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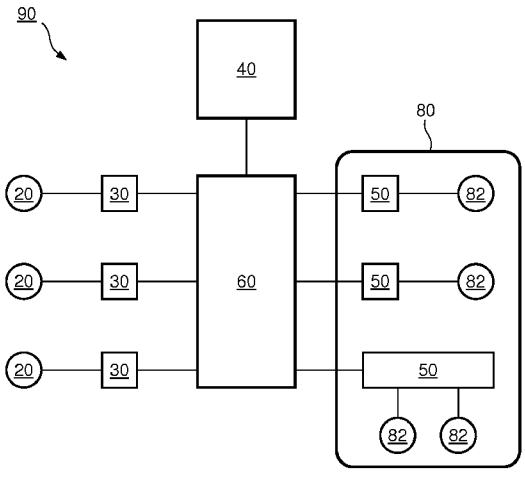

FIG. 1

(57) Abstract: A control system enabling users to have a predetermined degree of control over certain features of an outdoor lighting network, including user control apparatus; a central control apparatus; lighting unit control apparatus; and a communication system operably connected between the user control apparatus, the central control apparatus, and the lighting unit control apparatus. Each of the user control apparatus is operable to provide a control request in response to input from one of the users; the central control apparatus is operable to authenticate the control requests from the users, and resolve conflicts between the authenticated control requests for a lighting unit in an area of interest; and the lighting unit control apparatus for the lighting unit in the area of interest is operable to determine whether the resolved control request is valid, and execute the resolved control request when the resolved control request is valid.

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OUTDOOR LIGHTING NETWORK CONTROL SYSTEM

[0001] The technical field of this disclosure is outdoor lighting networks, particularly, outdoor lighting network (OLN) control systems.

[0002] Digital lighting technologies, i.e. illumination based on semiconductor light sources, such as light-emitting diodes (LEDs), offer a viable alternative to traditional fluorescent, HID, and incandescent lamps. Functional advantages and benefits of LEDs include high energy conversion and optical efficiency, durability, lower operating costs, and many others. Recent advances in LED technology have provided efficient and robust full-spectrum lighting sources that enable a variety of lighting effects in many applications. Some of the fixtures embodying these sources feature a lighting module, including one or more LEDs capable of producing different colors, e.g. red, green, and blue, as well as a controller for independently controlling the output of the LEDs in order to generate a variety of colors and color-changing lighting effects, for example, as discussed in detail in U.S. Patent Nos. 6,016,038 and 6,211,626, incorporated herein by reference.

[0003] Outdoor lights, such as lighting for roadways, streets, parking facilities, parks, landscapes, footpaths, and bicycle paths, are normally managed by a single authority. For example, street lights in New York City are managed by the Department of Transportation. Central control by one authority allows better security, better coordination of use, and reduced maintenance cost. Most outdoor lights currently operate independently or in small groups supplied from a common power source. However, with the rise of the Internet and wireless communication systems, there is a trend toward networking of outdoor lights and managing operation of the outdoor lights through a centralized server.

[0004] The new generation lights like LEDs have the capability to adjust dimming level and color on demand. This allows additional flexibility in saving energy, reducing light pollution, and complying with local lighting regulations. Unfortunately, the present generation of outdoor lighting does not adapt to or allow control by a user, such as the driver on the roadway, the pedestrian in the park, or an intelligent device with communication capabilities. Most outdoor lights follow pre-determined settings (e.g., turning on/off based on fixed time schedule via local

controller or remote server) and do not respond to user inputs in real time or otherwise. A few outdoor lights include local sensors for basic functions, such as ambient light sensors for dimming or movement detection sensors for turning on nearby outdoor lights when a user is present, but these lights cannot distinguish one user from another to provide lighting suited to the particular user. They also cannot take advantage of the additional flexibility of light systems like LED lights to provide different color or intensity light when desired by the user.

[0005] As an example, outdoor lights are normally dimmed during off-peak hours to save energy, but emergency responders (e.g., police, fire fighters, and emergency medics) need full light in performance of their duties. For instance, police need full light in pursuing a fugitive and emergency medics need full light in treating victims at an accident scene. The present generation of outdoor lighting does not allow the emergency responder users to quickly adapt the outdoor lighting to meet their needs.

[0006] A problem that arises with such user influenced light control is the issue of who is going to control the outdoor lighting. Different users have different and conflicting lighting requirements. While emergency responders prefer full brightness to evaluate an emergency, transportation departments and environment protection departments prefer reduced brightness during off peak, nighttime traffic periods to save energy and reduce light pollution (to preserve a dark sky). Yet another and very critical problem is that adaptive light control by users can present public safety issues, such as managing access to and communication with the outdoor lighting network control system: unauthorized users may maliciously or inadvertently take control of the outdoor lighting.

[0007] It would be desirable to have an outdoor lighting network control system that would overcome the above disadvantages.

[0008] The outdoor lighting network control system as described herein allows a user to control an outdoor lighting network in an area of interest (AOI), which is an area to be controllably illuminated and including at least a portion of the outdoor lighting network. The

user can be a person or intelligent device equipped with communications hardware, such as a computer, mobile phone, vehicle systems, devices found in a vehicle, or the like.

[0009] One aspect of the invention provides a control system enabling users to have a predetermined degree of control over certain features of an outdoor lighting network. The control system includes a plurality of user control apparatus; a central control apparatus; a lighting unit control apparatus; and a communication system operably connecting the user control apparatus, the central control apparatus, and the lighting unit control apparatus. Each of the plurality of user control apparatus is operable to provide a control request in response to input from one of the users; the central control apparatus is operable to authenticate the control requests from the users, and resolve conflicts between the authenticated control requests for a lighting unit in an area of interest; and the lighting unit control apparatus for the lighting unit in the area of interest is operable to execute the resolved control request.

[00010] Another aspect of the invention provides a user control apparatus enabling a user to have a predetermined degree of control over certain features of lighting units in an area of interest of an outdoor lighting network, the user control apparatus including a processor; a memory operably connected to the processor, the memory storing user authentication data of the user; and a communication module operably connected to the processor for communication between the user and the outdoor lighting network. The processor is operable to: provide a control request including the user authentication data; and transmit the control request through the communication module to the outdoor lighting network, the lighting units in the area of interest of the outdoor lighting network being controllable by the control request in accordance with permission and priority rules for the user.

[00011] Another aspect of the invention provides a central control apparatus receiving control requests and enabling users to have a predetermined degree of control over certain features of lighting units in an area of interest of an outdoor lighting network, the central control apparatus including a processor; a memory operably connected to the processor, the

memory storing user authentication information and user priority information; and a communication module operably connected to the processor for communication with the users and the outdoor lighting network. The processor is operable to: receive the control requests from the users through the communication module, each of the control requests including user authentication data; authenticate the control requests from the users using the user authentication data and the user authentication information; resolve the authenticated control requests for conflicts between the authenticated control requests with the user priority information to determine a resolved control request; determine the area of interest, illuminance requirements, and operation schedules for the resolved control request; identify the lighting units of the outdoor lighting network within the area of interest; schedule operation of the lighting units identified as being within the area of interest in accordance with the illuminance requirements and operation schedules of the resolved control request; and transmit the resolved control request through the communication module to the lighting units identified as being within the area of interest of the resolved control requests per the scheduled operation, the lighting units identified as being within the area of interest of the resolved control requests and being controllable by the resolved control request.

[00012] Another aspect of the invention provides a lighting unit control apparatus receiving a resolved control request and enabling users to have a predetermined degree of control over certain features of a lighting unit in an outdoor lighting network, the apparatus including a processor; a memory operably connected to the processor, the memory storing a lighting unit verification data of the lighting unit; and a communication module operably connected to the processor for communication between the users and the outdoor lighting network. The processor is operable to: receive the resolved control request through the communication module, the resolved control request being authenticated and prioritized; and execute the resolved control request to control the lighting unit in accordance with the resolved control request.

[00013] The foregoing and other features and advantages of the invention will become further apparent from the following detailed description of the presently preferred embodiments, read in conjunction with the accompanying drawings. The detailed description and drawings are merely illustrative of the invention, rather than limiting the scope of the invention being defined by the appended claims and equivalents thereof.

[00014] As used herein for purposes of the present disclosure, the term "LED" should be understood to include any electroluminescent diode or other type of carrier injection/junction-based system that is capable of generating radiation in response to an electric signal. Thus, the term LED includes, but is not limited to, various semiconductor-based structures that emit light in response to current, light emitting polymers, organic light emitting diodes (OLEDs), electroluminescent strips, and the like. In particular, the term LED refers to light emitting diodes of all types (including semi-conductor and organic light emitting diodes) that may be configured to generate radiation in one or more of the infrared spectrum, ultraviolet spectrum, and various portions of the visible spectrum (generally including radiation wavelengths from approximately 400 nanometers to approximately 700 nanometers). Some examples of LEDs include, but are not limited to, various types of infrared LEDs, ultraviolet LEDs, red LEDs, blue LEDs, green LEDs, yellow LEDs, amber LEDs, orange LEDs, and white LEDs (discussed further below). It also should be appreciated that LEDs may be configured and/or controlled to generate radiation having various bandwidths (e.g., full widths at half maximum, or FWHM) for a given spectrum (e.g., narrow bandwidth, broad bandwidth), and a variety of dominant wavelengths within a given general color categorization.

[00015] For example, one implementation of an LED configured to generate essentially white light (e.g., a white LED) may include a number of dies which respectively emit different spectra of electroluminescence that, in combination, mix to form essentially white light. In another implementation, a white light LED may be associated with a phosphor material that converts electroluminescence having a first spectrum to a different second spectrum. In one example of this implementation, electroluminescence having a relatively short wavelength and

narrow bandwidth spectrum "pumps" the phosphor material, which in turn radiates longer wavelength radiation having a somewhat broader spectrum.

[00016] It should also be understood that the term LED does not limit the physical and/or electrical package type of an LED. For example, as discussed above, an LED may refer to a single light emitting device having multiple dies that are configured to respectively emit different spectra of radiation (e.g., that may or may not be individually controllable). Also, an LED may be associated with a phosphor that is considered as an integral part of the LED (e.g., some types of white LEDs). In general, the term LED may refer to packaged LEDs, non-packaged LEDs, surface mount LEDs, chip-on-board LEDs, T-package mount LEDs, radial package LEDs, power package LEDs, LEDs including some type of encasement and/or optical element (e.g., a diffusing lens), etc.

[00017] It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent) are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein. It should also be appreciated that terminology explicitly employed herein that also may appear in any disclosure incorporated by reference should be accorded a meaning most consistent with the particular concepts disclosed herein.

[00018] In the drawing figures, like reference characters generally refer to the same parts throughout the different views. Also, the drawing figures are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention.

[00019] **FIG. 1** is a block diagram of a control system for an outdoor lighting network in accordance with the invention.

[00020] **FIG. 2** is a schematic diagram of one embodiment of a control system for an outdoor lighting network in accordance with the invention.

[00021] **FIGS. 3 & 4** are a block diagram and flow chart, respectively, for a user control apparatus for an outdoor lighting network in accordance with the invention.

[00022] **FIGS. 5 & 6** are a block diagram and flow chart, respectively, for a central control apparatus for an outdoor lighting network in accordance with the invention.

[00023] **FIGS. 7 & 8** are a block diagram and flow chart, respectively, for a lighting unit control apparatus for an outdoor lighting network in accordance with the invention.

[00024] **FIGS. 9 & 10** are schematic diagrams of applications of an outdoor lighting network control system in accordance with the invention.

[00025] **FIG. 1** is a block diagram of an exemplary embodiment of a control system for an outdoor lighting network in accordance with the invention. **FIG. 1** provides an overview of the control system, which enables users to have a predetermined degree of control over certain features of an outdoor lighting network. Details of portions of the overall control system, including the user control apparatus, the central control apparatus, and the lighting unit control apparatus, are provided in **FIGS. 3, 5,** and **7,** respectively.

[00026] Referring to **FIG. 1,** the control system **90** includes a number of user control apparatus **30,** a central control apparatus **40,** a number of lighting unit control apparatus **50,** and a communication system **60** operably connected between the user control apparatus **30,** the central control apparatus **40,** and the lighting unit control apparatus **50.** Each of the user control apparatus **30** is operable to provide a control request in response to input from one of the users **20.** The control request can request immediate action from the lighting unit control apparatus **50** or request a scheduled action at a later time. Each of the lighting unit control apparatus **50** is operably connected to one or more lighting unit **82.** The central control apparatus **40** is operable to authenticate the control requests from the users **20,** and resolve conflicts between the authenticated control requests and pass on the resolved control request for a lighting unit in an area of interest. The resolved control request is a request defined and/or formed by one or more of prioritizing, down-selecting, modifying, parsing/translating,

fusing, and/or combining one or more user control requests. In one example, the resolved control request can be the highest priority authenticated control request selected from among a number of user control requests received at the central control apparatus **40.** In another example, the resolved control request can be a single authenticated control request passing through the central control apparatus **40** without any conflicting authenticated control requests. In yet another example, the resolved control request can be a user control request translated from general language format (e.g., a street name as the area of interest) to a specific format which can be processed by lighting units within the area of interest. In yet another example, the resolved control request can be a fusion of multiple user control requests (e.g., the average of different light level requirements). The lighting unit control apparatus **50** for the lighting unit in the area of interest is operable to determine whether the resolved control request is valid, and execute the resolved control request when the resolved control request is valid. In one embodiment, the lighting unit control apparatus **50** is operable to transmit a service advertisement, and at least one of the user control apparatus **30** is operable to detect the service advertisement, so that the user **20** can determine that the OLN control system is available in the area of the user **20.**

[00027] The lighting unit control apparatus **50** can use one check or a combination of checks to determine when a resolved control request is valid, i.e., when a resolved control request should be allowed to be executed to control a lighting unit or group of lighting units. In one example, the lighting unit control apparatus **50** checks whether the lighting unit receiving the resolved control request is capable of performing the actions indicated by the resolved control request. In another example, the lighting unit control apparatus **50** checks whether the resolved control request conforms to a standard format used for resolved control requests.

