(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 July 2020 (30.07.2020)

WIPO | PCT

(10) International Publication Number
WO 2020/153897 A1

(51) International Patent Classification:
*G01S 5/00* (2006.01) *G01S 1/02* (2010.01)
*A61B 34/20* (2016.01) *G01S 19/34* (2010.01)

(21) International Application Number:
PCT/SE2020/050058

(22) International Filing Date:
24 January 2020 (24.01.2020)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
1950093-3 25 January 2019 (25.01.2019) SE

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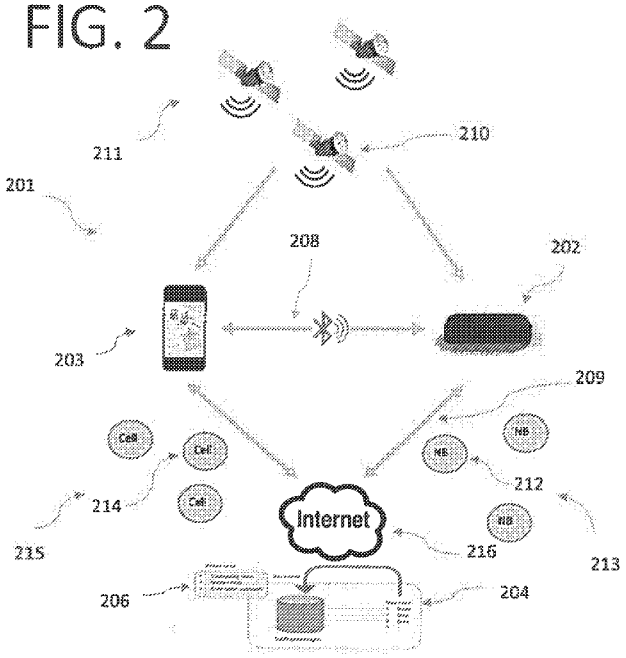
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

WO 2020/153897 A1

(54) Title: A LOW POWER PORTABLE LOCATION TRACKER, A LOCATION TRACKING SYSTEM AND METHODS

FIG. 2




(57) Abstract: The present invention relates to methods, a location tracking system and a portable location tracker for low power consuming uses cases when the state or position of the tracker needs to be determined also when the tracker is outside short-range wireless communication range with a mobile communications device. The technology disclosed further relates to a low power consuming location tracker system for controlling a plurality of portable location trackers comprising a movement sensor and a remote control and monitoring system for communicating with the portable location trackers via a cellular radio communications network.

*[Continued on next page]*

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Declarations under Rule 4.17:**

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

**Published:**

— *with international search report (Art. 21(3))*

# TITLE

A low power portable location tracker, a location tracking system and methods

# TECHNICAL FIELD

The present invention relates to methods, a location tracking system and a portable location tracker. Specifically, the present invention relates to methods, a location tracking system and a portable location tracker suitable for low power consuming uses cases when the state or position of the tracker needs to be determined also when the tracker is outside short-range wireless communication range with a mobile communications device and the owner of the portable location tracker needs to be notified about the whereabouts of the portable location tracker.

# BACKGROUND

Wireless telecommunication networks often include user equipment that connect to Radio Access Networks (RANs) of the wireless telecommunication network. The user equipment may include user devices, such as mobile communications devices (e.g. smartphones), tablet computers, etc., and Internet of Things (IoT) devices (also referred to as Machine Type Communication (MTC) devices and Machine-to-Machine (M2M) devices). An example of a portable location tracker device may include Category 1 (CAT 1) trackers (also referred to as an IoT tracker).

A GPS tracking unit is a navigation device, normally carried by a moving vehicle or person, that uses the Global Positioning System (GPS) to track and determine its location. The recorded location data can either be stored within the tracking unit or transmitted to an Internet-connected device using the cellular, radio, or satellite modem embedded in the unit. This allows the location to be displayed against a map backdrop either in real time or when analysing the track later, using GPS tracking software. Data tracking software is available for smartphones with GPS capability.

Data pusher is the most common type of GPS tracking unit, used for asset tracking, personal tracking and vehicle tracking systems. Also known as a GPS beacon, this kind of device pushes (i.e. "sends") the position of the device as well as other information

like speed or altitude at regular intervals, to a determined server, that can store and instantly analyse the data.

Most GPS trackers provide data "push" technology, enabling sophisticated GPS tracking in business environments, specifically organizations that employ a mobile workforce, such as a commercial fleet. GPS tracking systems used in commercial fleets are often configured to transmit location and telemetry input data at a set update rate or when an event (door open/close, auxiliary equipment on/off, geofence border cross) triggers the unit to transmit data. Live GPS tracking used in commercial fleets generally refers to systems that update regularly at one-minute, two-minute or five-minute intervals while the ignition status is on. Some tracking systems combine timed updates with heading change triggered updates.

GPS tracking solutions such as Telematics 2.0, an IoT based telematics technology for the automotive industry, are being used within mainstream commercial auto insurance.

The applications of trackers of this kind include GPS personal tracking devices are used in the care of the elderly and vulnerable. Devices allow users to call for assistance and optionally allow designated carers to locate the user's position, typically within 5 to 10 meters. Their use helps promote independent living and social inclusion for the elderly. Devices often incorporate either 1-way or 2-way voice communication. Some devices also allow the user to call several phone numbers using pre-programmed speed dial buttons. Trials using GPS personal tracking devices are also underway in several countries for use with sufferers of early-stage dementia.

The applications of trackers of this kind also include asset tracking such as solar powered. The advantage of some solar powered units is that they have much more power over their lifetime than battery powered units. This gives them the advantage of reporting their position and status much more often than battery units which need to conserve their energy to extend their life. Some wireless solar-powered units may report more than 20,000 times per year and work indefinitely on solar power, eliminating the need to change batteries.

Asset tracking devices often conserve battery life by reporting in less frequently than vehicle-powered counterparts. When put on a wildlife animal, e.g. in a collar, the tracker allows scientists to study its activities and migration patterns. Vaginal implant transmitters mark the location where pregnant females give birth. Animal trackers may also be put on domestic animals, to locate them in case they get lost.

KR20160046690 relates to a portable tracking device to be carried by a target and a method for operating the portable tracking device. The portable tracking device comprises a collection unit

for collecting sensor information on the target, a determination unit for determining whether the target is abnormal or not and a processing unit for analyzing collected sensor information and displaying an abnormal state on a screen. The processing unit may be a positioning module, or a sensor for measuring blood alcohol concentration. The portable tracking device is thus carried by a target and comprises a determining unit for determining whether the target is abnormal or not and a processing unit for analyzing the collected sensor information and displaying an abnormal state on a screen.

WO2011044337 relates to a system for backhauling health information over a mesh network. The system includes a plurality of first tags, a mesh network, and an information engine. Each of the plurality of first tags represents a first object. The mesh network preferably includes a plurality of plug-in sensors located within a facility. At least one node in the mesh network operates as healthcare device. The information engine is in communication with the mesh.

US2015087328 relates to a system for improving positioning accuracy of a mobile communication device with a lower positioning capability via one or more mobile communication devices with a higher positioning capability. An indication of a detected presence of a second mobile device may be communicated to a server. The server having received an indication may estimate a location of a second mobile device within an indoor or like area of interest identified via such an indication using one or more appropriate techniques.

## PROBLEMS WITH THE PRIOR ART

The location trackers known in the art are configured to periodically report their current location to a user device either via a cellular communications network, e.g. a wireless telecommunication network, or via short-range wireless communication with a known, trusted or associated user device within short-range communication.

In operation, some of the location trackers known in the art periodically determine a current geographic location, e.g. via Global Positioning System (GPS), of the portable location tracker and provide the location to a user device via a wireless telecommunication network. In this manner, the movements of a portable location tracker, and hence the movements of the object to which a portable location tracker is attached, may be monitored. Due to the mobile nature of these portable location trackers, they often include a small battery powered device. However, since the use of cellular radio communication capabilities to provide a location to a user device often

require a significant amount of power, these location trackers are typically not adapted for uses cases requiring a very low consumption of battery life, e.g. use cases including lots of periods when the location tracker is not at all moving.

A typical tracking device existing in the art uses a GPS satellite to determine the current location of the device. A wireless transceiver coupled to the GPS receiver, and GPS processor, transmits information from the GPS processor toward a central computer for processing. The algorithm then compares the current location coordinate of the GPS receiver to predetermined coordinates, or other definition of a geometric shape, such as an equation of a circle centered at a given location predetermined by a user at the central computer, to determine whether the GPS device, and thus what it is fixed to, is bounded by the geometric shape. If not, the central computer may generate a notification that the geometric shape does not bound the GPS device.

While such an approach performs the desired function of generating the notice when a tracked asset leaves the predetermined geographical boundary, for example, the approach also has drawbacks. The drawbacks include excessive power usage and wireless transmission bandwidth usage. To perform a comparison of the current location to the geographical boundary, a system may periodically transmit current location coordinates to the central server, and then the central server performs the comparison and generation of alerts if the comparison indicates that the geographical boundary does not bound the tracked asset. Since each transmission of a data unit, such as a packet, cost money, each periodic transmission of a data unit incurs a cost in air time.

Some of the location trackers known in the art require to be within short-range communication range with a known/trusted or associated user device, e.g. a mobile communications device, to periodically report their current positions. However, these location trackers are not adapted for situations or use cases when the location tracker often is not within short-range communication range with a known/trusted or associated mobile communications device but is only within short-range communication range with an unknown or untrusted user device. In these situations, or use cases, the monitoring of the movements of the portable location tracker, e.g. the knowledge about the current location and/or a changed movement pattern for the portable location tracker, may still be of high importance to the owner of the location tracker and/or a user of a known/trusted user device, e.g. in situations or use cases where the movements or movement pattern of the object to which a portable location tracker is attached is important to the owner of the portable location tracker and/or user of a known/trusted or associated user device.

A geo-fence is defined and established automatically based on a current location of an asset along with some range or distance, avoiding the need for a user to manually specify a location by drawing a perimeter, specifying a point location, or by any other means. Once established, the geo-fence can be activated so as to notify the owner of the asset and/or some other entity of movement of the asset beyond the boundary specified by the geo-fence. In one embodiment, the geo-fence can be automatically activated upon certain conditions, or can be manually activated, or any combination thereof.

Location tracking is a useful mechanism for limiting or preventing theft of assets such as vehicles, and for recovering stolen assets. Various location tracking mechanisms are well known in the art. For example, Global Positioning System (GPS) functionality is a well-known and ubiquitous technique for tracking a vehicle's location. In addition, other mechanisms are known, such as triangulation by cellular telephone signal or other means. Radio frequency identification (RFID) systems are also well known but are generally suitable only for short-range location tracking.

It is often useful to provide notification when an asset is moved beyond a defined geographic region, referred to herein as a “geo-fence”. A geo-fence can be defined by reference to a perimeter, or boundary, surrounding a geographic area. The geographic area can be substantially circular or can be a polygon or any other shape. A monitoring system includes a sensor mounted within the asset to be tracked, a communication link, and an alert notification mechanism. Asset owners and/or other parties can thus be notified when the geo-fence boundary is violated by the asset leaving the boundary. Notification of geo-fence violations in this manner can serve to limit or prevent theft, by promptly alerting an owner and/or law-enforcement authorities that the asset has been moved without authorization. Ongoing location tracking can help authorities in their efforts to find a vehicle that has been stolen.

A limitation inherent in many currently available GPS monitoring systems is that they require a user to specify the geo-fence boundary settings, for example by drawing a perimeter on a map. This can be done, for example, on a website designed to facilitate geo-fence configuration. Other systems allow a user to specify a geo-fence by specifying a point location, for example by entering an address or coordinates, and indicating a maximum distance from the specified point. Thus, the user must obtain, by some means, a description or indication as to where the geo-fence should be placed.

What is needed is a system and method of location tracking and boundary violation notification that avoids the limitations of the prior art. What is further needed is a system and method that automatically defines a geo-fence based on a current location of an asset. What is further needed

is a system and method that is adapted to automatically and/or passively activate boundary violation notification under certain conditions, so as to more reliably provide notification with a minimum of user effort. What is further needed is a system and method by which an owner of an asset can specify conditions in which the owner or some other entity is to be notified if the asset moves outside a geo-fence.

A portable location tracker typically relies on a power source, such as a battery, in order to function. However, the portable location trackers and systems of today are consuming too much energy and are not optimised for use cases when the object-to-track is often changing its position, have no access to external power, require a small tracker and cannot bear a too high cost for the tracking.

Hence, there is a need for solutions which are adapted to preserve the amount of power in a portable location tracker for the above uses cases and in situations when the tracker may or may not be within short-range communication with a known mobile communications device to which the tracker is linked.

## SUMMARY

The technology disclosed relates to a portable location tracker, a location tracker system and methods in a location tracker system comprising a plurality of portable location trackers.

The technology disclosed relates to a portable low power consuming location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the location tracker;
c. a control system;
d. a short-range wireless transmitter adapted to transmit data;
e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network.

The control system of the location tracker may comprise a memory configured to store the received position data for the location tracker and the movement data detected by the movement sensor of the location tracker. The control system of the location tracker may further comprise a data processing unit and computer program code control logics.

The movement sensor may be an accelerometer adapted to detect the movements of the portable location tracker, e.g. the acceleration and movement pattern of the portable location tracker.

In embodiments, the technology disclosed relates to a low power consuming portable location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the location tracker;
c. a control system for controlling the transmitters and receivers of the portable location tracker;
d. a short-range wireless transmitter adapted to transmit data;
e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range.

In embodiments, the control system may be further configured to turn on said GNSS receiver to obtain the current position of the location tracker upon expiration of a timer and/or at least partly based on input from said movement sensor. The control system may then be configured so that the GNSS receiver is turned on upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range.

In embodiments, the control system may be further configured to turn on said cellular radio communications transmitter receiver upon expiration of a timer and/or at least partly based on input from said movement sensor. The control system may then be configured so that the cellular radio communications transmitter receiver is turned on upon expiration of a timer indicating that there is no mobile communications device within short-range wireless

communication range. The portable location tracker may then provide data or information to a remote control and monitoring system via the cellular radio communications network and in return also receive data or information from the remote control and monitoring system via the cellular radio communications network.

In embodiments, the technology disclosed relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;
b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range, and
c. upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range:
d. turning on, by the control system of the portable location tracker, a cellular radio communications transmitter of the portable location tracker.

In embodiments, the technology disclosed relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;
b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range, and
c. upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range:
d. turning on, by the control system of the portable location tracker, at least one of a cellular radio communications transceiver, a cellular radio communications transmitter and a cellular radio communications receiver of the portable location tracker.

In embodiments, the turning on of at least one of said cellular radio communications transceiver, said cellular radio communications transmitter and said cellular radio communications receiver is at least partly also based on said obtained movement sensor data, and wherein said obtained movement sensor data is indicating at least one of an acceleration beyond a certain threshold value and a changed movement pattern for the location tracker.

In embodiments, the technology disclosed relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;
b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range,
c. obtaining, by a control system of the portable location tracker, movement sensor data from the movement sensor of the portable location tracker, and, upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range:
d. turning on, by the control system of the portable location tracker, a cellular radio communications transmitter of the portable location tracker.

In embodiments, the technology disclosed relates to a low power consuming portable location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the location tracker;
c. a control system for controlling the transmitters and receivers of the portable location tracker;
d. a short-range wireless transmitter adapted to transmit data;
e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular

radio communications network, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a timer indicating that there is no mobile communications device which is trusted by, or associated with, the low power consuming portable location tracker within short-range wireless communication range.

In embodiments, the control system may be further configured to turn on said GNSS receiver to obtain the current position of the location tracker upon expiration of a timer and/or at least partly based on input from said movement sensor. The control system may then be configured so that the GNSS receiver is turned on upon expiration of a timer indicating that there is no mobile communications device which is trusted by, or associated with, the portable location tracker within short-range wireless communication range.

In embodiments, the control system may be further configured to turn on said cellular radio communications transmitter receiver upon expiration of a timer and/or at least partly based on input from said movement sensor. The control system may then be configured so that the cellular radio communications transmitter receiver is turned on upon expiration of a timer indicating that there is no mobile communications device which is trusted by, or associated with, the portable location tracker within short-range wireless communication range. The portable location tracker may then receive data or information from a remote control and monitoring system via the cellular radio communications network.

In embodiments, the technology disclosed relates to a low power consuming portable location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the location tracker;
c. a control system for controlling the transmitters and receivers of the portable location tracker;
d. a short-range wireless transmitter adapted to transmit data;
e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on at least one of said cellular radio communications transmitter and said cellular radio communications transmitter upon expiration of a timer indicating

that there is no mobile communications device within short-range wireless communication range.

In embodiments, the control system of the low power consuming portable location tracker is configured to change how often at least one of the transmitters and receivers of the location tracker is turned on, and wherein said change is triggered by at least one of input from said movement sensor and upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range.

