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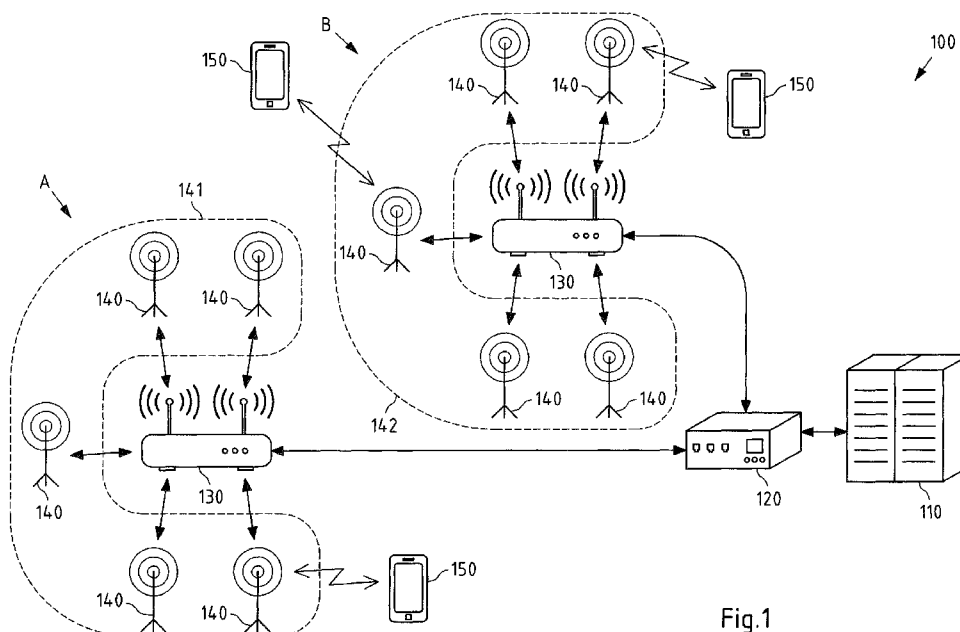


Fig.1

(57) Abstract: The invention relates to a method performed by at least one apparatus, the method comprising: determining whether a system or a part thereof is expected to be needed for positioning of a mobile device of a respective user, the system comprising at least one hub and a plurality of a radio nodes in communication with at least one of the at least one hub, the radio nodes being able to broadcast signals usable for positioning of a respective mobile device of a respective user in an area of the system, and controlling at least one property of at least one radio node of the system based on the result of the determining whether the system or a part thereof is expected to be needed. The invention also relates to an apparatus, a system, a computer program code and a computer readable storage medium.

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Controlling radio nodes of a radio node system based on the expected need

FIELD

The following disclosure relates primarily to the field of indoor positioning, and more particularly to systems, apparatuses, and methods for controlling a system, e.g. a
5 system usable for indoor positioning, such as a beacon monitoring and management system.

BACKGROUND

Indoor positioning requires novel systems and solutions that are specifically
10 developed and deployed for this purpose. The “traditional” positioning technologies, which are mainly used outdoors, for instance satellite and cellular positioning technologies, cannot deliver such performance indoors that would enable seamless and equal navigation experience in both environments.

15 The required positioning accuracy (within 2 to 3 meters), coverage (~100 %) and floor detection are challenging to achieve with satisfactory performance levels with the systems and signals that were not designed and specified for the indoor use cases in the first place. Satellite-based radio navigation signals simply do not penetrate through the walls and roofs for the adequate signal reception and the cellular signals
20 have too narrow bandwidth for accurate ranging by default.

Several indoor-dedicated solutions have already been developed and commercially deployed during the past years, for instance solutions based on pseudolites (Global Positioning System (GPS)-like short-range beacons), ultra-sound positioning,
25 Bluetooth Low Energy (BLE) signals (e.g. High-Accuracy Indoor Positioning, HAIP) and Wi-Fi fingerprinting. What is typical to these solutions is that they require either deployment of totally new infrastructure (radio nodes or radio beacons, or tags to name but a few non-limiting examples) or manual exhaustive radio surveying of the

buildings including all the floors, spaces and rooms. This is rather expensive and will take a considerable number of time to build the coverage to the commercially expected level, which in some cases narrowed the potential market segment only to very thin customer base, for instance for health care or dedicated enterprise solutions.

- 5 Also, the diversity of these technologies makes it difficult to build a globally scalable indoor positioning solution, and the integration and testing will become complex if a large number of technologies needs to be supported in the consumer devices (e.g. smartphones).
- 10 For an indoor positioning solution to be commercially successful, that is, i) being globally scalable, ii) having low maintenance and deployment costs, and iii) offering acceptable end-user experience, the solution needs to be based on an existing infrastructure in the buildings and on existing capabilities in the consumer devices. This leads to an evident conclusion that the indoor positioning needs to be based on
- 15 Wi-Fi- and/or Bluetooth (BT)-technologies that are already supported in every smartphone, tablet, laptop and even in the majority of feature phones. It is, thus, required to find a solution that uses the Wi-Fi- and BT-radio signals in such a way that makes it possible to achieve 2 to 3 meter horizontal positioning accuracy, close to 100% floor detection with the ability to quickly build the global coverage for this
- 20 approach.

- Further, a novel approach for radio-based indoor positioning that models for instance the Wi-Fi-radio environment (or any similar radio e.g. Bluetooth) from observed Received Signal Strength (RSS)-measurements as two-dimensional radio maps and is
- 25 hereby able to capture the dynamics of the indoor radio propagation environment in a compressible and highly accurate way. This makes it possible to achieve unprecedented horizontal positioning accuracy with the Wi-Fi signals only within the coverage of the created radio maps and also gives highly reliable floor detection.
- 30 To setup indoor positioning in a building, the radio environment in the building needs to be surveyed. This phase is called radiomapping. In the radiomapping phase samples

containing geolocation (like latitude, longitude, altitude; or x, y, floor) and radio measurements (Wi-Fi and/or Bluetooth radio node identities and signal strengths). Having these samples allows understanding how the radio signals behave in the building. This understanding is called a radio map. The radio map enables localization capability to devices. When they observe varying radio signals, the signals can be compared to the radio map resulting in the location information.

The radio samples for the radio map may be collected with special software tools or crowd-sourced from the user devices. While automated crowd-sourcing can enable indoor localization in large number of buildings, manual data collection using special software tools may be the best option, when the highest accuracy is desired.

SUMMARY

Yet another aspect of the modern radio node respectively beacon systems is beacon monitoring and management. The key aspect of these systems may be as follows:

Hubs are deployed throughout the venue so that each beacon can communicate with at least one hub. The hubs, on the other hand, are connected to a monitoring/management server via a gateway hub, which is essentially a wired/wireless router. The hubs may be connected to the gateway hub through cable (e.g. Ethernet) or wirelessly (e.g. Wi-Fi, Cellular). Additionally or alternatively, a plurality of radio nodes (e.g. beacons) may for instance form a mesh communication network. In such a case, it is possible that only a single gateway hub is required. The radio nodes may then be connected to the gateway hub, e.g. wirelessly (e.g. Wi-Fi, Cellular). The radio nodes forming the mesh communication network may communicate (e.g. transmit information) with each other. In either case, the gateway hub connected to the radio nodes forming the mesh communication network or connected to the further hubs is connected to a monitoring/management server.

The beacon monitoring refers to monitoring the beacon characteristics typically via one-way communications by the hubs. The beacons may e.g. periodically broadcast

their battery states, which transmissions are captured by the hubs and further routed to the monitoring/management server for analysis and visualization. The beacon management, on the other hand, refers to being able to perform two-way communication with the hubs and beacons. With a beacon management system e.g.
5 the beacon transmission power can be re-configured remotely or the advertisement message changed, when needed. The server managing/monitoring the hub and/or beacon constellations can be a virtual server operated in a cloud (e.g. AWS, Azure), or it can be also a physical local server constituting a self-hosted, high-security system.

- 10 In a standard setting, the beacons of such systems usually transmit advertisement packets for positioning purposes continuously. In that case, if the beacons continue to continuously transmit signals for positioning purposes (1Hz rate, 0 dbmW), energy is drained continuously. This may in particular be critical, as the beacons of such systems may run on battery power and the continuous transmission may result in a
15 quick drainage of the battery power.

Switching off beacons may not be desirable, as switched off beacons may become completely unresponsive. Also, switching off beacons may be undesirable, because this may result in positioning being completely unavailable for the user of a mobile
20 device.

It is thus, inter alia, an object of the invention to provide a solution for intelligently controlling the radio nodes of such a system and, in particular, to provide a solution for controlling of radio nodes of a system allowing for energy savings. It is also an
25 object of the invention to provide a controlling of radio nodes of a system with an as little impairment as possible on the positioning service for a user.

According to a first exemplary aspect of the present invention, a method is disclosed, performed by at least one apparatus, the method comprising:

- 30 - determining whether a system or a part thereof is expected to be needed for positioning of a mobile device of a respective user, the system comprising at

least one hub and a plurality of a radio nodes in communication with at least one of the at least one hub, the radio nodes being able to broadcast signals usable for positioning of the mobile device of the respective user in an area of the system, and

- 5 - controlling at least one property of at least one radio node of the system based on the result of the determining whether the system or a part thereof is expected to be needed.

10 According to a second exemplary aspect of the present invention, an apparatus is disclosed, configured to perform and/or control or comprising respective means for performing and/or controlling a method according to the first aspect, that is a method, the method comprising:

- determining whether a system or a part thereof is expected to be needed for positioning of a mobile device of a respective user, the system comprising at
15 least one hub and a plurality of a radio nodes in communication with at least one of the at least one hub, the radio nodes being able to broadcast signals usable for positioning of the mobile device of the respective user in an area of the system,
- controlling at least one property of at least one radio node of the system based
20 on the result of the determining whether the system or a part thereof is expected to be needed.

The means of an apparatus of the different aspects can be implemented in hardware and/or software. They may comprise for instance at least one processor for executing
25 computer program code for performing the required functions, at least one memory storing the program code, or both. Alternatively, they could comprise for instance circuitry that is designed to implement the required functions, for instance implemented in a chipset or a chip, like an integrated circuit. In general, the means may comprise for instance one or more processing means or processors.

In one example, the apparatus comprises at least one processor and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus to at least perform a method according to the first aspect.

5

The disclosed apparatus of any aspect may be a part of the described system of the different aspects, which can be used for positioning purposes and which comprises at least one hub and a plurality of radio nodes. Alternatively, the apparatus may also be an apparatus separate from the described system.

