bonnet), which is the hinged cover over the engine of motor vehicles that allows access to the engine compartment (or trunk on rear-engine and some mid-engine vehicles) for maintenance and repair. A vehicle may include a bumper, which is a structure attached, or integrated to, the front and rear of an automobile to absorb impact in a minor collision, ideally minimizing repair costs.

Bumpers also have two safety functions: minimizing height mismatches between vehicles and protecting pedestrians from injury. A vehicle may include a cowling, which is the covering of a vehicle's engine, most often found on automobiles and aircraft. A vehicle may include a dashboard (also called dash, instrument panel, or fascia), which is a control panel placed in front of the driver of an automobile, housing instrumentation and controls for operation of the vehicle. A vehicle may include a fender that frames a wheel well (the fender underside). Its primary purpose is to prevent sand, mud, rocks, liquids, and other road spray from being thrown into the air by the rotating tire. Fenders are typically rigid and can be damaged by contact with the road surface. Instead, flexible mud flaps are used close to the ground where contact may be possible. A vehicle may include a quarter panel (a.k.a. rear wing), which is the body panel (exterior surface) of an automobile between a rear door (or only door on each side for two-door models) and the trunk (boot) and typically wraps around the wheel well. Quarter panels are typically made of sheet metal, but are sometimes made of fiberglass, carbon fiber, or fiber-reinforced plastic. A vehicle may include a rocker, which is the body section below the base of the door openings. A vehicle may include a spoiler, which is an automotive aerodynamic device whose intended design function is to 'spoil' unfavorable air movement across a body of a vehicle in motion, usually described as turbulence or drag. Spoilers on the front of a vehicle are often called air dams. Spoilers are often fitted to race and high-performance sports cars, although they have become common on passenger vehicles as well. Some spoilers are added to cars primarily for styling purposes and have either little aerodynamic benefit or even make the aerodynamics worse. The trunk (a.k.a. boot) of a car is the vehicle's main storage compartment. A vehicle door is a type of door, typically hinged, but sometimes attached by other mechanisms such as tracks, in front of an opening, which is used for entering and exiting a vehicle. A vehicle door can be opened to provide access to the opening, or closed to secure it. These doors can be opened manually, or powered electronically. Powered doors are usually found on minivans, high-end cars, or modified cars. Car glass includes windcreens, side and rear windows, and glass panel roofs on a vehicle. Side windows can be either fixed or be raised and lowered by depressing a button (power window) or switch or using a hand-turned crank.

The lighting system of a motor vehicle consists of lighting and signaling devices mounted or integrated to the front, rear, sides, and in some cases, the top of a motor vehicle. This lights the roadway for the driver and increases the conspicuity of the

vehicle, allowing other drivers and pedestrians to see a vehicle's presence, position, size, direction of travel, and the driver's intentions regarding direction and speed of travel. Emergency vehicles usually carry distinctive lighting equipment to warn drivers and indicate priority of movement in traffic. A headlamp is a lamp attached to the front of a vehicle to light the road ahead. A chassis consists of an internal framework that supports a manmade object in its construction and use. An example of a chassis is the underpart of a motor vehicle, consisting of the frame (on which the body is mounted).

Autonomous car. An autonomous car (also known as a driverless car, self-driving car, or robotic car) is a vehicle that is capable of sensing its environment and navigating without human input. Autonomous cars use a variety of techniques to detect their surroundings, such as radar, laser light, GPS, odometry, and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage. Autonomous cars have control systems that are capable of analyzing sensory data to distinguish between different cars on the road, which is very useful in planning a path to the desired destination. Among the potential benefits of autonomous cars is a significant reduction in traffic collisions; the resulting injuries; and related costs, including a lower need for insurance. Autonomous cars are also predicted to offer major increases in traffic flow; enhanced mobility for children, the elderly, disabled and poor people; the relief of travelers from driving and navigation chores; lower fuel consumption; significantly reduced needs for parking space in cities; a reduction in crime; and the facilitation of different business models for mobility as a service, especially those involved in the sharing economy.

Modern self-driving cars generally use Bayesian Simultaneous Localization And Mapping (SLAM) algorithms, which fuse data from multiple sensors and an off-line map into current location estimates and map updates. SLAM with Detection and Tracking of other Moving Objects (DATMO), which also handles things such as cars and pedestrians, is a variant being developed by research at Google. Simpler systems may use roadside Real-Time Locating System (RTLS) beacon systems to aid localization. Typical sensors include LIDAR and stereo vision, GPS and IMU. Visual object recognition uses machine vision including neural networks.

The term 'Dynamic driving task' includes the operational (steering, braking, accelerating, monitoring the vehicle and roadway) and tactical (responding to events, determining when to change lanes, turn, use signals, etc.) aspects of the driving task, but

not the strategic (determining destinations and waypoints) aspect of the driving task. The term 'Driving mode' refers to a type of driving scenario with characteristic dynamic driving task requirements (e.g., expressway merging, high speed, cruising, low speed traffic jam, closed-campus operations, etc.). The term 'Request to intervene' refers to notification by the automated driving system to a human driver that s/he should promptly begin or resume performance of the dynamic driving task.

The SAE International standard J3016, entitled: "*Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems*" [Revised 2016-09], which is incorporated in its entirety for all purposes as if fully set forth herein, describes six different levels (ranging from none to fully automated systems), based on the amount of driver intervention and attentiveness required, rather than the vehicle capabilities. The levels are further described in a table 40 in FIG. 4. Level 0 refers to automated system issues warnings but has no vehicle control, while Level 1 (also referred to as "hands on") refers to driver and automated system that shares control over the vehicle. An example would be Adaptive Cruise Control (ACC) where the driver controls steering and the automated system controls speed. Using Parking Assistance, steering is automated while speed is manual. The driver must be ready to retake full control at any time. Lane Keeping Assistance (LKA) Type II is a further example of level 1 self-driving.

In Level 2 (also referred to as "hands off"), the automated system takes full control of the vehicle (accelerating, braking, and steering). The driver must monitor the driving and be prepared to immediately intervene at any time if the automated system fails to respond properly. In Level 3 (also referred to as "eyes off"), the driver can safely turn their attention away from the driving tasks, e.g. the driver can text or watch a movie. The vehicle will handle situations that call for an immediate response, like emergency braking. The driver must still be prepared to intervene within some limited time, specified by the manufacturer, when called upon by the vehicle to do so. A key distinction is between level 2, where the human driver performs part of the dynamic driving task, and level 3, where the automated driving system performs the entire dynamic driving task. Level 4 (also referred to as "mind off") is similar to level 3, but no driver attention is ever required for safety, i.e., the driver may safely go to sleep or leave the driver's seat. Self-driving is supported only in limited areas (geofenced) or under special circumstances, such as traffic jams. Outside of these areas or circumstances, the vehicle must be able to safely abort the trip, i.e., park the car, if the driver does not retake

control. In Level 5 (also referred to as "wheel optional"), no human intervention is required. An example would be a robotic taxi.

An autonomous vehicle and systems having an interface for payloads that allows integration of various payloads with relative ease are disclosed in U.S. Patent Application Publication No. 2007/0198144 to Norris *et al.* entitled: "*Networked multi-role robotic vehicle*", which is incorporated in its entirety for all purposes as if fully set forth herein. There is a vehicle control system for controlling an autonomous vehicle, receiving data, and transmitting a control signal on at least one network. A payload is adapted to detachably connect to the autonomous vehicle, the payload comprising a network interface configured to receive the control signal from the vehicle control system over the at least one network. The vehicle control system may encapsulate payload data and transmit the payload data over the at least one network, including Ethernet or CAN networks. The payload may be a laser scanner, a radio, a chemical detection system, or a Global Positioning System unit. In certain embodiments, the payload is a camera mast unit, where the camera communicates with the autonomous vehicle control system to detect and avoid obstacles. The camera mast unit may be interchangeable, and may include structures for receiving additional payload components.

Automotive electronics. Automotive electronics involves any electrically-generated systems used in vehicles, such as ground vehicles. Automotive electronics commonly involves multiple modular ECUs (Electronic Control Unit) connected over a network such as Engine Control Modules (ECM) or Transmission Control Modules (TCM). Automotive electronics or automotive embedded systems are distributed systems, and according to different domains in the automotive field, they can be classified into Engine electronics, Transmission electronics, Chassis electronics, Active safety, Driver assistance, Passenger comfort, and Entertainment (or infotainment) systems.

One of the most demanding electronic parts of an automobile is the Engine Control Unit. Engine controls demand one of the highest real time deadlines, as the engine itself is a very fast and complex part of the automobile. The computing power of the engine control unit is commonly the highest, typically a 32-bit processor, that typically controls in real-time in a diesel engine the Fuel injection rate, Emission control, NOx control, Regeneration of oxidation catalytic converter, Turbocharger control, Throttle control, and Cooling system control. In a gasoline engine, the engine control

typically involves Lambda control, OBD (On-Board Diagnostics), Cooling system control, Ignition system control, Lubrication system control, Fuel injection rate control, and Throttle control.

5 An engine ECU typically connects to, or includes, sensors that actively monitor in real-time engine parameters such as pressure, temperature, flow, engine speed, oxygen level and NOx level, plus other parameters at different points within the engine. All these sensor signals are analyzed by the ECU, which has the logic circuits to do the actual controlling. The ECU output is commonly connected to different actuators for the throttle valve, EGR valve, rack (in VGTs), fuel injector (using a pulse-width modulated
10 signal), dosing injector, and more.

Transmission electronics involves control of the transmission system, mainly the shifting of the gears for better shift comfort and to lower torque interrupt while shifting. Automatic transmissions use controls for their operation, and many semi-automatic transmissions having a fully automatic clutch or a semi-auto clutch (declutching only).
15 The engine control unit and the transmission control typically exchange messages, sensor signals and control signals for their operation. Chassis electronics typically includes many sub-systems that monitor various parameters and are actively controlled, such as ABS - Anti-lock Braking System, TCS – Traction Control System, EBD – Electronic Brake Distribution, and ESP – Electronic Stability Program. Active safety
20 systems involve modules that are ready-to-act when there is a collision in progress, or used to prevent it when it senses a dangerous situation, such as Air bags, Hill descent control, and Emergency brake assist system. Passenger comfort systems involve, for example, Automatic climate control, Electronic seat adjustment with memory, Automatic wipers, Automatic headlamps - adjusts beam automatically, and Automatic
25 cooling - temperature adjustment. Infotainment systems include systems such as Navigation system, Vehicle audio, and Information access.

Automotive electric and electronic technologies and systems are described in a book published by Robert Bosch GmbH (5th Edition, July 2007) entitled: “*Bosch Automotive Electric and Automotive Electronics*” [ISBN – 978-3-658-01783-5], which is
30 incorporated in its entirety for all purposes as if fully set forth herein.

ADAS. Advanced Driver Assistance Systems, or ADAS, are automotive electronic systems to help the driver in the driving process, such as to increase car safety and more generally, road safety using a safe Human-Machine Interface (HMI). Advanced driver assistance systems (ADAS) are developed to automate/adapt/enhance

vehicle systems for safety and better driving. Safety features are designed to avoid collisions and accidents by offering technologies that alert the driver to potential problems, or to avoid collisions by implementing safeguards and taking over control of the vehicle. Adaptive features may automate lighting, provide adaptive cruise control, automate braking, incorporate GPS/ traffic warnings, connect to smartphones, alert driver to other cars or dangers, keep the driver in the correct lane, or show what is in blind spots.

There are many forms of ADAS available; some features are built into cars or are available as an add-on package. ADAS technology can be based upon, or use, vision/camera systems, sensor technology, car data networks, Vehicle-to-vehicle (V2V), or Vehicle-to-Infrastructure systems (V2I), and leverage wireless network connectivity to offer improved value by using car-to-car and car-to-infrastructure data. ADAS technologies or applications comprise: Adaptive Cruise Control (ACC), Adaptive High Beam, Glare-free high beam and pixel light, Adaptive light control such as swiveling curve lights, Automatic parking, Automotive navigation system with typically GPS and TMC for providing up-to-date traffic information, Automotive night vision, Automatic Emergency Braking (AEB), Backup assist, Blind Spot Monitoring (BSM), Blind Spot Warning (BSW), Brake light or traffic signal recognition, Collision avoidance system (such as Precrash system), Collision Imminent Braking (CIB), Cooperative Adaptive Cruise Control (CACC), Crosswind stabilization, Driver drowsiness detection, Driver Monitoring Systems (DMS), Do-Not-Pass Warning (DNPW), Electric vehicle warning sounds used in hybrids and plug-in electric vehicles, Emergency driver assistant, Emergency Electronic Brake Light (EEBL), Forward Collision Warning (FCW), Heads-Up Display (HUD), Intersection assistant, Hill descent control, Intelligent speed adaptation or Intelligent Speed Advice (ISA), Intelligent Speed Adaptation (ISA), Intersection Movement Assist (IMA), Lane Keeping Assist (LKA), Lane Departure Warning (LDW) (a.k.a. Line Change Warning - LCW), Lane change assistance, Left Turn Assist (LTA), Night Vision System (NVS), Parking Assistance (PA), Pedestrian Detection System (PDS), Pedestrian protection system, Pedestrian Detection (PED), Road Sign Recognition (RSR), Surround View Cameras (SVC), Traffic sign recognition, Traffic jam assist, Turning assistant, Vehicular communication systems, Autonomous Emergency Braking (AEB), Adaptive Front Lights (AFL), or Wrong-way driving warning.

ADAS is further described in Intel Corporation 2015 Technical White Paper (0115/MW/HBD/PDF 331817-001US) by Meiyuan Zhao of Security & Privacy Research, Intel Labs entitled: “*Advanced Driver Assistant System - Threats, Requirements, Security Solutions*”, and in a PhD Thesis by Alexandre Dugarry submitted on June 2004 to the Cranfield University, School of Engineering, Applied Mathematics and Computing Group, entitled: “*Advanced Driver Assistance Systems - Information Management and Presentation*”, which are both incorporated in their entirety for all purposes as if fully set forth herein.

ACC. Autonomous cruise control (ACC; also referred to as ‘adaptive cruise control’ or ‘radar cruise control’) is an optional cruise control system for road vehicles that automatically adjusts the vehicle speed to maintain a safe distance from vehicles ahead. It makes no use of satellite or roadside infrastructures or of any cooperative support from other vehicles. The vehicle control is imposed based on sensor information from on-board sensors only. Cooperative Adaptive Cruise Control (CACC) further extends the automation of navigation by using information gathered from fixed infrastructure such as satellites and roadside beacons, or mobile infrastructure such as reflectors or transmitters on the back of other vehicles. These systems use either a radar or laser sensor setup allowing the vehicle to slow when approaching another vehicle ahead and accelerate again to the preset speed when traffic allows. ACC technology is widely regarded as a key component of any future generations of intelligent cars. The impact is equally on driver safety as on economizing capacity of roads by adjusting the distance between vehicles according to the conditions. Radar-based ACC often feature a pre-crash system, which warns the driver and/or provides brake support if there is a high risk of a collision. In certain cars it is incorporated with a lane maintaining system which provides power steering assist to reduce steering input burden in corners when the cruise control system is activated.

Adaptive High Beam. Adaptive High Beam Assist is Mercedes-Benz’ marketing name for a headlight control strategy that continuously automatically tailors the headlamp range so the beam just reaches other vehicles ahead, thus always ensuring maximum possible seeing range without glaring other road users. It provides a continuous range of beam reach from a low-aimed low beam to a high-aimed high beam, rather than the traditional binary choice between low and high beams. The range of the beam can vary between 65 and 300 meters, depending on traffic conditions. In traffic, the low beam cutoff position is adjusted vertically to maximize seeing range while

keeping glare out of leading and oncoming drivers' eyes. When no traffic is close enough for glare to be a problem, the system provides full high beam. Headlamps are adjusted every 40 milliseconds by a camera on the inside of the front windscreen which can determine distance to other vehicles. The adaptive high beam may be realized with LED headlamps.

Automatic parking. Automatic parking is an autonomous car-maneuvering system that moves a vehicle from a traffic lane into a parking spot to perform parallel, perpendicular or angle parking. The automatic parking system aims to enhance the comfort and safety of driving in constrained environments where much attention and experience is required to steer the car. The parking maneuver is achieved by means of coordinated control of the steering angle and speed, which takes into account the actual situation in the environment to ensure collision-free motion within the available space. The car is an example of a non-holonomic system where the number of control commands available is less than the number of coordinates that represent its position and orientation.

Automotive night vision. An automotive night vision system uses a thermographic camera to increase a driver's perception and seeing distance in darkness or poor weather beyond the reach of the vehicle's headlights. Active systems use an infrared light source built into the car to illuminate the road ahead with light that is invisible to humans. There are two kinds of active systems: gated and non-gated. The gated system uses a pulsed light source and a synchronized camera that enable long ranges (250m) and high performance in rain and snow. Passive infrared systems do not use an infrared light source, instead they capture thermal radiation already emitted by the objects, using a thermographic camera.

Blind spot monitor. The blind spot monitor is a vehicle-based sensor device that detects other vehicles located to the driver's side and rear. Warnings can be visual, audible, vibrating or tactile. Blind spot monitors may include more than monitoring the sides of the vehicle, such as 'Cross Traffic Alert', which alerts drivers backing out of a parking space when traffic is approaching from the sides. BLIS is an acronym for Blind Spot Information System, a system of protection developed by Volvo, and produced a visible alert when a car entered the blind spot while a driver was switching lanes, using two door mounted lenses to check the blind spot area for an impending collision.

Collision avoidance system. A collision avoidance system (a.k.a. Pre-crash system) is an automobile safety system designed to reduce the severity of an accident.

Such forward collision warning system or collision mitigating system typically uses radar (all-weather) and sometimes laser and camera (both sensor types are ineffective during bad weather) to detect an imminent crash. Once the detection is done, these systems either provide a warning to the driver when there is an imminent collision or
5 take action autonomously without any driver input (by braking or steering or both). Collision avoidance by braking is appropriate at low vehicle speeds (e.g. below 50 km/h), while collision avoidance by steering is appropriate at higher vehicle speeds. Cars with collision avoidance may also be equipped with adaptive cruise control, and use the same forward-looking sensors.

10 Intersection assistant. Intersection assistant is an advanced driver assistance system for city junctions that are a major accident blackspot. The collisions here can mostly be put down to driver distraction or mis-judgement. While humans often react too slowly, assistance systems are immune to that brief moment of shock. The system monitors cross traffic in an intersection/road junction. If this anticipatory system detects
15 a hazardous situation of this type, it prompts the driver to start emergency braking by activating visual and acoustic warnings and automatically engaging brakes.

Lane Departure Warning system. A lane departure warning system is a mechanism designed to warn the driver when the vehicle begins to move out of its lane (unless a turn signal is on in that direction) on freeways and arterial roads. These systems
20 are designed to minimize accidents by addressing the main causes of collisions: driver error, distractions, and drowsiness. There are two main types of systems: Systems which warn the driver (lane departure warning, LDW) if the vehicle is leaving its lane (visual, audible, and/or vibration warnings), and systems which warn the driver and, if no action is taken, automatically take steps to ensure the vehicle stays in its lane (Lane Keeping
25 System, LKS). Lane warning/keeping systems are based on video sensors in the visual domain (mounted behind the windshield, typically integrated beside the rear mirror), laser sensors (mounted on the front of the vehicle), or Infrared sensors (mounted either behind the windshield or under the vehicle).

ADASIS. The Advanced Driver Assistance System Interface Specification
30 (ADASIS) forum was established in May 2001 by a group of car manufacturers, in-vehicle system developers and map data companies with the primary goal of developing a standardized map data interface between stored map data and ADAS applications. Main objectives of the ADASIS Forum are to define an open standardized data model and structure to represent map data in the vicinity of the vehicle position (i.e. the ADAS

Horizon), in which map data is delivered by a navigation system or a general map data server, and to define an open standardized interface specification to provide ADAS horizon data (especially on a vehicle CAN bus) and enable ADAS applications to access the ADAS Horizon and position-related data of the vehicle. Using ADASIS, the available map data may not only be used for routing purposes but also to enable advanced in-vehicle applications. The area of potential features reaches from headlight control up to active safety applications (ADAS). With the ongoing development of navigation based ADAS features the interface to access the so-called ADAS Horizon is of rising importance. The ADASIS protocol is described in ADASIS Forum publication 200v2.0.3-D2.2-ADASIS_v2_Specification.0 dated December 2013 and entitled: “*ADASIS v2 Protocol – Version 2.0.3.0*”, which is incorporated in its entirety for all purposes as if fully set forth herein. Built-in vehicle sensors may be used to capture the vehicle's environment are limited to a relatively short range. However, the available digital map data can be used as a virtual sensor to look more forward on the path of the vehicle. The digital map contains attributes attached to the road segments, such as road geometry, functional road class, number of lanes, speed limits, traffic signs, etc. The “road ahead” concept is basically called Most Probable Path (or Most Likely Path) derived from the ADAS Horizon. For each street segment, the probability of driving through this segment is assigned and given by the ADASIS protocol.

ECU. In automotive electronics, an Electronic Control Unit (ECU) is a generic term for any embedded system that controls one or more of the electrical system or subsystems in a vehicle such as a motor vehicle. Types of ECU include Electronic/engine Control Module (ECM) (sometimes referred to as Engine Control Unit – ECU, which is distinct from the generic ECU - Electronic Control Unit), Airbag Control Unit (ACU), Powertrain Control Module (PCM), Transmission Control Module (TCM), Central Control Module (CCM), Central Timing Module (CTM), Convenience Control Unit (CCU), General Electronic Module (GEM), Body Control Module (BCM), Suspension Control Module (SCM), Door Control Unit (DCU), Powertrain Control Module (PCM), Electric Power Steering Control Unit (PSCU), Seat Control Unit, Speed Control Unit (SCU), Suspension Control Module (SCM), Telematic Control Unit (TCU), Telephone Control Unit (TCU), Transmission Control Unit (TCU), Brake Control Module (BCM or EBCM; such as ABS or ESC), Battery management system, control unit, or control module.

A microprocessor or a microcontroller serves as a core of an ECU, and uses a memory such as SRAM, EEPROM, and Flash. An ECU is power fed by a supply voltage, and includes or connects to sensors using analog and digital inputs. In addition to a communication interface, an ECU typically includes a relay, H-Bridge, injector, or logic drivers, or outputs for connecting to various actuators.

ECU technology and applications is described in the M. Tech. Project first stage report (EE696) by Vineet P. Aras of the Department of Electrical Engineering, Indian Institute of Technology Bombay, dated July 2004, entitled: "*Design of Electronic Control Unit (ECU) for Automobiles – Electronic Engine Management system*", and in National Instruments paper published Nov. 07, 2009 entitled: "*ECU Designing and Testing using National Instruments Products*", which are both incorporated in their entirety for all purposes as if fully set forth herein. ECU examples are described in a brochure by Sensor-Technik Wiedemann GmbH (headquartered in Kaufbeuren, Germany) dated 20110304 GB entitled "*Control System Electronics*", which is incorporated in its entirety for all purposes as if fully set forth herein. An ECU or an interface to a vehicle bus may use a processor such as the MPC5748G controller available from Freescale Semiconductor, Inc. (headquartered in Tokyo, Japan, and described in a data sheet Document Number MPC5748G Rev. 2, 05/2014 entitled: "*MPC5748 Microcontroller Datasheet*", which is incorporated in its entirety for all purposes as if fully set forth herein.

OSEK/VDX. OSEK/VDX, formerly known as OSEK (*Offene Systeme und deren Schnittstellen für die Elektronik in Kraftfahrzeugen*; in English: "*Open Systems and their Interfaces for the Electronics in Motor Vehicles*") OSEK is an open standard, published by a consortium founded by the automobile industry for an embedded operating system, a communications stack, and a network management protocol for automotive embedded systems. OSEK was designed to provide a standard software architecture for the various electronic control units (ECUs) throughout a car.

The OSEK standard specifies interfaces to multitasking functions—generic I/O and peripheral access—and thus remains architecture dependent. OSEK systems are expected to run on chips without memory protection. Features of an OSEK implementation can be usually configured at compile-time. The number of application tasks, stacks, mutexes, etc., is statically configured; it is not possible to create more at run time. OSEK recognizes two types of tasks/threads/compliance levels: basic tasks and enhanced tasks. Basic tasks never block; they "run to completion" (coroutine). Enhanced

tasks can sleep and block on event objects. The events can be triggered by other tasks (basic and enhanced) or interrupt routines. Only static priorities are allowed for tasks, and First-In-First-Out (FIFO) scheduling is used for tasks with equal priority. Deadlocks and priority inversion are prevented by priority ceiling (i.e. no priority inheritance). The specification uses ISO/ANSI-C-like syntax; however, the implementation language of the system services is not specified. OSEK/VDX Network Management functionality is described in a document by OSEK/VDX NM Concept & API 2.5.2 (Version 2.5.3, 26th July 2004) entitled: "*Open Systems and the Corresponding Interfaces for Automotive Electronics - Network Management - Concept and Application Programming Interface*", which is incorporated in its entirety for all purposes as if fully set forth herein. Some parts of the OSEK are standardized as part of ISO 17356 standard series entitled: "*Road vehicles — Open interface for embedded automotive applications*", such as ISO 17356-1 standard (First edition, 2005-01-15) entitled: "*Part 1: General structure and terms, definitions and abbreviated terms*", ISO 17356-2 standard (First edition, 2005-05-01) entitled: "*Part 2: OSEK/VDX specifications for binding OS, COM and NM*", ISO 17356-3 standard (First edition, 2005-11-01) entitled: "*Part 3: OSEK/VDX Operating System (OS)*", and ISO 17356-4 standard (First edition, 2005-11-01) entitled: "*Part 4: OSEK/VDX Communication (COM)*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

AUTOSAR. AUTOSAR (Automotive Open System Architecture) is a worldwide development partnership of automotive interested parties founded in 2003. It pursues the objective of creating and establishing an open and standardized software architecture for automotive electronic control units excluding infotainment. Goals include the scalability to different vehicle and platform variants, transferability of software, the consideration of availability and safety requirements, a collaboration between various partners, sustainable utilization of natural resources, maintainability throughout the whole "Product Life Cycle".

AUTOSAR provides a set of specifications that describe basic software modules, defines application interfaces, and builds a common development methodology based on standardized exchange format. Basic software modules made available by the AUTOSAR layered software architecture can be used in vehicles of different manufacturers and electronic components of different suppliers, thereby reducing expenditures for research and development, and mastering the growing complexity of automotive electronic and software architectures. Based on this guiding principle,

AUTOSAR has been devised to pave the way for innovative electronic systems that further improve performance, safety and environmental friendliness and to facilitate the exchange and update of software and hardware over the service life of the vehicle. It aims to be prepared for the upcoming technologies and to improve cost-efficiency without making any compromise with respect to quality.

AUTOSAR uses a three-layered architecture: Basic Software - standardized software modules (mostly) without any functional job itself that offers services necessary to run the functional part of the upper software layer; Runtime environment - Middleware which abstracts from the network topology for the inter- and intra-ECU information exchange between the application software components and between the Basic Software and the applications; and Application Layer - application software components that interact with the runtime environment. System Configuration Description includes all system information and the information that must be agreed between different ECUs (e.g. definition of bus signals). ECU extract is the information from the System Configuration Description needed for a specific ECU (e.g. those signals where a specific ECU has access to). ECU Configuration Description contains all basic software configuration information that is local to a specific ECU. The executable software can be built from this information, the code of the basic software modules and the code of the software components. The AUTOSAR specification is described in Release 4.2.2 released 31/01/2015 by the AUTOSAR consortium entitled: "*Release 4.2 Overview and Revision History*", which is incorporated in its entirety for all purposes as if fully set forth herein.

Vehicle bus. A vehicle bus is a specialized internal (in-vehicle) communications network that interconnects components inside a vehicle (e.g., automobile, bus, train, industrial or agricultural vehicle, ship, or aircraft). Special requirements for vehicle control such as assurance of message delivery, of non-conflicting messages, of minimum time of delivery, of low cost, and of EMF noise resilience, as well as redundant routing and other characteristics mandate the use of less common networking protocols. A vehicle bus typically connects the various ECUs in the vehicle. Common protocols include Controller Area Network (CAN), Local Interconnect Network (LIN) and others. Conventional computer networking technologies (such as Ethernet and TCP/IP) may as well be used.

Any in-vehicle internal network that interconnects the various devices and components inside the vehicle may use any of the technologies and protocols described

herein. Common protocols used by vehicle buses include a Control Area Network (CAN), FlexRay, and a Local Interconnect Network (LIN). Other protocols used for in-vehicle are optimized for multimedia networking such as MOST (Media Oriented Systems Transport). The CAN is described in the Texas Instrument Application Report No. SLOA101A entitled: *"Introduction to the Controller Area Network (CAN)"*, and may be based on, may be compatible with, or may be according to, ISO 11898 standards, ISO 11992-1 standard, SAE J1939 or SAE J2411 standards, which are all incorporated in their entirety for all purposes as if fully set forth herein. The LIN communication may be based on, may be compatible with, or according to, ISO 9141, and is described in *"LIN Specification Package – Revision 2.2A"* by the LIN Consortium, which are all incorporated in their entirety for all purposes as if fully set forth herein. In one example, the DC power lines in the vehicle may also be used as the communication medium, as described for example in U.S. Patent No. 7,010,050 to Maryanka, entitled: *"Signaling over Noisy Channels"*, which is incorporated in its entirety for all purposes as if fully set forth herein.

CAN. A controller area network (CAN bus) is a vehicle bus standard designed to allow microcontrollers and devices to communicate with each other in applications without a host computer. It is a message-based protocol, designed originally for multiplex electrical wiring within automobiles, but is also used in many other contexts. CAN bus is one of five protocols used in the on-board diagnostics (OBD)-II vehicle diagnostics standard. CAN is a multi-master serial bus standard for connecting Electronic Control Units [ECUs] also known as nodes. Two or more nodes are required on the CAN network to communicate. The complexity of the node can range from a simple I/O device up to an embedded computer with a CAN interface and sophisticated software. The node may also be a gateway allowing a standard computer to communicate over a USB or Ethernet port to the devices on a CAN network. All nodes are connected to each other through a two-wire bus. The wires are 120 Ω nominal twisted pair. Implementing CAN is described in an Application Note (AN10035-0-2/12(0) Rev. 0) published 2012 by Analog Devices, Inc. entitled: *"Controller Area Network (CAN) Implementation Guide – by Dr. Conal Watterson"*, which is incorporated in its entirety for all purposes as if fully set forth herein.

CAN transceiver is defined by ISO 11898-2/3 Medium Access Unit [MAU] standards, and in receiving, converts the levels of the data stream received from the CAN bus to levels that the CAN controller uses. It usually has protective circuitry to protect

the CAN controller, and in transmitting state converts the data stream from the CAN controller to CAN bus compliant levels. An example of a CAN transceiver is model TJA1055 or model TJA1044 both available from NXP Semiconductors N.V. headquartered in Eindhoven, Netherlands, respectively described in Product data sheets (document Identifier TJA1055, date of release: 6 December 2013) entitled: “*TJA1055 Enhanced fault-tolerant CAN transceiver – Rev. 5 - 6 December 2013 – Product data sheet*”, and Product data sheets (document Identifier TJA1055, date of release: 6 December 2013) entitled: “*TJA1044 High-speed CAN transceiver with Standby mode – Rev. 4 - 10 July 2015 – Product data sheet*”, which are both incorporated in their entirety for all purposes as if fully set forth herein.

Another example of a CAN Transceiver is Model No. SN65HVD234D available from Texas Instruments Incorporated (Headquartered in Dallas, Texas, U.S.A.), described in Datasheet SLLS557G (NOVEMBER 2002–REVISED JANUARY 2015), entitled: “*SN65HVD23x 3.3-V CAN Bus Transceivers*”, which is incorporated in its entirety for all purposes as if fully set forth herein. An example of a CAN controller is Model No. STM32F105Vc available from STMicroelectronics NV described in Datasheet DocID15724 Rev. 9, published September 2015 and entitled: “*STM32F105xx STM32F107xx*”, which is incorporated in its entirety for all purposes as if fully set forth herein, which is part of the STM32F105xx connectivity line family that incorporates the high-performance ARM®Cortex®-M3 32-bit RISC core operating at a 72 MHz frequency, high-speed embedded memories (Flash memory up to 256 Kbytes and SRAM 64 Kbytes), and an extensive range of enhanced I/Os and peripherals connected to two APB buses. All devices offer two 12-bit ADCs, four general-purpose 16-bit timers plus a PWM timer, as well as standard and advanced communication interfaces: up to two I2Cs, three SPIs, two I2Ss, five USARTs, an USB OTG FS and two CANs.

Each node is able to send and receive messages, but not simultaneously. A message or Frame consists primarily of the ID (identifier), which represents the priority of the message, and up to eight data bytes. A CRC, acknowledge slot [ACK] and other overhead are also part of the message. The improved CAN FD extends the length of the data section to up to 64 bytes per frame. The message is transmitted serially onto the bus using a non-return-to-zero (NRZ) format and may be received by all nodes. The devices that are connected by a CAN network are typically sensors, actuators, and other control devices. These devices are connected to the bus through a host processor, a CAN controller, and a CAN transceiver. A terminating bias circuit is power and ground

provided together with the data signaling in order to provide electrical bias and termination at each end of each bus segment to suppress reflections.

CAN data transmission uses a lossless bit-wise arbitration method of contention resolution. This arbitration method requires all nodes on the CAN network to be
5 synchronized to sample every bit on the CAN network at the same time. While some call CAN synchronous, the data is transmitted without a clock signal in an asynchronous format. The CAN specifications use the terms "dominant" bits and "recessive" bits where dominant is a logical '0' (actively driven to a voltage by the transmitter) and recessive is a logical '1' (passively returned to a voltage by a resistor). The idle state is
10 represented by the recessive level (Logical 1). If one node transmits a dominant bit and another node transmits a recessive bit, then there is a collision and the dominant bit "wins". This means there is no delay to the higher-priority message, and the node transmitting the lower priority message automatically attempts to re-transmit six bit clocks after the end of the dominant message. This makes CAN very suitable as a real
15 time prioritized communications system.

The exact voltages for a logical level '0' or '1' depend on the physical layer used, but the basic principle of CAN requires that each node listen to the data on the CAN network including the data that the transmitting node is transmitting. If a logical '1' is transmitted by all transmitting nodes at the same time, then a logical 1 is seen by
20 all of the nodes, including both the transmitting node(s) and receiving node(s). If a logical '0' is transmitted by all transmitting node(s) at the same time, then a logical '0' is seen by all nodes. If a logical '0' is being transmitted by one or more nodes, and a logical '1' is being transmitted by one or more nodes, then a logical '0' is seen by all nodes including the node(s) transmitting the logical '1'. When a node transmits a logical
25 '1' but sees a logical '0', it realizes that there is a contention and it quits transmitting. By using this process, any node that transmits a logical '1' when another node transmits a logical '0' "drops out" or loses the arbitration. A node that loses arbitration re-queues its message for later transmission and the CAN frame bit-stream continues without error until only one node is left transmitting. This means that the node that transmits the first
30 '1', loses arbitration. Since the 11 (or 29 for CAN 2.0B) bit identifier is transmitted by all nodes at the start of the CAN frame, the node with the lowest identifier transmits more zeros at the start of the frame, and that is the node that wins the arbitration or has the highest priority.

The CAN protocol, like many networking protocols, can be decomposed into the following abstraction layers - Application layer, Object layer (including Message filtering and Message and status handling), and Transfer layer.

Most of the CAN standard applies to the transfer layer. The transfer layer receives messages from the physical layer and transmits those messages to the object layer. The transfer layer is responsible for bit timing and synchronization, message framing, arbitration, acknowledgement, error detection and signaling, and fault confinement. It performs Fault Confinement, Error Detection, Message Validation, Acknowledgement, Arbitration, Message Framing, Transfer Rate and Timing, and Information Routing.

ISO 11898-2 describes the electrical implementation formed from a multi-dropped single-ended balanced line configuration with resistor termination at each end of the bus. In this configuration, a dominant state is asserted by one or more transmitters switching the CAN- to supply 0 V and (simultaneously) switching CAN+ to the +5 V bus voltage thereby forming a current path through the resistors that terminate the bus. As such, the terminating resistors form an essential component of the signaling system and are included not just to limit wave reflection at high frequency. During a recessive state, the signal lines and resistor(s) remain in a high impedances state with respect to both rails. Voltages on both CAN+ and CAN- tend (weakly) towards $\frac{1}{2}$ rail voltage. A recessive state is only present on the bus when none of the transmitters on the bus is asserting a dominant state. During a dominant state the signal lines and resistor(s) move to a low impedance state with respect to the rails so that current flows through the resistor. CAN+ voltage tends to +5 V and CAN- tends to 0 V. Irrespective of signal state the signal lines are always in low impedance state with respect to one another by virtue of the terminating resistors at the end of the bus. Multiple access on CAN bus is achieved by the electrical logic of the system supporting just two states that are conceptually analogous to a 'wired OR' network.

The CAN is standardized in a standards set ISO 11898 entitled: "*Road vehicles - Controller area network (CAN)*" that specifies physical and datalink layer (levels 1 and 2 of the ISO/OSI model) of serial communication technology called Controller Area Network that supports distributed real-time control and multiplexing for use within road vehicles. The standard ISO 11898-1:2015 entitled: "*Part 1: Data link layer and physical signalling*" specifies the characteristics of setting up an interchange of digital information between modules implementing the CAN data link layer. Controller area

network is a serial communication protocol, which supports distributed real-time control and multiplexing for use within road vehicles and other control applications. The ISO 11898-1:2015 specifies the Classical CAN frame format and the newly introduced CAN Flexible Data Rate Frame format. The Classical CAN frame format allows bit rates up to 1 Mbit/s and payloads up to 8 byte per frame. The Flexible Data Rate frame format allows bit rates higher than 1 Mbit/s and payloads longer than 8 byte per frame. ISO 11898-1:2015 describes the general architecture of CAN in terms of hierarchical layers according to the ISO reference model for open systems interconnection (OSI) according to ISO/IEC 7498-1. The CAN data link layer is specified according to ISO/IEC 8802-2 and ISO/IEC 8802-3. ISO 11898-1:2015 contains detailed specifications of the following: logical link control sub-layer; medium access control sub-layer; and physical coding sub-layer.

The standard ISO 11898-2:2003 entitled: “*Part 2: High-speed medium access unit*” specifies the high-speed (transmission rates of up to 1 Mbit/s) medium access unit (MAU), and some medium dependent interface (MDI) features (according to ISO 8802-3), which comprise the physical layer of the controller area network (CAN): a serial communication protocol that supports distributed real-time control and multiplexing for use within road vehicles.

The standard ISO 11898-3:2006 entitled: “*Part 3: Low-speed, fault-tolerant, medium-dependent interface*” specifies characteristics of setting up an interchange of digital information between electronic control units of road vehicles equipped with the controller area network (CAN) at transmission rates above 40 kBit/s up to 125 kBit/s.

The standard ISO 11898-4:2004 entitled: “*Part 4: Time-triggered communication*” specifies time-triggered communication in the controller area network (CAN): a serial communication protocol that supports distributed real-time control and multiplexing for use within road vehicles. It is applicable to setting up a time-triggered interchange of digital information between electronic control units (ECU) of road vehicles equipped with CAN, and specifies the frame synchronization entity that coordinates the operation of both logical link and media access controls in accordance with ISO 11898-1, to provide the time-triggered communication schedule.

The standard ISO 11898-5:2007 entitled: “*Part 5: High-speed medium access unit with low-power mode*” specifies the CAN physical layer for transmission rates up to 1 Mbit/s for use within road vehicles. It describes the medium access unit functions as well as some medium dependent interface features according to ISO 8802-2. ISO 11898-

5:2007 represents an extension of ISO 11898-2, dealing with new functionality for systems requiring low-power consumption features while there is no active bus communication. Physical layer implementations according to ISO 11898-5:2007 are compliant with all parameters of ISO 11898-2, but are defined differently within ISO 11898-5:2007. Implementations according to ISO 11898-5:2007 and ISO 11898-2 are interoperable and can be used at the same time within one network.

The standard ISO 11898-6:2013 entitled: “*Part 6: High-speed medium access unit with selective wake-up functionality*” specifies the controller area network (CAN) physical layer for transmission rates up to 1 Mbit/s. It describes the medium access unit (MAU) functions. ISO 11898-6:2013 represents an extension of ISO 11898-2 and ISO 11898-5, specifying a selective wake-up mechanism using configurable CAN frames. Physical layer implementations according to ISO 11898-6:2013 are compliant with all parameters of ISO 11898-2 and ISO 11898-5. Implementations according to ISO 11898-6:2013, ISO 11898-2 and ISO 11898-5 are interoperable and can be used at the same time within one network.

The standard ISO 11992-1:2003 entitled: “*Road vehicles -- Interchange of digital information on electrical connections between towing and towed vehicles -- Part 1: Physical and data-link layers*” specifies the interchange of digital information between road vehicles with a maximum authorized total mass greater than 3 500 kg, and towed vehicles, including communication between towed vehicles in terms of parameters and requirements of the physical and data link layer of the electrical connection used to connect the electrical and electronic systems. It also includes conformance tests of the physical layer.

The standard ISO 11783-2:2012 entitled: “*Tractors and machinery for agriculture and forestry -- Serial control and communications data network -- Part 2: Physical layer*” specifies a serial data network for control and communications on forestry or agricultural tractors and mounted, semi-mounted, towed or self-propelled implements. Its purpose is to standardize the method and format of transfer of data between sensors, actuators, control elements and information storage and display units, whether mounted on, or part of, the tractor or implement, and to provide an open interconnect system for electronic systems used by agricultural and forestry equipment. ISO 11783-2:2012 defines and describes the network's 250 kbit/s, twisted, non-shielded, quad-cable physical layer. ISO 11783-2 uses four unshielded twisted wires; two for CAN and two for terminating bias circuit (TBC) power and ground. This bus is used on

agricultural tractors. It is intended to provide interconnectivity between the tractor and any agricultural implement adhering to the standard.

The standard J1939/11_201209 entitled: “*Physical Layer, 250 Kbps, Twisted Shielded Pair*” defines a physical layer having a robust immunity to EMI and physical properties suitable for harsh environments. These SAE Recommended Practices are intended for light- and heavy-duty vehicles on- or off-road as well as appropriate stationary applications which use vehicle derived components (e.g., generator sets). Vehicles of interest include but are not limited to: on- and off-highway trucks and their trailers; construction equipment; and agricultural equipment and implements.

The standard SAE J1939/15_201508 entitled: “*Physical Layer, 250 Kbps, Un-Shielded Twisted Pair (UTP)*” describes a physical layer utilizing Unshielded Twisted Pair (UTP) cable with extended stub lengths for flexibility in ECU placement and network topology. CAN controllers are now available which support the newly introduced CAN Flexible Data Rate Frame format (known as “CAN FD”). These controllers, when used on SAE J1939-15 networks, must be restricted to use only the Classical Frame format compliant to ISO 11898-1 (2003).

The standard SAE J2411_200002 entitled: “*Single Wire Can Network for Vehicle Applications*” defines the Physical Layer and portions of the Data Link Layer of the OSI model for data communications. In particular, this document specifies the physical layer requirements for any Carrier Sense Multiple Access/Collision Resolution (CSMA/CR) data link, which operates on a single wire medium to communicate among Electronic Control Units (ECU) on road vehicles. Requirements stated in this document will provide a minimum standard level of performance to which all compatible ECUs and media shall be designed. This will assure full serial data communication among all connected devices regardless of the supplier. This document is to be referenced by the particular vehicle OEM Component Technical Specification which describes any given ECU, in which the single wire data link controller and physical layer interface is located. Primarily, the performance of the physical layer is specified in this document.

A specification for CAN FD (CAN with Flexible Data-Rate) version 1.0 was released on April 17th, 2012 by Robert Bosch GmbH entitled: CAN with Flexible Data-Rate Specification Version 1.0), and is incorporated in its entirety for all purposes as if fully set forth herein. This specification uses a different frame format that allows a different data length as well as optionally switching to a faster bit rate after the arbitration is decided. CAN FD is compatible with existing CAN 2.0 networks so new

CAN FD devices can coexist on the same network with existing CAN devices. CAN FD is further described in iCC 2013 CAN in Automation articles by Florian Hatwich entitled: "*Bit Time Requirements for CAN FD*" and "*Can with Flexible Data-Rate*", and in National Instruments article published Aug. 01, 2014 entitled: "*Understanding CAN with Flexible Data-Rate (CAN FD)*", which are all incorporated in their entirety for all purposes as if fully set forth herein. In one example, the CAN FD interface is based on, compatible with, or uses, the SPC57EM80 controller device available from STMicroelectronics described in an Application Note AN4389 (document number DocD025493 Rev 2) published 2014 entitled: "*SPC57472/SPC57EM80 Getting Started*", which is incorporated in its entirety for all purposes as if fully set forth herein. Further, a CAN FD transceiver may be based on, compatible with, or use, transceiver model MCP2561/2FD available from Microchip Technology Inc., described in a data sheet DS20005284A published 2014 [ISBN – 978-1-63276-020-3] entitled: "*MCP2561/2FD - High-Speed CAN Flexible Data Rate Transceiver*", which is incorporated in its entirety for all purposes as if fully set forth herein.

LIN. LIN (Local Interconnect Network) is a serial network protocol used for communication between components in vehicles. The LIN communication may be based on, compatible with, or is according to, ISO 9141, and is described in "*LIN Specification Package – Revision 2.2A*" by the LIN Consortium (dated December 31, 2010), which is incorporated in its entirety for all purposes as if fully set forth herein. The LIN standard is further standardized as part of ISO 17987-1 to 17987-7 standards. LIN may be used also over the vehicle's battery power-line with a special DC-LIN transceiver. LIN is a broadcast serial network comprising 16 nodes (one master and typically up to 15 slaves). All messages are initiated by the master with at most one slave replying to a given message identifier. The master node can also act as a slave by replying to its own messages, and since all communications are initiated by the master it is not necessary to implement a collision detection. The master and slaves are typically microcontrollers, but may be implemented in specialized hardware or ASICs in order to save cost, space, or power. Current uses combine the low-cost efficiency of LIN and simple sensors to create small networks that can be connected by a backbone network. (i.e., CAN in cars).

The LIN bus is an inexpensive serial communications protocol, which effectively supports remote application within a car's network, and is particularly intended for mechatronic nodes in distributed automotive applications, but is equally suited to industrial applications. The protocol's main features are single master, up to 16 slaves

(i.e. no bus arbitration), Slave Node Position Detection (SNPD) that allows node address assignment after power-up, Single wire communications up to 19.2 kbit/s @ 40 meter bus length (in the LIN specification 2.2 the speed up to 20 kbit/s), Guaranteed latency times, Variable length of data frame (2, 4 and 8 byte), Configuration flexibility, Multi-cast reception with time synchronization, without crystals or ceramic resonators, Data checksum and error detection, Detection of defective nodes, Low cost silicon implementation based on standard UART/SCI hardware, Enabler for hierarchical networks, and Operating voltage of 12 V. LIN is further described in U.S. Patent No. 7,091,876 to Steger entitled: "*Method for Addressing the Users of a Bus System by Means of Identification Flows*", which is incorporated in its entirety for all purposes as if fully set forth herein.

Data is transferred across the bus in fixed form messages of selectable lengths. The master task transmits a header that consists of a break signal followed by synchronization and identifier fields. The slaves respond with a data frame that consists of between 2, 4 and 8 data bytes plus 3 bytes of control information. The LIN uses Unconditional Frames, Event-triggered Frames, Sporadic Frames, Diagnostic Frames, User-Defined Frames, and Reserved Frames.

Unconditional Frames always carry signals and their identifiers are in the range 0 to 59 (0x00 to 0x3b) and all subscribers of the unconditional frame shall receive the frame and make it available to the application (assuming no errors were detected), and Event-triggered Frame, to increase the responsiveness of the LIN cluster without assigning too much of the bus bandwidth to the polling of multiple slave nodes with seldom occurring events. The first data byte of the carried unconditional frame shall be equal to a protected identifier assigned to an event-triggered frame. A slave shall reply with an associated unconditional frame only if its data value has changed. If none of the slave tasks responds to the header, the rest of the frame slot is silent and the header is ignored. If more than one slave task responds to the header in the same frame slot a collision will occur, and the master has to resolve the collision by requesting all associated unconditional frames before requesting the event-triggered frame again. Sporadic Frame is transmitted by the master as required, so a collision cannot occur. The header of a sporadic frame shall only be sent in its associated frame slot when the master task knows that a signal carried in the frame has been updated. The publisher of the sporadic frame shall always provide the response to the header. Diagnostic Frame always carries diagnostic or configuration data and they always contain eight data bytes.

The identifier is either 60 (0x3C), called master request frame, or 61(0x3D), called slave response frame. Before generating the header of a diagnostic frame, the master task asks its diagnostic module if it shall be sent or if the bus shall be silent. The slave tasks publish and subscribe to the response according to their diagnostic module. User-Defined Frame carries any kind of information. Their identifier is 62 (0x3E). The header of a user-defined frame is usually transmitted when a frame slot allocated to the frame is processed. Reserved Frame are not be used in a LIN 2.0 cluster, and their identifier is 63 (0x3F).

The LIN specification was designed to allow very cheap hardware-nodes being used within a network. The LIN specification is based on ISO 9141:1989 standard entitled: “*Road vehicles - Diagnostic systems - Requirements for interchange of digital information*” that Specifies the requirements for setting up the interchange of digital information between on-board Electronic Control Units (ECUs) of road vehicles and suitable diagnostic testers. This communication is established in order to facilitate inspection, test diagnosis and adjustment of vehicles, systems and ECUs. It does not apply when system-specific diagnostic test equipment is used. The LIN specification is further based on ISO 9141-2:1994 standard entitled: “*Road vehicles - Diagnostic systems - Part 2: CARB requirements for interchange of digital information*” that involves vehicles with nominal 12 V supply voltage, describes a subset of ISO 9141:1989, and specifies the requirements for setting-up the interchange of digital information between on-board emission-related electronic control units of road vehicles and the SAE OBD II scan tool as specified in SAE J1978. It is a low-cost, single-wire network, where microcontrollers with either UART capability or dedicated LIN hardware are used. The microcontroller generates all needed LIN data by software and is connected to the LIN network via a LIN transceiver (simply speaking, a level shifter with some add-ons). Working as a LIN node is only part of the possible functionality. The LIN hardware may include this transceiver and works as a pure LIN node without added functionality. As LIN Slave nodes should be as cheap as possible, they may generate their internal clocks by using RC oscillators instead of crystal oscillators (quartz or a ceramic). To ensure the baud rate-stability within one LIN frame, the SYNC field within the header is used. An example of a LIN transceiver is IC Model No. 33689D available from Freescale Semiconductor, Inc. described in a data-sheet Document Number MC33689 Rev. 8.0 (dated 9/2012) entitled: “*System Basis Chip with LIN Transceiver*”, which is incorporated in its entirety for all purposes as if fully set forth herein.

The LIN-Master uses one or more predefined scheduling tables to start the sending and receiving to the LIN bus. These scheduling tables contain at least the relative timing, where the message sending is initiated. One LIN Frame consists of the two parts header and response. The header is always sent by the LIN Master, while the response is sent by either one dedicated LIN-Slave or the LIN master itself. Transmitted data within the LIN is transmitted serially as eight-bit data bytes with one start & stop-bit and no parity. Bit rates vary within the range of 1 kbit/s to 20 kbit/s. Data on the bus is divided into recessive (logical HIGH) and dominant (logical LOW). The time normal is considered by the LIN Masters stable clock source, the smallest entity is one bit time (52 μ s @ 19.2 kbit/s).

Two bus states — Sleep-mode and active — are used within the LIN protocol. While data is on the bus, all LIN-nodes are requested to be in active state. After a specified timeout, the nodes enter Sleep mode and will be released back to active state by a WAKEUP frame. This frame may be sent by any node requesting activity on the bus, either the LIN Master following its internal schedule, or one of the attached LIN Slaves being activated by its internal software application. After all nodes are awakened, the Master continues to schedule the next Identifier.

MOST. MOST (Media Oriented Systems Transport) is a high-speed multimedia network technology optimized for use in an automotive application, and may be used for applications inside or outside the car. The serial MOST bus uses a ring topology and synchronous data communication to transport audio, video, voice and data signals via plastic optical fiber (POF) (MOST25, MOST150) or electrical conductor (MOST50, MOST150) physical layers. The MOST specification defines the physical and the data link layer as well as all seven layers of the ISO/OSI-Model of data communication. Standardized interfaces simplify the MOST protocol integration in multimedia devices. For the system developer, MOST is primarily a protocol definition. It provides the user with a standardized interface (API) to access device functionality, and the communication functionality is provided by driver software known as MOST Network Services. MOST Network Services include Basic Layer System Services (Layer 3, 4, 5) and Application Socket Services (Layer 6). They process the MOST protocol between a MOST Network Interface Controller (NIC), which is based on the physical layer, and the API (Layer 7).

A MOST network is able to manage up to 64 MOST devices in a ring configuration. Plug and play functionality allows MOST devices to be easily attached

and removed. MOST networks can also be set up in virtual star network or other topologies. Safety critical applications use redundant double ring configurations. In a MOST network, one device is designated the timing master, used to continuously supply the ring with MOST frames. A preamble is sent at the beginning of the frame transfer.

5 The other devices, known as timing followers, use the preamble for synchronization. Encoding based on synchronous transfer allows constant post-sync for the timing followers.

MOST25 provides a bandwidth of approximately 23 megabaud for streaming (synchronous) as well as package (asynchronous) data transfer over an optical physical
10 layer. It is separated into 60 physical channels. The user can select and configure the channels into groups of four bytes each. MOST25 provides many services and methods for the allocation (and deallocation) of physical channels. MOST25 supports up to 15 uncompressed stereo audio channels with CD-quality sound or up to 15 MPEG-1 channels for audio/video transfer, each of which uses four Bytes (four physical
15 channels). MOST also provides a channel for transferring control information. The system frequency of 44.1 kHz allows a bandwidth of 705.6 kbit/s, enabling 2670 control messages per second to be transferred. Control messages are used to configure MOST devices and configure synchronous and asynchronous data transfer. The system frequency closely follows the CD standard. Reference data can also be transferred via
20 the control channel. Some limitations restrict MOST25's effective data transfer rate to about 10 kB/s. Because of the protocol overhead, the application can use only 11 of 32 bytes at segmented transfer and a MOST node can only use one third of the control channel bandwidth at any time.

MOST50 doubles the bandwidth of a MOST25 system and increases the frame
25 length to 1024 bits. The three established channels (control message channel, streaming data channel, packet data channel) of MOST25 remain the same, but the length of the control channel and the sectioning between the synchronous and asynchronous channels are flexible. Although MOST50 is specified to support both optical and electrical physical layers, the available MOST50 Intelligent Network Interface Controllers (INICs)
30 only support electrical data transfer via Unshielded Twisted Pair (UTP).

MOST150 was introduced in October 2007 and provides a physical layer to implement Ethernet in automobiles. It increases the frame length up to 3072 bits, which is about 6 times the bandwidth of MOST25. It also integrates an Ethernet channel with adjustable bandwidth in addition to the three established channels (control message

channel, streaming data channel, packet data channel) of the other grades of MOST. MOST150 also permits isochronous transfer on the synchronous channel. Although the transfer of synchronous data requires a frequency other than the one specified by the MOST frame rate, it is also possible with MOST150. MOST150's advanced functions and enhanced bandwidth will enable a multiplex network infrastructure capable of transmitting all forms of infotainment data, including video, throughout an automobile. The optical transmission layer uses Plastic Optical Fibers (POF) with a core diameter of 1 mm as transmission medium, in combination with light emitting diodes (LEDs) in the red wavelength range as transmitters. MOST25 only uses an optical Physical Layer. MOST50 and MOST150 support both optical and electrical Physical Layers.

The MOST protocol is described in a book published 2011 by Franzis Verlag GmbH [ISBN – 978-3-645-65061-8] edited by Prof. Dr. Ing. Andreas Grzempa entitled: “MOST - The Automotive Multimedia Network – From MOST25 to MOST 150”, in MOST Dynamic Specification by MOST Cooperation Rev. 3.0.2 dated 10/2012 entitled: “MOST – Multimedia and Control Networking Technology”, and in MOST Specification Rev. 3.0 E2 dated 07/2010 by MOST Cooperation, which are all incorporated in their entirety for all purposes as if fully set forth herein.

MOST Interfacing may use a MOST transceiver, such as IC model No. OS81118 available from Microchip Technology Incorporated (headquartered in Chandler, AZ, U.S.A.) and described in a data sheet DS00001935A published 2015 by Microchip Technology Incorporated entitled: “MOST150 INIC with USB 2.0 Device Port”, or IC model No. OS8104A also available from Microchip Technology Incorporated and described in a data sheet PFL_OS8104A_V01_00_XX-4.fm published 08/2007 by Microchip Technology Incorporated entitled: “MOST Network Interface Controller”, which are both incorporated in their entirety for all purposes as if fully set forth herein.

FlexRay. FlexRay™ is an automotive network communications protocol developed by the FlexRay Consortium to govern on-board automotive computing. The FlexRay consortium disbanded in 2009, but the FlexRay standard is described in a set of ISO standards, ISO 17458 entitled: “Road vehicles -- FlexRay communications system”, including ISO 17458-1:2013 standard entitled: “Part 1: General information and use case definition”, ISO 17458-2:2013 standard entitled: “Part 2: Data link layer specification”, ISO 17458-3:2013 standard entitled: “Part 3: Data link layer conformance test specification”, ISO 17458-4:2013 standard entitled: “Part 4: Electrical

physical layer specification”, and ISO 17458-5:2013 standard entitled: “*Part 5: Electrical physical layer conformance test specification*”.

FlexRay supports high data rates, up to 10 Mbit/s, explicitly supports both star and “party line” bus topologies, and can have two independent data channels for fault-tolerance (communication can continue with reduced bandwidth if one channel is inoperative). The bus operates on a time cycle, divided into two parts: the static segment and the dynamic segment. The static segment is preallocated into slices for individual communication types, providing a stronger real-time guarantee than its predecessor CAN. The dynamic segment operates more like CAN, with nodes taking control of the bus as available, allowing event-triggered behavior. FlexRay specification Version 3.0.1 is described in FlexRay consortium October 2010 publication entitled: “*FlexRay Communications System – Protocol Specification – Version 3.0.1*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The FlexRay physical layer is described in Carl Hanser Verlag GmbH 2010 publication (Automotive 2010) by Lorenz, Steffen entitled: “*The FlexRay Electrical Physical Layer Evolution*”, and in National Instruments Corporation Technical Overview Publication (Aug. 21, 2009) entitled: “*FlexRay Automotive Communication Bus Overview*”, which are both incorporated in their entirety for all purposes as if fully set forth herein.

FlexRay system consists of a bus and processors (Electronic control unit, or ECUs), where each ECU has an independent clock. The clock drift must be not more than 0.15% from the reference clock, so the difference between the slowest and the fastest clock in the system is no greater than 0.3%. At each time, only one ECU writes to the bus, and each bit to be sent is held on the bus for 8 sample clock cycles. The receiver keeps a buffer of the last 5 samples, and uses the majority of the last 5 samples as the input signal. Single-cycle transmission errors may affect results near the boundary of the bits, but will not affect cycles in the middle of the 8-cycle region. The value of the bit is sampled in the middle of the 8-bit region. The errors are moved to the extreme cycles, and the clock is synchronized frequently enough for the drift to be small (Drift is smaller than 1 cycle per 300 cycles, and during transmission the clock is synchronized more than once every 300 cycles). An example of a FlexRay transceiver is model TJA1080A available from NXP Semiconductors N.V. headquartered in Eindhoven, Netherlands, described in Product data sheet (document Identifier TJA1080A, date of release: 28 November 2012) entitled: “*TJA1080A FlexRay Transceiver – Rev. 6 - 28 November*

2012 – *Product data sheet*”, which is incorporated in its entirety for all purposes as if fully set forth herein.

Further, the vehicular communication system employed may be used so that vehicles may communicate and exchange information with other vehicles and with roadside units, may allow for cooperation and may be effective in increasing safety such as sharing safety information, safety warnings, as well as traffic information, such as to avoid traffic congestion. In safety applications, vehicles that discover an imminent danger or obstacle in the road may inform other vehicles directly, via other vehicles serving as repeaters, or via roadside units. Further, the system may help in deciding right to pass first at intersections, and may provide alerts or warning about entering intersections, departing highways, discovery of obstacles, and lane change warnings, as well as reporting accidents and other activities in the road. The system may be used for traffic management, allowing for easy and optimal traffic flow control, in particular in the case of specific situations such as hot pursuits and bad weather. The traffic management may be in the form of variable speed limits, adaptable traffic lights, traffic intersection control, and accommodating emergency vehicles such as ambulances, fire trucks and police cars.

The vehicular communication system may further be used to assist the drivers, such as helping with parking a vehicle, cruise control, lane keeping, and road sign recognition. Similarly, better policing and enforcement may be obtained by using the system for surveillance, speed limit warning, restricted entries, and pull-over commands. The system may be integrated with pricing and payment systems such as toll collection, pricing management, and parking payments. The system may further be used for navigation and route optimization, as well as providing travel-related information such as maps, business location, gas stations, and car service locations. Similarly, the system may be used for emergency warning system for vehicles, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning (Blue Waves), vehicle safety inspection, transit or emergency vehicle signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, and electronic toll collection.

OBD. On-Board Diagnostics (OBD) refers to a vehicle's self-diagnostic and reporting capability. OBD systems give the vehicle owner or repair technician access to the status of the various vehicle subsystems. Modern OBD implementations use a

standardized digital communications port to provide real-time data in addition to a standardized series of diagnostic trouble codes, or DTCs, which allow one to rapidly identify and remedy malfunctions within the vehicle. Keyword Protocol 2000, abbreviated KWP2000, is a communications protocol used for on-board vehicle diagnostics systems (OBD). This protocol covers the application layer in the OSI model of computer networking. KWP2000 also covers the session layer in the OSI model, in terms of starting, maintaining and terminating a communications session, and the protocol is standardized by International Organization for Standardization as ISO 14230.

One underlying physical layer used for KWP2000 is identical to ISO 9141, with bidirectional serial communication on a single line called the K-line. In addition, there is an optional L-line for wakeup. The data rate is between 1.2 and 10.4 kilobaud, and a message may contain up to 255 bytes in the data field. When implemented on a K-line physical layer, KWP2000 requires special wakeup sequences: 5-baud wakeup and fast-initialization. Both of these wakeup methods require timing critical manipulation of the K-line signal, and are therefore not easy to reproduce without custom software. KWP2000 is also compatible on ISO 11898 (Controller Area Network) supporting higher data rates of up to 1 Mbit/s. CAN is becoming an increasingly popular alternative to K-line because the CAN bus is usually present in modern-day vehicles and thus removing the need to install an additional physical cable. Using KWP2000 on CAN with ISO 15765 Transport/Network layers is most common. Also using KWP2000 on CAN does not require the special wakeup functionality.

KWP2000 can be implemented on CAN using just the service layer and session layer (no header specifying length, source and target addresses is used and no checksum is used); or using all layers (header and checksum are encapsulated within a CAN frame). However using all layers is overkill, as ISO 15765 provides its own Transport/Network layers.

ISO 14230-1:2012 entitled: "*Road vehicles -- Diagnostic communication over K-Line (DoK-Line) -- Part 1: Physical layer*", which is incorporated in its entirety for all purposes as if fully set forth herein, specifies the physical layer, based on ISO 9141, on which the diagnostic services will be implemented. It is based on the physical layer described in ISO 9141-2, but expanded to allow for road vehicles with either 12 V DC or 24 V DC voltage supply.

ISO 14230-2:2013 entitled: "*Road vehicles -- Diagnostic communication over K-Line (DoK-Line) -- Part 2: Data link layer*", which is incorporated in its entirety for all

purposes as if fully set forth herein, specifies data link layer services tailored to meet the requirements of UART-based vehicle communication systems on K-Line as specified in ISO 14230-1. It has been defined in accordance with the diagnostic services established in ISO 14229-1 and ISO 15031-5, but is not limited to use with them, and is also compatible with most other communication needs for in-vehicle networks. The protocol specifies an unconfirmed communication. The diagnostic communication over K-Line (DoK-Line) protocol supports the standardized service primitive interface as specified in ISO 14229-2. ISO 14230-2:2013 provides the data link layer services to support different application layer implementations like: enhanced vehicle diagnostics (emissions-related system diagnostics beyond legislated functionality, non-emissions-related system diagnostics); emissions-related OBD as specified in ISO 15031, SAE J1979-DA, and SAE J2012-DA. In addition, ISO 14230-2:2013 clarifies the differences in initialization for K-line protocols defined in ISO 9141 and ISO 14230. This is important since a server supports only one of the protocols mentioned above and the client has to handle the coexistence of all protocols during the protocol-determination procedure.

The application layer is described in ISO 14230-3:1999 entitled: “*Road vehicles -- Diagnostic systems -- Keyword Protocol 2000 -- Part 3: Application layer*”, and the requirements for emission-related systems are described in ISO 14230-4:2000 entitled: “*Road vehicles -- Diagnostic systems -- Keyword Protocol 2000 -- Part 4: Requirements for emission-related systems*”, which are both incorporated in their entirety for all purposes as if fully set forth herein.

Fleetwide vehicle telematics systems and methods that includes receiving and managing fleetwide vehicle state data are described in U.S. Patent Application Publication No. 2016/0086391 to Ricci entitled: “*Fleetwide vehicle telematics systems and methods*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The fleetwide vehicle state data may be fused or compared with customer enterprise data to monitor conformance with customer requirements and thresholds. The fleetwide vehicle state data may also be analyzed to identify trends and correlations of interest to the customer enterprise.

Automotive Ethernet. Automotive Ethernet refers to the use of an Ethernet-based network for connections between in-vehicle electronic systems, and typically defines a physical network that is used to connect components within a car using a wired network. Ethernet is a family of computer networking technologies commonly used in Local Area

Networks (LAN), Metropolitan Area Networks (MAN) and Wide Area Networks (WAN). It was commercially introduced in 1980 and first standardized in 1983 as IEEE 802.3, and has since been refined to support higher bit rates and longer link distances. The Ethernet standards comprise several wiring and signaling variants of the OSI physical layer in use with Ethernet. Systems communicating over Ethernet divide a stream of data into shorter pieces called frames. Each frame contains source and destination addresses, and error-checking data so that damaged frames can be detected and discarded; most often, higher-layer protocols trigger retransmission of lost frames. As per the OSI model, Ethernet provides services up to and including the data link layer. Since its commercial release, Ethernet has retained a good degree of backward compatibility. Features such as the 48-bit MAC address and Ethernet frame format have influenced other networking protocols. Simple switched Ethernet networks, while a great improvement over repeater-based Ethernet, suffer from single points of failure, attacks that trick switches or hosts into sending data to a machine even if it is not intended for it, scalability and security issues with regard to switching loops, broadcast radiation and multicast traffic, and bandwidth choke points where a lot of traffic is forced down a single link.

Advanced networking features in switches use shortest path bridging (SPB) or the spanning-tree protocol (STP) to maintain a loop-free, meshed network, allowing physical loops for redundancy (STP) or load-balancing (SPB). Advanced networking features also ensure port security, provide protection features such as MAC lockdown and broadcast radiation filtering, use virtual LANs to keep different classes of users separate while using the same physical infrastructure, employ multilayer switching to route between different classes, and use link aggregation to add bandwidth to overloaded links and to provide some redundancy. IEEE 802.1aq (shortest path bridging) includes the use of the link-state routing protocol IS-IS to allow larger networks with shortest path routes between devices.

A data packet on an Ethernet link is called an Ethernet packet, which transports an Ethernet frame as its payload. An Ethernet frame is preceded by a preamble and Start Frame Delimiter (SFD), which are both part of the Ethernet packet at the physical layer. Each Ethernet frame starts with an Ethernet header, which contains destination and source MAC addresses as its first two fields. The middle section of the frame is payload data including any headers for other protocols (for example, Internet Protocol) carried in the frame. The frame ends with a frame check sequence (FCS), which is a 32-bit cyclic

redundancy check used to detect any in-transit corruption of data. Automotive Ethernet is described in a book by Charles M. Kozierok, Colt Correa, Robert B. Boatright, and Jeffrey Quesnelle entitled: “*Automotive Ethernet: The Definitive Guide*”, published 2014 by Interpid Control Systems [ISBN-13: 978-0-9905388-0-6] , and in a white paper document No. 915-3510-01 Rev. A published May 2014 by Ixia entitled: Automotive Ethernet: An Overview”, which are both incorporated in their entirety for all purposes as if fully set forth herein.

100BaseT1. 100BASE-T1 (and upcoming 1000Base-T1) is an Ethernet automotive standard, standardized in IEEE 802.3bw-2015 Clause 96 and entitled: “802.3bw-2015 - IEEE Standard for Ethernet Amendment 1: Physical Layer Specifications and Management Parameters for 100 Mb/s Operation over a Single Balanced Twisted Pair Cable (100BASE-T1)”. The data is transmitted over a single copper pair, 3 bits per symbol (PAM3), and it supports only full-duplex, transmitting in both directions simultaneously. The twisted-pair cable is required to support 66 MHz, with a maximum length of 15 m. The standard is intended for automotive applications or when Fast Ethernet is to be integrated into another application.

BroadR-Reach®. BroadR-Reach® technology is an Ethernet physical layer standard designed for use in automotive connectivity applications. BroadR-Reach® technology allows multiple in-vehicle systems to simultaneously access information over unshielded single twisted pair cable, intended for reduced connectivity costs and cabling weight. Using BroadR-Reach® technology in automotive enables the migration from multiple closed applications to a single open, scalable Ethernet-based network within the automobile. This allows automotive manufacturers to incorporate multiple electronic systems and devices, such as advanced safety features (i.e. 360- degree surround view parking assistance, rear-view cameras and collision avoidance systems) and comfort and infotainment features. The automotive-qualified BroadR-Reach® Ethernet physical layer standard can be combined with IEEE 802.3 compliant switch technology to deliver 100Mbit/s over unshielded single twisted pair cable.

The BroadR-Reach automotive Ethernet standard realizes simultaneous transmit and receive (i.e., full-duplex) operations on a single-pair cable instead of the half-duplex operation in 100BASE-TX, which uses one pair for transmit and one for receive to achieve the same data rate. In order to better de-correlate the signal, the digital signal processor (DSP) uses a highly optimized scrambler when compared to the scrambler used in 100BASE-TX. This provides a robust and efficient signaling scheme required by automotive applications. The BroadR-Reach automotive Ethernet standard uses a

signaling scheme with higher spectral efficiency than that of 100BASE-TX. This limits the signal bandwidth of Automotive Ethernet to 33.3 MHz, which is about half the bandwidth of 100BASE-TX. A lower signal bandwidth improves return loss, reduces crosstalk, and ensures that BroadR-Reach® automotive Ethernet standard passes the stringent automotive electromagnetic emission requirements. The physical layer of BroadR-Reach® is described in a specification authored by Dr. Bernd Korber and published November 28, 2014 by the OPEN Alliance, entitled: "*BroadR-Reach® Definitions for Communication Channel – Version 2.0*", which is incorporated in its entirety for all purposes as if fully set forth herein.

A method and a device for recording data or for transmitting stimulation data, which are transmitted in Ethernet-based networks of vehicles, are described in U.S. Patent Application No. 2015/0071115 to Neff *et al.* entitled: "*Data Logging or Stimulation in Automotive Ethernet Networks Using the Vehicle Infrastructure*", which is incorporated in its entirety for all purposes as if fully set forth herein. A method for recording data is described, wherein the data are transmitted from a transmitting control unit to a receiving control unit of a vehicle via a communication system of the vehicle. The communication system comprises an Ethernet network, wherein the data are conducted from a transmission component to a reception component of the Ethernet network via a transmission path, and wherein the data are to be recorded at a logging component of the Ethernet network, which does not lie on the transmission path. The method comprises the configuration of an intermediate component of the Ethernet network, which lies on the transmission path, to transmit a copy of the data as logging data to the logging component; and the recording of the logging data at the logging component.

A backbone network system for a vehicle enables high-speed and large-capacity data transmission between integrated control modules mounted in the vehicle, such that communication can be maintained through another alternative communication line when an error occurs in a specific communication line, is described in U.S. Patent No. 9,172,635 to Kim *et al.* entitled: "*Ethernet backbone network system for vehicle and method for controlling fail safe of the ethernet backbone network system*", which is incorporated in its entirety for all purposes as if fully set forth herein. The backbone network system enables various kinds of integrated control modules mounted in the vehicle to perform large-capacity and high-speed communications, based on Ethernet communication, by connecting domain gateways of the integrated control modules

through an Ethernet backbone network, and provides a fast fail-safe function so that domain gateways can perform communications through another communication line when an error occurs in a communication line between the domain gateways.

A system and method for managing a vehicle Ethernet communication network are disclosed in U.S. Patent No. 9,450,911 to CHA *et al.* entitled: “*System and method for managing ethernet communication network for use in vehicle*”, which is incorporated in its entirety for all purposes as if fully set forth herein. More specifically, each unit in a vehicle Ethernet communication network is configured to initially enter a power-on (PowerOn) mode when is applied to each unit of the vehicle to initialize operational programs. Once powered on, each unit enters a normal mode in which a node for each unit participates in a network to request the network. Subsequently, each unit enters a sleep indication (SleepInd) mode where other nodes are not requested even though the network has already been requested by the other nodes. A communication mode is then terminated at each unit and each unit enters a wait bus sleep (WaitBusSleep) mode in which all nodes connected to the network are no longer in communication and are waiting to switch to sleep mode. Finally, each unit is powered off to prevent communication between units in the network.

A system that includes an on-board unit (OBU) in communication with an internal subsystem in a vehicle on at least one Ethernet network and a node on a wireless network, is disclosed in U.S. Patent Application Publication No. 2014/0215491 to Addepalli *et al.* entitled: “*System and method for internal networking, data optimization and dynamic frequency selection in a vehicular environment*”, which is incorporated in its entirety for all purposes as if fully set forth herein. A method in one embodiment includes receiving a message on the Ethernet network in the vehicle, encapsulating the message to facilitate translation to Ethernet protocol if the message is not in Ethernet protocol, and transmitting the message in Ethernet protocol to its destination. Certain embodiments include optimizing data transmission over the wireless network using redundancy caches, dictionaries, object contexts databases, speech templates and protocol header templates, and cross layer optimization of data flow from a receiver to a sender over a TCP connection. Certain embodiments also include dynamically identifying and selecting an operating frequency with least interference for data transmission over the wireless network.

Internet. The Internet is a global system of interconnected computer networks that use the standardized Internet Protocol Suite (TCP/IP), including Transmission

Control Protocol (TCP) and the Internet Protocol (IP), to serve billions of users worldwide. It is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic and optical networking technologies. The Internet carries a vast range of information resources and services, such as the interlinked hypertext documents on the World Wide Web (WWW) and the infrastructure to support electronic mail. The Internet backbone refers to the principal data routes between large, strategically interconnected networks and core routers on the Internet. These data routers are hosted by commercial, government, academic, and other high-capacity network centers, the Internet exchange points and network access points that interchange Internet traffic between the countries, continents and across the oceans of the world. Traffic interchange between Internet service providers (often Tier 1 networks) participating in the Internet backbone exchange traffic by privately negotiated interconnection agreements, primarily governed by the principle of settlement-free peering.

The Transmission Control Protocol (TCP) is one of the core protocols of the Internet Protocol suite (IP) described in RFC 675 and RFC 793, and the entire suite is often referred to as TCP/IP. TCP provides reliable, ordered and error-checked delivery of a stream of octets between programs running on computers connected to a local area network, intranet or the public Internet. It resides at the transport layer. Web browsers typically use TCP when they connect to servers on the World Wide Web, and are used to deliver email and transfer files from one location to another. HTTP, HTTPS, SMTP, POP3, IMAP, SSH, FTP, Telnet, and a variety of other protocols are encapsulated in TCP. As the transport layer of TCP/IP suite, the TCP provides a communication service at an intermediate level between an application program and the Internet Protocol (IP). Due to network congestion, traffic load balancing, or other unpredictable network behavior, IP packets may be lost, duplicated, or delivered out-of-order. TCP detects these problems, requests retransmission of lost data, rearranges out-of-order data, and even helps minimize network congestion to reduce the occurrence of the other problems. Once the TCP receiver has reassembled the sequence of octets originally transmitted, it passes them to the receiving application. Thus, TCP abstracts the application's communication from the underlying networking details. The TCP is utilized extensively by many of the Internet's most popular applications, including the World Wide Web (WWW), E-mail, File Transfer Protocol, Secure Shell, peer-to-peer file sharing, and some streaming media applications.

While IP layer handles actual delivery of the data, TCP keeps track of the individual units of data transmission, called segments, which are divided smaller pieces of a message, or data for efficient routing through the network. For example, when an HTML file is sent from a web server, the TCP software layer of that server divides the sequence of octets of the file into segments and forwards them individually to the IP software layer (Internet Layer). The Internet Layer encapsulates each TCP segment into an IP packet by adding a header that includes (among other data) the destination IP address. When the client program on the destination computer receives them, the TCP layer (Transport Layer) reassembles the individual segments and ensures they are correctly ordered and error-free as it streams them to an application.

The TCP protocol operations may be divided into three phases. First, the connections must be properly established in a multi-step handshake process (connection establishment) before entering the data transfer phase. After data transmission is completed, the connection termination closes established virtual circuits and releases all allocated resources. A TCP connection is typically managed by an operating system through a programming interface that represents the local end-point for communications, the Internet socket. The local end-point undergoes a series of state changes throughout the duration of a TCP connection.

The Internet Protocol (IP) is the principal communications protocol used for relaying datagrams (packets) across a network using the Internet Protocol Suite. It is considered as the primary protocol that establishes the Internet, and is responsible for routing packets across the network boundaries. IP is the primary protocol in the Internet Layer of the Internet Protocol Suite and has the task of delivering datagrams from the source host to the destination host based on their addresses. For this purpose, IP defines addressing methods and structures for datagram encapsulation. Internet Protocol Version 4 (IPv4) is the dominant protocol of the Internet. IPv4 is described in Internet Engineering Task Force (IETF) Request for Comments (RFC) 791 and RFC 1349, and the successor, Internet Protocol Version 6 (IPv6), is currently active and in growing deployment worldwide. IPv4 uses 32-bit addresses (providing 4 billion: 4.3×10^9 addresses), while IPv6 uses 128-bit addresses (providing 340 undecillion or 3.4×10^{38} addresses), as described in RFC 2460.