In embodiments, the technology disclosed relates to a low power consuming portable location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the location tracker;
c. a control system for controlling the transmitters and receivers of the portable location tracker;
d. a short-range wireless transmitter adapted to transmit data;
e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on at least one of said cellular radio communications transmitter and said cellular radio communications transmitter upon expiration of a timer indicating that there is no mobile communications device which is trusted by, or associated with, the low power consuming portable location tracker within short-range wireless communication range.

In embodiments, the control system of the low power consuming portable location tracker is configured to change how often at least one of the transmitters and receivers of the location tracker is turned on, and wherein said change is triggered by at least one of input from said movement sensor and upon expiration of a timer indicating that there is no mobile communications device which is trusted by, or associated with, the low power consuming portable location tracker within short-range wireless communication range.

In embodiments, the technology disclosed relates to a low power consuming portable location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the location tracker;
c. a control system for controlling the transmitters and receivers of the portable location tracker;
d. a short-range wireless transmitter adapted to transmit data;
e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on at least one of said cellular radio communications transmitter and said cellular radio communications transmitter upon expiration of a timer indicating that there is at least one of:
    a. no mobile communications device within short-range wireless communication range, and
    b. no mobile communications device which is trusted by, or associated with, the low power consuming portable location tracker within short-range wireless communication range.

In embodiments, the location tracker may be further configured to transmit the current position, or the most recently obtained or received position, of the location tracker from the cellular radio communications transmitter to a remote control and monitoring system. The position data may then be transmitted via a cellular radio communications network such as a cellular narrowband radio communications network using low power cellular narrowband radio techniques like NB-IoT, SigFox or LoRa.

In embodiments, the technology disclosed relates to a low power consuming portable location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the portable location tracker;
c. a control system for controlling the transmitters and receivers of the portable location tracker;
d. a short-range wireless transmitter adapted to transmit data;

e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and

f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range, and

wherein said portable location tracker is further configured to, upon expiration of said timer indicating that there is no mobile communications device within short-range wireless communication range, transmit, via said cellular radio communications network to said remote control and monitoring system, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker.

In embodiments, the technology disclosed relates to a low power consuming portable location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;

b. a movement sensor adapted to detect the movements of the portable location tracker;

c. a control system for controlling the transmitters and receivers of the portable location tracker;

d. a short-range wireless transmitter adapted to transmit data;

e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and

f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range, and

wherein said portable location tracker is further configured to, upon expiration of said timer indicating that there is no mobile communications device within short-range wireless communication range, transmit, via said cellular radio communications network to said remote

control and monitoring system, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker.

In embodiments, the technology disclosed relates to a low power consuming portable location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the portable location tracker;
c. a control system for controlling the transmitters and receivers of the portable location tracker;
d. a short-range wireless transmitter adapted to transmit data;
e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range, and

wherein said portable location tracker is further configured to, upon expiration of said timer indicating that there is no mobile communications device within short-range wireless communication range and partly based on movement sensor data obtained by the movement sensor of the portable location tracker is indicating at least one of an acceleration beyond a certain threshold value and a changed movement pattern for the location tracker, transmit, via said cellular radio communications network to said remote control and monitoring system, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker.

In embodiments, the technology disclosed relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;

b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range, and
c. upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range:
d. turning on, by the control system of the portable location tracker, a cellular radio communications transmitter of the portable location tracker, and
e. transmitting, via a cellular radio communications network to a remote control and monitoring system, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker.

According to above method including the step of transmitting, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker, the remote control and monitoring system may inform the owner of the portable location tracker the obtained position data, i.e. current positioning of the portable location tracker, even when the portable location tracker is not within short-range wireless communication range with a mobile communications device. Hence, the remote control and monitoring system may then convey information about the status of the tracker via the cellular radio communications network to the owner of the tracker also when the tracker is outside short-range wireless communications range, e.g. by providing position data and/or movement status data that is presented on a mobile app and/or the display of the owner's mobile communications device. In the event the expiration of a timer is indicating that the tracker is outside short-range wireless communication range and position data and/or accelerometer data obtained by the tracker is indicating that the tracker is moving, the remote control and monitoring system may inform the owner of the tracker about the status of the tracker via the cellular radio communications network. As an example, if a bicycle, boat or animal is physically connected to or associated with the tracker, the remote control and monitoring system may inform the owner of the tracker via the cellular radio communication network that the bicycle, boat or animal appears to be moving even though the tracker is outside short-range wireless communication range, i.e. there is a risk that the product is stolen.

In embodiments, the method including the step of transmitting, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker may further comprise the step of turning on the GNSS receiver of the portable location tracker to obtain the current position of the location tracker upon expiration of a timer and/or at least partly based on input from said movement sensor. The control system of the portable location tracker may then be configured so that the GNSS receiver is turned on upon expiration of a timer

indicating that there is no mobile communications device within short-range wireless communication range.

In embodiments, the method including the step of transmitting, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker may further comprise the step of turning on the cellular radio communications receiver upon expiration of a timer and/or at least partly based on input from said movement sensor. The control system may then be configured so that the cellular radio communications receiver is turned on upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range. The portable location tracker may then communicate with and receive data or information from a remote control and monitoring system via the cellular radio communications network.

In embodiments, the technology disclosed relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;
b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range;
c. obtaining position data for said portable location tracker using a GNSS receiver of the portable location tracker, and
d. upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range:
e. turning on, by the control system of the portable location tracker, a cellular radio communications transmitter of the portable location tracker, and
f. transmitting, via a cellular radio communications network to a remote control and monitoring system, a signal including said obtained position data and/or data identifying said portable location tracker.

According to above method including the step of transmitting, a signal including said obtained position data and/or data identifying said portable location tracker via a cellular radio communications network, the remote control and monitoring system may inform the owner of

the portable location tracker the obtained position data, i.e. current positioning of the portable location tracker, even when the portable location tracker is not within short-range wireless communication range with a mobile communications device. Hence, the remote control and monitoring system may then convey information about the status of the tracker via the cellular radio communications network to the owner of the tracker also when the tracker is outside short-range wireless communications range, e.g. by providing position data and/or movement status data that is presented on a mobile app and/or the display of the owner's mobile communications device. In the event the expiration of a timer is indicating that the tracker is outside short-range wireless communication range and position data and/or accelerometer data obtained by the tracker is indicating that the tracker is moving, the remote control and monitoring system may inform the owner of the tracker about the status of the tracker via the cellular radio communications network. As an example, if a bicycle, boat or animal is physically connected to or associated with the tracker, the remote control and monitoring system may inform the owner of the tracker via the cellular radio communication network that the bicycle, boat or animal appears to be moving also when the tracker is outside short-range wireless communication range, e.g. to inform the owner that there is a risk that the product might be stolen.

In embodiments, the method including the step of transmitting a signal including said obtained position data and/or data identifying said portable location tracker via the cellular radio communications network may further comprise the step of turning on the GNSS receiver of the portable location tracker to obtain the current position of the location tracker upon expiration of a timer and/or at least partly based on input from said movement sensor. The control system of the portable location tracker may then be configured so that the GNSS receiver is turned on upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range.

In embodiments, the method including the step of transmitting a signal including said obtained position data and/or data identifying said portable location tracker via a cellular radio communications network may further comprise the step of turning on the cellular radio communications receiver upon expiration of a timer and/or at least partly based on input from said movement sensor. The control system may then be configured so that the cellular radio communications receiver is turned on upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range. The portable location tracker may then communicate with and receive data or information from a remote control and monitoring system via the cellular radio communications network.

In embodiments, the technology disclosed relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;
b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range;
c. obtaining position data for said portable location tracker using a GNSS receiver of the portable location tracker;
d. obtaining movement sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and
e. upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range and said obtained movement sensor data is indicating at least one of an acceleration beyond a certain threshold value and a changed movement pattern for the location tracker:
f. turning on, by the control system of the portable location tracker, a cellular radio communications transmitter of the portable location tracker, and
g. transmitting, via a cellular radio communications network to a remote control and monitoring system, a signal including movement sensor data and/or position data based on said obtained movement sensor data and/or position data and data identifying said portable location tracker.

In embodiments, the technology disclosed relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;

b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range;
c. obtaining position data for said portable location tracker using a GNSS receiver of the portable location tracker;
d. obtaining movement sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and
e. upon expiration of a timer indicating that there is no mobile communications device trusted by, or associated with, said portable location tracker within short-range wireless communication range and said obtained movement sensor data is indicating at least one of an acceleration beyond a certain threshold value and a changed movement pattern for the location tracker:
f. turning on, by the control system of the portable location tracker, a cellular radio communications transmitter of the portable location tracker, and
g. transmitting, via a cellular radio communications network to a remote control and monitoring system, a signal including position data based on said obtained position data and data identifying said portable location tracker.

In embodiments, the technology disclosed relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;
b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range, and
c. upon expiration of a timer indicating that there is no mobile communications device trusted by, or associated with, said portable location tracker within short-range wireless communication range:
d. turning on, by the control system of the portable location tracker, a cellular radio communications transmitter of the portable location tracker, and
e. transmitting, via a cellular radio communications network to a remote control and monitoring system, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker.

In embodiments, the technology disclosed relates to a low power consuming portable location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the portable location tracker;
c. a control system for controlling the transmitters and receivers of the portable location tracker;
d. a short-range wireless transmitter adapted to transmit data;
e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a timer indicating that there is no mobile communications device trusted by, or associated with, said portable location tracker within short-range wireless communication range, and

wherein said portable location tracker is further configured to, upon expiration of said timer, transmit, via said cellular radio communications network to said remote control and monitoring system, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker.

In embodiments, the technology disclosed relates to a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, said portable location tracker comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a movement sensor adapted to detect the movements of the portable location tracker;
c. a control system for controlling the transmitters and receivers of the portable location tracker;
d. a short-range wireless transmitter adapted to transmit data;
e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and

f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range, and

wherein said portable location tracker is further configured to, upon expiration of said timer, transmit, via said cellular radio communications network to said remote control and monitoring system, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker.

In embodiments, the remote control and monitoring system of the location tracker system may be configured to notify a mobile application program (APP) of a mobile communications device trusted by, or associated with, the portable location tracker in response to received position data and/or data identifying the portable location tracker or in response to status update information, which is received from the portable location tracker, that the portable location tracker is outside short-range wireless communication range but is still moving/accelerating, or in response to status update information indicating that the portable location tracker has a changed movement pattern.

In embodiments, the technology disclosed relates to a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system said portable location tracker comprising:

g. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
h. a movement sensor adapted to detect the movements of the portable location tracker;
i. a control system for controlling the transmitters and receivers of the portable location tracker;
j. a short-range wireless transmitter adapted to transmit data;
k. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
l. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a

timer indicating that there is no mobile communications device trusted by, or associated with, said portable location tracker within short-range wireless communication range, and

wherein said portable location tracker is further configured to, upon expiration of said timer, transmit, via said cellular radio communications network to said remote control and monitoring system, at least one of obtained position data for said portable location tracker and data identifying said portable location tracker.

In embodiments, the remote control and monitoring system may be configured to notify a mobile application program (APP) of a mobile communications device trusted by, or associated with, the portable location tracker in response to the received position data and/or data identifying said portable location tracker. The remote control and monitoring system of the location tracker system may be configured to notify a mobile application program (APP) of a mobile communications device trusted by, or associated with, the portable location tracker in response to received position data and/or data identifying the portable location tracker or in response to status update information, which is received from the portable location tracker, that the portable location tracker is outside short-range wireless communication range but is still moving/accelerating, or in response to status update information indicating that the portable location tracker has a changed movement pattern.

In embodiments, the control system of the portable location tracker may be configured to increase or decrease the periodicity and/or frequency of how often said short-range wireless receiver is turned on upon expiration of a timer and/or at least partly based on input from said movement sensor.

In embodiments, the control system of the portable location tracker may be configured to increased or decreased periodicity and/or frequency of short-range wireless transmissions is triggered by at least one of input from the movement sensor, a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by, or associated with, the location tracker and/or upon expiration of a timer of the location tracker.

In embodiments, the control system of the portable location tracker may be configured to increase or decrease the periodicity and/or frequency of how often the GNSS receiver is turned on to take position upon expiration of a timer and/or at least partly based on input from the movement sensor.

In embodiments, the control system of the portable location tracker may be configured to so that a decision to increase or decrease the periodicity and/or frequency of how often the GNSS receiver is turned on to take position is at least partly triggered by a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by or associated with the location tracker.

The technology disclosed further relates to a low power consuming location tracker system comprising:

a. at least one portable location tracker comprising a control system and a movement sensor, e.g. an accelerometer;
b. a remote control and monitoring system, e.g. a backend location tracker system, configured to communicate both with the at least one portable location tracker via a cellular radio communications network and communicate with a cellular mobile communications device;
c. an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities.

In embodiments, the technology disclosed further relates to a low power consuming location tracker system comprising:

a. a portable location tracker comprising a control system and a movement sensor, said portable location tracker is configured to:
    i. communicate with a remote control and monitoring system via a cellular radio communications network;
    ii. communicate with a cellular mobile communications device via short-range wireless communication;
b. a remote control and monitoring system configured to:
    i. communicate with a plurality of cellular mobile communications devices via at least one of a wideband cellular radio communications network, a wireless local network and the internet;
    ii. communicate with the portable location tracker via a cellular radio communications network; and

iii. store data related to the position data associated with the portable location tracker;

c. an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities, the cellular mobile communications device having computer program code portions adapted to control the mobile communications device to:

i. communicate with the portable location tracker via short-range wireless communication;

ii. communicate with the remote control and monitoring system via at least one of a wideband cellular radio communications network, a wireless local network and the internet.

The technology disclosed further relates to an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities, the application program having computer program code portions adapted to control the mobile communications device to:

i. communicate with the portable location tracker via short-range wireless communication;

ii. communicate with the remote control and monitoring system, e.g. via a cellular radio communications network, local wireless networks and/or the internet, and

iii. initiate actions in the mobile communications device triggered by or based on data received via communication with the portable location tracker via short-range wireless communication.

The technology disclosed further relates to an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities, the application program having computer program code portions adapted to control the mobile communications device to:

i. communicate with the portable location tracker via short-range wireless communication;

ii. communicate with the remote control and monitoring system via a cellular radio communications network, and

iii. initiate actions in the mobile communications device triggered by or based on data received from the remote control and monitoring system.

The technology disclosed further relates to an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities, the application program having computer program code portions adapted to control the mobile communications device to:

iv. communicate with the portable location tracker via short-range wireless communication;

v. communicate with the remote control and monitoring system the remote control and monitoring system via at least one of a wireless local network a cellular radio communications network and the internet, and

vi. present, in the application program and/or on a display, display data or information related to at least one of position data and movement status data associated with the portable location tracker.

The portable location trackers of the low power consuming location tracker system may be configured to at least one of communicating with a remote control and monitoring system, e.g. a backend system, via e.g. at least one of a cellular radio communications network and/or the internet and communicating with a cellular mobile communications device via short-range wireless communication. In embodiments, the at least one portable location tracker and the remote control and monitoring system of the above low power consuming location tracker system may be configured to communicate with each other via a cellular narrow band radio communications network, e.g. using low power cellular narrow band radio techniques like NB-IoT, SigFox or LoRa.

The technology disclosed further relates to a low power consuming location tracker system, the system comprising:

a. a portable location tracker comprising a control system and a movement sensor, e.g. an accelerometer, said portable location tracker is configured to:

i. communicate with a remote control and monitoring system, e.g. a backend system, via a cellular radio communications network, e.g. a narrowband cellular radio communications network;
ii. communicate with a cellular mobile communications device via short-range wireless communication, e.g. Bluetooth;

b. a remote control and monitoring system, e.g. a backend location tracker system, configured to:
i. communicate with a plurality of cellular mobile communications devices;
ii. communicate with the portable location tracker via a cellular radio communications network, e.g. a narrowband cellular radio communications network; and
iii. store data related to the position data associated with the portable location tracker;

c. an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities, the application program having computer program code portions adapted to control the mobile communications device to:
i. communicate with the portable location tracker via short-range wireless communication;
ii. communicate with the backend location tracker system via e.g. at least one of a wideband cellular radio communications network, a wireless local network and/or the internet, and
iii. present, in the application program and/or on a display, display data or information related to at least one of position data and movement status data associated with the portable location tracker.

The control system of the portable location tracker of the low power consuming location tracker system may be configured to use status data or instructions received from the remote control and monitoring system for making decisions whether to change how often at least one of a GNSS receiver, a cellular radio communications transmitter and a cellular radio communications transmitter of the portable location tracker is turned on. The status data exchanged between the portable location tracker and the mobile communications device may include at least one of GPS and/or cellular position data for the mobile communications device and GPS position data and/or movement sensor data for the portable location tracker.

The control system of the portable location tracker of the low power consuming location tracker system may be configured to use status data or instructions previously received from a nearby mobile communications device for making decisions whether to change how often at least one of a GNSS receiver, a cellular radio communications transmitter and a cellular radio communications transmitter of the portable location tracker is turned on. The status data exchanged between the portable location tracker and the mobile communications device may include at least one of GPS and/or cellular position data for the mobile communications device and GPS position data and/or movement sensor data for the portable location tracker.

