(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 836 761 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
16.06.2021 Bulletin 2021/24

(51) Int Cl.:
H05B 47/19 *(2020.01)*

(21) Application number: **19216034.9**

(22) Date of filing: **13.12.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
KH MA MD TN

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(54) A GATEWAY DEVICE AND A METHOD FOR CONNECTING LIGHTING SYSTEM ELEMENTS TO A DATA TRANSFER NETWORK

(57) A gateway device (101) for connecting lighting system elements to a data transfer network comprises a data interface (102) for connecting communicatively to the data transfer network, a wireless transceiver (103) for connecting communicatively to the lighting system elements, and a control system (104) for controlling data traffic between the data interface and the wireless transceiver. The control system is configured to select one of the lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and to control the wireless transceiver to establish a wireless point-to-point connection to the access point. Thus, the gateway device does not need to be a part of a wireless mesh-network formed by the lighting system elements, and therefore for example signal levels and other transmission parameters between the gateway device and the access point can be set more freely.

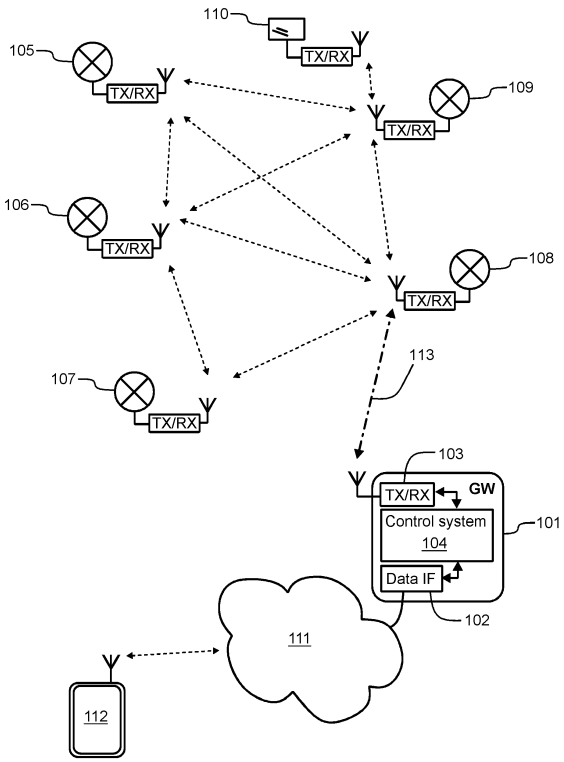

Figure 1

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Description

Field of the disclosure

[0001] The disclosure relates to a gateway device for connecting lighting system elements to a data transfer network. Each lighting system element can be for example a luminaire, a control panel, a sensor such as a motion or light sensor, or some other element of a lighting system. Furthermore, the disclosure relates to a method and to a data processor program for connecting lighting system elements to a data transfer network.

Background

[0002] In many lighting systems, lighting system elements are configured to constitute a wireless mesh-network to enable the lighting system elements to communicate with each other. The communication between the lighting system elements makes it possible to implement different functionalities in a lighting system such as for example a functionality where a light source is switched on prior to a user arrives at an area, e.g. a room or a part of a corridor, illuminated by the light source under consideration. The wireless mesh-network can be based on for example one of the following protocols: Bluetooth Low Energy "BLE", Zigbee, and Thread.

[0003] In many cases, there is a need to connect a lighting system to an external data transfer network, e.g. to connect the lighting system to one or more cloud services via the Internet. When a wireless mesh-network of the kind described above is connected to an external data transfer network, a gateway device is needed. In many lighting systems, the gateway device forms a part of the wireless mesh-network and the gateway device is an element, e.g. a dongle, situated in the vicinity of a router, a switch, a bridge, or some other network device that provides access to the external data transfer network. The gateway device is typically connected to the router or the other network device with a universal serial bus "USB" or some other connection technique. Therefore, the gateway device is typically located in an electrical cabinet, which limits ranges of radio signals between the gateway device and the lighting system elements. Furthermore, while many of the lighting system elements are typically installed in a ceiling, the electrical cabinet is typically located vertically lower, which also affects the signal quality because the lighting system elements may have been designed to optimize their mutual signal transfer when being installed on a same vertical level. Furthermore, the gateway device may be difficult to access during maintenance visits by a lighting system provider. Yet furthermore, the gateway device may need a certification concerning e.g. electrical safety and/or compatibility with the router or the other network device, causing further costs.

[0004] As mentioned above, the gateway device forms a part of the wireless mesh-network. This can be challenging especially in cases where there are many lighting system elements and thereby the wireless mesh-network is large. When the gateway device wants to send a message to a lighting system element that is far from the gateway device in terms of a hop-count, the time-to-live "TTL" limit of the message must be high to enable the message to reach the lighting system element under consideration. The high time-to-live limit causes however a significant traffic load in the large wireless mesh-network where each node forwards to other nodes a received message which is not addressed to the first mentioned node and whose hop-count is less than the time-to-live limit.

Summary

[0005] The following presents a simplified summary in order to provide a basic understanding of some aspects of various invention embodiments. The summary is not an extensive overview of the invention. It is neither intended to identify key or critical elements of the invention nor to delineate the scope of the invention. The following summary merely presents some concepts in a simplified form as a prelude to a more detailed description of exemplifying embodiments of the invention.

