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(54) **BEACON APPARATUS AND ASSOCIATED ROOM LAMP UNIT**

(57) The invention pertains to an apparatus (200) comprising:
a connector (232) for connecting a cable (250), configured so as to provide power to a room lamp (430) in accordance with a desired room lamp status; and a transmitter module (212, 222) configured to generate an electromagnetic signal in the ultrasonic frequency range, the electromagnetic signal having a beacon message encoded therein; wherein the transmitter module (212, 222) is operatively connected to the connector (232), so as to allow transmission of the electromagnetic signal over the cable (250). The invention also pertains to a corresponding system and room lamp unit.

Fig. 2

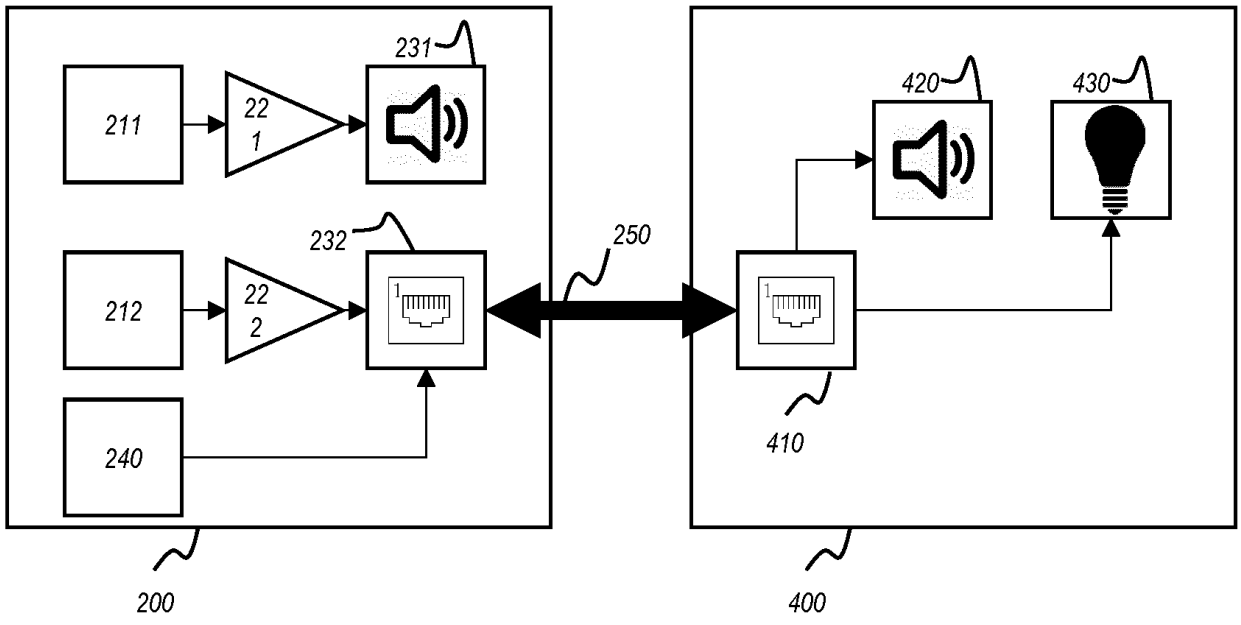

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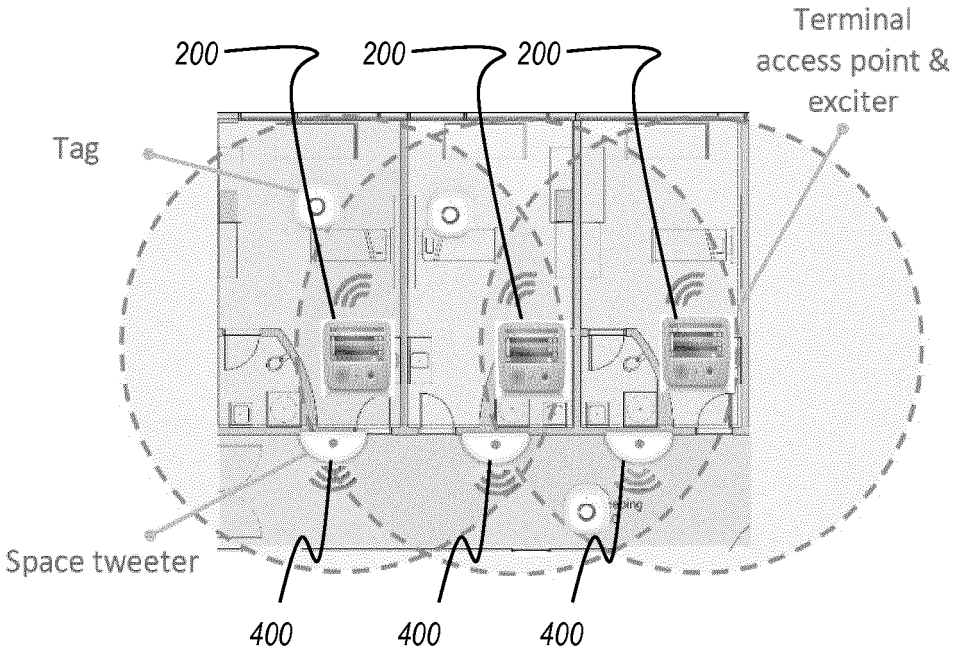
Fig. 3


200
200
200
Terminal access point & exciter
Tag
Space tweeter
400
400
400

Description

Field of the Invention

[0001] The present invention relates to a wireless localization system for movable objects or persons, such as a system to track the location of patients and/or assets in a facility such as a hospital. The present invention relates in particular to an apparatus combining a beacon function in a room I/O unit, and a remote room lamp unit having ultrasound reproducing means integrated therein.

Background

[0002] European patent application EP 2 469 298 A1 in the name of the present applicant, discloses a method and device for determining a location of a target, using mobile tags and fixed beacons, wherein the target location is estimated from a weighted sum of the indications of the received signal power of at least two received signals.

[0003] European patent applications EP 2 889 634 A1, EP 2 889 635 A1, and EP 2 889 636 A1, also in the name of the present applicant, present further advances in the field of wireless localization.

