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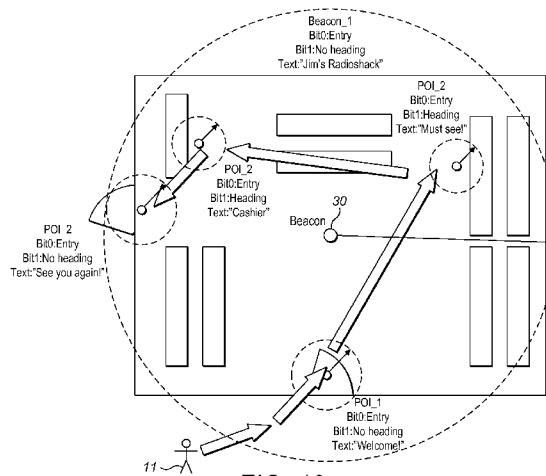


FIG. 10

(57) Abstract: Apparatus (30) is configured: to transmit angle-of-departure positioning messages from which a mobile device (11) can calculate a direction to the mobile device from the apparatus (30); and to transmit a point of interest packet data unit for providing a point of interest service to a mobile device (11), the first point of interest packet data unit comprising first data indicating a first range from a first point of interest.

Handling Positioning Messages

Field

The present application relates to handling positioning messages.

5

Background

Bluetooth Low Energy (BLE) is a new wireless communication technology published by the Bluetooth SIG as a component of Bluetooth Core Specification Version 4.0. BLE is a lower power, lower complexity, and lower cost wireless communication protocol, designed for applications requiring lower data rates and shorter duty cycles. Inheriting the protocol stack and star topology of classical Bluetooth, BLE redefines the physical layer specification, and involves many new features such as a very-low power idle mode, a simple device discovery, and short data packets, etc.

15 BLE technology is aimed at devices requiring a low power consumption, for example devices that may operate with one or more button cell batteries such as sensors, key fobs, and/or the like. BLE can also be incorporated into devices such as mobile phones, smart phones, tablet computers, laptop computers, desktop computers etc.

20 Summary

Various aspects of examples of the invention are set out in the claims.

A first aspect of the invention provides apparatus configured:

25 to transmit angle-of-departure positioning messages from which a mobile device can calculate a direction to the mobile device from the apparatus; and

to transmit a point of interest packet data unit for providing a point of interest service to a mobile device, the first point of interest packet data unit comprising first data indicating a first range from a first point of interest.

30 The first data may also indicate a location of the first point of interest.

The first point of interest may be co-located with the apparatus and the first range may indicate a range from the apparatus.

35 The first data may indicate whether a notification is to be triggered:

when the mobile device moves within an area defined by the first range from the first point of interest, or

when the mobile device moves without the area defined by the first range from the first point of interest.

5

The first data may indicate whether a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device.

The point of interest packet data unit may additionally comprise second data indicating a second range from a second point of interest. The second data may indicate a location of the second point of interest. Alternatively, the second point of interest may be co-located with the apparatus and the second range may indicate a range from the apparatus. The second data may indicate whether a notification is to be triggered:

when the mobile device moves within an area defined by the second range from the second point of interest, or

when the mobile device moves without the area defined by the second range from the second point of interest. The second data may indicate whether a notification is to be provided indicating a heading to the second point of interest from the location of the mobile device.

20

The apparatus may be configured to transmit coded text relating to the first point of interest.

The apparatus may be configured to transmit a first positioning advertising message including at least the first and second data relating to the first and second points of interest respectively, and to transmit a second positioning advertising message including data indicating to which of the points of interest the coded text relates.

The apparatus may be configured to create the point of interest packet data unit using configuration information received from an external device, such as a mobile device or a server.

The first point of interest packet data unit may be transmitted as part of a Bluetooth message, for example a Bluetooth advertising message, a Bluetooth Low Energy message, or a Bluetooth Low Energy advertising message.

35

A second aspect of the invention provides apparatus configured:

to receive at least one angle-of-departure positioning message from a positioning beacon;

5 to receive a point of interest packet data unit from the positioning beacon, the point of interest packet data unit comprising first data indicating a first range from a first point of interest;

to use the angle-of-departure positioning message to calculate a position of the apparatus; and

10 to respond to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the first point of interest by providing a notification.

The first data may also indicate a location of the first point of interest.

15 The first point of interest may be co-located with the beacon and the first range may indicate a range from the beacon.

When the first data may indicate that a notification is to be triggered when the mobile device moves within an area defined by the first range from the first point of interest, 20 the apparatus may be configured to respond to determining that the position of the apparatus has moved from without to within the area defined by the first range and the first point of interest by providing the notification.

When the first data may indicate that a notification is to be triggered when the mobile device moves without an area defined by the first range from the first point of interest, 25 the apparatus may be configured to respond to determining that the position of the apparatus has moved from within to without the area defined by the first range and the first point of interest by providing the notification.

30 When the first data may indicate that a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device, the apparatus may be configured to provide an indication of a heading to the first point of interest.

35 The apparatus may be configured:

to extract from the first positioning data unit second data indicating a second range from a second point of interest; and

to respond to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the second point of interest by providing a notification.

The apparatus may be configured:

to receive coded text relating to the first point of interest, and
to cause provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest or that the position of the apparatus has a certain relationship with respect to an area defined by the second range and the second point of interest by providing a notification.

The apparatus may be configured, when received data may indicate that the coded text relates to both the first and second points of interest, to cause provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest.

The point of interest packet data unit may be received as part of a Bluetooth message, for instance a Bluetooth advertising message.

The Bluetooth message may be a Bluetooth Low Energy message, for instance a Bluetooth Low Energy advertising message.

The apparatus may be a communication module and wherein the apparatus may be configured to provide the notification by providing a notification to a software application that is external to the communication module.

A third aspect of the invention provides a non-transitory computer-readable storage medium having stored thereon computer-readable code, which, when executed by computing apparatus, may cause the computing apparatus to perform a method comprising:

transmitting angle-of-departure positioning messages from which a mobile device can calculate a direction to the mobile device from an apparatus; and

transmitting a point of interest packet data unit for providing a point of interest service to a mobile device, the first point of interest packet data unit comprising first data indicating a first range from a first point of interest.

5 The first data may also indicate a location of the first point of interest.

The first point of interest may be co-located with the apparatus and the first range may indicate a range from the apparatus.

10 The first data may indicate whether a notification is to be triggered:

when the mobile device moves within an area defined by the first range from the first point of interest, or

when the mobile device moves without the area defined by the first range from the first point of interest.

15

The first data may indicate whether a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device.

20 The point of interest packet data unit additionally comprises second data indicating a second range from a second point of interest.

The second data may indicate a location of the second point of interest.

25 The second point of interest may be co-located with the apparatus and the second range may indicate a range from the apparatus.

The second data may indicate whether a notification is to be triggered:

when the mobile device moves within an area defined by the second range from the second point of interest, or

30 when the mobile device moves without the area defined by the second range from the second point of interest.

The second data may indicate whether a notification is to be provided indicating a heading to the second point of interest from the location of the mobile device.

35

The computer-readable code when executed may cause the computing apparatus to transmit coded text relating to the first point of interest.

5 The computer-readable code when executed may cause the computing apparatus to transmit a first positioning advertising message including at least the first and second data relating to the first and second points of interest respectively, and to transmit a second positioning advertising message including data indicating to which of the points of interest the coded text relates.

10 The computer-readable code when executed may cause the computing apparatus to create the point of interest packet data unit using configuration information received from an external device, such as a mobile device or a server.

15 The first point of interest packet data unit may be transmitted as part of a Bluetooth message, for example a Bluetooth advertising message, a Bluetooth Low Energy message, or a Bluetooth Low Energy advertising message.

A fourth aspect of the invention provides a non-transitory computer-readable storage medium having stored thereon computer-readable code, which, when executed by
20 computing apparatus, may cause the computing apparatus to perform a method comprising:

receiving at least one angle-of-departure positioning message from a positioning beacon;

25 receiving a point of interest packet data unit from the positioning beacon, the point of interest packet data unit comprising first data indicating a first range from a first point of interest;

using the angle-of-departure positioning message to calculate a position of an apparatus; and

30 responding to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the first point of interest by providing a notification.

The first data may also indicate a location of the first point of interest.

35 The first point of interest may be co-located with the beacon and the first range may indicate a range from the beacon.

The computer-readable code when executed may cause the computing apparatus to, when the first data may indicate that a notification is to be triggered when the mobile device moves within an area defined by the first range from the first point of interest, respond to determining that the position of the apparatus has moved from without to within the area defined by the first range and the first point of interest by providing the notification.

The computer-readable code when executed may cause the computing apparatus to, when the first data may indicate that a notification is to be triggered when the mobile device moves without an area defined by the first range from the first point of interest, respond to determining that the position of the apparatus has moved from within to without the area defined by the first range and the first point of interest by providing the notification.

The computer-readable code when executed may cause the computing apparatus to, when the first data may indicate that a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device, provide an indication of a heading to the first point of interest.

The computer-readable code when executed may cause the computing apparatus:
to extract from the first positioning data unit second data indicating a second range from a second point of interest; and
to respond to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the second point of interest by providing a notification.

The computer-readable code when executed may cause the computing apparatus :
to receive coded text relating to the first point of interest, and
to cause provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest or that the position of the apparatus has a certain relationship with respect to an area defined by the second range and the second point of interest by providing a notification.

35

The computer-readable code when executed may cause the computing apparatus to, when received data may indicate that the coded text relates to both the first and second points of interest, cause provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest.

The point of interest packet data unit may be received as part of a Bluetooth message, for instance a Bluetooth advertising message.

10 The Bluetooth message may be a Bluetooth Low Energy message, for instance a Bluetooth Low Energy advertising message.

The apparatus may be a communication module and the computer-readable code when executed may cause the computing apparatus to provide the notification by providing a notification to a software application that is external to the communication module.

Another aspect of the invention provides a method comprising:

transmitting angle-of-departure positioning messages from which a mobile device can calculate a direction to the mobile device from an apparatus; and
20 transmitting a point of interest packet data unit for providing a point of interest service to a mobile device, the first point of interest packet data unit comprising first data indicating a first range from a first point of interest.

The first data may also indicates a location of the first point of interest.

25

The first point of interest may be co-located with the apparatus and the first range may indicate a range from the apparatus.

The first data may indicate whether a notification is to be triggered:

30 when the mobile device moves within an area defined by the first range from the first point of interest, or
when the mobile device moves without the area defined by the first range from the first point of interest.

35 The first data may indicate whether a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device.

The point of interest packet data unit may additionally comprise second data indicating a second range from a second point of interest.

5 The second data may indicate a location of the second point of interest.

The second point of interest may be co-located with the apparatus and the second range may indicate a range from the apparatus.

10 The the second data may indicate whether a notification is to be triggered:
when the mobile device moves within an area defined by the second range from the second point of interest, or
when the mobile device moves without the area defined by the second range from the second point of interest.

15 The second data may indicate whether a notification is to be provided indicating a heading to the second point of interest from the location of the mobile device.

The method may further comprise the step of transmitting coded text relating to the
20 first point of interest.

The method may further comprise the steps of transmitting a first positioning advertising message including at least the first and second data relating to the first and second points of interest respectively, and transmitting a second positioning
25 advertising message including data indicating to which of the points of interest the coded text relates.

The method may further comprise the step of creating the point of interest packet data unit using configuration information received from an external device, such as a mobile
30 device or a server.

The the first point of interest packet data unit may be transmitted as part of a Bluetooth message, for example a Bluetooth advertising message, a Bluetooth Low Energy message, or a Bluetooth Low Energy advertising message.

35 A futher aspect of the invention providesa method comprising:

receiving at least one angle-of-departure positioning message from a positioning beacon;

receiving a point of interest packet data unit from the positioning beacon, the point of interest packet data unit comprising first data indicating a first range from a first point of interest;

using the angle-of-departure positioning message to calculate a position of an apparatus; and

responding to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the first point of interest by providing a notification.

The first data may also indicate a location of the first point of interest.

The first point of interest may be co-located with the beacon and the first range indicates a range from the beacon.

When the first data indicates that a notification is to be triggered when the mobile device moves within an area defined by the first range from the first point of interest, the apparatus may respond to determining that the position of the apparatus has moved from without to within the area defined by the first range and the first point of interest by providing the notification.

When the first data indicates that a notification is to be triggered when the mobile device moves without an area defined by the first range from the first point of interest, the apparatus may respond to determining that the position of the apparatus has moved from within to without the area defined by the first range and the first point of interest by providing the notification.

When the first data indicates that a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device, the apparatus may provide an indication of a heading to the first point of interest.

The method may further comprise the steps of:

extracting from the first positioning data unit second data indicating a second range from a second point of interest; and

responding to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the second point of interest by providing a notification.

5 The method may further comprise:

receiving coded text relating to the first point of interest, and
causing provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest or that the position of the apparatus has a certain
10 relationship with respect to an area defined by the second range and the second point of interest by providing a notification.

The method may further comprise, when received data indicates that the coded text relates to both the first and second points of interest, causing provision of the text in
15 response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest.

The the point of interest packet data unit may be received as part of a Bluetooth message, for instance a Bluetooth advertising message.
20

The Bluetooth message may be a Bluetooth Low Energy message, for instance a Bluetooth Low Energy advertising message.

The apparatus may be a communication module and the method may further comprise
25 the step of providing the notification by providing a notification to a software application that is external to the communication module.

Another aspect of the invention provides a computer program comprising instructions that when executed by a computer apparatus control it to perform the method as
30 heretofore described.

Another aspect of the invention provides apparatus, the apparatus having at least one processor and at least one memory having computer-readable code stored thereon which when executed controls the at least one processor:

35 to transmit angle-of-departure positioning messages from which a mobile device can calculate a direction to the mobile device from the apparatus; and

to transmit a point of interest packet data unit for providing a point of interest service to a mobile device, the first point of interest packet data unit comprising first data indicating a first range from a first point of interest.

5 The first data may also indicate a location of the first point of interest.

The first point of interest may be co-located with the apparatus and the first range may indicate a range from the apparatus.

