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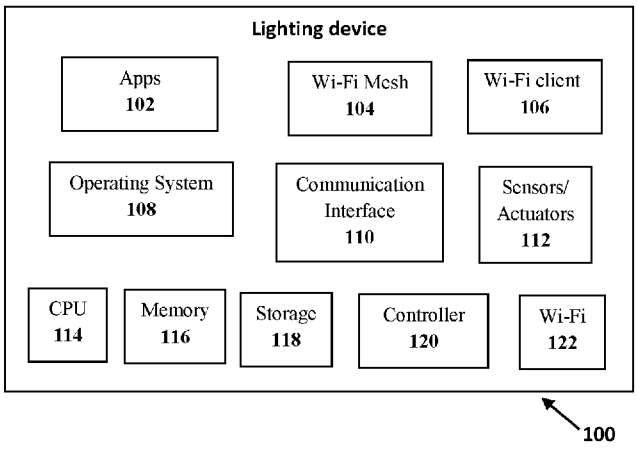

FIG. 1

(57) Abstract: The present invention provides a system for extending Wi-Fi coverage in a facility. Whenever a lighting device in the facility is unable to connect to the Wi-Fi network, it sends a message to the peer lighting device. If the peer lighting device has the Wi-Fi connectivity, then it starts working as a mesh point for providing mesh backhaul services and the lighting device that did not have Wi-Fi connectivity starts working as mesh point to provide traditional access point services such as connectivity to the clients in the facility so that the lighting device that was not able to connect to Wi-Fi network can connect.

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EXTENDING WI-FI COVERAGE ON DEMAND USING LED LAMPS

CROSS-REFERENCE TO RELATED APPLICATION

[001] This application claims benefit of and priority to U.S. Provisional Patent Application No. 62/524,356, filed June 23, 2017, entitled "Extending Wi-Fi Coverage on Demand Using LED Lamps", the disclosure of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[002] The present invention relates to a system and a method for utilizing a lighting system to extend Wi-Fi coverage in a facility, and more particularly, to a system and method of creating a mesh network of plurality of lighting systems to extend Wi-Fi coverage on demand in the facility.

BACKGROUND

[003] With the technological evolution, Wi-Fi has become a widespread technology used commonly in various installations to act as a wireless networking protocol that allows devices to communicate without internet cords. It encompasses the technologies of Wireless Local Area Networks (WLAN) and is based on the IEEE 802.11 specifications. A Wi-Fi device can connect to the internet when it is near an Access Point (AP). The wide adoption and popularity of Wi-Fi networks also created one of its biggest performance challenges like inter and intra-cell interference. It is susceptible to interference, obstacles and noise in the environment. The Wi-Fi standard does not have any central scheduler, which also means that there are no guarantees on throughput or latency for any client. The performance problem related to coverage area is one of the challenging issue in a facility, specifically, when the area of the facility is large and there are multiple number of devices accessing the Wi-Fi access point.

[004] Nowadays, the lighting systems comes equipped with the wireless technology that has been embedded on a single platform to make the lighting systems more intelligent and controllable. It provides a solution to controlling and programming lighting systems in the facility, such that the color and brightness of any individual light or a group of lights can be manually or automatically controlled using a wireless or Wi-Fi interface. It enables the lighting systems to be turned ON, OFF, or dimmed without the use of a wall switch.

[005] However, in large facilities with multiple devices accessing the Wi-Fi network, the signal strength remains a challenging issue. The present invention provides a solution to the aforementioned problem by providing a system and a method that extends the Wi-Fi coverage on demand by using lighting systems installed in the facility.

SUMMARY OF THE INVENTION

[006] The present invention provides a system and a method for extending Wi-Fi coverage in a facility so that all the lighting device in the facility can connect to the Wi-Fi network despite the WIFI coverage deficiencies in the facility.

[007] The lighting devices have a Wi-Fi client application running inside them that tries to connect to the Wi-Fi network in the facility. If the lighting device is not able to connect then it sends a message to the peer lighting device via Bluetooth. If the peer lighting device has Wi-Fi connectivity, then it starts working as a mesh point to provide traditional access point services so that the lighting device that was not able to connect to Wi-Fi network can connect. Additionally, if the peer lighting device does not have Wi-Fi connectivity, then it starts working as a mesh node for supporting the backhaul and requests it's another peer for support. In certain instances, the peer lighting device does not become mesh point automatically. Instead it communicates this

information to a Wi-Fi Coverage Application which then looks at coverage data in the facility holistically and makes decision as to which LED Lamps should become a Mesh points or not.

[008] In a first aspect of present invention, a lighting device that extends Wi-Fi coverage to an unconnected device in a facility is provided. The lighting device comprising: a lighting device embedded computing resources comprising a processor, a memory and a storage; a lighting device embedded Wi-Fi radio to connect the lighting device to a Wi-Fi access point; a lighting device embedded mesh application to receive a message from one or more peer lighting device disconnected from the Wi-Fi access point, said lighting device embedded mesh application provides traditional access service to one of the disconnected lighting device and instructs to act as access point for other disconnected devices. The lighting device embedded mesh application receives message using a Bluetooth protocol, or a Zigbee network, or a Radio Frequency Identification network, or a Near Field communication or an Infrared communication.

