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(54) **Title:** CHECKING WI-FI COVERAGE USING LED LAMPS

(57) **Abstract:** The present invention discloses a method and a system for monitoring Wi-Fi coverage in a facility. The lighting device continuously check coverage of Wi-Fi network and report issues to a Wi-Fi Monitoring Application via a peer lighting device. The application running on the computing platform inside the lighting device continuously connects and disconnects with the Wi-Fi network to monitor the availability and coverage of the Wi-Fi signals in the facility and notifies a user or a network administrator about lack of Wi-Fi coverage in a particular area.

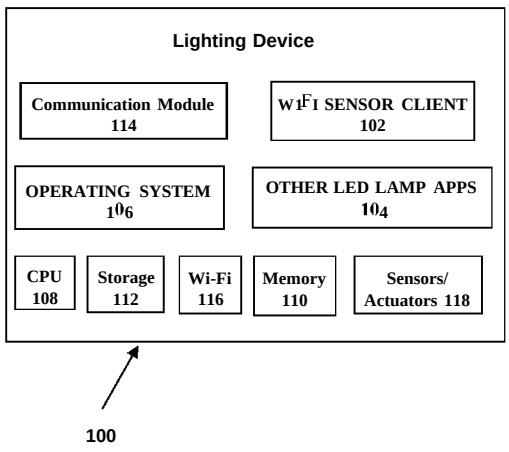

FIG. 1

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CHECKING WI-FI COVERAGE USING LED LAMPS

CROSS-REFERENCE TO RELATED APPLICATION

[001] This application claims benefit of and priority to U.S. Provisional Patent Application No. 62/524,303, filed June 23, 2017, entitled "Checking Wi-Fi Coverage 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 method and a system to monitor Wi-Fi network coverage in a facility, and more particularly, to a lighting system that monitors Wi-Fi network strength in a facility.

BACKGROUND

[003] Wi-Fi is a wireless networking protocol that allows devices to communicate without cords. Wi-Fi is the most popular means of communicating data wirelessly, within a fixed location. Today, Wi-Fi has moved from a nascent technology to one that is widely accepted and become so commonplace that we wonder how we ever functioned without it.

[004] Wi-Fi has become a mission critical asset for many organizations and the need for Wi-Fi performance management continues to grow. Wireless internet is everywhere these days and one can have several Wi-Fi capable devices connected to a wireless network. Because of that it becomes important that the Wi-Fi router is placed in the best available location to give the longest range and strongest signal to as many devices as possible. If the router is placed in a poor location the signal could be weak, intermittent or cause constant dropouts.

[005] There are many factors that can affect the quality and strength of a Wi-Fi network connection in a facility where it is installed. These include walls, floors, ceilings, electrical

appliances, anything emitting radiation or electromagnetism, and of course distance to the router. Windows and most bundled Wi-Fi software allows you to see how good the current wireless signal is. To get a better idea how the signal is behaving and whether it gets affected by other factors it is a good idea to monitor the signal strength over a period of time.

[006] In a wireless networks it is important to ensure good quality for the data traffic in the network. Quality can be verified and efficiently maintained by monitoring the functionalities of the wireless network with appropriate apparatus and procedures. The monitoring of the network reveals whether desired connection or services are available or whether a sufficient quality level for the connection is reached.

[007] Various wireless communication system prediction tools have been devised such as Wireless Valley Communications Incorporated's Predictor™ and Ericsson Radio Quality Information Systems' TEMS. Predictor™ allows a wireless communication system designer to predict the coverage area of a wireless system in a building or across multiple buildings. Based on the building configuration and building material properties defined in the database a prediction of the coverage area of the wireless system is extrapolated by site-specific propagation whereby rays drawn between the transmitter and receiver and three-dimensional building information are used for prediction computations. The TEMS system predicts indoor coverage of a wireless system based on a stored building map and input base transceiver locations and types using statistical radio coverage models.

[008] Even after years of evolution and innovation in the Wi-Fi performance monitor technology, the vendors avoid the conversations that are centred on the guarantee of quality of experience for wireless users. Wireless networks today still require hands and heads. The effort and time that goes into its support is significant. And, one of the key problems is that there is no

way to monitor the Wi-Fi performance at every spot in the facility. Even with the traditional approach, monitoring the Wi-Fi performance at every spot in the facility will increase the expenditure associated with networking technology.

[009] There, is therefore, a need for a cost effective solution that can monitor Wi-Fi performance at every spot in the facility. The present invention utilizes the computational ability of lighting devices that are installed in high density throughout the building as a sensor for Wi-Fi signal monitoring.

