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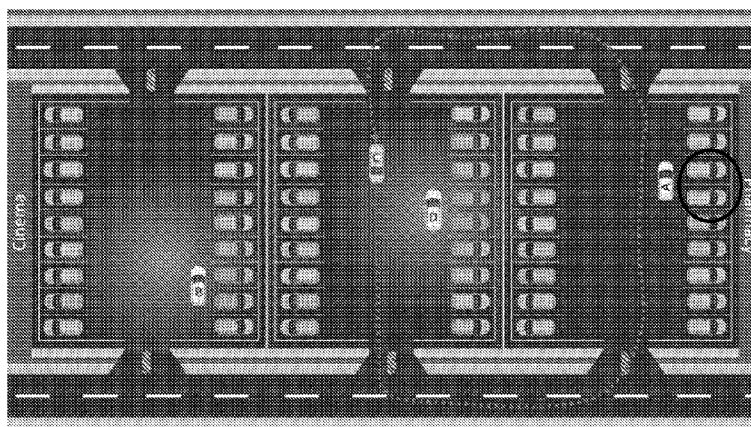
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(54) Title: APPARATUS, METHOD AND COMPUTER PROGRAM TO OPTIMIZE PARKING SPACE WAITING TIMES

Figure 7



(57) Abstract: There is provided an apparatus comprising means for receiving, from a plurality of sensors associated with a vehicle (A-D), information associated with the vehicle, determining, based on the information, occupancy status of at least one parking space in a location, determining, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location and providing the rate for display to a user.



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Apparatus, method and computer program to optimize parking space waiting times

5 *Field*

The present application relates to an apparatus, method, system and computer program and in particular, but not exclusively, to optimising parking space waiting times.

10 *Background*

A communication system can be seen as a facility that enables communication sessions between two or more entities such as user terminals, base stations and/or other nodes by providing carriers between the various entities involved in the communications path. A  
15 communication system can be provided for example by means of a communication network and one or more compatible communication devices. The communication sessions may comprise, for example, communication of data for carrying communications such as voice, video, electronic mail (email), text message, multimedia and/or content data and so on. Non-limiting examples of services provided comprise two-way or multi-way calls, data  
20 communication or multimedia services and access to a data network system, such as the Internet.

In a wireless communication system at least a part of a communication session between at least two stations occurs over a wireless link. Examples of wireless systems comprise public  
25 land mobile networks (PLMN), satellite based communication systems and different wireless local networks, for example wireless local area networks (WLAN). The wireless systems can typically be divided into cells, and are therefore often referred to as cellular systems.

A user can access the communication system by means of an appropriate communication  
30 device or terminal. A communication device of a user may be referred to as user equipment (UE) or user device. A communication device is provided with an appropriate signal receiving and transmitting apparatus for enabling communications, for example enabling access to a communication network or communications directly with other users. The communication device may access a carrier provided by a station, for example a base station of a cell, and  
35 transmit and/or receive communications on the carrier.

The communication system and associated devices typically operate in accordance with a given standard or specification which sets out what the various entities associated with the system are permitted to do and how that should be achieved. Communication protocols and/or parameters which shall be used for the connection are also typically defined. One example of a communications system is UTRAN (3G radio). Other examples of communication systems are the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology and so-called 5G or New Radio (NR) networks. NR is being standardized by the 3rd Generation Partnership Project (3GPP).

The Internet of Things (IoT) is a network of physical devices (such as mobile and/or status terminals), vehicles, home appliances and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these “things” to connect and exchange data. The Internet of Things is in development and may use communication systems as described above, or other communication systems such as Wi-Fi.

#### *Summary*

In a first aspect there is provided an apparatus comprising means for receiving, from a plurality of sensors associated with a vehicle, information associated with the vehicle, determining, based on the information, occupancy status of at least one parking space in a location, determining, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location and providing the rate for display to a user.

The apparatus may comprise means for determining at least one of the position of the vehicle and the parking status of the vehicle based on the information and determining the occupancy status of the at least one parking space based on at least one of the position of the vehicle and the parking status of the vehicle.

The apparatus may comprise means for determining the location and number of parking spaces in a location based on the location and parking status of at least one vehicle at the location.

The means for determining the rate of availability may comprise means for determining at least one of the number of unoccupied parking spaces in the location and the average length of occupancy of the at least one parking space in the location based on the occupancy status of the at least one parking space in the location.

The apparatus may comprise means for determining the rate of availability of parking spaces in the location for a given time.

5 The apparatus may comprise means for accessing a database comprising parking space information for the location, the parking space information to be used in determining the rate of availability of parking spaces in the location for a given time.

10 The apparatus may comprise means for determining, based on the information received from the plurality of sensors, a value for the predicted length of occupancy associated with the at least one parking space and providing said predicted value for display to a user.

15 The apparatus may comprise means for determining a trajectory for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space and providing said trajectory for display to a user.

The apparatus may comprise means for determining a waiting position for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space and providing said position for display to a user.

20 The location may comprise a parking lot or a road segment.

The plurality of sensors may comprise at least one of an image sensor, an audio sensor, a global positioning sensor, a network detection sensor, an accelerometer and a proximity sensor.

25 At least one of the plurality of sensors may be associated with the vehicle via a user of the vehicle.

30 The information may comprise at least one of vehicle location information, user location information, user behavioural information, temporal information and vehicle trajectory information.

35 In a second aspect there is provided an apparatus comprising at least one processor and at least one memory including a computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the apparatus at least to: receive, from a plurality of sensors associated with a vehicle, information associated with the vehicle, determine, based on the information, occupancy status of at least one parking space

in a location, determine, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location and provide the rate for display to a user.

The at least one memory and computer program code may be configured to, with the at least one processor, cause the apparatus at least to determine at least one of the position of the vehicle and the parking status of the vehicle based on the information and determine the occupancy status of the at least one parking space based on at least one of the position of the vehicle and the parking status of the vehicle.

The at least one memory and computer program code may be configured to, with the at least one processor, cause the apparatus at least to determine the location and number of parking spaces in a location based on the location and parking status of at least one vehicle at the location.

The at least one memory and computer program code may be configured to, with the at least one processor, cause the apparatus at least to determine at least one of the number of unoccupied parking spaces in the location and the average length of occupancy of the at least one parking space in the location based on the occupancy status of the at least one parking space in the location.

The at least one memory and computer program code may be configured to, with the at least one processor, cause the apparatus at least to determine the rate of availability of parking spaces in the location for a given time.

The at least one memory and computer program code may be configured to, with the at least one processor, cause the apparatus at least to access a database comprising parking space information for the location, the parking space information to be used in determining the rate of availability of parking spaces in the location for a given time.

The at least one memory and computer program code may be configured to, with the at least one processor, cause the apparatus at least to determine, based on the information received from the plurality of sensors, a value for the predicted length of occupancy associated with the at least one parking space and provide said predicted value for display to a user.

The at least one memory and computer program code configured to, with the at least one processor, cause the apparatus at least to determine a trajectory for a vehicle approaching

the location based on the value for the predicted length of occupancy associated with the at least one parking space and provide said trajectory for display to a user.

5 The at least one memory and computer program code may be configured to, with the at least one processor, cause the apparatus at least to determine a waiting position for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space and provide said position for display to a user.

The location may comprise a parking lot or a road segment.

10

The plurality of sensors may comprise at least one of an image sensor, an audio sensor, a global positioning sensor, a network detection sensor, an accelerometer and a proximity sensor.

15 At least one of the plurality of sensors may be associated with the vehicle via a user of the vehicle.

The information may comprise at least one of vehicle location information, user location information, user behavioural information, temporal information and vehicle trajectory information.

20

In a third aspect, there is provided a method comprising receiving, from a plurality of sensors associated with a vehicle, information associated with the vehicle, determining, based on the information, occupancy status of at least one parking space in a location, determining, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location and providing the rate for display to a user.

25

The method may comprise determining at least one of the position of the vehicle and the parking status of the vehicle based on the information and determining the occupancy status of the at least one parking space based on at least one of the position of the vehicle and the parking status of the vehicle.

30

The method may comprise determining the location and number of parking spaces in a location based on the location and parking status of at least one vehicle at the location.

35

Determining the rate of availability may comprise determining at least one of the number of unoccupied parking spaces in the location and the average length of occupancy of the at least

one parking space in the location based on the occupancy status of the at least one parking space in the location.

5 The method may comprise determining the rate of availability of parking spaces in the location for a given time.

10 The method may comprise accessing a database comprising parking space information for the location, the parking space information to be used in determining the rate of availability of parking spaces in the location for a given time.

The method may comprise determining, based on the information received from the plurality of sensors, a value for the predicted length of occupancy associated with the at least one parking space and providing said predicted value for display to a user.

15 The method may comprise determining a trajectory for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space and providing said trajectory for display to a user.

20 The method may comprise determining a waiting position for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space and providing said position for display to a user.

The location may comprise a parking lot or a road segment.

25 The plurality of sensors may comprise at least one of an image sensor, an audio sensor, a global positioning sensor, a network detection sensor, an accelerometer and a proximity sensor.