[009] In a second aspect of present invention, a system for extending Wi-Fi coverage to one or more unconnected lighting device in a facility. The system comprising: a plurality of lighting devices arranged in a mesh network in a facility; a Wi-Fi access point in the facility to provide Wi-Fi access to each of the plurality of lighting devices; a lighting device embedded mesh application that receives a message from one or more disconnected lighting devices, said lighting device embedded mesh application provides traditional access service to one of the disconnected lighting device and instructs to act as access point for other disconnected devices..The lighting device embedded mesh application receives the message using a Bluetooth protocol, or a Zigbee network, or a Radio Frequency Identification network, or a Near Field communication or an Infrared network. The system further comprising an external application in communication with the plurality of lighting device and receives a message from the lighting device embedded mesh

application about the connectivity status of the one or more unconnected lighting device. The external application can either reside in a network server or in the facility. The external application determines a lighting device that will provide traditional access service to the one or more unconnected lighting device. The external application can communicates the role to the determined lighting device over Wi-Fi or indirectly to the determined lighting device by communicating to a peer lighting device that in turn communicates to the determined lighting device using Bluetooth. The lighting device embedded mesh application has an ability to act as a Mesh node to provide backhaul. The lighting device embedded mesh application acts as a mesh access point to provide traditional Wi-Fi access point service.

[0010] In a third aspect of present invention, a method for extending Wi-Fi coverage to one or more unconnected devices in a facility is provided. The method comprising: monitoring the Wi-Fi performance metric by a lighting device embedded mesh application; sending a message by the lighting device embedded mesh application of one or more unconnected lighting device to a peer lighting device and requesting the access to Wi-Fi signals; analyzing the message by the lighting device embedded mesh application of the peer lighting device; providing traditional access service to one of the unconnected lighting device and instructing that device to provide access point service to other unconnected lighting device. The message is sent using a Bluetooth protocol, Zigbee network topology, or a Radio frequency Identification network, or a near field communication or Infrared communication. The method further comprising: notifying an external application by the peer lighting device regarding the Wi-Fi performance metrics of unconnected lighting device. The external application determines a lighting device that will act as a mesh point for the unconnected lighting device and communicates the role to the determined lighting device. The role is either communicated directly over Wi-Fi or indirectly by

communicating the role to a peer lighting device that in turn communicates to the determined lighting device using Bluetooth.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The foregoing summary, as well as the following detailed description of the invention, will be better understood when read in conjunction with the appended drawings. It should be understood, however, that the invention is not limited to the precise arrangements and instrumentalities shown. In the drawings:

[0012] FIG.1 shows a schematic illustration of a lighting device in accordance with an embodiment of present invention.

[0013] FIG. 2 shows a mesh network of plurality of lighting devices connected to a Wi-Fi access point in a facility, in accordance with an embodiment of present invention.

[0014] FIG. 3 is a schematic representation illustrating a lighting device that acts as a mesh point for providing traditional access point service to clients and a peer lighting system acts as mesh point for mesh backhaul.

[0015] FIG. 4 shows a remote application determining a mesh-point to extend Wi-Fi coverage to an unconnected lighting device, in accordance with another embodiment of present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] In the following detailed description of embodiments of the invention, numerous specific details are set forth in order to provide a thorough understanding of the embodiment of invention. However, it will be obvious to a person skilled in art that the embodiments of invention may be practiced with or without these specific details. In other instances well known methods, procedures and components have not been described in details, so as not to unnecessarily obscure aspects of the embodiments of the invention.

[0017] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well as the singular forms, unless the context clearly indicates otherwise.

[0018] It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof.

[0019] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one having ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0020] In describing the invention, it will be understood that a number of techniques and steps are disclosed. Each of these has individual benefit and each can also be used in conjunction with one or more, or in some cases all, of the other disclosed techniques. Accordingly, for the sake of clarity, this description will refrain from repeating every possible combination of the individual steps in an unnecessary fashion. Nevertheless, the specification and claims should be read with the understanding that such combinations are entirely within the scope of the invention and the claims.

[0021] The present disclosure is to be considered as an exemplification of the invention, and is not intended to limit the invention to the specific embodiments illustrated by the figures or description below. For example, in certain places, LED lighting device is used as specific examples to illustrate the working of invention, however, the present invention envisage any conventional lighting device as a mode to perform the invention. In certain instances, Bluetooth is shown as a preferable communication protocol between the lighting devices, however, other wireless or wired communication protocols could be employed without departing from the scope of the invention. The present invention makes use of following terminologies: Wi-Fi Radio is a Radio that is used for Wi-Fi communications. A MESH Point is a Wi-Fi Access Point that can provide traditional access point services such as Wi-Fi client connectivity or provide mesh backhaul/network connectivity or both. The term Wi-Fi Coverage is used to imply the geographic area within which the Wi-Fi clients can communicate with the access point for desired application such as data, voice, video etc.

[0022] Furthermore, it will be clear that the invention is not limited to these embodiments only. Numerous modifications, changes, variations, substitutions and equivalents will be apparent to those skilled in the art, without parting from the spirit and scope of the invention.