SUMMARY OF THE INVENTION

[0010] The present invention provides a method to utilize computing platform inside a lighting device to monitor Wi-Fi coverage area in the facility. Generally, infrastructural facilities are equipped with lighting devices installed in high density throughout the area and most of these are frequently in ON state, and hence can be used as sensors for Wi-Fi signal monitoring.

[0011] The present invention provides a lighting device that has an application running inside them that is always trying to connect and disconnect to the Wi-Fi network in the facility. The application running inside the lighting device prepares an indexing for all Wi-Fi traffic all the time and the data collected is analysed and sent to a Wi-Fi Monitoring application. The lighting device checks coverage of the Wi-Fi signal over a multiple frequency bands simultaneously, however, most preferable frequency bands are 2.4 GHz and 5 GHz bands.

[0012] In a first aspect of present invention, a lighting device 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 that enables the lighting system to connect to a Wi-Fi access point; a lighting device embedded Wi-Fi sensor client that monitor the Wi-Fi performance metrics, said lighting device embedded Wi-Fi sensor client communicates

the Wi-Fi performance metrics to a peer lighting device or the cloud. The lighting device embedded Wi-Fi Sensor Client uses the lighting device embedded Wi-Fi radio to monitor the health of the Wi-Fi network. The lighting device and the peer lighting devices are connected in a network using a Bluetooth protocol, or a Zigbee network, or a near-field communication, or an Infrared communication, or radio network identification. The lighting device further comprising: a controller to generate a visual indicator that the lighting device is not connected to Wi-Fi access point. The visual indicator can be: dimming the lighting device; changing color of the lighting device; switching on/off the lighting device; an LED indicator; partial change of color of light. The lighting device embedded Wi-Fi sensor client communicates to an external application when it is not able to connect to Wi-Fi access point. The external application sends a notification to a user or network administrator that the lighting device at a particular area is not able to connect to Wi-Fi access point. The Wi-Fi performance metrics include RSSI of the Wi-Fi access point beacons, retries, connection rates, packet latency, utilization, RF interference to gauge the quality of Wi-Fi radio signals in the area.

[0013] In a second aspect of present invention, a system for monitoring coverage of Wi-Fi in a facility is provided. The system comprising: a Wi-Fi access point providing wireless connectivity to Wi-Fi enable devices installed in the facility; a plurality of lighting device installed in a facility, said lighting device comprises a Wi-Fi radio to connect to the Wi-Fi access point, and a Wi-Fi sensor client to monitor the Wi-Fi performance metrics; the Wi-Fi sensor client of a disconnected lighting device communicates Wi-Fi performance metrics to a peer lighting device; an external application that receives the Wi-Fi performance metrics of the disconnected lighting device from the peer lighting device. The external application may reside either in the facility or in a cloud network. The Wi-Fi performance metrics comprises RSSI of the Wi-Fi access point

beacons, retries, connection rates, packet latency, utilization, RF interference to gauge the quality of Wi-Fi radio signals in the area. The lighting device periodically sends information to the external application, which then notifies the user or the network administrator. The external application sends notification to the user of network administrator when a lighting system is disconnected from the Wi-Fi access point. The lighting device may generate a visual indicator that the lighting device is disconnected from the Wi-Fi access point. The visual indicator can be: dimming the lighting device; changing color of the lighting device; switching on/off the lighting device; an LED indicator; partial change of color of light;

[0014] In a third aspect of present invention, a method for monitoring coverage of a Wi-Fi in a facility is provided. The method comprising: monitoring Wi-Fi performance metrics by a lighting device embedded Wi-Fi sensor client; communicating the Wi-Fi performance metrics of a disconnected lighting device by the lighting device embedded Wi-Fi sensor client to a peer lighting device; transmitting the Wi-Fi performance metrics of the disconnected lighting device by the peer lighting deice to an external application; notifying a user or a network administrator, the Wi-Fi performance metrics of the disconnected lighting device by the external application. The Wi-Fi performance metrics comprises RSSI of the Wi-Fi access point beacons, retries, connection rates, packet latency, utilization, RF interference to gauge the quality of Wi-Fi radio signals in the area. The external application notifies the user or the network administrator by sending notification in form of sms, text message, emails, mms or multimedia message. The disconnected lighting device generates a visual indicator which may include dimming the lighting device or changing color of the lighting device or switching on/off the lighting device or a LED indicator or a partial change of color of light. The plurality of lighting devices is

connected in a network using a Bluetooth protocol, or a near-field communication, or an Infra-red communication, or a Zigbee network or a Radio network identification protocol.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] 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:

[0016] FIG. **1** shows a schematic illustration of various components of a lighting device that can be installed in a building to monitor Wi-Fi network in a facility in accordance with the embodiment of the present invention.