[0004] As explained in the cited documents, each patient room of a modern hospital is equipped with a nurse call node or apparatus, which comprises at least an I/O unit adapted to capture a call signal (e.g., a distressed patient pushing an emergency button) and to relay said signal as a traceable call to a centralized assistance dispatching system. The I/O unit may serve as a beacon in a localization system, by emitting ultrasound signals that encode location information, which can be received by tags (worn by patients or attached to equipment) and subsequently relayed as an electromagnetic signal identifying the sender and its location.

[0005] It is a disadvantage of the above system, that the coverage of the localization system is limited to patient rooms and other areas where similar beacons are provided.

Summary of the Invention

[0006] According to an aspect of the present invention, there is provided an apparatus for relaying a call to a centralized dispatching system, the apparatus comprising: a connector for connecting a cable, configured so as to provide power to a room lamp in accordance with a desired room lamp status; and a transmitter module configured to generate an electromagnetic signal in the ultrasonic frequency range, said electromagnetic signal having a beacon message encoded therein; wherein said transmitter module is operatively connected to said connector, so as to allow transmission of said electromagnetic signal over said cable.

[0007] The present invention is based *inter alia* on the insight of the inventors that the logic and amplification circuits required to generate the ultrasound beacon signals are present in the I/O units of patient rooms, and need not be fully replicated for every single location that is to be equipped with beacon functionality.

[0008] The present invention is further based on the insight of the inventors that the I/O unit of a patient room is usually arranged at a location where it has an uninterrupted power supply.