The technology disclosed further relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in the cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the location tracker, a signal including a token or data identifying the portable location tracker and at least one of position data and movement status data for the location tracker;
b. turning on a short-range wireless receiver of the portable tracker, wherein the receiver is listening for a short-range wireless response from a device within short-range wireless communication range,
c. obtaining movement sensor data from the movement sensor of the portable location tracker, and, at least partly based on the obtained movement sensor data and/or upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range:
d. turning on at least one of a cellular radio communications transmitter and a GNSS receiver of the portable location tracker.

In embodiments, the method according to certain aspects of the technology disclosed includes that the obtained sensor data is indicating at least one of an acceleration beyond a certain threshold value and a changed movement pattern for the location tracker.

In embodiments, the method according to certain aspects of the technology disclosed further comprises receiving, at the portable location tracker, a short-range wireless response from a mobile communications device where a token or other identification data in the response is indicating that the response was not sent by a mobile communications device unknown to, or untrusted by, the location tracker.

In embodiments, the method according to certain aspects of the technology disclosed includes that the portable location tracker is turning on the cellular radio communications transmitter and/or the GNSS receiver at least partly based on the received token or other identification data indicating that mobile communications device is unknown or untrusted.

In embodiments, the method according to certain aspects of the technology disclosed further comprises transmitting, from the portable location tracker to the remote control and monitoring system via the cellular radio communications network, a message comprising at least one of position data and movement status data for the portable location tracker. The message may then be sent in response to at least one of the obtained sensor data from the movement sensor and a short-range wireless response from a mobile communications device where a token or other identification data in the response is indicating that the response was not sent by a mobile communications device trusted by or associated with the location tracker.

In embodiments, the method according to certain aspects of the technology disclosed further comprises receiving, at the remote control and monitoring system, a message comprising at least one of position data and movement status data for the portable location tracker and notifying, in response to receiving the at least one of position data and movement status data for the portable location tracker, the mobile application of a mobile communications device known to, or trusted by, the portable location tracker.

In embodiments, the method according to certain aspects of the technology disclosed further comprises presenting, in the application program and/or on a display of the mobile communications device, data or information related to at least one of position data and movement status data associated with the portable location tracker.

In embodiments, the control system of the portable low power consuming location tracker is configured to change how often at least one of the transmitters and receivers of the location tracker is turned on. This change may be triggered at least partly based on input from the movement sensor and/or upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range.

In embodiments, the control system of the portable low power consuming location tracker is configured to turn on the GNSS receiver to obtain the current position of the location tracker upon expiration of a timer and/or at least partly based on input from the movement sensor.

In embodiments, the control system of the portable low power consuming location tracker is configured to turn on the cellular radio communications transmitter upon expiration of a timer and/or at least partly based on input from the movement sensor. In certain embodiments, the control system of the location tracker is configured to turn on the cellular radio communications transmitter at least partly based on, or in response to, sensor data detected or measured by the movement sensor, e.g. an accelerometer. The sensor data triggering the control system to turn on the cellular radio communications transmitter may then indicate an acceleration of the location tracker beyond a certain threshold value and/or indicate a certain changed movement pattern for the location tracker.

In embodiments, the portable low power consuming location tracker is configured to transmit the current position, or the most recently obtained or received position, of the location tracker from the cellular radio communications transmitter to a remote control and monitoring system. The position data may then be transmitted via a cellular radio communications network such as a cellular narrowband radio communications network using low power cellular narrowband radio techniques like NB-IoT, SigFox or LoRa.

In embodiments, the control system of the portable low power consuming location tracker is configured to turn on the cellular radio communications transmitter at least partly based on a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by, or associated with, the location tracker.

In embodiments, the cellular radio communications transmitter of the portable low power consuming location tracker is turned on to transmit at least one of position data and movement status data sensor to a remote control and monitoring system at least partly based on input from the movement sensor. The control system of the location tracker may then configured so that the transmission of at least one of position data and movement status data via a cellular radio communications network is triggered by at least one of input from the movement sensor, a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by, or associated with, the location tracker and/or upon expiration of a timer of the location tracker. In embodiments, the expiration of the timer may indicate that there is no mobile communications device within short-range wireless communication range. In other embodiments, the expiration of the timer may indicate that there is no trusted or known mobile

communications device within short-range wireless communication range in that the location tracker is only receiving short-range wireless response(s) from an unknown or untrusted mobile communications device over a certain pre-determined period, e.g. the expiration of the timer indicates that there is no mobile communications device which is associated with the location tracker within short-range wireless communication range. In certain embodiments, the control system of the location tracker is configured to turn on the cellular radio communications transmitter at least partly based on, or in response to, sensor data detected or measured by the movement sensor, e.g. an accelerometer. The sensor data triggering the control system to turn on the cellular radio communications transmitter may then indicate an acceleration of the location tracker beyond a certain threshold value and/or indicate a certain changed movement pattern for the location tracker.

In embodiments, the control system of the portable low power consuming location tracker is configured to increase or decrease the periodicity and/or frequency of short-range wireless transmissions from the short-range wireless transmitter of the location tracker upon expiration of a timer and/or at least partly based on input from the movement sensor of the location tracker. The increased or decreased periodicity and/or frequency of short-range wireless transmissions may then be triggered by at least one of input from the movement sensor, a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by, or associated with, the location tracker and/or upon expiration of a timer of the location tracker. In embodiments, the expiration of the timer may then indicate that there is no mobile communications device within short-range wireless communication range over a certain period of time. In other embodiments, the expiration of the timer may indicate that there is no trusted or known mobile communications device within short-range wireless communication range in that the location tracker is only receiving short-range wireless response(s) from an unknown or untrusted mobile communications device over a certain pre-determined period of time, e.g. the expiration of the timer is indicating that there is no mobile communications device which is associated with the location tracker within short-range wireless communication range.

In embodiments, the control system of the portable low power consuming location tracker is configured to increase or decrease the periodicity and/or frequency of how often the short-range wireless receiver of the location tracker is turned on upon expiration of a timer and/or at least partly based on input from the movement sensor of the location tracker. The increase or decrease may then be triggered by at least one of input from the movement sensor, a received token or other identification data in a short-range wireless response is indicating that the short-

range wireless response was not sent by a mobile communications device trusted by, or associated with, the location tracker and/or upon expiration of a timer of the location tracker. In embodiments, the expiration of the timer may indicate that there is no mobile communications device within short-range wireless communication range over a certain period of time. In other embodiments, the expiration of the timer may indicate that there is no trusted or known mobile communications device within short-range wireless communication range in that the location tracker is only receiving short-range wireless response(s) from an unknown or untrusted mobile communications device over a certain period of time, e.g. the expiration of the timer is an indicating that there is no mobile communications device associated with the location tracker within short-range wireless communication range.

In embodiments, the control system of the portable low power consuming location tracker is configured to increase and/or decrease the periodicity and/or frequency of how often the GNSS receiver is turned on to take position upon expiration of a timer and/or at least partly based on input from the movement sensor. The increase or decrease may then be triggered by at least one of input from the movement sensor, a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by, or associated with, the location tracker and/or upon expiration of a timer of the location tracker. In embodiments, the decision by the control system to increase or decrease the periodicity and/or frequency of how often the GNSS receiver is turned on to take position is at least partly triggered by a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by or associated with the location tracker. In embodiments, the expiration of the timer may indicate that there is no mobile communications device within short-range wireless communication range over a certain period of time. In other embodiments, the expiration of the timer may indicate that there is no trusted or known mobile communications device within short-range wireless communication range in that the location tracker is only receiving short-range wireless response(s) from an unknown or untrusted mobile communications device over a certain period of time, e.g. the expiration of the timer is an indicating that there is no mobile communications device associated with the location tracker within short-range wireless communication range.

In embodiments, the control system of the portable low power consuming location tracker is configured to increase the periodicity and/or frequency of short-range wireless transmissions from the short-range wireless transmitter of the location tracker at least partly based on a received token or other identification data in a short-range wireless response is indicating that

the short-range wireless response was not sent by a mobile communications device trusted by, or associated with, the location tracker.

In embodiments, the control system of the portable low power consuming location tracker is configured to increase the periodicity and/or frequency of how often the short-range wireless receiver is turned on at least partly based on a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by or associated with the location tracker.

In embodiments, the control system of the portable low power consuming location tracker is configured to at least one of change the mode or state of the location tracker to thereby increase and/or decrease the periodicity and/or frequency of how often at least one of the transmitters and/or receivers of the location tracker is turned on. In different embodiments, the control system is configured so that the change of mode or state is triggered by at least one of instruction data received via short-range communication with a known or trusted mobile communications device and instruction data received from a remote control and monitoring system via a cellular radio communications network.

In embodiments of the technology disclosed, the system and portable location tracker may be configured to receive a short-range communication signal, or message, from a mobile communications device, and identify a unique identifier or token of the received signal or message to determine whether the mobile communications device is a known/trusted user device, or which is at least associated with the portable location tracker, or an unknown or untrusted user device, e.g. a user device not associated with the portable location tracker. In the event the mobile communications device is identified by the portable location tracker to be a known/trusted/associated user device, the control system/unit of the portable location tracker may be configured to decide that the portable location tracker should enter, leave or remain in a certain mode or state. The control system/unit may then be configured to control that the portable location tracker enters, leaves or remain in a sleep mode or extremely low-power consuming state in response to determining that a short-range communication signal, or message, was received from a known, trusted or associated user device such as a known, trusted or associated mobile communications device.

In embodiments of the technology disclosed, the system and portable location tracker may be configured to receive a short-range communication signal, or message, from a mobile communications device, and identify a unique identifier or token of the received signal or

message to determine whether the mobile communications device is a known/trusted user device, or is at least associated with the portable location tracker, or an unknown or untrusted user device which is not associated with the portable location tracker. In the event the mobile communications device is identified by the portable location tracker to be an unknown, untrusted and/or non-associated user device, the control system of the portable location tracker may be configured to decide that the portable location tracker should leave a certain mode or state, e.g. leave a sleep mode or extremely low-power consuming state by increasing the frequency of short-range wireless low energy advertisement transmissions and/or increasing the frequency of cellular radio communication transmissions to a remote control and monitoring system/node.

In embodiments of the technology disclosed, the portable location tracker of the technology disclosed may be configured to change its status, e.g. mode or operational state, in response to not receiving any short-range communication signal or message from a mobile communications device, e.g. during a certain period indicated by a timer of the tracker. According to certain embodiments and upon expiration of the timer, the tracker may then be configured to enter into a battery conservation mode/state in order to help preserve the amount of power in the battery of the portable location tracker. During this time, however, the location tracker may continue to monitor certain conditions. For example, the tracker may be configured to continue to monitor input from an accelerometer of the tracker indicating the movements and/or movement pattern of the portable location tracker.

In embodiments of the technology disclosed, the portable location tracker of the technology disclosed may be configured to obtain its position in response to not receiving any short-range communication signal or message from a mobile communications device, e.g. when no response has been received for a certain pre-determined period indicated by a timer of the tracker.

According to certain embodiments and upon expiration of the timer, the tracker may then be configured to obtain its position, e.g. through a GPS system, in response to not receiving any short-range communication signal or message. The position may then be obtained by turning on a GPS receiver in response to expiration of the timer or the portable location tracker may be configured to be in a mode or operational state where the GPS receiver of the tracker is periodically turned on to obtain the position of the tracker. The portable location tracker may then be further configured to transmit the obtained position to a remote control and monitoring system via a cellular radio communications network such as a cellular narrowband radio

communications network, e.g. using low power cellular narrowband radio techniques like NB-IoT, SigFox or LoRa.

In other embodiments, the portable location tracker may be configured to transmit its stored most recent position to the remote control and monitoring system via a cellular radio communications network when no response has been received for a certain pre-determined period indicated by the timer of the tracker, i.e. the stored position may then be transmitted to the remote control and monitoring system without first obtaining its current position through a GPS system.

The portable location tracker of the technology disclosed may be configured to monitor input from an accelerometer of the tracker indicating the movements and/or movement pattern of the portable location tracker. The control system/unit of the portable location tracker may then be configured to control the transmission of position data and/or the obtaining of position by turning on the GPS receiver based on at least one of input from the accelerometer and/or the current status for the tracker, e.g. the current mode or operational state for the tracker. For example, the tracker may be configured to continuously and periodically monitor input from an accelerometer of the tracker indicating the movements and/or movement pattern of the portable location tracker. The accelerometer of the tracker may then be configured to continuously and periodically measure or detect the movements and/or movement pattern of tracker.

In embodiments, the periodicity of short-range transmissions and/or turning on of a transmitter or GPS receiver of the portable location tracker may be adjusted by the control system/unit of the location tracker based on at least one of input from the accelerometer and/or the current status for the tracker, e.g. the current mode or operational state for the tracker.

According to certain embodiments and upon expiration of a timer, the control system/unit may be configured to transmit position data and/or obtain position data by turning on the GPS receiver, where a decision by the control system/node whether to turn on a GPS receiver and/or turn on a cellular radio communications transmitter is based on at least one of input from the accelerometer and/or the current status for the tracker.

In embodiments, the mode/state of the portable location tracker and/or the periodicity and/or frequency of transmissions of signals/messages transmitted from the tracker may be changed (e.g. by the control system/unit of the portable location tracker) based on input in a signal or

message received from a mobile communications device, e.g. received from a known/trusted/associated mobile communications device, via short-range wireless communication. In certain embodiments, the changed periodicity/frequency periodicity of transmissions of signals/messages from the tracker may comprise at least one of changing the periodicity/frequency of short-range wireless low energy advertisement transmissions (e.g. iBeacon transmissions from the portable location tracker, "ping") and changing the periodicity/frequency of cellular radio communication transmissions to a remote control and monitoring system/node. In certain embodiments, a mode/state, of the tracker may define at least one of the periodicity of short-range wireless transmissions, e.g. the periodicity of short-range wireless low energy advertisement transmissions (e.g. iBeacon transmissions from the portable location tracker, "ping") and the periodicity of cellular radio communication transmissions to a remote control and monitoring system/node from the portable location tracker.

The control system/unit of the portable location tracker may then be configured to change the periodicity of short-range wireless low energy advertisement transmissions and/or cellular radio communication transmissions to a remote control and monitoring system/node based on the input in the signal or message received from a mobile communications device via short-range wireless communication. In certain embodiments, the decision by the control system/unit to change the mode/state of the tracker and/or the periodicity of transmissions of signals/messages may in addition be at least partly based on input received from a movement sensor, e.g. accelerometer, of the tracker where the input from the movement sensor is indicating a movement for the tracker which is beyond a certain pre-determined threshold value or a changed movement pattern for the tracker. In certain embodiments, the decision by the control system/unit to change the mode/state of the tracker and/or the periodicity of transmissions of signals/messages may be triggered upon expiration of a timer of the portable location tracker.

In embodiments, the mode or state of the portable location tracker and/or the periodicity and/or frequency of transmissions of signals/messages transmitted from the tracker may be changed (e.g. by the control system/unit of the portable location tracker) based on input in a signal or message received from a control and monitoring system/node. In certain embodiments, the changed periodicity/frequency of transmissions of signals/messages from the tracker may comprise at least one of changing the periodicity/frequency of short-range wireless low energy advertisement transmissions (e.g. iBeacon transmissions from the portable location tracker, "ping") and changing the periodicity/frequency of cellular radio communication

transmissions to a remote control and monitoring system/node (e.g. using low power cellular narrow band radio techniques like NB-IoT, SigFox or LoRa). In certain embodiments, a pre-defined mode of the tracker may define at least one of the periodicity and/or frequency of short-range wireless transmissions, e.g. the periodicity of short-range wireless low energy advertisement transmissions (e.g. iBeacon transmissions from the portable location tracker, "ping") and the periodicity and/or frequency of cellular radio communication transmissions to a remote control and monitoring system/node from the portable location tracker.

The control system/unit of the portable location tracker may then be configured to change the periodicity and/or frequency of short-range wireless low energy advertisement transmissions and/or the periodicity and/or frequency of cellular radio communication transmissions to a remote control and monitoring system/node based on the input in the signal or message received from the remote control and monitoring system/node. In certain embodiments, a pre-defined mode of the portable location tracker may be changed by the control system/unit of the portable location tracker (e.g. without receiving any signal or message instructing the change from any device/unit/node) based on input from a movement sensor, e.g. an accelerometer, indicating a changed movement pattern and/or upon expiration of a timer of the portable location tracker. The pre-defined mode of the tracker may then define at least one of the periodicity and/or frequency of

The technology disclosed further relates to a low power consuming location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data for the location tracker from a global navigation satellite system;
b. a movement sensor, e.g. an accelerometer, adapted to detect the movements of the location tracker;
c. a control system/unit;
d. a short-range wireless transmitter adapted to transmit data;
e. a cellular radio communications transmitter for cellular radio communication with a remote control and monitoring system, e.g. a backend location tracker system;
f. a short-range wireless receiver adapted to wireless receive data from a mobile communications device within range for short-range communication, and
g. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network.