[0017] FIG. 2 shows arrangement of a plurality of lighting device in the facility to monitor Wi-Fi coverage in the facility, in accordance with the embodiment of the present invention.

[0018] FIG. 3 illustrates a schematic diagram showing the lighting device as a senor to monitor Wi-Fi network in the facility, in accordance with an embodiment of present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0019] 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.

[0020] 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.

[0021] 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.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] 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.

[0026] In order to overcome the disadvantages associated with prior art, the present invention provides a system with a plurality of lighting devices in a facility that utilizes the computing resources inside the lighting devices for the purpose of continuous Wi-Fi coverage check across 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.

[0027] The present invention relates to the integration of Wi-Fi radio, a communication module and a computing platform inside the lighting device to continuously check coverage of Wi-Fi network and report issues to a Wi-Fi Monitoring Application via a peer lighting device which has Wi-Fi connectivity. The facility in which a Wi-Fi access point is located has a plurality of lighting devices installed in it. The application or software running on the computing platform inside the lighting device continuously connects and disconnects with the Wi-Fi network to monitor the availability and coverage of the Wi-Fi signals. In this arrangement, whenever a lighting device is not able to connect to the Wi-Fi network, it notifies the users in that area with an indication. The indication can be a visual indicator or a notification. The visual indication can be dimming the lighting device by a defined percentage, or changing the color of lighting device or partial change in color of lighting device, or switching off the lighting device, and other

possible arrangement. In another instance, the lighting device can send a notification to the user or administrator through Wi-Fi monitoring application, which can be in forms of sms, text, email, multimedia message, or other possible notifications. In another arrangement, whenever any lighting device is not able to connect to the Wi-Fi network, it sends this information to its peer lighting device using a Communication module (a communication protocol) which in turn communicate with the Wi-Fi monitoring application. The software running on the computing platform inside the lighting device may also collect Wi-Fi performance metrics such as Received Signal Strength Indicator (RSSI) of access point beacons, retries, connection rates, packet latency, utilization, coverage, RF interference to gauge the quality of Wi-Fi in the facility and then communicate it to the users or network administrators directly or via the peer lighting device. In an embodiment of present invention, lighting device may include LED bulbs, LED lamps, LED tubes, compact Fluorescent lamps, Fluorescent tubes, Neon lamps, troffers etc.

[0028] FIG. 1 shows a schematic illustration of various components of a lighting device that can be installed in a building to monitor Wi-Fi coverage in a facility in accordance with the embodiment of the present invention. The lighting device 100 comprises a Wi-Fi sensor client 102 application running in the lighting device that collects the Wi-Fi performance metrics in the vicinity of the lighting device. Wi-Fi performance metrics may include but are not limited to Received Signal Strength Indicator (RSSI) of access point beacons, number of retries in the air, connection rates, packet latency, utilization, RF interference, throughput, Quality of Service (QoS), coverage etc. The Other Apps 104 in the lighting device 100 may performs various functions such as but are not limited to, controlling the intensity and color of light, controlling the input that lighting device receives, controlling operating voltage or current or temperature, turn on-off, dimming off the light to a specified percentage etc. The lighting device may also

include an Operating System 106 stored in a Memory 110, wherein the Memory 110 is a Random Access Memory (RAM). The Operating System 106 is a program that manages the various resources of the lighting device 100. Typically the resources include a Central processing Unit (CPU) 108 that handles all instructions it receives from hardware and software running in the lighting device 100, Storage 112 is a computer readable medium that may include but 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, Communication module 114, Wi-Fi 116, Sensors/Actuator 118, Wi-Fi sensor client 102 and Other LED lamp Apps 104.

[0029] The lighting device 100 also comprises a communication module that allows the lighting device 100 to exchange data with peer lighting device in a facility. Wi-Fi 116 is a technology for wireless local area networking with devices based on the IEEE 802.1 1 standards. Wi-Fi 116 helps in connecting the lighting device 100 to the Internet via a WLAN network in the facility. The most common band used by the lighting device for Wi-Fi connectivity are 2.4 GHz and 5.8 GHz radio bands. The Wi-Fi 116 is used by the Wi-Fi Sensor Client 102 to monitor the health/strength of Wi-Fi network in the vicinity of the concern lighting device. Furthermore, the Sensors/Actuators 118 in the lighting 100 detects or checks or monitors various parameters in the Facility. The sensor/actuator may include but are not limited to motion sensor, thermos-sensors, ambient light sensors, occupancy sensors etc.