[0006] In accordance with the invention, there is provided a new gateway device for connecting lighting system elements to an external data transfer network, e.g. the Internet. Each lighting system element can be for example a luminaire, a control panel, a sensor such as a motion or light sensor, or some other element of a lighting system. A gateway device according to the invention comprises:

- a data interface for connecting communicatively to the data transfer network, e.g. the Internet,
- a wireless transceiver for connecting communicatively to the lighting system elements, and
- a control system for controlling data traffic between the data interface and the wireless transceiver.

[0007] The control system is configured to select one of the lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and to control the wireless transceiver to establish a wireless point-to-point connection to the access point.

[0008] The wireless point-to-point connection can be for example a Bluetooth®, Zigbee, or WiFi point-to-point connection. The point-to-point connection can be based on for example the Generic Attribute Profile "GATT" layer of the Bluetooth low energy "BLE" protocol stack.

[0009] As there is the wireless point-to-point connection between the gateway device and the above-mentioned access point, the gateway device does not need to act as a part of a wireless mesh-network constituted

by the lighting system elements. Therefore, the signal levels and other transmission parameters between the gateway device and the access point can be set more freely than in a case where the gateway device acts as a part of the wireless mesh-network. Therefore, the signal transfer between the gateway device and the access point can be faster and more reliable than in a case where the gateway device acts as a part of the wireless mesh-network.

[0010] In many cases, the gateway device can be implemented with for example a standard BLE enabled radio module of a router, a switch, a bridge, or some other network device that provides access to an external data transfer network, and thus the gateway does not need to be a separate dongle or another element coupled to the router or the other network device. Therefore, the gateway device does not typically need a certification or the like concerning its compatibility with the router or the other network device.

[0011] The above-mentioned access point can be selected in many ways from among the lighting system elements. For example but not necessarily, the selection can be based on strengths of signals, e.g. broadcast advertisements, received at the gateway device from the lighting system elements, data transfer latencies from the lighting system elements to the gateway device, data loss levels on signal paths from the lighting system elements to the gateway device, and/or reachability information expressing, for each of the lighting system elements as a candidate access point, reachability of other lighting system elements via the candidate access point in terms of hop-counts in the wireless mesh-network constituted by the lighting system elements. In an exemplifying case, the gateway device is configured to receive signals, e.g. broadcast advertisements, from the lighting system elements after establishing the wireless point-to-point connection, and the gateway device is configured change the access point in response to a situation in which the received signals indicate that another lighting system element fulfills criteria for selecting the access point better than the earlier selected lighting system element does. Especially in cases where the number of the lighting system elements is high and thereby the wireless mesh-network between the lighting system elements is large, the access point is selected advantageously dynamically so that, in each operational situation, data traffic caused in the wireless mesh-network by a message sent by the gateway device via the wireless point-to-point connection is minimized or at least nearly minimized. This can be achieved by selecting the access point to be either a lighting system element that is to be contacted via the gateway or a lighting system element that is near to the lighting system element to be contacted, and by setting a low time-to-live "TTL" limit to the message sent by the gateway. As the access point is at or near to the lighting system element to be contacted, the message can reach the lighting system element to be contacted even if the time-to-live "TTL" limit of the message is low. On the other hand, the low time-to-live "TTL" limit reduces spreading of the message within the wireless mesh-network constituted by the lighting system elements.

[0012] In accordance with the invention, there is provided also a new lighting system that comprises:

- lighting system elements configured to constitute a wireless mesh-network with each other, and
- at least one gateway device according to the invention for connecting the lighting system elements to a data transfer network external to the wireless mesh-network.

[0013] The lighting system elements can be configured to constitute the wireless mesh-network in accordance with for example the Bluetooth Low Energy "BLE", Zigbee, or Thread.

[0014] In accordance with the invention, there is provided also a new method for connecting lighting system elements to a data transfer network. A method according to the invention comprises:

- controlling a data interface of a gateway device to connect communicatively to the data transfer network,
- selecting one of the lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and
- controlling a wireless transceiver of the gateway device to establish a wireless point-to-point connection to the access point.

[0015] In accordance with the invention, there is provided also a new data processor program for connecting lighting system elements to a data transfer network. A data processor program according to the invention comprises instructions for controlling a programmable data processor of a gateway device to:

- control a data interface of the gateway device to connect communicatively to the data transfer network,
- select one of the lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and
- control a wireless transceiver of the gateway device to establish a wireless point-to-point connection to the access point.

[0016] The above-mentioned data processor program can be called a computer program provided that a com-

puter is understood in a broad sense so that e.g. a programmable router or another programmable network device is deemed to be a computer.

[0017] In accordance with the invention, there is provided also a new data processor program product. The data processor program product comprises a non-volatile data processor readable medium encoded with a data processor program according to the invention.

[0018] Exemplifying and non-limiting embodiments are described in accompanied dependent claims.

[0019] Various exemplifying and non-limiting embodiments both as to constructions and to methods of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific exemplifying and non-limiting embodiments when read in conjunction with the accompanying drawings.

[0020] The verbs "to comprise" and "to include" are used in this document as open limitations that neither exclude nor require the existence of also un-recited features.

[0021] The features recited in dependent claims are mutually freely combinable unless otherwise explicitly stated. Furthermore, it is to be understood that the use of "a" or "an", i.e. a singular form, throughout this document does not exclude a plurality.

Brief description of the figures

[0022] Exemplifying and non-limiting embodiments and their advantages are explained in greater detail below with reference to the accompanying drawings, in which:

figure 1 illustrates an exemplifying lighting system that comprises a gateway device according to an exemplifying and non-limiting embodiment,

figure 2 illustrates an exemplifying lighting system that comprises gateway devices according to an exemplifying and non-limiting embodiment, and

figure 3 shows a flowchart of a method according to an exemplifying and non-limiting embodiment for connecting lighting system elements to a data transfer network.

