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Koo

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(45) **Date of Patent: Feb. 23, 2016**

(54) **LIGHT-BASED MESSAGING SYSTEMS**

(71) Applicant: **John C. S. Koo**, Los Angeles, CA (US)

(72) Inventor: **John C. S. Koo**, Los Angeles, CA (US)

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(22) Filed: **Jul. 30, 2013**

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/787,737, filed on Mar. 6, 2013, which is a continuation-in-part of application No. 13/559,372, filed on Jul. 26, 2012, now Pat. No. 8,924,255.

(51) **Int. Cl.**
H04L 12/58 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 51/20*** (2013.01)

(58) **Field of Classification Search**
CPC H04B 10/116; H04H 60/90; G01S 1/02; H04W 12/02; H04W 4/023; G06Q 30/0261
See application file for complete search history.

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Prosecution history of parent U.S. Appl. No. 13/787,737.

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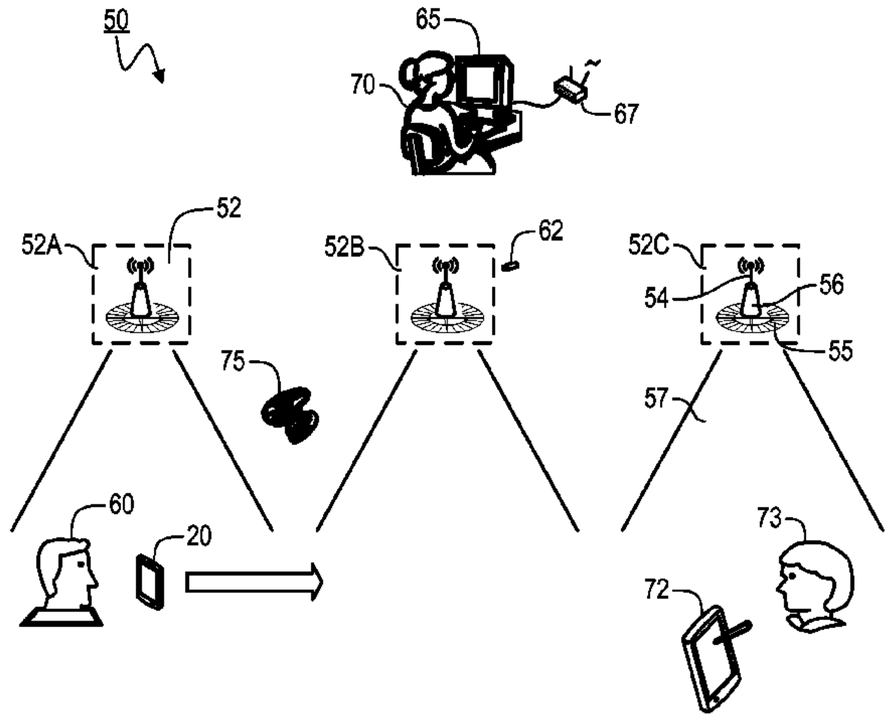
Primary Examiner — Kim T Nguyen
(74) *Attorney, Agent, or Firm* — Joseph G. Swan, P.C.

(57) **ABSTRACT**

Provided are, among other things, systems, methods and techniques for light-based communication. One representative embodiment includes: messaging units disposed at different locations within a space, each including at least one light source (e.g., light-emitting diode or LED); at least one messaging/modulation controller coupled to the light sources and configured to turn the light sources on and off so as to broadcast input digital messages; a central server coupled to the messaging/modulation controller(s) and configured to selectively provide messages to the messaging/modulation controller(s) for broadcast by different messaging units; and an associate device coupled to the central server and configured to: (a) display a user interface for manually inputting information about individuals within the space and (b) provide such information to the central server, where the central server selects messages to be broadcast by the messaging units based on the information received from the associate device.

20 Claims, 12 Drawing Sheets



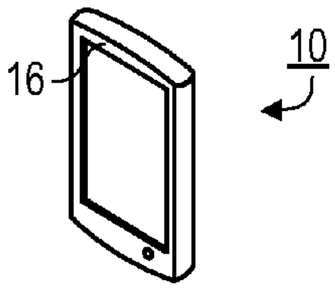


FIG. 1A
(Prior Art)

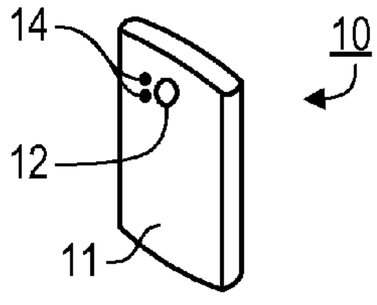


FIG. 1B
(Prior Art)

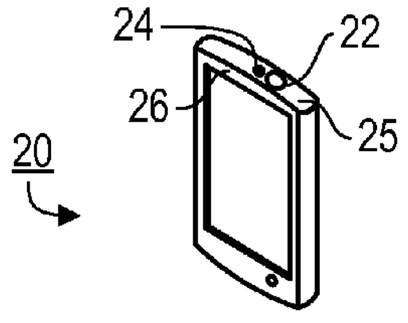


FIG. 2

FIG. 3

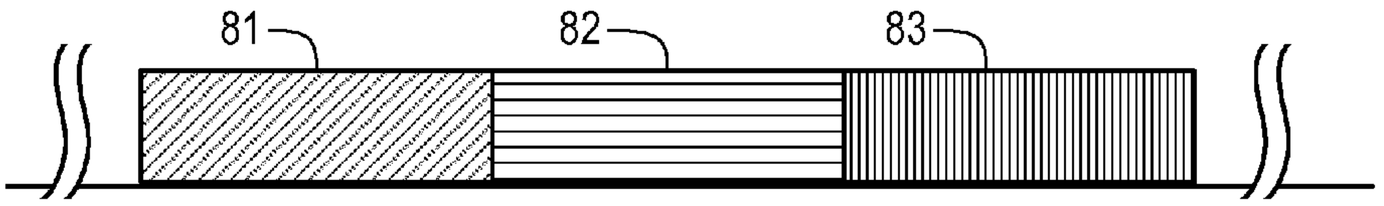


FIG. 4

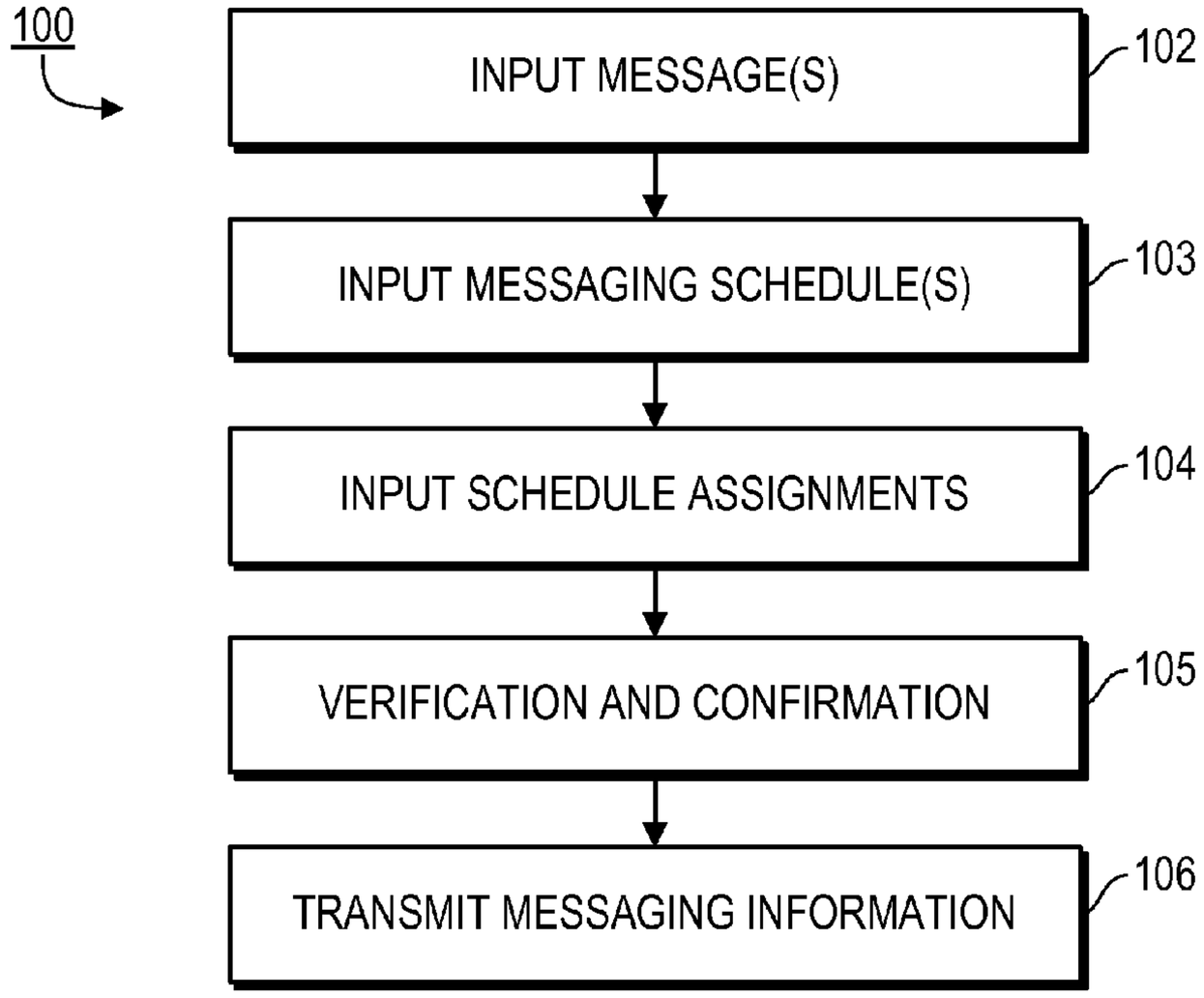

100
INPUT MESSAGE(S)
102
INPUT MESSAGING SCHEDULE(S)
103
INPUT SCHEDULE ASSIGNMENTS
104
VERIFICATION AND CONFIRMATION
105
TRANSMIT MESSAGING INFORMATION
106

FIG. 5

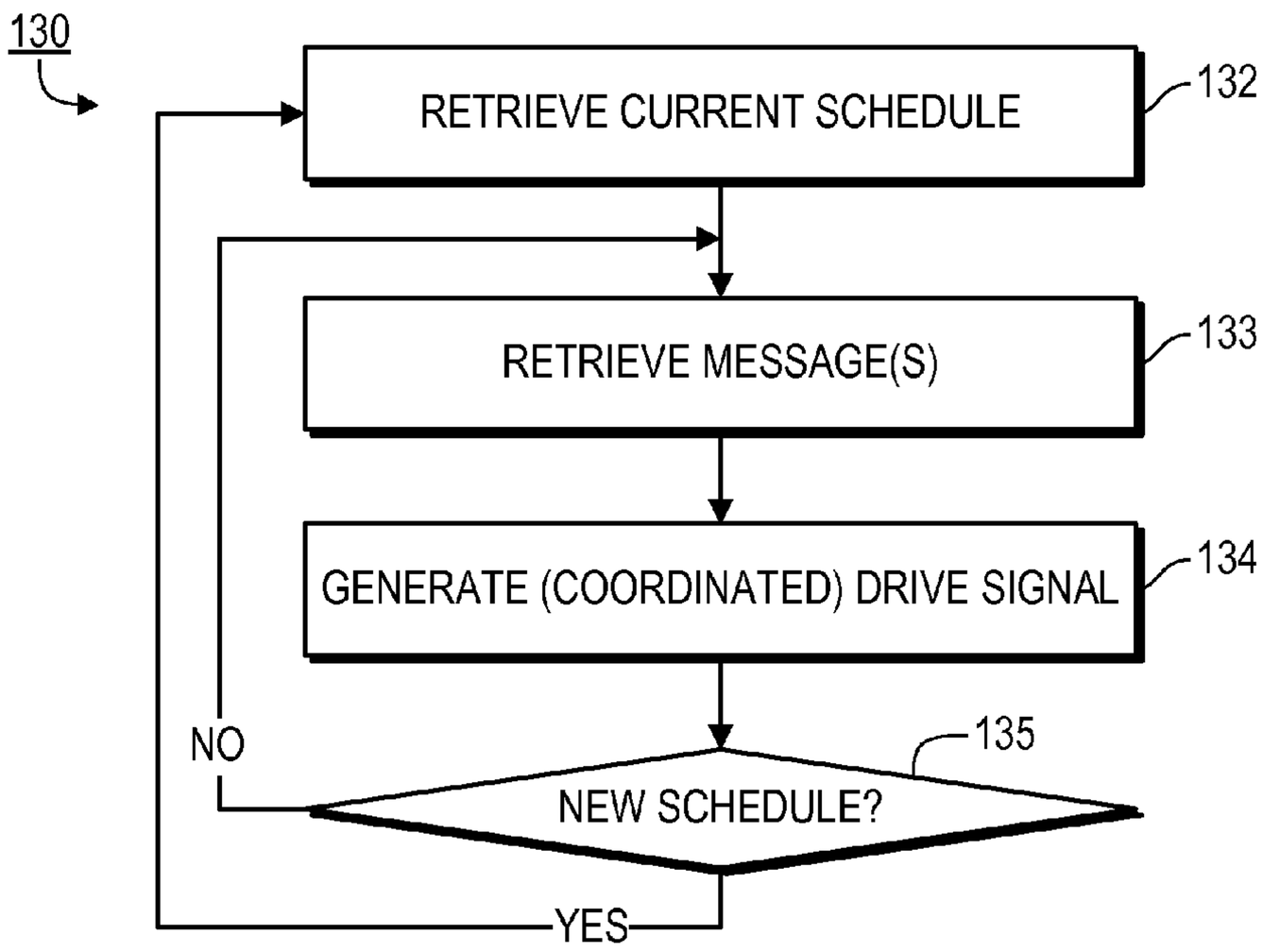

130
RETRIEVE CURRENT SCHEDULE
132
RETRIEVE MESSAGE(S)
133
GENERATE (COORDINATED) DRIVE SIGNAL
134
NEW SCHEDULE?
135
NO
YES