10

A herein-disclosed apparatus according to any aspect of the invention may be a module or a component for a device, for example a chip. Alternatively, a disclosed apparatus according to any aspect of the invention may be a device, for instance a server or server cloud. A disclosed apparatus according to any aspect of the invention may comprise only the disclosed components, for instance means, processor, memory, or may further comprise one or more additional components.

15

According to a third exemplary aspect of the present invention, a system is disclosed, comprising at least one hub and a plurality of a radio nodes in communication with at least one of the at least one hub, the radio nodes being able to broadcast signals usable for positioning of a mobile device of a respective user in an area of the system, the system being configured for performing a method according to the first aspect.

20

According to a fourth exemplary aspect of the present invention, a computer program code is disclosed, the computer program code when executed by a processor causing an apparatus to perform the actions of the method according to the first aspect.

25

According to a fifth exemplary aspect of the present invention, a computer readable storage medium is disclosed, in which computer program code according to the fourth aspect is stored.

30

The computer program may be stored on computer-readable storage medium, in particular a tangible and/or non-transitory medium. The computer readable storage medium could for example be a disk or a memory or the like. The computer program could be stored in the computer readable storage medium in the form of instructions
5 encoding the computer-readable storage medium. The computer readable storage medium may be intended for taking part in the operation of a device, like an internal or external memory, for instance a Read-Only Memory (ROM) or hard disk of a computer, or be intended for distribution of the program, like an optical disc.

- 10 The radio nodes of the system may repetitively and/or automatically broadcast radio signals. Thus, a corresponding radio node may be understood as a beacon. For this, a respective radio node may in particular comprise an energy storage, e.g. a battery. In this regard, the radio node may be self-sustaining. The radio nodes may use different radio technologies, e.g. a radio technology according to a BT- (Bluetooth) and/or BLE-
15 (Bluetooth Low Energy) specification, according to the Wi-Fi or WLAN (Wireless Local Area Network) specification (that is in particular the IEEE 802.11 standard). The radio node may thus be a Bluetooth beacon or may for instance be a Wi-Fi Access Point. Such radio signals allow for indoor positioning and/or floor detection. The radio node may for instance use a transceiver for transmitting and/or broadcasting radio signals.
- 20 Such radio signals may in particular comprise identifier information, identifying the radio node.

The described methods and systems may in particular be used in the context of indoor positioning. Indoor positioning may comprise a horizontal and/or vertical positioning.

- 25 A vertical positioning may be a floor detection, for instance.

Examples of radio signals usable for positioning of a mobile device of a respective user in the area of the system are identification or advertising information broadcast by the radio nodes, e.g. advertising packets (e.g. Eddystone or iBeacon advertising packets)

- 30 or (Basic) Service Set Identifiers ((B)SSIDs).

The area of the system may for instance be a building, a shopping mall, a car park, an office complex, a public accessible location (e.g. station, airport, university or the like) or a part thereof, to name but a few non-limiting examples.

- 5 The area of the system may be understood as being or comprising substantially the coverage area of the radio nodes, that is the area in which radio signals of the radio nodes are receivable (e.g. with a signal strength above a certain threshold).

Mobile devices of users in the area of the system may thus be able to receive radio
10 signals of the respective radio nodes. This may then allow a determination, e.g. by the mobile device itself or by another device, of the position of a respective mobile device (which is considered to be the position of the user of the respective mobile device). For this, the mobile device or the respective device performing the position determination may be or may have been provided with a radio map allowing for
15 deriving a geographical position of the mobile device in the area of the system from the received radio signal, e.g. via certain location specific characteristics of the radio signal, such as received signal strength (RSS). An example of a device other than the mobile device, which may alternatively perform the determination of the position of the mobile device, is a server or a server-cloud (server-based approach). In that case,
20 the mobile device may receive radio signals of the respective radio nodes and send the respective measurements or data representative thereof to the other device (that is to the server or to the server-cloud) for performing the position determination of the mobile device. The result may be used by the server and/or may be sent back to the mobile device.

25

For the monitoring, controlling and/or management of the radio nodes, the system comprises at least one hub. A hub may work on different network layers (e.g. of the OSI model). Typically, a hub works at the physical layer (layer one). However, a hub may also be understood to be an apparatus working at different layers (e.g. layer 2, 3,
30 4 etc.). Thus the hub may also have the functionality of a switch, router or gateway, for instance.

The at least one hub may be provided such that a communication connection between the at least one hub and the plurality of radio nodes of the system can be established.

The term communication is understood to cover a one-way communication and a two-

5 way communication between a respective radio node and a respective hub. In case the system comprises more than one hub, each of the plurality of radio nodes may for instance be deployed in the area of the system so that each radio node can communicate with the at least one hub. Typically, a radio node is in communication with only one hub. A hub is usually configured for communication with multiple radio
10 nodes. In case of multiple hubs, a hub may also be configured for communication with other hubs. At least one of the hubs may for instance be able to communicate with a (remote) server, e.g. via a wirebound or wireless communication connection. The hub able to communicate with a server may have the functionality of a gateway and may thus be seen as a gateway hub. In a preferred embodiment, the system may thus
15 comprise at least one gateway hub in communication with a (remote) server and a plurality of hubs in communication with the gateway hub.

A system or a part thereof may in particular be needed (e.g. by a user of the mobile device, by an application of the mobile device or by an external application being
20 executed on a server or in the cloud), for positioning of a respective mobile device, if one or more users are present in the area of the system and are using their respective mobile devices for positioning purposes. However, it may also be the case, that a system or part thereof is only considered needed if the system is to expected to be needed to a certain degree (e.g. at least by certain number of users). Whether a system
25 or a part thereof is expected to be needed may be determined based on different approaches as will be explained in more detail in the following.

A part of the system may be or may comprise a certain subset of radio nodes of the plurality of radio nodes of the system, for instance. As an example, a part of the system
30 may correspond to a certain sub-area of the system. For example, a part of the system may comprise only the radio nodes of a certain sub-area, e.g. a certain floor or a

certain section (of a building). Accordingly, that only a part of the system may or may not be expected to be needed may be understood that only a certain subset of radio nodes of the plurality of radio nodes (e.g. the ones arranged on a certain floor or in a certain section) is or is not expected to be needed.

5

Controlling at least one property of a radio node may in particular comprise changing or triggering changing a property of a respective radio node (if necessary). For this, at least a one-way communication from a respective hub to a respective radio node may be used, so that the respective radio node can at least receive respective controlling signals from or via the hub. However, a two-way communication between the
10 respective radio node and hub may also be used. In this case, the hub (and a managing server in communication with the hub) can also receive e.g. status information from the radio node. In case of multiple radio nodes, only the property of those radio nodes of the plurality of radio nodes may be changed, for which a change is necessary. It may
15 also be the case that for a first set of radio nodes a first property is controlled (e.g. changed), while for second set of radio nodes a second property is controlled (e.g. changed). For instance, if it is determined that only a part of the system is needed, preferably and if possible, only the property of radio nodes of the respective part of the system (i.e. a subset of the plurality of radio nodes covering a respective sub-area
20 of the system) is changed. The property to be controlled may in particular be a property related to the broadcasting of the signals, i.e. a broadcasting related property (such as a state of activity of the radio node, a broadcasting power or broadcasting interval of the radio node) as will be described in more detail further below.

25 A mobile device may for instance be a mobile terminal. The mobile device may in particular be a portable electronic device (e.g. a smartphone, a tablet, a portable navigation device, to name but a few non-limiting examples).

The described system according to the different aspects may be a radio node (e.g.
30 beacon) monitoring and management system.

In the following, exemplary features and exemplary embodiments of all aspects of the present invention will be described in further detail.

According to an exemplary embodiment of the different aspects, the determining
5 whether the system or a part thereof is expected to be needed for positioning of a mobile device of a respective user is at least based on a time of day and/or date. The time of day and/or the date have been shown to be reliable parameters for determining whether the system is expected to be needed. For example, the expected use of the system or of a part of the system may depend on the day of the week or on
10 whether it is a public holiday or not. Alternatively or additionally, the expected use of the system or of a part of the system may depend on the time of day, because e.g. during the night time there may be less need for positioning services, as no users are usually present at night time.

15 As an example, one may consider a car park as the venue or area of the system. In a typical setting, the radio nodes of the system may transmit advertising packets for positioning purposes in the area of the car park continuously (automatically and repeatedly). Now considering, for example, the number of people in the car park at different times of day: while the venue is very busy from 6am to 9am when people
20 arrive at work and also from 3pm to 9pm, when people leave work and/or return for shopping. However, during the remaining day time and especially during the nighttime, there will not be many people present. Therefore, if the radio nodes are continuously broadcasting radio signals for positioning purposes (e.g. at a 1Hz repetition rate, at a power of 0 dbmW), energy, i.e. the battery of the respective radio
25 node, is drained for nothing. The low-usage time can be identified to be at least a third of the day (e.g. from 9pm to 6am, i.e. 9 hours). Thus, it may be determined that during a low-usage time (e.g. 9pm to 6am) the system or a part thereof is not expected to be needed, while during a high-usage time (6am to 9pm) it may be determined that the system is expected to be needed. If a property of at least one radio node is controlled
30 based on the result of this determining, a significant energy (e.g. battery life-time) savings (e.g. of up to 50%) can be achieved.

According to an exemplary embodiment of the different aspects, the determining whether the system or a part thereof is expected to be needed for positioning of a mobile device of a respective user is at least based on a measurement result of at least one sensor indicative of the presence of a user and/or mobile device in the area of the system or a part thereof potentially needing the system or a part thereof for positioning.

In case a user is present in the area of the system, it may not necessarily be clear whether the user is or will need the system or a part thereof for positioning purposes. Thus, the user may be considered a user potentially having the need for using the system or a part thereof for positioning purposes. Thus, the measurement result may be considered indicative of the presence of user and/or mobile device potentially needing the system or a part thereof for positioning. In case of a presence of a user and/or mobile device in the area of the system or a part thereof, it may be determined that the system or the respective part thereof is expected to be needed for positioning of a mobile device of a respective user. In case no presence of a user and/or mobile device in the area of the system or a part thereof is determined, it may be determined that the system or the respective part thereof is not expected to be needed for positioning of a mobile device of a respective user.

Generally, a sensor may be any sensor suitable for detecting the presence of a person (i.e. a potential user of the system for positioning purposes) or a mobile device. The at least one sensor is preferably, but not necessarily arranged in the area of the system.

As an example, the at least one sensor may detect the radiation (e.g. infrared radiation) of a user. As another example, the at least one sensor may detect radiation (e.g. Wi-Fi radiation) of a mobile device of a user thus indicating the presence of a user. As another example, the sensor may also be a sensor indicating the use of a facility in or close to the area of the system (e.g. a door, an elevator or the like), thus being indicative of the presence of a user.