10 The first data may indicate whether a notification is to be triggered:

when the mobile device moves within an area defined by the first range from the first point of interest, or

when the mobile device moves without the area defined by the first range from the first point of interest.

15

The first data may indicate whether a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device.

20 The point of interest packet data unit may additionally comprise second data indicating a second range from a second point of interest.

The second data may indicate a location of the second point of interest.

25 The second point of interest may be co-located with the apparatus and the second range may indicate a range from the apparatus.

The second data may indicate whether a notification is to be triggered:

when the mobile device moves within an area defined by the second range from the second point of interest, or

30 when the mobile device moves without the area defined by the second range from the second point of interest.

The the second data may indicate whether a notification is to be provided indicating a heading to the second point of interest from the location of the mobile device.

35

The computer-readable code when executed may control the at least one processor to transmit coded text relating to the first point of interest.

5 The computer-readable code when executed may control the at least one processor to transmit a first positioning advertising message including at least the first and second data relating to the first and second points of interest respectively, and to transmit a second positioning advertising message including data indicating to which of the points of interest the coded text relates.

10 The computer-readable code when executed may control the at least one processor to create the point of interest packet data unit using configuration information received from an external device, such as a mobile device or a server.

15 The first point of interest packet data unit may be transmitted as part of a Bluetooth message, for example a Bluetooth advertising message, a Bluetooth Low Energy message, or a Bluetooth Low Energy advertising message.

The apparatus may have at least one processor and at least one memory having computer-readable code stored thereon which when executed controls the at least one processor:

- 20 to receive at least one angle-of-departure positioning message from a positioning beacon;
- to receive a point of interest packet data unit from the positioning beacon, the point of interest packet data unit comprising first data indicating a first range from a first point of interest;
- 25 to use the angle-of-departure positioning message to calculate a position of the apparatus; and
- to respond to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the first point of interest by providing a notification.
- 30

The first data may also indicate a location of the first point of interest.

35 The first point of interest may be co-located with the beacon and the first range may indicate a range from the beacon.

The computer-readable code when executed may control the at least one processor to, when the first data indicates that a notification is to be triggered when the mobile device moves within an area defined by the first range from the first point of interest, respond to determining that the position of the apparatus has moved from without to
5 within the area defined by the first range and the first point of interest by providing the notification.

The computer-readable code when executed may control the at least one processor to, when the first data indicates that a notification is to be triggered when the mobile
10 device moves without an area defined by the first range from the first point of interest, respond to determining that the position of the apparatus has moved from within to without the area defined by the first range and the first point of interest by providing the notification.

15 The computer-readable code when executed may control the at least one processor to, when the first data indicates that a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device, provide an indication of a heading to the first point of interest.

20 The computer-readable code when executed may control the at least one processor:
to extract from the first positioning data unit second data indicating a second range from a second point of interest; and
to respond to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the second point of
25 interest by providing a notification.

The the computer-readable code when executed may control the at least one processor:
to receive coded text relating to the first point of interest, and
to cause provision of the text in response to determining that the position of the
30 apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest or that the position of the apparatus has a certain relationship with respect to an area defined by the second range and the second point of interest by providing a notification.

35 The computer-readable code when executed may control the at least one processor, when received data indicates that the coded text relates to both the first and second

points of interest, to cause provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest.

- 5 The point of interest packet data unit may be received as part of a Bluetooth message, for instance a Bluetooth advertising message.

The Bluetooth message may be a Bluetooth Low Energy message, for instance a Bluetooth Low Energy advertising message.

10

The apparatus may be a communication module and the computer-readable code when executed may control the at least one processor to provide the notification by providing a notification to a software application that is external to the communication module.

- 15 Bluetooth Low Energy or BLE as used herein denotes Bluetooth Core Specification Version 4.0 or later versions that are backwards-compatible with Version 4.0. A BLE device or component is a device or component that is compatible with Bluetooth Core Specification Version 4.0.

20 **Brief Description Of The Drawings**

For a more complete understanding of example embodiments of the present invention, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

- 25 Figure 1 is a schematic diagram of a system according to aspects of the invention including components according to aspects of the invention and operating according to aspects of the invention;
Figure 2 presents the format of an Advertising Channel PDU used in embodiments of the invention;
- 30 Figure 3 is a flow chart illustrating operation of a beacon of Figure 1 according to embodiments of the invention;
Figures 4 to 7 are schematic diagrams indicating notifications and circumstances that result in notifications being generated, according to embodiments of the invention;
Figures 8 and 9 are flow charts illustrating operation of a mobile device of Figure 1
- 35 according to embodiments of the invention; and

Figure 10 is a schematic diagram illustrating one implementation of a system including a beacon and a mobile device of Figure 1

Detailed Description Of Various Embodiments

5 The following acronyms are used in the specification and have the meanings referred to:

BLE:	Bluetooth Low Energy
BT:	Bluetooth
10 BT SIG:	Bluetooth Special Interest Group
LE:	Low Energy
RFU:	Reserved for Future Use
HAIP:	High Accuracy Indoor Positioning
POI:	Point of interest

15

BLE technology has been proposed to be used in high accuracy indoor positioning (HAIP) systems. HAIP with BLE uses an array of phased antennas to calculate angle-of-departure or angle-of-arrival of a signal. The principles behind calculating the angle-of-departure or angle-of-arrival are described in the prior art.

20

There are two main options for positioning a mobile device or beacon in a BLE HAIP system.

In a first option, the mobiles/tags transmit a BLE positioning packet, which is received
25 at a base station (which can be called a locator) including an antenna array. The base station (or some other device) measures the angle-of-arrival (both azimuth and elevation angles) of the signal using samples of the positioning packet received at different elements of the antenna array, and consequently calculates the position of the mobile/tag. This can be called network-centric positioning. The network-centric
30 approach is limited by capacity.

In a second option, a base station includes an antenna array and transmits a BLE positioning packet from different elements of the antenna array in a way that allows the mobile/tag to calculate the angle-of-departure (both azimuth and elevation angles) of
35 the signal from the base station. The base station here can be termed a beacon. This can be termed mobile-centric positioning. The mobile-centric case is advantageous

from the capacity point of view as any number of devices can measure and use broadcast signals for positioning purposes.

A base station or beacon may be able to operate according to both options.

5

It is the mobile-centric option that is of primary interest in the following, although of course a beacon may operate in the mobile-centric mode as well as the network-centric mode.

10 Figure 1 shows a system according to embodiments of the invention. The system 10 includes a first device 11 and a second device 12. It also includes first to nth BLE beacons 30a, 30b to 30n, each of which may be referred to as a beacon 30. The system also includes a server 40. The first and second devices 11, 12 are mobile or portable and their locations can be tracked.

15

Briefly, the BLE beacons 30 are based at different locations within a building or complex of buildings and periodically transmit two different messages. These messages are, firstly, AoD positioning packets and, secondly, positioning advertisement messages. Both the AoD positioning messages and the positioning advertisement
20 messages transmitted by a given beacon 30 include an identifier that is unique to that beacon 30 within the building.

Each of the BLE beacons 30 includes multiple antenna elements and transmits the AoD positioning packets including a certain packet tail called AoD extension. The beacon
25 has multiple antenna elements which are used sequentially during the transmission of the AoD extension. The sequence of antenna elements involves switching between them in a pre-defined order. Each of the first and second devices 11, 12 is able to receive an AoD positioning packet from the BLE beacons 30 and calculate, from parameters of the received signal at the part corresponding to the AoD extension, a bearing from the
30 beacon 30 at which the AoD positioning packet was received at the device 11, 12. The bearing is able to be calculated because of the form given to the signal transmitted along the bearing by the multiple antenna elements.

The positioning advertisement messages include information designating the location
35 and orientation of the beacon 30. They may be sent from only a single element of the antenna 116. The positioning advertisement messages are received at the devices 11, 12.

Both AoD positioning packets and positioning advertisement messages are transmitted periodically, although the AoD positioning packets are transmitted more frequently.

5 The devices 11, 12 then can calculate their position using information designating the location and orientation of the beacon and the calculated bearing. Devices 11, 12 can calculate their locations having received an AoD positioning packet from one beacon with a reasonable degree of accuracy. Devices 11, 12 can calculate their locations with greater accuracy by triangulating information relating to AoD positioning packets
10 received from two or more beacons, although the accuracy achieved using only one beacon typically is sufficient. Devices 11, 12 are able to calculate their location without network assistance.

The first device 11 includes a BLE module 13, which operates according to the BLE
15 standard. Each of the BLE beacons 30 also includes a BLE module that operates according to the BLE standard.

The first device 11 includes a processor 112. The processor 112 is connected to volatile memory such as RAM 113 by a bus 118. The bus 118 also connects the processor 112
20 and the RAM 113 to non-volatile memory, such as ROM 114. A communications interface or module 115 is coupled to the bus 118, and thus also to the processor 112 and the memories 113, 114. A BLE module 13 is coupled to the bus 118, and thus also to the processor 112 and the memories 113, 114. An antenna 116 is coupled to the communications module 115 and the BLE module 13, although each may instead have
25 its own antenna. Within the ROM 114 is stored a software application 117. The software application 117 in these embodiments is a navigation application, although it may take some other form. An operating system (OS) 120 also is stored in the ROM 114.

30 The first device 11 may take any suitable form. Generally speaking, the first device 11 may comprise processing circuitry 112, including one or more processors, and a storage device 114, 113, comprising a single memory unit or a plurality of memory units. The storage device 114, 113 may store computer program instructions that, when loaded into the processing circuitry 112, control the operation of the first device 11.

35

The BLE module 13 may take any suitable form. Generally speaking, the BLE module 13 of the first device 11 may comprise processing circuitry, including one or more processors, and a storage device comprising a single memory unit or a plurality of memory units. The storage device may store computer program instructions that, when loaded into the processing circuitry, control the operation of the BLE module 13.

The first device 11 also comprises a number of components which are indicated together at 119. These components 119 may include any suitable combination of a display, a user input interface, other communication interfaces (e.g. wifi, etc.), a speaker, a microphone, and a camera. The components 119 may be arranged in any suitable way.

The BLE module 13 includes a communication stack that is implemented at least partly in software using processor and memory resources (not shown), all of which are included within the BLE module 13. The BLE module 13 is configured, when enabled by the navigation application 117, to calculate the location of the host device 11 as described above, and to report the location to the navigation application 117.

The navigation application 117 is configured to control the BLE module 13 to switch between a positioning mode in which it calculates the position of the host device 11, 12 and a non-positioning mode in which it does not calculate the position of the host device 11, 12, as required by the navigation application 117.

The navigation application 117 may for instance control the BLE module to reside in the positioning mode when positioning has been enabled by the user or by the operating system 120 and when outdoor positioning (e.g. GPS) is unavailable, and to reside in the non-positioning mode otherwise. Alternatively, the navigation application 117 may for instance control the BLE module to reside in the positioning mode when positioning has been enabled by the user or by the operating system 120 and when BLE positioning advertisement messages have been received within a certain time period (e.g. 10 minutes before the current time), and to reside in the non-positioning mode otherwise.

The second device 12 may be configured and operate in the same way as the first device 11.

The devices 11, 12 may be mobile phones, smart phones, tablet computers, laptop computers, cameras, mp3-players, equipment integrated within vehicles, etc. The devices 11, 12 may be based around any suitable operating system, for instance the Symbian operating system or Microsoft Windows operating system, although any other
5 operating system may instead be used. The devices 11, 12 may run different operating systems.

The beacon 30, for instance the first beacon 31a, includes a BLE module 121, an antenna 126 and a source of power 130. In the BLE module 121 of the beacon 30, a
10 processor 122, RAM 123, ROM 124, a transmitter 125, software 127 and a bus 128 are constituted and connected in any suitable way. The ROM 124 of the beacon 30 also stores information 129. The information 129 includes an identifier that identifies the beacon, the location of the beacon, and the orientation of the beacon.

15 The beacon 30 includes a communication interface 108, using which communications can be received from the server 40. The server 40 may be connected either directly or indirectly with the beacon 30. The server 40 may be connected with the beacon 30 by Ethernet.

20 The source of power 130 may be for instance a power-over-Ethernet source, a battery, or mains power. The source of power 130 powers the BLE module 121 and any other components of the beacon 30.

The BLE module 121 of the beacon 30 may solely be a transmitter 125 and may not
25 perform receiver functions. The transmitter 125 may include hardware needed for receiving, the receive function being disabled through the software 127. Alternatively, the transmitter 125 may be absent of some of the hardware needed for receiving. Put another way, it may be a transmitter or it may be a transceiver in which the receive functions have been disabled in software.

30 Each of the BLE beacons 30 includes multiple antenna elements (indicated together at 126 in the Figure) and transmits AoD positioning messages using these multiple antenna elements simultaneously. By transmitting the AoD positioning messages in this way, a device 11, 12 can calculate from parameters of the received signal that
35 included the AoD positioning message an angle (actually, both azimuth and elevation angles) from the beacon 30 at which the device 11, 12 is located.

Each of the BLE beacons 30 also is configured to transmit information designating the location and orientation of the beacon 30. This information forms part of the positioning advertisement messages. As such, devices 11, 12 can calculate their locations having received an AoD positioning packet from one beacon 30 with a reasonable degree of accuracy. Devices 11, 12 can calculate their locations with greater accuracy by triangulating or by combining location information relating to AoD positioning message received from two or more beacons, although the accuracy achieved using only one beacon typically is sufficient. Devices 11, 12 are able to calculate their location without network assistance. Additionally, the beacons 30 do not need to receive communications from the devices 11, 12 in order to allow the devices 11, 12 to calculate their positions from the received AoD positioning message.

Positioning advertisement messages may be transmitted by each beacon 30 periodically, for instance at 1Hz (1 second intervals) or 2Hz (0.5 second intervals) or at intervals defined by some component within the system. They may alternatively be transmitted on request of some component within the system.

AoD positioning messages may be transmitted by each beacon 30 periodically, for instance at 20Hz (50 millisecond intervals). Clearly, devices 11, 12 can calculate their positions at the same periodicity, or the devices 11, 12 can filter multiple measurements for better accuracy. Such a frequency of transmission of AoD positioning messages allows rapid and reliable positioning updates for the devices 11, 12.