[0030] In the embodiment of the present invention, the lighting device 100 in the Facility tries to connect with the Wi-Fi radio. If lighting device 100 is able to connect with the Wi-Fi, then it

disconnects after a specified time interval. The specified time interval can be set by the user or the network administrator, which can varies from 2 seconds to hours. After the specified time interval, the lighting device 100 then repeats the cycle of connecting and disconnecting. In this way it continuously checks the coverage of the Wi-Fi signal in its vicinity. The specified time interval can be defined by the users or network administrators.

[0031] The Wi-Fi Sensor Client 102 in the lighting device 100 collects the Wi-Fi performance metrics such as but not limited to Received Signal Strength Indicator (RSSI) of access point beacons, number of retries in the air, connection rates, packet latency, utilization, RF interference, throughput, Quality of Service (QoS), coverage etc. In one aspect of the present invention, the lighting device has an application running inside it that always tries to connect and disconnect from the Wi-Fi network in the facility.

[0032] In an embodiment of present invention, the lighting device 100 uses the communication module to communicate Wi-Fi connectivity issues to its peer lighting device. The communication module/interface 114 may use communication protocol from the group consisting of Bluetooth protocol, Near-Field communication, Infrared, Radio network identification or Zigbee network.

[0033] In an embodiment of present invention, lighting device may include LED bulbs, LED lamps, LED tubes, compact Fluorescent lamps, Fluorescent tubes, Neon lamps, troffers etc.

[0034] FIG. 2 shows arrangement of a plurality of lighting device in the facility to monitor Wi-Fi coverage in the facility, in accordance with the embodiment of the 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. Wi-Fi Access Point (AP) 122 is the networking device that allows wireless Wi-Fi devices to connect to the internet. The Wi-Fi Access Point 122 creates a wireless local area network, or WLAN, usually in but not limited to, an office or large building. The Wi-Fi access point 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 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 Monitoring Application 120 is a network analyzer that performs an analysis to determine the quality of Wi-Fi in the facility and helps to monitor the state of Wi-Fi networks by gathering data about its parameters.

[0035] 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. A Wi-Fi Monitoring Application 120 is a network analyzer that performs an analysis to determine the quality of Wi-Fi in the facility and helps to monitor the state of Wi-Fi networks by gathering data about its parameters.

[0036] The application running on the computing platform inside the lighting device 100 continuously connects and disconnects with the Wi-Fi network in the Facility 1. The application running on the computing platform inside the lighting device 100 collect the Wi-Fi performance metrics such as but not limited to Received Signal Strength Indicator (RSSI) of access point

beacons, number of retries in the air, connection rates, packet latency, utilization, RF interference to gauge, throughput, Quality of Wi-Fi in the area and then communicate it to the users or network administrators directly or via the peer lighting device in the Facility 1.

[0037] Whenever a lighting device 100 is not able to connect to the Wi-Fi network, it notifies the user in that area with a visual indicator such as but not limited to dimming the lighting device to 70%, show a red blink on one end of the lighting device, change the color of lighting device etc. The Wi-Fi monitoring application 120 in the lighting device monitors Wi-Fi signal in the facility at different frequency bands, but preferably at 2.4 GHz and 5 GHz bands and give the proper information to make adjustments to Wi-Fi access point 122 to get the best coverage, speed and security.

[0038] Whenever a lighting device is not able to connect to the Wi-Fi network, it sends this information to its peer lighting device using communication module which in turn communicate with the Wi-Fi Monitoring Application 120. The Wi-Fi monitoring application takes the holistic approach and continuously receives feedback from the lighting devices in the facility that which area is lacking Wi-Fi network.

[0039] FIG. 3 illustrates a schematic diagram showing the lighting device as a senor to monitor Wi-Fi network in the facility, in accordance with an embodiment of present invention. There is plurality of lighting devices 100 installed in the facility that continuously monitors the Wi-Fi network coverage in their vicinity. FIG. 3 shows two lighting devices: LAMP A (302) and Lamp (304) that are installed sequentially in the facility. All the lighting devices in the Facility 1 try to connect and disconnect from the Wi-Fi Network continuously. The Wi-Fi Sensor Client 202 in the LAMP A and the Wi-Fi Sensor Client 202 in the LAMP B try to connect and disconnect with the Wi-Fi network continuously in the Facility. The purpose behind to connect and disconnect

from the Wi-Fi network is to continuously check or monitor the Wi-Fi coverage in the vicinity of the concern Lamp in the facility. The Wi-Fi Sensor Client 202 in the LAMP B is not able to connect to Wi-Fi Access Point 222 in the Facility. When Wi-Fi Sensor Client 202 in the LAMP B determines that it is not able to connect with Wi-Fi Access Point 222, then it notifies to its peer LAMP A, over Bluetooth. The data by which the LAMP B notifies the LAMP A over Bluetooth may include but not limited to Received Signal Strength Indicator (RSSI) of access point beacons, number of retries in the air, connection rates, packet latency, utilization, RF interference, throughput, Quality of Service (QoS), coverage etc. in the vicinity of LAMP B. The LAMP A in turns notifies the Wi-Fi Monitoring Application 220 about the data received from LAMP B through Wi-Fi.