The Internet architecture employs a client-server model, among other arrangements. The terms 'server' or 'server computer' relates herein to a device or computer (or a plurality of computers) connected to the Internet, and is used for

providing facilities or services to other computers or other devices (referred to in this context as 'clients') connected to the Internet. A server is commonly a host that has an IP address and executes a 'server program', and typically operates as a socket listener. Many servers have dedicated functionality such as web server, Domain Name System (DNS) server (described in RFC 1034 and RFC 1035), Dynamic Host Configuration Protocol (DHCP) server (described in RFC 2131 and RFC 3315), mail server, File Transfer Protocol (FTP) server and database server. Similarly, the term 'client' is used herein to include, but not limited to, a program or a device, or a computer (or a series of computers) executing this program, which accesses a server over the Internet for a service or a resource. Clients commonly initiate connections that a server may accept. For non-limiting example, web browsers are clients that connect to web servers for retrieving web pages, and email clients connect to mail storage servers for retrieving mails.

Wireless. Any embodiment herein may be used in conjunction with one or more types of wireless communication signals and/or systems, for example, Radio Frequency (RF), Infra Red (IR), Frequency-Division Multiplexing (FDM), Orthogonal FDM (OFDM), Time-Division Multiplexing (TDM), Time-Division Multiple Access (TDMA), Extended TDMA (E-TDMA), General Packet Radio Service (GPRS), extended GPRS, Code-Division Multiple Access (CDMA), Wideband CDMA (WCDMA), CDMA 2000, single-carrier CDMA, multi-carrier CDMA, Multi-Carrier Modulation (MDM), Discrete Multi-Tone (DMT), Bluetooth (RTM), Global Positioning System (GPS), Wi-Fi, Wi-Max, ZigBee (TM), Ultra-Wideband (UWB), Global System for Mobile communication (GSM), 2G, 2.5G, 3G, 3.5G, Enhanced Data rates for GSM Evolution (EDGE), or the like. Any wireless network or wireless connection herein may be operating substantially in accordance with existing IEEE 802.11, 802.11a, 802.11b, 802.11g, 802.11k, 802.11n, 802.11r, 802.16, 802.16d, 802.16e, 802.20, 802.21 standards and/or future versions and/or derivatives of the above standards. Further, a network element (or a device) herein may consist of, be part of, or include, a cellular radio-telephone communication system, a cellular telephone, a wireless telephone, a Personal Communication Systems (PCS) device, a PDA device that incorporates a wireless communication device, or a mobile / portable Global Positioning System (GPS) device. Further, a wireless communication may be based on wireless technologies that are described in Chapter 20: "*Wireless Technologies*" of the publication number 1-587005-001-3 by Cisco Systems, Inc. (7/99) entitled: "*Internetworking Technologies*

Handbook", which is incorporated in its entirety for all purposes as if fully set forth herein. Wireless technologies and networks are further described in a book published 2005 by Pearson Education, Inc. William Stallings [ISBN: 0-13-191835-4] entitled: "*Wireless Communications and Networks – second Edition*", which is incorporated in its
5 entirety for all purposes as if fully set forth herein.

Wireless networking typically employs an antenna (a.k.a. aerial), which is an electrical device that converts electric power into radio waves, and vice versa, connected to a wireless radio transceiver. In transmission, a radio transmitter supplies an electric current oscillating at radio frequency to the antenna terminals, and the antenna radiates
10 the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a low voltage at its terminals that is applied to a receiver to be amplified. Typically an antenna consists of an arrangement of metallic conductors (elements), electrically connected (often through a transmission line) to the receiver or transmitter. An
15 oscillating current of electrons forced through the antenna by a transmitter will create an oscillating magnetic field around the antenna elements, while the charge of the electrons also creates an oscillating electric field along the elements. These time-varying fields radiate away from the antenna into space as a moving transverse electromagnetic field wave. Conversely, during reception, the oscillating electric and magnetic fields of an
20 incoming radio wave exert force on the electrons in the antenna elements, causing them to move back and forth, creating oscillating currents in the antenna. Antennas can be designed to transmit and receive radio waves in all horizontal directions equally (omnidirectional antennas), or preferentially in a particular direction (directional or high gain antennas). In the latter case, an antenna may also include additional elements or
25 surfaces with no electrical connection to the transmitter or receiver, such as parasitic elements, parabolic reflectors or horns, which serve to direct the radio waves into a beam or other desired radiation pattern.

ISM. The Industrial, Scientific and Medical (ISM) radio bands are radio bands (portions of the radio spectrum) reserved internationally for the use of radio frequency
30 (RF) energy for industrial, scientific and medical purposes other than telecommunications. In general, communications equipment operating in these bands must tolerate any interference generated by ISM equipment, and users have no regulatory protection from ISM device operation. The ISM bands are defined by the ITU-R in 5.138, 5.150, and 5.280 of the Radio Regulations. Individual countries use of

the bands designated in these sections may differ due to variations in national radio regulations. Because communication devices using the ISM bands must tolerate any interference from ISM equipment, unlicensed operations are typically permitted to use these bands, since unlicensed operation typically needs to be tolerant of interference from other devices anyway. The ISM bands share allocations with unlicensed and licensed operations; however, due to the high likelihood of harmful interference, licensed use of the bands is typically low. In the United States, uses of the ISM bands are governed by Part 18 of the Federal Communications Commission (FCC) rules, while Part 15 contains the rules for unlicensed communication devices, even those that share ISM frequencies. In Europe, the ETSI is responsible for governing ISM bands.

Commonly used ISM bands include a 2.45 GHz band (also known as 2.4 GHz band) that includes the frequency band between 2.400 GHz and 2.500 GHz, a 5.8 GHz band that includes the frequency band 5.725 – 5.875 GHz, a 24GHz band that includes the frequency band 24.000 – 24.250 GHz, a 61 GHz band that includes the frequency band 61.000 – 61.500 GHz, a 122 GHz band that includes the frequency band 122.000 – 123.000 GHz, and a 244 GHz band that includes the frequency band 244.000 – 246.000 GHz.

ZigBee. ZigBee is a standard for a suite of high-level communication protocols using small, low-power digital radios based on an IEEE 802 standard for Personal Area Network (PAN). Applications include wireless light switches, electrical meters with in-home-displays, and other consumer and industrial equipment that require a short-range wireless transfer of data at relatively low rates. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee is targeted at Radio-Frequency (RF) applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 kbps suited for periodic or intermittent data or a single signal transmission from a sensor or input device.

ZigBee builds upon the physical layer and medium access control defined in IEEE standard 802.15.4 (2003 version) for low-rate WPANs. The specification further discloses four main components: network layer, application layer, ZigBee Device Objects (ZDOs), and manufacturer-defined application objects, which allow for customization and favor total integration. The ZDOs are responsible for a number of tasks, which include keeping of device roles, management of requests to join a network, device discovery, and security. Because ZigBee nodes can go from a sleep to active

mode in 30 ms or less, the latency can be low and devices can be responsive, particularly compared to Bluetooth wake-up delays, which are typically around three seconds. ZigBee nodes can sleep most of the time, thus the average power consumption can be lower, resulting in longer battery life.

5 There are three defined types of ZigBee devices: ZigBee Coordinator (ZC), ZigBee Router (ZR), and ZigBee End Device (ZED). ZigBee Coordinator (ZC) is the most capable device and forms the root of the network tree and might bridge to other networks. There is exactly one defined ZigBee coordinator in each network, since it is the device that started the network originally. It is able to store information about the
10 network, including acting as the Trust Center & repository for security keys. ZigBee Router (ZR) may be running an application function as well as may be acting as an intermediate router, passing on data from other devices. ZigBee End Device (ZED) contains functionality to talk to a parent node (either the coordinator or a router). This relationship allows the node to be asleep a significant amount of the time, thereby giving
15 long battery life. A ZED requires the least amount of memory, and therefore can be less expensive to manufacture than a ZR or ZC.

 The protocols build on recent algorithmic research (Ad-hoc On-demand Distance Vector, neuRFon) to automatically construct a low-speed ad-hoc network of nodes. In most large network instances, the network will be a cluster of clusters. It can also form a
20 mesh or a single cluster. The current ZigBee protocols support beacon and non-beacon enabled networks. In non-beacon-enabled networks, an unslotted CSMA/CA channel access mechanism is used. In this type of network, ZigBee Routers typically have their receivers continuously active, requiring a more robust power supply. However, this allows for heterogeneous networks in which some devices receive continuously, while
25 others only transmit when an external stimulus is detected.

 In beacon-enabled networks, the special network nodes called ZigBee Routers transmit periodic beacons to confirm their presence to other network nodes. Nodes may sleep between the beacons, thus lowering their duty cycle and extending their battery life. Beacon intervals depend on the data rate; they may range from 15.36 milliseconds
30 to 251.65824 seconds at 250 Kbit/s, from 24 milliseconds to 393.216 seconds at 40 Kbit/s, and from 48 milliseconds to 786.432 seconds at 20 Kbit/s. In general, the ZigBee protocols minimize the time the radio is on to reduce power consumption. In beaconing networks, nodes only need to be active while a beacon is being transmitted. In non-

beacon-enabled networks, power consumption is decidedly asymmetrical: some devices are always active while others spend most of their time sleeping.

Except for the Smart Energy Profile 2.0, current ZigBee devices conform to the IEEE 802.15.4-2003 Low-Rate Wireless Personal Area Network (LR-WPAN) standard.

5 The standard specifies the lower protocol layers—the PHYSical layer (PHY), and the Media Access Control (MAC) portion of the Data Link Layer (DLL). The basic channel access mode is "Carrier Sense, Multiple Access / Collision Avoidance" (CSMA/CA), that is, the nodes talk in the same way that people converse; they briefly check to see that no one is talking before they start. There are three notable exceptions to the use of
10 CSMA. Beacons are sent on a fixed time schedule, and do not use CSMA. Message acknowledgments also do not use CSMA. Finally, devices in Beacon Oriented networks that have low latency real-time requirement, may also use Guaranteed Time Slots (GTS), which by definition do not use CSMA.

Z-Wave. Z-Wave is a wireless communications protocol by the Z-Wave Alliance
15 (<http://www.z-wave.com>) designed for home automation, specifically for remote control applications in residential and light commercial environments. The technology uses a low-power RF radio embedded or retrofitted into home electronics devices and systems, such as lighting, home access control, entertainment systems and household appliances. Z-Wave communicates using a low-power wireless technology designed specifically for
20 remote control applications. Z-Wave operates in the sub-gigahertz frequency range, around 900 MHz. This band competes with some cordless telephones and other consumer electronics devices, but avoids interference with WiFi and other systems that operate on the crowded 2.4 GHz band. Z-Wave is designed to be easily embedded in consumer electronics products, including battery-operated devices such as remote
25 controls, smoke alarms, and security sensors.

Z-Wave is a mesh networking technology where each node or device on the network is capable of sending and receiving control commands through walls or floors, and use intermediate nodes to route around household obstacles or radio dead spots that might occur in the home. Z-Wave devices can work individually or in groups, and can
30 be programmed into scenes or events that trigger multiple devices, either automatically or via remote control. The Z-wave radio specifications include bandwidth of 9,600 bit/s or 40 Kbit/s, fully interoperable, GFSK modulation, and a range of approximately 100 feet (or 30 meters) assuming "open air" conditions, with reduced range indoors depending on building materials, etc. The Z-Wave radio uses the 900 MHz ISM band:

908.42 MHz (United States); 868.42 MHz (Europe); 919.82 MHz (Hong Kong); and 921.42 MHz (Australia/New Zealand).

Z-Wave uses a source-routed mesh network topology and has one or more master controllers that control routing and security. The devices can communicate to another by using intermediate nodes to actively route around, and circumvent household obstacles or radio dead spots that might occur. A message from node A to node C can be successfully delivered even if the two nodes are not within range, providing that a third node B can communicate with nodes A and C. If the preferred route is unavailable, the message originator will attempt other routes until a path is found to the "C" node.

Therefore, a Z-Wave network can span much farther than the radio range of a single unit; however, with several of these hops, a delay may be introduced between the control command and the desired result. In order for Z-Wave units to be able to route unsolicited messages, they cannot be in sleep mode. Therefore, most battery-operated devices are not designed as repeater units. A Z-Wave network can consist of up to 232 devices with the option of bridging networks if more devices are required.

WWAN. Any wireless network herein may be a Wireless Wide Area Network (WWAN) such as a wireless broadband network, and the WWAN port may be an antenna and the WWAN transceiver may be a wireless modem. The wireless network may be a satellite network, the antenna may be a satellite antenna, and the wireless modem may be a satellite modem. The wireless network may be a WiMAX network such as according to, compatible with, or based on, IEEE 802.16-2009, the antenna may be a WiMAX antenna, and the wireless modem may be a WiMAX modem. The wireless network may be a cellular telephone network, the antenna may be a cellular antenna, and the wireless modem may be a cellular modem. The cellular telephone network may be a Third Generation (3G) network, and may use UMTS W-CDMA, UMTS HSPA, UMTS TDD, CDMA2000 1xRTT, CDMA2000 EV-DO, or GSM EDGE-Evolution. The cellular telephone network may be a Fourth Generation (4G) network and may use or be compatible with HSPA+, Mobile WiMAX, LTE, LTE-Advanced, MBWA, or may be compatible with, or based on, IEEE 802.20-2008.

WLAN. Wireless Local Area Network (WLAN), is a popular wireless technology that makes use of the Industrial, Scientific and Medical (ISM) frequency spectrum. In the US, three of the bands within the ISM spectrum are the A band, 902-928 MHz; the B band, 2.4-2.484 GHz (a.k.a. 2.4 GHz); and the C band, 5.725-5.875 GHz (a.k.a. 5 GHz). Overlapping and / or similar bands are used in different regions

such as Europe and Japan. In order to allow interoperability between equipment manufactured by different vendors, few WLAN standards have evolved, as part of the IEEE 802.11 standard group, branded as WiFi (www.wi-fi.org). IEEE 802.11b describes a communication using the 2.4GHz frequency band and supporting communication rate of 11Mb/s, IEEE 802.11a uses the 5GHz frequency band to carry 54MB/s and IEEE 802.11g uses the 2.4 GHz band to support 54Mb/s. The WiFi technology is further described in a publication entitled: “*WiFi Technology*” by Telecom Regulatory Authority, published on July 2003, which is incorporated in its entirety for all purposes as if fully set forth herein. The IEEE 802 defines an ad-hoc connection between two or more devices without using a wireless access point: the devices communicate directly when in range. An ad hoc network offers peer-to-peer layout and is commonly used in situations such as a quick data exchange or a multiplayer LAN game, because the setup is easy and an access point is not required.

A node / client with a WLAN interface is commonly referred to as STA (Wireless Station / Wireless client). The STA functionality may be embedded as part of the data unit, or alternatively be a dedicated unit, referred to as bridge, coupled to the data unit. While STAs may communicate without any additional hardware (ad-hoc mode), such network usually involves Wireless Access Point (a.k.a. WAP or AP) as a mediation device. The WAP implements the Basic Stations Set (BSS) and / or ad-hoc mode based on Independent BSS (IBSS). STA, client, bridge and WAP will be collectively referred to hereon as WLAN unit. Bandwidth allocation for IEEE 802.11g wireless in the U.S. allows multiple communication sessions to take place simultaneously, where eleven overlapping channels are defined spaced 5MHz apart, spanning from 2412 MHz as the center frequency for channel number 1, via channel 2 centered at 2417 MHz and 2457 MHz as the center frequency for channel number 10, up to channel 11 centered at 2462 MHz. Each channel bandwidth is 22MHz, symmetrically (+/-11 MHz) located around the center frequency. In the transmission path, first the baseband signal (IF) is generated based on the data to be transmitted, using 256 QAM (Quadrature Amplitude Modulation) based OFDM (Orthogonal Frequency Division Multiplexing) modulation technique, resulting a 22 MHz (single channel wide) frequency band signal. The signal is then up converted to the 2.4 GHz (RF) and placed in the center frequency of required channel, and transmitted to the air via the antenna. Similarly, the receiving path comprises a received channel in the RF spectrum, down converted to the baseband (IF) wherein the data is then extracted.

In order to support multiple devices and using a permanent solution, a Wireless Access Point (WAP) is typically used. A Wireless Access Point (WAP, or Access Point – AP) is a device that allows wireless devices to connect to a wired network using Wi-Fi, or related standards. The WAP usually connects to a router (via a wired network) as a standalone device, but can also be an integral component of the router itself. Using Wireless Access Point (AP) allows users to add devices that access the network with little or no cables. A WAP normally connects directly to a wired Ethernet connection, and the AP then provides wireless connections using radio frequency links for other devices to utilize that wired connection. Most APs support the connection of multiple wireless devices to one wired connection. Wireless access typically involves special security considerations, since any device within a range of the WAP can attach to the network. The most common solution is wireless traffic encryption. Modern access points come with built-in encryption such as Wired Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA), typically used with a password or a passphrase. Authentication in general, and a WAP authentication in particular, is used as the basis for authorization, which determines whether a privilege may be granted to a particular user or process, privacy, which keeps information from becoming known to non-participants, and non-repudiation, which is the inability to deny having done something that was authorized to be done based on the authentication. An authentication in general, and a WAP authentication in particular, may use an authentication server that provides a network service that applications may use to authenticate the credentials, usually account names and passwords of their users. When a client submits a valid set of credentials, it receives a cryptographic ticket that it can subsequently be used to access various services. Authentication algorithms include passwords, Kerberos, and public key encryption.

Prior art technologies for data networking may be based on single carrier modulation techniques, such as AM (Amplitude Modulation), FM (Frequency Modulation), and PM (Phase Modulation), as well as bit encoding techniques such as QAM (Quadrature Amplitude Modulation) and QPSK (Quadrature Phase Shift Keying). Spread spectrum technologies, to include both DSSS (Direct Sequence Spread Spectrum) and FHSS (Frequency Hopping Spread Spectrum) are known in the art. Spread spectrum commonly employs Multi-Carrier Modulation (MCM) such as OFDM (Orthogonal Frequency Division Multiplexing). OFDM and other spread spectrum are commonly used in wireless communication systems, particularly in WLAN networks.

Bluetooth. Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices, and building personal area networks (PANs). It can connect several devices, overcoming problems of synchronization. A
5 Personal Area Network (PAN) may be according to, compatible with, or based on, Bluetooth™ or IEEE 802.15.1-2005 standard. A Bluetooth controlled electrical appliance is described in U.S. Patent Application No. 2014/0159877 to Huang entitled: “*Bluetooth Controllable Electrical Appliance*”, and an electric power supply is described in U.S. Patent Application No. 2014/0070613 to Garb *et al.* entitled: “*Electric Power
10 Supply and Related Methods*”, which are both incorporated in their entirety for all purposes as if fully set forth herein. Any Personal Area Network (PAN) may be according to, compatible with, or based on, Bluetooth™ or IEEE 802.15.1-2005 standard. A Bluetooth controlled electrical appliance is described in U.S. Patent Application No. 2014/0159877 to Huang entitled: “*Bluetooth Controllable Electrical
15 Appliance*”, and an electric power supply is described in U.S. Patent Application No. 2014/0070613 to Garb *et al.* entitled: “*Electric Power Supply and Related Methods*”, which are both incorporated in their entirety for all purposes as if fully set forth herein.

Bluetooth operates at frequencies between 2402 and 2480 MHz, or 2400 and 2483.5 MHz including guard bands 2 MHz wide at the bottom end and 3.5 MHz wide at
20 the top. This is in the globally unlicensed (but not unregulated) Industrial, Scientific and Medical (ISM) 2.4 GHz short-range radio frequency band. Bluetooth uses a radio technology called frequency-hopping spread spectrum. Bluetooth divides transmitted data into packets, and transmits each packet on one of 79 designated Bluetooth channels. Each channel has a bandwidth of 1 MHz. It usually performs 800 hops per second, with
25 Adaptive Frequency-Hopping (AFH) enabled. Bluetooth low energy uses 2 MHz spacing, which accommodates 40 channels. Bluetooth is a packet-based protocol with a master-slave structure. One master may communicate with up to seven slaves in a piconet. All devices share the master's clock. Packet exchange is based on the basic clock, defined by the master, which ticks at 312.5 μ s intervals. Two clock ticks make up
30 a slot of 625 μ s, and two slots make up a slot pair of 1250 μ s. In the simple case of single-slot packets the master transmits in even slots and receives in odd slots. The slave, conversely, receives in even slots and transmits in odd slots. Packets may be 1, 3 or 5 slots long, but in all cases the master's transmission begins in even slots and the slave's in odd slots.

A master Bluetooth device can communicate with a maximum of seven devices in a piconet (an ad-hoc computer network using Bluetooth technology), though not all devices reach this maximum. The devices can switch roles, by agreement, and the slave can become the master (for example, a headset initiating a connection to a phone necessarily begins as master—as initiator of the connection—but may subsequently operate as slave). The Bluetooth Core Specification provides for the connection of two or more piconets to form a scatternet, in which certain devices simultaneously play the master role in one piconet and the slave role in another. At any given time, data can be transferred between the master and one other device (except for the little-used broadcast mode). The master chooses which slave device to address; typically, it switches rapidly from one device to another in a round-robin fashion. Since it is the master that chooses which slave to address, whereas a slave is supposed to listen in each receive slot, being a master is a lighter burden than being a slave. Being a master of seven slaves is possible; being a slave of more than one master is difficult.

Bluetooth Low Energy. Bluetooth low energy (Bluetooth LE, BLE, marketed as Bluetooth Smart) is a wireless personal area network technology designed and marketed by the Bluetooth Special Interest Group (SIG) aimed at novel applications in the healthcare, fitness, beacons, security, and home entertainment industries. Compared to Classic Bluetooth, Bluetooth Smart is intended to provide considerably reduced power consumption and cost while maintaining a similar communication range. Bluetooth low energy is described in a Bluetooth SIG published Dec. 2, 2014 standard Covered Core Package version: 4.2, entitled: “*Master Table of Contents & Compliance Requirements – Specification Volume 0*”, and in an article published 2012 in Sensors [ISSN 1424-8220] by Carles Gomez et al. [Sensors 2012, 12, 11734-11753; doi:10.3390/s120211734] entitled: “*Overview and Evaluation of Bluetooth Low Energy: An Emerging Low-Power Wireless Technology*”, which are both incorporated in their entirety for all purposes as if fully set forth herein.

Bluetooth Smart technology operates in the same spectrum range (the 2.400 GHz-2.4835 GHz ISM band) as Classic Bluetooth technology, but uses a different set of channels. Instead of the Classic Bluetooth 79 1-MHz channels, Bluetooth Smart has 40 2-MHz channels. Within a channel, data is transmitted using Gaussian frequency shift modulation, similar to Classic Bluetooth's Basic Rate scheme. The bit rate is 1Mbit/s, and the maximum transmit power is 10 mW. Bluetooth Smart uses frequency hopping to counteract narrowband interference problems. Classic Bluetooth also uses

frequency hopping but the details are different; as a result, while both FCC and ETSI classify Bluetooth technology as an FHSS scheme, Bluetooth Smart is classified as a system using digital modulation techniques or a direct-sequence spread spectrum. All Bluetooth Smart devices use the Generic Attribute Profile (GATT). The application programming interface offered by a Bluetooth Smart aware operating system will typically be based around GATT concepts.

Cellular. Cellular telephone network may be according to, compatible with, or may be based on, a Third Generation (3G) network that uses UMTS W-CDMA, UMTS HSPA, UMTS TDD, CDMA2000 1xRTT, CDMA2000 EV-DO, or GSM EDGE-Evolution. The cellular telephone network may be a Fourth Generation (4G) network that uses HSPA+, Mobile WiMAX, LTE, LTE-Advanced, MBWA, or may be based on or compatible with IEEE 802.20-2008.

DSRC. Dedicated Short-Range Communication (DSRC) is a one-way or two-way short-range to medium-range wireless communication channels specifically designed for automotive use and a corresponding set of protocols and standards. DSRC is a two-way short-to-medium range wireless communications capability that permits very high data transmission critical in communications-based active safety applications. In Report and Order FCC-03-324, the Federal Communications Commission (FCC) allocated 75 MHz of spectrum in the 5.9 GHz band for use by intelligent transportation systems (ITS) vehicle safety and mobility applications. DSRC serves a short to medium range (1000 meters) communications service and supports both public safety and private operations in roadside-to-vehicle and vehicle-to-vehicle communication environments by providing very high data transfer rates where minimizing latency in the communication link and isolating relatively small communication zones is important. DSRC transportation applications for Public Safety and Traffic Management include Blind spot warnings, Forward collision warnings, Sudden braking ahead warnings, Do not pass warnings, Intersection collision avoidance and movement assistance, Approaching emergency vehicle warning, Vehicle safety inspection, Transit or emergency vehicle signal priority, Electronic parking and toll payments, Commercial vehicle clearance and safety inspections, In-vehicle signing, Rollover warning, and Traffic and travel condition data to improve traveler information and maintenance services.

The European standardization organization European Committee for Standardization (CEN), sometimes in co-operation with the International Organization

for Standardization (ISO) developed some DSRC standards: EN 12253:2004 Dedicated Short-Range Communication – Physical layer using microwave at 5.8 GHz (review), EN 12795:2002 Dedicated Short-Range Communication (DSRC) – DSRC Data link layer: Medium Access and Logical Link Control (review), EN 12834:2002 Dedicated Short-Range Communication – Application layer (review), EN 13372:2004 Dedicated Short-Range Communication (DSRC) -- DSRC profiles for RTTT applications (review), and EN ISO 14906:2004 Electronic Fee Collection – Application interface. An overview of the DSRC/WAVE technologies is described in a paper by Yunxin (Jeff) Li (Eveleigh, NSW 2015, Australia) downloaded from the Internet on July 2017, entitled: “*An Overview of the DSRC/WAVE Technology*”, and the DSRC is further standardized as ARIB STD—T75 VERSION 1.0, published September 2001 by Association of Radio Industries and Businesses Kasumigaseki, Chiyoda-ku, Tokyo 100-0013, Japan, entitled: “*DEDICATED SHORT-RANGE COMMUNICATION SYSTEM - ARIB STANDARD Version 1.0*”, which are both incorporated in their entirety for all purposes as if fully set forth herein.

IEEE 802.11p. The IEEE 802.11p standard is an example of DSRC and is a published standard entitled: “*Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications Amendment 6: Wireless Access in Vehicular Environments*”, that adds wireless access in vehicular environments (WAVE), a vehicular communication system, for supporting Intelligent Transportation Systems (ITS) applications. It includes data exchange between high-speed vehicles and between the vehicles and the roadside infrastructure, so called V2X communication, in the licensed ITS band of 5.9 GHz (5.85-5.925 GHz). IEEE 1609 is a higher layer standard based on the IEEE 802.11p, and is also the base of a European standard for vehicular communication known as ETSI ITS-G5.2. The Wireless Access in Vehicular Environments (WAVE/DSRC) architecture and services necessary for multi-channel DSRC/WAVE devices to communicate in a mobile vehicular environment is described in the family of IEEE 1609 standards, such as IEEE 1609.1-2006 Resource Manager, IEEE Std 1609.2 Security Services for Applications and Management Messages, IEEE Std 1609.3 Networking Services, IEEE Std 1609.4 Multi-Channel Operation IEEE Std 1609.5 Communications Manager, as well as IEEE P802.11p Amendment: “*Wireless Access in Vehicular Environments*”.

As the communication link between the vehicles and the roadside infrastructure might exist for only a short amount of time, the IEEE 802.11p amendment defines a way to exchange data through that link without the need to establish a Basic Service Set (BSS), and thus, without the need to wait for the association and authentication procedures to complete before exchanging data. For that purpose, IEEE 802.11p enabled stations use the wildcard BSSID (a value of all 1s) in the header of the frames they exchange, and may start sending and receiving data frames as soon as they arrive on the communication channel. Because such stations are neither associated nor authenticated, the authentication and data confidentiality mechanisms provided by the IEEE 802.11 standard (and its amendments) cannot be used. These kinds of functionality must then be provided by higher network layers. IEEE 802.11p standard uses channels within the 75 MHz bandwidth in the 5.9 GHz band (5.850-5.925 GHz). This is half the bandwidth, or double the transmission time for a specific data symbol, as used in 802.11a. This allows the receiver to better cope with the characteristics of the radio channel in vehicular communications environments, e.g., the signal echoes reflected from other cars or houses.

Electronic circuits and components are described in a book by Wikipedia entitled: “*Electronics*” downloaded from en.wikibooks.org dated March 15, 2015, and in a book authored by Owen Bishop entitled: “*Electronics - Circuits and Systems*” Fourth Edition, published 2011 by Elsevier Ltd. [ISBN – 978-0-08-096634-2], which are both incorporated in its entirety for all purposes as if fully set forth herein

Smartphone. A mobile phone (also known as a cellular phone, cell phone, smartphone, or hand phone) is a device which can make and receive telephone calls over a radio link whilst moving around a wide geographic area, by connecting to a cellular network provided by a mobile network operator. The calls are to and from the public telephone network, which includes other mobiles and fixed-line phones across the world. The Smartphones are typically hand-held and may combine the functions of a personal digital assistant (PDA), and may serve as portable media players and camera phones with high-resolution touch-screens, web browsers that can access, and properly display, standard web pages rather than just mobile-optimized sites, GPS navigation, Wi-Fi, and mobile broadband access. In addition to telephony, the Smartphones may support a wide variety of other services such as text messaging, MMS, email, Internet access, short-range wireless communications (infrared, Bluetooth), business applications, gaming and photography.

An example of a contemporary smartphone is model iPhone 6 available from Apple Inc., headquartered in Cupertino, California, U.S.A. and described in iPhone 6 technical specification (retrieved 10/2015 from www.apple.com/iphone-6/specs/), and in a User Guide dated 2015 (019-00155/2015-06) by Apple Inc. entitled: “*iPhone User Guide For iOS 8.4 Software*”, which are both incorporated in their entirety for all purposes as if fully set forth herein. Another example of a smartphone is Samsung Galaxy S6 available from Samsung Electronics headquartered in Suwon, South-Korea, described in the user manual numbered English (EU), 03/2015 (Rev. 1.0) entitled: “*SM-G925F SM-G925FQ SM-G925I User Manual*” and having features and specification described in “*Galaxy S6 Edge – Technical Specification*” (retrieved 10/2015 from www.samsung.com/us/explore/galaxy-s-6-features-and-specs), which are both incorporated in their entirety for all purposes as if fully set forth herein.

A mobile operating system (also referred to as mobile OS), is an operating system that operates a smartphone, tablet, PDA, or another mobile device. Modern mobile operating systems combine the features of a personal computer operating system with other features, including a touchscreen, cellular, Bluetooth, Wi-Fi, GPS mobile navigation, camera, video camera, speech recognition, voice recorder, music player, near field communication and infrared blaster. Currently popular mobile OSs are Android, Symbian, Apple iOS, BlackBerry, MeeGo, Windows Phone, and Bada. Mobile devices with mobile communications capabilities (e.g. smartphones) typically contain two mobile operating systems - a main user-facing software platform is supplemented by a second low-level proprietary real-time operating system that operates the radio and other hardware.

Android is an open source and Linux-based mobile operating system (OS) based on the Linux kernel that is currently offered by Google. With a user interface based on direct manipulation, Android is designed primarily for touchscreen mobile devices such as smartphones and tablet computers, with specialized user interfaces for televisions (Android TV), cars (Android Auto), and wrist watches (Android Wear). The OS uses touch inputs that loosely correspond to real-world actions, such as swiping, tapping, pinching, and reverse pinching to manipulate on-screen objects, and a virtual keyboard. Despite being primarily designed for touchscreen input, it also has been used in game consoles, digital cameras, and other electronics. The response to user input is designed to be immediate and provides a fluid touch interface, often using the vibration capabilities

of the device to provide haptic feedback to the user. Internal hardware such as accelerometers, gyroscopes and proximity sensors are used by some applications to respond to additional user actions, for example, adjusting the screen from portrait to landscape depending on how the device is oriented, or allowing the user to steer a vehicle in a racing game by rotating the device by simulating control of a steering wheel.

Android devices boot to the homescreen, the primary navigation and information point on the device, which is similar to the desktop found on PCs. Android homescreens are typically made up of app icons and widgets; app icons launch the associated app, whereas widgets display live, auto-updating content such as the weather forecast, the user's email inbox, or a news ticker directly on the homescreen. A homescreen may be made up of several pages that the user can swipe back and forth between, though Android's homescreen interface is heavily customizable, allowing the user to adjust the look and feel of the device to their tastes. Third-party apps available on Google Play and other app stores can extensively re-theme the homescreen, and even mimic the look of other operating systems, such as Windows Phone. The Android OS is described in a publication entitled: "*Android Tutorial*", downloaded from tutorialspoint.com on July 2014, which is incorporated in its entirety for all purposes as if fully set forth herein.

iOS (previously iPhone OS) from Apple Inc. (headquartered in Cupertino, California, U.S.A.) is a mobile operating system distributed exclusively for Apple hardware. The user interface of the iOS is based on the concept of direct manipulation, using multi-touch gestures. Interface control elements consist of sliders, switches, and buttons. Interaction with the OS includes gestures such as swipe, tap, pinch, and reverse pinch, all of which have specific definitions within the context of the iOS operating system and its multi-touch interface. Internal accelerometers are used by some applications to respond to shaking the device (one common result is the undo command) or rotating it in three dimensions (one common result is switching from portrait to landscape mode). The iOS OS is described in a publication entitled: "*IOS Tutorial*", downloaded from tutorialspoint.com on July 2014, which is incorporated in its entirety for all purposes as if fully set forth herein.

An apparatus for protecting a vehicle electronic system is disclosed in U.S. Patent Application Publication No. 2015/0020152 to Litichever et al. entitled: "*Security system and method for protecting a vehicle electronic system*", which is incorporated in its entirety for all purposes as if fully set forth herein. The protecting is by selectively

intervening in the communications path in order to prevent the arrival of malicious messages at ECUs, in particular at the safety critical ECUs. The security system includes a filter, which prevents illegal messages sent by any system or device communicating over a vehicle communications bus from reaching their destination. The filter may, at its
5 discretion according to preconfigured rules, send messages as is, block messages, change the content of the messages, request authentication or limit the rate such messages can be delivered, by buffering the messages and sending them only in preconfigured intervals.

A mobile application on a mobile device communicates with a head-unit of a navigation system is disclosed in U.S. Patent No. 8,762,059 to Balogh entitled:
10 *“Navigation system application for mobile device”*, which is incorporated in its entirety for all purposes as if fully set forth herein. The mobile application may retrieve data such as map data, user input data, and other data and communicate the updates to the head unit. By retrieving map data through the mobile application, the head unit may be updated much easier than systems of the prior art. The data may be retrieved through
15 cellular networks, Wi-Fi networks, or other networks which accessible to a user and compatible with the mobile device. Updates may be stored in the mobile device and automatically uploaded to the navigation system head unit when the user is in the vicinity of the head unit. The mobile application may establish a logical connection with one or more head units. The logical connection bounds the mobile application to the
20 head unit and allows for data sharing and synchronization.

Systems and methods for promoting connectivity between a mobile communication device having a touch screen and a vehicle touch screen installed in a vehicle are disclosed in U.S. Patent No. 9,535,602 to Gutentag *et al.* entitled: *“System and method for promoting connectivity between a mobile communication device and a
25 vehicle touch screen”*, which is incorporated in its entirety for all purposes as if fully set forth herein. According to an embodiment, a system may include a controller configured to: connect to the mobile communication device and to the vehicle touch screen. The controller may also be configured to receive video signal of a current screen video image shown on the touch screen of the mobile communication device and transmit the current
30 video image to the vehicle touch screen, causing a corresponding video image of the current screen video image to be displayed on the vehicle touch screen. The controller may further be configured to receive a signal indicative of a touch action that was performed on the vehicle touch screen, and cause the mobile communication device to respond as if a touch action corresponding to the touch action that was performed on the

vehicle touch screen was performed on the touch screen of the mobile communication device.

A system and method for connection management between a consumer device and a vehicle is disclosed in U.S. Patent Application Publication No. 2013/0106750 to Kurosawa entitled: “*Connecting Touch Screen Phones in a Vehicle*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The connection management is performed automatically using a computing device, e.g., an application executing on a smartphone. The system and method configure the vehicle and consumer device in a manner that the screen display of the consumer device is mirrored on a touch panel of the in-vehicle computer system and the consumer device is controlled remotely by the user using the touch panel of the in-vehicle computer system.

A multi-screen display device and program of the same is disclosed in U.S. Patent Application Publication No. 2009/0171529 to Hayatoma entitled: “*Multi-screen display device and program of the same*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The multi display screen is constituted of a wide-screen displaying simultaneously two or more of a navigation search control screen setting necessary requirements to search for a route from a place of departure to a destination of a vehicle, a navigation map screen displaying the position of the vehicle on a map, a night vision screen recognizing an object on a road at night by infrared, a back guide monitor screen for recognizing a rear side of the vehicle, a blind corner monitor screen for recognizing an orthogonal direction of the vehicle, and a hands-free transmission/reception screen of a car phone. Screens to be displayed on the multi-display screen constituted of the wide screen is selected according to a vehicle driving state detected in a vehicle driving state detecting unit, and a display on the multi-display screen of a “screen 1”, a “screen 2”, and a “screen 3” constituted of the wide screen is determined according to the vehicle driving state detected in the vehicle driving state detecting unit.

An engine control device and method for use in a vehicle incorporating an internal combustion engine and a motor that are capable of transmitting motive power to an axle is disclosed in U.S. Patent Application Publication No. 2010/0280737 to Ewert *et al.* entitled: “*Engine Control Device and Method for a Hybrid Vehicle*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The device has an engine utilization reduction portion configured to reduce the power supplied by the engine when a requested engine power is above a predefined engine power minimum

value when the device is in a hybrid mode thereby increasing power provided by the electric motor. The device also may have a computer readable engine off portion configured to prevent the engine from starting or consuming fuel thereby causing the vehicle to be directionally powered by the electric motor only. The device may also have
5 a warm up portion configured to operate the engine in warmup mode and limit the power supplied by the engine when the engine temperature is below a predefined engine operating temperature thereby reducing emissions during engine warmup.

A handsfree apparatus is disclosed in U.S. Patent Application Publication No. 2010/0210315 to Miyake entitled: "*Handsfree Apparatus*", which is incorporated in its
10 entirety for all purposes as if fully set forth herein. The apparatus notifies a user of the reception of a mail if the reception of the mail by a cellular phone happens during a call, and stores an unread history of the received mail in a memory unit if a mail content display operation is not performed. Further, the handsfree apparatus notifies the user of the unread history of the received mail when Bluetooth connection link to the cellular
15 phone having received the mail is disconnected, thereby enabling the received mail to be recognized by the user.

A system and method for implementing cross-network synchronization of nodes on a vehicle bus is disclosed in U.S. Patent Application Publication No. 2012/0278507 to Menon et al. entitled: "*Cross-network synchronization of application s/w execution*
20 *using flexray global time*", which is incorporated in its entirety for all purposes as if fully set forth herein. The system and method include periodically sampling a notion of time from a first network, transmitting a message from the first network to a node on a second network, wherein the message includes the notion of time, and updating a local clock on the second network node based on the notion of time in the message.

Methods and devices supporting the management of a plurality of electronic devices and processing of update information for updating software and/or firmware in the electronic devices are disclosed in U.S. Patent Application Publication No. 2012/0210315 to Kapadekar *et al.* entitled: "*Device management in a network*", which is
25 incorporated in its entirety for all purposes as if fully set forth herein. Prompting of users may be made using a language associated with the electronic device, and authorization
30 to update an electronic device may be secured using a subscriber identity module

An in-car information system that includes a portable information terminal and an in-car device is disclosed in U.S. Patent Application Publication No. 2013/0298052 to NARA *et al.* entitled: "*In-Car Information System, Information Terminal, And*

Application Execution Method", which is incorporated in its entirety for all purposes as if fully set forth herein. The information terminal identifies a specific application being executed in the foreground and transmits restriction information pertaining to the particular application to the in-car device. The in-car device either allows or disallows, based upon the restriction information transmitted from the information terminal, image display corresponding to the application being executed in the foreground and transmission of operation information corresponding to an input operation.

A vehicle control system that includes a display device located in a vehicle. The display device displays a plurality of display icons with one of the display icons representing an active display icon is disclosed in U.S. Patent Application Publication No. 2015/0378598 to Takeshi entitled: "*Touch control panel for vehicle control system*", which is incorporated in its entirety for all purposes as if fully set forth herein. A touchpad is located in the vehicle remote from the display device. The touchpad provides virtual buttons corresponding to the display icons that have relative orientations corresponding to the display icons. The touchpad establishes a home location on the touchpad based on a location where a user of the vehicle touches the touchpad. The home location corresponds to the active display icon such that the virtual button representing the active display icon is located at the home location and the other virtual buttons are oriented about the home location.

A WiFi wireless rear view parking system comprises a main body, a camera sensor, a Wifi transmission module, a mobile personal electronics device, is disclosed in U.S. Patent Application Publication No. 2016/0127693 to Chung entitled: "*WiFi Wireless Rear View Parking System*", which is incorporated in its entirety for all purposes as if fully set forth herein. The main body is installed at a license plate of an automobile. The camera sensor is provided in the main body for sensing images and video of rear regions of the automobile and generating images and video data. The Wifi transmission module transmits the image and video data from the camera. The mobile personal electronic device is for receiving image and video data transmitted by the Wifi transmission module and displaying them. The WiFi wireless rear view parking system provides rear view of the automobile to a driver. The mobile personal electronic device includes a smartphone.

An image display device, which detects image characteristic information from an image of a screen provided by a mobile terminal, is disclosed in U.S. Patent Application Publication No. 2012/0242687 to CHOI entitled: "*Image processing apparatus and*

image processing method”, which is incorporated in its entirety for all purposes as if fully set forth herein. The device extracts a characteristic area based on the image characteristic information, and automatically magnifies or reduces the extracted characteristic area and displays the same, to thereby allow a user to conveniently and effectively view the image provided from the mobile terminal in a vehicle. The image display device includes: a communication unit configured to receive an image from a mobile terminal; a controller configured to detect image characteristic information of the received image, extract a first area on the basis of the detected image characteristic information, determine an image processing scheme with respect to the extracted first area, and process an image corresponding to the extracted first area according to the determined image processing scheme; and a display unit configured to display the processed image.

A system and method in a building or vehicle for an actuator operation in response to a sensor according to a control logic are disclosed in U.S. Patent Application Publication No. 2013/0201316 to Binder *et al.* entitled: “*System and method for server based control*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The system comprising a router or a gateway communicating with a device associated with the sensor and a device associated with the actuator over in-building or in-vehicle networks, and an external Internet-connected control server associated with the control logic implementing a PID closed linear control loop and communicating with the router over external network for controlling the in-building or in-vehicle phenomenon. The sensor may be a microphone or a camera, and the system may include voice or image processing as part of the control logic. A redundancy is used by using multiple sensors or actuators, or by using multiple data paths over the building or vehicle internal or external communication. The networks may be wired or wireless, and may be BAN, PAN, LAN, WAN, or home networks.

A system that includes a database that stores an expert knowledgebase, and one or more servers configured to implement an expert system, is disclosed in U.S. Patent No. 8,600,831 to Xiao *et al.* entitled: “*Automated automobile maintenance using a centralized expert system*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The one or more servers receive sensor data associated with sensors from automobile maintenance systems associated with respective ones of multiple automobiles, and analyze the sensor data, using the expert system and the expert knowledgebase, to diagnose whether the multiple automobiles require

maintenance and/or repair. The one or more servers send, via a network, results of the analysis of the sensor data to service stations for scheduling maintenance and/or repair of the multiple automobiles.

A system that includes an on-board unit (OBU) in communication with an internal subsystem in a vehicle on at least one Ethernet network and a node on a wireless network is disclosed in U.S. Patent Application Publication No. 2014/0215491 to Addepalli *et al.* entitled: “*System and method for internal networking, data optimization and dynamic frequency selection in a vehicular environment*”, which is incorporated in its entirety for all purposes as if fully set forth herein. A method in one embodiment includes receiving a message on the Ethernet network in the vehicle, encapsulating the message to facilitate translation to Ethernet protocol if the message is not in Ethernet protocol, and transmitting the message in Ethernet protocol to its destination. Certain embodiments include optimizing data transmission over the wireless network using redundancy caches, dictionaries, object contexts databases, speech templates and protocol header templates, and cross layer optimization of data flow from a receiver to a sender over a TCP connection. Certain embodiments also include dynamically identifying and selecting an operating frequency with least interference for data transmission over the wireless network.

Road traffic safety. Road traffic safety refers to the methods and measures used to prevent road users from being killed or seriously injured. Typical road users include pedestrians, cyclists, motorists, vehicle passengers, and passengers of on-road public transport (mainly buses and trams). Road traffic crashes are one of the world’s largest public health and injury prevention problems. The problem is all the more acute because the victims are overwhelmingly healthy before their crashes. The basic strategy of a Safe System approach is to ensure that in the event of a crash, the impact energies remain below the threshold likely to produce either death or serious injury. This threshold will vary from crash scenario to crash scenario, depending upon the level of protection offered to the road users involved. For example, the chances of survival for an unprotected pedestrian hit by a vehicle diminish rapidly at speeds greater than 30 Km/h, whereas for a properly restrained motor vehicle occupant the critical impact speed is 50 Km/h (for side impact crashes) and 70 Km/h (for head-on crashes).

As sustainable solutions for all classes of road have not been identified, particularly low-traffic rural and remote roads, a hierarchy of control should be applied, similar to classifications used to improve occupational safety and health. At the highest

level is sustainable prevention of serious injury and death crashes, with sustainable requiring all key result areas to be considered. At the second level is real time risk reduction, which involves providing users at severe risk with a specific warning to enable them to take mitigating action. The third level is about reducing the crash risk
5 which involves applying the road design standards and guidelines (such as from AASHTO), improving driver behavior and enforcement.

Vehicle speed within the human tolerances for avoiding serious injury and death is a key goal of modern road design because impact speed affects the severity of injury to both occupants and pedestrians. Contributing factors to highway crashes may be
10 related to the driver (such as driver error, illness, or fatigue), the vehicle (brake, steering, or throttle failures), or the road itself (lack of sight distance, poor roadside clear zones, etc.). Interventions may seek to reduce or compensate for these factors, or reduce the severity of crashes. In addition to management systems, which apply predominantly to networks in built-up areas, another class of interventions relates to the design of roadway
15 networks for new districts. Such interventions explore the configurations of a network that will inherently reduce the probability of collisions.

For road traffic safety purposes it can be helpful to classify roads into three usages: built-up urban streets with slower speeds, greater densities, and more diversity among road users; non built-up rural roads with higher speeds; and major highways
20 (motorways/ Interstates/ freeways/ Autobahns, etc.) reserved for motor-vehicles, and which are often designed to minimize and attenuate crashes. Most injuries occur on urban streets but most fatalities on rural roads, while motorways are the safest in relation to distance traveled. Turning across traffic (i.e., turning left in right-hand drive countries, turning right in left-hand drive countries) poses several risks. The more serious risk is a
25 collision with oncoming traffic. Since this is nearly a head-on collision, injuries are common. It is the most common cause of fatalities in a built-up area. Another major risk is involvement in a rear-end collision while waiting for a gap in oncoming traffic.

Countermeasures for this type of collision include addition of left turn lanes, providing protected turn phasing at signalized intersections, using indirect turn
30 treatments such as the Michigan left, and converting conventional intersections to roundabouts. Safety can be improved by reducing the chances of a driver making an error, or by designing vehicles to reduce the severity of crashes that do occur. Most industrialized countries have comprehensive requirements and specifications for safety-related vehicle devices, systems, design, and construction. These may include passenger

restraints such as seat belts - often in conjunction with laws requiring their use - and airbags, crash avoidance equipment such as lights and reflectors, driver assistance systems such as Electronic Stability Control, and crash survivability design including fire-retardant interior materials, standards for fuel system integrity, and the use of safety glass.

A traffic collision, also called a Motor Vehicle Collision (MVC) among other terms, occurs when a vehicle collides with another vehicle, pedestrian, animal, road debris, or other stationary obstruction, such as a tree or pole. Traffic collisions often result in injury, death, and property damage. A number of factors contribute to the risk of collision, including vehicle design, speed of operation, road design, road environment, and driver skill, impairment due to alcohol or drugs, and behavior, notably speeding and street racing. Worldwide, motor vehicle collisions lead to death and disability as well as financial costs to both society and the individuals involved.

Traffic collisions can be classified by general type. Types of collision include head-on, road departure, rear-end, side collisions, and rollovers. Many different terms are commonly used to describe vehicle collisions. The World Health Organization use the term road traffic injury, while the U.S. Census Bureau uses the term Motor Vehicle Accidents (MVA), and Transport Canada uses the term "Motor Vehicle Traffic Collision" (MVTC). Other common terms include auto accident, car accident, car crash, car smash, car wreck, Motor Vehicle Collision (MVC), Personal Injury Collision (PIC), road accident, Road Traffic Accident (RTA), Road Traffic Collision (RTC), Road Traffic Incident (RTI), road traffic accident and later road traffic collision, as well as more unofficial terms including smash-up, pile-up, and fender bender.

Road traffic collisions generally fall into one of four common types: (a) Lane departure crashes, which occur when a driver leaves the lane they are in and collide with another vehicle or a roadside object. These include head-on collisions and run-off-road collisions. (b) Collisions at junctions include rear-end collision and angle or side impacts. (c) Collisions involving pedestrians and cyclists, and (d) Collisions with animals. Other types of collision may occur. Rollovers are not very common, but lead to greater rates of severe injury and death. Some of these are secondary events that occur after a collision with a run-off-road crash or a collision with another vehicle. If several vehicles are involved, the term 'serial crash' may be used. If many vehicles are involved, the term 'major incident' may be used rather than 'pile up'.

The likelihood of head-on collision is at its greatest on roads with narrow lanes, sharp curves, no separation of lanes of opposing traffic, and high volumes of traffic. Crash severity, measured as risk of death and injury, and repair costs to vehicles, increases as speed increases. Therefore, the roads with the greatest risk of head-on collision are busy single-carriageway roads outside urban areas where speeds are highest. Contrast this with motorways, which rarely have a high risk of head-on collision in spite of the high speeds involved, because of the median separation treatments such as cable barriers, Concrete step barriers, Jersey barriers, metal crash barriers, and wide medians.

The greatest risk reduction in terms of head-on collision comes through the separation of oncoming traffic, also known as median separation or median treatment, which can reduce road collisions in the order of 70%. Indeed both Ireland and Sweden have undertaken large programs of safety fencing on 2+1 roads. Median barriers can be divided into three basic categories: rigid barrier systems, semi-rigid barrier systems, and flexible barrier systems. Rigid barrier systems are made up of concrete and are the most common barrier type in use today (e.g. Jersey barrier or concrete step barrier). They are the most costly to install, but have relatively low life-cycle costs, making them economically viable over time. The second barrier type, semi-rigid, is commonly known as guardrail or guiderail barriers. The third median barrier type is the flexible barrier systems (e.g., cable barriers). Cable barriers are the most forgiving and the least expensive to install, but have high life-cycle costs due to repair needs after crashes. Much cheaper collision reduction methods are to improve road markings, to reduce speeds and to separate traffic with wide central hatching.

Sealing of safety zones along the side of the road (also known as a hard-shoulder) can also reduce the risk of head-on collisions caused by steering over-correction. Where a hard shoulder cannot be provided, a "safety edge" can reduce the chances of steering overcorrection. An attachment is added to the paving machine to provide a beveled edge at 30 to 35-degree angle to horizontal, rather than the usual near-vertical edge. This works by reducing the steering angle needed for the tire to climb up the pavement edge. For a vertical edge, the steering angle needed to mount the pavement edge is sharp enough to cause loss of control once the vehicle is back on top of the pavement. If the driver cannot correct this in time, the vehicle may veer into oncoming traffic, or off the opposite side of the road.

A single-vehicle collision is defined when a single road vehicle has a collision without involving any other vehicle. They usually have similar root causes as head-on collisions, but no other vehicle happened to be in the path of the vehicle leaving its lane. Severe collisions of this type can happen on motorways, since speeds are extra high,
5 increasing the severity. Crashes at intersections (road junctions) are a very common type of road collision types. Collisions may involve head-on impact when one vehicle crosses an opposing lane of traffic to turn at an intersection, or side impacts when one vehicle crosses the path of an adjoining vehicle at an intersection.

Safety can be improved by reducing the chances of a driver making an error, or
10 by designing vehicles to reduce the severity of crashes that do occur. Most industrialized countries have comprehensive requirements and specifications for safety-related vehicle devices, systems, design, and construction. These may include Passenger restraints such as seat belts - often in conjunction with laws requiring their use - and airbags, Crash avoidance equipment such as lights and reflectors, Driver assistance systems such as
15 Electronic Stability Control, Crash survivability design including fire-retardant interior materials, standards for fuel system integrity, and the use of safety glass.

A plurality of vehicles with cameras and other sensors collect images and other data as a normal event, or upon demand, or when requested to do so by another vehicle, an occupant or a service center, are disclosed in U.S. Patent Application Publication No.
20 2003/0210806 to Yoichi *et al.* entitled: "*Navigational information service with image capturing and sharing*", which is incorporated in its entirety for all purposes as if fully set forth herein. Images may be permanently stored in the vehicles and indexed in a directory at a service center, so that the images may selectively sent to the service center or another vehicle without consuming storage space at the service center. When the
25 service center is managing sufficient current data for an area, the service center generates a suspension signal to discard or instruct vehicles not to send further images from that area.

A plurality of vehicles with cameras and other sensors collect images, including other data as a normal event, or upon demand in an emergency, or when requested to do
30 so by another vehicle, an occupant or a service center, are disclosed in U.S. Patent Application Publication No. 2003/0212567 to Shintani *et al.* entitled: "*Witness information service with image capturing and sharing*", which is incorporated in its entirety for all purposes as if fully set forth herein.. Images may be permanently stored in the vehicles and indexed in a directory at the service center so that the images may

selectively sent to the service center or another vehicle without consuming storage space at the service center. Upon the occurrence of an emergency event, an emergency signal is broadcast to vehicles within the area to save and transmit an immediate past image history and an immediate future image history.

5 An apparatus, a system and a method of collecting vehicle data for use in incident investigations, are disclosed in U.S. Patent Application Publication No. 2007/0150140 to Seymour entitled: "*Incident alert and information gathering method and system*", which is incorporated in its entirety for all purposes as if fully set forth herein. The apparatus, the system and the method are including: a vehicle data recorder
10 for recording vehicle parameters such as geographic location, speed, azimuth of motion, acceleration, brake pedal pressure and similar parameters: a means for detecting incidents such as an accident, and sending an incident message to an incident monitoring station, which then transmits a broadcast message. Other vehicles within communication range of the incident monitoring station each respond to the broadcast message with a
15 report message including a unique identifier. When an incident occurs, a portion of the data stored prior to, and at the time of, the incident is saved for future retrieval. The incident message may be reported to a central site or other authority so that emergency response can be provided.

 A system and associated method for gathering and submitting data to a third
20 party in response to a vehicle being involved in an accident are disclosed in U.S. Patent Application Publication No. 2010/00048160 to Bauchot *et al.* entitled: "*System and method for gathering and submitting data to a third party in response to a vehicle being involved in an accident*", which is incorporated in its entirety for all purposes as if fully set forth herein. First, an information manager stores data regardless of the vehicle being
25 involved in an accident. Next, the event detection manager stores data in response to detecting the vehicle being involved in an accident. Next, the information manager stores state data pertaining to the vehicle's current state. Then an adjacent identifier manager requests, receives, and stores data from surrounding vehicles in memory. Next, a report is generated and encrypted. Finally, the encryption and transmission manager stores the
30 report in memory.

 Systems and methods to request and collect evidence elements from one or more evidence systems responsive to a triggering event are disclosed in U.S. Patent Application Publication No. 2014/0156104 to Healey *et al.* entitled: "*Systems and methods for collecting vehicle evidence*", which is incorporated in its entirety for all

purposes as if fully set forth herein. An evidence request beacon may be generated based at least in part on information associated with the triggering event. The evidence request beacon may be received by one or more evidence systems and may be evaluated to determine if potentially relevant evidence is available from the evidence system. If
5 potentially relevant evidence elements are available from the one or more evidence systems, then the potentially relevant evidence elements may be provided to the requesting system.

A device and method for post event data retrieval that uses an electronic communications system are disclosed in U.S. Patent Application Publication No.
10 2015/0094013 to DIMITRI *et al.* entitled: “*System and Method for Participants DATA Retrieval Post Accident or Event*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The method and system can utilize a detection device for detecting the event and facilitating the post event data retrieval. The system and method include detecting an event using a detection device. The detection device includes a
15 location tool configured to determine a position of the detection device. The detection device defines a specified vicinity with respect to itself. A location is determined of the detection device using the location tool, after the event has occurred. Data including an identification (ID) is automatically requested of a communications device in the specified vicinity, using the detection device. A reply is received by the detection device,
20 which includes the ID from the communications device for identifying the communications device.

A system for documenting an accident that includes a vehicle that includes a transceiver device and a processing circuit is disclosed in U.S. Patent Application Publication No. 2015/0145695 to Hyde *et al.* entitled: “*Systems and methods for
25 automatically documenting an accident*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The processing circuit is configured to receive data from a collision detection device of the vehicle, determine, based on the received data, that an accident is impending or occurring involving the vehicle, generate a request for a nearby vehicle, and transmit, via the transceiver device, the request to the nearby vehicle.
30 The request is for the nearby vehicle to illuminate a region associated with the accident, actively acquire data related to the accident, and record actively acquired data related to the accident.

A method and apparatus for uploading DME is disclosed in U.S. Patent Application Publication No. 2015/0281651 to Kaushik *et al.* entitled: “*Method and*

apparatus for uploading data”, which is incorporated in its entirety for all purposes as if fully set forth herein. During operation vehicles in the field will upload their digital multimedia evidence (DME) to a mobile/intermediary upload point(s). These mobile/intermediary upload points preferably comprise computers existing in other vehicles that are not currently connected to a central repository. A mobile recorder (mDVR) will choose a particular mobile/intermediary upload point(s) based on a probability that the mobile upload point(s) will return to a connected upload point to upload the transferred DME.

An approach for corroborating with the investigation of an emergency event is disclosed in U.S. Patent Application Publication No. 2015/0327039 to Kumar JAIN entitled: “*Method and apparatus for providing event investigation through witness devices*”, which is incorporated in its entirety for all purposes as if fully set forth herein. An event processor receives an event data corresponding to an event from a mobile device, and the location of the mobile device is determined. Participating device(s) within the vicinity of the emergency event, as defined by the location of the mobile device, are selected and provided with the option to submit information regarding the event to a database used by authorities.

Vehicle registration plate. Countries typically employ registration of vehicle using a registration identifier that is a numeric or alphanumeric identity that uniquely identifies the vehicle (or vehicle owner) within the country issuing vehicle register. A vehicle registration plate, also known as a number plate or a license plate, is metal or plastic plate attached to a motor vehicle or trailer for official identification purposes, displaying the registration identifier. All countries require registration plates for road vehicles such as cars, trucks, and motorcycles. Some countries require a registration number and Vehicle registration plate for other vehicles, such as bicycles, boats, or tractors. Most governments require a registration plate to be attached to both the front and rear of a vehicle, although certain jurisdictions or vehicle types, such as motorboats, require only one plate, which is usually attached to the rear of the vehicle. National databases relate this number to other information describing the vehicle, such as the make, model, color, year of manufacture, engine size, type of fuel used, mileage recorded, Vehicle Identification (Chassis) Number, and the name and address of the vehicle's registered owner or keeper.

For a vehicle, the term “make” refers to either the name of its manufacturer or, if the manufacturer has more than one operating unit, the name of that unit. A “model” is a

specific vehicle brand identified by a name or number (and which is usually further classified by trim or style level). The term “Engine size” refers to a vehicle engine displacement, typically in liters, according to its manufacturer. The term “Vehicle type” refers to the type of vehicle class, examples of which are large cars, midsize cars, minivans, pickup trucks, small cars, special purpose vehicles, sports utility vehicles, station wagons and vans. The term “Model year” refers to the calendar year designation assigned by the manufacturer to the annual version of that model.

Vehicle Identification Number (VIN). A vehicle identification number (VIN), also referred to as a chassis number, is a unique code, including a serial number, used by the automotive industry to identify individual motor vehicles, towed vehicles, motorcycles, scooters and mopeds, as defined in International Organization for Standardization (ISO) 3833.

Modern VINs are based on two related standards, originally issued by the International Organization for Standardization (ISO) ISO 3780 and ISO 3779:2009 entitled: “*Road vehicles - Vehicle identification number (VIN) - Content and structure*”. The first three characters in a VIN uniquely identify the manufacturer of the vehicle using the World Manufacturer Identifier or WMI code. Some manufacturers use the third character as a code for a vehicle category (e.g., bus or truck), a division within a manufacturer, or both. For example, within 1G (assigned to General Motors in the United States), 1G1 represents Chevrolet passenger cars; 1G2, Pontiac passenger cars; and 1GC, Chevrolet trucks. The Society of Automotive Engineers (SAE) in the U.S. assigns WMIs to countries and manufacturers. The fourth to eighth positions in the VIN are the Vehicle Descriptor Section or VDS. This is used, according to local regulations, to identify the vehicle type, and may include information on the automobile platform used, the model, and the body style. Each manufacturer has a unique system for using this field. Most manufacturers since the 1980s have used the eighth digit to identify the engine type whenever there is more than one engine choice for the vehicle. The 10th to 17th positions of the VIN are used as the ‘Vehicle Identifier Section’ (VIS). This is used by the manufacturer to identify the individual vehicle, and may include information on options installed or engine and transmission choices, but often is a simple sequential number. In North America, the last five digits must be numeric. One consistent element of the VIS is the 10th digit, which is required worldwide to encode the model year of the vehicle. Besides the three letters that are not allowed in the VIN itself (I, O and Q), the letters U and Z and the digit 0 are not used for the model year code. The year code is the

model year for the vehicle. Compulsory in North America is the use of the 11th character to identify the factory at which the vehicle was built. Each manufacturer has its own set of plant codes. In the United States, the 12th to 17th digits are the vehicle's serial or production number. This is unique to each vehicle, and every manufacturer uses its own sequence.

A vehicle computer system is disclosed in U.S. Patent No. 8,866,604 to Rankin *et al.* entitled: "*System and method for a human machine interface*", which is incorporated in its entirety for all purposes as if fully set forth herein. The system comprising a wireless transceiver configured to send a nomadic device human machine interface to a nomadic device in a web browser format. The vehicle computer system further comprises a vehicle server utilizing a contextual data aggregator that utilizes vehicle data and off-board data to generate a dynamic human machine interface, the server further configured to generate an in-vehicle human machine interface for output on a vehicle display and generate the nomadic device human machine interface for the nomadic device to display.

Currently vehicles typically include an engine computer that outputs diagnostic trouble codes (DTC) that are indicative of some fault condition in a vehicle, as disclosed in U.S. Patent No. 9,384,597 to Koch *et al.* entitled: "*System and method for crowdsourcing vehicle-related analytics*", which is incorporated in its entirety for all purposes as if fully set forth herein. DTCs can tell a specific problem with a particular part such as that a cylinder in an engine is misfiring, but do not provide any indication as to the cause of the problem and do not propose any solutions for solving the problem. This disclosure advantageously describes systems that can analyze DTCs and other telematics data using crowdsourcing principles to recommend vehicle maintenance and other solutions.

Systems and methods are disclosed for collecting vehicle data from a vehicle engine computer of a vehicle and a plurality of sensors disposed about the vehicle and generating feedbacks for a driver of the vehicle using at least the vehicle data are disclosed in U.S. Patent No. 9,424,751 to HODGES *et al.* entitled: "*Systems and methods for performing driver and vehicle analysis and alerting*", which is incorporated in its entirety for all purposes as if fully set forth herein. The systems and methods additionally provide for receiving user inputs from the driver responding to the feedbacks so that the user inputs are associated with corresponding rule violations that triggered the feedbacks.

A system that includes a processor configured to receive vehicle data from a plurality of vehicles is disclosed in U.S. Patent Application Publication No. 2016/0035145 to McEwan *et al.* entitled: “*Method and Apparatus for Vehicle Data Gathering and Analysis*”, which is incorporated in its entirety for all purposes as if fully
5 set forth herein. The processor is also configured to save the data with respect to a reporting vehicle. Further, the processor is configured to associate the data with any recent reporting vehicle repairs. The processor is additionally configured to analyze the associated data with respect to other vehicles having similar repairs to determine root causes of malfunction leading to the repair and save a record of identified causes of the
10 malfunction.

A computer-implemented method and system for providing transport information to a plurality of user computing devices are disclosed in U.S. Patent Application Publication No. 2016/0078692 to Tutte entitled: “*Method and system for sharing transport information*”, which is incorporated in its entirety for all purposes as if
15 fully set forth herein. The method is performed by a cloud computing system and includes operating a processor associated with the cloud computing system to: analyse vehicle data collated from one or more vehicles remote from the cloud computing system to generate processed vehicle data; and configure the processed vehicle data to be accessed through a portal of each of the user computing devices.

Fleetwide vehicle telematics systems and methods that includes receiving and managing fleetwide vehicle state data devices are disclosed in U.S. Patent Application Publication No. 2016/0086391 to Ricci entitled: “*Fleetwide vehicle telematics systems and methods*”, which is incorporated in its entirety for all purposes as if fully set forth
20 herein. The fleetwide vehicle state data may be fused or compared with customer enterprise data to monitor conformance with customer requirements and thresholds. The fleetwide vehicle state data may also be analyzed to identify trends and correlations of interest to the customer enterprise.
25

A system for tracking and remote control of a personal recreational vehicle that has at least two sensors is disclosed in U.S. Patent Application Publication No.
30 2016/0180721 to Otulic entitled: “*System and method for tracking, surveillance and remote control of powered personal recreational*”, which is incorporated in its entirety for all purposes as if fully set forth herein. Each sensor senses at least a respective and distinct one of temperature, pressure, acceleration, geoposition orientation relative to a horizontal plane and communication signal strength. A microcontroller receives inputs

from the at least two sensors, and determines whether a change in environmental conditions in which the personal vehicle is operating has occurred. The microcontroller sends an alarm to a user of the personal recreational vehicle if a change in the environmental conditions has exceeded a predetermined value.

5 A vehicle Electronic Control Unit (ECU) is disclosed in U.S. Patent Application Publication No. 2016/0203652 to Throop *et al.* entitled: “*Efficient telematics data upload*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The ECU may control a vehicle subsystem and be configured to receive from a remote server via a Vehicle Telematics Unit (TCU), a parameter definition of a processed
10 parameter to be computed by the ECU; generate the processed parameter according to the parameter definition based on a raw parameter generated by the ECU; and send the processed parameter to a vehicle data buffer associated with the ECU for upload to the remote server via the TCU.

 Timestamp. A timestamp is a sequence of characters or encoded information
15 identifying when a certain event occurred, usually giving date and time of day, sometimes accurate to a small fraction of a second, and also refers to digital date and time information attached to the digital data. For example, computer files contain timestamps that tell when the file was last modified, and digital cameras add timestamps to the pictures they take, recording the date and time the picture was taken. A timestamp
20 is typically the time at which an event is recorded by a computer, not the time of the event itself. In many cases, the difference may be inconsequential - the time at which an event is recorded by a timestamp (e.g., entered into a log file) should be close to the time of the event. Timestamps are typically used for logging events or in a Sequence of Events (SOE), in which case, each event in the log or SOE is marked with a timestamp.
25 In a file system such as a database, timestamp commonly mean the stored date/time of creation or modification of a file or a record. The ISO 8601 standard standardizes the representation of dates and times which are often used to construct timestamp values, and IETF RFC 3339 defines a date and time format for use in Internet protocols using the ISO 8601 standard representation.

30 Geolocation is the identification or estimation of the real-world geographic location of an object, such as a mobile phone or an Internet-connected computer terminal. Typically, geolocation involves the generation of a set of geographic coordinates that may be used to determine a meaningful location, such as a street address. For either geolocating or positioning, the locating engine often uses Radio-

Frequency (RF) location methods, for example Time-Difference-Of-Arrival (TDOA) for precision, where the TDOA often utilizes mapping displays or other geographic information system. When a GPS signal is unavailable, geolocation applications can use information from cell towers to triangulate the approximate position.

5 Internet and computer geolocation can be performed by associating a geographic location with the Internet Protocol (IP) address, MAC address, RFID, hardware embedded article/production number, embedded software number (such as UUID, Exif/IPTC/XMP or modern steganography), invoice, Wi-Fi positioning system, device fingerprint, canvas fingerprinting, or device GPS coordinates. Geolocation may work by
10 automatically looking up an IP address on a WHOIS service and retrieving the registrant's physical address. IP address location data can include information such as country, region, city, postal/zip code, latitude, longitude, and timezone.

Location may further be determined by one or more ranging or angulating methods, such as Angle of arrival (AoA), Line-of-Sight (LoS), Time of arrival (ToA),
15 Multilateration (Time difference of arrival) (TDoA), Time-of-flight (ToF), Two-way ranging (TWR), Symmetrical Double Sided – Two Way Ranging (SDS-TWR), or Near-field electromagnetic ranging (NFER).

An Angle-of-Arrival (AoA) method may be used for determining the direction of propagation of a Radio-Frequency (RF) wave incident on an antenna array. AoA
20 determines the direction by measuring the Time-Difference-of-Arrival (TDOA) at individual elements of the array, and the AoA is calculated based on these delays. Line-of-Sight (LoS) propagation is a characteristic of electromagnetic radiation or acoustic wave propagation, which means waves that travel in a direct path from the source to the receiver. Electromagnetic transmission includes light emissions traveling in a straight
25 line. The rays or waves may be diffracted, refracted, reflected, or absorbed by atmosphere and obstructions with material and generally cannot travel over the horizon or behind obstacles. Time-of-Arrival (TOA or ToA) (also referred to as Time-of-Flight (ToF), is the travel time of a radio signal from a single transmitter to a remote single receiver. Compared to the TDOA technique, time-of-arrival uses the absolute time of
30 arrival at a certain base station rather than the measured time difference between departing from one and arriving at the other station. The distance can be directly calculated from the time of arrival as signals travel with a known velocity. Time of arrival data from two base stations will narrow a position to a position circle; data from a third base station is required to resolve the precise position to a single point.

Multilateration (MLAT) is a surveillance technique based on the measurement of the difference in distance to two stations at known locations by broadcast signals at known times. Unlike measurements of absolute distance or angle, measuring the difference in distance between two stations results in an infinite number of locations that satisfy the measurement. When these possible locations are plotted, they form a hyperbolic curve. To locate the exact location along that curve, multilateration relies on multiple measurements: a second measurement taken to a different pair of stations will produce a second curve, which intersects with the first. When the two curves are compared, a small number of possible locations are revealed, producing a "fix". Time-of-Flight (TOF) describes a variety of methods that measure the time that it takes for an object, particle or acoustic, electromagnetic or other wave to travel a distance through a medium. This measurement can be used for a time standard (such as an atomic fountain), as a way to measure velocity or path length through a given medium, or as a way to learn about the particle or medium (such as composition or flow rate). The traveling object may be detected directly (e.g., ion detector in mass spectrometry) or indirectly (e.g., light scattered from an object in laser Doppler velocimetry). Symmetrical Double-Sided Two-Way Ranging (SDS-TWR) is a ranging method that uses two delays that naturally occur in signal transmission to determine the range between two stations, using a signal propagation delay between two wireless devices and processing delay of acknowledgements within a wireless device. Near-Field Electromagnetic Ranging (NFER) refers to any radio technology employing the near-field properties of radio waves as a Real Time Location System (RTLS). Near-field Electromagnetic Ranging employs transmitter tags and one or more receiving units. Operating within a half-wavelength of a receiver, transmitter tags must use relatively low frequencies (less than 30 MHz) to achieve significant ranging. Depending on the choice of frequency, NFER has the potential for range resolution of 30 cm (1 ft) and ranges up to 300 m (1,000 ft).

A localization in wireless environment may use triangulation, trilateration, or multilateration. Triangulation, which uses the measurement of absolute angles, is the process of determining the location of a point by forming triangles to it from known points. Specifically in surveying, triangulation per se involves only angle measurements, rather than measuring distances to the point directly as in trilateration; the use of both angles and distance measurements is referred to as triangulation. Trilateration is the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres or triangles. Trilateration typically uses

distances or absolute measurements of time-of-flight from three or more sites, and does have practical applications in surveying and navigation, including global positioning systems (GPS). In contrast to triangulation, it does not involve the measurement of angles. In two-dimensional geometry, it is known that if a point lies on two circles, then the circle centers and the two radii provide sufficient information to narrow the possible locations down to two. Additional information may narrow the possibilities down to one unique location. In three-dimensional geometry, when it is known that a point lies on the surfaces of three spheres, then the centers of the three spheres along with their radii provide sufficient information to narrow the possible locations down to no more than two (unless the centers lie on a straight line).

Multilateration (MLAT) is a surveillance technique based on the measurement of the difference in distance to two stations at known locations by broadcast signals at known times. Unlike measurements of absolute distance or angle, measuring the difference in distance between two stations results in an infinite number of locations that satisfy the measurement. When these possible locations are plotted, they form a hyperbolic curve. To locate the exact location along that curve, multilateration relies on multiple measurements: a second measurement taken to a different pair of stations will produce a second curve, which intersects with the first. When the two curves are compared, a small number of possible locations are revealed, producing a "fix". Multilateration is a common technique in radio navigation systems, where it is known as hyperbolic navigation. These systems are relatively easy to construct as there is no need for a common clock, and the difference in the signal timing can be measured visibly using an oscilloscope.

Wireless indoor positioning systems are described in a paper by Hui Liu (Student Member, IEEE), Houshang Darabi (Member, IEEE), Pat Banerjee, and Jing Liu published in IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART C: APPLICATIONS AND REVIEWS, VOL. 37, NO. 6, NOVEMBER 2007 [1094-6977/\$25.00 © 2007 IEEE] entitled: "*Survey of Wireless Indoor Positioning Techniques and Systems*", which is incorporated in its entirety for all purposes as if fully set forth herein. The paper describes systems that have been successfully used in many applications such as asset tracking and inventory management, and provides an overview of the existing wireless indoor positioning solutions and attempts to classify different techniques and systems. Three typical location estimation schemes of triangulation, scene analysis, and proximity are described. The paper further discusses location

fingerprinting in detail, since it is used in most current system or solutions. A set of properties is examined by which location systems are evaluated, and this evaluation method is used to survey a number of existing systems. Comprehensive performance comparisons including accuracy, precision, complexity, scalability, robustness, and cost are presented.

An overview of various algorithms for wireless position estimation is presented in a paper by Sinan Gezici Published 2 October 2007 by Springer Science+Business Media, LLC [Wireless Pers Commun (2008) 44:263–282, DOI 10.1007/s11277-007-9375-z] entitled: “*A Survey on Wireless Position Estimation*”, which is incorporated in its entirety for all purposes as if fully set forth herein. Although the position of a node in a wireless network can be estimated directly from the signals traveling between that node and a number of reference nodes, it is more practical to estimate a set of signal parameters first, and then to obtain the final position estimation using those estimated parameters. In the first step of such a two-step positioning algorithm, various signal parameters such as time of arrival, angle of arrival or signal strength are estimated. In the second step, mapping, geometric or statistical approaches are commonly employed. In addition to various positioning algorithms, theoretical limits on their estimation accuracy are also presented in terms of Cramer–Rao lower bounds.

For outdoor positioning service the Global Positioning Systems (GPS) are the earliest widely used modern systems. In GPS technology Satellite signals cannot penetrate in indoor environment since they are blocked by building obstructions thus satellite signal cannot provide good accuracy in indoor environments due to lack of LoS (Line Of Sight). Indoor positioning techniques are described in a paper by Siddhesh Doiphode, J.W. Bakal, and Madhuri Gedam, published in International Journal of Computer Applications (0975 – 8887) Volume 140 – No.7, April 2016, entitled: “*Survey of Indoor Positioning Measurements, Methods and Techniques*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The paper describes a large variety of technologies that have been designed for dealing with the problem since the indoor environments are very difficult to track. The paper also provide brief description on various indoor wireless tracking measurements, methodologies and technologies. The paper illustrates the theoretical points, the main tools, and the most promising technologies for indoor tracking infrastructure.

Various localization techniques are described in a paper by Santosh Pandey and Prathima Agrawal, and published in the Journal of the Chinese Institute of Engineers,

Vol. 29, No. 7, pp. 1125-1148 (2006), entitled: "*A SURVEY ON LOCALIZATION TECHNIQUES FOR WIRELESS NETWORKS*", which is incorporated in its entirety for all purposes as if fully set forth herein. Wireless networks have displaced the well-established and widely deployed wired communication networks of the past. Tetherless access and new services offered to mobile users contribute to the popularity of these networks, thus users have access from many locations and can roam ubiquitously. The knowledge of the physical location of mobile user devices, such as phones, laptops and PDAs, is important in several applications such as network planning, location based services, law enforcement and for improving network performance. A device's location is usually estimated by monitoring a distance dependent parameter such as wireless signal strength from a base station whose location is known. In practical deployments, signal strength varies with time and its relationship to distance is not well defined. This makes location estimation difficult. Many location estimation or localization schemes have been proposed for networks adopting a variety of wireless technologies. This paper reviews a broad class of localization schemes that are differentiated by the fundamental techniques adopted for distance estimation, indoor vs. outdoor environments, relative cost and accuracy of the resulting estimates and ease of deployment.

IP-Based Geolocation. IP-based geolocation (commonly known as geolocation) is a mapping of an IP address (or MAC address) to the real-world geographic location of a computing device or a mobile device connected to the Internet. The IP address based location data may include information such as country, region, city, postal/zip code, latitude, longitude, or Timezone. Deeper data sets can determine other parameters such as domain name, connection speed, ISP, Language, proxies, company name, US DMA/MSA, NAICS codes, and home/business classification. The geolocation is further described in the publication entitled: "Towards Street-Level Client-Independent IP Geolocation" by Yong Wang et al., downloaded from the Internet on July 2014, and in an Information Systems Audit and Control Association (ISACA) 2011 white paper entitled: "Geolocation: Risk, Issues and Strategies", which are both incorporated in their entirety for all purposes as if fully set forth herein. There are a number of commercially available geolocation databases, such as a web-site <http://www.ip2location.com> operated by Ip2location.com headquartered in Penang, Malaysia, offering IP geolocation software applications, and geolocation databases may be obtained from IpInfoDB operating web-site <http://ipinfodb.com>, and by Max Mind, Inc., based in Waltham, Massachusetts, U.S.A., operating the web-site www.maxmind.com/en/home.