[0023] The present invention is directed generally to devices and applications related to extend Wi-Fi coverage on demand for other devices in the facility. More particularly, the invention dynamically adjusts the Wi-Fi coverage issues based on state of coverage of the network so that Wi-Fi Coverage can be provided to every spot in the facility. The present invention provides an integrated platform by utilizing a Wi-Fi Radio, a Bluetooth radio and computing resources inside the lighting device for the purpose of extending Wi-Fi coverage on demand for other devices in the facility. The preferred process configuration and operating conditions are described in the

following without limiting the present invention to the specific examples used to illustrate the process design.

[0024] The present invention relates to the integration of Wi-Fi radio, communication interface and computing platform inside the lighting device so that Wi-Fi coverage can be extended to all the devices present in the facility. The disclosed embodiment extends the Wi-Fi coverage on demand for other devices present in the facility so that Wi-Fi Coverage can be provided to every spot in the facility. The lighting devices in the facility have a Wi-Fi client application running inside them that tries to connect to the Wi-Fi network in the facility. In this arrangement, whenever a lighting device in the facility is not able to connect to the Wi-Fi network, it sends a message to the peer lighting device via communication interface. If the peer lighting device has the Wi-Fi connectivity, then it starts working as a mesh point for providing mesh backhaul services and the lighting device that was unable to connect to Wi-Fi connectivity starts working as mesh point to provide traditional access point services such as connectivity to the clients in the facility so that other device in the facility that were unable to connect to Wi-Fi network can connect. In another arrangement, the peer lighting device does not become mesh point automatically, rather the peer lighting device communicates this information to Wi-Fi Coverage Application which then looks at coverage data in the facility holistically and makes decision as to which lighting device should become a Mesh points for backhaul and which device should act as a mesh point for providing traditional access service.

[0025] In an embodiment of present invention, the Wi-Fi coverage in the facility is extended to be utilized by the installed lighting devices as well as other client devices, such as smartphone, laptops and other devices.

[0026] The lighting devices installed in the facility are provided with radio means to communicates with each other through a communication protocol, where the communication can be wired or wireless. The wireless communication between the lighting devices can be through Bluetooth, MIDI, Zigbee protocol, or a Radio Frequency Identification Network.

[0027] Due to the dynamic changes associated with coverage area of Wi-Fi access point, one or more lighting device may get disconnected from the access point and thus left uncontrolled. In this scenario, the present invention provides a method and system where the unconnected lighting device communicates with the connected lighting device that there is a break in connection with Wi-Fi access point. The connected lighting device will then communicate the issue either with a access control application present in a server to provide a temporary mesh point to the unconnected lighting device or it itself forms a mesh point of its own and act as access point to the unconnected lighting device.

[0028] In an embodiment of present invention, the lighting device may comprise but are not limited to LED bulbs, LED lamps, LED tubes, compact Fluorescent lamps, Fluorescent tubes, Neon lamps, troffers etc.

[0029] FIG. 1 shows a schematic illustration of a lighting device in accordance with an embodiment of present invention. The lighting device 100 is an intelligent device having features that enables monitoring, controlling and regulation of the lighting device. The lighting device along with a lighting source comprises an operating system 108, a CPU 114 for processing the instructions, a memory 116 and storage 118 to store the data, one or more sensors/actuators 112 to monitor the parameters associated with intelligent lighting system, a controller 120 that acts under the instructions of sensors and CPU, a Wi-Fi radio 122 that enable the lighting system to connect to a Wi-Fi access point, a communication interface 110 that helps in communicating

with peer lighting device, one or more App 102 to regulate the lighting device, and a Wi-Fi mesh module 104 and Wi-Fi client module 106 for extending the Wi-Fi coverage to peer devices.

[0030] The sensors or actuators 112 monitors the ambient parameters which can then be used to control the illumination of lighting device. The sensors or actuators 112 may include but are not limited to occupancy sensors, photocells, ambient light sensors, light control switches, or fire alarm sensors or HVAC sensors. One lighting device establish communication with other lighting device through a communication interface 100. The communication interface 100 may include but are not limited to Bluetooth, Zigbee, NFC, Infrared, Radio frequency network Identification. The lighting device gets connected to internet through a Wi-Fi access point and is in communication with remote device. The instructions received by the lighting device is executed by the controller 120.

[0031] The Wi-Fi client application 106 enables the lighting device 100 to connect to the Wi-Fi (wireless) network. The Wi-Fi Mesh 104 provides the lighting device with an ability to work as a Mesh Point for mesh backhaul and Mesh Point for providing traditional access point services so that the lighting device that was not able to connect to Wi-Fi network can connect to the internet in the Facility. Wi-Fi Mesh 104 can exchange messages with the peer lighting device over communication interface 100 (Bluetooth, or other communication, such as Infrared or NFC) to communicate lack of Wi-Fi coverage and to take a new role (either working as a Mesh Point for mesh backhaul or Mesh Point for providing traditional access point services) in the mesh. Wi-Fi Mesh 104 notifies the Wi-Fi coverage application about lack of Wi-Fi coverage experienced by a peer lighting system in the Facility. The one or more Apps 102 in the lighting device may perform various functions such as but not limited to, control the intensity and color of light, control the input that the lighting device receives, control operating voltage or current or

temperature, turn on-off etc. The Operating System 108 can be a program that manages the various resources of the LED lamp 100. Typically the resources include the Central processing Unit (CPU) 114 that handles all instructions it receives from hardware and software running in the lighting device 100. The Storage 118 is a computer readable medium that may include but is not limited to magnetic storage devices (e.g., hard disk, floppy disk, magnetic strips), optical disks (e.g., compact disk (CD), digital versatile disk (DVD)), smart cards, and flash memory devices (e.g., card, stick, key drive); wherein the computer readable medium having executable instructions for performing the acts and/or events of the various methods of the claimed subject matter.