In embodiments, the control system/unit of the location tracker may comprise a memory configured to store received position data for the location tracker and/or the movement data detected by the movement sensor of the location tracker. In embodiments, the control system/unit of the location tracker may also comprise a data processing unit and computer program code control logics.

In embodiments, the technology disclosed relates to a method in a location tracker system comprising the steps of obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to at least one of not receiving any response from any mobile communications device within short-range wireless communication range and the obtained sensor data: turning on at least one of a cellular radio communications transmitter of the portable location tracker and at least one of a short-range wireless transmitter and a global navigation satellite system (GNSS) receiver of the portable location tracker. The obtained sensor data may then indicate at least one of an acceleration beyond a certain threshold and a certain changed movement pattern for the location tracker.

In embodiments, the technology disclosed relates to a method in a location tracker system comprising the steps of:

a. receiving position data for the portable location tracker from a global navigation satellite system (GNSS); and
b. obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to at least one of not receiving any response from any mobile communications device within short-range wireless communication range and the obtained sensor data:
c. transmitting previously received position data for the portable location tracker to a remote control and monitoring system/node.

In embodiments, the transmission of position data for the portable location tracker to a remote control and monitoring system/node is triggered by the location tracker identifying that it has not received any response from any mobile communications device within short-range wireless communication range for a certain time period where the time period may be a pre-determined time period.

In embodiments, the transmission of position data for the portable location tracker to a remote control and monitoring system/node is triggered by the location tracker identifying that it has not received any response from any trusted or associated mobile communications device within

short-range wireless communication range for a certain time period where the time period may be a pre-determined time period.

In embodiments, the transmission of position data from the portable location tracker to a remote control and monitoring system/node is triggered by the obtained movement sensor data indicating at least one of an acceleration beyond a certain threshold value and a certain changed movement pattern for the location tracker.

In embodiments, the technology disclosed relates to a method in a location tracker system comprising the steps of:

a. obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to at least one of not receiving any response from any mobile communications device within short-range wireless communication range and the obtained sensor data:
b. receiving position data for the portable location tracker from a global navigation satellite system (GNSS); and
c. transmitting the received position data for the portable location tracker to a remote control and monitoring system/node.

In embodiments, the technology disclosed relates to a method in a location tracker system comprising the steps of:

a. obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to at least one of not receiving any response from any mobile communications device within short-range wireless communication range and the obtained sensor data:
b. turning a global navigation satellite system (GNSS) receiver of the portable location tracker to receive position data for the portable location tracker from a global navigation satellite system (GNSS); and
c. turning on a cellular radio communications transmitter of the portable location tracker to transmit position data for the portable location tracker to a remote control and monitoring system/node.

In embodiments, the technology disclosed relates to a method in a location tracker system comprising the steps of:

a. receiving position data for the portable location tracker from a global navigation satellite system (GNSS) or from a mobile communications device within short-range wireless communication range;
b. obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to receiving a response from a mobile communications device which is identified by the location tracker not be trusted by or associated with the location tracker and the obtained sensor data indicating a certain movement pattern for the portable location tracker:
c. transmitting the previously received position data for the portable location tracker, via short-range transmission to the mobile communications device identified not being trusted or associated with the portable location tracker, to a remote control and monitoring system/node,

wherein the mobile communications device identified not being trusted or associated with the portable location tracker relays the position data to the remote control and monitoring system/node via a cellular radio communications network.

In embodiments and upon expiration of a timer of the portable location tracker, the portable location tracker may be configured to, at least partly in response to an identified token or identification data in a short-range wireless response indicating that the response was sent by an unknown or untrusted user device, perform at least one of the actions of:

a. turning on the cellular radio communications transmitter for transmitting at least one of position data and accelerometer data directly, without using the capabilities of a mobile communications device, to the remote control and monitoring system via the cellular radio communications network, and

In embodiments and upon expiration of a timer of the portable location tracker, the portable location tracker may be configured to, at least partly in response to an identified token or other identification data in a short-range wireless response indicating that the response was sent by an unknown or untrusted user device, perform at least one of the actions of:

a. turning on at least one of the GNSS receiver and the short-range wireless transmitter for transmitting at least one of position data and accelerometer data to the remote control and monitoring system via short-range communication with the untrusted mobile communications device from which the short-range wireless response was received.

In embodiments and upon expiration of a timer of the portable location tracker, the portable location tracker may be configured to, in response to an identified token or other identification data in a short-range wireless response indicating that the response was sent by an unknown or untrusted user device, perform at least one of the actions of:

a. turning on the cellular radio communications transmitter for transmitting at least one of position data and accelerometer data directly, without using the capabilities of a mobile communications device, to the remote control and monitoring system via the cellular radio communications network, and
b. turning on at least one of the GNSS receiver and the short-range wireless transmitter for transmitting at least one of position data and accelerometer data to the remote control and monitoring system via short-range communication with the untrusted mobile communications device from which the short-range wireless response was received.

In embodiments and upon expiration of a timer of the portable location tracker, the portable location tracker may be configured to, at least partly based on movement sensor data indicating a changed movement pattern and in response to an identified token or identification data in a short-range wireless response indicating that the response was sent by an unknown or untrusted user device, perform the actions of:

a. turning on the cellular radio communications transmitter for transmitting at least one of position data and movement sensor data to the remote control and monitoring system via the cellular radio communications network.

In embodiments, the portable location tracker may be configured to transmit the at least one of position data and movement sensor data directly to the remote control and monitoring system via a cellular radio communications network without using the capabilities of any mobile communications device within short-range communication range.

In certain embodiments, the portable location tracker may be configured to transmit the at least one of position data and movement sensor data directly to the remote control and monitoring system via a cellular narrow band radio communications network, e.g. NB-IoT, SigFox or LoRa, without using the capabilities of any mobile communications device within short-range communication range,

In embodiments and upon expiration of a timer of the portable location tracker, the portable location tracker may be configured to, at least partly based on movement sensor data indicating a changed movement pattern and in response to an identified token or other identification data in a short-range wireless response indicating that the response was sent by an unknown or untrusted user device, perform the actions of:

a. transmitting at least one of position data and movement status data to the remote control and monitoring system via short-range communication with the untrusted mobile communications device from which the short-range wireless response was received.

In embodiments and upon expiration of a timer of the portable location tracker, the portable location tracker may be configured to, at least partly based on movement sensor data indicating a changed movement pattern and in response to an identified token or other identification data in a short-range wireless response indicating that the response was sent by an unknown or untrusted user device, perform the actions of:

a. turning on at least one of the GNSS receiver to take its position, and
b. transmitting the obtained position to the remote control and monitoring system via short-range communication with the untrusted mobile communications device from which the short-range wireless response was received.

In embodiments, the above methods may further comprise transmitting, from the portable location tracker to the remote control and monitoring system and via the cellular radio communications network, a message comprising at least one of position data and accelerometer data for the portable location tracker. The message may be sent in response to at least one of the obtained sensor data from the movement sensor indicating a certain unwanted movement pattern and a short-range wireless response from a mobile communications device, where a token or other identification data in the response is indicating that the response was not sent by a mobile communications device trusted by or associated with the portable location tracker. The obtained sensor data indicating a certain unwanted movement pattern may then indicate at least one of an acceleration beyond a certain threshold and a certain changed movement pattern for the location tracker. In embodiments, the portable location tracker may further be configured to turn on its cellular radio communications transmitter and/or turn on at least one of its short-range wireless transmitter and GNSS receiver at least partly based on the received token or other identification data in the response is indicating that mobile communications device is unknown and/or untrusted.

In embodiments, the above methods may further comprise the steps of receiving, at the remote control and monitoring system, a message comprising at least one of position data and accelerometer data for the portable location tracker; and notifying, in response to the received at least one of position data and accelerometer data for the portable location tracker, the mobile application program (APP) of a mobile communications device trusted by, or associated with, the portable location tracker, e.g. via a radio communications network, in response to receiving a message from the portable location tracker. The notification may then include at least one of information or data about the movement status, e.g. accelerometer data and/or position data, for the portable location tracker, and information or data about an unknown and/or untrusted mobile communications device from which the portable location tracker received a short-range wireless response. The notified mobile communications device which is trusted by, or associated with, the portable location tracker is then a different mobile communications device from the unknown and/or untrusted mobile communications device relaying the message from the portable location tracker to the remote control and monitoring system.

In embodiments, the technology disclosed relates to a method in a location tracker system comprising the steps of:

a. obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to receiving a response from a mobile communications device which is not trusted by or associated with the location tracker and the obtained sensor data indicating a certain movement pattern for the portable location tracker:
b. receiving position data for the portable location tracker from a global navigation satellite system (GNSS); and
c. transmitting the received position data for the portable location tracker, via short-range transmission to the not trusted or associated mobile communications device, to a remote control and monitoring system/node, where the not trusted or associated mobile communications device relays the position data to the remote control and monitoring system/node.

In embodiments, the technology disclosed relates to a method in a location tracker system comprising the steps of:

a. obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to receiving a response from a mobile communications device which is not trusted by or associated with

the location tracker and the obtained sensor data indicating a certain movement pattern for the portable location tracker:

b. turning on a global navigation satellite system (GNSS) receiver of the portable location tracker to receive position data for the portable location tracker from a global navigation satellite system (GNSS); and

c. turning on a short-range wireless transmitter of the portable location tracker to transmit position data for the portable location tracker, via the not trusted or associated mobile communications device, to a remote control and monitoring system/node.

In embodiments, the technology disclosed relates to a low power consuming location tracker comprising a receiver adapted to receive position data for the location tracker from a global navigation satellite system, a movement sensor such as an accelerometer, transmitter and receiver, or transceiver, for short-range wireless communication and transmitter and receiver, or transceiver, for cellular radio communication.

In embodiments, the technology disclosed relates to a system comprising a control and monitoring system, e.g. a backend location tracker system, configured to communicate both with portable location trackers via a cellular radio communications network and with cellular mobile communications device via at least one of a wideband cellular radio communications network, a local wireless network and/or the internet.

In embodiments, the technology disclosed relates to a method in a location tracker system comprising a control and monitoring system, portable location trackers and mobile communications devices, comprising:

a. transmitting, from a short-range wireless transmitter of a portable location tracker, a signal including a token or data identifying the portable location tracker;

b. obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to at least one of not receiving any response from any device within short-range wireless communication range and the obtained sensor data:

c. turning on a global navigation satellite system (GNSS) receiver of the portable location tracker to receive position data for the portable location tracker from a global navigation satellite system; and

d. turning on the cellular radio communications transmitter of the portable location tracker to transmit the received position data to a remote control and monitoring system via a cellular radio communications network.

In embodiments, the above method in a location tracker system further comprises obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to at least one of not receiving any response from any device within short-range wireless communication range, e.g. over a certain period, and the obtained sensor data: turning on at least one of a cellular radio communications transmitter of the portable location tracker and at least one of a short-range wireless transmitter and a global navigation satellite system (GNSS) receiver, or GPS receiver, of the portable location tracker.

In embodiments, the technology disclosed relates to a method in a location tracker system comprising a control and monitoring system, portable location trackers and mobile communications devices, comprising:

a. turning on a short-range wireless receiver of a portable location tracker,
b. transmitting, from a short-range wireless transmitter, a signal including a token or data identifying the portable location tracker;
c. obtaining sensor data from a movement sensor, e.g. an accelerometer, of the portable location tracker, and, in response to at least one of not receiving any response from any device within short-range wireless communication range over a certain period and the obtained sensor data:
d. turning on at least one of a cellular radio communications transmitter, a short-range wireless transmitter and a global navigation satellite system (GNSS) receiver of the portable location tracker.

In embodiments, the technology disclosed relates to a method in a system comprising a control and monitoring system, portable location trackers and mobile communications devices, comprising:

a. turning on a short-range wireless receiver of a portable tracker, wherein the receiver is configured to be listening for a short-range wireless response from a mobile communications device within short-range wireless communication range,
b. transmitting, from a short-range wireless transmitter of the portable location tracker, signals, including a token or data identifying the portable location tracker;

c. obtaining sensor data from the movement sensor of the portable location tracker, and, in response to at least one of not receiving any response from any mobile communications device within short-range wireless communication range, e.g. over a certain period, and the obtained sensor data:

d. turning on at least one of a cellular radio communications transmitter of the portable location tracker and at least one of a short-range wireless transmitter and a global navigation satellite system (GNSS) receiver, or GPS receiver, of the portable location tracker.

In embodiments, the above signal transmitted from the short-range wireless transmitter of the portable location tracker also includes at least one of position data for the location tracker and movement status data for the portable location tracker which is based on sensor data detected by the movement sensor, e.g. an accelerometer, of the portable location tracker. In different embodiments, the signal transmitted from the short-range wireless transmitter of the portable location tracker may be a short-range wireless low-energy advertisement such as an iBeacon signal.

In embodiments, the technology disclosed relates to a low power consuming location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data for the location tracker from a global navigation satellite system;

b. a movement sensor, e.g. an accelerometer, adapted to detect the movements of the location tracker;

c. a control system comprising a memory configured to store the received position data for the location tracker and the movement data detected by the movement sensor of the location tracker;

d. a short-range wireless transmitter adapted to transmit data;

e. a control system comprising a data processing unit and computer program code control logics;

f. a cellular radio communications transmitter for cellular radio communication with a remote control and monitoring system, e.g. a backend location tracker system;

g. a short-range wireless receiver adapted to wireless receive data from a mobile communications device within range for short-range communication, and

h. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network.

In embodiments, the control system of the low power consuming location tracker may be configured to control so that the location tracker communicates with the remote control and monitoring system via a cellular radio communications network when there is no mobile communications device available for short-range communication with the location tracker. In certain embodiments, the location tracker may be configured to communicate with the remote control and monitoring system via a cellular narrow band radio communications network when there is no mobile communications device available for short-range communication, e.g. Bluetooth communication.

In embodiments, the short-range wireless transmitter of the low power consuming location tracker is configured to frequently, e.g. at least 4 times every minute, transmit a signal, e.g. a short-range wireless low-energy advertisement such as an iBeacon signal, including a token or data identifying the location tracker and at least one of position data for the location tracker and movement status data for the location tracker which is based on sensor data detected by the movement sensor. The short-range wireless receiver may then be configured to frequently, e.g. at least two times every minute, be turned on and be listening for a short-range wireless response from a device, e.g. a mobile communications device, within short-range wireless communication range, e.g. within Bluetooth communication range.

In embodiments, the control system of the low power consuming location tracker is further configured to, upon expiration of a timer of the location tracker indicating that no short-range wireless response was received for a certain period and/or in response to a token or identification data in a received short-range wireless response, perform at least one of the actions of:

a. turning on the cellular radio communications transmitter for transmitting at least one of obtained position data and movement status data to the remote control and monitoring system via the cellular radio communications network, and
b. turning on at least one of the GNSS receiver to obtain the current position of the location tracker and the short-range wireless transmitter, and
c. transmitting the current position of the location tracker to the remote control and monitoring system via a mobile communications device within short-range wireless communication range.

In embodiments, the control system of the low power consuming location tracker is configured to, upon expiration of a timer of the location tracker indicating that no short-range wireless response was received for a certain pre-defined period, perform the action of:

a. transmitting the current position of the location tracker to the remote control and monitoring system via the cellular radio communications network.

In embodiments, the control system of the low power consuming location tracker is configured to, upon expiration of a timer of the location tracker indicating that no short-range wireless response was received for a certain pre-defined period, perform the action of:

a. turning on the cellular radio communications transmitter of the location tracker, and
b. transmitting the current position of the location tracker to the remote control and monitoring system via the cellular radio communications network.

In embodiments, the control system of the low power consuming location tracker is configured to, upon expiration of a timer of the location tracker indicating that no short-range wireless response was received for a certain period, perform the actions of:

a. turning on the GNSS receiver of the location tracker to obtain the current position of the location tracker;
b. turning on the cellular radio communications transmitter of the location tracker, and
c. transmitting the obtained current position of the location tracker to the remote control and monitoring system via the cellular radio communications network.

In embodiments, the control system of the low power consuming location tracker is further configured to, upon expiration of a timer of the location tracker indicating that no short-range wireless response was received for a certain period and/or in response to a token or identification data in a received short-range wireless response, perform at least one of the actions of:

a. turning on the cellular radio communications transmitter for transmitting at least one of obtained position data and movement status data to the remote control and monitoring system via the cellular radio communications network, and
b. turning on at least one of the GNSS receiver (to obtain the current position of the location tracker) and the short-range wireless transmitter and then transmitting the current position of the location tracker to the

remote control and monitoring system via a mobile communications device within short-range wireless communication range.

In embodiments, the control system of the low power consuming location tracker is further configured to at least one of turning on the cellular radio communications transmitter and turning on at least one of the short-range wireless transmitter and the GNSS receiver in response to at least one of not receiving any response from any device within short-range wireless communication range over a certain period, e.g. a pre-defined period.