[00028] The control request can include different information as desired for a particular application. In one embodiment, each of the user control apparatus **30** is operable in one embodiment to provide a control request including user authentication data for one of the users, and the central control apparatus **40** is operable to authenticate the control requests

using the user authentication data. Each of the user control apparatus **30** can also be operable to provide a control request including the area of interest of the outdoor lighting network, which can optionally include illuminance requirements and operation schedules for the area of interest. In one embodiment, the area of interest is specified by a location identifier, such as GPS coordinates, road/street/area name, zip code, and travel route, or the like.

[00029] The control system **90** can allow local preauthorization in which a user or users are allowed to operate lighting units locally without the user request passing through the central control apparatus **40** by sending a local user control request directly to the lighting unit control apparatus **50.** In one embodiment, the control request can be a local preauthorization control request and the central control apparatus **40** is further operable to transmit a local preauthorization resolved control request through the communication system **60** to the outdoor lighting network to allow the user to directly control lighting units in the area of interest. Local preauthorization avoids any delay that can occur in processing a control request through the central control apparatus **40.** The user **20** directs the user control apparatus **30** to send a local user control request directly to the lighting unit control apparatus **50** without passing the local user control request through the central control apparatus **40.** The local user control request can request immediate action from the lighting unit control apparatus **50** or request a scheduled action at a later time. To work out conflicts between a resolved control request and either a local preauthorization resolved control request or a local user control request, each lighting unit or group of lighting units can include local conflict resolution control, e.g., a stored table designating which of the requests has priority, which determines which request is to take precedence when the control request and either the preauthorized control request or the local user control request require different actions from the lighting unit or group of lighting units.

[00030] The lighting unit control apparatus **50** can also check validity when the control system **90** allows local preauthorization. In one example, the lighting unit control apparatus **50** checks whether the local user control request conforms to a standard format used for the local

user control requests. In another example, the lighting unit control apparatus **50** checks whether the local user control request received from a user is timely, i.e., whether the local user control request is received at the lighting unit control apparatus **50** within a time period specified in the local preauthorization resolved control request received from the central control apparatus **40.**

[00031] The users **20** can be any type of users who are given authority to control an outdoor lighting network. In one example, the user can be an administrator responsible for day to day operation of the outdoor lighting network. In another example, the user can be emergency responders, such as police, fire fighters, or emergency medics, on foot or in vehicles, who are authorized to use local light control to facilitate their public safety duties. In yet another example, the user can be an artist or event planner who incorporates lighting in an art performance or public event. In yet another example, the user can be a member of the public at large who activates local lighting along foot or bicycle paths. In yet another example, the user can be an intelligent device, such as a vehicle with onboard communications and electronics, to transmit a control request when triggered by a sensor or predetermined conditions being satisfied.

[00032] The outdoor lighting network **80** can be any type of outdoor lighting network or portion of an outdoor lighting network under central control. The lighting units within the outdoor lighting network can be individually controlled or controlled as lighting unit groups made up of individual lighting units. A lighting unit as defined herein is one or more light emitting source with any supporting hardware, communications devices, and/or software, such as ballasts, fixtures, processors, and the like, needed to controllably operate the lighting unit. The lighting units **82** can be any type of controllable lighting unit, such as incandescent, fluorescent, high intensity discharge (HID), and/or solid state lighting units, presently in existence or similar later developed devices. Those skilled in the art will appreciate that solid state lighting units, such as LED lighting units, offer a greater degree of controllability of features than other current lighting unit types, particularly for features such as intensity, color,

and/or flashing. The lighting units within the outdoor lighting network **80** can be a mixture of different lighting unit types. In one example, a number of the lighting unit control apparatus **50** can be combined as units with the lighting units **82** to form portions of the outdoor lighting network **80.**

[00033] The communication system **60** can be any single or combination of communications networks enabling direct or indirect communication between the users **70** and the outdoor lighting network **80.** In one example, the communication system communicates over a wide area network (WAN), which is a communications network that uses such devices as telephone lines, satellite dishes, or radio waves to span a larger geographic area than can be covered by a local area network (LAN). One example of a WAN is the Internet. In another example, the communication system communicates over a public safety communication network. In another example, the communication system communicates over a cellular or personal communications service (PCS) network. The network for users to communicate with the outdoor lighting network can be part of outdoor lighting network or can be totally independent of the outdoor lighting network. Those skilled in the art will appreciate that the different networks can be used in combination, such as the user communicating with the public safety communication network and the outdoor lighting network communicating with WAN, or private mesh networks accessible only to the lighting managers. The different networks can be controlled by different entities, such as one network for city streets being controlled by city authorities and one network for highways being controlled by state or federal authorities.

[00034] In one exemplary embodiment, the control system **90** for the outdoor lighting network incorporates a policy-based light management (PBLM) system, which allows an operator to specify behavior of the outdoor lighting network without having to separately specify behavior of each lighting unit control apparatus **50.** In one example, the PBLM system operates on the central control apparatus **40,** and includes a policy server and an outdoor lighting network (OLN) repository having OLN attributes and an OLN policy set. When the outdoor lighting network is initially set up, the installer populates the OLN attributes with

information about the lighting unit control apparatus **50,** such as one or more of the following with examples of information in parentheses: device type (lighting unit, camera, sensor), lighting unit ID (number), lighting unit type (street light, highway, city center, ballpark), lamp type (LED, sodium-scandium metal halide, high pressure sodium), max lamp power (Watts), dimming range (range of supported dimming values), and any other information desired concerning the lighting unit control apparatus **50** and associated lighting unit(s) **82.** The installer also populates the OLN policy set, which governs operation of the outdoor lighting network, considering such constraints as regulatory, management, and device policy subsets. The policy subsets implement the operating goals and limits of each entity.

[00035] When a policy subset is proposed, e.g., when new regulations are passed, the policy server reviews the proposed policy subset against the existing OLN policy set to determine that the proposed policy subset is feasible and that it does not conflict with any higher ranked policy subset. For example, a proposed management policy subset to leave the lighting units on all the time would not be feasible if an existing regulatory policy subset required the lighting units to be dimmed or off for certain hours. The policy server determines that the proposed policy subset is feasible or resolves conflicts between the policy sets, then updates the OLN policy set with the proposed policy subset as feasible. The policy server can execute the updated OLN policy set by providing information to the lighting unit control apparatus **50** as required. In one exemplary embodiment, a newly installed device can automatically provide a device policy subset to the policy server for review when the device is installed.

[00036] **FIG. 2** is a schematic diagram of one exemplary embodiment of a control system for an outdoor lighting network in accordance with the invention, which shows an exemplary general outdoor lighting network control system. The illustrated communication system includes a public safety communication network, a wide area network (WAN), and a lighting control gateway permitting communication between one or more users and the outdoor lighting network; and the processor is a light management server.

[00037] In this example, the user oriented outdoor lighting system **100** includes a public communication system **110**, a light management server **120** as the central control apparatus, and a number of outdoor lighting units **140**. The communication system **110** permits communication between a user **102** and the outdoor lighting network **140**, allowing control of lighting units **142** in an area of interest **150** within the outdoor lighting network **140**. The public communication system **110** also permits the outdoor lighting network to communicate (advertise) to users the availability of the user control service. The communication system **110** includes a public safety communication network **112** (illustrated in this example as a single wireless device within the network), a wide area network (WAN) **114**, and a lighting control gateway **116**, which is one or more optional network node equipped for interfacing with networks that uses different protocols. In one embodiment, each of the outdoor lighting units **142** is independently controllable. In another embodiment, the outdoor lighting units **142** are controllable in lighting unit groups. The area of interest **150** can be specified by a location identifier such as GPS coordinates, road/street/area name, zip code, and/or travel route. Those skilled in the art will appreciate that in other embodiments the lighting control gateway can be omitted and the light management server can communicate with and directly control the outdoor lighting units.

[00038] In operation, the user **102** using a user control apparatus transmits a control request **104** to the light management server **120** through the public safety communication network **112**. The control request **104** includes user authentication information, an area of interest, illuminance requirements, and operation schedules. The light management server **120** authenticates and prioritizes the control request **104** and generates a resolved control request **132**. The light management server **120** authenticates the control request **104** from the user **102** using user authentication information stored in the light management server **120**. For example, the light management server **120** stores the user's public key and can use the user's public key to decipher the digital signature for the control request **104** which is encrypted by the user's secret private key, thereby validating the identity of the user and proving the

integrity of the control request (i.e., proving the control request has not been tampered with). In addition to public-private-key cryptography, symmetric key algorithms can be also used for authentication. Symmetric key algorithms may require a secure initial exchange of one or more secret keys to both light management server **120** and the user **102.**

[00039] Conflicts between the control request of the user **102** and other users are resolved by user priority using user priority information stored in the light management server **120** to generate a resolved control request, which governs lighting unit operation in the area of interest. Conflicts between users can be also resolved by other priority factors instead of or in addition to the user priority. Other exemplary priority factors, besides user priority, include event priority (e.g., emergency response vs. energy efficiency vs. city beautification), time of use priority, order of control request receipt priority, and the like. The various priority factors can be weighted in resolving the conflicts among control requests, so that an individual priority factor can be weighted between zero and a controlling level as desired for a particular application.

[00040] When the control request **104** is authenticated and does not conflict with any higher priority user light control requests, the resolved control request **132** is transmitted through the wide area network (WAN) **114** and lighting control gateway **116** to the outdoor lighting units **142** in the area of interest **150** included in the control request **104** or determined by the light management server **120.** The outdoor lighting units **142** then operate in accordance with the resolved control request. In one embodiment, at least one of the control requests can be a local preauthorization control request and the central control apparatus can be further operable to transmit a local preauthorization resolved control request through the communication system to the outdoor lighting network to allow the user to directly control lighting units in the area of interest with a local user control request, i.e., the user can control lighting units in the area of interest without the control request from the user being sent through the light management server **120** at the time of use. The local user control request can request immediate action from the lighting unit control apparatus **50** or request a scheduled

action at a later time. To work out conflicts between a resolved control request and either a local preauthorized resolved control request or a local user control request, each lighting unit or group of lighting units can include local conflict resolution control, e.g., a stored table designating which of the requests has priority, which determines which request is to take precedence when the control request and either the local preauthorized resolved control request or the local user control request require different actions from the lighting unit or group of lighting units.

[00041] **FIGS. 3 & 4** are a block diagram and flow chart, respectively, for an exemplary embodiment of a user control apparatus for an outdoor lighting network in accordance with the invention. As illustrated in **FIG. 1,** the user control apparatus is accessible to the user and can be used to control the outdoor lighting network through the central control apparatus. The user can control the outdoor lighting network to the extent which the user is authorized. The user control apparatus can be implemented as a dedicated device or incorporated in another device. The user control apparatus can be implemented in a mobile phone, PDA, computer (e.g., laptop, tablet such as an iPad), vehicle including a car, airplane, helicopter, boat, or the like), device in a vehicle, mobile GPS device, embedded device, any intelligent device/machine, or any other device accessible to a user. The user control apparatus can also be incorporated in a device which is itself a user, e.g., a security camera which needs different light levels according to the particular situation. In one example, a user control apparatus can operate independently as an autonomous device, and autonomously generate user control requests without human interaction.

[00042] Referring to **FIG. 3,** the user control apparatus **200** enables a user **202,** such as a person or an intelligent device, to have a predetermined degree of control over certain features of an outdoor lighting network **204.** The user control apparatus **200** also enables a user to discover (or detect) the availability of the user oriented lighting control service at any given location and time. The user control apparatus **200** can be any type of apparatus receiving user input and producing a control request. In one embodiment, the control request includes user

authentication information, an area of interest, illuminance requirements, and operation schedules. In one embodiment, the control request is encrypted with the user's secret private key to allow validation of the identity of the user and proof of the integrity of the control request.

[00043] When the user **202** is an intelligent device, the user control apparatus **200** can automatically generate the user input and produce the control request. In one embodiment, the intelligent device responds to external stimulus, such as a transponder operating independently of the user control apparatus **200,** e.g., receiving/detecting weather and roadway conditions, to initiate the user input. Another example of this would be a communication device within a vehicle that alerts a local sensor external to the vehicle, and the local sensor provides external stimulus to an intelligent device of the user control apparatus **200,** which automatically generates the user input, e.g., to turn on darkened lighting units when a vehicle approaches. In another embodiment, the user control apparatus **200** can include a means to detect when/where the user lighting control service is available for a given user by combining information received from the OLN with user location information. Once the service availability is detected, the user control apparatus **200** can indicate such availability to the user and enable the user input interface.

[00044] The user control apparatus **200** includes a processor **210;** a memory **220** operably connected to the processor **210,** the memory **220** storing user authentication data of the user **202;** and a communication module **230** operably connected to the processor **210** for communication between the user **202** and the outdoor lighting network **204.** The processor **210** is operable to provide a control request including the user authentication data, and transmit the control request through the communication module **230** to the outdoor lighting network, the lighting units in the area of interest of the outdoor lighting network **204** being controllable by the control request in accordance with permission and priority policies for the user **202.** The area of interest need not be explicitly included in the control request, but can be associated with other information included in the control request. For example, the area of

interest for a user with particular user authentication data can be specified by a location identifier such as GPS coordinates, and the area of interest calculated as an area of a predetermined distance around the GPS coordinate location. For another example, the area of interest for a user is fixed therefore the area of interest can be identified once the identity of the user is verified / authenticated by parsing the control request. In one embodiment, the illuminance requirements include one or more of the following: intensity, uniformity (point or flood lighting, for example), color, flashing state, direction, beam formation, beam shaping, and/or scene setting.

[00045] The various parameters can be identified or specified in different ways. In one embodiment, the processor **210** is operable to determine the area of interest in the outdoor lighting network and include the area of interest in the control request. The area of interest can be identified by a location identifier such as GPS coordinates, road/street/area name, zip code, travel route, and/or the like. In one embodiment, the area of interest is determined by the processor from actual user location. In another embodiment, the area of interest is calculated and determined by the processor from expected user location, e.g., a user location preselected by a user or a user location predicted by the GPS.

[00046] The processor **210** can be operable to determine illuminance requirements and operation schedules for the area of interest, and include the illuminance requirements and the operation schedules in the control request. In one embodiment, the illuminance requirements can be designated by a mode number to allow rapid entry by the user. Examples of illuminance requirements include intensity, uniformity, color, flashing state, direction, beam formation, beam shaping, scene setting, and the like. The operation schedules can include a combination of operational characteristics and time.