Further, the W3C Geolocation API is an effort by the World Wide Web Consortium (W3C) to standardize an interface to retrieve the geographical location information for a client-side device. It defines a set of objects, ECMA Script standard compliant, executing in the client application, give the client's device location through the consulting of Location Information Servers, which are transparent for the Application Programming Interface (API). The most common sources of location information are IP address, Wi-Fi and Bluetooth MAC address, radio-frequency identification (RFID), Wi-Fi connection location, or device Global Positioning System (GPS) and GSM/CDMA cell IDs. The location is returned with a given accuracy depending on the best location information source available. The W3C Recommendation for the geolocation API specifications draft dated October 24, 2013, is available from the web-site <http://www.w3.org/TR/2013/REC-geolocation-API-20131024>. Geolocation-based addressing is described in U.S. Patent No. 7,929,535 to Chen et al., entitled: "Geolocation-based Addressing Method for IPv6 Addresses", and in U.S. Patent No. 6,236,652 to Preston et al., entitled: "Geo-spacial Internet Protocol Addressing", and in U.S. Patent Application Publication No. 2005/0018645 to Mustonen et al., entitled: "Utilization of Geographic Location Information in IP Addressing", which are all incorporated in their entirety for all purposes as if fully set forth herein.

The Global Positioning System (GPS) is a space-based radio navigation system owned by the United States government and operated by the United States Air Force. It is a global navigation satellite system that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The GPS system does not require the user to transmit any data, and it operates independently of any telephonic or internet reception, though these technologies can enhance the usefulness of the GPS positioning information. The GPS system provides critical positioning capabilities to military, civil, and commercial users around the world. The United States government created the system, maintains it, and makes it freely accessible to anyone with a GPS receiver. In addition to GPS, other systems are in use or under development, mainly because of a potential denial of access by the US government. The Russian Global Navigation Satellite System (GLONASS) was developed contemporaneously with GPS, but suffered from incomplete coverage of the globe until the mid-2000s. GLONASS can be added to GPS devices, making more satellites available and enabling positions to be fixed more quickly and accurately, to

within two meters. There are also the European Union Galileo positioning system, China's BeiDou Navigation Satellite System and India's NAVIC.

The Indian Regional Navigation Satellite System (IRNSS) with an operational name of NAVIC ("sailor" or "navigator" in Sanskrit, Hindi and many other Indian languages, which also stands for NAVigation with Indian Constellation) is an autonomous regional satellite navigation system, that provides accurate real-time positioning and timing services. It covers India and a region extending 1,500 km (930 mi) around it, with plans for further extension. NAVIC signals will consist of a Standard Positioning Service and a Precision Service. Both will be carried on L5 (1176.45 MHz) and S band (2492.028 MHz). The SPS signal will be modulated by a 1 MHz BPSK signal. The Precision Service will use BOC(5,2). The navigation signals themselves would be transmitted in the S-band frequency (2–4 GHz) and broadcast through a phased array antenna to maintain required coverage and signal strength. The satellites would weigh approximately 1,330 kg and their solar panels generate 1,400 watts. A messaging interface is embedded in the NavIC system. This feature allows the command center to send warnings to a specific geographic area. For example, fishermen using the system can be warned about a cyclone.

The GPS concept is based on time and the known position of specialized satellites, which carry very stable atomic clocks that are synchronized with one another and to ground clocks, and any drift from true time maintained on the ground is corrected daily. The satellite locations are known with great precision. GPS receivers have clocks as well; however, they are usually not synchronized with true time, and are less stable. GPS satellites continuously transmit their current time and position, and a GPS receiver monitors multiple satellites and solves equations to determine the precise position of the receiver and its deviation from true time. At a minimum, four satellites must be in view of the receiver for it to compute four unknown quantities (three position coordinates and clock deviation from satellite time).

Each GPS satellite continually broadcasts a signal (carrier wave with modulation) that includes: (a) A pseudorandom code (sequence of ones and zeros) that is known to the receiver. By time-aligning a receiver-generated version and the receiver-measured version of the code, the Time-of-Arrival (TOA) of a defined point in the code sequence, called an epoch, can be found in the receiver clock time scale. (b) A message that includes the Time-of-Transmission (TOT) of the code epoch (in GPS system time scale) and the satellite position at that time. Conceptually, the receiver measures the

TOAs (according to its own clock) of four satellite signals. From the TOAs and the TOTs, the receiver forms four Time-Of-Flight (TOF) values, which are (given the speed of light) approximately equivalent to receiver-satellite range differences. The receiver then computes its three-dimensional position and clock deviation from the four TOFs. In practice, the receiver position (in three dimensional Cartesian coordinates with origin at the Earth's center) and the offset of the receiver clock relative to the GPS time are computed simultaneously, using the navigation equations to process the TOFs. The receiver's Earth-centered solution location is usually converted to latitude, longitude and height relative to an ellipsoidal Earth model. The height may then be further converted to height relative to the geoid (e.g., EGM96) (essentially, mean sea level). These coordinates may be displayed, e.g., on a moving map display, and/or recorded and/or used by some other system (e.g., a vehicle guidance system).

Although usually not formed explicitly in the receiver processing, the conceptual Time-Differences-of-Arrival (TDOAs) define the measurement geometry. Each TDOA corresponds to a hyperboloid of revolution. The line connecting the two satellites involved (and its extensions) forms the axis of the hyperboloid. The receiver is located at the point where three hyperboloids intersect.

In typical GPS operation as a navigator, four or more satellites must be visible to obtain an accurate result. The solution of the navigation equations gives the position of the receiver along with the difference between the time kept by the receiver's on-board clock and the true time-of-day, thereby eliminating the need for a more precise and possibly impractical receiver based clock. Applications for GPS such as time transfer, traffic signal timing, and synchronization of cell phone base stations, make use of this cheap and highly accurate timing. Some GPS applications use this time for display, or, other than for the basic position calculations, do not use it at all. Although four satellites are required for normal operation, fewer apply in special cases. If one variable is already known, a receiver can determine its position using only three satellites. For example, a ship or aircraft may have known elevation. Some GPS receivers may use additional clues or assumptions such as reusing the last known altitude, dead reckoning, inertial navigation, or including information from the vehicle computer, to give a (possibly degraded) position when fewer than four satellites are visible.

The GPS level of performance is described in a 4th Edition of a document published September 2008 by U.S. Department of Defense (DoD) entitled: "*GLOBAL POSITIONING SYSTEM - STANDARD POSITIONING SERVICE PERFORMANCE*"

STANDARD", which is incorporated in its entirety for all purposes as if fully set forth herein. The GPS is described in a book by Jean-Marie_Zogg (dated 26/03/2002) published by u-blox AG (of CH-8800 Thalwil, Switzerland) [Doc Id GPS-X-02007] entitled: "*GPS Basics - Introduction to the system - Application overview*", and in a book
5 by El-Rabbany, Ahmed published 2002 by ARTECH HOUSE, INC. [ISBN 1-58053-183-1] entitled: "*Introduction to GPS: the Global Positioning System*", which are both incorporated in their entirety for all purposes as if fully set forth herein. Methods and systems for enhancing line records with Global Positioning System coordinates are disclosed in in U.S. Patent No. 7,932,857 to Ingman *et al.*, entitled: "GPS for
10 communications facility records", which is incorporated in its entirety for all purposes as if fully set forth herein. Global Positioning System information is acquired and a line record is assembled for an address using the Global Positioning System information.

GNSS stands for Global Navigation Satellite System, and is the standard generic term for satellite navigation systems that provide autonomous geo-spatial positioning
15 with global coverage. The GPS is an example of GNSS. GNSS-1 is the first generation system and is the combination of existing satellite navigation systems (GPS and GLONASS), with Satellite Based Augmentation Systems (SBAS) or Ground Based Augmentation Systems (GBAS). In the United States, the satellite based component is the Wide Area Augmentation System (WAAS), in Europe it is the European
20 Geostationary Navigation Overlay Service (EGNOS), and in Japan it is the Multi-Functional Satellite Augmentation System (MSAS). Ground based augmentation is provided by systems like the Local Area Augmentation System (LAAS). GNSS-2 is the second generation of systems that independently provides a full civilian satellite navigation system, exemplified by the European Galileo positioning system. These
25 systems will provide the accuracy and integrity monitoring necessary for civil navigation; including aircraft. This system consists of L1 and L2 frequencies (in the L band of the radio spectrum) for civil use and L5 for system integrity. Development is also in progress to provide GPS with civil use L2 and L5 frequencies, making it a GNSS-2 system.

30 An example of global GNSS-2 is the GLONASS (GLObal NAVigation Satellite System) operated and provided by the formerly Soviet, and now Russia, and is a space-based satellite navigation system that provides a civilian radio-navigation-satellite service and is also used by the Russian Aerospace Defence Forces. The full orbital constellation of 24 GLONASS satellites enables full global coverage. Other core GNSS

are Galileo (European Union) and Compass (China). The Galileo positioning system is operated by The European Union and European Space Agency. Galileo became operational on 15 December 2016 (global Early Operational Capability (EOC)), and the system of 30 MEO satellites was originally scheduled to be operational in 2010. Galileo is expected to be compatible with the modernized GPS system. The receivers will be able to combine the signals from both Galileo and GPS satellites to greatly increase the accuracy. Galileo is expected to be in full service in 2020 and at a substantially higher cost. The main modulation used in Galileo Open Service signal is the Composite Binary Offset Carrier (CBOC) modulation. An example of regional GNSS is China's Beidou. China has indicated they plan to complete the entire second generation Beidou Navigation Satellite System (BDS or BeiDou-2, formerly known as COMPASS), by expanding current regional (Asia-Pacific) service into global coverage by 2020. The BeiDou-2 system is proposed to consist of 30 MEO satellites and five geostationary satellites.

Mobile phone tracking is the ascertaining of the position or location of a mobile phone, whether stationary or moving. Localization may occur either via multilateration of radio signals between (several) cell towers of the network and the phone. To locate a mobile phone using multilateration of radio signals, it must emit at least the roaming signal to contact the next nearby antenna tower, but the process does not require an active call. The Global System for Mobile Communications (GSM) is based on the phone's signal strength to nearby antenna masts. The technology of locating is commonly based on measuring power levels and antenna patterns and uses the concept that a powered mobile phone always communicates wirelessly with one of the closest base stations, so knowledge of the location of the base station implies the cell phone is nearby. Advanced systems determine the sector in which the mobile phone is located and roughly further estimates the distance to the base station. Further approximation use interpolating signals between adjacent antenna towers. Qualified services may achieve a precision of down to 50 meters in urban areas where mobile traffic and density of antenna towers (base stations) is sufficiently high. Rural and desolate areas may see miles between base stations and therefore determine locations less precisely. The location of a mobile phone can be determined by using network-based, handset-based, or SIM-based methods.

The location of a mobile phone can be determined using the service provider's network infrastructure. The advantage of network-based techniques, from a service provider's point of view, is that they can be implemented non-intrusively without affecting handsets. The accuracy of network-based techniques varies, with cell identification as the least accurate and triangulation as moderately accurate, and newer "advanced forward link trilateration" timing methods as the most accurate. The accuracy of network-based techniques is both dependent on the concentration of cell base stations, with urban environments achieving the highest possible accuracy because of the higher number of cell towers, and the implementation of the most current timing methods.

The location of a mobile phone can be determined using client software installed on the handset. This technique determines the location of the handset by putting its location by cell identification, signal strengths of the home and neighboring cells, which is continuously sent to the carrier. In addition, if the handset is also equipped with GPS then significantly more precise location information can be then sent from the handset to the carrier. Another approach is to use a fingerprinting-based technique, where the "signature" of the home and neighboring cells signal strengths at different points in the area of interest is recorded by war-driving and matched in real-time to determine the handset location.

Using the Subscriber Identity Module (SIM) in GSM and Universal Mobile Telecommunications System (UMTS) handsets, it is possible to obtain raw radio measurements from the handset. Available measurements include the serving Cell ID, round-trip time, and signal strength. The type of information obtained via the SIM can differ from that which is available from the handset. For example, it may not be possible to obtain any raw measurements from the handset directly, yet still obtain measurements via the SIM.

In order to route calls to a phone, the cell towers listen for a signal sent from the phone and negotiate which tower is best able to communicate with the phone. As the phone changes location, the antenna towers monitor the signal, and the phone is "roamed" to an adjacent tower as appropriate. By comparing the relative signal strength from multiple antenna towers, a general location of a phone can be roughly determined. Other means make use of the antenna pattern, which supports angular determination and phase discrimination.

Various location technologies are described in a presentation by Shu Wang, Jungwon Min and Byung K. Yi, in the IEEE International Conference on

Communication (ICC) 2008, Beijing, China, entitled: “*Location Based Services for Mobiles: Technologies and Standards*“, which is incorporated in its entirety for all purposes as if fully set forth herein. An overview of Cellular Positioning Techniques is described in a paper by Balaram Singh, Soumya Pallai, and Susil Kumar published as conference Paper on September 2012, entitled: “*A Survey of Cellular Positioning Techniques in GSM Networks*“, which is incorporated in its entirety for all purposes as if fully set forth herein. Various methods for estimation of the location of a Mobile Station accurately are described, as a key requirement to effectively provide a wide range of Location Based Services over mobile networks. Applications requiring positioning in mobile networks gained importance in recent years. This gives rise to the various location based services (LBS), hence developing cellular positioning techniques has been a key research problem, with numerous localization solutions been proposed. There are several methods present to find the location, where the main objective is to find the location information more accurately without much modification in existing infrastructure, which ensures low cost.

Several methods are presented for finding the location are described in an article by Balaram Singh, Santosh Kumar Sahoo, and Soumya Ranjan Pradhan (all of JVCCE, B. B. Mahavidyalaya, Utkal University, Odisha, India) published January 2014 in the Journal of Telecommunication, Switching Systems and Networks Volume 1, Issue 1 entitled: “*Analysis of Cellular Positioning Techniques in UMTS Networks*“, which is incorporated in its entirety for all purposes as if fully set forth herein. The main objective is to find the location information more accurately without much modification in existing infrastructure which ensures low cost. This paper presents a review of location estimation techniques in UMTS Networks in terms of range accuracy in both urban and rural Sectors.

Wi-Fi Positioning System (WPS) (or WiPS/WFPS) is commonly used where GPS (or GLONASS) are inadequate due to various causes including multipath and signal blockage indoors, such as in indoor positioning systems. The most common and widespread localization technique used for positioning with wireless access points is based on measuring the intensity of the received signal (Received Signal Strength Indication or RSSI) and the method of “fingerprinting”. Typical parameters useful to geolocate the Wi-Fi hotspot or wireless access point include the SSID and the MAC address of the access point. The accuracy depends on the number of positions that have been entered into the database. The Wi-Fi hotspot database gets filled by correlating

mobile device GPS location data with Wi-Fi hotspot MAC addresses. The possible signal fluctuations that may occur can increase errors and inaccuracies in the path of the user. To minimize fluctuations in the received signal, there are certain techniques that can be applied to filter the noise. Accurate indoor localization is becoming more important for Wi-Fi based devices due to the increased use of augmented reality, social networking, health care monitoring, personal tracking, inventory control and other indoor location-aware applications.

The problem of Wi-Fi based indoor localization of a device consists in determining the position of client devices with respect to access points. Many techniques exist to accomplish this, and these may be classified into four main types: received signal strength indication (RSSI), fingerprinting, angle of arrival (AoA) and time of flight (ToF) based techniques. In most cases, the first step to determine a device's position is to determine the distance between the target client device and a few access points. With the known distances between the target device and access points, trilateration algorithms may be used to determine the relative position of the target device, using the known position of access points as a reference. Alternatively, the angle of arriving signals at a target client device can be employed to determine the device's location based on triangulation algorithms.

RSSI. RSSI localization techniques are based on measuring signal strength from a client device to several different access points, and then combining this information with a propagation model to determine the distance between the client device and the access points. Trilateration (sometimes called multilateration) techniques can be used to calculate the estimated client device position relative to the known position of access points.

Fingerprinting. Traditional fingerprinting is also RSSI-based, but it simply relies on the recording of the signal strength from several access points in range and storing this information in a database along with the known coordinates of the client device in an offline phase. This information can be deterministic or probabilistic. During the online tracking phase, the current RSSI vector at an unknown location is compared to those stored in the fingerprint and the closest match is returned as the estimated user location.

Angle of Arrival (AoA). Linear array of antennas are used for receiving a signal, and the phase-shift difference of the received signal arriving at antennas equally separated by a "d" distance is used to compute the angle of arrival of the signal. With the

advent of MIMO WiFi interfaces, which use multiple antennas, it is possible to estimate the AoA of the multipath signals received at the antenna arrays in the access points, and apply triangulation to calculate the location of client devices.

Time of Flight (ToF). This localization approach takes timestamps provided by the wireless interfaces to calculate the ToF of signals and then use this information to estimate the distance and relative position of one client device with respect to access points. The granularity of such time measurements is in the order of nanoseconds and systems which use this technique have reported localization errors in the order of 2m. The time measurements taken at the wireless interfaces are based on the fact that RF waves travel close to the speed of light, which remains nearly constant in most propagation media in indoor environments. Therefore, the signal propagation speed (and consequently the ToF) is not affected so much by the environment as the RSSI measurements are. As in the RSSI approach, the ToF is used only to estimate the distance between the client device and access points. Then a trilateration technique can be used to calculate the estimated position of the device relative to the access points. The greatest challenges in the ToF approach consist in dealing with clock synchronization issues, noise, sampling artifacts and multipath channel effects. Some techniques use mathematical approaches to remove the need for clock synchronization.

WiFi localization is described in a guide published May 20, 2008 by Cisco Systems, Inc. (headquartered in 170 West Tasman Drive San Jose, CA 95134-1706 USA) entitled: "*Wi-Fi Location-Based Services 4.1 Design Guide*" [Text Part Number: OL-11612-01], which is incorporated in its entirety for all purposes as if fully set forth herein. The accuracy of various WiFi positioning and the optimal area of their applications are described in a paper by Robin Henniges presented on TU-Berlin, 2012 as part of SERVICE-CENTRIC NETWORKING - SEMINAR WS2011/2012, entitled: "*Current approaches of Wifi Positioning*", which is incorporated in its entirety for all purposes as if fully set forth herein. It will make use of existing WiFi infrastructure, although this was never designed to do so. Methods that were used for other positioning technologies can be adopted for WiFi.

A system built using probabilistic techniques that allows for remarkably accurate localization across our entire office building using nothing more than the built-in signal intensity meter supplied by standard 802.11 cards is described in a paper by Andreas Haeberlen, Eliot Flannery, Andrew M. Ladd, Algis Rudys, Dan S. Wallach, and Lydia E. Kavraki (all of Rice University) published by ACM 2004 in MobiCom'04, Sept. 26-

Oct. 1, 2004, Philadelphia, Pennsylvania, USA [1-58113-868-7/04/0009 ...\$5.00], entitled: "*Practical Robust Localization over Large-Scale 802.11 Wireless Networks*", which is incorporated in its entirety for all purposes as if fully set forth herein. While prior systems have required significant investments of human labor to build a detailed
5 signal map, we can train our system by spending less than one minute per office or region, walking around with a laptop and recording the observed signal intensities of our building's unmodified base stations. We actually collected over two minutes of data per office or region, about 28 man-hours of effort. Using less than half of this data to train the localizer, we can localize a user to the precise, correct location in over 95% of our
10 attempts, across the entire building. Even in the most pathological cases, we almost never localize a user any more distant than to the neighboring office. A user can obtain this level of accuracy with only two or three signal intensity measurements, allowing for a high frame rate of localization results. Furthermore, with a brief calibration period, our system can be adapted to work with previously unknown user hardware. We present
15 results demonstrating the robustness of our system against a variety of untrained time-varying phenomena, including the presence or absence of people in the building across the day. Our system is sufficiently robust to enable a variety of locationaware applications without requiring special-purpose hardware or complicated training and calibration procedures.

20 IP-based geolocation (commonly known as geolocation) is a mapping of an IP address (or MAC address) to the real-world geographic location of a computing device or a mobile device connected to the Internet. The IP address based location data may include information such as country, region, city, postal/zip code, latitude, longitude, or Timezone. Deeper data sets can determine other parameters such as domain name,
25 connection speed, ISP, language, proxies, company name, US DMA/MSA, NAICS codes, and home/business classification. The geolocation is further described in the publication entitled: "*Towards Street-Level Client-Independent IP Geolocation*" by Yong Wang et al., downloaded from the Internet on July 2014, and in an Information Systems Audit and Control Association (ISACA) 2011 white-paper entitled:
30 "*Geolocation: Risk, Issues and Strategies*", which are both incorporated in their entirety for all purposes as if fully set forth herein. There are a number of commercially available geolocation databases, such as a web-site <http://www.ip2location.com> operated by Ip2location.com headquartered in Penang, Malaysia, offering IP geolocation software applications, and geolocation databases may be obtained from IpInfoDB operating web-

site <http://ipinfodb.com>, and by Max Mind, Inc., based in Waltham, Massachusetts, U.S.A, operating the web-site <https://www.maxmind.com/en/home>.

Further, the W3C Geolocation API is an effort by the World Wide Web Consortium (W3C) to standardize an interface to retrieve the geographical location information for a client-side device. It defines a set of objects, ECMA Script standard compliant, that executing in the client application give the client's device location through the consulting of Location Information Servers, which are transparent for the Application Programming Interface (API). The most common sources of location information are IP address, Wi-Fi and Bluetooth MAC address, radio-frequency identification (RFID), Wi-Fi connection location, or device Global Positioning System (GPS) and GSM/CDMA cell IDs. The location is returned with a given accuracy depending on the best location information source available. The W3C Recommendation for the geolocation API specifications draft dated October 24, 2013, is available from the web-site <http://www.w3.org/TR/2013/REC-geolocation-API-20131024>. Geolocation-based addressing is described in U.S. Patent No. 7,929,535 to Chen *et al.*, entitled: “*Geolocation-based Addressing Method for IPv6 Addresses*”, and in U.S. Patent No. 6,236,652 to Preston *et al.*, entitled: “*Geo-spacial Internet Protocol Addressing*”, and in U.S. Patent Application Publication No. 2005/0018645 to Mustonen *et al.*, entitled: “*Utilization of Geographic Location Information in IP Addressing*”, which are all incorporated in their entirety for all purposes as if fully set forth herein.

Geolocation may be used by any network element. The peer devices described above as storing a content (chunks) that is required by a client device, and thus the client device fetches the content from the peer devices rather than directly from the web server (or in addition to it). In some cases, multiple devices are available storing unknown content which may be the content required by a client device. The geolocation may be used to determine which available devices may be, or are expected to be, storing the content that is requested. In this context, two Internet-connected devices, each identified by a respective IP address, for example, are considered as being ‘close’ if there is a likelihood that the same content is stored in both, or that both devices fetched the same content from a data server. Similarly, two devices are considered closer than the other two devices if there is a higher likelihood that they store the same content (from the same data server).

In one example, the selection is based only on the obtained the geographical location. In one example, such selection may be based on the physical geographical

location of the requesting device (obtained locally at the requesting device or by using a geolocation), a physical geographical location of the data server storing a content that is requested (obtained locally or by using geolocation), or relating to physical geographical location of IP addressable, Internet connected device. In one example, the devices may
5 be selected based on being in the same location, such as in the same continent, country, region, city, street, or timezone. The devices may be selected from the list based on the physical geographical distance, where 'closeness' is defined as based on actual geographical distance between devices, where shorter distance indicates closer devices. For example, is the case where the latitude and the longitude are obtained, the physical
10 distance between each device in the list and the requesting device (or the data server or another device) may be calculated, and the nearest device will be first selected, then the second nearest device, and so on. Alternatively or in addition, devices in the same city (or street) as the requesting device are considered as the closest and may be first selected, then the devices that are in the same region or country may be considered as close and
15 may be selected next.

A software and hardware system capable of operating on a signal controller platform is disclosed in U.S. Patent Application Publication No. 2006/0287807 to Teffer entitled: "*Method for incorporating individual vehicle data collection, detection and recording of traffic violations in a traffic signal*", which is incorporated in its entirety for
20 all purposes as if fully set forth herein. The signal controller platform detects and records individual vehicle data including but not limited to dangerous driving behavior such as red light running and speeding. The disclosure teaches sharing of the computing platform and infrastructure of the traffic control system. The disclosure also teaches receiving, interpreting, and organizing data collected through the traffic control system's
25 vehicle detection infrastructure, and driving cameras, video, or other recording devices to provide additional evidence of an individual vehicle's behavior.

A method and apparatus for collecting, uploading and evaluating motor vehicle operation are disclosed in U.S. Patent No. 6,931,309 to Phelan *et al.* entitled: "*Motor vehicle operating data collection and analysis*", which is incorporated in its entirety for
30 all purposes as if fully set forth herein. The method and apparatus are utilizing on-board diagnostic components (OBDII) and ground positioning satellite (GPS) systems, whereby operator identifiable behavior can be rated for driving safety and other characteristics.

An on-board intelligent vehicle system is disclosed in U.S. Patent No. 7,421,334 to Dahlgren *et al.* entitled: “*Centralized facility and intelligent on-board vehicle platform for collecting, analyzing and distributing information relating to transportation infrastructure and conditions*”, which is incorporated in its entirety for all purposes as if
5 fully set forth herein. The system includes a sensor assembly to collect data and a processor to process the data to determine the occurrence of at least one event. The data may be collected from existing standard equipment such as the vehicle communication bus or add-on sensors. The data may be indicative of conditions relating to the vehicle, roadway infrastructure, and roadway utilization, such as vehicle performance, roadway
10 design, roadway conditions, and traffic levels. The detection of an event may signify abnormal, substandard, or unacceptable conditions prevailing in the roadway, vehicle, or traffic. The vehicle transmits an event indicator and correlated vehicle location data to a central facility for further management of the information. The central facility sends communications reflecting event occurrence to various relevant or interested users. The
15 user population can include other vehicle subscribers (e.g., to provide rerouting data based on location-relevant roadway or traffic events), roadway maintenance crews, vehicle manufacturers, and governmental agencies (e.g., transportation authorities, law enforcement, and legislative bodies).

Systems, methods and computer readable media for determining compliance
20 with recommendations are disclosed in U.S. Patent Application Publication No. 2014/0279707 to Joshua *et al.* entitled: “*System and method for vehicle data analysis*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The systems and methods may involve generating a vehicle recommendation; transmitting the vehicle recommendation to at least one output device, wherein the at least one output
25 device communicates the vehicle recommendation to one or more users; collecting vehicle telemetry data from a vehicle sensor device located in a vehicle, wherein the vehicle sensor device is coupled to one or more vehicle sensors; and determining compliance data based on the vehicle recommendation and the vehicle telemetry data, wherein the compliance data indicates compliance with the recommended vehicle action.
30 The compliance data may be used to determine service rates and/or service level coverage for users.

A system for monitoring and reporting incidences of traffic violations at a traffic location is disclosed in U.S. Patent Application Publication No. 6,546,119 to Ciolli *et al.* entitled: “*Automated traffic violation monitoring and reporting system*”, which is

incorporated in its entirety for all purposes as if fully set forth herein. The system comprises a digital camera system deployed at a traffic location. The camera system is remotely coupled to a data processing system. The data processing system comprises an image processor for compiling vehicle and scene images produced by the digital camera system, a verification process for verifying the validity of the vehicle images, an image processing system for identifying driver information from the vehicle images, and a notification process for transmitting potential violation information to one or more law enforcement agencies.

A distributed individual vehicle information capture method for capturing individual vehicle data at traffic intersections and transmitting the data to a central station for storage and processing is disclosed in U.S. Patent Application Publication No. 2005/0122235 to Teffer *et al.* entitled: "*Method and system for collecting traffic data, monitoring traffic, and automated enforcement at a centralized station*", which is incorporated in its entirety for all purposes as if fully set forth herein. The method includes capturing individual vehicle information at a plurality of intersections (122) and transmitting the individual vehicle information from the intersections to a central station (124). Consequently, the individual vehicle information is available to be stored and processed by a device at the central station (126). Traffic intersection equipment for capturing individual vehicle data at traffic intersections and transmitting the data to a central station for storage and processing is also disclosed. The equipment includes a traffic detection device (159) for capturing individual vehicle data at an intersection (158) and a network connection to a central station (174). The traffic detection device (159) is operably configured to transmit to the central station (174) the individual vehicle information.

A system and method for acquiring image evidence of traffic violations are disclosed in U.S. Patent Application Publication No. 2003/0189499 to Stricklin *et al.* entitled: "*System and method for traffic*", which is incorporated in its entirety for all purposes as if fully set forth herein. The system has a controller, an image acquisition system, and sensors. The controller acquires data from the sensors to determine the likelihood of a traffic violation. The controller determines a schedule for acquiring images associated with the violation. Multiple images may be acquired as evidence of the violation. The controller then directs the image acquisition to acquire images in compliance with the schedule. The controller may then package, encrypt, and authenticate data and images associated with the violation. The controller may then

transfer the data to a remote location. The system may also determine a schedule to acquire images associated with multiple violations and/or traffic accidents.

A system for monitoring and reporting incidences of traffic violations at a traffic location is disclosed in U.S. Patent Application Publication No. 2004/0252193 to Higgins entitled: “*Automated traffic violation monitoring and reporting system with combined video and still-image data*”, which is incorporated in its entirety for all purposes as if fully set forth herein. The system comprises one or more digital still cameras and one or more digital video cameras system deployed at a traffic location. The camera system is coupled to a data processing system, which comprises an image processor for compiling vehicle and scene images produced by the digital camera system, a verification process for verifying the validity of the vehicle images, an image processing system for identifying driver information from the vehicle images, and a notification process for transmitting potential violation information to one or more law enforcement agencies. The video camera system is configured to record footage both before and after the offense is detected. The video camera system includes a non-stop video capture buffer that records the preceding few seconds of violation. The buffer holds a number of seconds of video data in memory. When an offense is detected, a timer is started. At the end of the timer period a video clip of the current buffer contents is recorded. The resulting video clip is incorporated with the conventional evidence set comprising the digital still images of the offense with the identifying data of the car and driver.

An example of an electronics architecture in a vehicle **11** is illustrated in a schematic block diagram **10** shown in FIG. 1. The vehicle **11** comprises five ECUs: A Telematic ECU **12b**, a Communication ECU **12a**, an ECU #1 **12c**, an ECU #2 **12d**, and an ECU #3 **12e**. While five ECUs are shown, any number of ECUs may be employed. Each of the ECUs may comprises, may consists of, or may be part of, Electronic/engine Control Module (ECM), Engine Control Unit (ECU), Powertrain Control Module (PCM), Transmission Control Module (TCM), Brake Control Module (BCM or EBCM), Central Control Module (CCM), Central Timing Module (CTM), General Electronic Module (GEM), Body Control Module (BCM), Suspension Control Module (SCM), Door Control Unit (DCU), Electric Power Steering Control Unit (PSCU), Seat Control Unit, Speed Control Unit (SCU), Telematic Control Unit (TCU), Transmission Control Unit (TCU), Brake Control Module (BCM; ABS or ESC), Battery management system, control unit, and a control module. The ECUs communicates with each other over a

vehicle bus **13**, which may consists of, comprises, or may be based on, Controller Area Network (CAN) standard (such as Flexible Data-Rate (CAN FD) protocol), Local Interconnect Network (LIN), FlexRay protocol, or Media Oriented Systems Transport (MOST) (such as MOST25, MOST50, or MOST150). In one example, the vehicle bus
5 may consists of, comprises, or may be based on, automotive Ethernet, may use only a single twisted pair, and may consist of, employ, use, may be based on, or may be compatible with, IEEE802.3 100BaseT1, IEEE802.3 1000BaseT1, BroadR-Reach®, or IEEE 802.3bw-2015 standard.

An ECU may connect to, or include, a sensor for sensing a phenomenon in the
10 vehicle or in the vehicle environment. In the exemplary vehicle **11** shown in the arrangement **11**, a sensor **14b** is connected to the ECU #1 **12c**, and an additional sensor **14a** is connected to the ECU #3 **12e**. Further, an ECU may connect to, or include, an actuator for affecting, generating, or controlling a phenomenon in the vehicle or in the vehicle environment. In the exemplary vehicle **11** shown in the arrangement **10**, an
15 actuator **15b** is connected to the ECU #2 **12d**, and an additional actuator **15a** is connected to the ECU #3 **12e**.

The vehicle **11** may communicate over a wireless network **9** with other vehicles or with stationary devices, directly or via the Internet. The communication with the wireless network **9** uses an antenna **19** and a wireless transceiver **18**, which may part of
20 the Communication ECU **12a**. The wireless network **9** may be a Wireless Wide Area Network (WWAN), such as WiMAX network or a cellular telephone network (such as Third Generation (3G) or Fourth Generation (4G) network). Alternatively or in addition, the wireless network **9** may be a Wireless Personal Area Network (WPAN) that may be according to, may be compatible with, or may be based on, Bluetooth™ or IEEE
25 802.15.1-2005 standards, or may be according to, or may be based on, ZigBee™, IEEE 802.15.4-2003, or Z-Wave™ standard. Alternatively or in addition, the wireless network **9** may be a Wireless Local Area Network (WLAN) that may be according to, may be compatible with, or may be based on, IEEE 802.11-2012, IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, or IEEE 802.11ac.

Alternatively or in addition, the wireless network **9** may use a Dedicated Short-Range Communication (DSRC), that may be according to, compatible with, or based on, European Committee for Standardization (CEN) EN 12253:2004, EN 12795:2002, EN 12834:2002, EN 13372:2004, or EN ISO 14906:2004 standard, or may be according to,
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compatible with, or based on, IEEE 802.11p, IEEE 1609.1-2006, IEEE 1609.2, IEEE 1609.3, IEEE 1609.4, or IEEE1609.5.

The vehicle **11** may include a GPS receiver for a localization, navigation, or tracking of the vehicle **11**. In the exemplary vehicle **11** shown in the arrangement **10**, a GPS receiver **17** receives RF signals from the GPS satellites **8a** and **8b**, and is part of, or connected to, the Telematics ECU **12b**. The Telematics ECU **12b** may further include, or connect to, a dashboard display **16**, (also known as instrument panel (IP), or fascia) that is a control panel located directly ahead, or in plain view, of a vehicle's driver or passenger, displaying instrumentation, infotainment, and controls for the vehicle's operation.

An arrangement **20** shown in FIG. 2 describes an exemplary block diagram of the ECU #3 **12e** shown as part of the vehicle **11** that is described in the arrangement **10** shown in FIG. 1. The ECU #3 **12e** connects to the vehicle bus **13** via two conductors or wires **29a** and **29b** using a connector **28**. A transceiver and a controller are used for respectively handling the physical layer and the higher layers of the vehicle bus **13** interface and protocol. In an example where the vehicle bus **13** is a CAN bus, the physical layer is supported by a CAN transceiver **26** that includes a bus driver (or transmitter) **27a** for transmitting data to the vehicle bus **13**, and a bus receiver **27b** for receiving data from the vehicle bus **13**. A CAN controller **23**, which may include a processor for controlling and supporting the functionalities and features of the ECU #3 **12e**. The software (or firmware) **25** to be executed by the controller (or processor) **23** is stored in a memory **24**, which is typically a non-volatile memory. In a case where the sensor **14a** is an analog sensor having an analog signal output, an Analog-to-Digital converter (A/D) **22a** is used for digitization of the output, providing digital samples that can be read by the controller (or processor) **23**. Similarly, in a case where the actuator **15a** is an analog actuator controlled or activated through an analog signal input, a Digital-to-Analog converter (D/A) **22b** is used for converting digital values from the controller (or processor) **23** and providing analog signal that can affect the actuator **15a** operation.

The signal received from the analog sensor **14a**, or transmitted to the analog actuator **15a**, may be respectively conditioned by signal conditioners **21a** and **21b**. The signal conditioner may involve time, frequency, or magnitude related manipulations, typically adapted to optimally operate, activate, or interface the Analog-to-Digital (A/D) converter **22a** or Digital-to-Analog converter (D/A) **22b**. Each of the signal conditioners

21a and **21b** may be linear or non-linear, and may include an operation or an instrument amplifier, a multiplexer, a frequency converter, a frequency-to-voltage converter, a voltage-to-frequency converter, a current-to-voltage converter, a current loop converter, a charge converter, an attenuator, a sample-and-hold circuit, a peak-detector, a voltage or current limiter, a delay line or circuit, a level translator, a galvanic isolator, an impedance transformer, a linearization circuit, a calibrator, a passive or active (or adaptive) filter, an integrator, a deviator, an equalizer, a spectrum analyzer, a compressor or a decompressor, a coder (or decoder), a modulator (or demodulator), a pattern recognizer, a smoother, a noise remover, an average or RMS circuit, or any combination thereof. Each of the signal conditioners **21a** and **21b** may use any one of the schemes, components, circuits, interfaces, or manipulations described in a handbook published 2004-2012 by Measurement Computing Corporation entitled: "*Data Acquisition Handbook – A Reference For DAQ And Analog & Digital Signal Conditioning*", which is incorporated in its entirety for all purposes as if fully set forth herein. Further, the conditioning may be based on the book entitled: "*Practical Design Techniques for Sensor Signal Conditioning*", by Analog Devices, Inc., 1999 (ISBN-0-916550-20-6), which is incorporated in its entirety for all purposes as if fully set forth herein.

The controller (or processor **23**) may be based on a discrete logic or an integrated device, such as a processor, microprocessor or microcomputer, and may include a general-purpose device or may be a special purpose processing device, such as an ASIC, PAL, PLA, PLD, Field Programmable Gate Array (FPGA), Gate Array, or other customized or programmable device. In the case of a programmable device as well as in other implementations, a memory is required. The processor **23** commonly includes a memory, which may comprise, may be part of, or may consist of, the memory **24** that may include a static RAM (random Access Memory), dynamic RAM, flash memory, ROM (Read Only Memory), or any other data storage medium. The memory may include data, programs, and / or instructions and any other software or firmware executable by the processor. Control logic can be implemented in hardware or in software, such as a firmware stored in the memory. The processor **23** controls and monitors the ECU #3 **12e** operation, such as initialization, configuration, interface, analysis, notification, communication, and commands.

In consideration of the foregoing, it would be an advancement in the art to provide a method or a system for improving awareness, notifying drivers, and affecting

vehicles operation regarding road hazards or traffic anomalies (such as collisions or accidents, or traffic law violations). Preferably, such methods or systems may be providing an improved, simple, automatic, secure, cost-effective, reliable, versatile, easy to install, use or monitor, has a minimum part count, portable, handheld, enclosed in a small or portable housing, minimum hardware, and / or using existing and available components, protocols, programs and applications, and providing a better user experience, for collecting data from vehicles based of their sensors, and for affecting vehicles operations in response to other vehicles in the area.

SUMMARY

A method may be used for affecting an actuator in a second vehicle in response to a sensor output in a first vehicle, where the first and second vehicles are located at respective first and second locations and are communicating with a server over the Internet via respective first and second wireless networks. The method may be used with a group of vehicles that includes the second vehicle, and the method may comprise the steps of receiving, at the first vehicle, sensor data from the sensor; sending, by the first vehicle, a first message that comprises the sensor data, the first vehicle identifier, and the first vehicle location, to the server over the Internet via the first wireless network; receiving, by the server from the first vehicle, the sensor data and the first vehicle location; selecting, by the server, the second vehicle from the group based on the second vehicle location; sending, by the server over the Internet, a second message to the second vehicle in response the received sensor data from the first vehicle; receiving, by the second vehicle over the Internet via the second wireless network, the second message; and activating, controlling, or affecting, at the second vehicle, the actuator, in response to the second message. A non-transitory computer readable medium having computer executable instructions stored thereon, wherein the instructions include part of, or all of, the steps of the method. The first or second message may be timestamped. The first message may comprise the time of receiving of sensor data from the sensor, or the time of sending of the first message.

The first and second networks may consist of the same network, may be identical networks, or may use the same protocol. Alternatively, the first and second networks may be distinct and different networks, or may use different protocols. Further, the first and second networks may be different and each of them may be a WWAN, WLAN, or

WPAN. The step of sending of the first message, by the first vehicle to the server, may be only in response to the sensor data being above or below a threshold value.

The steps of receiving of the sensor data from the sensor and the sending of the first message to the server over the Internet via the first wireless network may be performed periodically by the first vehicle every time period, that may be above than, or lower than, 1 second, 2 seconds, 5 seconds, 10 seconds, 20 seconds, 30 seconds, 50 seconds, 100 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes, 20 minutes, 30 minutes, 50 minutes, 100 minutes, 1 hour, 2 hours, 5 hours, 10 hours, 20 hours, 30 hours, 50 hours, 100 hours, 1 day, 2 days, 5 days, 10 days, 20 days, 30 days, 50 days, or 100 days. Alternatively or in addition, the step of sending, by the server over the Internet, of the second message to the second vehicle, may be only in response to the sensor data being above or below the threshold value.

The method may further comprise estimating, by the second vehicle, the geographical location of the second vehicle. Alternatively or in addition, the method may further comprise sensing, by the second device to the server, the estimated geographical location of the second vehicle; and receiving and storing, by the server, the received estimated geographical location of the second vehicle. The selecting of the second vehicle from the group may be based on comparing the geographical locations of the first and second vehicles, such as by estimating that the first and second vehicles are in the same area, such as in the same region, city, street, ZIP code, latitude, or longitude. Alternatively or in addition, the selecting of the second vehicle from the group may be based on estimating the distance between the first and second vehicles, such as where the estimated distance between the first and second vehicles is less than 1 meter, 2 meters, 5 meters, 10 meters, 20 meters, 30 meters, 50 meters, 100 meters, 200 meters, 300 meters, 500 meters, 1 kilometer, 2 kilometers, 3 kilometers, 5 kilometers, 10 kilometers, 20 kilometers, 50 kilometers, or 100 kilometers.

The first vehicle may further comprise an additional sensor having an additional output, the method may further comprise receiving, at the first vehicle, the additional sensor data from the additional sensor, and the first message may further comprise the additional sensor data. The second message may further comprise, or may be in response to, the additional sensor data.

The method may be used with a third vehicle (or any other vehicle) that may comprise an additional sensor having an additional output, and the method may further comprise receiving, at the third vehicle (or any other vehicle), additional sensor data

from the additional sensor; and sending, by the third vehicle (or any other vehicle), a third message that may comprise the additional sensor data, the third vehicle identifier, and the third vehicle location, to the server over the Internet via a wireless network; and receiving, by the server from the third vehicle (or any other vehicle), the additional sensor data and the third vehicle location. The second message may comprise, or may be based on, or in response to, the third message.

The second vehicle (or any other vehicle) may further comprise an additional actuator, and the method may further comprise activating, controlling, or affecting, at the second vehicle (or any other vehicle), the additional actuator, in response to the second message.

The method may be used with a third vehicle (or any other vehicle) that comprises an additional actuator, and the method may further comprise sending, by the server over the Internet, a second message to the third vehicle (or any other vehicle) in response to the received sensor data from the first vehicle; receiving, by the third vehicle (or any other vehicle) over the Internet via a wireless network, the second message; and activating, controlling, or affecting, at the second vehicle (or any other vehicle), the additional actuator, in response to the second message.

Any method herein may be used for detecting a road-related anomaly or hazard, and the sensor may be operative to sense the road-related anomaly or hazard, such as a traffic collision, traffic regulation violation, or a road infrastructure or surface damage. Alternatively or in addition, the sensor may be operative to sense a motion, velocity, or acceleration of the first vehicle, such as to sense a traffic collision, a stopping, or over speeding, of the first vehicle.

Alternatively or in addition, any method described herein may be used for, or may be part of, parking help, cruise control, lane keeping, road sign recognition, surveillance, speed limit warning, restricted entries, and pull-over commands, travel information, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning, vehicle safety inspection, transit or emergency vehicle signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, or electronic toll collection. Further, any sensor herein may be configured to sense, or any actuator herein may be configured to affect, as part of parking help, cruise control, lane keeping, road sign recognition, surveillance, speed limit warning, restricted entries, and pull-over

commands, travel information, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning, vehicle safety inspection, transit or emergency vehicle signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-
5 vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, or electronic toll collection.

Alternatively or in addition, any method described herein may be used for, or may be part of, fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, on-board computer, fuel level,
10 relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold
15 surface temperature, or a Vehicle Identification Number (VIN). Further, any sensor herein may be configured to sense, or any actuator herein, may be configured to affect, as part of fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, on-board computer, fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel
20 type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, or a Vehicle Identification Number (VIN).

25 Any vehicle, apparatus, or device herein may be operative for estimating its geographical location. Such localization may be used with multiple RF signals transmitted by multiple sources, and the geographical location may be estimated by receiving the RF signals from the multiple sources via one or more antennas, and processing or comparing the received RF signals. The multiple sources may comprise
30 satellites, that may be Global Positioning System (GPS), and the RF signals may be received using a GPS antenna coupled to a GPS receiver for receiving and analyzing the GPS signals. Alternatively or in addition, the multiple sources may comprise satellites that may be part of any Global Navigation Satellite System (GNSS), such as the

GLONASS (GLObal NAVigation Satellite System), the Beidou-1, the Beidou-2, the Galileo, or the IRNSS/VAVIC.

Alternatively or in addition, the processing or comparing may comprise, or may be based on, performing TOA (Time-Of-Arrival) measurement, performing TDOA (Time Difference-Of-Arrival) measurement, performing an AoA (Angle-Of-Arrival) measurement, performing a Line-of-Sight (LoS) measurement, performing a Time-of-Flight (ToF) measurement, performing a Two-Way Ranging (TWR) measurement, performing a Symmetrical Double Sided – Two Way Ranging (SDS-TWR) measurement, performing a Near-field electromagnetic ranging (NFER) measurement, or performing triangulation, trilateration, or multilateration (MLAT). Alternatively or in addition, the RF signals may be part of the communication over a wireless network in which the vehicle, apparatus, or device is communicating over. The wireless network may be a cellular telephone network, and the sources may be cellular towers or base-stations. Alternatively or in addition, the wireless network may be a WLAN, and the sources may be hotspots or Wireless Access Points (WAPs). Alternatively or in addition, the geographical location may be estimated using, or based on, geolocation, which may be is based on W3C Geolocation API. Any geographical location herein may consist of, or may comprise, a country, a region, a city, a street, a ZIP code, latitude, or longitude.

Alternatively or in addition, the server transmits the message to a client device such as a smartphone. The message may be a text-based message and the IM service may be a text messaging service, and the message may be according to, may use, or may be based on, a Short Message Service (SMS) message, the IM service may be a SMS service, the message may be according to, or may be based on, an electronic-mail (e-mail) message and the IM service may be an e-mail service, the message may be according to, or may be based on, WhatsApp message and the IM service may be a WhatsApp service, the message may be according to, or may be based on, a Twitter message and the IM service may be a Twitter service, or the message may be according to, or may be based on, a Viber message and the IM service may be a Viber service. Alternatively or in addition, the message may be a Multimedia Messaging Service (MMS) or an Enhanced Messaging Service (EMS) message that may include audio or video, and the IM service may respectively be an NMS or EMS service.

Any vehicle herein may be a ground vehicle adapted to travel on land, such as a bicycle, a car, a motorcycle, a train, an electric scooter, a subway, a train, a trolleybus, or a tram. Alternatively or in addition, the vehicle may be a buoyant or submerged

watercraft adapted to travel on or in water, and the watercraft may be a ship, a boat, a hovercraft, a sailboat, a yacht, or a submarine. Alternatively or in addition, the vehicle may be an aircraft adapted to fly in air, and the aircraft may be a fixed wing or a rotorcraft aircraft, such as an airplane, a spacecraft, a glider, a drone, or an Unmanned Aerial Vehicle (UAV). Any vehicle herein may be a ground vehicle that may consist of, or may comprise, an autonomous car, which may be according to levels 0, 1, 2, 3, 4, or 5 of the Society of Automotive Engineers (SAE) J3016 standard.

Any apparatus, device, sensor, or actuator herein, or any part thereof, may be mounted onto, may be attached to, may be part of, or may be integrated with, a rear or front view camera, chassis, lighting system, headlamp, door, car glass, windscreen, side or rear window, glass panel roof, hood, bumper, cowling, dashboard, fender, quarter panel, rocker, or a spoiler of a vehicle. Any vehicle herein may further comprise an Advanced Driver Assistance Systems (ADAS) functionality, system, or scheme, and any apparatus, device, sensor, or actuator herein may be part of, may be integrated with, may be communicating with, or may be coupled to, the ADAS functionality, system, or scheme. The ADAS functionality, system, or scheme may consist of, may comprise, or may use, Adaptive Cruise Control (ACC), Adaptive High Beam, Glare-free high beam and pixel light, Adaptive light control such as swiveling curve lights, Automatic parking, Automotive navigation system with typically GPS and TMC for providing up-to-date traffic information, Automotive night vision, Automatic Emergency Braking (AEB), Backup assist, Blind Spot Monitoring (BSM), Blind Spot Warning (BSW), Brake light or traffic signal recognition, Collision avoidance system, Pre-crash system, Collision Imminent Braking (CIB), Cooperative Adaptive Cruise Control (CACC), Crosswind stabilization, Driver drowsiness detection, Driver Monitoring Systems (DMS), Do-Not-Pass Warning (DNPW), Electric vehicle warning sounds used in hybrids and plug-in electric vehicles, Emergency driver assistant, Emergency Electronic Brake Light (EEBL), Forward Collision Warning (FCW), Heads-Up Display (HUD), Intersection assistant, Hill descent control, Intelligent speed adaptation or Intelligent Speed Advice (ISA), Intelligent Speed Adaptation (ISA), Intersection Movement Assist (IMA), Lane Keeping Assist (LKA), Lane Departure Warning (LDW) (a.k.a. Line Change Warning - LCW), Lane change assistance, Left Turn Assist (LTA), Night Vision System (NVS), Parking Assistance (PA), Pedestrian Detection System (PDS), Pedestrian protection system, Pedestrian Detection (PED), Road Sign Recognition (RSR), Surround View Cameras (SVC), Traffic sign recognition, Traffic jam assist, Turning assistant, Vehicular

communication systems, Autonomous Emergency Braking (AEB), Adaptive Front Lights (AFL), or Wrong-way driving warning.

Any vehicle herein may further employ an Advanced Driver Assistance System Interface Specification (ADASIS) functionality, system, or scheme, and any sensor or actuator herein may be part of, integrated with, communicates with, or coupled to, the ADASIS functionality, system, or scheme. Further, any message herein may comprise a map data relating to the location of a respective vehicle.

Any vehicle identifier herein may comprise a set of characters or numbers uniquely identifying the vehicle, and any vehicle identifier herein may comprise a license plate number, or a Vehicle Identification Number (VIN) that is according to, or based on, ISO 3779. Alternatively or in addition, any vehicle identifier herein may comprise a code that identifies the first vehicle make, model, color, model year, engine size, or vehicle type. Alternatively or in addition, any vehicle identifier herein may comprise an address that uniquely identifies the vehicle in a digital network, in the Internet, or in the first or second networks, and the address may comprise an IP address (such as in IPv4 or IPv6 form). or a Medium Access Control (MAC) address.

Any sensor herein may be an electrical sensor used to measure electrical quantities or electrical properties. The electrical sensor may be conductively connected to the measured element. Alternatively or in addition, the electrical sensor may use non-conductive or non-contact coupling to the measured element, such as measuring a phenomenon associated with the measured quantity or property. The electric sensor may be a current sensor or an ampmeter (a.k.a. ampermeter) for measuring DC or AC (or any other waveform) electric current passing through a conductor or wire. The current sensor may be connected such that part or all of the measured electric current may be passing through the ampermeter, such as a galvanometer or a hot-wire ampermeter. An ampermeter may be a current clamp or current probe, and may use the 'Hall effect' or a current transformer concept for non-contact or non-conductive current measurement. The electrical sensor may be a voltmeter for measuring the DC or AC (or any other waveform) voltage, or any potential difference between two points. The voltmeter may be based on the current passing a resistor using the Ohm's law, may be based on a potentiometer, or may be based on a bridge circuit.

The sensor may be a wattmeter measuring the magnitude of the active AC or DC power (or the supply rate of electrical energy). The wattmeter may be a bolometer, used for measuring the power of incident electromagnetic radiation via the heating of a

material with a temperature-dependent electrical resistance. The sensor may be an electricity AC (single or multi-phase) or DC type meter (or electrical energy meter), that measures the amount of electrical energy consumed by a load. The electricity meter may be based on a wattmeter, which accumulates or takes the average readings, may be based on induction, or may be based on multiplying measured voltage and current.

The electrical sensor may be an ohmmeter for measuring the electrical resistance (or conductance), and may be a megohmmeter or a microohmmeter. The ohmmeter may use the Ohm's law to derive the resistance from voltage and current measurements, or may use a bridge such as a Wheatstone bridge. The sensor may be a capacitance meter for measuring capacitance. A sensor may be an inductance meter for measuring inductance. A sensor may be an impedance meter for measuring an impedance of a device or a circuit. A sensor may be an LCR meter, used to measure inductance (L), capacitance (C), and resistance (R). A meter may use sourcing a DC or an AC voltage, and use the ratio of the measured voltage and current (and their phase difference) through the tested device according to Ohm's law to calculate the resistance, the capacitance, the inductance, or the impedance ($R=V/I$). Alternatively or in addition, a meter may use a bridge circuit (such as Wheatstone bridge), where variable calibrated elements may be adjusted to detect a null. The measurement may be using DC with a single frequency or a range of frequencies.

Any sensor herein may be a scalar or a vector magnetometer for measuring an H or B magnetic fields. The magnetometer may be based on a Hall effect sensor, magnetodiode, magneto-transistor, AMR magnetometer, GMR magnetometer, magnetic tunnel junction magnetometer, magneto-optical sensor, Lorentz force based MEMS sensor, Electron Tunneling based MEMS sensor, MEMS compass, Nuclear precession magnetic field sensor (a.k.a. Nuclear Magnetic Resonance - NMR), optically pumped magnetic field sensor, fluxgate magnetometer, search coil magnetic field sensor, or Superconducting Quantum Interference Device (SQUID) magnetometer.

Any sensor herein may be an occupancy sensor for detecting occupancy of a space by a human body, and the sensor output may be responsive to detecting a presence of a human by using electric effect, inductive coupling, capacitive coupling, triboelectric effect, piezoelectric effect, fiber optic transmission, or radar intrusion sensing. The occupancy sensor may consist of, may comprise, or may be based on, an acoustic sensor, opacity, geomagnetism, magnetic sensors, magnetometer, reflection of transmitted energy, infrared laser radar, microwave radar, electromagnetic induction, or vibration.

Alternatively or in addition, the occupancy sensor may consist of, may comprises, or may be based on, a motion sensor that may be a mechanically actuated sensor, passive or active electronic sensor, ultrasonic sensor, microwave sensor, tomographic detector, Passive Infra-Red (PIR) sensor, laser optical detector, or acoustical detector.

5 Alternatively or in addition, the sensor may be a photoelectric sensor that may respond to a visible or an invisible light, the invisible light may be infrared, ultraviolet, X-rays, or gamma rays, and the photoelectric sensor may be based on the photoelectric or photovoltaic effect, and may consist of, or may comprise, a semiconductor component that may consist of, or may comprise, a photodiode, or a phototransistor that may be
10 based on Charge-Coupled Device (CCD) or a Complementary Metal-Oxide Semiconductor (CMOS) component. Alternatively or in addition, the sensor may be an electrochemical sensor that may respond to an object chemical structure, properties, composition, or reactions, the electrochemical sensor may be a pH meter or a gas sensor responding to a presence of radon, hydrogen, oxygen, or Carbon-Monoxide (CO), may
15 be based on optical detection or on ionization and may be a smoke, a flame, or a fire detector, or may be responsive to combustible, flammable, or toxic gas.

Alternatively or in addition, the sensor may be an electrical sensor that may respond to an electrical characteristics or an electrical phenomenon quantity in an electrical circuit, and may be conductively coupled to the electrical circuit, or may be a
20 non-contact sensor that may be non-conductively coupled to the electrical circuit. The electrical sensor may be responsive to an Alternating Current (AC) or a Direct Current (DC) electric signal.

The electrical sensor may be an amperimeter that responds to electrical current passing through a conductor or wire, and may consist of, or may comprise, a
25 galvanometer, a hot-wire amperimeter, a current clamp, or a current probe. The electrical sensor may be an AC amperimeter connected to measure an AC current from the AC power source or an AC current via the AC load. Alternatively or in addition, the electrical sensor may be a voltmeter that may respond to an electrical voltage, and may consist of, or may comprise, an electrometer, a resistor, a potentiometer, or a bridge
30 circuit. Alternatively or in addition, the electrical sensor may be a wattmeter that may respond to active electrical power. Alternatively or in addition, the electrical sensor may be an AC power wattmeter that may be based on induction, or may be based on multiplying measured voltage and measured current, and may be connected to measure the AC power source supplied power or the AC load consumed power. Alternatively or

in addition, the electrical sensor may be an electricity meter that responds to electrical energy, and may be connected to measure the AC power source supplied electrical energy or the AC load consumed electrical energy.

Any element capable of measuring or responding to a physical phenomenon may be used as a sensor. An appropriate sensor may be adapted for a specific physical phenomenon, such as a sensor responsive to temperature, humidity, pressure, audio, vibration, light, motion, sound, proximity, flow rate, electrical voltage, and electrical current.

Any sensor herein may be an analog sensor having an analog signal output such as analog voltage or current, or may have continuously variable impedance. Alternatively on in addition, a sensor may have a digital signal output. Any sensor herein may serve as a detector, notifying only the presence of a phenomenon, such as by a switch, and may use a fixed or settable threshold level. Any sensor herein may measure time-dependent or space-dependent parameters of a phenomenon. Any sensor herein may measure time-dependencies or a phenomenon such as the rate of change, time-integrated or time-average, duty-cycle, frequency or time period between events. Any sensor herein may be a passive sensor, or an active sensor requiring an external source of excitation. Any sensor herein may be semiconductor-based, and may be based on MEMS technology.

Any sensor herein may measure the amount of a property or of a physical quantity or the magnitude relating to a physical phenomenon, body or substance. Alternatively or in addition, a sensor may be used to measure the time derivative thereof, such as the rate of change of the amount, the quantity or the magnitude. In the case of space related quantity or magnitude, a sensor may measure the linear density, surface density, or volume density, relating to the amount of property per volume. Alternatively or in addition, a sensor may measure the flux (or flow) of a property through a cross-section or surface boundary, the flux density, or the current. In the case of a scalar field, a sensor may measure the quantity gradient. A sensor may measure the amount of property per unit mass or per mole of substance. A single sensor may be used to measure two or more phenomena.

Any sensor herein may be thermoelectric sensor, for measuring, sensing or detecting the temperature (or the temperature gradient) of an object, which may be solid, liquid or gas. Such sensor may be a thermistor (either PTC or NTC), a thermocouple, a quartz thermometer, or an RTD. The sensor may be based on a Geiger counter for

detecting and measuring radioactivity or any other nuclear radiation. Light, photons, or other optical phenomena may be measured or detected by a photosensor or photodetector, used for measuring the intensity of visible or invisible light (such as infrared, ultraviolet, X-ray or gamma rays). A photosensor may be based on the photoelectric or the photovoltaic effect, such as a photodiode, a phototransistor, solar cell or a photomultiplier tube. A photosensor may be a photoresistor based on photoconductivity, or a CCD where a charge is affected by the light.

Any sensor herein may be a physiological sensor for measuring, sensing or detecting parameters of a live body, such as animal or human body. Such a sensor may involve measuring of body electrical signals such as an EEG or ECG sensor, a gas saturation sensor such as oxygen saturation sensor, mechanical or physical parameter sensors such as a blood pressure meter. A sensor (or sensors) may be external to the sensed body, implanted inside the body, or may be wearable. The sensor may be an

electracoustic sensor for measuring, sensing or detecting sound, such as a microphone. Typically microphones are based on converting audible or inaudible (or both) incident sound to an electrical signal by measuring the vibration of a diaphragm or a ribbon. The microphone may be a condenser microphone, an electret microphone, a dynamic microphone, a ribbon microphone, a carbon microphone, or a piezoelectric microphone.

Any sensor herein may be an image sensor for providing digital camera functionality, allowing an image (either as still images or as a video) to be captured, stored, manipulated and displayed. The image capturing hardware integrated with the sensor unit may contain a photographic lens (through a lens opening) focusing the required image onto a photosensitive image sensor array disposed approximately at an image focal point plane of the optical lens, for capturing the image and producing electronic image information representing the image. The image sensor may be based on Charge-Coupled Devices (CCD) or Complementary Metal–Oxide–Semiconductor (CMOS). The image may be converted into a digital format by an image sensor AFE (Analog Front End) and an image processor, commonly including an analog to digital (A/D) converter coupled to the image sensor for generating a digital data representation of the image. The unit may contain a video compressor, coupled between the analog to digital (A/D) converter and the transmitter for compressing the digital data video before transmission to the communication medium. The compressor may be used for lossy or non-lossy compression of the image information, for reducing the memory size and reducing the data rate required for the transmission over the communication medium.

The compression may be based on a standard compression algorithm such as JPEG (Joint Photographic Experts Group) and MPEG (Moving Picture Experts Group), ITU-T H.261, ITU-T H.263, ITU-T H.264, or ITU-T CCIR 601.

5 The digital data video signal carrying a digital data video according to a digital video format, and a transmitter coupled between the port and the image processor for transmitting the digital data video signal to the communication medium. The digital video format may be based on one out of: TIFF (Tagged Image File Format), RAW format, AVI (Audio Video Interleaved), DV, MOV, WMV, MP4, DCF (Design Rule for Camera Format), ITU-T H.261, ITU-T H.263, ITU-T H.264, ITU-T CCIR 601, ASF, 10 Exif (Exchangeable Image File Format), and DPOF (Digital Print Order Format) standards.

Any sensor herein may be an electrical sensor used to measure electrical quantities or electrical properties. The electrical sensor may be conductively connected to the measured element. Alternatively or in addition, the electrical sensor may use non- 15 conductive or non-contact coupling to the measured element, such as measuring a phenomenon associated with the measured quantity or property. The electric sensor may be a current sensor or an ampmeter (a.k.a. ampermeter) for measuring DC or AC (or any other waveform) electric current passing through a conductor or wire. The current sensor may be connected such that part or entire of the measured electric current may be 20 passing through the ampermeter, such as a galvanometer or a hot-wire ampermeter. An ampermeter may be a current clamp or current probe, and may use the 'Hall effect' or a current transformer concept for non-contact or non-conductive current measurement. The electrical sensor may be a voltmeter for measuring the DC or AC (or any other waveform) voltage, or any potential difference between two points. The voltmeter may 25 be based on the current passing a resistor using the Ohm's law, may be based on a potentiometer, or may be based on a bridge circuit.

Any sensor herein may be a Time-Domain Reflectometer (TDR) used to characterize and locate faults in transmission-lines such as conductive or metallic lines, based on checking the reflection of a transmitted short rise time pulse. Similarly, an 30 optical TDR may be used to test optical fiber cables.

Any sensor herein may be a strain gauge, used to measure the strain, or any other deformation, of an object. The sensor may be based on deforming a metallic foil, semiconductor strain gauge (such as piezoresistors), measuring the strain along an optical fiber, capacitive strain gauge, and vibrating or resonating of a tensioned wire.

Any sensor herein may be a tactile sensor, being sensitive to force or pressure, or being sensitive to a touch by an object, typically a human touch. A tactile sensor may be based on a conductive rubber, a lead zirconate titanate (PZT) material, a polyvinylidene fluoride (PVDF) material, a metallic capacitive element, or any combination thereof. A tactile sensor may be a tactile switch, which may be based on the human body conductance, using measurement of conductance or capacitance.

Any sensor herein may be a piezoelectric sensor, where the piezoelectric effect is used to measure pressure, acceleration, strain or force, and may use transverse, longitudinal, or shear effect mode. A thin membrane may be used to transfer and measure pressure, while mass may be used for acceleration measurement. A piezoelectric sensor element material may be a piezoelectric ceramics (such as PZT ceramic) or a single crystal material. A single crystal material may be gallium phosphate, quartz, tourmaline, or Lead Magnesium Niobate-Lead Titanate (PMN-PT).

Any sensor herein may be a motion sensor, and may include one or more accelerometers, which measures the absolute acceleration or the acceleration relative to freefall. The accelerometer may be piezoelectric, piezoresistive, capacitive, MEMS or electromechanical switch accelerometer, measuring the magnitude and the direction the device acceleration in a single-axis, 2-axis or 3-axis (omnidirectional). Alternatively or in addition, the motion sensor may be based on electrical tilt and vibration switch or any other electromechanical switch.

Any sensor herein may be a force sensor, a load cell, or a force gauge (a.k.a. force gage), used to measure a force magnitude and / or direction, and may be based on a spring extension, a strain gauge deformation, a piezoelectric effect, or a vibrating wire. Any sensor herein may be a driving or passive dynamometer, used to measure torque or any moment of force.

Any sensor herein may be a pressure sensor (a.k.a. pressure transducer or pressure transmitter / sender) for measuring a pressure of gases or liquids, and for indirectly measuring other parameters such as fluid/gas flow, speed, water-level, and altitude. A pressure sensor may be a pressure switch. A pressure sensor may be an absolute pressure sensor, a gauge pressure sensor, a vacuum pressure sensor, a differential pressure sensor, or a sealed pressure sensor. The changes in pressure relative to altitude may be used for an altimeter, and the Venturi effect may be used to measure flow by a pressure sensor. Similarly, the depth of a submerged body or the fluid level on contents in a tank may be measured by a pressure sensor.

A pressure sensor may be of a force collector type, where a force collector (such a diaphragm, piston, bourdon tube, or bellows) is used to measure strain (or deflection) due to applied force (pressure) over an area. Such sensor may be based on the piezoelectric effect (a piezoresistive strain gauge), may be of a capacitive or of an electromagnetic type. A pressure sensor may be based on a potentiometer, or may be based on using the changes in resonant frequency or the thermal conductivity of a gas, or may use the changes in the flow of charged gas particles (ions).

Any sensor herein may be a position sensor for measuring linear or angular position (or motion). A position sensor may be an absolute position sensor, or may be a displacement (relative or incremental) sensor, measuring a relative position, and may be an electromechanical sensor. A position sensor may be mechanically attached to the measured object, or alternatively may use a non-contact measurement.

A position sensor may be an angular position sensor, for measuring involving an angular position (or the rotation or motion) of a shaft, an axle, or a disk. Absolute angular position sensor output indicates the current position (angle) of the shaft, while incremental or displacement sensor provides information about the change, the angular speed or the motion of the shaft. An angular position sensor may be of optical type, using reflective or interruption schemes, or may be of magnetic type, such as based on variable-reluctance (VR), Eddy-current killed oscillator (ECKO), Wiegand sensing, or Hall-effect sensing, or may be based on a rotary potentiometer. An angular position sensor may be transformer based such as a RVDT, a resolver or a synchro. An angular position sensor may be based on an absolute or incremental rotary encoder, and may be a mechanical or optical rotary encoder, using binary or gray encoding schemes.

Any sensor herein may be an angular rate sensor, used to measure the angular rate, or the rotation speed, of a shaft, an axle or a disc, and may be electromechanical (such as centrifugal switch), MEMS based, Laser based (such as Ring Laser Gyroscope - RLG), or a gyroscope (such as fiber-optic gyro) based. Some gyroscopes use the measurement of the Coriolis acceleration to determine the angular rate. An angular rate sensor may be a tachometer, which may be based on measuring the centrifugal force, or based on optical, electric, or magnetic sensing a slotted disk.

A position sensor may be a linear position sensor, for measuring a linear displacement or position typically in a straight line, and may use a transformer principle such as such as LVDT, or may be based on a resistive element such as linear potentiometer. A linear position sensor may be an incremental or absolute linear

encoder, and may employ optical, magnetic, capacitive, inductive, or eddy-current principles.

Any sensor herein may be a mechanical or electrical motion detector (or an occupancy sensor), for discrete (on/off) or magnitude-based motion detection. A motion
5 detector may be based on sound (acoustic sensors), opacity (optical and infrared sensors and video image processors), geomagnetism (magnetic sensors, magnetometers), reflection of transmitted energy (infrared laser radar, ultrasonic sensors, and microwave radar sensors), electromagnetic induction (inductive-loop detectors), or vibration (triboelectric, seismic, and inertia-switch sensors). Acoustic sensors may use electric
10 effect, inductive coupling, capacitive coupling, triboelectric effect, piezoelectric effect, fiber optic transmission, or radar intrusion sensing. An occupancy sensor is typically a motion detector that may be integrated with hardware or software-based timing device.

A motion sensor may be a mechanically-actuated switch or trigger, or may use passive or active electronic sensors, such as passive infrared sensors, ultrasonic sensors,
15 microwave sensor or tomographic detector. Alternatively or in addition, motion can be electronically identified using infrared (PIR) or laser optical detection or acoustical detection, or may use a combination of the technologies disclosed herein.

A sensor may be a humidity sensor, such as a hygrometer or a humidistat, and may respond to an absolute, relative, or specific humidity. The measurement may be
20 based on optically detecting condensation, or may be based on changing the capacitance, resistance, or thermal conductivity of materials subjected to the measured humidity.

Any sensor herein may be a clinometer for measuring angle (such as pitch or roll) of an object, typically with respect to a plane such as the earth ground plane. A clinometer may be based on an accelerometer, a pendulum, or on a gas bubble in liquid,
25 or may be a tilt switch such as a mercury tilt switch for detecting inclination or declination with respect to a determined tilt angle.

Any sensor herein may be a gas or liquid flow sensor, for measuring the volumetric or mass flow rate via a defined area or a surface. A liquid flow sensor typically involves measuring the flow in a pipe or in an open conduit. A flow
30 measurement may be based on a mechanical flow meter, such as a turbine flow meter, a Woltmann meter, a single jet meter, or a paddle wheel meter. Pressure-based meters may be based on measuring a pressure or a pressure differential based on Bernoulli's principle, such as a Venturi meter. The sensor may be an optical flow meter or be based on the Doppler-effect.

A flow sensor may be an air flow sensor, for measuring the air or gas flow, such as through a surface (e.g., through a tube) or a volume, by actually measuring the air volume passing, or by measuring the actual speed or air flow. In some cases, a pressure, typically differential pressure, may be measured as an indicator for the air flow measurements. An anemometer is an air flow sensor primarily for measuring wind speed, and may be cup anemometer, a windmill anemometer, hot-wire anemometer such as CCA (Constant-Current Anemometer), CVA (Constant-Voltage Anemometer) and CTA (Constant-Temperature Anemometer). Sonic anemometers use ultrasonic sound waves to measure wind velocity. Air flow may be measured by a pressure anemometer that may be a plate or tube class.

Any sensor herein may be a gyroscope, for measuring orientation in space, such as the conventional mechanical type, a MEMS gyroscope, a piezoelectric gyroscope, a FOG, or a VSG type. A sensor may be a nanosensor, a solid-state, or an ultrasonic based sensor. Any sensor herein may be an eddy-current sensor, where the measurement may be based on producing and / or measuring eddy-currents. Sensor may be a proximity sensor, such as metal detector. Any sensor herein may be a bulk or surface acoustic sensor, or may be an atmospheric sensor.

In one example, multiple sensors may be used arranged as a sensor array (such as linear sensor array), for improving the sensitivity, accuracy, resolution, and other parameters of the sensed phenomenon. The sensor array may be directional, and better measure the parameters of the impinging signal to the array, such as the number, magnitudes, frequencies, Direction-Of-Arrival (DOA), distances, and speeds of the signals. The processing of the entire sensor array outputs, such as to obtain a single measurement or a single parameter, may be performed by a dedicated processor, which may be part of the sensor array assembly, may be performed in the processor of the field unit, may be performed by the processor in the router, may be performed as part of the controller functionality (e.g., in the control server), or any combination thereof. The same component may serve both as a sensor and as actuator, such as during different times, and may be associated with the same or different phenomenon. A sensor operation may be based on an external or integral mechanism for generating a stimulus or an excitation to generate influence or create a phenomenon. The mechanism may be controlled as an actuator or as part of the sensor.

Any sensor herein may provide a digital output, and the sensor output may include an electrical switch, and the electrical switch state may be responsive to the phenomenon

magnitude measured versus a threshold, which may be set by the actuator. Any sensor herein may provide an analog output, and the first device may comprise an analog to digital converter coupled to the analog output, for converting the sensor output to a digital data.

5 Any sensor herein may be a photoelectric sensor that responds to a visible or an invisible light or both, such as infrared, ultraviolet, X-rays, or gamma rays. The photoelectric sensor may be based on the photoelectric or photovoltaic effect, and consists of, or comprises, a semiconductor component such as a photodiode, a phototransistor, or a solar cell. The photoelectric sensor may be based on Charge-
10 Coupled Device (CCD) or a Complementary Metal-Oxide Semiconductor (CMOS) element. The sensor may be a photosensitive image sensor array comprising multiple photoelectric sensors, and may be operative for capturing an image and producing an electronic image information representing the image, and may comprise one or more optical lens for focusing the received light and mechanically oriented to guide the image,
15 and the image sensor may be disposed approximately at an image focal point plane of the one or more optical lens for properly capturing the image. An image processor may be coupled to the image sensor for providing a digital data video signal according to a digital video format, the digital video signal carrying digital data video based on the captured images, and the digital video format may be according to, or based on, one out
20 of: TIFF (Tagged Image File Format), RAW format, AVI, DV, MOV, WMV, MP4, DCF (Design Rule for Camera Format), ITU-T H.261, ITU-T H.263, ITU-T H.264, ITU-T CCIR 601, ASF, Exif (Exchangeable Image File Format) and DPOF (Digital Print Order Format) standards. A video compressor may be coupled to the image sensor for lossy or non-lossy compressing of the digital data video, and may be based on a
25 standard compression algorithm such as JPEG (Joint Photographic Experts Group) and MPEG (Moving Picture Experts Group), ITU-T H.261, ITU-T H.263, ITU-T H.264, or ITU-T CCIR 601.

Any sensor herein may be an electrochemical sensor and may respond to an object chemical structure, properties, composition, or reactions. The electrochemical
30 sensor may be a pH meter or may be a gas sensor responding to the presence of radon, hydrogen, oxygen, or Carbon-Monoxide (CO). The electrochemical sensor may be a smoke, a flame, or a fire detector, and may be based on optical detection or on ionization for responding to combustible, flammable, or toxic gas.

Any sensor herein may be a physiological sensor and may respond to parameters associated with a live body, and may be external to the sensed body, implanted inside the sensed body, attached to the sensed body, or wearable on the sensed body. The physiological sensor may be responding to body electrical signals such as an EEG
5 Electroencephalography (EEG) or an Electrocardiography (ECG) sensor, or may be responding to oxygen saturation, gas saturation, or blood pressure.

The sensor may be an electroacoustic sensor and may respond to a sound, such as inaudible or audible audio. The electroacoustic sensor may be a an omnidirectional, unidirectional, or bidirectional microphone, may be based on the sensing the incident
10 sound based motion of a diaphragm or a ribbon, and may consist of, or comprise, a condenser, an electret, a dynamic, a ribbon, a carbon, or a piezoelectric microphone.

Any sensor herein may be an absolute, a relative displacement, or an incremental position sensor, and may respond to a linear or angular position, or motion, of a sensed element. The position sensor may be an optical type or a magnetic type angular position
15 sensor, and may respond to an angular position or the rotation of a shaft, an axle, or a disk. The angular position sensor may be based on a Variable-Reluctance (VR), an Eddy-Current Killed Oscillator (ECKO), a Wiegand sensing, or a Hall-effect sensing, and may be transformer based such as an RVDT, a resolver or a synchro. The angular position sensor may be an electromechanical type such as an absolute or an incremental,
20 mechanical or optical, rotary encoder. The angular position sensor may be an angular rate sensor and may respond to the angular rate, or the rotation speed, of a shaft, an axle, or a disc, and may consist of, or comprise, a gyroscope, a tachometer, a centrifugal switch, a Ring Laser Gyroscope (RLG), or a fiber-optic gyro. The position sensor may be a linear position sensor and may respond to a linear displacement or position along a
25 line, and may consist of, or comprise, a transformer, an LVDT, a linear potentiometer, or an incremental or absolute linear encoder.

Any sensor herein may be a strain gauge and may respond to the deformation of an object, and may be based on a metallic foil, a semiconductor, an optical fiber, vibrating or resonating of a tensioned wire, or a capacitance meter. The sensor may be a
30 hygrometer and may respond to an absolute, relative, or specific humidity, and may be based on optically detecting condensation, or based on changing the capacitance, resistance, or thermal conductivity of materials subjected to the measured humidity. The sensor may be a clinometer and may respond to inclination or declination, and may be based on an accelerometer, a pendulum, a gas bubble in liquid, or a tilt switch.

Any sensor herein may be a flow sensor and may measure the volumetric or mass flow rate via a defined area, volume or surface. The flow sensor may be a liquid flow sensor and may be measuring the liquid flow in a pipe or in an open conduit. The liquid flow sensor may be a mechanical flow meter and may consist of, or comprise, a turbine flow meter, a Woltmann meter, a single jet meter, or a paddle wheel meter. The liquid flow sensor may be a pressure flow meter based on measuring an absolute pressure or a pressure differential. The flow sensor may be a gas or an air flow sensor such as anemometer for measuring wind or air speed, and may measure the flow through a surface, a tube, or a volume, and may be based on measuring the air volume passing in a time period. The anemometer may consist of, or comprise, cup anemometer, a windmill anemometer, a pressure anemometer, a hot-wire anemometer, or a sonic anemometer.

Any sensor herein may be a gyroscope for measuring orientation in space, and may consist of, or comprise, a MEMS, a piezoelectric, a FOG, or a VSG gyroscope, and may be based on a conventional mechanical type, a nanosensor, a crystal, or a semiconductor.