[0040] The application running inside the lighting device is always trying to connect and disconnect from the Wi-Fi network in the Facility. In specific example of Fig. 3, the lighting device uses Bluetooth to communicate Wi-Fi Connectivity issues to its peer which in turn communicate to the Wi-Fi Monitoring Application that notifies the users or network administrators.

[0041] The Wi-Fi Sensor Client 102 sends this data instantaneously or periodically to the Wi-Fi Monitoring Application 120. The Wi-Fi Monitoring Application 120 performs an analysis based on the data received from Wi-Fi Sensor Client 102 to determine the quality of the Wi-Fi in the vicinity of the concern Lamp in the Facility.

[0042] The Wi-Fi Sensor Client 102 monitors the health of the Wi-Fi network and collects the various Wi-Fi performance metrics such as but not limited to Received Signal Strength Indicator (RSSI) of access point beacons, number of retries in the air, connection rates, packet latency, utilization, RF interference, throughput, Quality of Service (QoS), coverage etc. Wi-Fi Sensor

Client 102 communicates the Wi-Fi coverage issues such as not able to connect, or observing one or more Wi-Fi performance metrics indicating lack of sufficient coverage to another LED Lamp over Bluetooth. It listen for Bluetooth messages such as Wi-Fi coverage issues coming from other LED Lamps in the Facility 1. It communicates the Wi-Fi performance metrics issues or coverage issues as detected by itself or communicated to it by its peers to a Wi-Fi Monitoring Application 120.

[0043] The Wi-Fi sensor client can monitor the Wi-Fi data at different wavelength, but most preferably, it monitors the Wi-Fi radios in 2.4 GHz and 5 GHz bands simultaneously.

[0044] The Wi-Fi monitoring application may either reside in the facility or can be located in a cloud server. Once the Wi-Fi coverage application determines that a lighting device located in a particular area of the facility is unable to connect the Wi-Fi radio signals, it send the notifications to the user or the administrator of network, informing him that a specific area is lacking the Wi-Fi network coverage. The notification can be in form of text, sms, emails, mms, or multimedia message.

[0045] In another embodiment of present invention, the lighting device when unable to connect the Wi-Fi radio generates visual indicator in the facility to notify the user or network administrator that the particular area is not receiving Wi-Fi signal. The visual indication can be in form of change of color of light, change in intensity of light, dimming of light, blinking of light, LED notification etc.

[0046] 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 that enables the lighting system to connect to a Wi-Fi access point;
   c) a lighting device embedded Wi-Fi sensor client that monitor the Wi-Fi performance metrics, said lighting device embedded Wi-Fi sensor client communicates the Wi-Fi performance metrics to a peer lighting device or the cloud.
2. The lighting device of claim 1, wherein the lighting device embedded Wi-Fi Sensor Client uses the lighting device embedded Wi-Fi radio to monitor the health of the Wi-Fi network.
3. The lighting device of claim 1 wherein the lighting device and the peer lighting devices are connected in a network using a Bluetooth protocol, or a Zigbee network, or a near-field communication, or an Infrared communication, or a radio network identification.
4. The lighting device of claim 1 further comprising: a controller to generate a visual indicator that the lighting device is not connected to Wi-Fi access point.
5. The lighting device of claim 4, wherein the visual indicator can be: dimming the lighting device; changing color of the lighting device; switching on/off the lighting device; an LED indicator; partial change of color of light.
6. The lighting device of claim 1, wherein the lighting device embedded Wi-Fi sensor client communicates to an external application when it is not able to connect to Wi-Fi access point.
7. The lighting device of claim 6, wherein the external application sends a notification to a user or network administrator that the lighting device at a particular area is not able to connect to Wi-Fi access point.

8. The lighting device of claim 1 wherein the Wi-Fi performance metrics include RSSI of the Wi-Fi access point beacons, retries, connection rates, packet latency, utilization, RF interference to gauge the quality of Wi-Fi radio signals in the area.

9. A system for monitoring coverage of Wi-Fi in a facility, the system comprising:

a) a Wi-Fi access point providing wireless connectivity to Wi-Fi enable devices installed in the facility;

b) a plurality of lighting device installed in a facility, said lighting device comprises a Wi-Fi radio to connect to the Wi-Fi access point, and a Wi-Fi sensor client to monitor the Wi-Fi performance metrics;

the Wi-Fi sensor client of a disconnected lighting device communicates Wi-Fi performance metrics to a peer lighting device;

c) an external application that receives the Wi-Fi performance metrics of the disconnected lighting device from the peer lighting device.