[0009] The present invention is further based on the insight of the inventors that a typical I/O unit of a patient room is equipped with a connector for a cable that provides power to a room lamp in accordance with the desired room lamp status (on or off), typically located in a corridor, just outside the patient room. The room lamp is used to attract attention from personnel when lit.

[0010] The inventors have judiciously combined these insights to arrive at a solution where hardware provided inside the I/O unit is used to drive a passive beacon unit outside the patient room, the passive beacon unit being optionally integrated with the room lamp.

[0011] In an embodiment of the apparatus according to the present invention, said cable is a multi-pair cable, said connector is a multi-pair connector, configured so as to provide said power to said room lamp over a first pair of said multi-pair cable, and said transmitter module is operatively connected to said multi-pair connector so as to allow transmission of said electromagnetic signal over a second pair of said multi-pair cable.

[0012] This embodiment is particularly suited for use with multi-pair structured wiring, such as CAT-3 or CAT-5(e) wiring.

[0013] In an embodiment of the apparatus according to the present invention, said connector is an RJ-45 connector.

[0014] According to an aspect of the present invention, there is provided a system comprising the apparatus as described above, a room lamp having a room lamp housing with a room lamp cable connector, and a cable connected between said connector of said apparatus and said room lamp cable connector; wherein said room lamp housing further comprises means for converting said electromagnetic signal received through said room lamp cable connector into an acoustic ultrasound signal.

[0015] According to an aspect of the present invention, there is provided a room lamp unit for use in the system as described above, said room lamp unit comprising a room lamp housing with a room lamp cable connector and means for converting an electromagnetic signal received through said room lamp cable connector into an acoustic ultrasound signal.

[0016] The technical effects and advantages of embodiments of the system and the room lamp unit according to the present invention correspond *mutatis mutandis* to those of the corresponding embodiments of the apparatus according to the present invention.

Brief Description of the Figures

[0017] These and other features and advantages of embodiments of the present invention will now be described in more detail with reference to the accompanying drawings, in which:

- Figure 1 schematically illustrates a localization system comprising beacons and tags as used in embodiments of the present invention;
- Figure 2 schematically illustrates elements of an apparatus according to an embodiment of the present invention;
- Figure 3 schematically illustrates a building layout in which embodiments of the present invention may be used; and
- Figure 4 illustrates an exemplary design of a room lamp unit according to an embodiment of the present invention.

Description of Embodiments

[0018] Figure 1 schematically illustrates a localization system comprising beacons and tags.

[0019] A specific application of the system described herein is a wireless nurse call system for use in hospitals and other institutions where patients may move about, possibly without being fully conscious of their own exact location. The system should provide a very accurate determination of the location of the patient or asset to be tracked, both in the spatial dimension (high spatial accuracy) and in the time dimension (low latency tracking), such that adequate responses to tracking events can be deployed immediately and at the right place.

[0020] Beacons **200** are provided at fixed locations throughout an area in which the location of mobile objects or persons is to be monitored. The beacons may generally be mounted to walls, doors, pillars, and the like. They may have a basic user interface comprising a display and one or more keys; in particular they may be integrated in a terminal that also provides other functions.

[0021] The beacons emit an identification element modulated onto an ultrasound signal. Ultrasound communication is based on electromechanically induced vibrations that generate propagating longitudinal acoustic waves. As ultrasound waves are, by definition, in a frequency range beyond the audible range for humans, their use is no hindrance to humans present in the monitored area.

[0022] Within building environments, ultrasound waves are almost completely blocked by walls (contrary to electromagnetic waves). Ultrasound waves are therefore a suitable signal type to obtain room-level localization accuracy.

[0023] The mobile objects or persons to be monitored are provided with identification tags (hereinafter also referred to as "tags") **100**, which comprise an ultrasound receiver.

[0024] Upon receiving the beacon identification element encoded in the ultrasound signal, the tag **100** will be aware of its location (in the sense of being able to identify the nearest beacon **200**) down to room-level accuracy, without any need for triangulation.