The beacon 30 may take any suitable form. Generally speaking, the beacon 30 may comprise processing circuitry, including one or more processors, and a storage device, comprising a single memory unit or a plurality of memory units. The storage device may store computer program instructions that, when loaded into the processing circuitry, control the operation of the beacon 30.

The other beacons 30b ... 30n may be configured and operate in the same way as the first beacon 30a. The other beacons are different to the first beacon 30a at least in that the information 129 stored in the ROM 124 includes a different identifier and a different location, and may also include a different orientation of the beacon.

35

The server 40 includes a processor 412. The processor 412 is connected to volatile memory such as RAM 413 by a bus 418. The bus 418 also connects the processor 112 and the RAM 413 to non-volatile memory, such as ROM 414. A communications interface 415 is coupled to the bus 418, and thus also to the processor 412 and the memories 413, 414. The interface 415 is connected to the radio network 50 in any suitable way, for instance via the Internet or a local network. Within the ROM 414 is stored a software application 417. An operating system (OS) 420 also is stored in the ROM 414. Within the ROM 414 is also stored a location database 422.

10 An output device such as a display 419 may be provided with the server 40. An input device such as a keyboard 421 may be provided with the server 40.

The server 40 may take any suitable form. Generally speaking, the server 40 may comprise processing circuitry 412, including one or more processors, and a storage device 414, 413, comprising a single memory unit or a plurality of memory units. The storage device 414, 413 may store computer program instructions that, when loaded into the processing circuitry 412, control the operation of the server 40.

Some further details of components and features and alternatives for them will now be described.

The computer program instructions 117 may provide the logic and routines that enables the first device 11 to perform the functionality described below. The computer program instructions 117 may be pre-programmed into the first device 11. Alternatively, they may arrive at the first device 11 via an electromagnetic carrier signal or be copied from a physical entity such as a computer program product, a non-volatile electronic memory device (e.g. flash memory) or a record medium such as a CD-ROM or DVD. They may for instance be downloaded to the first device 11 from a server, for instance the server 40 but possibly another server such as a server of an application marketplace or store.

30 The processing circuitry 112, 122, 412 may be any type of processing circuitry. For example, the processing circuitry may be a programmable processor that interprets computer program instructions and processes data. The processing circuitry may include plural programmable processors. Alternatively, the processing circuitry may be, for example, programmable hardware with embedded firmware. The processing circuitry or processor 112, 122, 412 may be termed processing means.

Typically, the BLE modules 13, 121 each comprise a processor coupled connected to both volatile memory and non-volatile memory. The computer program is stored in the non-volatile memory and is executed by the processor using the volatile memory for
5 temporary storage of data or data and instructions.

The term 'memory' when used in this specification is intended to relate primarily to memory comprising both non-volatile memory and volatile memory unless the context implies otherwise, although the term may also cover one or more volatile memories
10 only, one or more non-volatile memories only, or one or more volatile memories and one or more non-volatile memories. Examples of volatile memory include RAM, DRAM, SDRAM etc. Examples of non-volatile memory include ROM, PROM, EEPROM, flash memory, optical storage, magnetic storage, etc.

Each BLE module 13, 121 may be a single integrated circuits. Each may alternatively be provided as a set of integrated circuits (i.e. a chipset). The BLE modules 13, 121 may alternatively be hardwired, application-specific integrated circuits (ASIC).
15

The communication interface 115 may be configured to allow two-way communication with external devices and/or networks. The communication interface may be
20 configured to communicate wirelessly via one or more of several protocols such as Global System for Mobile Communications (GSM), Code Division Multiple Access (CDMA), Universal Mobile Telecommunications System (UMTS) and IEEE 802.11 (Wi-Fi). Alternatively or additionally, the communication interface 115 may be configured
25 for wired communication with a device or network.

The apparatus 11, 12, 40, 30 may comprise further optional software components which are not described in this specification since they may not have direct interaction with the features described.
30

The BLE beacons 30 are distributed around a building or premises. For instance a first beacon 30a may be located in a canteen, a second beacon 30b may be located in a reception area, and so on. The first and second beacons 30a and 30b can be referred to as beacons 30. Beacons 30 do not need to provide complete coverage of a building, but
35 advantageously are provided to provide good coverage of all key locations within the building.

The beacon identifier transmitted by a beacon 30 may be provided in a Device Address field or in a Device Identifier field of an advertising message, according to the BLE specification, or it may take some other form.

5

The latest version of the BLE specification defines three advertising channels, which serve for device discovery and other broadcasting purpose. To identify BLE devices, two important identifies - Device Address and Device Name - are highly relied upon. According to the BLE specification, packets sent in the advertising channels (index=37, 10 38 and 39) shall contain the device addresses, which are used to identify a BLE device. The identifier relating to a beacon may be a device address included in the Device Address field, or it may be included in a payload of the advertising message.

There are two types of device addresses: public device address and random device 15 address, each of them is 48 bits in length. A device shall contain at least one type of device address and may contain both.

- **Public Device Address**

The content of a public device address contains two fields:

- company_assigned field is in the 24 least significant bits
- company_id field is in the 24 most significant bits

The public device address shall be created in accordance with section 9.2 ("48-bit universal LAN MAC addresses") of the IEEE 802-2001 standard (http://standards.ieee.org/getieee802/download/802-2001.pdf) and using a valid 25 Organizationally Unique Identifier (OUI) obtained from the IEEE Registration Authority (see http://standards.ieee.org/regauth/oui/forms/ and sections 9 and 9.1 of the IEEE 802-2001 specification).

- **Random Device Address**

30 A random device address is divided into the following two fields:

- hash field is in the 24 least significant bits
- random field is in the 24 most significant bits

The detailed specification of the hash field and random field can be found in BT Specification v4.0, Vol.3, Part C, Section 10.8.2.3 and Section 10.8.2.2, respectively.

35

On the other hand, the Generic Access Profile (GAP) also provides a Local Name AD Type to contain the device name in the BLE advertising data (BT Specification v4.0, Vol.3, Part C, Section 11.1.2).

5 A positioning advertisement message may be a BLE link layer packet, an example of which is shown in Figure 2. Figure 2A shows higher level components of the positioning advertisement messages, and Figure 2B shows some lower level components of the positioning advertisement messages.

10 As shown in Figure 2, there are four main components to the message. The first part is a preamble. The second part is a sync word. The third part is a packet data unit (PDU). The fourth part is a cyclic redundancy check (CRC).

Here, the preamble is one octet (eight data bits, also known as one byte). The sync
15 word is four octets. The PDU is between two and 39 octets. The CRC is three octets.

As shown in Figure 2A, the PDU includes two main sections. The first is the header, and the second is the payload. The header here has 64 bits (six octets). The payload has a length that is between zero and 31 octets, as per the length field in the header part
20 of the PDU.

The header is shown in Figure 2A as being divided into six fields. The PDU type field comprises four bits, and identifies the type of the PDU. The second field is reserved for future use (RFU) and includes two bits. A TxAdd field is one bit. The fourth field is
25 reserved for future use (RFU) and includes one bit. The Length field includes six bits. The sixth field is reserved for future use (RFU) and includes two bits. An AdvA field (or AdvAdd field) is 6 octets (48 bits).

The TxAdd field indicates whether the address of the beacon 30 in the AdvA field is public or random. The AdvA field includes the public or random address of the beacon
30 30.

The payload of the PDU, hereafter termed the Positioning Beacon AD Type, includes eight fields. The first of these is a length field, of one octet. The second is an AdType
35 field which is one octet. The AdType field is used for structuring advertising data contents for different purposes. For example, the content may be a list of Service IDs,

or just one service ID followed by the data related to that service ID. In these examples, there is a set of parameters that are known by the BLE module 113 of the receiver.

5 A BestInterval field is two octets long. This indicates the interval between successive Broadcasts. A BestChannels field is two octets long. This indicates the channels that are used for broadcast. A BestActive field is one bit long. This bit indicates whether broadcasting is active. A TransmitPower field is seven bits long. The transmit power is indicated in this field. A ClockAccuracy field is sixteen bits long. This includes data that indicates the accuracy of the clock within the beacon 30. Lastly, a Profile Data field is between 0 and 22 octets long, according to the value included in the Length field.

15 The Positioning Beacon AD Type is shown both Figures 2A and 2B, but this is the same in both Figures. Figure 2B shows in detail the Profile Data field of the Positioning Beacon AD Type.

The Profile Data field of the Positioning Beacon AD Type includes four fields. The first is ServiceID, which is two octets in length. The data included in the ServiceID field is used only by the Host of the BT communications stack. An identifier of the service that is provided by the positioning messages is included in this field. A PageID field is three 20 bits. A PageIDData field is five bits long. Lastly, a Data field is between 0 and 19 octets, according to the data included in the Length field of the Positioning Beacon AD Type.

25 Briefly, embodiments of the invention provide basic geofencing and proximity detection features, for instance for location based advertisements, within a positioning system. Features of the embodiments can make it possible to provide this without any network connectivity for mobile devices, whilst having low power consumption. In brief, a beacon transmits proximity services along with angle-of-departure positioning 30 messages. A receiver receiving those messages can determine its position and create notifications when the user has a predetermined relationship with a point of interest (POI) defined in the broadcast data. The POI can be defined with respect to the position (in two dimensions) of the beacon itself, or with respect to a location within the range of the beacon and defined by the data broadcast from the beacon. The mobile device can use data included in the broadcast messages to trigger a notification either 35 when a device enters an a POI or exits such a POI. The mobile device may also provide

an indication of a heading to the centre of the POI, based on data received from the beacon. A proximity data positioning message transmitted by the beacon may indicate multiple POIs. In the specific examples, a proximity data positioning message indicates two different ranges with respect to the (two-dimensional) location of the beacon itself, and five POIs, with respective ranges etc, within the range of the beacon.

Embodiments will now be described, starting with reference to Figure 3. Figure 3 is a flowchart illustrating operation of a beacon 30 according to the invention.

10 The operation starts at step S1. At step S2, one or more points of interest (POI) PDUs are created. Each POI PDU defines one or more POIs. Each POI is defined by a centre for the POI and a range from the centre of the POI. The centre for the POI may be defined either explicitly or implicitly. Where multiple POIs are signalled in a POI PDU, each POI may have a different range. Where a centre of a POI is not co-located with the
15 beacon 30, the POI PDU contains data indicating the location of the centre of the POI.

In the following, a POI is an area which is formed by a circle drawn around a location with a radial equal to the range. As such, a POI is defined by a location, which is at the centre of the POI, and a range. In the following, references to a device being within the
20 POI refer to a device being within the area defined by the centre of the POI and the range, and the converse is true for a device being outside the POI. In relation to a heading to a POI, the heading is provided to the centre of the POI.

At step S3, one or more proximity data PDUs are created. Each proximity data PDU
25 created at step S3 includes coded text that relates to one or more POIs. The proximity data PDUs also indicate to which POIs the proximity data relates.

At step S4, the beacon 30 schedules transmission of advertising messages. Each of the POI PDUs and proximity data PDUs are included in a respective, separate advertising
30 message. Other advertising messages include antenna coordinate positioning advertisement messages, which identify the location of the beacon 30, for allowing mobile devices 11 to calculate their position from angle-of-departure (AoD) positioning messages transmitted by the beacons 30. There may also be Location Data advertising messages that are scheduled for transmission in step S4.

35

The schedule may be created such that antenna coordinates, relating to the location of the beacon 30, are transmitted relatively frequently by the beacon 30. A desirable effect of this is to reduce the maximum time to first fix, which is the longest period of time that a mobile device 11, 12 could need to obtain the information it needs from signals transmitted from the beacon 30 in order to calculate the position of the mobile device 11, 12. For instance, the antenna coordinates may be transmitted every other slot, that is in slots 1, 3, 5 etc.

Interleaved between the antenna coordinate slots are slots in which positioning advertisement messages containing POI PDUs and Proximity Data PDUs are transmitted. The schedule is created by the beacon 30 such as to transmit all the POI PDUs and Proximity Data PDUs once each in a sequence, before repeating the sequence.

Scheduling the advertising messages in this way allows the POI PDUs and Proximity Data PDUs to be transmitted in such a way that the maximum time to fix a location is not reduced significantly compared to the situation in which the antenna coordinates are transmitted at every slot in the sequence. It will be appreciated that the antenna coordinates are given higher priority than the POI PDUs and Proximity Data PDUs in the sequence, which in most cases is likely to be appropriate because in most instances the mobile devices 11, 12 and the users will be more interested in knowing their location quickly than in having information about POIs quickly.

The beacon 30 may be configured to schedule the positioning advertising messages such that the antenna coordinates are provided in a first coordinate frame, for instance a global coordinate frame, in slots 1, 5, 9 etc. and in a second coordinate frame, for instance a local coordinate frame, in slots 3, 7, etc. Providing PDUs for the antenna coordinates in different coordinate frames increases the likelihood that a mobile device 11, 12 will receive the antenna coordinates in a form that is usable, or more easily usable, by that device 11, 12.

After the schedule has been created, at step S5 the beacon 30 transmits the positioning advertising messages and the AoD messages. Here, the advertising messages are transmitted according to the schedule as created at step S4. The AoD messages are transmitted separately. The advertising messages may be transmitted on a different periodicity to the AoD messages. For instance, the advertising messages can be

transmitted once per second, so at a frequency of 1 Hz. The AoD messages may be transmitted more frequently, for instance at 50 millisecond intervals, i.e. at 20 Hz.

The frequency of transmission of AoD messages dictates the intervals between successive position fixes for mobile devices. The interval between successive advertising messages dictates the maximum time to a mobile device obtaining antenna coordinates relating to a location of a beacon 30. It also dictates, along with the number of advertising messages included in the schedule, a maximum time to the mobile device 11 receiving all of the advertising messages that are transmitted by the beacon 30.

An example form for a POI PDU is shown in the table below. This part of the POI PDU is the part that is included in the Data field of the PDU shown in Figures 2A and 2B.