Description of exemplifying and non-limiting embodiments

[0023] The specific examples provided in the description below should not be construed as limiting the scope and/or the applicability of the accompanied claims. Lists and groups of examples provided in the description below are not exhaustive unless otherwise explicitly stated.

[0024] Figure 1 illustrates an exemplifying lighting system that comprises a gateway device 101 according to an exemplifying and non-limiting embodiment. The lighting system comprises lighting system elements 105, 106, 107, 108, 109, and 110 each of which comprises a wireless communication unit and a controller. In the exemplifying case illustrated in figure 1, each of the lighting system elements 105-109 further comprises a light source, and the lighting system element 110 further comprises a motion and/or light sensor. For another example, it is also possible that each lighting system element comprises a wireless communication unit, a controller, a light source, and a motion and/or light sensor. The wireless communication units of the lighting system elements 105-110 are configured to form a wireless mesh-network where the lighting system elements 105-110 broadcast information, such as e.g. their current status. The wireless mesh-network can be for example a Bluetooth Low Energy "BLE" mesh-network, a Zigbee mesh-network, or a Thread mesh-network, or a mesh-network based on some other protocol.

[0025] The gateway device 101 comprises a data interface 102 for connecting communicatively to a data transfer network 111 that can be for example the Internet. The lighting system can be connected to for example one or more cloud services running in the data transfer network 111. The gateway device 101 comprises a wireless transceiver 103 for connecting communicatively to the lighting system elements 105-110, and a control system 104 for controlling data traffic between the data interface 102 and the wireless transceiver 103. The control system 104 is configured to select one of the lighting system elements 105-110 to be an access point in accordance with information related to the lighting system elements 105-110 and to the gateway device 101. In the exemplifying situation shown in figure 1, the lighting system element 108 has been selected to be the access point. The control system 104 is configured to control the wireless transceiver 103 to establish a wireless point-to-point connection 113 to the access point. The wireless point-to-point connection 113 can be for example a Bluetooth®, Zigbee, or WiFi point-to-point connection. The point-to-point connection 113 can be based on for example the Generic Attribute Profile "GATT" layer of the Bluetooth low energy "BLE" protocol stack. The controller of the lighting system element 108 that acts as the access point has two functions: it controls the lighting system element 108 and it also operates as a pathway to the wireless mesh-network constituted by the lighting system elements 105-110. The gateway device 101 can be placed e.g. in an electrical cabinet in an area where the lighting system is installed.

[0026] The gateway device 101 enables data transfer from the wireless mesh-network to the data transfer network 111, e.g. to a cloud service running in the data transfer network 111. The data may comprise e.g. a status history of one or more of the lighting system elements 105-110 and/or sensor readings of sensors installed in one or more of the lighting system elements 105-110, such as e.g. carbon dioxide "CO_2", volatile organic compounds "VOC", temperature, etc. This data can be further

used to monitor and improve the operation of the lighting system and/or other building management systems such as heating, ventilation, and air conditioning "HVAC". Furthermore, the data can be provided to other systems and/or service providers, for example to improve facility management. The gateway device 101 enables also data transfer from the data transfer network 111 to the lighting system elements 105-110. For example, the gateway device 101 may request sending of information, such as a status of one or more of the lighting system elements 105-110, learned behaviour of one or more of the lighting system elements 105-110, parameters being used in one or more of the lighting system elements 105-110, energy consumption data, etc. Additionally, the gateway device 101 may transmit commands to the lighting system elements 105-110 and/or write parameter values on databases maintained in the lighting system elements 105-110, for example based on an analysis performed by a cloud service. In an exemplifying and non-limiting embodiment, the lighting system elements 105-110 can be individually controlled with a mobile device 112 via the data transfer network 111 and via the gateway device 101. In an exemplifying lighting system, a mobile device is able to form a direct connection, e.g. a BLE connection, to a lighting system element to be controlled with the mobile device and/or the mobile device is able to form a direct connection, e.g. a BLE connection, to a first lighting system element and control a second lighting system element via the wireless mesh-network.

[0027] The above-mentioned access point can be selected in many ways from among the lighting system elements 105-110. For example, if the intention is just to collect data from the lighting system, the wireless point-to-point connection can be made with the closest one of the lighting system elements 105-110. In an exemplifying and non-limiting embodiment, the control system 104 of the gateway device 101 is configured to select one of the lighting system elements 105-110 to be the access point in accordance with connectivity information expressing capabilities of one or more of the lighting system elements to communicate with the gateway device 101. The connectivity information may express for example, strengths of signals received at the gateway device 101 from the lighting system elements, data transfer latencies from the lighting system elements to the gateway device 101, and/or data loss levels on signal paths from the lighting system elements to the gateway device 101. The received signals can be e.g. broadcast advertisements sent by the lighting system elements, and the strengths of the received signals can be expressed with received signal strength indicator "RSSI" values. In an exemplifying and non-limiting embodiment, the wireless transceiver 103 of the gateway device 101 is configured to receive signals, e.g. the broadcast advertisements, from the lighting system elements 105-110 and the control system 104 is configured to form the connectivity information based on the strengths of the received signals, the data transfer latencies, and/or the data loss levels. In an exemplifying and non-limiting embodiment, the gateway device 101 is configured to scan the broadcast advertisements from the lighting system elements other than the selected access point, and if the gateway device 101 notices that another one of the lighting system elements provides a more reliable and/or otherwise better connection, the access point is changed.