[0032] FIG. 2 shows a mesh network of plurality of lighting devices connected to a Wi-Fi access point in a facility, in accordance with an embodiment of present invention. The facility 200 in FIG. 2 is a location where plurality of lighting devices are arranged in order to provide desired lighting. The facility can be a residential, commercial, official, medical, education, industrial or government owned or any other kind of property. There are plurality of lighting device installed in the facility 200. The facility has a Wi-Fi access point 202 which provide connectivity to the lighting devices with the internet. A Wi-Fi coverage application is monitoring the coverage of Wi-Fi signal in the facility and is continuously monitoring the connectivity of the lighting devices with the Wi-Fi access point. The Wi-Fi coverage application can either be situated in a cloud server or it can reside in a computational device present in the facility. In the facility, there may be a situation where few of the lighting devices are in close proximity with the Wi-Fi access point while few are at far points. With the unreliability associated with Wi-Fi signals it is probable that one or more than lighting device are unable to connect to Wi-Fi access point at a certain time. For example, in FIG.2, Lamp B, Lamp H, Lamp A, Lamp D and Lamp I are at a

considerable distance from Wi-Fi access point and therefore, can get disconnected from the Wi-Fi access point at a certain time. As shown in Figure, Lamp B is acting as a mesh point to provide traditional access point service to Lamps A, D, I and H, whereas lamp F is acting as a mesh point to provide backhaul service to Lamp B.

[0033] FIG. 3 is a schematic representation illustrating a lighting device that acts as a mesh point for providing traditional access point service to clients and a peer lighting system acts as mesh point for mesh backhaul. The representation illustrates that a lighting device automatically becomes a mesh point for providing traditional access point services such as connectivity to clients and its peer starts acting as mesh point for mesh backhaul in the facility. The facility may include, but is not limited to, a residential, a commercial, an office, a medical institutions, educational institutions, industrial or government owned or any other kind of property. A Wi-Fi Access Point (AP) 202 is a networking device that allows wireless Wi-Fi devices to connect to a wired network. The Wi-Fi Access Point 202 creates a wireless local area network, or WLAN. The Wi-Fi Access Point 124 connects to a wired router, switch, or hub via an Ethernet cable, and projects a Wi-Fi signal to a designated area. A Wi-Fi Coverage Application 204 is a network analyzer that makes use of the holistic view of all the lighting devices and coverage information in the facility 200. The Wi-Fi Coverage Application 204 may receive messages from the plurality of lighting devices in the Facility 200 about the status of Wi-Fi Coverage in the facility. Based on the messages received from the lighting devices in the Facility 1, it analyses the coverage gaps and determines which lighting device should act as MESH Point for mesh backhaul and which lighting device in the Facility 200 should act as MESH Point for providing traditional access point services so that other devices (lighting devices and other client devices) can connect to the internet. The Wi-Fi Coverage Application 204 may directly communicate with

the lighting devices that have Wi-Fi Connectivity to initiate them to start working as MESH Point for mesh backhaul or as MESH Point for providing traditional access point services. The Wi-Fi coverage application 204 communicates indirectly to those lighting devices that do not have Wi-Fi connectivity, by communicating it to their peer lighting devices, which in turn then communicate to unconnected lighting devices.

[0034] In this embodiment of the present invention, there are two Lamps labeled as Lamp A 302 and Lamp B 304 arranged in the mesh network in the Facility 1. A Wi-Fi Access Point 202 is the networking device that allows wireless Wi-Fi devices to connect to internet. In step 1; the Wi-Fi client application of the Lamps A and B tries to connect with the Wi-Fi Access Point 204 on the Wi-Fi radio in the Facility 1. In the example, at Step 2; Lamp B being unable to connect to the Wi-Fi network informs the Wi-Fi Mesh application of the Lamp B. In step 3; the Wi-Fi Mesh application makes use of Bluetooth radio to exchange Bluetooth messages to peer Lamp A to communicate that it does not have Wi-Fi Connectivity. In Step 4; the Wi-Fi Mesh application of the peer Lamp (Lamp A) automatically starts working as a Mesh Point to provide mesh backhaul services. In Step 5; the Wi-Fi mesh application of peer lamp A communicates the Wi-Fi Mesh application of Lamp B to start acting as Mesh Point to provide traditional access point services so that the Wi-Fi devices in and around the Lamp B can connect. In Step 6; the Lamp B starts working as a Mesh Point for providing traditional access point services so that Wi-Fi Coverage can be provided to every spot in the Facility 1. The devices around the Lamp B in the facility, such as Lamp D, Lamp I, smartphones, and Lamp H can access the Wi-Fi connectivity using Lamp B as traditional access point.

[0035] FIG. 4 shows a remote application determining a mesh-point to extend Wi-Fi coverage to an unconnected lighting device, in accordance with another embodiment of present invention.