[00047] In one embodiment, the control request can be associated with a user priority level, which that can be used to resolve the control requests for conflicts between user requests from different users. In one embodiment, the control request includes the user

priority level. In another embodiment, the control request is associated with a user priority level stored in a table. In one embodiment, the control request is secure, e.g., encrypted by a method such as user pre-authentication or key authentication. In one embodiment, the control request is a local preauthorization control request to allow the user to directly control the lighting units in the area of interest.

[00048] The communication module **230** can be any type of device that can communicate with the outdoor lighting network **204,** such as a ZigBee chip, radio chip with an application layer, application-specific integrated circuit (ASIC), or the like. The communication module **230** can communicate using any desired technology, such as a cellular data communication protocol (e.g., GSM, CDMA, GPRS, EDGE, 3G, LTE, WiMAX), ZigBee protocol operating on top of the IEEE 802.15.4 wireless standard, WiFi protocol under IEEE standard 802.11 (such as 802.11b/g/n), Bluetooth protocol, Bluetooth Low Energy protocol, or the like. In one example, the communication module **230** communicates with the outdoor lighting network **204** through a communication system.

[00049] The user control apparatus **200** can include an input device **240,** such as a keyboard, touch screen, or the like, operably connected to the communication module **230** to allow the user to manually input data, such as user authentication data, area of interest, illuminance requirements, and/or operation schedules. The user **202** can input data individually as desired for a particular application or can input data as a pre-configured request selectable by the user **202** from a number of pre-configured requests.

[00050] The user control apparatus **200** can include a geolocation module **250,** such as a global positioning system (GPS) receiver, providing the current location, such as GPS coordinates, of the user **202** to the processor **210.** In one embodiment, the user control apparatus **200** includes a light demand analyzer **260** operably connected to the processor **210** to determine the area of interest, illuminance requirements, and/or operation schedules from

user input, external input, additional sensors, additional processors, combinations thereof, or the like.

[00051] The user control apparatus **200** can also include devices (e.g., sensor and/or receiver) to detect the availability of the lighting control service provided by the outdoor lighting network at any particular location and time. Furthermore, the user control apparatus can include means to display or enable the access to the user-oriented lighting control service to the user at any given location and time. Given that all lighting units may not implement or support the OLN control system (deployment may be gradual and over a long time period), means for the user control device to detect where and when the OLN control system is available can be useful. This can be enabled by service advertisement from the outdoor lighting network and discovery of the service advertisement by the user control apparatus **200.** In one embodiment, the processor **210** is operable to detect a service advertisement received at the communication module **230.**

[00052] The memory **220** can store user authentication data and other information facilitating operations to be performed by the processor **210,** e.g., user preferences for light requirements, and preset modes for user control requests for certain areas of interest or time schedules. The communication module **230** permits communication between the one or more users **202** and the outdoor lighting network **204.** The processor **210** is operable to receive control requests from the users **202** through the communication module **230,** each of the control requests specifying an area of interest in the outdoor lighting network **204** for operation. The area of interest need not be explicitly included in the control request, but can be associated with other information included in the control request. For example, the area of interest for an emergency responder with particular user identification, which is provided in the control request, can be specified by a location identifier such as GPS coordinates, and the physical area of interest calculated as an area of a predetermined distance around the GPS coordinate location.

[00053] The processor **210** can be any type of device that can perform at least one or more of the following: create instructions, execute instructions, and/or process data in accordance with instructions. In one example, the processor is a computer, such as a personal computer, server, or the like. The memory **220 can** be any type of memory capable of storing data, programs, and/or instructions. Exemplary memory includes random access memory (RAM), read-only memory (ROM), flash memory, magnetic computer storage devices (e.g. hard disks, floppy discs, and magnetic tape), optical discs, and the like. The memory **220** can be used for long term and/or short term storage.

[00054] **FIG. 4** illustrates one exemplary method of user control. The method **300** of user control includes storing user authentication data of the user **310,** providing a control request including the user authentication data **320,** and transmitting the control request **330** through the communication system to the outdoor lighting network, the lighting units in the area of interest of the outdoor lighting network being controllable by the control request in accordance with permission and priority rules for the respective user.

[00055] **FIGS. 5 & 6** are a block diagram and flow chart, respectively, for an exemplary embodiment of a central control apparatus **400** operatively connected to an outdoor lighting network **404** and a user **402** in accordance with the invention. The central control apparatus can be implemented in a processor, microprocessor, server, computer, or any other intelligent device with access to the user and the outdoor lighting network. The central control apparatus can be located in a central location or can be distributed over a number of locations.

[00056] Referring to **FIG. 5,** the central control apparatus **400** receives control requests from and enables users **402** to have a predetermined degree of control over certain features of lighting units in an area of interest of an outdoor lighting network **404.** The central control apparatus **400** includes a processor **410;** a memory **420** operably connected to the processor **410,** the memory **420** storing user authentication information and user priority information; and a communication module **430** operably connected to the processor **410** for communication

with the users **402** and the outdoor lighting network **404.** The memory **420** can optionally store rules to filter/prioritize/resolve-conflict user control requests. In one example, the resolved control request can be the highest priority authenticated control request selected from among a number of user control requests received at the central control apparatus **400.** In another example, the resolved control request can be a single authenticated control request passing through the central control apparatus **400** without any conflicting authenticated control requests. In yet another example, the resolved control request can be a user control request translated from general language format (e.g., a street name as the area of interest) to a specific format which can be processed by lighting units within the area of interest. In yet another example, the resolved control request can be a fusion of multiple user control requests (e.g., the average of different light level requirements).

[00057] The central control apparatus **400** authenticates the control requests from users using user authentication information stored in the memory **420.** For example, the memory **420** stores the user's public key and can use the user's public key to decipher the digital signature for the control request which is encrypted by the user's secret private key, thereby validating the identity of the user and proving the integrity of the control request (i.e., proving the control request has not been tampered with). In addition to public-private-key cryptography, symmetric key algorithms can be also used for authentication. Symmetric key algorithms may require a secure initial exchange of one or more secret keys to both central control apparatus **400** and the user.

[00058] The processor **410** is operable to receive the control requests from the users through the communication module **430,** each of the control requests including user authentication data; to authenticate the control requests from the users using the user authentication data and the user authentication information; to resolve the authenticated control requests for conflicts between the authenticated control requests with the user priority information to determine a resolved control request; to determine the area of interest, illuminance requirements, and operation schedules for the resolved control request; identify

the lighting units of the outdoor lighting network within the area of interest; to schedule operation of the lighting units identified as being within the area of interest in accordance with the illuminance requirements and operation schedules of the resolved control request; and to transmit the resolved control request through the communication module **430** to the lighting units identified as being within the area of interest of the resolved control requests per the scheduled operation. The lighting units identified as being within the area of interest of the resolved control requests are controllable by the resolved control request in accordance with validity of the resolved control request. In one embodiment, the processor **410** is further operable to resolve the authenticated control requests for event priority. For example, an emergency response event can have higher priority than a city beautification event. In one embodiment, the processor **410** is further operable to provide the resolved control request to a format specific to the lighting units of the outdoor lighting network within the area of interest, through a process such as parsing, down-selecting, prioritizing, modifying, fusion, or the like.

[00059] The control requests can include additional information as desired for a particular application. In one embodiment, each of the control requests also includes a user area of interest and the processor **410** is operable to determine the area of interest for the resolved control request from the control requests. In another embodiment, each of the control requests also includes the illuminance requirements and the operation schedules and the processor **410** is operable to determine the illuminance requirements and the operation schedules for the resolved control request from the control requests. In another embodiment, the processor **410** is operable to determine the area of interest for the resolved control request by calculation from the control requests. In one embodiment, at least one of the control requests is a local preauthorization control request and the resolved control requests are local preauthorization resolved control requests to allow at least one of the users **402** to directly control lighting units in the area of interest.

[00060] The memory can store additional information as desired for a particular application. In one embodiment, the memory **420** further stores user operation restriction

information and the processor **410** is operable to restrict the control requests from the users using the user authentication data and the user operation restriction information. The user operation restriction information can include limitations on operating parameters such as the area of interest, the illuminance requirements, the operation schedules, or the like.

[00061] In this example, the communication module **430** includes a user communication module **432** operably connected to communicate between the processor **410** and the user **402** and a light communication module **434** operably connected to communicate between the processor **410** and the outdoor lighting network **404** including the lighting units. The communication module **430** is operable to receive control requests from the users **402** and to transmit resolved control requests to the lighting units in the outdoor lighting network **404.** The memory **420** stores light information **422** for the lighting units of the outdoor lighting unit **404,** user information **424** for the user **402,** service management instructions **426,** and light task management instructions **428.** The processor **410** is further operable to identify the lighting units of the outdoor lighting network within the area of interest of the resolved control request by applying the service management instructions **426** and the light information **422.** The light information can include light address/locations, cluster IDs, light status, light capabilities/specifications, light use codes, light use policies, current user, user priority, or the like. In one example, the light use codes can be light level requirements for certain areas during certain periods. In another example, the light use policies can be set to minimize light level during late night hours.

[00062] In one embodiment, the memory **420** stores light task management instructions **428,** and the processor **410** is further operable to schedule control commands for the lighting units identified as being within the area of interest of the resolved control request in accordance with the illuminance requirements and operation schedules of the resolved control request by applying the light task management instructions **428** and the light information **422.** The light task management instructions can be the resolved control requests. The light information can include lighting unit information, such as one or more of the following:

location, status, capabilities (e.g., dimmable ranges, maximum power, color control, and the like) and other characteristics (e.g., model of devices, light distribution pattern, height, tilting angle, and the like). The service management instructions can include user authentication instructions, user request processing instructions, user authorization instructions, user billing instructions, user coordination instructions, conflict resolution instructions, or the like.

[00063] Conflicts between the control requests of users can be resolved by user priority using user priority information stored in the central control apparatus **400.** Conflicts between users can be also resolved by other priority factors instead of or in addition to the user priority. Other exemplary priority factors, besides user priority, include event priority (e.g., emergency response vs. energy efficiency vs. city beautification), time of use priority, order of control request receipt priority, and the like. The various priority factors can be weighted in resolving the conflicts among control requests so that the weighting of the individual priority factor can be from zero to a controlling level as desired for a particular application.

[00064] In one embodiment, the communication system **430** can be used to transmit information to the user indicating the availability of the outdoor lighting network control system at a particular location and time. The information can be transmitted as a lighting control service advertisement including exemplary information such as a service identification code, service mode, service accounting options, and service specific information, which may include any capabilities (hardware and/or software) needed by the user in order to access the outdoor lighting network control system. The transmission of the lighting control service advertisement to the user could be based on user location with respect to the outdoor lighting network coverage area and availability of the capabilities needed to implement the outdoor lighting network control system at the lighting units in that location. In another embodiment, the outdoor lighting network **404** can transmit the lighting control service advertisement directly to the user control apparatus (e.g., through modulated light or other communication link (wireless or wired) available between the outdoor lighting network and the user).

[00065] The communication module **430** can be any type of device that can communicate with the user **402** and/or the outdoor lighting network **404,** such as a ZigBee chip, radio chip with an application layer, application-specific integrated circuit (ASIC), or the like. The communication module **430** can communicate using any desired technology, such as a cellular data communication protocol (e.g., GSM, CDMA, GPRS, EDGE, 3G, LTE, WiMAX), ZigBee protocol operating on top of the IEEE 802.15.4 wireless standard, WiFi protocol under IEEE standard 802.11 (such as 802.11b/g/n), Bluetooth protocol, Bluetooth Low Energy protocol, or the like. In one example, the communication module **430** communicates with the user **402** and/or the outdoor lighting network **404** through a communication system.

[00066] The processor **410** can be any type of device that can perform one or more of the following: create instructions, execute instructions, and/or process data in accordance with instructions. In one example, the processor is a computer, such as a personal computer, server, or the like. The memory **420** can be any type of memory capable of storing data, programs, and/or instructions. Exemplary memory includes random access memory (RAM), read-only memory (ROM), flash memory, magnetic computer storage devices (e.g. hard disks, floppy discs, and magnetic tape), optical discs, and the like. The memory **420** can be used for long term and/or short term storage.

[00067] **FIG. 6** illustrates an exemplary method operation of the central control apparatus **400.** The method **500** includes receiving the control requests from the users **510,** authenticating the control requests from the users **520,** resolving conflicts among the authenticated control requests **530,** determining the area of interest, illuminance requirements, and operation schedules for the resolved control request **540,** identifying the lighting units of the outdoor lighting network within the area of interest **550,** scheduling operation of the lighting units identified as being within the area of interest **560,** and transmitting the resolved control request through the communication system to the lighting units identified as being within the area of interest **570.**

[00068] Receiving the control requests from the users **510** includes receiving the control requests including user authentication data. The control requests can optionally include one or more of the following: an area of interest, illuminance requirements, and an operation time. The area of interest can be specified by a location identifier such as GPS coordinates, road/street/area name, zip code, or travel route. The illuminance requirements can include one or more of the following: intensity, uniformity, color, flashing state, direction, beam formation, beam shaping, and/or scene setting for the area of interest. The operation time specifies the time and duration the user wants the illuminance requirements applied to the area of interest.

[00069] Authenticating the control requests from the users **520** uses the user authentication data and the user authentication information, which can be stored in the memory. This provides assurance that the user sending the control request is authorized to control the public lighting. In one embodiment, the authenticating **520** can include denying the control request when the control request is not authenticated. In another embodiment, the authenticating **520** can include activating an alarm when the control request is not authenticated. Thus, a person sending an unauthenticated control request is prevented from controlling the public lighting and an alarm can be raised.

[00070] Resolving the authenticated control requests for conflicts **530** resolves the authenticated control requests for conflicts between the authenticated control requests with the user priority information to determine a resolved control request. Conflicts between users can be also resolved by other priority factors instead of or in addition to the user priority. Other exemplary priority factors, besides user priority, include event priority (e.g., emergency response vs. energy efficiency vs. city beautification), time of use priority, order of control request receipt priority, and the like. The various priority factors can be weighted in resolving the conflicts among control requests, so that an individual priority factor can be weighted between zero and a controlling level as desired for a particular application.