[0028] In an exemplifying and non-limiting embodiment, the control system 104 of the gateway device 101 is configured to set the connection information to express an order of priority of the lighting system elements 105-110 to act as the access point in accordance with at least one of the following: the strengths of the received signals, the data transfer latencies, and the data loss levels. A stronger received signal, a smaller data transfer latency, and a lower data loss level are indications for a better priority to act as the access point. If a lighting system element that acts as the access point gets disabled, a lighting system element that is next on the order of priority can be selected to be a new access point. Thus, the new access point can be activated without delays e. g. in a case where the current access point gets unexpectedly disabled.

[0029] In an exemplifying and non-limiting embodiment, the control system 104 of the gateway device 101 is configured to select the access point dynamically in accordance with target information expressing which one or ones of the lighting system elements 105-110 are to be contacted, e.g. controlled and/or monitored, via the gateway device 101 after establishing the wireless point-to-point connection. The access point is advantageously selected to be a lighting system element that is to be contacted or a lighting system element that is near to the lighting system element to be contacted. Thus, a low time-to-live "TTL" limit can be used in messaging within the wireless mesh-network and therefore data traffic load within the wireless mesh-network is limited.

[0030] In an exemplifying and non-limiting embodiment, the control system 104 of the gateway device 101 is configured to select the access point in accordance with reachability information that expresses, for each of the lighting system elements as a candidate access point, reachability of other ones of the lighting system elements via the candidate access point in terms of hop-counts in the wireless mesh-network constituted by the lighting system elements 105-110. In an exemplifying and non-limiting embodiment, the control system 104 of the gateway device 101 is configured to read, from messages received via the wireless point-to-point connection, metadata that expresses originators and hop-counts of the messages. The control system 104 is configured to form a part of the reachability information related to the currently used access point based on the metadata, and to store the formed part of the reachability information for a later use. Thus, the reachability information can be formed during operation of the lighting system when different ones of the lighting system elements are, each in turn, used as the access point. When the wireless point-

to-point connection is set up to a certain access point, conclusions can be drawn based on the above-mentioned metadata: from which lighting system elements the received data has originated, the amount of the received data, messages per second in the received data, how many different lighting system elements have provided the received data, and hop-counts of messages in the received data. These can be used to form the part of the reachability information related to the access point under consideration. A lighting system element that reaches more other lighting system elements even if the lighting system element has a lower received signal strength at the gateway device, i.e. a lower RSSI value, may be preferred in a selection of the access point over another lighting system element that has a higher received signal strength but reaches fewer other lighting system elements.

[0031] It is to be noted that the above-described selection principles are examples only, and the invention is not limited to the above-described exemplifying selection principles, but many different selection principles are applicable in conjunction with the invention. For example, the selection of the access point can be based on a combination of two or more of the above-described exemplifying selection principles.

[0032] In an exemplifying and non-limiting embodiment, the control system 104 of the gateway device 101 is configured to carry out an authorization process with the access point after establishing the wireless point-to-point connection. The authorization process enables reading data from one or more of the lighting system elements 105-110 via the gateway device 101 and/or writing data to one or more of the lighting system elements via the gateway device 101. The authorization process can be based on e.g. a procedure where a lighting system element sends a key number and the gateway device 101 responds with a check number that corresponds to the key number in a way known only by devices which have a permission to read data from the lighting system and/or a permission to write data to the lighting system.

[0033] Figure 2 illustrates an exemplifying lighting system that comprises gateway devices 201, 221, and 222 according to an exemplifying and non-limiting embodiment. The lighting system comprises lighting system elements each of which comprises a wireless communication unit and a controller. Furthermore, each lighting system element may comprise a light source, a motion sensor, and/or light sensor. The wireless communication units of the lighting system elements are configured to form a wireless mesh-network where the lighting system elements broadcast information. In figure 2, three of the lighting system elements are denoted with references 205, 206, and 207. Each of the gateway devices 201, 221, and 222 comprises a data interface for connecting communicatively to a data transfer network 211, a wireless transceiver for connecting communicatively to the lighting system elements, and a control system comprising means for controlling data traffic between the data interface and the wireless transceiver. The control system of each gateway device comprises means for selecting one of the lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and means for controlling the wireless transceiver of the gateway device to establish a wireless point-to-point connection to the selected access point. In the exemplifying situation shown in figure 2, the gateway device 201 has selected the lighting system element 205 to be the access point of the gateway device 201, the gateway device 221 has selected the lighting system element 206 to be the access point of the gateway device 221, and the gateway device 222 has selected the lighting system element 207 to be the access point of the gateway device 222.

[0034] In the exemplifying lighting system illustrated in figure 2, the three gateway devices 201, 221, and 222 can be used to reach all the lighting system elements so that the time-to-live "TTL" limit in messaging within the wireless mesh-network can be so low that traffic load in the wireless mesh-network remains in an acceptable level. In an exemplifying and non-limiting embodiment, each of the gateway devices 201, 221, and 222 is configured to select its access point in accordance with allocation information expressing which one or ones of the lighting system elements have been allocated to be connected to the data transfer network 211 via the gateway device under consideration. In the exemplifying situation shown in figure 2, the lighting system elements denoted with a reference 214 have been allocated for the gateway device 201, the lighting system elements denoted with a reference 215 have been allocated for the gateway device 221, and the lighting system elements denoted with a reference 216 have been allocated for the gateway device 222. In the exemplifying situation shown in figure 2, at most three hops are needed to reach each lighting system element from the closest one of the access points. Thus, the time-to-live "TTL" limit can be significantly smaller than in a case where there is only one gateway device. The above-mentioned approach improves the scalability of the lighting system.