FIG. 4 illustrates another embodiment of the invention, wherein all the lighting device in the facility, try to connect to the Wi-Fi Network via the Wi-Fi Access Point 202 and there is an external Wi-Fi Coverage Application 204. The external Wi-Fi Coverage Application 204 can be in the same facility or in cloud. In Step 1; The Wi-Fi Client application in Lamp A 302 and Lamp B 304 tries to connect with the Wi-Fi Access Point 202. In step 2; if the Wi-Fi Client application is not able to connect with the Wi-Fi Access Point, then the information is communicated to Wi-Fi Mesh application present in the same Lamp. In the Figure, Lamp B is unable to connect to Wi-Fi Network. In Step 3; the Wi-Fi Mesh application makes use of Bluetooth radio to exchange messages to peer Lamp A to communicate that it does not have Wi-Fi connectivity. In Step 4; the Wi-Fi Mesh application in the peer Lamp A in the case, now communicates this information to the Wi-Fi Coverage Application. The Wi-Fi Coverage Application makes use of the holistic view of all Lamps and coverage information communicated to it to determine which Lamp should work as MESH Point for mesh backhaul and which Lamp in the facility should act as MESH Point for providing traditional access point services so that other Lamps and devices can connect. In step 5; The Wi-Fi Coverage Application may directly communicate with the Lamps that have Wi-Fi Connectivity to initiate them to start working as MESH Point for mesh backhaul or as MESH Point for providing traditional access point services based on the decision taken by it. For issuing a request to those Lamps that do not have Wi-Fi connectivity, it communicates to them indirectly, i.e. the Wi-Fi coverage application issue request to the peer Lamps, which in turn then communicate the request to lamp through Bluetooth. The Wi-Fi Coverage Application may receive messages from the plurality of Lamps in the Facility about state of Wi-Fi Coverage in the Facility. Based on the messages received from the Lamp(s) in the Facility, it analyses the coverage gaps and decides

which LED to be configured as Mesh Point for mesh backhaul and which LED Lamp to be configured as Mesh point for providing traditional access point services. It decides and communicates the role to the LED Lamp(s) in the mesh in the Facility 1. In step 6; after receiving instructions from Wi-Fi coverage application, the Lamp B will start acting as a Mesh point for providing traditional access service to the devices and other lamps. In FIG.4, Lamp B starts acting as a traditional access point to Lamp D, Lamp I, Lamp H and smartphone.

[0036] While the above detailed description has shown, described, and pointed out novel features as applied to various embodiments, it can be understood that various omissions, substitutions, and changes in the form and details of the devices or algorithms illustrated can be made without departing from the spirit of the disclosure. As can be recognized, certain embodiments described herein can be embodied within a form that does not provide all of the features and benefits set forth herein, as some features can be used or practiced separately from others.

We Claim:

1. A lighting device comprising:
   a) a lighting device embedded computing resources comprising a processor, a memory and a storage;
   b) a lighting device embedded Wi-Fi radio to connect the lighting device to a Wi-Fi access point;
   c) a lighting device embedded mesh application to receive a message from one or more peer lighting device disconnected from the Wi-Fi access point, said lighting device embedded mesh application provides traditional access service to one of the disconnected lighting device and instructs to act as access point for other disconnected devices.
2. The lighting device of claim 1, wherein the lighting device embedded mesh application receives message using a Bluetooth protocol, or a Zigbee network, or a Radio Frequency Identification network, or a Near Field communication or an Infrared communication.
3. A system for extending Wi-Fi coverage to one or more unconnected lighting device in a facility, said system comprising:
   a) a plurality of lighting devices arranged in a mesh network in a facility;
   b) a Wi-Fi access point in the facility to provide Wi-Fi access to each of the plurality of lighting devices;
   c) a lighting device embedded mesh application that receives a message from one or more disconnected lighting devices, said lighting device embedded mesh application provides traditional access service to one of the disconnected lighting device and instructs to act as access point for other disconnected devices..

4. The system of claim 3, wherein the lighting device embedded mesh application receives the message using a Bluetooth protocol, or a Zigbee network, or a Radio Frequency Identification network, or a Near Field communication or an Infrared network.
5. The system of claim 3 further comprising an external application in communication with the plurality of lighting device and receives a message from the lighting device embedded mesh application about the connectivity status of the one or more unconnected lighting device.
6. The system of claim 5, wherein the external application can either reside in a network server or in the facility.
7. The system of claim 5, wherein the external application determines a lighting device that will provide traditional access service to the one or more unconnected lighting device.
8. The system of claim 7, wherein the external application communicates the role to the determined lighting device over Wi-Fi.
9. The system of claim 7, wherein the external application communicates the role indirectly to the determined lighting device by communicating to a peer lighting device that in turn communicates to the determined lighting device using Bluetooth.
10. The system of claim 3, wherein the lighting device embedded mesh application has an ability to act as a Mesh node to provide backhaul.
11. The system of claim 3, wherein the lighting device embedded mesh application acts as a mesh access point to provide traditional Wi-Fi access point service.
12. A method for extending Wi-Fi coverage to one or more unconnected devices in a facility, said method comprising:

a) monitoring the Wi-Fi performance metric by a lighting device embedded mesh application;

b) sending a message by the lighting device embedded mesh application of one or more unconnected lighting device to a peer lighting device and requesting the access to Wi-Fi signals;

c) analyzing the message by the lighting device embedded mesh application of the peer lighting device;

d) providing traditional access service to one of the unconnected lighting device and instructing that device to provide access point service to other unconnected lighting device.