[00071] In one embodiment, the resolving **530** can include resolving conflicting control requests for the identified lighting units when a number of control requests are received from a number of users. In one embodiment, the resolving **530** can also include denying at least one of the control requests based on the rank of the users. In another embodiment, the resolving **530** can also include notifying one of the users when the control request sent by the user is denied. In yet another embodiment, the resolving **530** can include optimizing operation of the identified lighting units in response to a number of control requests from a number of users.

[00072] Determining the area of interest, illuminance requirements, and operation schedules for the resolved control request **540** determines how the lighting units are to be operated. Identifying lighting units of the outdoor lighting network within the area of interest **550** selects the lighting units that the user wants to or is allowed to control. In one embodiment, the central control apparatus performs calculations and Identifies lighting units of the outdoor lighting network within the area of interest.

[00073] Scheduling operation of the lighting units identified as being within the area of interest **560** schedules operation of the lighting units identified as being within the area of interest in accordance with the illuminance requirements and operation schedules of the resolved control request. This places the resolved control request in the form of a command or instruction understandable by the identified lighting units to operate them in the desired mode at the desired time.

[00074] Transmitting the resolved control request through the communication system to the lighting units identified as being within the area of interest **570** directs the identified lighting units to carry out the scheduled operations. The transmitting **570** transmits the resolved control request through the communication system to the lighting units identified as being within the area of interest of the resolved control requests per the scheduled operation. The lighting units identified as being within the area of interest of the resolved control requests

are controllable by the resolved control request in accordance with validity of the resolved control request.

[00075] **FIGS. 7 & 8** are a block diagram and flow chart, respectively, for an exemplary embodiment of a lighting unit control apparatus **600** for an outdoor lighting network in accordance with the invention. The lighting unit control apparatus can be implemented in a processor, microprocessor, computer, embedded system, or any other electronic device with access to the user and the central control apparatus. The lighting unit control apparatus can be located conveniently in or near the lighting units, such as in a luminaire/fixture, a ballast, an LED driver, an LED panel, a light pole, an associated software/electronics module, or the like. The lighting unit control apparatus can be used to control an individual lighting unit or a group of lighting units. The light unit control apparatus can also be used to control the transmission of lighting control service advertisements to users within its coverage area, where its coverage area may include coverage of the lighting signal, and coverage of any other communication signal that is transmitted by the lighting unit.

[00076] Referring to **FIG. 7,** the lighting unit control apparatus **600** can receive a resolved control request from and enables user(s) **602** to have a predetermined degree of control over certain features of one or more lighting units in an outdoor lighting network **604.** The lighting unit control apparatus **600** includes a processor **610;** a memory **620** operably connected to the processor **610,** the memory **620** storing lighting unit verification data of the lighting unit; and a communication module **630** operably connected to the processor **610** for communication between the user(s) **602** and the outdoor lighting network **604.** The lighting unit verification data is stored at the lighting unit and can include information such as local preauthorization data, a lighting unit ID, lighting unit use information, current clock time, digital signature or other pre-authentication information, or the like.

[00077] The processor **610** is operable to receive the resolved control request through the communication module **630,** the resolved control request being authenticated and

prioritized, e.g., being authenticated and prioritized before reaching the processor; determine whether the resolved control request is valid using the lighting unit verification data; and execute the resolved control request when the resolved control request is valid to control the lighting unit in accordance with the resolved control request. In one embodiment, the communication module **630** is operable to transmit lighting unit status from the lighting unit as well as receiving the resolved control request.

[00078] In one embodiment, the resolved control request is a local preauthorization resolved control request to allow the user to control the lighting unit directly. In one embodiment, the light unit verification data includes local preauthorization data (e.g., a key) which is pre-set by the central control apparatus as the result of a preauthorization process between the user control apparatus and the central control apparatus. For example, in order to use direct local light control, a user can first perform pre-authorization with the central control apparatus by sending a local preauthorization control request to the central control apparatus. If the user is authorized, the central control apparatus assigns a preauthorization key to the user and distributes a corresponding preauthorization key (which can be the same as or different from the preauthorization key provided to the user depending on the security scheme) to the lighting units in the area of interest by sending a local preauthorization resolved control request to the lighting units. The user can then use the preauthorization key to encrypt a user control request and generate a local user control request. The lighting unit control apparatus can use the light unit verification data (including the corresponding preauthorization key) to verify the local user control request, which is received directly from the user. In one embodiment, at least a portion of the memory **620** is tamper resistant, such as read-only memory (ROM), password protected memory, or the like, with the protected data encoded in the tamper resistant memory. When the tamper resistant memory is writeable, the protected data can be updated using a handshake protocol, such as with a handshake protocol with the central control apparatus or other update (commissioning) apparatus. Examples of data which can be treated as protected data include one or more of the following: lighting unit

identification, lighting unit verification data to determine the validity of the local user control request (e.g., the encryption key) received directly from a user or the resolved control request received from the central control apparatus, and/or a lighting use code that specifies the light level requirements for certain areas during certain periods.

[00079] In one embodiment, the lighting unit control apparatus **600** is operable to generate lighting control service advertisement signals that describe the type, and characteristics of the service provided by the OLN to the users and the required capabilities for users to access the service. The service advertisement can be transmitted through the communication module **630** and/or by modulating the light from a lighting unit in such a way to carry the service advertisement information. In one embodiment, the processor **610** is operable to direct the communication module **630** to transmit a service advertisement.

[00080] In one embodiment, the lighting control service advertisement can include one or more of a service identification code, service mode, service accounting options, and service specific information. The service identification code uniquely identifies the type of service, e.g., control of certain lighting characteristics in an area of interest. The service mode describes the alternative ways in which the service can be provided to users. For instance, a lighting control service could be provided as open service where any user could access it, or as a restricted service that is available only to certain group of users. The service accounting option identifies whether the service is offered free of charge or whether any specific charging mode is used. The service specific information may include any capabilities (hardware and/or software) and requirements needed by the user in order to access the service.

[00081] In one embodiment, the lighting unit control apparatus **600** includes one or more local sensors **640** operably connected to the processor **610**. For example, an ambient light sensor can be provided as a local sensor detecting the ambient light level at the lighting unit. Such an ambient light sensor can be used to provide fall-back control when communication to the lighting unit control apparatus is lost, with the lighting unit being turned

on when the ambient light sensor detects that it is dark. Other local sensors can include weather sensors, traffic sensors, presence detection sensors, and/or object recognition sensors.

[00082] The processor **610** can be any type of device that can perform one or more of the following: create instructions, execute instructions, and/or process data in accordance with instructions. In one example, the processor is a computer, such as a personal computer, server, or the like. The memory **620** can be any type of memory capable of storing data, programs, and/or instructions. Exemplary memory includes random access memory (RAM), read-only memory (ROM), flash memory, magnetic computer storage devices (e.g. hard disks, floppy discs, and magnetic tape), optical discs, and the like. The memory **620** can be used for long term and/or short term storage.

[00083] The communication module **630** can be any type of device that can communicate with the user **602** and/or the outdoor lighting network **604,** such as a ZigBee chip, radio chip with an application layer, application-specific integrated circuit (ASIC), or the like. The communication module **630** can communicate using any desired technology, such as a cellular data communication protocol (e.g., GSM, CDMA, GPRS, EDGE, 3G, LTE, WiMAX), ZigBee protocol operating on top of the IEEE 802.15.4 wireless standard, WiFi protocol under IEEE standard 802.11 (such as 802.11b/g/n), Bluetooth protocol, Bluetooth Low Energy protocol, or the like. In one example, the communication module **630** communicates with the user **602** and/or the outdoor lighting network **604** through a communication system.

[00084] **FIG. 8** illustrates one exemplary method of lighting unit control. The method **700** includes receiving the resolved control request **710** through the communication system, the resolved control request being authenticated and prioritized, e.g., being authenticated and prioritized before reaching the processor; determining whether the resolved control request is valid **720** using the lighting unit verification data; and executing the resolved control request when the resolved control request is valid **730** to control the lighting unit in accordance with the resolved control request. In one embodiment, the method **700** can further include

retaining a previous valid resolved control request **740** when the resolved control request is not valid. In another embodiment, the method **700** can include entering default operation when the resolved control request is not valid. The lighting unit control apparatus can optionally notify the central control apparatus when the resolved control request is not valid. The optional notification can also include the reason why the resolved control request was not valid. Those skilled in the art will appreciate that the criteria for a valid resolved control request can be selected as desired for a particular application. In one embodiment, the lighting unit verification data includes a lighting unit ID which is compared to a lighting unit ID in the resolved control request to determine validity of the lighting unit ID in the resolved control request.

[00085] In one embodiment, the lighting unit verification data includes lighting unit use information which is compared to lighting unit use instructions in the resolved control request to determine validity of the lighting unit use instructions to be carried out by the lighting unit. In one embodiment, the lighting unit verification data includes a current clock time which is compared to a command creation time in the resolved control request to determine validity of the resolved control request from whether the command creation time is out-of-date. In one embodiment, the lighting unit verification data includes the digital signature or other pre-authentication information to authenticate the local user control request received directly from the user control apparatus. The lighting unit control apparatus receives pre-authentication information from the central control apparatus once the user control apparatus and the central control apparatus establishes the local preauthorization.

[00086] **FIGS. 9 & 10,** in which like elements share like reference numbers with **FIG. 2** and with each other, are schematic diagrams of applications of an outdoor lighting network control system in accordance with the invention. **FIG. 9** illustrates the use of the outdoor lighting network control system in the pursuit of a vehicle by the police and **FIG. 10** illustrates the use of the outdoor lighting network control system in lighting an accident scene and transporting victims to the hospital on an ambulance.

[00087] Referring to FIG. 9, the user 102 is the police with user control apparatus in a police vehicle in pursuit of another vehicle 106. In this example, it is late night and the lighting units 142 in an area of interest 150 within the outdoor lighting network are dimmed for energy savings. The police (user 102) would like to increase the lighting level in the area of interest 150 to provide a better view of the vehicle 106 being pursued and to provide increased visibility for the safety of anyone in the path of the pursuit.

[00088] In one embodiment, the user control apparatus used by the user 102 can detect the availability of the lighting control service in the area by receiving information from the public safety communication network 112 or from the lighting units 142. Once availability of the service is detected the user control input interface at the user control apparatus can be enabled automatically, such that the user will be able to identify whether the user control capability is available in the area. When service advertisement is available, it can enable the capability at the user control input interface, e.g., an icon can appear, telling the user that the service is actually supported, as not all lighting systems may support these features.

[00089] In this application, the user 102 following the vehicle 106 sends a control request 104 to the light management server 120, which is the central control apparatus, through the public safety communication network 112. The control request 104 includes user authentication data, area of interest, illuminance requirements, and operation schedules. The user authentication data can be a user ID for the user 102 and/or a digital signature for the control request 104 which is encrypted by the user's secret private key. The lighting units in the area of interest 150 provide light around the user 102 and vehicle 106, and ahead of the user 102, with the area of interest 150 constantly changing geographical location in the outdoor lighting network and moving ahead of the user 102. A user control apparatus accompanying the user 102 can calculate the area of interest 150 based on the location and velocity of the user 102. In an alternate embodiment, the central control apparatus can track the user's movement and predict the changes in the area of interest in terms of lighting units as the user moves based on the geographical information of the area, the location of the lighting units, and

the possible routes for the user (roads, streets, buildings, etc). Typical illuminance requirements are full intensity, white color, non-flashing state, downward direction to maximize the light on the roadway in the area of interest **150**. The operation schedule can cover the duration of the police pursuit, i.e., starting with the time of sending the control request **104** and continuing until a predetermined conservative time period passes, until the velocity of the user **102** is reduced below a predetermined velocity or is zero, and/or until the user **102** manually cancels the control request by submitting a new control request. Those skilled in the art will appreciate that the user authentication data, area of interest, illuminance requirements, and operation schedules in the control request **104** can be manually input by the user **102**, can be input by voice commands by the user **102**, can be selected by the user **102** from preprogrammed options provided by a user control apparatus or can be calculated by the central control apparatus.

[00090] In this embodiment, the light management server **120** authenticates and prioritizes the control request **104** and generates a resolved control request **132**. The control request **104** includes user authentication information, an area of interest, illuminance requirements, and operation schedules. The light management server **120** authenticates the control request **104** from the user **102** using user authentication information stored in the light management server **120**. For example, the light management server **120** stores the user's public key and can use the user's public key to decipher the digital signature for the control request **104** which is encrypted by the user's secret private key, thereby validating the identity of the user and proving the integrity of the control request (i.e., proving the control request has not been tampered with). In addition to public-private-key cryptography, symmetric key algorithms can be also used for authentication. Symmetric key algorithms may require a secure initial exchange of one or more secret keys to both light management server **120** and the user **102**.

[00091] Conflicts between the control request of the user **102** and other users are resolved by user priority using user priority information stored in the light management server

120 to generate a resolved control request, which governs lighting unit operation in the area of interest. The user in this application is the police in pursuit of a vehicle, so the user priority is high, only being outranked by a system administrator. As such, the control request 104 should be the resolved control request. Conflicts between users can be also resolved by other priority factors instead of or in addition to the user priority. Other exemplary priority factors, besides user priority, include event priority (e.g., emergency response vs. energy efficiency vs. city beautification), time of use priority, order of control request receipt priority, and the like. The various priority factors can be weighted in resolving the conflicts among control requests so that the weighting of the individual priority factor can be from zero to a controlling level as desired for a particular application.

[00092] The light management server 120 also identifies lighting units 142 within the area of interest 150 of the resolved control request and schedules resolved control requests for those lighting units 142 in accordance with the illuminance requirements and operation schedules of the resolved control request. The resolved control requests are transmitted through the wide area network (WAN) 114 and lighting control gateway 116 to the outdoor lighting units 142 in the area of interest 150 per the scheduled operation. In one embodiment, the lighting management server 120 can also indentify changes in the area of interest as the user moves and can predict which new lighting units are likely to be included in the area of interest as the user moves. The prediction of lighting units to be included in the area of interest and controlled according the user request can be based on the geographical information of the area, the location of the lighting units and the possible routes for the user (roads, streets, buildings, etc) and location of the user.