10. The system of claim 9, wherein the external application resides either in the facility or in a cloud network.

11. The system of claim 9, wherein the Wi-Fi performance metrics comprises RSSI of the Wi-Fi access point beacons, retries, connection rates, packet latency, utilization, RF interference to gauge the quality of Wi-Fi radio signals in the area.

12. The system of claim 11, wherein the lighting device periodically sends information to the external application, which then notifies the user or the network administrator.

13. The system of claim 9, wherein the external application sends notification to the user of network administrator when a lighting system is disconnected from the Wi-Fi access point.

14. The system of claim 9, wherein the lighting device generates a visual indicator that the lighting device is disconnected from the Wi-Fi access point.

15. The system of claim 14, wherein the visual indicator can be: dimming the lighting device; changing color of the lighting device; switching on/off the lighting device; an LED indicator; partial change of color of light.

16. A method for monitoring coverage of a Wi-Fi in a facility, the method comprising:

a) monitoring Wi-Fi performance metrics by a lighting device embedded Wi-Fi sensor client;

b) communicating the Wi-Fi performance metrics of a disconnected lighting device by the lighting device embedded Wi-Fi sensor client to a peer lighting device;

c) transmitting the Wi-Fi performance metrics of the disconnected lighting device by the peer lighting deice to an external application;

d) notifying a user or a network administrator, the Wi-Fi performance metrics of the disconnected lighting device by the external application.

17. The method of claim 16, wherein the Wi-Fi performance metrics comprises RSSI of the Wi-Fi access point beacons, retries, connection rates, packet latency, utilization, RF interference to gauge the quality of Wi-Fi radio signals in the area.

18. The method of claim 16, wherein the external application notifies the user or the network administrator by sending notification in form of sms, text message, emails, mms or multimedia message.

19. The method of claim 16, wherein the disconnected lighting device generates a visual indicator which may include dimming the lighting device or changing color of the lighting

device or switching on/off the lighting device or a LED indicator or a partial change of color of light.

20. The method of claim 16, wherein the plurality of lighting device are connected in a network using a Bluetooth protocol, or a near-field communication, or an Infra-red communication, or a Zigbee network or a Radio network identification protocol.

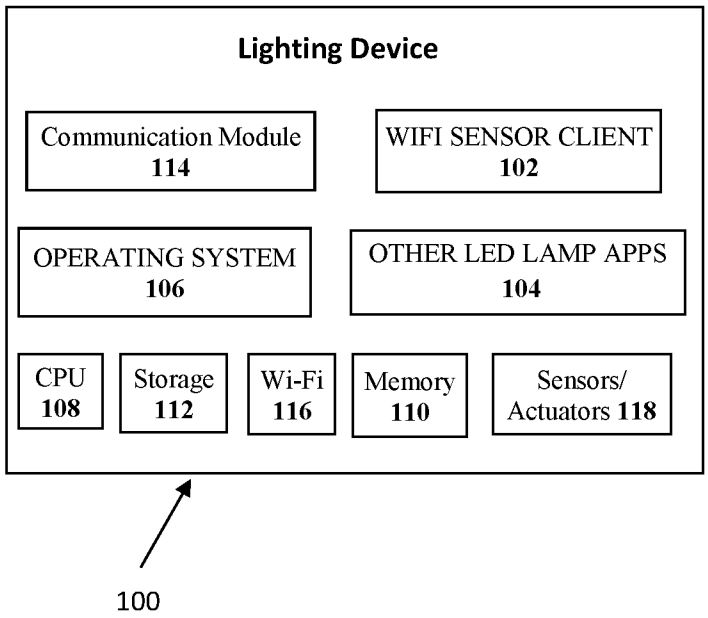
Lighting Device
Communication Module 114
WIFI SENSOR CLIENT 102
OPERATING SYSTEM 106
OTHER LED LAMP APPS 104
CPU 108
Storage 112
Wi-Fi 116
Memory 110
Sensors/ Actuators 118
100

