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(54) Title: A NODE FOR A MULTI-HOP COMMUNICATION NETWORK, RELATED LIGHTING SYSTEM, METHOD OF UPDATING THE SOFTWARE OF LIGHTING MODULES AND COMPUTER-PROGRAM PRODUCT

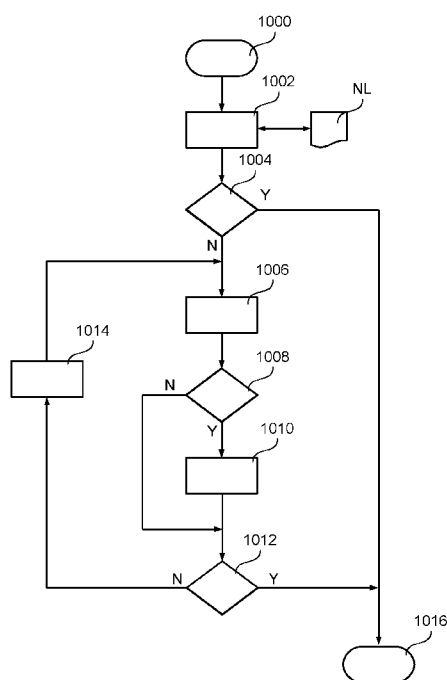


Fig. 6

(57) Abstract: There is described a node for a multi-hop communication network. The node includes a wireless communication interface, configured to exchange data with the multi-hop communication network. The node moreover includes a processing unit, configured to drive the operation of the node as a function of the commands received via the wireless communication interface, and a memory storing a firmware for the processing unit. The node is configured to receive, via the wireless communication interface, an updated firmware, and to store the updated firmware into the memory (110). Moreover, the node is configured to detect (1002), via the wireless communication interface, other nodes that are in the vicinity of the node, and to send (1010) the firmware stored in the memory to one or more of said nodes.



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A NODE FOR A MULTI-HOP COMMUNICATION NETWORK, RELATED
LIGHTING SYSTEM, METHOD OF UPDATING THE SOFTWARE OF
LIGHTING MODULES AND COMPUTER-PROGRAM PRODUCT

5 Field of the Invention

The description relates to multi-hop/mesh networks. Various embodiments of the present description refer to updating the firmware of lighting modules connected to each other via a multi-hop/mesh
10 network.

Description of the Related Art

Figure 1 shows a lighting system including a plurality of lighting modules 10. For example, Figure 1 shows six lighting modules 10₁...10₆.

15 Generally speaking, each lighting module includes one or more light radiation sources, such as e.g. one or more LEDs (Light Emitting Diodes) or other solid-state light radiation means, e.g. laser diodes. Generally speaking, each lighting module 10 may
20 therefore be on or off. Moreover, one or more lighting modules 10 may enable an adjustment of the emitted light intensity, so-called dimming function. For example, the lighting modules 10 may be:

- RGB, e.g. LED, lamps, including at least three
25 light radiation sources, respectively emitting red light (R), green light (G) and blue light (B), or
- RGBW, e.g. LED, lamps, including at least four light radiation sources respectively emitting red light (R), green light (G), blue light (B) and white light
30 (W).

Generally speaking, one or more lighting modules 10 may thus enable adjusting the colour of the emitted light.

In order to monitor and/or control the various
35 functions of the lighting modules 10, the lighting

modules 10 may be mutually connected via a communication network 30. For example, in some solutions each lighting module 10 supports the ZigBee® communication protocol, or another communication protocol adapted to create *multi-hop* or *mesh* networks, such as e.g. Thread, 6LOWPAN, Mesh over Bluetooth® Low Energy Network (BLE). For example, such lighting modules are described in the document "CC2531 *Zlight2* Reference Design", Texas Instruments, 2012, <http://www.ti.com/tool/CC2531ZLIGHT2-RD>, the content whereof is incorporated herein by way of reference.

For example, as shown in Figure 2, said lighting module 10 may include an electronic converter 102 and at least one light radiation source 104. For example, the electronic converter 102 may include an AC/DC or DC/DC switching supply, which receives at input, via two terminals T1 and T2, a supply signal (e.g. from the mains or a battery) and outputs, via two terminals T3 and T4, a regulated voltage V_{out} or a regulated current i_{out} . The light radiation 104 may be for example a LED or a LED string.

The light radiation source 10 moreover includes a bidirectional radio (i.e. wireless) communication interface 106, which typically has a short range (e.g. between 5 and 200 m), such as e.g. a ZigBee, Bluetooth, Wi-Fi communication interface (according to the IEEE 802.11 standard).

Finally, the lighting module 10 includes a processing unit 108, which is configured to receive commands via the communication interface 106 and to drive the operation of the electronic converter 102 as a function of the received commands, e.g. in order to switch the light radiation sources 104 on or off, and/or adjust the brightness and/or the colour of the light emitted by the light radiation sources. For

example, the processing unit 108 is often implemented via a microprocessor, which has a memory 110 associated thereto which stores the code being executed by microprocessor 110.

5 Typically the electronic converter 102, the communication interface 106 and the processing unit 108 (with memory 110) are integrated in one housing 100, and are often mounted onto a single printed circuit. Generally speaking, the light radiation sources 104 may
10 also be integrated in said housing 100, e.g. they may be mounted on the printed circuit itself, or they may be connected externally to the electronic converter 102 via cables.

 Generally speaking, one or more lighting modules
15 10 may also include one or more sensors 112 and/or actuators 114, in order to perform monitoring and/or control functions. For example, sensors 112 may include one or more of the following:

- sensors configured to monitor the operation of
20 the electronic converter 102 and/or the light radiation sources 104, and/or
- sensors configured to monitor environmental parameters (light, temperature, humidity etc.) and/or
- movement sensors, e.g. Passive InfraRed (PIR)
25 sensors.

 On the other hand, the actuators 114 may include one or more electrical or electronic switches, in order to control the on/off switching of other devices and/or motors, e.g. in order to orient the light emitted by
30 the light radiation sources 104.

 Therefore, the processing unit 108 may be configured to detect the data provided by the sensors 112 and to send the data (optionally in processed form) through the communication interface 106. Moreover, the

processing unit 106 may be configured to drive actuators 112 as a function of the detected data.

Therefore, as shown in Figure 1, the lighting modules 10 are connected to each other via a communication network 30. For instance, with reference to the ZigBee® standard, the lighting modules 10 may only perform the function of a *ZigBee End Device*. However, preferably, the lighting modules 10 are configured to implement, in addition, the function of a *ZigBee Router*, and optionally of a *ZigBee Coordinator*.

Typically, the network 30 also includes a gateway node 20, enabling access to the communication network 30 by devices which do not support the protocol used for the communication network 30.

For example, as shown in Figure 3, such a gateway node 20 typically includes a communication interface 206 matching the protocol of the communication network, e.g. a ZigBee interface. For example, with reference to the ZigBee standard, said gateway node 20 may implement the function of a *ZigBee Router* and optionally of a *ZigBee Coordinator*.

The gateway node 20 also includes one or more further communication interfaces 202 for a wired or wireless communication, such as e.g.:

- a Wi-Fi communication interface 202a for the communication with a wireless communication network; and/or
- an Ethernet communication interface 202b for the connection to a Local Area Network (LAN); and/or
- a transceiver, which may be a GSM (Global System for Mobile Communications), CDMA (Code Division Multiple Access), W-CDMA (Wideband Code Division Multiple Access), UMTS (Universal Mobile Telecommunications System), HSPA (High-Speed Packet Access) and/or LTE (Long Term Evolution) transceiver,

for the connection to a Wide Area Network (WAN), such as the Internet; and/or

- one or more further communication interfaces 202d, which are typically supported by mobile devices (laptop computers, tablets or mobile phones), such as e.g. USB (Universal Serial Bus), Bluetooth, NFC (Near Field Communication).

Finally, the gateway node 20 includes a processing unit 204, configured to manage the information exchange between the communication interfaces 202 and 206.

Therefore, generally speaking, said function of the gateway node 20 may also be implemented in one or more lighting modules 20, e.g. by employing one or more further communication interfaces (see the description of interface 202) and including the functions performed by the processing unit 204 into the processing unit 206.

Therefore, in Figure 1, a further device 40 such as e.g. a remote control, a computer, a tablet or a mobile phone, may control the operation of the lighting modules 10 by sending commands to a communication interface 202 of the gateway node 20, and the gateway node 20 may forward said commands to network 30.

Specifically, the communication network 30 is a multi-hop or mesh network, i.e. one or more lighting modules 10 perform the function of a router, in order to forward the commands to one or more other lighting modules 10 which are not adapted to directly receive the commands from the gateway node 20, e.g. because they are located too far away.

For example, in Figure 1, the lighting modules 10₁ and 10₂ may be reached directly. Said lighting modules 10₁ and 10₂ may forward the commands to the lighting modules 10₃ and 10₄, respectively. Finally, the lighting module 10₅ may exchange data with the lighting

modules 10₃, 10₄ and 10₆. For example, in order to send a command to the lighting module 10₆, the respective data package may actually traverse the lighting modules 10₁, 10₃ and 10₅.

5 Therefore, thanks to the presence of a multi-hop network 30 and the gateway node 20, device 40 is adapted to control and/or monitor the operation of the lighting devices 10.

10 For example, as shown in Figure 4a, the device 40 may have installed an application which enables turning the various lighting modules 10 on or off. For example, for each lighting module 10 a respective name 400 and a respective on/off switch 402 may be shown.