13. The method of claim 12, wherein the message is sent using a Bluetooth protocol, Zigbee network topology, or a Radio frequency Identification network, or a near field communication or Infrared communication.

14. The method of claim 12 further comprising: notifying an external application by the peer lighting device regarding the Wi-Fi performance metrics of unconnected lighting device.

15. The method of claim 14, wherein the external application determines a lighting device that will act as a mesh point for the unconnected lighting device and communicates the role to the determined lighting device.

16. The method of claim 15, wherein the role is either communicated directly over Wi-Fi or indirectly by communicating the role to a peer lighting device that in turn communicates to the determined lighting device using Bluetooth.

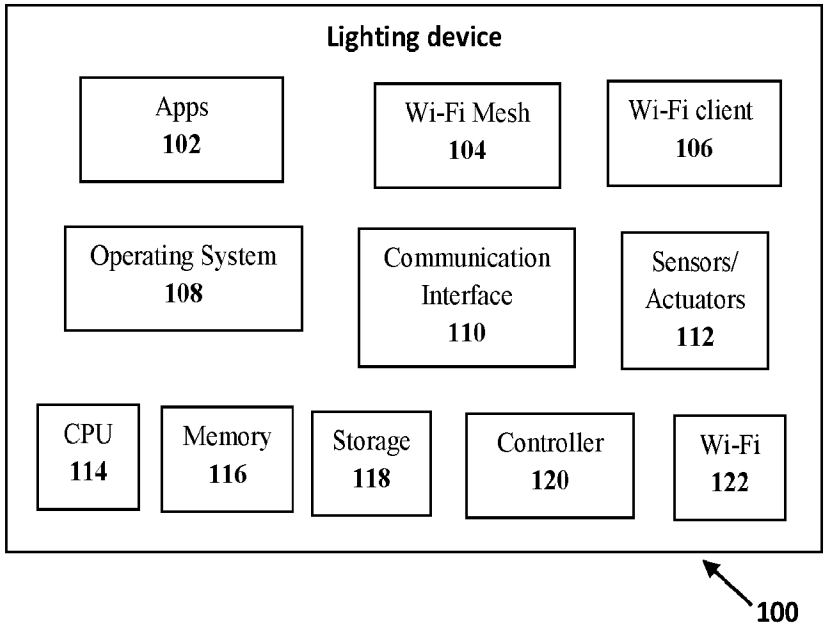
Lighting device
Apps
102
Wi-Fi Mesh
104
Wi-Fi client
106
Operating System
108
Communication Interface
110
Sensors/ Actuators
112
CPU
114
Memory
116
Storage
118
Controller
120
Wi-Fi
122
100

FIG. 1

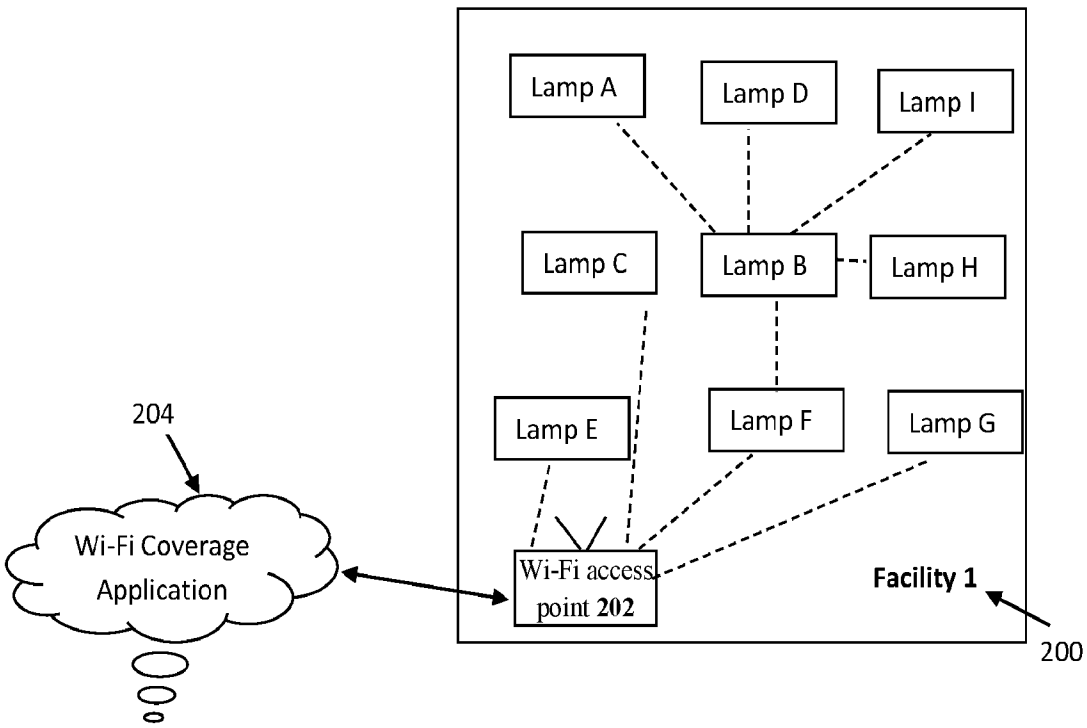
Lamp A
Lamp D
Lamp I
Lamp C
Lamp B
Lamp H
Lamp E
Lamp F
Lamp G
204
Wi-Fi Coverage Application
Wi-Fi access point 202
Facility 1
200