In certain embodiments, the decision by the control system/unit to turn on the cellular radio communications transmitter and/or at least one of the short-range wireless transmitter and the GNSS receiver of the location tracker is at least partly based on obtained sensor data indicating an acceleration beyond a certain threshold and/or indicating a certain changed movement pattern for the location tracker, where the obtained sensor data is based on sensor data detected by the movement sensor, e.g. an accelerometer.

In embodiments, the decision by the control system/unit of the low power consuming location tracker to turn on the cellular radio communications transmitters to transmit data to a remote control and monitoring system/node and/or turn on at least one of the short-range wireless transmitter and the GNSS receiver is triggered upon expiration of a timer of the location tracker and is at least partly based on a short-range wireless response from a mobile communications device, where a token or other identification data in the response is indicating that the response was not sent by a known mobile communications device trusted by, or associated with, the location tracker.

In embodiments, the control system/unit of the low power consuming location tracker is further configured to transmit data via a cellular radio communications transmitters or turn on at least one of the short-range wireless transmitter and the GNSS receiver at least partly based on the receiving of a short-range wireless response from a mobile communications device, where a token or other identification data in the response is indicating that the response was not sent by a known mobile communications device trusted by or associated with the location tracker.

In embodiments, the above low power consuming location tracker is further configured to send at least one of position data and accelerometer to a remote control and monitoring system via an unknown and/or untrusted mobile communications device within short-range wireless communication range.

In embodiments, the control system of the low power consuming location tracker is configured to obtain sensor data from its movement sensor, e.g. an accelerometer, and change the operations of the location tracker at least partly based on the obtained sensor data indicating at least one of an acceleration beyond a certain threshold and a certain changed movement pattern for the location tracker. The change of operations may then include at least one of turning on at least one transmitter or receiver in the location tracker and changing the frequency for how often a transmitter or receiver in the location tracker is turned on. In embodiments, the control system is configured to use the sensor data obtained from the movement sensor for making decisions whether to change how often at least one of the GNSS receiver, the cellular radio communications transmitter and the cellular radio communications transmitter of the location tracker is turned on.

In embodiments, the low power consuming location tracker is configured to receive status data from a mobile communications device via short-range wireless communication. The status data received from mobile communications device may then include data related to at least one of positioning data and movement data for the location tracker. The control system of the location tracker may be configured to use the status data received from the mobile communications device for controlling the operations of the location tracker, e.g. turning on at least one transmitter or receiver in the location tracker and/or changing the frequency for how often a transmitter or receiver in the location tracker is turned on.

In embodiments, the short-range wireless receiver of the low power consuming location tracker is configured to receive, from a mobile communications device, data defining a future time slot and/or series of time cycles during which the cellular radio communications receiver is turned on to receive data from a remote control and monitoring system, e.g. a backend system, via the cellular radio communications network. The control system may then be configured to turn on the cellular radio communications receiver at the beginning of the time slot and/or series of time cycles defined by the received data and turn off the cellular radio communications receiver after the time slot and/or series of time cycles for receiving data from the remote control and monitoring system have lapsed.

In embodiments, the control system of the low power consuming location tracker is configured to turn on its GNSS receiver between 1 and 10 times over a period of 4 hours when the location tracker is in its most extreme battery conserving mode.

In embodiments, the low power consuming location tracker may be configured to be in an extremely low power state among a plurality of possible low power states. In certain embodiments and without first receiving data from a mobile communications device defining a future time slot, the location tracker may then be configured to transmit at least one of position data and movement status data to a backend location tracker system via the cellular radio communications network. In certain specific embodiments, the location tracker may be configured to transmit at least one of position data and movement status data between 1 and 20 times over a period of 96 hours, e.g. the number of transmissions over a certain period may be fixed so long as the location tracker is in an extremely low power state.

In embodiments, the technology disclosed relates to an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities, where the application program has computer program code portions adapted to control the mobile communications device to:

i. communicate with location trackers via short-range wireless communication, e.g. via Bluetooth; and
ii. communicate with a backend location tracker system via at least one of a wideband cellular radio communications network, a wireless local network and/or the internet.

In certain embodiments, the cellular mobile communications may be configured to store, e.g. temporarily store data related to the position data associated with the location trackers.

In embodiments, the technology disclosed relates to a low power consuming location tracker system comprising:

a. at least one portable location tracker comprising a control system and a movement sensor, e.g. an accelerometer;
b. a remote control and monitoring system, e.g. a backend location tracker system, configured to communicate both with the at least one portable location tracker via a cellular radio communications network and communicate with a cellular mobile communications device;
c. an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities.

The portable location trackers of the above low power consuming location tracker system may be configured to at least one of communicating with a remote control and monitoring system, e.g. a backend system, via a cellular radio communications network and communicating with a cellular mobile communications device via short-range wireless communication.

The remote control and monitoring system of the above low power consuming location tracker system may be configured to at least one of communicating with the portable location tracker via a cellular radio communications network and communicating with a cellular mobile communications device via a cellular radio communications network. The remote control and monitoring system may also be configured to store data related to the position data associated with a plurality of portable location trackers.

The application program may have computer program code portions adapted to control the mobile communications device to at least one of communicating with portable location trackers via short-range wireless communication and communicating with the remote control and monitoring system via at least one of a wideband cellular radio communications network, a wireless network and/or the internet. These code portions may also be adapted to control the mobile communications device to store data related to the position data associated with the portable location trackers.

In embodiments, the above low power consuming location tracker system may be configured to control so that a portable location tracker and the remote control and monitoring system communicate with each other via a cellular radio communications network when there is no mobile communications device available for short-range communication with the at least one portable location tracker.

In embodiments, the at least one portable location tracker and the remote control and monitoring system of the above low power consuming location tracker system may be configured to communicate with each other via a cellular radio communications network when there is no mobile communications device available for short-range communication with the at least one portable location tracker.

In embodiments, the portable location tracker(s) and the remote control and monitoring system of the above low power consuming location tracker system may be configured to communicate with each other via a cellular narrow band radio communications network.

In embodiments, the technology disclosed relates to a low power consuming location tracker system, where the system comprises:

a. a portable location tracker comprising a control system and a movement sensor, e.g. an accelerometer, the portable location tracker is configured to:
    i. communicate with a remote control and monitoring system, e.g. a backend system, via a cellular radio communications network;
    ii. communicate with a cellular mobile communications device via short-range wireless communication, e.g. Bluetooth;
b. a remote control and monitoring system, e.g. a backend location tracker system, configured to:
    i. communicate with the portable location tracker via a cellular radio communications network;
    ii. communicate with a cellular mobile communications device via at least one of a wideband cellular radio communications network, a wireless local network and/or the internet; and
    iii. storing data related to the position data associated with the portable location tracker;
c. an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities, the application program having computer program code portions adapted to control the mobile communications device to:
    i. communicate with the portable location tracker via short-range wireless communication; and
    ii. communicate with the backend location tracker system via a cellular radio communications network, and

The mobile communications device comprising the application program may then be configured to store data related to the position data associated with the portable location tracker.

In embodiments, the portable location tracker(s) and the remote control and monitoring system of the above low power consuming location tracker system are configured to communicate with each other via a cellular narrow band radio communications network.

## BRIEF DESCRIPTION OF DRAWINGS

Preferred embodiments of a location tracker system according to the technology disclosed will be described more in detail below with reference to the accompanying drawings wherein:

FIG. 1 illustrates a location tracking system according to embodiments of the technology disclosed.

FIG. 2 illustrates an example location tracking system and communication interfaces according to embodiments of the technology disclosed.

FIG. 3 illustrates an example location tracking system and communication interfaces according to embodiments of the technology disclosed.

## DETAILED DESCRIPTION

In the drawings, similar details are denoted with the same reference number throughout the different embodiments. In the various embodiments of the location tracker system according to the technology disclosed, the different subsystems are denoted. The “boxes”/subsystems shown in the drawings are by way of example only and can within the scope of the technology disclosed be arranged in any other way or combination.

In the drawings, similar details are denoted with the same reference number throughout the different embodiments.

Bluetooth is a short-range wireless technology standard that allows data to be exchanged between fixed and mobile devices. The technology uses short wavelength radio waves from 2.4 to 2.485 GHz. Unlike other forms of connectivity such as wi-fi or 4G, Bluetooth carries connections between devices and other devices as opposed to carrying data to and from the internet.

BLE stands for Bluetooth Low Energy and is a form of wireless communication designed especially for short-range communication. BLE is very similar to Wi-Fi in the sense that it allows devices to communicate with each other. However, BLE is meant for situations where battery life is preferred over high data transfer speeds. The amount of data you need to transfer to a visitor’s smartphone is extremely small, hence BLE compatible beacons do the job quickly without

draining the battery. Most mobile communications device of today are BLE compatible, which means they can seamlessly communicate with Bluetooth enabled location trackers.

BLE data transfer is essentially a one-way communication. A BLE beacon trying to communicate with a smartphone in close proximity transmits Bluetooth Low Energy beacon broadcasts packets of data at regular intervals of time. These data packets are detected by app/pre-installed services on smartphones nearby. This BLE communication may trigger actions such as, pushing a message or promoting a mobile application (APP).

Bluetooth beacons are hardware transmitters - a class of Bluetooth low energy (LE) devices that broadcast their identifier to nearby portable electronic devices. The technology enables smartphones, tablets and other devices to perform actions when in close proximity to a beacon.

Bluetooth beacons use Bluetooth low energy proximity sensing to transmit a universally unique identifier picked up by a compatible mobile application (APP) or operating system. The identifier and several bytes sent with it can be used to determine the device's physical location, track customers, or trigger a location-based action on the device such as a check-in on social media or a push notification.

Examples of Bluetooth beacons for BLE data transfer used as the short-range transmission, or communication, according to example embodiments of the technology disclosed may include fast beacon detection for Androids and iBeacon technology. Due to typically use cases or applications for these types of BLE transmissions, the BLE data transfer or transmission may also be referred to as a short-range wireless low energy advertisement transmission sending out a short-range wireless low energy advertisement signal.

iBeacon-compatible hardware transmitters, typically called beacons, are a class of Bluetooth low energy (BLE) devices that broadcast their identifier to nearby portable electronic devices. The technology enables smartphones, tablets and other devices to perform actions when in close proximity to an iBeacon.

iBeacon is based on Bluetooth low energy proximity sensing by transmitting a universally unique identifier picked up by a compatible app or operating system. The identifier and several bytes sent with it can be used to determine the device's physical location, track customers, or trigger a location-based action on the device.

The frequency of the iBeacon transmissions depends on the configuration of the iBeacon and can be altered using device specific methods. Both the rate and the transmit power have an effect on the iBeacon battery life.

A low-power wide-area network (LPWAN) or low-power wide-area (LPWA) network or low-power network (LPN) is a type of wireless telecommunication wide area network designed to allow long range communications at a low bit rate among things (connected objects), such as sensors operated on a battery. The low power, low bit rate and intended use distinguish this type of network from a wireless WAN that is designed to connect users or businesses, and carry more data, using more power.

Narrowband IoT (NB-IoT) is a Low Power Wide Area Network (LPWAN) radio technology standard developed by 3GPP to enable a wide range of cellular devices and services. NB-IoT focuses specifically on indoor coverage, low cost, long battery life, and high connection density.

SigFox is a narrowband (or ultra-narrowband) technology. It uses a standard radio transmission method called binary phase-shift keying (BPSK), and it takes very narrow chunks of spectrum and changes the phase of the carrier radio wave to encode the data. This allows the receiver to only listen in a tiny slice of spectrum, which mitigates the effect of noise. It requires an inexpensive endpoint radio and a more sophisticated base station to manage the network.

SigFox communication tends to be better if it's headed up from the endpoint to the base station. It has bidirectional functionality, but its capacity going from the base station back to the endpoint is constrained, and you'll have less link budget going down than going up. This is because the receiver sensitivity on the endpoint is not as good as on the expensive base station.

LoRa (Long Range) is a digital wireless data communication technology. LoRa uses license-free sub-gigahertz radio frequencyy bands like 169 MHz, 433 MHz, 868 MHz (Europe) and 915 MHz (North America). LoRa enables very-long-range transmissions (more than 10 km in rural areas) with low power consumption. The technology is presented in two parts — LoRa, the physical layerr and LoRaWAN (Long Range Wide Area Network), the upper layers.

LoRaWAN looks at a wider amount of spectrum than SigFox (and thus gets more interference). However, because it's looking for a very specific type of communication, the elevate noise due to a larger receiver bandwidth is mitigated by the coding gains. Practical link budgets are about the same for SigFox and LoRaWAN.

Unlike SigFox, both the endpoint and the basestation are relatively inexpensive with LoRa-enabled devices. This is primarily because you can use the same radio for a receiver on the

basestation and at the endpoint. While the LoRaWAN base station tends to be more expensive than the endpoint, it's inexpensive in comparison to a SigFox base station.

LoRa and LoRaWAN permit inexpensive, long-range connectivity for Internet of Things (IoT) devices in rural, remote and offshore industries. They are typically used in mining, natural resource management, renewable energy, transcontinental logistics, and supply chain management.

Geofencing is a technology that defines a virtual boundary around a real-world geographical area. In doing so, a radius of interest is established that can trigger an action in a geo-enabled phone or other portable electronic device. The term "geofencing" refers to a technology that uses GPS coordinates or RFID signals to draw a virtual boundary in space and to trigger certain actions on the basis of this boundary. This virtual border is called a geofence, which is a portmanteau word made up of geographic and fence. The actions that are triggered by the user when a geofence is crossed can result in the sending of push messages, emails, SMS or in more complex applications, which sometimes include programming instructions.

Both objects and persons can be located within a geofence. If a receiver device such as a smartphone or a microchip in a car is within the range of a predefined geofence, subsequent actions are triggered by the exchange of signals between the receiver and the transmitter. The receiver receives a message, for example, that special offers are submitted to him or that the car with the microchip is not allowed to cross the national boundaries.

Geofencing is technically based on a GPS system, but can also be implemented using RFID chips and M2M communication. It is commonly assumed that geofencing will be an important technology for the Internet of Things. The technology is already being used in mobile marketing. Geofencing is used in a wide variety of areas to manage administrative tasks, supplement marketing, or to check security-relevant aspects. In principle, such systems work like positioning and navigation systems. The difference is in the boundary coordinates, which enclose a specific area in the shape of a rectangle or circle and function as a geofilter. This virtual positioning is known from vehicle location by GPS. By distinguishing between the inside and the outside of a precisely defined area, it is possible to trigger actions on entering or exiting from this defined area.

An accelerometer, is a device that measures proper acceleration. Proper acceleration, being the acceleration (or rate of change of velocity) of a body in its own instantaneous rest frame, is not the same as coordinate acceleration, being the acceleration in a fixed coordinate system.

Those skilled in the art will recognize that the accelerometer has been used in the past as an energy conservation tool, reducing the number of transmissions when the location tracker is not moving. What is not shown in the prior art is a location tracker that will factor the accelerometer state into the decision of whether to perform any of the battery power consuming actions of turning on its GPS receiver to receive its position data and/or turn on at least one of its cellular radio communications transmitter and its short-range wireless transmitter to transmit a signal including position data for the location tracker. Imagine a case where the location tracker is in an extremely low power consuming state because it believes not to be within short-range wireless communication range with a mobile communications device that is trusted by or associated with the location tracker, and a token or data in a short-range wireless response received by the location tracker identifies a mobile communications device within short-range communication range with the location tracker which is not associated with or trusted by the location tracker. If the accelerometer of the location tracker then shows certain movement, e.g. shows an acceleration beyond a certain threshold and/or a certain changed movement pattern for the location tracker, the control system/unit of the location tracker may be configured to decide that the location tracker needs to turn on its GPS receiver to take its position and/or turn on its cellular radio communications transmitter to transmit data identifying the untrusted mobile communications device to a remote control and monitoring system, e.g. a backend location tracker system.

According to certain aspects of the technology disclosed, the remote control and monitoring system may then notify, in response to the received data identifying the untrusted mobile communications device, the mobile application program (APP) or the operating system of a mobile communications device trusted by, or associated with, the portable location tracker, e.g. via a radio communications network. The remote control and monitoring system may thus notify the trusted mobile communications device in response to receiving a message from the location tracker. In different embodiments, the notification may include at least one of information or data about the movement status, e.g. accelerometer data and/or position data, for the portable location tracker, and information or data about an unknown and/or untrusted mobile communications device from which the portable location tracker received a short-range wireless response. The notified mobile communications device which is trusted by, or associated with, the portable location tracker is then a different mobile communications device from the unknown and/or untrusted mobile communications device relaying the message from the portable location tracker to the remote control and monitoring system.

A portable location tracker device may rely on a power source, such as a battery, in order to function. Once the battery is depleted, the portable location tracker may cease to operate until

the battery is recharged or replaced. In embodiments of the technology disclosed and in order to preserve battery power, the portable location tracker may periodically enter into battery conservation mode, which may include a sleep mode, a Power Save Mode (PSM), etc. Since location services and other types of network services often require a significant amount of power, a battery conservation mode may be directed at limiting communications between the portable location tracker and external networks (as opposed to, for example, processes that are completely internal to the IoT device).