[0035] The above-mentioned allocation information can be for example input data that is delivered to the gateway devices 201, 221, and 222 via the data transfer network 211. For another example, the gateway devices 201, 221, and 222 can be configured to negotiate among themselves which lighting system elements are allocated to each gateway device. The negotiations can be based on for example strengths of signals, e.g. broadcast advertisements, received at each gateway device from the lighting system elements, data transfer latencies from the lighting system elements to each gateway device, and/or data loss levels on signal paths from the lighting system elements to each gateway device. It is also possible that the gateway devices 201, 221, and 222 deliver information of the kind mentioned above to e.g. a cloud service running in the data transfer network 211. Thereafter, the cloud service forms the allocation information,

and the cloud service delivers the allocation information to the gateway devices via the data transfer network 211.

[0036] The control system 104 of the gateway device 101, as well as the control system of each of the gateway devices 201, 221, and 222, can be implemented with one or more data processors each of which can be a programmable data processor provided with an appropriate software, a dedicated hardware data processor such as for example an application specific integrated circuit "ASIC", and/or a configurable hardware data processor such as for example a field programmable gate array "FPGA". Furthermore, the control system 104 of the gateway device 101, as well as the control system of each of the gateway devices 201, 221, and 222, may comprise one or more memory devices such as e.g. a random-access memory "RAM" circuit.

[0037] Figure 3 shows a flowchart of a method according to an exemplifying and non-limiting embodiment for connecting lighting system elements to a data transfer network. The method comprises the following actions:

- action 301: controlling a data interface of a gateway device to connect communicatively to the data transfer network,
- action 302: selecting one of the lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and
- action 303: controlling a wireless transceiver of the gateway device to establish a wireless point-to-point connection to the access point.

[0038] A method according to an exemplifying and non-limiting embodiment comprises selecting one of the lighting system elements to be the access point in accordance with connectivity information expressing capabilities of one or more of the lighting system elements to communicate with the gateway device. In a method according to an exemplifying and non-limiting embodiment, the connectivity information is formed based on at least one of the following: strengths of signals received at the gateway device from the lighting system elements, data transfer latencies from the lighting system elements to the gateway device, and data loss levels on signal paths from the lighting system elements to the gateway device.

[0039] A method according to an exemplifying and non-limiting embodiment comprises setting the connection information to express an order of priority of the lighting system elements to act as the access point in accordance with at least one of the following: the above-mentioned strengths of the received signals, the above-mentioned data transfer latencies, and the above-mentioned data loss levels.

[0040] A method according to an exemplifying and non-limiting embodiment comprises selecting, dynamically in each messaging situation, one of the lighting system elements to be the access point in accordance with target information expressing which one or ones of the lighting system elements are to be contacted in the messaging situation under consideration via the gateway device after establishing the wireless point-to-point connection.

[0041] A method according to an exemplifying and non-limiting embodiment comprises selecting one of the lighting system elements to be the access point in accordance with allocation information expressing which one or ones of the lighting system elements have been allocated to be connected to the data transfer network via the gateway device.

[0042] A method according to an exemplifying and non-limiting embodiment comprises selecting one of the lighting system elements to be the access point in accordance with reachability information that expresses, for each of the lighting system elements as a candidate access point, reachability of other ones of the lighting system elements via the candidate access point in terms of hop-counts in a wireless mesh-network constituted by the lighting system elements. A method according to an exemplifying and non-limiting embodiment comprises reading metadata indicative of originators and hop-counts from messages received via the wireless point-to-point connection, forming a part of the reachability information related to the access point based on the metadata, and storing the formed part of the reachability information for a later use.

[0043] A method according to an exemplifying and non-limiting embodiment comprises receiving, at the gateway device, signals from the lighting system elements after establishing the wireless point-to-point connection, and replacing the wireless point-to-point connection with a new wireless point-to-point connection to another one of the lighting system elements in response to a situation in which the received signals indicate that the other one the lighting system elements fulfills criteria for selecting the access point better than the earlier selected one of the lighting system elements does.

[0044] A method according to an exemplifying and non-limiting embodiment comprises carrying out an authorization process with the access point after establishing the wireless point-to-point connection, wherein the authorization process enables reading data from one or more of the lighting system elements via the gateway device and/or writing data to one or more of the lighting system elements via the gateway device.

[0045] A data processor program according to an exemplifying and non-limiting embodiment comprises data processor executable instructions for controlling a programmable data processor to carry out actions related to a method according to any of the above-described exemplifying embodiments.

[0046] A data processor program according to an exemplifying and non-limiting embodiment comprises software modules for connecting lighting system elements to a data transfer network. The software modules com-

prise data processor executable instructions for controlling a programmable data processor of a gateway device to:

- control a data interface of the gateway device to connect communicatively to the data transfer network,
- select one of the lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and
- control a wireless transceiver of the gateway device to establish a wireless point-to-point connection to the access point.

[0047] The above-mentioned software modules can be e.g. subroutines or functions implemented with a programming language suitable for the programmable data processor.

[0048] A data processor program product according to an exemplifying and non-limiting embodiment comprises a data processor readable medium encoded with a data processor program according to an embodiment of invention.

[0049] A signal according to an exemplifying and non-limiting embodiment is encoded to carry information defining a data processor program according to an embodiment of invention.