FIG. 6

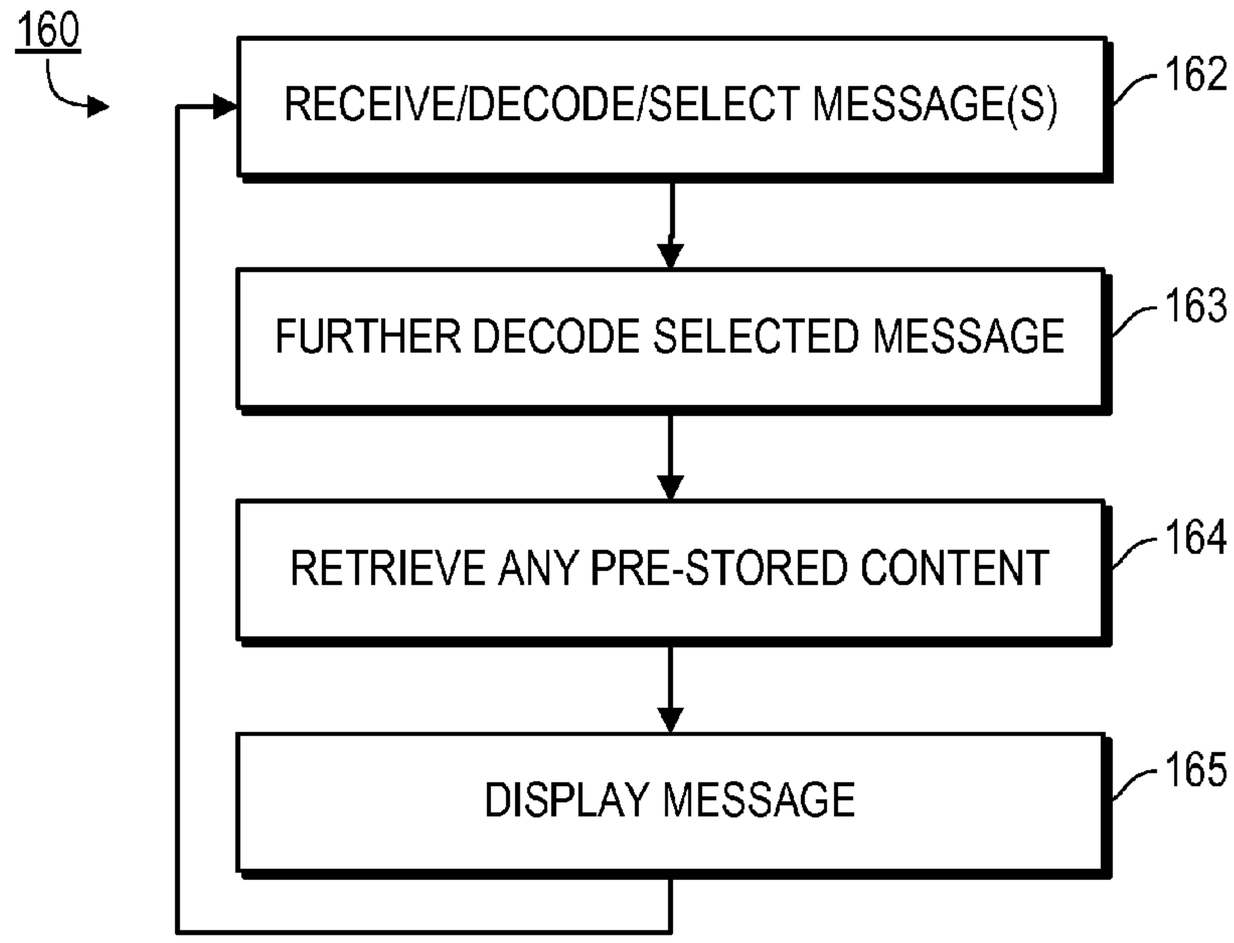

160
RECEIVE/DECODE/SELECT MESSAGE(S)
162
FURTHER DECODE SELECTED MESSAGE
163
RETRIEVE ANY PRE-STORED CONTENT
164
DISPLAY MESSAGE
165