#Octet	Type	Service	Comments
0	Service ID	-	Fixed
1	Service ID	-	Fixed
2	Page ID reserved	-	Fixed/reserved
3	exit/entry heading range	Proximity_1 wrt beacon	Resolution: 0.50 m, max range 32 m
4	exit/entry heading range	Proximity_2 wrt beacon	Resolution: 0.50 m, max range 32 m
5	exit/entry heading range	Proximity wrt POI_1	Resolution: 0.50 m, max range 32 m
6	POI_ΔEast	Proximity wrt POI_1	Resolution 0.50 m, range: [-64, 64] m
7	POI_ΔNorth	Proximity wrt POI_1	Resolution 0.50 m, range: [-64, 64] m
8	exit/entry heading range	Proximity wrt POI_2	Resolution: 0.50 m, max range 32 m
9	POI_ΔEast	Proximity wrt POI_2	Resolution 0.50 m, range: [-64, 64] m
10	POI_ΔNorth	Proximity wrt POI_2	Resolution 0.50 m, range: [-64, 64] m

11	exit/entry heading range	Proximity wrt POI_3	Resolution: 0.50 m, max range 32 m
12	POI_ΔEast	Proximity wrt POI_3	Resolution 0.50 m, range: [- 64, 64] m
13	POI_ΔNorth	Proximity wrt POI_3	Resolution 0.50 m, range: [- 64, 64] m
14	exit/entry heading range	Proximity wrt POI_4	Resolution: 0.50 m, max range 32 m
15	POI_ΔEast	Proximity wrt POI_4	Resolution 0.50 m, range: [- 64, 64] m
16	POI_ΔNorth	Proximity wrt POI_4	Resolution 0.50 m, range: [- 64, 64] m
17	exit/entry heading range	Proximity wrt POI_5	Resolution: 0.50 m, max range 32 m
18	POI_ΔEast	Proximity wrt POI_5	Resolution 0.50 m, range: [- 64, 64] m
19	POI_ΔNorth	Proximity wrt POI_5	Resolution 0.50 m, range: [- 64, 64] m

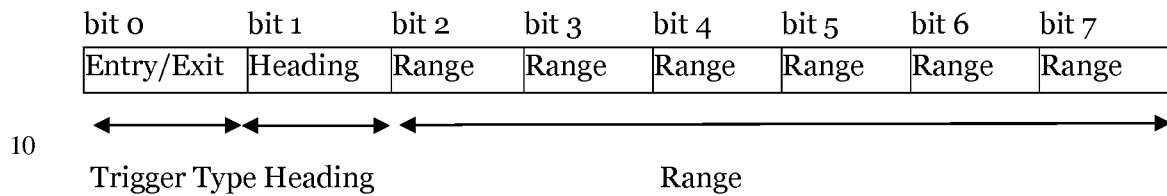
This PDU includes twenty octets of data, labelled from octet number 0 to octet number 19. Octet numbers 0 and 1 are reserved for the Service ID field. Octet number 2 includes the Page ID field and the PageIDData field. Octet numbers 3 to 18 define POIs.

In particular, proximity octet numbers 3 and 4 each define a POI that is co-located with the beacon 30.

For POIs that are not co-located with the beacon 30, three octets are used to define the POI. A first POI is defined by octet numbers 5 to 8. A second POI is defined with respect to octet numbers 8 to 10. A third is defined with respect to octet numbers 11 to 13. A fourth is defined with respect to octets 14 to 16. A fifth is defined with respect to octet numbers 17 to 19.

A basic POI definition includes information identifying a range to a centre of a POI, as discussed above. It also includes information identifying whether a notification is to be triggered upon entry to the POI or upon exit from the POI.

- 5 A proximity octet indicating proximity with respect to the beacon 30, such as either of proximity octet numbers 3 and 4, is shown below.



This can be termed a proximity octet.

- 15 Here, it can be seen that bit 0 is given over to an Entry/Exit field. Bit 1 is given over to a Heading field. Bits 2 to 7 are given over to a Range field.

The value of the data in the entry/exit field is an indication as to whether a notification is to be provided when the receiving mobile device moves from outside to within the POI or whether a notification is to be provided when the device moves from inside without the POI. For instance, a value of 1 can indicate triggering a notification on exit from the POI, and a value of 0 can indicate triggering a notification on entry to the POI.

Data in the Heading field indicates whether heading and range information is to be provided in respect of the POI. If a heading is not to be provided, then a mobile device 11 takes no action to display a heading to a POI. If data included in the Heading field indicates that a heading is to be required, a mobile device 11 may respond to this data by providing a heading to the centre of the POI, and may also indicate the range to the POI in terms of the distance between the mobile device 11 and the centre of the POI.

Data in the Range field indicate the radius of a circle originating at the centre of the POI. By having six bits, the range may take one of 64 different values. The range may be specified by the data in the Range field in any suitable way. For instance, the unit of 1 may indicate a distance of 0.5 metres, which defines the resolution of the range measurement.

In combination, the proximity octet shown above indicates to a mobile device 11 a range from a location (which is the centre of the POI, for instance the two dimensional location of the beacon 30), whether a notification is to be triggered upon entry to or exit from the POI, and whether a heading (and optionally range) is to be notified in respect of the POI.

Referring to Figure 4, a beacon 30 is shown. The same beacon 30 is shown in Figure 5. Figure 4 shows a circle formed by a first proximity range, centred on the beacon 30. In Figure 5, a second proximity range is defined with reference to the beacon 30. The second proximity range in this instance is smaller than, i.e. has a lower value than, the first proximity range.

In Figure 4, a notification is shown as being triggered when a user of a mobile device 11 enters the POI defined by the first proximity range. This notification is caused by the beacon 30 providing the proximity octet, for instance octet number 3 or octet number 4, with a value 0 in the Entry/Exit field, indicating that a notification is triggered on entry to the POI, and including data in the Range field indicating the first proximity range. In this example, what is included in the Heading field is not used at this time.

In the Figure 5 example, the data included in the Range field has a different value, and indicates a lower range, or smaller distance from the beacon 30. Also, the data in the Entry/Exit field has a value of 1, indicating that a trigger is required upon exit from the POI. With the example of Figure 5, a notification is triggered when the user of the mobile device 11 moves from within a distance of the beacon 30 set by the second proximity range to a location that is greater than the second proximity range from the beacon 30.

As can be seen from the example given above with reference to Figures 4 and 5, a geofence is set by a proximity octet in the POI PDU that defines a POI. The same proximity octet also indicates whether a notification is to be triggered upon entry to or exit from the POI. The radius/diameter of the geofence is set by data included in the Range field of the proximity octet of the POI PDU. As such, a relatively highly configurable geofence is set up using only one octet of data in a POI PDU transmitted by the beacon 30.

In the examples given above with reference to Figures 4 and 5, relating to proximity octet numbers 3 and 4 in the POI PDU, the centre of the POI is the (two-dimensional) location of the beacon 30. With other POIs defined in the POI PDU, the centre of the POI has some different location.

5

Referring to POI number 1 (POI_1 in the Figure), defined with reference to octet numbers 5 to 7, for instance, there are additional fields that define the centre of the POI. In particular, a first octet, in this instance octet number 5, is a proximity octet, and includes an Exit/Entry field. It also includes a Range field. It also includes a
10 Heading field. In this example, the first, proximity octet has the same format as the proximity octet shown above, as is included as one of proximity octet numbers 3 and 4. The above description of the fields and the meaning of data included in the fields of proximity octet 3 applies also to POI_1, and is not repeated here.

15 Additionally, the centre of POI_1 is defined. In this example, the centre of POI_1 is defined relative to the position of the beacon 30. In other examples, it may be defined as an absolute position, for instance using a global coordinate frame. Continuing with the local coordinate frame example, octet number 6 includes data that indicates a distance of the centre of POI_1 from the location of the beacon in one dimension and
20 octet number 7 indicates a distance from the centre of POI_1 to the beacon 30 in another dimension. Here, octet number 6 relates to a distance in the East direction, and can take a negative or positive value. Similarly, the data in octet number 7 indicates a distance in the North direction, and can take a positive or negative value. In this example, the East and North distances are defined with a resolution of 0.5 metres.
25 The use of 8 bits allows a maximum range of -64 to +64 metres (128 metres in total) to be defined.

The effects of this will now be described with reference to Figures 6 and 7.

30 As can be seen from Figure 6, a first POI is defined within a range of the beacon 30. The POI is centred in a positive direction East of the beacon and in a negative direction North. The first POI POI_1 has a range that is relatively small compared with the range of the beacon 30. The data in the Entry/Exit field of the data relating to the first POI indicates that a notification is to be triggered upon entry into the first POI POI_1. As
35 such, when a user of a mobile device 11 moves into the first POI, as defined by the

location at the centre of the POI and the proximity range of the POI, a notification is triggered.

Figure 7 relates to the situation in which the data in the heading bit relating to the first
5 POI indicates that heading information is to be provided. The proximity range of the
POI is not shown in Figure 7 because the provision of the heading on the mobile device
11 is not dependent on whether the device 11 is within the POI, as defined by the centre
location of the POI and the range of the POI. Instead, the heading notification may be
provided whenever the mobile device 11 is within range of the beacon 30. An additional
10 notification may occur when the mobile device 11 enters or exits the POI, depending on
the information included in the proximity octet of the PDU relating to the POI.

In the proximity octets, the data in the Range field may never have a value of zero,
which would relate to a range of zero metres. Instead, a range of zero metres has a
15 special purpose indicating that the proximity service is not enabled for the particular
POI. As such, the smallest range is one unit, which depends on the resolution in which
the range is defined. In this example, the smallest range is 0.5 metres.

The provision of POIs that are not centred on the location of the beacon allows
20 notifications to be triggered at specific locations or areas. For instance, it makes it
possible to define that a notification will be triggered when a certain part of an aisle in a
retail outlet or a certain booth in a conference hall is exited or entered. Because the
POI PDU can define multiple POIs that are not centred on the beacon, a single beacon
can provide for multiple notifications to be provided in respect of multiple POIs.
25 Moreover, the conditions for triggering each of the POIs may be different.
Furthermore, the sizes of the POIs, as defined by the range from the centre location of
the POI, may be different for each of the POIs. Additionally, a separate heading
requirement may be defined for each of the POIs. By using the form of the POI PDU
shown in the table above, seven different POIs can be defined, two of them centred on
30 the location of the beacon 30 and five of them centred on other locations, within a
single positioning advertisement message.

The beacon 30 may be configured with POI data and/or proximity data for broadcast in
any suitable way.

For instance, the beacon 30 may be configured with POI data and proximity data by the server 40, for instance through an Ethernet connection. This provides a particularly flexible solution. It also allows the POIs to be reconfigured or modified during the business day, for instance to direct users to different parts of a retail outlet at
5 lunchtimes versus afternoons.

It may alternatively be configured to create PDUs with POI data and proximity data provided by an operator connected to the beacon 30 through a portable device, such as a tablet computer or some other portable device 11. Access may be through a secured
10 wireless connection. Access may be dependent on operator authentication, for instance by requiring a password. Configuration may occur through the device 11 being provided with a configuration software application or through a web interface, for instance. The software or web interface may provide a visual indication of the floor plan of the premises and the location of the beacon. The software or web interface
15 allows the operator to set up POIs and provide information such as range, heading, type, messages etc. for storage in the beacon 30. The POI configuration of the beacon 30 may change periodically or occasionally as needed.

Operation of the mobile device 11 in handling the above-described PDUs will now be
20 described with reference to Figures 8 and 9.

At step S1 of Figure 8, the operation starts. At step S2, a PDU is received. At step S3 it is determined whether the PDU is a POI PDU. A POI PDU is indicated by a value of 11 in the LSBs of the Page ID field, as described above. If it is determined that the PDU is
25 a POI PDU, at step S4 geofences are set by the mobile device 11. This step involves setting up the POIs that are defined within the POI PDU. The geofences may be set in any suitable way. The effect of setting the geofences is to enable the mobile device 11 to determine when the position has changed such that it has crossed a boundary defined by a range from a centre of a POI.

30
If at step S3 it is determined that the PDU is not a POI PDU, the PDU is processed at step S5.

After step S5 or step S4, it is determined whether all of the PDUs in the sequence
35 transmitted by the beacon 30 have been received. If they have not been received, the operation returns to step S2. Once all PDUs have been determined to have been

received, the operation ends at step S7. Here, the mobile device 11 goes into a partial sleep, at least in the sense that it does not receive any further positioning advertising messages from the beacon 30.

5 If the mobile device 11 detects the presence of a different beacon 30, the operation of Figure 4 is performed also in respect of the new beacon. PDUs from the old beacon may be retained only until the mobile device 11 moves out of range of the beacon 30, or may be retained for an additional further period (for instance 12 hours).

10 The operation of Figure 8 can run in parallel with other operations in the mobile device 11. If there are multiple beacons in range, PDUs from all beacons are ensured to have been received.

An effect of the operation of Figure 8 is to ensure that all of the unique PDUs
15 transmitted by a beacon 30 have been received by the mobile device. Another effect is to ensure that geofences are set for all of the POIs indicated by the POI PDUs transmitted by the beacon.

The operation of Figure 9 is performed by the mobile device in parallel with the
20 operation of Figure 8.

The operation starts at step S1. At step S2, it is determined whether any POIs in the POI PDUs received from the beacon 30 indicate that heading information is required to be notified. This is indicated by a value of 1 in the Heading field in the relevant
25 proximity octets. On a positive determination, at step S3, the POIs and their headings (and also optionally ranges for the POIs) are provided.

Following a negative determination from step S2 or following step S3, an AoD positioning message is received at step S4. At step S5, the device 11 determines its
30 position using the received AoD positioning message.

At step S6, the mobile device 11 determines whether a geofence perimeter has been crossed since the last calculated position. This can be performed in any suitable way, and the way in which it is performed may depend on the way in which the geofences
35 were set at step S4 of Figure 8. On a negative determination, the operation returns to step S4, where another AoD positioning message is received.