30 AT least one of the plurality of sensors may be associated with the vehicle via a user of the vehicle.

The information may comprise at least one of vehicle location information, user location information, user behavioural information, temporal information and vehicle trajectory information.

35 In a fourth aspect there is provided a computer readable medium comprising program instructions for causing an apparatus to perform at least the following receiving, from a plurality

of sensors associated with a vehicle, information associated with the vehicle, determining, based on the information, occupancy status of at least one parking space in a location, determining, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location and providing the rate for display to a user.

5

The apparatus may be caused to perform determining at least one of the position of the vehicle and the parking status of the vehicle based on the information and determining the occupancy status of the at least one parking space based on at least one of the position of the vehicle and the parking status of the vehicle.

10

The apparatus may be caused to perform determining the location and number of parking spaces in a location based on the location and parking status of at least one vehicle at the location.

15 Determining the rate of availability may comprise determining at least one of the number of unoccupied parking spaces in the location and the average length of occupancy of the at least one parking space in the location based on the occupancy status of the at least one parking space in the location.

20 The apparatus may be caused to perform determining the rate of availability of parking spaces in the location for a given time.

The apparatus may be caused to perform accessing a database comprising parking space information for the location, the parking space information to be used in determining the rate  
25 of availability of parking spaces in the location for a given time.

The apparatus may be caused to perform determining, based on the information received from the plurality of sensors, a value for the predicted length of occupancy associated with the at least one parking space and providing said predicted value for display to a user.

30

The apparatus may be caused to perform determining a trajectory for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space and providing said trajectory for display to a user.

35 The apparatus may be caused to perform determining a waiting position for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space and providing said position for display to a user.

The location may comprise a parking lot or a road segment.

The plurality of sensors may comprise at least one of an image sensor, an audio sensor, a  
5 global positioning sensor, a network detection sensor, an accelerometer and a proximity  
sensor.

At least one of the plurality of sensors may be associated with the vehicle via a user of the  
vehicle.

10 The information may comprise at least one of vehicle location information, user location  
information, user behavioural information, temporal information and vehicle trajectory  
information.

15 In a fifth aspect there is provided a non-transitory computer readable medium comprising  
program instructions for causing an apparatus to perform at least the following receiving, from  
a plurality of sensors associated with a vehicle, information associated with the vehicle,  
determining, based on the information, occupancy status of at least one parking space in a  
location, determining, based on the occupancy status of the at least one parking space, the  
20 rate of availability of parking spaces in the location and providing the rate for display to a user.

The apparatus may be caused to perform determining at least one of the position of the vehicle  
and the parking status of the vehicle based on the information and determining the occupancy  
status of the at least one parking space based on at least one of the position of the vehicle  
25 and the parking status of the vehicle.

The apparatus may be caused to perform determining the location and number of parking  
spaces in a location based on the location and parking status of at least one vehicle at the  
location.

30 Determining the rate of availability may comprise determining at least one of the number of  
unoccupied parking spaces in the location and the average length of occupancy of the at least  
one parking space in the location based on the occupancy status of the at least one parking  
space in the location.

35 The apparatus may be caused to perform determining the rate of availability of parking spaces  
in the location for a given time.

The apparatus may be caused to perform accessing a database comprising parking space information for the location, the parking space information to be used in determining the rate of availability of parking spaces in the location for a given time.

5

The apparatus may be caused to perform determining, based on the information received from the plurality of sensors, a value for the predicted length of occupancy associated with the at least one parking space and providing said predicted value for display to a user.

- 10 The apparatus may be caused to perform determining a trajectory for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space and providing said trajectory for display to a user.

- 15 The apparatus may be caused to perform determining a waiting position for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space and providing said position for display to a user.

The location may comprise a parking lot or a road segment.

- 20 The plurality of sensors may comprise at least one of an image sensor, an audio sensor, a global positioning sensor, a network detection sensor, an accelerometer and a proximity sensor.

- 25 At least one of the plurality of sensors may be associated with the vehicle via a user of the vehicle.

The information may comprise at least one of vehicle location information, user location information, user behavioural information, temporal information and vehicle trajectory information.

30

In the above, many different embodiments have been described. It should be appreciated that further embodiments may be provided by the combination of any two or more of the embodiments described above.

- 35 *Description of Figures*

Embodiments will now be described, by way of example only, with reference to the accompanying Figures in which:

5 Figure 1 shows a schematic diagram of an example communication system comprising a base station and a plurality of communication devices;

Figure 2 shows a schematic diagram of an example mobile communication device;

10 Figure 3 shows a schematic diagram of an example control apparatus;

Figure 4 shows a schematic diagram of a traffic flow in a location;

Figure 5 shows a schematic diagram of a traffic flow in a location;

15 Figure 6 shows a flowchart of an example method according to an embodiment;

Figure 7 shows a schematic diagram of an output which may be displayed to a user;

20 Figure 8 shows a schematic diagram of a traffic flow in a location;

Figure 9 shows a block diagram of a system according to an embodiment.

### *Detailed description*

25 Before explaining in detail the examples, certain general principles of a wireless communication system and mobile communication devices are briefly explained with reference to Figures 1 to 3 to assist in understanding the technology underlying the described examples.

30 In a wireless communication system 100, such as that shown in figure 1, mobile communication devices or user equipment (UE) 102, 104, 105 are provided wireless access via at least one base station or similar wireless transmitting and/or receiving node or point. Base stations are typically controlled by at least one appropriate controller apparatus, so as to enable operation thereof and management of mobile communication devices in  
35 communication with the base stations. The controller apparatus may be located in a radio access network (e.g. wireless communication system 100) or in a core network (CN) (not shown) and may be implemented as one central apparatus or its functionality may be

distributed over several apparatus. The controller apparatus may be part of the base station and/or provided by a separate entity such as a Radio Network Controller. In Figure 1 control apparatus 108 and 109 are shown to control the respective macro level base stations 106 and 107. The control apparatus of a base station can be interconnected with other control entities.

5 The control apparatus is typically provided with memory capacity and at least one data processor. The control apparatus and functions may be distributed between a plurality of control units. In some systems, the control apparatus may additionally or alternatively be provided in a radio network controller.

10 In Figure 1 base stations 106 and 107 are shown as connected to a wider communications network 113 via gateway 112. A further gateway function may be provided to connect to another network.

The smaller base stations 116, 118 and 120 may also be connected to the network 113, for  
15 example by a separate gateway function and/or via the controllers of the macro level stations. The base stations 116, 118 and 120 may be pico or femto level base stations or the like. In the example, stations 116 and 118 are connected via a gateway 111 whilst station 120 connects via the controller apparatus 108. In some embodiments, the smaller stations may not be provided. Smaller base stations 116, 118 and 120 may be part of a second network,  
20 for example WLAN and may be WLAN APs.

The communication devices 102, 104, 105 may access the communication system based on various access techniques, such as code division multiple access (CDMA), or wideband CDMA (WCDMA). Other non-limiting examples comprise time division multiple access  
25 (TDMA), frequency division multiple access (FDMA) and various schemes thereof such as the interleaved frequency division multiple access (IFDMA), single carrier frequency division multiple access (SC-FDMA) and orthogonal frequency division multiple access (OFDMA), space division multiple access (SDMA) and so on.

30 An example of wireless communication systems are architectures standardized by the 3rd Generation Partnership Project (3GPP). A latest 3GPP based development is often referred to as the long term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. The various development stages of the 3GPP specifications are referred to as releases. More recent developments of the LTE are often referred to as LTE  
35 Advanced (LTE-A). The LTE employs a mobile architecture known as the Evolved Universal Terrestrial Radio Access Network (E-UTRAN). Base stations of such systems are known as evolved or enhanced Node Bs (eNBs) and provide E-UTRAN features such as user plane

Packet Data Convergence/Radio Link Control/Medium Access Control/Physical layer protocol (PDCP/RLC/MAC/PHY) and control plane Radio Resource Control (RRC) protocol terminations towards the communication devices. Other examples of radio access system comprise those provided by base stations of systems that are based on technologies such as wireless local area network (WLAN) and/or WiMax (Worldwide Interoperability for Microwave Access). A base station can provide coverage for an entire cell or similar radio service area.

An example of a suitable communications system is the 5G or NR concept. Network architecture in NR may be similar to that of LTE-advanced. Base stations of NR systems may be known as next generation Node Bs (gNBs). Changes to the network architecture may depend on the need to support various radio technologies and finer QoS support, and some on-demand requirements for e.g. QoS levels to support QoE of user point of view. Also network aware services and applications, and service and application aware networks may bring changes to the architecture. Those are related to Information Centric Network (ICN) and User-Centric Content Delivery Network (UC-CDN) approaches. NR may use multiple input – multiple output (MIMO) antennas, many more base stations or nodes than the LTE (a so-called small cell concept), including macro sites operating in co-operation with smaller stations and perhaps also employing a variety of radio technologies for better coverage and enhanced data rates.