[0050] The specific examples provided in the description given above should not be construed as limiting the scope and/or the applicability of the appended claims. Lists and groups of examples provided in the description given above are not exhaustive unless otherwise explicitly stated.

Claims

1. A gateway device (101, 201, 221, 222) comprising:

- a data interface (102) for connecting communicatively to a data transfer network,
- a wireless transceiver (103) for connecting communicatively to lighting system elements, and
- a control system (104) for controlling data traffic between the data interface and the wireless transceiver,

wherein the control system is configured to select one of the lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and to control the wireless transceiver to establish a wireless point-to-point connection to the access point.

2. A gateway device according to claim 1, wherein the control system is configured to select the one of the lighting system elements in accordance with connectivity information expressing capabilities of one or more of the lighting system elements to communicate with the gateway device.

3. A gateway device according to claim 2, wherein the wireless transceiver is configured to receive signals from the lighting system elements and the control system is configured to form the connectivity information based on at least one of the following: strengths of the signals received from the lighting system elements, data transfer latencies from the lighting system elements to the gateway device, and data loss levels on signal paths from the lighting system elements to the gateway device.

4. A device according to claim 3, wherein the control system is configured to set the connection information to express an order of priority of the lighting system elements to act as the access point in accordance with at least one of the following: the strengths of the received signals, the data transfer latencies, and the data loss levels.

5. A gateway device according to any one of claims 1-4, wherein the control system is configured to select the one of the lighting system elements in accordance with target information expressing which one or ones of the lighting system elements are to be contacted via the gateway device after establishing the wireless point-to-point connection.

6. A gateway device according to any one of claims 1-5, wherein the control system is configured to select the one of the lighting system elements in accordance with allocation information expressing which one or ones of the lighting system elements have been allocated to be connected to the data transfer network via the gateway device.

7. A gateway device according to any one of claims 1-6, wherein the control system is configured to select the one of the lighting system elements in accordance with reachability information expressing, for each of the lighting system elements as a candidate access point, reachability of other ones of the lighting system elements via the candidate access point in terms of hop-counts in a wireless mesh-network constituted by the lighting system elements.

8. A gateway device according to claim 7, wherein the control system is configured read metadata indicative of originators and hop-counts from messages received via the wireless point-to-point connection, to form a part of the reachability information related to the access point based on the metadata, and to

store the formed part of the reachability information for a later use.

9. A gateway device according to any one of claims 1-8, wherein the wireless transceiver is configured to receive signals from the lighting system elements after establishing the wireless point-to-point connection, and the control system is configured to replace the wireless point-to-point connection with a new wireless point-to-point connection to another one of the lighting system elements in response to a situation in which the received signals indicate that the other one the lighting system elements fulfills criteria for selecting the access point better than the earlier selected one of the lighting system elements does.

10. A gateway device according to any one of claims 1-9, wherein the control system is configured to carry out an authorization process with the access point after establishing the wireless point-to-point connection, the authorization process enabling at least one of the following: reading data from one or more of the lighting system elements via the gateway device, writing data to one or more of the lighting system elements via the gateway device.

11. A lighting system comprising:

- lighting system elements (105-110, 205-207) configured to constitute a wireless mesh-network with each other, and
- at least one gateway device (101, 201, 221, 222) according to any one of claims 1-10 for connecting the lighting system elements to a data transfer network external to the wireless mesh-network.

12. A lighting system according to claim 11, wherein the gateway device is configured to establish the wireless point-to-point connection in accordance with one of the following data transfer protocols: Bluetooth®, Zigbee, WiFi ,and wherein the lighting system elements are configured to constitute the wireless mesh-network in accordance with one of the following protocols: Bluetooth Low Energy, Zigbee, Thread.

13. A method comprising:

- controlling (301) a data interface of a gateway device to connect communicatively to a data transfer network,
- selecting (302) one of lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and
- controlling (303) a wireless transceiver of the gateway device to establish a wireless point-to-point connection to the access point.

14. A data processor program comprising instructions for controlling a programmable data processor of a gateway device to:

- control a data interface of the gateway device to connect communicatively to a data transfer network,
- select one of lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device, and
- control a wireless transceiver of the gateway device to establish a wireless point-to-point connection to the access point.

15. A data processor program product comprising a non-transitory processor readable medium encoded with a data processor program according to claim 14.