In this regard and according to an exemplary embodiment of the different aspects, the at least one sensor is or comprises a motion detector for detecting motion of a user in the area of the system. A motion detector may be a passive infrared (PIR) based motion detector, a microwave based motion detector, a ultrasonic motion detector, a tomographic motion detector and/or a video camera based motion detector, to name a few examples. In case the motion detector detects a motion, the measurement result would indicate the presence of a (potential) user of the system for positioning purposes.

- 10 In one example, respective sensors may be provided at some or all of the hubs of the system. The sensors may be integrally formed with the hubs. Alternatively the sensors may be arranged in the area of the system independent from the locations of the hubs. In another example, the sensors may be sensors of another system, e.g. sensors (in particular motion detectors) of a lighting system. The measurement results of these
15 sensors may be used as an input for said determining whether the system or a part thereof is expected to be needed.

- According to an exemplary embodiment of the different aspects, the determining whether the system or a part thereof is expected to be needed for positioning of a
20 mobile device of a respective user is at least based on a positioning result of a positioning of a respective mobile device of a respective user. For instance, if the positioning result of the positioning is within the area of the system or a part thereof, it may be determined that the system or the respective part thereof is expected to be needed for positioning of a mobile device of a respective user. If the positioning result
25 of the positioning is outside the area of the system or a part thereof, it may be determined that the system or the respective part thereof is not expected to be needed for positioning of a mobile device of a respective user. The positioning result may be based on positioning techniques performed by the respective mobile device. The positioning result may in particular be based on a position estimate for the mobile
30 device obtained via a positioning technique not based on the described system. For instance, the positioning result may be obtained based on a satellite navigation system

(e.g. NAVSTAR, GPS (Global Positioning System), GLONASS (Global Navigation Satellite System), Galileo, Beidou). The positioning estimate may have a low accuracy (e.g. a lower accuracy than what is achievable with the described system in the area of the system).

5

However, it is also possible that, according to an exemplary embodiment of the different aspects, the positioning of a respective mobile device of a respective user is at least partially based on the signals broadcast by one or more radio nodes of the system. This (first) positioning may be of a low Quality of Service (e.g. low accuracy or
10 slow), because parts of the system (that is a part of the radio nodes) are not broadcasting or broadcasting with a low broadcasting power. The results of the positioning service provided by the broadcast signals of the radio nodes of the described system in this case not only serve for positioning a respective mobile device but at the same time as a basis for determining whether the system or a part thereof is
15 expected to be needed for positioning of a mobile device of a respective user. For instance, the respective mobile device may, after the (first) positioning of the mobile device at least partially based on the signals broadcast by one or more radio nodes of the system, provide the (first) positioning result to the system (e.g. to a server in communication with a hub or gateway hub of the system). A (second) positioning of
20 the mobile device or a positioning of further devices can then be performed with a better Quality of Service (e.g. higher accuracy or faster). The described system and the mobile device may constitute a feedback loop or closed loop.

According to an exemplary embodiment of the different aspects, the determining
25 whether the system or a part thereof is expected to be needed for positioning of a mobile device of a respective user is at least based on a monitoring of a radio activity in the area of the system or a part thereof other than the radio activity due to the signals broadcast by the radio nodes of the system. The monitoring of a radio activity may be considered a monitoring of the radio environment in the area of the system or
30 a part thereof. For instance, the monitoring may comprise (e.g. by the hubs of the system) listening to radio transmissions, such as generic Bluetooth transmissions or

Wi-Fi transmission of mobile devices. Radio activity can be seen as an indication of the presence of mobile devices or users, respectively. For instance, if the radio activity in the area of the system or a part thereof is above a threshold, it may be determined that the system or the respective part thereof is expected to be needed for positioning of a mobile device of a respective user. If the radio activity in the area of the system or a part thereof is below a threshold, it may be determined that the system or the respective part thereof is not expected to be needed for positioning of a mobile device of a respective user. A measure for the radio activity may for instance be the number of connections, the intensity of the radio activity, the amount of data transmitted and/or the duration of radio activity, to name a few examples.

In this regard and according to an exemplary embodiment of the different aspects, the monitoring of a radio activity comprises monitoring Bluetooth signals and/or monitoring Wi-Fi signals. As mobile devices are typically equipped with such technologies, the monitoring of such signals provides reliable results on the presence of users and thus on the expected need of the system.

Further, in this regard and according to an exemplary embodiment of the different aspects, the monitoring of a radio activity in the area of the system or a part thereof comprises checking that a source of the radio activity is a mobile source. The radio activity of undesired sources of radio activity, e.g. constant stationary sources, such as wireless access points or routers which may be set up in the area of the system, can be excluded from being considered and such sources are not erroneously provoking a determination that the system is expected to be needed due to the assumed presence of a user. For instance, if the result of the checking is that the source of the radio activity is not a mobile source, the radio activity is not considered. If the result of the checking is that the source of the radio activity is a mobile source, the radio activity may be considered for said determining whether the system or a part thereof is expected to be needed.

According to an exemplary embodiment of the different aspects, the checking that a source of the radio activity is a mobile source considers the history and/or development of the radio activity. For instance, the overall history and/or development of the radio activity is considered. Alternatively, only the history and/or development of the radio activity with respect to a certain source is considered. As an example, the history and/or development of the radio activity comprises the change of one or more parameters of a radio signal over time. As an example, a parameter of a radio signal may be the received signal strength (RSS), as a change of the RSS values may indicate a change of the location of the transmitter. For instance, if the history and/or development of the radio activity indicates a sufficient change of the radio activity or a sufficient deviation from the past, the source of the radio activity may be considered a mobile source. Otherwise the source of the radio activity may be considered a stationary source, which is not to be considered for a radio activity relevant for determining the expected need of the system.

In the following, different actions and in particular different ways of controlling a respective radio node are described depending on whether the system or a part thereof is expected to be needed.

- According to an exemplary embodiment of the different aspects, the at least one property comprises a state of activity of the at least radio node and the controlling of at least one property of at least one radio node of the system comprises
- at least partially deactivating the at least one radio node, if it is determined that the system or a part thereof is not expected to be needed and/or
 - at least partially activating the at least one radio node, if it is determined that the system or a part thereof is expected to be needed.

Partially activating or deactivating the at least one radio node may be understood as activating or deactivating certain structures or functionalities of the radio node. The state of activity may in particular refer to the transmitting or broadcasting functionality of the radio node. For instance, the radio node may be or be brought in a

(partially) activated state (in which the respective radio node is broadcasting) or in a (partially) deactivated state (in which the respective radio node is not broadcasting). While it may be the case that the radio node is deactivated completely, it is preferred that the radio node is only deactivated partially (e.g. brought into a state in which the radio node is not broadcasting but can still receive or listen to signals, e.g. in order to wake up again). In any case, it is preferred, that the at least partial deactivating or activating of the at least one radio node deactivates or activates at least the transmitting or broadcasting functionality of the radio node (Tx activities).

According to an exemplary embodiment of the different aspects, the controlling of at least one property of at least one radio node of the system comprises identifying at least one subset of multiple radio nodes of the plurality of radio nodes of the system to be controlled and controlling said at least one identified subset. For instance, only the at least one property of the identified subset is then changed accordingly. The at least one property of the other nodes not belonging to the identified subset may not be changed or may be changed differently. For instance the identified subset may represent a part of the system. Different subsets of parts of the system may thus be controlled individually and/or independently from one another.

In this regard and according to an exemplary embodiment of the different aspects, at least one identified subset comprises radio nodes geographically substantially contiguously arranged in the area of the system or a part thereof. For instance, geographically substantially contiguously (e.g. neighboring) radio nodes may be some or all radio nodes associated with a hub of the system. For instance, geographically substantially contiguously radio nodes may be some or all radio nodes of a floor. For instance, geographically substantially contiguously radio nodes may be some or all radio nodes of a contiguous or connected section of the area of the system. As an example, when considering a car park during the night time, the radio nodes for instance may be (partially) deactivated. If there is now a person picking up their car at night in a specific floor, it suffices to turn on activate the broadcasting functionality of the radio nodes in that floor. The identified subset would in that case comprise or

consist of the radio nodes of one floor. As an advantage, the radio nodes of the other floors do not need to be activated.

In this regard and according to an exemplary embodiment of the different aspects, at least one identified subset comprises radio nodes geographically substantially

discontiguously arranged in the area of the system or a part thereof. For instance, an identified subset may comprises or consist of every n -th (n being an integer greater or equal than 2, that is e.g. every second, every third or every fourth, etc.) radio node. Therein, the radio nodes of the subset are preferably substantially uniformly distributed in an area of the system or a part thereof. Preferably, geographically substantially discontiguously arranged radio nodes of the subset are not directly neighboring radio nodes. As an advantage, it is possible to still provide a positioning service via the described system, substantially over the whole area of the system without any (larger) dead zones (possibly only with a lower quality of service, e.g. lower accuracy or longer time until the result of the positioning), even though a substantial part of $1/n$ -th (e.g. half, a third or a fourth etc.) of the radio nodes is (partially) deactivated. In order to equally drain the energy storages of the radio nodes, the identified set of radio nodes to be activated or deactivated is changed (e.g. by cycling through the available radio nodes) after a given time (e.g. every day).

Considering for instance a scenario, in which the broadcasting functionality of half of radio nodes (e.g. every second radio node) is deactivated during the night time, because it is expected that the system is not expected to be needed for positioning purposes at that time. During the next night the other half of the radio nodes (which remained active during the night before) is deactivated.

According to an exemplary embodiment of the different aspects, the at least one property comprises a broadcasting power of the at least one radio node and the controlling of at least one property of at least one radio node of the system comprises changing the broadcasting power of the at least one radio node based on the result of the determining whether the system or a part thereof is expected to be needed. As already described, in case it is determined that only a part of the system is expected to

be needed or not needed, only the broadcasting power of the radio nodes of the respective part of the system (i.e. of an identified subset of radio nodes) may be changed. The broadcasting (or transmission) power may for instance be used for a communication link between, e.g. between the radio node and the mobile device. The
5 broadcasting power may for instance be changed to one of a plurality of available discrete broadcasting powers (e.g. by changing a broadcasting power parameter). In particular, a broadcasting power may for instance be changed to a certain value in the unit dBm. For instance, a broadcasting power may be set to one of a plurality of possible broadcasting powers. As an example, there may be six possible broadcasting
10 powers (which may for instance be pre-defined according to e.g. requirements of an indoor positioning system). A broadcasting power may for instance be set to one of the following broadcasting powers: 0 dBm (1 mW transmission power), 5 dBm (approx. 3.2 mW transmission power), 10 dBm (10 mW transmission power), 15 dBm (approx. 31.6 mW transmission power), 20 dBm (100 mW transmission power) or 30
15 dBm (1000 mW transmission power).