Future networks may utilise network functions virtualization (NFV) which is a network architecture concept that proposes virtualizing network node functions into “building blocks” or entities that may be operationally connected or linked together to provide services. A virtualized network function (VNF) may comprise one or more virtual machines running computer program codes using standard or general type servers instead of customized hardware. Cloud computing or data storage may also be utilized. In radio communications this may mean node operations to be carried out, at least partly, in a server, host or node operationally coupled to a remote radio head. It is also possible that node operations will be distributed among a plurality of servers, nodes or hosts. It should also be understood that the distribution of labour between core network operations and base station operations may differ from that of the LTE or even be non-existent.

A possible mobile communication device will now be described in more detail with reference to Figure 2 showing a schematic, partially sectioned view of a communication device 200. Such a communication device is often referred to as user equipment (UE) or terminal. An appropriate mobile communication device may be provided by any device capable of sending and receiving radio signals. Non-limiting examples comprise a mobile station (MS) or mobile

device such as a mobile phone or what is known as a 'smart phone', a computer provided with a wireless interface card or other wireless interface facility (e.g., USB dongle), personal data assistant (PDA) or a tablet provided with wireless communication capabilities, or any combinations of these or the like. A mobile communication device may provide, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and so on. Users may thus be offered and provided numerous services via their communication devices. Non-limiting examples of these services comprise two-way or multi-way calls, data communication or multimedia services or simply an access to a data communications network system, such as the Internet. Users may also be provided broadcast or multicast data. Non-limiting examples of the content comprise downloads, television and radio programs, videos, advertisements, various alerts and other information.

A mobile device is typically provided with at least one data processing entity 201, at least one memory 202 and other possible components 203 for use in software and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 204. The user may control the operation of the mobile device by means of a suitable user interface such as key pad 205, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 208, a speaker and a microphone can be also provided. Furthermore, a mobile communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto.

The mobile device 200 may receive signals over an air or radio interface 207 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 2 transceiver apparatus is designated schematically by block 206. The transceiver apparatus 206 may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the mobile device.

Figure 3 shows an example of a control apparatus for a communication system, for example to be coupled to and/or for controlling a station of an access system, such as a RAN node, e.g. a base station, eNB or gNB, a relay node or a node of a core network such as an MME or S-GW, or a server or host. The method may be implanted in a single control apparatus or across more than one control apparatus. The control apparatus may be integrated with or external to a node or module of a core network or RAN. In some embodiments, base stations

comprise a separate control apparatus unit or module. In other embodiments, the control apparatus can be another network element such as a radio network controller or a spectrum controller. In some embodiments, each base station may have such a control apparatus as well as a control apparatus being provided in a radio network controller. The control apparatus 300 can be arranged to provide control on communications in the service area of the system. The control apparatus 300 comprises at least one memory 301, at least one data processing unit 302, 303 and an input/output interface 304. Via the interface the control apparatus can be coupled to a receiver and a transmitter of the base station. The receiver and/or the transmitter may be implemented as a radio front end or a remote radio head.

Cities are becoming larger in area, with increasing numbers of inhabitants. The inhabitants are becoming more mobile. Electric cars, smart cars (moving toward autonomous driving) and car sharing provides provide more people with the option to complete journeys by car. The distance one may travel for an event may increase as well. Social networks, such as Facebook, make people more agile by making event organization and access much easier.

Autonomous driving is the concept of operating a vehicle that is capable of sensing its environment without human input. With developments in digital chip design, image processing techniques, localization techniques, artificial intelligence, and so on, the concept of autonomous driving is becoming realisable.

Research for autonomous driving may be focused on the super computer visualization capability of a vehicle, to achieve secure driving. One aspect of the visualisation is to make use of the developing Internet of Things (IoT) to broadcast information from the "environment" (e.g. roadside units).

Autonomous vehicles use a variety of sensing techniques to detect their surroundings, such as GPS, cameras, Radar, LIDAR and odometry. The sensing techniques are used to perform measurements of the surrounding environment.

High mobility and agility, and/or a possible increase in the number of vehicles, may put a stress on the available parking places in a city. At some point in time an area is almost empty, while a short while later a large number of people arrive with vehicles. Smart city planning may prepare for such fluctuations, but not all can be covered.

Although mass transportation is constantly improving, the demand for parking places will not disappear. Some parking issues can be solved via schemes such as park and ride, some cannot.

- 5 That is, situations from time to time will arise when someone will travel to a location and require vehicle parking at a crowded place.

For example, a vehicle may be at a specific part of the city but all the parking places are occupied.

10

If moving to another area is not an option, the vehicle is required to wait until a parking space becomes available. There are two scenarios; the vehicle can wait at a road segment (assuming there is a position to wait) or the vehicle can drive around the area (execute a trajectory) looking for an available parking space.

15

Figure 4 shows a first traffic situation. The area shown may be a parking lot, i.e. a dedicated area comprising a plurality of parking spaces away from a road. In this situation there is enough space for a vehicle to wait next to an occupied parking space. Vehicles B and D are waiting near potential slots (circled). As there are more users waiting they may catch only the nearest vacancies.

20

An alternative strategy is to circle, as illustrated by vehicle C. There is a risk that if all areas are watched by others vehicle C can circle forever. Vehicle A enters the parking lot and must determine an appropriate strategy. Vehicle A may either choose to stop at a position and wait or execute a trajectory around the parking lot.

25

Figure 5 shows an alternative situation where the parking spaces are situated on a road. In this situation, there is no space for a vehicle to wait and a vehicle must constantly move. Vehicle A has a number of options for the trajectory it can take.

30

It may be desirable to minimise the waiting time and/or the distance travelled when looking for an available parking space. One way to do so may be to execute a trajectory which is most likely to arrive at a parking space as the vehicle occupying that parking space is leaving.

35

However, if the vehicle is the only vehicle in an area, it may be a waste of time and/or fuel to drive until an unoccupied space is found. If the vehicle is not the only one looking for a slot, usually the closest car gets the empty slot. It is necessary to be positioned near the parking

space at the time it becomes available which may result on racing conditions. If the wrong trajectory is selected, the vehicle can theoretically circle forever.

In Figure 4 a pharmacy is positioned next to some parking spaces and a cinema next to others.

- 5 There may be larger fluctuations in availability in the parking spaces near the pharmacy as people will spend less time in a pharmacy than a cinema.

- If a vehicle could be provided with information indicating the next parking space to become available, the vehicle can move to that location and wait. Alternatively, the vehicle can execute  
10 a circular trajectory which visits many potential vacancies as possible.

- Methods for determining the parking difficulty of an area have been suggested, wherein the difficulty of a segment corresponds to the number of cars circling that area. Real time detection of parking space availability based on sensors associated with a particular parking location,  
15 e.g. detecting a symbol in an image of the parking space if the parking space is unoccupied, have been proposed. Providing a sensor associated with each parking space may be expensive, and or impractical to implement.

- To support various applications, an integrated system of the vehicular networking, known as  
20 vehicle-to-everything (V2X), has been proposed to enable vehicles to communicate with each other and beyond. V2X provides three types of communications, vehicle-to-vehicle (V2V), vehicle-to-pedestrian (V2P), and vehicle-to-infrastructure/network (V2I/N) referring to the communication between a vehicle and a roadside unit/network.

- 25 The precision of location positioning in urban areas is improving. GPS may be used as a tool to position a vehicle. The precision of GPS in urban areas may be affected, e.g. by tall buildings. However, GPS can be supplemented with other sources (e.g. V2V, V2X or Base Station signal strength) to increase the accuracy. Machine learning may be used to fine-tune positioning as well.

30

- The Internet of Things (IoT) is being introduced. As part of this development, more and more sensors are being introduced. The sensors provide data over the internet. It can be assumed that machine learning in the cloud can be used to predict/deduct things from our sensor signals with increasing accuracy. For example, there are increasing number of small cells. The  
35 introduction of 5G comes with additional small cells. Increasing number of cells in dense urban areas assist both in location position and user behaviour analysis.

Figure 6 shows a flowchart of a method which may be used to minimise waiting time for a parking space.

5 In a first step, S1, the method comprises receiving, from a plurality of sensors associated with a vehicle, information associated with the vehicle.

In a second step, S2, the method comprises determining, based on the information, occupancy status of at least one parking space in a location.

10 In a third step, S3, the method comprises determining, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location.

In a fourth step, S4, the method comprises providing the rate for display to a user.

15 The location may be a parking lot or a road segment.

Determining the occupancy status of a parking space may comprise determining the position and parking status (i.e. whether the vehicle is considered to be parked or not) of the vehicle based on the information. If the vehicle is determined to be parked at a position, then a parking  
20 space at that position may be considered to be occupied.

The location and number of (legal/valid) parking spaces in a location may be determined based on the location and parking status of vehicles at the location. Looking at patterns in historical data alongside data received from other IoT sources may be used to filter out illegal  
25 parking spots. An example IoT source may be a camera feed, which can reveal road signs or recognize parking enforcement officers in action. Assuming that only small percent of population park illegally, filtering out very rarely used spots may identify invalid or illegal parking spaces. Feedback from users may be used to detect illegal parking spots.

30 Alternatively, or in addition, the method may comprise accessing a database, said database comprising parking space information (e.g. the position of a parking space, the validity of a parking space at a given time, the number of parking spaces) for the location. Said information may be used to determine that a vehicle is parked in a valid parking space. The database may be located at the apparatus or in a server accessed by the internet.