As mentioned in the background part, the portable location trackers and systems of today are consuming too much energy and are not optimised for any of the use cases, or combination of use cases, when the object-to-track (i) is often changing its position, (ii) have no access to external power, (iii) require a small tracker and (iv) cannot bear a too high cost for the tracking. The problem will be partly addressed by the introduction of new cellular narrow band radio techniques (like NB-IoT, SigFox or LoRa), but well-defined methods and/or capabilities in the form of e.g. communication capabilities and movement sensors, for further optimisation of the four areas defined above is needed.

Some of the location trackers known in the art require to be within short-range communication range with a known/trusted or associated user device, e.g. a mobile communications device, to periodically report their current positions. However, these location trackers are not adapted for situations or use cases when the location tracker often is not within short-range communication range with a known/trusted or associated mobile communications device but is only within short-range communication range with an unknown or untrusted user device. In these situations, or use cases, the monitoring of the movements of the portable location tracker, e.g. the knowledge about the current location and/or a changed movement pattern for the portable location tracker, may still be of high importance to the owner of the location tracker and/or a user of a known/trusted user device, e.g. in situations or use cases where the movements or movement pattern of the object to which a portable location tracker is attached is important to the owner of the portable location tracker and/or user of a known/trusted or associated user device.

The location tracker system and portable location trackers of the technology disclosed take advantage of both mobile communications devices with their positioning skills and communication capabilities and a remote control and monitoring system, e.g. a backend system, for making decisions. The bidirectional communication between the mobile communications device and the tracker allows the tracker to receive messages to make the tracker aware of its own status and the mobile communications device it is communicating with. Similarly, the

tracker of the technology disclosed may also be configured to communicate directly with a remote control and monitoring system via the cellular radio communications network. The technology disclosed enables the owner of the tracker and the remote control and monitoring system to communicate with the tracker also when the tracker is outside short-range wireless communication range with a mobile communication device. In this way, the tracker may use the remote control and monitoring system as an intermediate hub, or middle man, for conveying information about the status of the tracker to the owner of the tracker, e.g. by providing position data and movement status data that is presented on a mobile app and/or the display of the owner's mobile communications device. The identity of the tracker may be linked to its owner's mobile communications device in a database of the remote control and monitoring system, which enables that the owner of the tracker is provided with information about the status and positioning of the tracker also when the tracker is outside short-range wireless communication range with a mobile communication device. The above capabilities make the system and portable location tracker of the technology disclosed not only optimized for different use cases, but also more power effective and reliable than state of the art trackers relying on just one of these systems separately.

In other words, the technology disclosed describes methods, capabilities and a combination of modes of communication, which are adapted for providing optimized and faster responses and decisions yet consuming little battery life for the trackers. In conclusion, the system and portable location trackers of the technology disclosed becomes much more useful for different applications on less battery power.

In embodiments, the technology disclosed relates to a method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;
b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range;
c. obtaining, by a GNSS receiver of said portable location tracker, position data for the portable location tracker, and
d. upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range or that no mobile

communications device which is trusted by, or associated with, the portable location tracker is within short-range wireless communication range:

e. turning on, by the control system of the portable location tracker, a cellular radio communications transmitter of the portable location tracker, and

f. transmitting, via a cellular radio communications network to a remote control and monitoring system, a signal including said obtained position data and/or data identifying said portable location tracker.

According to the present invention, the portable location tracker itself is configured to control which communication capabilities it will turn on and use for communicating with the remote control and monitoring system, e.g. use for providing the remote control and monitoring system with status update information about the whereabouts of the portable location tracker such as movement status data and position data.

The technical effects of the present invention of configuring the control system of the portable location tracker to control when to turn on the transmitters and receivers of the portable location tracker include that the portable location tracker may use less power/energy-consuming short-range wireless communication such as BLE when there is a mobile communication device within short-range wireless communication range, but still be able to communicate via a cellular radio communications network, e.g. with a remote control and monitoring system, when the portable location tracker itself has identified that there is no mobile communications device within short-range wireless communication range.

Since the control system is configured to switch between which available communication capabilities is turned on and used for communication by turning on the cellular radio communications transmitter when there is no mobile communications device, or no trusted or associated mobile communications device, within short-range wireless communication range, the present invention provides an energy/power effective portable location tracker which both saves battery life and is configured to always be in communication from time to time with a remote control and monitoring system, including at instances when the tracker is located outside short-range wireless communication range for a longer period of time. As an example, the remote control and monitoring system may receive data/information from a portable location tracker which is outside short-range wireless communication range where the data/information received may indicate that the portable location tracker is accelerating/moving and/or has a changed movement pattern.

Furthermore, the portable location tracker of the present invention may not only be optimized for different use cases, but it is also more reliable than state of the art trackers relying on just one of these communication capabilities separately. In the event the expiration of a timer is indicating that the tracker is outside short-range wireless communication range and position data and/or accelerometer data obtained by the tracker is indicating that the tracker is moving, the remote control and monitoring system may inform the owner of the tracker about the status of the tracker via the cellular radio communications network. As an example, a bicycle, boat or animal which is physically connected to or associated with the portable location tracker, the remote control and monitoring system may inform the owner of the tracker via the cellular radio communication network that the bicycle, boat or animal appears to be moving even though the tracker is outside short-range wireless communication range, i.e. the owner of the product/tracker is informed about that the risk that the product or animal is stolen or lost.

In spite of being in its deepest sleep mode or an extremely low power state, the tracker will always be communicable in that it will have a communicate interface both with a mobile communications device within short-range communication, e.g. Bluetooth range, and directly via a cellular radio communications network to the remote control and monitoring system/node, e.g. via a cellular narrowband radio communications network using low power cellular narrowband radio techniques like NB-IoT, SigFox or LoRa. The location tracker system of the technology disclosed thereby provides a low power-consuming solution that in addition is reliable and robust in that the remote control and monitoring system may always communicate with the trackers and convey information such as position and movement status data between the trackers and their respective owners.

Even though cellular narrowband radio techniques like NB-IoT, SigFox or LoRa were developed for low power applications, it is still more power consuming to communicate using these cellular narrowband radio techniques than via short-range wireless communication like Bluetooth low energy (BLE) proximity sensing. The system and location tracker of the technology disclosed are configured to uses the cellular radio communication interface as rarely as possible. However, introducing the capabilities of cellular radio communication into the tracker makes sure that the tracker is never invisible to the remote control and monitoring system. The second most power consuming way for the tracker to find out its position is with the built-in GNSS/GPS receiver. Therefore, the tracker of the technology disclosed always tries to get its position from an external source as often as possible and if there is no movement or acceleration detected by movements sensor, e.g. accelerometer, of the tracker, the remote control and monitoring system

and/or control system of the tracker assesses that it is unlikely that the tracker has a new position or has changed its movement pattern.

Bringing a lifetime through short-range wireless communication like Bluetooth low energy (BLE) proximity sensing is not as power/battery consuming, why the tracker of the technology disclosed uses short-range wireless communication like BLE far more often than the tracker is using its cellular radio communications capabilities or its built-in GNSS/GPS receiver to take its position. According to technology disclosed, a mobile communications device within short-range wireless range may capture a signal from the tracker by identifying the universally unique identifier (UID) of the tracker and the notify the remote control and monitoring system that it has recognized the tracker. In the notification to remote control and monitoring system, the mobile communications device may also include position and/or status data for the tracker. The mobile communications devices will also send a response signal back to the tracker so that the control system of the tracker is aware of that there has been a mobile communications device that captured the short-range wireless communications signal. All in all, these increase the system and the tracker's own awareness of the status of the tracker and its environment. The location tracker system and the control system of the trackers of the technology disclosed take advantage of this awareness in providing a solution that is extremely low power-consuming and fast solution in that the tracker most of the time is using the communication and positioning capabilities of a mobile communications device within short-range wireless communication range for providing the remote control and monitoring system with information about the position and status of the tracker. The positioning capabilities of the mobile communications device to take its position, and the position of a nearby tracker, may include a GNSS/GPS receiver and/or cellular-based positioning technology. The location tracker system is robust and reliable also when the trackers are outside short-range communication range by providing the trackers themselves with cellular radio communications capabilities and a built-in GNSS/GPS receiver to take its own position.

Using iBeacon as the short-range wireless communication technology used in connection with the technology disclosed puts a limit on how much data you can send so the nature of the use case and the requirements on battery consumption may decide what information in addition to the beyond the MAC address and the universally unique identifier (UID) that is included in the iBeacon signal, e.g. whether position data (e.g. input from the tracker's GPS receiver) and movement sensor data (e.g. input from the tracker's accelerometer) are included in the iBeacon signal.

The short-range wireless transmitter of the location tracker of the technology disclosed may periodically or frequently, e.g. at least 4 times every minute, transmit a signal, e.g. a short-range wireless low energy advertisement signal, including a token or data identifying the location tracker. The short-range wireless low energy advertisement signal, e.g. an iBeacon signal, may in addition comprise at least one of position data and movement status data for the location tracker where the movement status data is based on sensor data detected by a movement sensor of the location tracker, e.g. an accelerometer.

The short-range wireless receiver of the location tracker of the technology disclosed may then be periodically or frequently be turned on to be listening for a short-range wireless response from a user device, e.g. a mobile communications device, within short-range wireless communication range. A token or other identification data in a received in a short-range wireless response may indicate whether a short-range wireless response was sent from a mobile communications device trusted by, or associated with, the location tracker or whether the short-range wireless response was sent from a mobile communications device not associated with the location tracker, e.g. an unknown or untrusted mobile communications device.

The control system of the location tracker according to the technology disclosed may be configured to at least one of turn on he cellular radio communications transmitter and at least one of the short-range wireless transmitter and the GNSS receiver in response to a combination of the expiration of a timer of the location indicating that no short-range wireless response from any mobile communications device was received over a certain period of time, e.g. a pre-determined period, and the obtaining of sensor data, e.g. sensor data indicating an acceleration beyond a certain threshold and/or indicating a certain changed movement pattern for the location tracker. The obtained sensor data may then be sensor data detected by the movement sensor of the location tracker, e.g. an accelerometer. The input from the movement sensor based on sensor data indicating an acceleration beyond a certain threshold value and/or a certain changed movement pattern for the location tracker may then trigger the control system to turn on the cellular radio communications transmitter.

The control system of the location tracker according to the technology disclosed may be configured to at least one of turn on the cellular radio communications transmitter and turn of the GNSS receiver in response to at least one of, or a combination of, not receiving any response from any device, e.g. a mobile communications device, within short-range wireless communication range over a certain period of the, e.g. a pre-determined period, and the obtaining of sensor data, e.g. sensor data indicating an acceleration beyond a certain threshold and/or indicating a certain changed movement pattern for the location tracker, where the

obtained sensor data is based on sensor data detected by a movement sensor of the location tracker, e.g. an accelerometer.

The control system of the location tracker according to the technology disclosed may be configured to at least one of turn on the cellular radio communications transmitter and at least one of the short-range wireless transmitter and the GNSS receiver in response to a combination of the expiration of a timer of the location indicating that no short-range wireless response from any trusted or known/friendly mobile communications device was received over a certain period of time, e.g. a pre-determined period, and the obtaining of sensor data, e.g. sensor data indicating an acceleration beyond a certain threshold and/or indicating a certain changed movement pattern for the location tracker. The obtained sensor data may then be sensor data detected by the movement sensor of the location tracker, e.g. an accelerometer. The input from the movement sensor based on sensor data indicating an acceleration beyond a certain threshold value and/or a certain changed movement pattern for the location tracker may then trigger the control system to turn on the cellular radio communications transmitter. In this embodiment, the location tracker may receive short-range wireless response(s) from an untrusted or unauthorized user device, e.g. an untrusted or unauthorized mobile communications device during the pre-determined period.

The control system of the location tracker according to the technology disclosed may be configured to turn on the cellular radio communications transmitter and/or turn on of at least one of the short-range wireless transmitter and the GNSS receiver at least partly based on the receiving of a short-range wireless response from a mobile communications device, where a token or other identification data in the response is indicating that the response was not sent by a mobile communications device trusted by, or associated with, the location tracker. The location tracker may then send at least one of position data and movement sensor data to a remote control and monitoring system via an unknown and/or untrusted mobile communications device within short-range wireless communication range.

The control system of the location tracker according to certain embodiments of the technology disclosed may be configured to obtain sensor data from a movement sensor of the location tracker, e.g. in form of an accelerometer. A change of mode or state for the location tracker may then be at least partly based on the obtained sensor data indicating at least one of an acceleration beyond a certain threshold and a certain changed movement pattern for the location tracker. The changed mode or state of the location tracker may then include at least one of the actions of turning on at least one transmitter and/or receiver of the location tracker and

changing the frequency for how often a transmitter and/or receiver in the location tracker is turned on.

The control system may be configured to use sensor data obtained from the movement sensor for making decisions whether to change how often at least one of the GNSS receiver, the cellular radio communications transmitter and the cellular radio communications transmitter is turned on.

In embodiments, the location tracker is configured to be in two-way short-range communication with a mobile communications device to receive instruction data and/or status data via short-range wireless communication. The control system may then be further configured to use the instruction data and/or status data received from the mobile communications device for controlling the operations of the location tracker, e.g. for changing the mode or state of the location tracker. As an example, the control system may be configured to use instructions or status data received from the mobile communications device for making decisions whether to change how often at least one of the GNSS receiver, the cellular radio communications transmitter and the cellular radio communications transmitter is turned on. The status data may then include data related to at least one of position data for the location tracker and movement status data for the location tracker, e.g. indicating a changed movement pattern for the location tracker.

The location tracker according to certain embodiments of the technology disclosed may be configured to perform two-way communication with a remote control and monitoring system in form of a backend location tracker system via a cellular radio communications network when there is no mobile communications device available for short-range communication.

In embodiments, the location tracker of the technology disclosed may be configured to receive, via short-range communication with a mobile communications device, data defining a future time slot and/or series of time cycles during which the cellular radio communications receiver of the location tracker is turned on to receive data from a backend location tracker system via a cellular radio communications network, e.g. such as a cellular narrowband radio communications network using low power cellular narrowband radio techniques like NB-IoT, SigFox or LoRa. In certain embodiments, the control system is configured to turn on the cellular radio communications receiver at the beginning of the time slot and/or series of time cycles defined by the received data and turn off the cellular radio communications receiver after the

time slot and/or series of time cycles for receiving data from the remote control and monitoring system has lapsed.

In certain embodiments of the technology disclosed and when the location tracker is in an extremely low power state among a plurality of possible low power states, the control system may be configured to increase the frequency of how often the G NSS receiver is turned on and is active in receiving position data from the global navigation satellite system. The decision by the control system to increase the frequency may then be at least partly based on the movements of the location tracker detected by the movement sensor. The location tracker then enters another low power state which is less battery conserving than the extremely low power state.

In certain embodiments and when the location tracker is in an extremely low power state, among a plurality of possible low power states, the short-range wireless transmitter may be configured to wirelessly transmit data between 1 and 40 times over a time period of 10 seconds. At least one of the transmissions over the time period of 10 seconds may then include at least one of position data and movements status data for the location tracker.

In certain applications and when the location tracker is in an extremely low power state, among a plurality of possible low power states, the control system may be configured to turn on the GNSS receiver to take the location tracker's current position at an interval which is less than four times over a time period of 4 hours.

In certain applications and when the location tracker is in an extremely low power state, among a plurality of possible low power states, the control system may be configured to turn on the GNSS receiver to take the location tracker's current position at an interval which is less than three times over a time period of 48 hours.

In certain applications and when the location tracker is in an extremely low power state, among a plurality of possible low power states, and without first receiving from a mobile communications device data defining a future time slot, the location tracker may be configured to transmit at least one of position data and movement status data for the location tracker to a remote control and monitoring system, e.g. a backend location tracker system, via the cellular radio communications network. In embodiments, the cellular radio communication transmitter of the location tracker may be configured to transmit at least one of position data and movement status data to the remote control and monitoring system at an interval between 1 and 20 times over a time period of 96 hours.

FIG. 1 illustrates a location tracking system 101 according to embodiments of the technology disclosed. The location tracking system 101 in FIG. 1 comprises a portable location tracker 102, a mobile communications device 103, a frontend system 106 and a backend system 104. The mobile communications device 103 comprises at least one mobile application (APP) which may be activated by the user and may relate to at least one use case 107a, 107b, 107c, or application, among a plurality of applications 107 handled by the backend system 104.

The unique identity of the portable location tracker 102 may be linked to the unique identity of the mobile communications device 103. The backend system 104 comprises a database 105 in which the unique identity, e.g. a unique identifier or UID, of each of a plurality of portable location trackers is linked to, or associated with, at least one unique identity, or UID, of a trusted or known mobile communications device.

A number of applications and/or use cases 107a, 107b, 107c, corresponding to the applications and use cases run by the mobile application (APP) of the mobile communications device, are handled by the backend system. The thick arrow 108 in FIG. 1 illustrates that an association between a portable location tracker 102 and a (trusted) mobile communications device 103 may be registered in the database 105 of the backend system 104. The thick arrow 108 also illustrates that position data and/or movement status data, e.g. the movement pattern, for each of the portable location tracker 102 may be stored and updated in the database 105 of the backend system 104.