On a positive determination from step S6, indicating that a geofence has been crossed since the last position, it is determined at step S7 whether a notification in respect of that geofence is already being provided. If the notification is already being provided, then it is cancelled at step S8, before the operation returns again to step S4. Heading notifications are considered separately to proximity notifications in the performance of this step. As such, a heading notification for a given POI may be cancelled, and the operation proceeds to step S9 for the handling of proximity notifications. If a (proximity) notification is not yet being provided, it is determined at step S9 whether an entry/exit condition specified in the corresponding POI is correct. This will be determined to be correct if the mobile device has exited the POI and the data value in the Entry/Exit field in the proximity octet is 1, or if the mobile device has entered the POI and the data in the Entry/Exit field is 0. On a negative determination, the operation proceeds again to step S4.

15

On determining that the entry/exit condition is correct, a notification is provided at step S10. Following step S10, any text associated with the location is provided at step S11. As described above, text associated with a notification is provided by the beacon in a Location Data advertisement message, and has been processed by the mobile device 11 at step S5 of Figure 8. Following step S11, the operation returns to step S4, to receive another AoD message.

20

The operations described above with reference to Figures 8 and 9 are performed within the BLE module 113 of the device 11. That is, all of the steps of the method are effected by the BLE stack and BLE controller within the BLE module 113. The notifications that are provided by the BLE module 113 are received at the navigation application 117, which uses the notifications to make any needed interactions with the user. The notifications provided by the BLE module 113 to the navigation application may take any suitable form. In other embodiments, some or all of the steps of the operations of Figures 8 and 9 are performed externally of the BLE module 113 within the device 11, for instance by the application 117. In these other embodiments, PDUs are passed from the BLE module 113 to the application 117 as they are received from the beacon 30, and are then processed by the application 117.

30

An example implementation or deployment will now be described with reference to Figure 10.

35

In this example, a beacon 30 is located at a relatively central position in a retail establishment, named in this example “Jim’s Radioshack”. The beacon 30 is configured to create a POI PDU that defines four POIs that are not centred on the location of the beacon, and one POI that is centred on the location of the beacon 30.
5 The beacon 30 is also configured to create multiple proximity data PDUs that include text that are associated with the POIs defined in the POI PDU. The construction of the various PDUs is as described above, and the specific data value provided in the various fields will be apparent.

10

The user 11 is walking past Jim’s Radioshack and his device reads the broadcast data of the beacon 30 located in the store. The device 11 is HAIP enabled and starts positioning, that is calculating the position of the device 11, in the background, that is as a background task.

15

Once Joe moves inside the range of the beacon_1 proximity criterion, the device 11 creates an event with Location Data: “Jim’s Radioshack”. The user decides to go into the store.

20

At the entrance to the store, the device 11 enters a first POI. The POI is defined such as to create a notification event with the text “Welcome” on the device 11.

Two of the POIs, in particular the second POI and the third POI, indicate that headings are to be provided. As such, the device 11 informs the user about two different destinations, including the heading to the destination and optionally including the range. One destination is notified as being the “Cashier” and the other destination is notified as being “Must see!”, which text is provided from proximity data PDUs. In this example, the user follows the heading to the “must see!” POI, which is the second POI in Figure 10. The application 117 may provide visualization and triggering of the headings in any suitable way. For instance, provision of headings to the user may be based on user settings, user interaction (e.g. a specific request for headings), or proximity (either to the beacon 30 or to the POI).
25
30

As the device 11 enters the geofence defined by the second POI, a notification is triggered. This notification includes the text “Must see!”. This indicates to the user 11 that they have reached the POI whose heading they were following. Once the user
35

reaches the POI, the heading information is ceased to be provided, having been replaced with the text relating to the POI.

5 Afterwards, the heading for the third POI, for which the text “Cashier” is provided, remains for the user. The user then follows the heading to the third POI. Upon entering the geofence defined by the third POI, a notification is provided by the device with the text “cashier”. The heading is ceased to be provided once the POI is reached.

10 On leaving the store, the device 11 enters a fourth POI, which relates to the exit. The fourth POI is defined as creating a notification only once the POI is exited, so no notification is generated as the device 11 enters the POI. However, as the user exits the device, a notification is triggered, the notification including the text “See you again!”.

15 It will be appreciated that the features described above allow the provision of POI notifications and headings etc. to be provided without requiring the mobile device to obtain any data from a device or system other than the beacon 30. Additionally, it does not require the device 11 to communicate with the beacon 30; the device can provide the notifications and headings after receiving messages passively from the beacon 30.

20 It will be appreciated that the above-described embodiments are not limiting on the scope of the invention, which is defined by the appended claims and their alternatives. Various alternative implementations will be envisaged by the skilled person, and all such alternatives are intended to be within the scope of the claims. A number of alternatives will now be described.

25 Although it is described above that the beacon 30 creates the PDUs that form part of the positioning advertisement messages, this step may be performed instead by the server 40. In this case, the PDUs are created by the server 40 and sent to the beacon 30, from where they are incorporated in positioning advertisement messages and broadcast. The server 40 thus causes the beacon 30 to transmit the PDUs. Here, the beacons 30 do not need to store information concerning POIs etc.

35 Although in the above the AoD positioning packets and the positioning advertisement messages are separate, they may instead be combined. For instance, an AoD tail can be added to a positioning advertisement message, allowing a mobile device 11, 12 to determine its position after having received only one message from a beacon. However,

the inclusion of the AoD tail limits the number of bits available for communicating the other information needed by the mobile devices 11, 12.

5 Although in the above the positioning advertisement messages are transmitted on BLE advertising channels, it will be appreciated that the information communicated to the mobile devices 11, 12 in the positioning advertisement messages need not be communicated in this way. For instance, the positioning advertisement messages may be broadcast on one or more BLE data channels, for instance in SCAN_RSP containers.

10 Indeed, the invention is not limited to BLE. It will be appreciated that the concept underlying the above-described embodiments, as defined in the claims, is applicable to other systems in which the same considerations (e.g. limited bandwidth, positioning resolution etc.) are applicable. Other systems to which the invention may be applied and which are intended to be covered by the claims include unidirectional and
15 bidirectional systems both present and future. Systems to which the invention may be applied include WiFi systems, pseudolite-based systems and such like.

Embodiments of the present invention may be implemented in software, hardware, application logic or a combination of software, hardware and application logic. The
20 software, application logic and/or hardware may reside on memory, or any computer media. In an example embodiment, the application logic, software or an instruction set is maintained on any one of various conventional computer-readable media. In the context of this document, a "computer-readable medium" may be any media or means that can contain, store, communicate, propagate or transport the instructions for use by
25 or in connection with an instruction execution system, apparatus, or device, such as a computer.

A computer-readable medium may comprise a computer-readable storage medium that may be any tangible media or means that can contain or store the instructions for use
30 by or in connection with an instruction execution system, apparatus, or device, such as a computer as defined previously.

According to various embodiments of the previous aspect of the present invention, the computer program according to any of the above aspects, may be implemented in a
35 computer program product comprising a tangible computer-readable medium bearing

computer program code embodied therein which can be used with the processor for the implementation of the functions described above.

Reference to "computer-readable storage medium", "computer program product",
5 "tangibly embodied computer program" etc, or a "processor" or "processing circuit" etc.
should be understood to encompass not only computers having differing architectures
such as single/multi processor architectures and sequencers/parallel architectures, but
also specialised circuits such as field programmable gate arrays FPGA, application
specify circuits ASIC, signal processing devices and other devices. References to
10 computer program, instructions, code etc. should be understood to express software
for a programmable processor firmware such as the programmable content of a
hardware device as instructions for a processor or configured or configuration settings
for a fixed function device, gate array, programmable logic device, etc.

15 If desired, the different functions discussed herein may be performed in a different
order and/or concurrently with each other. Furthermore, if desired, one or more of the
above-described functions may be optional or may be combined.

Although various aspects of the invention are set out in the independent claims, other
20 aspects of the invention comprise other combinations of features from the described
embodiments and/or the dependent claims with the features of the independent
claims, and not solely the combinations explicitly set out in the claims.

Claims

1. Apparatus configured:
 - to transmit angle-of-departure positioning messages from which a mobile device can calculate a direction to the mobile device from the apparatus; and
 - 5 to transmit a point of interest packet data unit for providing a point of interest service to a mobile device, the first point of interest packet data unit comprising first data indicating a first range from a first point of interest.
- 10 2. Apparatus as claimed in claim 1, wherein the first data also indicates a location of the first point of interest.
3. Apparatus as claimed in claim 1, wherein the first point of interest is co-located with the apparatus and the first range indicates a range from the apparatus.
- 15 4. Apparatus as claimed in any preceding claim, wherein the first data indicates whether a notification is to be triggered:
 - when the mobile device moves within an area defined by the first range from the first point of interest, or
 - when the mobile device moves without the area defined by the first
 - 20 range from the first point of interest.
5. Apparatus as claimed in any preceding claim, wherein the first data indicates whether a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device.
- 25 6. Apparatus as claimed in any preceding claim, wherein the point of interest packet data unit additionally comprises second data indicating a second range from a second point of interest.
- 30 7. Apparatus as claimed in claim 6, wherein the second data indicates a location of the second point of interest.
8. Apparatus as claimed in claim 6, wherein the second point of interest is co-located with the apparatus and the second range indicates a range from the apparatus.

9. Apparatus as claimed in any of claims 6 to 8, wherein the second data indicates whether a notification is to be triggered:

when the mobile device moves within an area defined by the second range from the second point of interest, or

5 when the mobile device moves without the area defined by the second range from the second point of interest.

10. Apparatus as claimed in any of claims 6 to 9, wherein the second data indicates whether a notification is to be provided indicating a heading to the second point of
10 interest from the location of the mobile device.

11. Apparatus as claimed in any preceding claim, configured to transmit coded text relating to the first point of interest.

15 12. Apparatus as claimed in claim 11 when dependent on any of claims 6 to 10, configured to transmit a first positioning advertising message including at least the first and second data relating to the first and second points of interest respectively, and to transmit a second positioning advertising message including data indicating to which of the points of interest the coded text relates.

20

13. Apparatus as claimed in any preceding claim, configured to create the point of interest packet data unit using configuration information received from an external device, such as a mobile device or a server.

25 14. Apparatus as claimed in any preceding claim, wherein the first point of interest packet data unit is transmitted as part of a Bluetooth message, for example a Bluetooth advertising message, a Bluetooth Low Energy message, or a Bluetooth Low Energy advertising message.

30 15. Apparatus configured:

to receive at least one angle-of-departure positioning message from a positioning beacon;

to receive a point of interest packet data unit from the positioning beacon, the point of interest packet data unit comprising first data indicating a first range from a
35 first point of interest;

to use the angle-of-departure positioning message to calculate a position of the apparatus; and

to respond to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the first point of interest by providing a notification.

16. Apparatus as claimed in claim 15, wherein the first data also indicates a location of the first point of interest.

10 17. Apparatus as claimed in claim 15, wherein the first point of interest is co-located with the beacon and the first range indicates a range from the beacon.

18. Apparatus as claimed in any of claims 15 to 17, wherein, when the first data indicates that a notification is to be triggered when the mobile device moves within an area defined by the first range from the first point of interest, the apparatus is configured to respond to determining that the position of the apparatus has moved from without to within the area defined by the first range and the first point of interest by providing the notification.

20 19. Apparatus as claimed in any of claims 15 to 18, wherein, when the first data indicates that a notification is to be triggered when the mobile device moves without an area defined by the first range from the first point of interest, the apparatus is configured to respond to determining that the position of the apparatus has moved from within to without the area defined by the first range and the first point of interest by providing the notification.

20. Apparatus as claimed in any of claims 15 to 19, wherein, when the first data indicates that a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device, the apparatus is configured to provide an indication of a heading to the first point of interest.

21. Apparatus as claimed in any of claims 15 to 20, configured:

to extract from the first positioning data unit second data indicating a second range from a second point of interest; and

to respond to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the second point of interest by providing a notification.

5 22. Apparatus as claimed in any of claims 15 to 21, configured:
to receive coded text relating to the first point of interest, and
to cause provision of the text in response to determining that the position of the
apparatus has the certain relationship with respect to the area defined by the first range
and the first point of interest or that the position of the apparatus has a certain
10 relationship with respect to an area defined by the second range and the second point
of interest by providing a notification.

23. Apparatus as claimed in claim 22 when dependent on claim 21, configured,
when received data indicates that the coded text relates to both the first and second
15 points of interest, to cause provision of the text in response to determining that the
position of the apparatus has the certain relationship with respect to the area defined
by the first range and the first point of interest.

24. Apparatus as claimed in any of claims 15 to 23, wherein the point of interest
20 packet data unit is received as part of a Bluetooth message, for instance a Bluetooth
advertising message.

25. Apparatus as claimed in claim 24, wherein Bluetooth message is a Bluetooth
Low Energy message, for instance a Bluetooth Low Energy advertising message.

25

26. Apparatus as claimed in any of claims 15 to 25, wherein the apparatus is a
communication module and wherein the apparatus is configured to provide the
notification by providing a notification to a software application that is external to the
communication module.

30

27. A non-transitory computer-readable storage medium having stored thereon
computer-readable code, which, when executed by computing apparatus, causes the
computing apparatus to perform a method comprising:

35 transmitting angle-of-departure positioning messages from which a mobile
device can calculate a direction to the mobile device from an apparatus; and

transmitting a point of interest packet data unit for providing a point of interest service to a mobile device, the first point of interest packet data unit comprising first data indicating a first range from a first point of interest.

5 28. A non-transitory computer-readable storage medium according to claim 27, wherein the first data also indicates a location of the first point of interest.

29. A non-transitory computer-readable storage medium according to claim 27, wherein the first point of interest is co-located with the apparatus and the first range
10 indicates a range from the apparatus.

30. A non-transitory computer-readable storage medium according to any of claims 27 to 29, wherein the first data indicates whether a notification is to be triggered:
when the mobile device moves within an area defined by the first range
15 from the first point of interest, or
when the mobile device moves without the area defined by the first range from the first point of interest.

31. A non-transitory computer-readable storage medium according to any of claims
20 27 to 30, wherein the first data indicates whether a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device.

32. A non-transitory computer-readable storage medium according to any of claims 27 to 31, wherein the point of interest packet data unit additionally comprises second
25 data indicating a second range from a second point of interest.

33. A non-transitory computer-readable storage medium according to claim 32, wherein the second data indicates a location of the second point of interest.