FIG. 2

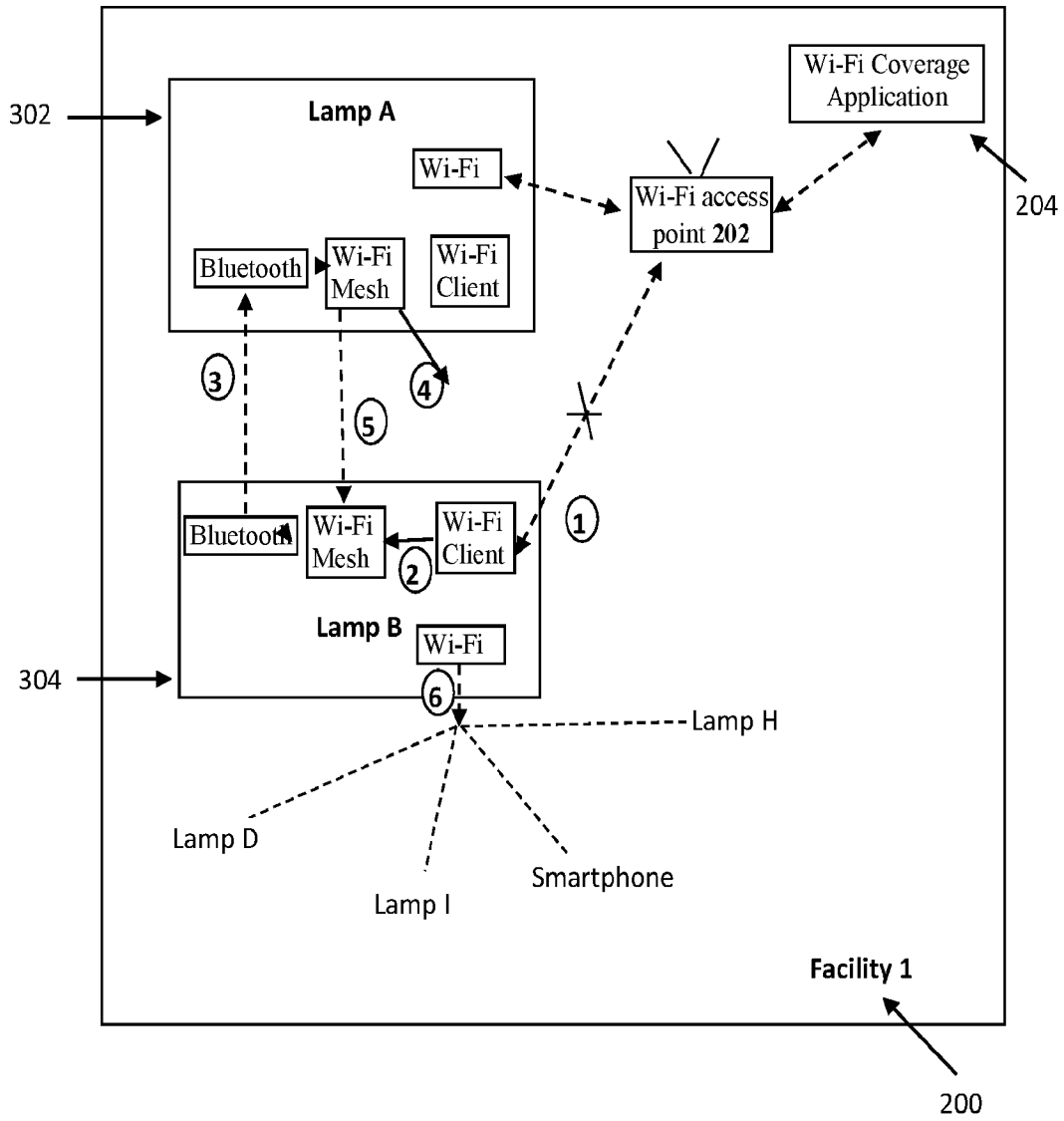
302
Lamp A
Wi-Fi
Bluetooth
Wi-Fi Mesh
Wi-Fi Client
Wi-Fi Coverage Application
Wi-Fi access point 202
204
3
4
5
1
Bluetooth
Wi-Fi Mesh
Wi-Fi Client
2
Lamp B
Wi-Fi
304
6
Lamp H
Lamp D
Lamp I
Smartphone
Facility 1
200