FIG. 1

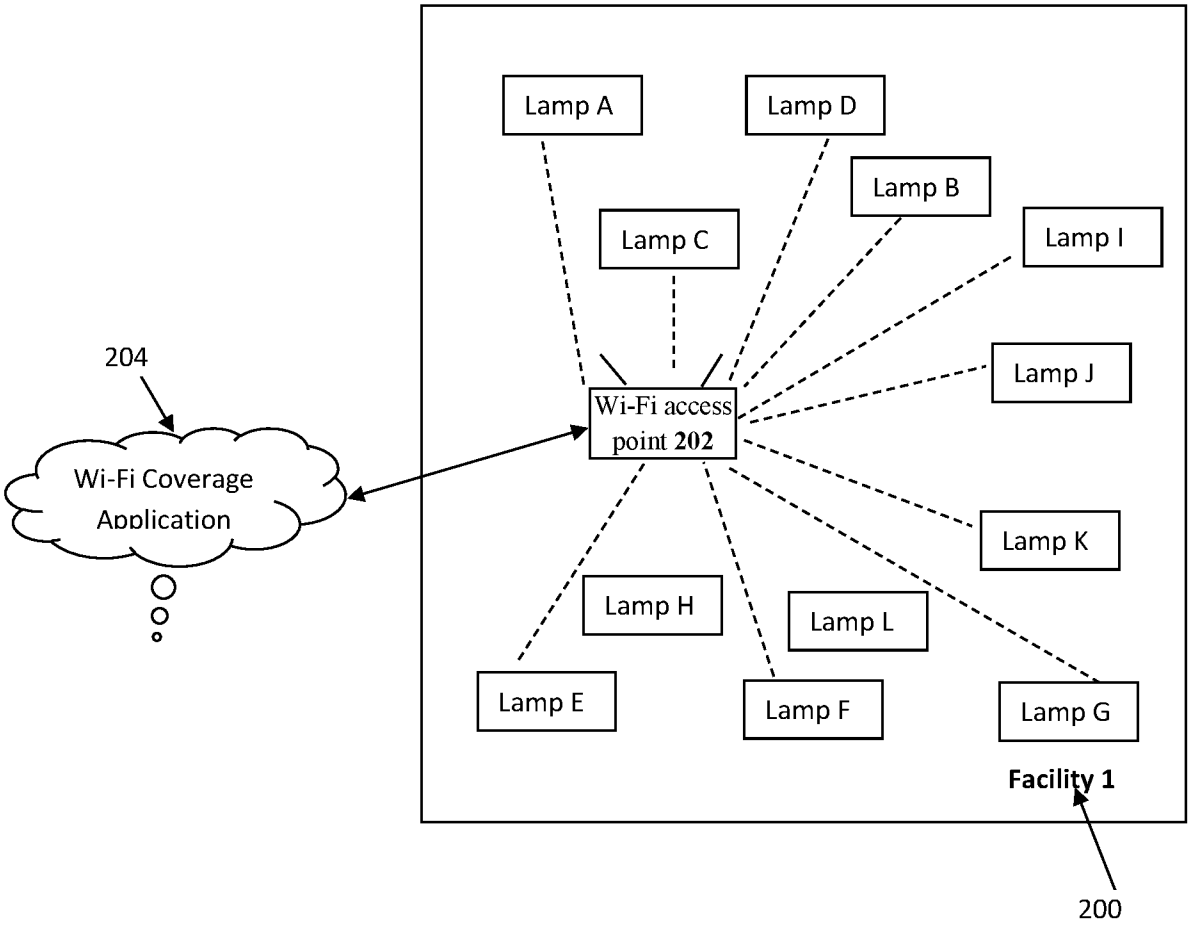
Lamp A
Lamp D
Lamp B
Lamp C
Lamp I
Lamp J
Wi-Fi access point 202
204
Wi-Fi Coverage Application
Lamp K
Lamp H
Lamp L
Lamp E
Lamp F
Lamp G
Facility 1
200