FIG. 7

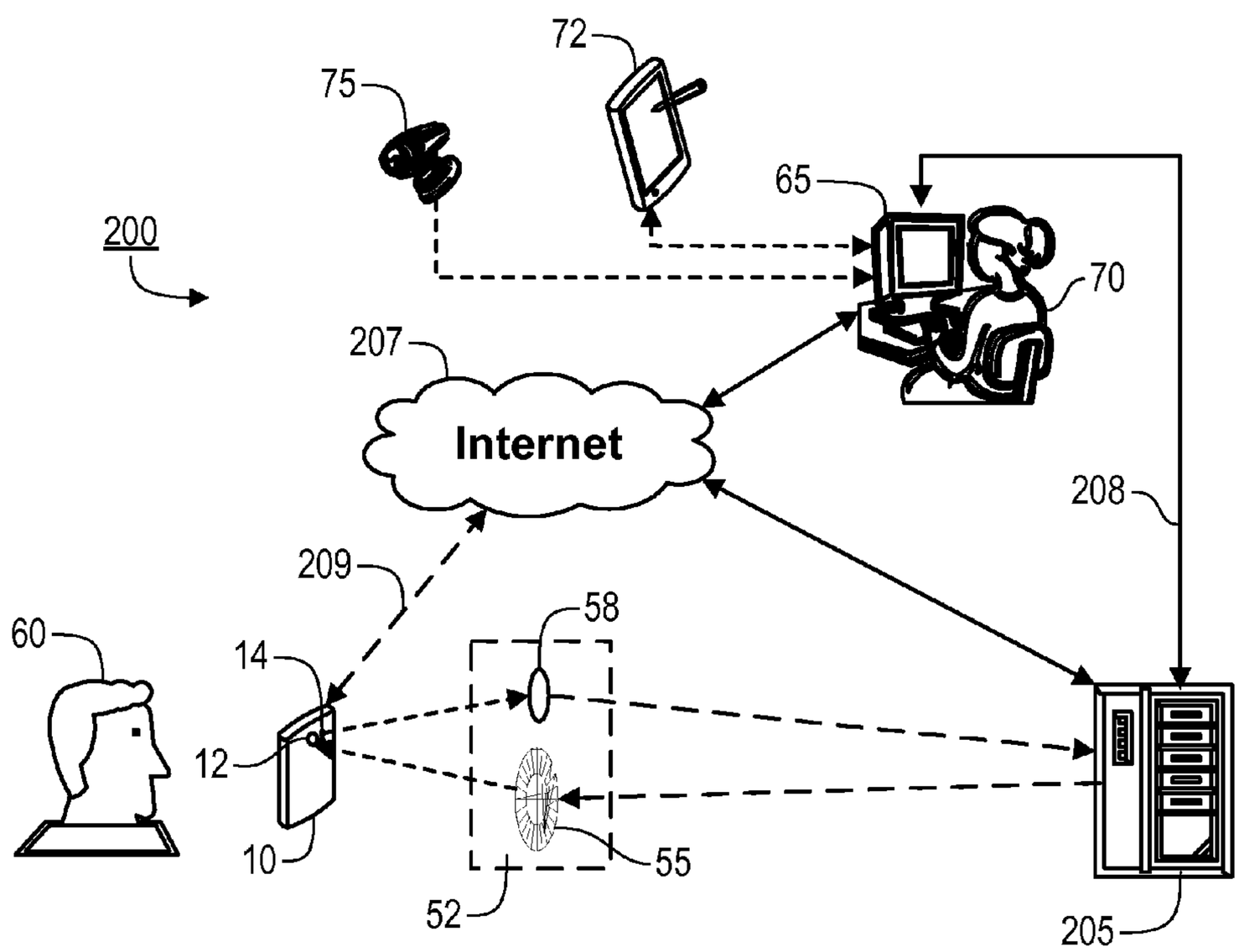

72
75
65
200
70
207
Internet
208
209
58
60
14
12
10
55
52
205

FIG. 8

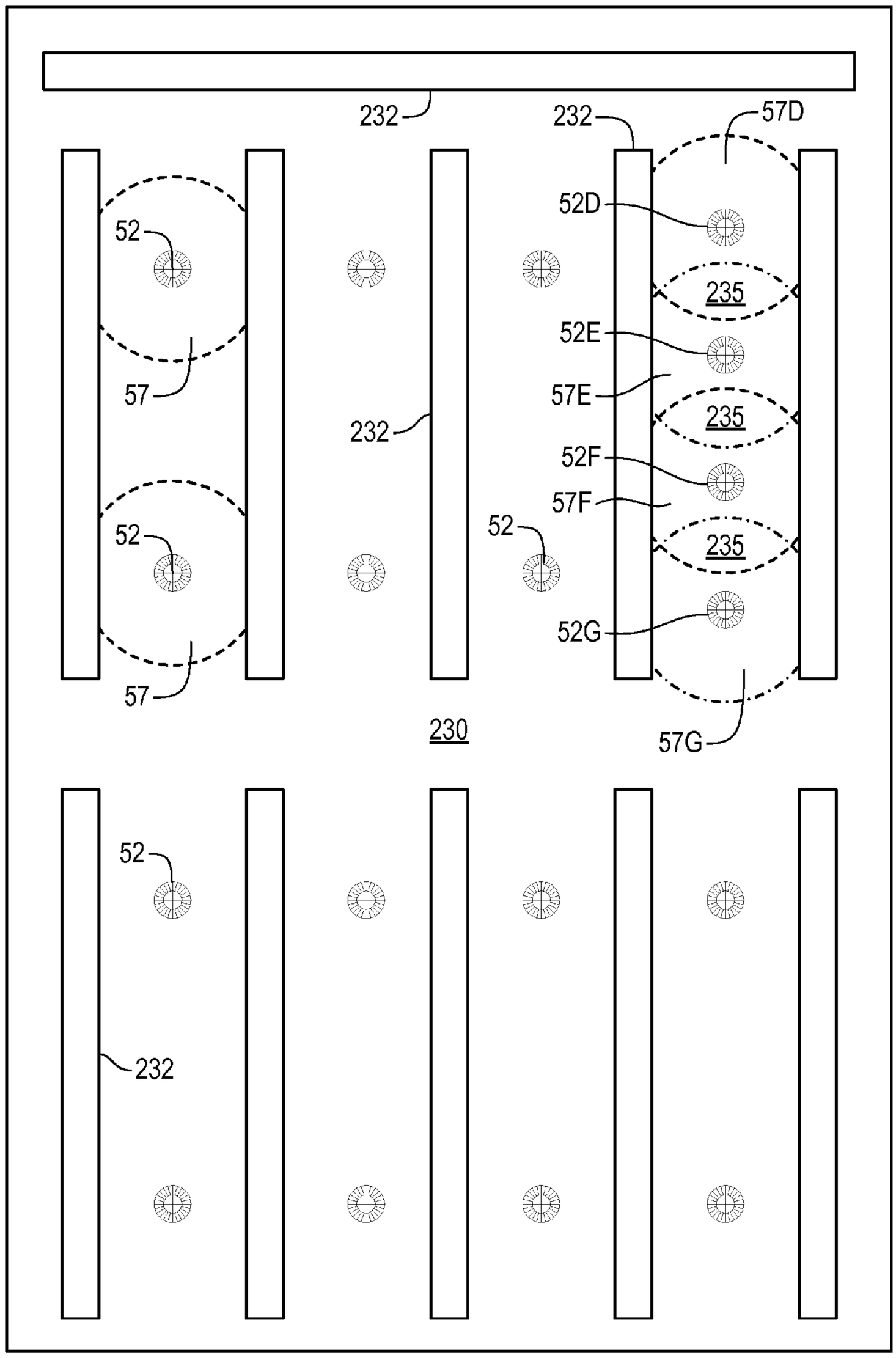

232
232
57D
52D
52
235
52E
57
57E
232
235
52F
57F
52
235
52
52G
57
230
57G
52
232

FIG. 9

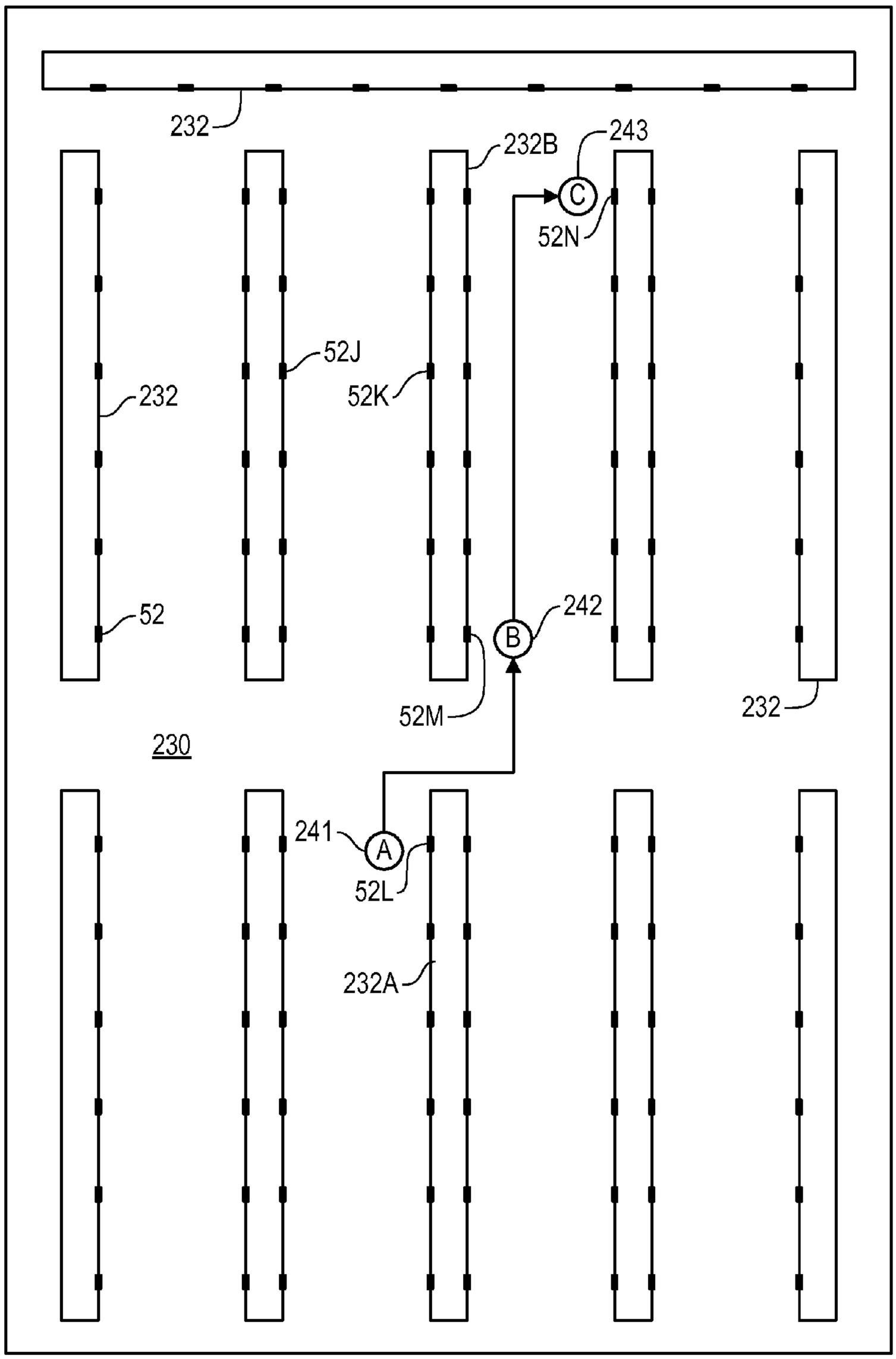


FIG. 10

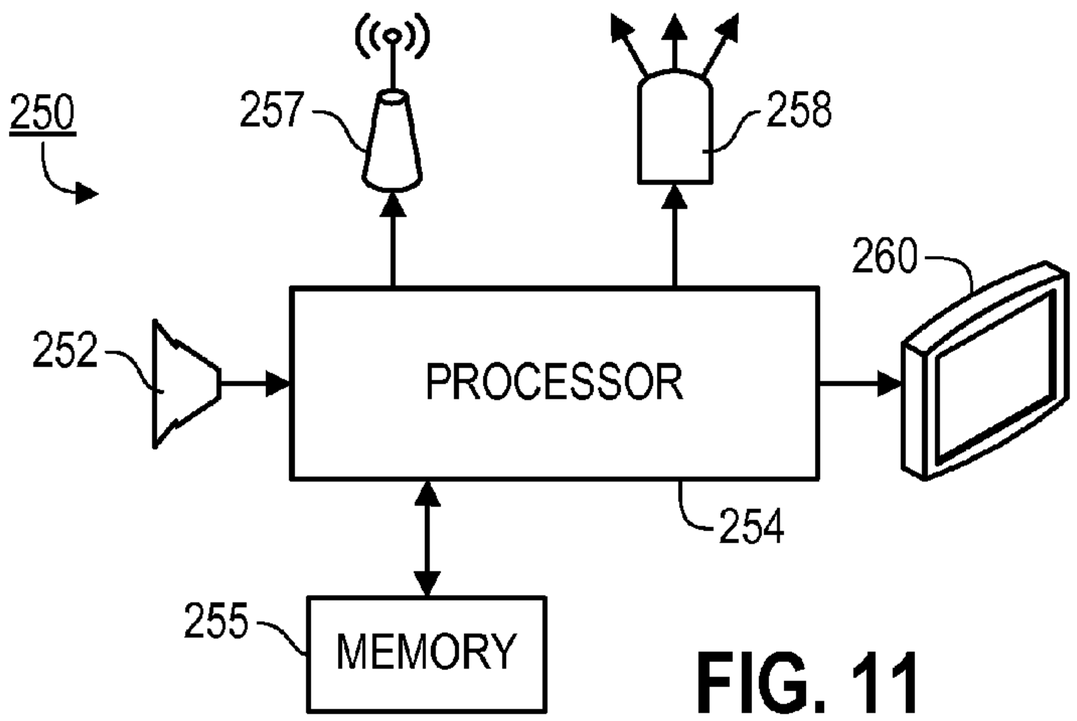


FIG. 11

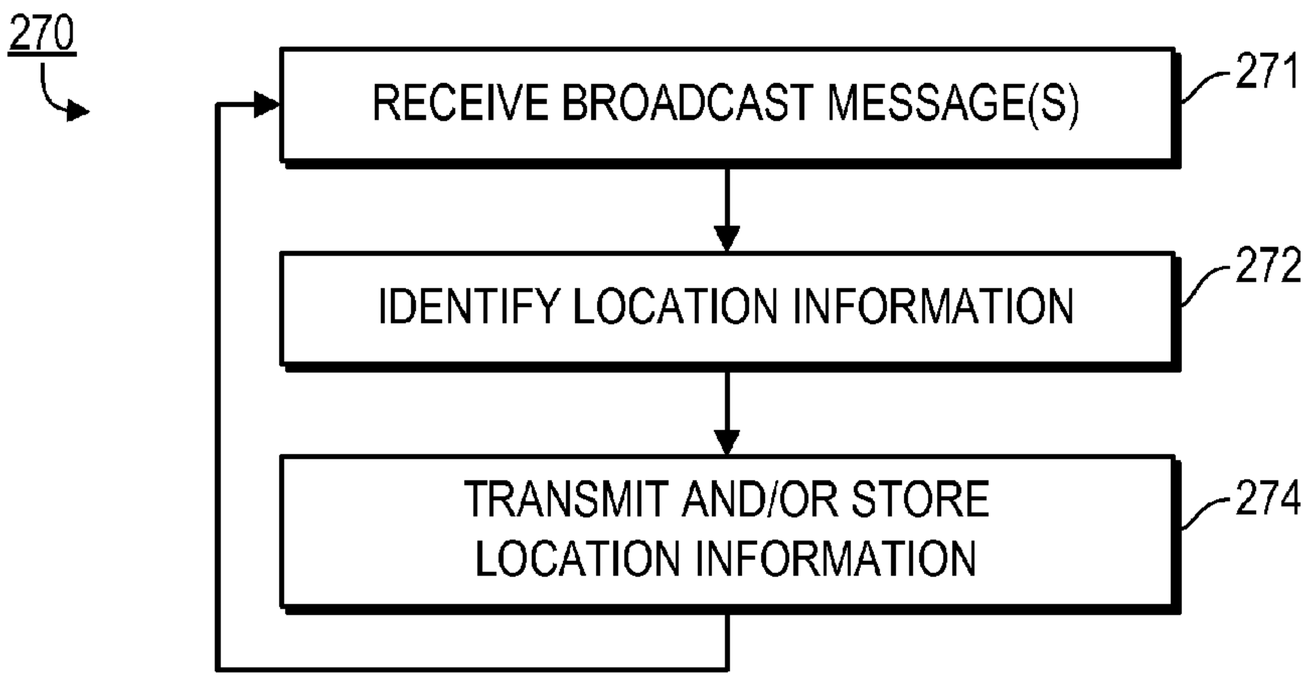


FIG. 12

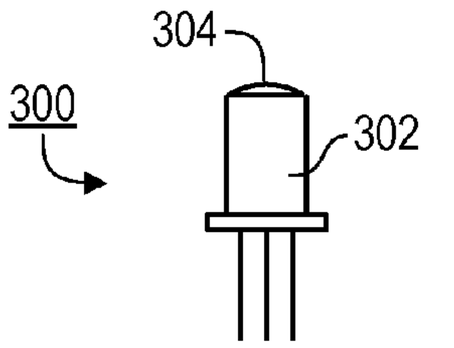


FIG. 13

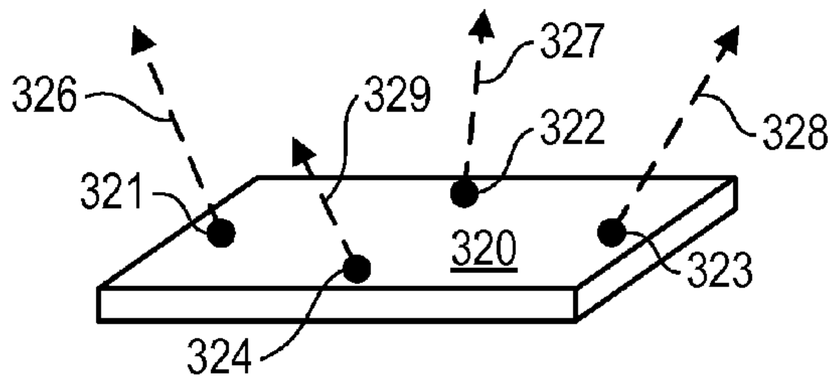


FIG. 14

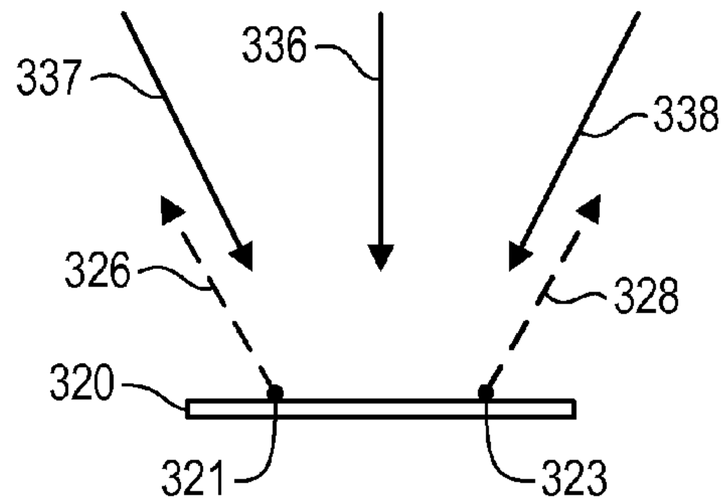