[0025] The tag **100** may further comprise communication means to relay the decoded beacon identification element, along with its own identity, to the central monitoring system. The communication means may include a radio frequency (RF) transmitter adapted to wirelessly communicate the information to a beacon (the same beacon whose identification element was received and/or another beacon within radio range), which is in turn preferably connected to a wired or wireless network **250** that allows it to communicate with a centralized management system **300**.

[0026] As the range of the RF transmission is also limited in practice, the identity of the beacon **200** at which the radio signal of the tag **100** is received provides another clue to the location of the tag **100**. This localization step is coarser than the ultrasound-based localization, because the range of an RF transmission with typical properties (e.g., using the legally permitted transmit power in the unlicensed ISM bands at 434 MHz, 2.4 GHz, or 5 GHz, or the SRD860 band) will be longer than that of an ultrasound transmission, and will in particular not significantly be constrained by walls. The combination of RF-based localization at a coarse level and ultrasound-based localization at a finer level allows for a cellular naming system for the beacons; i.e., the beacon identities transmitted in the ultrasound signal need only be unique within the set of beacons with overlapping ultrasound communication ranges. This allows for a shorter "beacon identity" field to be used in the messages conveyed by the ultrasound signals, which in turn leads to a lower average data rate and thus lower power consumption at the transmitter (beacon) and the receiver (tag). Further details on this aspect may be found in European patent application no. 13199601.9 in the name of the present applicant and filed on 24 December 2013.

[0027] In order to achieve localization with room level accuracy, beacons with an ultrasound emitter are required in each physical location, such as a room, a sector of a room, a hallway, etc. However, as each beacon requires an ultrasound emitter, electronics to drive the ultrasound emitter, control logic, and a communication interface, the infrastructure costs rise considerable if a large building infrastructure must be covered.

[0028] An apparatus according to an embodiment of the present invention will now be described with reference to Figure 2. The illustrated system **200** is based on an apparatus for relaying a call to a centralized dispatching system, i.e. a terminal or an I/O unit such as those used in a nurse call system of a hospital. The apparatus **200** comprises a connector **232** for connecting a cable,

illustrated without loss of generality as an RJ-45 connector for a multi-pair cable such as a CAT-3 or a CAT-5(e) network cable. The connector **232** is configured so as to provide power to a room lamp **430** in accordance with a desired room lamp status; i.e., the apparatus **200** includes logic **240** configure to turn the room lamp **430** on (to attract attention from personnel outside the room) or off in accordance with a predetermined condition. The apparatus **200** further includes a transmitter module **212, 222** configured to generate an electromagnetic signal in the ultrasonic frequency range, having a beacon message encoded therein. The transmitter module **212, 222** is operatively connected to the connector **230**, so as to allow transmission of the electromagnetic signal over the cable.

[0029] Typically, but not necessarily, the I/O unit also serves as a beacon for the area in which it is located, to which end it may have additional driver circuits **211, 221** and conversion means **321** within its own housing, preferably configured to emit beacon signals with a different identifier.

[0030] Without loss of generality, the transmitter modules are illustrated as comprising a first circuit **211/212** that performs modulation (D/A conversion) and a second circuit **221/222** that provides amplification of the signals. Some or all of the functions described hereinabove as pertaining to these circuits **211, 212, 221, 222** may be implemented separately or in combination in dedicated hardware (e.g., ASIC), configurable hardware (e.g., FPGA), programmable components (e.g., a DSP or general purpose processor with appropriate software), or any combination thereof. The same component(s) may also include other functions.

[0031] While the generated signals are said to be in the ultrasonic frequency range, they are not actually acoustic signals until they reach a conversion means for transforming the electromagnetic waves transmitted over the cable into sound waves - according to the present invention, said conversion means is provided in a separate housing, connected to the I/O unit by means of the cable.