[00093] The outdoor lighting units 142, which include lighting unit control apparatus, then operate in accordance with the control request. Each of the outdoor lighting units 142 in the area of interest 150 receives a resolved control request, determines whether the resolved control request is valid, and executes the resolved control request when the resolved control request is valid. In one embodiment, each of the outdoor lighting units 142 operates

independently. In another embodiment, at least some of the outdoor lighting units **142** operate as lighting group units. The net result is that the outdoor lighting network provides a moving area of interest **150** ahead of the police (user **102)** with the outdoor lighting units **142** in the area of interest **150** fully lit to provide a better view of the vehicle **106** being pursued and to provide increased visibility for the safety of anyone in the path of the pursuit.

[00094] As the user moves and the lighting units within the area of interest change, the central controller can track the user's location and predict the new lighting units to be included in the changing area of interest and send control requests to such new lighting units in the most likely route(s) the user is expected to take. Alternatively, as the user moves, the user control apparatus can also calculate its relative position with respect to the outdoor lighting network by detecting signals from the outdoor lighting network (e.g., service advertisement signals) and may also forward this location information periodically to the outdoor lighting network central control apparatus. In one embodiment, the user control apparatus can use a sensor to decode information that uniquely identifies a lighting unit that is transmitted as coded visual light. The user can transmit this information to the outdoor lighting network control center that can track the relative position to the outdoor lighting network and predict possible routes for the user using geographical information of the area and the location of the lighting units. By combining user location information with respect to the outdoor lighting network with geographical information of the area (e.g., city maps), the location of the lighting units and the possible routes for the user (roads, streets, buildings, etc.) the lighting manager server can calculate the changes in terms of lighting units and control them accordingly (by sending control requests before the user enters their coverage area) to maintain a moving area of interest as the user moves.

[00095] Some applications require that the user control the lighting units quickly: there is not time to send a control request to a light management server and wait for the light management server to process the request and send the resolved control request to the lighting units. For example, the police can observe a crime in progress and need lighting

immediately. In one embodiment, the user can be preauthorized to control lighting units locally and directly, as an alternative to or in addition to the outdoor lighting network control system discussed above for **FIG. 9**. In addition, the user control apparatus can automatically detect the availability of the direct lighting control service in the area by receiving information from the outdoor lighting network or from another communication network. When this capability is supported, the user control apparatus can enable service on the OLN control system to the user, who will know beforehand whether the OLN control system is available in a particular area.

[00096] The local preauthorization control request can be processed in the same manner as the control request discussed above for **FIG. 9**. In addition to the user authentication data, area of interest, illuminance requirements, and operation schedules, the local preauthorization control request includes a local preauthorization request flag. After the local preauthorization control request has been authenticated and prioritized, the light management server sends a local preauthorization resolved control request to the lighting units in the outdoor lighting network. The local preauthorization resolved control request authorizes a user to have a predetermined degree of control over certain features of certain lighting units through direct communication with the lighting units. The local preauthorization resolved control request includes the verification data such as digital signature or key to allow the lighting unit control apparatus to authenticate the control request received directly from the particular user control apparatus.

[00097] One example of an application of local preauthorization control is the police pursuit discussed above for **FIG. 9**. Rather than controlling the lighting units in the area of interest through the light management server, the police can be preauthorized to controlling the lighting units by communicating directly with the local lighting units. When the service advertisement and discovery capabilities are supported by the outdoor lighting network and user control apparatus, the user control apparatus can detect and inform the user whether the lighting control service is available or what lighting services are available at the user's current

location. As the police initiate the pursuit, the police as user send a local command request to the local lighting units requesting lighting with full intensity, white color, non-flashing state, and downward direction to maximize the light on the roadway. The local lighting units determine whether the local command request is valid based on local preauthorization information stored at the local lighting unit, and executes the local command request when the local command request is valid. The user can continue to send additional local command requests as the pursuit proceeds, so that a series of the local lighting units provide light along the path of the pursuit.

[00098] Alternatively, the lighting units can forward control requests received from the user to other lighting units that are not within the current area of interest but are likely to be part of the area of interest as the user moves. In another embodiment, once lighting units receive a direct control request, they can inform the lighting manager server, which can predict the candidate lighting units to be included in a moving area of interest as the user moves. The lighting manager server can also forward pre-authorization information to the candidate lighting units such that when they receive a local user control request from the user, the authentication and verification process of the request can be minimized or avoided, reducing the authorization/authentication processing overhead.

[00099] Those skilled in the art will appreciate that the control request for local preauthorization need not come from the user directly. In one embodiment, an administrator can make the local preauthorization control request on behalf of one or a group of users directly at the light management server, which then sends the local preauthorization resolved control request to the lighting units.

[000100] **FIG. 10** illustrates the use of the outdoor lighting network control system in lighting an accident scene and the roadway to assist in transporting victims to the hospital in an ambulance. The user **103** is an emergency medic in an ambulance with user control apparatus transporting victims to the hospital **170.** In this example, it is late night and the lighting units

142 in an area of interest **150, 151** within the outdoor lighting network are dimmed for energy savings. The emergency medic (user **103)** would like to increase the lighting level in the area of interest **150** to provide a better view ahead of the ambulance and to provide increased visibility for the safety of anyone along the route. The role of the emergency medic in this example is similar to the role of the police as discussed for **FIG. 9.** In **FIG. 10,** a second user **183** is the police at an accident scene **180.** The police (second user **183),** also with user control apparatus, would like to increase the lighting level in the area of interest **151** at the accident scene **180** to assist emergency responders (fire personnel **184)** and crash victims **186.**

[000101] Assuming that the second user **183** is the first to the accident scene **180,** the second user **183** sends a control request **105** to the light management server **120** through the public safety communication network **112.** In this example, the light management server **120** is connected to the public safety communication network **112** through the wide area network (WAN) **114.** The control request **105** includes user authentication data, area of interest, illuminance requirements, and operation schedules. The user authentication data can be a user ID for the second user **183** and/or a digital signature for the control request **105** which is encrypted by the user's encryption key. The area of interest **151** for the second user **183** provides light around the second user **183** at the accident scene **180.** The illuminance requirements are full intensity, white color, non-flashing state, downward direction to maximize the light on the roadway in the area of interest **151.** The operation schedule can cover the expected duration of the accident investigation and clean up, i.e., starting with the time of sending the control request **105** and continuing until a predetermined conservative time period passes and/or until the second user **183** manually cancels the control request by submitting a new control request. Those skilled in the art will appreciate that the user authentication data, area of interest, illuminance requirements, and operation schedules in the control request **105** can be manually input by the second user **183** or can be selected by the second user **183** from preprogrammed options provided by a user control apparatus.

[000102] The light management server **120,** which is the central control apparatus, authenticates and prioritizes the control request **105** and generates a resolved control request **133.** The control request **105** includes user authentication information, an area of interest, illuminance requirements, and operation schedules. The light management server **120** authenticates the control request **105** from the second user **183** using user authentication information stored in the light management server **120.** Conflicts between the authenticated control request of the second user **183** and other users are resolved by user priority using user priority information stored in the light management server **120,** which governs lighting unit operation in the area of interest. The users in this application are the emergency medic in an ambulance (user **103)** and the police (second user **183)** at the accident scene **180,** so the user priorities of both the user **103** and the second user **183** are high, only being outranked by a system administrator. As such, the control request **105** should be the resolved control request in the area of interest **151** for the second user **183,** and the control request **104** should be the resolved control request in the area of interest **150** for the user **103.**

[000103] The light management server **120** also identifies lighting units **142** within the area of interest **151** of the resolved control request and schedules resolved control requests for those lighting units **142** in accordance with the illuminance requirements and operation schedules of the resolved control request. The resolved control requests are transmitted through the wide area network (WAN) **114** and lighting control gateway **116** to the outdoor lighting units **142** in the area of interest **151** per the scheduled operation.

[000104] The outdoor lighting units **142,** which include lighting unit control apparatus, then operate in accordance with the control request. Each of the outdoor lighting units **142** in the area of interest **151** receives a resolved control request, determines whether the resolved control request is valid, and executes the resolved control request when the resolved control request is valid. In one embodiment, each of the outdoor lighting units **142** operates independently. In another embodiment, at least some of the outdoor lighting units **142** operate as lighting group units. The net result is that the outdoor lighting network provides a

stationary area of interest **151** for the police (second user **183)** with the outdoor lighting units **142** in the area of interest **151** fully lit to increase the lighting level to assist emergency responders (fire personnel **184)** and crash victims **186.**

[000105] **FIG. 10** also illustrates the use of the outdoor lighting network control system in lighting the roadway to assist in transporting victims to the hospital in an ambulance. In this example, the user **103** is an emergency medic in an ambulance transporting victims to the hospital **170.** The emergency medic (user **103)** would like to increase the lighting level in the area of interest **150** to provide a better view ahead of the ambulance and to provide increased visibility for the safety of anyone along the route. The emergency medic (user **103)** controls lighting in a moving area of interest **150** ahead of the ambulance in the same way as the police (user **102)** controlled the lighting in a moving area of interest as discussed for **FIG. 9.**

[000106] Those skilled in the art will appreciate that the outdoor lighting network control system is not limited to public safety applications, but can be used aesthetically for beautification and entertainment. In one example, the lighting units can change brightness, color, and direction throughout the day and evening to light areas of a city to the best effect. In another example, the brightness, color, direction, and flashing state of the lighting units can be changed as an artistic display. In yet another example, the brightness, color, direction, and flashing state of the lighting units can be changed as an artistic display synchronized with a public performance such as music, fireworks, or the like.

[000107] While several inventive embodiments have been described and illustrated herein, those of ordinary skill in the art will readily envision a variety of other means and/or structures for performing the function and/or obtaining the results and/or one or more of the advantages described herein, and each of such variations and/or modifications is deemed to be within the scope of the inventive embodiments described herein. More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions,

materials, and/or configurations will depend upon the specific application or applications for which the inventive teachings is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific inventive embodiments described herein. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, inventive embodiments may be practiced otherwise than as specifically described and claimed. Inventive embodiments of the present disclosure are directed to each individual feature, system, article, material, kit, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or methods are not mutually inconsistent, is included within the inventive scope of the present disclosure.

[000108] All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms.

[000109] The indefinite articles "a" and "an," as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean "at least one."

[000110] The phrase "and/or," as used herein in the specification and in the claims, should be understood to mean "either or both" of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with "and/or" should be construed in the same fashion, i.e., "one or more" of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the "and/or" clause, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, a reference to "A and/or B", when used in conjunction with open-ended language such as "comprising" can refer, in one embodiment, to A only (optionally including elements other than B); in another embodiment, to B only

(optionally including elements other than A); in yet another embodiment, to both A and B (optionally including other elements); etc.

[000111] As used herein in the specification and in the claims, "or" should be understood to have the same meaning as "and/or" as defined above. For example, when separating items in a list, "or" or "and/or" shall be interpreted as being inclusive, i.e., the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as "only one of" or "exactly one of," or, when used in the claims, "consisting of," will refer to the inclusion of exactly one element of a number or list of elements. In general, the term "or" as used herein shall only be interpreted as indicating exclusive alternatives (i.e. "one or the other but not both") when preceded by terms of exclusivity, such as "either," "one of," "only one of," or "exactly one of." "Consisting essentially of," when used in the claims, shall have its ordinary meaning as used in the field of patent law.

[000112] As used herein in the specification and in the claims, the phrase "at least one," in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily including at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifically identified within the list of elements to which the phrase "at least one" refers, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, "at least one of A and B" (or, equivalently, "at least one of A or B," or, equivalently "at least one of A and/or B") can refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including elements other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including elements other than A); in yet another embodiment, to at least one,

optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other elements); etc.

[000113] It should also be understood that, unless clearly indicated to the contrary, in any methods claimed herein that include more than one step or act, the order of the steps or acts of the method is not necessarily limited to the order in which the steps or acts of the method are recited.

[000114] In the claims, as well as in the specification above, all transitional phrases such as "comprising," "including," "carrying," "having," "containing," "involving," "holding," "composed of," and the like are to be understood to be open-ended, i.e., to mean including but not limited to. Only the transitional phrases "consisting of" and "consisting essentially of" shall be closed or semi-closed transitional phrases, respectively, as set forth in the United States Patent Office Manual of Patent Examining Procedures, Section 2111.03.

CLAIMS

1. A control system enabling users to have a predetermined degree of control over certain features of an outdoor lighting network, the system comprising:

a plurality of user control apparatus (30);

a central control apparatus (40);

a lighting unit control apparatus (50); and

a communication system (60) operably connecting the user control apparatus (30), the central control apparatus (40), and the lighting unit control apparatus (50);

wherein:

each of the plurality of user control apparatus (30) is operable to provide a control request in response to input from one of the users;

the central control apparatus (40) is operable to authenticate the control requests from the users, and resolve conflicts between the authenticated control requests for a lighting unit in an area of interest; and

the lighting unit control apparatus (50) for the lighting unit in the area of interest is operable to execute the resolved control request.

2. The apparatus of claim 1 wherein:

each of the plurality of user control apparatus (30) is operable to provide a control request including user authentication data for one of the users; and

the central control apparatus (40) is operable to authenticate the control requests using the user authentication data.

3. The apparatus of claim 2 wherein:

each of the plurality of user control apparatus (30) is further operable to provide a control request including the area of interest of the outdoor lighting network.

4. The apparatus of claim 3 wherein:

each of the plurality of user control apparatus (30) is further operable to provide a control request including illuminance requirements and operation schedules for the area of interest.

5. The apparatus of claim 3 wherein the area of interest is specified by a location identifier selected from the group consisting of GPS coordinates, road/street/area name, zip code, and travel route.

6. The apparatus of claim 1 wherein at least one of the control requests is a local preauthorization control request and the central control apparatus (40) is further operable to transmit a local preauthorization resolved control request through the communication system (60) to the outdoor lighting network to allow the user to directly control lighting units in the area of interest.

7. The apparatus of claim 1 wherein the lighting unit control apparatus (50) for the lighting unit in the area of interest is further operable to determine whether the resolved control request is valid, and execute the resolved control request when the resolved control request is valid.