15 On the other hand, Figure 4b shows a screen which may be opened e.g. by pressing name 400 in the screen shown in Figure 4a, enabling the setting of brightness and/or colour in the light emitted by the respective lighting module 10. For example, the screen shown in Figure 4b may display the name 404 of the respective
20 lighting module 10, a button 406 for switching the respective lighting module 10 on or off, a bar 408 for setting the brightness of the respective lighting module 10 and a colour map 410 enabling selecting the colour of the respective lighting module 10.

25 A firmware update of the lighting modules 10 may frequently be required, e.g. at least of a portion of the software code stored in memory 108 (see Figure 2). For example, said updates may be useful in order to correct errors and/or to implement new functions.

30 Generally speaking, said update of a lighting module 10 may be carried out by sending the new firmware to the lighting module 10 through network 30, implementing a so-called Over The Air (OTA) update.

35 For instance, Figure 5a shows an example wherein device 40 is connected to a remote server 52, e.g.

through the Internet 50. For example, the remote server 52 may be associated to a database 54, which stores the firmware for one or more types of lighting modules 10, which may be classified e.g. on the basis of a model number which may indicate e.g. the hardware version and/or the supported functions.

Device 40 may therefore detect the type of each lighting module 10 connected to network 30, download the corresponding firmware and update the respective lighting module 10, by sending the firmware to the lighting device 10 through the gateway node 20 and the communication network 30.

On the other hand, Figure 5b shows an example wherein the gateway node 20 is adapted to communicate (directly through an interface 202) with the remote server 52. For example, in Figure 5b the gateway node 20 is connected to the Internet 50. In this case, the processing unit 204 (see Figure 3) may implement an update server which automatically monitors the type of each lighting module 10 connected to network 30, downloads the corresponding firmware (e.g. if a newer version is available) and updates the respective lighting module 10, by sending the firmware to the lighting module 10 through network 30.

Object and Summary

The inventors have observed that multi-hop networks show a drawback in that the update of the software/firmware of the lighting modules 10 may be inefficient. As a matter of fact, typically, multi-hop networks are designed so as to have a low energy consumption. Therefore, also the bandwidth available for the communication is limited. For example, a typical update of a single lighting module 10 may take up to several minutes.

However, the lighting system described in the foregoing may be employed in the industrial field or for street lighting, wherein a high number of lighting modules 10 are connected to the communication network 30. Therefore, the software update of all lighting modules 10 may take up to several hours.

Therefore, various embodiments of the present specification aim at providing solutions for improving the software update of the nodes in a multi-hop network, specifically of lighting modules.

According to various embodiments, said object is achieved thanks to a node of a multi-hop network having the features set forth in the claims that follow. The claims also concern a corresponding lighting system and a method of updating the software of lighting modules, as well as a computer program product, which may be loaded into the memory of at least one processor and which includes software code portions adapted to implement the method steps when the product is run on at least one processor. As employed herein, the reference to said computer program product indicates a processor-readable medium, containing instructions for controlling the processing system, in order to coordinate the implementation of the method according to the invention. The reference to "at least one processor" evidently implies the option that the present invention may be implemented in a modular and/or distributed form.

The claims are an integral part of the technical teaching provided herein with reference to the invention.

As stated in the foregoing, the present description concerns a node for a multi-hop communication network.

Said node includes a wireless communication interface, configured to exchange data with the multi-hop communication network, as well as a processing unit configured for driving the operation of the node as a function of commands received through the wireless communication interface. Specifically, the processing unit has an associated memory storing a firmware for the processing unit. For example, in various embodiments, the node is a lighting module including an electronic converter configured to supply at least one light radiation source. In this case, the processing unit drives the operation of the electronic converter as a function of commands received via the wireless communication interface.

In various embodiments, the node is configured to receive, via the wireless communication interface, an updated firmware.

For example, in various embodiments, said firmware is sent directly to the node, i.e. the node receives the firmware by analysing a point-to-point, multi-cast or broadcast communication addressed to the node.

In addition or as an alternative, the node may analyse the content of a multi-hop communication which traverses the node, so as to extract the firmware from a communication addressed to another node.

Subsequently, the node stores the updated firmware into its memory. Specifically, in various embodiments, the node determines if the received updated firmware is compatible with the node and, if said updated firmware is compatible, the node stores the updated firmware, so that the processing unit may use the updated firmware.

In various embodiments, the node is configured to independently send its own firmware to other nodes in the network. For this purpose the node detects, through the wireless communication interface, other nodes in

the vicinity of the node, i.e. nodes which may be reached via a single-hop communication. Subsequently the node sends, to one or more said nodes, the firmware stored in the memory.

5 For example, in various embodiments, the node detects the model number and the version of the node firmware. The node also detects the model number and the firmware version of other neighbour nodes. Subsequently, the node determines the other nodes which
10 have a model number corresponding to the model number of the node, and which have a firmware version which is older than the firmware version of the node. Finally, the node sends such nodes the firmware stored in the memory. Generally speaking, the node may send the
15 firmware to the other neighbour nodes via a point-to-point, multi-cast or broadcast communication.

 Therefore, each node may behave, from the point of view of OTA firmware updating, as a special server. That is to say, it is adapted to propagate its own
20 firmware to similar nodes. Said procedure takes place in a distributed fashion, silently and automatically, like a virus spreading by infecting neighbour compatible organisms. Therefore, this method does not involve a multitude of OTA general servers, because
25 this would imply the need of conspicuous memory resources, in order to manage a plurality of different firmware. In the present case, the resources needed do not increase, because in the simplest of cases each node only transmits its own firmware to the compatible
30 nodes which require the same.

 The presently described solution is particularly useful for lighting systems including a plurality of lighting modules implementing the automatic updating function described in the foregoing. As a matter of
35 fact, a lighting system typically includes a high

number of lighting devices of the same type, i.e. nodes having the same model number.

Therefore, it may be sufficient to update a single lighting module in order to update all the lighting
5 modules in the system.

Brief Description of the Annexed Views

Embodiments will now be described, by way of non-limiting example only, with reference to the annexed views, wherein:

10 - Figures 1 to 5 have already been described in the foregoing,

- Figure 6 shows a first embodiment of a node / lighting module configured to be connected to a multi-hop network according to the present specification;

15 - Figures 7a to 7d show an exemplary operation of nodes which operate as described in Figure 6;

- Figures 8a and 8b show a second exemplary operation of nodes / lighting modules according to the present specification;

20 - Figure 9 shows a further embodiment of a node / lighting module configured to be connected to a multi-hop network according to the present specification;

- Figures 10a to 10c show an exemplary operation of nodes operating as described in Figure 9.

Detailed Description of Embodiments

25 In the following description, various specific details are given to provide a thorough understanding of the embodiments. The embodiments may be practiced without one or several specific details, or with other
30 methods, components, materials, etc. In other instances, well-known structures, materials or operations are not shown or described in detail in order to avoid obscuring various aspects of the embodiments.

35 Reference throughout this specification to "one

embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the possible appearances of the
5 phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, particular features, structures, or characteristics may be combined in a suitable manner in
10 one or more embodiments.

The headings provided herein are for convenience only, and therefore do not interpret the extent of protection or scope of the embodiments.

In the following Figures 6 to 10 the parts,
15 elements or components which have already been described with reference to Figures 1 to 5 are denoted with the same references which have previously been used in said Figures; the description of said previously described elements will not be repeated in
20 the following, in order not to overburden the present detailed description.

As previously mentioned, the present specification aims at providing solutions for updating the firmware/software of nodes of a multi-hop network, such
25 as e.g. lighting modules 20. Therefore, the presently described solutions may be used e.g. in the system described with reference to Figures 1 to 5, and the corresponding description applies entirely.

In various embodiments, the firmware updating is
30 improved by including a software module into the processing unit 108 of each node/lighting module 10, wherein said additional software module implements an update server having limited capacities.

Figure 6 shows a first embodiment of the operation
35 of the additional module of a node/lighting module 10,

which will be named "master node" in the following.

Specifically, after a start step 1000, the update module monitors, at a step 1002, the presence of other nodes/lighting modules 10 in the vicinity of the master node, which will be named "slave nodes" in the following. This step is usually employed in all multi-hop/mesh networks. For example, each node/lighting module 10 (and similarly the gateway node 20) may periodically send a broadcast message, containing data identifying the node/lighting module 10, such as e.g. a unique code, such as the serial number of the node/lighting module 10.

Therefore, the update module may create a list NL including the IDs of the slave nodes which are located in the vicinity of the respective master node. Specifically, "vicinity" means that said nodes may be reached directly, i.e. with a single hop, i.e. without the need of forwarding data packages through other nodes of the communication network 30.

Generally speaking, the monitoring function performed at step 1002 may also be implemented in the software module which manages the communication through network 30, because such information is useful for directing the communication through network 30.

At a subsequent step 1004, the update module checks if list NL is empty.

If list NL is empty (output "Y" of the verification step 1004), the update procedure ends at an end step 1016.

On the contrary, if list NL is not empty (output "N" at verification step 1004), the update module selects the first slave node of list NL as the current slave node, and proceeds to a step 1006.

Specifically, at step 1006, the update module obtains data which identify the type and the version of

the firmware/software installed in the current slave node. Generally speaking, said information may be stored already in list NL, for example, because each node/lighting module 10 transmits said information with
5 the broadcast message which also notifies its presence. Otherwise, the update module may send a query to the current slave node, in order to request the type and the version of the installed firmware/software.

At a subsequent step 1008, the update module
10 checks whether the type of the current slave node corresponds to the type of the master node, and whether the version of the firmware/software installed in the master node is newer than the version of the firmware/software installed in the current slave node.