[0032] Thanks to the invention, it becomes possible to use the hardware provided inside the I/O unit to drive a passive beacon unit outside the patient room, optionally integrated with a room lamp, to increase the coverage of the localization system without any significant increase in the overall cost of the system. In addition to the communication interface, the existing cabling can be shared. This is particularly advantageous for extending the coverage of the location system to corridors, where access to the backend is less straightforward and adding standalone beacons is expensive.

[0033] The cable may be a multi-pair cable, and the connector **232** may be an appropriate multi-pair connector, configured so as to provide power to the room lamp **430** over a first pair of the multi-pair cable, while the transmitter module **212, 222** is operatively connected to the multi-pair connector **232** so as to allow transmission of the electromagnetic (beacon) signal over a second pair of the multi-pair cable. Other embodiments may use the same pair for transmission of both the power for the room lamp **430** and the electromagnetic (beacon) signal, both components being separated at the receiving end by appropriate filtering means that are well known to the skilled person. In the latter case, the cable may be a single-pair cable and the connector may be a single-pair connector.

[0034] A system according to an embodiment of the present invention comprises the apparatus **200** as described above, a room lamp **430** having a room lamp housing **400** with a room lamp cable connector **410,** and a cable **250** connected between the connector **232** of the apparatus and the room lamp cable connector **410.** The room lamp housing **400** further comprises means **420** for converting said electromagnetic signal received through the room lamp cable connector **410** into an acoustic ultrasound signal, such as a speaker or a piezoelectric transducer.

[0035] A room lamp unit according to an embodiment of the present invention, for use in the system as described above, comprises a room lamp housing **400** with a room lamp cable connector **410** and means **420** for converting an electromagnetic signal received through the room lamp cable connector **410** into an acoustic ultrasound signal.

[0036] Figure 3 schematically illustrates a building layout in which embodiments of the present invention may be used. It shows three adjacent rooms, connecting to a common corridor. In each of the rooms, an I/O unit is provided, in particular a nurse call station. The I/O unit includes the necessary hardware to function as a local beacon, i.e. to provide coverage for the location system within the room in which it is mounted. Each I/O unit is connected to a room lamp unit in the corridor, just outside the respective room, by means of appropriate cabling. By deploying I/O units **200** and room lamp units **400** as described in connection with Figure 2, the room lamp units **400** can act as additional beacons, extending the coverage of the location system to the corridor at very limited additional expense.

[0037] Figure 4 illustrates an exemplary design of a room lamp unit **400** according to an embodiment of the present invention. The room lamp housing has a room lamp cable connector (not shown) and means for converting an electromagnetic signal received through the room lamp cable connector into an acoustic ultrasound signal; in the illustrated case, said means are a speaker arranged inside the housing, and the housing is provided with a pattern of openings to allow the acoustic ultrasound signal to propagate outside the housing.

[0038] While the invention has been described hereinabove with reference to specific embodiments, this is done to illustrate and not to limit the invention, the scope of which is defined by the accompanying claims. The skilled person will readily appreciate that different combinations of features than those described herein are possible without departing from the scope of the claimed

invention.

Claims

1. An apparatus (200) comprising:

   - a connector (232) for connecting a cable (250), configured so as to provide power to a room lamp (430) in accordance with a desired room lamp status; and
   - a transmitter module (212, 222) configured to generate an electromagnetic signal in the ultrasonic frequency range, said electromagnetic signal having a beacon message encoded therein;

   characterized in that said transmitter module (212, 222) is operatively connected to said connector (232), so as to allow transmission of said electromagnetic signal over said cable (250).

2. The apparatus according to claim 1, wherein said cable (250) is a multi-pair cable, said connector (232) is a multi-pair connector, configured so as to provide said power to said room lamp (430) over a first pair of said multi-pair cable (232), and said transmitter module (212, 222) is operatively connected to said multi-pair connector (232) so as to allow transmission of said electromagnetic signal over a second pair of said multi-pair cable (250).