Any sensor herein may be an image sensor for capturing an image or video, and the system may include an image processor for recognition of a pattern, and the control logic may be operative to respond to the recognized pattern such as appearance-based analysis of hand posture or gesture recognition. The system may comprise an additional image sensor, and the control logic may be operative to respond to the additional image sensor such as to cooperatively capture a 3-D image and for identifying the gesture recognition from the 3-D image, based on volumetric or skeletal models, or a combination thereof.

Any sensor herein be an image sensor for capturing still or video image, and the sensor or the system may comprise an image processor having an output for processing the captured image (still or video). The image processor (hardware or software based, or a hardware/software combination) may be encased entirely or in part in the first device, the router, the control server, or any combination thereof, and the control logic may respond to the image processor output. The image sensor may be a digital video sensor for capturing digital video content, and the image processor may be operative for enhancing the video content such as by image stabilization, unsharp masking, or super-resolution, or for Video Content Analysis (VCA) such as Video Motion Detection (VMD), video tracking, egomotion estimation, identification, behavior analysis, situation

awareness, dynamic masking, motion detection, object detection, face recognition, automatic number plate recognition, tamper detection, video tracking, or pattern recognition. The image processor may be operative for detecting a location of an element, and may be operative for detecting and counting the number of elements in the captured image, such as a human body parts (such as human face or a human hand) in the captured image.

Any photosensor herein may convert light into an electrical phenomenon and may be semiconductor-based. Further, any photosensor herein may consist of, may comprise, may use, or may be based on, a photodiode, a phototransistor, a Complementary Metal–Oxide–Semiconductor (CMOS), or a Charge-Coupled Device (CCD). The photodiode may consist of, may comprise, may use, or may be based on, a PIN diode or an Avalanche PhotoDiode (APD). Any photosensor herein may convert sound into an electrical phenomenon, and may consist of, may comprise, may use, or may be based on, measuring the vibration of a diaphragm or a ribbon. Further, any photosensor may consist of, may comprise, may use, or may be based on, a condenser microphone, an electret microphone, a dynamic microphone, a ribbon microphone, a carbon microphone, or a piezoelectric microphone.

Any sensor herein may consist of, or comprise, an angular position sensor for measuring angular setting or a change of an angle, that may be configured for throttle-valve-angle measuring as part of an engine management on gasoline (SI) engines in the first vehicle. Any sensor herein may consist of, or comprise, a rotational-speed sensor for measuring rotational speeds, positions or angles in excess of 360°, that may be configured for measuring wheel-speed, engine speeds, engine positioning angle, steering-wheel angle, distance covered, or road curves / bends. Any sensor herein may consist of, or comprise, a spring-mass acceleration sensor for measuring changes in the first vehicle speed, and may be configured for measuring vehicular acceleration and deceleration, as part of the Anti-Breaking System (ABS) or the Traction Control System (TCS) of the first vehicle. Any sensor herein may consist of, or comprise, a bending beam acceleration sensor for registering or detecting shock and vibration, and may be configured for detecting impacts or measuring shocks and vibration, or for triggering airbags or belt tighteners. Any sensor herein may consist of, or comprise, a yaw sensor for measuring skidding movements, or for measuring yaw rate and lateral acceleration, of a vehicle, that may be configured for affecting a vehicle dynamics control (e.g., ESP – Electronic Stability Program). Any sensor herein may consist of, or comprise, a vibration

sensor for measuring structure-borne vibrations at an engine, a machine, or a pivot bearing, of a vehicle, and may be configured for engine-knock detection as part of an anti-knock control in an engine management system.

Any sensor herein may consist of, or comprise, an absolute-pressure sensor for measuring ranges from 50% to 500% of the earth's atmospheric pressure, and may be configured for manifold vacuum measurement, charge-air-pressure measurement for charge-air pressure control, or altitude-dependent fuel injection for diesel engines. Any sensor herein may consist of, or comprise, a differential-pressure sensor for measuring differential gas pressure, and may be configured for pressure measurement in a fuel tank, or evaporative-emission control system, in a vehicle.

Any sensor herein may consist of, or comprise, a temperature sensor for measuring the temperature of gaseous material or a liquid, and may be configured for displaying of outside and inside temperature, controlling of air conditioner or inside temperature, controlling of radiator or thermostat, or measuring of lube-oil, coolant, or engine temperature. Any sensor herein may consist of, or comprise, a Lambda oxygen sensor for determining the residual oxygen content in the exhaust gas, and may be for controlling of A/F mixture for minimization of pollutant emissions on gasoline and gas engines. Any sensor herein may consist of, or comprise, an air-mass meter used for measuring the flow rate of gas, and may be configured for measuring of the mass of the air drawn in by the engine.

Any vehicle, apparatus, ECU, or device herein may further comprise an actuator that converts electrical energy to affect or produce a physical phenomenon, the actuator may be coupled to be operated, controlled, or activated, by a processor, in response to an input value or any combination, manipulation, or function thereof. The actuator may be housed in the single enclosure or be integrated with an ECU.

Any vehicle, apparatus, ECU, or device herein may further comprise a signal conditioning circuit coupled between the processor and the actuator. The signal conditioning circuit may be operative for attenuating, delaying, filtering, amplifying, digitizing, comparing, or manipulating a signal from the processor, and may comprise an amplifier, a voltage or current limiter, an attenuator, a delay line or circuit, a level translator, a galvanic isolator, an impedance transformer, a linearization circuit, a calibrator, a passive filter, an active filter, an adaptive filter, an integrator, a deviator, an equalizer, a spectrum analyzer, a compressor or a de-compressor, a coder, a decoder, a

modulator, a demodulator, a pattern recognizer, a smoother, a noise remover, an average circuit, a Digital-to-Analog (A/D) converter, or an RMS circuit.

Any actuator herein may be electrically powered from a power source, and may convert electrical power from the power source to affect or produce the physical phenomenon. Each of the actuator, the signal conditioning circuit, and power source may be housed in, or may be external to, the single enclosure. The power source may be an Alternating Current (AC) or a Direct Current (DC) power source, and may be a primary or a rechargeable battery, housed in a battery compartment.

Any actuator herein may affect, create, or change the phenomenon that is associated with an object that is gas, air, liquid, or solid. Alternatively or in addition, any actuator herein may be operative to affect time-dependent characteristic that is a time-integrated, an average, an RMS (Root Mean Square) value, a frequency, a period, a duty-cycle, a time-integrated, or a time-derivative, of the phenomenon. Alternatively or in addition, any actuator herein may be operative to affect space-dependent characteristic that is a pattern, a linear density, a surface density, a volume density, a flux density, a current, a direction, a rate of change in a direction, or a flow, of the phenomenon.

Any actuator herein may consist of, or may comprise, an electric light source that converts electrical energy into light, and may emit visible or non-visible light for illumination or indication, and the non-visible light may be infrared, ultraviolet, X-rays, or gamma rays. Any electric light source herein may consist of, or may comprise, a lamp, an incandescent lamp, a gas discharge lamp, a fluorescent lamp, a Solid-State Lighting (SSL), a Light Emitting Diode (LED), an Organic LED (OLED), a polymer LED (PLED), or a laser diode.

Any actuator herein may consist of, or may comprise, a motion actuator that causes linear or rotary motion, and any apparatus or device herein may further comprise a conversion mechanism that may be coupled to, attached to, or part of, the actuator for converting to rotary or linear motion based on a screw, a wheel and axle, or a cam. Any conversion mechanism herein may consist of, may comprise, or may be based on, a screw, and any apparatus or device herein may further comprise a leadscrew, a screw jack, a ball screw or a roller screw that may be coupled to, attached to, or part of, the actuator. Alternatively or in addition, any conversion mechanism herein may consist of, may comprise, or may be based on, a wheel and axle, and any apparatus or device herein may further comprise a hoist, a winch, a rack and pinion, a chain drive, a belt drive, a rigid chain, or a rigid belt that may be coupled to, attached to, or part of, the actuator.

Any motion actuator herein may further comprise a lever, a ramp, a screw, a cam, a crankshaft, a gear, a pulley, a constant-velocity joint, or a ratchet, for effecting the motion. Alternatively or in addition, any motion actuator herein may consist of, or may comprise, a pneumatic, hydraulic, or electrical actuator, which may be an electrical motor.

Any electrical motor herein may be a brushed, a brushless, or an uncommutated DC motor, and any DC motor herein may be a stepper motor that may be a Permanent Magnet (PM) motor, a Variable reluctance (VR) motor, or a hybrid synchronous stepper. Alternatively or in addition, any electrical motor herein may be an AC motor that may be an induction motor, a synchronous motor, or an eddy current motor. Further, any AC motor herein may be a single-phase AC induction motor, a two-phase AC servo motor, or a three-phase AC synchronous motor, and may further be a split-phase motor, a capacitor-start motor, or a Permanent-Split Capacitor (PSC) motor. Alternatively or in addition, any electrical motor herein may be an electrostatic motor, a piezoelectric actuator, or is a MEMS-based motor. Alternatively or in addition, any motion actuator herein may consist of, or may comprise, a linear hydraulic actuator, a linear pneumatic actuator, a linear induction electric motor (LIM), or a Linear Synchronous electric Motor (LSM). Alternatively or in addition, any motion actuator herein may consist of, or may comprise, a piezoelectric motor, a Surface Acoustic Wave (SAW) motor, a Squiggle motor, an ultrasonic motor, or a micro- or nanometer comb-drive capacitive actuator, a Dielectric or Ionic based Electroactive Polymers (EAPs) actuator, a solenoid, a thermal bimorph, or a piezoelectric unimorph actuator.

Any actuator herein may consist of, or may comprise, a compressor or a pump and may be operative to move, force, or compress a liquid, a gas or a slurry. Any pump herein may be a direct lift, an impulse, a displacement, a valveless, a velocity, a centrifugal, a vacuum, or a gravity pump. Further, any pump herein may be a positive displacement pump that may be a rotary lobe, a progressive cavity, a rotary gear, a piston, a diaphragm, a screw, a gear, a hydraulic, or a vane pump. Alternatively or in addition, any positive displacement pump herein may be a rotary-type positive displacement pump that is an internal gear, a screw, a shuttle block, a flexible vane, a sliding vane, a rotary vane, a circumferential piston, a helical twisted roots, or a liquid ring vacuum pump, may be a reciprocating-type positive displacement type that may be a piston, a diaphragm, a plunger, a diaphragm valve, or a radial piston pump, or may be a linear-type positive displacement type that may be a rope-and-chain pump. Alternatively

or in addition, any pump herein may be an impulse pump that is a hydraulic ram, a pulser, or an airlift pump, may be a rotodynamic pump that may be a velocity pump, or may be a centrifugal pump that may be a radial flow, an axial flow, or a mixed flow pump. Any actuator herein may consist of, or may comprise, a display screen for
5 visually presenting information.

Any display or any display screen herein may consist of, or may comprise, a monochrome, grayscale or color display and consists of an array of light emitters or light reflectors, or a projector that is based on an Eidophor, Liquid Crystal on Silicon (LCoS or LCOS), LCD, MEMS or Digital Light Processing (DLP™) technology. Any projector
10 herein may consist of, or may comprise, a virtual retinal display. Further, any display or any display screen herein may consist of, or may comprise, a 2D or 3D video display that may support Standard-Definition (SD) or High-Definition (HD) standards, and may be capable of scrolling, static, bold or flashing the presented information.

Alternatively or in addition, any display or any display screen herein may consist
15 of, or may comprise, an analog display having an analog input interface supporting NTSC, PAL or SECAM formats, and the analog input interface may include RGB, VGA (Video Graphics Array), SVGA (Super Video Graphics Array), SCART or S-video interface. Alternatively or in addition, any display or any display screen herein may consist of, or may comprise, a digital display having a digital input interface that may
20 include IEEE1394, FireWire™, USB, SDI (Serial Digital Interface), HDMI (High-Definition Multimedia Interface), DVI (Digital Visual Interface), UDI (Unified Display Interface), DisplayPort, Digital Component Video or DVB (Digital Video Broadcast) interface. Alternatively or in addition, any display or any display screen herein may consist of, or may comprise, a Cathode-Ray Tube (CRT), a Field Emission Display
25 (FED), an Electroluminescent Display (ELD), a Vacuum Fluorescent Display (VFD), or an Organic Light-Emitting Diode (OLED) display, a passive-matrix (PMOLED) display, an active-matrix OLEDs (AMOLED) display, a Liquid Crystal Display (LCD) display, a Thin Film Transistor (TFT) display, an LED-backlit LCD display, or an Electronic Paper Display (EPD) display that may be based on Gyricon technology, Electro-Wetting
30 Display (EWD), or Electrofluidic display technology. Alternatively or in addition, any display or any display screen herein may consist of, or may comprise, a laser video display that is based on a Vertical-External-Cavity Surface-Emitting-Laser (VECSEL) or a Vertical-Cavity Surface-Emitting Laser (VCSEL). Further, any display or any display screen herein may consist of, or may comprise, a segment display based on a

seven-segment display, a fourteen-segment display, a sixteen-segment display, or a dot matrix display, and may be operative to display digits, alphanumeric characters, words, characters, arrows, symbols, ASCII, non-ASCII characters, or any combination thereof.

Any actuator herein may consist of, or may comprise, a thermoelectric actuator
5 that may be a heater or a cooler, may be operative for affecting the temperature of a solid, a liquid, or a gas object, and may be coupled to the object by conduction, convection, force convention, thermal radiation, or by the transfer of energy by phase changes. Any thermoelectric actuator herein may consist of, or may comprise, a cooler
10 based on a heat pump driving a refrigeration cycle using a compressor-based electric motor, or an electric heater that may be a resistance heater or a dielectric heater. Further, any electric heater herein may consist of, or may comprise, an induction heater, and may be solid-state based or may be an active heat pump that may use, or may be based on, the Peltier effect.

Any actuator herein may consist of, or may comprise, a chemical or an
15 electrochemical actuator, and may be operative for producing, changing, or affecting a matter structure, properties, composition, process, or reactions. Any electrochemical actuator herein may be operative for producing, changing, or affecting, an oxidation/reduction or an electrolysis reaction. Any actuator herein may consist of, or may comprise, an electromagnetic coil or an electromagnet operative for generating a
20 magnetic or electric field. Any actuator herein may consist of, or may comprise, an electrical signal generator that may be operative to output repeating or non-repeating electronic signals, and the signal generator may be an analog signal generator having an analog voltage or analog current output, and the output of the analog signal generator may be a sine wave, a saw-tooth, a step (pulse), a square, or a triangular waveform, an
25 Amplitude Modulation (AM), a Frequency Modulation (FM), or a Phase Modulation (PM) signal. Further, the signal generator may be an Arbitrary Waveform Generator (AWG) or a logic signal generator.

Any actuator herein may consist of, or may comprise, a sounder for converting
an electrical energy to omnidirectional, unidirectional, or bidirectional pattern of emitted,
30 audible or inaudible, sound waves. Any sounder herein may be audible, and may be an electromagnetic loudspeaker, a piezoelectric speaker, an electrostatic loudspeaker (ESL), a ribbon or planar magnetic loudspeaker, or a bending wave loudspeaker. Any sounder herein may be operative to emit a single or multiple tones, or may be operative to continuous or intermittent operation. Any sounder herein may be an electromechanical

or a ceramic-based, and may be an electric bell, a buzzer (or beeper), a chime, a whistle or a ringer. Any sound herein may be audible, and any sounder herein may be a loudspeaker, and any apparatus or device herein may be operative to store and play one or more digital audio content files.

5 Any system, device, apparatus, or ECU herein may comprise an actuator that may convert electrical energy to affect a phenomenon, the actuator may be coupled to the respective processor for affecting the phenomenon in response to a respective processor control, and may be connected to be powered by the respective DC power signal. The respective processor may be further coupled to operate, control, or activate
10 the actuator in response to the state of the switch. The actuator may be a sounder for converting an electrical energy to omnidirectional, unidirectional, or bidirectional pattern of emitted, audible or inaudible, sound waves, the sound may be audible, and the sounder may be an electromagnetic loudspeaker, a piezoelectric speaker, an electrostatic loudspeaker (ESL), a ribbon or planar magnetic loudspeaker, or a bending wave
15 loudspeaker. Alternatively or in addition, the actuator may be an electric thermoelectric actuator that may be a heater or a cooler, operative for affecting a temperature of a solid, a liquid, or a gas object, and may be coupled to the object by conduction, convection, force convection, thermal radiation, or by a transfer of energy by phase changes. The thermoelectric actuator may be a cooler based on a heat pump driving a refrigeration
20 cycle using a compressor-based electric motor, or may be an electric heater that may be a resistance heater or a dielectric heater. Alternatively or in addition, the actuator may be a display for visually presenting information, and may be a monochrome, grayscale or color display, and may consist of an array of light emitters or light reflectors. The display may be a video display supporting Standard-Definition (SD) or High-Definition (HD)
25 standard, and may be capable of scrolling, static, bold or flashing a presented information. Alternatively or in addition, the actuator may be a motion actuator that may cause linear or rotary motion, and the system may further comprise a conversion mechanism for respectfully converting to rotary or linear motion based on a screw, a wheel and axle, or a cam. The motion actuator may be a pneumatic, hydraulic, or
30 electrical actuator, and may be an AC or a DC electrical motor.

Any single enclosure herein may be a hand-held enclosure or a portable enclosure, or may be a surface mountable enclosure. Any device or apparatus herein may further be integrated with at least one of a wireless device, a notebook computer, a laptop computer, a media player, a Digital Still Camera (DSC), a Digital video Camera (DVC

or digital camcorder), a Personal Digital Assistant (PDA), a cellular telephone, a digital camera, a video recorder, a smartphone, or any combination thereof. The smartphone may consist of, comprise, or may be based on, Apple iPhone 6 or Samsung Galaxy S6.

Any software or firmware herein may comprise an operating system that may be
5 a mobile operating system. The mobile operating system may consist of, may comprise, may be according to, or may be based on, Android version 2.2 (Froyo), Android version 2.3 (Gingerbread), Android version 4.0 (Ice Cream Sandwich), Android Version 4.2 (Jelly Bean), Android version 4.4 (KitKat)), Apple iOS version 3, Apple iOS version 4, Apple iOS version 5, Apple iOS version 6, Apple iOS version 7, Microsoft Windows®
10 Phone version 7, Microsoft Windows® Phone version 8, Microsoft Windows® Phone version 9, or Blackberry® operating system.

Any apparatus or device herein may be operative to connected to, coupled to, communicating with, an automotive electronics in a vehicle, or may be part of, or may be integrated with, an automotive electronics in a vehicle. The first vehicle may
15 comprise an Electronic Control Unit (ECU) that may comprise, or may connect to, the sensor. Alternatively or in addition, the second vehicle may comprise an Electronic Control Unit (ECU) that may comprise, or may connect to, the actuator.

An Electronic Control Unit (ECU) may comprise, or may be part of, any apparatus or device herein. Alternatively or in addition, any apparatus or device herein
20 may consist of, may be part of, may be integrated with, may be connectable to, or may be coupleable to, an Electronic Control Unit (ECU) in the vehicle. Any Electronic Control Unit (ECU) herein may be Electronic/engine Control Module (ECM), Engine Control Unit (ECU), Powertrain Control Module (PCM), Transmission Control Module (TCM), Brake Control Module (BCM or EBCM), Central Control Module (CCM),
25 Central Timing Module (CTM), General Electronic Module (GEM), Body Control Module (BCM), Suspension Control Module (SCM), Door Control Unit (DCU), Electric Power Steering Control Unit (PSCU), Seat Control Unit, Speed Control Unit (SCU), Telematic Control Unit (TCU), Transmission Control Unit (TCU), Brake Control Module (BCM; ABS or ESC), Battery management system, control unit, or a control
30 module. Alternatively or in addition, the Electronic Control Unit (ECU) may comprise, may use, may be based on, or may execute a software, an operating-system, or a middleware, that may comprise, may be based on, may be according to, or may use, OSEK/VDX, International Organization for Standardization (ISO) 17356-1, ISO 17356-2, ISO 17356-3, ISO 17356-4, ISO 17356-5, or AUTOSAR standard. Any software

herein may comprise, may use, or may be based on, an operating-system or a middleware, that may comprise, may be based on, may be according to, or may use, OSEK/VDX, International Organization for Standardization (ISO) 17356-1, ISO 17356-2, ISO 17356-3, ISO 17356-4, ISO 17356-5, or AUTOSAR standard.

5 Any sensor data herein may be carried over a vehicle bus in the first vehicle. Alternatively or in addition, the actuator may be controlled, affected, or activated, based on data received over a vehicle bus in the second vehicle. Any network data link layer or any physical layer signaling herein may be according to, may be based on, may be using, or may be compatible with, ISO 11898-1:2015 or On-Board Diagnostics (OBD) standard. Any network medium access herein may be according to, may be based on, may be using, or may be compatible with, ISO 11898-2:2003 or On-Board Diagnostics (OBD) standard. Any vehicle bus herein may employ, may use, may be based on, or may be compatible with, a multi-master, serial protocol using acknowledgement, arbitration, and error-detection schemes. Any network or vehicle bus herein may employ, may use, may be based on, or may be compatible with, a synchronous and frame-based protocol, and may further consist of, may employ, may use, may be based on, or may be compatible with, a Controller Area Network (CAN), that may be according to, may be based on, may use, or may be compatible with, ISO 11898-3:2006, ISO 11898-2:2004, ISO 11898-5:2007, ISO 11898-6:2013, ISO 11992-1:2003, ISO 11783-2:2012, SAE J1939/11_201209, SAE J1939/15_201508, On-Board Diagnostics (OBD), or SAE J2411_200002 standards. Any CAN herein may be according to, may be based on, may use, or may be compatible with, Flexible Data-Rate (CAN FD) protocol.

Alternatively or in addition, any network or vehicle bus herein may consist of, may employ, may use, may be based on, or may be compatible with, a Local Interconnect Network (LIN), which may be according to, may be based on, may use, or may be compatible with, ISO 9141-2:1994, ISO 9141:1989, ISO 17987-1, ISO 17987-2, ISO 17987-3, ISO 17987-4, ISO 17987-5, ISO 17987-6, or ISO 17987-7 standard. Alternatively or in addition, any network or vehicle bus herein may consist of, may employ, may use, may be based on, or may be compatible with, FlexRay protocol, which may be according to, may be based on, may use, or may be compatible with, ISO 17458-1:2013, ISO 17458-2:2013, ISO 17458-3:2013, ISO 17458-4:2013, or ISO 17458-5:2013 standard. Alternatively or in addition, any network or vehicle bus herein may consist of, may employ, may use, may be based on, or may be compatible with, Media

Oriented Systems Transport (MOST) protocol, which may be according to, may be based on, may use, or may be compatible with, MOST25, MOST50, or MOST150.

Alternatively or in addition, any network or vehicle bus herein may consist of, may employ, may use, may be based on, or may be compatible with, automotive
5 Ethernet, may use only a single twisted pair, and may consist of, employ, use, may be based on, or may be compatible with, IEEE802.3 100BaseT1, IEEE802.3 1000BaseT1, BroadR-Reach®, or IEEE 802.3bw-2015 standard.

Any ECU, vehicle, apparatus, or device herein may further be addressable in a wireless network using a digital address. The wireless network may connect to, may use,
10 or may comprise, the Internet. The digital address may be a MAC layer address that may be MAC-48, EUI-48, or EUI-64 address type. Alternatively or in addition, the digital address may be a layer 3 address and may be a static or dynamic IP address that may be of IPv4 or IPv6 type address.

Any apparatus or device herein may further be operative to send a notification
15 message over a wireless network using the wireless transceiver via the antenna, and may further be operative to periodically send multiple notification messages. The notification messages may be sent substantially every 1, 2, 5, or 10 seconds, every 1, 2, 5, or 10 minutes, every 1, 2, 5, or 10 hours, or every 1, 2, 5, or 10 days, or may be sent in response to a value of a measurement or a function thereof. Using a minimum or
20 maximum threshold, the message may be sent in response to the value respectively below the minimum threshold or above the maximum threshold, and the sent message may comprise an indication of the time when the threshold was exceeded, and an indication of the value of the measurement or the function thereof.

The message may be sent over the Internet via the wireless network to a client
25 device using a peer-to-peer scheme. Alternatively or in addition, the message may be sent over the Internet via the wireless network to an Instant Messaging (IM) server for being sent to a client device as part of an IM service. The message or the communication with the IM server may use, may be compatible with, or may be based on, SMTP (Simple Mail Transfer Protocol), SIP (Session Initiation Protocol), SIMPLE (SIP for
30 Instant Messaging and Presence Leveraging Extensions), APEX (Application Exchange), Prim (Presence and Instance Messaging Protocol), XMPP (Extensible Messaging and Presence Protocol), IMPS (Instant Messaging and Presence Service), RTMP (Real Time Messaging Protocol), STM (Simple TCP/IP Messaging) protocol,

Azureus Extended Messaging Protocol, Apple Push Notification Service (APNs), or Hypertext Transfer Protocol (HTTP).

Alternatively or in addition, the message may be a text-based message and the IM service may be a text messaging service, and the message may be according to, may use, or may be based on, a Short Message Service (SMS) message, the IM service may be a SMS service, the message may be according to, or may be based on, an electronic-mail (e-mail) message and the IM service may be an e-mail service, the message may be according to, or may be based on, WhatsApp message and the IM service may be a WhatsApp service, the message may be according to, or may be based on, a Twitter message and the IM service may be a Twitter service, or the message may be according to, or may be based on, a Viber message and the IM service may be a Viber service. Alternatively or in addition, the message may be a Multimedia Messaging Service (MMS) or an Enhanced Messaging Service (EMS) message that may include audio or video, and the IM service may respectively be an NMS or EMS service. Alternatively or in addition, any notification herein may use a notification mechanism that is part of a mobile operating system, such as Apple iOS or Google Android operating system.

Any wireless network herein may be a Wireless Wide Area Network (WWAN), any wireless transceiver herein may be a WWAN transceiver, and any antenna herein may be a WWAN antenna. The WWAN may be a wireless broadband network, or may be a WiMAX network. Any antenna herein may be a WiMAX antenna, and any wireless transceiver herein may be a WiMAX modem, and the WiMAX network may be according to, may be compatible with, or may be based on, IEEE 802.16-2009. Alternatively or in addition, any wireless network herein may be a cellular telephone network, any antenna may be a cellular antenna, and any wireless transceiver may be a cellular modem. The cellular telephone network may be a Third Generation (3G) network that may use UMTS W-CDMA, UMTS HSPA, UMTS TDD, CDMA2000 1xRTT, CDMA2000 EV-DO, or GSM EDGE-Evolution, or the cellular telephone network may be a Fourth Generation (4G) network that uses HSPA+, Mobile WiMAX, LTE, LTE-Advanced, MBWA, or may be based on IEEE 802.20-2008.

Any wireless network herein may be a Wireless Personal Area Network (WPAN), any wireless transceiver may be a WPAN transceiver, and any antenna herein may be a WPAN antenna. The WPAN may be according to, may be compatible with, or may be based on, Bluetooth™ or IEEE 802.15.1-2005 standards, or the WPAN may be a

wireless control network that may be according to, or may be based on, ZigBee™, IEEE 802.15.4-2003, or Z-Wave™ standard.

Any wireless network herein may be a Wireless Local Area Network (WLAN), any wireless transceiver may be a WLAN transceiver, and any antenna herein may be a WLAN antenna. The WLAN may be according to, may be compatible with, or may be based on, IEEE 802.11-2012, IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, or IEEE 802.11ac. Any wireless network herein may use a licensed or unlicensed radio frequency band, and the unlicensed radio frequency band may be an Industrial, Scientific and Medical (ISM) radio band.

Any network herein may be a wireless network, the first port may be an antenna for transmitting and receiving first Radio-Frequency (RF) signals over the air, and the first transceiver may be a wireless transceiver coupled to the antenna for wirelessly transmitting and receiving first data over the air using the wireless network. Alternatively or in addition, the network may be a wired network, the first port may be a connector for connecting to the network medium, and the first transceiver may be a wired transceiver coupled to the connector for transmitting and receiving first data over the wireless medium.

Any wireless network herein may use a Dedicated Short-Range Communication (DSRC), that may be according to, compatible with, or based on, European Committee for Standardization (CEN) EN 12253:2004, EN 12795:2002, EN 12834:2002, EN 13372:2004, or EN ISO 14906:2004 standard, or may be according to, compatible with, or based on, IEEE 802.11p, IEEE 1609.1-2006, IEEE 1609.2, IEEE 1609.3, IEEE 1609.4, or IEEE1609.5.

Any apparatus or device herein may further comprise an actuator that converts electrical energy to affect or produce a physical phenomenon, the actuator may be coupled to be operated, controlled, or activated, by the processor, in response to a value of the first distance, the second distance, the first angle, or any combination, manipulation, or function thereof. The actuator may be housed in the single enclosure.

Any apparatus or device herein may further comprise a signal conditioning circuit coupled between the processor and the actuator. The signal conditioning circuit may be operative for attenuating, delaying, filtering, amplifying, digitizing, comparing, or manipulating a signal from the processor, and may comprise an amplifier, a voltage or current limiter, an attenuator, a delay line or circuit, a level translator, a galvanic isolator, an impedance transformer, a linearization circuit, a calibrator, a passive filter, an active

filter, an adaptive filter, an integrator, a deviator, an equalizer, a spectrum analyzer, a compressor or a de-compressor, a coder, a decoder, a modulator, a demodulator, a pattern recognizer, a smoother, a noise remover, an average circuit, a Digital-to-Analog (A/D) converter, or an RMS circuit.

5 The actuator may be electrically powered from a power source, and may convert electrical power from the power source to affect or produce the physical phenomenon. Each of the actuator, the signal conditioning circuit, and power source may be housed in, or may be external to, the single enclosure. The power source may be an Alternating Current (AC) or a Direct Current (DC) power source, and may be a primary or a
10 rechargeable battery, housed in a battery compartment.

 Alternatively or in addition, the power source may be a domestic AC power, such as nominally 120VAC / 60Hz or 230VAC / 50Hz, and the apparatus or device may further comprise an AC power plug for connecting to the domestic AC power. Any apparatus or device herein may further comprise an AC/DC adapter connected to the AC
15 power plug for being powered from the domestic AC power, and the AC/DC adapter may comprise a step-down transformer and an AC/DC converter for DC powering the actuator. Any apparatus or device herein may further comprise a switch coupled between the power source and the actuator, and the switch may be coupled to be controlled by the processor.

20 Any actuator herein may comprise, or may be part of, a water heater, HVAC device, air conditioner, heater, washing machine, clothes dryer, vacuum cleaner, microwave oven, electric mixer, stove, oven, refrigerator, freezer, food processor, dishwasher, food blender, beverage maker, coffeemaker, answering machine, telephone set, home cinema device, HiFi device, CD or DVD player, induction cooker, electric
25 furnace, trash compactor, electric shutter, or dehumidifier. Further, any actuator herein may comprise, may be part of, or may be integrated in part, or entirely, in an appliance.

 Any actuator herein may affect, create, or change the phenomenon that is associated with an object that is gas, air, liquid, or solid. Alternatively or in addition, any actuator herein may be operative to affect time-dependent characteristic that is a time-
30 integrated, an average, an RMS (Root Mean Square) value, a frequency, a period, a duty-cycle, a time-integrated, or a time-derivative, of the phenomenon. Alternatively or in addition, any actuator herein may be operative to affect space-dependent characteristic that is a pattern, a linear density, a surface density, a volume density, a flux density, a current, a direction, a rate of change in a direction, or a flow, of the phenomenon.

Any actuator herein may consist of, or may comprise, an electric light source that converts electrical energy into light, and may emit visible or non-visible light for illumination or indication, and the non-visible light may be infrared, ultraviolet, X-rays, or gamma rays. Any electric light source herein may consist of, or may comprise, a lamp, an incandescent lamp, a gas discharge lamp, a fluorescent lamp, a Solid-State Lighting (SSL), a Light Emitting Diode (LED), an Organic LED (OLED), a polymer LED (PLED), or a laser diode.

Any actuator herein may consist of, or may comprise, a motion actuator that causes linear or rotary motion, and any apparatus or device herein may further comprise a conversion mechanism that may be coupled to, attached to, or part of, the actuator for converting to rotary or linear motion based on a screw, a wheel and axle, or a cam. Any conversion mechanism herein may consist of, may comprise, or may be based on, a screw, and any apparatus or device herein may further comprise a leadscrew, a screw jack, a ball screw or a roller screw that may be coupled to, attached to, or part of, the actuator. Alternatively or in addition, any conversion mechanism herein may consist of, may comprise, or may be based on, a wheel and axle, and any apparatus or device herein may further comprise a hoist, a winch, a rack and pinion, a chain drive, a belt drive, a rigid chain, or a rigid belt that may be coupled to, attached to, or part of, the actuator. Any motion actuator herein may further comprise a lever, a ramp, a screw, a cam, a crankshaft, a gear, a pulley, a constant-velocity joint, or a ratchet, for effecting the motion. Alternatively or in addition, any motion actuator herein may consist of, or may comprise, a pneumatic, hydraulic, or electrical actuator, which may be an electrical motor.

Any electrical motor herein may be a brushed, a brushless, or an uncommutated DC motor, and any DC motor herein may be a stepper motor that may be a Permanent Magnet (PM) motor, a Variable reluctance (VR) motor, or a hybrid synchronous stepper. Alternatively or in addition, any electrical motor herein may be an AC motor that may be an induction motor, a synchronous motor, or an eddy current motor. Further, any AC motor herein may be a single-phase AC induction motor, a two-phase AC servo motor, or a three-phase AC synchronous motor, and may further be a split-phase motor, a capacitor-start motor, or a Permanent-Split Capacitor (PSC) motor. Alternatively or in addition, any electrical motor herein may be an electrostatic motor, a piezoelectric actuator, or is a MEMS-based motor. Alternatively or in addition, any motion actuator herein may consist of, or may comprise, a linear hydraulic actuator, a linear pneumatic

actuator, a linear induction electric motor (LIM), or a Linear Synchronous electric Motor (LSM). Alternatively or in addition, any motion actuator herein may consist of, or may comprise, a piezoelectric motor, a Surface Acoustic Wave (SAW) motor, a Squiggle motor, an ultrasonic motor, or a micro- or nanometer comb-drive capacitive actuator, a Dielectric or Ionic based Electroactive Polymers (EAPs) actuator, a solenoid, a thermal bimorph, or a piezoelectric unimorph actuator.

Any actuator herein may consist of, or may comprise, a compressor or a pump and may be operative to move, force, or compress a liquid, a gas or a slurry. Any pump herein may be a direct lift, an impulse, a displacement, a valveless, a velocity, a centrifugal, a vacuum, or a gravity pump. Further, any pump herein may be a positive displacement pump that may be a rotary lobe, a progressive cavity, a rotary gear, a piston, a diaphragm, a screw, a gear, a hydraulic, or a vane pump. Alternatively or in addition, any positive displacement pump herein may be a rotary-type positive displacement pump that is an internal gear, a screw, a shuttle block, a flexible vane, a sliding vane, a rotary vane, a circumferential piston, a helical twisted roots, or a liquid ring vacuum pump, may be a reciprocating-type positive displacement type that may be a piston, a diaphragm, a plunger, a diaphragm valve, or a radial piston pump, or may be a linear-type positive displacement type that may be a rope-and-chain pump. Alternatively or in addition, any pump herein may be an impulse pump that is a hydraulic ram, a pulser, or an airlift pump, may be a rotodynamic pump that may be a velocity pump, or may be a centrifugal pump that may be a radial flow, an axial flow, or a mixed flow pump. Any actuator herein may consist of, or may comprise, a display screen for visually presenting information.

Any display or any display screen herein may consist of, or may comprise, a monochrome, grayscale or color display and consists of an array of light emitters or light reflectors, or a projector that is based on an Eidophor, Liquid Crystal on Silicon (LCoS or LCOS), LCD, MEMS or Digital Light Processing (DLP™) technology. Any projector herein may consist of, or may comprise, a virtual retinal display. Further, any display or any display screen herein may consist of, or may comprise, a 2D or 3D video display that may support Standard-Definition (SD) or High-Definition (HD) standards, and may be capable of scrolling, static, bold or flashing the presented information.

Alternatively or in addition, any display or any display screen herein may consist of, or may comprise, an analog display having an analog input interface supporting NTSC, PAL or SECAM formats, and the analog input interface may include RGB, VGA

(Video Graphics Array), SVGA (Super Video Graphics Array), SCART or S-video interface. Alternatively or in addition, any display or any display screen herein may consist of, or may comprise, a digital display having a digital input interface that may include IEEE1394, FireWire™, USB, SDI (Serial Digital Interface), HDMI (High-
5 Definition Multimedia Interface), DVI (Digital Visual Interface), UDI (Unified Display Interface), DisplayPort, Digital Component Video or DVB (Digital Video Broadcast) interface. Alternatively or in addition, any display or any display screen herein may consist of, or may comprise, a Cathode-Ray Tube (CRT), a Field Emission Display (FED), an Electroluminescent Display (ELD), a Vacuum Fluorescent Display (VFD), or
10 an Organic Light-Emitting Diode (OLED) display, a passive-matrix (PMOLED) display, an active-matrix OLEDs (AMOLED) display, a Liquid Crystal Display (LCD) display, a Thin Film Transistor (TFT) display, an LED-backlit LCD display, or an Electronic Paper Display (EPD) display that may be based on Gyricon technology, Electro-Wetting Display (EWD), or Electrofluidic display technology. Alternatively or in addition, any
15 display or any display screen herein may consist of, or may comprise, a laser video display that is based on a Vertical-External-Cavity Surface-Emitting-Laser (VECSEL) or a Vertical-Cavity Surface-Emitting Laser (VCSEL). Further, any display or any display screen herein may consist of, or may comprise, a segment display based on a seven-segment display, a fourteen-segment display, a sixteen-segment display, or a dot
20 matrix display, and may be operative to display digits, alphanumeric characters, words, characters, arrows, symbols, ASCII, non-ASCII characters, or any combination thereof.

Any actuator herein may consist of, or may comprise, a thermoelectric actuator that may be a heater or a cooler, may be operative for affecting the temperature of a solid, a liquid, or a gas object, and may be coupled to the object by conduction,
25 convection, force convention, thermal radiation, or by the transfer of energy by phase changes. Any thermoelectric actuator herein may consist of, or may comprise, a cooler based on a heat pump driving a refrigeration cycle using a compressor-based electric motor, or an electric heater that may be a resistance heater or a dielectric heater. Further, any electric heater herein may consist of, or may comprise, an induction heater, and may
30 be solid-state based or may be an active heat pump that may use, or may be based on, the Peltier effect.

Any actuator herein may consist of, or may comprise, a chemical or an electrochemical actuator, and may be operative for producing, changing, or affecting a matter structure, properties, composition, process, or reactions. Any electrochemical

actuator herein may be operative for producing, changing, or affecting, an oxidation/reduction or an electrolysis reaction.

Any actuator herein may consist of, or may comprise, an electromagnetic coil or an electromagnet operative for generating a magnetic or electric field.

5 Any actuator herein may consist of, or may comprise, an electrical signal generator that may be operative to output repeating or non-repeating electronic signals, and the signal generator may be an analog signal generator having an analog voltage or analog current output, and the output of the analog signal generator may be a sine wave, a saw-tooth, a step (pulse), a square, or a triangular waveform, an Amplitude Modulation
10 (AM), a Frequency Modulation (FM), or a Phase Modulation (PM) signal. Further, the signal generator may be an Arbitrary Waveform Generator (AWG) or a logic signal generator.

Any actuator herein may consist of, or may comprise, a sounder for converting an electrical energy to omnidirectional, unidirectional, or bidirectional pattern of emitted,
15 audible or inaudible, sound waves. Any sounder herein may be audible, and may be an electromagnetic loudspeaker, a piezoelectric speaker, an electrostatic loudspeaker (ESL), a ribbon or planar magnetic loudspeaker, or a bending wave loudspeaker. Any sounder herein may be operative to emit a single or multiple tones, or may be operative to continuous or intermittent operation. Any sounder herein may be an electromechanical
20 or a ceramic-based, and may be an electric bell, a buzzer (or beeper), a chime, a whistle or a ringer. Any sound herein may be audible, and any sounder herein may be a loudspeaker, and any apparatus or device herein may be operative to store and play one or more digital audio content files.

Any system, device, module, or circuit herein may comprise an actuator that may
25 convert electrical energy to affect a phenomenon, the actuator may be coupled to the respective processor for affecting the phenomenon in response to a respective processor control, and may be connected to be powered by the respective DC power signal. The respective processor may be further coupled to operate, control, or activate the actuator in response to the state of the switch. The actuator may be a sounder for converting an
30 electrical energy to omnidirectional, unidirectional, or bidirectional pattern of emitted, audible or inaudible, sound waves, the sound may be audible, and the sounder may be an electromagnetic loudspeaker, a piezoelectric speaker, an electrostatic loudspeaker (ESL), a ribbon or planar magnetic loudspeaker, or a bending wave loudspeaker. Alternatively or in addition, the actuator may be an electric thermoelectric actuator that may be a

heater or a cooler, operative for affecting a temperature of a solid, a liquid, or a gas object, and may be coupled to the object by conduction, convection, force convention, thermal radiation, or by a transfer of energy by phase changes. The thermoelectric actuator may be a cooler based on a heat pump driving a refrigeration cycle using a compressor-based electric motor, or may be an electric heater that may be a resistance heater or a dielectric heater. Alternatively or in addition, the actuator may be a display for visually presenting information, and may be a monochrome, grayscale or color display, and may consist of an array of light emitters or light reflectors. The display may be a video display supporting Standard-Definition (SD) or High-Definition (HD) standard, and may be capable of scrolling, static, bold or flashing a presented information. Alternatively or in addition, the actuator may be a motion actuator that may cause linear or rotary motion, and the system may further comprise a conversion mechanism for respectfully converting to rotary or linear motion based on a screw, a wheel and axle, or a cam. The motion actuator may be a pneumatic, hydraulic, or electrical actuator, and may be an AC or a DC electrical motor.

Any system, device, module, or circuit herein may be addressable in a wireless network (such as the Internet) using a digital address that may be a MAC layer address that may be MAC-48, EUI-48, or EUI-64 address type, or may be a layer 3 address and may be a static or dynamic IP address that may be of IPv4 or IPv6 type address. Any system, device, or module herein may be further configured as a wireless repeater, such as a WPAN, WLAN, or a WWAN repeater.

Any system, device, module, or circuit herein may further be operative to send a notification message over a wireless network using the first or second transceiver via the respective first or second antenna. The system may be operative to periodically sending multiple notification messages, such as substantially every 1, 2, 5, or 10 seconds, every 1, 2, 5, or 10 minutes, every 1, 2, 5, or 10 hours, or every 1, 2, 5, or 10 days. Alternatively or in addition, any system, device, module, or circuit herein may further comprise a sensor having an output and responsive to a physical phenomenon, and the message may be sent in response to the sensor output. Any system herein may be uses with a minimum or maximum threshold, and the message may be sent in response to the sensor output value respectively below the minimum threshold or above the maximum threshold. The sent message may comprise an indication of the time when the threshold was exceeded, and an indication of the value of the sensor output.

Any message herein may comprise the time of the message and the controlled switch status, and may be sent over the Internet via the wireless network to a client device using a peer-to-peer scheme. Alternatively or in addition, any message herein may be sent over the Internet via the wireless network to an Instant Messaging (IM) server for being sent to a client device as part of an IM service. The message or the communication with the IM server may use, may be compatible with, or may be based on, SMTP (Simple Mail Transfer Protocol), SIP (Session Initiation Protocol), SIMPLE (SIP for Instant Messaging and Presence Leveraging Extensions), APEX (Application Exchange), Prim (Presence and Instance Messaging Protocol), XMPP (Extensible Messaging and Presence Protocol), IMPS (Instant Messaging and Presence Service), RTMP (Real Time Messaging Protocol), STM (Simple TCP/IP Messaging) protocol, Azureus Extended Messaging Protocol, Apple Push Notification Service (APNs), or Hypertext Transfer Protocol (HTTP). The message may be a text-based message and the IM service may be a text messaging service, and may be according to, may be compatible with, or may be based on, a Short Message Service (SMS) message and the IM service may be a SMS service, the message may be according to, may be compatible with, or based on, an electronic-mail (e-mail) message and the IM service may be an e-mail service, the message may be according to, may be compatible with, or based on, WhatsApp message and the IM service may be a WhatsApp service, the message may be according to, may be compatible with, or based on, a Twitter message and the IM service may be a Twitter service, or the message may be according to, may be compatible with, or based on, a Viber message and the IM service may be a Viber service. Alternatively or in addition, the message may be a Multimedia Messaging Service (MMS) or an Enhanced Messaging Service (EMS) message that includes audio or video data, and the IM service may respectively be a MMS or EMS service.

Any wireless network herein may be a Wireless Personal Area Network (WPAN), the wireless transceiver may be a WPAN transceiver, and the antenna may be a WPAN antenna, and further the WPAN may be according to, may be compatible with, or may be based on, Bluetooth™ or IEEE 802.15.1-2005 standards, or the WPAN may be a wireless control network that may be according to, may be compatible with, or may be based on, ZigBee™, IEEE 802.15.4-2003 or Z-Wave™ standards. Alternatively or in addition, the wireless network may be a Wireless Local Area Network (WLAN), the wireless transceiver may be a WLAN transceiver, and the antenna may be a WLAN antenna, and further the WLAN may be according to, or base on, IEEE 802.11-2012,

IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, or IEEE 802.11ac. The wireless network may use a licensed or unlicensed radio frequency band, and the unlicensed radio frequency band may be an Industrial, Scientific and Medical (ISM) radio band. Alternatively or in addition, the wireless network may be a Wireless Wide Area Network (WWAN), the wireless transceiver may be a WWAN transceiver, and the antenna may be a WWAN antenna, and the WWAN may be a wireless broadband network or a WiMAX network, where the antenna may be a WiMAX antenna and the wireless transceiver may be a WiMAX modem, and the WiMAX network may be according to, may be compatible with, or may be based on, IEEE 802.16-2009. Alternatively or in addition, the wireless network may be a cellular telephone network, the antenna may be a cellular antenna, and the wireless transceiver may be a cellular modem, and the cellular telephone network may be a Third Generation (3G) network that uses UMTS W-CDMA, UMTS HSPA, UMTS TDD, CDMA2000 1xRTT, CDMA2000 EV-DO, or GSM EDGE-Evolution. Alternatively or in addition, the cellular telephone network may be a Fourth Generation (4G) network that uses HSPA+, Mobile WiMAX, LTE, LTE-Advanced, MBWA, or may be based on IEEE 802.20-2008.

Any network herein may be a vehicle network, such as a vehicle bus or any other in-vehicle network. A connected element comprises a transceiver for transmitting to, and receiving from, the network. The physical connection typically involves a connector coupled to the transceiver. The vehicle bus may consist of, may comprise, may be compatible with, may be based on, or may use a Controller Area Network (CAN) protocol, specification, network, or system. The bus medium may consist of, or comprise, a single wire, or a two-wire such as an UTP or a STP. The vehicle bus may employ, may use, may be compatible with, or may be based on, a multi-master, serial protocol using acknowledgement, arbitration, and error-detection schemes, and may further use synchronous, frame-based protocol.

The network data link and physical layer signaling may be according to, compatible with, based on, or use, ISO 11898-1:2015. The medium access may be according to, compatible with, based on, or use, ISO 11898-2:2003. The vehicle bus communication may further be according to, compatible with, based on, or use, any one of, or all of, ISO 11898-3:2006, ISO 11898-2:2004, ISO 11898-5:2007, ISO 11898-6:2013, ISO 11992-1:2003, ISO 11783-2:2012, SAE J1939/11_201209, SAE J1939/15_201508, or SAE J2411_200002 standards. The CAN bus may consist of, may

be according to, may be compatible with, may be based on, or may use a CAN with Flexible Data-Rate (CAN FD) protocol, specification, network, or system.

Alternatively or in addition, the vehicle bus may consist of, may comprise, may be based on, may be compatible with, or may use a Local Interconnect Network (LIN) protocol, network, or system, and may be according to, may be compatible with, may be based on, or may use any one of, or all of, ISO 9141-2:1994, ISO 9141:1989, ISO 17987-1, ISO 17987-2, ISO 17987-3, ISO 17987-4, ISO 17987-5, ISO 17987-6, or ISO 17987-7 standards. The battery power-lines or a single wire may serve as the network medium, and may use a serial protocol where a single master controls the network, while all other connected elements serve as slaves.

Alternatively or in addition, the vehicle bus may consist of, may comprise, be compatible with, may be based on, or may use a FlexRay protocol, specification, network or system, and may be according to, may be compatible with, may be based on, or may use any one of, or all of, ISO 17458-1:2013, ISO 17458-2:2013, ISO 17458-3:2013, ISO 17458-4:2013, or ISO 17458-5:2013 standards. The vehicle bus may support a nominal data rate of 10Mb/s, and may support two independent redundant data channels, as well as independent clock for each connected element.

Alternatively or in addition, the vehicle bus may consists of, comprise, be compatible with, may be based on, or may use a Media Oriented Systems Transport (MOST) protocol, network or system, and may be according to, may be compatible with, may be based on, or may use any one of, or all of, MOST25, MOST50, or MOST150. The vehicle bus may employ a ring topology, where one connected element may be the timing master that continuously transmits frames where each comprises a preamble used for synchronization of the other connected elements. The vehicle bus may support both synchronous streaming data as well as asynchronous data transfer. The network medium may be wires (such as UTP or STP), or may be an optical medium such as Plastic Optical Fibers (POF) connected via an optical connector.

The above summary is not an exhaustive list of all aspects of the present invention. Indeed, the inventor contemplates that his invention includes all systems and methods that can be practiced from all suitable combinations and derivatives of the various aspects summarized above, as well as those disclosed in the detailed description below, and particularly pointed out in the claims filed with the application. Such combinations have particular advantages not specifically recited in the above summary.

BRIEF DESCRIPTION OF THE DRAWINGS

Various aspects of the system and method are herein described, by way of non-limiting examples only, with reference to the accompanying drawings, wherein like designations denote like elements. Understanding that these drawings only provide
5 information concerning typical embodiments of the invention and are not therefore to be considered limiting in scope:

FIG. 1 illustrates a simplified schematic block diagram of a prior-art electronics architecture of a vehicle;

FIG. 2 illustrates a simplified schematic block diagram of a prior-art Electronic
10 Control Unit (ECU);

FIG. 3 illustrates a simplified schematic block diagram of a system for a server communicating with various vehicles;

FIG. 4 illustrates a table of the various classification levels of autonomous car is according to the Society of Automotive Engineers (SAE) J3016 standard;

FIG. 5 illustrates a simplified schematic flow chart of a method for affecting a
15 vehicle based on an exception detected by a sensor in other vehicle;

FIG. 5a illustrates a simplified schematic flow chart of a method for affecting a vehicle based on an exception determined by a server based on sensor data in other vehicle; and

FIG. 6 illustrates a simplified schematic block diagram of messages flow in a
20 system for affecting a vehicle based on an exception detected by a sensor in other vehicle.

DETAILED DESCRIPTION

25 The principles and operation of an apparatus according to the present invention may be understood with reference to the figures and the accompanying description wherein similar components appearing in different figures are denoted by identical reference numerals. The drawings and descriptions are conceptual only. In actual practice, a single component can implement one or more functions; alternatively or in
30 addition, each function can be implemented by a plurality of components and devices. In the figures and descriptions, identical reference numerals indicate those components that are common to different embodiments or configurations. Identical numerical references (even in the case of using different suffix, such as **5**, **5a**, **5b** and **5c**) refer to functions or

actual devices that are either identical, substantially similar, or having similar functionality. It will be readily understood that the components of the present invention, as generally described and illustrated in the figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of the apparatus, system, and method of the present invention, as represented in the figures herein, is not intended to limit the scope of the invention, as claimed, but is merely the representative embodiments of the invention. It is to be understood that the singular forms "a," "an," and "the" herein include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a component surface" includes reference to one or more of such surfaces. By the term "substantially" it is meant that the recited characteristic, parameter, or value need not be achieved exactly, but that deviations or variations, including for example, tolerances, measurement error, measurement accuracy limitations and other factors known to those of skill in the art, may occur in amounts that do not preclude the effect the characteristic was intended to provide.

Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as "first," "second," and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

Spatially relative terms, such as "inner," "outer," "beneath," "below," "right," "left," "upper," "lower," "above," , "front", "rear" "left", "right" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the example term "below" can encompass both an orientation of above and below. The

device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

Any vehicle herein may be a ground vehicle adapted to travel on land, such as a bicycle, a car, a motorcycle, a train, an electric scooter, a subway, a train, a trolleybus, or a tram. Alternatively or in addition, the vehicle may be a buoyant or submerged watercraft adapted to travel on or in water, and the watercraft may be a ship, a boat, a hovercraft, a sailboat, a yacht, or a submarine. Alternatively or in addition, the vehicle may be an aircraft adapted to fly in air, and the aircraft may be a fixed wing or a rotorcraft aircraft, such as an airplane, a spacecraft, a glider, a drone, or an Unmanned Aerial Vehicle (UAV).

Any apparatus, device, sensor, or actuator, or any part thereof, may be mounted onto, may be attached to, may be part of, or may be integrated with, a rear or front view camera, chassis, lighting system, headlamp, door, car glass, windscreen, side or rear window, glass panel roof, hood, bumper, cowling, dashboard, fender, quarter panel, rocker, or a spoiler of a vehicle.

Any vehicle herein may further comprise an Advanced Driver Assistance Systems (ADAS) functionality, system, or scheme, and any apparatus, device, sensor, or actuator herein may be part of, may be integrated with, may be communicating with, or may be coupled to, the ADAS functionality, system, or scheme. The ADAS functionality, system, or scheme may consist of, may comprise, or may use, Adaptive Cruise Control (ACC), Adaptive High Beam, Glare-free high beam and pixel light, Adaptive light control such as swiveling curve lights, Automatic parking, Automotive navigation system with typically GPS and TMC for providing up-to-date traffic information, Automotive night vision, Automatic Emergency Braking (AEB), Backup assist, Blind Spot Monitoring (BSM), Blind Spot Warning (BSW), Brake light or traffic signal recognition, Collision avoidance system, Pre-crash system, Collision Imminent Braking (CIB), Cooperative Adaptive Cruise Control (CACC), Crosswind stabilization, Driver drowsiness detection, Driver Monitoring Systems (DMS), Do-Not-Pass Warning (DNPW), Electric vehicle warning sounds used in hybrids and plug-in electric vehicles, Emergency driver assistant, Emergency Electronic Brake Light (EEBL), Forward Collision Warning (FCW), Heads-Up Display (HUD), Intersection assistant, Hill descent control, Intelligent speed adaptation or Intelligent Speed Advice (ISA), Intelligent Speed Adaptation (ISA), Intersection Movement Assist (IMA), Lane Keeping Assist (LKA), Lane Departure Warning (LDW) (a.k.a. Line Change Warning - LCW), Lane change

assistance, Left Turn Assist (LTA), Night Vision System (NVS), Parking Assistance (PA), Pedestrian Detection System (PDS), Pedestrian protection system, Pedestrian Detection (PED), Road Sign Recognition (RSR), Surround View Cameras (SVC), Traffic sign recognition, Traffic jam assist, Turning assistant, Vehicular communication systems, Autonomous Emergency Braking (AEB), Adaptive Front Lights (AFL), or Wrong-way driving warning.

Any vehicle herein may further employ an Advanced Driver Assistance System Interface Specification (ADASIS) functionality, system, or scheme, and any sensor or actuator herein may be part of, integrated with, communicates with, or coupled to, the ADASIS functionality, system, or scheme. Further, any message herein may comprise a map data relating to the location of a respective vehicle.

An arrangement **30** of vehicles communicating with a server **32** is shown in FIG. 3. A vehicle **11a**, shown as a truck, includes an actuator **15c**, which may be connected to an ECU and accessed via an internal vehicle bus. A vehicle **11b** includes a sensor **14c**, which may be connected to an ECU and accessed via an internal vehicle bus. Similarly, a vehicle **11c** includes an actuator **15d**, which may be connected to an ECU and accessed via an internal vehicle bus. The vehicle **11a** communicates with the server **32** over the Internet **31** via a wireless network **9a**, the vehicle **11b** communicates with the server **32** over the Internet **31** via a wireless network **9b**, and the vehicle **11c** communicates with the server **32** over the Internet **31** via a wireless network **9c**. The server **32** may further communicate with a client device, such as a smartphone **35**, over the Internet **31** via a wireless network **9d**. Any two or more of the wireless networks **9a**, **9b**, **9c**, and **9d** may be the same network, or may be identical or similar networks. Alternatively or in addition, any two or more of the wireless networks **9a**, **9b**, **9c**, and **9d** may be different, such as using different protocols or frequency bands. Each of the of the wireless networks **9a**, **9b**, **9c**, and **9d** may be WWAN, WLAN, or WPAN. The server **32** may store record as part of a record set **34**, which may be stored in a database **33** that is part of a memory that may be integrated with, or connected to, the server **32**.

Each of the vehicles **11a**, **11b**, and **11c** may be identified using an identifier uniquely identifying the vehicle, which may comprise a Vehicle Identification Number (VIN) or a license plate number, or may comprise a code that identifies the vehicle make, model, color, model year, engine size, or vehicle type. Alternatively or in addition, the identifier of a vehicle may be a digital address such as a layer 3 address that may be a static or dynamic IP address, preferably using IPv4 or IPv6 type address.

Alternatively or in addition, the digital address is a MAC layer address selected from the group consisting of MAC-48, EUI-48, and EUI-64 address type.

Any vehicle may estimate its geographical location. Such localization may be used with multiple RF signals transmitted by multiple sources, and the geographical location may be estimated by receiving the RF signals from the multiple sources via one or more antennas, and processing or comparing the received RF signals. The multiple sources may comprise geo-stationary or non-geo-stationary satellites, that may be Global Positioning System (GPS), and the RF signals may be received using a GPS antenna coupled to the GPS receiver 17 for receiving and analyzing the GPS signals. Alternatively or in addition, the multiple sources comprises satellites may be part of a Global Navigation Satellite System (GNSS), such as the GLONASS (GLObal NAVigation Satellite System), the Beidou-1, the Beidou-2, the Galileo, or the IRNSS/VAVIC.

Alternatively or in addition, the processing or comparing may comprise, or may be based on, performing TOA (Time-Of-Arrival) measurement, performing TDOA (Time Difference-Of-Arrival) measurement, performing an AoA (Angle-Of-Arrival) measurement, performing a Line-of-Sight (LoS) measurement, performing a Time-of-Flight (ToF) measurement, performing a Two-Way Ranging (TWR) measurement, performing a Symmetrical Double Sided – Two Way Ranging (SDS-TWR) measurement, performing a Near-field electromagnetic ranging (NFER) measurement, or performing triangulation, trilateration, or multilateration (MLAT). Alternatively or in addition, the RF signals may be part of the communication over a wireless network in which the vehicle, apparatus, or device is communicating over. The wireless network may be a cellular telephone network, and the sources may be cellular towers or base-stations. Alternatively or in addition, the wireless network may be a WLAN, and the sources may be hotspots or Wireless Access Points (WAPs). Alternatively or in addition, the geographical location may be estimated using, or based on, geolocation, which may be is based on W3C Geolocation API. Any geographical location herein may consist of, or may comprise, a country, a region, a city, a street, a ZIP code, latitude, or longitude.

A flow-chart 50 of an exemplary method of the system 30 operation is shown in FIG. 5, and a corresponding messages flow 60 is described in FIG. 6. The vehicle 11b may execute a flow chart 50a that is part of the flow chart 50. The sensor 14c output is received as part of a “Receive Sensor Data” step 51, and is continuously monitored as part of a “Exception ?” step 52. In the case where the output is within normal or pre-

defined limits, an 'Exception' state is not declared, and the vehicle **11b** continues to monitor the sensor **14c** status. Upon sensing of anomaly or exceeding a pre-defined limit or threshold, the event is notified to the server **32**, as part of a "Send Data To Server" step **53**, shown as message path **62a** in the arrangement **60** in FIG. 6.

5 The message sent over the message path **62a** from the vehicle **11b** to the server **32** may include an identifier of the vehicle **11b**, the current or former location of the vehicle **11b**, the sensor **14c** identification, such as the type and the phenomenon sensed. Further, the message is timestamped to include the time of the sensing of the exception in the "Exception ?" step **52**, or of the message sending as part of the "Send Data To Server" step **53**. The message sent over the message path **62a** from the vehicle **11b** to the server **32** may include the current or former geographical location of the vehicle **11b**.

10 While the flow chart **50a** (or **50'a**) was exemplified using a single sensor, any number of sensor may be used. As part of the "Receive Sensor Data" **51**, the data from the multiple sensors is received, and checked as part of the "Exception ?" step **52**. The data from the multiple sensors may be sent to the server **32** as part of the "Send Data To Server" step **53**. The flow chart **50b** (or **50'b**) executed by the server **32** may operate in response to the multiple sensors data. While the flow chart **50a** (or **50'a**) was exemplified as being executed by a single vehicle **11b**, any number of vehicles may be used, having one or more sensors in each vehicle. Each of the vehicles may independently execute the flow chart **50a** (or **50'a**), and the flow chart **50b** (or **50'b**) executed by the server **32** may operate in response to the multiple sensors data received from the multiple vehicles.

15 The server **32** may execute the flow chart **50b** that is part of the flow chart **50**. As part of a "Receive Data" step **54**, the data sent from the vehicle **11b** over the path **62a** is received by the server **32**. The received data may be stored as a record in the records set **34** in the database **33** associated with the server **32** as part of a "Store Record" step **56**. Further, the received data may be processed by the server **32** as part of a "Process Data" step **55**. As result of the processing in the "Process Data" step **55**, the server **32** may send a notification message to a client device as part of a "Notify Users" step **58b**, such as the smartphone **35**, over a message path **62e**. Such a notification message may include part or all of the information received from the vehicle **11b** as part of the "Receive Data" step **54**.

20 The notification message may be a text-based message and the IM service may be a text messaging service, and the notification message may be according to, may use, or may be based on, a Short Message Service (SMS) message, the IM service may be a

SMS service, the notification message may be according to, or may be based on, an electronic-mail (e-mail) message and the IM service may be an e-mail service, the notification message may be according to, or may be based on, WhatsApp message and the IM service may be a WhatsApp service, the notification message may be according to, or may be based on, a Twitter message and the IM service may be a Twitter service, or the message may be according to, or may be based on, a Viber message and the IM service may be a Viber service. Alternatively or in addition, the notification message may be a Multimedia Messaging Service (MMS) or an Enhanced Messaging Service (EMS) message that may include audio or video, and the IM service may respectively be an NMS or EMS service.

Alternatively or addition, the notification mechanism may use using notification services or applications provided by the operating system in the client device. For example, the iOS operating system provides remote notifications feature service named Push Notification service (APNs), described in Local and Remote Notification Programming Guide chapter of Apple Developer guide available at web site developer.apple.com/library/content/documentation/NetworkingInternet/Conceptual/RemoteNotificationsPG/APNSOverview.html#//apple_ref/doc/uid/TP40008194-CH8-SW1 (preceded by <http://>) updated 2017-03-27 and downloaded 7-2017, which is incorporated in its entirety for all purposes as if fully set forth herein. Similarly, Android provides API for notifications as described in Android developers guide at web site developer.android.com/guide/topics/ui/notifiers/notifications.html (preceded by <http://>), downloaded 7-2017, which is incorporated in its entirety for all purposes as if fully set forth herein.

The server **32** may store in its associated memory or in the database **33** a list of vehicles. Alternatively or addition, these list is accessed by the server **32** from other servers or databases over the Internet. As part of a “Select Vehicle Group” step **57**, the server **32** selects a group of vehicles from the list. Preferably, the selected vehicles in the group may benefit, utilize, or otherwise benefit from the information received from the sensor **14c** of the vehicle **11b**. Preferably, the vehicles are selected based on their location, such as selecting vehicles that are at the vicinity of the vehicle **11b**. As part of a “Send to Group” step **58a**, the server **32** sends a message to the selected vehicle. In the example shown as the arrangement **60** in FIG. 6, assuming that the vehicles **11a**, **11b** and **11c** are selected, the message is sent to the vehicle **11a** over a message path **62b**, to the vehicle **11b** over a message path **62c**, and to the vehicle **11c** over a message path

62d. In a case where only the vehicle **11c** is selected, the message may be only sent to the vehicle **11c** over the message path **62d**, while the message paths **62b** and **62c** are not operative.

The exception or anomaly was exemplified above, in the flow-chart **50**, to be detected or determined by the vehicle **11b** having the sensor **14c**. Alternatively or in addition, the exception or anomaly may be detected or determined by the server **32**, as described in a flow-chart **50'** shown in FIG. 5a. The vehicle **11b** may execute a flow chart **50'a** that is part of the flow chart **50'**, where all sensed data is sent to the server **32**, and no determination is made in the sensing vehicle **11b** itself. In one example, the sensor **14c** output, either as raw data or manipulated, is periodically sent over the message path **62a** to the server **32**. For example, the sensor data (or any manipulation thereof) may be sent to the server **32** periodically, repeating in less than 1 second, 2 seconds, 5 seconds, 10 seconds, 20 seconds, 30 seconds, 50 seconds, 100 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes, 22 minutes, 30 minutes, 50 minutes, 100 minutes, 1 hour, 2 hours, 5 hours, 10 hours, 20 hours, 30 hours, 50 hours, 100 hours, 1 day, 2 days, 5 days, 10 days, 22 days, 30 days, 50 days, or 100 days. Alternatively or in addition, the time period may be more than 1 second, 2 seconds, 5 seconds, 10 seconds, 20 seconds, 30 seconds, 50 seconds, 100 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes, 22 minutes, 30 minutes, 50 minutes, 100 minutes, 1 hour, 2 hours, 5 hours, 10 hours, 20 hours, 30 hours, 50 hours, 100 hours, 1 day, 2 days, 5 days, 10 days, 22 days, 30 days, 50 days, or 100 days. The exception or anomaly is determined by the server **32** as part of the "Exception ?" step **52**, being executed as part of the flow chart **50'b** by the server **32**.

Each of the selected vehicles, such as the vehicles **11a** and **11c**, may execute a flow chart **50c** that is part of the flow chart **50**. The message sent by the server **32** as part of the "Send To Group" step **58a** is received by a selected vehicle as part of a "Receive Message" step **59**, and is acted upon by the receiving selected vehicle as part of a "Take Action" step **61**. In one example, the selected vehicle use the received message, or any manipulation thereof, to notify the driver of the vehicle, such as displaying information, alert, or notification on a display, such as the dashboard display **16** of the selected vehicle, as part of a "Display to Driver" step **61a**. Alternatively or in addition, the information received from the server **32** may be used to control, activate, de-activate, limit, or otherwise affect an actuator in the selected vehicle as part of an "Affect Actuator" step **61b**. For example, the actuator **15c** of the vehicle **11a** or the actuator **15d**

of the vehicle **11c**, may be affected in response to the information received over the respective message paths **62b** and **62d**.

Any element capable of measuring or responding to a physical phenomenon may be used as a sensor. An appropriate sensor may be adapted for a specific physical phenomenon, such as a sensor responsive to temperature, humidity, pressure, audio, vibration, light, motion, sound, proximity, flow rate, electrical voltage, and electrical current.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be an image sensor, for capturing an image (still or video). The respective controller may respond to characteristics or events extracted by image processing of the captured image or video. For example, the image processing may be face detection, face recognition, gesture recognition, compression or de-compression, or motion sensing. In another aspect, one of the sensors may be a microphone for capturing a human voice. The controller responds to characteristics or events extracted by voice processing of the captured audio. The voice processing functionality may include compression or de-compression.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be an analog sensor having an analog signal output such as analog voltage or current, or may have continuously variable impedance. Alternatively on in addition, the sensor may have a digital signal output. The sensor may serve as a detector, notifying only the presence of a phenomenon, such as by a switch, and may use a fixed or settable threshold level. The sensor may measure time-dependent or space-dependent parameters of a phenomenon. The sensor may measure time-dependencies or a phenomenon such as the rate of change, time-integrated or time-average, duty-cycle, frequency or time period between events. The sensor may be a passive sensor, or an active sensor requiring an external source of excitation. The sensor may be semiconductor-based, and may be based on MEMS technology.

The sensor may measure the amount of a property or of a physical quantity, or the magnitude relating to a physical phenomenon, body, or substance. Alternatively or in addition, a sensor may be used to measure the time derivative thereof, such as the rate of change of the amount, the quantity or the magnitude. In the case of space related quantity or magnitude, a sensor may measure the linear density, surface density, or volume density, relating to the amount of property per volume. Alternatively or in addition, a sensor may measure the flux (or flow) of a property through a cross-section or surface boundary, the flux density, or the current. In the case of a scalar field, a sensor

may measure the quantity gradient. A sensor may measure the amount of property per unit mass or per mole of substance. A single sensor may be used to measure two or more phenomena.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be an electrochemical sensor that is used to measure, sense or detect a matter structure, properties, composition, and reactions. In one example, the sensor is a pH meter for measuring the pH (acidity or alkalinity) of a liquid. Commonly such pH meter comprises a pH probe, which measures pH as the activity of the hydrogen cations at the tip of a thin-walled glass bulb. In one example, the electrochemical sensor is a gas detector, which detects the presence or various gases within an area, usually as part of a safety system, such as for detecting gas leak. Normally gas detectors are used to detect combustible, flammable, or toxic gases, as well as oxygen depletion, using semiconductors, oxidation, catalytic, infrared or other detection mechanisms, and capable to detect a single gas or several gases. Further, an electrochemical sensor may be an electrochemical gas sensor, used to measure the concentration of a target gas, typically by oxidation or reducing the target gas at an electrode, and measuring the resulting current. The gas sensor may be a hydrogen sensor for measuring or detecting the presence of hydrogen, commonly based on palladium-based electrodes, or a Carbon-Monoxide detector (CO Detector) used to detect the presence of carbon-monoxide, commonly in order to prevent carbon monoxide poisoning. A Carbon-Monoxide detector may be according to, or based on, the sensor described in U.S. Patent No. 8,016,205 to Drew, entitled: "*Thermostat with Replaceable Carbon Monoxide Sensor Module*", in U.S. Patent Application Publication No. 2010/0201531 to Pakravan *et al.*, entitled: "*Carbon Monoxide Detector*", in U.S. Patent No. 6,474,138 to Chang *et al.*, entitled: "*Adsorption Based Carbon Monoxide sensor and Method*", or in U.S. Patent No. 5,948,965 to Upchurch, entitled: "*Solid State Carbon Monoxide Sensor*", which are all incorporated in their entirety for all purposes as if fully set forth herein. The gas sensor may be an oxygen sensor (a.k.a. lambda sensor) for measuring the proportion of oxygen (O₂) in a gas or liquid.

In one example, each of the sensors **14a**, **14b**, or **14c** (or all of them) may be a smoke detector, for detecting smoke, which is typically an indication of fire. The smoke detectors work either by optical detection (photoelectric) or by physical process (ionization), while some use both detection methods to increase sensitivity to smoke. An optical based smoke detector is based on a light sensor, and includes a light source (incandescent bulb or infrared LED), a lens to collimate the light into a beam, and a

photodiode or other photoelectric sensor at an angle to the beam as a light detector. In the absence of smoke, the light passes in front of the detector in a straight line. When smoke enters the optical chamber across the path of the light beam, some light is scattered by the smoke particles, directing it at the sensor and thus triggering the alarm.

5 An ionization type smoke detector can detect particles of smoke that are too small to be visible, and use a radioactive element such as americium-241 (^{241}Am). The radiation passes through an ionization chamber, an air-filled space between two electrodes, and permits a small, constant current between the electrodes. Any smoke that enters the chamber absorbs the alpha particles, which reduces the ionization and interrupts this
10 current, setting off the alarm. Some smoke alarms use a carbon-dioxide sensor or carbon-monoxide sensor to detect extremely dangerous products of combustion. In one example, the TeX module **32** may be integrated with a smoke detector assembly, which is typically housed in a disk-shaped plastic enclosure, which may be about 150 millimeters (6 inch) in diameter and 25 millimeters (1 inch) thick, and is commonly
15 mounted on a ceiling or on a wall.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be thermoelectric sensor, for measuring, sensing or detecting the temperature (or the temperature gradient) of an object, which may be solid, liquid, or gas. Such sensor may be a thermistor (either PTC or NTC), a thermocouple, a quartz thermometer, or an RTD. The sensor may be
20 based on a Geiger counter for detecting and measuring radioactivity or any other nuclear radiation. Light, photons, or other optical phenomena may be measured or detected by a photosensor or photodetector, used for measuring the intensity of visible or invisible light (such as infrared, ultraviolet, X-ray or gamma rays). A photosensor may be based on the photoelectric or the photovoltaic effect, such as a photodiode, a phototransistor,
25 solar cell or a photomultiplier tube. A photosensor may be a photoresistor based on photoconductivity, or a CCD where a charge is affected by the light. The sensor may be an electrochemical sensor used to measure, sense or detect a matter structure, properties, composition, and reactions, such as pH meters, gas detector, or gas sensor. Using
semiconductors, oxidation, catalytic, infrared or other sensing or detection mechanisms,
30 gas detector may be used to detect the presence of a gas (or gases) such as hydrogen, oxygen or CO. The sensor may be a smoke detector for detecting smoke or fire, typically by an optical detection (photoelectric) or by a physical process (ionization).

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be a physiological sensor for measuring, sensing or detecting parameters of a live body, such as animal or

human body. Such a sensor may involve measuring of body electrical signals such as an EEG or ECG sensor, a gas saturation sensor such as oxygen saturation sensor, mechanical or physical parameter sensors such as a blood pressure meter. The sensor (or sensors) may be external to the sensed body, implanted inside the body, or may be wearable. The sensor may be an electracoustic sensor for measuring, sensing or detecting sound, such as a microphone. Typically microphones are based on converting audible or inaudible (or both) incident sound to an electrical signal by measuring the vibration of a diaphragm or a ribbon. The microphone may be a condenser microphone, an electret microphone, a dynamic microphone, a ribbon microphone, a carbon microphone, or a piezoelectric microphone.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be an image sensor for providing digital camera functionality, allowing an image (either as still images or as a video) to be captured, stored, manipulated and displayed. The image capturing hardware integrated with the sensor unit may contain a photographic lens (through a lens opening) focusing the required image onto a photosensitive image sensor array disposed approximately at an image focal point plane of the optical lens, for capturing the image and producing electronic image information representing the image. The image sensor may be based on Charge-Coupled Devices (CCD) or Complementary Metal–Oxide–Semiconductor (CMOS). The image may be converted into a digital format by an image sensor AFE (Analog Front End) and an image processor, commonly including an analog to digital (A/D) converter coupled to the image sensor for generating a digital data representation of the image. The unit may contain a video compressor, coupled between the analog to digital (A/D) converter and the transmitter for compressing the digital data video before transmission to the communication medium. The compressor may be used for lossy or non-lossy compression of the image information, for reducing the memory size and reducing the data rate required for the transmission over the communication medium. The compression may be based on a standard compression algorithm such as JPEG (Joint Photographic Experts Group) and MPEG (Moving Picture Experts Group), ITU-T H.261, ITU-T H.263, ITU-T H.264, or ITU-T CCIR 601.

The digital data video signal carrying a digital data video according to a digital video format, and a transmitter coupled between the port and the image processor for transmitting the digital data video signal to the communication medium. The digital video format may be based on one out of: TIFF (Tagged Image File Format), RAW format, AVI (Audio Video Interleaved), DV, MOV, WMV, MP4, DCF (Design Rule for

Camera Format), ITU-T H.261, ITU-T H.263, ITU-T H.264, ITU-T CCIR 601, ASF, Exif (Exchangeable Image File Format), and DPOF (Digital Print Order Format) standards.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be a strain gauge, used to measure the strain, or any other deformation, of an object. The sensor may be based on deforming a metallic foil, semiconductor strain gauge (such as piezoresistors), measuring the strain along an optical fiber, capacitive strain gauge, and vibrating or resonating of a tensioned wire. A sensor may be a tactile sensor, being sensitive to force or pressure, or being sensitive to a touch by an object, typically a human touch. A tactile sensor may be based on a conductive rubber, a lead zirconate titanate (PZT) material, a Polyvinylidene Fluoride (PVDF) material, a metallic capacitive element, or any combination thereof. A tactile sensor may be a tactile switch, which may be based on the human body conductance, using measurement of conductance or capacitance.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be a piezoelectric sensor, where the piezoelectric effect is used to measure pressure, acceleration, strain or force, and may use transverse, longitudinal, or shear effect mode. A thin membrane may be used to transfer and measure pressure, while mass may be used for acceleration measurement. A piezoelectric sensor element material may be a piezoelectric ceramics (such as PZT ceramic) or a single crystal material. A single crystal material may be gallium phosphate, quartz, tourmaline, or Lead Magnesium Niobate-Lead Titanate (PMN-PT).

The sensor may be a motion sensor, and may include one or more accelerometers, which measure the absolute acceleration or the acceleration relative to freefall. The accelerometer may be piezoelectric, piezoresistive, capacitive, MEMS, or electromechanical switch accelerometer, measuring the magnitude and the direction the device acceleration in a single-axis, 2-axis or 3-axis (omnidirectional). Alternatively or in addition, the motion sensor may be based on electrical tilt and vibration switch or any other electromechanical switch.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be a force sensor, a load cell, or a force gauge (a.k.a. force gage), used to measure a force magnitude and / or direction, and may be based on a spring extension, a strain gauge deformation, a piezoelectric effect, or a vibrating wire. A sensor may be a driving or passive dynamometer, used to measure torque or any moment of force.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be a pressure sensor (a.k.a. pressure transducer or pressure transmitter / sender) for measuring a pressure of gases or liquids, and for indirectly measuring other parameters such as fluid/gas flow, speed, water-level, and altitude. A pressure sensor may be a pressure switch. A pressure sensor may be an absolute pressure sensor, a gauge pressure sensor, a vacuum pressure sensor, a differential pressure sensor, or a sealed pressure sensor. The changes in pressure relative to altitude may be used for an altimeter, and the Venturi effect may be used to measure flow by a pressure sensor. Similarly, the depth of a submerged body or the fluid level on contents in a tank may be measured by a pressure sensor.