15 If the type of the current slave node corresponds to the type of the master node, and if the version of the firmware/software installed in the master node is newer than the version of the firmware/software installed in the current slave node (output "Y" of
20 verification step 1008), the update module sends, at a step 1010, the firmware/software installed on the master node to the current slave node, i.e. the update module sends the firmware/software used by the master node to the current slave node.

25 Subsequently, the update module proceeds to a step 1012, in order to check if the current slave node is the last one in the list NL.

If the current slave node is the last one in the list NL (output "Y" of verification step 1012), the
30 procedure ends at the end step 1016.

On the other hand, if the current slave node is not the last one in the list NL (output "N" of verification step 1012), the update module selects, at a step 1014, the following slave node, and the
35 procedure is repeated at step 1006.

If the type of the current slave node does not correspond to the type of the master node, or if the version of the firmware/software installed in the master node is not newer than the version of the
5 firmware/software installed in the current slave node (output "N" of verification step 1008), the update module may directly proceed to the verification step 1012, i.e. the update module does not attempt to update the current slave node.

10 Figures 7a to 7d show an example of the update of the nodes/lighting modules 10 of the communication network 30, assuming that all nodes are of the same type.

Specifically, in the presently considered
15 embodiment, gateway node 20 starts updating network 30. As described with reference to Figures 5a and 5b, the update may be started manually, e.g. via device 40, or automatically by contacting a remote server 52.

At the beginning (Figure 7a), the gateway node 20
20 sends the update to a first node/lighting module 10, e.g. the nearest node, e.g. node 10₁.

In the following step (Figure 7b), the gateway node 20 sends the update to a second node/lighting module 10, e.g. the following nearest node, e.g. node
25 10₂. However, in the meanwhile, the updated node 10₁ detects that at least node 10₃ has not been updated yet, and therefore sends the updated firmware to that node as well.

In the following step (Figure 7c), the gateway
30 node 20 may only monitor the update of the network. As a matter of fact, during this step, the updated nodes 10₁, 10₂ and 10₃ independently proceed to update the neighbour nodes. For example, node 10₁ has no other neighbour nodes to update. On the contrary, node 10₂
35 detects that at least node 10₄ has not been updated

yet, and therefore proceeds to send the updated firmware to that node as well. Similarly, node 10₃ detects that at least node 10₅ has not been updated yet, and therefore proceeds to send the updated
5 firmware to that node, too.

Finally (Figure 7d), node 10₅ detects that node 10₆ has not been updated yet, and therefore proceeds to send the updated software to said node, too.

Thanks to the knowledge of the network structure,
10 the gateway node 20 may also determine the nodes 10 to which it is necessary to send the updated firmware, so as to speed up the network update.

Therefore, in various embodiments, the firmware update takes place in the same way as a virus, which
15 propagates among the nodes/lighting modules 10.

Generally speaking, as an alternative or in addition to a point-to point update of a current slave node, the gateway node 10 and/or the update module may also send a multi-cast communication, addressed to all
20 neighbour slave nodes which are of the same type and have an older firmware version.

Moreover, if at least one slave node of the same type is detected having an older firmware version, the update module may also send a broadcast communication
25 to all neighbour slave nodes, and each slave node may analyse the communication and determine whether the firmware version is directed to its own type of node/lighting module 10, and whether the firmware version is newer than the installed version.

30 For example, Figures 8a and 8b show an example of the update of the nodes/lighting modules 10 of the communication network 30 through the use of multi-cast or broadcast communications.

For example, at the beginning (Figure 8a), the
35 gateway node 20 chooses to initially send the update to

node 10₅ via a point-to-point communication.

As a matter of fact, in the following step (Figure 8b), the gateway node 20 may use a multi-cast or broadcast communication, in order to simultaneously
5 update nodes 10₁ and 10₂. In the meanwhile, the updated module 10₅ may employ a multi-cast or broadcast communication in order to simultaneously update modules 10₃, 10₄ and 10₆.

Figure 9 shows a second embodiment of the update
10 module of a node/lighting module 10. Generally speaking, the operation of said module may also be combined with the previously described operation.

After a start step 2000 the update module monitors, at a step 2002, the communications that the
15 respective node/lighting module 10 is supposed to forward to another node/lighting module 10, i.e. the multi-hop communications which pass through node 10.

If said communications do not include firmware (output "N" of the verification step 2002), the update
20 module returns to step 2002, in order to monitor the following communication.

On the other hand, if said communications include firmware (output "Y" of the verification step 2002), at a step 2004 the update module stores the firmware also
25 locally, i.e. within node 10, without however executing the update.

Once the node/lighting module 10 has received and forwarded the whole firmware, the update module checks, at a step 2006, whether the locally stored firmware is
30 compatible with the respective node/lighting module 10, i.e. whether the type corresponds and whether the firmware version is newer.

If the received firmware is compatible and newer (output "Y" of verification step 2006), the update
35 module updates, at a step 2008, the firmware of the

respective node/lighting module 10 and returns to step 2002.

On the other hand, if the received firmware is not compatible nor newer (output "N" of verification step 2006), the update module returns to step 2002.

Generally speaking, the update module may delete the received firmware, or may store the firmware (albeit non compatible). As a matter of fact, as previously described, the update module may attempt to update other slave nodes in the vicinity, which are compatible with the locally stored firmware(s), by using in this case the stored firmware, i.e. the firmware incompatible with the master node, instead of the firmware of the master node.

For example, Figures 10a to 10c show an example wherein both functions are used jointly in the update module.

For example, at the beginning (Figure 10a), the gateway node 20 chooses to initially send the update to node 10₆ via a point-to-point and multi-hop communication. For example, said communication is forwarded through nodes 10₁, 10₃ and 10₅. Therefore, as previously described with reference to Figure 9, the update modules of said nodes/lighting modules 10 also locally store, during information forwarding, a copy of the firmware.

Therefore, as shown in Figure 10b, the update module of nodes 10₁, 10₃ and 10₅ may make use of the firmware copy in order to update the respective node.

Finally, the updated nodes, i.e. nodes 10₁, 10₃, 10₅ and 10₆, may monitor the neighbouring nodes and update such nodes. For example, node 10₁ may update node 10₂ and node 10₅ may update node 10₄.

Therefore, thanks to the presently described solutions, the update may be carried out in a

distributed fashion, by updating one or more nodes/lighting modules 10 of the network, which in turn will update other neighbour nodes.

As previously mentioned, the update modules of the
5 nodes/lighting modules 10 are adapted to update only devices in the immediate vicinity. Therefore, such communications are performed as single-hop communications, which also speeds up data transmission.

If some of the nodes/lighting modules cannot be
10 updated in this way, the device 40 (see Figure 5a) or the gateway node (see Figure 5b) may send the updated firmware via a point-to-point and multi-hop communication to these nodes, which in turn will provide updating to the neighbour modules.

15 Preferably, the intermediate nodes of this multi-hop communication store the firmware locally and perform their own update (if compatible) and optionally the update of other nodes 10.

Therefore, the update of the nodes/lighting
20 modules 10 is started by device 40 or gateway node 20, and then the update takes place automatically. In various embodiments, the gateway node 20 or the device 40 (via the gateway node) may also send broadcast communications, in order to request information about
25 the update status of each node. For example, in order to reduce the risk of a simultaneous response of several nodes 10, the query may specify a time interval, and each node 10 may respond after a random time included in said time interval.

30 Generally speaking, the update of network 30 is therefore also performed by inserting a new node/lighting module 10 having an updated firmware into the communication network 10.

Therefore, the solutions described herein enable a
35 reduction of the time needed to carry out the update of

the nodes 10 of network 30. Moreover, the update of one single node 10 is often sufficient to automatically update all the nodes 10 of network 30. Therefore, the user does not need to provide an individual update to
5 each node 10. Moreover, a homogeneous network ensures that all nodes 10 are updated to the same firmware version.

Of course, without prejudice to the principle of the invention, the implementation details and the
10 embodiments may vary, even appreciably, with respect to what has been described herein by way of non-limiting example only, without departing from the scope of the invention as defined by the annexed claims.

CLAIMS

1. A node (10) for a multi-hop communication network (30), comprising:

5 - a wireless communication interface (106) configured to exchange data with said multi-hop communication network (30);

10 - a processing unit (108) configured to command the operation of said node (10) as a function of commands received via said wireless communication interface (106);

- a memory (110) which contains a firmware for said processing unit (108);

wherein said node (10) is configured for:

15 - receiving via said wireless communication interface (106) an updated firmware;

- storing (2006) said updated firmware in said memory (110);

20 - detecting (1002) via said wireless communication interface (106) other nodes which are in the vicinity of said node (10); and

- sending (1010) said firmware stored in said memory (110) to one or more of said other nodes.

2. The node according to Claim 1, comprising:

25 - detecting a model number of said node (10) and a version of said firmware stored in said memory (110);

- detecting (1006), for each of said other nodes which are in the vicinity of said node (10), a respective model number and a respective firmware version; and

30 - determining (1008), for each of said other nodes (10) which are in the vicinity of said node (10), whether the model number of said node (10) corresponds to the model number of the respective other node;

35 - determining (1008), for each of said other nodes (10) which are in the vicinity of said node (10),

whether the version of the firmware of said node (10) is newer than the firmware version of the respective other node; and

5 - sending (1010) the firmware stored in said memory (110) to said other nodes which have a model number which corresponds to the model number of said node (10) and a firmware version which is older than the firmware version of said node (10).