3. The apparatus according to claim 2, wherein said connector (232) is an RJ-45 connector.

4. A system comprising the apparatus (200) according to any of the preceding claims, a room lamp unit having a room lamp housing (400) with a room lamp cable connector (410), and a cable (250) connected between said connector (410) of said apparatus (200) and said room lamp cable connector (410); wherein said room lamp housing (400) further comprises means (420) for converting said electromagnetic signal received through said room lamp cable connector (410) into an acoustic ultrasound signal.

5. A room lamp unit for use in the system according to claim 4, said room lamp comprising a room lamp housing (400) with a room lamp cable connector (410) and means (420) for converting an electromagnetic signal received through said room lamp cable connector (410) into an acoustic ultrasound signal.

Fig. 1

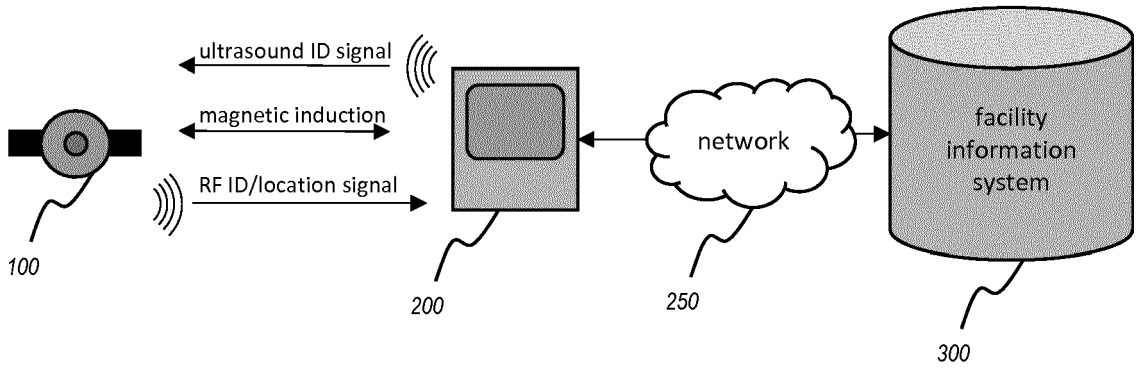

ultrasound ID signal
magnetic induction
RF ID/location signal
network
facility information system
100
200
250
300