FIG. 15

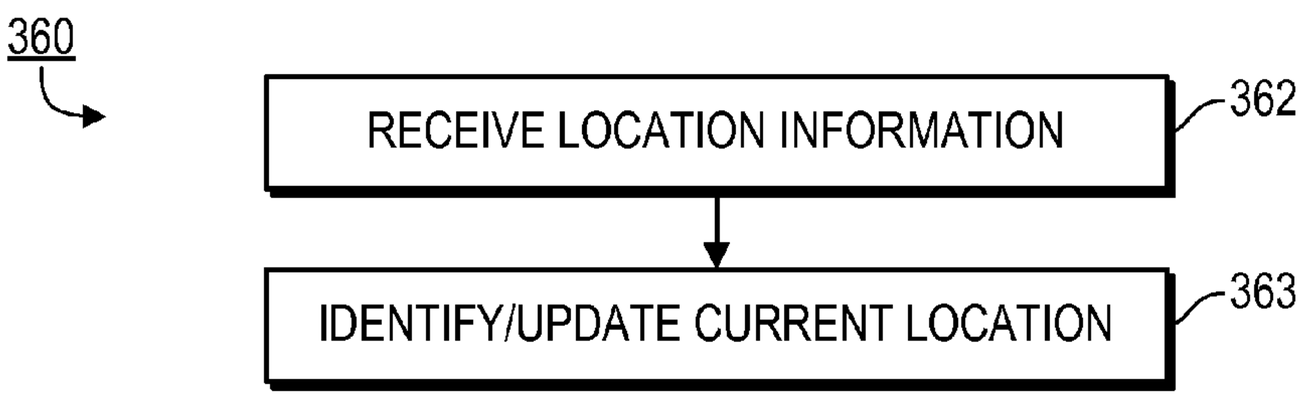


FIG. 16

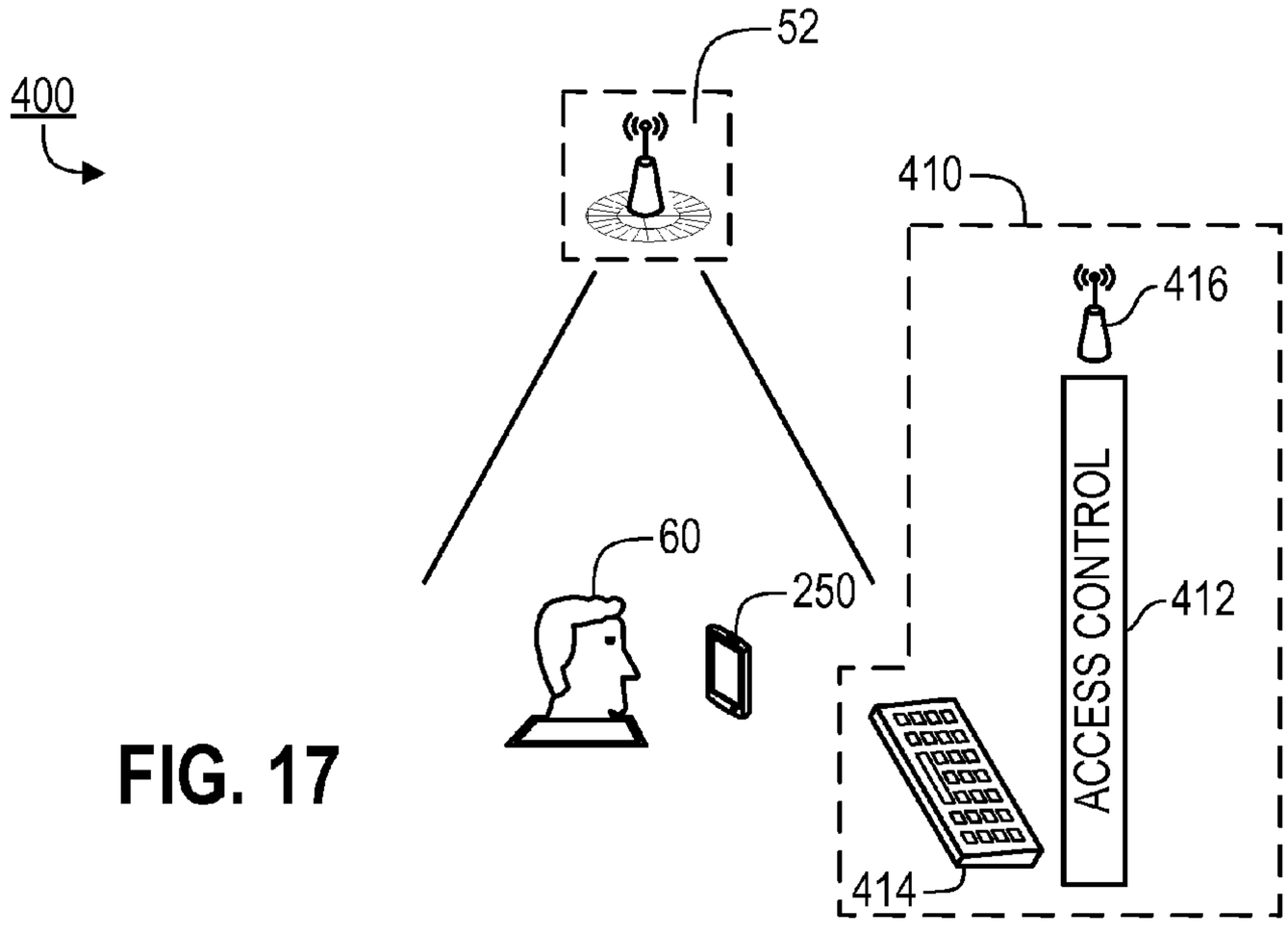


FIG. 17

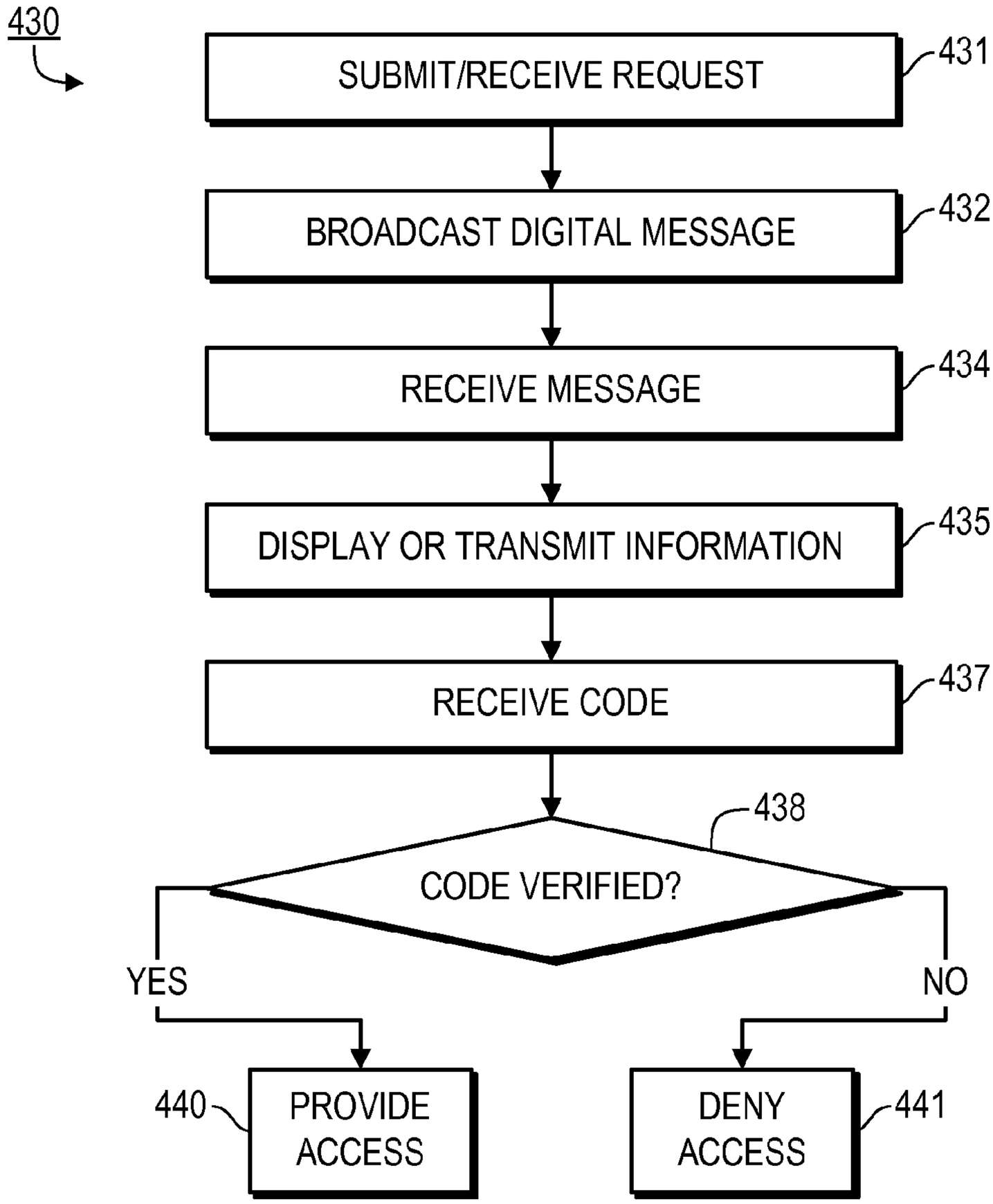

430
SUBMIT/RECEIVE REQUEST
431
BROADCAST DIGITAL MESSAGE
432
RECEIVE MESSAGE
434
DISPLAY OR TRANSMIT INFORMATION
435
RECEIVE CODE
437
CODE VERIFIED?
438
YES
NO
440
PROVIDE ACCESS
DENY ACCESS
441

FIG. 18

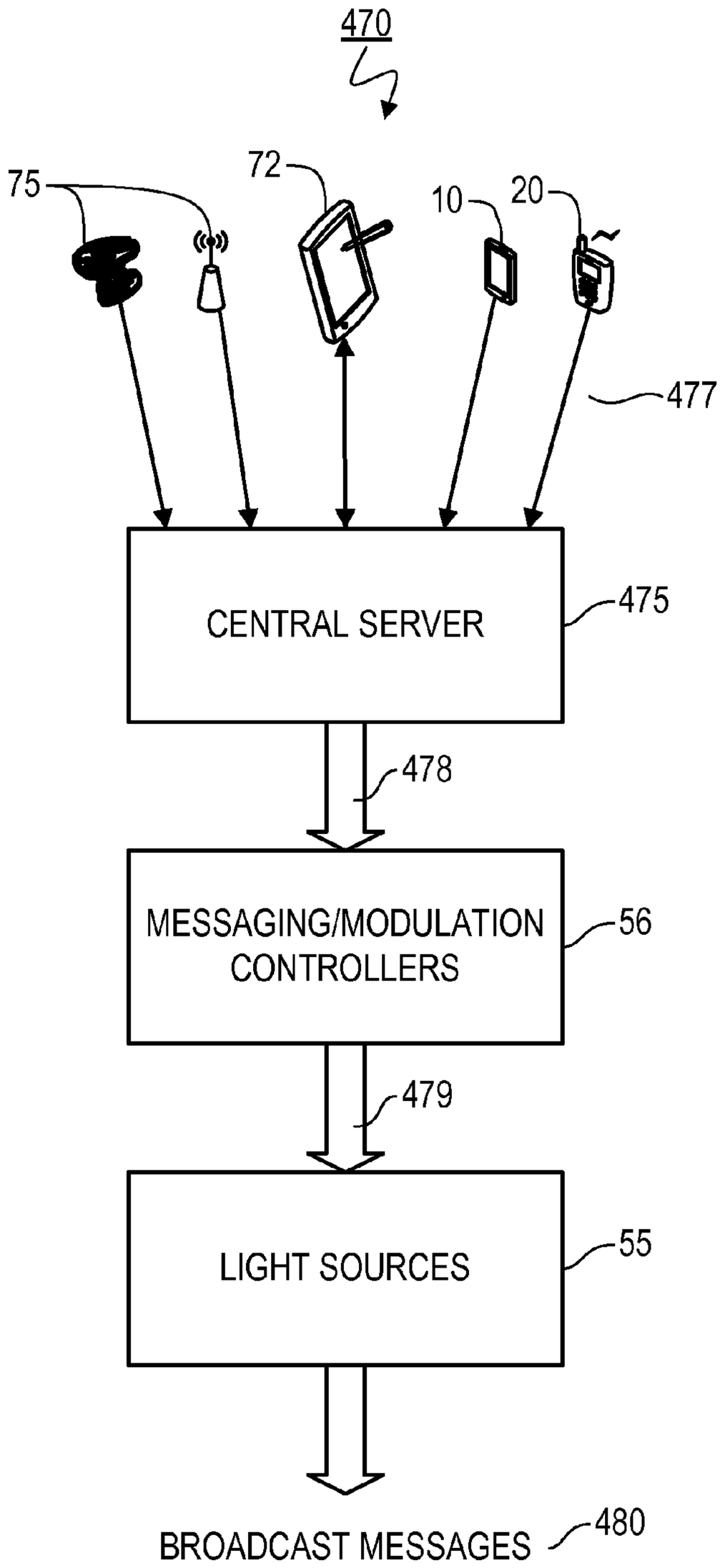

470
75
72
10
20
477
CENTRAL SERVER
475
478
MESSAGING/MODULATION CONTROLLERS
56
479
LIGHT SOURCES
55
BROADCAST MESSAGES
480