10 3. The node according to Claim 1 or Claim 2, wherein said sending (1010) to one or more of said other nodes the firmware stored in said memory (110), comprises sending (1010) the firmware stored in said memory (110) to said other nodes via a point-to-point, multi-cast or broadcast communication.

15 4. The node according to any of the previous claims, wherein said receiving via said wireless communication interface (106) an updated firmware comprises:

20 - analyzing a point-to-point, multi-cast or broadcast communication addressed to said node (10).

5. The node according to any of the previous claims, wherein said receiving via said wireless communication interface (106) an updated firmware comprises:

25 - analyzing (2002) the content of a multi-hop communication passing through said node (10).

6. The node according to any of the previous claims, wherein said storing (2004) said updated firmware in said memory (110) comprises:

30 - determining (2006) whether the updated firmware received via said wireless communication interface (106) is compatible with said node (10); and

- in case said updated firmware is compatible with said node (10), storing (2008) said updated firmware in

said memory (110), such that said processing unit (108) uses said updated firmware.

7. The node according to any of the previous claims, comprising one or more sensors (112) and/or
5 actuators (114).

8. The node according to any of the previous claims, wherein said node (10) is a lighting module comprising:

- an electronic converter (102) configured to
10 power at least one light source (104), wherein said processing unit (108) is configured to command the operation of said electronic converter (102) as a function of commands received via said wireless communication interface (106).

15 9. A lighting system comprising a plurality of nodes according to Claim 8.

10. The lighting system according to Claim 9, comprising a gateway node (20) comprising:

- a wireless communication interface (206)
20 configured to exchange data with said multi-hop communication network (30);

- one or more further communication interfaces (202) for a wired or wireless communication; and

- a processing unit (204) configured to manage the
25 exchange of data between said one or more further communication interfaces (202) and said wireless communication interface (206).

11. A method of updating the software of lighting modules in a lighting system according to Claim 9 or
30 Claim 10, comprising:

- receiving from a remote server (52) an updated firmware, and

- sending the updated firmware to at least one of said nodes (10).

12. A computer-program product that can be loaded into a memory (110) associated with a processing unit (108) of a node (10) for a multi-hop communication network (30), said node (10) comprising a wireless communication interface (106) configured to exchange data with said multi-hop communication network (30), wherein the computer-program product comprises portions of software code for implementing the following operations:

- 10 - receiving via said wireless communication interface (106) an updated firmware;
- storing (2006) said updated firmware in said memory (110);
- detecting (1002) via said wireless communication
- 15 interface (106) other nodes which are in the vicinity of said node (10); and
- sending (1010) said firmware stored in said memory (110) to one or more of said other nodes.

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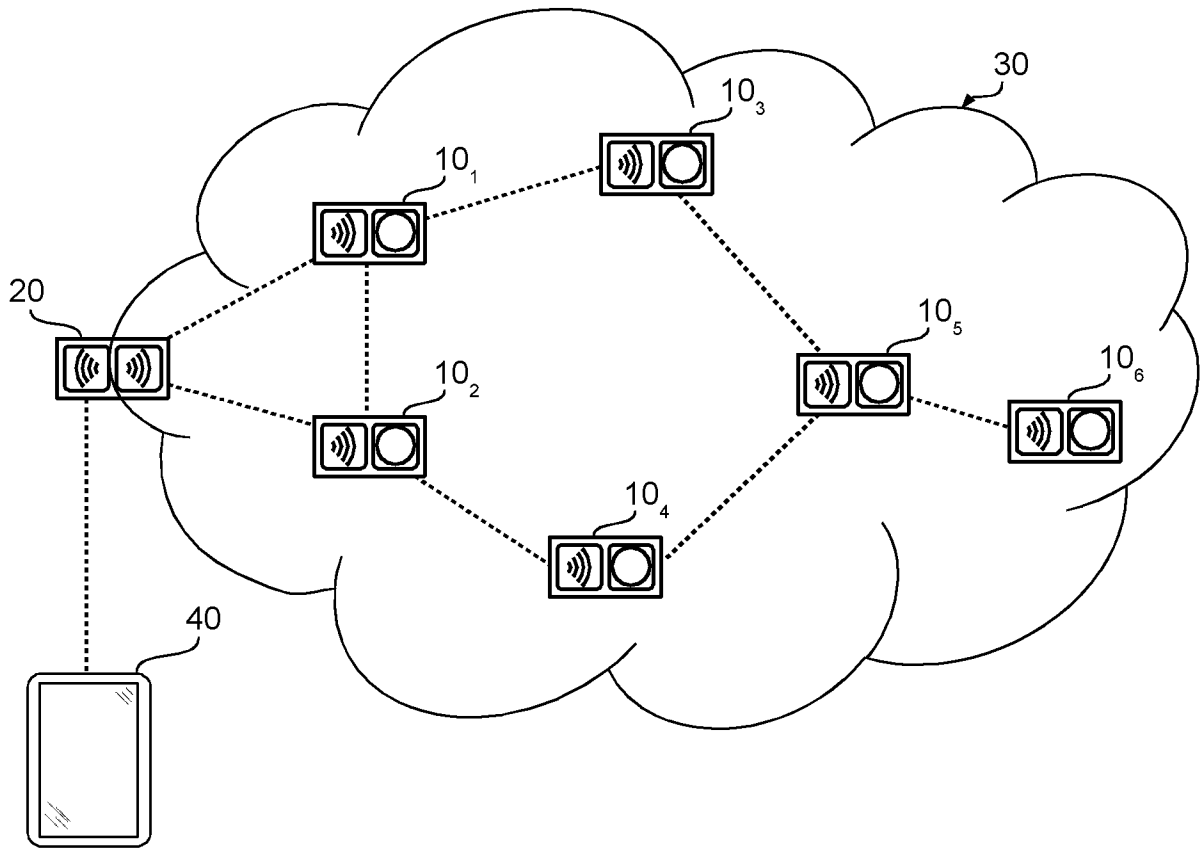


Fig. 1

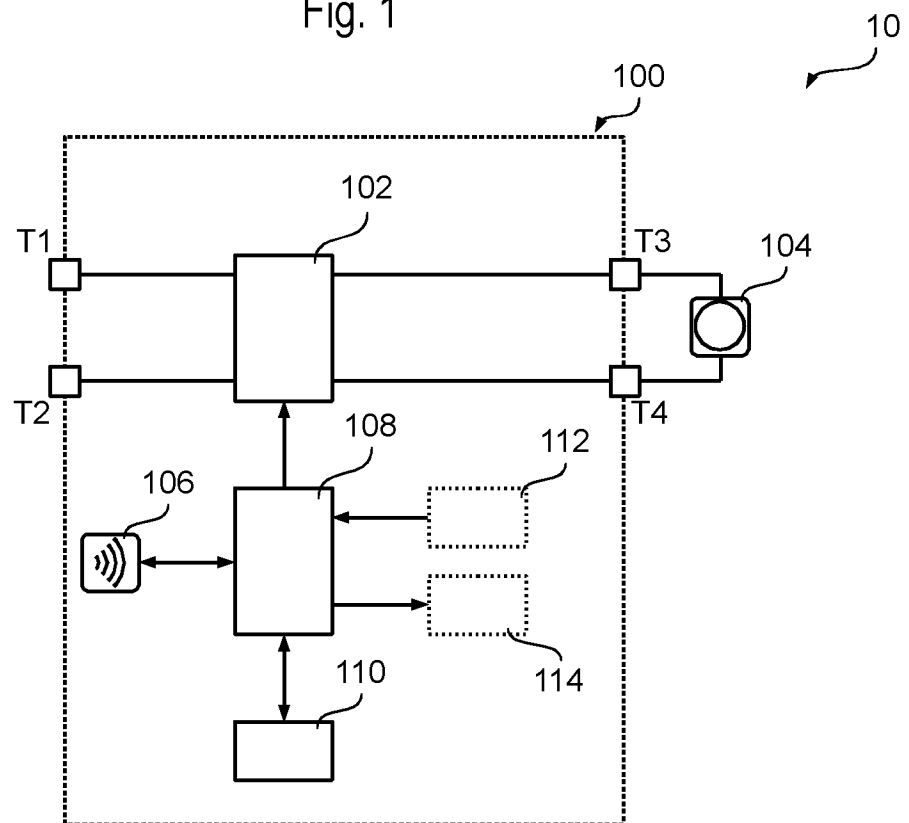


Fig. 2

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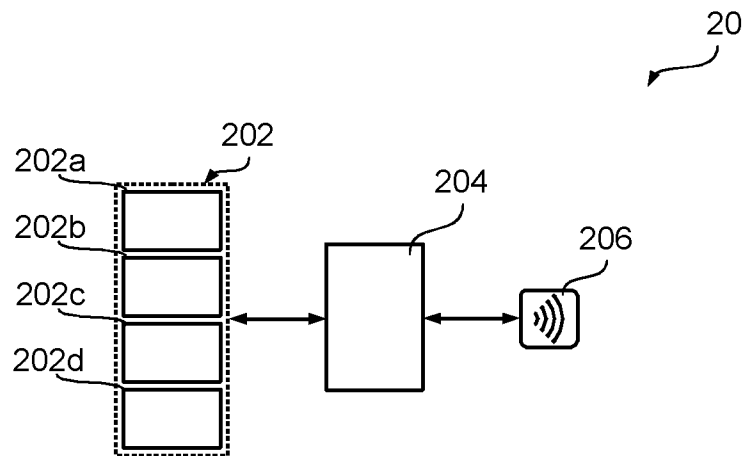