Fig. 2

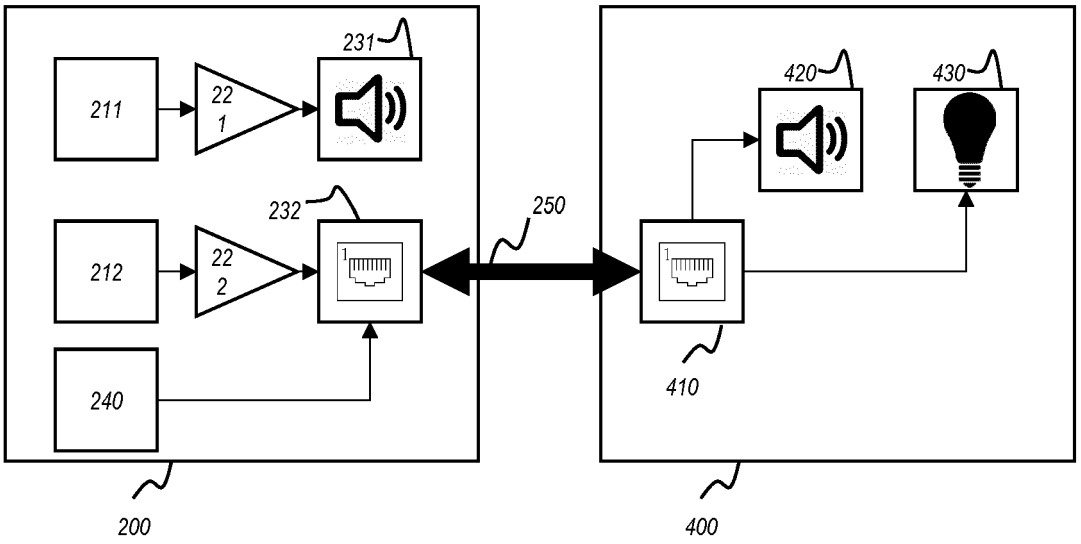

211
22 1
231
212
22 2
232
240
250
420
430
410
200
400

Fig. 3

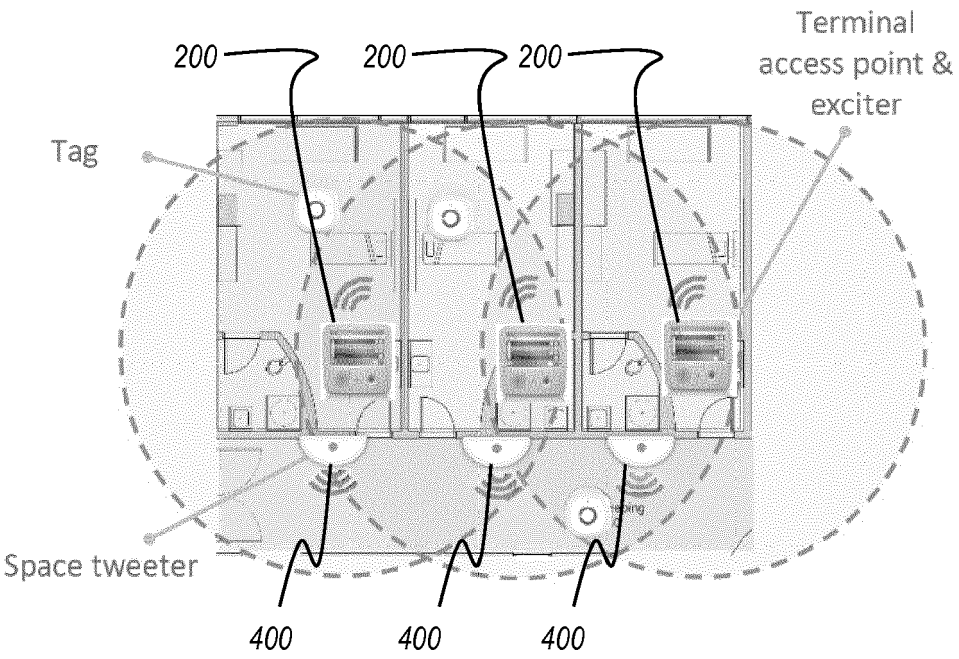
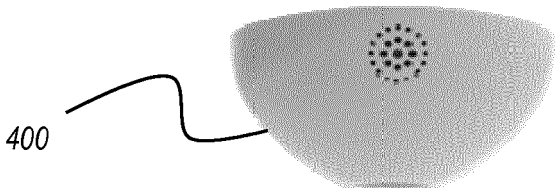

200
200
200
Terminal access point & exciter
Tag
Space tweeter
400
400
400

Fig. 4


400

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EUROPEAN SEARCH REPORT

Application Number
EP 15 20 2195

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	"Welcome to our world of innovation: ultrasound real time location systems", , 1 August 2011 (2011-08-01), XP055255709, Retrieved from the Internet: URL:http://www.staticsystems.co.uk/Fusion-IP_RTLS_Datasheets.pdf [retrieved on 2016-03-07]	1-3	INV. G01S5/18 H04L12/10
A	* the whole document *	4,5	
A	"Over door units", , 1 April 2014 (2014-04-01), XP055255723, Retrieved from the Internet: URL:http://www.staticsystems.co.uk/34-Over-door-units-codem-optima-ultima.pdf [retrieved on 2016-03-07] * the whole document *	1-5	

TECHNICAL FIELDS SEARCHED (IPC)

G01S
H04L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 March 2016	D'Alessandro, S

CATEGORY OF CITED DOCUMENTS

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- EP 2889634 A1 **[0003]**
- EP 2889635 A1 **[0003]**
- EP 2889636 A1 **[0003]**
- EP 13199601 A **[0026]**