A pressure sensor may be of a force collector type, where a force collector (such as a diaphragm, piston, bourdon tube, or bellows) is used to measure strain (or deflection) due to applied force (pressure) over an area. Such sensor may be based on the piezoelectric effect (a piezoresistive strain gauge), may be of a capacitive, or of an electromagnetic type. A pressure sensor may be based on a potentiometer, or may be based on using the changes in resonant frequency or the thermal conductivity of a gas, or may use the changes in the flow of charged gas particles (ions).

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be a position sensor for measuring linear or angular position (or motion). A position sensor may be an absolute position sensor, or may be a displacement (relative or incremental) sensor, measuring a relative position, and may be an electromechanical sensor. A position sensor may be mechanically attached to the measured object, or alternatively may use a non-contact measurement.

A position sensor may be an angular position sensor, for measuring involving an angular position (or the rotation or motion) of a shaft, an axle, or a disk. Absolute angular position sensor output indicates the current position (angle) of the shaft, while incremental or displacement sensor provides information about the change, the angular speed, or the motion of the shaft. An angular position sensor may be of optical type, using reflective or interruption schemes, or may be of magnetic type, such as based on variable-reluctance (VR), Eddy-current killed oscillator (ECKO), Wiegand sensing, or Hall-effect sensing, or may be based on a rotary potentiometer. An angular position sensor may be transformer based such as a RVDT, a resolver or a synchro. An angular position sensor may be based on an absolute or incremental rotary encoder, and may be a mechanical or optical rotary encoder, using binary or gray encoding schemes.

Any sensor herein may provide an electrical output signal in response to a physical, chemical, biological or any other phenomenon, serving as a stimulus to the sensor. The sensor may serve as, or be, a detector, for detecting the presence of the phenomenon. Alternatively or in addition, a sensor may measure (or respond to) a parameter of a phenomenon or a magnitude of the physical quantity thereof. For example, each of the sensors **14a**, **14b**, or **14c** (or all of them) may be a thermistor or a platinum resistance temperature detector, a light sensor, a pH probe, a microphone for audio receiving, or a piezoelectric bridge. Similarly, each of the sensors **14a**, **14b**, or **14c** (or all of them) may be used to measure pressure, flow, force or other mechanical quantities. The sensor output may be amplified by an amplifier connected to the sensor output. Other signal conditioning may also be applied in order to improve the handling of the sensor output or adapting it to the next stage or manipulating, such as attenuation, delay, current or voltage limiting, level translation, galvanic isolation, impedance transformation, linearization, calibration, filtering, amplifying, digitizing, integration, derivation, and any other signal manipulation. Some sensors conditioning involves connecting them in a bridge circuit. In the case of conditioning, the conditioning circuit may added to manipulate the sensor output, such as filter or equalizer for frequency related manipulation such as filtering, spectrum analysis or noise removal, smoothing or de-blurring in case of image enhancement, a compressor (or de-compressor) or coder (or decoder) in the case of a compression or a coding/decoding schemes, modulator or demodulator in case of modulation, and extractor for extracting or detecting a feature or parameter such as pattern recognition or correlation analysis. In case of filtering, passive, active or adaptive (such as Wiener or Kalman) filters may be used. The conditioning circuits may apply linear or non-linear manipulations. Further, the manipulation may be time-related such as analog or digital delay-lines, integrators, or rate-based manipulation. Each of the sensors **14a**, **14b**, or **14c** (or all of them) may have analog output, requiring an A/D to be connected thereto, or may have digital output. Further, the conditioning may be based on the book entitled: "*Practical Design Techniques for Sensor Signal Conditioning*", by Analog Devices, Inc., 1999 (ISBN-0-916550-20-6), which is incorporated in its entirety for all purposes as if fully set forth herein.

The sensor may directly or indirectly measure the rate of change of the physical quantity (gradient) versus the direction around a particular location, or between different locations. For example, a temperature gradient may describe the differences in the temperature between different locations. Further, a sensor may measure time-dependent

or time-manipulated values of the phenomenon, such as time-integrated, average or Root Mean Square (RMS or rms), relating to the square root of the mean of the squares of a series of discrete values (or the equivalent square root of the integral in a continuously varying value). Further, a parameter relating to the time dependency of a repeating phenomenon may be measured, such as the duty-cycle, the frequency (commonly measured in Hertz – Hz) or the period. A sensor may be based on the Micro Electro-Mechanical Systems – MEMS (a.k.a. Micro-mechanical electrical systems) technology. A sensor may respond to environmental conditions such as temperature, humidity, noise, vibration, fumes, odors, toxic conditions, dust, and ventilation.

A sensor may be an active sensor, requiring an external source of excitation. For example, resistor-based sensors such as thermistors and strain gages are active sensors, requiring a current to pass through them in order to determine the resistance value, corresponding to the measured phenomenon. Similarly, a bridge circuit based sensors are active sensors depending on external electrical circuit for their operation. A sensor may be a passive sensor, generating an electrical output without requiring any external circuit or any external voltage or current. Thermocouples and photodiodes are examples or passive sensors.

A sensor may measure the amount of a property or of a physical quantity or the magnitude relating to a physical phenomenon, body or substance. Alternatively or in addition, a sensor may be used to measure the time derivative thereof, such as the rate of change of the amount, the quantity or the magnitude. In the case of space related quantity or magnitude, a sensor may measure the linear density, relating to the amount of property per length, a sensor may measure the surface density, relating to the amount of property per area, or a sensor may measure the volume density, relating to the amount of property per volume. Alternatively or in addition, a sensor may measure the amount of property per unit mass or per mole of substance. In the case of a scalar field, a sensor may further measure the quantity gradient, relating to the rate of change of property with respect to position. Alternatively or in addition, a sensor may measure the flux (or flow) of a property through a cross-section or surface boundary. Alternatively or in addition, a sensor may measure the flux density, relating to the flow of property through a cross-section per unit of the cross-section, or through a surface boundary per unit of the surface area. Alternatively or in addition, a sensor may measure the current, relating to the rate of flow of property through a cross-section or a surface boundary, or the current density, relating to the rate of flow of property per unit through a cross-section or a

surface boundary. A sensor may include or consists of a transducer, defined herein as a device for converting energy from one form to another for the purpose of measurement of a physical quantity or for information transfer. Further, a single sensor may be used to measure two or more phenomena. For example, two characteristics of the same element may be measured, each characteristic corresponding to a different phenomenon.

A sensor output may have multiple states, where the sensor state is depending upon the measured parameter of the sensed phenomenon. A sensor may be based on a two state output (such as '0' or '1', or 'true' and 'false'), such as an electric switch having two contacts, where the contacts can be in one of two states: either "closed" meaning the contacts are touching and electricity can flow between them, or "open", meaning the contacts are separated and the switch is non-conducting. The sensor may be a threshold switch, where the switch changes its state upon sensing that the magnitude of the measured parameter of a phenomenon exceeds a certain threshold. For example, a sensor may be a thermostat is a temperature-operated switch used to control a heating process. Another example is a voice operated switch (a.k.a. VOX), which is a switch that operates when sound over a certain threshold is detected. It is usually used to turn on a transmitter or recorder when someone speaks and turn it off when they stop speaking. Another example is a mercury switch (also known as a mercury tilt switch), which is a switch whose purpose is to allow or interrupt the flow of electric current in an electrical circuit in a manner that is dependent on the switch's physical position or alignment relative to the direction of the "pull" of earth's gravity, or other inertia. The threshold of a threshold based switch may be fixed or settable. Further, an actuator may be used in order to locally or remotely set the threshold level.

In some cases, a sensor operation is based on generating a stimulus or an excitation to generate influence or create a phenomenon. The entire or part of the generating or stimulating mechanism may be in this case an integral part of the sensor, or may be regarded as independent actuators, and thus may be controlled by the controller. Further, a sensor and an actuator, independent or integrated, may be cooperatively operating as a set, for improving the sensing or the actuating functionality. For example, a light source, treated as an independent actuator, may be used to illuminate a location, in order to allow an image sensor to faithfully and properly capture an image of that location. In another example, where a bridge is used to measure impedance, the excitation voltage of the bridge may be supplied from a power supply treated and acting as an actuator.

A sensor may respond to chemical process or may be involved in fluid handling, such as measuring flow or velocity. A sensor may be responsive to the location or motion such as navigational instrument, or be used to detect or measure position, angle, displacement, distance, speed or acceleration. A sensor may be responsive to mechanical phenomenon such as pressure, force, density or level. The environmental related sensor may respond to humidity, air pressure, and air temperature. Similarly, any sensor used to detect or measure a measurable attribute and converts it into an electrical signal may be used. Further, a sensor may be a metal detector, which detects metallic objects by detecting their conductivity.

In one example, the sensor is used to measure, sense or detect the temperature of an object, that may be solid, liquid or gas (such as the air temperature), in a location. Such sensor may be based on a thermistor, which is a type of resistor whose resistance varies significantly with temperature, and is commonly made of ceramic or polymer material. A thermistor may be a PTC (Positive Temperature Coefficient) type, where the resistance increases with increasing temperatures, or may be an NTC (Negative Temperature Coefficient) type, where the resistance decreases with increasing temperatures. Alternatively (or in addition), a thermoelectric sensor may be based on a thermocouple, consisting of two different conductors (usually metal alloys), that produce a voltage proportional to a temperature difference. For higher accuracy and stability, an RTD (Resistance Temperature Detector) may be used, typically consisting of a length of fine wire-wound or coiled wire wrapped around a ceramic or glass core. The RTD is made of a pure material whose resistance at various temperatures is known (R vs. T). A common material used may be platinum, copper, or nickel. A quartz thermometer may be used as well for high-precision and high-accuracy temperature measurement, based on the frequency of a quartz crystal oscillator. The temperature may be measured using conduction, convection, thermal radiation, or by the transfer of energy by phase changes. The temperature may be measured in degrees Celsius ($^{\circ}\text{C}$) (a.k.a. Centigrade), Fahrenheit ($^{\circ}\text{F}$), or Kelvin ($^{\circ}\text{K}$). In one example, the temperature sensor (or its output) is used to measure a temperature gradient, providing in which direction and at what rate the temperature changes the most rapidly around a particular location. The temperature gradient is a dimensional quantity expressed in units of degrees (on a particular temperature scale) per unit length, such as the SI (International System of Units) unit Kelvin per meter (K/m).

A radioactivity may be measured using a sensor based on a Geiger counter, measuring ionizing radiation. The emission of alpha particles, beta particles or gamma rays are detected and counted by the ionization produced in a low-pressure gas ion a Geiger-Muller tube. The SI unit of radioactive activity is the Becquerel (Bq).

5 In one example, a photoelectric sensor is used to measure, sense or detect light or the luminous intensity, such as a photosensor or a photodetector. The light sensed may be a visible light, or invisible light such as infrared, ultraviolet, X-ray or gamma rays. Such sensors may be based on the quantum mechanical effects of light on electronic materials, typically semiconductors such as silicon, germanium, and Indium gallium
10 arsenide. A photoelectric sensor may be based on the photoelectric or photovoltaic effect, such as a photodiode, phototransistor and a photomultiplier tube. The photodiode typically uses a reverse biased p-n junction or PIN structure diode, and a phototransistor is in essence a bipolar transistor enclosed in a transparent case so that light can reach the base-collector junction, and the electrons that are generated by photons in the base-
15 collector junction are injected into the base, and this photodiode current is amplified by the transistor's current gain β (or h_{fe}). A reverse-biased LED (Light Emitting Diode) may also act as a photodiode. Alternatively or in addition, a photosensor may be based on photoconductivity, where the radiation or light absorption changes the conductivity of a photoconductive material, such as selenium, lead sulfide, cadmium sulfide, or
20 polyvinylcarbazole. In such a case, the sensor may be based on photoresistor or LDR (Light Dependent Resistor), which is a resistor whose resistance decreases with increasing incident light intensity. In one example, Charge-Coupled Devices (CCD) and CMOS (Complementary Metal-Oxide-Semiconductor) may be used as the light-sensitive elements, where incoming photons are converted into electron charges at the
25 semiconductor-oxide interface. The sensor may be based an Active Pixel Sensor (APS), for example as an element in an image sensor, and may be according to, or based on, the sensor described in U.S. Patent No. 6,549,234 to Lee, entitled: "*Pixel Structure of Active Pixel Sensor (APS) with Electronic Shutter Function*", in U.S. Patent No. 6,844,897 to Andersson, entitled: "*Active Pixel Sensor (APS) Readout Structure with Amplification*",
30 in U.S. Patent No. 7,342,212 to Mentzer *et al.*, entitled: "*Analog Vertical Sub-Sampling in an Active Pixel Sensor (APS) Image Sensor*", or in U.S. Patent No. 6,476,372 to Merrill *et al.*, entitled: "*CMOS Active Pixel Sensor Using Native Transistors*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

In one example, an electrochemical sensor is used to measure, sense or detect a matter structure, properties, composition, and reactions. In one example, the sensor is a pH meter for measuring the pH (acidity or alkalinity) of a liquid. Commonly such pH meter comprises a pH probe which measures pH as the activity of the hydrogen cations at the tip of a thin-walled glass bulb. In one example, the electrochemical sensor is a gas detector, which detects the presence or various gases within an area, usually as part of a safety system, such as for detecting gas leak. Commonly gas detectors are used to detect combustible, flammable, or toxic gases, as well as oxygen depletion, using semiconductors, oxidation, catalytic, infrared or other detection mechanisms, and capable to detect a single gas or several gases. Further, an electrochemical sensor may be an electrochemical gas sensor, used to measure the concentration of a target gas, typically by oxidation or reducing the target gas at an electrode, and measuring the resulting current. The gas sensor may be a hydrogen sensor for measuring or detecting the presence of hydrogen, commonly based on palladium based electrodes, or a Carbon-Monoxide detector (CO Detector) used to detect the presence of carbon-monoxide, commonly in order to prevent carbon monoxide poisoning. A Carbon-Monoxide detector may be according to, or based on, the sensor described in U.S. Patent No. 8,016,205 to Drew, entitled: "*Thermostat with Replaceable Carbon Monoxide Sensor Module*", in U.S. Patent Application Publication No. 2010/0201531 to Pakravan *et al.*, entitled: "*Carbon Monoxide Detector*", in U.S. Patent No. 6,474,138 to Chang *et al.*, entitled: "*Adsorption Based Carbon Monoxide sensor and Method*", or in U.S. Patent No. 5,948,965 to Upchurch, entitled: "*Solid State Carbon Monoxide Sensor*", which are all incorporated in their entirety for all purposes as if fully set forth herein. The gas sensor may be an oxygen sensor (a.k.a. lambda sensor) for measuring the proportion of oxygen (O₂) in a gas or liquid.

In one example, one or more of the sensors is a smoke detector, for detecting smoke which is typically an indication of fire. The smoke detectors work either by optical detection (photoelectric) or by physical process (ionization), while some use both detection methods to increase sensitivity to smoke. An optical based smoke detector is based on a light sensor, and includes a light source (incandescent bulb or infrared LED), a lens to collimate the light into a beam, and a photodiode or other photoelectric sensor at an angle to the beam as a light detector. In the absence of smoke, the light passes in front of the detector in a straight line. When smoke enters the optical chamber across the path of the light beam, some light is scattered by the smoke particles, directing it at the

sensor and thus triggering the alarm. An ionization type smoke detector can detect particles of smoke that are too small to be visible, and use a radioactive element such as americium-241 (^{241}Am). The radiation passes through an ionization chamber, an air-filled space between two electrodes, and permits a small, constant current between the electrodes. Any smoke that enters the chamber absorbs the alpha particles, which reduces the ionization and interrupts this current, setting off the alarm. Some smoke alarms use a carbon-dioxide sensor or carbon-monoxide sensor to detect extremely dangerous products of combustion.

A sensor may include a physiological sensor, for monitoring a live body such as a human body, for example as part of the telemedicine concept. The sensors may be used to sense, log and monitor vital signs, such as of patients suffering from chronic diseases such as diabetes, asthma, and heart attack. The sensor may be ECG (Electrocardiography), involving interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the outer surface of the skin. The sensor may be used to measure oxygen saturation (SO_2), involving the measuring the percentage of hemoglobin binding sites in the bloodstream occupied by oxygen. A pulse oximeter relies on the light absorption characteristics of saturated hemoglobin to give an indication of oxygen saturation. Venous oxygen saturation (SvO_2) is measured to see how much oxygen the body consumes, tissue oxygen saturation (StO_2) can be measured by near infrared spectroscopy, and Saturation of peripheral oxygen (SpO_2) is an estimation of the oxygen saturation level usually measured with a pulse oximeter device. Other sensors may be a blood pressure sensor, for measuring is the pressure exerted by circulating blood upon the walls of blood vessels, which is one of the principal vital signs, and may be based on a sphygmomanometer measuring the arterial pressure. An EEG (Electroencephalography) sensor may be used for the monitoring of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain. The sensors (or the sensor units) may be a small bio-sensor implanted inside the human body, or may be worn at the human body, or as wearable, near, on or around a live body. Non-human applications may involve the monitoring of crops and animals. Such networks involving biological sensors may be part of a Body Area Network (BAN) or Body Sensor Network (BSN), and may be in accordance to, or based on, IEEE 802.15.6. The sensor may be a biosensor, and may be according to, or based on, the sensor described in U.S. Patent No. 6,329,160 to Schneider *et al.*, entitled: “*Biosensors*”, in U.S. Patent Application Publication No.

2005/0247573 to Nakamura *et al.*, entitled: "Biosensors", in U.S. Patent Application Publication No. 2007/0249063 to Deshong *et al.*, entitled: "Biosensors", or in U.S. Patent No. 4,857,273 to Stewart, entitled: "Biosensors", which are all incorporated in their entirety for all purposes as if fully set forth herein.

5 The sensor may be an electroacoustic sensor that responds to sound waves (which are essentially vibrations transmitted through an elastic solid or a liquid or gas), such as a microphone, which converts sound into electrical energy, usually by means of a ribbon or diaphragm set into motion by the sound waves. The sound may be audio or audible, having frequencies in the approximate range of 20 to 20,000 hertz, capable of
10 being detected by human organs of hearing. Alternatively or in addition, the microphone may be used to sense inaudible frequencies, such as ultrasonic (a.k.a. ultrasound) acoustic frequencies that are above the range audible to the human ear, or above approximately 20,000 Hz. A microphone may be a condenser microphone (a.k.a. capacitor or electrostatic microphone) where the diaphragm acts as one plate of a two
15 plates capacitor, and the vibrations changes the distance between plates, hence changing the capacitance. An electret microphone is a capacitor microphone based on a permanent charge of an electret or a polarized ferroelectric material. A dynamic microphone is based on electromagnetic induction, using a diaphragm attached to a small movable induction coil that is positioned in a magnetic field of a permanent magnet. The incident
20 sound waves cause the diaphragm to vibrate, and the coil to move in the magnetic field, producing a current. Similarly, a ribbon microphone uses a thin, usually corrugated metal ribbon suspended in a magnetic field, and its vibration within the magnetic field generates the electrical signal. A loudspeaker is commonly constructed similar to a dynamic microphone, and thus may be used as a microphone as well. In a carbon
25 microphone, the diaphragm vibrations apply varying pressure to a carbon, thus changing its electrical resistance. A piezoelectric microphone (a.k.a. crystal or piezo microphone) is based on the phenomenon of piezoelectricity in piezoelectric crystals such as potassium sodium tartrate. A microphone may be omnidirectional, unidirectional, bidirectional, or provide other directionality or polar patterns.

30 A sensor may be used to measure electrical quantities. An electrical sensor may be conductively connected to measure the electrical parameter, or may be non-conductively coupled to measure an electric-related phenomenon, such as magnetic field or heat. Further, the average or RMS value may be measured. An amperimeter (a.k.a. ammeter) is a current sensor that measures the magnitude of the electric current in a

circuit or in a conductor such as a wire. Electric current is commonly measured in Amperes, milliamperes, microamperes, or kiloamperes. The sensor may be an integrating ammeter (a.k.a. watt-hour meter) where the current is summed over time, providing a current/time product, which is proportional to the energy transferred. The measured electric current may be an Alternating Current (AC) such as a sinewave, a Direct Current (DC), or an arbitrary waveform. A galvanometer is a type of ampermeter for detecting or measuring low current, typically by producing a rotary deflection of a coil in a magnetic field. Some ampermeters use a resistor (shunt), whose voltage is directly proportional to the current flowing through, requiring the current to pass through the meter. A hot-wire ampermeter involves passing the current through a wire which expands as it heats, and the expansion is measured. A non-conductive or non-contact current sensor may be based on 'Hall effect' magnetic field sensor, measuring the magnetic field generated by the current to be measured. Other non-conductive current sensors involve a current clamp or current probe, which has two jaws which open to allow clamping around an electrical conductor, allowing for measuring of the electric current properties (commonly AC), without making a physical contact or disconnecting the circuit. Such current clamp commonly comprises a wire coil wound around a split ferrite ring, acting as the secondary winding of a current transformer, with the current-carrying conductor acting as the primary winding. Other current sensors and related circuits are described in Zetex Semiconductors PLC application note "AN39 – Current measurement application handbook" Issue 5, January 2008, which is incorporated in its entirety for all purposes as if fully set forth herein.

A sensor may be a voltmeter, commonly used for measuring the magnitude of the electric potential difference between two points. Electric voltage is commonly measured in volts, millivolts, microvolts, or kilovolts. The measured electric voltage may be an Alternating Current (AC) such as a sinewave, a Direct Current (DC), or an arbitrary waveform. Similarly, an electrometer may be used for measuring electric charge (commonly in Coulomb units – C) or electrical potential difference, with very low leakage current. The voltmeter commonly works by measuring the current through a fixed resistor, which, according to Ohm's Law, is proportional to the voltage across the resistor. A potentiometer-based voltmeter works by balancing the unknown voltage against a known voltage in a bridge circuit. A multimeter (a.k.a. VOM – Volt-Ohm-Milliammeter) as well as Digital MultiMeter (DMM), typically includes a voltmeter, an ampermeter and an ohmmeter.

A sensor may be a wattmeter measuring the magnitude of the active power (or the supply rate of electrical energy), commonly using watts (W), milliwatts, kilowatts, or megawatts units. A wattmeter may be based on measuring the voltage and the current, and multiplying to calculate the power $P=VI$. In AC measurement, the true power is $P=VI\cos(\phi)$. The wattmeter may be a bolometer, used for measuring the power of incident electromagnetic radiation via the heating of a material with a temperature-dependent electrical resistance. A sensor may be an electricity meter (or electrical energy meter) that measures the amount of electrical energy consumed by a load. Commonly, an electricity meter is used to measure the energy consumed by a single load, an appliance, a residence, a business, or any electrically powered device, and may provide or be the basis for the electricity cost or billing. The electricity meter may be an AC (single or multi-phase) or DC type, and the common unit of measurement is kilowatt-hour, however any energy related unit may be used such as Joules. Some electricity meters are based on wattmeters, which accumulate or average the readings, or may be based on induction.

A sensor may be an ohmmeter measuring the electrical resistance, commonly measured in ohms (Ω), milliohms, kilohms or megohms, or conductance measured in Siemens (S) units. Low-resistance measurements commonly use micro-ohmmeter, while megohmmeter (a.k.a. Megger) measures large value of resistance. Common ohmmeter passes a constant known current through the measured unknown resistance (or conductance), while measuring the voltage across the resistance, and deriving the resistance (or conductance) value from Ohm's law ($R=V/I$). A Wheatstone bridge may also be used as a resistance sensor, by balancing two legs of a bridge circuit, where one leg includes the unknown resistance (or conductance) component. Variations of Wheatstone bridge may be used to measure capacitance, inductance, impedance and other electrical or non-electrical quantities.

A sensor may be a capacitance meter for measuring capacitance, commonly using units of picofarads, nanofarads, microfarads, and Farads (F). A sensor may be an inductance meter for measuring inductance, commonly using SI units of Henry (H), such as microHenry, milliHenry, and Henry. Further, a sensor may be an impedance meter for measuring an impedance of a device or a circuit. A sensor may be an LCR meter, used to measure inductance (L), capacitance (C), and resistance (R). A meter may use sourcing an AC voltage, and use the ratio of the measured voltage and current (and their phase difference) through the tested device according to Ohm's law to calculate the impedance.

Alternatively or in addition, a meter may use a bridge circuit (Similar to Wheatstone bridge concept), where variable calibrated elements are adjusted to detect a null. The measurement may be in a single frequency or over a range of frequencies.

The sensor may be a Time-Domain Reflectometer (TDR) used to characterize and locate faults in transmission-lines, typically conductive or metallic lines, such as twisted wire pairs and coaxial cables. Optical TDR is used to test optical fiber cables. Typically, a TDR transmits a short rise time pulse along the checked medium. If the medium is a uniformly impedance medium and properly terminated, the entire transmitted pulse will be absorbed in the far-end terminal and no signal will be reflected toward the TDR. Any impedance discontinuities will cause some of the incident signal to be sent back towards the source. Increases in the impedance create a reflection that reinforces the original pulse whilst decreases in the impedance create a reflection that opposes the original pulse. The resulting reflected pulse that is measured at the output/input to the TDR is measured as a function of time and, because the speed of signal propagation is almost constant for a given transmission medium, can be read as a function of cable length. A TDR may be used to verify cable impedance characteristics, splice and connector locations and associated losses, and estimate cable lengths. The TDR may be according to, or based on, the TDR described in U.S. Patent No. 6,437,578 to Gumm, entitled: "*Cable Loss Correction of Distance to Fault and Time Domain Reflectometer Measurements*", in U.S. Patent No. 6,714,021 to Williams, entitled: "*Integrated Time Domain Reflectometry (TDR) Tester*", or in U.S. Patent No. 6,820,225 to Johnson *et al.*, entitled: "*Network Test Instrument*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

A sensor may be a magnetometer for measuring a local H or B magnetic fields. The B-field (a.k.a. magnetic flux density or magnetic induction) is measured in Tesla (T) in SI units and Gauss in cgs units, and magnetic flux is measured in Weber (Wb) units. The H-field (a.k.a. magnetic field intensity or magnetic field strength) is measured in ampere-turn per meter (A/m) in SI units, and in Oersteds (Oe) in cgs units. Many Smartphones contain magnetometers serving as compasses. A magnetometer may be a scalar magnetometer, measuring the total strength, or may be a vector magnetometer, providing both magnitude and direction (relative to the spatial orientation) of the magnetic field. Common magnetometers include Hall effect sensor, magneto-diode, magneto-transistor, AMR magnetometer, GMR magnetometer, magnetic tunnel junction magnetometer, magneto-optical sensor, Lorentz force based MEMS sensor (a.k.a.

Nuclear Magnetic Resonance - NMR), Electron Tunneling based MEMS sensor, MEMS compasses, Nuclear precession magnetic field sensor, optically pumped magnetic field sensor, fluxgate magnetometer, search coil magnetic field sensor, and Superconducting Quantum Interference Device (SQUID) magnetometer. 'Hall effect' magnetometers are based on Hall probe, which contains an indium compound semiconductor crystal such as indium antimonide, mounted on an aluminum backing plate, and provides a voltage a voltage in response to the measured B-field. A fluxgate magnetometer makes use of the non-linear magnetic characteristics of a probe or sensing element that has a ferromagnetic core. NMR and Proton Precession Magnetometers (PPM) measure the resonance frequency of protons in the magnetic field to be measured. SQUID meters are very sensitive vector magnetometers, based on superconducting loops containing Josephson junctions. The magnetometer may be Lorentz-force-based MEMS sensor, relying on the mechanical motion of the MEMS structure due to the Lorentz force acting on the current-carrying conductor in the magnetic field.

A sensor may be a strain gauge, used to measure the strain, or any other deformation, of an object. A strain gauge commonly comprises a metallic foil pattern supported by an insulating flexible backing. As the object is deformed, the foil is deformed (due to the object tension or the compression), causing its electrical resistance to change. Some strain gauges are based on semiconductor strain gauge (such as piezoresistors), while others are using fiber optic sensors measuring the strain along an optical fiber. Capacitive strain gauges use a variable capacitor to indicate the level of mechanical deformation. Vibrating wire strains are based on vibrating tensioned wire, where the strain is calculated by measuring the resonant frequency of the wire. A sensor may be a strain gauge rosette, comprising multiple strain gauges, and can detect or sense force or torque in a particular direction, or to determine the pattern of forces or torques.

A sensor may be a tactile sensor, being sensitive to force or pressure, or being sensitive to a touch by an object, typically a human touch. A tactile sensor is commonly based on piezoresistive, piezoelectric, capacitive, or elastoresistive sensor. Further, a tactile sensor may be based on a conductive rubber, a lead zirconate titanate (PZT) material, a polyvinylidene fluoride (PVDF) material, or a metallic capacitive element. A sensor may include an array of tactile sensor elements, and may provide an 'image' of a contact surface, distribution of pressures, or pattern of forces. A tactile sensor may be a tactile switch where the touch sensing is used to trigger a switch, which may be a capacitance touch switch, where the human body capacitance increases a sensed

capacitance, or may be a resistance touch switch, where the human body part such as a finger (or any other conductive object) conductivity is sensed between two conductors (e.g., two pieces of metal).

A sensor may be a piezoelectric sensor, where the piezoelectric effect is used to
5 measure pressure, acceleration, strain or force. Depending on how the piezoelectric material is cut, there are three main modes of operation: transverse longitudinal and shear. In the transverse effect mode, a force applied along an axis generates charges in a direction perpendicular to the line of force, and in the longitudinal effect mode, the amount of charge produced is proportional to the applied force and is independent of size
10 and shape of the piezoelectric element. When using as a pressure sensor, commonly a thin membrane is used to transfer the force to the piezoelectric element, while in accelerometer use, a mass is attached to the element, and the load of the mass is measured. A piezoelectric sensor element material may be a piezoelectric ceramics (such as PZT ceramic) or a single crystal material. A single crystal material may be gallium
15 phosphate, quartz, tourmaline, or Lead Magnesium Niobate-Lead Titanate (PMN-PT).

In one example, the sensor is a motion sensor, and may include one or more accelerometers, which measures the absolute acceleration or the acceleration relative to freefall. For example, one single-axis accelerometer per axis may be used, requiring three such accelerometers for three-axis sensing. The motion sensor may be a single or
20 multi-axis sensor, detecting the magnitude and direction of the acceleration as a vector quantity, and thus can be used to sense orientation, acceleration, vibration, shock and falling. The motion sensor output may be analog or digital signals, representing the measured values. The motion sensor may be based on a piezoelectric accelerometer that utilizes the piezoelectric effect of certain materials to measure dynamic changes in
25 mechanical variables (e.g., acceleration, vibration, and mechanical shock). Piezoelectric accelerometers commonly rely on piezoceramics (e.g., lead zirconate titanate) or single crystals (e.g., Quartz, tourmaline). A piezoelectric quartz accelerometer is disclosed in U.S. Patent No. 7,716,985 to Zhang *et al.* entitled: "*Piezoelectric Quartz Accelerometer*", U.S. Patent No. 5,578,755 to Offenberg entitled: "*Accelerometer Sensor of Crystalline Material and Method for Manufacturing the Same*" and U.S. Patent No.
30 5,962,786 to Le Traon *et al.* entitled: "*Monolithic Accelerometric Transducer*", which are all incorporated in their entirety for all purposes as if fully set forth herein. Alternatively or in addition, the motion sensor may be based on the Micro Electro-Mechanical Systems (MEMS, a.k.a. Micro-mechanical electrical system) technology. A

MEMS based motion sensor is disclosed in U.S. Patent No. 7,617,729 to Axelrod *et al.* entitled: “*Accelerometer*”, U.S. Patent No. 6,670,212 to McNie *et al.* entitled: “*Micro-Machining*” and in U.S. Patent No. 7,892,876 to Mehregany entitled: “*Three-axis Accelerometers and Fabrication Methods*”, which are all incorporated in their entirety
5 for all purposes as if fully set forth herein. An example of MEMS motion sensor is LIS302DL manufactured by STMicroelectronics NV and described in Data-sheet LIS302DL STMicroelectronics NV, ‘*MEMS motion sensor 3-axis - $\pm 2g/\pm 8g$ smart digital output "piccolo" accelerometer*’, Rev. 4, October 2008, which is incorporated in its entirety for all purposes as if fully set forth herein.

10 Alternatively or in addition, the motion sensor may be based on electrical tilt and vibration switch or any other electromechanical switch, such as the sensor described in U.S. Patent No. 7,326,866 to Whitmore *et al.* entitled: “*Omnidirectional Tilt and vibration sensor*”, which is incorporated in its entirety for all purposes as if fully set forth herein. An example of an electromechanical switch is SQ-SEN-200 available from
15 SignalQuest, Inc. of Lebanon, NH, USA, described in the data-sheet ‘*DATASHEET SQ-SEN-200 Omnidirectional Tilt and Vibration Sensor*’ Updated 2009-08-03, which is incorporated in its entirety for all purposes as if fully set forth herein. Other types of motion sensors may be equally used, such as devices based on piezoelectric, piezoresistive and capacitive components to convert the mechanical motion into an
20 electrical signal. Using an accelerometer to control is disclosed in U.S. Patent No. 7,774,155 to Sato *et al.* entitled: “*Accelerometer-Based Controller*”, which is incorporated in its entirety for all purposes as if fully set forth herein.

A sensor may be a force sensor, a load cell, or a force gauge (a.k.a. force gage), used to measure a force magnitude commonly using Newton (N) units, and typically
25 during a push or pull action. A force sensor may be based on measured spring displacement or extension according to Hooke's law. A load cell may be based on the deformation of a strain gauge, or may be a hydraulic or hydrostatic, a piezoelectric, or a vibrating wire load cell. A sensor may be a dynamometer for measuring torque or moment or force. A dynamometer may be a motoring type or a driving type, measuring
30 the torque or power required to operate a device, or may be an absorption or passive dynamometer, designed to be driven. The SI unit for torque is the Newton-meter (N·m). The force sensor may be according to, or based on, the sensor described in U.S. Patent No. 4,594,898 to Kirman *et al.*, entitled: “*Force Sensors*”, in U.S. Patent No. 7,047,826 to Peshkin, entitled: “*Force Sensors*”, in U.S. Patent No. 6,865,953 to Tsukada *et al.*,

entitled: "*Force Sensors*", or in U.S. Patent No. 5,844,146 to Murray *et al.*, entitled: "*Fingerpad Force Sensing System*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

A sensor may be a pressure sensor (a.k.a. pressure transducer or pressure transmitter / sender) for measuring a pressure of gases or liquids, commonly using units of Pascal (Pa), Bar (b) (such as millibar), Atmosphere (atm), Millimeter of Mercury (mmHg), or Torr, or in terms of force per unit area such as Barye - dyne per square centimeter (Ba). Pressure sensor may indirectly measure other variable such as fluid/gas flow, speed, water-level, and altitude. A pressure sensor may be a pressure switch, acting to complete or break an electric circuit in response to measured pressure magnitude. A pressure sensor may be an absolute pressure sensor, where the pressure is measured relative to a perfect vacuum, may be a gauge pressure sensor where the pressure is measured relative to an atmospheric pressure, may be a vacuum pressure sensor where a pressure below atmospheric pressure is measured, may be a differential pressure sensor where the difference between two pressures is measured, or may be a sealed pressure sensor where the pressure is measured relative to some fixed pressure. The changes in pressure relative to altitude may serve to use a pressure sensor for altitude sensing, and the Venturi effect may be used to measure flow by a pressure sensor. Similarly, the depth of a submerged body or the fluid level on contents in a tank may be measured by a pressure sensor.

A pressure sensor may be of a force collector type, where a force collector (such a diaphragm, piston, bourdon tube, or bellows) is used to measure strain (or deflection) due to applied force (pressure) over an area. Such sensor may be based on the piezoelectric effect (a piezoresistive strain gauge), and may use Silicon (Monocrystalline), Polysilicon Thin Film, Bonded Metal Foil, Thick Film, or Sputtered Thin Film. Alternatively or in addition, such force collector type sensor may be of a capacitive type, which uses a metal, a ceramic, or a silicon diaphragm in a pressure cavity to create a variable capacitor to detect strain due to applied pressure. Alternatively or in addition, such force collector type sensor may be of an electromagnetic type, where the displacement of a diaphragm by means of changes in inductance is measured. Further, in optical type the physical change of an optical fiber, such as strain, due to applied pressure is sensed. Further, a potentiometric type may be used, where the motion of a wiper along a resistive mechanism is used to measure the strain caused by the applied pressure. A pressure sensor may measure the stress or the changes in gas density,

caused by the applied pressure, by using the changes in resonant frequency in a sensing mechanism, by using the changes in thermal conductivity of a gas, or by using the changes in the flow of charged gas particles (ions). An air pressure sensor may be a barometer, typically used to measure the atmospheric pressure, commonly used for weather forecast applications.

A pressure sensor may be according to, or based on, the sensor described in U.S. Patent No. 5,817,943 to Welles, II *et al.*, entitled: "*Pressure Sensors*", in U.S. Patent No. 6,606,911 to Akiyama *et al.*, entitled: "*Pressure Sensors*", in U.S. Patent No. 4,434,451 to Delatorre, entitled: "*Pressure Sensors*", or in U.S. Patent No. 5,134,887 to Bell, entitled: "*Pressure Sensors*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

A sensor may be a position sensor for measuring linear or angular position (or motion). A position sensor may be an absolute position sensor, or may be a displacement (relative or incremental) sensor, measuring a relative position, and may further be an electromechanical sensor. A position sensor may be mechanically attached to the measured object, or alternatively may use a non-contact measurement.

A position sensor may be an angular position sensor, for measuring involving an angular position (or the rotation or motion) of a shaft, an axle, or a disk. Angles are commonly expressed in radians (rad), or in degrees ($^{\circ}$), minutes ($'$), and seconds ($''$), and angular velocity commonly uses units of radian per second (rad/s). Absolute angular position sensor output indicates the current position (angle) of the shaft, while incremental or displacement sensor provides information about the change, the angular speed or the motion of the shaft. An angular position sensor may be of optical type, using reflective or interruption schemes. A reflective sensor is based on a light-detector that senses a reflected beam from a light emitter, while an interruptive sensor is based on interrupting the light path between the emitter and the detector. An angular position sensor may be of magnetic type, relying on detection based on the changes in the magnetic field. A magnetic-based angular position sensor may be based on a variable-reluctance (VR), Eddy-Current Killed Oscillator (ECKO), Wiegand sensing, or Hall-effect sensing, used to detect a pattern in the rotating disc. A rotary potentiometer may serve as an angular position sensor.

An angular position sensor may be based on a Rotary Variable Differential Transformer (RVDT), used for measuring the angular displacement by using a type of an electrical transformer. An RVDT is commonly composed of a salient two-pole rotor and

a stator consisting of a primary excitation coil and a pair of secondary output coils, electromagnetically coupled to the excitation coil. The coupling is proportional to the angle of the measured shaft; hence the AC output voltage is proportional to the angular shaft displacement. A resolver and a synchro are similar transformer based angular position sensors.

An angular position sensor may be based on a rotary encoder (a.k.a. shaft encoder), used for measuring angular position commonly by using a disc, which is rigidly fixed to the measured shaft, and contain conductive, optical, or magnetic tracks. A rotary encoder may be an absolute encoder, or may be an incremental rotary encoder, where output is provided only when the encoder is rotating. A mechanical rotary encoder use an insulating disc and sliding contacts, which close electrical circuits upon rotation of the disc. An optical rotary encoder uses a disc having transparent and opaque areas, and a light source and a photo detector to sense the optical pattern on the disc. Both mechanical and optical rotary encoders, and may use binary or gray encoding schemes.

A sensor may be an angular rate sensor, used to measure the angular rate, or the rotation speed, of a shaft, an axle or a disk. An angular rate sensor may be electromechanical, MEMS based, Laser based (such as Ring Laser Gyroscope - RLG), or a gyroscope (such as fiber-optic gyro) based. Some gyroscopes use the measurement of the Coriolis acceleration to determine the angular rate.

An angular rate sensor may be a tachometer (a.k.a. RPM gauge and revolution-counter), used to measure the rotation speed of a shaft, an axle or a disk, commonly by units of RPM (Revolutions per Minute) annotating the number of full rotations completed in one minute around the axis. A tachometer may be based on any angular position sensor, for example sensors that are described herein, using further conditioning or processing to obtain the rotation speed. A tachometer may be based on measuring the centrifugal force, or based on sensing a slotted disk, using optical means where an optical beam is interrupted, electrical means where electrical contacts sense the disk, or by using magnetic sensors, such as based on Hall-effect. Further, an angular rate sensor may be a centrifugal switch, which is an electric switch that operates using the centrifugal force created from a rotating shaft, most commonly that of an electric motor or a gasoline engine. The switch is designed to activate or de-activate as a function of the rotational speed of the shaft.

A position sensor may be a linear position sensor, for measuring a linear displacement or position typically in a straight line. The SI unit for length is meter (m),

and prefixes may be used such as nanometer (nm), micrometer, centimeter (cm), millimeter (mm), and kilometer (Km). A linear position sensor may be based on a resistance changing element such as linear potentiometer.

A linear position sensor may be a Linear Variable Differential Transformer (LVDT) used for measuring linear displacement based on the transformer concept. An LVDT has three coils placed in a tube, where the center coil serves as the primary winding coil, and the two outer coils serve as the transformer secondary windings. The position of a sliding cylindrical ferromagnetic core is measured by changing the mutual magnetic coupling between the windings.

A linear position sensor may be a linear encoder, which may be similar to the rotary encoder counterpart, and may be based on the same principles. A linear encoder may be either incremental or absolute, and may be of optical, magnetic, capacitive, inductive, or eddy-current type. Optical linear encoder typically uses a light source such as an LED or laser diode, and may employ shuttering, diffraction, or holographic principles. A magnetic linear encoder may employ an active (magnetized) or passive (variable reluctance) scheme, and the position may be sensed using a sense coil, 'Hall effect' or magneto-resistive read-head. A capacitive or inductive linear encoder respectively measures the changes of capacitance or the inductance. Eddy-current linear encoder may be based on U.S. Patent No. 3,820,110 to Henrich *et al.* entitled: "*Eddy Current Type Digital Encoder and Position Reference*".

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be a motion detector or an occupancy sensor. A motion detector is a device for motion detection, that contains a physical mechanism or electronic sensor that quantifies motion commonly in order alert the user of the presence of a moving object within the field of view, or in general confirming a change in the position of an object relative to its surroundings or the change in the surroundings relative to an object. This detection can be achieved by both mechanical and electronic methods. In addition to discrete, on or off motion detection, it can also consist of magnitude detection that can measure and quantify the strength or speed of this motion or the object that created it. Motion can be typically detected by sound (acoustic sensors), opacity (optical and infrared sensors and video image processors), geomagnetism (magnetic sensors, magnetometers), reflection of the transmitted energy (infrared laser radar, ultrasonic sensors, and microwave radar sensors), electromagnetic induction (inductive-loop detectors), and vibration (triboelectric, seismic, and inertia-switch sensors). Acoustic sensors are based on:

Electret effect, inductive coupling, capacitive coupling, triboelectric effect, piezoelectric effect, and fiber optic transmission. Radar intrusion sensors usually have the lowest rate of false alarms. In one example, an electronic motion detector contains a motion sensor that transforms the detection of motion into an electrical signal. This can be achieved by measuring optical or acoustical changes in the field of view. Most motion detectors can detect up to 15 – 25 meters (50–80 ft). An occupancy sensor is typically a motion detector that is integrated with hardware or software-based timing device. For example, it can be used for preventing illumination of unoccupied spaces, by sensing when motion has stopped for a specified time period, in order to trigger a light extinguishing signal.

One basic form of mechanical motion detection is in the form of a mechanically-actuated switch or trigger. For electronic motion detection, passive or active sensors may be used, where four types of sensors commonly used in motion detectors spectrum: Passive infrared sensors (passive) which looks for body heat, while no energy is emitted from the sensor, ultrasonic (active) sensors that send out pulses of ultrasonic waves and measures the reflection off a moving object, microwave (active) sensor that sends out microwave pulses and measures the reflection off a moving object, and tomographic detector (active) which senses disturbances to radio waves as they travel through an area surrounded by mesh network nodes. Alternatively or in addition, motion can be electronically identified using optical detection or acoustical detection. Infrared light or laser technology may be used for optical detection. Motion detection devices, such as PIR (Passive Infrared Sensor) motion detectors, have a sensor that detects a disturbance in the infrared spectrum, such as a person or an animal.

Many motion detectors use a combination of different technologies. These dual-technology detectors benefit with each type of sensor, and false alarms are reduced. Placement of the sensors can be strategically mounted so as to lessen the chance of pets activating alarms. Often, PIR technology will be paired with another model to maximize accuracy and reduce energy usage. PIR draws less energy than microwave detection, and so many sensors are calibrated so that when the PIR sensor is tripped, it activates a microwave sensor. If the latter also picks up an intruder, then the alarm is sounded. As interior motion detectors do not ‘see’ through windows or walls, motion-sensitive outdoor lighting is often recommended to enhance comprehensive efforts to protect a property. Some application for motion detection are (a) detection of unauthorized entry, (b) detection of cessation of occupancy of an area to extinguish lights and (c) detection of a moving object which triggers a camera to record subsequent events.

A sensor may be a humidity sensor, such as a hygrometer, used for measuring the humidity in the environmental air or other gas, relating to the water vapors or the moisture content, or any water content in a gas-vapor mixture. The hygrometer may be a humidistat, which is a switch that responds to a relative humidity level, and commonly
5 used to control humidifying or dehumidifying equipment. The measured humidity may be an absolute humidity, corresponding to the amount of water vapor, commonly expressed in water mass per unit of volume. Alternatively or in addition, the humidity may be relative humidity, defined as the ratio of the partial pressure of water vapor in an air-water mixture to the saturated vapor pressure of water at those conditions, commonly
10 expressed in percent (%), or may be specific humidity (a.k.a. humidity ratio), which is the ratio of water vapor to dry air in a particular mass. The humidity may be measured with a dew-point hygrometer, where condensation is detected by optical means. In capacitive humidity sensors, the effect of humidity on the dielectric constant of a polymer or metal oxide material is measured. In resistive humidity sensors, the
15 resistance of salts or conductive polymers is measured. In thermal conductivity humidity sensors, the change in thermal conductivity of air due to the humidity is checked, providing indication of absolute humidity. The humidity sensor may be a humidistat, which is a switch that responds to a relative humidity level, and commonly used to control humidifying or dehumidifying equipment. The humidity sensor may be
20 according to, or based on, the sensor described in U.S. Patent No. 5,001,453 to Ikejiri *et al.*, entitled: "*Humidity Sensor*", in U.S. Patent No. 6,840,103 to Lee *et al.*, entitled: "*Absolute Humidity Sensor*", in U.S. Patent No. 6,806,722 to Shon *et al.*, entitled: "*Polymer-Type Humidity Sensor*", or in U.S. Patent No. 6,895,803 to Seakins *et al.*, entitled: "*Humidity Sensor*", which are all incorporated in their entirety for all purposes
25 as if fully set forth herein.

A sensor may be an atmospheric sensor, and may be according to, or based on, the sensor described in U.S. Patent Application Publication No. 2004/0182167 to Orth *et al.*, entitled: "*Gage Pressure Output From an Absolute Pressure Measurement Device*", in U.S. Patent No. 4,873,481 to Nelson *et al.*, entitled: "*Microwave Radiometer and
30 Methods for Sensing Atmospheric Moisture and Temperature*", in U.S. Patent No. 3,213,010 to Saunders *et al.*, entitled: "*Vertical Drop Atmospheric Sensor*", or in U.S. Patent No. 5,604,595 to Schoen, entitled: "*Long Stand-Off Range Differential Absorption Tomographic Atmospheric Trace Substances Sensor Systems Utilizing Bistatic Configurations of Airborne and Satellite Laser Source and Detector Reflector*"

Platforms", which are all incorporated in their entirety for all purposes as if fully set forth herein.

A sensor may be a bulk or surface acoustic wave sensor, and may be according to, or based on, the sensor described in U.S. Patent Application Publication No. 5 2010/0162815 to Lee, entitled: "*Manufacturing Method for Acoustic Wave Sensor Realizing Dual Mode in Single Chip and Biosensor Using the Same*", in U.S. Patent Application Publication No. 2009/0272193 to Okaguchi *et al.*, entitled: "*Surface Acoustic Wave Sensor*", in U.S. Patent No. 7,219,536 to Liu *et al.*, entitled: "*System and Method to Determine Oil Quality Utilizing a Single Multi-Function Surface Acoustic*
10 *Wave Sensor*", or in U.S. Patent No. 7,482,732 to Kalantar-Zadeh, entitled: "*Layered Surface Acoustic Wave Sensor*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

A sensor may be a clinometer (a.k.a. inclinometer, tilt sensor, slope gauge, and pitch/roll indicator) for measuring angle (or slope or tilt), elevation or depression of an
15 object, or pitch or roll (commonly with respect to gravity), with respect to the earth ground plane, or with respect to the horizon, commonly expressed in degrees. The clinometers may measure inclination (positive slope), declination (negative slope), or both. A clinometer may be based on an accelerometer, a pendulum, or on a gas bubble in liquid. The inclinometer may be a tilt switch, such as a mercury tilt switch, commonly
20 based on a sealed glass envelope which contains a bead or mercury. When tilted in the appropriate direction, the bead touches a set (or multiple sets) of contacts, thus completing an electrical circuit.

The sensor may be an angular rate sensor, and may be according to, or based on, the sensor described in U.S. Patent No. 4,759,220 to Burdess *et al.*, entitled: "*Angular*
25 *Rate Sensors*", in U.S. Patent Application Publication No. 2011/0041604 to Kano *et al.*, entitled: "*Angular Rate Sensor*", in U.S. Patent Application Publication No. 2011/0061460 to Seeger *et al.*, entitled: "*Extension-Mode Angular Velocity Sensor*", or in U.S. Patent Application Publication No. 2011/0219873 to OHTA *et al.*, entitled: "*Angular Rate Sensor*", which are all incorporated in their entirety for all purposes as if
30 fully set forth herein.

A sensor may be a proximity sensor for detecting the presence of nearby objects without any physical contact. A proximity sensor may be of ultrasonic, capacitive, inductive, magnetic, eddy-current or infrared (IR) type. A typical proximity sensor emits a field or a signal, and senses the changes in the field due to the object. An inductive type

emits magnetic field, and may be used with a metal or conductive object. An optical type emits a beam (commonly infrared), and measures the reflected optical signal. A proximity sensor may be a capacitive displacement sensor, based on the capacitance change due to the proximity of conductive and non-conductive materials. A metal
5 detector is one type of a proximity sensor using inductive sensing, responding to conductive material such as metal. Commonly a coil produces an alternating magnetic field, and measuring eddy-currents or the changes in the magnetic fields.

A sensor may be a flow sensor, for measuring the volumetric or mass flow rate (or flow velocity) of gas or liquid such as via a defined area or a surface, commonly
10 expressed in liters per second, kilogram per second, gallons per minute, or cubic-meter per second. A liquid flow sensor typically involves measuring the flow in a pipe or in an open conduit. A flow measurement may be based on a mechanical flow meter, where the flow affects a motion to be sensed. Such meter may be a turbine flow meter, based on measuring the rotation of a turbine, such as axial turbine, in the liquid (or gas) flow
15 around an axis. A mechanical flow meter may be based on a rotor with helical blades inserted axially in the flow (Woltmann meter), or a single jet meter based on a simple impeller with radial vanes, impinged upon by a single jet (such as a paddle wheel meter). Pressure-based meters may be based on measuring a pressure or a pressure differential, caused by the flow, commonly based on Bernoulli's principle. A Venturi meter is based
20 on constricting the flow (e.g., by an orifice), and measuring the pressure differential before and within the constriction. Commonly a concentric, eccentric, or segmental orifice plate may be used, including a plate with a hole. An optical flow meter use light to determine the flow-rate, commonly by measuring the actual speed of particles in the gas (or liquid) flow, by using a light emitter (e.g., laser) and a photo-detector. Similarly,
25 the Doppler-effect may be used with sound, such as an ultrasonic sound, or with light, such as a laser Doppler. The sensor may be based on an acoustic velocity sensor, and may be according to, or based on, the sensor described in U.S. Patent No. 5,930,201 to Cray, entitled: "*Acoustic Vector Sensing Sonar System*", in U.S. Patent No. 4,351,192 to Toda *et al.*, entitled: "*Fluid Flow Velocity Sensor Using a Piezoelectric Element*", or in
30 U.S. Patent No. 7,239,577 to Tenganm *et al.*, entitled: "*Apparatus and Methods for Multicomponent Marine Geophysical Data Gathering*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

A flow sensor may be an air flow sensor, for measuring the air flow, such as through a surface (e.g., through a tube) or a volume. The sensor may actually measure

the air volume passing (such as in vane / flap air flow meter), or may measure the actual speed or air flow. In some cases, a pressure, typically differential pressure, is measured as an indicator for the air flow measurements.

An anemometer is an air flow sensor primarily for measuring wind speed. Air or
5 wind flow may use cup anemometer, which typically consists of hemispherical cups mounted on the ends of horizontal arms. The air flow past the cups in any horizontal direction turns the cups proportional to the wind speed. A windmill anemometer combines a propeller and a tail on the same axis, to obtain wind speed and direction measurements. Hot-wire anemometer commonly uses a fine (several micrometers)
10 tungsten (or other metal) wire, heated to some temperature above the ambient, and uses the cooling effect of the air flowing past the wire. Hot-wire devices can be further classified as CCA (Constant-Current Anemometer), CVA (Constant-Voltage Anemometer) and CTA (Constant-Temperature Anemometer). The voltage output from these anemometers is thus the result of some sort of circuit within the device trying to
15 maintain the specific variable (current, voltage or temperature) constant. Laser Doppler anemometers use a beam of light from a laser that is divided into two beams, with one propagated out of the anemometer. Particulates (or deliberately introduced seed material) flowing along with air molecules near where the beam exits reflect, or backscatter, the light back into a detector, where it is measured relative to the original laser beam. When
20 the particles are in great motion, they produce a Doppler shift for measuring wind speed in the laser light, which is used to calculate the speed of the particles, and therefore the air around the anemometer. Sonic anemometers use ultrasonic sound waves to measure wind velocity. They measure wind speed based on the time of flight of sonic pulses between pairs of transducers. Measurements from pairs of transducers can be combined
25 to yield a measurement of velocity in 1-, 2-, or 3-dimensional flow. The spatial resolution is given by the path length between transducers, which is typically 10 to 20 cm. Sonic anemometers can take measurements with very fine temporal resolution, 20 Hz or better, which makes them well suited for turbulence measurements. Air flow may be further measured by pressure anemometers, which may be a plate or a tube type. Plate
30 anemometer uses a flat plate suspended from the top so that the wind deflects the plate, or by balancing a spring compressed by the pressure of the wind on its face. Tube anemometer comprises a glass U tube containing a liquid manometer serving as a pressure gauge, with one end bent in a horizontal direction to face the wind and the other vertical end remains parallel to the wind flow.

An inductive sensor may be eddy-current (a.k.a. Foucault currents) based sensor, used for high-resolution non-contact measurement of a position, or a change in the position, of a conductive object (such as a metal). Eddy-Current sensors operate with magnetic fields, where a driver creates an alternating current in a coil at the end of the probe. This creates an alternating magnetic field which induces small currents (eddy currents) in the target material. The eddy currents create an opposing magnetic field which resists the field being generated by the probe coil and the interaction of the magnetic fields is dependent on the distance between the probe and the target, providing a displacement measurement. Such sensors may be used to sense the vibration and position measurements, such as measurements of a rotating shaft, and to detect flaws in conductive materials, as well as in a proximity and metal detectors.

A sensor may be an ultrasound (or ultrasonic) sensor, based on transmitting and receiving ultrasound energy, and may be according to, or based on, the sensor described in U.S. Patent Application Publication No. 2011/0265572 to Hoenes, entitled: *"Ultrasound Transducer, Ultrasound Sensor and Method for Operating an Ultrasound Sensor"*, in U.S. Patent No. 7,614,305 to Yoshioka *et al.*, entitled: *"Ultrasonic Sensor"*, in U.S. Patent Application Publication No. 2008/0257050 to Watanabe, entitled: *"Ultrasonic Sensor"*, or in U.S. Patent Application Publication No. 2010/0242611 to Terazawa, entitled: *"Ultrasonic Sensor"*, which are all incorporated in their entirety for all purposes as if fully set forth herein.

A sensor may be a solid state sensor, which is typically a semiconductor device and which have no mobile parts, and commonly enclosed as a chip. The sensor may be according to, or based on, the sensor described in U.S. Patent No. 5,511,547 to Markle, entitled: *"Solid State Sensors"*, in U.S. Patent No. 6,747,258 to Benz *et al.*, entitled: *"Intensified Hybrid Solid-State Sensor with an Insulating Layer"*, in U.S. Patent No. 5,105,087 to Jagielinski, entitled: *"Large Solid State Sensor Assembly Formed from Smaller Sensors"*, or in U.S. Patent No. 4,243,631 to Ryerson, entitled: *"Solid State Sensor"*, which are all incorporated in their entirety for all purposes as if fully set forth herein.

A sensor may be a nanosensor, which is a biological, chemical or physical sensor constructed using nanoscale components, usually microscopic or submicroscopic in size. A nanosensor may be according to, or based on, the sensor described in U.S. Patent No. 7,256,466 to Lieber *et al.*, entitled: *"Nanosensors"*, in U.S. Patent Application Publication No. 2007/0264623 to Wang *et al.*, entitled: *"Nanosensors"*, in U.S. Patent

Application Publication No. 2011/0045523 to Strano *et al.*, entitled: “*Optical Nanosensors Comprising Photoluminescent Nanostructures*”, or in U.S. Patent Application Publication No. 2011/0275544 to Zhou *et al.*, entitled: “*Microfluidic Integration with Nanosensor Platform*”, which are all incorporated in their entirety for
5 all purposes as if fully set forth herein.

A sensor may consist of, or be based on, a gyroscope, for measuring orientation in space. A conventional gyroscope is a mechanical type, consisting of a wheel or disk mounted so that it can spin rapidly about an axis that is itself free to alter in direction. The orientation of the axis is not affected by tilting of the mounting; so gyroscopes are
10 commonly used to provide stability or maintain a reference direction in navigation systems, automatic pilots, and stabilizers. A MEMS gyroscope may be based on a vibrating element based on the Foucault pendulum concept. A Fiber Optic Gyroscope (FOG) uses the interference of light to detect mechanical rotation. A Vibrating structure Gyroscope (VSG, a.k.a. Coriolis Vibratory Gyroscope – CVG), is based on a metal alloy
15 resonator, and may be a piezoelectric gyroscope type where a piezoelectric material is vibrating and the lateral motion due to centrifugal force is measured.

In one example, the same component serves as both a sensor and as an actuator. For example, a loudspeaker may serve as a microphone, as some speakers are structured similar to a dynamic or magnetic microphone. In another example, a reverse-biased LED
20 (Light Emitting Diode) may serve as a photodiode. Further, a coil may be used to produce a magnetic field by excitation electrical current through it, or may be used as a sensor generating an electrical signal when subjected to a changing magnetic field. In another example, the piezoelectric effect may be used, converting between mechanical phenomenon and electrical signal. A transducer is a device that converts one form of
25 energy to another. Energy types include (but are not limited to) electrical, mechanical, electromagnetic (including light), chemical, acoustic or thermal energy. Transducers that convert to an electrical signal may serve as sensors, while transducers that convert electrical energy to another form of energy may serve as actuators. Reversible transducers, that are able to convert energy both ways, may serve as both sensors and
30 actuators. In one example, the same component (e.g., transducer) serves at one time as a sensor, and at another time as an actuator. Further, the phenomenon sensed when serving as a sensor may be the same or different phenomena affected when serving as an actuator.

In one example, multiple sensors are used arranged as a sensor array, where a set of several sensors, typically identical or similar, is used to gather information that cannot be gathered from a single sensor, or improve the measurement or sensing relating to a single sensor. A sensor array commonly improves the sensitivity, accuracy, resolution, and other parameters of the sensed phenomenon, and may be arranged as a linear sensor array. The sensor array may be directional, and better measure the parameters of the impinging signal to the array. Parameters that may be identified include the number, magnitudes, frequencies, Direction-Of-Arrival (DOA), distances and speeds of the signals. Estimation of the DOA may be improved in far-field signal applications, and may be based on Spectral-based (Non-parametric) that is based on maximizing the power of the beamforming output for a given input signal (such as Barlett beamformer, Capon beamformer and MUSIC beamformer), or may be based on Parametric approaches that is based on minimizing quadratic penalty functions. The processing of the entire sensor array outputs, such as to obtain a single measurement or a single parameter, may be performed by a dedicated processor, which may be part of the sensor array assembly, may be performed in the processor of the field unit, may be performed by the processor in the router, may be performed as part of the controller functionality (e.g., in the control server), or any combination thereof. Further, sensor array may be used to sense a phenomenon pattern in a surface or in space, as well as the phenomenon motion or distribution in a location.

Alternatively or in addition, a sensor, a sensor technology, a sensor conditioning or handling circuits, or a sensor application, may be according to the book entitled: "*Sensors and Control Systems in manufacturing*", Second Edition 2010, by Sabrie Soloman, The McGraw-Hill Companies, ISBN: 978-0-07-160573-1, or according to the book entitled: "*Fundamentals of Industrial Instrumentation and Process Control*", by William C. Dunn, 2005, The McGraw-Hill Companies, ISBN: 0-07-145735-6, or according to the book entitled: "*Sensor technology Handbook*", Edited by Jon Wilson, by Newnes-Elsevier 2005, ISBN:0-7506-7729-5, which are all incorporated in their entirety for all purposes as if fully set forth herein.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be used for measuring magnetic or electrical quantities such as voltage (e.g., voltmeter), current (e.g., ampermeter), resistance (e.g., ohmmeter), conductance, reactance, magnetic flux, electrical charge, magnetic field (e.g., Hall sensor), electric field, electric power (e.g., electricity meter), S-matrix (e.g., network analyzer), power spectrum (e.g., spectrum

analyzer), inductance, capacitance, impedance, phase, noise (amplitude or phase), transconductance, transimpedance, and frequency.

In one example, the sensor element includes a solar cell or photovoltaic cell, for sensing or measuring light intensity. The luminance is commonly measured in Lux (lx) units, the luminous flux is measured in Lumens (lm), and the luminous intensity is commonly measured in Candela (cd) units. A solar cell (also called photovoltaic cell or photoelectric cell) is a solid state electrical device that converts the energy of light directly into electricity by the photovoltaic effect. Assemblies of solar cells are used to make solar modules, which are used to capture energy from sunlight. Cells are described as photovoltaic cells when the light source is not necessarily sunlight. These are used for detecting light or other electromagnetic radiation near the visible range, for example infrared detectors, or measurement of light intensity. The solar cell works in three steps: Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon, electrons (negatively charged) are knocked loose from their atoms, causing an electric potential difference, and current starts flowing through the material to cancel the potential and this electricity is captured. Due to the special composition of solar cells, the electrons are only allowed to move in a single direction. An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.

Materials for efficient solar cells must have characteristics matched to the spectrum of available light. Some cells are designed to efficiently convert wavelengths of solar light that reach the Earth's surface. However, some solar cells are optimized for light absorption beyond Earth's atmosphere as well. Light absorbing materials can often be used in multiple physical configurations to take advantage of different light absorption and charge separation mechanisms. Materials presently used for photovoltaic solar cells include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium selenide/sulfide. Many currently available solar cells are made from bulk materials that are cut into wafers between 180 to 240 micrometers thick that are then processed like other semiconductors. Other materials are made as thin-film layers, organic dyes, and organic polymers that are deposited on supporting substrates. A third group is made of nanocrystals and used as quantum dots (electron-confined nanoparticles). Silicon remains the only material that is well-researched in both bulk and thin-film forms. The most prevalent bulk material for solar cells is crystalline silicon (abbreviated as a group as c-Si), also known as "solar grade

silicon". Bulk silicon is separated into multiple categories according to crystallinity and crystal size in the resulting ingot, ribbon, or wafer.

Each of the sensors **14a**, **14b**, or **14c** (or all of them) may be an automotive sensor. Automotive sensors are described in a brochure entitled: "*Sensors*" published by Robert Bosch GmbH (downloaded 2016 from the Internet), which is incorporated in its entirety for all purposes as if fully set forth herein. The automotive sensor may be an angular position sensor, used for measuring angular setting or a change of an angle, such as throttle-valve-angle measuring for engine management on gasoline (SI) engines. In another example, the automotive sensor may be a rotational-speed sensor, used for measuring rotational speeds, positions and angles in excess of 360°, such as wheel-speed measurement for ABS/TCS, engine speeds, positioning angle for engine management, steering-wheel angle, distance covered, and curves / bends for navigation system. In another example, the automotive sensor may be a spring-mass acceleration sensor, used for measuring changes in speed (such as are common in road traffic), such as for registration of vehicular acceleration and deceleration, typically used for the Anti-Breaking System (ABS) or the Traction Control System (TCS). In another example, the automotive sensor may be a bending beam acceleration sensor, used for registering or detecting shock and vibration caused by impacts on rough or unpaved road surface or contact with curbstones, such as for engine management. In another example, the automotive sensor may be a piezoelectric acceleration sensor, used for detecting impacts and measuring shocks and vibration when the vehicle body impacts against an obstacle, such as for triggering airbags and belt tighteners. In another example, the automotive sensor may be a yaw sensor for measuring skidding movements (such as are common in specific road traffic), such as for vehicle dynamics control (e.g., ESP – Electronic Stability Program) for measuring yaw rate and lateral acceleration, and for a navigation system. In another example, the automotive sensor may be a vibration sensor, used for measuring structure-borne vibrations typically occurring at engines, machines, and pivot bearings, such as for engine-knock detection for anti-knock control in an engine management system.

Alternatively or in addition, the automotive sensor may be an absolute-pressure sensor, used for measuring ranges from 50% to 500% of the earth's atmospheric pressure, such as manifold vacuum measurement, charge-air-pressure measurement for charge-air pressure control, or altitude-dependent fuel injection for diesel engines. In another example, the automotive sensor may be a differential-pressure sensor, used for

measuring differential gas pressures, e.g., for pressure compensation purposes, such as for pressure measurement in the fuel tank, or evaporative-emission control system. In another example, the automotive sensor may be a temperature sensor, used for measuring the temperature of gaseous materials and liquids (such as water), such as for displaying of outside and inside temperature, control of air conditioners and inside temperature, or control of radiator and thermostats, measurement of lube-oil, coolant, and engine temperature. In another example, the automotive sensor may be a Lambda oxygen sensor, used to determine the residual oxygen content in the exhaust gas, such as for control of A/F mixture for minimization of pollutant emissions on gasoline and gas engines. In another example, the automotive sensor may be an air-mass meter used for measuring the flow rate of gases, such as for measuring of the mass of the air drawn in by the engine.

Any device, component, or element designed for, or capable of, directly or indirectly affecting, changing, producing, or creating a physical phenomenon under an electric signal control may be used as each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them). An appropriate actuator may be adapted for a specific physical phenomenon, such as an actuator affecting temperature, humidity, pressure, audio, vibration, light, motion, sound, proximity, flow rate, electrical voltage, and electrical current. Each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may include one or more actuators, each affecting or generating a physical phenomenon in response to an electrical command, which can be an electrical signal (such as voltage or current), or by changing a characteristic (such as resistance or impedance) of an element. The actuators may be identical, similar or different from each other, and may affect or generate the same or different phenomena. Two or more actuators may be connected in series or in parallel.

Each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may be an analog actuator having an analog signal input such as analog voltage or current, or may have continuously variable impedance. Alternatively on in addition, each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may have a digital signal input. Each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may affect time-dependent or space-dependent parameters of a phenomenon. Alternatively on in addition, each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may affect time-dependencies or a phenomenon such as the rate of change, time-integrated or time-average, duty-cycle, frequency or time period between events. Each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may be semiconductor-based, and may be based on MEMS technology.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may affect the amount of a property or of a physical quantity or the magnitude relating to a physical phenomenon, body or substance. Alternatively or in addition, the actuator may be used to affect the time derivative thereof, such as the rate of change of the amount, the quantity or the magnitude. In the case of space related quantity or magnitude, an actuator may affect the linear density, surface density, or volume density, relating to the amount of property per volume. Alternatively or in addition, each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may affect the flux (or flow) of a property through a cross-section or surface boundary, the flux density, or the current. In the case of a scalar field, an actuator may affect the quantity gradient. Alternatively on in addition, each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may affect the amount of property per unit mass or per mole of substance. Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be used to affect two or more phenomena.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may affect, create, or change a phenomenon associated with an object, and the object may be gas, air, liquid, or solid. Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be controlled by a digital input, and may be electrical actuator powered by an electrical energy. Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be operative to affect time-dependent characteristic such as a time-integrated, an average, an RMS (Root Mean Square) value, a frequency, a period, a duty-cycle, a time-integrated, or a time-derivative, of the affected or produced phenomenon. Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be operative to affect or change space-dependent characteristic of the phenomenon, such as a pattern, a linear density, a surface density, a volume density, a flux density, a current, a direction, a rate of change in a direction, or a flow, of the sensed phenomenon.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be a light source used to emit light by converting electrical energy into light, and where the luminous intensity may be fixed or may be controlled, commonly for illumination or indication purposes. The actuator may be used to activate or control the light emitted by a light source, being based on converting electrical energy or another energy to a light. The light emitted may be a visible light, or invisible light such as infrared, ultraviolet, X-ray or gamma rays. A shade, reflector, enclosing globe, housing, lens, and other accessories may be used, typically as part of a light fixture, in order to control the illumination intensity, shape or direction. Electrical sources of illumination commonly use a gas, a

plasma (such as in arc and fluorescent lamps), an electrical filament, or Solid-State Lighting (SSL), where semiconductors are used. An SSL may be a Light-Emitting Diode (LED), an Organic LED (OLED), Polymer LED (PLED), or a laser diode.

A light source may consist of, or may comprise, a lamp which may be an arc lamp, a fluorescent lamp, a gas-discharge lamp (such as a fluorescent lamp), or an incandescent light (such as a halogen lamp). An arc lamp is the general term for a class of lamps that produce light by an electric arc voltaic arc. Such a lamp consists of two electrodes, first made from carbon but typically made today of tungsten, which are separated by a noble gas.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may comprise, or may consist of, a motion actuator that may be a rotary actuator that produces a rotary motion or torque, commonly to a shaft or axle. The motion produced by a rotary motion actuator may be either continuous rotation, such as in common electric motors, or movement to a fixed angular position as for servos and stepper motors. A motion actuator may be a linear actuator that creates motion in a straight line. A linear actuator may be based on an intrinsically rotary actuator, by converting from a rotary motion created by a rotary actuator, using a screw, a wheel and axle, or a cam. A screw actuator may be a leadscrew, a screw jack, a ball screw or roller screw. A wheel-and-axle actuator operates on the principle of the wheel and axle, and may be hoist, winch, rack and pinion, chain drive, belt drive, rigid chain, or rigid belt actuator. Similarly, a rotary actuator may be based on an intrinsically linear actuator, by converting from a linear motion to a rotary motion, using the above or other mechanisms. Motion actuators may include a wide variety of mechanical elements and/or prime movers to change the nature of the motion such as provided by the actuating / transducing elements, such as levers, ramps, screws, cams, crankshafts, gears, pulleys, constant-velocity joints, or ratchets. A motion actuator may be part of a servomotor system.

A motion actuator may be a pneumatic actuator that converts compressed air into rotary or linear motion, and may comprises a piston, a cylinder, valves, or ports. Motion actuators are commonly controlled by an input pressure to a control valve, and may be based on moving a piston in a cylinder. A motion actuator may be a hydraulic actuator using a pressure of the liquid in a hydraulic cylinder to provide force or motion. A hydraulic actuator may be a hydraulic pump, such as a vane pump, a gear pump, or a piston pump. A motion actuator may be an electric actuator where electrical energy may

be converted into motion, such as an electric motor. A motion actuator may be a vacuum actuator producing a motion based on vacuum pressure.

An electric motor may be a DC motor, which may be a brushed, brushless, or uncommutated type. An electric motor may be a stepper motor, and may be a Permanent
5 Magnet (PM) motor, a Variable reluctance (VR) motor, or a hybrid synchronous stepper. An electric motor may be an AC motor, which may be an induction motor, a synchronous motor, or an eddy current motors. An AC motor may be a two-phase AC servo motor, a three-phase AC synchronous motor, or a single-phase AC induction
10 motor, such as a split-phase motor, a capacitor start motor, or a Permanent-Split Capacitor (PSC) motor. Alternatively or in addition, an electric motor may be an electrostatic motor, and may be MEMS based.

A rotary actuator may be a fluid power actuator, and a linear actuator may be a linear hydraulic actuator or a pneumatic actuator. A linear actuator may be a piezoelectric actuator, based on the piezoelectric effect, may be a wax motor, or may be
15 a linear electrical motor, which may be a DC brush, a DC brushless, a stepper, or an induction motor type. A linear actuator may be a telescoping linear actuator. A linear actuator may be a linear electric motor, such as a linear induction motor (LIM), or a Linear Synchronous Motor (LSM).

A motion actuator may be a linear or rotary piezoelectric motor based on
20 acoustic or ultrasonic vibrations. A piezoelectric motor may use piezoelectric ceramics such as Inchworm or PiezoWalk motors, may use Surface Acoustic Waves (SAW) to generate the linear or the rotary motion, or may be a Squiggle motor. Alternatively or in addition, an electric motor may be an ultrasonic motor. A linear actuator may be a micro- or nanometer comb-drive capacitive actuator. Alternatively or in addition, a
25 motion actuator may be a Dielectric or Ionic based Electroactive Polymers (EAPs) actuator. A motion actuator may also be a solenoid, thermal bimorph, or a piezoelectric unimorph actuator.

An actuator may be a pump, typically used to move (or compress) fluids or liquids, gasses, or slurries, commonly by pressure or suction actions, and the activating
30 mechanism is often reciprocating or rotary. A pump may be a direct lift, impulse, displacement, valveless, velocity, centrifugal, vacuum pump, or gravity pump. A pump may be a positive displacement pump, such as a rotary-type positive displacement type such as internal gear, screw, shuttle block, flexible vane or sliding vane, circumferential piston, helical twisted roots or liquid ring vacuum pumps, a reciprocating-type positive

displacement type, such as piston or diaphragm pumps, and a linear-type positive displacement type, such as rope pumps and chain pumps, a rotary lobe pump, a progressive cavity pump, a rotary gear pump, a piston pump, a diaphragm pump, a screw pump, a gear pump, a hydraulic pump, and a vane pump. A rotary positive displacement pumps may be a gear pump, a screw pump, or a rotary vane pumps. Reciprocating positive displacement pumps may be plunger pumps type, diaphragm pumps type, diaphragm valves type, or radial piston pumps type.

A pump may be an impulse pump such as hydraulic ram pumps type, pulser pumps type, or airlift pumps type. A pump may be a rotodynamic pump such as a velocity pump or a centrifugal pump. A centrifugal pump may be a radial flow pump type, an axial flow pump type, or a mixed flow pump. Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be an electrochemical or chemical actuator, used to produce, change, or otherwise affect a matter structure, properties, composition, process, or reactions, such as oxidation/reduction or an electrolysis process.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be a sounder, which converts electrical energy to sound waves transmitted through the air, an elastic solid material, or a liquid, usually by means of a vibrating or moving ribbon or diaphragm. The sound may be audible or inaudible (or both), and may be omnidirectional, unidirectional, bidirectional, or provide other directionality or polar patterns. A sounder may be an electromagnetic loudspeaker, a piezoelectric speaker, an electrostatic loudspeaker (ESL), a ribbon or planar magnetic loudspeaker, or a bending wave loudspeaker.

A sounder may be an electromechanical type, such as an electric bell, a buzzer (or beeper), a chime, a whistle or a ringer and may be either electromechanical or ceramic-based piezoelectric sounders. The sounder may emit a single or multiple tones, and can be in continuous or intermittent operation.

The sounder may be used to play digital audio content, either stored in, or received by, the sounder, the actuator unit, the router, the control server, or any combination thereof. The audio content stored may be either pre-recorded or using a synthesizer. Few digital audio files may be stored, selected by a control logic. Alternatively or in addition, the source of the digital audio may be a microphone serving as a sensor. In another example, the system uses the sounder for simulating the voice of a human being or generates music. The music produced, can emulate the sounds of a conventional acoustical music instrument, such as a piano, tuba, harp, violin, flute, guitar

and so forth. A talking human voice may be played by the sounder, either pre-recorded or using human voice synthesizer, and the sound may be a syllable, a word, a phrase, a sentence, a short story or a long story, and can be based on speech synthesis or pre-recorded, using male or female voice.

5 A human speech may be produced using a hardware, software (or both) speech synthesizer, which may be Text-To-Speech (TTS) based. The speech synthesizer may be a concatenative type, using unit selection, diphone synthesis, or domain-specific synthesis. Alternatively or in addition, the speech synthesizer may be a formant type, and may be based on articulatory synthesis or hidden Markov models (HMM) based. Each of
10 the actuators **15a, 15b, 15c, or 15d** (or all of them) may be used to generate an electric or magnetic field, and may be an electromagnetic coil or an electromagnet.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them), or dashboard display **16**, may be a display for presentation of visual data or information, commonly on a screen, and may consist of an array (e.g., matrix) of light emitters or light reflectors, and
15 may present text, graphics, image or video. A display may be a monochrome, gray-scale, or color type, and may be a video display. The display may be a projector (commonly by using multiple reflectors), or alternatively (or in addition) have the screen integrated. A projector may be based on an Eidophor, Liquid Crystal on Silicon (LCoS or LCOS), or LCD, or may use Digital Light Processing (DLP™) technology, and may be MEMS
20 based or be a virtual retinal display. A video display may support Standard-Definition (SD) or High-Definition (HD) standards, and may support 3D. The display may present the information as scrolling, static, bold or flashing. The display may be an analog display, such as having NTSC, PAL or SECAM formats. Similarly, analog RGB, VGA (Video Graphics Array), SVGA (Super Video Graphics Array), SCART or S-video
25 interface, or may be a digital display, such as having IEEE1394 interface (a.k.a. FireWire™), may be used. Other digital interfaces that can be used are USB, SDI (Serial Digital Interface), HDMI (High-Definition Multimedia Interface), DVI (Digital Visual Interface), UDI (Unified Display Interface), DisplayPort, Digital Component Video or DVB (Digital Video Broadcast) interface. Various user controls may include an on/off
30 switch, a reset button and others. Other exemplary controls involve display associated settings such as contrast, brightness and zoom.