Once the user has registered an account, the application (APP) in the mobile communications device 103 is connected to the user and is then also used for communicating with the user about the current positioning, whereabouts and statuses of the portable location tracker 102. This is regarded the frontend system/solution 106 of the location tracker system 101. The online purchasing (web shop) and the company web page may be loosely connected to the backend system 104 whereas the adminweb and the end user account page, which gives similar information as the mobile applications, is more integrated but nevertheless regarded as the frontend system 106.

FIG. 2 illustrates an example location tracking system and communication interfaces according to embodiments of the technology disclosed. The portable location tracker 202 according to embodiments of the technology disclosed, and which is illustrated in FIG.2, is configured to use short-range wireless communication 208 for communicating with a mobile communications

device 203 and use cellular radio communication 209 for communicating with a remote control and monitoring system 204, i.e. the backend system 204. The portable location tracker 202 in FIG. 2 continuously receives its current position from a satellite 210 of a global navigation satellite system 211. In the embodiment illustrated in FIG. 2, the portable location tracker 202 is communicating with the remote control and monitoring system 204 via a base station 212 of a narrowband radio communications network 213 and the mobile communications device 202 is communicating with the remote control and monitoring system 204 via a base station 214 of a wideband radio communications network 215 and/or the internet 216.

FIG. 3 illustrates an example location tracking system and communication interfaces according to embodiments of the technology disclosed. The portable location tracker 302 according to embodiments of the technology disclosed, and which is illustrated in FIG.3, is configured to use both short-range wireless communication 308 for communicating with a plurality of mobile communications devices 303 and cellular radio communication 317 with the base stations 318 of a cellular radio network 319, e.g. a narrowband radio communications network 319.

The backend system shown in FIGS. 1 and 2 is configured to communicate both with the mobile communications device and the portable location tracker. The backend system, or remote control and monitoring system, typically comprises a database in which the unique identity, e.g. a unique identifier or UID, of each of a plurality of portable location trackers is linked to, or associated with, at least one unique identity, or UID, of a trusted or known mobile communications device. The backend system including the database may also be configured to receive position data from at least one of the mobile communications devices and the portable location trackers to store and update position information, e.g. positions obtained from a GPS or via cellular triangulation, for each of a plurality of portable location trackers registered in the database. The backend system and its database may thus be configured to store and update the tracker's physical location, but may also be configured to trigger an action on the mobile communications devices via push notifications. In embodiments, the remote control and monitoring system, or backend system, is configured to receive a message comprising at least one of position data and movement status data for the portable location tracker and, in response to receiving the at least one of position data and movement status data for the portable location tracker, notifying a mobile application of a mobile communications device. This notification may be a push notification and may or may not trigger and action on the mobile communications device such as presenting display data, e.g. in the mobile application (APP) of the mobile communications device. The action on the mobile communication device may be handled by the mobile application program (APP) or the operating system of the mobile communications

device. The mobile application program (APP) of the mobile communications device according to the technology disclosed may be configured to receive a notification, e.g. a push notification or message, from the remote control and monitoring system, or backend system, and may further be configured to perform certain tasks or actions, e.g. presenting or changing display data, in response to receiving the notification from the remote control and monitoring system.

The location tracker system and methods of the technology disclosed define how the backend system, the mobile communications device and portable location trackers are interworking and communicating to optimize the power consumption for a specific use case. The centralized backend system, or remote control and monitoring system, will frequently collect data from the portable location trackers and the physical components and perform calculations and logical decisions, presenting it to the users through the mobile application (APP). In embodiments, the backend system/solution may be configured to optimize and control the performance of the portable location trackers (and/or the mobile communications devices) and calibrate the state and parameters for these devices so that the short-range wireless communication and cellular communication capabilities of these devices run in an optimized way in relation to each other. As an example, the power consumption of the individual portable location trackers may be optimized by the backend system in that the physical components in the portable location trackers may also be controlled by the parameter settings. In embodiments, a change of the state or in the parameter settings for a portable location tracker may be triggered by control data transmitted from the backend system to the portable location tracker, e.g. via a mobile communication device the portable location tracker is currently in short-range wireless communication with.

In embodiments, the portable location tracker shown in FIGS. 1 may be configured to communicate via Bluetooth using Beacon advertisement service, in both connected and not connected mode, to a nearby smartphone (IoS or Android). As mentioned above, the Beacon is based on Bluetooth low energy (BLE) proximity sensing by letting the tracker transmitting a universally unique identifier, a UID, picked up by the mobile application (APP) or the smartphone's operating system.

In certain embodiments of the technology disclosed, the tracker may use two methods to communicate its data to the internet:

1. Transmit data using a Beacon Advertising to a nearby smartphone (IoS or Android). The Beacon Advertising is based on Bluetooth low energy (BLE) proximity sensing by letting

the tracker transmitting a universally unique identifier, a UID, picked up by the mobile application (APP) or the smartphone's operating system. Advertisement request will be used by the mobile application (APP) to catch responses (that includes certain payload, e.g. a token to identify the tracker) on from the short-range advertisement message sent.At some occasions, e.g. at registration, more data may temporarily be transmitted from the mobile phone/backend- Bluetooth connect will then be used for that specific use case.

2. Via Narrowband IoT (NB-IoT). This is a Low Power radio technology standard developed by 3GPP. NB-IoT focuses specifically on improved coverage, low cost, long battery life, and high connection density. NB-IoT uses a subset of the LTE standard but limits the bandwidth to a single narrow-band of 200kHz.

It is envisioned that the mobile application (APP) of the technology disclosed will be widely installed. Therefore, all mobile phones with the APP installed, whether it is running or not or whether is registered to a user, may act as receivers of the Advertisement Beacons (short-range advertisement messages) and hence be nodes in a distributed and meshed network. The tracker will be most power efficient when it is communicating over BLE Advertisement and via a smartphone, so this method will play a vital role in the low power consumption strategy.

In certain embodiment and situations when it is not possible to communicate over BLE and via a smartphone, the technology disclosed will use the NB-IoT technology. This technology is the most power effective cellular communication technology with global coverage. In contrast, the short-range wireless communication/transmission according to the technology disclosed does not have global coverage but rather a short-range communication range comparable with the communication range of Bluetooth technology.

The mobile application (APP) typically needs to be installed and registered on the users' mobile phones and is using the GPS and Radio (Bluetooth and cellular radio) functionality of the mobile phone. All mobile phones with the APP installed, whether it is running or not or whether it is registered to a user, will act as receivers of the short-range wireless transmissions, e.g. Advertisement Beacons, and hence be nodes in a distributed and meshed network. The mobile application (APP) may therefore function as an extension of the backend system/solution and the data and functionality of the mobile phone may be used as input and information used by the backend system.

In embodiments, the portable location tracker uses Narrowband IoT (NB-IoT). This is a Low Power radio technology standard developed by 3GPP. NB-IoT focuses specifically on improved coverage, low cost, long battery life, and high connection density. NB-IoT uses a subset of the LTE standard but limits the bandwidth to a single narrow-band of 200kHz.

In specific embodiments, saving public data in a public distributed ledger will be valuable for assurance issues and other cases where full transparency and untampered data is needed. It could be considered to use a private chain for non-public and high speed/low latency transactions.

In example embodiments of the technology disclosed, the location tracker system illustrated in FIGS. 1, 2 and 3 may be built on a number of distributed physical components and functions. The components defined below may then be implemented over time, in different stages:

1) Two (2) physical GNSS receivers, i.e. (i) one GNSS in the tracker and (ii) one GNSS in a cellular mobile phone with the mobile application (APP) installed
2) One (1) physical CPU/Memory Areas, in the tracker.
3) Two (2) physical short-range wireless radios, e.g. Bluetooth Radio transmitters/receivers, i.e. (i) one Bluetooth TX/RX in the tracker and (ii) one Bluetooth TX/RX in a cellular mobile phone - with the mobile application (APP) installed - close to the user.
4) Two (2) physical cellular radio Radios, i.e. (i) one Radio RX/TX in the tracker and (ii) one Radio RX/TX in a cellular mobile phone - with the mobile application of installed - of the user.
5) One (1) physical accelerometers in the tracker
6) One (1) cloud-based frontend solution including Android apps, IoS apps, company webpage, web shop, admin web, etc
7) One (1) cloud based centralized backend solution, with centralized databases
8) Two (2) decentralized ledgers for storing of data, i.e. one public ledger, e.g. Ethereum and one private ledger, e.g. Hyperledger.

The location tracker system and methods of the technology disclosed define how the above listed components and functions are interworking and communicating to optimize the power consumption for a specific use case. The centralized backend system/solution, or remote control and monitoring system, will frequently collect data from the tracker and the physical components and perform calculations and logical decisions, presenting it to the users through frontend components. The backend system/solution may further be configured to optimize and control the performance of the components and calibrate the parameters so that the

components run in an optimized way in relation to each other. By this, the overall system performance and the power consumption will be optimized. The physical components in the tracker may also be controlled by the parameter settings.

The backend system is controlling and interacting with the entire system including the trackers, the mobile applications on the users' mobile phones and with the frontend applications that, for example, handle online purchasing (web shop), the company web page and the admin web page.

The portable location tracker is a physical device and is linked in the database of the backend system to a user. A user can be allocated, linked or associated with one or more trackers and the user may "distribute" a tracker to other users. In embodiments, the location trackers are visible to all users who are entitled to view them, but typically only the registered user of a tracker is authorized to change the settings and parameters for the location tracker. The registered user may also grant other trusted party access to change certain settings in the tracker. In embodiments, the parameters that control the behaviour of the tracker and software of the trackers may be update over Bluetooth and/or Cellular Radio.

Once the user has registered an account, the application (APP) in the mobile phone is connected to the user and is then also used for communicating with the user about the whereabouts and statuses of the trackers. This is regarded the frontend system/solution of the location tracker system. The online purchasing (web shop) and the company web page may be loosely connected to the backend system whereas the adminweb and the end user account page, that gives similar info as the mobile applications, is more integrated but nevertheless regarded as the frontend.

The functions and logic of the portable location tracker of the technology disclosed typically comprise a CPU, accelerometer, position (GNSS), radio#1 (short-range wireless radio, e.g. Bluetooth) and radio#2 (Cellular radio, e.g NB-IoT) are the main components in the portable location tracker, together with antennas for the two radio transmitters/receivers and the GNSS receiver. The accelerometer and GNSS may collectively be referred to as “Sensors” as they are measuring surrounding input data such as acceleration and position data. The radio#1 and radio#2 may collectively be referred to as “Access Function”. How these Sensors and Access Functions are controlled and used is the foundation for a number of predefined so-called Use Cases and a Use Case defines what the tracker shall track and/or where it will be physically placed. The portable location tracker typically behaves differently when in an alarm state compared to a non-alarm state. A Use Case may be defined by how many cycles elapses between each time any of the components generates data to be used by a certain Logical Function. A typical sequence and cycles of the execution of each Logical Function is controlled by the CPU. The Logical Function is defined by a set of rules and calculations that describe what actions the

data collected from one or several components will result in after it has been calculated by the CPU in the tracker. An example, and the most common, could be to put the tracker in an alarm/notification state.

The Radio #1 (e.g. Bluetooth/Bluetooth Low Energy Radio) is frequently (typically 1-5 times per second) transmitting a BLE Beacon Advertising and after the transmission listening for a BLE response and a possible Connect.

The Radio #2 (NB-Iot) is transmitting frequently (PSM) or on demand. It can also be listening, and hence reachable, at specific paging time frames that is set by the IoT-NB Cellular network (e.g. eDRX). PSM is intended for applications that seldom send data (once a day, for instance), and does not need to be reachable or reachable with long latency (several hours, for instance) and eDRX is intended for applications that need to be reachable but tolerate latency in an order of magnitude of 10 seconds or more.

The Logical Function is defining what the tracker will do based on the input from the Sensors but also information on e.g. the availability of the radio resources (NB and/or Bluetooth). For example, if the CPU has detected a movement through the Accelerometer and the Radio #2 is available, but not Radio #1 and alarm could be transmitted.

In embodiments, the technology disclosed describes a location tracker system which is built on a number of distributed physical components and functions, including:

a. two physical GNSS receivers, one GNSS in the tracker and one GNSS in a cellular mobile communications device having a mobile app for location tracking use installed,
b. two physical CPUs/Memory Areas, one CPU/Memory Area in the tracker and one CPU/Memory Area in the cellular mobile communications device,
c. two (2) physical Bluetooth Radio2 transmitters/receivers, one Bluetooth transmitter in the tracker and one Bluetooth in the cellular mobile communications device,
d. two (2) physical cellular Radio3 transmitters/receivers, one Radio RX/TX in the tracker and one Radio RX/TX in the cellular mobile communications device,
e. one physical accelerometers in the tracker, and
one remote control and monitoring system, e.g. a cloud-based backend system.

In addition to above-listed, the location tracker system may include one cloud-based frontend solution including Android apps, IoS apps, company webpage, web shop, admin web, etc. The location tracker system may also include two decentralized ledgers for storing of data, i.e. one public ledger, e.g. Ethereum and one private ledger, e.g. Hyperledger

In embodiments, the tracker of technology disclosed is configured to communicate via Bluetooth by repeatedly transmitting a short-range wireless low energy advertisement such as an iBeacon signal, which may or may not be captures by a nearby smartphone (IoS or Android). The iBeacon is based on Bluetooth low energy (BLE) proximity sensing by letting the tracker transmitting a universally unique identifier, a UID, picked up by the mobile app or the smartphone's operating system. BLE Receiving will be used by mobile app to catch responses on from the iBeacon messages sent.

The portable location tracker of the technology disclosed may use Narrowband IoT (NB-IoT) as its cellular radio communications interface. This is a low power radio technology standard developed by 3GPP. NB-IoT focuses specifically on improved coverage, low cost, long battery life, and high connection density. NB-IoT uses a subset of the LTE standard but limits the bandwidth to a single narrow-band of 200kHz.

In embodiments, the technology disclosed describes a location tracker system, comprising:

a. a portable location tracker;
b. a backend location tracker system adapted to:
    i. communicate with the portable location tracker via a cellular narrow band radio communications network;
    ii. communicate with a cellular communication terminal via at least one of a wideband cellular radio communications network, a wireless local network and/or the internet;
    iii. register latest position data associated with the portable location tracker;
c. an application program for execution in a location tracker control terminal being provided with short range radio communication capabilities (e.g. Bluetooth) and cellular radio communication capabilities (GSM etc), the application program having computer program code portions adapted to control the location tracker control terminal to:

i. communicate with the portable location tracker via short-range radio communication on a “low level data communication layer”;
ii. communicate with the backend location tracker system via at least one of a wideband cellular radio communications network, a wireless local network and/or the internet;
iii. receive and register position data from a global navigation satellite system.

In embodiments, the technology disclosed describes a location tracker, comprising:

a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
b. a narrow band radio communication unit adapted to communicate data with a backend location tracker system via a cellular narrow band communications network;
c. a short-range radio communication (Bluetooth) unit adapted to communicate with a location tracker control terminal associated with the location tracker and provided with short range cellular communication capabilities (Bluetooth);
d. a movement sensor adapted to deliver a movement indication signal in response to movement of the location tracker;
e. a control system having a data processing unit, a memory and computer program code control logics, the control system being adapted to:
i. deactivate selected functions of the location tracker in the absence of movement or dependent on a movement pattern (movement & time)) determined based on the movement indication signal from the movement sensor;
ii. activate position data acquisition in response to a detected movement pattern (movement & time);
iii. activate communication via a selected one of said narrow band communication unit or the short-range radio communication unit in accordance with a predetermined set of rules defined in the control logics.

In embodiments, the technology disclosed describes a method for controlling a portable location tracker, comprising:

a. deactivating selected functions in the absence of movement of the portable location tracker;
b. activating position data acquisition in response to a detected movement pattern (movement & time);
c. communicating position data to a backend location tracker system via a cellular narrow band communications network based on predetermined rules;
d. communicating position data to a location tracker control terminal via short range radio communication based on predetermined rules.

# CLAIMS

1. A low power consuming portable location tracker, comprising:
    a. a global navigation satellite system (GNSS) receiver adapted to receive position data from a global navigation satellite system;
    b. a movement sensor adapted to detect the movements of the location tracker;
    c. a control system for controlling the transmitters and receivers of the portable location tracker;
    d. a short-range wireless transmitter adapted to transmit data;
    e. a short-range wireless receiver adapted to receive data from a mobile communications device within range for short-range communication; and
    f. a cellular radio communications transmitter and receiver adapted for cellular radio communication with a remote control and monitoring system via a cellular radio communications network, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range.

2. The location tracker according to claim 1, wherein said control system is configured to change how often at least one of the transmitters and receivers of the location tracker is turned on, and wherein said change is triggered by at least one of input from said movement sensor and upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range.

3. The location tracker according to any of claims 1 and 2, wherein said control system is further configured to turn on said GNSS receiver to obtain the current position of the location tracker upon expiration of a timer and/or at least partly based on input from said movement sensor.