In this regard and according to an exemplary embodiment of the different aspects, the controlling of at least one property of at least one radio node of the system comprises

- decreasing the broadcasting power of the at least one radio node, if it is
20 determined that the system or a part thereof is not expected to be needed and/or
- increasing the broadcasting power of the at least one radio node, if it is determined that the system or a part thereof is expected to be needed.

25 For instance, in case of decreasing the broadcasting power, the broadcasting power may be decreased from a first (higher) broadcasting power to a second (lower) broadcasting power (but preferably without completely deactivating the broadcasting). Likewise, in case of increasing the broadcasting power, the broadcasting power may be increased from a first (lower) broadcasting power to a
30 second (higher) broadcasting power.

According to an exemplary embodiment of the different aspects, the at least one property comprises a broadcasting interval of the at least one radio node and the controlling of at least one property of at least one radio node of the system comprises changing the broadcasting interval of the at least one radio node based on the result of the determining whether the system or a part thereof is expected to be needed. As described, in case it is determined that only a part of the system is expected to be needed or not needed, only the broadcasting interval of the radio nodes of the respective part of the system (i.e. of an identified subset of radio nodes) may be changed. The broadcasting interval may for instance describe how often the radio node broadcasts e.g. an advertising packet that notifies nearby devices (e.g. the mobile device of a respective user) about the existence of the radio nodes. In one example the radio node may (automatically and repetitively) broadcast identifier information and the identifier information may comprise information about the channels used by the radio node, e.g. for broadcasting the advertising packets. For instance, the information about the channels used by the radio node may be encoded in the identifier information. The broadcasting interval may for instance be changed to a certain value in the unit Hz. For instance, a broadcasting interval may be set to one of a plurality of possible broadcasting intervals (e.g. by changing a broadcasting interval parameter). As an example, there may be six possible broadcasting intervals (which may for instance be pre-defined according to e.g. requirements of an indoor positioning system). The broadcasting interval may for instance be set to one of the following broadcasting intervals: 1 Hz broadcasting interval, 2 Hz broadcasting interval, 3 Hz broadcasting interval, 4 Hz broadcasting interval, 5 Hz broadcasting interval, or 6 Hz broadcasting interval.

In this regard and according to an exemplary embodiment of the different aspects, the controlling of at least one property of at least one radio node of the system comprises

- decreasing the broadcasting interval of the at least one radio node, if it is determined that the system or a part thereof is not expected to be needed and/or

- increasing the broadcasting interval of the at least one radio node, if it is determined that the system or a part thereof is expected to be needed.

For instance, in case of decreasing the broadcasting interval, the broadcasting interval may be decreased from a first (higher) broadcasting interval to a second (lower) broadcasting interval (but preferably without completely deactivating the broadcasting). Likewise, in case of increasing the broadcasting interval, the broadcasting interval may be increased from a first (lower) broadcasting interval to a second (higher) broadcasting interval.

According to an exemplary embodiment of the different aspects, the at least one property comprises a number of broadcasting channels used by the at least one radio node and the controlling of at least one property of at least one radio node of the system comprises changing the number of broadcasting channels used by the at least one radio node based on the result of the determining whether the system or a part thereof is expected to be needed. As described, in case it is determined that only a part of the system is expected to be needed or not needed, only the number of broadcasting channels of the radio nodes of the respective part of the system (i.e. of an identified subset of radio nodes) may be changed. A broadcasting channel may for instance be used by the radio node for broadcasting advertising packets and/or communicating with another device, e.g. the mobile device. The broadcasting channel may thus be an advertising channel. As a minimum, one broadcasting channel may for instance be used. For instance, the number of used broadcasting channels may be set to one of a plurality of possible numbers of broadcasting channels, e.g. one, two or three broadcasting channels. In more detail, the used broadcasting channel(s) may in particular be set to one of e.g. seven different combinations of possible broadcasting channels (which may for instance be pre-defined, as aforementioned). For instance, it may be chosen between three different broadcasting channels, exemplarily referred to as broadcasting channels 37, 38 and 39. Therein, any combination between the three broadcasting channels may be possible. Thus, the used broadcasting channels may for instance be one of the following, wherein the exemplary broadcasting channels 37, 38

and 39 are used in this non-limiting example: broadcasting channel 37, broadcasting channel 38 or broadcasting channel 39 (one channel), broadcasting channels 37 and 38, broadcasting channels 37 and 39 or broadcasting channels 38 and 39 (two channels), or broadcasting channels 37, 38 and 39 (three channels).

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In this regard and according to an exemplary embodiment of the different aspects, the controlling of at least one property of at least one radio node of the system comprises

- decreasing the number of broadcasting channels used by the at least one radio node, if it is determined that the system or a part thereof is not expected to be needed and/or
- increasing a number of broadcasting channels used by the at least one radio node, if it is determined that the system or a part thereof is expected to be needed.

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For instance, in case of decreasing the number of broadcasting channels, the number of broadcasting channels may be decreased from a first (higher) number of broadcasting channels to a second (lower) number of broadcasting channels (but preferably without completely deactivating the broadcasting). Likewise, in case of increasing the number of broadcasting channels, the number of broadcasting channels may be increased from a first (lower) number of broadcasting channels to a second (higher) number of broadcasting channels.

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The described approaches of at least partially deactivating the at least one radio node, decreasing the broadcasting power or interval of the at least one radio node and/or decreasing the number of broadcasting channels used by the at least one radio node may also be advantageous in other scenarios and independent from a determination whether a system or a part thereof is expected to be needed by one or more users for positioning of a respective mobile device of a respective user. For instance, it may be determined that an energy storage of a radio node is running low (e.g. is below a predefined threshold). In order to ensure or maximize the service continuity, one of

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the above actions may be taken until the energy storage of the respective radio node is recharged/replaced.

According to an exemplary embodiment of the different aspects, the method further comprising:

- providing a radio map for at least one radio node of the plurality of radio nodes, the radio map being associated with identifier information, the identifier information allowing the respective radio node for which the radio map is provided to be identified, wherein at least a part of the identifier information depends on the at least one property of the respective radio node.

A radio map may for instance comprise a radio model (e.g. a radio propagation model or fingerprints, i.e. a combination of a radio measurements and a geo-location) from the surrounding of the respective radio node. A radio map may for instance be generated based at least partially on one or more radio measurements collected (e.g. measured), e.g. automatically or manually (e.g. by surveying the area of the system).

The identifier information may be determined at least based on the one or more properties of the respective radio node. This may in particular be the case for a property, which influences the radio map and thus the position determination of the mobile device. An example of such a property is the broadcasting power. Thus, the determined identifier information may be different from another identifier information, which is determined for the same radio node but with another property (e.g. another broadcasting power). It will be understood, however, that the identifier information may for instance be determined based on further information and not exclusively based on the at least one property of the radio node. Thus, depending on the broadcasting properties used by a radio node, the radio node may broadcast different identifier information.

According to an exemplary embodiment of the different aspects, the method further comprising:

- changing, in case at least one property of a radio node of the system is changed by the controlling of the at least one property, identifier information to be broadcast by the radio node of the system, the identifier information allowing the radio node of the system to be identified.

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In order to broadcast the correct identifier information (which is in conformity with the property of the radio node for broadcasting radio signals) at any given time, so that the corresponding radio map can be used for positioning, it is preferred if the identifier information to be broadcast by the radio node of the system is changed, in case the at least one property of a radio node of the system is changed by the controlling of the at least one property. A radio node may have multiple (broadcasting) properties. However, it will be understood, that only a change of certain properties (relevant for positioning and e.g. influencing a corresponding radio map of the radio node) may lead to a change in the identifier information to be broadcast.

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According to an exemplary embodiment of the different aspects, the system comprises one or more of

- a plurality of hubs;
- a gateway hub in communication with the at least one hub; and/or
- a server in communication with the at least one hub and/or the gateway hub.

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In an example, the described method according to the first aspect may be performed by a single apparatus (e.g. any of the hubs, the gateway hubs or the server). In another example the described method may be performed together by multiple of these apparatuses. As explained before, a hub may generally work on any of the network layers. Also, a gateway hub may work on any of the network layers. However, it is preferred, when the gateway hub works on a higher network layer than a hub. The server may generally be a virtual server operated in a cloud (e.g. AWS, Azure), or the server can be also be a physical local or remote server.

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According to an exemplary embodiment of the different aspects, the at least one apparatus performing the method is or comprises at least one of

- the at least one hub;
- a gateway hub; and/or
- 5 - a server.

The features and example embodiments of the invention described above may equally pertain to the different aspects according to the present invention.

- 10 Also, it will be understood that all the different described approaches for determining whether the system or a part thereof is expected to be needed can be combined with all the different described approaches for controlling at least one property of at least one radio node of the system and the corresponding actions.
- 15 It is to be understood that the presentation of the invention in this section is merely by way of examples and non-limiting. Other features of the invention will become apparent from the following detailed description considered in conjunction with the accompanying drawings. It is to be understood, however, that the drawings are designed solely for purposes of illustration and not as a definition of the limits of the
- 20 invention, for which reference should be made to the appended claims. It should be further understood that the drawings are not drawn to scale and that they are merely intended to conceptually illustrate the structures and procedures described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

25 In the figures show:

Fig. 1 a schematic block diagram of a system 100 according to the different aspects of the present invention;

30 Fig. 2 a flowchart 200 showing an example embodiment of a method according to the different aspects of the present invention;

Fig. 3 a flowchart 300 showing an example embodiment of a method according to the different aspects of the present invention;

5 Fig. 4 a flowchart 400 showing an example embodiment of a method according to the different aspects of the present invention;

Fig. 5 a flowchart 500 showing an example embodiment of a method according to the different aspects of the present invention; and

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Fig. 6 a schematic block diagram of an apparatus 600 according to the different aspects of the present invention.

The following description serves to deepen the understanding of the present invention and shall be understood to complement and be read together with the description as provided in the above summary section of this specification.

Fig. 1 is a schematic high-level block diagram of a system 100 according to the exemplary aspects of the present invention. System 100 comprises a server 110, a gateway hub 120, one or more hubs 130, one or more radio nodes 140, at hand embodied as beacons. In the area of the system coverage area of radio nodes 140 mobile devices 150 of respective users (not shown) are present. Such a mobile device may for instance be a smartphone, a tablet, a portable navigation device, an IoT (Internet of Things) device to name but a few non-limiting examples. One or more of the aforementioned entities of the system 100 may for instance be comprised (e.g. installed and/or located) in an area of the system, e.g. a venue such as a mall, an office building or a car park.