A display may be a Cathode-Ray Tube (CRT) display, or a Liquid Crystal Display (LCD) display. The LCD display may be passive (such as CSTN or DSTN based) or active matrix, and may be Thin Film Transistor (TFT) or LED-backlit LCD

display. A display may be a Field Emission Display (FED), Electroluminescent Display (ELD), Vacuum Fluorescent Display (VFD), or may be an Organic Light-Emitting Diode (OLED) display, based on passive-matrix (PMOLED) or active-matrix OLEDs (AMOLED).

5 A display may be based on an Electronic Paper Display (EPD), and be based on Gyricon technology, Electro-Wetting Display (EWD), or Electrofluidic display technology. A display may be a laser video display or a laser video projector, and may be based on a Vertical-External-Cavity Surface-Emitting-Laser (VECSEL) or a Vertical-Cavity Surface-Emitting Laser (VCSEL).

10 A display may be a segment display, such as a numerical or an alphanumeric display that can show only digits or alphanumeric characters, words, characters, arrows, symbols, ASCII and non-ASCII characters. Examples are Seven-segment display (digits only), Fourteen-segment display, and Sixteen-segment display, and a dot matrix display.

Each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may be a
15 thermoelectric actuator such as a cooler or a heater for changing the temperature of a solid, liquid or gas object, and may use conduction, convection, thermal radiation, or by the transfer of energy by phase changes. A heater may be a radiator using radiative heating, a convector using convection, or a forced convection heater. A thermoelectric actuator may be a heating or cooling heat pump, and may be electrically powered,
20 compression-based cooler using an electric motor to drive a refrigeration cycle. A thermoelectric actuator may be an electric heater, converting electrical energy into heat, using resistance, or a dielectric heater. A thermoelectric actuator may be a solid-state active heat pump device based on the Peltier effect. A thermoelectric actuator may be an air cooler, using a compressor-based refrigeration cycle of a heat pump. An electric
25 heater may be an induction heater.

Each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may include a signal generator serving as an actuator for providing an electrical signal (such as a voltage or current), or may be coupled between the processor and the actuator for controlling the actuator. A signal generator may be an analog or digital signal generator, and may be
30 based on software (or firmware) or may be a separated circuit or component. A signal may generate repeating or non-repeating electronic signals, and may include a digital to analog converter (DAC) to produce an analog output. Common waveforms are a sine wave, a saw-tooth, a step (pulse), a square, and a triangular waveforms. The generator may include some sort of modulation functionality such as Amplitude Modulation

(AM), Frequency Modulation (FM), or Phase Modulation (PM). A signal generator may be an Arbitrary Waveform Generators (AWGs) or a logic signal generator.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be a light source that emits visible or non-visible light (infrared, ultraviolet, X-rays, or gamma rays) such as for illumination or indication. The actuator may comprise a shade, a reflector, an enclosing globe, or a lens, for manipulating the emitted light. The light source may be an electric light source for converting electrical energy into light, and may consist of, or comprise, a lamp, such as an incandescent, a fluorescent, or a gas discharge lamp. The electric light source may be based on Solid-State Lighting (SSL) such as a Light Emitting Diode (LED) which may be Organic LED (OLED), a polymer LED (PLED), or a laser diode. The actuator may be a chemical or electrochemical actuator, and may be operative for producing, changing, or affecting a matter structure, properties, composition, process, or reactions, such as producing, changing, or affecting an oxidation/reduction or an electrolysis reaction.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be a motion actuator and may cause linear or rotary motion or may comprise a conversion mechanism (may be based on a screw, a wheel and axle, or a cam) for converting to rotary or linear motion. The conversion mechanism may be based on a screw, and the system may include a leadscrew, a screw jack, a ball screw or a roller screw, or may be based on a wheel and axle, and the system may include a hoist, a winch, a rack and pinion, a chain drive, a belt drive, a rigid chain, or a rigid belt. The motion actuator may comprise a lever, a ramp, a screw, a cam, a crankshaft, a gear, a pulley, a constant-velocity joint, or a ratchet, for affecting the produced motion. The motion actuator may be a pneumatic actuator, a hydraulic actuator, or an electrical actuator. The motion actuator may be an electrical motor such as brushed, a brushless, or an uncommutated DC motor, or a Permanent Magnet (PM) motor, a Variable reluctance (VR) motor, or a hybrid synchronous stepper DC motor. The electrical motor may be an induction motor, a synchronous motor, or an eddy current AC motor. The AC motor may be a single-phase AC induction motor, a two-phase AC servo motor, or a three-phase AC synchronous motor, and may be a split-phase motor, a capacitor-start motor, or a Permanent-Split Capacitor (PSC) motor. The electrical motor may be an electrostatic motor, a piezoelectric actuator, or a MEMS-based motor.

The motion actuator may be a linear hydraulic actuator, a linear pneumatic actuator, or a linear electric motor such as linear induction motor (LIM) or a Linear

Synchronous Motor (LSM). The motion actuator may be a piezoelectric motor, a Surface Acoustic Wave (SAW) motor, a Squiggle motor, an ultrasonic motor, or a micro- or nanometer comb-drive capacitive actuator, a Dielectric or Ionic based Electroactive Polymers (EAPs) actuator, a solenoid, a thermal bimorph, or a piezoelectric unimorph actuator.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be operative to move, force, or compress a liquid, a gas or a slurry, and may be a compressor or a pump. The pump may be a direct lift, an impulse, a displacement, a valveless, a velocity, a centrifugal, a vacuum, or a gravity pump. The pump may be a positive displacement pump such as a rotary lobe, a progressive cavity, a rotary gear, a piston, a diaphragm, a screw, a gear, a hydraulic, or a vane pump. The positive displacement pump may be a rotary-type positive displacement pump such as an internal gear, a screw, a shuttle block, a flexible vane, a sliding vane, a rotary vane, a circumferential piston, a helical twisted roots, or a liquid ring vacuum pump. The positive displacement pump may be a reciprocating-type positive displacement type such as a piston, a diaphragm, a plunger, a diaphragm valve, or a radial piston pump. The positive displacement pump may be a linear-type positive displacement type such as rope-and-chain pump. The pump may be an impulse pump such as a hydraulic ram, a pulser, or an airlift pump. The pump may be a rotodynamic pump, such as a velocity pump or a centrifugal pump, that may be a radial flow, an axial flow, or a mixed flow pump.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be a sounder for converting an electrical energy to emitted audible or inaudible sound waves, emitted as omnidirectional, unidirectional, or bidirectional pattern. The sound may be audible, and the sounder may be an electromagnetic loudspeaker, a piezoelectric speaker, an electrostatic loudspeaker (ESL), a ribbon or planar magnetic loudspeaker, or a bending wave loudspeaker. The sounder may be electromechanical or ceramic based, and may be operative to emit a single or multiple tones, and may be operative to continuous or intermittent operation. The sounder may be an electric bell, a buzzer (or beeper), a chime, a whistle or a ringer. The sounder may be a loudspeaker, and the system may be operative to play one or more digital audio content files (which may include a pre-recorded audio) stored entirely or in part in the second device, the router, or the control server. The system may comprise a synthesizer for producing the digital audio content. The sensor may be a microphone for capturing the digital audio content to play by the sounder. The control logic or the system may be operative to select one of the digital

audio content files, and may be operative for playing the selected file by the sounder. The digital audio content may be music, and may include the sound of an acoustical musical instrument such as a piano, a tuba, a harp, a violin, a flute, or a guitar. The digital audio content may be a male or female human voice saying a syllable, a word, a phrase, a sentence, a short story or a long story. The system may comprise a speech synthesizer (such as a Text-To-Speech (TTS) based) for producing a human speech, being part of the second device, the router, the control server, or any combination thereof. The speech synthesizer may be a concatenative type, and may use unit selection, diphone synthesis, or domain-specific synthesis. Alternatively or in addition, the speech synthesizer may be a formant type, articulatory synthesis based, or hidden Markov models (HMM) based.

Each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may be a monochrome, grayscale or color display for visually presenting information, and may consist of an array of light emitters or light reflectors. Alternatively or in addition, the display may be a visual retinal display or a projector based on an Eidophor, Liquid Crystal on Silicon (LCoS or LCOS), LCD, MEMS or Digital Light Processing (DLP™) technology. The display may be a video display that may support Standard-Definition (SD) or High-Definition (HD) standards, and may be 3D video display. The display may be capable of scrolling, static, bold or flashing the presented information. The display may be an analog display having an analog input interface such as NTSC, PAL or SECAM formats, or analog input interface such as RGB, VGA (Video Graphics Array), SVGA (Super Video Graphics Array), SCART or S-video interface. Alternatively or in addition, the display may be a digital display having a digital input interface such as IEEE1394, FireWire™, USB, SDI (Serial Digital Interface), HDMI (High-Definition Multimedia Interface), DVI (Digital Visual Interface), UDI (Unified Display Interface), DisplayPort, Digital Component Video, or DVB (Digital Video Broadcast) interface. The display may be a Liquid Crystal Display (LCD) display, a Thin Film Transistor (TFT), or an LED-backlit LCD display, and may be based on a passive or an active matrix. The display may be a Cathode-Ray Tube (CRT), a Field Emission Display (FED), Electronic Paper Display (EPD) display (based on Gyricon technology, Electro-Wetting Display (EWD), or Electrofluidic display technology), a laser video display (based on a Vertical-External-Cavity Surface-Emitting-Laser (VECSEL) or a Vertical-Cavity Surface-Emitting Laser (VCSEL)), an Electroluminescent Display (ELD), a Vacuum Fluorescent Display (VFD), or a passive-matrix (PMOLED) or active-matrix

OLEDs (AMOLED) Organic Light-Emitting Diode (OLED) display. The display may be a segment display (such as Seven-segment display, a fourteen-segment display, a sixteen-segment display, or a dot matrix display), and may be operative to only display digits, alphanumeric characters, words, characters, arrows, symbols, ASCII, non-ASCII
5 characters, or any combination thereof.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be a thermoelectric actuator (such as an electric thermoelectric actuator) and may be a heater or a cooler, and may be operative for affecting or changing the temperature of a solid, a liquid, or a gas object. The thermoelectric actuator may be coupled to the object by
10 conduction, convection, force convention, thermal radiation, or by the transfer of energy by phase changes. The thermoelectric actuator may include a heat pump, or may be a cooler based on an electric motor based compressor for driving a refrigeration cycle. The thermoelectric actuator may be an induction heater, may be an electric heater such as a resistance heater or a dielectric heater, or may be solid-state based such as an active heat
15 pump device based on the Peltier effect. The actuator may be an electromagnetic coil or an electromagnet and may be operative for generating a magnetic or electric field.

The apparatus may produce actuator commands in response to the sensor data according to control logic, and may deliver the actuator commands to the actuator over the internal network. The control logic may affect a control loop for controlling the
20 condition, and the control loop may be a closed linear control loop where the sensor data serve as a feedback to command the actuator based on the loop deviation from a setpoint or a reference value that may be fixed, set by a user, or may be time dependent. The closed control loop may be a proportional-based, an integral-based, a derivative-based, or a Proportional, Integral, and Derivative (PID) based control loop, and the control loop
25 may use feed-forward, Bistable, Bang-Bang, Hysteretic, or fuzzy logic based control. The control loop may be based on, or associated with, randomness based on random numbers; and the apparatus may comprise a random number generator for generating random numbers that may be hardware-based using thermal noise, shot noise, nuclear decaying radiation, photoelectric effect, or quantum phenomena. Alternatively or in
30 addition, the random number generator may be software-based and may execute an algorithm for generating pseudo-random numbers. The apparatus may couple to, or comprise in the single enclosure, an additional sensor responsive to a third condition distinct from the first or second conditions, and the setpoint may be dependent upon the output of the additional sensor.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be any mechanism, system, or device that creates, produces, changes, stimulates, or affects a phenomenon, in response to an electrical signal or an electrical power. Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may affect a physical, chemical, biological or any other phenomenon, serving as a stimulus to the sensor. Alternatively or in addition, the actuator may affect the magnitude of the phenomenon, or any parameter or quantity thereof. For example, the actuator may be used to affect or change pressure, flow, force or other mechanical quantities. The actuator may be an electrical actuator, where electrical energy is supplied to affect the phenomenon, or may be controlled by an electrical signal (e.g., voltage or current). A signal conditioning may be used in order to adapt the actuator operation, or in order to improve the handling of the actuator input or adapting it to the former stage or manipulating, such as attenuation, delay, current or voltage limiting, level translation, galvanic isolation, impedance transformation, linearization, calibration, filtering, amplifying, digitizing, integration, derivation, and any other signal manipulation. Further, in the case of conditioning, the conditioning circuit may involve time related manipulation, such as filter or equalizer for frequency related manipulation such as filtering, spectrum analysis or noise removal, smoothing or de-blurring in case of image enhancement, a compressor (or de-compressor) or coder (or decoder) in the case of a compression or a coding/decoding schemes, modulator or demodulator in case of modulation, and extractor for extracting or detecting a feature or parameter such as pattern recognition or correlation analysis. In case of filtering, passive, active or adaptive (such as Wiener or Kalman) filters may be used. The conditioning circuits may apply linear or non-linear manipulations. Further, the manipulation may be time-related such as using analog or digital delay-lines or integrators, or any rate-based manipulation. Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may have an analog input, requiring a D/A to be connected thereto, or may have a digital input.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may directly or indirectly create, change or otherwise affect the rate of change of the physical quantity (gradient) versus the direction around a particular location, or between different locations. For example, a temperature gradient may describe the differences in the temperature between different locations. Further, an actuator may affect time-dependent or time-manipulated values of the phenomenon, such as time-integrated, average or Root Mean Square (RMS or rms), relating to the square root of the mean of the squares of a series of discrete values (or the equivalent square root of the integral in a continuously

varying value). Further, a parameter relating to the time dependency of a repeating phenomenon may be affected, such as the duty-cycle, the frequency (commonly measured in Hertz – Hz) or the period. An actuator may be based on the Micro Electro-Mechanical Systems – MEMS (a.k.a. Micro-mechanical electrical Systems) technology.

5 An actuator may affect environmental conditions such as temperature, humidity, noise, vibration, fumes, odors, toxic conditions, dust, and ventilation.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may change, increase, reduce, or otherwise affect the amount of a property or of a physical quantity or the magnitude relating to a physical phenomenon, body or substance. Alternatively or in
10 addition, each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be used to affect the time derivative thereof, such as the rate of change of the amount, the quantity or the magnitude. In the case of space related quantity or magnitude, an actuator may affect the linear density, relating to the amount of property per length, an actuator may affect the surface density, relating to the amount of property per area, or an actuator may
15 affect the volume density, relating to the amount of property per volume. In the case of a scalar field, an actuator may further affect the quantity gradient, relating to the rate of change of property with respect to position. Alternatively or in addition, an actuator may affect the flux (or flow) of a property through a cross-section or surface boundary. Alternatively or in addition, an actuator may affect the flux density, relating to the flow
20 of property through a cross-section per unit of the cross-section, or through a surface boundary per unit of the surface area. Alternatively or in addition, an actuator may affect the current, relating to the rate of flow of property through a cross-section or a surface boundary, or the current density, relating to the rate of flow of property per unit through a cross-section or a surface boundary. An actuator may include or consists of a
25 transducer, defined herein as a device for converting energy from one form to another for the purpose of measurement of a physical quantity or for information transfer. Further, a single actuator may be used to affect two or more phenomena. For example, two characteristics of the same element may be affected, each characteristic corresponding to a different phenomenon. An actuator may have multiple states, where
30 the actuator state is depending upon the control signal input. An actuator may have a two state operation such as 'on' (active) and 'off' (non active), based on a binary input such as '0' or '1', or 'true' and 'false'. In such a case, it can be activated by controlling an electrical power supplied or switched to it, such as by an electric switch.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be a light source used to emit light by converting electrical energy into light, and where the luminous intensity is fixed or may be controlled, commonly for illumination or indicating purposes. Further, an actuator may be used to activate or control the light emitted by a light source, being based on converting electrical energy or other energy to a light. The light emitted may be a visible light, or invisible light such as infrared, ultraviolet, X-ray or gamma rays. A shade, reflector, enclosing globe, housing, lens, and other accessories may be used, typically as part of a light fixture, in order to control the illumination intensity, shape or direction. The illumination (or the indication) may be steady, blinking or flashing. Further, the illumination can be directed for lighting a surface, such as a surface including an image or a picture. Further, a single-state visual indicator may be used to provide multiple indications, for example by using different colors (of the same visual indicator), different intensity levels, variable duty-cycle and so forth.

Electrical sources of illumination commonly use a gas, a plasma (such as in an arc and fluorescent lamps), an electrical filament, or Solid-State Lighting (SSL), where semiconductors are used. An SSL may be a Light-Emitting Diode (LED), an Organic LED (OLED), or Polymer LED (PLED). Further, an SSL may be a laser diode, which is a laser whose active medium is a semiconductor, commonly based on a diode formed from a p-n junction and powered by the injected electric current.

A light source may consist of, or comprise, a lamp, which is typically replaceable and is commonly radiating a visible light. A lamp, sometimes referred to as 'bulb', may be an arc lamp, a Fluorescent lamp, a gas-discharge lamp, or an incandescent light. An arc lamp (a.k.a. arc light) is the general term for a class of lamps that produce light by an electric arc (also called a voltaic arc). Such a lamp consists of two electrodes, first made from carbon but typically made today of tungsten, which are separated by a gas. The type of lamp is often named by the gas contained in the bulb; including Neon, Argon, Xenon, Krypton, Sodium, metal Halide, and Mercury, or by the type of electrode as in carbon-arc lamps. The common fluorescent lamp may be regarded as a low-pressure mercury arc lamp.

Gas-discharge lamps are a family of artificial light sources that generate light by sending an electrical discharge through an ionized gas (plasma). Typically, such lamps use a noble gas (argon, neon, krypton and xenon) or a mixture of these gases and most lamps are filled with additional materials, like mercury, sodium, and metal halides. In operation the gas is ionized, and free electrons, accelerated by the electrical field in the

tube, collide with gas and metal atoms. Some electrons in the atomic orbitals of these atoms are excited by these collisions to a higher energy state. When the excited atom falls back to a lower energy state, it emits a photon of a characteristic energy, resulting in infrared, visible light, or ultraviolet radiation. Some lamps convert the ultraviolet
5 radiation to visible light with a fluorescent coating on the inside of the lamp's glass surface. The fluorescent lamp is perhaps the best known gas-discharge lamp.

A fluorescent lamp (a.k.a. fluorescent tube) is a gas-discharge lamp that uses electricity to excite mercury vapor, and is commonly constructed as a tube coated with phosphor containing low pressure mercury vapor that produces white light. The excited
10 mercury atoms produce short-wave ultraviolet light that then causes a phosphor to fluoresce, producing visible light. A fluorescent lamp converts electrical power into useful light more efficiently than an incandescent lamp. Lower energy cost typically offsets the higher initial cost of the lamp. A neon lamp (a.k.a. Neon glow lamp) is a gas discharge lamp that typically contains neon gas at a low pressure in a glass capsule. Only
15 a thin region adjacent to the electrodes glows in these lamps, which distinguishes them from the much longer and brighter neon tubes used for public signage.

An incandescent light bulb (a.k.a. incandescent lamp or incandescent light globe) produces light by heating a filament wire to a high temperature until it glows. The hot filament is protected from oxidation in the air commonly with a glass enclosure that is
20 filled with inert gas or evacuated. In a halogen lamp, filament evaporation is prevented by a chemical process that redeposits metal vapor onto the filament, extending its life. The light bulb is supplied with electrical current by feed-through terminals or wires embedded in the glass. Most bulbs are used in a socket which provides mechanical support and electrical connections. A halogen lamp (a.k.a. Tungsten halogen lamp or
25 quartz iodine lamp) is an incandescent lamp that has a small amount of a halogen such as iodine or bromine added. The combination of the halogen gas and the tungsten filament produces a halogen cycle chemical reaction which redeposits evaporated tungsten back to the filament, increasing its life and maintaining the clarity of the envelope. Because of this, a halogen lamp can be operated at a higher temperature than a standard gas-filled
30 lamp of similar power and operating life, producing light of a higher luminous efficacy and color temperature. The small size of halogen lamps permits their use in compact optical systems for projectors and illumination.

A Light-Emitting Diode (LED) is a semiconductor light source, based on the principle that when a diode is forward-biased (switched on), electrons are able to

recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. Conventional LEDs are made from a variety of inorganic semiconductor materials, such as Aluminium gallium arsenide (AlGaAs), Gallium arsenide phosphide (GaAsP) Aluminium gallium indium phosphide (AlGaInP), Gallium (III) phosphide (GaP), Zinc selenide (ZnSe), Indium gallium nitride (InGaN), and Silicon carbide (SiC) as substrate.

In an Organic Light-Emitting Diodes (OLEDs) the electroluminescent material comprising the emissive layer of the diode, is an organic compound. The organic material is electrically conductive due to the delocalization of pi electrons caused by conjugation over all or part of the molecule, and the material therefore functions as an organic semiconductor. The organic materials can be small organic molecules in a crystalline phase, or polymers.

High-power LEDs (HPLED) can be driven at currents from hundreds of mAs to more than an amper, compared with the tens of mAs for other LEDs. Some can emit over a thousand Lumens. Since overheating is destructive, the HPLEDs are commonly mounted on a heat sink to allow for heat dissipation.

LEDs are efficient, and emit more light per watt than incandescent light bulbs. They can emit light of an intended color without using any color filters as traditional lighting methods need. LEDs can be very small (smaller than 2 mm²) and are easily populated onto printed circuit boards. LEDs light up very quickly. A typical red indicator LED will achieve full brightness in under a microsecond. LEDs are ideal for uses subject to frequent on-off cycling, unlike fluorescent lamps that fail faster when cycled often, or HID lamps that require a long time before restarting and can very easily be dimmed either by pulse-width modulation or lowering the forward current. Further, in contrast to most light sources, LEDs radiate very little heat in the form of IR that can cause damage to sensitive objects or fabrics, and typically have a relatively long useful life.

Each of the actuators **15a**, **15b**, **15c**, or **15d** (or all of them) may be a thermoelectric actuator such as a cooler or a heater for changing the temperature of an object, that may be solid, liquid or gas (such as the air temperature), using conduction, convection, thermal radiation, or by the transfer of energy by phase changes. Radiative heaters contain a heating element that reaches a high temperature. The element is usually

packaged inside a glass envelope resembling a light bulb and with a reflector to direct the energy output away from the body of the heater. The element emits infrared radiation that travels through air or space until it hits an absorbing surface, where it is partially converted to heat and partially reflected. In a convection heater, the heating element
5 heats the air next to it by convection. Hot air is less dense than cool air, so it rises due to buoyancy, allowing more cool air to flow in to take its place. This sets up a constant current of hot air that leaves the appliance through vent holes and heats up the surrounding space. These are generally filled with oil, in an oil heater, due to oil functioning as an effective heat reservoir. They are ideally suited for heating a closed
10 space. They operate silently and have a lower risk of ignition hazard in the event that they make unintended contact with furnishings compared to radiant electric heaters. This is a good choice for long periods of time, or if left unattended. A fan heater, also called a forced convection heater, is a variety of convection heater that includes an electric fan to speed up the airflow. This reduces the thermal resistance between the heating element
15 and the surroundings faster than passive convection, allowing heat to be transferred more quickly.

A thermoelectric actuator may be a heat pump, which is a machine or device that transfers thermal energy from one location, called the "source," which is at a lower temperature, to another location called the "sink" or "heat sink", which is at a higher
20 temperature. Heat pumps may be used for cooling or for heating. Thus, heat pumps move thermal energy opposite to the direction that it normally flows, and may be electrically driven such as compressor-driven air conditioners and freezers. A heat pump may use an electric motor to drive a refrigeration cycle, drawing energy from a source such as the ground or outside air and directing it into the space to be warmed. Some
25 systems can be reversed so that the interior space is cooled and the warm air is discharged outside or into the ground.

A thermoelectric actuator may be an electric heater, converting electrical energy into heat, such as for space heating, cooking, water heating, and industrial processes. Commonly, the heating element inside every electric heater is simply an electrical
30 resistor, and works on the principle of Joule heating: an electric current through a resistor converts electrical energy into heat energy. In a dielectric heater, high-frequency alternating electric field, or radio wave or microwave electromagnetic radiation heats a dielectric material, and is based on heating caused by molecular dipole rotation within the dielectric. Microwave heaters, as distinct from RF heating, is a sub-category of

dielectric heating at frequencies above 100 MHz, where an electromagnetic wave can be launched from a small dimension emitter and conveyed through space to the target. Modern microwave ovens make use of electromagnetic waves (microwaves) with electric fields of much higher frequency and shorter wavelength than RF heaters. Typical domestic microwave ovens operate at 2.45 GHz, but 0.915 GHz ovens also exist, thus the wavelengths employed in microwave heating are 12 or 33 cm, providing for highly efficient, but less penetrative, dielectric heating.

A thermoelectric actuator may be a thermoelectric cooler or a heater (or a heat pump) based on the Peltier effect, where heat flux in the junction of two different types of materials is created. When direct current is supplied to this solid-state active heat pump device (a.k.a. Peltier device, Peltier heat pump, solid state refrigerator, or ThermoElectric Cooler – TEC), heat is moved from one side to the other, building up a difference in temperature between the two sides, and hence can be used for either heating or cooling. A Peltier cooler can also be used as a thermoelectric generator, such that when one side of the device is heated to a temperature greater than the other side, a difference in voltage will build up between the two sides.

A thermoelectric actuator may be an air cooler, sometimes referred to as an air conditioner. Common air coolers, such as in refrigerators, are based on a refrigeration cycle of a heat pump. This cycle takes advantage of the way phase changes work, where latent heat is released at a constant temperature during a liquid/gas phase change, and where varying the pressure of a pure substance also varies its condensation/boiling point. The most common refrigeration cycle uses an electric motor to drive a compressor.

An electric heater may be an induction heater, producing the process of heating an electrically conducting object (usually a metal) by electromagnetic induction, where eddy currents (also called Foucault currents) are generated within the metal and resistance leads to Joule heating of the metal. An induction heater (for any process) consists of an electromagnet, through which a high-frequency Alternating Current (AC) is passed. Heat may also be generated by magnetic hysteresis losses in materials that have significant relative permeability.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may use pneumatics, involving the application of pressurized gas to affect mechanical motion. A motion actuator may be a pneumatic actuator that converts energy (typically in the form of compressed air) into rotary or linear motion. In some arrangements, a motion actuator may be used to provide force or torque. Similarly, force or torque actuators may be used

as motion actuators. A pneumatic actuator mainly consists of a piston, a cylinder, and valves or ports. The piston is covered by a diaphragm, or seal, which keeps the air in the upper portion of the cylinder, allowing air pressure to force the diaphragm downward, moving the piston underneath, which in turn moves the valve stem, which is linked to the internal parts of the actuator. Pneumatic actuators may only have one spot for a signal input, top or bottom, depending on the action required. Valves input pressure is the "control signal", where each different pressure is a different set point for a valve. Valves typically require little pressure to operate and usually double or triple the input force. The larger the size of the piston, the larger the output pressure can be. Having a larger piston can also be good if air supply is low, allowing the same forces with less input.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may use hydraulics, involving the application of a fluid to affect mechanical motion. Common hydraulics systems are based on Pascal's famous theory, which states that the pressure of the liquid produced in an enclosed structure has the capacity of releasing a force up to ten times the pressure that was produced earlier. A hydraulic actuator may be a hydraulic cylinder, where pressure is applied to the fluids (oil), to get the desired force. The force acquired is used to power the hydraulic machine. These cylinders typically include the pistons of different sizes, used to push down the fluids in the other cylinder, which in turn exerts the pressure and pushes it back again. A hydraulic actuator may be a hydraulic pump, is responsible for supplying the fluids to the other essential parts of the hydraulic system. The power generated by a hydraulic pump is about ten times more than the capacity of an electrical motor. There are different types of hydraulic pumps such as the vane pumps, gear pumps, piston pumps, etc. Among them, the piston pumps are relatively more costly, but they have a guaranteed long life and are even able to pump thick, difficult fluids. Further, a hydraulic actuator may be a hydraulic motor, where the power is achieved with the help of exerting pressure on the hydraulic fluids, which is normally oil. The benefit of using hydraulic motors is that when the power source is mechanical, the motor develops a tendency to rotate in the opposite direction, thus acting like a hydraulic pump.

A motion actuator may further be a vacuum actuator, producing a motion based on vacuum pressure, commonly controlled by a Vacuum Switching Valve (VSV), which controls the vacuum supply to the actuator. A motion actuator may be a rotary actuator that produces a rotary motion or torque, commonly to a shaft or axle. The simplest rotary

actuator is a purely mechanical linear actuator, where linear motion in one direction is converted to a rotation. A rotary actuator may be electrically powered, or may be powered by pneumatic or hydraulic power, or may use energy stored internally by springs. The motion produced by a rotary motion actuator may be either continuous rotation, such as in common electric motors, or movement to a fixed angular position as for servos and stepper motors. A further form, the torque motor, does not necessarily produce any rotation but merely generates a precise torque which then either cause rotation, or is balanced by some opposing torque. Some motion actuators may be intrinsically linear, such as those using linear motors. Motion actuators may include, or coupled with, a wide variety of mechanical elements to change the nature of the motion such as provided by the actuating / transducing elements, such as levers, ramps, limit switches, screws, cams, crankshafts, gears, pulleys, wheels, constant-velocity joints, shock absorbers or dampers, or ratchets.

A stepper motor (a.k.a. step motor) is a brushless DC electric motor that divides a full rotation into a number of equal steps, commonly of a fixed size. The motor position can then be commanded to move and hold on one of these steps without any feedback sensor (an open-loop controller), or may be combined with either a position encoder or at least a single datum sensor at the zero position. The stepper motor may be a switched reluctance motor, which is a very large stepping motor with a reduced pole count, and generally is closed-loop commutated. A stepper motor may be a permanent magnet stepper type, using a Permanent Magnet (PM) in the rotor and operate on the attraction or repulsion between the rotor PM and the stator electromagnets. Further, a stepper motor may be a variable reluctance stepper using a Variable Reluctance (VR) motor that has a plain iron rotor and operate based on the principle that minimum reluctance occurs with minimum gap, hence the rotor points are attracted toward the stator magnet poles. Further, a stepper motor may be a hybrid synchronous stepper, where a combination of the PM and VR techniques are used to achieve maximum power in a small package size. Furthermore, a stepper motor may be a Lavet type stepping motor using a single-phase stepping motor, where the rotor is a permanent magnet and the motor is built with a strong magnet and large stator to deliver high torque.

A rotary actuator may be a servomotor (a.k.a. servo), which is a packaged combination of a motor (usually electric, although fluid power motors may also be used), a gear train to reduce the many rotations of the motor to a higher torque rotation, and a position encoder that identifies the position of the output shaft and an inbuilt control

system. The input control signal to the servo indicates the desired output position. Any difference between the position commanded and the position of the encoder gives rise to an error signal that causes the motor and geartrain to rotate until the encoder reflects a position matching that commanded. Further, a rotary actuator may be a memory wire type, which uses applying current such that the wire is heated above its transition temperature and so changes shape, applying a torque to the output shaft. When power is removed, the wire cools and returns to its earlier shape.

A rotary actuator may be a fluid power actuator, where hydraulic or pneumatic power may be used to drive a shaft or an axle. Such fluid power actuators may be based on driving a linear piston, to where a cylinder mechanism is geared to produce rotation, or may be based on a rotating asymmetrical vane that swings through a cylinder of two different radii. The differential pressure between the two sides of the vane gives rise to an unbalanced force and thus a torque on the output shaft. Such vane actuators require a number of sliding seals and the joins between these seals have tended to cause more problems with leakage than for the piston and cylinder type.

Alternatively or in addition, a motion actuator may be a linear actuator that creates motion in a straight line. Such linear actuator may use hydraulic or pneumatic cylinders which inherently produce linear motion, or may provide a linear motion by converting from a rotary motion created by a rotary actuator, such as electric motors. Rotary-based linear actuators may be a screw, a wheel and axle, or a cam type. A screw actuator operates on the screw machine principle, whereby rotating the actuator nut, the screw shaft moves in a line, such as a lead-screw, a screw jack, a ball screw or roller screw. A wheel-and-axle actuator operates on the principle of the wheel and axle, where a rotating wheel moves a cable, rack, chain or belt to produce linear motion. Examples are hoist, winch, rack and pinion, chain drive, belt drive, rigid chain, and rigid belt actuators. Cam actuator includes a wheel-like cam, which upon rotation, provides thrust at the base of a shaft due to its eccentric shape. Mechanical linear actuators may only pull, such as hoists, chain drive and belt drives, while others only push (such as a cam actuator). Some pneumatic and hydraulic cylinder based actuators may provide force in both directions.

A linear hydraulic actuator (a.k.a. hydraulic cylinder) commonly involves a hollow cylinder having a piston inserted in it. An unbalanced pressure applied to the piston provides a force that can move an external object, and since liquids are nearly incompressible, a hydraulic cylinder can provide controlled precise linear displacement

of the piston. The displacement is only along the axis of the piston. Pneumatic actuators, or pneumatic cylinders, are similar to hydraulic actuators except they use compressed gas to provide pressure instead of a liquid. A linear pneumatic actuator (a.k.a. pneumatic cylinder) is similar to hydraulic actuator, except that it uses compressed gas to provide
5 pressure instead of a liquid.

A linear actuator may be a piezoelectric actuator, based on the piezoelectric effect in which application of a voltage to the piezoelectric material causes it to expand. Very high voltages correspond to only tiny expansions. As a result, piezoelectric actuators can achieve extremely fine positioning resolution, but also have a very short
10 range of motion.

A linear actuator may be a linear electrical motor. Such a motor may be based on a conventional rotary electrical motor, connected to rotate a lead screw, that has a continuous helical thread machined on its circumference running along the length (similar to the thread on a bolt). Threaded onto the lead screw is a lead nut or ball nut
15 with corresponding helical threads, used for preventing from rotating with the lead screw (typically the nut interlocks with a non-rotating part of the actuator body). The electrical motor may be a DC brush, a DC brushless, a stepper, or an induction motor type.

Telescoping linear actuators are specialized linear actuators used where space restrictions or other requirements require, where their range of motion is many times
20 greater than the unextended length of the actuating member. A common form is made of concentric tubes of approximately equal length that extend and retract like sleeves, one inside the other, such as the telescopic cylinder. Other more specialized telescoping actuators use actuating members that act as rigid linear shafts when extended, but break that line by folding, separating into pieces and/or uncoiling when retracted. Examples of
25 telescoping linear actuators include a helical band actuator, a rigid belt actuator, a rigid chain actuator, and a segmented spindle.

A linear actuator may be a linear electric motor, that has had its stator and rotor "unrolled" so that instead of producing a torque (rotation) it produces a linear force along its length. The most common mode of operation is as a Lorentz-type actuator, in which
30 the applied force is linearly proportional to the current and the magnetic field. A linear electric motor may be a Linear Induction Motor (LIM), which is an AC (commonly 3-phase) asynchronous linear motor that works with the same general principles as other induction motors but which has been designed to directly produce motion in a straight line. In such motor type, the force is produced by a moving linear magnetic field acting

on conductors in the field, such that any conductor, be it a loop, a coil or simply a piece of plate metal, that is placed in this field, will have eddy currents induced in it thus creating an opposing magnetic field, in accordance with Lenz's law. The two opposing fields will repel each other, thus creating motion as the magnetic field sweeps through the metal. The primary of a linear electric motor typically consists of a flat magnetic core (generally laminated) with transverse slots which are often straight cut with coils laid into the slots, while the secondary is frequently a sheet of aluminum, often with an iron backing plate. Some LIMs are double sided, with one primary either side of the secondary, and in this case, no iron backing is needed. A LIM may be based on a synchronous motor, where the rate of movement of the magnetic field is controlled, usually electronically, to track the motion of the rotor. A linear electric motor may be a Linear Synchronous Motor (LSM), in which the rate of movement of the magnetic field is controlled, usually electronically, to track the motion of the rotor. Synchronous linear motors may use commutators, or preferably the rotor may contain permanent magnets, or soft iron.

A motion actuator may be a piezoelectric motor (a.k.a. piezo motor), which is based upon the change in shape of a piezoelectric material when an electric field is applied. Piezoelectric motors make use of the converse piezoelectric effect whereby the material produces acoustic or ultrasonic vibrations in order to produce a linear or rotary motion. In one mechanism, the elongation in a single plane is used to make a series of stretches and position holds, similar to the way a caterpillar moves. Piezoelectric motors may be made in both linear and rotary types.

One drive technique is to use piezoelectric ceramics to push a stator. Commonly known as Inchworm or PiezoWalk motors, these piezoelectric motors use three groups of crystals: two of which are Locking and one Motive, permanently connected to either the motor's casing or stator (not both) and sandwiched between the other two, which provides the motion. These piezoelectric motors are fundamentally stepping motors, with each step comprising either two or three actions, based on the locking type. Another mechanism employs the use of Surface Acoustic Waves (SAW) to generate linear or rotary motion. An alternative drive technique is known as Squiggle motor, in which piezoelectric elements are bonded orthogonally to a nut and their ultrasonic vibrations rotate and translate a central lead screw, providing a direct drive mechanism. The piezoelectric motor may be according to, or based on, the motor described in U.S. Patent No. 3,184,842 to Maropis, entitled: *"Method and Apparatus for Delivering Vibratory*

Energy", in U.S. Patent No. 4,019,073 to Vishnevsky *et al.*, entitled: "*Piezoelectric Motor Structures*", or in U.S. Patent No. 4,210,837 to Vasiliev *et al.*, entitled: "*Piezoelectrically Driven Torsional Vibration Motor*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

5 A linear actuator may be a comb-drive capacitive actuator utilizing electrostatic forces that act between two electrically conductive combs. The attractive electrostatic forces are created when a voltage is applied between the static and moving combs causing them to be drawn together. The force developed by the actuator is proportional to the change in capacitance between the two combs, increasing with driving voltage, the
10 number of comb teeth, and the gap between the teeth. The combs are arranged so that they never touch (because then there would be no voltage difference). Typically the teeth are arranged so that they can slide past one another until each tooth occupies the slot in the opposite comb. Comb drive actuators typically operate at the micro- or nanometer scale and are generally manufactured by bulk micromachining or surface
15 micromachining a silicon wafer substrate.

 An electric motor may be an ultrasonic motor, which is powered by the ultrasonic vibration of a component, the stator, placed against another component, the rotor or slider depending on the scheme of operation (rotation or linear translation). Ultrasonic motors and piezoelectric actuators typically use some form of piezoelectric
20 material, most often lead zirconate titanate and occasionally lithium niobate or other single-crystal materials. In ultrasonic motors, resonance is commonly used in order to amplify the vibration of the stator in contact with the rotor.

 A motion actuator may consist of, or based on, Electroactive Polymers (EAPs), which are polymers that exhibit a change in size or shape when stimulated by an electric
25 field, and may use as actuators and sensors. A typical characteristic property of an EAP is that they will undergo a large amount of deformation while sustaining large forces. EAPs are generally divided into two principal classes: Dielectric and Ionic. Dielectric EAPs, are materials in which actuation is caused by electrostatic forces between two electrodes which squeeze the polymer. Dielectric elastomers are capable of very high
30 strains and are fundamentally a capacitor that changes its capacitance when a voltage is applied, by allowing the polymer to compress in thickness and expand in the area due to the electric field. This type of EAP typically requires a large actuation voltage to produce high electric fields (hundreds to thousands of volts), but very low electrical power consumption. Dielectric EAPs require no power to keep the actuator at a given position.

Examples are electrostrictive polymers and dielectric elastomers. In Ionic EAPs, actuation is caused by the displacement of ions inside the polymer. Only a few volts are needed for actuation, but the ionic flow implies a higher electrical power needed for actuation, and energy is needed to keep the actuator at a given position. Examples of
5 ionic EAPS are conductive polymers, ionic polymer-metal composites (IPMCs), and responsive gels.

A linear motion actuator may be a wax motor, typically providing smooth and gentle motion. Such a motor comprises a heater that when energized, heats a block of wax causing it to expand and to drive a plunger outwards. When the electric current is
10 removed, the wax block cools and contracts, causing the plunger to withdraw, usually by spring force applied externally or by a spring incorporated directly into the wax motor.

A motion actuator may be a thermal bimorph, which is a cantilever that consists of two active layers: piezoelectric and metal. These layers produce a displacement via thermal activation where a temperature change causes one layer to expand more than the
15 other. A piezoelectric unimorph is a cantilever that consists of one active layer and one inactive layer. In the case where active layer is piezoelectric, deformation in that layer may be induced by the application of an electric field. This deformation induces a bending displacement in the cantilever. The inactive layer may be fabricated from a non-piezoelectric material.

20 An electric motor may be an electrostatic motor (a.k.a. capacitor motor), which is based on the attraction and repulsion of electric charge. Often, electrostatic motors are the dual of conventional coil-based motors. They typically require a high voltage power supply, although very small motors employ lower voltages. The electrostatic motor may be used in micro-mechanical (MEMS) systems where their drive voltages are below 100
25 volts, and where moving charged plates are far easier to fabricate than coils and iron cores. An alternative type of electrostatic motor is the spacecraft electrostatic ion drive thruster where forces and motion are created by electrostatically accelerating ions. The electrostatic motor may be according to, or based on, the motor described in U.S. Patent No. 3,433,981 to Bollee, entitled: "*Electrostatic Motor*", in U.S. Patent No. 3,436,630 to
30 Bollee, entitled: "*Electrostatic Motor*", in U.S. Patent No. 3,436,630 to Robert *et al.* entitled: "*Electrostatic Motor*", or in U.S. Patent No. 5,552,654 to Konno *et al.*, entitled: "*Electrostatic actuator*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

An electric motor may be an AC motor, which is driven by an Alternating Current (AC). Such a motor commonly consists of two basic parts, an outside stationary stator having coils supplied with alternating current to produce a rotating magnetic field, and an inside rotor attached to the output shaft that is given a torque by the rotating field.

5 An AC motor may be an induction motor, which runs slightly slower than the supply frequency, where the magnetic field on the rotor of this motor is created by an induced current. Alternatively, an AC motor may be a synchronous motor, which does not rely on induction and as a result, can rotate exactly at the supply frequency or a sub-multiple of the supply frequency. The magnetic field on the rotor is either generated by current
10 delivered through slip rings or by a permanent magnet. Other types of AC motors include eddy current motors, and also AC/DC mechanically commutated machines in which speed is dependent on voltage and winding connection.

An AC motor may be a two-phase AC servo-motor, typically having a squirrel cage rotor and a field consisting of two windings: a constant-voltage (AC) main winding
15 and a control-voltage (AC) winding in quadrature (i.e., 90 degrees phase shifted) with the main winding, to produce a rotating magnetic field. Reversing phase makes the motor reverse. The control winding is commonly controlled and fed from an AC servo amplifier and a linear power amplifier.

An AC motor may be a single-phase AC induction motor; where the rotating
20 magnetic field must be produced using other means, such as shaded-pole motor, commonly including a small single-turn copper "shading coil" creates the moving magnetic field. Part of each pole is encircled by a copper coil or strap; the induced current in the strap opposes the change of flux through the coil. Another type is a split-phase motor, having a startup winding separate from the main winding. When the motor
25 is started, the startup winding is connected to the power source via a centrifugal switch, which is closed at low speed. Another type is a capacitor start motor, including a split-phase induction motor with a starting capacitor inserted in series with the startup winding, creating an LC circuit that is capable of a much greater phase shift (and so, a much greater starting torque). The capacitor naturally adds expense to such motors.
30 Similarly, a resistance-start motor is a split-phase induction motor with a starter inserted in series with the startup winding, creating a reactance. This added starter provides assistance in the starting and the initial direction of rotation. Another variation is the Permanent-Split Capacitor (PSC) motor (also known as a capacitor start and run motor), which operates similarly to the capacitor-start motor described above, but there is no

centrifugal starting switch, and what correspond to the start windings (second windings) are permanently connected to the power source (through a capacitor), along with the run windings. PSC motors are frequently used in air handlers, blowers, and fans (including ceiling fans) and other cases where a variable speed is desired.

5 An AC motor may be a three-phase AC synchronous motor, where the connections to the rotor coils of a three-phase motor are taken out on slip-rings and fed a separate field current to create a continuous magnetic field (or if the rotor consists of a permanent magnet), the result is called a synchronous motor because the rotor will rotate synchronously with the rotating magnetic field produced by the polyphase electrical supply.

10 An electric motor may be a DC motor, which is driven by a Direct Current (DC), and is, similarly based on a torque that is produced by the principle of Lorentz force. Such a motor may be a brushed, a brushless, or an uncommutated type. A brushed DC electric motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets (permanent or electromagnets), and rotating electrical magnets. Brushless DC motors use a rotating permanent magnet or soft magnetic core in the rotor, and stationary electrical magnets on the motor housing, and use a motor controller that converts DC to AC. Other types of DC motors require no commutation, such as a homopolar motor that has a magnetic field along the axis of rotation and an electric current that at some point is not parallel to the magnetic field, and a ball bearing motor that consists of two ball bearing-type bearings, with the inner races mounted on a common conductive shaft, and the outer races connected to a high current, low voltage power supply. An alternative construction fits the outer races inside a metal tube, while the inner races are mounted on a shaft with a non-conductive section (e.g., two sleeves on an insulating rod). This method has the advantage that the tube will act as a flywheel. The direction of rotation is determined by the initial spin which is usually required to get it going.

20 An actuator may be a pump, typically used to move (or compress) fluids or liquids, gasses, or slurries, commonly by pressure or suction actions. Pumps commonly consume energy to perform mechanical work by moving the fluid or the gas, where the activating mechanism is often reciprocating or rotary. Pumps may be operated in many ways, including manual operation, electricity, a combustion engine of some type, and wind action. An air pump moves air either into, or out of, something, and a sump pump used for the removal of liquid from a sump or sump pit. A fuel pump is commonly used

to move transport the fuel through a pipe, and a vacuum pump is a device that removes gas molecules from a sealed volume in order to leave behind a partial vacuum. A gas compressor is a mechanical device that increases the pressure of a gas by reducing its volume. A pump may be a valveless pump, where no valves are present to regulate the flow direction, and are commonly used in biomedical and engineering systems. Pumps can be classified into many major groups, for example according to their energy source or according to the method they use to move the fluid, such as direct lift, impulse, displacement, velocity, centrifugal, and gravity pumps.

A positive displacement pump causes a fluid to move by trapping a fixed amount of it and then forcing (displacing) that trapped volume into the discharge pipe. Some positive displacement pumps work using an expanding cavity on the suction side and a decreasing cavity on the discharge side. The liquid flows into the pump as the cavity on the suction side expands, and the liquid flows out of the discharge as the cavity collapses. The volume is constant given each cycle of operation. A positive displacement pump can be further classified according to the mechanism used to move the fluid: A rotary-type positive displacement type such as internal gear, screw, shuttle block, flexible vane or sliding vane, circumferential piston, helical twisted roots (e.g., Wendelkolben pump) or liquid ring vacuum pumps, a reciprocating-type positive displacement type, such as a piston or diaphragm pumps, and a linear-type positive displacement type, such as rope pumps and chain pumps. The positive displacement principle applies also to a rotary lobe pump, a progressive cavity pump, a rotary gear pump, a piston pump, a diaphragm pump, a screw pump, a gear pump, a hydraulic pump, and a vane pump.

A rotary positive displacement pumps can be grouped into three main types: Gear pumps where the liquid is pushed between two gears, Screw pumps where the shape of the pump internals usually two screws turning against each other pump the liquid, and Rotary vane pumps, which are similar to scroll compressors, and are consisting of a cylindrical rotor enclosed in a similarly shaped housing. As the rotor turns, the vanes trap fluid between the rotor and the casing, drawing the fluid through the pump.

Reciprocating positive displacement pumps cause the fluid to move using one or more oscillating pistons, plungers or membranes (diaphragms). Typical reciprocating pumps include plunger pumps type, which are based on a reciprocating plunger that pushes the fluid through one or two open valves, closed by suction on the way back,

diaphragm pumps type which are similar to plunger pumps, where the plunger pressurizes hydraulic oil which is used to flex a diaphragm in the pumping cylinder, diaphragm valves type that are used to pump hazardous and toxic fluids, piston displacement pumps type that are usually simple devices for pumping small amounts of liquid or gel manually, and radial piston pumps type.

A pump may be an impulse pump, which uses pressure created by gas (usually air). In some impulse pumps the gas trapped in the liquid (usually water), is released and accumulated somewhere in the pump, creating a pressure which can push part of the liquid upwards. Impulse pump types include: a hydraulic ram pump type, which use a pressure built up internally from a released gas in a liquid flow; a pulser pump type which runs with natural resources by kinetic energy only; and an airlift pump type which runs on air inserted into a pipe, pushing up the water, when bubbles move upward, or on a pressure inside the pipe pushing the water up.

A velocity pump may be a rotodynamic pump (a.k.a. dynamic pump), which is a type of velocity pump in which kinetic energy is added to the fluid by increasing the flow velocity. This increase in energy is converted to a gain in potential energy (pressure) when the velocity is reduced prior to or as the flow exits the pump into the discharge pipe. This conversion of kinetic energy to pressure is based on the First law of thermodynamics or more specifically by Bernoulli's principle.

A pump may be a centrifugal pump, which is a rotodynamic pump that uses a rotating impeller to increase the pressure and flow rate of a fluid. Centrifugal pumps are the most common type of pump used to move liquids through a piping system. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward or axially into a diffuser or volute chamber, from where it exits into the downstream piping system. A centrifugal pump may be a radial flow pump type, where the fluid exits at right angles to the shaft, an axial flow pump type where the fluid enters and exits along the same direction parallel to the rotating shaft, or may be a mixed flow pump, where the fluid experiences both radial acceleration and lift and exits the impeller somewhere between 0–90 degrees from the axial direction.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be an electrochemical or chemical actuator, used to produce, change, or otherwise affect a matter structure, properties, composition, process, or reactions. An electrochemical actuator may affect or generate a chemical reaction or an oxidation/reduction (redox) reaction, such as an electrolysis process.

An actuator may be an electroacoustic actuator, such as a sounder which converts electrical energy to sound waves transmitted through the air, an elastic solid material, or a liquid, usually by means of a vibrating or moving ribbon or diaphragm. The sound may be audio or audible, having frequencies in the approximate range of 20 to 20,000 hertz, capable of being detected by human organs of hearing. Alternatively or in addition, the sounder may be used to emit inaudible frequencies, such as ultrasonic (a.k.a. ultrasound) acoustic frequencies that are above the range audible to the human ear, or above approximately 20,000 Hz. A sounder may be omnidirectional, unidirectional, bidirectional, or provide other directionality or polar patterns.

A loudspeaker (a.k.a. speaker) is a sounder that produces sound in response to an electrical audio signal input, typically audible sound. The most common form of loudspeaker is the electromagnetic (or dynamic) type, uses a paper cone supporting a moving voice coil electromagnet acting on a permanent magnet. Where accurate reproduction of sound is required, multiple loudspeakers may be used, each reproducing a part of the audible frequency range. A loudspeaker is commonly optimized for middle frequencies; tweeters for high frequencies; and sometimes supertweeter is used which is optimized for the highest audible frequencies.

A loudspeaker may be a piezo (or piezoelectric) speaker contains a piezoelectric crystal coupled to a mechanical diaphragm and is based on the piezoelectric effect. An audio signal is applied to the crystal, which responds by flexing in proportion to the voltage applied across the crystal surfaces, thus converting electrical energy into mechanical. Piezoelectric speakers are frequently used as beepers in watches and other electronic devices, and are sometimes used as tweeters in less-expensive speaker systems, such as computer speakers and portable radios. A loudspeaker may be a magnetostrictive transducers, based on magnetostriction, have been predominantly used as sonar ultrasonic sound wave radiators, but their usage has spread also to audio speaker systems.

A loudspeaker may be an electrostatic loudspeaker (ESL), in which sound is generated by the force exerted on a membrane suspended in an electrostatic field. Such speakers use a thin flat diaphragm usually consisting of a plastic sheet coated with a conductive material such as graphite sandwiched between two electrically conductive grids, with a small air gap between the diaphragm and grids. The diaphragm is usually made from a polyester film (thickness 2–20 μm) with exceptional mechanical properties, such as PET film. By means of the conductive coating and an external high voltage

supply the diaphragm is held at a DC potential of several kilovolts with respect to the grids. The grids are driven by the audio signal; and the front and rear grids are driven in antiphase. As a result, a uniform electrostatic field proportional to the audio signal is produced between both grids. This causes a force to be exerted on the charged
5 diaphragm, and its resulting movement drives the air on either side of it.

A loudspeaker may be a magnetic loudspeaker, and may be a ribbon or planar type, is based on a magnetic field. A ribbon speaker consists of a thin metal-film ribbon suspended in a magnetic field. The electrical signal is applied to the ribbon, which moves with it to create the sound. Planar magnetic speakers are speakers with roughly
10 rectangular flat surfaces that radiate in a bipolar (i.e., front and back) manner, and may be having printed or embedded conductors on a flat diaphragm. Planar magnetic speakers consist of a flexible membrane with a voice coil printed or mounted on it. The current flowing through the coil interacts with the magnetic field of carefully placed magnets on either side of the diaphragm, causing the membrane to vibrate more
15 uniformly and without much bending or wrinkling. A loudspeaker may be a bending wave loudspeaker, which uses a diaphragm that is intentionally flexible.

A sounder may be an electromechanical type, such as an electric bell, which may be based on an electromagnet, causing a metal ball to clap on cup or half-sphere bell. A sounder may be a buzzer (or beeper), a chime, a whistle or a ringer. Buzzers may be
20 either electromechanical or ceramic-based piezoelectric sounders which make a high-pitch noise, and may be used for alerting. The sounder may emit a single or multiple tones, and can be in continuous or intermittent operation.

In one example, the sounder is used to play a stored digital audio. The digital audio content can be stored in the sounder. Further, few files may be stored (e.g.,
25 representing different announcements or songs), selected by the control logic. Alternatively or in addition, the digital audio data may be received by the sounder from external sources via any of the above networks. Furthermore, the source of the digital audio may be a microphone serving as a sensor, either after processing, storing, delaying, or any other manipulation, or as originally received resulting 'doorphone' or
30 'intercom' functionality between a microphone and a sounder in the building.

In another example, the sounder simulates the voice of a human being or generates music, typically by using an electronic circuit having a memory for storing the sounds (e.g., music, song, voice message, etc.), a digital to analog converter **22b** to reconstruct the electrical representation of the sound, and a driver for driving a

loudspeaker, which is an electro-acoustic transducer that converts an electrical signal to sound. An example of a greeting card providing music and mechanical movement is disclosed in U.S. Patent Application No. 2007/0256337 to Segan entitled: "*User Interactive Greeting Card*", which is incorporated in its entirety for all purposes as if
5 fully set forth herein.

In one example, the system is used for sound or music generation. For example, the sound produced can emulate the sounds of a conventional acoustical music instrument, such as a piano, tuba, harp, violin, flute, guitar and so forth. In one example, the sounder is an audible signaling device, emitting audible sounds that can be heard
10 (having frequency components in the 20-20,000 Hz band). In one example the sound generated is music or song. The elements of the music such as pitch (which governs melody and harmony), rhythm (and its associated concepts tempo, meter, and articulation), dynamics, and the sonic qualities of timbre and texture, may be associated with the shape theme. For example, if a musical instrument shown in the picture, the
15 music generated by that instrument will be played, e.g., drumming sound of drums and playing of a flute or guitar. In one example, a talking human voice is played by the sounder. The sound may be a syllable, a word, a phrase, a sentence, a short story or a long story, and can be based on speech synthesis or pre-recorded. Male or female voice can be used, further being young or old.

Some examples of toys that include generation of an audio signal such as music are disclosed in U.S. Patent No. 4,496,149 to Schwartzberg entitled: "*Game Apparatus Utilizing Controllable Audio Signals*", in U.S. Patent No. 4,516,260 to Breedlove *et al.* entitled: "*Electronic Learning Aid or Game having Synthesized Speech*", in U.S. Patent No. 7,414,186 to Scarpa *et al.* entitled: "*System and Method for Teaching Musical
25 Notes*", in U.S. Patent No. 4,968,255 to Lee *et al.*, entitled: "*Electronic Instructional Apparatus*", in U.S. Patent No. 4,248,123 to Bunger *et al.*, entitled: "*Electronic Piano*" and in U.S. Patent No. 4,796,891 to Milner entitled: "*Musical Puzzle Using Sliding Tiles*", and toys with means for synthesizing human voice are disclosed in U.S. Patent No. 6,527,611 to Cummings entitled: "*Place and Find Toy*", and in U.S. Patent No.
30 4,840,602 to Rose entitled: "*Talking Doll Responsive to External Signal*", which are all incorporated in their entirety for all purposes as if fully set forth herein. A music toy kit combining music toy instrument with a set of construction toy blocks is disclosed in U.S. Patent No. 6,132,281 to Klitsner *et al.* entitled: "*Music Toy Kit*" and in U.S. Patent No.

5,349,129 to Wisniewski *et al.* entitled: "*Electronic Sound Generating Toy*", which are incorporated in their entirety for all purposes as if fully set forth herein.

A speech synthesizer used to produce natural and intelligible artificial human speech may be implemented in hardware, in software, or combination thereof. A speech synthesizer may be Text-To-Speech (TTS) based, that converts normal language text to speech, or alternatively (or in addition) may be based on rendering symbolic linguistic representation like phonetic transcription. A TTS typically involves two steps, the front-end where the raw input text is pre-processed to fully write-out words replacing numbers and abbreviations, followed by assigning phonetic transcriptions to each word (text-to-phoneme), and the back-end (or synthesizer) where the symbolic linguistic representation is converted to output sound.

The generating of synthetic speech waveform typically uses a concatenative or formant synthesis. The concatenative synthesis commonly produces the most natural-sounding synthesized speech, and is based on the concatenation (or stringing together) of segments of recorded speech. There are three main types of concatenative synthesis: Unit selection, diphone synthesis, and domain-specific synthesis. Unit selection synthesis is based on large databases of recorded speech including individual phones, diphones, half-phones, syllables, morphemes, words, phrases, and sentences, indexed based on the segmentation and acoustic parameters like the fundamental frequency (pitch), duration, position in the syllable, and neighboring phones. At run time, the desired target utterance is created by determining (typically using a specially weighted decision tree) the best chain of candidate units from the database (unit selection). Diphone synthesis uses a minimal speech database containing all the diphones (sound-to-sound transitions) occurring in a language, and at runtime, the target prosody of a sentence is superimposed on these minimal units by means of digital signal processing techniques such as linear predictive coding. Domain-specific synthesis is used where the output is limited to a particular domain, using concatenated prerecorded words and phrases to create complete utterances. In formant synthesis the synthesized speech output is created using additive synthesis and an acoustic model (physical modeling synthesis), rather than on using human speech samples. Parameters such as fundamental frequency, voicing, and noise levels are varied over time to create a waveform of artificial speech. The synthesis may further be based on articulatory synthesis where computational techniques for synthesizing speech are based on models of the human vocal tract and the articulation processes occurring there, or may be HMM-based synthesis which is based

on hidden Markov models, where the frequency spectrum (vocal tract), fundamental frequency (vocal source), and duration (prosody) of speech are modeled simultaneously by HMMs and generated based on the maximum likelihood criterion. The speech synthesizer may further be based on the book entitled: "*Development in Speech*
5 *Synthesis*", by Mark Tatham and Katherine Morton, published 2005 by John Wiley & Sons Ltd., ISBN: 0-470-85538-X, and on the book entitled: "*Speech Synthesis and Recognition*" by John Holmes and Wendy Holmes, 2nd Edition, published 2001 ISBN: 0-7484-0856-8, which are both incorporated in their entirety for all purposes as if fully set forth herein.

10 A speech synthesizer may be software based such as Apple VoiceOver utility which uses speech synthesis for accessibility, and is part of the Apple iOS operating system used on the iPhone, iPad and iPod Touch. Similarly, Microsoft uses SAPI 4.0 and SAPI 5.0 as part of Windows operating system. Similarly, hardware may be used, and may be based on an IC. A tone, voice, melody, or song hardware-based sounder
15 typically contains a memory storing a digital representation of the pre-recorder or synthesized voice or music, a Digital to Analog (D/A) converter for creating an analog signal, a speaker and a driver for feeding the speaker. A sounder may be based on Holtek HT3834 CMOS VLSI Integrated Circuit (IC) named '36 Melody Music Generator' available from Holtek Semiconductor Inc., headquartered in Hsinchu, Taiwan, and
20 described with application circuits in a data sheet Rev. 1.00 dated November 2, 2006, on EPSON 7910 series 'Multi-Melody IC' available from Seiko-Epson Corporation, Electronic Devices Marketing Division located in Tokyo, Japan, and described with application circuits in a data sheet PF226-04 dated 1998, on Magnevation SpeakJet chip available from Magnevation LLC and described in 'Natural Speech & Complex Sound
25 Synthesizer', described in User's Manual Revision 1.0 July 27, 2004, on Sensory Inc. NLP-5x described in the Data sheet "Natural Language Processor with Motor, Sensor and Display Control", P/N 80-0317-K, published 2010 by Sensory, Inc. of Santa-Clara, California, U.S.A., or on OPTi 82C931 'Plug and Play Integrated Audio Controller' described in Data Book 912-3000-035 Revision: 2.1 published on August 1, 1997, which
30 are all incorporated herein in their entirety for all purposes as if fully set forth herein. Similarly, a music synthesizer may be based on YMF721 OPL4-ML2 FM + Wavetable Synthesizer LSI available from Yamaha Corporation described in YMF721 Catalog No. LSI-4MF721A20, which is incorporated in its entirety for all purposes as if fully set forth herein.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be used to generate an electric or magnetic field. An electromagnetic coil (sometimes referred to simply as a "coil") is formed when a conductor (usually an insulated solid copper wire) is wound around a core or form, to create an inductor or electromagnet. One loop of wire is usually referred to as a turn, and a coil consists of one or more turns. Coils are often coated with varnish or wrapped with insulating tape to provide additional insulation and secure them in place. A completed coil assembly with taps is often called a winding. An electromagnet is a type of magnet in which the magnetic field is produced by the flow of electric current, and disappears when the current is turned off. A simple electromagnet consisting of a coil of insulated wire wrapped around an iron core. The strength of the magnetic field generated is proportional to the amount of current.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be a display for presentation of visual data or information, commonly on a screen. A display is typically consists of an array of light emitters (typically in a matrix form), and commonly provides a visual depiction of a single, integrated, or organized set of information, such as text, graphics, image or video. A display may be a monochrome (a.k.a. black-and-white) type, which typically displays two colors, one for the background and one for the foreground. Old computer monitor displays commonly use black and white, green and black, or amber and black. A display may be a gray-scale type, which is capable of displaying different shades of gray, or may be a color type, capable of displaying multiple colors, anywhere from 16 to over many millions different colors, and may be based on Red, Green, and Blue (RGB) separate signals. A video display is designed for presenting video content. The screen is the actual location where the information is actually optically visualized by humans. The screen may be an integral part of the display. Alternatively or in addition, the display may be an image or video projector, that projects an image (or a video consisting of moving images) onto a screen surface, which is a separate component and is not mechanically enclosed with the display housing. Most projectors create an image by shining a light through a small transparent image, but some newer types of projectors can project the image directly, by using lasers. A projector may be based on an Eidophor, Liquid Crystal on Silicon (LCoS or LCOS), or LCD, or may use Digital Light Processing (DLP™) technology, and may further be MEMS based. A virtual retinal display, or retinal projector, is a projector that projects an image directly on the retina instead of using an external projection screen. Common display resolutions used today include SVGA (800×600 pixels), XGA (1024×768

pixels), 720p (1280×720 pixels), and 1080p (1920×1080 pixels). Standard-Definition (SD) standards, such as used in SD Television (SDTV), are referred to as 576i, derived from the European-developed PAL and SECAM systems with 576 interlaced lines of resolution; and 480i, based on the American National Television System Committee (ANTSC) NTSC system. High-Definition (HD) video refers to any video system of higher resolution than standard-definition (SD) video, and most commonly involves display resolutions of 1,280×720 pixels (720p) or 1,920×1,080 pixels (1080i/1080p). A display may be a 3D (3 –Dimensions) display, which is the display device capable of conveying a stereoscopic perception of 3-D depth to the viewer. The basic technique is to present offset images that are displayed separately to the left and right eye. Both of these 2-D offset images are then combined in the brain to give the perception of 3-D depth. The display may present the information as scrolling, static, bold or flashing.

The display may be an analog display having an analog signal input. Analog displays are commonly using interfaces such as composite video such as NTSC, PAL or SECAM formats. Similarly, analog RGB, VGA (Video Graphics Array), SVGA (Super Video Graphics Array), SCART, S-video and other standard analog interfaces can be used. Alternatively or in addition, a display may be a digital display, having a digital input interface. Standard digital interfaces such as an IEEE1394 interface (a.k.a. FireWire™), may be used. Other digital interfaces that can be used are USB, SDI (Serial Digital Interface), HDMI (High-Definition Multimedia Interface), DVI (Digital Visual Interface), UDI (Unified Display Interface), DisplayPort, Digital Component Video and DVB (Digital Video Broadcast). In some cases, an adaptor is required in order to connect an analog display to the digital data. For example, the adaptor may convert between composite video (PAL, NTSC) or S-Video and DVI or HDTV signal. Various user controls can be available to allow the user to control and effect the display operations, such as an on/off switch, a reset button and others. Other exemplary controls involve display associated settings such as contrast, brightness and zoom.

A display may be a Cathode-Ray Tube (CRT) display, which is based on moving an electron beam back and forth across the back of the screen. Such a display commonly comprises a vacuum tube containing an electron gun (a source of electrons), and a fluorescent screen used to view images. It further has a means to accelerate and deflect the electron beam onto the fluorescent screen to create the images. Each time the beam makes a pass across the screen, it lights up phosphor dots on the inside of the glass tube, thereby illuminating the active portions of the screen. By drawing many such lines from

the top to the bottom of the screen, it creates an entire image. A CRT display may be a shadow mask or an aperture grille type.

A display may be a Liquid Crystal Display (LCD) display, which utilize two sheets of polarizing material with a liquid crystal solution between them. An electric
5 current passed through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing a backlit light to pass through or blocking the light. In monochrome LCD, images usually appear as blue or dark gray images on top of a grayish-white background. Color LCD displays commonly use passive matrix and Thin Film Transistor (TFT) (or active-matrix) for
10 producing color. Recent passive-matrix displays are using new CSTN and DSTN technologies to produce sharp colors rivaling active-matrix displays.

Some LCD displays use Cold-Cathode Fluorescent Lamps (CCFLs) for backlight illumination. An LED-backlit LCD is a flat panel display that uses LED
15 backlighting instead of the cold cathode fluorescent (CCFL) backlighting, allowing for a thinner panel, lower power consumption, better heat dissipation, a brighter display, and better contrast levels. Three forms of LED may be used: White edge-LEDs around the rim of the screen, using a special diffusion panel to spread the light evenly behind the screen (the most usual form currently), an array of LEDs arranged behind the screen whose brightness are not controlled individually, and a dynamic “local dimming” array
20 of LEDs that are controlled individually or in clusters to achieve a modulated backlight light pattern. A Blue Phase Mode LCD is an LCD technology that uses highly twisted cholesteric phases in a blue phase, in order to improve the temporal response of liquid crystal displays (LCDs).

A Field Emission Display (FED) is a display technology that uses large-area
25 field electron emission sources to provide the electrons that strike colored phosphor, to produce a color image as an electronic visual display. In a general sense, a FED consists of a matrix of cathode ray tubes, each tube producing a single sub-pixel, grouped in threes to form red-green-blue (RGB) pixels. FEDs combine the advantages of CRTs, namely their high contrast levels and very fast response times, with the packaging
30 advantages of LCD and other flat panel technologies. They also offer the possibility of requiring less power, about half that of an LCD system. FED display operates like a conventional cathode ray tube (CRT) with an electron gun that uses high voltage (10 kV) to accelerate electrons which in turn excite the phosphors, but instead of a single electron gun, a FED display contains a grid of individual nanoscopic electron guns. A FED

screen is constructed by laying down a series of metal stripes onto a glass plate to form a series of cathode lines.

A display may be an Organic Light-Emitting Diode (OLED) display, a display device that sandwiches carbon-based films between two charged electrodes, one a metallic cathode and one a transparent anode, usually being glass. The organic films consist of a hole-injection layer, a hole-transport layer, an emissive layer and an electron-transport layer. When voltage is applied to the OLED cell, the injected positive and negative charges recombine in the emissive layer and create electro luminescent light. Unlike LCDs, which require backlighting, OLED displays are emissive devices - they emit light rather than modulate transmitted or reflected light. There are two main families of OLEDs: those based on small molecules and those employing polymers. Adding mobile ions to an OLED creates a light-emitting electrochemical cell or LEC, which has a slightly different mode of operation. OLED displays can use either Passive-Matrix (PMOLED) or active-matrix addressing schemes. Active-Matrix OLEDs (AMOLED) require a thin-film transistor backplane to switch each individual pixel on or off, but allow for higher resolution and larger display sizes.

A display may be an Electroluminescent Displays (ELDs) type, which is a flat panel display created by sandwiching a layer of electroluminescent material such as GaAs between two layers of conductors. When current flows, the layer of material emits radiation in the form of visible light. Electroluminescence (EL) is an optical and electrical phenomenon where a material emits light in response to an electric current passed through it, or to a strong electric field.

A display may be based on an Electronic Paper Display (EPD) (a.k.a. e-paper and electronic ink) display technology which is designed to mimic the appearance of ordinary ink on paper. Unlike conventional backlit flat panel displays which emit light, electronic paper displays reflect light like ordinary paper. Many of the technologies can hold static text and images indefinitely without using electricity, while allowing images to be changed later. Flexible electronic paper uses plastic substrates and plastic electronics for the display backplane.

An EPD may be based on Gyricon technology, using polyethylene spheres between 75 and 106 micrometers across. Each sphere is a janus particle composed of negatively charged black plastic on one side and positively charged white plastic on the other (each bead is thus a dipole). The spheres are embedded in a transparent silicone sheet, with each sphere suspended in a bubble of oil so that they can rotate freely. The

polarity of the voltage applied to each pair of electrodes then determines whether the white or black side is face-up, thus giving the pixel a white or black appearance. Alternatively or in addition, an EPD may be based on an electrophoretic display, where titanium dioxide (Titania) particles approximately one micrometer in diameter are dispersed in hydrocarbon oil. A dark-colored dye is also added to the oil, along with surfactants and charging agents that cause the particles to take on an electric charge. This mixture is placed between two parallel, conductive plates separated by a gap of 10 to 100 micrometers. When a voltage is applied across the two plates, the particles will migrate electrophoretically to the plate bearing the opposite charge from that on the particles.

Further, an EPD may be based on Electro-Wetting Display (EWD), which is based on controlling the shape of a confined water/oil interface by an applied voltage. With no voltage applied, the (colored) oil forms a flat film between the water and a hydrophobic (water-repellent) insulating coating of an electrode, resulting in a colored pixel. When a voltage is applied between the electrode and the water, it changes the interfacial tension between the water and the coating. As a result, the stacked state is no longer stable, causing the water to move the oil aside. Electrofluidic displays are a variation of an electrowetting display, involving the placing of aqueous pigment dispersion inside a tiny reservoir. Voltage is used to electromechanically pull the pigment out of the reservoir and spread it as a film directly behind the viewing substrate. As a result, the display takes on color and brightness similar to that of conventional pigments printed on paper. When voltage is removed liquid surface tension causes the pigment dispersion to rapidly recoil into the reservoir.

A display may be a Vacuum Fluorescent Display (VFD) that emits a very bright light with high contrast and can support display elements of various colors. VFDs can display seven-segment numerals, multi-segment alphanumeric characters or can be made in a dot-matrix to display different alphanumeric characters and symbols.

A display may be a laser video display or a laser video projector. A Laser display requires lasers in three distinct wavelengths—red, green, and blue. Frequency doubling can be used to provide the green wavelengths, and a small semiconductor laser such as Vertical-External-Cavity Surface-Emitting-Laser (VECSEL) or a Vertical-Cavity Surface-Emitting Laser (VCSEL) may be used. Several types of lasers can be used as the frequency doubled sources: fiber lasers, inter cavity doubled lasers, external cavity doubled lasers, eVCSELs, and OPSLs (Optically Pumped Semiconductor Lasers). Among the inter-cavity doubled lasers VCSELs have shown much promise and potential

to be the basis for a mass produced frequency doubled laser. A VECSEL is a vertical cavity, and is composed of two mirrors. On top of one of them is a diode as the active medium. These lasers combine high overall efficiency with good beam quality. The light from the high power IR-laser diodes is converted into visible light by means of extra-
5 cavity waveguided second harmonic generation. Laser-pulses with about 10 KHz repetition rate and various lengths are sent to a Digital Micromirror Device where each mirror directs the pulse either onto the screen or into the dump.

A display may be a segment display, such as a numerical or an alphanumeric display that can show only digits or alphanumeric characters, commonly composed of
10 several segments that switch on and off to give the appearance of desired glyph. The segments are usually single LEDs or liquid crystals, and may further display visual display material beyond words and characters, such as arrows, symbols, ASCII and non-ASCII characters. Non-limiting examples are Seven-segment display (digits only), Fourteen-segment display, and Sixteen-segment display. A display may be a dot matrix
15 display, used to display information on machines, clocks, railway departure indicators and many other devices requiring a simple display device of limited resolution. The display consists of a matrix of lights or mechanical indicators arranged in a rectangular configuration (other shapes are also possible, although not common) such that by switching on or off selected lights, text or graphics can be displayed. A dot matrix
20 controller converts instructions from a processor into signals which turns on or off the lights in the matrix so that the required display is produced.

In one non-limiting example, the display is a video display used to play a stored digital video, or an image display used to present stored digital images, such as photos. The digital video (or image) content can be stored in the display, the actuator unit, the
25 router, the control server, or any combination thereof. Further, few video (or still image) files may be stored (e.g., representing different announcements or songs), selected by the control logic. Alternatively or in addition, the digital video data may be received by the display, the actuator unit, the router, the control server, or any combination thereof, from external sources via any one of the networks. Furthermore, the source of the digital video
30 or image may be an image sensor (or video camera) serving as a sensor, either after processing, storing, delaying, or any other manipulation, or as originally received, resulting Closed-Circuit Television (CCTV) functionality between an image sensor or camera and a display in the building, which may be used for surveillance in areas that

may need monitoring such as banks, casinos, airports, military installations, and convenience stores.

In one non-limiting example, an actuator unit further includes a signal generator coupled between the processor and the actuator. The signal generator may be used to control the actuator, for example, by providing an electrical signal affecting the actuator operation, such as changing the magnitude of the actuator affect or operation. Such a signal generator may be a digital signal generator, or may be an analog signal generator, having an analog electrical signal output.

A signal generator (a.k.a. frequency generator) is an electronic device or circuit devices that can generate repeating or non-repeating electronic signals (typically voltage or current), having an analog output (analog signal generator) or a digital output (digital signal generator). The output signal may be based on an electrical circuit, or may be based on a generated or stored digital data. A function generator is typically a signal generator which produces simple repetitive waveforms. Such devices contain an electronic oscillator, a circuit that is capable of creating a repetitive waveform, or may use digital signal processing to synthesize waveforms, followed by a digital to analog converter, or DAC, to produce an analog output. Common waveforms are a sine wave, a saw-tooth, a step (pulse), a square, and a triangular waveforms. The generator may include some sort of modulation functionality such as Amplitude Modulation (AM), Frequency Modulation (FM), or Phase Modulation (PM). An Arbitrary Waveform Generators (AWGs) are sophisticated signal generators which allow the user to generate arbitrary waveforms, within published limits of frequency range, accuracy, and output level. Unlike function generators, which are limited to a simple set of waveforms; an AWG allows the user to specify a source waveform in a variety of different ways. Logic signal generator (a.k.a. data pattern generator and digital pattern generator) is a digital signal generator that produces logic types of signals - that is logic 1's and 0's in the form of conventional voltage levels. The usual voltage standards are: LVTTTL, LVCMOS.

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may produce a physical, chemical, or biological action, stimulation or phenomenon, such as a changing or generating temperature, humidity, pressure, audio, vibration, light, motion, sound, proximity, flow rate, electrical voltage, and electrical current, in response to the electrical input (current or voltage). For example, an actuator may provide visual or audible signaling, or physical movement. An actuator may include motors, winches, fans,

reciprocating elements, extending or retracting, and energy conversion elements, as well as a heater or a cooler

Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) may be or may include a visual or audible signaling device, or any other device that indicates a status to the person. In one example, the device illuminates a visible light, such as a Light-Emitting-Diode (LED). However, any type of visible electric light emitter such as a flashlight, an incandescent lamp and compact fluorescent lamps can be used. Multiple light emitters may be used, and the illumination may be steady, blinking or flashing. Further, the illumination can be directed for lighting a surface, such as a surface including an image or a picture. Further, a single single-state visual indicator may be used to provide multiple indications, for example, by using different colors (of the same visual indicator), different intensity levels, variable duty-cycle and so forth.

In one example, each of the actuators **15a, 15b, 15c, or 15d** (or all of them) includes a solenoid, which is typically a coil wound into a packed helix, and used to convert electrical energy into a magnetic field. Commonly, an electromechanical solenoid is used to convert energy into linear motion. Such electromagnetic solenoid commonly consists of an electromagnetically inductive coil, wound around a movable steel or iron slug (the armature), and shaped such that the armature can be moved along the coil center. In one example, the actuator may include a solenoid valve, used to actuate a pneumatic valve, where the air is routed to a pneumatic device, or a hydraulic valve, used to control the flow of a hydraulic fluid. In another example, the electromechanical solenoid is used to operate an electrical switch. Similarly, a rotary solenoid may be used, where the solenoid is used to rotate a ratcheting mechanism when power is applied.

In one example, Each of the actuators **15a, 15b, 15c, or 15d** (or all of them) is used for effecting or changing magnetic or electrical quantities such as voltage, current, resistance, conductance, reactance, magnetic flux, electrical charge, magnetic field, electric field, electric power, S-matrix, power spectrum, inductance, capacitance, impedance, phase, noise (amplitude or phase), trans-conductance, trans-impedance, and frequency.