35

The plurality of sensors may be at least one of an image sensor (e.g. camera) positioned inside or outside the vehicle, an optical light sensor, an infrared sensor, a radar sensor, an

audio sensor (e.g. microphone), a global positioning sensor, a network detection sensor (such as eNB, gNB or other network node or a node for detecting, e.g. Wifi broadcast message SSIDs), a network strength detector (for detecting e.g. WiFi signal strength), a user equipment such as a mobile terminal, temperature sensors, an accelerometer and a proximity sensor or any other suitable data sensor associated with the vehicle. The plurality of sensors may comprise Internet of Things (IoT) sensors. The sensors may be associated with the vehicle. Alternatively, or in addition, at least one of the sensors may be associated with a user of the vehicle (e.g. a mobile terminal of a user), i.e. they are associated with the vehicle via a user of the vehicle.

The information may comprise information sensed at any of the sensors described. The sensor information may comprise, or be used to determine, at least one of vehicle location information, user location information, user behavioural information (such as mobile terminal user movement, mobile terminal traffic, information received from mobile terminal application use etc.) temporal information and vehicle trajectory information (i.e. vehicle velocity).

Machine learning may be used to determine vehicle position and or parking status. For example, mobile phone signals may be used to supplement GPS signals to provide an accurate location for a vehicle in an urban environment. Image data provided from a camera, or audio signals from a microphone may be used to supplement location information. The speed and direction of a vehicle may be used to determine whether it is stationary.

Each type of combination of sensor information may have has different machine learning techniques. A scenario may rely on a general Discriminative model which is used in machine learning for modeling the dependence of unobserved variable (i.e. precise vehicle location) variables on a number of observed variables (e.g. GPS, on-camera image).

In one example, on-camera image yields are processed for a neural network, handling GPS yields for a Kalman Filter type estimator. In one example, a mobile phone may be localized indoors based on three sensor inputs, Wi-Fi signal strength, magnetic field and landmark detection (camera), with a Discriminative Model. Information from sensors may be combined one-by-one using machine learning techniques. Neural networks, especially convolutional networks may be a fast alternative for classification when assumptions cannot be made and very complex statistical patterns are to be learnt.

User behavioural information, such as location information received from, for example, a vehicle user's mobile terminal, may be used to determine whether or not a vehicle is empty (and so whether it is likely to have been parked and thus the vehicle's parking status).

- 5 By determining the location and parking status of a vehicle via the information received from a plurality of sensors, the occupancy of a parking space at a location may be determined. IoT sensors may be used to provide information to determine the location and parking status with the required degree of accuracy. The arrival time and departure time of a vehicle in a parking space (and thus the length of occupancy) may also be determined based on the occupancy  
10 determination.

That is, determining the rate of availability may comprise determining at least one of the number of unoccupied parking spaces in the location at a given time and the average length of occupancy of the at least one parking space in the location at a given time based on the  
15 occupancy status of the at least one parking space in a location. The rate of availability may be based on historical occupancy status information.

In this way, the average number of empty parking spaces and an average waiting time at a given time for vehicles arriving at a location at that time can be provided for display to a user.  
20

Determining the rate of availability of parking spaces at a given time may be referred to as a system operating in offline mode. In offline mode, a system operating using the method above may display statistics per location (e.g. per road segment) for an arbitrary time. Statistics may include the number of available parking spaces at a location and/or the average length of  
25 occupancy of a parking space in the location (e.g. the rate of turnover of parking spaces at a location). These statistics may be helpful for a user planning an optimised route and used to reduce waiting time and thus fuel consumption or emissions.

The method may further comprise determining, based on the information received from the  
30 plurality of sensors, the number of valid parking spaces available at a location in real time and/or a value for the predicted length of occupancy associated with the at least one parking space. The method may comprise providing said number and/or predicted value for display to a user.

35 This step may be described as a real-time mode. In real time, a system operating using the method above may be used to find the parking space which is soonest to become unoccupied. Real-time mode is basically an extension of offline mode in which user behavior statistics and

real-time data are used as well. 5G IoT connection of several sensors may be used to provide real-time data.

In real-time mode, real-time user behavior prediction based on user behavior information received from sensors, such as IoT sensors, may be combined with learned parking statistics (from offline mode) to estimate the the availability of parking slots per road segment, the estimated waiting times for new-comers per road segments and/or the estimated remaining time for each vehicle already parked.

Machine learning may be used to detect and predict user behavior patterns based on user behavior information. User behavior estimation based on learned user behavior information is becoming increasingly reliable.

A user associated with a vehicle may have a daily routine. For example, the user may have an online and offline fingerprint each day before they finish work. Such a routine may comprise the user checking a particular social network, then visiting the kitchen to remove items from a fridge in a 15-minute period before their departure. IoT sensors in the fridge and on a user terminal can detect these events. The system can use this information to determine that the estimated waiting time for the parking space occupied by the vehicle associated with this user is approximately 15 minutes.

The predicted value may be displayed as an overlay on a map of the parking spaces in a location. For example, the predicted waiting time for a specific parking space may be displayed using colours, or a direct indication of the predicted time.

The method may comprise determining a trajectory for an approaching vehicle based on the value for the predicted length of occupancy associated with the at least one parking space and providing said trajectory for display to a user.

The trajectory may comprise an optimal waiting position. The optimal waiting position may be calculated for the driver given the target position (e.g. the parking space with the shortest estimated waiting time). The optimal waiting position can be calculated with a baseline graph algorithm given the shortest distance between the target and the lowest waiting time nodes. Alternatively, the user may determine a coefficient based on the length they are willing to walk to the target.

If waiting is not possible in the location, an optimal circle trajectory can be calculated. The calculation of the optimal circle trajectory visiting all the lowest waiting time nodes is equivalent to the famous travelling salesman problem, and a baseline graph algorithm may be used.

- 5 The method described above relies on vehicle specific information to determine the occupancy status of a parking space, the rate of availability of a parking space in a location at a given time, the real time occupancy of a location comprising at least one parking space and the predicted waiting time for a parking space in a location. Using a plurality of sources of data associated with the vehicle to determine the occupancy status may increase the accuracy of  
10 the determined occupancy status, and so the reliability and accuracy of output provided to a user.

Figure 7 shows an overlay of traffic on an output which may be displayed to a user. The vehicles which have a long waiting time may be indicated in one colour, while the vehicles  
15 with a shorter waiting time may be indicated in a different colour. In the example shown in Figure 4, vehicle A can then choose to wait near vehicles that are indicated to have short waiting times (circled).

Figure 8 shows an alternative overlay of traffic on an output which may be displayed to a user.  
20 In this case, vehicles A, B, C and D are all using the system described above and a quest forms around the potential parking spaces, eliminating the racing condition.

Visualization may alternatively or additionally display the actual value for waiting time: e.g. 5 minutes and/or the standard deviation to approximate the confidence in the prediction.

25

The use of information received from a number of sources (e.g. IoT sensors as well as GPS sensors, network nodes etc.) means that location and parking status of a vehicle, as well as the predicted departure time, can be determined for parking spaces in a variety of locations. The locations may include road segments with or without specifically designated parking  
30 spaces or a dedicated location comprising a number of parking spaces, such as a parking lot or garage.

Nodes of existing communication networks such as LTE, 5G, V2X and IoT networks can be used to provide sensor information, avoiding the implantation of hardware specific to parking  
35 spaces.

The method may be implemented in self-driving cars. A self-driving car may use the provided results to efficiently locate empty slots.

The method may be integrated to parking lots to augment a binary occupied/unoccupied indication (detected for example by sensors associated with a particular parking slot with a waiting time estimation) For example, in a shopping mall it is straightforward to track a user. User behaviour, based on the shops or restaurants visited, can be used in predict when the user leaves.

For example, in the situations shown in Figures 4, 5, 7 and 8, whether the user visits a pharmacy (for example if he submits a prescription request online) or buys a cinema ticket may be determined to provide information to the system to use in determining predicted waiting time for a parking space.

Figure 9 shows a block diagram of a system according to some embodiments. The system comprises three helper modules which receive data from a plurality of data sources. Two of the modules determine the location and the parking status for a vehicle, respectively, and thus the occupancy status of a parking space. A third module learns user behaviour and determines a predicted departure for a parking space. These modules then provide the output for display to a user. The output may comprise an indication of the number of unoccupied parking spaces in a location at a given time, average waiting for a parking space in a location at a given time, the predicted number of parking spaces, the predicted waiting time, a waiting position or a trajectory.

It should be understood that each block of the flowchart of Figure 6 and any combination thereof may be implemented by various means or their combinations, such as hardware, software, firmware, one or more processors and/or circuitry.

The method may be implemented on a control apparatus as shown in Figure 3.

Control functions may comprise receiving, from a plurality of sensors associated with a vehicle, information associated with the vehicle, determining, based on the information, occupancy status of at least one parking space in a location, determining, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location and providing the rate for display to a user.

An apparatus may comprise means for receiving, from a plurality of sensors associated with a vehicle, information associated with the vehicle, determining, based on the information, occupancy status of at least one parking space in a location, determining, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location and providing the rate for display to a user.