30 34. A non-transitory computer-readable storage medium according to claim 32, wherein the second point of interest is co-located with the apparatus and the second range indicates a range from the apparatus.

35 35. A non-transitory computer-readable storage medium according to any of claims 32 to 34, wherein the second data indicates whether a notification is to be triggered:

when the mobile device moves within an area defined by the second range from the second point of interest, or

when the mobile device moves without the area defined by the second range from the second point of interest.

5

36. A non-transitory computer-readable storage medium according to any of claims 32 to 35, wherein the second data indicates whether a notification is to be provided indicating a heading to the second point of interest from the location of the mobile device.

10

37. A non-transitory computer-readable storage medium according to any of claims 27 to 36, wherein the computer-readable code when executed causes the computing apparatus to transmit coded text relating to the first point of interest.

15

38. A non-transitory computer-readable storage medium according to claim 37 when dependant on any of claims 32 to 36, wherein the computer-readable code when executed causes the computing apparatus to transmit a first positioning advertising message including at least the first and second data relating to the first and second points of interest respectively, and to transmit a second positioning advertising message including data indicating to which of the points of interest the coded text relates.

20

39. A non-transitory computer-readable storage medium according to any of claims 27 to 38, wherein the computer-readable code when executed causes the computing apparatus to create the point of interest packet data unit using configuration information received from an external device, such as a mobile device or a server.

25

40. A non-transitory computer-readable storage medium according to any of claims 27 to 39, wherein the first point of interest packet data unit is transmitted as part of a Bluetooth message, for example a Bluetooth advertising message, a Bluetooth Low Energy message, or a Bluetooth Low Energy advertising message.

30

41. A non-transitory computer-readable storage medium having stored thereon computer-readable code, which, when executed by computing apparatus, causes the computing apparatus to perform a method comprising:

35

receiving at least one angle-of-departure positioning message from a positioning beacon;

receiving a point of interest packet data unit from the positioning beacon, the point of interest packet data unit comprising first data indicating a first range from a first point of interest;

using the angle-of-departure positioning message to calculate a position of an apparatus; and

responding to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the first point of interest by providing a notification.

42. A non-transitory computer-readable storage medium according to claim 41, wherein the first data also indicates a location of the first point of interest.

43. A non-transitory computer-readable storage medium according to claim 41, wherein the first point of interest is co-located with the beacon and the first range indicates a range from the beacon.

44. A non-transitory computer-readable storage medium according to any of claims 41 to 43, wherein the computer-readable code when executed causes the computing apparatus to, when the first data indicates that a notification is to be triggered when the mobile device moves within an area defined by the first range from the first point of interest, respond to determining that the position of the apparatus has moved from without to within the area defined by the first range and the first point of interest by providing the notification.

45. A non-transitory computer-readable storage medium according to any of claims 41 to 44, wherein the computer-readable code when executed causes the computing apparatus to, when the first data indicates that a notification is to be triggered when the mobile device moves without an area defined by the first range from the first point of interest, respond to determining that the position of the apparatus has moved from within to without the area defined by the first range and the first point of interest by providing the notification.

46. A non-transitory computer-readable storage medium according to any of claims 41 to 45, wherein the computer-readable code when executed causes the computing

apparatus to, when the first data indicates that a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device, provide an indication of a heading to the first point of interest.

5 47. A non-transitory computer-readable storage medium according to any of claims 41 to 46, wherein the computer-readable code when executed causes the computing apparatus:

to extract from the first positioning data unit second data indicating a second range from a second point of interest; and

10 to respond to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the second point of interest by providing a notification.

48. A non-transitory computer-readable storage medium according to any of claims 15 41 to 47, wherein the computer-readable code when executed causes the computing apparatus :

to receive coded text relating to the first point of interest, and

20 to cause provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest or that the position of the apparatus has a certain relationship with respect to an area defined by the second range and the second point of interest by providing a notification.

49. A non-transitory computer-readable storage medium according to claim 48 25 when dependant on claim 47, wherein the computer-readable code when executed causes the computing apparatus to, when received data indicates that the coded text relates to both the first and second points of interest, cause provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest.

30

50. A non-transitory computer-readable storage medium according to any of claims 41 to 49, wherein the point of interest packet data unit is received as part of a Bluetooth message, for instance a Bluetooth advertising message.

51. A non-transitory computer-readable storage medium according to claim 50, wherein Bluetooth message is a Bluetooth Low Energy message, for instance a Bluetooth Low Energy advertising message.

5 52. A non-transitory computer-readable storage medium according to any of claims 41 to 51, wherein the apparatus is a communication module and wherein the computer-readable code when executed causes the computing apparatus to provide the notification by providing a notification to a software application that is external to the communication module.

10

53. A method comprising:

transmitting angle-of-departure positioning messages from which a mobile device can calculate a direction to the mobile device from an apparatus; and

15 transmitting a point of interest packet data unit for providing a point of interest service to a mobile device, the first point of interest packet data unit comprising first data indicating a first range from a first point of interest.

54. The method as claimed in claim 53, wherein the first data also indicates a location of the first point of interest.

20

55. The method as claimed in claim 53, wherein the first point of interest is co-located with the apparatus and the first range indicates a range from the apparatus.

56. The method as claimed in any of claims 53 to 55, wherein the first data indicates whether a notification is to be triggered:

when the mobile device moves within an area defined by the first range from the first point of interest, or

when the mobile device moves without the area defined by the first range from the first point of interest.

30

57. The method as claimed in any of claims 53 to 56, wherein the first data indicates whether a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device.

58. The method as claimed in any of claims 53 to 57, wherein the point of interest packet data unit additionally comprises second data indicating a second range from a second point of interest.

5 59. The method as claimed in claim 58, wherein the second data indicates a location of the second point of interest.

60. The method as claimed in claim 58, wherein the second point of interest is co-located with the apparatus and the second range indicates a range from the apparatus.

10

61. The method as claimed in any of claims 58 to 60, wherein the second data indicates whether a notification is to be triggered:

when the mobile device moves within an area defined by the second range from the second point of interest, or

15

when the mobile device moves without the area defined by the second range from the second point of interest.

62. The method as claimed in any of claims 58 to 61, wherein the second data indicates whether a notification is to be provided indicating a heading to the second point of interest from the location of the mobile device.

20

63. The method as claimed in any of claims 53 to 62, further comprising the step of transmitting coded text relating to the first point of interest.

25 64. The method as claimed in claim 63 when dependent on any of claims 58 to 62, further comprising the steps of transmitting a first positioning advertising message including at least the first and second data relating to the first and second points of interest respectively, and transmitting a second positioning advertising message including data indicating to which of the points of interest the coded text relates.

30

65. The method as claimed in any of claims 53 to 64, further comprising the step of creating the point of interest packet data unit using configuration information received from an external device, such as a mobile device or a server.

35 66. The method as claimed in any of claims 53 to 65, wherein the first point of interest packet data unit is transmitted as part of a Bluetooth message, for example a

Bluetooth advertising message, a Bluetooth Low Energy message, or a Bluetooth Low Energy advertising message.

67. A method comprising:

5 receiving at least one angle-of-departure positioning message from a positioning beacon;

receiving a point of interest packet data unit from the positioning beacon, the point of interest packet data unit comprising first data indicating a first range from a first point of interest;

10 using the angle-of-departure positioning message to calculate a position of an apparatus; and

responding to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the first point of interest by providing a notification.

15

68. The method of claim 67, wherein the first data also indicates a location of the first point of interest.

69. The method as claimed in claim 67, wherein the first point of interest is co-
20 located with the beacon and the first range indicates a range from the beacon.

70. The method as claimed in any of claims 67 to 69, wherein, when the first data indicates that a notification is to be triggered when the mobile device moves within an area defined by the first range from the first point of interest, the apparatus responds to
25 determining that the position of the apparatus has moved from without to within the area defined by the first range and the first point of interest by providing the notification.

71. The method as claimed in any of claims 67 to 70, wherein, when the first data
30 indicates that a notification is to be triggered when the mobile device moves without an area defined by the first range from the first point of interest, the apparatus responds to determining that the position of the apparatus has moved from within to without the area defined by the first range and the first point of interest by providing the notification.

35

72. The method as claimed in any of claims 67 to 71, wherein, when the first data indicates that a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device, the apparatus provides an indication of a heading to the first point of interest.

5

73. The method as claimed in any of claims 67 to 72, further comprising the steps of:

extracting from the first positioning data unit second data indicating a second range from a second point of interest; and

10 responding to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the second point of interest by providing a notification.

74. The method as claimed in any of claims 67 to 73, further comprising:

15 receiving coded text relating to the first point of interest, and

causing provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest or that the position of the apparatus has a certain relationship with respect to an area defined by the second range and the second point of interest by providing a notification.

20

75. The method of claim 74 when dependent on claim 73, further comprising, when received data indicates that the coded text relates to both the first and second points of interest, causing provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest.

25

76. The method as claimed in any of claims 67 to 75, wherein the point of interest packet data unit is received as part of a Bluetooth message, for instance a Bluetooth advertising message.

30

77. The method as claimed in claim 76, wherein Bluetooth message is a Bluetooth Low Energy message, for instance a Bluetooth Low Energy advertising message.

35 78. The method as claimed in any of claims 67 to 77, wherein the apparatus is a communication module and the method further comprises the step of providing the

notification by providing a notification to a software application that is external to the communication module.

79. A computer program comprising instructions that when executed by a computer
5 apparatus control it to perform the method of any of claims 53 to 78.

80. Apparatus, the apparatus having at least one processor and at least one memory having computer-readable code stored thereon which when executed controls the at least one processor:

10 to transmit angle-of-departure positioning messages from which a mobile device can calculate a direction to the mobile device from the apparatus; and
to transmit a point of interest packet data unit for providing a point of interest service to a mobile device, the first point of interest packet data unit comprising first data indicating a first range from a first point of interest.

15

81. Apparatus as claimed in claim 80, wherein the first data also indicates a location of the first point of interest.

82. Apparatus as claimed in claim 80, wherein the first point of interest is co-
20 located with the apparatus and the first range indicates a range from the apparatus.

83. Apparatus as claimed in any of claims 80 to 82, wherein the first data indicates whether a notification is to be triggered:

25 when the mobile device moves within an area defined by the first range from the first point of interest, or

when the mobile device moves without the area defined by the first range from the first point of interest.

84. Apparatus as claimed in any of claims 80 to 83, wherein the first data indicates
30 whether a notification is to be provided indicating a heading to the first point of interest from the location of the mobile device.

85. Apparatus as claimed in any of claims 80 to 84, wherein the point of interest packet data unit additionally comprises second data indicating a second range from a
35 second point of interest.

86. Apparatus as claimed in claim 85, wherein the second data indicates a location of the second point of interest.

87. Apparatus as claimed in claim 85, wherein the second point of interest is co-
5 located with the apparatus and the second range indicates a range from the apparatus.

88. Apparatus as claimed in any of claims 85 to 87, wherein the second data indicates whether a notification is to be triggered:

10 when the mobile device moves within an area defined by the second range from the second point of interest, or

when the mobile device moves without the area defined by the second range from the second point of interest.

89. Apparatus as claimed in any of claims 85 to 88, wherein the second data
15 indicates whether a notification is to be provided indicating a heading to the second point of interest from the location of the mobile device.

90. Apparatus as claimed in any of claims 80 to 89, wherein the computer-readable code when executed controls the at least one processor to transmit coded text relating
20 to the first point of interest.

91. Apparatus as claimed in claim 90 when dependent on any of claims 85 to 89, wherein the computer-readable code when executed controls the at least one processor to transmit a first positioning advertising message including at least the first and
25 second data relating to the first and second points of interest respectively, and to transmit a second positioning advertising message including data indicating to which of the points of interest the coded text relates.

92. Apparatus as claimed in any of claims 80 to 91, wherein the computer-readable code when executed controls the at least one processor to create the point of interest
30 packet data unit using configuration information received from an external device, such as a mobile device or a server.

93. Apparatus as claimed in any of claims 80 to 92, wherein the first point of
35 interest packet data unit is transmitted as part of a Bluetooth message, for example a

Bluetooth advertising message, a Bluetooth Low Energy message, or a Bluetooth Low Energy advertising message.

94. Apparatus, the apparatus having at least one processor and at least one memory
5 having computer-readable code stored thereon which when executed controls the at least one processor:
- to receive at least one angle-of-departure positioning message from a positioning beacon;
 - to receive a point of interest packet data unit from the positioning beacon, the
10 point of interest packet data unit comprising first data indicating a first range from a first point of interest;
 - to use the angle-of-departure positioning message to calculate a position of the apparatus; and
 - to respond to determining that the position of the apparatus has a certain
15 relationship with respect to an area defined by the first range and the first point of interest by providing a notification.

95. Apparatus as claimed in claim 94, wherein the first data also indicates a location
of the first point of interest.

20

96. Apparatus as claimed in claim 94, wherein the first point of interest is co-located with the beacon and the first range indicates a range from the beacon.

97. Apparatus as claimed in any of claims 94 to 96, wherein the computer-readable
25 code when executed controls the at least one processor to, when the first data indicates that a notification is to be triggered when the mobile device moves within an area defined by the first range from the first point of interest, respond to determining that the position of the apparatus has moved from without to within the area defined by the first range and the first point of interest by providing the notification.

30

98. Apparatus as claimed in any of claims 94 to 97, wherein the computer-readable
code when executed controls the at least one processor to, when the first data indicates that a notification is to be triggered when the mobile device moves without an area defined by the first range from the first point of interest, respond to determining that
35 the position of the apparatus has moved from within to without the area defined by the first range and the first point of interest by providing the notification.

99. Apparatus as claimed in any of claims 94 to 98, wherein the computer-readable code when executed controls the at least one processor to, when the first data indicates that a notification is to be provided indicating a heading to the first point of interest
5 from the location of the mobile device, provide an indication of a heading to the first point of interest.

100. Apparatus as claimed in any of claims 94 to 99, wherein the computer-readable code when executed controls the at least one processor:
10 to extract from the first positioning data unit second data indicating a second range from a second point of interest; and
to respond to determining that the position of the apparatus has a certain relationship with respect to an area defined by the first range and the second point of interest by providing a notification.