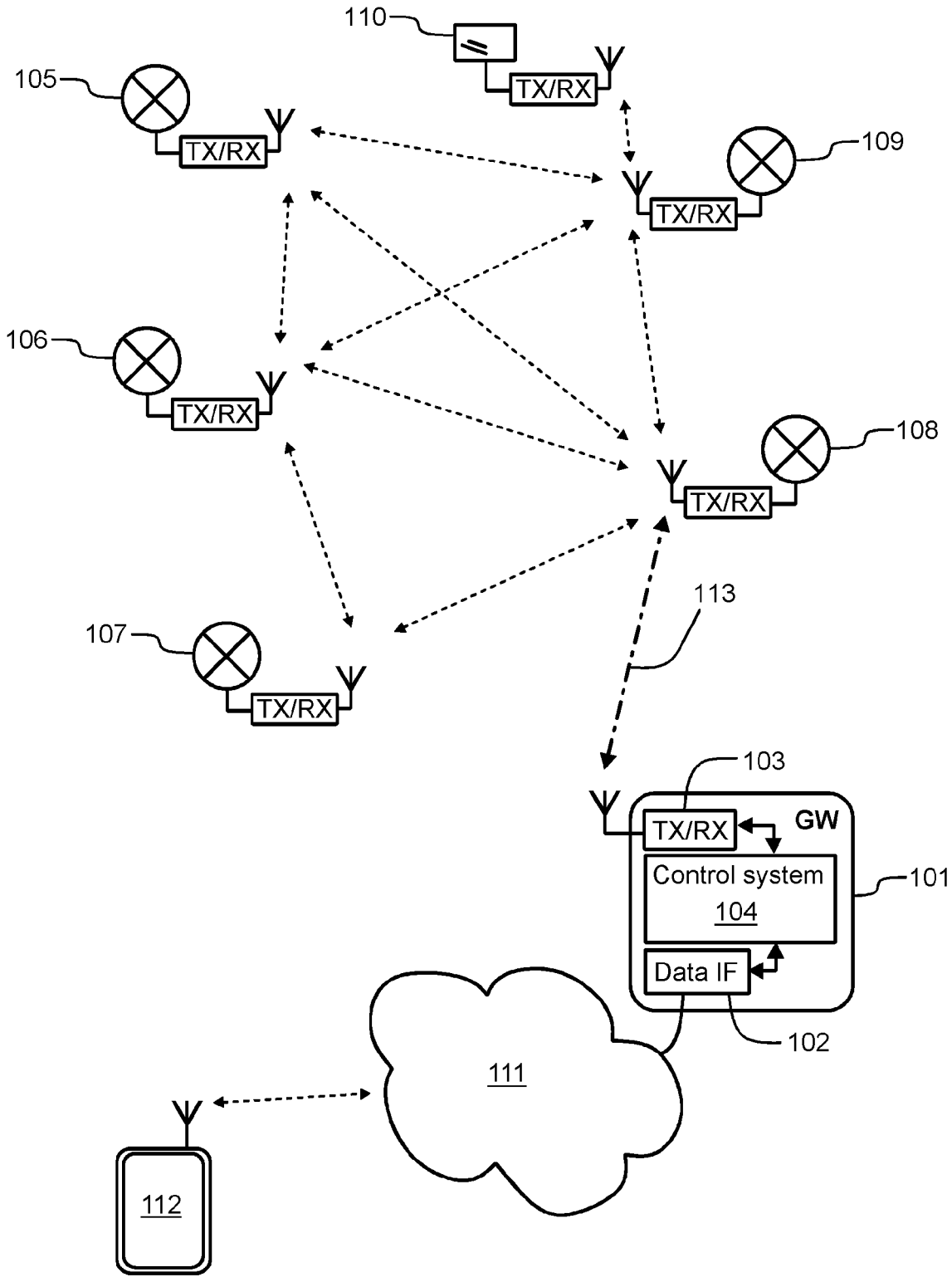
110
TX/RX
105
TX/RX
109
TX/RX
106
TX/RX
108
TX/RX
113
107
TX/RX
103
TX/RX
GW
Control system
104
101
Data IF
102
111
112