The server 110 may alternatively be embodied as a cloud server (e.g. a plurality of servers connected, e.g. via the Internet and providing services at least partially jointly). Further, the one or more radio nodes 140 may for instance be embodied as

one or more IoT devices. In this scenario, the hubs 130 may communicate (via one-way or two-way communication) with the radio nodes 140, but the radio nodes may not communicate with each other. In the shown scenario, the gateway hub 120 may for instance also be optional. In this case, the server 110 may be directly connected to the one or more hubs 130 e.g. via the Internet or via a wirebound or wireless communication connection (e.g. according to the Wi-Fi, BT, and/or BLE communication standard).

As another example, the hubs 130 may be optional and only a single hub acting as the gateway hub 120 may be provided and comprised by the system 100, being in communication (e.g. Wi-Fi, Cellular) with the radio nodes 140 without the one or more hubs 130. In this case, the radio nodes 140 may for instance form a mesh communication network. The radio nodes 140 forming the mesh communication network may in this case communicate (e.g. transmit information) with each other. The gateway hub 120 connected to the radio nodes 140 forming the mesh communication network is further connected to the server 110, which may for instance be embodied as a monitoring and/or management server for the radio nodes 140.

In another example, the server 110 may for instance be optional. In this case, at least one of the hubs 130 or the gateway hub 120 may for instance provide the functionalities and/or services, which the server 110 provides in the other alternative embodiment, e.g. to the one or more radio nodes 140.

The radio nodes 140 are able to broadcast signals (e.g. advertising packets) usable for positioning of a respective mobile device 150 of a respective user in an area of the system 100. Further, each radio node 140 of the system 100 may for instance broadcast identifier information, which was provided to each radio node 140, e.g. via at least one of the one or more hubs 130, e.g. by the server 110. All radio nodes 140 associated and communicating with the same hub 130 may be geographically close to each other. Thus, all radio nodes 140 of subset 141 belonging to part A of the system

100 (and here also being associated with the same hub) may be considered geographically substantially contiguously arranged in the area of the system 100. Likewise, all radio nodes 140 of subset 142 belonging to part B of the system 100 (and here being associated with the same hub) may be considered geographically
5 substantially contiguously arranged in the area of the system 100.

According to embodiments of the present invention, the server 110 (or in alternative embodiments alternatively or additionally the gateway hub 120 and/or the hubs 130) can monitor and/or manage and in particular control the one or more radio nodes 140
10 of the system 100. For this, the server 110 can determine whether the system 100 (or a part thereof) is expected to be for positioning of a mobile device 150 of a respective user.

Examples of realizing the determination of an expected need of the system are a
15 determination based on a time of day and/or date, a determination based on a measurement result of at least one sensor (e.g. motion detector) indicative of the presence of a user and/or mobile device 150 in the area of the system 100, a determination based on a positioning result of a positioning of a respective mobile device 150 of a respective user (wherein the positioning may inter alia be based on
20 signals broadcast by one or more radio nodes 140 of the system 100), a determination based on a monitoring of a radio activity (other than the radio activity due to the signals broadcast by the radio nodes 140 of the system 100) in the area of the system 100.

25 Based on the result of this determining whether the system 100 (or a part thereof) is expected to be needed, the server 110 can control at least one property of at least one radio node 140 (preferably of all radio nodes 140) of the system 100. Examples for the at least one property of a respective radio node 140 are a state of activity of the radio node 140, a broadcasting power of the radio node 140, a broadcasting interval of the
30 radio node 140 or a number of broadcasting channels of the radio node 140. Accordingly, by controlling a radio node 140, the respective property may be changed

(e.g. (partially) activating/deactivating the radio node, increasing/decreasing the broadcasting power of the radio node, increasing/decreasing the broadcasting interval of the radio node, increasing/decreasing the number of broadcasting channels of the radio node).

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Fig. 2 is a flowchart 200 showing an example embodiment of a method according to the different aspects of the present invention. The method of Fig. 2 (and also of Fig. 3 to 5) may for instance be performed by server 110, gateway hub 120 and/or hub 130 of Fig. 1.

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Now turning to Fig. 1, it is determining whether a system (e.g. system 100 of Fig. 1) or a part thereof (e.g. part A, B) is expected to be needed for positioning of a mobile device (e.g. one of the mobile devices 150 of Fig. 1) of a respective user (action 210).

15 Optionally, at least one subset 141, 142 of multiple radio nodes 140 of the plurality of radio nodes of the system 100 to be controlled is identified (action 220). This may be advantageous, if it can be determined that only a part of the system is or is not expected to be used (e.g. only part A, or only part B of the system in Fig. 1). In that case, only the radio nodes 140 associated and communicating with of the specific hub
20 130 may be identified as a subset 141, 142 of all radio nodes and only those radio nodes would need to be controlled accordingly. Radio nodes 140 of the respective other subset of the system 100 would not need to be controlled.

If it is determined that the system 100 or a part A, B thereof is not expected to be
25 needed, the broadcasting functionality of the respective radio nodes 140 of the identified subset 141, 142 is deactivated (action 230).

On the other hand, if it is determined that the system 100 or a part A, B thereof is expected to be needed, the broadcasting functionality of the respective radio nodes
30 140 of the identified subset 141, 142 is activated, if not already activated (action 240).

Fig. 3 is a flowchart 300 showing an example embodiment of a method according to the different aspects of the present invention.

It is determining whether a system (e.g. system 100 of Fig. 1) or a part thereof (e.g. part A, B) is expected to be needed for positioning of a mobile device (e.g. one of the mobile devices 150 of Fig. 1) of a respective user (action 310).

If it is determined that the system 100 or a part A, B thereof is not expected to be needed, the broadcasting interval of the respective radio nodes 140 is decreased (action 320).

On the other hand, if it is determined that the system 100 or a part A, B thereof is expected to be needed, the broadcasting interval of the respective radio nodes 140 is increased (action 330).

Fig. 4 is a flowchart 400 showing an example embodiment of a method according to the different aspects of the present invention.

It is determining whether a system (e.g. system 100 of Fig. 1) or a part thereof (e.g. part A, B) is expected to be needed for positioning of a mobile device (e.g. one of the mobile devices 150 of Fig. 1) of a respective user (action 410).

If it is determined that the system 100 or a part A, B thereof is not expected to be needed, the number of broadcasting channels used by the respective radio nodes 140 is decreased (action 420).

On the other hand, if it is determined that the system 100 or a part A, B thereof is expected to be needed, the number of broadcasting channels used by the respective radio nodes 140 is increased (action 430).

Fig. 5 is a flowchart 500 showing an example embodiment of a method according to the different aspects of the present invention.

It is determining whether a system (e.g. system 100 of Fig. 1) or a part thereof (e.g. part A, B) is expected to be needed for positioning of a mobile device (e.g. one of the mobile devices 150 of Fig. 1) of a respective user (action 510).

If it is determined that the system 100 or a part A, B thereof is not expected to be needed, the broadcasting power of the respective radio nodes 140 is increased (action 520).

On the other hand, if it is determined that the system 100 or a part A, B thereof is expected to be needed, the broadcasting power of the respective radio nodes 140 is decreased (action 530).

However, the change of the broadcasting power influences the positioning determination at a mobile device 150, in particular if the signal strength received (RSS) at the mobile device 150 is used for positioning the mobile device 150. In order to account for this change of the radio environment during positioning, the identifier information to be broadcast by the respective radio node 140 of the system 100 is changed (action 540). Therein, at least a part of the identifier information depends on the set broadcasting power of the respective radio node. Thus, for one and the same radio node 140, there is different identifier information for each of the different possible broadcasting powers.

Also, there is provided a radio map for the respective radio node 140, which radio map is associated with the (changed) identifier information (action 550). Thus, there is no risk of using a radio map for positioning, which was generated based on measurements for a different broadcasting power of the same radio node.

Fig. 6 is a schematic block diagram of an apparatus 600 according to the different aspects of the present invention. Apparatus 600 may as an exemplary embodiment represent server 110, gateway hub 120, hub 130, radio node 140 and/or mobile device 150.

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Apparatus 600 comprises a processor 610, working memory 620, program memory 630, data memory 640, communication interface(s) 650, an optional user interface 660 and an optional sensor(s) 670.

10 Apparatus 600 may for instance be configured to perform and/or control or comprise respective means (at least one of 610 to 670) for performing and/or controlling the method according to the first aspect. Apparatus 600 may as well constitute an apparatus comprising at least one processor 610 and at least one memory 620 including computer program code, the at least one memory and the computer
15 program code configured to, with the at least one processor, cause an apparatus, e.g. apparatus 600 at least to perform and/or control the method according to the first aspect of the invention.

Processor 610 may for instance comprise a determination unit as a functional and/or
20 structural unit for determining whether a system (e.g. system 100) or a part thereof is expected to be needed by one or more users for positioning of a respective mobile device (e.g. mobile device 150) of a respective user (see e.g. actions 210, 310, 410, 510 of Fig. 2 to 5). Processor 610 for instance further comprise a control unit as a functional and/or structural unit for controlling at least one property of at least one
25 radio node of the system based on the result of the determining whether the system or a part thereof is expected to be needed (see e.g. actions 230/240, 320/330, 420/430, 520/530 of Fig. 2 to 5).

Processor 610 may for instance further control the memories 620 to 640, the
30 communication interface(s) 650, the optional user interface 660 and the optional sensor(s) 670.

Processor 610 may for instance execute computer program code stored in program memory 630, which may for instance represent a computer readable storage medium comprising program code that, when executed by processor 610, causes the processor
5 610 to perform the method according to the first exemplary aspect.

Processor 610 may be a processor of any suitable type. Processor 610 may comprise but is not limited to one or more microprocessor(s), one or more processor(s) with accompanying one or more digital signal processor(s), one or more processor(s)
10 without accompanying digital signal processor(s), one or more special-purpose computer chips, one or more field-programmable gate array(s) (FPGA(s)), one or more controller(s), one or more application-specific integrated circuit(s) (ASIC(s)), or one or more computer(s). The relevant structure/hardware has been programmed in such a way to carry out the described function. Processor 610 may for instance be an
15 application processor that runs an operating system.

Program memory 630 may also be included into processor 610. This memory may for instance be fixedly connected to processor 610, or be at least partially removable from processor 610, for instance in the form of a memory card or stick. Program memory
20 630 may for instance be non-volatile memory. It may for instance be a FLASH memory (or a part thereof), any of a ROM, PROM, EPROM and EEPROM memory (or a part thereof) or a hard disc (or a part thereof), to name but a few examples. Program memory 630 may also comprise an operating system for processor 610. Program memory 630 may also comprise a firmware for apparatus 600.