15

101. Apparatus as claimed in any of claims 94 to 100, wherein the computer-readable code when executed controls the at least one processor:
to receive coded text relating to the first point of interest, and
to cause provision of the text in response to determining that the position of the
20 apparatus has the certain relationship with respect to the area defined by the first range and the first point of interest or that the position of the apparatus has a certain relationship with respect to an area defined by the second range and the second point of interest by providing a notification.

25 102. Apparatus as claimed in claim 101 when dependent on claim 100, wherein the computer-readable code when executed controls the at least one processor, when received data indicates that the coded text relates to both the first and second points of interest, to cause provision of the text in response to determining that the position of the apparatus has the certain relationship with respect to the area defined by the first
30 range and the first point of interest.

103. Apparatus as claimed in any of claims 94 to 102, wherein the point of interest packet data unit is received as part of a Bluetooth message, for instance a Bluetooth advertising message.

35

104. Apparatus as claimed in claim 103, wherein Bluetooth message is a Bluetooth Low Energy message, for instance a Bluetooth Low Energy advertising message.

105. Apparatus as claimed in any of claims 94 to 104, wherein the apparatus is a
5 communication module and wherein the computer-readable code when executed controls the at least one processor to provide the notification by providing a notification to a software application that is external to the communication module.

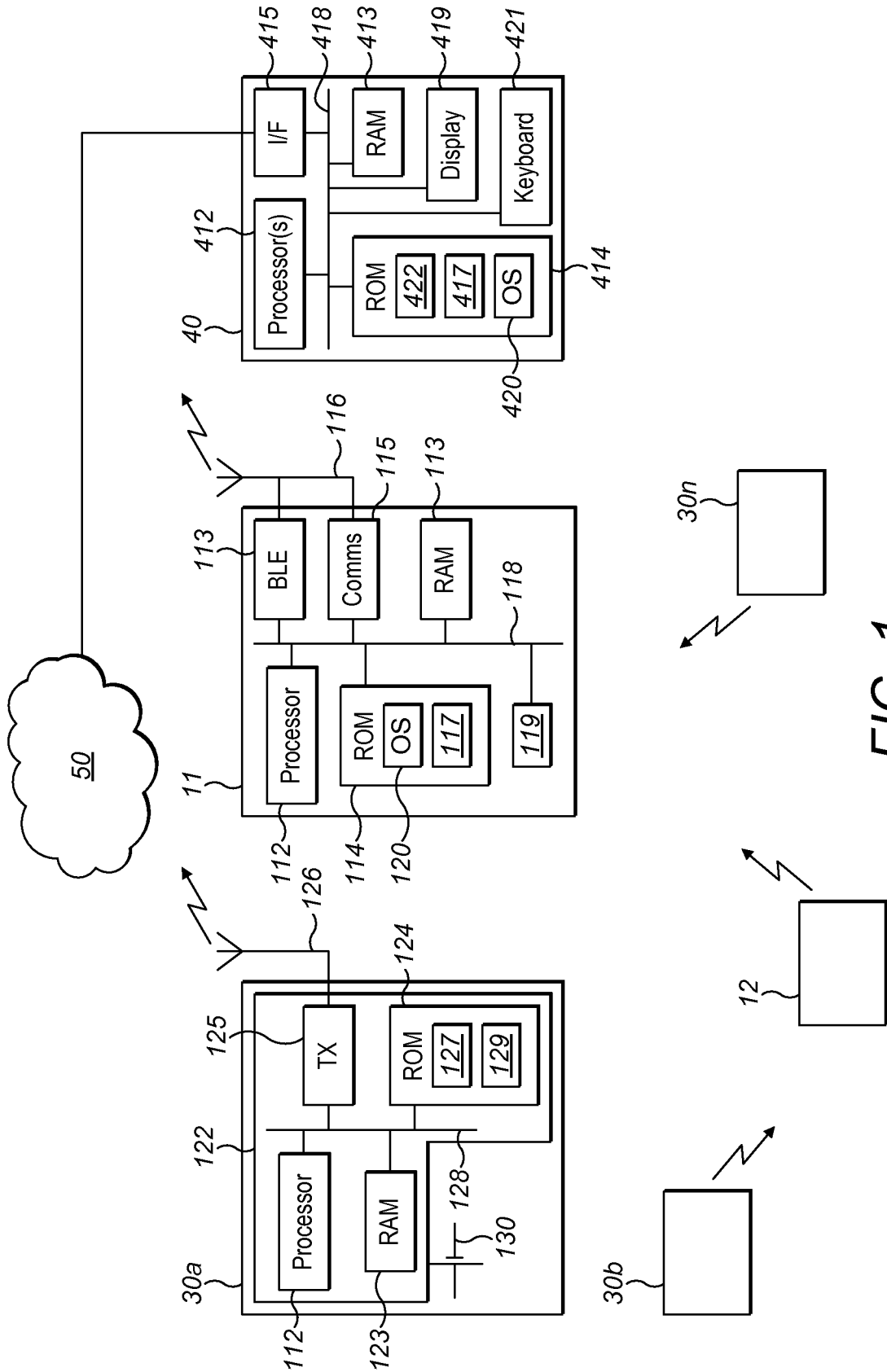


FIG. 1

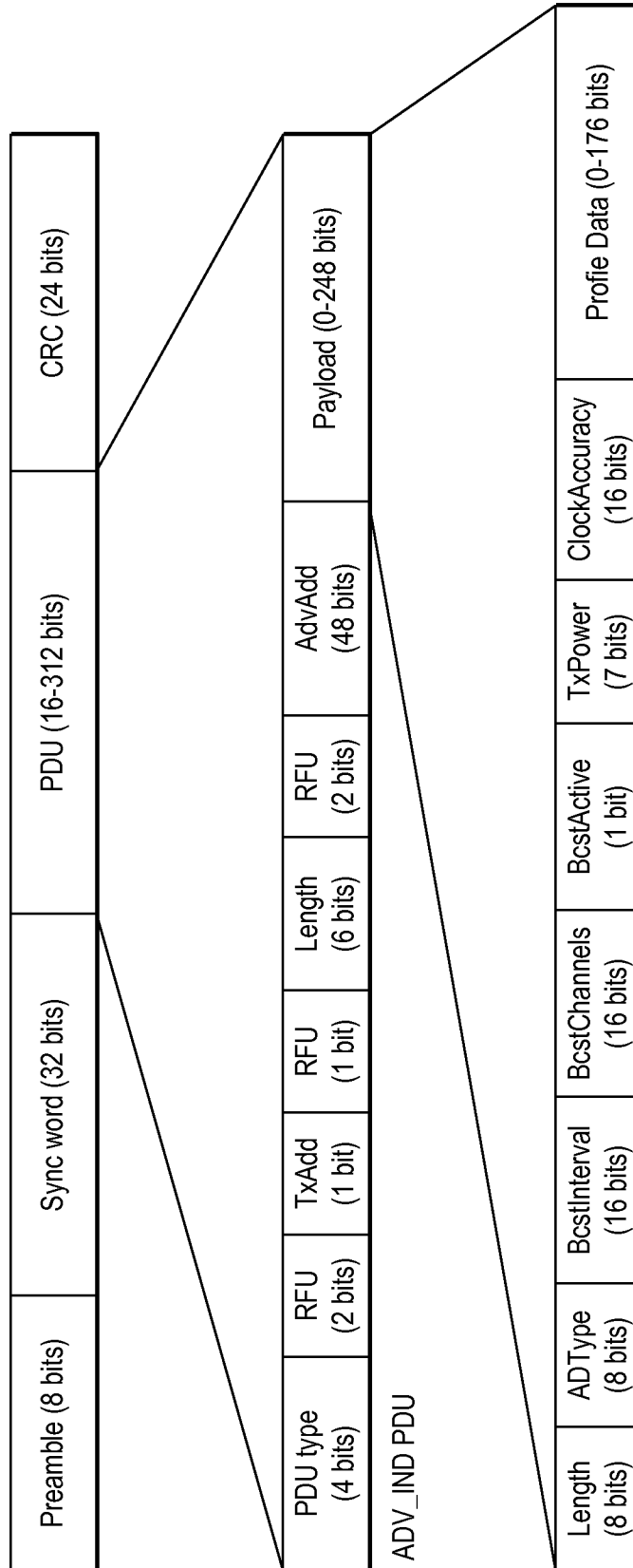


FIG. 2a

Positioning Beacon AD type

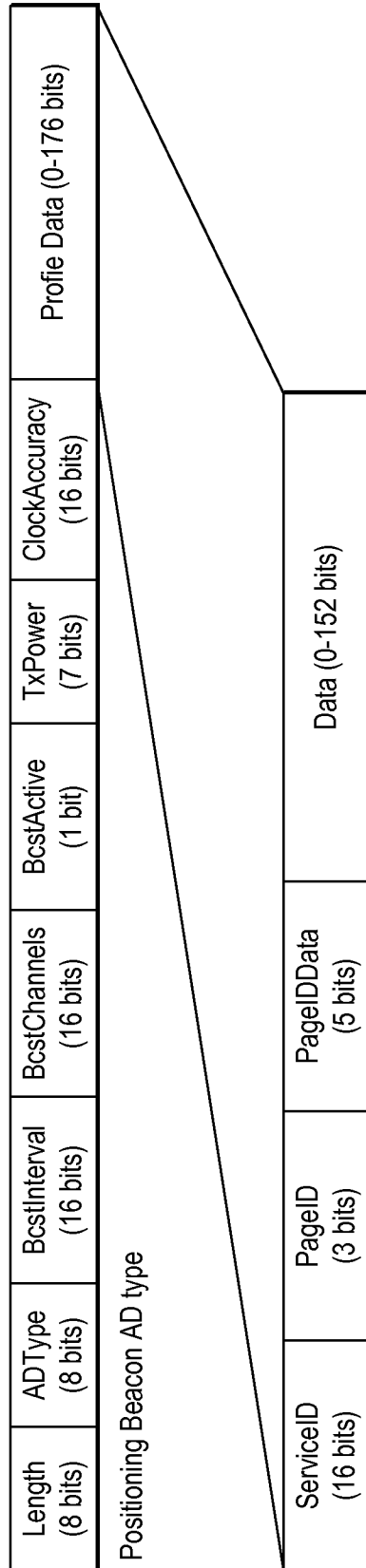


FIG. 2b

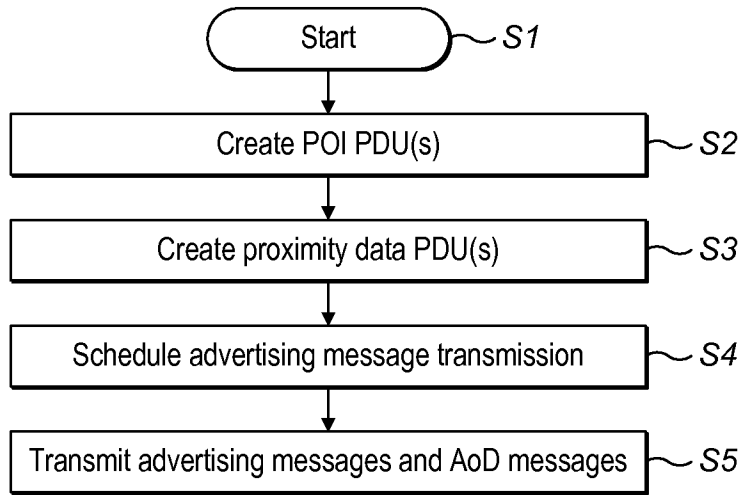


FIG. 3

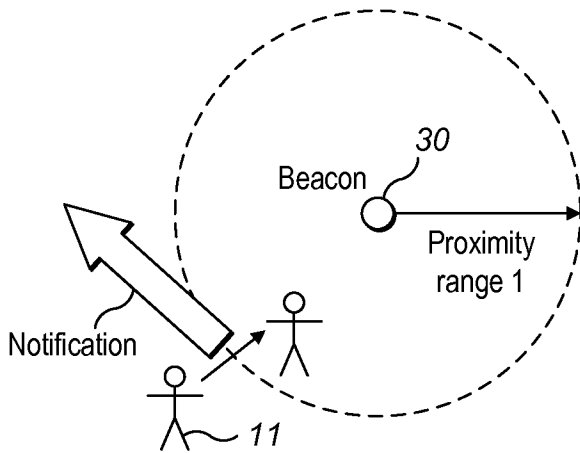