It should be understood that the apparatuses may comprise or be coupled to other units or modules etc., such as radio parts or radio heads, used in or for transmission and/or reception. Although the apparatuses have been described as one entity, different modules and memory may be implemented in one or more physical or logical entities.

It is noted that whilst embodiments have been described in relation to IoT and 5G communication networks, similar principles can be applied in relation to other networks and communication systems where environmental information is collected by sensors. Therefore, although certain embodiments were described above by way of example with reference to certain example architectures for wireless networks, technologies and standards, embodiments may be applied to any other suitable forms of communication systems than those illustrated and described herein.

It is also noted herein that while the above describes example embodiments, there are several variations and modifications which may be made to the disclosed solution without departing from the scope of the present invention.

In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects of the invention may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

The embodiments of this invention may be implemented by computer software executable by a data processor of the mobile device, such as in the processor entity, or by hardware, or by a combination of software and hardware. Computer software or program, also called program

product, including software routines, applets and/or macros, may be stored in any apparatus-readable data storage medium and they comprise program instructions to perform particular tasks. A computer program product may comprise one or more computer-executable components which, when the program is run, are configured to carry out embodiments. The one or more computer-executable components may be at least one software code or portions of it.

Further in this regard it should be noted that any blocks of the logic flow as in the Figures may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions. The software may be stored on such physical media as memory chips, or memory blocks implemented within the processor, magnetic media such as hard disk or floppy disks, and optical media such as for example DVD and the data variants thereof, CD. The physical media is a non-transitory media.

The memory may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory. The data processors may be of any type suitable to the local technical environment, and may comprise one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASIC), FPGA, gate level circuits and processors based on multi core processor architecture, as non-limiting examples.

Embodiments of the inventions may be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

The foregoing description has provided by way of non-limiting examples a full and informative description of the exemplary embodiment of this invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention as defined in the appended claims. Indeed there is a further embodiment comprising a combination of one or more embodiments with any of the other embodiments previously discussed.

*Claims*

1. An apparatus comprising means for:  
receiving, from a plurality of sensors associated with a vehicle, information  
5 associated with the vehicle;  
determining, based on the information, occupancy status of at least one parking  
space in a location;  
determining, based on the occupancy status of the at least one parking space, the  
rate of availability of parking spaces in the location; and  
10 providing the rate for display to a user.
2. An apparatus according to claim 1, comprising means for determining at least one  
of the position of the vehicle and the parking status of the vehicle based on the  
information; and  
15 determining the occupancy status of the at least one parking space based on at  
least one of the position of the vehicle and the parking status of the vehicle.
3. An apparatus according to claim 2, comprising means for: determining the location  
and number of parking spaces in a location based on the location and parking  
20 status of at least one vehicle at the location.
4. An apparatus according to any of claims 1 to 3, wherein the means for determining  
the rate of availability comprises means for determining at least one of the number  
of unoccupied parking spaces in the location and the average length of occupancy  
25 of the at least one parking space in the location based on the occupancy status of  
the at least one parking space in the location.
5. An apparatus according to any of claims 1 to 4 comprising means for determining  
the rate of availability of parking spaces in the location for a given time.  
30
6. An apparatus according to any of claims 1 to 5, comprising means for accessing a  
database comprising parking space information for the location, the parking space  
information to be used in determining the rate of availability of parking spaces in  
the location for a given time.  
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7. An apparatus according to any of claims 1 to 6 comprising means for:

determining, based on the information received from the plurality of sensors, a value for the predicted length of occupancy associated with the at least one parking space; and

providing said predicted value for display to a user.

5

8. An apparatus according to claim 7, comprising means for:  
determining a trajectory for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space; and

10

providing said trajectory for display to a user.

9. An apparatus according to claim 7 or claim 8, comprising means for:  
determining a waiting position for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking space; and

15

providing said position for display to a user.

10. An apparatus according to any of claims 1 to 9 wherein the location comprises a parking lot or a road segment.

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11. An apparatus according to any of claims 1 to 10, wherein the plurality of sensors comprise at least one of an image sensor, an audio sensor, a global positioning sensor, a network detection sensor, an accelerometer and a proximity sensor.

25

12. An apparatus according to any of claims 1 to 11, wherein at least one of the plurality of sensors is associated with the vehicle via a user of the vehicle.

13. An apparatus according to any of claims 1 to 12, wherein the information comprises at least one of vehicle location information, user location information, user behavioural information, temporal information and vehicle trajectory information.

30

14. An apparatus comprising:  
at least one processor and at least one memory including a computer program code, the at least one memory and computer program code configured to, with the at least one processor, cause the apparatus at least to:

35

receive, from a plurality of sensors associated with a vehicle, information associated with the vehicle;

determine, based on the information, occupancy status of at least one parking space in a location;

5       determine, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location; and  
provide the rate for display to a user.

10       15.   An apparatus according to claim 14, the at least one memory and computer program code configured to, with the at least one processor, cause the apparatus at least to:

determine at least one of the position of the vehicle and the parking status of the vehicle based on the information; and

15       determine the occupancy status of the at least one parking space based on at least one of the position of the vehicle and the parking status of the vehicle.

16.   An apparatus according to claim 15, the at least one memory and computer program code configured to, with the at least one processor, cause the apparatus at least to:

20       determine the location and number of parking spaces in a location based on the location and parking status of at least one vehicle at the location.

17.   An apparatus according to any of claims 14 to 16 the at least one memory and computer program code configured to, with the at least one processor, cause the apparatus at least to:

25       determine at least one of the number of unoccupied parking spaces in the location and the average length of occupancy of the at least one parking space in the location based on the occupancy status of the at least one parking space in the location.

30       18.   An apparatus according to any of claims 14 to 17 the at least one memory and computer program code configured to, with the at least one processor, cause the apparatus at least to:

35       determine the rate of availability of parking spaces in the location for a given time.

19. An apparatus according to any of claims 14 to 18, the at least one memory and computer program code configured to, with the at least one processor, cause the apparatus at least to:  
access a database comprising parking space information for the location, the  
5 parking space information to be used in determining the rate of availability of parking spaces in the location for a given time.
20. An apparatus according to any of claims 14 to 19 the at least one memory and computer program code configured to, with the at least one processor, cause the  
10 apparatus at least to:  
determine, based on the information received from the plurality of sensors, a value for the predicted length of occupancy associated with the at least one parking space; and  
provide said predicted value for display to a user.
21. An apparatus according to claim 20, the at least one memory and computer program code configured to, with the at least one processor, cause the apparatus  
15 at least to:  
determine a trajectory for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking  
20 space; and  
provide said trajectory for display to a user.
22. An apparatus according to claim 20 or claim 21, the at least one memory and computer program code configured to, with the at least one processor, cause the  
25 apparatus at least to:  
determine a waiting position for a vehicle approaching the location based on the value for the predicted length of occupancy associated with the at least one parking  
space; and  
30 provide said position for display to a user.
23. An apparatus according to any of claims 14 to 22 wherein the location comprises a parking lot or a road segment.
- 35 24. An apparatus according to any of claims 14 to 23, wherein the plurality of sensors comprise at least one of an image sensor, an audio sensor, a global positioning sensor, a network detection sensor, an accelerometer and a proximity sensor.

25. An apparatus according to any of claims 14 to 24, wherein at least one of the plurality of sensors is associated with the vehicle via a user of the vehicle.

5 26. An apparatus according to any of claims 14 to 25, wherein the information comprises at least one of vehicle location information, user location information, user behavioural information, temporal information and vehicle trajectory information.

10 27. A method comprising:  
receiving, from a plurality of sensors associated with a vehicle, information associated with the vehicle;  
determining, based on the information, occupancy status of at least one parking space in a location;  
15 determining, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location; and  
providing the rate for display to a user.

20 28. A computer readable medium comprising program instructions for causing an apparatus to perform at least the following:  
receiving, from a plurality of sensors associated with a vehicle, information associated with the vehicle;  
determining, based on the information, occupancy status of at least one parking space in a location;  
25 determining, based on the occupancy status of the at least one parking space, the rate of availability of parking spaces in the location; and  
providing the rate for display to a user.