Apparatus 600 comprises a working memory 620, for instance in the form of a volatile memory. It may for instance be a Random Access Memory (RAM) or Dynamic RAM (DRAM), to give but a few non-limiting examples. It may for instance be used by processor 610 when executing an operating system and/or computer program.

Data memory 640 may for instance be a non-volatile memory. It may for instance be a FLASH memory (or a part thereof), any of a ROM, PROM, EPROM and EEPROM memory (or a part thereof) or a hard disc (or a part thereof), to name but a few examples. Data memory 640 may for instance store parameters for determining
5 whether a system or a part thereof is expected to be needed for positioning purposes (e.g. a time schedule, history of the radio environment etc.) and/or parameters for controlling properties of radio nodes of the system (e.g. broadcasting parameters indicating the broadcasting power, interval, channel to be used etc.). Also, data
10 memory 640 may for instance store radio maps associated with respective identifier information in order to provide the radio maps and/or to use the radio maps for positioning purposes.

Communication interface(s) 650 enable apparatus 600 to communicate with other entities, e.g. with one or more mobile devices 150 of Fig. 1, one or more hubs 130 of
15 Fig. 1, gateway hub 120 of Fig. 1, server 110 of Fig. 1 and/or radio nodes 140 of Fig. 1. The communication interface(s) 650 may for instance comprise a wireless interface, e.g. a cellular radio communication interface and/or a WLAN interface) and/or wire-bound interface, e.g. an IP-based interface, for instance to communicate with entities via the Internet.

20 User interface 660 is optional and may comprise a display for displaying information to a user and/or an input device (e.g. a keyboard, keypad, touchpad, mouse, etc.) for receiving information from a user.

25 Sensor(s) 670 are optional and may for instance comprise an accelerometer, a camera, or the like to name but a few non-limiting examples, e.g. to determine further pieces of information, which may for instance be used in a method according to the first exemplary aspect of the present invention.

In particular in case of the apparatus being a hub 130 of Fig. 1, the sensor 670 of apparatus 600 may also be a sensor (e.g. a motion detector) for detecting the presence of a user and/or mobile device in the area of the system or a part thereof.

- 5 Some or all of the components of the apparatus 600 may for instance be connected via a bus. Some or all of the components of the apparatus 600 may for instance be combined into one or more modules.

10 In the following, further exemplary embodiments are disclosed describing further exemplary features and advantages of the invention:

In a venue, the radio node (in the following simply referred to as beacons) transmission for positioning can be driven and controlled in at least the following ways:

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- Time-based control: Beacon transmissions are turned off for e.g. night time. In a shopping mall the beacon transmission can be turned off outside of the opening hours, say from 9pm until 9am. This is simple to implement and reduces beacon power consumption to roughly half.
- 20 • Movement sensors: Beacon management hubs can be equipped with movement sensors. Using this sensor data as an input the beacon constellation responsiveness can be made totally dynamic. Whenever there are people, beacon transmission is on, and when there are no users, beacons do not transmit. As also lighting is controlled by movement sensors in intelligent
- 25 buildings, these sensors could be used as an internal input to the beacon management system, if the hubs do not have their own sensors.
- Feedback from the service users: The system can be made a closed-loop one so that movements of the positioning service users act as an input for the beacon management system. This scheme requires that at least some beacons are
- 30 continuously activated so that a rough user position can be deduced at all

times. The user locations are sent to the beacon management system, which then makes a decision on which beacons to turn on and off.

- Beacon management hubs monitoring radio environment: Beacon management hubs can often also listen to the generic Bluetooth transmissions from the visitor mobile devices. The presence of non-beacon transmissions is an indication that there are people nearby (assuming they have Bluetooth turned on). This can be used as an input for turning the beacon transmissions on and off. For this purpose, the beacon management hub could also listen to the Wi-Fi transmissions from the visitor mobile devices and use the presence of Wi-Fi transmissions from mobile devices as an input to controlling beacon transmissions. To exclude stationary Bluetooth/Wi-Fi transmitters, the hubs can also monitor the profile/history of the RSS (received signal strength) to conclude that the visitor is truly mobile before turning on the beacons.
- Service continuity: In case the beacons are running out of battery, the service continuity could be ensured by managing the beacon power consumption into a lower drainage level until the batteries/beacons are replaced. The expected drawback is a decrease in the quality of the positioning service, but this might avoid total service outages.

Some options of what actions to take, in particular if it is in particular determined that a system or a part thereof is not expected to be needed include:

- Fully shutting down the constellation: This approach works e.g. in shopping malls and offices which are empty of customers/employees during the closing hours. There is no point in keeping any of the beacons transmitting.
- Fully shutting down a sub-constellation (part of the building): This is a good option e.g. in parking halls during night time. If there is a person picking up his car at night in the 2nd floor, it suffices to turn on the beacon transmissions in that floor.
- Decreasing the Tx power or Tx interval (lower QoS) and using only one Tx channel: If for some reason the whole constellation cannot be shutdown, one

option is to decrease the Tx power and/or interval during low-usage times (e.g. nighttime). Lower Tx power/interval/channels reduce the beacon energy consumption.

- Shutting down e.g. every second beacon: Again, if the whole constellation cannot be shut down for some reason, a good option is to shut down e.g. half of the beacons during low-usage times. The important thing here is to change the set of shut down beacons e.g. every day to drain the batteries equally.

Advantages: When a radio node management system is used to control transmissions intelligently, radio node lifetime can significantly be lengthened. While some additional complexity may be added to the system, the additional complexity is negligible (e.g. if for example the whole constellation is shut down based on time-of-day).

In the present specification, any presented connection in the described embodiments is to be understood in a way that the involved components are operationally coupled. Thus, the connections can be direct or indirect with any number or combination of intervening elements, and there may be merely a functional relationship between the components.

Moreover, any of the methods, processes and actions described or illustrated herein may be implemented using executable instructions in a general-purpose or special-purpose processor and stored on a computer-readable storage medium (e.g., disk, memory, or the like) to be executed by such a processor. References to a 'computer-readable storage medium' should be understood to encompass specialized circuits such as FPGAs, ASICs, signal processing devices, and other devices.

The expression "A and/or B" is considered to comprise any one of the following three scenarios: (i) A, (ii) B, (iii) A and B. Furthermore, the article "a" is not to be understood as "one", i.e. use of the expression "an element" does not preclude that also further elements are present. The term "comprising" is to be understood in an open sense, i.e.

in a way that an object that “comprises an element A” may also comprise further elements in addition to element A.

It will be understood that all presented embodiments are only exemplary, and that
5 any feature presented for a particular example embodiment may be used with any aspect of the invention on its own or in combination with any feature presented for the same or another particular example embodiment and/or in combination with any other feature not mentioned. In particular, the example embodiments presented in this specification shall also be understood to be disclosed in all possible combinations
10 with each other, as far as it is technically reasonable and the example embodiments are not alternatives with respect to each other. It will further be understood that any feature presented for an example embodiment in a particular category (method/apparatus/computer program/system) may also be used in a corresponding manner in an example embodiment of any other category. It should also be
15 understood that presence of a feature in the presented example embodiments shall not necessarily mean that this feature forms an essential feature of the invention and cannot be omitted or substituted.

The statement of a feature comprises at least one of the subsequently enumerated
20 features is not mandatory in the way that the feature comprises all subsequently enumerated features, or at least one feature of the plurality of the subsequently enumerated features. Also, a selection of the enumerated features in any combination or a selection of only one of the enumerated features is possible. The specific combination of all subsequently enumerated features may as well be considered. Also,
25 a plurality of only one of the enumerated features may be possible.

The sequence of all method steps presented above is not mandatory, also alternative sequences may be possible. Nevertheless, the specific sequence of method steps exemplarily shown in the figures shall be considered as one possible sequence of
30 method steps for the respective embodiment described by the respective figure.

The invention has been described above by means of example embodiments. It should be noted that there are alternative ways and variations which are obvious to a skilled person in the art and can be implemented without deviating from the scope of the appended claims.

Claims

1. A method performed by at least one apparatus, the method comprising:
 - determining whether a system or a part thereof is expected to be needed for positioning of a mobile device of a respective user, the system comprising at least one hub and a plurality of a radio nodes in communication with at least one of the at least one hub, the radio nodes being able to broadcast signals usable for positioning of the mobile device of the respective user in an area of the system, and
 - controlling at least one property of at least one radio node of the system based on the result of the determining whether the system or a part thereof is expected to be needed.
2. The method according to claim 1, wherein the determining whether the system or a part thereof is expected to be needed for positioning of a mobile device of a respective user is at least based on a time of day and/or date.
3. The method according to any of the preceding claims, wherein the determining whether the system or a part thereof is expected to be needed for positioning of a mobile device of a respective user is at least based on a measurement result of at least one sensor indicative of the presence of a user and/or mobile device in the area of the system or a part thereof potentially needing the system or a part thereof for positioning.
4. The method according to claim 3, wherein the at least one sensor is or comprises a motion detector for detecting motion of one or more users in the area of the system.

5. The method according to any of the preceding claims, wherein the determining whether the system or a part thereof is expected to be needed for positioning of a mobile device of a respective user is at least based on a positioning result of a positioning of a respective mobile device of a respective user.
- 5
6. The method according to claim 5, wherein the positioning of a respective mobile device of a respective user is at least partially based on the signals broadcast by one or more radio nodes of the system.
- 10 7. The method according to any of the preceding claims, wherein the determining whether the system or a part thereof is expected to be needed for positioning of a mobile device of a respective user is at least based on a monitoring of a radio activity in the area of the system or a part thereof other than the radio activity due to the signals broadcast by the radio nodes of the system.
- 15
8. The method according to claim 7, wherein the monitoring of a radio activity comprises
- monitoring Bluetooth signals and/or
 - monitoring Wi-Fi signals.
- 20
9. The method according to claims 7 or 8, wherein the monitoring of a radio activity in the area of the system or a part thereof comprises checking that a source of the radio activity is a mobile source.
- 25 10. The method according to claim 9, wherein the checking that a source of the radio activity is a mobile source considers the history and/or development of the radio activity.
- 30 11. The method according to any of the preceding claims, wherein the at least one property comprises a state of activity of the at least radio node and the

controlling of at least one property of at least one radio node of the system comprises

- at least partially deactivating the at least one radio node, if it is determined that the system or a part thereof is not expected to be needed and/or
- 5 - at least partially activating the at least one radio node, if it is determined that the system or a part thereof is expected to be needed.

12. The method according to any of the preceding claims, wherein the controlling of at least one property of at least one radio node of the system comprises
10 identifying at least one subset of multiple radio nodes of the plurality of radio nodes of the system to be controlled and controlling said at least one identified subset.