The method described may be used for sensing, by one or more vehicles, a road-related anomaly or hazard, such as a traffic collision, traffic regulation violation, road infrastructure or surface damage, or any other anomaly or obstruction to traffic. Vehicles in the relevant area may be alerted or affected by the information regarding the road-

related anomaly or hazard. For example, a driver or passenger may be notified, or the vehicle operation may be affected accordingly, taking into account the notified anomaly or hazard.

In one example, the method described may be used for, or may be part of, parking help, cruise control, lane keeping, road sign recognition, surveillance, speed limit warning, restricted entries, and pull-over commands, travel information, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning, vehicle safety inspection, transit or emergency vehicle signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, or electronic toll collection. Further, the sensor may be configured to sense, or wherein the actuator may be configured to affect, as part of parking help, cruise control, lane keeping, road sign recognition, surveillance, speed limit warning, restricted entries, and pull-over commands, travel information, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning, vehicle safety inspection, transit or emergency vehicle signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, or electronic toll collection.

Alternatively or in addition, the method described may be used for, or may be part of, fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, on-board computer, fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, or a Vehicle Identification Number (VIN). Further, the sensor may be configured to sense, or wherein the actuator may be configured to affect, as part of fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, on-board computer, fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure,

injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, or a Vehicle Identification Number (VIN).

Any network or vehicle bus data link and physical layer signaling may be according to, compatible with, based on, or use, ISO 11898-1:2015. The medium access may be according to, compatible with, based on, or use, ISO 11898-2:2003. The vehicle bus communication may further be according to, compatible with, based on, or use, any one of, or all of, ISO 11898-3:2006, ISO 11898-2:2004, ISO 11898-5:2007, ISO 11898-6:2013, ISO 11992-1:2003, ISO 11783-2:2012, SAE J1939/11_201209, SAE J1939/15_201508, or SAE J2411_200002 standards. The CAN bus may consist of, may be according to, compatible with, may be based on, compatible with, or may use a CAN with Flexible Data-Rate (CAN FD) protocol, specification, network, or system.

Alternatively or in addition, the vehicle bus may consist of, may comprise, may be based on, may be compatible with, or may use a Local Interconnect Network (LIN) protocol, network, or system, and may be according to, may be compatible with, may be based on, or may use any one of, or all of, ISO 9141-2:1994, ISO 9141:1989, ISO 17987-1, ISO 17987-2, ISO 17987-3, ISO 17987-4, ISO 17987-5, ISO 17987-6, or ISO 17987-7 standards. The battery power-lines or a single wire may serve as the network medium, and may use a serial protocol where a single master controls the network, while all other connected elements serve as slaves.

Alternatively or in addition, the vehicle bus may consist of, may comprise, may be compatible with, may be based on, or may use a FlexRay protocol, specification, network or system, and may be according to, may be compatible with, may be based on, or may use any one of, or all of, ISO 17458-1:2013, ISO 17458-2:2013, ISO 17458-3:2013, ISO 17458-4:2013, or ISO 17458-5:2013 standards. The vehicle bus may support a nominal data rate of 10Mb/s, and may support two independent redundant data channels, as well as independent clock for each connected element.

Alternatively or in addition, the vehicle bus may consist of, may comprise, may be based on, may be compatible with, or may use a Media Oriented Systems Transport (MOST) protocol, network or system, and may be according to, may be compatible with, may be based on, or may use any one of, or all of, MOST25, MOST50, or MOST150. The vehicle bus may employ a ring topology, where one connected element is the timing master that continuously transmit frames where each comprises a preamble used for synchronization of the other connected elements. The vehicle bus may support both

synchronous streaming data as well as asynchronous data transfer. The network medium may be wires (such as UTP or STP), or may be an optical medium such as Plastic Optical Fibers (POF) connected via an optical connector.

Any apparatus (such as devices, systems, modules, sensor, actuator, or any other arrangement) described herein may consist of, be integrated with, be connected to, or be communicating with, an ECU, which may be an Electronic/engine Control Module (ECM) or Engine Control Unit (ECU), Powertrain Control Module (PCM), Transmission Control Module (TCM), Brake Control Module (BCM or EBCM), Central Control Module (CCM), Central Timing Module (CTM), General Electronic Module (GEM), Body Control Module (BCM), Suspension Control Module (SCM), Door Control Unit (DCU), Electric Power Steering Control Unit (PSCU), Seat Control Unit, Speed control unit (SCU), Telematic Control Unit (TCU), Transmission Control Unit (TCU), Brake Control Module (BCM; ABS or ESC), Battery management system, control unit, or control module.

Any ECU herein may comprise a software, such as an operating system or middleware that may use, may comprise, or may be according to, a part or whole of the OSEK/VDX, ISO 17356-1, ISO 17356-2, ISO 17356-3, ISO 17356-4, ISO 17356-5, or AUTOSAR standards, or any combination thereof.

The notification by the server to any user device may be text based, such as an electronic mail (e-mail), website content, fax, or a Short Message Service (SMS). Alternatively or in addition, the notification or alert to the user device may be voice based, such as a voicemail, a voice message to a telephone device. Alternatively or in addition, the notification or the alert to the user device may activate a vibrator, causing vibrations that are felt by human body touching, or may be based on, or may be compatible with a Multimedia Message Service (MMS) or Instant Messaging (IM). The messaging, alerting, and notifications may be based on, include part of, or may be according to U.S. Patent Application No. 2009/0024759 to McKibben *et al.* entitled: “*System and Method for Providing Alerting Services*”, U.S. Patent No. 7,653,573 to Hayes, Jr. *et al.* entitled: “*Customer Messaging Service*”, U.S. Patent No. 6,694,316 to Langseth. *et al.* entitled: “*System and Method for a Subject-Based Channel Distribution of Automatic, Real-Time Delivery of Personalized Informational and Transactional Data*”, U.S. Patent No. 7,334,001 to Eichstaedt *et al.* entitled: “*Method and System for Data Collection for Alert Delivery*”, U.S. Patent No. 7,136,482 to Wille entitled: “*Progressive Alert Indications in a Communication Device*”, U.S. Patent Application

No. 2007/0214095 to Adams *et al.* entitled: “*Monitoring and Notification System and Method*”, U.S. Patent Application No. 2008/0258913 to Busey entitled: “*Electronic Personal Alert System*”, or U.S. Patent No. 7,557,689 to Seddigh *et al.* entitled: “*Customer Messaging Service*”, which are all incorporated in their entirety for all
5 purposes as if fully set forth herein.

Any wireless network herein may be a control network (such as ZigBee or Z-Wave), a home network, a WPAN (Wireless Personal Area Network), a WLAN (wireless Local Area Network), a WWAN (Wireless Wide Area Network), or a cellular network. An example of a Bluetooth-based wireless controller that may be included in
10 the wireless transceiver 18 is SPBT2632C1A Bluetooth module available from STMicroelectronics NV and described in the data sheet DocID022930 Rev. 6 dated April 2015 entitled: “*SPBT2632C1A - Bluetooth® technology class-1 module*”, which is incorporated in its entirety for all purposes as if fully set forth herein. Similarly, other network may be used to cover another geographical scale or coverage, such as NFC,
15 PAN, LAN, MAN, or WAN type. The network may use any type of modulation, such as Amplitude Modulation (AM), a Frequency Modulation (FM), or a Phase Modulation (PM).

Some embodiments may be used in conjunction with one or more types of wireless communication signals and/or systems, for example, Radio Frequency (RF),
20 Infra-Red (IR), Frequency-Division Multiplexing (FDM), Orthogonal FDM (OFDM), Time-Division Multiplexing (TDM), Time-Division Multiple Access (TDMA), Extended TDMA (E-TDMA), General Packet Radio Service (GPRS), extended GPRS, Code-Division Multiple Access (CDMA), Wideband CDMA (WCDMA), CDMA 2000, single-carrier CDMA, multi-carrier CDMA, Multi-Carrier Modulation (MDM), Discrete
25 Multi-Tone (DMT), Bluetooth (RTM), Global Positioning System (GPS), Wi-Fi, Wi-Max, ZigBee (TM), Ultra-Wideband (UWB), Global System for Mobile communication (GSM), 2G, 2.5G, 3G, 3.5G, Enhanced Data rates for GSM Evolution (EDGE), or the like. Further, a wireless communication may be based on, or may be compatible with, wireless technologies that are described in Chapter 20: “*Wireless Technologies*” of the
30 publication number 1-587005-001-3 by Cisco Systems, Inc. (7/99) entitled: “*Internetworking Technologies Handbook*”, which is incorporated in its entirety for all purposes as if fully set forth herein.

Any one of the apparatuses described herein, such as a vehicle, device, module, ECU, or system, may be integrated or communicating with, or connected to, the vehicle self-diagnostics and reporting capability, commonly referred to as On-Board Diagnostics (OBD), to a Malfunction Indicator Light (MIL), or to any other vehicle network, sensors, or actuators that may provide the vehicle owner or a repair technician access to health or state information of the various vehicle sub-systems and to the various computers in the vehicle. Common OBD systems, such as the OBD-II and the EOBD (European On-Board Diagnostics), employ a diagnostic connector, allowing for access to a list of vehicle parameters, commonly including Diagnostic Trouble Codes (DTCs) and Parameters IDentification numbers (PIDs). The OBD-II is described in the presentation entitled: "*Introduction to On Board Diagnostics (II)*" downloaded on 11/2012 from: http://groups.engin.umd.umich.edu/vi/w2_workshops/OBD_ganesan_w2.pdf, which is incorporated in its entirety for all purposes as if fully set forth herein. The diagnostic connector commonly includes pins that provide power for the scan tool from the vehicle battery, thus eliminating the need to connect a scan tool to a power source separately. The status and faults of the various sub-systems accessed via the diagnostic connector may include fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, and the on-board computer. The diagnostics system may provide access and information about the fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, and the Vehicle Identification Number (VIN). The OBD-II specifications defines the interface and the physical diagnostic connector to be according to the Society of Automotive Engineers (SAE) J1962 standard, the protocol may use SAE J1850 and may be based on, or may be compatible with, SAE J1939 Surface Vehicle Recommended Practice entitled: "*Recommended Practice for a Serial Control and Communication Vehicle Network*" or SAE J1939-01 Surface Vehicle Standard entitled: "*Recommended Practice for Control and Communication Network for On-Highway Equipment*", and the PIDs are defined in SAE International Surface Vehicle Standard J1979 entitled: "*E/E Diagnostic Test Modes*", which are all incorporated in their entirety for all purposes as if fully set forth herein. Vehicle diagnostics systems are also described in the International

Organization for Standardization (ISO) 9141 standard entitled: "*Road vehicles — Diagnostic systems*", and the ISO 15765 standard entitled: "*Road vehicles — Diagnostics on Controller Area Networks (CAN)*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

5 The physical layer of the in-vehicle network may be based on, compatible with, or according to, J1939-11 Surface Vehicle Recommended Practice entitled: "*Physical Layer, 250K bits/s, Twisted Shielded Pair*" or J1939-15 Surface Vehicle Recommended Practice entitled: "*Reduced Physical Layer, 250K bits/s, Un-Shielded Twisted Pair (UTP)*", the data link may be based on, compatible with, or according to, J1939-21
10 Surface Vehicle Recommended Practice entitled: "*Data Link Layer*", the network layer may be based on, compatible with, or according to, J1939-31 Surface Vehicle Recommended Practice entitled: "*Network Layer*", the network management may be based on, compatible with, or according to, J1939-81 Surface Vehicle Recommended Practice entitled: "*Network Management*", and the application layer may be based on,
15 compatible with, or according to, J1939-71 Surface Vehicle Recommended Practice entitled: "*Vehicle Application Layer (through December 2004)*", J1939-73 Surface Vehicle Recommended Practice entitled: "*Application Layer - Diagnostics*", J1939-74 Surface Vehicle Recommended Practice entitled: "*Application – Configurable Messaging*", or J1939-75 Surface Vehicle Recommended Practice entitled: "*Application*
20 *Layer – Generator Sets and Industrial*", which are all incorporated in their entirety for all purposes as if fully set forth herein.

Any device herein may serve as a client device in the meaning of client / server architecture, commonly initiating requests for receiving services, functionalities, and resources, from other devices (servers or clients). Each of the these devices may further
25 employ, store, integrate, or operate a client-oriented (or end-point dedicated) operating system, such as Microsoft Windows® (including the variants: Windows 7, Windows XP, Windows 8, and Windows 8.1, available from Microsoft Corporation, headquartered in Redmond, Washington, U.S.A.), Linux, and Google Chrome OS available from Google Inc. headquartered in Mountain View, California, U.S.A.. Further, each of the
30 these devices may further employ, store, integrate, or operate a mobile operating system such as Android (available from Google Inc. and includes variants such as version 2.2 (Froyo), version 2.3 (Gingerbread), version 4.0 (Ice Cream Sandwich), Version 4.2 (Jelly Bean), and version 4.4 (KitKat)), iOS (available from Apple Inc., and includes variants such as versions 3-7), Windows® Phone (available from Microsoft Corporation

and includes variants such as version 7, version 8, or version 9), or Blackberry® operating system (available from BlackBerry Ltd., headquartered in Waterloo, Ontario, Canada). Alternatively or in addition, each of the devices that are not denoted herein as servers may equally function as a server in the meaning of client / server architecture.

5 Any one of the servers herein may be a web server using Hyper Text Transfer Protocol (HTTP) that responds to HTTP requests via the Internet, and any request herein may be an HTTP request.

Examples of web browsers include Microsoft Internet Explorer (available from Microsoft Corporation, headquartered in Redmond, Washington, U.S.A.), Google
10 Chrome that is a freeware web browser (developed by Google, headquartered in Googleplex, Mountain View, California, U.S.A.), Opera™ (developed by Opera Software ASA, headquartered in Oslo, Norway), and Mozilla Firefox® (developed by Mozilla Corporation headquartered in Mountain View, California, U.S.A.). The web-browser may be a mobile browser, such as Safari (developed by Apple Inc.
15 headquartered in Apple Campus, Cupertino, California, U.S.A.), Opera Mini™ (developed by Opera Software ASA, headquartered in Oslo, Norway), and Android web browser.

Any apparatus herein, which may be any of the systems, devices, modules, or functionalities described herein, may be integrated with a smartphone. The integration
20 may be by being enclosed in the same housing, sharing a power source (such as a battery), using the same processor, or any other integration functionality. In one example, the functionality of any apparatus herein, which may be any of the systems, devices, modules, or functionalities described here, is used to improve, to control, or otherwise be used by the smartphone. In one example, a measured or calculated value by
25 any of the systems, devices, modules, or functionalities described herein, is output to the smartphone device or functionality to be used therein. Alternatively or in addition, any of the systems, devices, modules, or functionalities described herein is used as a sensor for the smartphone device or functionality.

A 'nominal' value herein refers to a designed, expected, or target value. In
30 practice, a real or actual value is used, obtained, or exists, which varies within a tolerance from the nominal value, typically without significantly affecting functioning. Common tolerances are 20%, 15%, 10%, 5%, or 1% around the nominal value.

Discussions herein utilizing terms such as, for example, "processing," "computing", "calculating", "determining", "establishing", "analyzing", "checking", or

the like, may refer to operation(s) and/or process(es) of a computer, a computing platform, a computing system, or other electronic computing device, that manipulate and/or transform data represented as physical (e.g., electronic) quantities within the computer's registers and/or memories into other data similarly represented as physical quantities within the computer's registers and/or memories or other information storage medium that may store instructions to perform operations and/or processes.

Throughout the description and claims of this specification, the word "couple" and variations of that word such as "coupling", "coupled", and "couplable", refers to an electrical connection (such as a copper wire or soldered connection), a logical connection (such as through logical devices of a semiconductor device), a virtual connection (such as through randomly assigned memory locations of a memory device) or any other suitable direct or indirect connections (including combination or series of connections), for example, for allowing the transfer of power, signal, or data, as well as connections formed through intervening devices or elements.

The arrangements and methods described herein may be implemented using hardware, software or a combination of both. The term "integration" or "software integration" or any other reference to the integration of two programs or processes herein refers to software components (e.g., programs, modules, functions, processes etc.) that are (directly or via another component) combined, working or functioning together or form a whole, commonly for sharing a common purpose or a set of objectives. Such software integration can take the form of sharing the same program code, exchanging data, being managed by the same manager program, executed by the same processor, stored on the same medium, sharing the same GUI or other user interface, sharing peripheral hardware (such as a monitor, printer, keyboard and memory), sharing data or a database, or being part of a single package. The term "integration" or "hardware integration" or integration of hardware components herein refers to hardware components that are (directly or via another component) combined, working or functioning together or form a whole, commonly for sharing a common purpose or set of objectives. Such hardware integration can take the form of sharing the same power source (or power supply) or sharing other resources, exchanging data or control (e.g., by communicating), being managed by the same manager, physically connected or attached, sharing peripheral hardware connection (such as a monitor, printer, keyboard and memory), being part of a single package or mounted in a single enclosure (or any other physical collocating), sharing a communication port, or used or controlled with the

same software or hardware. The term "integration" herein refers (as applicable) to a software integration, a hardware integration, or any combination thereof.

The term "port" refers to a place of access to a device, electrical circuit or network, where energy or signal may be supplied or withdrawn. The term "interface" of a networked device refers to a physical interface, a logical interface (e.g., a portion of a physical interface or sometimes referred to in the industry as a sub-interface - for example, such as, but not limited to a particular VLAN associated with a network interface), and/or a virtual interface (e.g., traffic grouped together based on some characteristic - for example, such as, but not limited to, a tunnel interface). As used herein, the term "independent" relating to two (or more) elements, processes, or functionalities, refers to a scenario where one does not affect nor preclude the other. For example, independent communication such as over a pair of independent data routes means that communication over one data route does not affect nor preclude the communication over the other data routes.

As used herein, the term "portable" herein refers to physically configured to be easily carried or moved by a person of ordinary strength using one or two hands, without the need for any special carriers.

Any mechanical attachment of joining two parts herein refers to attaching the parts with sufficient rigidity to prevent unwanted movement between the attached parts. Any type of fastening means may be used for the attachments, including chemical material such as an adhesive or a glue, or mechanical means such as screw or bolt. An adhesive (used interchangeably with glue, cement, mucilage, or paste) is any substance applied to one surface, or both surfaces, of two separate items that binds them together and resists their separation. Adhesive materials may be reactive and non-reactive adhesives, which refers to whether the adhesive chemically reacts in order to harden, and their raw stock may be of natural or synthetic origin.

The term "processor" is meant to include any integrated circuit or other electronic device (or collection of devices) capable of performing an operation on at least one instruction including, without limitation, Reduced Instruction Set Core (RISC) processors, CISC microprocessors, Microcontroller Units (MCUs), CISC-based Central Processing Units (CPUs), and Digital Signal Processors (DSPs). The hardware of such devices may be integrated onto a single substrate (e.g., silicon "die"), or distributed among two or more substrates. Furthermore, various functional aspects of the processor may be implemented solely as software or firmware associated with the processor.

A non-limiting example of a processor may be 80186 or 80188 available from Intel Corporation located at Santa-Clara, California, USA. The 80186 and its detailed memory connections are described in the manual "*80186/80188 High-Integration 16-Bit Microprocessors*" by Intel Corporation, which is incorporated in its entirety for all purposes as if fully set forth herein. Other non-limiting example of a processor may be MC68360 available from Motorola Inc. located at Schaumburg, Illinois, USA. The MC68360 and its detailed memory connections are described in the manual "*MC68360 Quad Integrated Communications Controller – User's Manual*" by Motorola, Inc., which is incorporated in its entirety for all purposes as if fully set forth herein. While exemplified above regarding an address bus having an 8-bit width, other widths of address buses are commonly used, such as the 16-bit, 32-bit and 64-bit. Similarly, while exemplified above regarding a data bus having an 8-bit width, other widths of data buses are commonly used, such as 16-bit, 32-bit and 64-bit width. In one example, the processor consists of, comprises, or is part of, Tiva™ TM4C123GH6PM Microcontroller available from Texas Instruments Incorporated (Headquartered in Dallas, Texas, U.S.A.), described in a data sheet published 2015 by Texas Instruments Incorporated [DS-TM4C123GH6PM-15842.2741, SPMS376E, Revision 15842.2741 June 2014], entitled: "*Tiva™ TM4C123GH6PM Microcontroller – Data Sheet*", which is incorporated in its entirety for all purposes as if fully set forth herein, and is part of Texas Instrument's Tiva™ C Series microcontrollers family that provides designers a high-performance ARM® Cortex™-M-based architecture with a broad set of integration capabilities and a strong ecosystem of software and development tools. Targeting performance and flexibility, the Tiva™ C Series architecture offers an 80 MHz Cortex-M with FPU, a variety of integrated memories and multiple programmable GPIO. Tiva™ C Series devices offer consumers compelling cost-effective solutions by integrating application-specific peripherals and providing a comprehensive library of software tools that minimize board costs and design-cycle time. Offering quicker time-to-market and cost savings, the Tiva™ C Series microcontrollers are the leading choice in high-performance 32-bit applications. Targeting performance and flexibility, the Tiva™ C Series architecture offers an 80 MHz Cortex-M with FPU, a variety of integrated memories and multiple programmable GPIO. Tiva™ C Series devices offer consumers compelling cost-effective solutions.

As used herein, the term "Integrated Circuit" (IC) shall include any type of integrated device of any function where the electronic circuit is manufactured by the

patterned diffusion of trace elements into the surface of a thin substrate of semiconductor material (e.g., Silicon), whether single or multiple die, or small or large scale of integration, and irrespective of process or base materials (including, without limitation Si, SiGe, CMOS and GAs) including, without limitation, applications specific integrated
5 circuits (ASICs), field programmable gate arrays (FPGAs), digital processors (e.g., DSPs, CISC microprocessors, or RISC processors), so-called "system-on-a-chip" (SoC) devices, memory (e.g., DRAM, SRAM, flash memory, ROM), mixed-signal devices, and analog ICs.

The circuits in an IC are typically contained in a silicon piece or in a
10 semiconductor wafer, and commonly packaged as a unit. The solid-state circuits commonly include interconnected active and passive devices, diffused into a single silicon chip. Integrated circuits can be classified into analog, digital and mixed signal (both analog and digital on the same chip). Digital integrated circuits commonly contain many of logic gates, flip-flops, multiplexers, and other circuits in a few square
15 millimeters. The small size of these circuits allows high speed, low power dissipation, and reduced manufacturing cost compared with board-level integration. Further, a multi-chip module (MCM) may be used, where multiple integrated circuits (ICs), the semiconductor dies, or other discrete components are packaged onto a unifying substrate, facilitating their use as a single component (as though a larger IC).

20 The term "computer-readable medium" (or "machine-readable medium") as used herein is an extensible term that refers to any non-transitory computer readable medium or any memory, that participates in providing instructions to a processor, (such as processor 23) for execution, or any mechanism for storing or transmitting information in a form readable by a machine (e.g., a computer). Such a medium may store computer-
25 executable instructions to be executed by a processing element and/or software, and data that is manipulated by a processing element and/or software, and may take many forms, including but not limited to, non-volatile medium, volatile medium, and transmission medium. Transmission media includes coaxial cables, copper wire and fiber optics. Transmission media can also take the form of acoustic or light waves, such as those
30 generated during radio-wave and infrared data communications, or other form of propagating signals (e.g., carrier waves, infrared signals, digital signals, etc.). Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, or any other magnetic medium, a CD-ROM, any other optical medium, punch-cards, paper-tape, any other physical medium with patterns of holes, a

RAM, a PROM, and EPROM, a FLASH-EPROM, any other memory chip or cartridge, a carrier wave as described hereinafter, or any other medium from which a computer can read.

Any process descriptions or blocks in any logic flowchart herein should be understood as representing modules, segments, portions of code, or steps that include one or more instructions for implementing specific logical functions in the process, and alternative implementations are included within the scope of the present invention in which functions may be executed out of order from that shown or discussed, including substantially concurrently or in reverse order, depending on the functionality involved, as would be understood by those reasonably skilled in the art of the present invention.

Each of the methods or steps herein, may consist of, include, be part of, be integrated with, or be based on, a part of, or the whole of, the steps, functionalities, or structure (such as software) described in the publications that are incorporated in their entirety herein. Further, each of the components, devices, or elements herein may consist of, integrated with, include, be part of, or be based on, a part of, or the whole of, the components, systems, devices or elements described in the publications that are incorporated in their entirety herein.

Any part of, or the whole of, any of the methods described herein may be provided as part of, or used as, an Application Programming Interface (API), defined as an intermediary software serving as the interface allowing the interaction and data sharing between an application software and the application platform, across which few or all services are provided, and commonly used to expose or use a specific software functionality, while protecting the rest of the application. The API may be based on, or according to, Portable Operating System Interface (POSIX) standard, defining the API along with command line shells and utility interfaces for software compatibility with variants of Unix and other operating systems, such as POSIX.1-2008 that is simultaneously IEEE STD. 1003.1™ - 2008 entitled: "*Standard for Information Technology - Portable Operating System Interface (POSIX(R)) Description*", and The Open Group Technical Standard Base Specifications, Issue 7, IEEE STD. 1003.1™, 2013 Edition.

The term "computer" is used generically herein to describe any number of computers, including, but not limited to personal computers, embedded processing elements and systems, software, ASICs, chips, workstations, mainframes, etc. Any computer herein may consist of, or be part of, a handheld computer, including any

portable computer that is small enough to be held and operated while holding in one hand or fit into a pocket. Such a device, also referred to as a mobile device, typically has a display screen with touch input and / or miniature keyboard. Non-limiting examples of such devices include a Digital Still Camera (DSC), a Digital video Camera (DVC or digital camcorder), a Personal Digital Assistant (PDA), and mobile phones and Smartphones. The mobile devices may combine video, audio and advanced communication capabilities, such as PAN and WLAN. A mobile phone (also known as a cellular phone, cell phone and a hand phone) is a device that can make and receive telephone calls over a radio link whilst moving around a wide geographic area, by connecting to a cellular network provided by a mobile network operator. The calls are to and from the public telephone network, which includes other mobiles and fixed-line phones across the world. The Smartphones may combine the functions of a personal digital assistant (PDA), and may serve as portable media players and camera phones with high-resolution touch-screens, web browsers that can access, and properly display, standard web pages rather than just mobile-optimized sites, GPS navigation, Wi-Fi and mobile broadband access. In addition to telephony, the Smartphones may support a wide variety of other services such as text messaging, MMS, email, Internet access, short-range wireless communications (infrared, Bluetooth), business applications, gaming and photography.

With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations can be expressly set forth herein for sake of clarity.

It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims can contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim

recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible subranges and combinations of subranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," and the like include the number recited and refer to ranges which can be subsequently broken down into subranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each

individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

Some embodiments may be used in conjunction with various devices and systems, for example, a Personal Computer (PC), a desktop computer, a mobile computer, a laptop computer, a notebook computer, a tablet computer, a server computer, a handheld computer, a handheld device, a Personal Digital Assistant (PDA) device, a cellular handset, a handheld PDA device, an on-board device, an off-board device, a hybrid device, a vehicular device, a non-vehicular device, a mobile or portable device, a non-mobile or non-portable device, a wireless communication station, a wireless communication device, a wireless Access Point (AP), a wired or wireless router, a wired or wireless modem, a wired or wireless network, a Local Area Network (LAN), a Wireless LAN (WLAN), a Metropolitan Area Network (MAN), a Wireless MAN (WMAN), a Wide Area Network (WAN), a Wireless WAN (WWAN), a Personal Area Network (PAN), a Wireless PAN (WPAN), devices and/or networks operating substantially in accordance with existing IEEE 802.11, 802.11a, 802.11b, 802.11g, 802.11k, 802.11n, 802.11r, 802.16, 802.16d, 802.16e, 802.20, 802.21 standards and/or future versions and/or derivatives of the above standards, units and/or devices that are part of the above networks, one way and/or two-way radio communication systems, cellular radio-telephone communication systems, a cellular telephone, a wireless telephone, a Personal Communication Systems (PCS) device, a PDA device that incorporates a wireless communication device, a mobile or portable GNSS such as the Global Positioning System (GPS) device, a device that incorporates a GNSS or GPS receiver or transceiver or chip, a device that incorporates an RFID element or chip, a Multiple Input Multiple Output (MIMO) transceiver or device, a Single Input Multiple Output (SIMO) transceiver or device, a Multiple Input Single Output (MISO) transceiver or device, a device having one or more internal antennas and/or external antennas, Digital Video Broadcast (DVB) devices or systems, multi-standard radio devices or systems, a wired or wireless handheld device (e.g., BlackBerry, Palm Treo), a Wireless Application Protocol (WAP) device, or the like.

As used herein, the terms "program", "programmable", and "computer program" are meant to include any sequence or human or machine cognizable steps, which perform a function. Such programs are not inherently related to any particular computer or other apparatus, and may be rendered in virtually any programming language or

environment, including, for example, C/C++, Fortran, COBOL, PASCAL, Assembly language, markup languages (e.g., HTML, SGML, XML, VoXML), and the like, as well as object-oriented environments, such as the Common Object Request Broker Architecture (CORBA), Java™ (including J2ME, Java Beans, etc.) and the like, as well as in firmware or other implementations. Generally, program modules include routines, subroutines, procedures, definitional statements and macros, programs, objects, components, data structures, etc., that perform particular tasks or implement particular abstract data types. A compiler may be used to create an executable code, or a code may be written using interpreted languages such as PERL, Python, or Ruby.

The terms "task" and "process" are used generically herein to describe any type of running programs, including, but not limited to a computer process, task, thread, executing application, operating system, user process, device driver, native code, machine or other language, etc., and can be interactive and/or non-interactive, executing locally and/or remotely, executing in foreground and/or background, executing in the user and/or operating system address spaces, a routine of a library and/or standalone application, and is not limited to any particular memory partitioning technique. The steps, connections, and processing of signals and information illustrated in the figures, including, but not limited to, any block and flow diagrams and message sequence charts, may typically be performed in the same or in a different serial or parallel ordering and/or by different components and/or processes, threads, etc., and/or over different connections and be combined with other functions in other embodiments, unless this disables the embodiment or a sequence is explicitly or implicitly required (e.g., for a sequence of reading the value, processing the value: the value must be obtained prior to processing it, although some of the associated processing may be performed prior to, concurrently with, and/or after the read operation). Where certain process steps are described in a particular order or where alphabetic and / or alphanumeric labels are used to identify certain steps, the embodiments of the invention are not limited to any particular order of carrying out such steps. In particular, the labels are used merely for convenient identification of steps, and are not intended to imply, specify or require a particular order for carrying out such steps. Furthermore, other embodiments may use more or less steps than those discussed herein. The invention may also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing

environment, program modules may be located in both local and remote memory storage devices.

As used in this application, the term “about” or “approximately” refers to a range of values within plus or minus 10% of the specified number. As used in this application, the term “substantially” means that the actual value is within about 10% of the actual
5 desired value, particularly within about 5% of the actual desired value and especially within about 1% of the actual desired value of any variable, element or limit set forth herein.

Any steps described herein may be sequential, and performed in the described
10 order. For example, in a case where a step is performed in response to another step, or upon completion of another step, the steps are executed one after the other. However, in case where two or more steps are not explicitly described as being sequentially executed, these steps may be executed in any order or may be simultaneously performed. Two or more steps may be executed by two different network elements, or in the same network
15 element, and may be executed in parallel using multiprocessing or multitasking.

The corresponding structures, materials, acts, and equivalents of all means plus function elements in the claims below are intended to include any structure, or material, for performing the function in combination with other claimed elements as specifically claimed. The description of the present invention has been presented for purposes of
20 illustration and description, but is not intended to be exhaustive or limited to the invention in the form disclosed. The present invention should not be considered limited to the particular embodiments described above, but rather should be understood to cover all aspects of the invention as fairly set out in the attached claims. Various modifications, equivalent processes, as well as numerous structures to which the present invention may
25 be applicable, will be readily apparent to those skilled in the art to which the present invention is directed upon review of the present disclosure.

All publications, standards, patents, and patent applications cited in this specification are incorporated herein by reference as if each individual publication, patent, or patent application were specifically and individually indicated to be
30 incorporated by reference and set forth in its entirety herein.

CLAIMS

1. A method for affecting an actuator in a second vehicle in response to a sensor output
5 in a first vehicle, the first and second vehicles located at respective first and second locations and communicating with a server over the Internet via respective first and second wireless networks and, for use with a group of vehicles that includes the second vehicle, the method comprising:

receiving, at the first vehicle, sensor data from the sensor;

10 sending, by the first vehicle, a first message that comprises the sensor data, the first vehicle identifier, and the first vehicle location, to the server over the Internet via the first wireless network;

receiving, by the server from the first vehicle, the sensor data and the first vehicle location;

15 selecting, by the server, the second vehicle from the group based on the second vehicle location;

sending, by the server over the Internet, a second message to the second vehicle in response the received sensor data from the first vehicle;

20 receiving, by the second vehicle over the Internet via the second wireless network, the second message; and

activating, controlling, or affecting, at the second vehicle, the actuator, in response to the second message.

2. A non-transitory computer readable medium having computer executable instructions stored thereon, wherein the instructions include the steps according to claim 1.

25 3. The method according to claim 1, wherein the first and second networks consists of the same network, wherein the first and second networks are identical networks, or wherein the first and second networks use the same protocol.

4. The method according to claim 1, wherein the first and second networks are distinct and different networks, or wherein the first and second networks use different protocols.

30 5. The method according to claim 4, wherein the first and second networks are different and each of the first and second networks is a WWAN, WLAN, or WPAN.

6. The method according to claim 1, for use with a threshold value, wherein the sending of the first message, by the first vehicle to the server, is in response to the sensor data being above or below the threshold value.

7. The method according to claim 6, wherein the sending of the first message, by the first vehicle to the server, is only in response to the sensor data being above or below the threshold value.

8. The method according to claim 1, wherein the receiving of the sensor data from the sensor and the sending of the first message to the server over the Internet via the first wireless network is performed periodically by the first vehicle every time period.

9. The method according to claim 8, wherein the time period is less than 1 second, 2 seconds, 5 seconds, 10 seconds, 20 seconds, 30 seconds, 50 seconds, 100 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes, 22 minutes, 30 minutes, 50 minutes, 100 minutes, 1 hour, 2 hours, 5 hours, 10 hours, 20 hours, 30 hours, 50 hours, 100 hours, 1 day, 2 days, 5 days, 10 days, 22 days, 30 days, 50 days, or 100 days.

10. The method according to claim 8, wherein the time period is more than 1 second, 2 seconds, 5 seconds, 10 seconds, 20 seconds, 30 seconds, 50 seconds, 100 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes, 22 minutes, 30 minutes, 50 minutes, 100 minutes, 1 hour, 2 hours, 5 hours, 10 hours, 20 hours, 30 hours, 50 hours, 100 hours, 1 day, 2 days, 5 days, 10 days, 22 days, 30 days, 50 days, or 100 days.

11. The method according to claim 8, for use with a threshold value, wherein the sending, by the server over the Internet, of the second message to the second vehicle, is in response to the sensor data being above or below the threshold value.

12. The method according to claim 11, wherein the sending, by the server over the Internet, of the second message to the second vehicle, is only in response to the sensor data being above or below the threshold value.

13. The method according to claim 1, wherein the first or second message is timestamped.

14. The method according to claim 1, wherein the first message comprises the time of receiving of the sensor data from the sensor, or the time of sending of the first message.

15. The method according to claim 1, further comprising estimating, by second vehicle, a geographical location of the second vehicle.

16. The method according to claim 15, further comprising:

sending, by the second vehicle to the server, the estimated geographical location of the second vehicle; and

receiving and storing, by the server, the received estimated geographical location of the second vehicle.

17. The method according to claim 16, wherein the selecting of the second vehicle from the group is based on comparing the geographical locations of the first and second vehicles.

18. The method according to claim 17, wherein the selecting of the second vehicle from the group is based on estimating that the first and second vehicles are in the same area.

19. The method according to claim 18, wherein the first and second vehicles are estimated to be in the same region, city, street, ZIP code, latitude, or longitude.

20. The method according to claim 18, wherein the selecting of the second vehicle from the group is based on estimating the distance between the first and second vehicles.

21. The method according to claim 20, wherein the selecting of the second vehicle from the group is based on estimated distance between the first and second vehicles being less than 1 meter, 2 meters, 5 meters, 10 meters, 20 meters, 30 meters, 50 meters, 100 meters, 200 meters, 300 meters, 500 meters, 1 kilometer, 2 kilometers, 3 kilometers, 5 kilometers, 10 kilometers, 20 kilometers, 50 kilometers, or 100 kilometers.

22. The method according to claim 1, wherein the first vehicle further comprises an additional sensor having an additional output, the method further comprising receiving, at the first vehicle, the additional sensor data from the additional sensor, and wherein the first message further comprises the additional sensor data.

23. The method according to claim 22, wherein the second message further comprises, or is in response to, the additional sensor data.

24. The method according to claim 1, for use with a third vehicle that comprises an additional sensor having an additional output, the method further comprising:

receiving, at the third vehicle, additional sensor data from the additional sensor;

sending, by the third vehicle, a third message that comprises the additional sensor data, the third vehicle identifier, and the third vehicle location, to the server over the Internet via a wireless network; and

receiving, by the server from the third vehicle, the additional sensor data and the third vehicle location.

25. The method according to claim 24, wherein the second message is in response to the third message.

26. The method according to claim 1, wherein the second vehicle further comprises an additional actuator, and the method further comprising activating, controlling, or affecting, at the second vehicle, the additional actuator, in response to the second message.

27. The method according to claim 1, for use with a third vehicle that comprises an additional actuator, the method further comprising:

 sending, by the server over the Internet, a second message to the third vehicle in response the received sensor data from the first vehicle;

5 receiving, by the third vehicle over the Internet via a wireless network, the second message; and

 activating, controlling, or affecting, at the second vehicle, the additional actuator, in response to the second message.

28. The method according to claim 1, further for detecting a road-related anomaly or hazard, wherein the sensor is operative to sense the road-related anomaly or hazard.

29. The method according to claim 28, wherein the road-related anomaly or hazard comprises a traffic collision, traffic regulation violation, or a road infrastructure or surface damage.

30. The method according to claim 1, wherein the sensor is operative to sense a motion, velocity, or acceleration or the first vehicle.

31. The method according to claim 1, wherein the sensor is operative to sense a traffic collision, a stopping, or over speeding, of the first vehicle.

32. The method according to claim 1, further used for parking help, cruise control, lane keeping, road sign recognition, surveillance, speed limit warning, restricted entries, and pull-over commands, travel information, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning, vehicle safety inspection, transit or emergency vehicle signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, or electronic toll collection.

33. The method according to claim 32, wherein the sensor is configured to sense, or wherein the actuator is configure to affect, as part of parking help, cruise control, lane keeping, road sign recognition, surveillance, speed limit warning, restricted entries, and pull-over commands, travel information, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning, vehicle safety inspection, transit or emergency vehicle signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, or electronic toll collection.

34. The method according to claim 1, further used for fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, on-board computer, fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine
5 oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, or a Vehicle Identification Number (VIN).

35. The method according to claim 34, wherein the sensor is configured to sense, or
10 wherein the actuator is configured to affect, as part of fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, on-board computer, fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake
15 air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, or a Vehicle Identification Number (VIN).

36. The method according to claim 1, further comprising estimating, by the first vehicle or the second vehicle, the geographical location of the respective first or second vehicle.

20 37. The method according to claim 36, for use with multiple RF signals transmitted by multiple sources, and wherein the geographical location is estimated, by the respective first or second vehicle, by receiving the RF signals from the multiple sources via one or more antennas, and processing or comparing the received RF signals.

38. The method according to claim 37, wherein the multiple sources comprises satellites
25 that are part of Global Navigation Satellite System (GNSS).

39. The method according to claim 38, wherein the GNSS is the Global Positioning System (GPS), and wherein the first vehicle comprises a GPS antenna coupled to a GPS receiver for receiving and analyzing the GPS signals.

40. The method according to claim 38, wherein the GNSS is the GLONASS (GLObal
30 NAvigation Satellite System), the Beidou-1, the Beidou-2, the Galileo, or the IRNSS/VAVIC.

41. The method according to claim 37, wherein the processing or comparing comprises, or is based on, performing TOA (Time-Of-Arrival) measurement, performing TDOA (Time Difference-Of-Arrival) measurement, performing an AoA (Angle-Of-Arrival)

measurement, performing a Line-of-Sight (LoS) measurement, performing a Time-of-Flight (ToF) measurement, performing a Two-Way Ranging (TWR) measurement, performing a Symmetrical Double Sided – Two Way Ranging (SDS-TWR) measurement, performing a Near-field electromagnetic ranging (NFER) measurement,
5 or performing triangulation, trilateration, or multilateration (MLAT).

42. The method according to claim 37, wherein the RF signals are part of the communication over the respective first or second wireless network.

43. The method according to claim 42, wherein the respective first or second wireless network is a cellular telephone network, and wherein the sources are cellular towers or
10 base-stations.

44. The method according to claim 42, wherein the respective first or second wireless network is a WLAN, and wherein the sources are hotspots or Wireless Access Points (WAPs).

45. The method according to claim 36, wherein the geographical location is estimated,
15 by the first vehicle, using, or based on, geolocation.

46. The method according to claim 45, wherein the geolocation is based on W3C Geolocation API.

47. The method according to claim 36, wherein the geographical location consists of, or comprises, one out of a country, a region, a city, a street, a ZIP code, latitude, or
20 longitude.

48. The method according to claim 1, wherein the first vehicle identifier comprises a set of characters or numbers uniquely identifying the first vehicle.

49. The method according to claim 48, wherein the first vehicle identifier comprises a Vehicle Identification Number (VIN) or a license plate number.

50. The method according to claim 49, wherein the first vehicle identifier comprises a
25 Vehicle Identification Number (VIN) that is according to, or based on, ISO 3779.

51. The method according to claim 48, wherein the first vehicle identifier comprises a code that identifies the first vehicle make, model, color, model year, engine size, or vehicle type.

52. The method according to claim 48, wherein the first vehicle identifier comprises a digital address that uniquely identifies the first vehicle in a digital network, in the Internet, or in the first network.

53. The method according to claim 52, wherein the digital address comprises an IP address or a Medium Access Control (MAC) address.

54. The method according to claim 53, wherein the digital address is a layer 3 address and is a static or dynamic IP address that is of IPv4 or IPv6 type address.

55. The method according to claim 53, wherein the digital address is a MAC layer address selected from the group consisting of MAC-48, EUI-48, and EUI-64 address type.

56. The method according to claim 1, wherein the first or second vehicle is a ground vehicle adapted to travel on land.

57. The method according to claim 56, wherein the ground vehicle is selected from the group consisting of a bicycle, a car, a motorcycle, a train, an electric scooter, a subway, a train, a trolleybus, and a tram.

58. The method according to claim 56, wherein the ground vehicle consists of, or comprises, is an autonomous car.

59. The method according to claim 58, wherein the autonomous car is according to levels 0, 1, or 2 of the Society of Automotive Engineers (SAE) J3016 standard.

60. The method according to claim 58, wherein the autonomous car is according to levels 3, 4, or 5 of the Society of Automotive Engineers (SAE) J3016 standard.

61. The method according to claim 1, wherein the first or second vehicle is a buoyant or submerged watercraft adapted to travel on or in water.

62. The method according to claim 61, wherein the watercraft is selected from the group consisting of a ship, a boat, a hovercraft, a sailboat, a yacht, and a submarine.

63. The method according to claim 1, wherein the first or second vehicle is an aircraft adapted to fly in air.

64. The method according to claim 63, wherein the aircraft is a fixed wing or a rotorcraft aircraft.

65. The method according to claim 63, wherein the aircraft is selected from the group consisting of an airplane, a spacecraft, a glider, a drone, or an Unmanned Aerial Vehicle (UAV).

66. The method according to claim 1, wherein the sensor or the actuator is mounted onto, is attached to, is part of, or is integrated with a rear or front view camera, chassis, lighting system, headlamp, door, car glass, windscreen, side or rear window, glass panel roof, hood, bumper, cowling, dashboard, fender, quarter panel, rocker, or a spoiler of the vehicle.

67. The method according to claim 1, wherein the first or second vehicle further comprises an Advanced Driver Assistance Systems (ADAS) functionality, system, or scheme.

68. The method according to claim 67, wherein the sensor or the actuator is part of, integrated with, communicates with, or coupled to, the ADAS functionality, system, or scheme.

69. The method according to claim 67, wherein the ADAS functionality, system, or scheme is selected from a group consisting of Adaptive Cruise Control (ACC), Adaptive High Beam, Glare-free high beam and pixel light, Adaptive light control such as swiveling curve lights, Automatic parking, Automotive navigation system with typically GPS and TMC for providing up-to-date traffic information, Automotive night vision, Automatic Emergency Braking (AEB), Backup assist, Blind Spot Monitoring (BSM), Blind Spot Warning (BSW), Brake light or traffic signal recognition, Collision avoidance system, Pre-crash system, Collision Imminent Braking (CIB), Cooperative Adaptive Cruise Control (CACC), Crosswind stabilization, Driver drowsiness detection, Driver Monitoring Systems (DMS), Do-Not-Pass Warning (DNPW), Electric vehicle warning sounds used in hybrids and plug-in electric vehicles, Emergency driver assistant, Emergency Electronic Brake Light (EEBL), Forward Collision Warning (FCW), Heads-Up Display (HUD), Intersection assistant, Hill descent control, Intelligent speed adaptation or Intelligent Speed Advice (ISA), Intelligent Speed Adaptation (ISA), Intersection Movement Assist (IMA), Lane Keeping Assist (LKA), Lane Departure Warning (LDW) (a.k.a. Line Change Warning - LCW), Lane change assistance, Left Turn Assist (LTA), Night Vision System (NVS), Parking Assistance (PA), Pedestrian Detection System (PDS), Pedestrian protection system, Pedestrian Detection (PED), Road Sign Recognition (RSR), Surround View Cameras (SVC), Traffic sign recognition, Traffic jam assist, Turning assistant, Vehicular communication systems, Autonomous Emergency Braking (AEB), Adaptive Front Lights (AFL), and Wrong-way driving warning.

70. The method according to claim 1, wherein the first or second vehicle further employs an Advanced Driver Assistance System Interface Specification (ADASIS) functionality, system, or scheme.

71. The method according to claim 70, wherein the sensor or the actuator is part of, integrated with, communicates with, or coupled to, the ADASIS functionality, system, or scheme.

72. The method according to claim 70, wherein the first or second message comprises a map data relating to the location of the respective first or second vehicle.

73. The method according to claim 1, wherein the first and second wireless networks uses the same protocol.

5 74. The method according to claim 73, wherein the first and second wireless networks are the same network.

75. The method according to claim 1, wherein the first and second wireless networks are different networks.

10 76. The method according to claim 75, wherein the first and second wireless networks uses the same protocol.

77. The method according to claim 75, wherein the first and second wireless networks uses different protocols.

15 78. The method according to claim 1, wherein each of the first and second wireless networks is Wireless Wide Area Network (WWAN), Wireless Personal Area Network (WPAN), or Wireless Local Area Network (WLAN).

79. The method according to claim 1, wherein the first vehicle comprises a first antenna and a first wireless transceiver for communicating over the first wireless network, and wherein the second vehicle comprises a second antenna and a second wireless transceiver for communicating over the second wireless network.

20 80. The method according to claim 79, wherein the first or second wireless network is a Wireless Wide Area Network (WWAN), wherein the respective first or second wireless transceiver comprises a WWAN transceiver, and wherein the respective first or second wireless antenna comprises an WWAN antenna.

25 81. The method according to claim 80, wherein the WWAN is a wireless broadband network.

82. The method according to claim 81, wherein the WWAN is a WiMAX network, wherein the antenna is a WiMAX antenna and the wireless transceiver is a WiMAX modem, and the WiMAX network is according to, compatible with, or based on, IEEE 802.16-2009.

30 83. The method according to claim 81, wherein the WWAN is a cellular telephone network, the antenna is a cellular antenna, and the wireless transceiver is a cellular modem.

84. The method according to claim 83, wherein the cellular telephone network is a Third Generation (3G) network that uses a protocol selected from the group consisting of

UMTS W-CDMA, UMTS HSPA, UMTS TDD, CDMA2000 1xRTT, CDMA2000 EV-DO, and GSM EDGE-Evolution, or wherein the cellular telephone network uses a protocol selected from the group consisting of a Fourth Generation (4G) network that uses HSPA+, Mobile WiMAX, LTE, LTE-Advanced, MBWA, or is based on IEEE 802.20-2008.

85. The method according to claim 79, wherein the first or second wireless network is a Wireless Personal Area Network (WPAN), wherein the respective first or second wireless transceiver comprises a WPAN transceiver, and wherein the respective first or second wireless antenna comprises an WPAN antenna.

86. The method according to claim 85, wherein the WPAN is according to, compatible with, or based on, Bluetooth™, Bluetooth Low Energy (BLE), or IEEE 802.15.1-2005 standards, or wherein the WPAN is a wireless control network that is according to, or based on, Zigbee™, IEEE 802.15.4-2003, or Z-Wave™ standards.

87. The method according to claim 79, wherein the first or second wireless network is a Wireless Local Area Network (WLAN), wherein the respective first or second wireless transceiver comprises a WLAN transceiver, and wherein the respective first or second wireless antenna comprises an WLAN antenna.

88. The method according to claim 87, wherein the WLAN is according to, compatible with, or is based on, a standard selected from the group consisting of IEEE 802.11-2012, IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, and IEEE 802.11ac.

89. The method according to claim 79, wherein the first or second wireless network is over a licensed or unlicensed radio frequency band.

90. The method according to claim 89, wherein the respective first or second wireless network is over the unlicensed radio frequency band that is an Industrial, Scientific and Medical (ISM) radio band.

91. The method according to claim 79, wherein the first or second wireless network is using, or is based on, Dedicated Short-Range Communication (DSRC).

92. The method according to claim 91, wherein the DSRC is according to, compatible with, or based on, European Committee for Standardization (CEN) EN 12253:2004, EN 12795:2002, EN 12834:2002, EN 13372:2004, or EN ISO 14906:2004 standard.

93. The method according to claim 91, wherein the DSRC is according to, compatible with, or based on, IEEE 802.11p, IEEE 1609.1-2006, IEEE 1609.2, IEEE 1609.3, IEEE 1609.4, or IEEE 1609.5.

94. The method according to claim 1, wherein the sensor data is responsive to a physical phenomenon.

95. The method according to claim 94, wherein the sensor consists of, or comprises, an occupancy sensor for detecting occupancy of a space by a human body by using electric effect, inductive coupling, capacitive coupling, triboelectric effect, piezoelectric effect, fiber optic transmission, or radar intrusion sensing.

96. The method according to claim 95, wherein the occupancy sensor consists of, comprises, or is based on, an acoustic sensor, opacity, geomagnetism, magnetic sensors, magnetometer, reflection of transmitted energy, infrared laser radar, microwave radar, electromagnetic induction, or vibration.

97. The method according to claim 96, wherein the occupancy sensor consists of, comprises of, or is based on, a motion sensor.

98. The method according to claim 97, wherein the motion sensor consists of, or comprises, a mechanically actuated sensor, passive or active electronic sensor, ultrasonic sensor, microwave sensor, tomographic detector, Passive InfraRed (PIR) sensor, laser optical detector, or acoustical detector.

99. The method according to claim 94, wherein the sensor consists of, or comprises, a photoelectric sensor that responds to a visible or an invisible light, the invisible light is infrared, ultraviolet, X-rays, or gamma rays, and wherein the photoelectric sensor is based on the photoelectric or photovoltaic effect, and consists of, or comprises, a semiconductor component that consists of, or comprises, a photodiode, or a phototransistor.

100. The method according to claim 99, wherein the photoelectric sensor consists of, comprises, or is based on Charge-Coupled Method (CCD) or a Complementary Metal-Oxide Semiconductor (CMOS) component.

101. The method according to claim 94, wherein the sensor consists of, or comprises, an electrochemical sensor that responds to an object chemical structure, properties, composition, or reactions.

102. The method according to claim 101, wherein the electrochemical sensor consists of, or comprises, a pH meter or a gas sensor responding to a presence of radon, hydrogen, oxygen, or Carbon-Monoxide (CO), or wherein the electrochemical sensor is based on optical detection or on ionization and is a smoke, a flame, or a fire detector, or is responsive to combustible, flammable, or toxic gas.

103. The method according to claim 94, wherein the sensor consists of, or comprises, an electric sensor that responds to an electrical characteristics or electrical phenomenon quantity in an electrical circuit.

104. The method according to claim 103, wherein the electrical sensor is conductively
5 coupled to the electrical circuit.

105. The method according to claim 103, wherein the electrical sensor is a non-contact sensor non-conductively to the electrical circuit.

106. The method according to claim 103, wherein the electrical sensor is responsive to Alternating Current (AC) or Direct Current (DC).

107. The method according to claim 103, wherein the electrical sensor consists of, or
10 comprises, an ampermeter that responds to electrical current passing through a conductor or wire.

108. The method according to claim 107, wherein the electrical sensor consists of, or
comprises, an AC ampermeter connected to measure an AC current from an AC power
15 source or via an AC load.

109. The method according to claim 107, wherein the ampermeter consists of, or
comprises, a galvanometer, a hot-wire ampermeter, a current clamp, or a current probe.

110. The method according to claim 103, wherein the electrical sensor consists of, or
comprises, a voltmeter that responds to an electrical voltage.

111. The method according to claim 110, wherein the voltmeter consists of, or
20 comprises, an electrometer, a resistor, a potentiometer, or a bridge circuit.

112. The method according to claim 103, wherein the electrical sensor consists of, or
comprises, a wattmeter that responds to active electrical power.

113. The method according to claim 103, wherein the electrical sensor consists of, or
25 comprises, an AC power wattmeter that is connected to measure an AC power source
supplied power or an AC load consumed power.

114. The method according to claim 113, wherein the wattmeter is based on induction,
or is based on multiplying measured voltage and measured current.

115. The method according to claim 103, wherein the electrical sensor consists of, or
30 comprises, an electricity meter that responds to electrical energy.

116. The method according to claim 115, wherein the electricity meter is connected to
measure an AC power source supplied electrical energy or an AC load consumed
electrical energy.

117. The method according to claim 94, wherein the sensor consists of, or comprises, a piezoelectric sensor that includes single crystal material or a piezoelectric ceramics and uses a transverse, longitudinal, or shear effect mode of the piezoelectric effect.

118. The method according to claim 94, further comprising multiple sensors arranged as
5 a directional sensor array operative to estimate the number, magnitude, frequency, Direction-Of-Arrival (DOA), distance, or speed of the phenomenon impinging the sensor array, and wherein said control logic includes processing of the sensor array outputs.

119. The method according to claim 94, wherein the sensor consists of, or comprises, a
10 thermoelectric sensor that responds to a temperature or to a temperature gradient of an object using conduction, convection, or radiation, and wherein the thermoelectric sensor consists of, or comprises, a Positive Temperature Coefficient (PTC) thermistor, a Negative Temperature Coefficient (NTC) thermistor, a thermocouple, a quartz crystal, or a Resistance Temperature Detector (RTD).

120. The method according to claim 94, wherein the sensor consists of, or comprises, a
15 nanosensor, a crystal, or a semiconductor, or wherein: the sensor is an ultrasonic based, the sensor is an eddy-current sensor, the sensor is a proximity sensor, the sensor is a bulk or surface acoustic sensor, or the sensor is an atmospheric or an environmental sensor.

121. The method according to claim 94, wherein the sensor consists of, or comprises, a
20 radiation sensor that responds to radioactivity, nuclear radiation, alpha particles, beta particles, or gamma rays, and is based on gas ionization.

122. The method according to claim 94, wherein the sensor consists of, or comprises, a photoelectric sensor that responds to a visible or an invisible light, the invisible light is infrared, ultraviolet, X-rays, or gamma rays, and wherein the photoelectric sensor
25 consists of, comprises, or is based on the photoelectric or photovoltaic effect, and consists of, or comprises, a semiconductor component that consists of, or comprises, a photodiode, a phototransistor, or a solar cell.

123. The method according to claim 122, wherein the photoelectric sensor consists of, comprises, or is based on Charge-Coupled Device (CCD) or a Complementary Metal-
30 Oxide Semiconductor (CMOS) element.

124. The method according to claim 94, wherein the sensor consists of, or comprises, a photosensitive image sensor array comprising multiple photoelectric sensors, for capturing an image and producing electronic image information representing the image, and the method further comprising one or more optical lens for focusing the received

light and to guide the image, and wherein the image sensor is disposed approximately at an image focal point plane of the one or more optical lens for properly capturing the image.

125. The method according to claim 124, further comprising an image processor coupled to the image sensor for providing a digital data video signal according to a digital video format, the digital video signal carrying digital data video based on the captured images, and wherein the digital video format is based on one out of: TIFF (Tagged Image File Format), RAW format, AVI, DV, MOV, WMV, MP4, DCF (Design Rule for Camera Format), ITU-T H.261, ITU-T H.263, ITU-T H.264, ITU-T CCIR 601, ASF, Exif (Exchangeable Image File Format), and DPOF (Digital Print Order Format) standards.

126. The method according to claim 125, further comprising a intraframe or interframe compression based video compressor coupled to the image sensor for lossy or non-lossy compressing the digital data video, wherein the compression is based on a standard compression algorithm which is one or more out of JPEG (Joint Photographic Experts Group) and MPEG (Moving Picture Experts Group), ITU-T H.261, ITU-T H.263, ITU-T H.264 and ITU-T CCIR 601.

127. The method according to claim 94, wherein the sensor consists of, or comprises, an electrochemical sensor that responds to an object chemical structure, properties, composition, or reactions.

128. The method according to claim 127, wherein the electrochemical sensor consists of, or comprises, a pH meter or a gas sensor responding to a presence of radon, hydrogen, oxygen, or Carbon-Monoxide (CO), or wherein the electrochemical sensor consists of, comprises, or is based on optical detection or on ionization and is a smoke, a flame, or a fire detector, or is responsive to combustible, flammable, or toxic gas.

129. The method according to claim 94, wherein the sensor consists of, or comprises, a physiological sensor that responds to parameters associated with a live body, and is external to the sensed body, implanted inside the sensed body, attached to the sensed body, or wearable on the sensed body.

130. The method according to claim 129, wherein the physiological sensor is responding to body electrical signals and consists of, or comprises, an EEG Electroencephalography (EEG) or an Electrocardiography (ECG) sensor.

131. The method according to claim 129, wherein the physiological sensor is responding to oxygen saturation, gas saturation, or a blood pressure in the sensed body.

132. The method according to claim 94, wherein the sensor is an electroacoustic sensor that responds to an audible or inaudible sound.

133. The method according to claim 132, wherein the electroacoustic sensor consists of, or comprises, an omnidirectional, unidirectional, or bidirectional microphone that
5 consists of, comprises, or is based on the sensing the incident sound based motion of a diaphragm or a ribbon, and the microphone consists of, or comprises, a condenser, an electret, a dynamic, a ribbon, a carbon, or a piezoelectric microphone.

134. The method according to claim 94, wherein the sensor is operative for sensing fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and
10 idle control, transmission, on-board computer, fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas
15 temperature, engine run time, NOx sensor, manifold surface temperature, or a Vehicle Identification Number (VIN).

135. The method according to claim 94, wherein the sensor consists of, or comprises, an angular position sensor for measuring angular setting or a change of an angle.

136. The method according to claim 135, wherein the angular position sensor is
20 configured for throttle-valve-angle measuring as part of an engine management on gasoline (SI) engines in the first vehicle.

137. The method according to claim 94, wherein the sensor consists of, or comprises, a rotational-speed sensor for measuring rotational speeds, positions or angles in excess of 360°.

25 138. The method according to claim 137, wherein the rotational-speed sensor is configured for measuring wheel-speed, engine speeds, engine positioning angle, steering-wheel angle, distance covered, or road curves / bends.

139. The method according to claim 94, wherein the sensor consists of, or comprises, a spring-mass acceleration sensor for measuring changes in the first vehicle speed.

30 140. The method according to claim 139, wherein the spring-mass acceleration is configured for measuring vehicular acceleration and deceleration, as part of an Anti-Breaking System (ABS) or a Traction Control System (TCS) of the first vehicle.

141. The method according to claim 94, wherein the sensor consists of, or comprises, a bending beam acceleration sensor for registering or detecting shock and vibration.

142. The method according to claim 141, wherein the bending beam acceleration sensor is configured for detecting impacts or measuring shocks and vibration, or for triggering airbags or belt tighteners.

143. The method according to claim 94, wherein the sensor consists of, or comprises, a yaw sensor for measuring skidding movements, or for measuring yaw rate and lateral acceleration, of the first vehicle.

144. The method according to claim 143, wherein the yaw sensor is configured for affecting a vehicle dynamics control.

145. The method according to claim 94, wherein the sensor consists of, or comprises, a vibration sensor for measuring structure-borne vibrations at an engine, a machines, or a pivot bearing, of the first vehicle.

146. The method according to claim 145, wherein the vibration sensor is configured for engine-knock detection as part of an anti-knock control in an engine management system.

147. The method according to claim 94, wherein the sensor consists of, or comprises, an absolute-pressure sensor for measuring ranges from 50% to 500% of the earth's atmospheric pressure.

148. The method according to claim 147, wherein the absolute-pressure sensor is configured for manifold vacuum measurement, charge-air-pressure measurement for charge-air pressure control, or altitude-dependent fuel injection for diesel engines.

149. The method according to claim 94, wherein the sensor consists of, or comprises, a differential-pressure sensor for measuring differential gas pressure.

150. The method according to claim 149, wherein the differential-pressure sensor is configured for pressure measurement in a fuel tank, or evaporative-emission control system, in the first vehicle.

151. The method according to claim 94, wherein the sensor consists of, or comprises, a temperature sensor for measuring the temperature of gaseous material or a liquid.

152. The method according to claim 151, wherein the temperature sensor is configured for displaying of outside and inside temperature, controlling of air conditioner or inside temperature, controlling of radiator or thermostat, or measuring of lube-oil, coolant, or engine temperature.

153. The method according to claim 94, wherein the sensor consists of, or comprises, a Lambda oxygen sensor for determining the residual oxygen content in the exhaust gas.

154. The method according to claim 153, wherein the Lambda oxygen sensor is configured for controlling of A/F mixture for minimization of pollutant emissions on gasoline and gas engines.

155. The method according to claim 94, wherein the sensor consists of, or comprises, an
5 air-mass meter used for measuring the flow rate of gas.

156. The method according to claim 155, wherein the Lambda oxygen sensor is configured for measuring of the mass of the air drawn in by the engine.

157. The method according to claim 1, wherein the actuator is operative to provide time-
dependent characteristic of the phenomenon selected from the group consisting of a
10 time-integrated, an average, an RMS (Root Mean Square) value, a frequency, a period, a
duty-cycle, a time-integrated, and a time-derivative.

158. The method according to claim 1, wherein the actuator influences, affects, creates,
or changes the phenomenon that is associated with an object that is a gas, an air, a liquid,
or a solid.

159. The method according to claim 158, wherein the actuator is operative to provide
15 space-dependent characteristic that is selected from the group consisting of a pattern, a
linear density, a surface density, a volume density, a flux density, a current, a direction, a
rate of change in a direction, and a flow.

160. The method according to claim 158, wherein the actuator consists of, or comprises,
20 an electric light source that converts electrical energy into light, and emits visible or non-
visible light for illumination or indication, and the non-visible light is infrared,
ultraviolet, X-rays, or gamma rays.

161. The method according to claim 160, wherein the electric light source consists of, or
comprises, a lamp, an incandescent lamp, a gas discharge lamp, a fluorescent lamp, a
25 Solid-State Lighting (SSL), a Light Emitting Diode (LED), an Organic LED (OLED), a
polymer LED (PLED), or a laser diode.

162. The method according to claim 158, wherein the actuator consists of, or comprises,
a motion actuator that causes linear or rotary motion, and the method further comprising
a conversion mechanism coupled to, attached to, or part of, the actuator for converting to
30 rotary or linear motion based on a screw, a wheel and axle, or a cam.

163. The method according to claim 162, wherein the conversion mechanism consists of,
comprises, or is based on, a screw, and the method further comprises a leadscrew, a
screw jack, a ball screw or a roller screw that is coupled to, attached to, or part of, the
actuator.

164. The method according to claim 162, wherein the conversion mechanism consists of, comprises, or is based on, a wheel and axle, and the method further comprises a hoist, a winch, a rack and pinion, a chain drive, a belt drive, a rigid chain, or a rigid belt that is coupled to, attached to, or part of, the actuator.

5 165. The method according to claim 162, wherein the motion actuator further comprises a lever, a ramp, a screw, a cam, a crankshaft, a gear, a pulley, a constant-velocity joint, or a ratchet, for effecting the motion.

166. The method according to claim 162, wherein the motion actuator consists of, or comprises, a pneumatic actuator, hydraulic actuator, or electrical actuator.

10 167. The method according to claim 166, wherein the motion actuator consists of, or comprises, an electrical motor.

168. The method according to claim 167, wherein the electrical motor is a brushed motor, a brushless motor, or an uncommutated DC motor.

169. The method according to claim 168, wherein the electrical motor is a DC stepper motor that is a Permanent Magnet (PM) motor, a Variable reluctance (VR) motor, or a hybrid synchronous stepper motor.

170. The method according to claim 167, wherein the electrical motor is an AC motor that is an induction motor, a synchronous motor, or an eddy current motor.

171. The method according to claim 170, wherein the AC motor is a single-phase AC induction motor, a two-phase AC servo motor, or a three-phase AC synchronous motor, and the AC motor is a split-phase motor, a capacitor-start motor, or a Permanent-Split Capacitor (PSC) motor.

172. The method according to claim 167, wherein the electrical motor is an electrostatic motor, a piezoelectric actuator, or is a MEMS-based motor.

25 173. The method according to claim 162, wherein the motion actuator consists of, or comprises, a linear hydraulic actuator, a linear pneumatic actuator, a linear induction electric motor (LIM), or a Linear Synchronous electric Motor (LSM).

174. The method according to claim 162, wherein the motion actuator consists of, or comprises, a piezoelectric motor, a Surface Acoustic Wave (SAW) motor, a Squiggle motor, an ultrasonic motor, or a micro- or nanometer comb-drive capacitive actuator, a Dielectric or Ionic based Electroactive Polymers (EAPs) actuator, a solenoid, a thermal bimorph, or a piezoelectric unimorph actuator.

175. The method according to claim 158, wherein the actuator consists of, or comprises, a compressor or a pump and is operative to move, force, or compress a liquid, a gas or a slurry.

176. The method according to claim 175, wherein the pump is a direct lift pump, an impulse pump, a displacement pump, a valveless pump, a velocity pump, a centrifugal pump, a vacuum pump, or a gravity pump.

177. The method according to claim 175, wherein the pump is a positive displacement pump that is a rotary lobe pump, a progressive cavity pump, a rotary gear pump, a piston pump, a diaphragm pump, a screw pump, a gear pump, a hydraulic pump, or a vane pump.

178. The method according to claim 177, wherein the positive displacement pump is a rotary-type positive displacement pump that is an internal gear pump, a screw pump, a shuttle block pump, a flexible vane pump, a sliding vane pump, a rotary vane pump, a circumferential piston pump, a helical twisted roots pump, or a liquid ring vacuum pump.

179. The method according to claim 177, wherein the positive displacement pump is a reciprocating-type positive displacement type that is a piston pump, a diaphragm pump, a plunge pump, a diaphragm valve pump, or a radial piston pump.

180. The method according to claim 177, wherein the positive displacement pump is a linear-type positive displacement type that is a rope-and-chain pump.

181. The method according to claim 175, wherein the pump is an impulse pump that is a hydraulic ram pump, a pulser pump, or an airlift pump.

182. The method according to claim 175, wherein the pump is a rotodynamic pump that is a velocity pump, or is a centrifugal pump that is a radial flow pump, an axial flow pump, or a mixed flow pump.

183. The method according to claim 158, wherein the actuator consists of, or comprises, a display screen for visually presenting information.

184. The method according to claim 183, wherein the display or the display screen consists of, or comprises, a monochrome, grayscale or color display, having an array of light emitters or light reflectors.

185. The method according to claim 183, wherein the display or the display screen consists of, or comprises, a projector selected from the group consisting of an Eidophor projector, Liquid Crystal on Silicon (LCoS or LCOS) projector, LCD projector, MEMS projector, and Digital Light Processing (DLP™) projector.

186. The method according to claim 185, wherein the projector consists of, or comprises, a virtual retinal display.

187. The method according to claim 183, wherein the display or the display screen consists of, or comprises, a video display supporting Standard-Definition (SD) or High-
5 Definition (HD) standards, and is capable of scrolling, static, bold or flashing the presented information.

188. The method according to claim 187, wherein the video display is a 3D video display.

189. The method according to claim 183, wherein the display or the display screen
10 consists of, or comprises, an analog display having an analog input interface supporting NTSC, PAL or SECAM formats, and the analog input interface comprises of RGB, VGA (Video Graphics Array), SVGA (Super Video Graphics Array), SCART or S-video interface.

190. The method according to claim 183, wherein the display or the display screen
15 consists of, or comprises, a digital display having a digital input interface selected from the group consisting of IEEE1394, FireWire™, USB, SDI (Serial Digital Interface), HDMI (High-Definition Multimedia Interface), DVI (Digital Visual Interface), UDI (Unified Display Interface), DisplayPort, Digital Component Video, and DVB (Digital Video Broadcast) interface.

20 191. The method according to claim 183, wherein the display or the display screen selected from the group consisting of a Cathode-Ray Tube (CRT), a Field Emission Display (FED), an Electroluminescent Display (ELD), a Vacuum Fluorescent Display (VFD), or an Organic Light-Emitting Diode (OLED) display, a passive-matrix (PMOLED) display, an active-matrix OLEDs (AMOLED) display, a Liquid Crystal
25 Display (LCD) display, a Thin Film Transistor (TFT) display, an LED-backlit LCD display, or an Electronic Paper Display (EPD) display that is based on Gyricon technology, Electro-Wetting Display (EWD), and Electrofluidic display technology.

192. The method according to claim 183, wherein the display or the display screen consists of, or comprises, a laser video display that is based on a Vertical-External-
30 Cavity Surface-Emitting-Laser (VECSEL) or a Vertical-Cavity Surface-Emitting Laser (VCSEL).

193. The method according to claim 183, wherein the display or the display screen consists of, or comprises, a segment display based on a seven-segment display, a fourteen-segment display, a sixteen-segment display, or a dot matrix display, and is

operative to only display at least one of digits, alphanumeric characters, words, characters, arrows, symbols, ASCII, and non-ASCII characters.

194. The method according to claim 158, wherein the actuator consists of, or comprises, a thermoelectric actuator and is a heater or a cooler, operative for affecting the temperature of a solid, a liquid, or a gas object, and is coupled to the object by conduction, convection, force convention, thermal radiation, or by the transfer of energy by phase changes.

195. The method according to claim 194, wherein the thermoelectric actuator consists of, or comprises, a cooler based on a heat pump driving a refrigeration cycle using a compressor-based electric motor.

196. The method according to claim 194, wherein the thermoelectric actuator consists of, or comprises, an electric heater that is a resistance heater or a dielectric heater.

197. The method according to claim 196, wherein the electric heater consists of, or comprises, an induction heater, and is solid-state based or is an active heat pump that uses, or is based on, the Peltier effect.

198. The method according to claim 158, wherein the actuator consists of, or comprises, a chemical or an electrochemical actuator, and is operative for producing, changing, or affecting a matter structure, properties, composition, process, or reactions.

199. The method according to claim 198, wherein the electrochemical actuator is operative for producing, changing, or affecting, an oxidation/reduction or an electrolysis reaction.

200. The method according to claim 158, wherein the actuator consists of, or comprises, an electromagnetic coil or an electromagnet operative for generating a magnetic or electric field.

201. The method according to claim 158, wherein the actuator consists of, or comprises, an electrical signal generator.

202. The method according to claim 201, wherein the signal generator is operative to output repeating or non-repeating electronic signals.

203. The method according to claim 201, wherein the signal generator is an analog signal generator having an analog voltage or analog current output, and wherein the output of the analog signal generator is a sine wave, a sawtooth wave, a step (pulse), a square wave, or a triangular wave, an Amplitude Modulation (AM), a Frequency Modulation (FM), or a Phase Modulation (PM) signal.

204. The method according to claim 201, wherein the signal generator is an Arbitrary Waveform Generator (AWG) or a logic signal generator.

205. The method according to claim 158, wherein the actuator consists of, or comprises, a sounder for converting an electrical energy to omnidirectional, unidirectional, or bidirectional pattern of emitted, audible or inaudible, sound waves.

206. The method according to claim 205, wherein the sound waves are audible, and wherein the sounder is an electromagnetic loudspeaker, a piezoelectric speaker, an electrostatic loudspeaker (ESL), a ribbon or planar magnetic loudspeaker, or a bending wave loudspeaker.

207. The method according to claim 205, wherein the sounder is operative to emit a single or multiple tones, or wherein the sounder is operative to perform continuous or intermittent operation.

208. The method according to claim 205, wherein the sounder is an electromechanical or a ceramic-based, and is an electric bell, a buzzer (or beeper), a chime, a whistle or a ringer.

209. The method according to claim 205, wherein the sound audible, and wherein the sounder is a loudspeaker, and wherein the method is operative to store and play one or more digital audio content files.

210. The method according to claim 1, further comprising conditioning or manipulating of the sensor output signal by a signal conditioner coupled to the output of the sensor, or wherein the method further comprising conditioning or manipulating of the actuator control input signal by a signal conditioner coupled to the input of the actuator.

211. The method according to claim 210, wherein the signal conditioner is operative to perform a linear or non-linear conditioning or manipulating.

212. The method according to claim 210, wherein the signal conditioner is selected from the group consisting of an operational or an instrument amplifier, a multiplexer, a frequency converter, a frequency-to-voltage converter, a voltage-to-frequency converter, a current-to-voltage converter, a current loop converter, a charge converter, an attenuator, a sample-and-hold circuit, a peak-detector, a voltage or current limiter, a delay line or circuit, a level translator, a galvanic isolator, an impedance transformer, a linearization circuit, a calibrator, a passive or active (or adaptive) filter, an integrator, a deviator, an equalizer, a spectrum analyzer, a compressor or a de-compressor, a coder (or decoder), a modulator (or demodulator), a pattern recognizer, a smoother, a noise

remover, an average or RMS circuit, an analog to digital (A/D) converter, and any combination thereof.

213. The method according to claim 1, wherein the method further comprising sending, by the server over the Internet, a notification message over the Internet via a wireless network to a device in response the received sensor data from the first vehicle.

214. The method according to claim 213, wherein the method is further operative to periodically send multiple notification messages.

215. The method according to claim 213, wherein the notification message is sent in response to a value of the sensor data or a function thereof.

216. The method according to claim 215, for use with a minimum or maximum threshold, wherein the notification message is sent in response to the value respectively below the minimum threshold or above the maximum threshold.

217. The method according to claim 216, wherein the notification message comprises an indication of the time when the threshold was exceeded, and an indication of the value of the measurement or the function thereof.

218. The method according to claim 213, wherein the notification message is sent over the Internet via the wireless network to a client method using a peer-to-peer scheme.

219. The method according to claim 213, wherein the notification message is sent over the Internet via the wireless network to an Instant Messaging (IM) server for being sent to a client method as part of an IM service.

220. The method according to claim 219, wherein the sending of the notification message or the communication with the IM server uses, is compatible with, or is based on, a protocol selected from the group consisting of SMTP (Simple Mail Transfer Protocol), SIP (Session Initiation Protocol), SIMPLE (SIP for Instant Messaging and Presence Leveraging Extensions), APEX (Application Exchange), Prim (Presence and Instance Messaging Protocol), XMPP (Extensible Messaging and Presence Protocol), IMPS (Instant Messaging and Presence Service), RTMP (Real Time Messaging Protocol), STM (Simple TCP/IP Messaging) protocol, Azureus Extended Messaging Protocol, Apple Push Notification Service (APNs), and Hypertext Transfer Protocol (HTTP).

221. The method according to claim 219, wherein the notification message is a text-based message and the IM service is a text messaging service.

222. The method according to claim 219, wherein the notification message is according to, or based on, message selected from the group consisting of a Short Message Service

(SMS) message and the IM service is a SMS service, an electronic-mail (e-mail) message and the IM service is an e-mail service, a WhatsApp message and the IM service is a WhatsApp service, a Twitter message and the IM service is a Twitter service, and a Viber message and the IM service is a Viber service.

5 223. The method according to claim 219, wherein the notification message is a Multimedia Messaging Service (MMS) or an Enhanced Messaging Service (EMS) message that includes audio or video, and the IM service is respectively a NMS or EMS service.

10 224. The method according to claim 213, wherein the device is a hand-held or a portable device.

225. The method according to claim 213, wherein the device is a wireless device, a notebook computer, a laptop computer, a media player, a Digital Still Camera (DSC), a Digital video Camera (DVC or digital camcorder), a Personal Digital Assistant (PDA), a cellular telephone, a digital camera, a video recorder, or a smartphone.

15 226. The method according to claim 225, wherein the device consists of, comprises, is part of, or is integrated with, a smartphone that comprises, or is based on, an Apple iPhone 6 or a Samsung Galaxy S6.

227. The method according to claim 226, wherein the device operates a mobile operating system that provides the notification mechanism.

20 228. The method according to claim 227, wherein the mobile operating system consists of, comprises, is part of, or is integrated with, Apple iOS or Google Android operating system.

229. The method according to claim 1, wherein the first vehicle comprises an Electronic Control Unit (ECU) that comprises, or connects to, the sensor, or wherein the second
25 vehicle comprises an Electronic Control Unit (ECU) that comprises, or connects to, the actuator.

230. The method according to claim 229, wherein the Electronic Control Unit (ECU) is selected from the group consisting of Electronic/engine Control Module (ECM), Engine Control Unit (ECU), Powertrain Control Module (PCM), Transmission Control Module
30 (TCM), Brake Control Module (BCM or EBCM), Central Control Module (CCM), Central Timing Module (CTM), General Electronic Module (GEM), Body Control Module (BCM), Suspension Control Module (SCM), Door Control Unit (DCU), Electric Power Steering Control Unit (PSCU), Seat Control Unit, Speed Control Unit (SCU), Telematic Control Unit (TCU), Transmission Control Unit (TCU), Brake Control

Module (BCM; ABS or ESC), Battery management system, control unit, and a control module.