FIG. 19

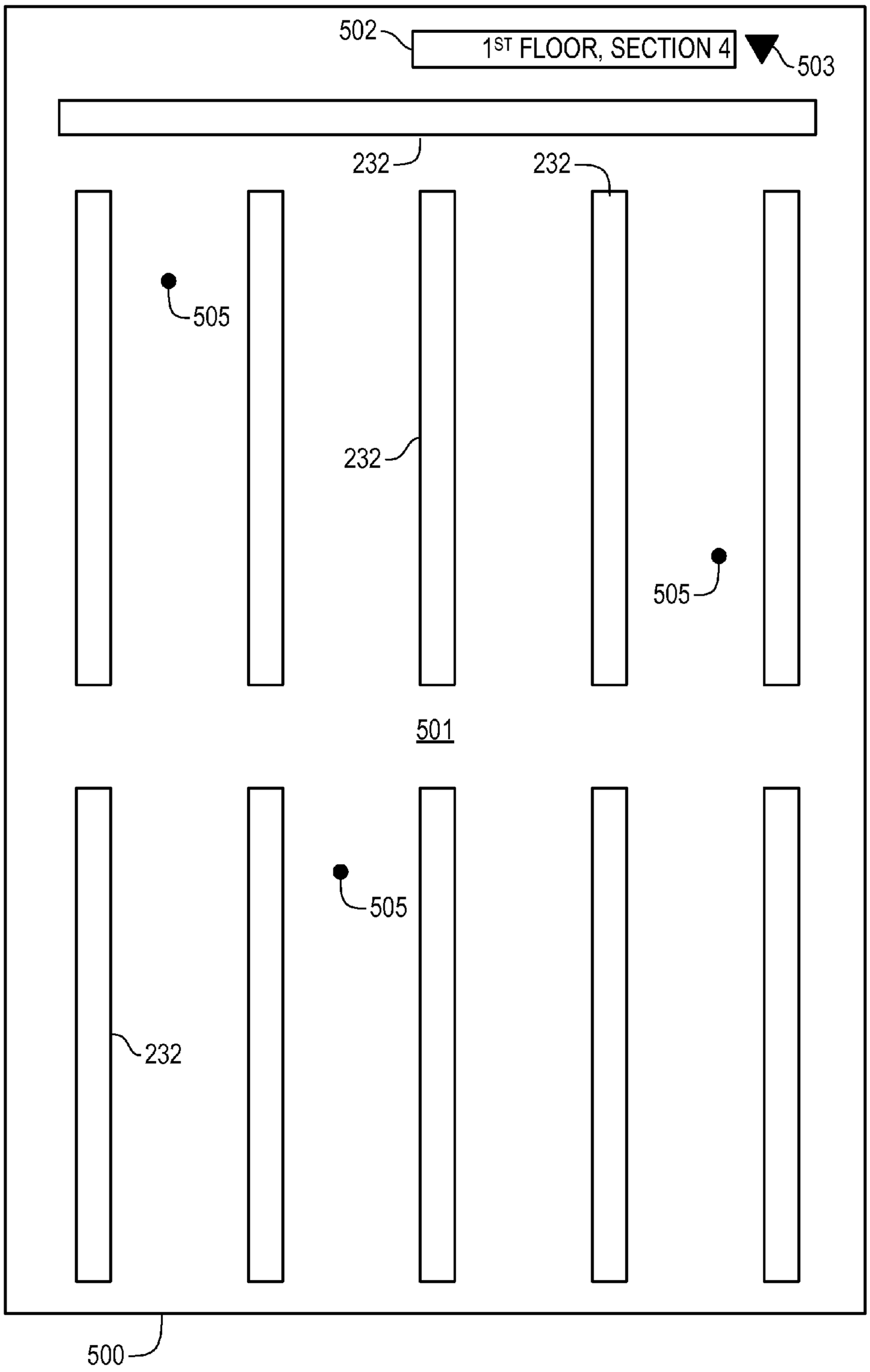


FIG. 20

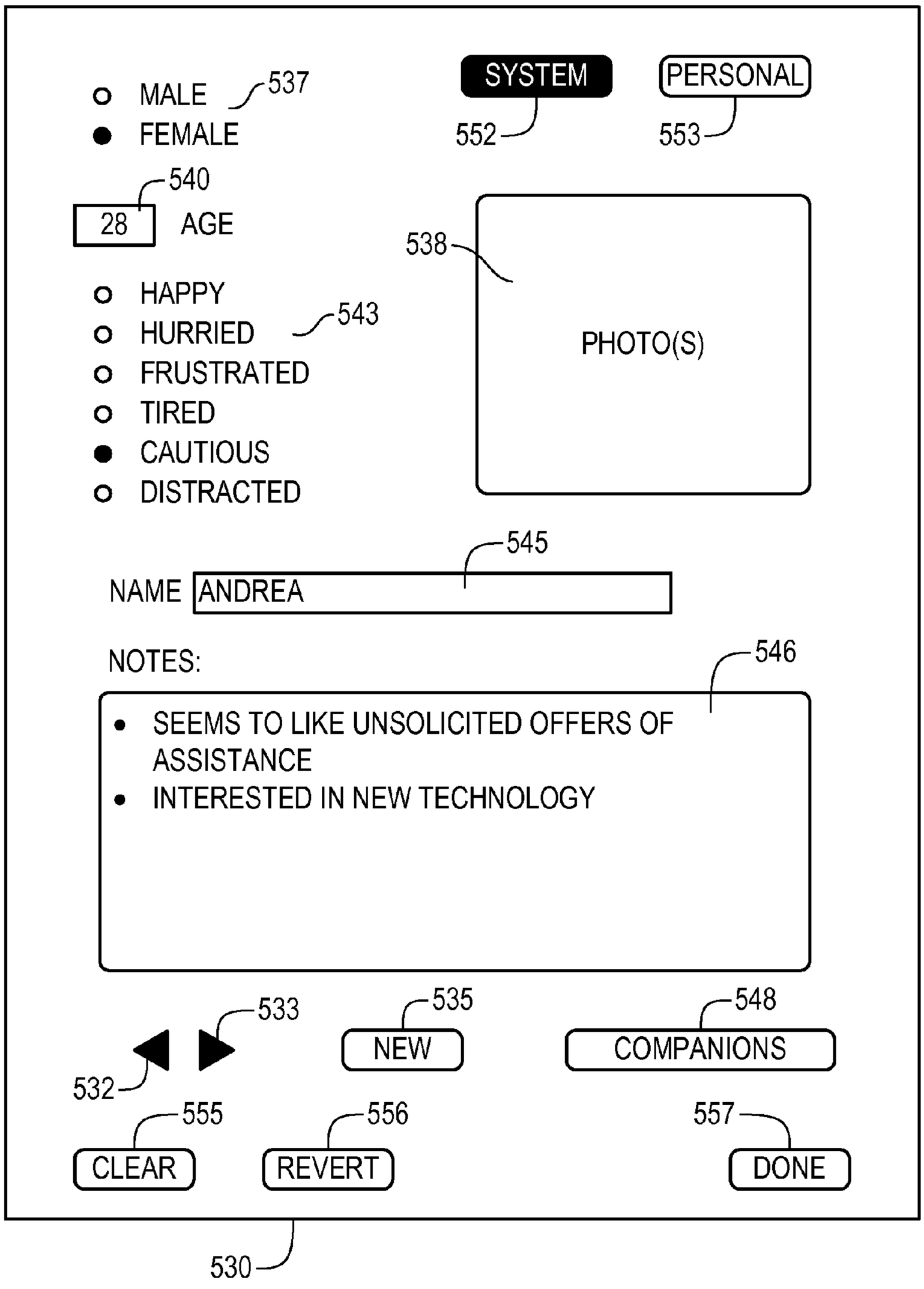

MALE
537
FEMALE
SYSTEM
PERSONAL
552
553
540
28
AGE
538
HAPPY
HURRIED
543
FRUSTRATED
TIRED
CAUTIOUS
DISTRACTED
PHOTO(S)
545
NAME
ANDREA
NOTES:
546
• SEEMS TO LIKE UNSOLICITED OFFERS OF ASSISTANCE
• INTERESTED IN NEW TECHNOLOGY
533
535
548
532
NEW
COMPANIONS
555
556
557
CLEAR
REVERT
DONE
530

FIG. 21

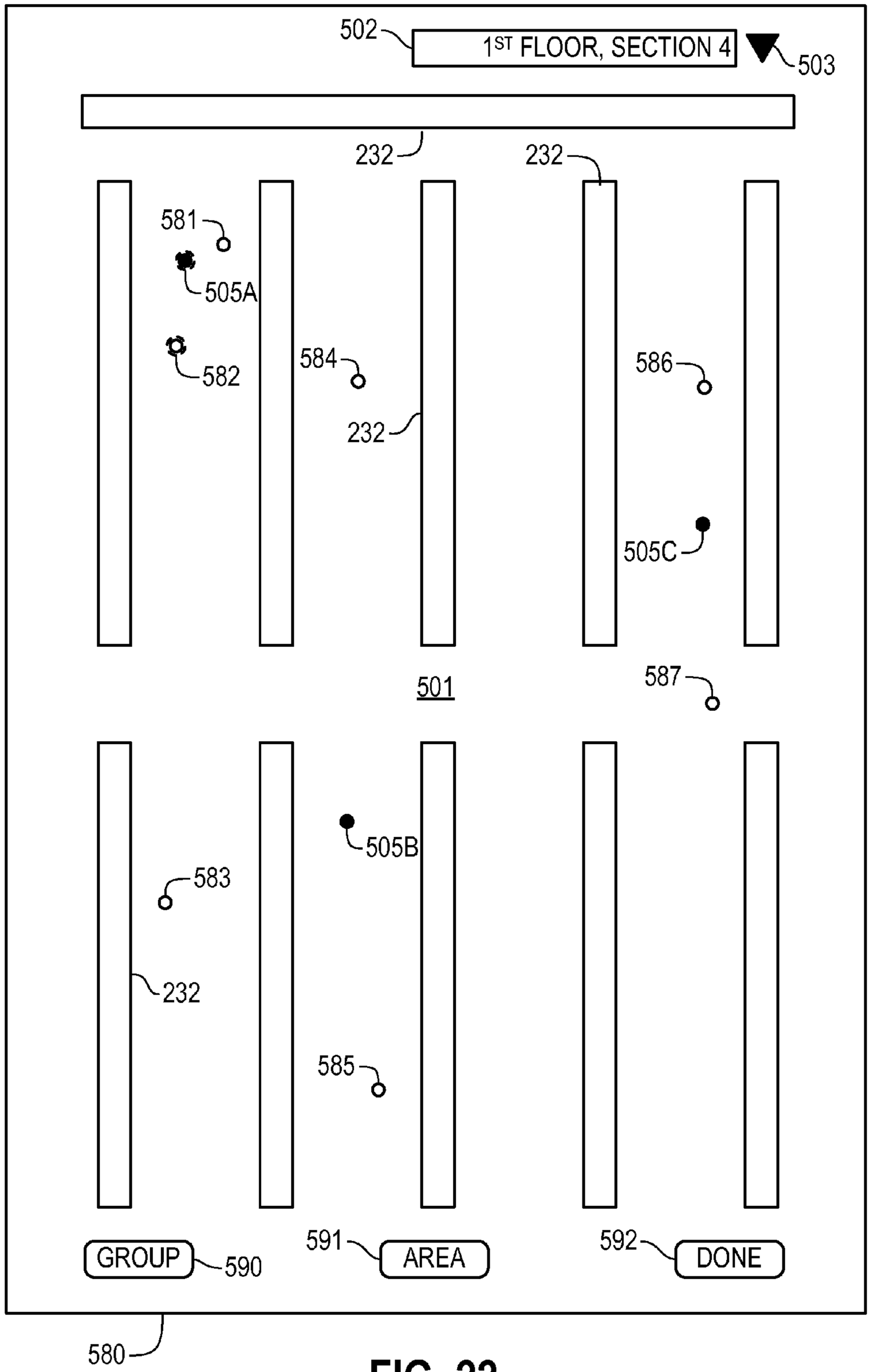

502
1ST FLOOR, SECTION 4
503
232
232
581
505A
582
584
232
586
505C
501
587
505B
583
232
585
GROUP
590
591
AREA
592
DONE
580

FIG. 22

LIGHT-BASED MESSAGING SYSTEMS

This application is a continuation in part of U.S. patent application Ser. No. 13/787,737, filed on Mar. 6, 2013, which in turn is a continuation in part of U.S. patent application Ser. No. 13/559,372, filed on Jul. 26, 2012. Each of the foregoing applications is incorporated by reference herein as though set forth herein in full.

FIELD OF THE INVENTION

The present invention pertains to light-based systems for sending and/or receiving messages, particularly individualized messages based on the locations and/or characteristics of the recipients and/or other individuals.

BACKGROUND

A variety of different messaging systems currently exist. Examples include SMS or text messaging, e-mail, Twitter, Facebook and other social-network messaging protocols. However, each of such systems has its own shortcomings. The present inventor has discovered that one significant problem with existing messaging systems is that they fail to adequately take into account the locations of the individuals who are communicating. Efforts to address this problem typically focus on the use of a global positioning system (GPS) or, in some cases, an indoor variation of such a system. Unfortunately, the present inventors discovered that such solutions often do not work well. Another problem with existing messaging systems that has been discovered by the present inventor is that they often are inadequate at personalizing or individualizing messages.

Also, systems have been used or proposed for tracking and/or monitoring the locations of people or objects. Most of such systems use GPS or related techniques. However, such systems have a number of drawbacks, e.g., in terms of cost and/or the amount of effort required to implement them.

Still further, systems have been used or proposed for providing secured access to various kinds of resources, such as data or physical locations. Such systems typically rely on the use of passwords, physical keys or biometric information. However, these systems also have drawbacks.

SUMMARY OF THE INVENTION

The present invention addresses the foregoing problems, e.g., by providing systems, apparatuses, methods and techniques that employ light-based messaging. Such approaches often can provide: fairly precise location-based and/or characteristic-based message targeting, e.g., for large numbers of people in locations that would not be appropriate for GPS-based systems; spatial tracking of people, machines and other objects; and/or enhanced security systems.

Thus, one embodiment of the invention is directed to a messaging system that includes: messaging units disposed at different locations within a space, each including at least one light source (e.g., light-emitting diode or LED); at least one messaging/modulation controller coupled to the light sources and configured to turn the light sources on and off so as to broadcast input digital messages; a central server coupled to the messaging/modulation controller(s) and configured to selectively provide messages to the messaging/modulation controller(s) for broadcast by different ones of the messaging units; and an associate device coupled to the central server and configured to: (a) display a user interface for manually inputting information about individuals within the space and

(b) provide such information to the central server. Preferably, the central server selects messages to be broadcast by individual ones of the messaging units based on the information received from the associate device.

Another embodiment is directed to a messaging system that includes multiple messaging units at different locations within a commercial space, with each of such messaging units including: a light-emitting diode (LED) or other light source; and a messaging/modulation controller coupled to the light source and configured to turn the light source on and off so as to broadcast a digital message, with each of the messaging units configured to broadcast a different digital message, including substantive content that is different from what is broadcast by the other messaging units.

A still further embodiment is directed to a location monitoring system that includes: (a) a plurality of messaging units disposed at different locations within a space, each of such messaging units including: (i) a light source, and (ii) a messaging/modulation controller coupled to the light source and configured to turn the light source on and off so as to broadcast a digital message; and (b) a receiving unit that includes: (i) a light sensor, and (ii) a processor coupled to the light sensor. The messaging units are configured to broadcast different location codes via their corresponding light sources, and the processor is configured to (1) receive the location codes through the light sensor, (2) in response, to obtain location information based on the location codes, and (3) at least one of store and use, or cause the transmission of, the location information.