4. The location tracker according to any of claims 1 to 3, wherein said control system is configured to turn on said cellular radio communications transmitter upon expiration of a timer and at least partly based on input from said movement sensor.

5. The location tracker according to claim 4, wherein said location tracker is further configured to transmit the current position, or the most recently obtained or received

position, of the location tracker from said cellular radio communications transmitter to a remote control and monitoring system, and wherein said position data is transmitted via a cellular radio communications network such as a cellular narrowband radio communications network using low power cellular narrowband radio techniques.

6. The location tracker according to any of claims 1 to 5, wherein said control system is further configured to turn on said cellular radio communications transmitter at least partly based on a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by or associated with the location tracker.

7. The location tracker according to claim 6, wherein said cellular radio communications transmitter is turned on to transmit at least one of position data and movement status data based on input from said movement sensor to a remote control and monitoring system, and wherein said transmission of at least one of position data and movement status data via a cellular radio communications network is triggered by at least one of input from said movement sensor, a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by or associated with the location tracker and/or upon expiration of a timer of the location tracker.

8. The location tracker according to any of claims 1 to 7, wherein said control system is further configured to increase or decrease the periodicity and/or frequency of short-range wireless transmissions from said short-range wireless transmitter upon expiration of a timer and/or at least partly based on input from said movement sensor.

9. The location tracker according to claim 8, wherein said increased or decreased periodicity and/or frequency of short-range wireless transmissions is triggered by at least one of input from said movement sensor, a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by, or associated with, the location tracker and/or upon expiration of a timer of the location tracker.

10. The location tracker according to any of claims 1 to 9, wherein said control system is further configured to increase the periodicity and/or frequency of short-range wireless transmissions from said short-range wireless transmitter at least partly based on a received token or other identification data in a short-range wireless response is

indicating that the short-range wireless response was not sent by a mobile communications device trusted by or associated with the location tracker.

11. The location tracker according to any of claims 1 to 10, wherein said control system is further configured to increase the periodicity and/or frequency of how often said short-range wireless receiver is turned on at least partly based on a received token or other identification data in a short-range wireless response is indicating that the short-range wireless response was not sent by a mobile communications device trusted by or associated with the location tracker.

12. The location tracker according to any of claims 1 to 11, wherein said control system is further configured to at least one of change the mode or state of the location tracker to increase or decrease the periodicity and/or frequency of how often at least one of the transmitters and/or receivers of the location tracker is turned on, and wherein said control system is further configured so that said change is triggered by at least one of instruction data received via short-range communication with a known/friendly or trusted mobile communications device and instruction data received from a remote control and monitoring system via a cellular radio communications network.

13. A location tracker system for low power consumption in a portable location tracker, said system comprising:
    a. a portable location tracker comprising a control system and a movement sensor, said portable location tracker is configured to:
        i. communicate with a remote control and monitoring system via a cellular radio communications network;
        ii. communicate with a cellular mobile communications device via short-range wireless communication;
    b. a remote control and monitoring system configured to:
        i. communicate with a plurality of cellular mobile communications devices via at least one of a wideband cellular radio communications network, a wireless local network and the internet;
        ii. communicate with the portable location tracker via a cellular radio communications network; and
        iii. store data related to the position data associated with the portable location tracker;

c. an application program for execution in a cellular mobile communications device being provided with short range wireless communication capabilities and cellular radio communication capabilities, said cellular mobile communications device having computer program code portions adapted to control the mobile communications device to:

iii. communicate with the portable location tracker via short-range wireless communication;

iv. communicate with the remote control and monitoring system via at least one of a wideband cellular radio communications network, a wireless local network and the internet.

14. The system according to claim 13, wherein said portable location tracker and said remote control and monitoring system are configured to communicate with each other via a cellular narrowband radio communications network.

15. The system according to any of claims 13 and 14, wherein said portable location tracker and said remote control and monitoring system are configured to communicate with each other via a cellular radio communications network only when there is no mobile communications device available for short-range communication with the portable location tracker.

16. The system according to any of claims 13 to 15, wherein said remote control and monitoring system is configured to notify said mobile application of a mobile communications device trusted by, or associated with, the portable location tracker, and wherein said notification is triggered by the receiving of said message from the portable location tracker.

17. The system according to claim 16, wherein said mobile application is configured to present, in the application program and/or on a display, data or information related to at least one of position data and movement status data associated with the portable location tracker.

18. A method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution

in said cellular mobile communications device, and a remote control and monitoring system, comprising:

a. transmitting, from a short-range wireless transmitter of the location tracker, a signal including a token or data identifying the portable location tracker and at least one of position data and movement status data for the location tracker;
b. turning on a short-range wireless receiver of the portable tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range,
c. obtaining movement sensor data from the movement sensor of the portable location tracker, and, at least partly based on said obtained movement sensor data and/or upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range:
d. turning on at least one of a cellular radio communications transmitter and a GNSS receiver of the portable location tracker.

19. The method according to claim 18, wherein said obtained movement sensor data is indicating at least one of an acceleration beyond a certain threshold value and a changed movement pattern for the location tracker.

20. The method according to any of claims 18 to19, further comprising:

a. transmitting, from the portable location tracker to the remote control and monitoring system via the cellular radio communications network, a signal or message comprising at least one of position data and movement status data for the portable location tracker, wherein the said signal or message is sent in response to said obtained sensor data from the movement sensor.

21. The method according to any of claims 18 to 20, further comprising:

a. receiving, at said remote control and monitoring system, a signal or message comprising at least one of position data and movement status data for the portable location tracker; and
b. notifying, in response to receiving said at least one of position data and movement status data for the portable location tracker, said mobile application of a mobile communications device known to, or trusted by, the portable location tracker.

22. The method according to claim 21, further comprising:
    a. presenting, in the application program and/or on a display of the mobile communications device, display data or information related to at least one of position data and movement status data associated with the portable location tracker, wherein said presenting of display data is triggered by or based on said signal or message received from the portable location tracker.

23. The method according to any of claims 18 to 22, wherein said token or data of the signal transmitted from the short-range wireless transmitter of the location tracker is further identifying at least one of position data and movement status data for the location tracker.

24. A method in a location tracker system including a portable location tracker, at least one cellular mobile communications device comprising an application program for execution in said cellular mobile communications device, and a remote control and monitoring system, comprising:
    a. transmitting, from a short-range wireless transmitter of the portable location tracker, a signal including a token or data identifying the portable location tracker;
    b. turning on a short-range wireless receiver of the portable location tracker, wherein said receiver is listening for a short-range wireless response from a device within short-range wireless communication range;
    c. obtaining, by a GNSS receiver of said portable location tracker, position data for the portable location tracker, and
    d. upon expiration of a timer indicating that there is no mobile communications device within short-range wireless communication range or that no mobile communications device which is trusted by, or associated with, the portable location tracker is within short-range wireless communication range:
    e. turning on, by the control system of the portable location tracker, a cellular radio communications transmitter of the portable location tracker, and
    f. transmitting, via a cellular radio communications network to a remote control and monitoring system, a signal including said obtained position data and/or data identifying said portable location tracker.

25. The method according to claim 24, further comprising the step of:
    g. notifying, by the remote control and monitoring system and in response to the received position data and/or data identifying said portable location tracker, the

mobile application program (APP) of a mobile communications device trusted by, or associated with, the portable location tracker.

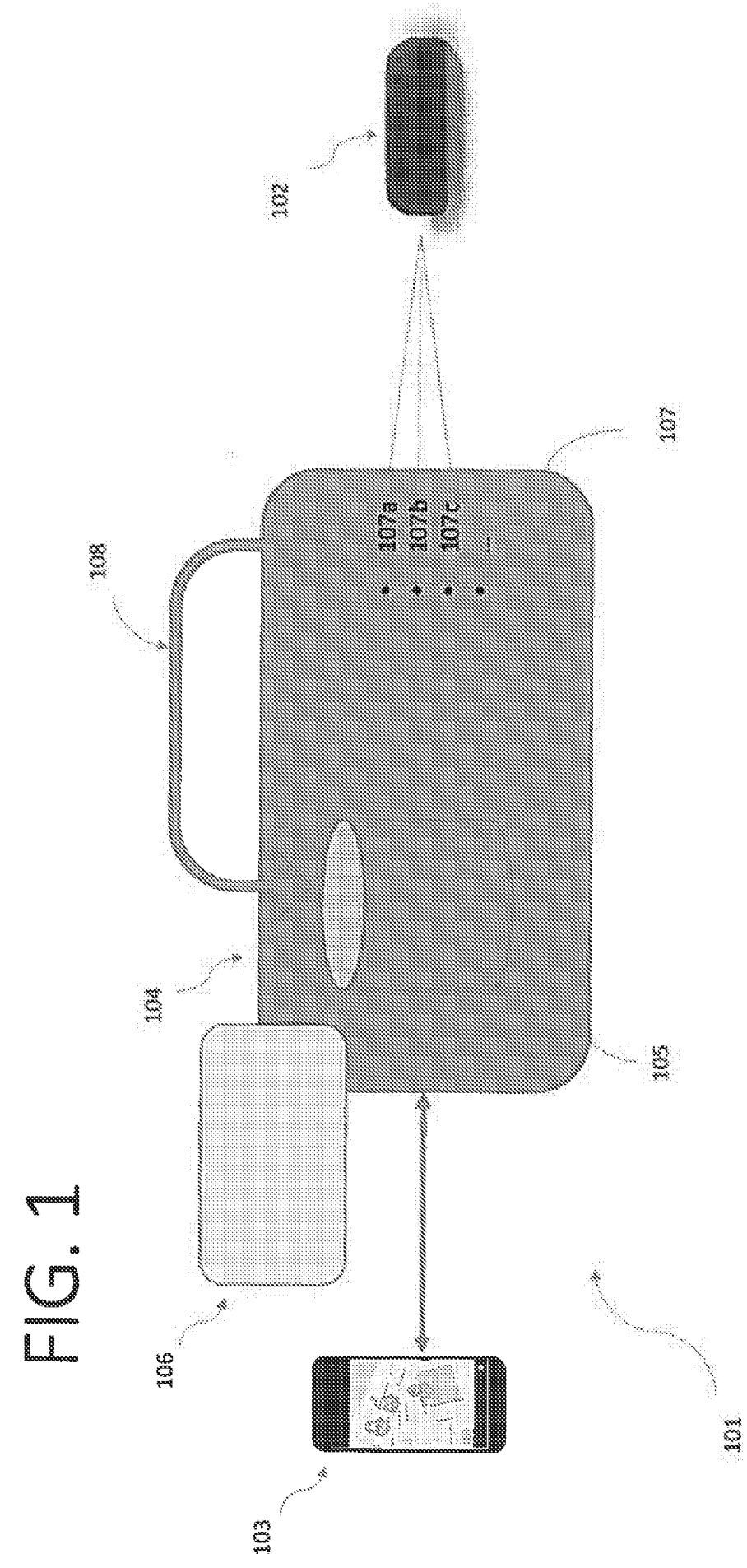
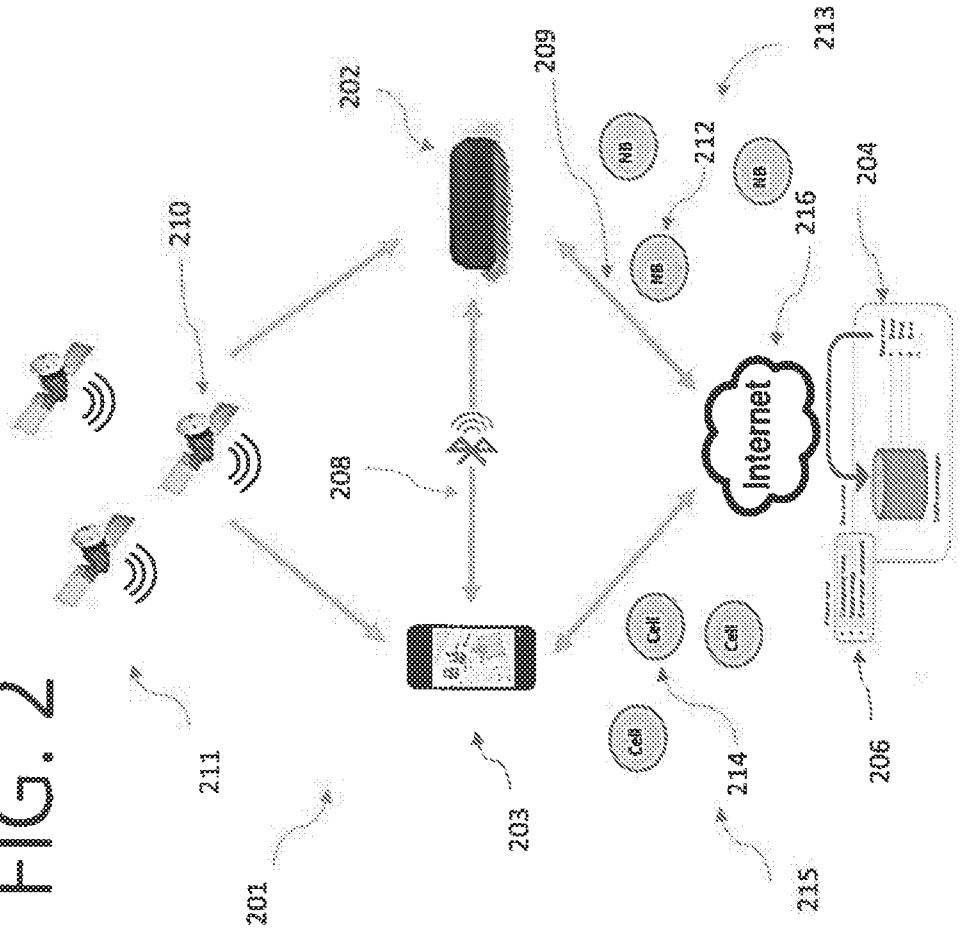



FIG. 1

FIG. 2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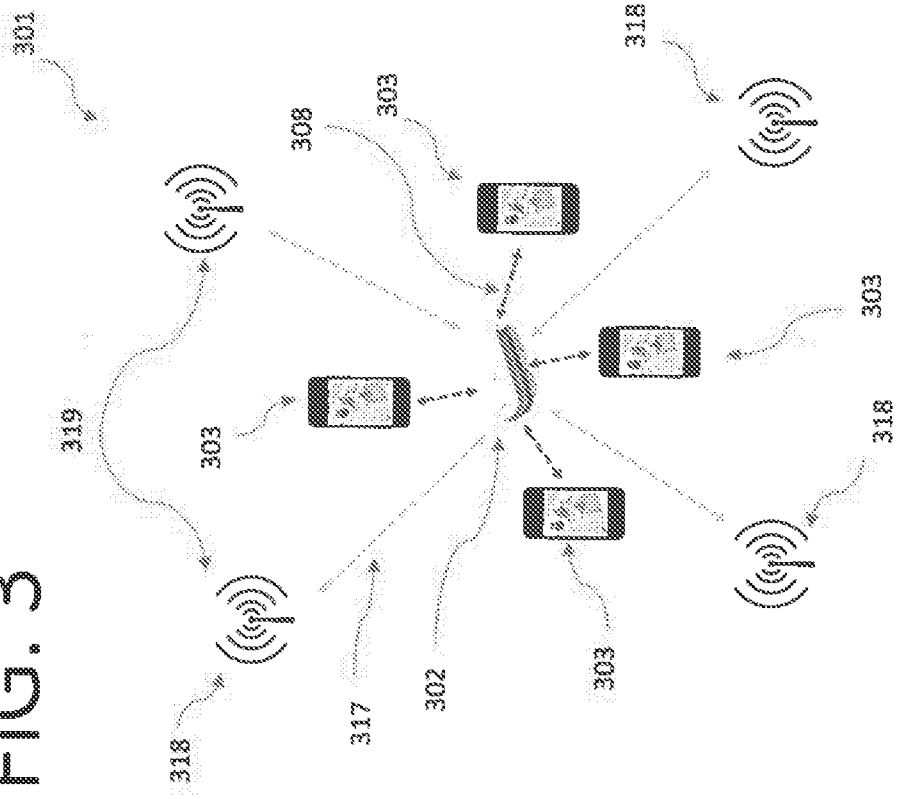
NB
Cell

FIG. 3


301
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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/SE2020/050058

A. CLASSIFICATION OF SUBJECT MATTER

IPC: 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: A61B, G01S

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. 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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| Y | US 9974020 B1 (DOYLE THOMAS F ET AL), 15 May 2018 (2018-05-15); column 1, line 2 - column 3, line 19; column 4, line 29 - line 56; column 5, line 3 - line 8; column 7, line 33 - line 35 | 1-25 |
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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|---|---|
| 12-05-2020 | 12-05-2020 |


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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/SE2020/050058

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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**Continuation of:** second sheet

**International Patent Classification (IPC)**

***G01S 5/00*** (2006.01)
*A61B 34/20* (2016.01)
*G01S 1/02* (2010.01)
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