231. The method according to claim 229, wherein the Electronic Control Unit (ECU) contains or executes software, an operating-system, or a middleware, that comprises, or
5 uses OSEK/VDX, International Organization for Standardization (ISO) 17356-1, ISO 17356-2, ISO 17356-3, ISO 17356-4, ISO 17356-5, or AUTOSAR standard.

232. The method according to claim 231, wherein the software comprises, uses, or is based on, an operating-system or a middleware, that comprises, or uses OSEK/VDX, International Organization for Standardization (ISO) 17356-1, ISO 17356-2, ISO 17356-
10 3, ISO 17356-4, ISO 17356-5, or AUTOSAR standard.

233. The method according to claim 1, wherein the sensor data is carried over a vehicle bus in the first vehicle, or wherein the actuator is controlled, affected, or activated, based on data received over a vehicle bus in the second vehicle.

234. The method according to claim 233, wherein the vehicle bus uses a data link layer
15 or a physical layer signaling that is according to, based on, uses, or is compatible with, ISO 11898-1:2015 or On-Board Diagnostics (OBD) standard.

235. The method according to claim 233, wherein the vehicle bus uses a medium access that is according to, is based on, uses, or is compatible with, ISO 11898-2:2003 or On-Board Diagnostics (OBD) standard.

20 236. The method according to claim 233, wherein the vehicle bus uses, or is compatible with, a multi-master, serial protocol using acknowledgement, arbitration, and error-detection schemes.

237. The method according to claim 236, wherein the vehicle bus employs, uses, is based on, or is compatible with, a synchronous and frame-based protocol.

25 238. The method according to claim 233, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, a Controller Area Network (CAN).

239. The method according to claim 238, wherein the CAN is according to, based on, uses, or is compatible with, a standard selected from the group consisting of ISO 11898-3:2006, ISO 11898-2:2004, ISO 11898-5:2007, ISO 11898-6:2013, ISO 11992-1:2003,
30 ISO 11783-2:2012, SAE J1939/11_201209, SAE J1939/15_201508, On-Board Diagnostics (OBD), and SAE J2411_200002.

240. The method according to claim 238, wherein the CAN is according to, based on, uses, or is compatible with, Flexible Data-Rate (CAN FD) protocol.

241. The method according to claim 233, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, a Local Interconnect Network (LIN).

242. The method according to claim 241, wherein the LIN is according to, based on, uses, or is compatible with, a standard selected from a group consisting of ISO 9141-2:1994, ISO 9141:1989, ISO 17987-1, ISO 17987-2, ISO 17987-3, ISO 17987-4, ISO 17987-5, ISO 17987-6, and ISO 17987-7.

243. The method according to claim 233, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, FlexRay protocol.

244. The method according to claim 243, wherein the FlexRay protocol is according to, based on, uses, or is compatible with, a standard selected from a group consisting of ISO 17458-1:2013, ISO 17458-2:2013, ISO 17458-3:2013, ISO 17458-4:2013, or ISO 17458-5:2013.

245. The method according to claim 233, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, Media Oriented Systems Transport (MOST) protocol.

246. The method according to claim 245, wherein the MOST protocol is according to, based on, uses, or is compatible with, a standard selected from a group consisting of MOST25, MOST50, and MOST150.

247. The method according to claim 233, wherein the vehicle bus uses, or is compatible with, automotive Ethernet.

248. The method according to claim 247, wherein the vehicle bus uses a single twisted pair.

249. The method according to claim 248, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, IEEE802.3 100BaseT1, IEEE802.3 1000BaseT1, BroadR-Reach®, or IEEE 802.3bw-2015 standard.

250. A system for affecting a vehicle operation by sensing a phenomenon in another vehicle, the system comprising:

a first vehicle identified by a first vehicle identifier and located at a first geographical location, comprising:

5 a sensor that output data in response to a first physical phenomenon; and

a first antenna and a first wireless transceiver coupled to the sensor for communicating over a first wireless network;

a second vehicle identified by a second vehicle identifier and located at a second geographical location, comprising:

10 an actuator that influences, affects, creates, or changes a second physical phenomenon; and

a second antenna and a second wireless transceiver coupled to the actuator for communicating over a second wireless network; and

15 an Internet-connected server storing a list of a group of vehicles that includes the second vehicle and operative to communicate with the first and second vehicle over the respective first and second wireless networks,

wherein the first vehicle is operative to send a first message that comprises the sensor output data, the first vehicle identifier, and the first vehicle location, to the server over the Internet via the first wireless network,

20 wherein the server and is operative to select the second vehicle from the group based on the second vehicle location and to send a second message to the second vehicle over the Internet via the second wireless network in response the received sensor data from the first vehicle, and

25 wherein the second vehicle is operative to activate, control, or affect the actuator, in response to receiving the second message.

251. The system according to claim 250, wherein the first and second networks consists of the same network, wherein the first and second networks are identical networks, or wherein the first and second networks use the same protocol.

252. The system according to claim 250, wherein the first and second networks are 30 distinct and different networks, or wherein the first and second networks use different protocols.

253. The system according to claim 252, wherein the first and second networks are different and each of the first and second networks is a WWAN, WLAN, or WPAN.

254. The system according to claim 250, for use with a threshold value, wherein the sending of the first message, by the first vehicle to the server, is in response to the sensor data being above or below the threshold value.

255. The system according to claim 254, wherein the sending of the first message, by the first vehicle to the server, is only in response to the sensor data being above or below the threshold value.

256. The system according to claim 250, wherein the receiving of the sensor data from the sensor and the sending of the first message to the server over the Internet via the first wireless network is performed periodically by the first vehicle every time period.

257. The system according to claim 256, wherein the time period is less than 1 second, 2 seconds, 5 seconds, 10 seconds, 20 seconds, 30 seconds, 50 seconds, 100 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes, 22 minutes, 30 minutes, 50 minutes, 100 minutes, 1 hour, 2 hours, 5 hours, 10 hours, 20 hours, 30 hours, 50 hours, 100 hours, 1 day, 2 days, 5 days, 10 days, 22 days, 30 days, 50 days, or 100 days.

258. The system according to claim 256, wherein the time period is more than 1 second, 2 seconds, 5 seconds, 10 seconds, 20 seconds, 30 seconds, 50 seconds, 100 seconds, 1 minute, 2 minutes, 5 minutes, 10 minutes, 22 minutes, 30 minutes, 50 minutes, 100 minutes, 1 hour, 2 hours, 5 hours, 10 hours, 20 hours, 30 hours, 50 hours, 100 hours, 1 day, 2 days, 5 days, 10 days, 22 days, 30 days, 50 days, or 100 days.

259. The system according to claim 256, for use with a threshold value, wherein the sending, by the server over the Internet, of the second message to the second vehicle, is in response to the sensor data being above or below the threshold value.

260. The system according to claim 259, wherein the sending, by the server over the Internet, of the second message to the second vehicle, is only in response to the sensor data being above or below the threshold value.

261. The system according to claim 250, wherein the first or second message is timestamped.

262. The system according to claim 250, wherein the first message comprises the time of receiving of sensor data from the sensor, or the time of sending of the first message.

263. The system according to claim 250, wherein the second vehicle is operative to estimate the geographical location of the second vehicle.

264. The system according to claim 263, wherein the second vehicle is further operative to send to the server the estimated geographical location of the second vehicle; and

wherein the server is further operative to receive and store the received estimated geographical location of the second vehicle.

265. The system according to claim 264, wherein the selecting of the second vehicle from the group is based on comparing the geographical locations of the first and second vehicles.

266. The system according to claim 265, wherein the selecting of the second vehicle from the group is based on estimating that the first and second vehicles are in the same area.

267. The system according to claim 266, wherein the first and second vehicles are estimated to be in the same region, city, street, ZIP code, latitude, or longitude.

268. The system according to claim 266, wherein the selecting of the second vehicle from the group is based on estimating the distance between the first and second vehicles.

269. The system according to claim 268, wherein the selecting of the second vehicle from the group is based on estimated distance between the first and second vehicles being less than 1 meter, 2 meters, 5 meters, 10 meters, 20 meters, 30 meters, 50 meters, 100 meters, 200 meters, 300 meters, 500 meters, 1 kilometer, 2 kilometers, 3 kilometers, 5 kilometers, 10 kilometers, 20 kilometers, 50 kilometers, or 100 kilometers.

270. The system according to claim 250, wherein the first vehicle further comprises an additional sensor having an additional output, and wherein the first vehicle is further operative to receive the additional sensor data from the additional sensor, and wherein the first message further comprises the additional sensor data.

271. The system according to claim 270, wherein the second message further comprises, or is in response to, the additional sensor data.

272. The system according to claim 250, further comprising a third vehicle that comprises an additional sensor having an additional output, and wherein the third vehicle is operative to receive the additional sensor data from the additional sensor and to send a third message that comprises the additional sensor data, the third vehicle identifier, and the third vehicle location, to the server over the Internet via a wireless network, and wherein the server is further operative to receive the additional sensor data and the third vehicle location from the third vehicle.

273. The system according to claim 272, wherein the second message is in response to the third message.

274. The system according to claim 250, wherein the second vehicle further comprises an additional actuator, and wherein the second vehicle is further operative for activating, controlling, or affecting, the additional actuator, in response to the second message.

275. The system according to claim 250, further comprising a third vehicle that
5 comprises an additional actuator, and wherein the server is operative to send over the Internet a second message to the third vehicle in response the received sensor data from the first vehicle, and wherein the third vehicle is operative to receive over the Internet via a wireless network, the second message, and to activate, control, or affect, at the third vehicle, the additional actuator, in response to the second message.

10 276. The system according to claim 250, further operative for detecting a road-related anomaly or hazard, wherein the sensor is operative to sense the road-related anomaly or hazard.

277. The system according to claim 276, wherein the road-related anomaly or hazard
15 comprises a traffic collision, traffic regulation violation, or a road infrastructure or surface damage.

278. The system according to claim 250, wherein the sensor is operative to sense a motion, velocity, or acceleration or the first vehicle.

279. The system according to claim 250, wherein the sensor is operative to sense a traffic collision, a stopping, or over speeding, of the first vehicle.

20 280. The system according to claim 250, further operative for parking help, cruise control, lane keeping, road sign recognition, surveillance, speed limit warning, restricted entries, and pull-over commands, travel information, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning, vehicle safety inspection, transit or emergency vehicle
25 signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, or electronic toll collection.

281. The system according to claim 280, wherein the sensor is configured to sense, or
30 wherein the actuator is configure to affect, as part of parking help, cruise control, lane keeping, road sign recognition, surveillance, speed limit warning, restricted entries, and pull-over commands, travel information, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning, vehicle safety inspection, transit or emergency vehicle signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-

vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, or electronic toll collection.

282. The system according to claim 250, further for fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, on-board computer, fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, or a Vehicle Identification Number (VIN).

283. The system according to claim 282, wherein the sensor is configured to sense, or wherein the actuator is configured to affect, as part of fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, on-board computer, fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, or a Vehicle Identification Number (VIN).

284. The system according to claim 250, wherein the first vehicle or the second vehicle is operative to estimate the geographical location of the respective first or second vehicle.

285. The system according to claim 284, wherein the geographical location is estimated, by the first vehicle, using, or based on, geolocation.

286. The system according to claim 285, wherein the geolocation is based on W3C Geolocation API.

287. The system according to claim 284, wherein the geographical location consists of, or comprises, one out of a country, a region, a city, a street, a ZIP code, latitude, or longitude.

288. The system according to claim 284, for use with multiple RF signals transmitted by multiple sources, and wherein the geographical location is estimated, by the respective first or second vehicle, by receiving the RF signals from the multiple sources via one or more antennas, and processing or comparing the received RF signals.

289. The system according to claim 288, wherein the multiple sources comprises satellites that are part of Global Navigation Satellite System (GNSS).

290. The system according to claim 289, wherein the GNSS is the Global Positioning System (GPS), and wherein the first vehicle comprises a GPS antenna coupled to a GPS receiver for receiving and analyzing the GPS signals.

291. The system according to claim 289, wherein the GNSS is the GLONASS (GLObal NAvigation Satellite System), the Beidou-1, the Beidou-2, the Galileo, or the IRNSS/VAVIC.

292. The system according to claim 288, wherein the processing or comparing comprises, or is based on, performing TOA (Time-Of-Arrival) measurement, performing TDOA (Time Difference-Of-Arrival) measurement, performing an AoA (Angle-Of-Arrival) measurement, performing a Line-of-Sight (LoS) measurement, performing a Time-of-Flight (ToF) measurement, performing a Two-Way Ranging (TWR) measurement, performing a Symmetrical Double Sided – Two Way Ranging (SDS-TWR) measurement, performing a Near-field electromagnetic ranging (NFER) measurement, or performing triangulation, trilateration, or multilateration (MLAT).

293. The system according to claim 288, wherein the RF signals are part of the communication over the respective first or second wireless network.

294. The system according to claim 293, wherein the respective first or second wireless network is a cellular telephone network, and wherein the sources are cellular towers or base-stations.

295. The system according to claim 294, wherein the respective first or second wireless network is a WLAN, and wherein the sources are hotspots or Wireless Access Points (WAPs).

296. The system according to claim 250, wherein the first vehicle identifier comprises a set of characters or numbers uniquely identifying the first vehicle.

297. The system according to claim 296, wherein the first vehicle identifier comprises a Vehicle Identification Number (VIN) or a license plate number.

298. The system according to claim 297, wherein the first vehicle identifier comprises a Vehicle Identification Number (VIN) that is according to, or based on, ISO 3779.

299. The system according to claim 296, wherein the first vehicle identifier comprises a code that identifies the first vehicle make, model, color, model year, engine size, or vehicle type.

300. The system according to claim 296, wherein the first vehicle identifier comprises a digital address that uniquely identifies the first vehicle in a digital network, in the Internet, or in the first network.

301. The system according to claim 296, wherein the digital address comprises an IP address or a Medium Access Control (MAC) address.

302. The system according to claim 301, wherein the digital address is a layer 3 address and is a static or dynamic IP address that is of IPv4 or IPv6 type address.

303. The system according to claim 301, wherein the digital address is a MAC layer address selected from the group consisting of MAC-48, EUI-48, and EUI-64 address type.

304. The system according to claim 250, wherein the first or second vehicle is a ground vehicle adapted to travel on land.

305. The system according to claim 304, wherein the ground vehicle is selected from the group consisting of a bicycle, a car, a motorcycle, a train, an electric scooter, a subway, a train, a trolleybus, and a tram.

306. The system according to claim 304, wherein the ground vehicle consists of, or comprises, is an autonomous car.

307. The system according to claim 306, wherein the autonomous car is according to levels 0, 1, or 2 of the Society of Automotive Engineers (SAE) J3016 standard.

308. The system according to claim 306, wherein the autonomous car is according to levels 3, 4, or 5 of the Society of Automotive Engineers (SAE) J3016 standard.

309. The system according to claim 250, wherein the first or second vehicle is a buoyant or submerged watercraft adapted to travel on or in water.

310. The system according to claim 309, wherein the watercraft is selected from the group consisting of a ship, a boat, a hovercraft, a sailboat, a yacht, and a submarine.

311. The system according to claim 250, wherein the first or second vehicle is an aircraft adapted to fly in air.

312. The system according to claim 311, wherein the aircraft is a fixed wing or a rotorcraft aircraft.

313. The system according to claim 311, wherein the aircraft is selected from the group consisting of an airplane, a spacecraft, a glider, a drone, or an Unmanned Aerial Vehicle (UAV).

314. The system according to claim 250, wherein the sensor or the actuator is mounted onto, is attached to, is part of, or is integrated with a rear or front view camera, chassis,

lighting system, headlamp, door, car glass, windscreen, side or rear window, glass panel roof, hood, bumper, cowl, dashboard, fender, quarter panel, rocker, or a spoiler of the vehicle.

315. The system according to claim 250, wherein the first or second vehicle further comprises an Advanced Driver Assistance Systems (ADAS) functionality, system, or scheme.

316. The system according to claim 315, wherein the sensor or the actuator is part of, integrated with, communicates with, or coupled to, the ADAS functionality, system, or scheme.

317. The system according to claim 315, wherein the ADAS functionality, system, or scheme is selected from a group consisting of Adaptive Cruise Control (ACC), Adaptive High Beam, Glare-free high beam and pixel light, Adaptive light control such as swiveling curve lights, Automatic parking, Automotive navigation system with typically GPS and TMC for providing up-to-date traffic information, Automotive night vision, Automatic Emergency Braking (AEB), Backup assist, Blind Spot Monitoring (BSM), Blind Spot Warning (BSW), Brake light or traffic signal recognition, Collision avoidance system, Pre-crash system, Collision Imminent Braking (CIB), Cooperative Adaptive Cruise Control (CACC), Crosswind stabilization, Driver drowsiness detection, Driver Monitoring Systems (DMS), Do-Not-Pass Warning (DNPW), Electric vehicle warning sounds used in hybrids and plug-in electric vehicles, Emergency driver assistant, Emergency Electronic Brake Light (EEBL), Forward Collision Warning (FCW), Heads-Up Display (HUD), Intersection assistant, Hill descent control, Intelligent speed adaptation or Intelligent Speed Advice (ISA), Intelligent Speed Adaptation (ISA), Intersection Movement Assist (IMA), Lane Keeping Assist (LKA), Lane Departure Warning (LDW) (a.k.a. Line Change Warning - LCW), Lane change assistance, Left Turn Assist (LTA), Night Vision System (NVS), Parking Assistance (PA), Pedestrian Detection System (PDS), Pedestrian protection system, Pedestrian Detection (PED), Road Sign Recognition (RSR), Surround View Cameras (SVC), Traffic sign recognition, Traffic jam assist, Turning assistant, Vehicular communication systems, Autonomous Emergency Braking (AEB), Adaptive Front Lights (AFL), and Wrong-way driving warning.

318. The system according to claim 250, wherein the first or second vehicle further employs an Advanced Driver Assistance System Interface Specification (ADASIS) functionality, system, or scheme.

319. The system according to claim 318, wherein the sensor or the actuator is part of, integrated with, communicates with, or coupled to, the ADASIS functionality, system, or scheme.

320. The system according to claim 318, wherein the first or second message comprises
5 a map data relating to the location of the respective first or second vehicle.

321. The system according to claim 250, wherein the first and second wireless networks uses the same protocol.

322. The system according to claim 321, wherein the first and second wireless networks are the same network.

10 323. The system according to claim 250, wherein the first and second wireless networks are different networks.

324. The system according to claim 323, wherein the first and second wireless networks uses the same protocol.

15 325. The system according to claim 323, wherein the first and second wireless networks uses different protocols.

326. The system according to claim 250, wherein each of the first and second wireless networks is Wireless Wide Area Network (WWAN), Wireless Personal Area Network (WPAN), or Wireless Local Area Network (WLAN).

20 327. The system according to claim 250, wherein the first vehicle comprises a first antenna and a first wireless transceiver for communicating over the first wireless network, and wherein the second vehicle comprises a second antenna and a second wireless transceiver for communicating over the second wireless network.

25 328. The system according to claim 327, wherein the first or second wireless network is a Wireless Wide Area Network (WWAN), wherein the respective first or second wireless transceiver comprises a WWAN transceiver, and wherein the respective first or second wireless antenna comprises an WWAN antenna.

329. The system according to claim 328, wherein the WWAN is a wireless broadband network.

30 330. The system according to claim 329, wherein the WWAN is a WiMAX network, wherein the antenna is a WiMAX antenna and the wireless transceiver is a WiMAX modem, and the WiMAX network is according to, compatible with, or based on, IEEE 802.16-2009.

331. The system according to claim 329, wherein the WWAN is a cellular telephone network, the antenna is a cellular antenna, and the wireless transceiver is a cellular modem.

332. The system according to claim 331, wherein the cellular telephone network is a
5 Third Generation (3G) network that uses a protocol selected from the group consisting of UMTS W-CDMA, UMTS HSPA, UMTS TDD, CDMA2000 1xRTT, CDMA2000 EV-DO, and GSM EDGE-Evolution, or wherein the cellular telephone network uses a protocol selected from the group consisting of a Fourth Generation (4G) network that uses HSPA+, Mobile WiMAX, LTE, LTE-Advanced, MBWA, or is based on IEEE
10 802.20-2008.

333. The system according to claim 327, wherein the first or second wireless network is a Wireless Personal Area Network (WPAN), wherein the respective first or second wireless transceiver comprises a WPAN transceiver, and wherein the respective first or second wireless antenna comprises an WPAN antenna.

334. The system according to claim 333, wherein the WPAN is according to, compatible with, or based on, Bluetooth™, Bluetooth Low Energy (BLE), or IEEE 802.15.1-2005 standards, or wherein the WPAN is a wireless control network that is according to, or based on, Zigbee™, IEEE 802.15.4-2003, or Z-Wave™ standards.

335. The system according to claim 327, wherein the first or second wireless network is
20 a Wireless Local Area Network (WLAN), wherein the respective first or second wireless transceiver comprises a WLAN transceiver, and wherein the respective first or second wireless antenna comprises an WLAN antenna.

336. The system according to claim 335, wherein the WLAN is according to, compatible with, or is based on, a standard selected from the group consisting of IEEE 802.11-2012,
25 IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, and IEEE 802.11ac.

337. The system according to claim 327, wherein the first or second wireless network is over a licensed or unlicensed radio frequency band.

338. The system according to claim 337, wherein the respective first or second wireless network is over the unlicensed radio frequency band that is an Industrial, Scientific and
30 Medical (ISM) radio band.

339. The system according to claim 327, wherein the first or second wireless network is using, or is based on, Dedicated Short-Range Communication (DSRC).

340. The system according to claim 339, wherein the DSRC is according to, compatible with, or based on, European Committee for Standardization (CEN) EN 12253:2004, EN 12795:2002, EN 12834:2002, EN 13372:2004, or EN ISO 14906:2004 standard.

341. The system according to claim 339, wherein the DSRC is according to, compatible with, or based on, IEEE 802.11p, IEEE 1609.1-2006, IEEE 1609.2, IEEE 1609.3, IEEE 1609.4, or IEEE1609.5.

342. The system according to claim 250, wherein the sensor consists of, or comprises, an occupancy sensor for detecting occupancy of a space by a human body by using electric effect, inductive coupling, capacitive coupling, triboelectric effect, piezoelectric effect, fiber optic transmission, or radar intrusion sensing.

343. The system according to claim 342, wherein the occupancy sensor consists of, comprises, or is based on, an acoustic sensor, opacity, geomagnetism, magnetic sensors, magnetometer, reflection of transmitted energy, infrared laser radar, microwave radar, electromagnetic induction, or vibration.

344. The system according to claim 343, wherein the occupancy sensor consists of, comprises of, or is based on, a motion sensor.

345. The system according to claim 344, wherein the motion sensor consists of, or comprises, a mechanically actuated sensor, passive or active electronic sensor, ultrasonic sensor, microwave sensor, tomographic detector, passive infrared (PIR) sensor, laser optical detector, or acoustical detector.

346. The system according to claim 250, wherein the sensor consists of, or comprises, a photoelectric sensor that responds to a visible or an invisible light, the invisible light is infrared, ultraviolet, X-rays, or gamma rays, and wherein the photoelectric sensor is based on the photoelectric or photovoltaic effect, and consists of, or comprises, a semiconductor component that consists of, or comprises, a photodiode, or a phototransistor.

347. The system according to claim 346, wherein the photoelectric sensor consists of, comprises, or is based on Charge-Coupled System (CCD) or a Complementary Metal-Oxide Semiconductor (CMOS) component.

348. The system according to claim 250, wherein the sensor consists of, or comprises, an electrochemical sensor that responds to an object chemical structure, properties, composition, or reactions.

349. The system according to claim 348, wherein the electrochemical sensor consists of, or comprises, a pH meter or a gas sensor responding to a presence of radon, hydrogen,

oxygen, or Carbon-Monoxide (CO), or wherein the electrochemical sensor is based on optical detection or on ionization and is a smoke, a flame, or a fire detector, or is responsive to combustible, flammable, or toxic gas.

5 350. The system according to claim 250, wherein the sensor consists of, or comprises, an electric sensor that responds to an electrical characteristics or electrical phenomenon quantity in an electrical circuit.

351. The system according to claim 350, wherein the electrical sensor is conductively coupled to the electrical circuit.

10 352. The system according to claim 350, wherein the electrical sensor is a non-contact sensor non-conductively to the electrical circuit.

353. The system according to claim 350, wherein the electrical sensor is responsive to Alternating Current (AC) or Direct Current (DC).

15 354. The system according to claim 350, wherein the electrical sensor consists of, or comprises, an ampermeter that responds to electrical current passing through a conductor or wire.

355. The system according to claim 354, wherein the electrical sensor consists of, or comprises, an AC ampermeter connected to measure an AC current from an AC power source or via an AC load.

20 356. The system according to claim 354, wherein the ampermeter consists of, or comprises, a galvanometer, a hot-wire ampermeter, a current clamp, or a current probe.

357. The system according to claim 350, wherein the electrical sensor consists of, or comprises, a voltmeter that responds to an electrical voltage.

358. The system according to claim 350, wherein the electrical sensor consists of, or comprises, a wattmeter that responds to active electrical power.

25 359. The system according to claim 358, wherein the electrical sensor consists of, or comprises, an AC power wattmeter that is connected to measure an AC power source supplied power or an AC load consumed power.

360. The system according to claim 358, wherein the wattmeter is based on induction, or is based on multiplying measured voltage and measured current.

30 361. The system according to claim 350, wherein the electrical sensor consists of, or comprises, an electricity meter that responds to electrical energy.

362. The system according to claim 361, wherein the electricity meter is connected to measure an AC power source supplied electrical energy or an AC load consumed electrical energy.

363. The system according to claim 250, wherein the sensor consists of, or comprises, a piezoelectric sensor that includes single crystal material or a piezoelectric ceramics and uses a transverse, longitudinal, or shear effect mode of the piezoelectric effect.

5 364. The system according to claim 250, further comprising multiple sensors arranged as a directional sensor array operative to estimate the number, magnitude, frequency, Direction-Of-Arrival (DOA), distance, or speed of the phenomenon impinging the sensor array, and wherein said control logic includes processing of the sensor array outputs.

10 365. The system according to claim 250, wherein the sensor consists of, or comprises, a thermoelectric sensor that responds to a temperature or to a temperature gradient of an object using conduction, convection, or radiation, and wherein the thermoelectric sensor consists of, or comprises, a Positive Temperature Coefficient (PTC) thermistor, a Negative Temperature Coefficient (NTC) thermistor, a thermocouple, a quartz crystal, or
15 a Resistance Temperature Detector (RTD).

366. The system according to claim 250, wherein the sensor consists of, or comprises, a nanosensor, a crystal, or a semiconductor, or wherein: the sensor is an ultrasonic based, the sensor is an eddy-current sensor, the sensor is a proximity sensor, the sensor is a bulk or surface acoustic sensor, or the sensor is an atmospheric or an environmental sensor.

20 367. The system according to claim 250, wherein the sensor consists of, or comprises, a radiation sensor that responds to radioactivity, nuclear radiation, alpha particles, beta particles, or gamma rays, and is based on gas ionization.

368. The system according to claim 250, wherein the sensor consists of, or comprises, a photoelectric sensor that responds to a visible or an invisible light, the invisible light is
25 infrared, ultraviolet, X-rays, or gamma rays, and wherein the photoelectric sensor consists of, comprises, or is based on the photoelectric or photovoltaic effect, and consists of, or comprises, a semiconductor component that consists of, or comprises, a photodiode, a phototransistor, or a solar cell.

369. The system according to claim 368, wherein the photoelectric sensor consists of,
30 comprises, or is based on Charge-Coupled Device (CCD) or a Complementary Metal-Oxide Semiconductor (CMOS) element.

370. The system according to claim 250, wherein the sensor consists of, or comprises, a photosensitive image sensor array comprising multiple photoelectric sensors, for capturing an image and producing electronic image information representing the image,

and the system further comprising one or more optical lens for focusing the received light and to guide the image, and wherein the image sensor is disposed approximately at an image focal point plane of the one or more optical lens for properly capturing the image.

5 371. The system according to claim 370, further comprising an image processor coupled to the image sensor for providing a digital data video signal according to a digital video format, the digital video signal carrying digital data video based on the captured images, and wherein the digital video format is based on one out of: TIFF (Tagged Image File Format), RAW format, AVI, DV, MOV, WMV, MP4, DCF (Design Rule for Camera
10 Format), ITU-T H.261, ITU-T H.263, ITU-T H.264, ITU-T CCIR 601, ASF, Exif (Exchangeable Image File Format), and DPOF (Digital Print Order Format) standards.

372. The system according to claim 371, further comprising a intraframe or interframe compression based video compressor coupled to the image sensor for lossy or non-lossy
15 compressing the digital data video, wherein the compression is based on a standard compression algorithm which is one or more out of JPEG (Joint Photographic Experts Group) and MPEG (Moving Picture Experts Group), ITU-T H.261, ITU-T H.263, ITU-T H.264 and ITU-T CCIR 601.

373. The system according to claim 250, wherein the sensor consists of, or comprises, an electrochemical sensor that responds to an object chemical structure, properties,
20 composition, or reactions.

374. The system according to claim 373, wherein the electrochemical sensor consists of, or comprises, a pH meter or a gas sensor responding to a presence of radon, hydrogen, oxygen, or Carbon-Monoxide (CO), or wherein the electrochemical sensor consists of, comprises, or is based on optical detection or on ionization and is a smoke, a flame, or a
25 fire detector, or is responsive to combustible, flammable, or toxic gas.

375. The system according to claim 250, wherein the sensor consists of, or comprises, a physiological sensor that responds to parameters associated with a live body, and is external to the sensed body, implanted inside the sensed body, attached to the sensed body, or wearable on the sensed body.

30 376. The system according to claim 375, wherein the physiological sensor is responding to body electrical signals and consists of, or comprises, an EEG Electroencephalography (EEG) or an Electrocardiography (ECG) sensor.

377. The system according to claim 375, wherein the physiological sensor is responding to oxygen saturation, gas saturation, or a blood pressure in the sensed body.

378. The system according to claim 250, wherein the sensor is an electroacoustic sensor that responds to an audible or inaudible sound.

379. The system according to claim 378, wherein the electroacoustic sensor consists of, or comprises, an omnidirectional, unidirectional, or bidirectional microphone that consists of, comprises, or is based on the sensing the incident sound based motion of a diaphragm or a ribbon, and the microphone consists of, or comprises, a condenser, an electret, a dynamic, a ribbon, a carbon, or a piezoelectric microphone.

380. The system according to claim 250, wherein the sensor is operative for sensing fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, on-board computer, fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, or a Vehicle Identification Number (VIN).

381. The system according to claim 250, wherein the sensor consists of, or comprises, an angular position sensor for measuring angular setting or a change of an angle.

382. The system according to claim 381, wherein the angular position sensor is configured for throttle-valve-angle measuring as part of an engine management on gasoline (SI) engines in the first vehicle.

383. The system according to claim 250, wherein the sensor consists of, or comprises, a rotational-speed sensor for measuring rotational speeds, positions or angles in excess of 360°.

384. The system according to claim 383, wherein the rotational-speed sensor is configured for measuring wheel-speed, engine speeds, engine positioning angle, steering-wheel angle, distance covered, or road curves / bends.

385. The system according to claim 250, wherein the sensor consists of, or comprises, a spring-mass acceleration sensor for measuring changes in the first vehicle speed.

386. The system according to claim 385, wherein the spring-mass acceleration is configured for measuring vehicular acceleration and deceleration, as part of an Anti-Breaking System (ABS) or a Traction Control System (TCS) of the first vehicle.

387. The system according to claim 250, wherein the sensor consists of, or comprises, a bending beam acceleration sensor for registering or detecting shock and vibration.

388. The system according to claim 387, wherein the bending beam acceleration sensor is configured for detecting impacts or measuring shocks and vibration, or for triggering airbags or belt tighteners.

389. The system according to claim 250, wherein the sensor consists of, or comprises, a yaw sensor for measuring skidding movements, or for measuring yaw rate and lateral acceleration, of the first vehicle.

390. The system according to claim 389, wherein the yaw sensor is configured for affecting a vehicle dynamics control or is part of an Electronic Stability Program (ESP).

391. The system according to claim 250, wherein the sensor consists of, or comprises, a vibration sensor for measuring structure-borne vibrations at an engine, a machines, or a pivot bearing, of the first vehicle.

392. The system according to claim 391, wherein the vibration sensor is configured for engine-knock detection as part of an anti-knock control in an engine management system.

393. The system according to claim 250, wherein the sensor consists of, or comprises, an absolute-pressure sensor for measuring ranges from 50% to 500% of the earth's atmospheric pressure.

394. The system according to claim 393, wherein the absolute-pressure sensor is configured for manifold vacuum measurement, charge-air-pressure measurement for charge-air pressure control, or altitude-dependent fuel injection for diesel engines.

395. The system according to claim 250, wherein the sensor consists of, or comprises, a differential-pressure sensor for measuring differential gas pressure.

396. The system according to claim 395, wherein the differential-pressure sensor is configured for pressure measurement in a fuel tank, or evaporative-emission control system, in the first vehicle.

397. The system according to claim 250, wherein the sensor consists of, or comprises, a temperature sensor for measuring the temperature of gaseous material or a liquid.

398. The system according to claim 397, wherein the temperature sensor is configured for displaying of outside and inside temperature, controlling of air conditioner or inside temperature, controlling of radiator or thermostat, or measuring of lube-oil, coolant, or engine temperature.

399. The system according to claim 250, wherein the sensor consists of, or comprises, a Lambda oxygen sensor for determining the residual oxygen content in the exhaust gas.

400. The system according to claim 399, wherein the Lambda oxygen sensor is configured for controlling of A/F mixture for minimization of pollutant emissions on gasoline and gas engines.

401. The system according to claim 250, wherein the sensor consists of, or comprises, an air-mass meter used for measuring the flow rate of gas.

402. The system according to claim 401, wherein the Lambda oxygen sensor is configured for measuring of the mass of the air drawn in by the engine.

403. The system according to claim 250, wherein the actuator is operative to provide time-dependent characteristic of the phenomenon selected from the group consisting of a time-integrated, an average, an RMS (Root Mean Square) value, a frequency, a period, a duty-cycle, a time-integrated, and a time-derivative.

404. The system according to claim 250, wherein the actuator influences, affects, creates, or changes the phenomenon that is associated with an object that is a gas, an air, a liquid, or a solid.

405. The system according to claim 404, wherein the actuator is operative to provide space-dependent characteristic that is selected from the group consisting of a pattern, a linear density, a surface density, a volume density, a flux density, a current, a direction, a rate of change in a direction, and a flow.

406. The system according to claim 404, wherein the actuator consists of, or comprises, an electric light source that converts electrical energy into light, and emits visible or non-visible light for illumination or indication, and the non-visible light is infrared, ultraviolet, X-rays, or gamma rays.

407. The system according to claim 406, wherein the electric light source consists of, or comprises, a lamp, an incandescent lamp, a gas discharge lamp, a fluorescent lamp, a Solid-State Lighting (SSL), a Light Emitting Diode (LED), an Organic LED (OLED), a polymer LED (PLED), or a laser diode.

408. The system according to claim 404, wherein the actuator consists of, or comprises, a motion actuator that causes linear or rotary motion, and the system further comprising a conversion mechanism coupled to, attached to, or part of, the actuator for converting to rotary or linear motion based on a screw, a wheel and axle, or a cam.

409. The system according to claim 408, wherein the conversion mechanism consists of, comprises, or is based on, a screw, and the system further comprises a leadscrew, a screw jack, a ball screw or a roller screw that is coupled to, attached to, or part of, the actuator.

410. The system according to claim 408, wherein the conversion mechanism consists of, comprises, or is based on, a wheel and axle, and the system further comprises a hoist, a winch, a rack and pinion, a chain drive, a belt drive, a rigid chain, or a rigid belt that is coupled to, attached to, or part of, the actuator.

5 411. The system according to claim 408, wherein the motion actuator further comprises a lever, a ramp, a screw, a cam, a crankshaft, a gear, a pulley, a constant-velocity joint, or a ratchet, for effecting the motion.

412. The system according to claim 408, wherein the motion actuator consists of, or comprises, a pneumatic actuator, hydraulic actuator, or electrical actuator.

10 413. The system according to claim 412, wherein the motion actuator consists of, or comprises, an electrical motor.

414. The system according to claim 413, wherein the electrical motor is a brushed motor, a brushless motor, or an uncommutated DC motor.

15 415. The system according to claim 414, wherein the electrical motor is a DC stepper motor that is a Permanent Magnet (PM) motor, a Variable reluctance (VR) motor, or a hybrid synchronous stepper motor.

416. The system according to claim 413, wherein the electrical motor is an AC motor that is an induction motor, a synchronous motor, or an eddy current motor.

20 417. The system according to claim 416, wherein the AC motor is a single-phase AC induction motor, a two-phase AC servo motor, or a three-phase AC synchronous motor, and the AC motor is a split-phase motor, a capacitor-start motor, or a Permanent-Split Capacitor (PSC) motor.

418. The system according to claim 413, wherein the electrical motor is an electrostatic motor, a piezoelectric actuator, or is a MEMS-based motor.

25 419. The system according to claim 408, wherein the motion actuator consists of, or comprises, a linear hydraulic actuator, a linear pneumatic actuator, a Linear Induction electric Motor (LIM), or a Linear Synchronous electric Motor (LSM).

30 420. The system according to claim 408, wherein the motion actuator consists of, or comprises, a piezoelectric motor, a Surface Acoustic Wave (SAW) motor, a Squiggle motor, an ultrasonic motor, or a micro- or nanometer comb-drive capacitive actuator, a Dielectric or Ionic based Electroactive Polymers (EAPs) actuator, a solenoid, a thermal bimorph, or a piezoelectric unimorph actuator.

421. The system according to claim 404, wherein the actuator consists of, or comprises, a compressor or a pump and is operative to move, force, or compress a liquid, a gas or a slurry.

422. The system according to claim 421, wherein the pump is a direct lift pump, an impulse pump, a displacement pump, a valveless pump, a velocity pump, a centrifugal pump, a vacuum pump, or a gravity pump.

423. The system according to claim 421, wherein the pump is a positive displacement pump that is a rotary lobe pump, a progressive cavity pump, a rotary gear pump, a piston pump, a diaphragm pump, a screw pump, a gear pump, a hydraulic pump, or a vane pump.

424. The system according to claim 423, wherein the positive displacement pump is a rotary-type positive displacement pump that is an internal gear pump, a screw pump, a shuttle block pump, a flexible vane pump, a sliding vane pump, a rotary vane pump, a circumferential piston pump, a helical twisted roots pump, or a liquid ring vacuum pump.

425. The system according to claim 423, wherein the positive displacement pump is a reciprocating-type positive displacement type that is a piston pump, a diaphragm pump, a plunge pump, a diaphragm valve pump, or a radial piston pump.

426. The system according to claim 423, wherein the positive displacement pump is a linear-type positive displacement type that is a rope-and-chain pump.

427. The system according to claim 421, wherein the pump is an impulse pump that is a hydraulic ram pump, a pulser pump, or an airlift pump.

428. The system according to claim 421, wherein the pump is a rotodynamic pump that is a velocity pump, or is a centrifugal pump that is a radial flow pump, an axial flow pump, or a mixed flow pump.

429. The system according to claim 404, wherein the actuator consists of, or comprises, a display screen for visually presenting information.

430. The system according to claim 429, wherein the display or the display screen consists of, or comprises, a monochrome, grayscale or color display, having an array of light emitters or light reflectors.

431. The system according to claim 429, wherein the display or the display screen consists of, or comprises, a projector selected from the group consisting of an Eidophor projector, Liquid Crystal on Silicon (LCoS or LCOS) projector, LCD projector, MEMS projector, and Digital Light Processing (DLP™) projector.

432. The system according to claim 431, wherein the projector consists of, or comprises, a virtual retinal display.

433. The system according to claim 429, wherein the display or the display screen consists of, or comprises, a video display supporting Standard-Definition (SD) or High-Definition (HD) standards, and is capable of scrolling, static, bold or flashing the presented information.

434. The system according to claim 433, wherein the video display is a 3D video display.

435. The system according to claim 429, wherein the display or the display screen consists of, or comprises, an analog display having an analog input interface supporting NTSC, PAL or SECAM formats, and the analog input interface comprises of RGB, VGA (Video Graphics Array), SVGA (Super Video Graphics Array), SCART or S-video interface.

436. The system according to claim 429, wherein the display or the display screen consists of, or comprises, a digital display having a digital input interface selected from the group consisting of IEEE1394, FireWire™, USB, SDI (Serial Digital Interface), HDMI (High-Definition Multimedia Interface), DVI (Digital Visual Interface), UDI (Unified Display Interface), DisplayPort, Digital Component Video, and DVB (Digital Video Broadcast) interface.

437. The system according to claim 429, wherein the display or the display screen selected from the group consisting of a Cathode-Ray Tube (CRT), a Field Emission Display (FED), an Electroluminescent Display (ELD), a Vacuum Fluorescent Display (VFD), or an Organic Light-Emitting Diode (OLED) display, a passive-matrix (PMOLED) display, an active-matrix OLEDs (AMOLED) display, a Liquid Crystal Display (LCD) display, a Thin Film Transistor (TFT) display, an LED-backlit LCD display, or an Electronic Paper Display (EPD) display that is based on Gyricon technology, Electro-Wetting Display (EWD), and Electrofluidic display technology.

438. The system according to claim 429, wherein the display or the display screen consists of, or comprises, a laser video display that is based on a Vertical-External-Cavity Surface-Emitting-Laser (VECSEL) or a Vertical-Cavity Surface-Emitting Laser (VCSEL).

439. The system according to claim 429, wherein the display or the display screen consists of, or comprises, a segment display based on a seven-segment display, a fourteen-segment display, a sixteen-segment display, or a dot matrix display, and is

operative to only display at least one of digits, alphanumeric characters, words, characters, arrows, symbols, ASCII, and non-ASCII characters.

440. The system according to claim 404, wherein the actuator consists of, or comprises, a thermoelectric actuator and is a heater or a cooler, operative for affecting the temperature of a solid, a liquid, or a gas object, and is coupled to the object by conduction, convection, force convention, thermal radiation, or by the transfer of energy by phase changes.

441. The system according to claim 440, wherein the thermoelectric actuator consists of, or comprises, a cooler based on a heat pump driving a refrigeration cycle using a compressor-based electric motor.

442. The system according to claim 440, wherein the thermoelectric actuator consists of, or comprises, an electric heater that is a resistance heater or a dielectric heater.

443. The system according to claim 442, wherein the electric heater consists of, or comprises, an induction heater, and is solid-state based or is an active heat pump that uses, or is based on, the Peltier effect.

444. The system according to claim 404, wherein the actuator consists of, or comprises, a chemical or an electrochemical actuator, and is operative for producing, changing, or affecting a matter structure, properties, composition, process, or reactions.

445. The system according to claim 444, wherein the electrochemical actuator is operative for producing, changing, or affecting, an oxidation/reduction or an electrolysis reaction.

446. The system according to claim 404, wherein the actuator consists of, or comprises, an electromagnetic coil or an electromagnet operative for generating a magnetic or electric field.

447. The system according to claim 404, wherein the actuator consists of, or comprises, an electrical signal generator.

448. The system according to claim 447, wherein the signal generator is operative to output repeating or non-repeating electronic signals.

449. The system according to claim 447, wherein the signal generator is an analog signal generator having an analog voltage or analog current output, and wherein the output of the analog signal generator is a sine wave, a sawtooth wave, a step (pulse), a square wave, or a triangular wave, an Amplitude Modulation (AM), a Frequency Modulation (FM), or a Phase Modulation (PM) signal.

450. The system according to claim 447, wherein the signal generator is an Arbitrary Waveform Generator (AWG) or a logic signal generator.

451. The system according to claim 404, wherein the actuator consists of, or comprises, a sounder for converting an electrical energy to omnidirectional, unidirectional, or bidirectional pattern of emitted, audible or inaudible, sound waves.

452. The system according to claim 451, wherein the sound waves are audible, and wherein the sounder is an electromagnetic loudspeaker, a piezoelectric speaker, an electrostatic loudspeaker (ESL), a ribbon or planar magnetic loudspeaker, or a bending wave loudspeaker.

453. The system according to claim 451, wherein the sounder is operative to emit a single or multiple tones, or wherein the sounder is operative to perform continuous or intermittent operation.

454. The system according to claim 451, wherein the sounder is an electromechanical or a ceramic-based, and is an electric bell, a buzzer (or beeper), a chime, a whistle or a ringer.

455. The system according to claim 451, wherein the sound audible, and wherein the sounder is a loudspeaker, and wherein the system is operative to store and play one or more digital audio content files.

456. The system according to claim 250, further comprising a signal conditioner coupled to the output of the sensor for conditioning or manipulating of the sensor output signal by or wherein the system further comprising a signal conditioner coupled to the input of the actuator for conditioning or manipulating of the actuator control input signal.

457. The system according to claim 456, wherein the signal conditioner is operative to perform a linear or non-linear conditioning or manipulating.

458. The system according to claim 456, wherein the signal conditioner is selected from the group consisting of an operational or an instrument amplifier, a multiplexer, a frequency converter, a frequency-to-voltage converter, a voltage-to-frequency converter, a current-to-voltage converter, a current loop converter, a charge converter, an attenuator, a sample-and-hold circuit, a peak-detector, a voltage or current limiter, a delay line or circuit, a level translator, a galvanic isolator, an impedance transformer, a linearization circuit, a calibrator, a passive or active (or adaptive) filter, an integrator, a deviator, an equalizer, a spectrum analyzer, a compressor or a de-compressor, a coder (or decoder), a modulator (or demodulator), a pattern recognizer, a smoother, a noise

remover, an average or RMS circuit, an analog to digital (A/D) converter, and any combination thereof.

459. The system according to claim 250, wherein the system is further operative for sending, by the server over the Internet, a notification message over the Internet via a wireless network to a device in response the received sensor data from the first vehicle.

460. The system according to claim 459, wherein the system is further operative to periodically send multiple notification messages.

461. The system according to claim 459, wherein the notification message is sent in response to a value of the sensor data or a function thereof.

462. The system according to claim 461, for use with a minimum or maximum threshold, wherein the notification message is sent in response to the value respectively below the minimum threshold or above the maximum threshold.

463. The system according to claim 462, wherein the notification message comprises an indication of the time when the threshold was exceeded, and an indication of the value of the measurement or the function thereof.

464. The system according to claim 459, wherein the notification message is sent over the Internet via the wireless network to a client system using a peer-to-peer scheme.

465. The system according to claim 459, wherein the notification message is sent over the Internet via the wireless network to an Instant Messaging (IM) server for being sent to a client system as part of an IM service.

466. The system according to claim 465, wherein the sending of the notification message or the communication with the IM server uses, is compatible with, or is based on, a protocol selected from the group consisting of SMTP (Simple Mail Transfer Protocol), SIP (Session Initiation Protocol), SIMPLE (SIP for Instant Messaging and Presence Leveraging Extensions), APEX (Application Exchange), Prim (Presence and Instance Messaging Protocol), XMPP (Extensible Messaging and Presence Protocol), IMPS (Instant Messaging and Presence Service), RTMP (Real Time Messaging Protocol), STM (Simple TCP/IP Messaging) protocol, Azureus Extended Messaging Protocol, Apple Push Notification Service (APNs), and Hypertext Transfer Protocol (HTTP).

467. The system according to claim 465, wherein the notification message is a text-based message and the IM service is a text messaging service.

468. The system according to claim 465, wherein the notification message is according to, or based on, message selected from the group consisting of a Short Message Service (SMS) message and the IM service is a SMS service, an electronic-mail (e-mail)

message and the IM service is an e-mail service, a WhatsApp message and the IM service is a WhatsApp service, a Twitter message and the IM service is a Twitter service, and a Viber message and the IM service is a Viber service.

469. The system according to claim 465, wherein the notification message is a
5 Multimedia Messaging Service (MMS) or an Enhanced Messaging Service (EMS) message that includes audio or video, and the IM service is respectively a NMS or EMS service.

470. The system according to claim 459, wherein the device is a hand-held or a portable device.

10 471. The system according to claim 459, wherein the device is a wireless device, a notebook computer, a laptop computer, a media player, a Digital Still Camera (DSC), a Digital video Camera (DVC or digital camcorder), a Personal Digital Assistant (PDA), a cellular telephone, a digital camera, a video recorder, or a smartphone.

472. The system according to claim 471, wherein the device consists of, comprises, is
15 part of, or is integrated with, a smartphone that comprises, or is based on, an Apple iPhone 6 or a Samsung Galaxy S6.

473. The system according to claim 472, wherein the device operates a mobile operating system that provides the notification mechanism.

474. The system according to claim 473, wherein the mobile operating system consists
20 of, comprises, is part of, or is integrated with, Apple iOS or Google Android operating system.

475. The system according to claim 250, wherein the first vehicle comprises an Electronic Control Unit (ECU) that comprises, or connects to, the sensor, or wherein the second vehicle comprises an Electronic Control Unit (ECU) that comprises, or connects
25 to, the actuator.

476. The system according to claim 475, wherein the Electronic Control Unit (ECU) is selected from the group consisting of Electronic/engine Control Module (ECM), Engine Control Unit (ECU), Powertrain Control Module (PCM), Transmission Control Module (TCM), Brake Control Module (BCM or EBCM), Central Control Module (CCM),
30 Central Timing Module (CTM), General Electronic Module (GEM), Body Control Module (BCM), Suspension Control Module (SCM), Door Control Unit (DCU), Electric Power Steering Control Unit (PSCU), Seat Control Unit, Speed Control Unit (SCU), Telematic Control Unit (TCU), Transmission Control Unit (TCU), Brake Control

Module (BCM; ABS or ESC), Battery management system, control unit, and a control module.

477. The system according to claim 475, wherein the Electronic Control Unit (ECU) contains or executes software, an operating-system, or a middleware, that comprises, or
5 uses OSEK/VDX, International Organization for Standardization (ISO) 17356-1, ISO 17356-2, ISO 17356-3, ISO 17356-4, ISO 17356-5, or AUTOSAR standard.

478. The system according to claim 477, wherein the software comprises, uses, or is based on, an operating-system or a middleware, that comprises, or uses OSEK/VDX, International Organization for Standardization (ISO) 17356-1, ISO 17356-2, ISO 17356-
10 3, ISO 17356-4, ISO 17356-5, or AUTOSAR standard.

479. The system according to claim 250, wherein the first vehicle further comprises a vehicle bus coupled to carry the sensor data, or wherein the second vehicle further comprises a vehicle bus coupled to carry data for controlling, affecting, or activating, the actuator.

480. The system according to claim 479, wherein the vehicle bus uses a data link layer or a physical layer signaling that is according to, based on, uses, or is compatible with, ISO
15 11898-1:2015 or On-Board Diagnostics (OBD) standard.

481. The system according to claim 479, wherein the vehicle bus uses a medium access that is according to, is based on, uses, or is compatible with, ISO 11898-2:2003 or On-
20 Board Diagnostics (OBD) standard.

482. The system according to claim 479, wherein the vehicle bus uses, or is compatible with, a multi-master, serial protocol using acknowledgement, arbitration, and error-detection schemes.

483. The system according to claim 482, wherein the vehicle bus employs, uses, is based on, or is compatible with, a synchronous and frame-based protocol.
25

484. The system according to claim 479, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, a Controller Area Network (CAN).

485. The system according to claim 484, wherein the CAN is according to, based on, uses, or is compatible with, a standard selected from the group consisting of ISO 11898-
30 3:2006, ISO 11898-2:2004, ISO 11898-5:2007, ISO 11898-6:2013, ISO 11992-1:2003, ISO 11783-2:2012, SAE J1939/11_201209, SAE J1939/15_201508, On-Board Diagnostics (OBD), and SAE J2411_200002.

486. The system according to claim 484, wherein the CAN is according to, based on, uses, or is compatible with, Flexible Data-Rate (CAN FD) protocol.

487. The system according to claim 479, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, a Local Interconnect Network (LIN).

488. The system according to claim 487, wherein the LIN is according to, based on, uses, or is compatible with, a standard selected from a group consisting of ISO 9141-2:1994, ISO 9141:1989, ISO 17987-1, ISO 17987-2, ISO 17987-3, ISO 17987-4, ISO 17987-5, ISO 17987-6, and ISO 17987-7.

489. The system according to claim 479, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, FlexRay protocol.

490. The system according to claim 489, wherein the FlexRay protocol is according to, based on, uses, or is compatible with, a standard selected from a group consisting of ISO 17458-1:2013, ISO 17458-2:2013, ISO 17458-3:2013, ISO 17458-4:2013, or ISO 17458-5:2013.

491. The system according to claim 479, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, Media Oriented Systems Transport (MOST) protocol.

492. The system according to claim 491, wherein the MOST protocol is according to, based on, uses, or is compatible with, a standard selected from a group consisting of MOST25, MOST50, and MOST150.

493. The system according to claim 479, wherein the vehicle bus uses, or is compatible with, Automotive Ethernet.

494. The system according to claim 493, wherein the vehicle bus uses a single twisted pair.

495. The system according to claim 494, wherein the vehicle bus consists of, employs, uses, is based on, or is compatible with, IEEE802.3 100BaseT1, IEEE802.3 1000BaseT1, BroadR-Reach®, or IEEE 802.3bw-2015 standard.

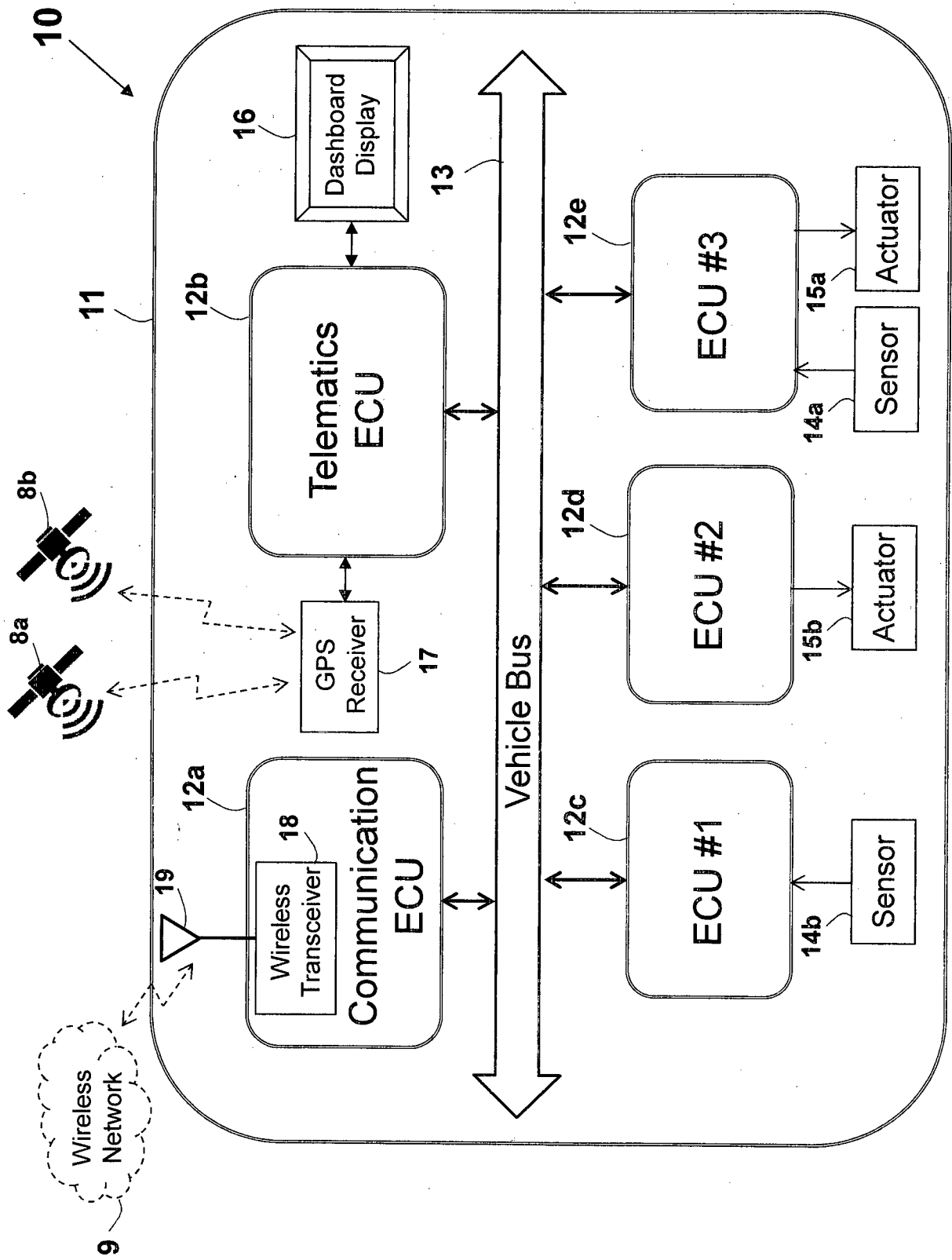


FIG. 1 (Prior Art)

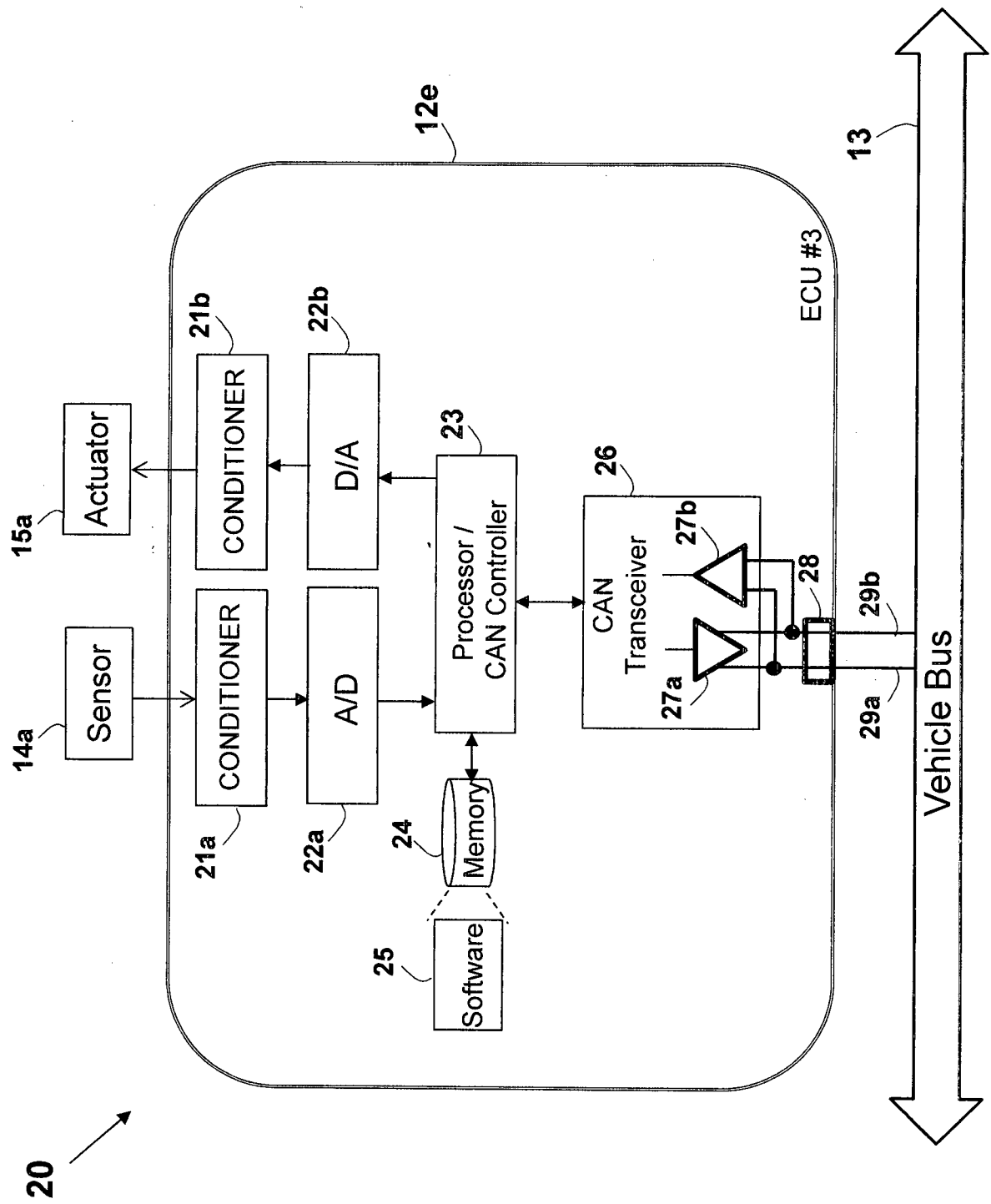


FIG. 2 (Prior Art)

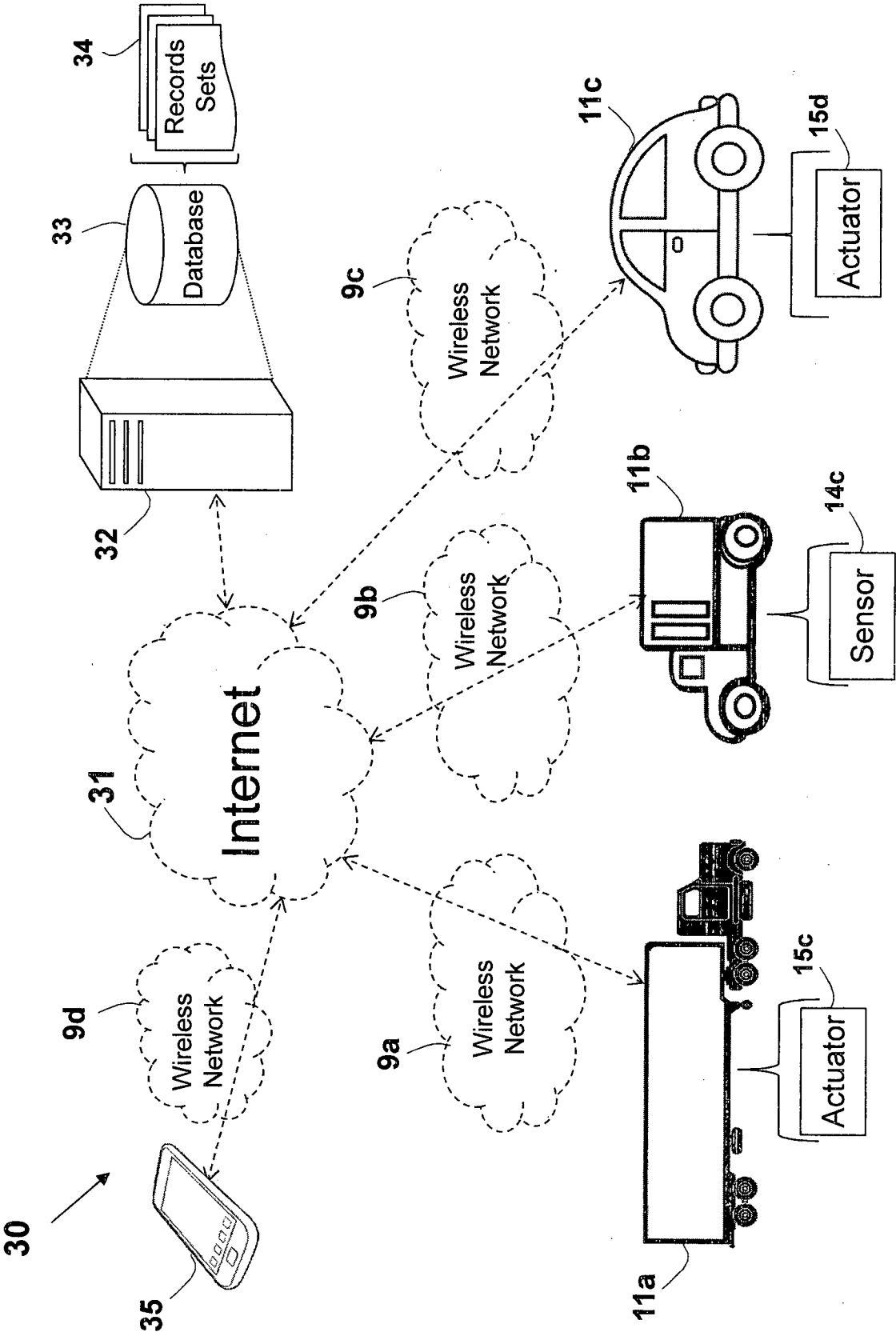


FIG. 3

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/Deceleration	Monitoring of Driving Environment	Fallback Performance of Dynamic Driving Task	System Capability (Driving Modes)
Human driver monitors the driving environment						
0	No Automation	the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the driving mode-specific execution by one or more driver assistance systems of both steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task	System	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the driving mode-specific performance by an automated driving system of all the aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene	System	System	Human driver	Some driving modes
4	High Automation	the driving mode-specific performance by an automated driving system of all the aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an automated driving system of all the aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver	System	System	System	All driving modes

FIG. 4

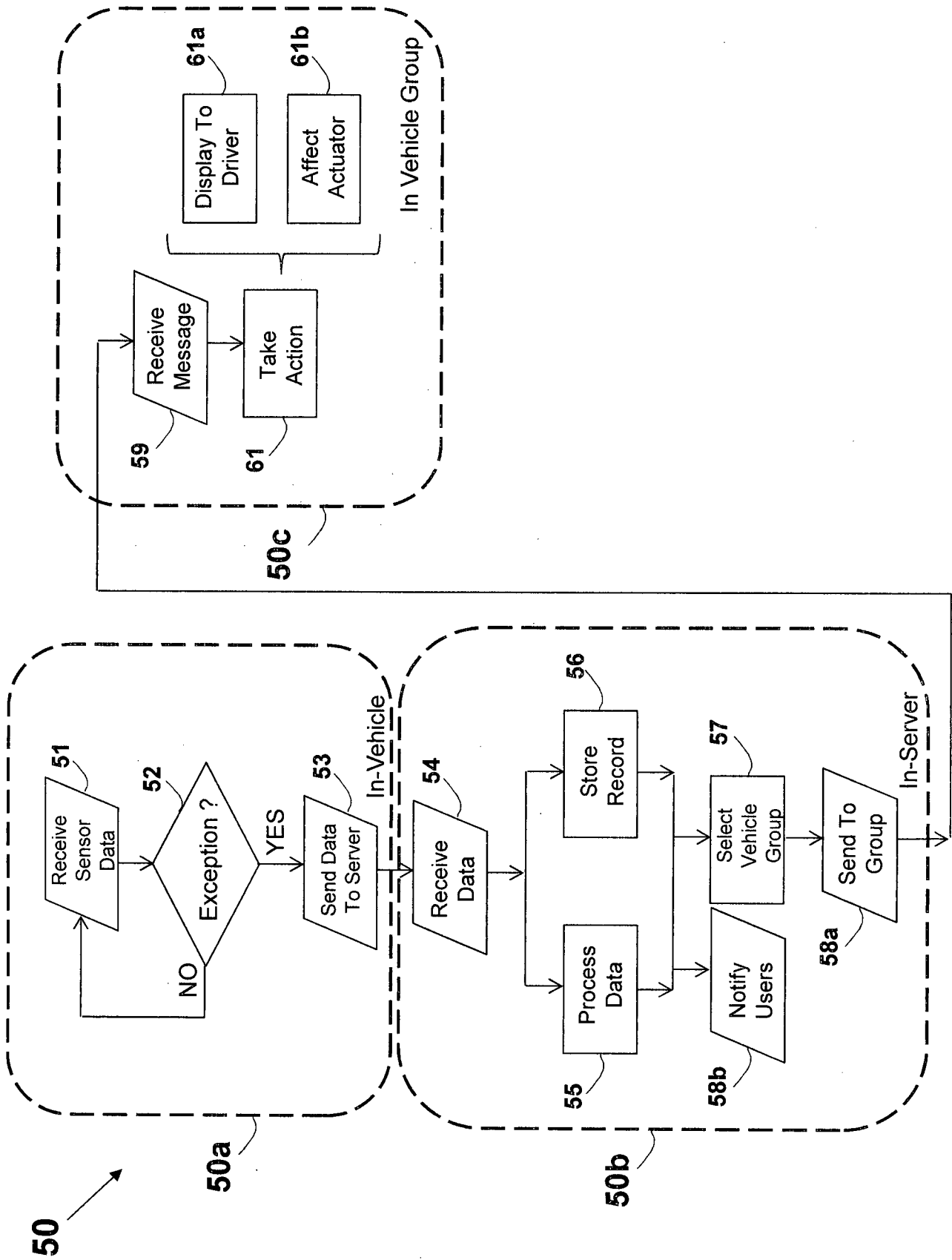


FIG. 5

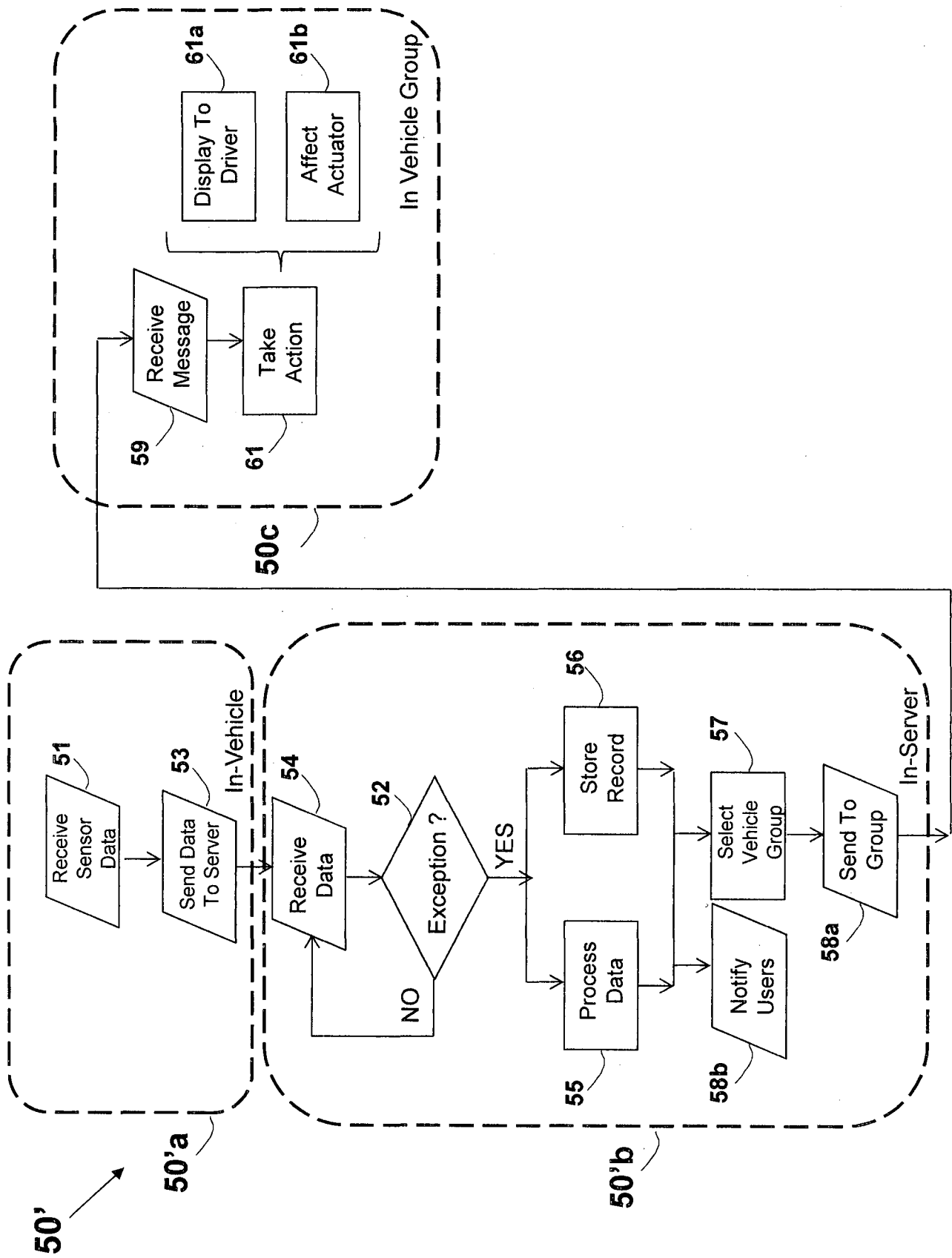


FIG. 5a

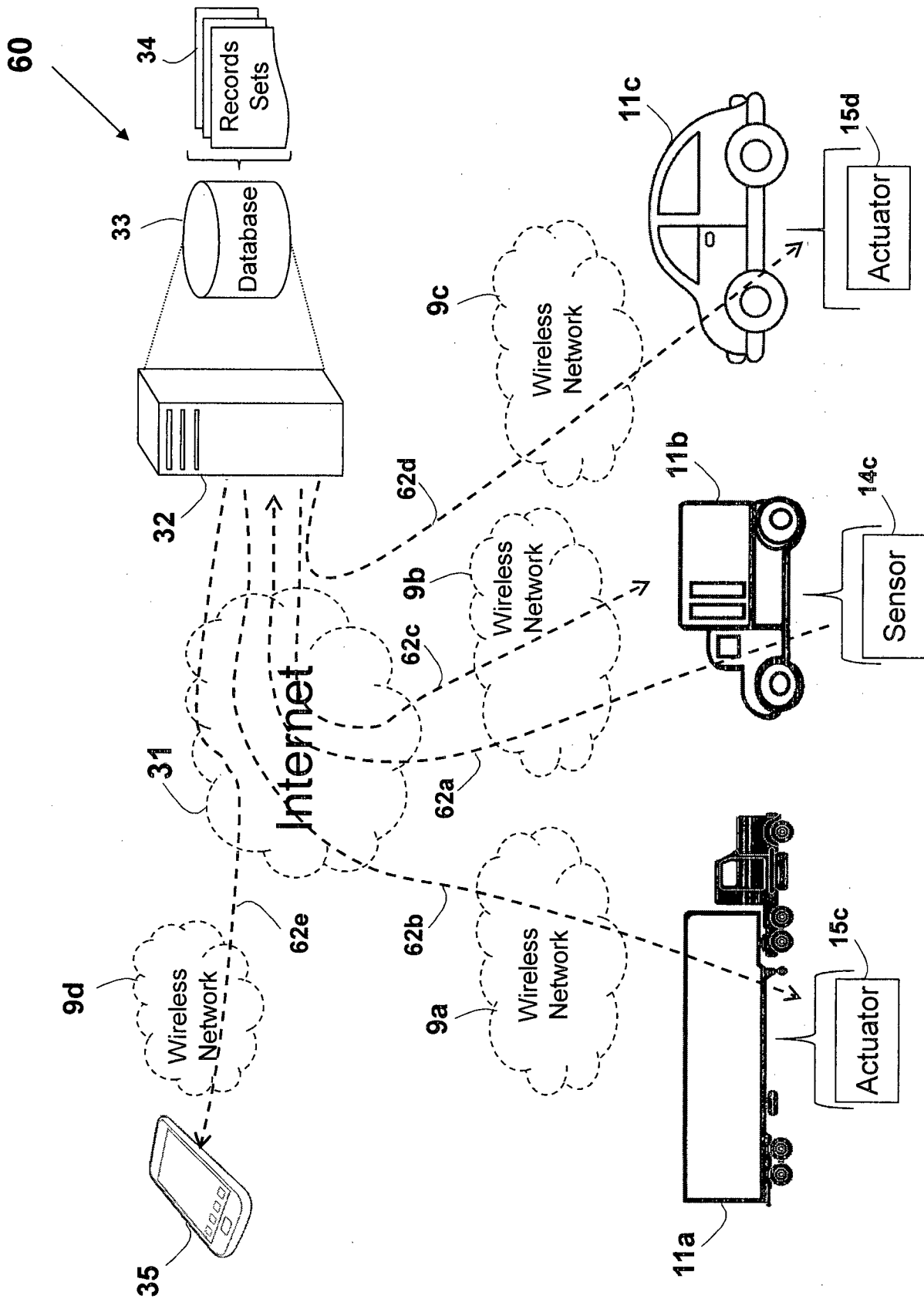


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2018/000804

A. CLASSIFICATION OF SUBJECT MATTER
INV. G08G1/16 G08G1/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G05D G08G G07C G01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2015 214575 A1 (BOSCH GMBH ROBERT [DE]) 2 February 2017 (2017-02-02) abstract; figure 1 paragraphs [0007] - [0011], [0019] - [0024] paragraphs [0033] - [0050] -----	1-495
X	US 9 632 507 B1 (KORN ALAN [US]) 25 April 2017 (2017-04-25) abstract; claims 1-11; figures 1,2b,3 column 3, line 34 - column 4, line 3 column 6, lines 11-58 column 7, line 19 - column 8, line 55 column 11, lines 12-40 ----- -/--	1-495



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

17 October 2018

Date of mailing of the international search report

24/10/2018

Name and mailing address of the ISA/

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Authorized officer

Buron, Emmanuel

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2018/000804

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2017/132929 A1 (MAYS WESLEY M [US] ET AL) 11 May 2017 (2017-05-11) abstract; claims 1,2,6,19; figures paragraph [0026] paragraph [0036] paragraph [0037] - paragraph [0039] paragraph [0055] - paragraph [0059] -----	1-495
X	US 2012/188097 A1 (BRILLHART DAVID C [US] ET AL) 26 July 2012 (2012-07-26) abstract; claims 1-5; figures paragraphs [0053] - [0062] -----	1-495
X	WO 2014/032682 A1 (VOLVO TRUCK CORP [SE]; HELLAKER JAN [US]; WOCKATZ PHILIP [SE]) 6 March 2014 (2014-03-06) abstract; claims 1,14; figures 1,2 page 2, line 14 - page 3, line 31 page 9, line 23 - page 11, line 27 page 13, lines 8-19 page 15, line 12 - page 16, line 6 -----	1-49, 250-495
A	US 2013/201316 A1 (BINDER YEHUDA [IL] ET AL) 8 August 2013 (2013-08-08) cited in the application abstract; claims -----	1-495

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Information on patent family members

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		EP 3371024 A1	12-09-2018
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		US 2017331899 A1	16-11-2017
		US 2018034912 A1	01-02-2018
		US 2018124181 A1	03-05-2018
		US 2018278693 A1	27-09-2018
		US 2018278694 A1	27-09-2018