A still further embodiment is directed to a security system that includes: (a) a messaging unit that includes: (i) a light source, and (ii) a messaging/modulation controller coupled to the light source and configured to turn the light source on and off so as to broadcast a digital message; and (b) a receiving unit that includes: (i) a light sensor, and (ii) a processor coupled to the light sensor; and (c) an access-control unit that includes: (i) a user interface, and (ii) a processor coupled to the user interface. The receiving unit is configured to receive the digital message broadcast by the messaging/modulation controller and, in response, to at least one of display or transmit information based on such broadcast digital message. The user interface of the access-control unit is configured to input a code based on the displayed or transmitted information, and the processor of the access-control unit is configured to verify whether the input code corresponds to a reference code that is based on the digital message broadcast by the messaging/modulation controller and, only if so, to provide access to a secure resource.

The foregoing summary is intended merely to provide a brief description of certain aspects of the invention. A more complete understanding of the invention can be obtained by referring to the claims and the following detailed description of the preferred embodiments in connection with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following disclosure, the invention is described with reference to the attached drawings. However, it should be understood that the drawings merely depict certain representative and/or exemplary embodiments and features of the present invention and are not intended to limit the scope of the invention in any manner. The following is a brief description of each of the attached drawings.

FIGS. **1**A&B are front and rear perspective views, respectively, of a small, portable, mobile device.

FIG. **2** is a front perspective view of an alternate small, portable, mobile device.

FIG. **3** is a block diagram of a messaging system according to a representative embodiment of the present invention.

FIG. **4** illustrates an exemplary timeline showing time-division multiplexing of multiple different messages.

FIG. **5** is a flow diagram illustrating a process, executed by a central computer, for enabling an administrator to create and distribute a messaging pattern.

FIG. **6** is a flow diagram illustrating a process, executed by the controller of a messaging unit, for causing messages to be broadcast.

FIG. **7** is a flow diagram illustrating a process, executed by a user device, for receiving and presenting messages.

FIG. **8** is a block diagram of an alternate messaging system according to a representative embodiment of the present invention.

FIG. **9** is a top plan view of a commercial space showing an example of ceiling-based placement of messaging units according to a representative embodiment of the present invention.

FIG. **10** is a top plan view of a commercial space showing an example of shelf-based placement of messaging units according to an alternate representative embodiment of the present invention, and also illustrating how a user can be guided to different locations within the commercial space.

FIG. **11** is a block diagram of a representative receiving unit.

FIG. **12** is a flow diagram illustrating processing performed by a receiving unit according to a representative embodiment of the present invention.

FIG. **13** illustrates a directional sensors for use in certain embodiments of the invention.

FIG. **14** illustrates a card with four directional sensors.

FIG. **15** illustrates overlapping reception patterns forward to directional sensors on a single card.

FIG. **16** is a flow diagram illustrating processing performed by a location-monitoring and/or tracking device according to a representative embodiment of the present invention.

FIG. **17** is a block diagram illustrating a security system according to a representative embodiment of the present invention.

FIG. **18** is a flow diagram illustrating processing performed within a security system according to a representative embodiment of the present invention.

FIG. **19** is a block diagram illustrating a system for delivering messages based on user characteristics according to a representative embodiment of the present invention.

FIG. **20** is an exemplary page of a user interface showing the layout of a portion of a covered space and the locations of registered, active users.

FIG. **21** is an exemplary page of a user interface for inputting and displaying information regarding a user or other individual.

FIG. **22** is an exemplary page of a user interface showing the layout of a portion of a covered space and the locations of registered, active users and other individuals.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

Any of a variety of different conventional, portable, typically handheld user devices can be used within, or included within, a system according to the preferred embodiments of the present invention. One example of such a user device **10** (which could be a mobile cellular-based phone or a tablet computer) is shown in FIGS. **1**A&B. As shown, user device **10** includes, on its back side **11**, a light sensor **12** (typically a camera) and one or more light sources **14** (such as light-emitting diodes or LEDs, e.g., of the type conventionally placed in close proximity to the camera **12** and used as a camera flash, among other things). To achieve greater reception efficiency in certain environments, a user device **20** (e.g., a mobile phone or tablet computer), shown in FIG. **2**, also (or instead) includes a light sensor **22** (such as a camera or a simple light-detecting sensor) and/or a light source **24** (preferably one or more LEDs) on its top edge **25**. Similarly, a light sensor and/or a light source also (or instead) can be included on the front side **16** or **26** of a user device (e.g., user device **10** or **20**, respectively).

For ease of description, the following discussion typically refers to user device **10** or user device **20**; however, it should be understood that such references can be replaced with references to any other portable (typically handheld) user device, such as any of the devices contemplated herein. In fact, any appropriately configured user device can be used in any embodiment of the present invention. The preferred user device includes at least: (1) a processor and storage medium for executing and storing a software application (or set of computer-executable process steps) to provide the functionality ascribed to user device **10** or **20** herein (typically referred to herein as the "user app"); (2) a light sensor for receiving the broadcast, modulated light discussed herein; and (3) and one or more hardware user interface components (typically, a display screen and/or a speaker or output audio jack) for presenting the received messages that are discussed herein. It is noted that the expression "presenting messages" and similar expressions are used herein to refer to visually showing, displaying, playing or otherwise providing such messages, which could involve presenting any kind of content or any combination of different kinds of content (e.g., any combination of text, graphics, images, audio and/or video content). In addition, in certain embodiments it is preferable for the user device to have other hardware and/or software capabilities, such as the ability to wirelessly access the Internet and/or a light source for also (or even instead) transmitting messages within a system according to the present invention.

Location-Based Messaging within a Designated Space

One such system **50**, shown in FIG. **3**, includes a user device **20** (preferably running the user app) and a plurality of messaging units **52** (such as messaging units **52**A-C) disposed at different locations throughout an overall space. In the preferred embodiments, this space is a commercial space, such as a single retail store (or other establishment) or a shopping center or mall containing a plurality of independently managed and/or operated retail establishments. However, a system according to the present invention can be implemented in any kind of (typically large) space. Although only three messaging units **52**A-C are shown in FIG. **3**, more typically there will be many more such messaging units **52**, e.g., at least 5-50 such units.

Each of the messaging units **52** preferably includes one or more light sources **55** (typically, each such light source including one or more LEDs) and a processor-based messaging/modulation controller **56**. However, the messaging/modulation controller **56** need not be included within a messaging unit **52**; instead, one or more messaging/modulation controllers **56** may be coupled to one or more messaging units **52** (so that each controller **56** controls one or more messaging units **52**). Nevertheless, for ease of description, the following discussion assumes that each messaging unit **52** includes its own controller **56**.

In the current embodiments, each messaging unit **52** broadcasts a digital message, including substantive content that is

different than the substantive content of the digital messages broadcast by all (or a majority or at least some) of the other messaging units **52**. However, such messages preferably are coordinated with each other in order to provide a desired overall user experience. To broadcast such message(s), each controller **56** modulates (typically by turning on and off) the light **57** emitted from the unit's light source **55**. Then, as any particular user device **20** is moved about within the space covered by the messaging units **52**, it receives the light **57**, and therefore the corresponding digital message, from different ones of the messaging units **52**. For example, as depicted in FIG. **3**, user device **20** currently is receiving and presenting to user **60** any message(s) broadcast by messaging unit **52**A; then, as user device **20** is moved forward by user **60**, it ceases to receive (or at least to present to user **60**) messages broadcast from messaging unit **52**A and begins to receive and present to user **60** messages broadcast from messaging unit **52**B. In this way, the system **50** provides a structure for communicating different messages at different locations within the overall space and, typically, for fairly precisely controlling what messages are presented at different locations and/or (e.g., in the embodiment described below in reference to FIG. **10**) even at different orientations of the user **60**.

Each light source **55** preferably is modulated on and off at a very high rate (e.g., at least 1,000, 10,000, 100,000, 1 million, 10 million or 100 million times per second) so that, although a binary signal is being broadcast via such modulation, the variation is too fast to be noticed by the human eye. The sensor **22** of user device **20** receives this modulated light, decodes it and presents the corresponding message, in accordance with the logical rules encoded in the user app and, in some embodiments, with the user app referencing data that it previously stored into the memory of user device **20**.

The user app often will have been initially downloaded by the user device **20** via a wireless Internet connection or else will have been downloaded by a different computer (via its Internet connection) and then transferred to user device **20**. Upon such initial downloading, the user **60** preferably has the ability to establish a profile (and in some cases is incentivized or required to do so), and preferably may elect to have special offers and/or suggestions delivered to him or her via in-store communications and/or may elect to have such notifications sent to him or her, irrespective of his or her location, by e-mail, via a social-networking site or in any other manner. Thereafter, updates to the user app and/or additional (e.g., pre-stored) content can be received in either of those ways, or instead can be downloaded from one of the messaging units **52** (e.g., the first messaging unit **52** that device **20** receives from after entering the space. Still further, if the user device **20** previously had an application for interfacing with Li-Fi system **50**, the user app initially could have been downloaded from one of the messaging units **52**.

As indicated above, in addition to transferring messages and delivery schedules into the controller **56**, in certain embodiments of the present invention pre-stored content also can be placed in the controller **56**. Typically, such pre-stored content is content that is intended to be used by multiple different messages and can include, e.g., logos, backgrounds, music and/or other audio clips.

The digital messages and other content broadcast by the messaging units **52** can be encoded using any of the techniques used for other kinds of digital transmissions. In addition, multiple messages (and/or other kinds of content) can be delivered simultaneously by using time-division multiplexing (i.e., broadcasting each message in a stream of time slices that alternate with the times slices allocated to the other messages), or by using any other multiplexing technique. As a result, for example, in these embodiments it is possible to simultaneously broadcast both a new message and any update to the user app or the pre-stored content accessible by it.

In the preferred embodiments, the messages broadcast by the messaging units **52** are modified or replaced from time to time, e.g., from moment to moment, at different times of day, and/or over extended periods of time. In this regard, the controller **56** preferably includes memory and/or one or more other storage devices that store one or more such messages and computer-executable process steps for implementing the controller functionality described herein (typically referred to as the "messaging app"). The controller **56** also includes a processor for executing the messaging app. Still further, in certain embodiments the controller **56** includes a real-time clock and/or scheduling information also is stored into its storage device(s); then, the messaging app can cause different messages to be broadcast, e.g.: at different times of the day, on different days of the week, in one or more specified sequences, at one or more different time intervals and/or in any other time-varying manner. In this way, once the controller **56** is loaded with a set of messages and a schedule, it can automatically change the messages that it causes to be broadcast over time in accordance with any specified schedule.

Typically, however, it also will be desirable, from time to time, to change the stored messages and/or the schedule according to which they are broadcast. Any of a variety of different approaches can be employed to change or update such information. For example, in certain embodiments, controller **56** is provided with a physical port (e.g., USB), and when a physical storage medium (e.g., flash drive **62** shown in FIG. **3**) is inserted into such a port, the messaging app automatically retrieves the new or replacement messages and scheduling information stored within it and uses it to update and/or replace the corresponding information currently stored within the storage device(s) of controller **56**.

More preferably, however, such updates are delivered automatically to the individual messaging units **52**. Some of the reasons for this preference are that there often will be a large number of messaging units **52** and access to them often will be fairly cumbersome, e.g., when they are mounted on or within the ceiling. Therefore, the messaging units **52** preferably are in (or capable of) real-time communications with one or more central computers (e.g., computer **65**), and both the individual messaging units **52** and such a central computer **65** are configured to interface with each other, e.g., such that computer **65** can directly address and update each desired messaging unit **52**.

Even more preferably, as shown in FIG. **3**, the communication link between the central computer **65** and the individual messaging units **52** is a wireless link (e.g., a WiFi network according to any of the 802.11x protocols). For this purpose, computer **65** is shown connected to a wireless router **67**, and the controller **56** within each of the messaging units **52** includes a corresponding wireless transceiver and antenna **54**. In addition, for covering a large space, one or more wireless signal repeaters may also be incorporated into system **50**. In any event, although a hardwired network instead could be used, wireless technology eliminates the effort and expense of having to physically connect all of the messaging units **52** to such a network. On the other hand, use of a hardwired network often will be a good option when infrastructure already exists, e.g., using the same lines from which central computer **65** and the messaging units **52** obtain their electrical power to also transmit communication signals.

The messaging app (e.g., including any wireless communication interfaces) preferably is stored within each controller **56** as firmware. The scheduling and message information

preferably is stored within a non-volatile storage device, such as flash memory, within the corresponding controller **56**. Preferably, however, most of the functionality is implemented by computer **65**, with the individual messaging units **52** including just enough processing power and corresponding functionality to perform message and schedule updates, to implement the stored schedule(s), and to generate corresponding drive signals for their light sources **55** based on the stored digital messages.

In the simplest embodiments of the present invention, the messaging app executed by the controller **56** simply causes its currently loaded message to be repeatedly broadcast, over and over, but that single message is capable of being replaced by a new message, e.g., using any of the techniques described above. However, in certain embodiments, the messaging app continuously broadcasts in accordance with one or more messaging schedules (as discussed in more detail below). In the following discussions, this latter type of embodiment usually is assumed, in order to be as comprehensive as possible.