Fig. 3

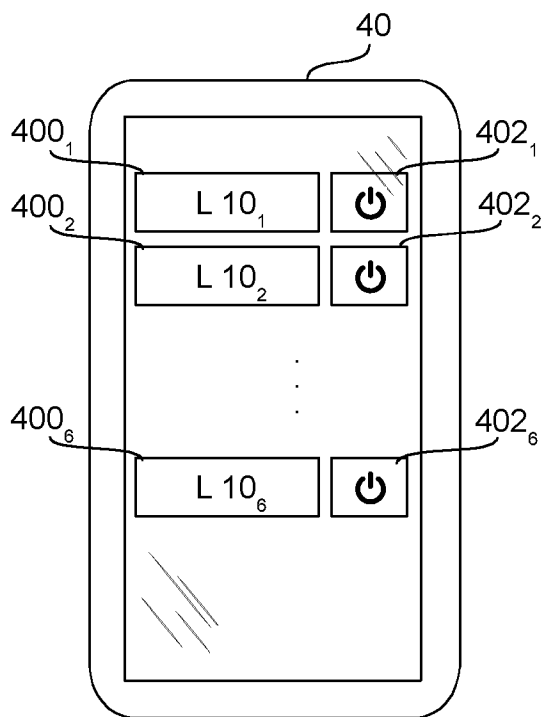


Fig. 4a

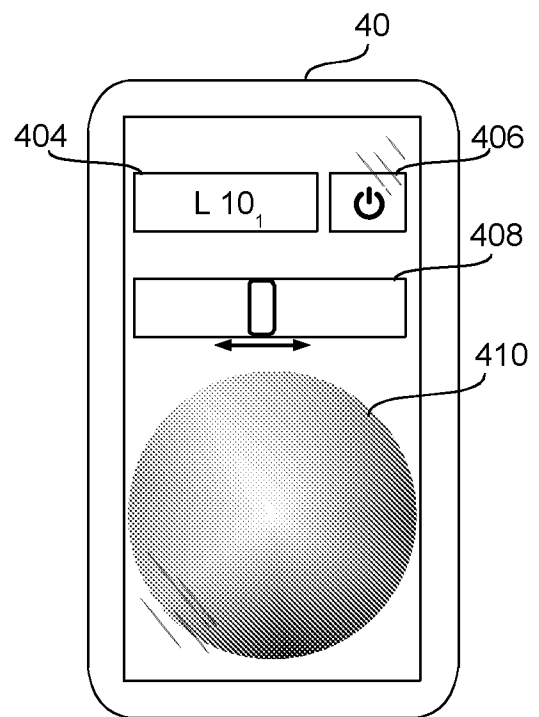


Fig. 4b

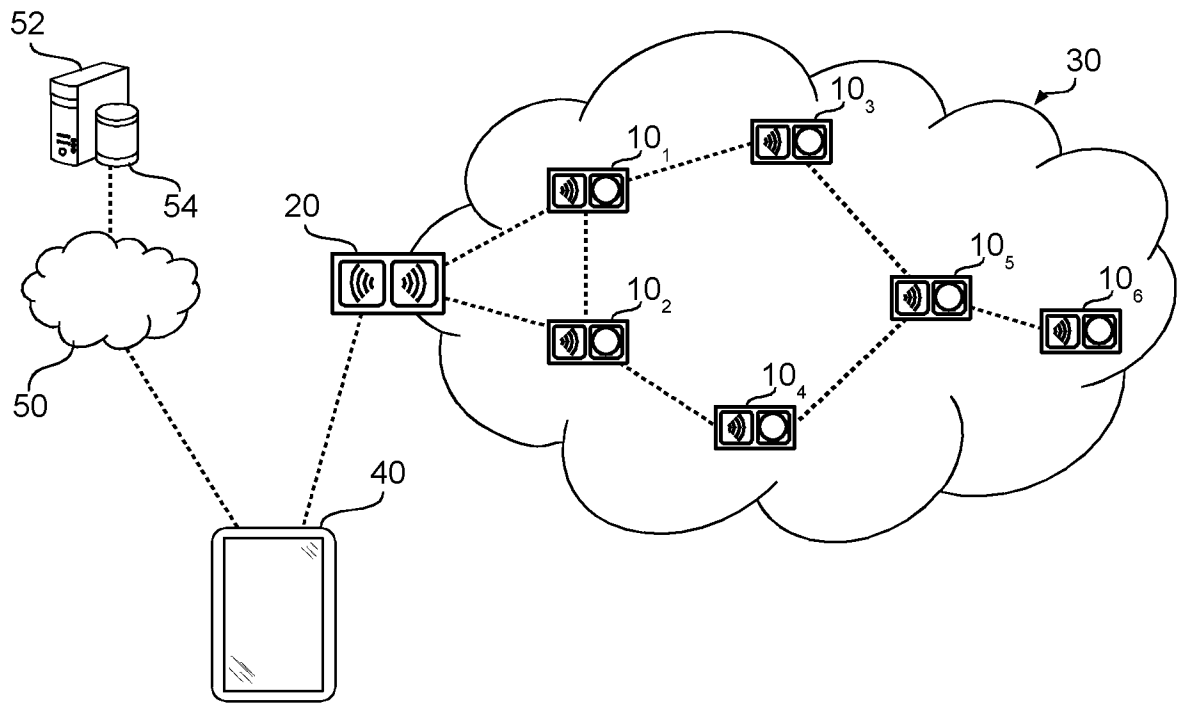


Fig. 5a

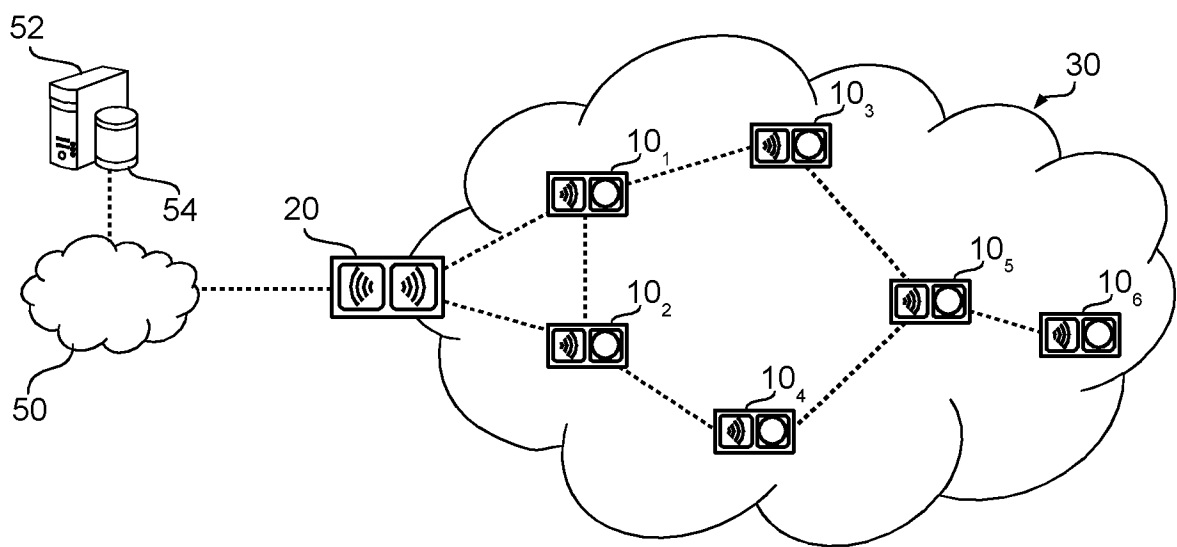


Fig. 5b

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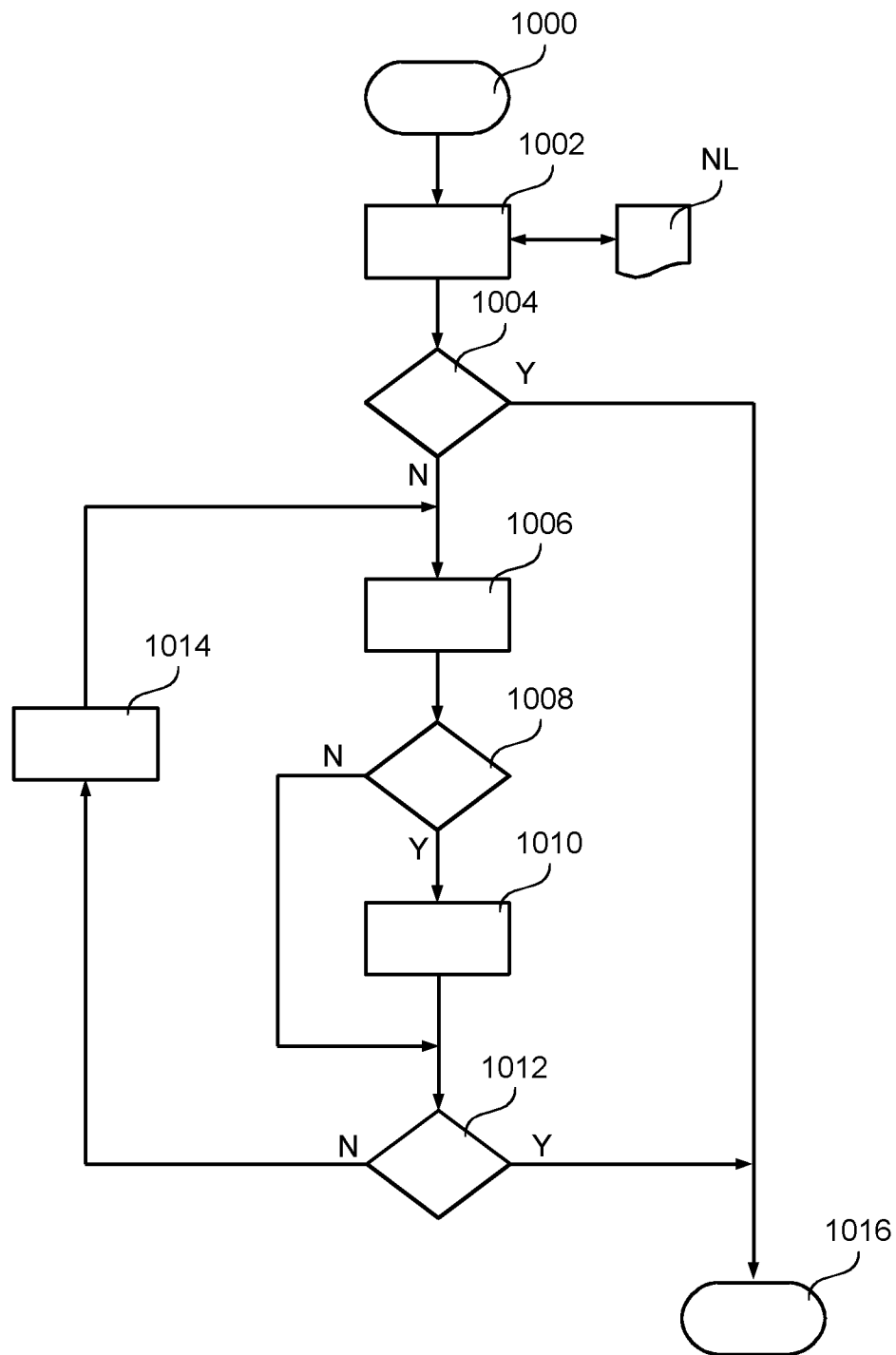