8. The apparatus of claim 1 wherein the lighting unit control apparatus (50) is operable to transmit a service advertisement, and at least one of the plurality of user control apparatus (30) is operable to detect the service advertisement.

9. A user control apparatus enabling a user to have a predetermined degree of control over certain features of lighting units in an area of interest of an outdoor lighting network, the apparatus comprising:

a processor (210);

a memory (220) operably connected to the processor (210), the memory (220) storing user authentication data of the user; and

a communication module (230) operably connected to the processor (210) for communication between the user and the outdoor lighting network;

wherein the processor (210) is operable to:

provide a control request including the user authentication data; and

transmit the control request through the communication module (230) to the outdoor lighting network, the lighting units in the area of interest of the outdoor lighting network being controllable by the control request in accordance with permission and priority rules for the user.

10. The apparatus of claim 9 wherein the processor (210) is further operable to determine the area of interest in the outdoor lighting network and include the area of interest in the control request.

11. The apparatus of claim 9 wherein the processor (210) is further operable to detect a service advertisement received at the communication module (230).

12. The apparatus of claim 10 wherein the area of interest is identified by a location identifier selected from the group consisting of GPS coordinates, road/street/area name, zip code, and travel route.

13. The apparatus of claim 10 wherein the area of interest is determined by the processor from actual user location.

14. The apparatus of claim 10 wherein the area of interest is determined by the processor from expected user location.

15. The apparatus of claim 10 wherein the processor (210) is further operable to determine illuminance requirements and operation schedules for the area of interest, and include the illuminance requirements and the operation schedules in the control request.

16. The apparatus of claim 15 wherein the illuminance requirements are designated by a mode number.

17. The apparatus of claim 15 wherein the illuminance requirements are selected from the group consisting of intensity, uniformity, color, flashing state, direction, beam formation, beam shaping, and scene setting.

18. The apparatus of claim 9 wherein the control request is a local preauthorization control request to allow the user to directly control the lighting units in the area of interest.

19. The apparatus of claim 9 wherein the control request is secure.

20. The apparatus of claim 9 wherein the control request is further associated with a user priority level.

21. The apparatus of claim 9 further comprising an input device (240) operably connected to the communication module (230) to allow the user to manually input at least one of the user authentication data, the area of interest, illuminance requirements, and operation schedules.

22. The apparatus of claim 9 further comprising an input device (240) operably connected to the communication module (230) to allow the user to select a pre-configured request selectable by the user from a plurality of pre-configured requests.

23. The apparatus of claim 9 further comprising a geolocation module (250) operably connected to the processor (210) to provide a current location of the user.

24. A central control apparatus receiving control requests and enabling users to have a predetermined degree of control over certain features of lighting units in an area of interest of an outdoor lighting network, the apparatus comprising:

a processor (410);

a memory (420) operably connected to the processor (410), the memory (420) storing user authentication information and user priority information; and

a communication module (430) operably connected to the processor for communication with the users and the outdoor lighting network;

wherein the processor (410) is operable to:

receive the control requests from the users through the communication module (430), each of the control requests including user authentication data;

authenticate the control requests from the users using the user authentication data and the user authentication information;

resolve the authenticated control requests for conflicts between the authenticated control requests with the user priority information to determine a resolved control request;

determine the area of interest, illuminance requirements, and operation schedules for the resolved control request;

identify the lighting units of the outdoor lighting network within the area of interest;

schedule operation of the lighting units identified as being within the area of interest in accordance with the illuminance requirements and operation schedules of the resolved control request; and

transmit the resolved control request through the communication module (430) to the lighting units identified as being within the area of interest of the resolved control requests per the scheduled operation, the lighting units identified as being within the area of interest of the resolved control requests and being controllable by the resolved control request.

25. The apparatus of claim 24 wherein each of the control requests further includes a user area of interest and the processor (410) is operable to determine the area of interest for the resolved control request from the control requests.

26. The apparatus of claim 24 wherein each of the control requests further includes the illuminance requirements and the operation schedules and the processor (410) is operable to determine the illuminance requirements and the operation schedules for the resolved control request from the control requests.

27. The apparatus of claim 24 wherein the processor (410) is operable to determine the area of interest for the resolved control request by calculation from the control requests.

28. The apparatus of claim 24 wherein the processor (410) is further operable to resolve the authenticated control requests for event priority.

29. The apparatus of claim 24 wherein the memory (420) further stores user operation restriction information and the processor (410) is operable to restrict the control requests from the users using the user authentication data and the user operation restriction information.

30. The apparatus of claim 29 wherein the user operation restriction information includes limitations on operating parameters selected from the group consisting of the area of interest, the illuminance requirements, and the operation schedules.

31. The apparatus of claim 24 wherein the processor (410) is operable to provide the resolved control request to a format specific to the lighting units of the outdoor lighting network within the area of interest.

32. The apparatus of claim 31 wherein the processor (410) is operable to provide the resolved control request through a process selected from the group consisting of parsing, down-selecting, prioritizing, modifying, and fusion.

33. The apparatus of claim 24 wherein the processor (410) is further operable to control the lighting units identified as being within the area of interest of the resolved control requests in accordance with validity of each of the resolved control requests.

34. The apparatus of claim 24 wherein at least one of the control requests is a local preauthorization control request and the resolved control request is a local preauthorization resolved control request to allow at least one of the users to directly control lighting units in the area of interest.

35. The apparatus of claim 24 wherein the communication module (430) includes a user communication module (432) operably connected to communicate between the processor (410) and the user and a light communication module (434) operably connected to communicate between the processor (410) and the outdoor lighting network.

36. The apparatus of claim 24 wherein the memory (420) stores light information (422) for the lighting units of the outdoor lighting network and service management instructions (426), and the processor (410) is further operable to identify the lighting units of the outdoor lighting network within the area of interest of the resolved control request by applying the service management instructions (426) and the light information (422).

37. The apparatus of claim 36 wherein the light information includes light address/locations, cluster IDs, light status, light capabilities/specifications, light use codes, light use policies, current user, and user priority.

38. The apparatus of claim 24 wherein the memory (420) stores light task management instructions (428), and the processor (410) is further operable to schedule control commands for the lighting units identified as being within the area of interest of the resolved control request in accordance with the illuminance requirements and operation schedules of the resolved control request by applying the light task management instructions (228) and the light information (222).

39. The apparatus of claim 38 wherein the service management instructions include user authentication instructions, user request processing instructions, user authorization instructions, user billing instructions, user coordination instructions, and conflict resolution instructions.

40. The apparatus of claim 24 wherein the illuminance requirements are selected from the group consisting of intensity, uniformity, color, flashing state, direction, beam formation, beam shaping, and scene setting.

41. The apparatus of claim 24 wherein the area of interest is specified by a location identifier selected from the group consisting of GPS coordinates, road/street/area name, zip code, and travel route.

42. A lighting unit control apparatus receiving a resolved control request and enabling users to have a predetermined degree of control over certain features of a lighting unit in an outdoor lighting network, the apparatus comprising:

a processor (610);

a memory (620) operably connected to the processor (610), the memory (620) storing lighting unit verification data of the lighting unit; and

a communication module (630) operably connected to the processor (610) for communication between the users and the outdoor lighting network;

wherein the processor (610) is operable to:

receive the resolved control request through the communication module (630), the resolved control request being authenticated and prioritized; and

execute the resolved control request to control the lighting unit in accordance with the resolved control request.

43. The apparatus of claim 42 wherein the resolved control request is a local preauthorization resolved control request to allow the user to directly control the lighting unit.

44. The apparatus of claim 42 wherein at least a portion of the memory (620) is tamper resistant memory.

45. The apparatus of claim 42 wherein the lighting unit verification data includes local preauthorization data which is updated by the central control apparatus as the result of the local preauthorization process between a corresponding user control apparatus and the central control apparatus.

46. The apparatus of claim 42 wherein the processor (610) is further operable to:

determine whether the resolved control request is valid using the lighting unit verification data; and

execute the resolved control request when the resolved control request is valid to control the lighting unit in accordance with the resolved control request.

47. The apparatus of claim 46 wherein the processor (610) is further operable to retain a previous valid resolved control request when the resolved control request is not valid to control the lighting unit in accordance with the previous valid resolved control request.

48. The apparatus of claim 42 wherein the processor (610) is further operable to enter default operation when the resolved control request is not valid.

49. The apparatus of claim 42 wherein the processor (610) is further operable to direct the communication module (630) to transmit a service advertisement.