Figure 1

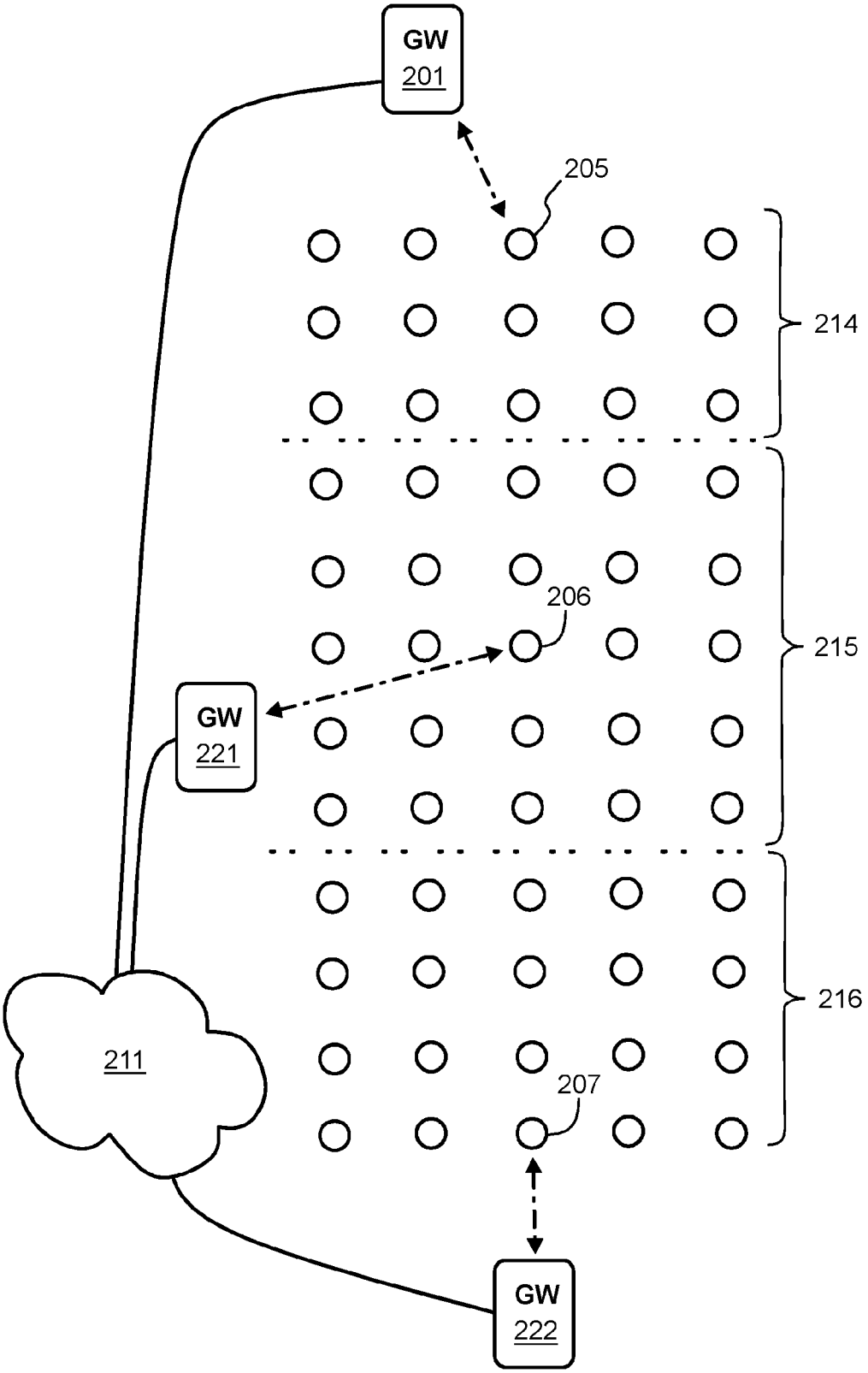

Figure 2

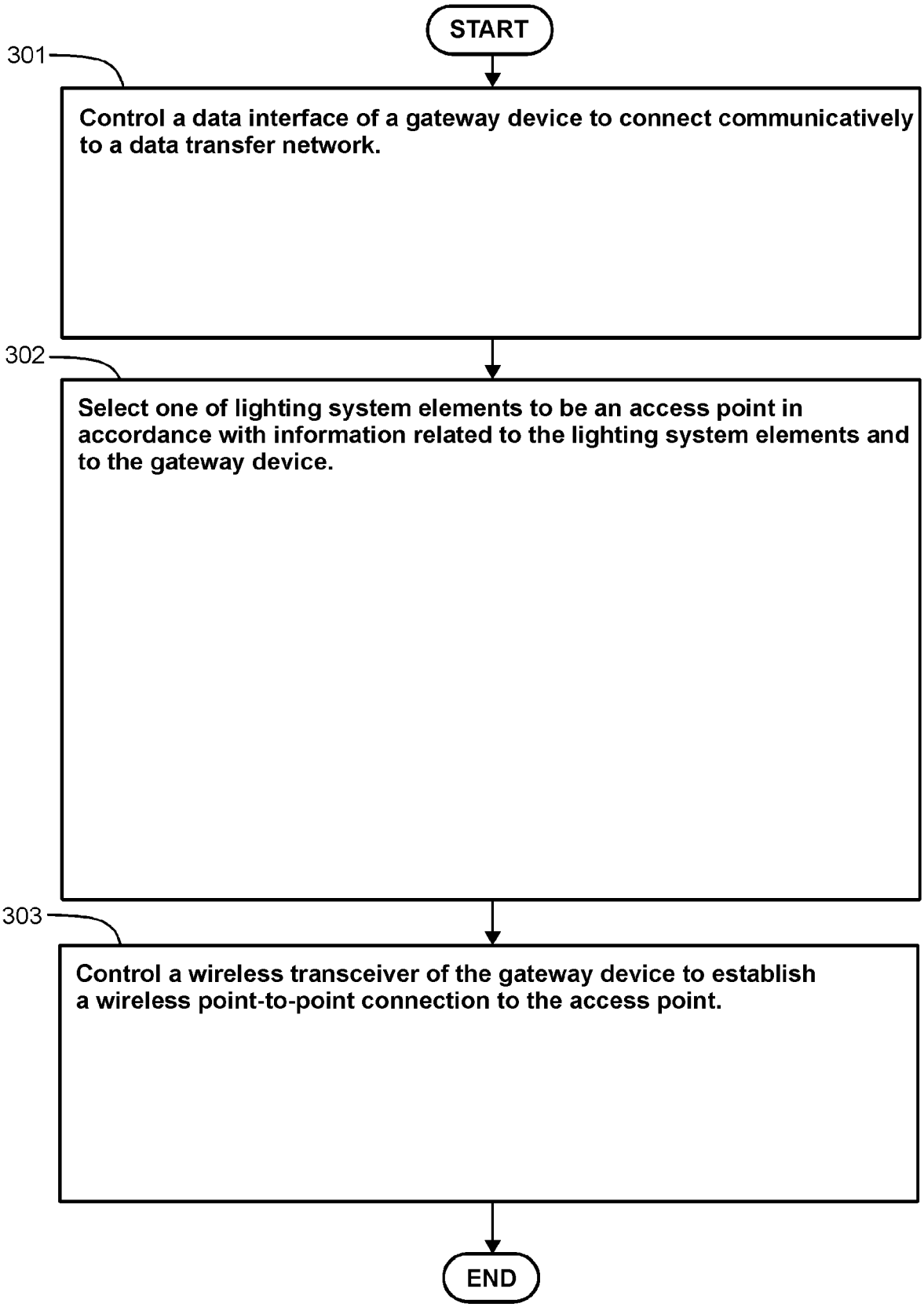
START
301
Control a data interface of a gateway device to connect communicatively to a data transfer network.
302
Select one of lighting system elements to be an access point in accordance with information related to the lighting system elements and to the gateway device.
303
Control a wireless transceiver of the gateway device to establish a wireless point-to-point connection to the access point.
END

Figure 3

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EUROPEAN SEARCH REPORT

Application Number
EP 19 21 6034

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 April 2020	Morrish, Ian

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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21-04-2020

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