Fig. 6

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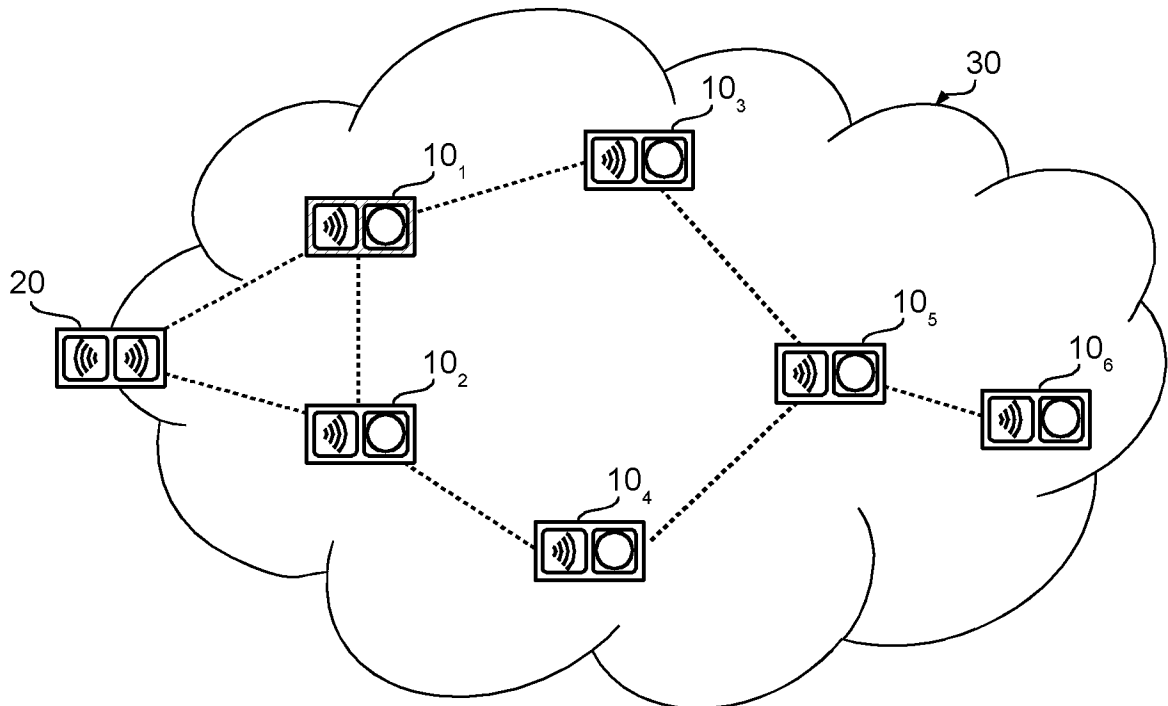