FIG. 2

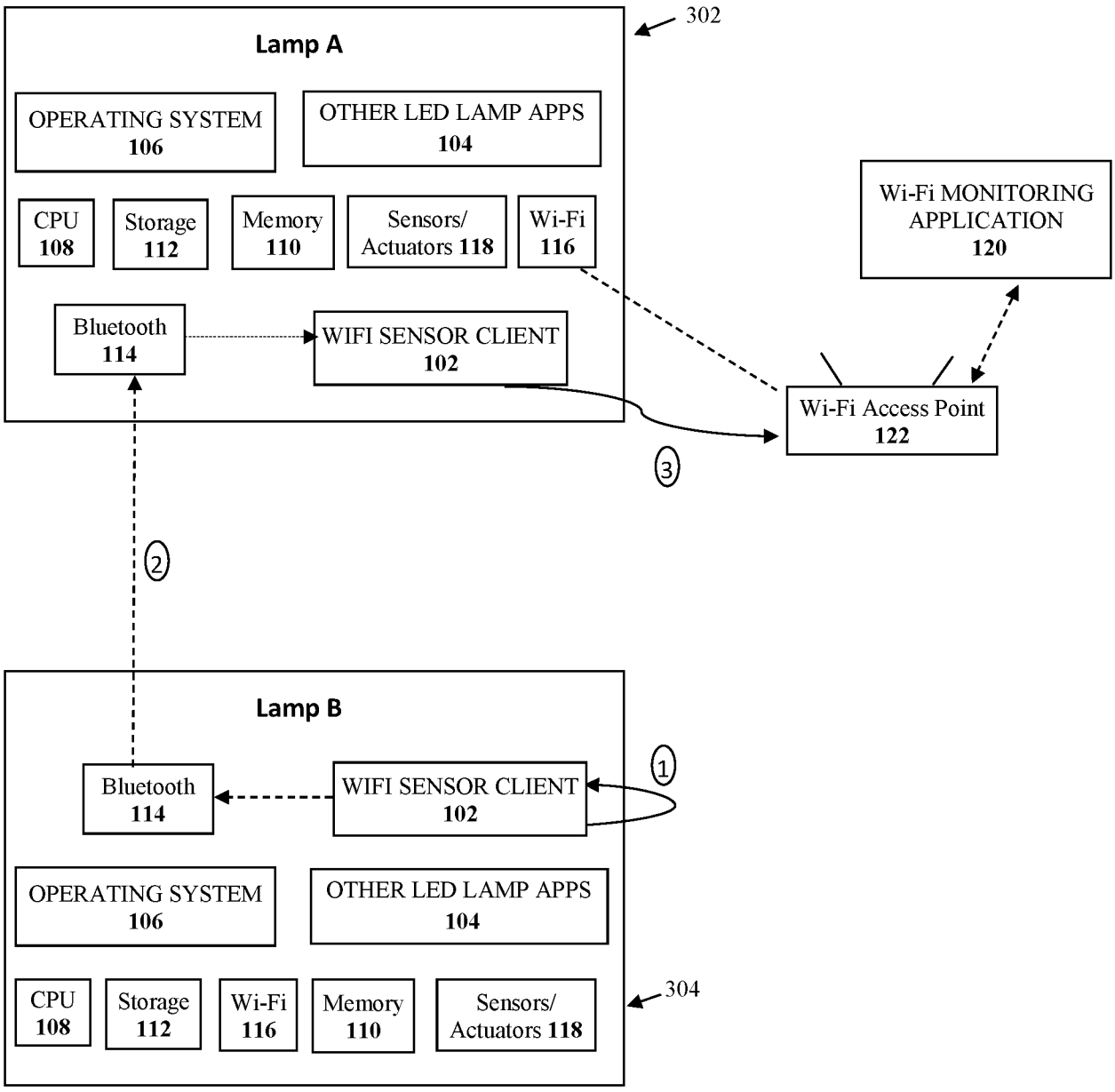
Lamp A
302
OPERATING SYSTEM
106
OTHER LED LAMP APPS
104
CPU
108
Storage
112
Memory
110
Sensors/
Actuators 118
Wi-Fi
116
Wi-Fi MONITORING
APPLICATION
120
Bluetooth
114
WIFI SENSOR CLIENT
102
Wi-Fi Access Point
122
3
2
Lamp B
1
Bluetooth
114
WIFI SENSOR CLIENT
102
OPERATING SYSTEM
106
OTHER LED LAMP APPS
104
CPU
108
Storage
112
Wi-Fi
116
Memory
110
Sensors/
Actuators 118
304

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 18/39356

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G06F 15/173 (2018.01)
CPC - H04L 29/08072, H04L 29/06, H04L 43/00, H04L 12/2602, H04L 41/22

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.
X --- Y	US 2016/0105344 A1 (Belkin International Inc.) 14 April 2016 (14.04.2016); entire document, especially para [0052], para [0054], para [0080], para [0082], para [0101], para [0172], para [0173], para [0179], para [0194], Fig. 23, 25-28	1-7, 9-10, 13-16, 18-20 --- 8, 11-12, 17
Y	US 8,365,018 B2 (Mcintosh et al.) 29 January 2013 (29.01.2013); entire document, especially col 21, ln 3-18	8, 11-12, 17
A	US 2016/0366751 A1 (SENGLED OPTOELECTRONICS CO., LTD.) 15 December 2016 (15.12.2016); entire document	1-20
A	US 2016/0219447 A1 (ZHEJIANG SHENGHUI LIGHTING CO., LTD) 28 July 2016 (28.07.2016); entire document	1-20
A	US 2012/0040606 A1 (Verfuerth) 16 February 2012 (16.02.2012); entire document	1-20

☐ 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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"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 slep 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
27 August 2018 (27.08.2018)	27 SEP 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

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