30

35

Figure 1

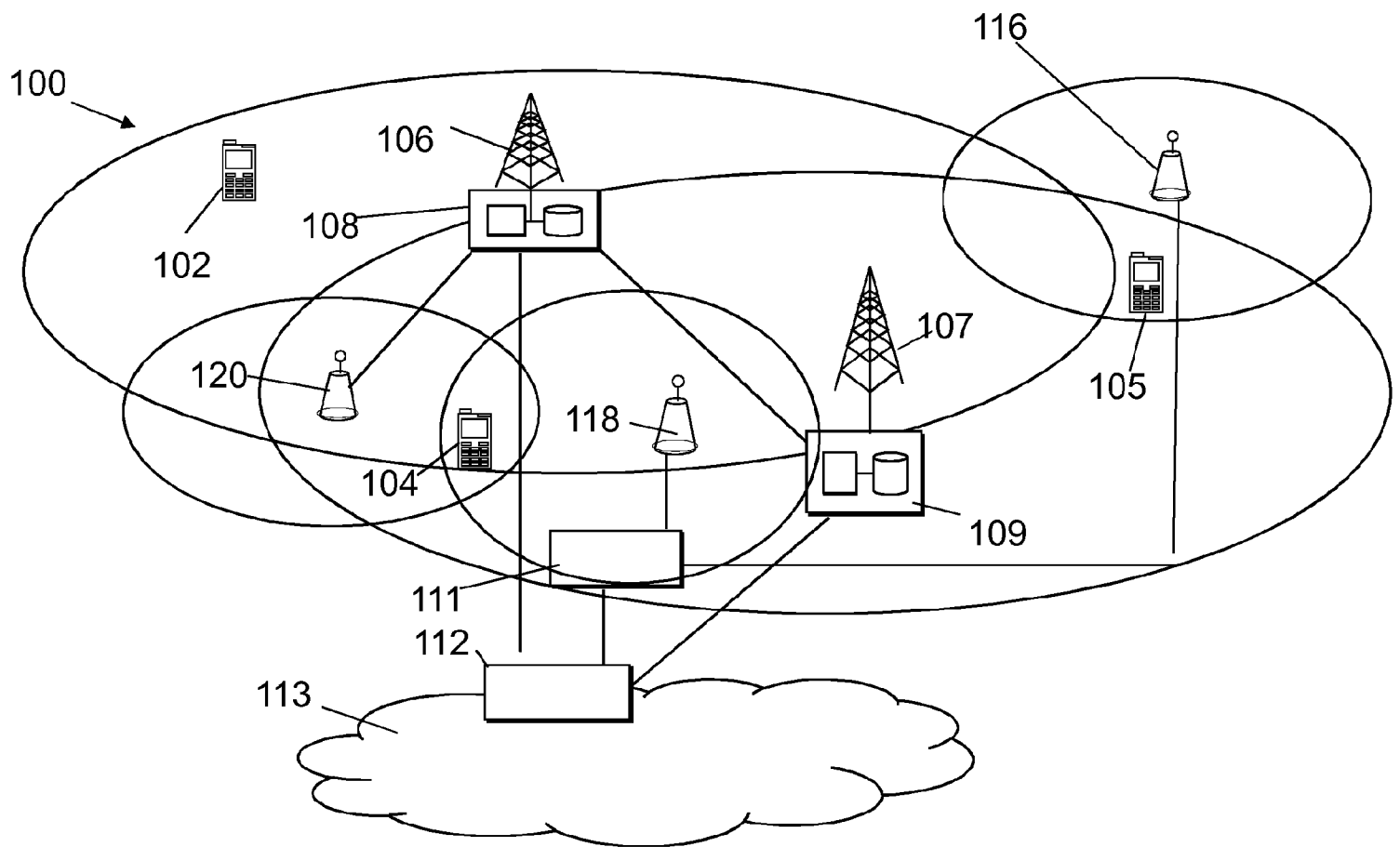


Figure 2

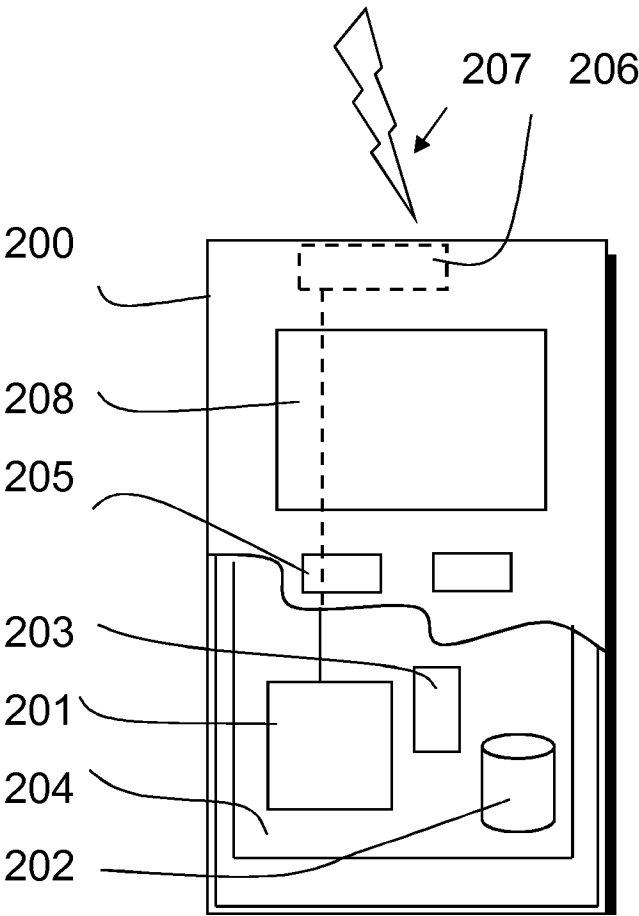


Figure 3

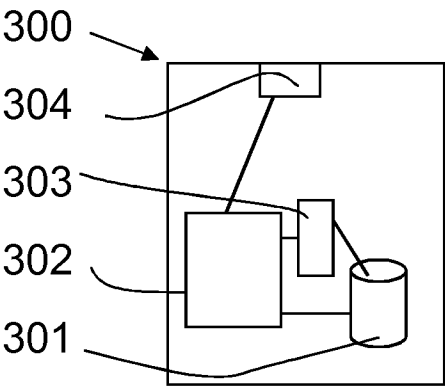


Figure 4

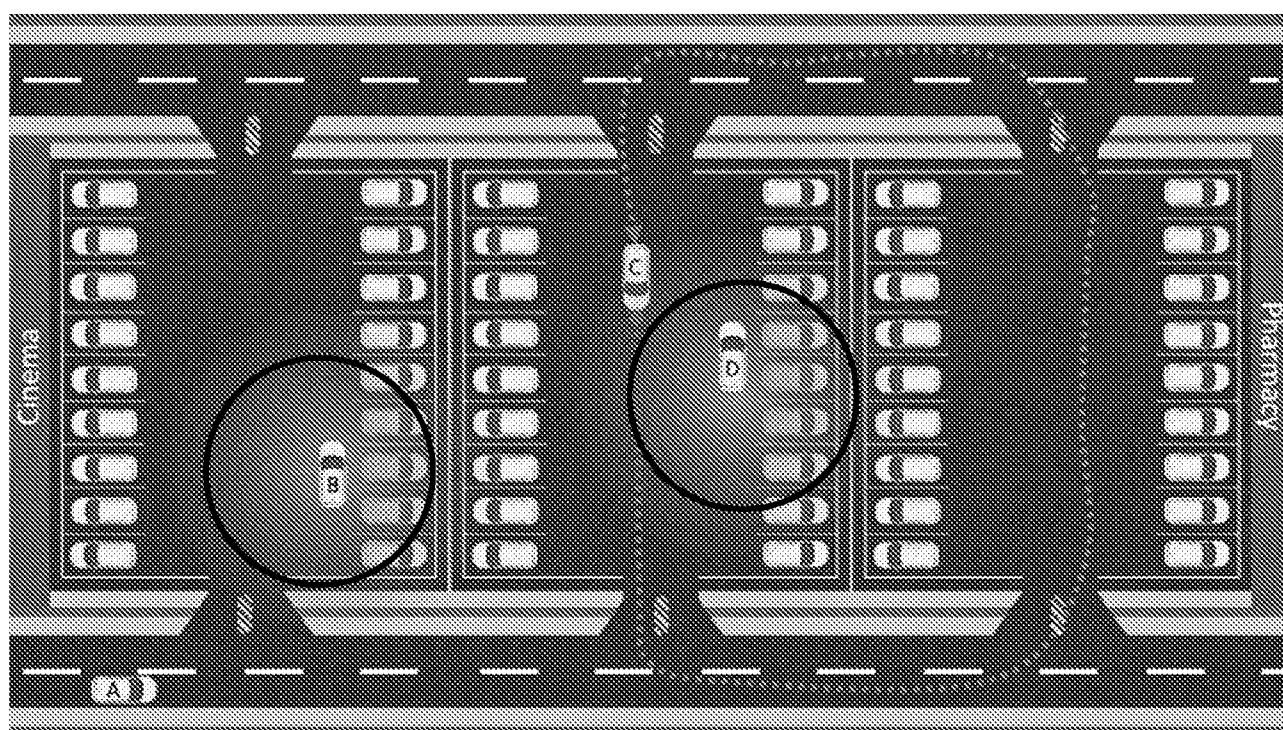


Figure 5

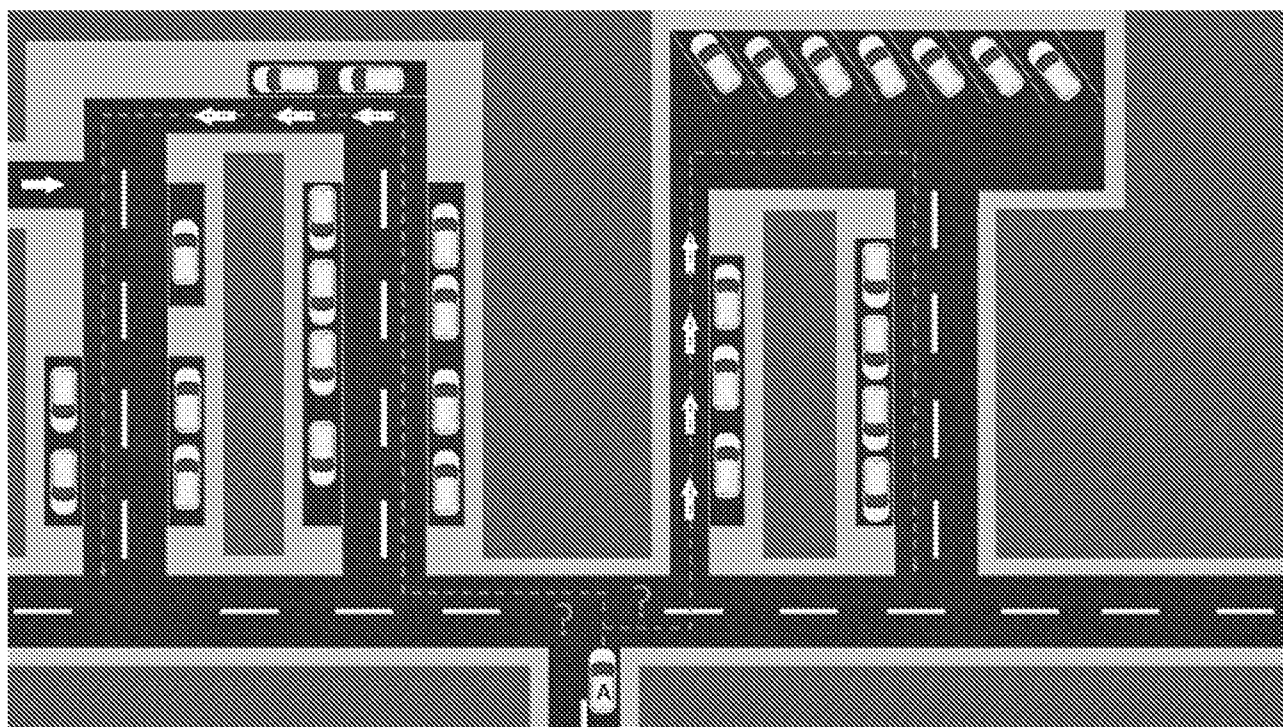


Figure 6

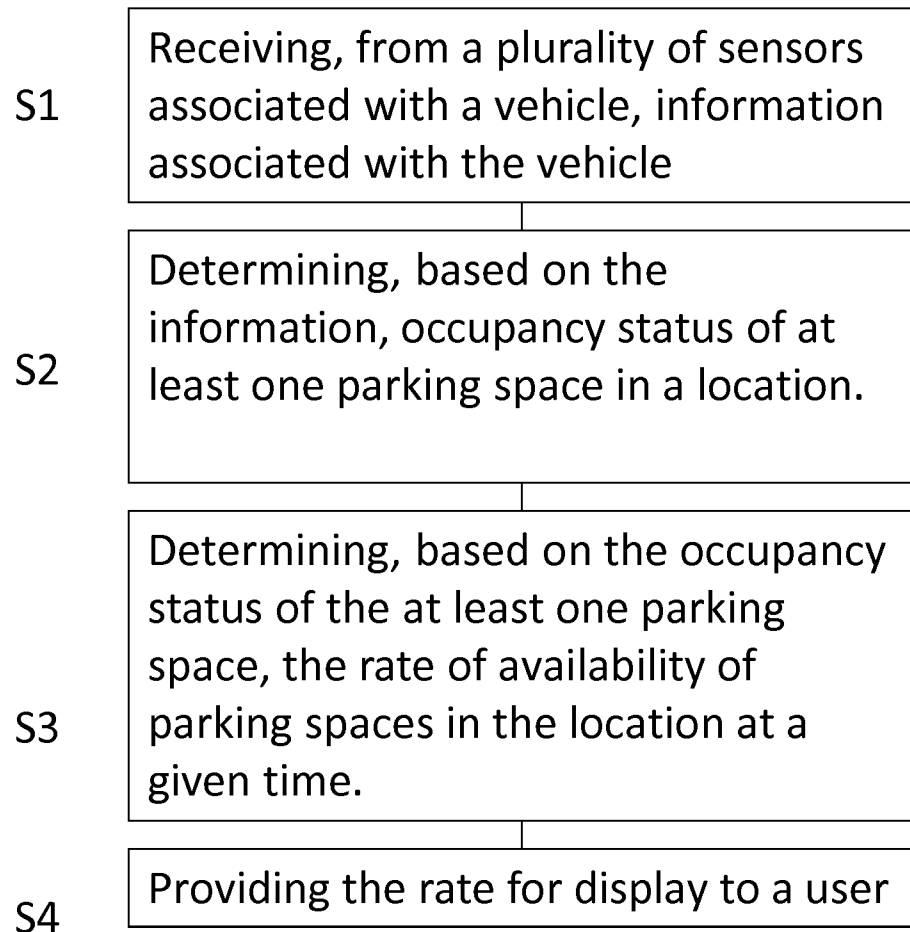


Figure 7

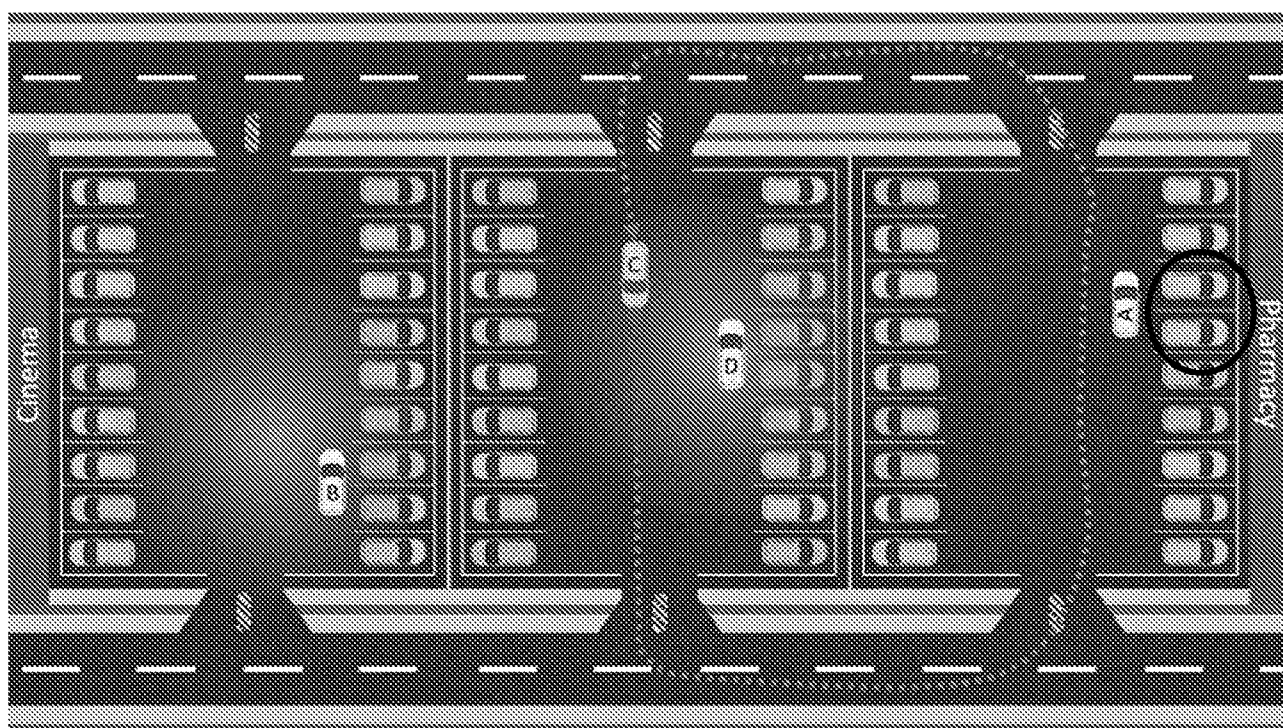


Figure 8

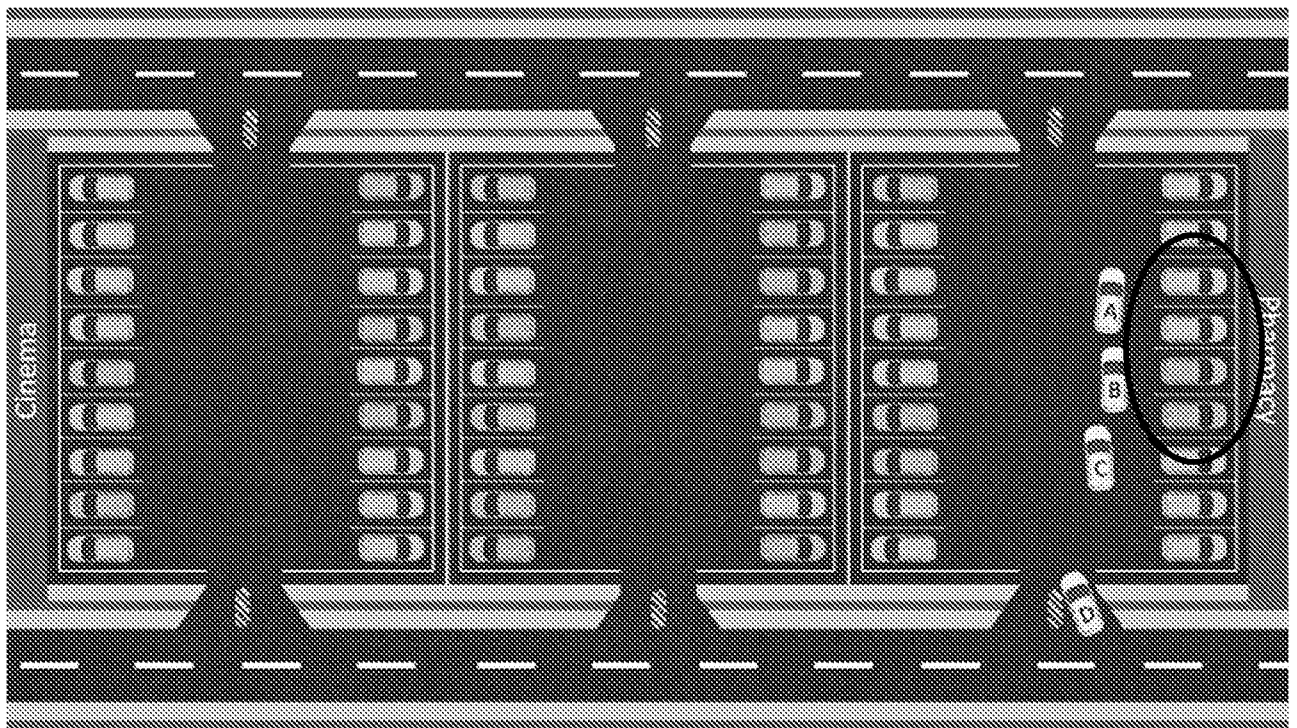
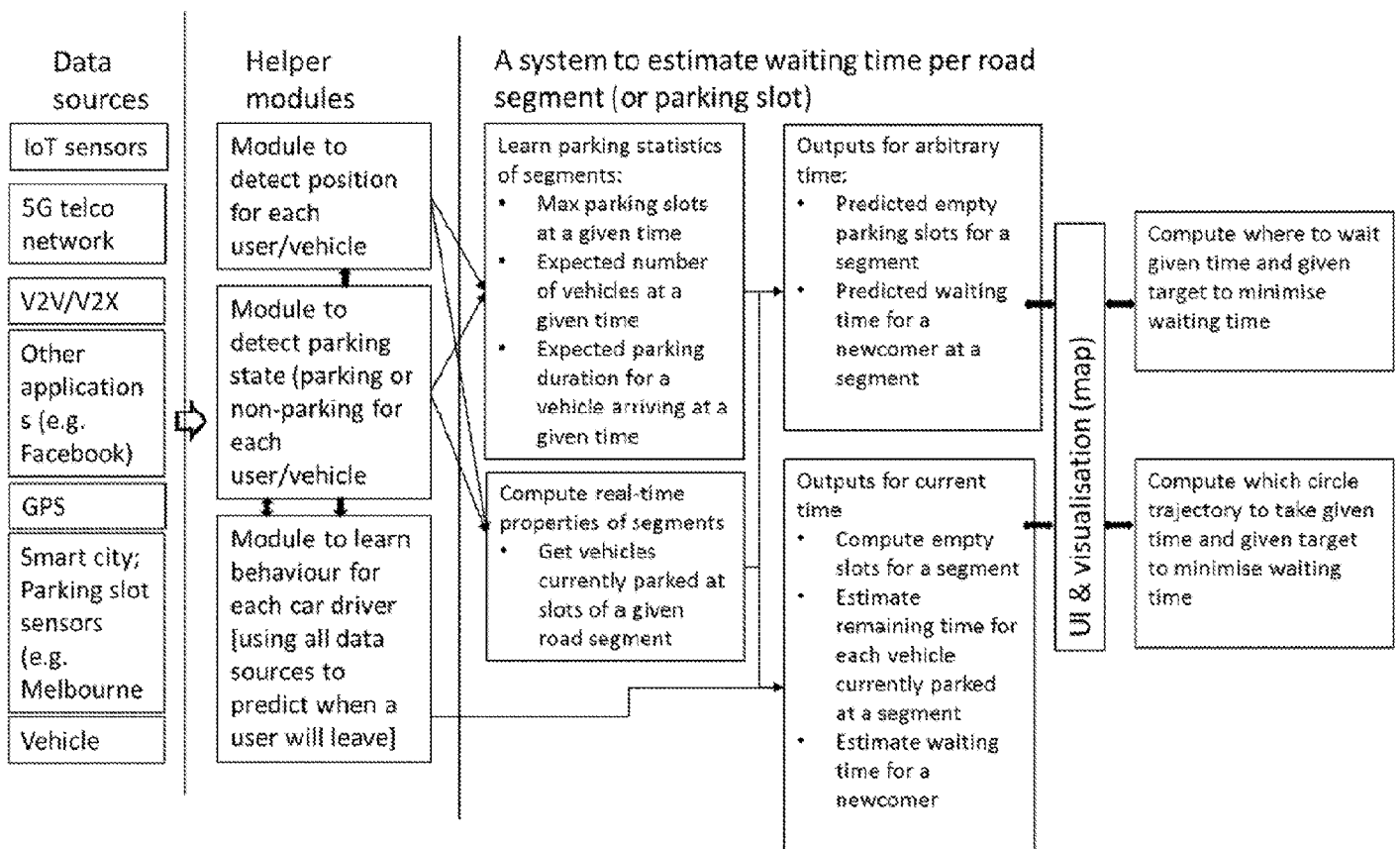


Figure 9



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2018/050491

**A. CLASSIFICATION OF SUBJECT MATTER**

See extra sheet

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)

IPC: G08G, G01C, G07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base, and, where practicable, search terms used)

EPODOC, EPO-Internal full-text databases, Full-text translation databases from Asian languages, WPIAP, PRH-Internal, XP3GPP, XPAIP, XPESP, XPETSI, XPI3E, XPIEE, XPIETF, XPIOP, XPIPCOM, XPJPEG, XPMISC, XPOAC, XPRD, COMPD, INSPEC, TDB, NPL

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                                       | Relevant to claim No.            |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| X         | US 2017148324 A1 (HIGH DONALD [US] et al.)<br>25 May 2017 (25.05.2017)<br>abstract; par. [0016], [0034]-[0035], [0038]-[0044], [0054]-[0059]; fig. 2                                                                                     | 1-2, 4-8, 10-15,<br>17-21, 23-28 |
| X         | US 2017178511 A1 (BERNS LANDON [US] et al.)<br>22 June 2017 (22.06.2017)<br>par. [0013], [0015], [0022], [0026]-[0040], [0043]-[0048], [0068], [0105]-[0106], [0117], [0120]; fig. 4                                                     | 1-2, 4-8, 10-15,<br>17-21, 23-28 |