13. The method according to claim 12, wherein at least one identified subset
15 comprises radio nodes geographically substantially contiguously arranged in the area of the system or a part thereof.

14. The method according to claim 12, wherein at least one identified subset
20 comprises radio nodes geographically substantially discontinuously arranged in the area of the system or a part thereof.

15. The method according to any of the preceding claims, wherein the at least one property comprises a broadcasting power of the at least one radio node and the controlling of at least one property of at least one radio node of the system
25 comprises changing the broadcasting power of the at least one radio node based on the result of the determining whether the system or a part thereof is expected to be needed.

16. The method according to claim 15, wherein the controlling of at least one
30 property of at least one radio node of the system comprises

- decreasing the broadcasting power of the at least one radio node, if it is determined that the system or a part thereof is not expected to be needed and/or
- increasing the broadcasting power of the at least one radio node, if it is determined that the system or a part thereof is expected to be needed.

17. The method according to any of the preceding claims, wherein the at least one property comprises a broadcasting interval of the at least one radio node and the controlling of at least one property of at least one radio node of the system comprises changing the broadcasting interval of the at least one radio node based on the result of the determining whether the system or a part thereof is expected to be needed.

18. The method according to claim 17, wherein the controlling of at least one property of at least one radio node of the system comprises

- decreasing the broadcasting interval of the at least one radio node, if it is determined that the system or a part thereof is not expected to be needed and/or
- increasing the broadcasting interval of the at least one radio node, if it is determined that the system or a part thereof is expected to be needed.

19. The method according to any of the preceding claims, wherein the at least one property comprises a number of broadcasting channels used by the at least one radio node and the controlling of at least one property of at least one radio node of the system comprises changing the number of broadcasting channels used by the at least one radio node based on the result of the determining whether the system or a part thereof is expected to be needed.

20. The method according to claim 19, wherein the controlling of at least one property of at least one radio node of the system comprises

- decreasing the number of broadcasting channels used by the at least one radio node, if it is determined that the system or a part thereof is not expected to be needed and/or
- increasing a number of broadcasting channels used by the at least one radio node, if it is determined that the system or a part thereof is expected to be needed.

21. The method according to any of the preceding claims, the method further comprising:

- providing a radio map for at least one radio node of the plurality of radio nodes, the radio map being associated with identifier information, the identifier information allowing the respective radio node for which the radio map is provided to be identified, wherein at least a part of the identifier information depends on the at least one property of the respective radio node.

22. The method according to any of the preceding claims, the method further comprising:

- changing, in case at least one property of a radio node of the system is changed by the controlling of the at least one property, identifier information to be broadcast by the radio node of the system, the identifier information allowing the radio node of the system to be identified.

23. The method according to any of the preceding claims, wherein the system comprises one or more of

- a plurality of hubs;
- a gateway hub in communication with the at least one hub; and/or
- a server in communication with the at least one hub and/or the gateway hub.

24. The method according to any of the preceding claims, wherein the at least one apparatus performing the method is or comprises at least one of

- the at least one hub;
- a gateway hub; and/or
- a server.

25. An apparatus configured to perform and/or control or comprising respective means for performing and/or controlling the method according to any of the preceding claims.

26. A system comprising at least one hub and a plurality of a radio nodes in communication with at least one of the at least one hub, the radio nodes being able to broadcast signals usable for positioning of a mobile device of a respective user in an area of the system, the system being configured for performing a method according to any of claims 1 to 24.

27. The system according to claim 45, further comprising one or more of:

- a plurality of hubs;
- a gateway hub in communication with the at least one hub; and/or
- a server in communication with the at least one hub and/or the gateway hub.

28. A computer program code, the computer program code when executed by a processor causing an apparatus to perform the actions of the method of any one of claims 1 to 24.