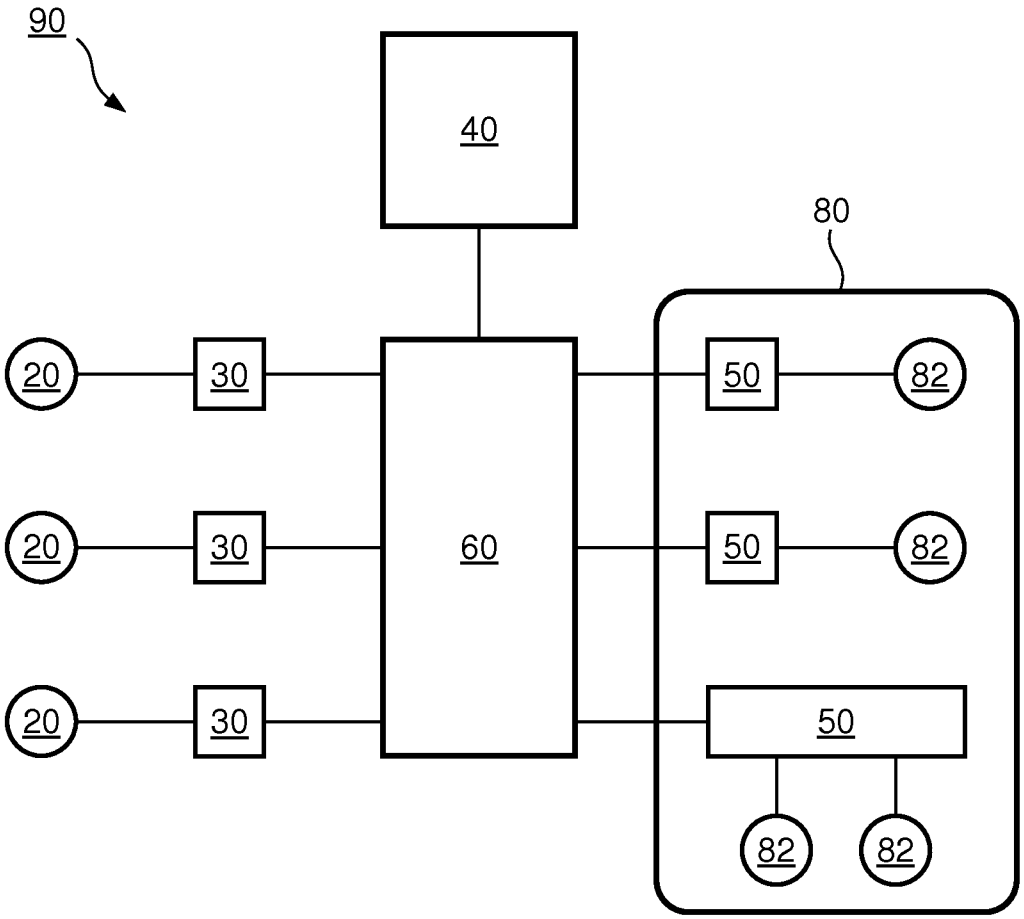

FIG. 1

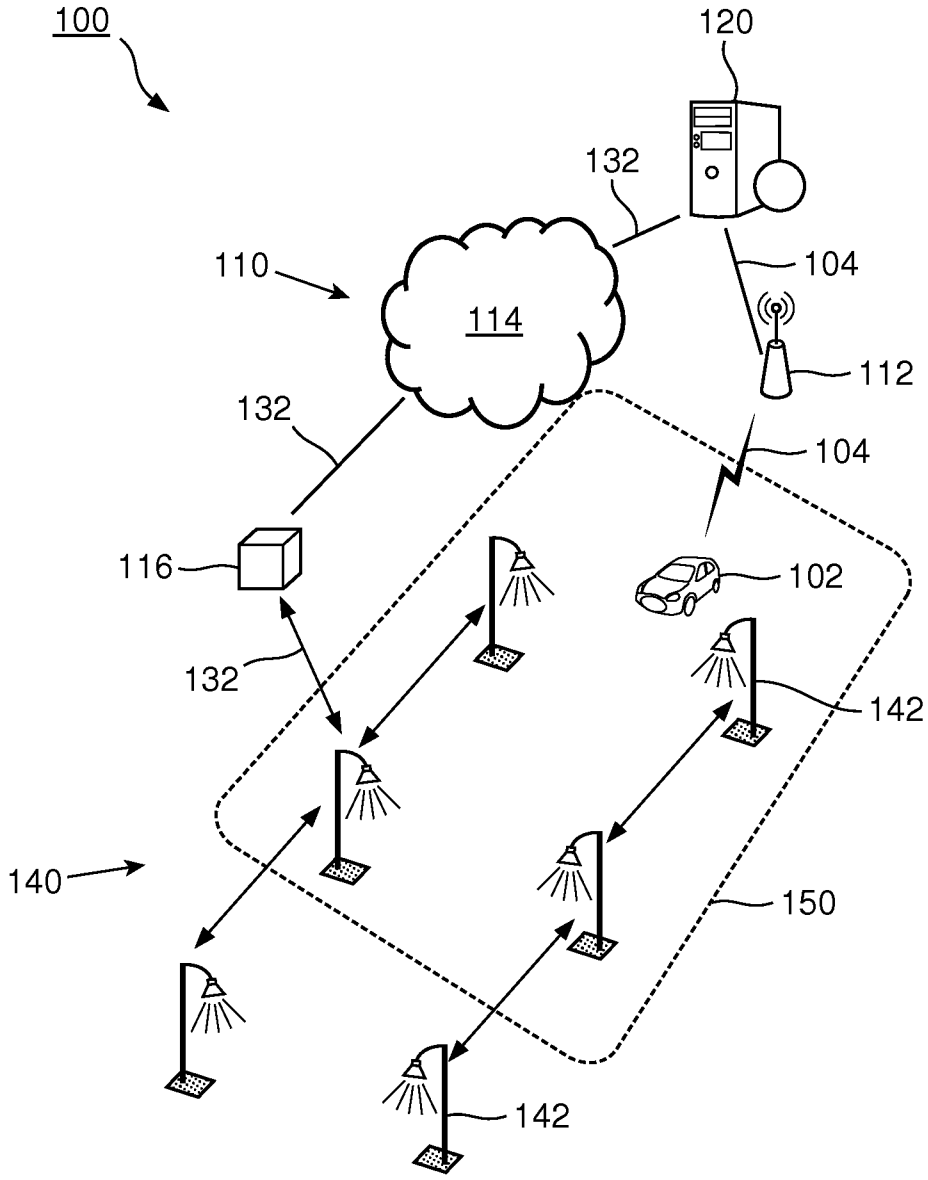

FIG. 2

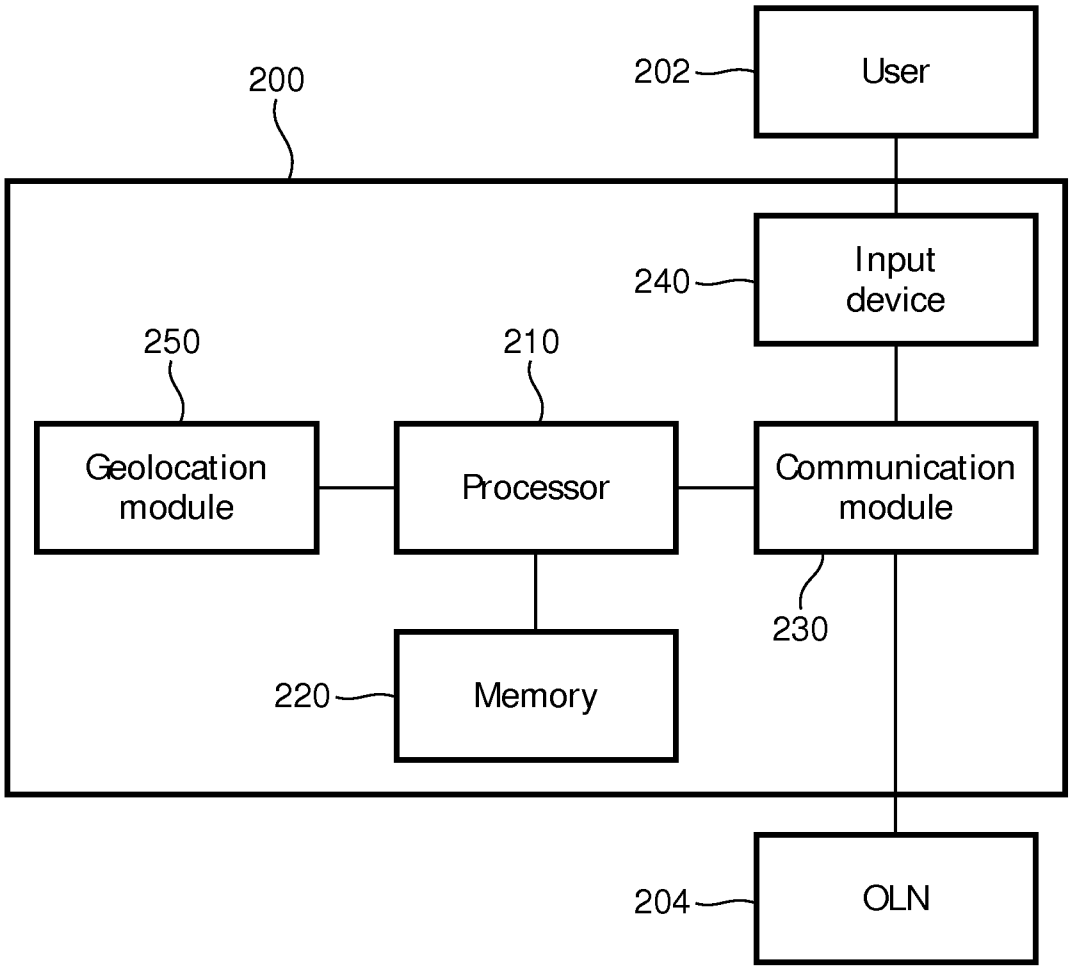
200
202
User
240
Input device
250
210
Geolocation module
Processor
Communication module
230
220
Memory
204
OLN

FIG. 3

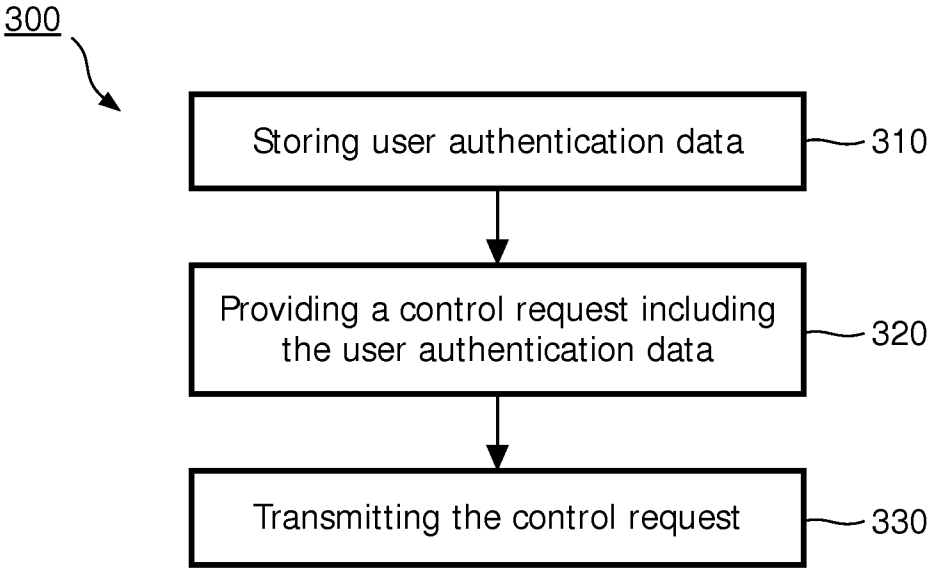
300
Storing user authentication data
310
Providing a control request including the user authentication data
320
Transmitting the control request
330

FIG. 4

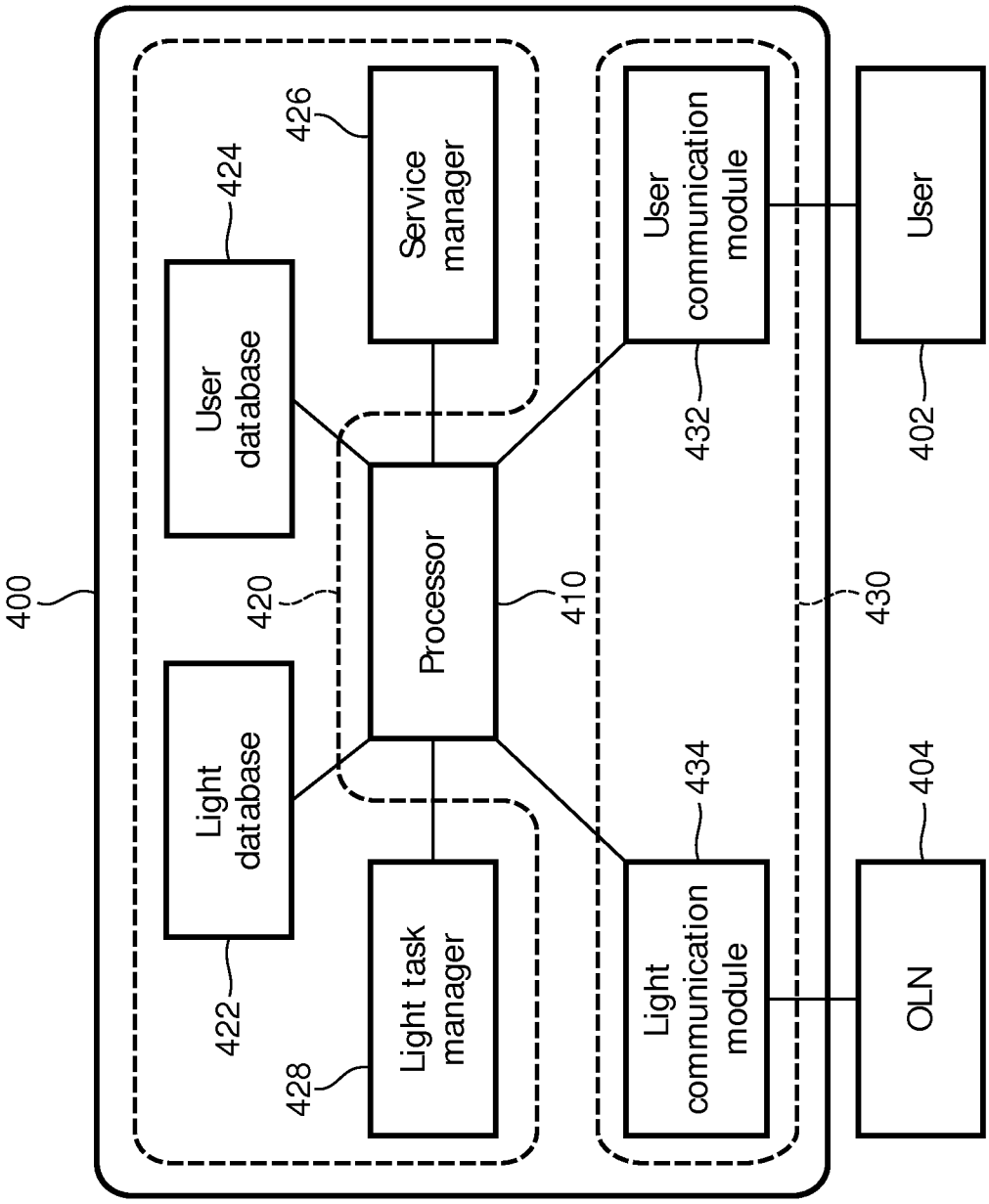
400
420
Processor
410
430
User database
424
Service manager
426
Light database
422
Light task manager
428
User communication module
432
User
402
Light communication module
434
OLN
404

FIG. 5

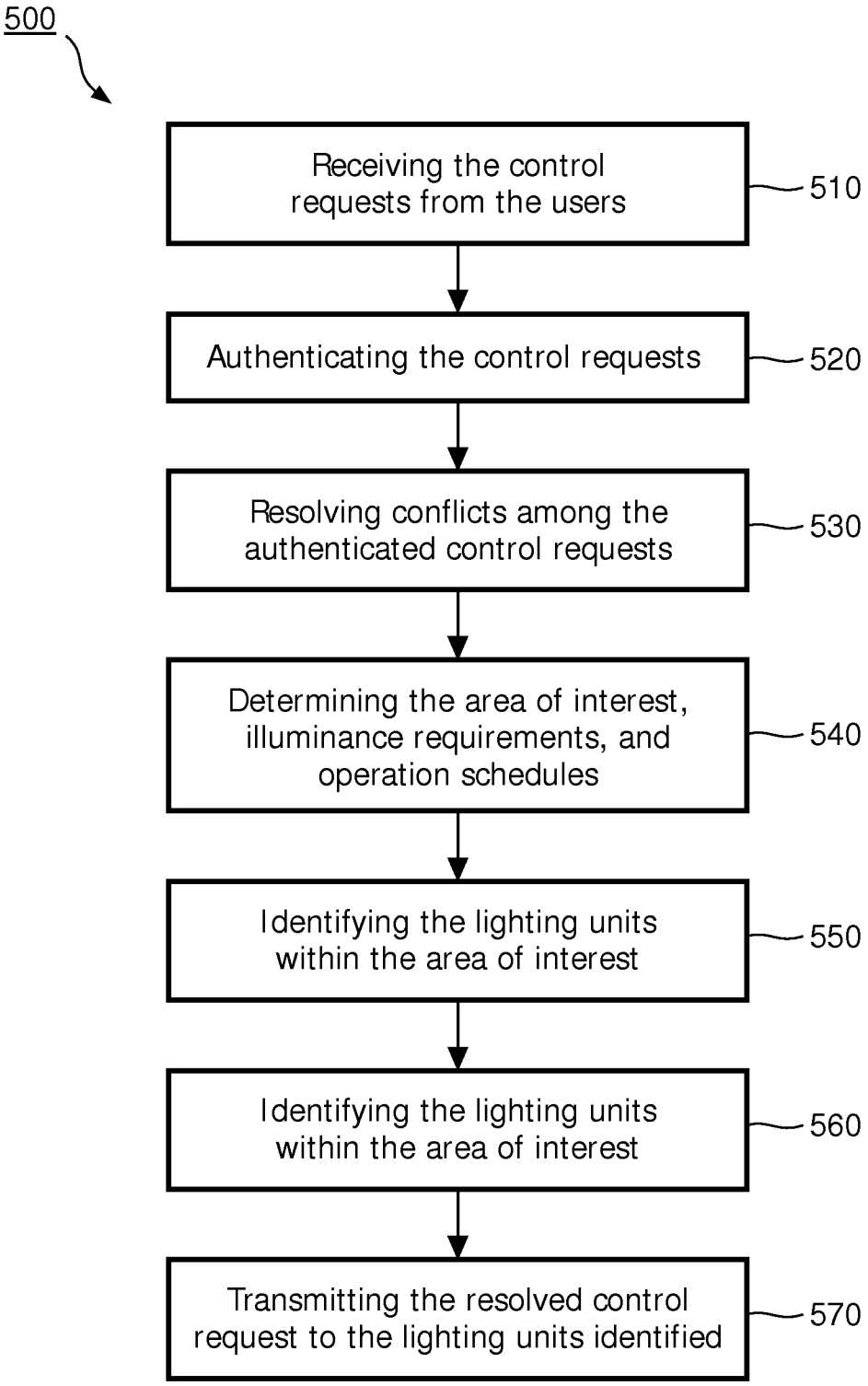
500
Receiving the control requests from the users
510
Authenticating the control requests
520
Resolving conflicts among the authenticated control requests
530
Determining the area of interest, illuminance requirements, and operation schedules
540
Identifying the lighting units within the area of interest
550
Identifying the lighting units within the area of interest
560
Transmitting the resolved control request to the lighting units identified
570