Fig. 7a

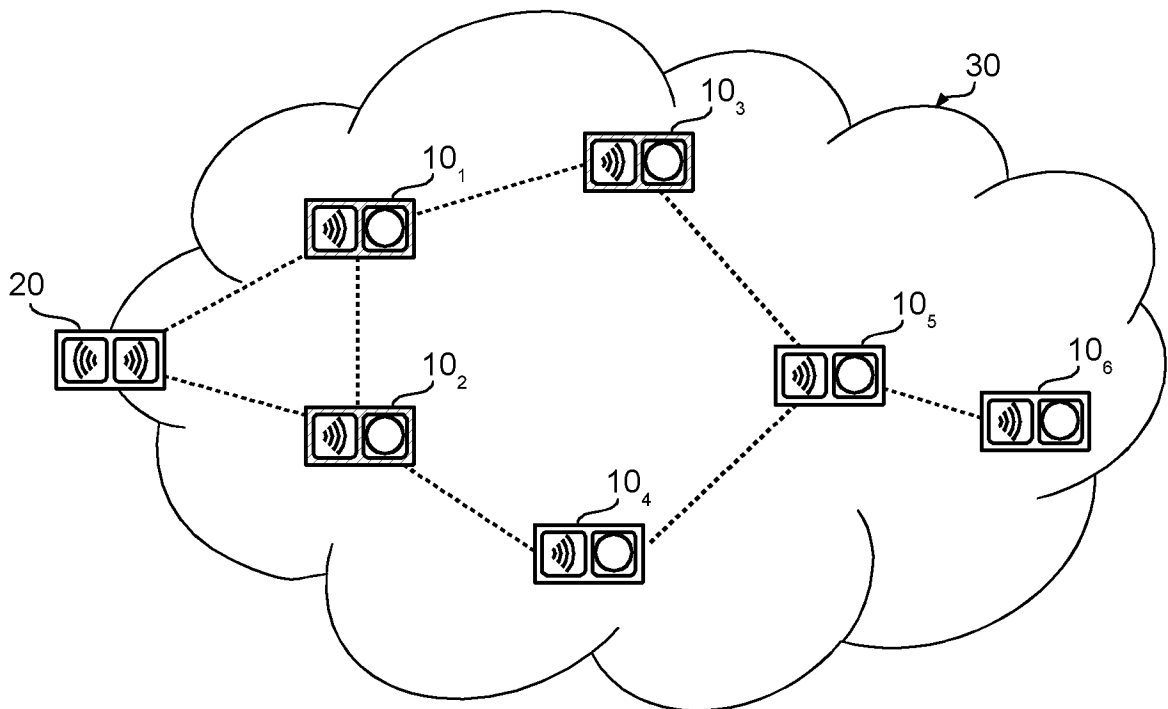


Fig. 7b

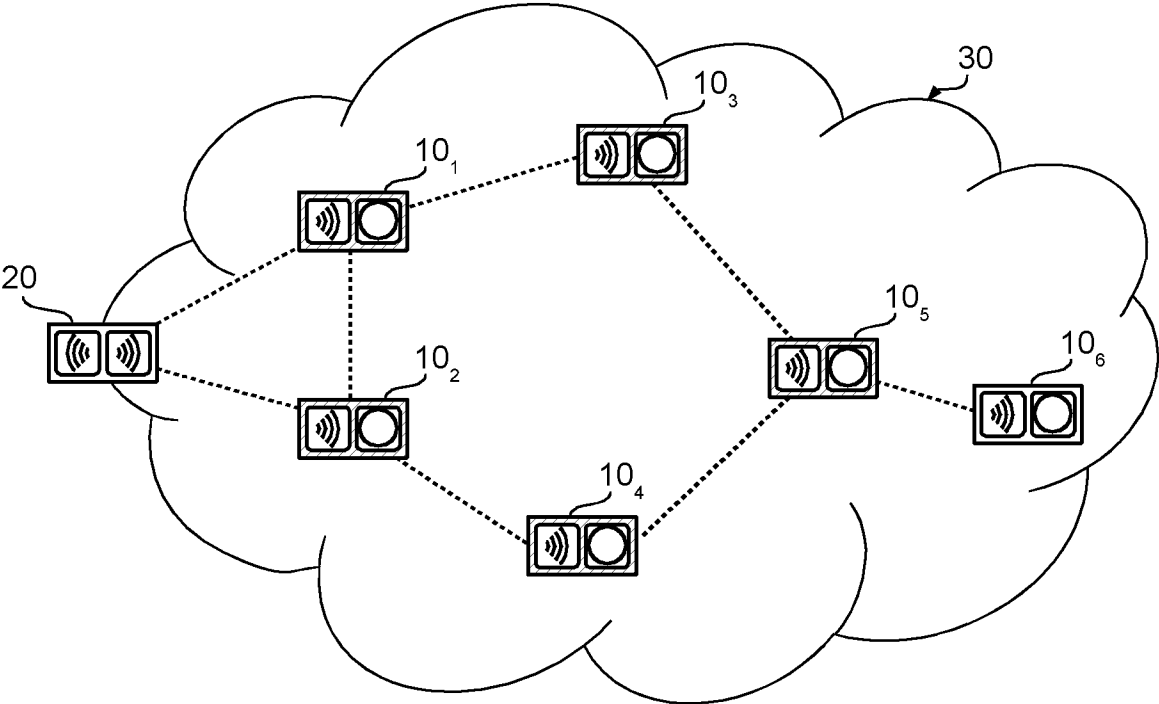


Fig. 7c

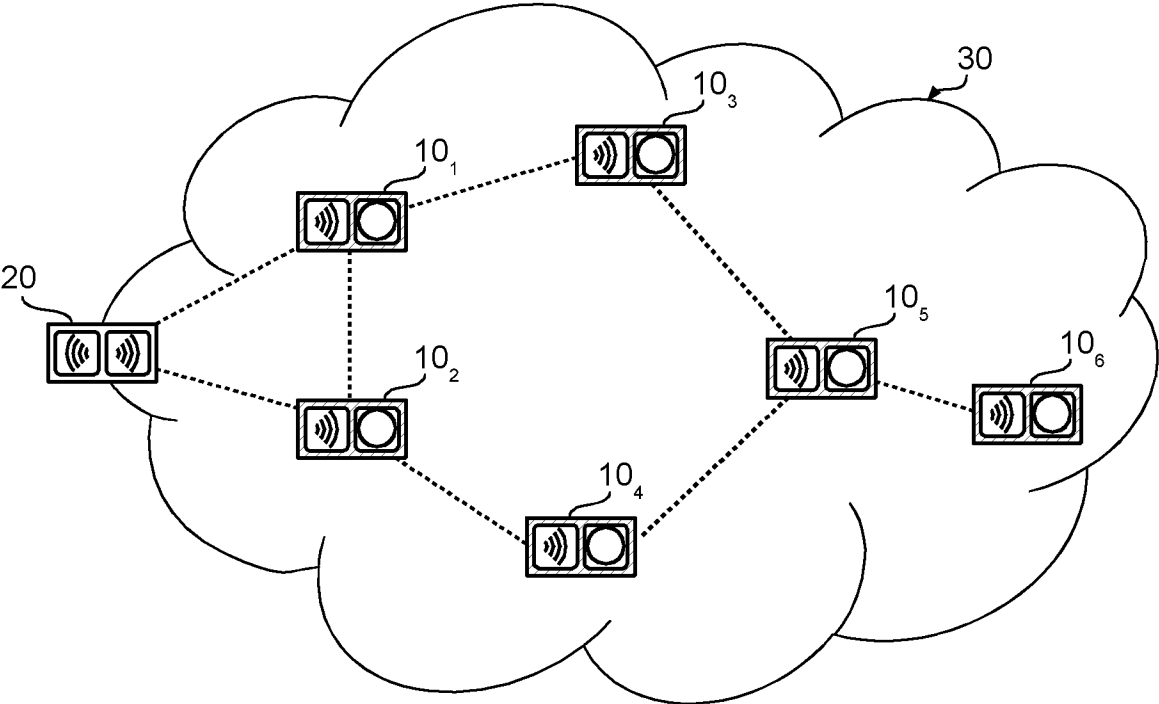


Fig. 7d

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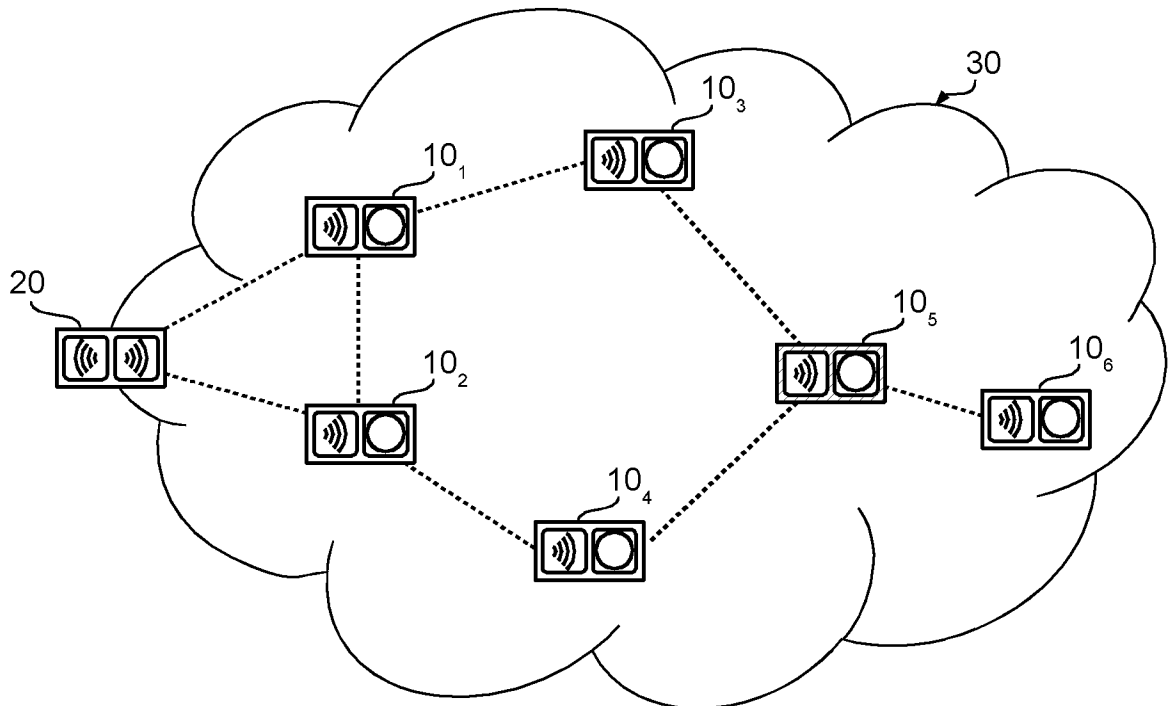