Also, upon receipt of a signal from the wireless interface (or other interface used for updates) indicating that new updates are available, controller **56** performs the updating operation. In this regard, the updating message preferably includes a set of instructions (or a script) indicating what changes should be made, together with any new or replacement messages or other content. For instance, such a script might include simple statements to delete particular messages, content and/or schedules (each specified with a unique identifier) and/or to add the new blocks of information appended to the received message, with each such new block including a unique identifier, a type identifier (e.g., message, media content or schedule) and a main body that includes the actual content. Similarly, each schedule also can be specified as a script with instructions indicating, e.g.: any condition(s) as to when it should be executed (such as time of day and/or day of week), the sequence in which messages are to be broadcast (if more than one), any messages to be broadcast concurrently (e.g., multiplexed), any desired pauses between sequentially broadcast messages, any specific times at which messages are to be broadcast, and the like.

Also, in certain embodiments the messaging units **50** include real-time clocks. In that case, the messaging app preferably also includes functionality for receiving a timestamp and a synchronization signal and for setting the device's real-time clock to the specified time at the moment indicated by the synchronization signal.

In certain embodiments of the invention (discussed in greater detail below), additional components also are included within system **50**. Such components can include, e.g., one or more associate devices **72**, each typically being a wireless handheld device, such as a tablet computer or a wireless telephone, but any or all instead could be, e.g., laptop or desktop computers. Each such associate device **72** is operated by an individual **73** who is associated with the system **50** and is coupled to the central computer **65**, e.g., via one of the presently disclosed LiFi systems, such as system **50**, a wireless Wi-Fi connection, an ethernet connection, or any other wireless or hardwired connection. In addition (or instead) system **50** can include one or more automated sensors **75** (such as a video or still-image camera, operating in the visible and/or infrared spectra, a radio receiver configured to receive transmissions from user devices **20**, or a radio transceiver for use in combination with RFID devices) for obtaining information regarding the users **60**. Such sensors **75** can be located anywhere in the covered space, such as on items that are being offered for sale, on shelves or other fixtures, or on ceilings, walls or other portions of a structure that makes up, encloses or borders the covered space.

A representative example of time-division multiplexing is shown in FIG. **4**. In this particular example, portions of three different messages **81-83** are broadcast using alternating time slices over a relatively short period of broadcast time (e.g., between 10^{-2} and 10^{-7} second, or even less), followed by a longer time period (e.g., 5-10 times as long) during which the light source **55** remains continuously on, with this pattern repeating potentially indefinitely. Preferably, an entire static message is delivered within a time period of 0.5-3.0 seconds, and time-varying content (such as audio or video) is delivered in real-time. At the same time, because only a relatively small fraction of the time (e.g., a maximum of 10-20%) is used for modulated broadcasting, the intensity of the light need not be significantly reduced.

Computer **65** preferably is configured with a software application that executes a process for allowing an administrator **70** to create and distribute a desired messaging pattern. An example of one such process **100** is discussed with reference to FIG. **5**.

Initially, in step **102** a user interface for inputting or creating one or more messages is displayed. If a desired message just includes text, the administrator **70** preferably can simply type in (or otherwise enter) the message. In addition, the displayed interface preferably permits the administrator **70** to specify, e.g.: (1) the display of pre-stored discrete graphical elements and/or a background or wallpaper; or (2) the playing of a pre-stored audio track. Still further, the displayed interface preferably permits the administrator **70** to upload new content (such as images, audio, video, or any combination of such content) and then incorporate such new content into any particular message. In this regard, a variety of conventional software applications exist for authoring content in one or more types of media, and any of the features incorporated into such conventional applications also can be incorporated into the user interface displayed in this step. Preferably, the displayed user interface permits the creation of any number of messages in this manner.

In step **103**, a user interface is displayed for creating schedules that specify how and when the message(s) created in step **102** are to be broadcast, e.g., the sequences in which such messages are to be broadcast (if more than one are to be broadcast by a particular messaging unit **52** during any given time period) and/or the times and/or days when they are to be broadcast. In most embodiments, each of the messaging units **52** broadcasts just a single message at any given time. However, the present interface preferably permits the administrator **70** to specify that different messages are to be broadcast at different times of day and/or on different days (e.g., different days of the week).

For this purpose, the present user interface preferably allows the administrator **70** to specify a time segment for each message that has been assigned to a messaging unit or, conversely, to specify different time segments and one or more messages to be broadcast during each. If multiple messages are specified for any particular time segment, the default preferably is that the messages are broadcast sequentially without any significant delay between them, in the order selected by the administrator **70** within the present user interface (e.g., in the order the administrator **70** lists them for that time segment). However, in certain embodiments the present interface provides the administrator **70** with a great deal of flexibility in specifying how and when messages are to be broadcast by individual messaging units **52**. In certain embodiments, the present interface even permits the admin-

istrator **70** to specify that two or more different messages are to be played simultaneously on the user device (e.g., device **10** or **20**). More preferably, however, any such concurrent combinations preferably are specified during the message-authoring process in step **102**.

In one example, the foregoing schedule information is input by the administrator **70** in textual format, e.g., using a scripting language such as:

```
Schedule255(M,Tu,W:11AM-1.30PM;  Th,F:11.30AM-
  2PM)
Play(Msg435);
Play_Concurrent(Msg 112, Msg390, dur10sec);
Wait(5 sec);
Play(Msg029);
Return
```

which would be interpreted to mean that when this schedule (with the unique identifier "Schedule255") has been assigned to a messaging unit **52**, it is to be executed on Monday Tuesday and Wednesday from 11:00 AM until 1:30 PM and on Thursday and Friday from 11:30 AM until 2:00 PM (sometimes referred to herein as the "applicability" of the schedule), and during those times the following actions should be executed: play Message 435, then immediately play Messages 112 and 390 together (i.e., simultaneously) for a period of 10 seconds (e.g., one being the visual portion and the other being the audio portion), then wait 5 seconds, then play Message 029, then immediately return to the beginning (i.e., begin again playing Message 435). In this example, it assumed that Messages 435 and 029 have an inherent duration (e.g., a video or audio clip) or a duration that has been explicitly specified within the messages themselves (e.g., as metadata), while Messages 112 and 390 potentially could be played indefinitely (e.g., text, static images and/or looping audio). In alternate embodiments, the present user interface allows the administrator **70** to define schedules (or to otherwise specify the schedule information) using a graphical user interface, e.g., with real-time presentation of the messages that are being specified to be presented, a "start" button and/or a "stop" button.

In the preferred embodiments, it is possible to specify the applicability of a particular schedule to be the "default", either instead of or in addition to specific times, dates and/or days. A default schedule is one that is to be implemented if and when no other schedule currently stored within the messaging unit **52** is applicable. More preferably, at least one schedule stored by each messaging unit **52** is required to be the default schedule, and this requirement preferably is verified in step **105** (discussed below).

It should be noted that the times at which the digital messages are broadcast can be somewhat independent of when those messages are to be displayed (or otherwise played or presented), e.g., by configuring the user device (e.g., **10** or **20**) to have buffering capabilities. It is also noted that it is possible to combine this step with step **102**, e.g., providing a single user interface for both authoring messages and specifying broadcasting schedules.

In step **104**, a user interface is displayed for assigning any of the schedules created in step **103** to any of the messaging units **52**. For this purpose, each of such messaging units **52** and each of the schedules preferably has a unique identifier. In one example, a separate window, containing a complete list of the available schedules, is opened for a selected messaging unit **52**, and then the administrator **70** simply selects the schedule(s) to be assigned to that messaging unit **52**, e.g., by clicking on checkboxes next to the desired schedule(s). It also should be noted that this step **104** can be combined with step **102** and/or step **103**, e.g., so that a message is assigned to one or more messaging units **52** at the time it is created, and/or so that messages, schedules and message or schedule assignments are all defined in a single step, and/or so that the instructions for transferring, deleting and/or replacing messages and/or content are generated automatically based on the schedules that have been selected for the corresponding messaging unit **52**.

In step **105**, a user interface is displayed for performing any desired verification (automatic and/or manual) of the overall messaging pattern that has been specified in steps **102-104**. For example, in certain embodiments a map showing the layout of the space covered by the messaging units **52** (e.g., similar to the maps shown in FIGS. **9** and **10**, discussed below) is displayed, and then the administrator **70** is able to input any desired day and time and then hover over (or click on) any of the graphic symbols representing the locations of the messaging units **52**, causing the corresponding digital message(s) to be presented.

In certain embodiments, this simulation also takes into account functionality that is expected (or known) to be implemented by the user app (running on the user device **10** or **20**). For instance, as discussed in greater detail below, in certain embodiments the user app on the user device **10** receives multiple messages from a single messaging unit (as discussed in greater detail below) but only presents one, depending upon the recent location history of the user device **10** (e.g., the sequence of messaging units **52** from which it has received broadcasts). As result, the administrator **70** would be able to click on different sequences of messaging units **52** and observe the corresponding sequences of messages that would be played by the user device **10** of an individual who traveled that same path through the space.

This verification procedure can be important for identifying any problems or schedule inconsistencies. In this latter regard, it might have been the case that two different schedules inadvertently were made active for the same messaging unit **52** and for the same period of time. Preferably, any such overlapping schedules are automatically highlighted in this verification step. Although certain embodiments permit intentionally overlapping schedules (e.g., with the different messages being multiplexed together), more preferably only a single schedule can be made active at any given time for any given messaging unit **52**. In any event, based on these verifications, the administrator **70** preferably can either modify the messaging pattern (by revisiting any of steps **102-104**) or confirm the existing messaging pattern.

In step **106**, the messaging pattern information is transmitted (preferably automatically once the pattern has been confirmed) to the appropriate ones of the messaging units **52**. Typically, this step involves transmitting: (1) the new schedules that are to be implemented by the corresponding messaging unit **52** (e.g., with a "store_schedule" command); (2) instructions to delete (or in some cases, just inactivate) any existing schedules that are not currently desired to be executed (e.g., with a "delete_schedule" or "inactivate_schedule" command); (3) any new content that is needed in connection with the new schedules, such as any new messages and/or any new pre-stored content or other new content that is referenced by, but not explicitly part of, any such new messages (with a "store_content" command); and/or (4) instructions to delete any messages or other content that are no longer needed (with a "delete_content" command).

In certain embodiments, for each of the messaging units **52**, only the new or changed information is transmitted, in order to reduce the amount of data transmission required. In any event, the new information preferably replaces any corresponding existing information. The actual information

transmitted can also include any combination of (1) raw data that has not been pre-stored by the recipient messaging unit or assumed to have been stored by the user device **10** through its system-interface software application or (2) identification codes for messaging information previously stored by either such device. In certain embodiments, from time to time or upon receipt of an indication that a particular messaging unit **52** is not currently storing the information that it is supposed to, a reset operation is performed in which all the information currently stored in that messaging unit **52** is deleted and a complete set of the proper information is transmitted to it.

In this way, each of the messaging units **52** can be kept up-to-date on an ongoing basis. The processing of such new information by the individual messaging units **52** preferably is performed on a transaction basis (e.g., by or under the control of the controller **56**), so that the processing associated with receipt of a new message from computer **65** is performed only when there is an indication that such a message has been received (e.g., on an interrupt basis). When that occurs, the controller **56** of the corresponding messaging unit **52** preferably executes the received commands (e.g., those noted above) in order to store, delete or inactivate any schedules, messages or other content, as applicable. In addition, in certain embodiments the controller **56** also creates or updates and applicability table that indicates when each of the stored schedules is applicable.

Most of the time, the messaging units **52** broadcast the stored digital messages in accordance with the currently active stored schedules. One example of a process **130** for doing so, e.g., executed by a processor within the controller **56** for the messaging unit **52**, is now discussed with reference to FIG. **6**.

Initially, in step **132** the currently applicable schedule is identified. This step can be performed by directly reading the applicability information from the stored schedules or by reading such information from an applicability table that has been created for the schedules.

In step **133**, the first message (or multiple messages if there is to be a concurrent broadcast) identified in the applicable schedule is retrieved. As noted above, each message preferably has a unique identifier and therefore the current message can be retrieved based on its identifier, as specified in the current schedule.

In step **134**, a drive signal for the light source **55** is generated based on the current message. For this purpose, the content preferably is converted into a binary signal, e.g., using any of the techniques conventionally used in conjunction with digital transmissions. Examples include compression, encryption, interleaving and/or error correction/detection. In addition, multiplexing can be used for broadcasting multiple messages simultaneously. Preferably, the signal that is generated is a fairly high-frequency (as noted above) binary-encoded digital signal which corresponds to when the light source **55** is to be turned on and when it is to be turned off. This signal is then output to drive the light source **55** (either directly or after being amplified first). In certain embodiments, the messages are delivered at relatively high frequencies for relatively short periods of time so that the light source **55** is continuously on (i.e., non-modulated) for at least 50-99% of any given interval of 1.00 to 0.01 second. As result, the intensity of the light source **55** (which preferably also is being used to provide illumination) is not unduly impaired as a result of the modulation.

Still further, in certain embodiments the light **57** from one of the messaging units (e.g., unit **52**A) significantly overlaps with the light **57** from one of the other messaging units (e.g., unit **52**B). In some of such embodiments, the two messaging units coordinate with each other, e.g., using the same wireless network that is also used for communicating with central computer **65** so that each's message is broadcast in a separate set of time slices (i.e., using time-division multiplexing). Alternatively, each's message can have a different code applied to it, within an overall code division multiple access (CDMA) system, so that the receiving user device **10** can selectively receive either one or both. Still further, any other multiplexing technique instead may be used, either with or without coordination between the individual messaging units **52**. Instead (or in addition), adjacent messaging units **52** can be provided with light sources **55** that produce different colors, so that they can be distinguished by the user devices **10** or **20** on that basis.