29. A computer readable storage medium in which computer program code according to claim 28 is stored.

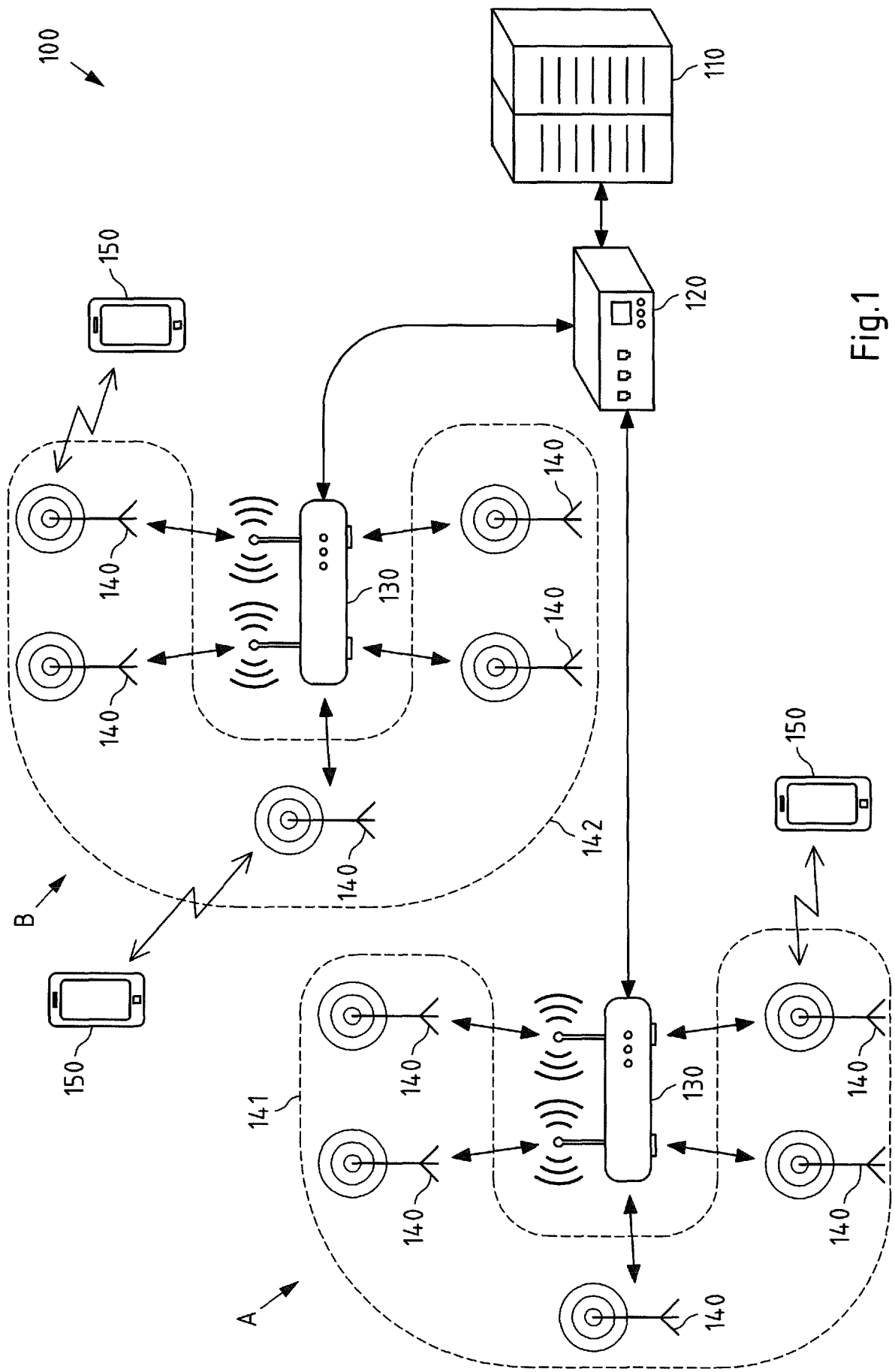


Fig.1

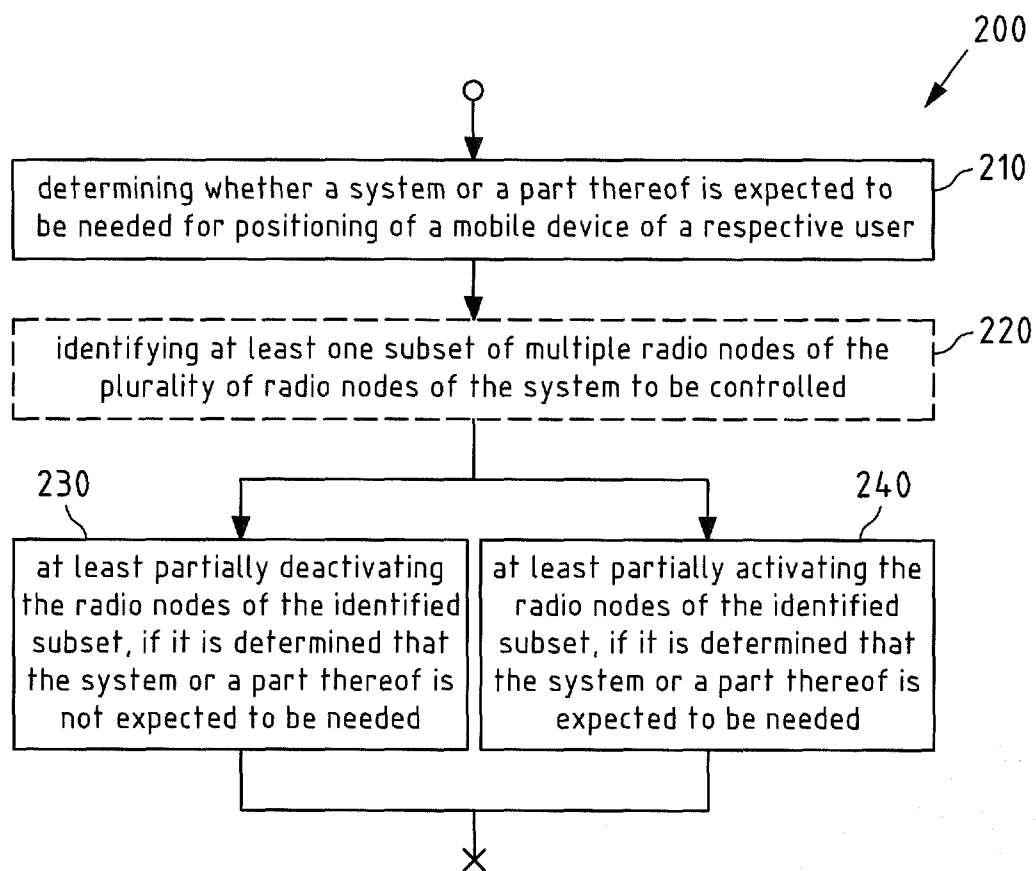


Fig.2

3/5

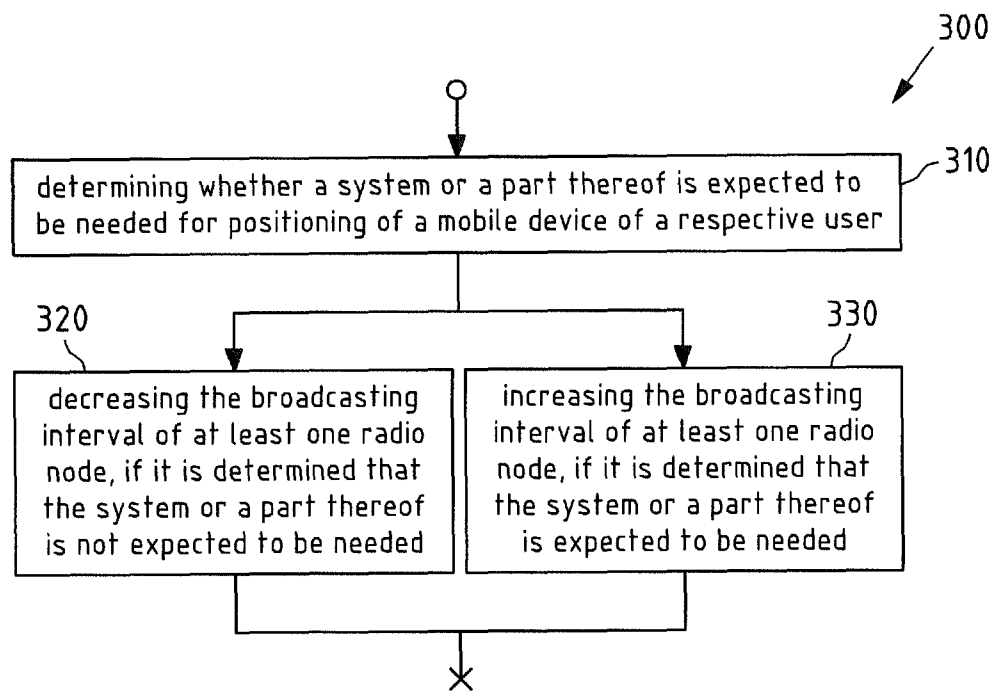


Fig.3

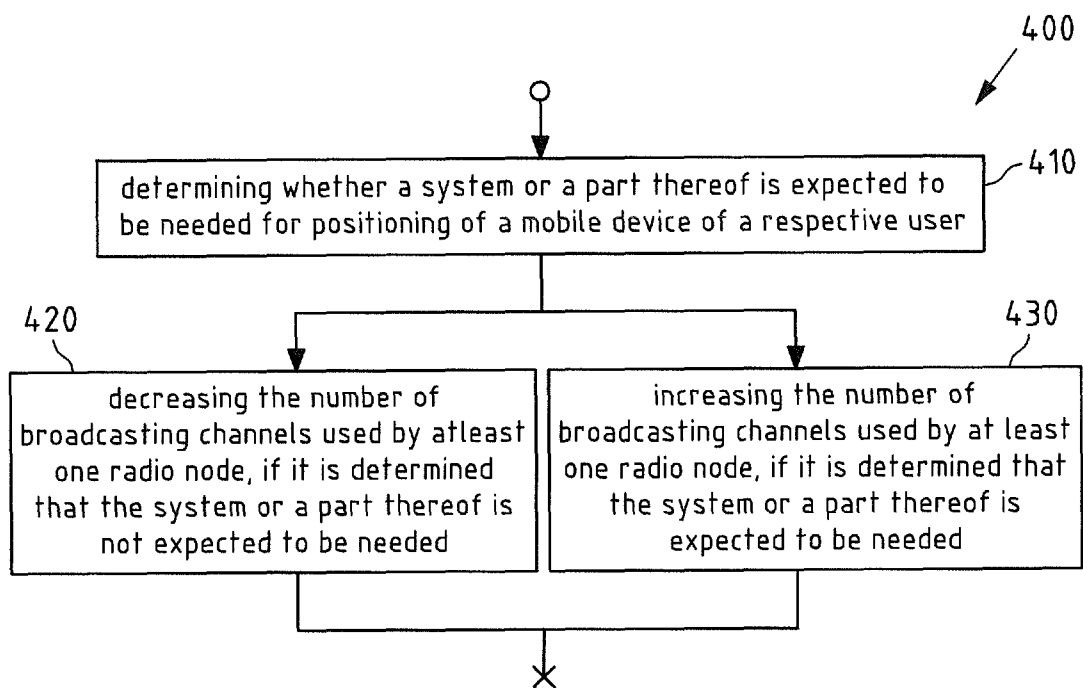


Fig.4

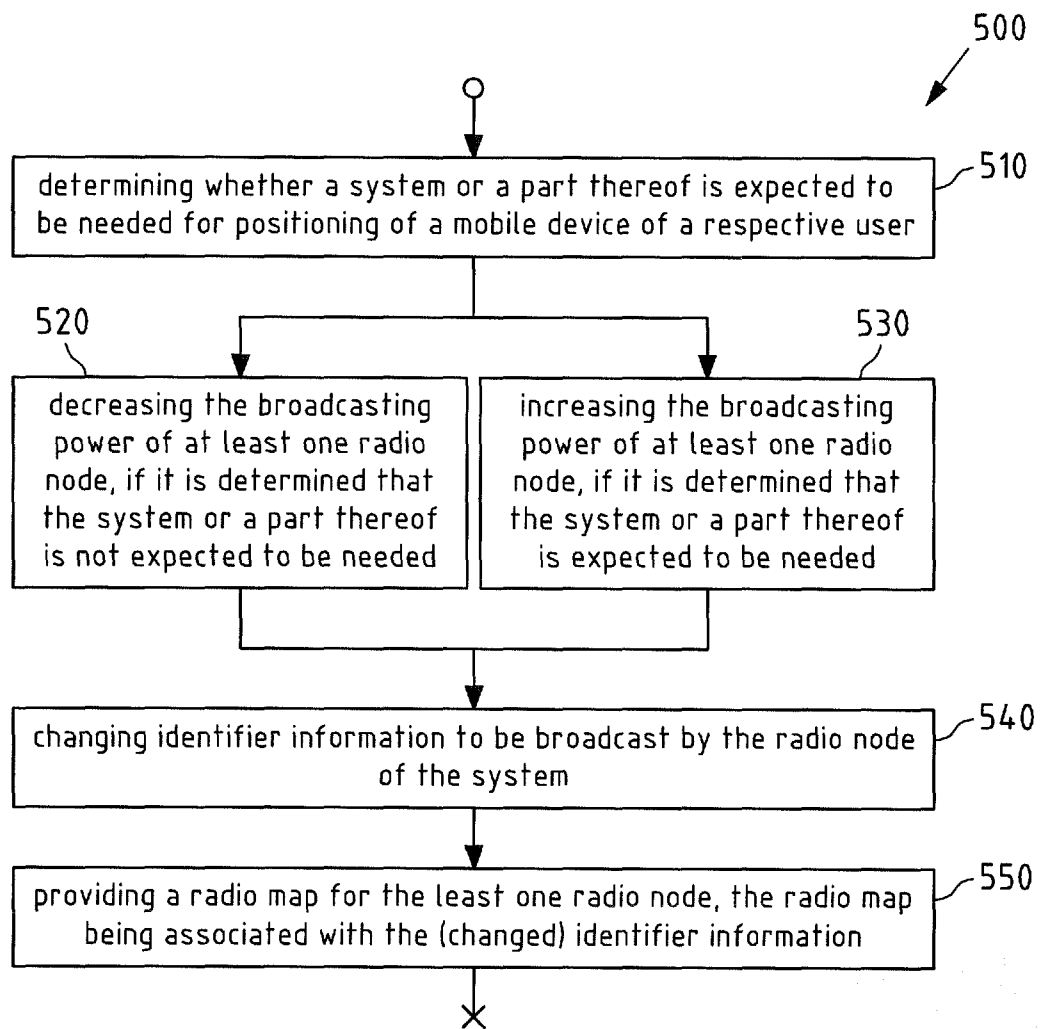


Fig.5

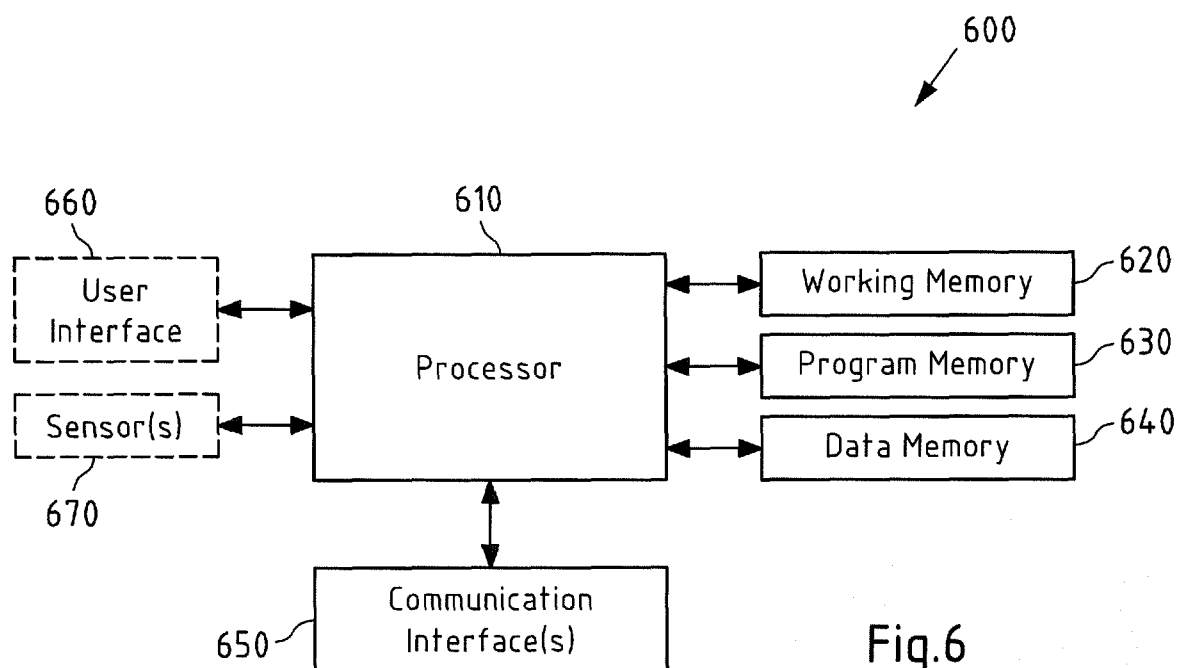


Fig.6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/081830

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01S5/02
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01S

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

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

EPO-Internal, WPI Data

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Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

1 August 2018

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/081830

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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