Fig. 8a

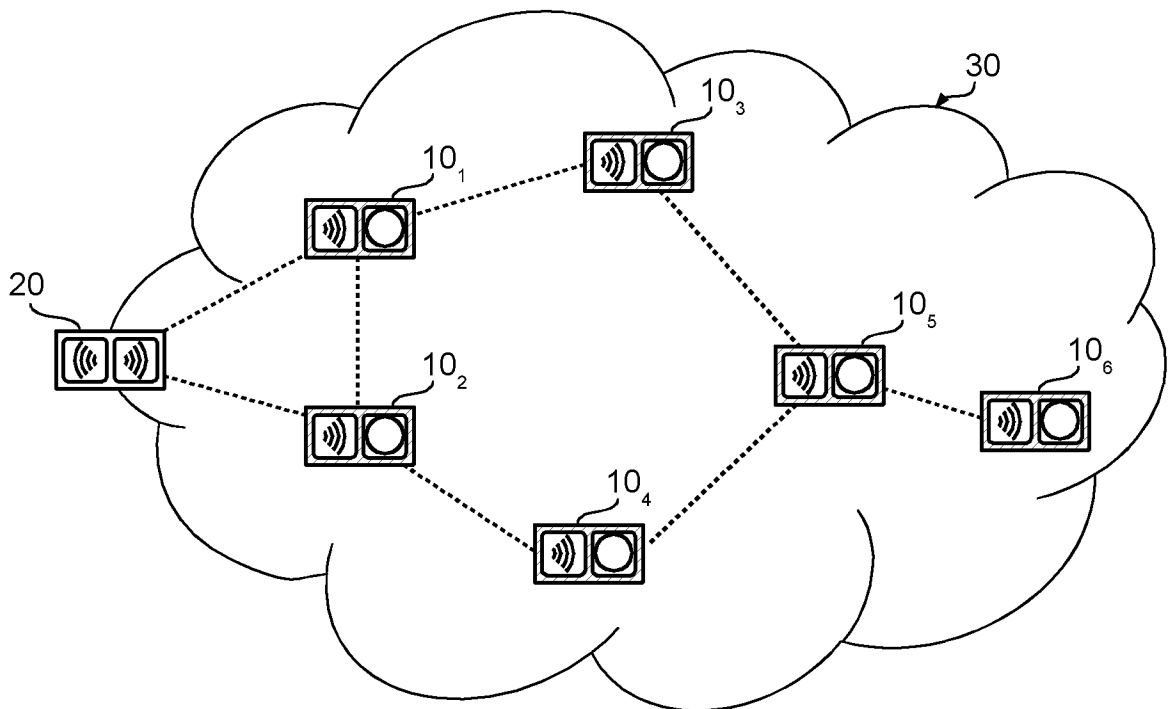


Fig. 8b

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Fig. 9

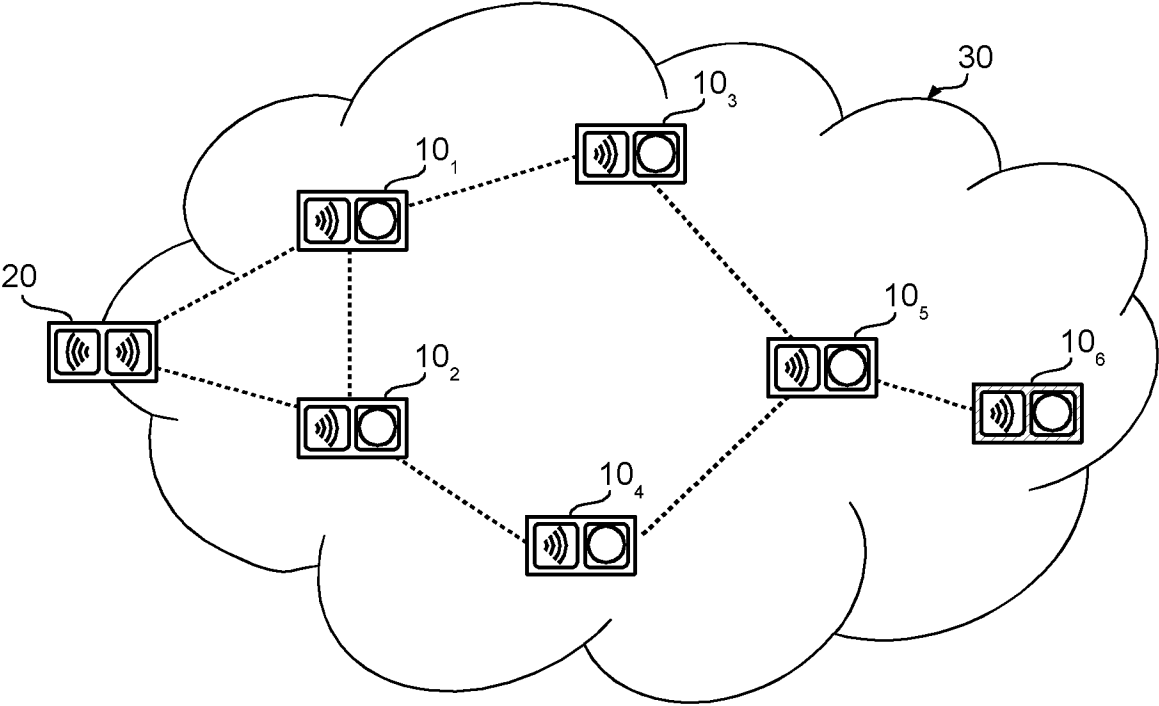
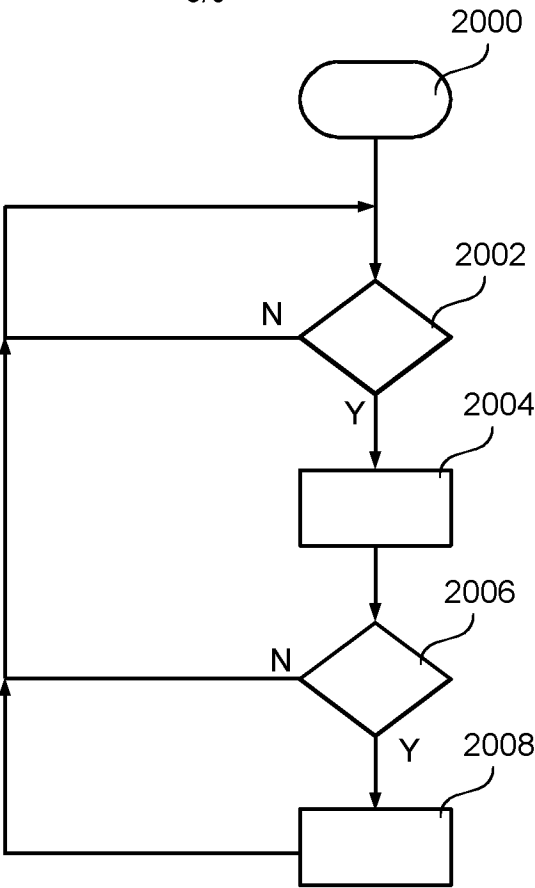


Fig. 10a

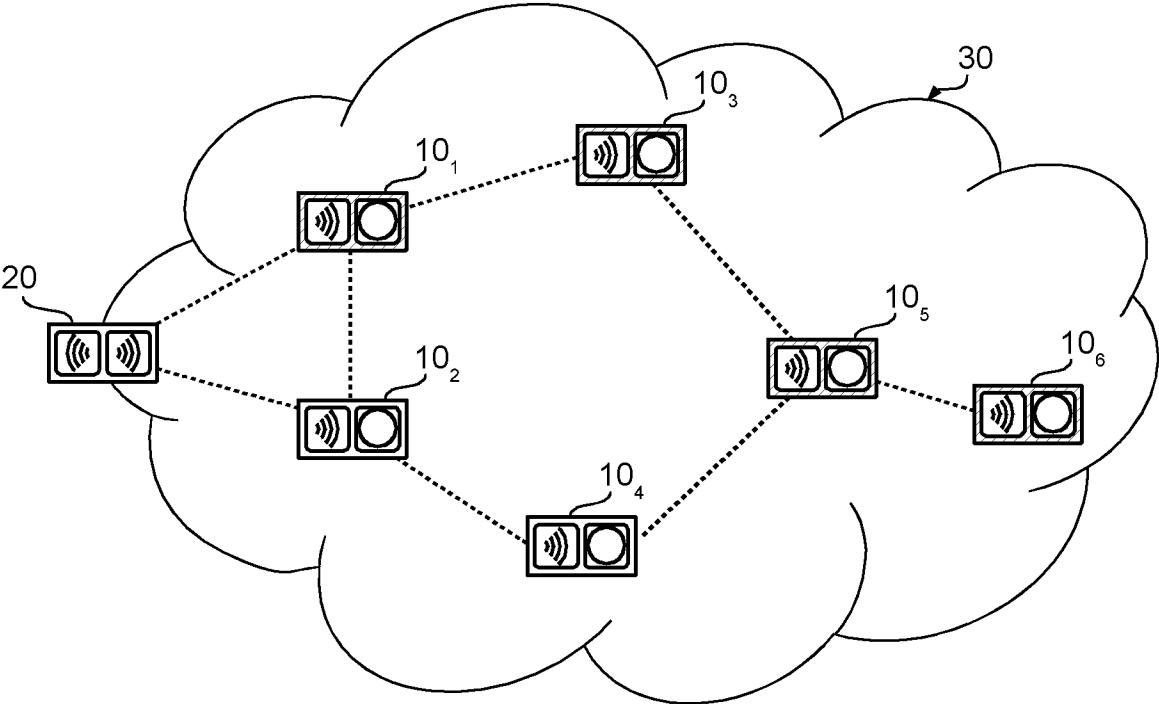


Fig. 10b

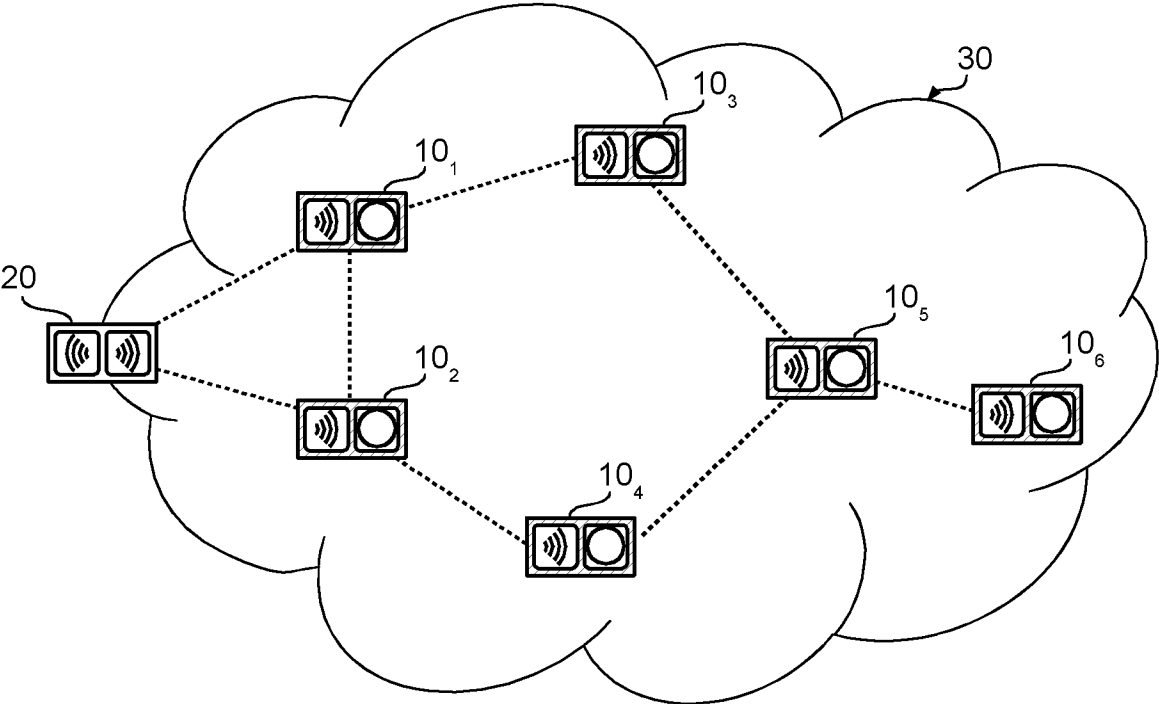


Fig. 10c

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2018/051023

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L29/08
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L H04W

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/335219 A1 (MALKOWSKI BERNARD M [US]) 19 December 2013 (2013-12-19) abstract paragraphs [0004], [0005], [0017] - [0024] figure 1	1-12
A	----- KR 2014 0145306 A (LG ELECTRONICS INC [KR]) 23 December 2014 (2014-12-23) abstract paragraphs [0001] - [0021], [0066] - [0129] -----	1-12



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

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"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

10 April 2018

Date of mailing of the international search report

18/04/2018

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Authorized officer

Pandolfi, Alessandra

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2018/051023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013335219	A1	19-12-2013	NONE

KR 20140145306	A	23-12-2014	NONE