FIG. 6

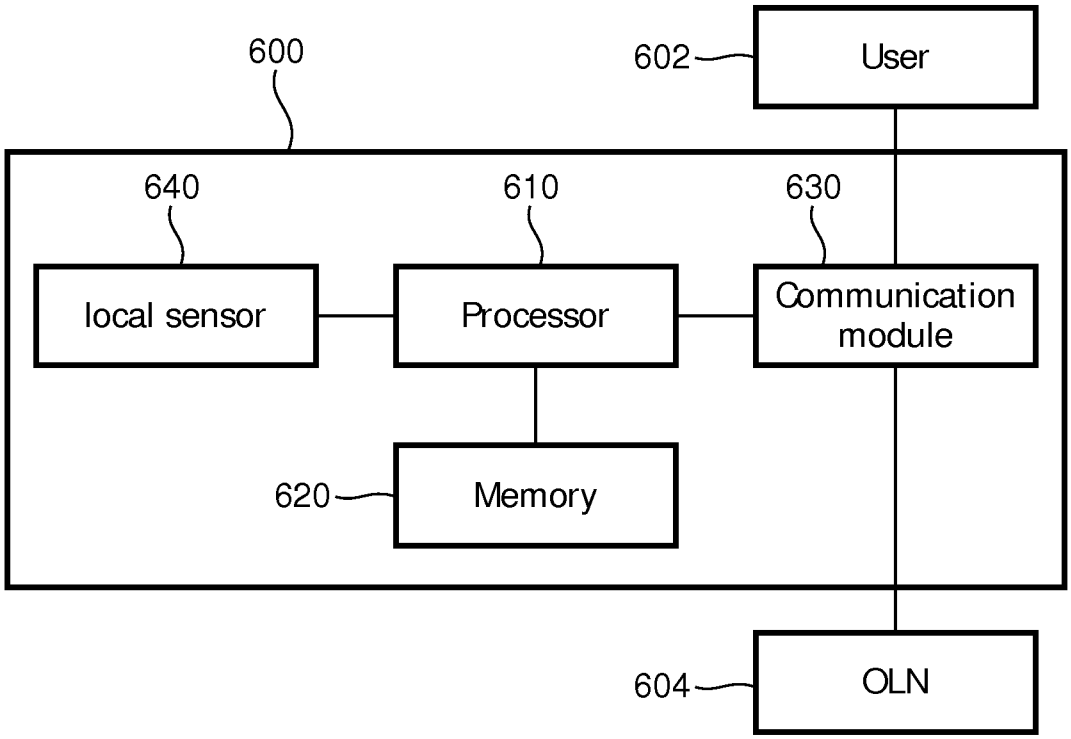
600
602
User
640
610
630
local sensor
Processor
Communication module
620
Memory
604
OLN

FIG. 7

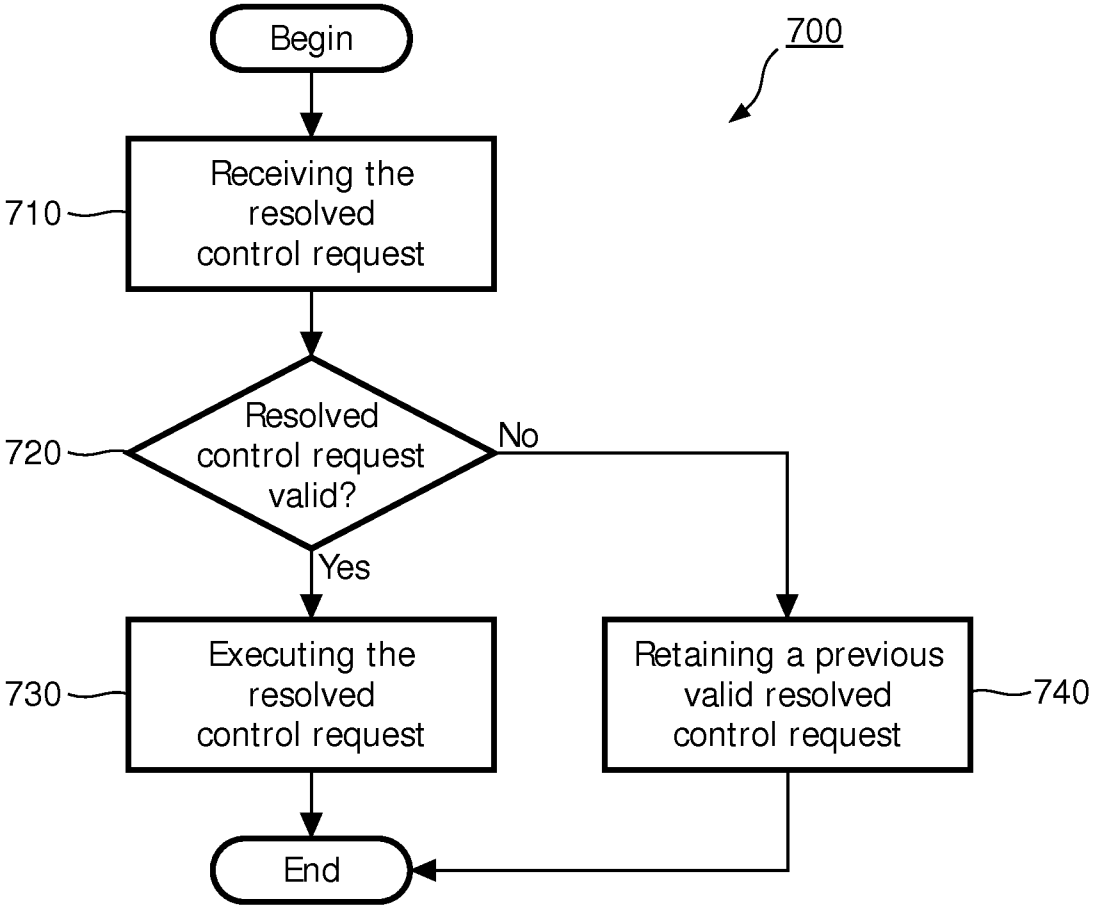
Begin
700
710
Receiving the resolved control request
720
Resolved control request valid?
No
Yes
730
Executing the resolved control request
Retaining a previous valid resolved control request
740
End

FIG. 8

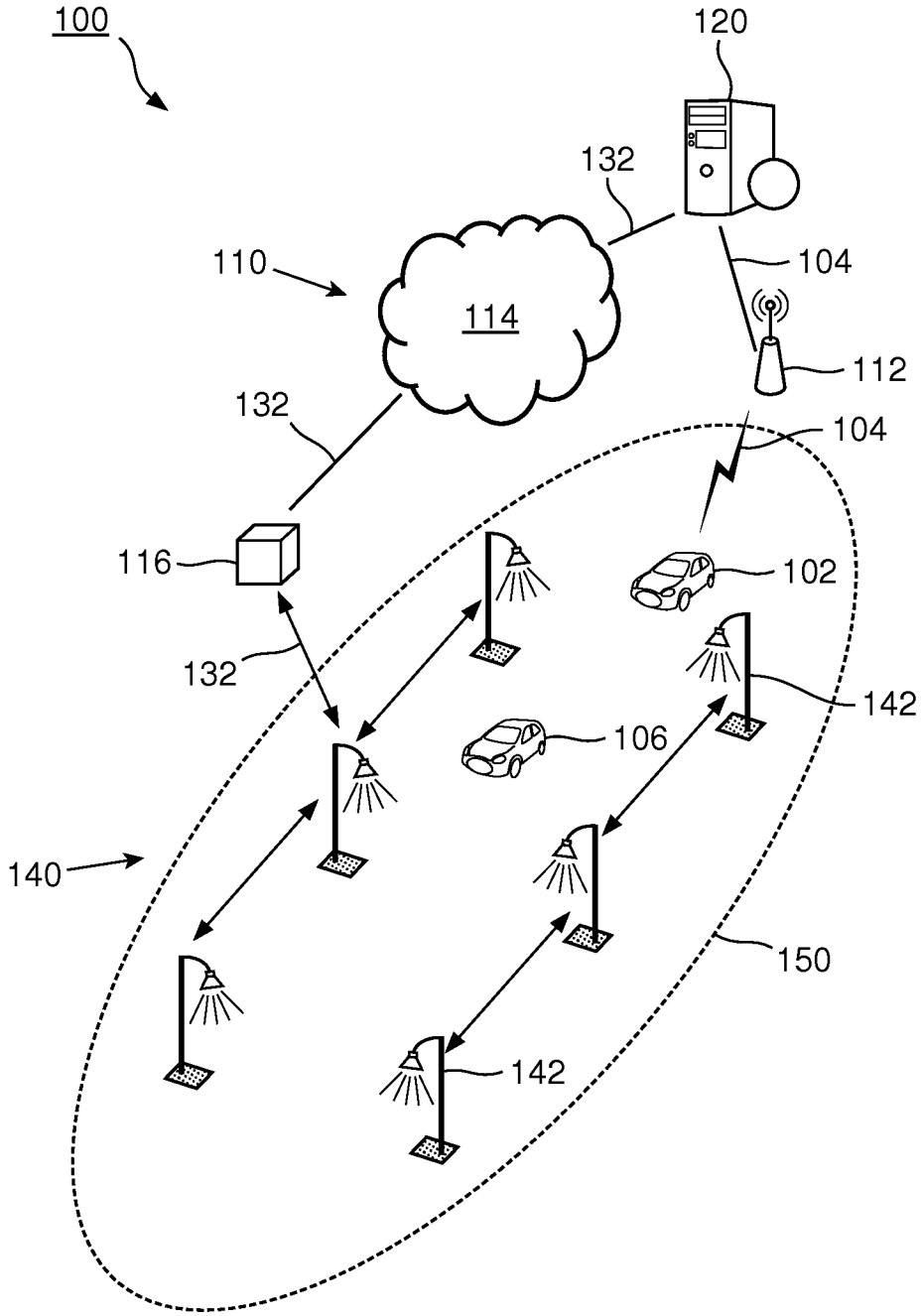
100
120
132
110
114
104
112
132
104
116
102
132
142
106
140
150
142

FIG. 9

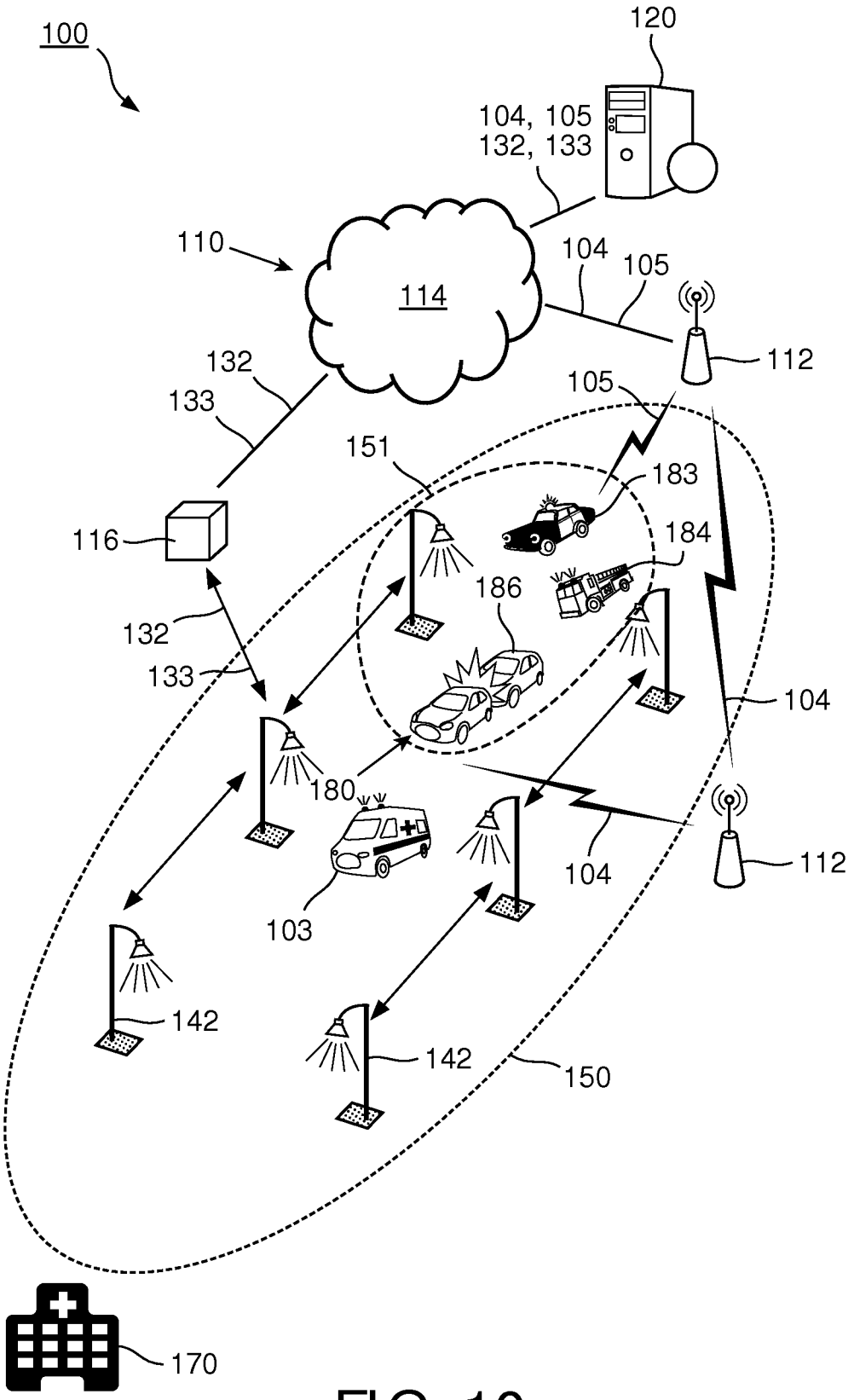
100
120
104, 105
132, 133
110
114
104
105
112
132
133
105
151
183
116
184
186
132
133
104
180
112
104
103
142
142
150
170

FIG. 10