| X         | US 2014156183 A1 (WINDELER JOSHUA G [US] et al.)<br>05 June 2014 (05.06.2014)<br>abstract; par. [0013]-[0016], [0021]-[0024], [0043]; figs. 1-4                                                                                          | 1-2, 4-6, 10-15,<br>17-19, 23-28 |
| X         | WO 2010081545 A1 (TOMTOM INT BV [NL]) 22 July 2010 (22.07.2010)<br>abstract; page 2, line 4-page 3, line 4; page 18, line 18-page 20, line 32;<br>page 26, lines 8-33; page 28, lines 11-25; page 37, line 35-page 38, line 2;<br>fig. 6 | 1-3, 5-6, 10-16,<br>18-19, 23-28 |

☒ Further documents are listed in the continuation of Box C.
☒ See patent family annex.

|                                                                                                                                                                         |                                                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| * Special categories of cited documents:                                                                                                                                | "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                                              |
| "A" document defining the general state of the art which is not considered to be of particular relevance                                                                | "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                                                                     |
| "E" earlier application or patent but published on or after the international filing date                                                                               | "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 |
| "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "&" document member of the same patent family                                                                                                                                                                                                    |
| "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                                                                  |                                                                                                                                                                                                                                                  |

|                                                                                                                                             |                                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Date of the actual completion of the international search<br>17 January 2019 (17.01.2019)                                                   | Date of mailing of the international search report<br>22 January 2019 (22.01.2019) |
| Name and mailing address of the ISA/FI<br>Finnish Patent and Registration Office<br>FI-00091 PRH, FINLAND<br>Facsimile No. +358 29 509 5328 | Authorized officer<br>Mikko Kyrö<br>Telephone No. +358 29 509 5000                 |

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2018/050491

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                             | Relevant to claim No. |
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**INTERNATIONAL SEARCH REPORT**  
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CLASSIFICATION OF SUBJECT MATTER

IPC

**G08G 1/14** (2006.01)

**G08G 1/0968** (2006.01)

**G08G 1/065** (2006.01)

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