FIG. 4

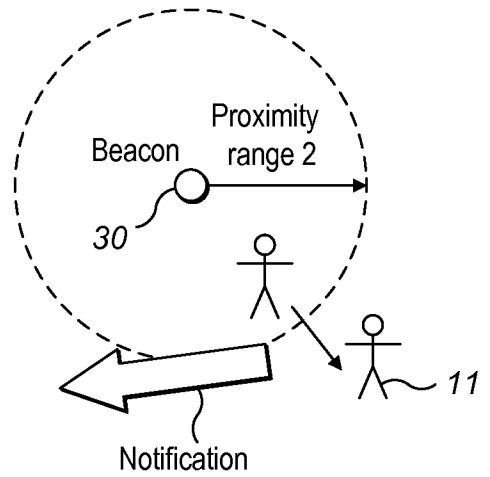


FIG. 5

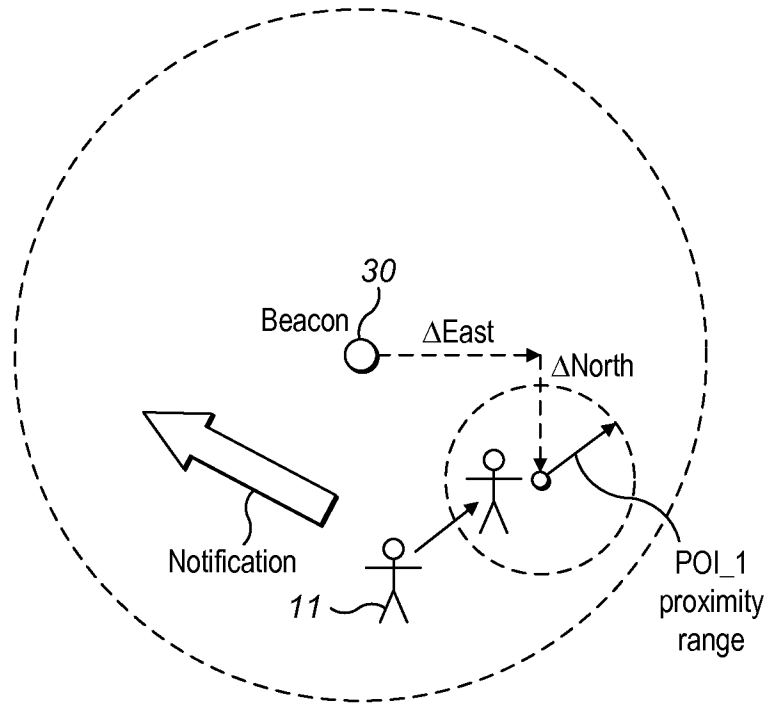


FIG. 6

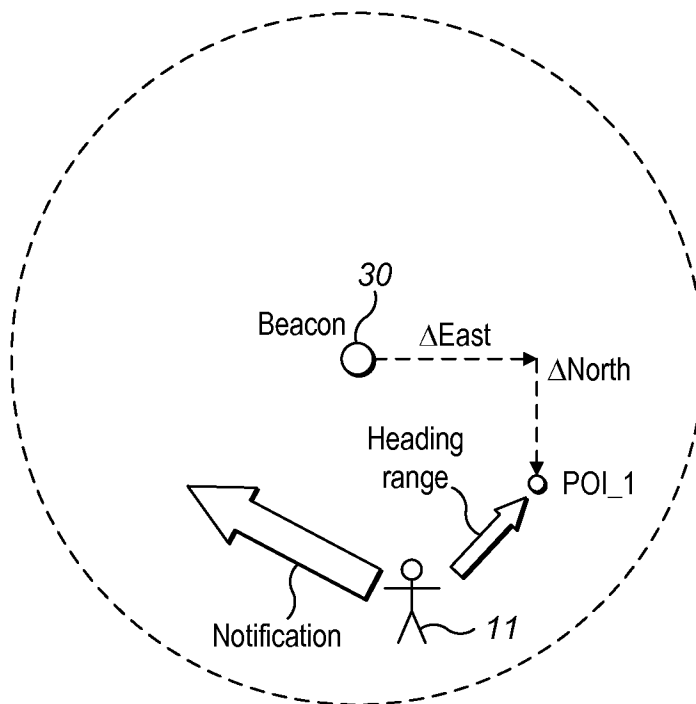


FIG. 7

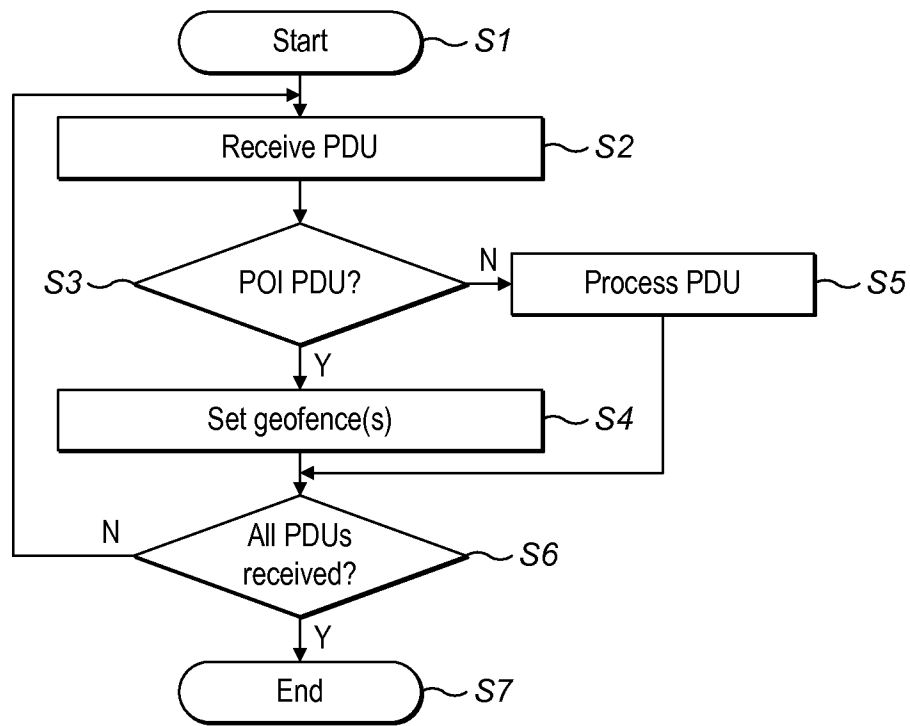


FIG. 8

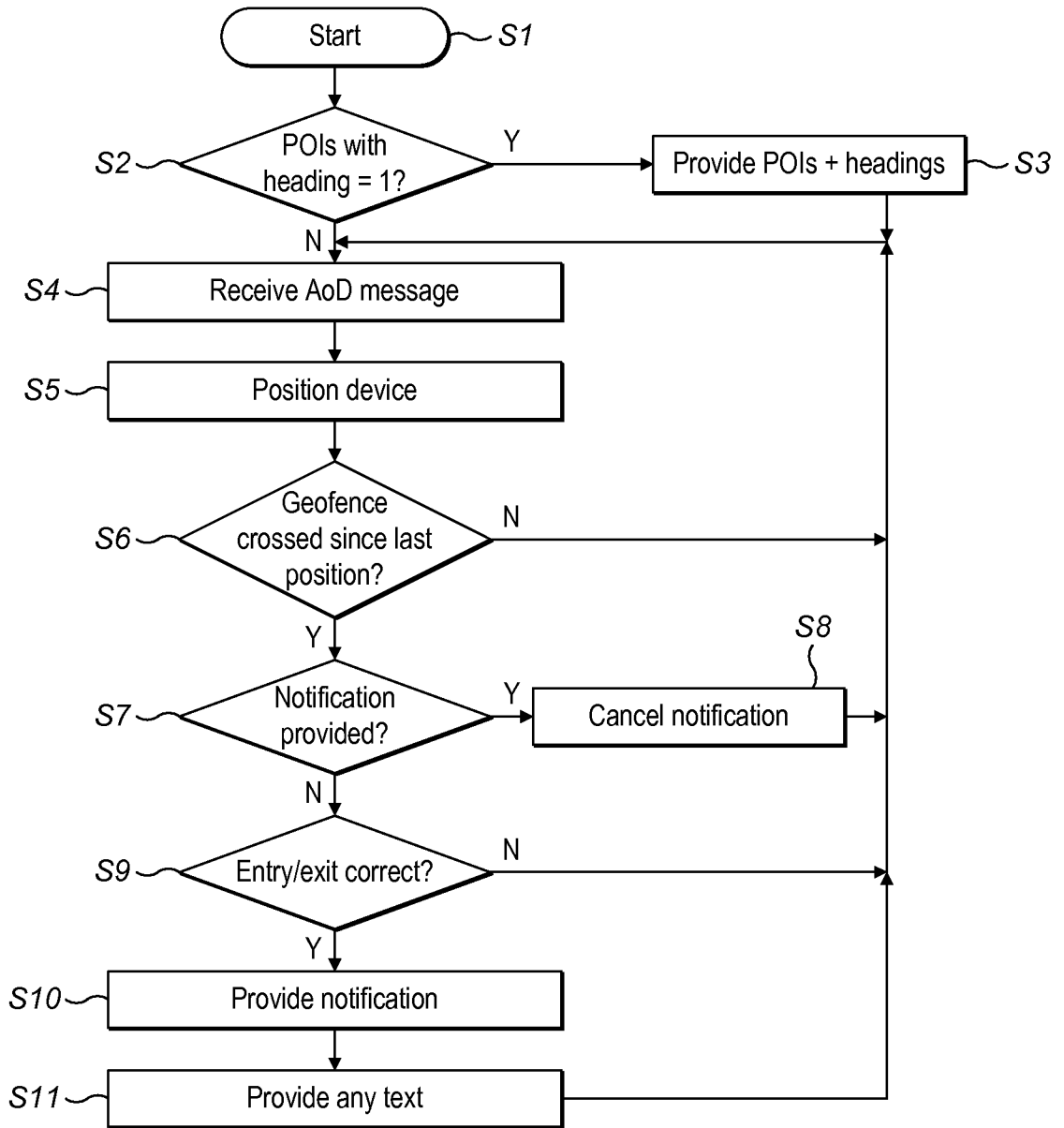


FIG. 9

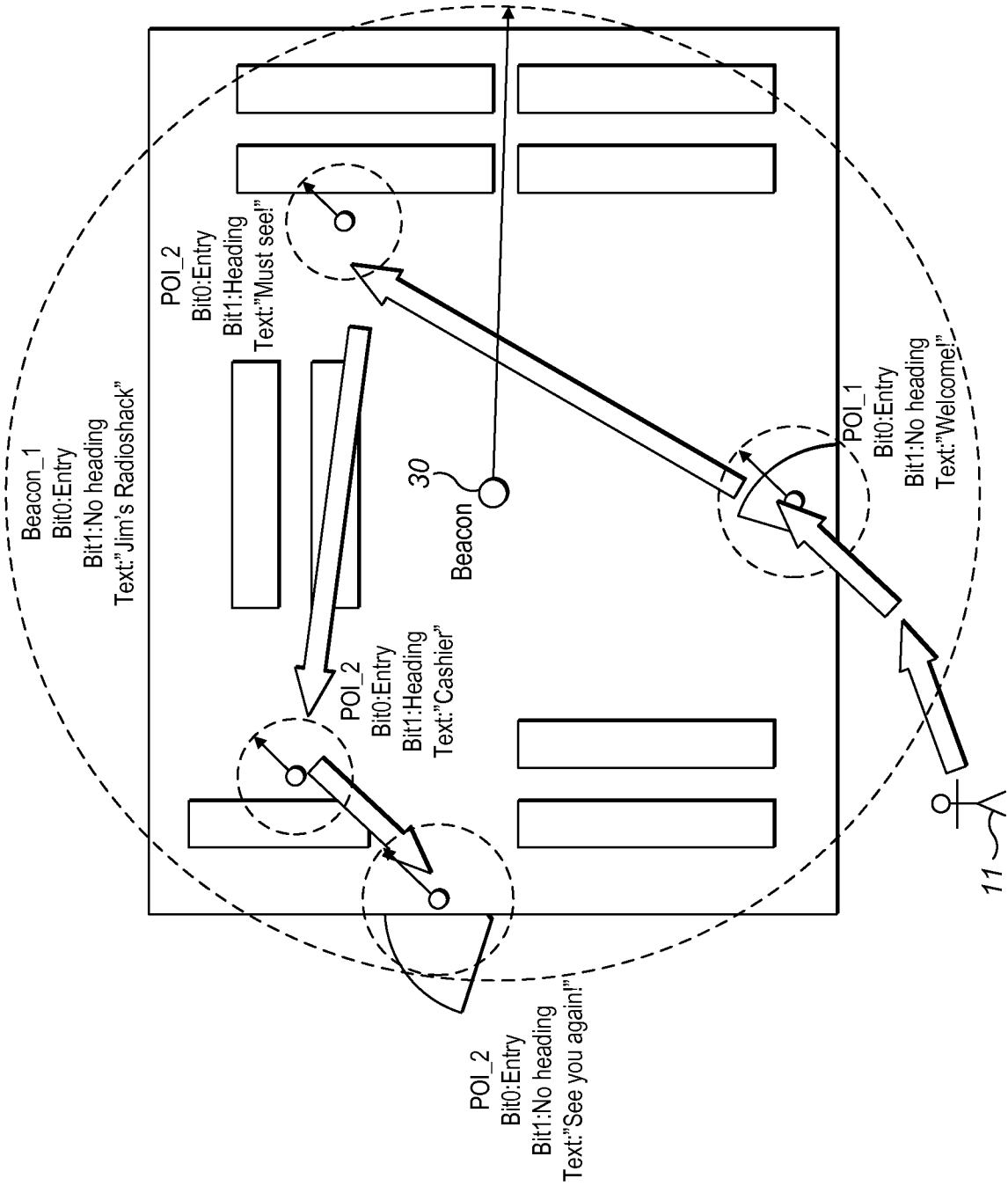


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2012/057070

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G01C, G01S, G06Q, H04W

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

FI, SE, NO, DK

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

EPO-Internal, WPI, XP3GPP, XPAIP, XPESP, XPESP2, XPETSI, XPI3E, XPIEE, XPIETF, XPIOP, XPIPCOM, XPMISC, XPOAC, XPRD, COMPDX, INSPEC, NPL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007001904 A1 (MENDELSON E. [US]) 04 January 2007 (04.01.2007) abstract; par. [0081]-[0085], [0162], [0198]	1-5, 11, 13-20, 24-31, 37, 39-46, 50-57, 63, 65-72, 76-84, 90, 92-99, 103-105
Y	WO 2012152988 A1 (NOKIA CORP [FI]) 15 November 2012 (15.11.2012) abstract	1-5, 11, 13-20, 24-31, 37, 39-46, 50-57, 63, 65-72, 76-84, 90, 92-99, 103-105
A	US 2012028654 A1 (GUPTA R. [US] et al.) 02 February 2012 (02.02.2012) abstract; par. [0007]	1-105

 Further documents are listed in the continuation of Box C.

 See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

04 September 2013 (04.09.2013)

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2012/057070

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2008124074 A1 (HUMAN NETWORK LABS INC [US]) 16 October 2008 (16.10.2008) abstract; par. [00308]	1-105
A	US 2012235812 A1 (MAIA E. [US] et al.) 20 September 2012 (20.09.2012) abstract; par. [0005]	1-105

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.

G01C 21/20 (2006.01)**G01S 1/06** (2006.01)**G01S 1/08** (2006.01)**G01C 3/06** (2006.01)**H04W 4/02** (2009.01)**G06Q 30/02** (2012.01)**G06Q 90/00** (2006.01)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2012/057070

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