FIG. 3

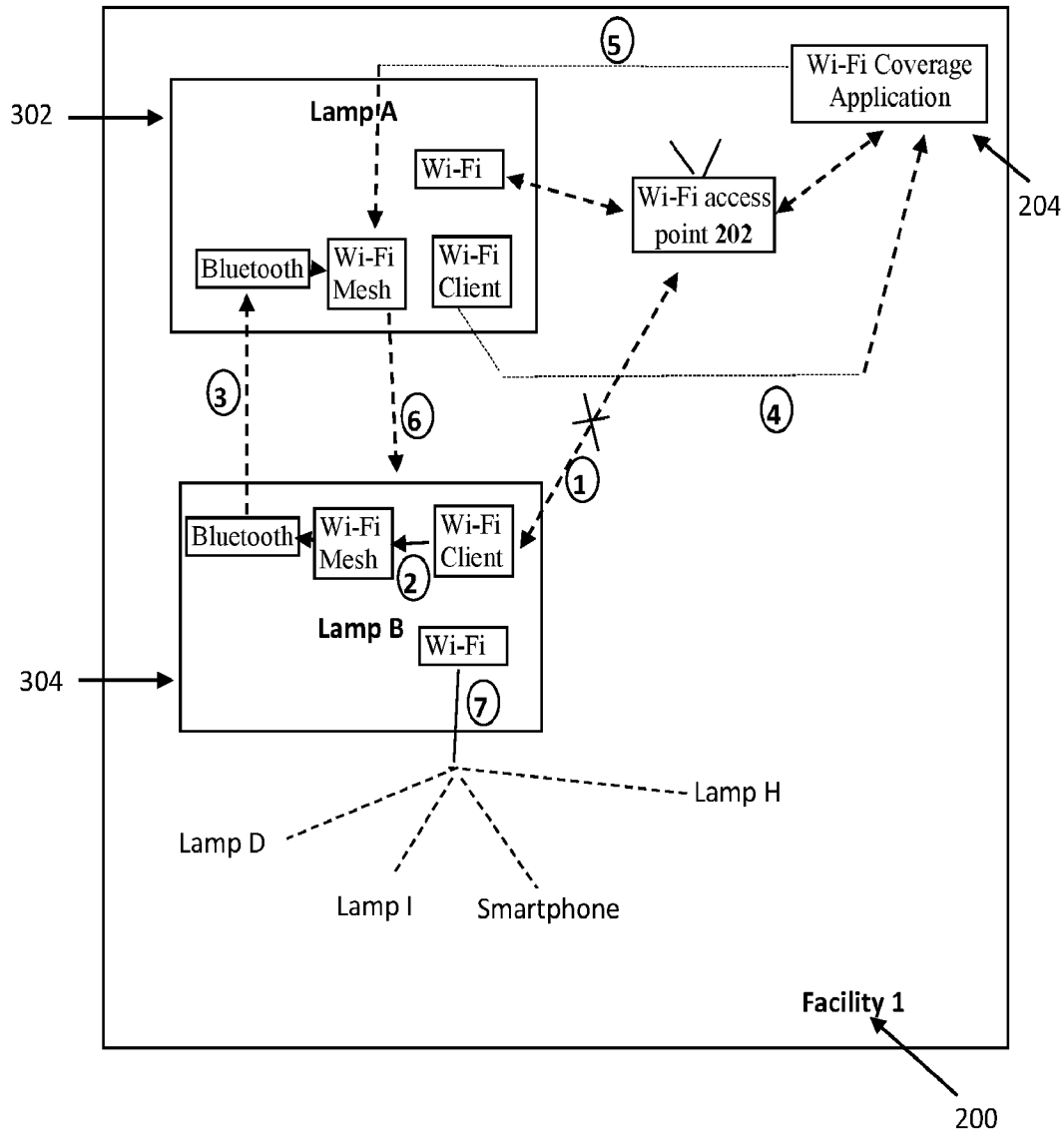
5
Wi-Fi Coverage Application
302
Lamp A
Wi-Fi
Wi-Fi access point 202
204
Bluetooth
Wi-Fi Mesh
Wi-Fi Client
3
6
4
1
Bluetooth
Wi-Fi Mesh
Wi-Fi Client
2
Lamp B
Wi-Fi
304
7
Lamp H
Lamp D
Lamp I
Smartphone
Facility 1
200

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 18/39360

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G06F 1/26, H04W 84/12 (2018.01)
CPC - H04W 84/00, H04L 12/28, H04L 12/2816, H04W 4/00, H05B 37/00, H04L 2012/2841, H04W 84/18, H04L 2012/285, H04W 84/12, H05B 33/0842, H05B 37/0272, H05B 33/086, H04L 61/2015, Y02B 20/48

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)
See Search History Document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2016/0366751 A1 (SENGLED OPTOELECTRONICS CO., LTD), 15 December 2016 (15.12.2016), entire document, especially Abstract; para [0029], [0053], [0071]-[0072]	1-16
Y	US 2016/0021688 A1 (Facebook, Inc), 21 January 2016 (21.01.2016), entire document, especially Abstract; para [0039], [0044]-[0045], [0058]-[0059]	1-16
Y	US 2007/0011335 A1 (Burns et al.), 11 January 2007 (11.01.2007), entire document, especially Abstract; para [0011]-[0012], [0030]	2, 4, 9, 13
Y	US 2017/0171950 A1 (RAB Lighting Inc), 15 June 2017 (15.06.2017), entire document, especially Abstract; para [0085], [0165], [0213], [0379]-[0381]	5-9 and 14-16
A	US 2014/0300293 A1 (ZHEJIANG SHENGHUI LIGHTING CO., LTD), 09 October 2014 (09.10.2014), entire document	1-16
A	US 2010/0204847 A1 (Leete, III et al.), 12 August 2010 (12.08.2010), entire document	1-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 October 2018	17 OCT 2018

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774