In step **135**, a determination is made as to whether a new schedule is now applicable (e.g., the applicability of the current schedule has expired and/or the time period for the applicability of another schedule has just begun). If so, processing returns to step **132** to retrieve and implement this newly applicable schedule, typically instead of (but in some cases in addition to) the current schedule. Otherwise, processing returns to step **133** to retrieve the next message (if any) specified by the current schedule. If the current schedule specifies just a single message, then that message is simply rebroadcast (e.g., immediately or with any specified delay).

FIG. **7** illustrates a representative process **160** executed by the user app running on the various user devices **10**. Process **160** concerns the receipt and presentation of messages from the various messaging units **52**. In addition, the user app may also perform a variety of other functions, e.g., including communications via WiFi or via a wireless Internet connection.

Initially, in step **162** one or more messages is/are received and preliminarily decoded, and then one or more of them is/are selected for further processing. The initial receipt of the messages is via light sensor **12** or **22**, which converts the light into an electrical signal. In the case of a camera, the signals from the charge-coupled device (CCD) or other individual elements are summed, averaged or otherwise combined together to provide one signal that represents the light intensity received by the sensor **12** at any given moment. This signal preferably is digitized and high-pass filtered (not necessarily in that order) in order to remove any relatively slow-changing variations. What results is a relatively high-frequency binary signal representing one or more messages from the nearby messaging unit(s) **52**.

In the present embodiment, it is assumed (without loss of generality) that when multiple different messages within system **50** are to be broadcast simultaneously and are capable of being received simultaneously, such messages are time-multiplexed with each other. It is noted that simultaneous broadcast can be either from the same messaging unit **52** or from two or more different messaging units **52** and that simultaneous receipt when two or more messaging units **52** are involved typically is because the light **57** from such messaging units **52** shine on the same spot with intensity levels such that one does not completely overwhelm the other.

The preliminary decoding in this step preferably involves demultiplexing in order to identify the message(s) that are to be selected. In this regard, when messages from two or more messaging units **52** are identified after demultiplexing (e.g., based on messaging-unit identifiers included in the messages' metadata), preferably only the message(s) corresponding to the strongest signal is/are selected. However, to avoid switching back and forth between different messaging units **52**, the user app preferably also includes logic that keeps track of the messaging unit **52** from which messages are currently being received (e.g., based on the units' unique identifiers) and only

switches to a different messaging units **52** when its signal strength exceeds that of the current unit by at least a specified amount (e.g., at least 20-40%), or employs other logic that tends to stay with the current messaging unit **52** until there is a clear indication that the user device **10** has been moved into an area corresponding to a new unit.

Also, as indicated above, the selection of a message (e.g., from among plural messages received from the same messaging unit **52**) in this step may be based on past history of the user device **10** (e.g., the sequence of messages presented prior to the present message). The object for implementing this particular aspect of the selection, when employed, preferably is part of an overall game or game-like interaction sequence implemented by the user app.

In step **163**, the message(s) from the selected messaging unit **52** is/are further decoded. This further decoding step preferably is just a straightforward reversal of the encoding mentioned above. What results is the original message (assuming from this point forward that there is just one).

In step **164**, any pre-stored content referenced in the message is retrieved from one or more storage media in the controller **56**. As noted above, rather than repeatedly embedding the same content in different messages, such content may be pre-stored and then just referenced by its unique identifier in multiple different messages.

In step **165**, the entire message is presented (e.g., shown visually and/or played audibly). This step can be implemented, e.g., using conventional players and/or other user interface processes.

The system **50** depicted in FIG. **3** contemplates a situation in which the administrator **70** is on site locally. In a system **200** according to an alternate embodiment illustrated in FIG. **8**, the administrator **70** is located remotely from the site covered by the messaging units **52**, and the computer **65** communicates with a server **205** via the Internet **207** or another wide-area network **208**. Server **205** then relays the messages (preferably wirelessly) to the individual messaging units **52**. Also, in this embodiment, the individual user devices **10** can communicate **209** (e.g., via LiFi, Wi-Fi or a wireless Internet connection) directly with the central computer **65** (e.g., to download the user app and/or other content).

Still further, in the present embodiment, in addition to receiving messages broadcast by the messaging units **52**, the present user device **10** can transmit messages to such messaging units **52** using its own light source **14**. In order to receive these messages, the individual messaging units **52** also include a light sensor **58**. In one representative embodiment, the messaging unit **52** initiates the communication and broadcasts synchronization signals. Then, the user device **10** synchronizes or coordinates with the messaging unit **52** so that only one is communicating at any given time.

Any of a variety of different kinds of messages preferably can be transmitted in this way, including, e.g., an identifier for the user device **10**, current status information regarding the user device **10**, and/or information currently being received by one or more other sensors or user interfaces on user device **10**. As a result of these bidirectional communications, the system **200** can provide a more fully interactive experience to the user **60**. Such bidirectional communications also can be effected, e.g., via a wireless interface (e.g., a WiFi link to server **205** or a wireless connection **209** to a cellular-based Internet service provider) on user device **10**, either alone or in combination with the light-based communications described herein.

As with system **50** depicted in FIG. **3**, the present system **200** optionally includes one or more associate devices **72** and/or one or more sensors **75** for obtaining information about the users **60** and/or for any of the other purposes discussed herein. In the illustrated embodiment, an associate device **72** and a sensor **75** communicate with the central computer **65**. However, in alternate embodiments they communicate, either directly or indirectly (e.g., through central computer **65**), with server **205**.

A sample layout of a space (or site) **230** covered by a plurality of messaging units **52** is shown in FIG. **9**. In this case, the space **230** covered by the messaging units **52** is the interior space of a single retail store, and the messaging units **52** are installed in the ceiling of the aisles between the store's shelves **232** (e.g., replacing conventional light sources), so that the light shines down. However, even the user device **10** (having its light sensor **12** on its back surface) typically will be able to detect the messages, due to reflection of the light **57** that is emitted from the messaging units **52**.

As shown, in most of the space **230**, the messaging units **52** are sufficiently far apart that the light **57** emitted from their light sources **55** does not significantly overlap. This may be, for example, because conventional light sources (not shown) are disposed between the messaging units **52**, so that although the entire space **230** is illuminated, or because in only certain areas are messages being broadcast. However, messaging units **52**D-G are sufficiently close to each other that there areas of significant overlap **235** between the light **57**D-G, respectively, that they emit. As noted above, in these overlap areas **235**, multiplexing, color separation and/or other techniques can be used to distinguish the messages broadcast by one messaging unit **52** from the messages broadcast by another.

Another exemplary layout is shown in FIG. **10**. Here, messaging units **52** are located on or attached to the shelves **232** so that the light is emitted primarily laterally, rather than downwardly. As a result, the particular message received by a user device **10** might depend not only on the location of the user device **10**, but also its orientation (e.g., whether its back surface is generally oriented in the direction of messaging unit **52**J or messaging unit **52**K which is directly across the aisle).

In addition, FIG. **10** illustrates certain messaging patterns. Initially, for example, the user **60** may be browsing items on the shelf **232**A at position **241**, facing toward messaging unit **52**L. There, the user's device **10** receives and presents a message from messaging unit **52**L that might be related to a product on the shelf **232** in fairly close proximity to messaging unit **52**L (e.g., a promotional message).

Alternatively (or in addition), the user's device **10** receives and presents a message from messaging unit **52**L that directs the user **60** to a different position **242** within the overall space **230**, at an orientation facing messaging unit **52**M. Such a message might be in the form of a promotion for a product located at or near messaging unit **52**M or position **242**. Alternatively, such a message might be in the form of a clue or other indirect instruction. In this latter case, the user **60** might need to move about within the space **230** until he or she finally finds the correct position **242** and orientation. In that event, the user app might cease receiving messages until it picks up the broadcast from messaging unit **52**M. On the other hand, the user app might be configured so as to receive and present messages from other messaging units (e.g., containing additional clues about position **242** and/or a shelf location near messaging unit **52**M). As noted above, user device **10** might receive multiple messages from a particular messaging unit **52** and then select the one with the appropriate clue based on the device's previous history. In any event, a messaging pattern is being used to guide a user **60** around the space **230**. This use of individual messages to guide the user **60** may be

repeated any number of times, causing or encouraging the user **60** to move to any number of different positions (or shelf locations) within the overall space **230**. In the present example, at position **242** facing messaging unit **52**M, the user device **10** receives and presents a message that directly or indirectly guides the user **60** to position **243** and toward an orientation where the user **60** is facing messaging unit **52**N, so that the entire route consists of three different positions (i.e., guidance to two new positions and orientations from a starting position and orientation).

Such a multi-position guidance messaging pattern can be used in connection with a game, such as a scavenger hunt, or can be used as a part of a marketing system, e.g., encouraging the user **60** to make purchases (or at least look at items) related to what the user **60** currently is looking at and/or related to the user **60**'s current and/or previous (or historical): purchasing habits, location, orientation, in-store browsing, Web browsing, other online activity, or other type of activities. For any of such purposes, in certain embodiments the user device **10** receives multiple messages (either multiplexed as noted above or contained within a single chunk of data) but the user app only causes the one(s) that are most appropriate based on any of the preceding historical information (and/or any other historical information) to be presented.

Alternatively, e.g., when equipped with its own light source **14**, the user device **10** can transmit any such historical information to a nearby messaging unit **52**, the server **205** or the computer **65** (e.g., using any of the communication links described herein). Upon receiving such information, the corresponding device executes computer-executable process steps for selecting an appropriate message to be broadcast based on such information.

In any event, although the guidance path shown in FIG. **10** includes just three positions **241**-**243** (with the user **60** being guided to two positions **242** and **243** from an initial position **241**), in many embodiments there will be at least 3-8 such positions to which the user **60** is guided (starting from an initial position), with any combinations of direct and indirect guidance. Also, in the preceding embodiment, the user **60** is guided to specific locations and orientations. Although a similar guidance pattern can be used in connection with the embodiment illustrated in FIG. **9**, in such embodiments the system **50** ordinarily will only guide the user **62** positions within the overall space **230** and not to any particular orientation at that position.

In the preceding embodiments, the discussion focused mainly on light-based communications between the light sources **55** and the user devices **10**. Typically, this light will be visible light because the light sources can then have the dual purposes of providing the necessary illumination within the space (potentially just replacing any existing light sources) and also providing the messaging functionality discussed herein. For this purpose, the messaging units **52** preferably are physically configured to screw into a conventional light bulb socket or otherwise to fit into a conventional light fixture. At the same time, it is noted that in some embodiments the light emitted by some or all of the light sources **55** is non-visible, such as infrared or ultraviolet.

Also, the foregoing embodiments generally contemplate processes in which a given user device **10** or **20** receives and presents messages in real time from the messaging units **52** to which it is exposed. However, in alternate embodiments the user device **10** or **20** receives (or downloads) messages (in whole or in part) in advance from a single messaging unit **52**, but initially just stores them and then only presents them when in the presence of another specified messaging unit **52** or upon the occurrence of any other specified condition. That is, such embodiments use conditional messaging, which can be helpful, e.g., when it is known or expected that a future message will need to be presented but when that message includes a large amount of content or for other reasons might take a long time to receive.

In addition to basing the position of a particular user device **10** or **20** on the identifier for the messaging unit **52** embedded within the messages (or the strongest messages) received by such device **10** or **20**, any other indicia can be used by user device **10** or **20**, the messaging units **52**, the central computer **65** or any other component of the system **50** to help better or more accurately determine the position and/or orientation of the user **60**. Examples of such indicia include the relative strength of the light received from multiple different messaging units **52** (due to overlapping light patterns) and/or information provided by the accelerometer, orientation sensor and/or other sensor(s) within the user device **10** or **20**.

In addition to (or in some embodiments, instead of) the position and/or orientation of the user **60**, any of a variety of other kinds of information can be generated and used within a system according to the present invention. For instance, sensors on the user device **10** or **20**, on a shopping basket that is being used by the user **60**, and/or on the shelves, walls, ceilings and/or floors of the commercial space can be employed to determine when specific items have been picked up by the user **60** and/or deposited into his or her shopping basket. Such sensors can include, e.g.: (1) a camera for taking photographs and/or videos of the items, which can then be uploaded (e.g., using any of the techniques described herein) to the central computer **65** and/or server **205** for identification of the items (e.g., using conventional image-recognition techniques); and/or (2) one or more RFID sensors (reading corresponding RFID tags on such items). As a more specific example, a conventional RFID tracking system can be used to determine when any particular item is moved closer to the position of a particular user **60**, how long that item remains with the user **60**, and whether the user **60** ends up keeping the item (such that their positions subsequently move together) or, alternatively, whether the item is returned to the shelf.

Any or all of this information, especially how long the user **60** studied the item and whether or not the user **60** ultimately decided to keep the item, can be used by the central computer **65** and/or server **205** (e.g., executing any conventional collaborative filtering algorithm) to determine what kinds of messages to send to the user **60**. Examples of such messages can include promotions, deals and purchase suggestions. In addition, or instead, such information can be used to guide the user **60** through a multi-position pattern, either by itself or in conjunction with any of the other information mentioned above for that purpose.

In the embodiments discussed above, the administrator **70** directly controls the messaging that is sent through the messaging units **52**. However, in alternate embodiments, central computer **65** and/or server **205** also (or instead) is accessible by outside entities that have been granted permission (e.g., subject to any constraints imposed by the administrator **70**) to design and/or broadcast messages, or at least to submit message broadcasts to administrator **70** for approval before being broadcast.

For example, in one representative embodiment, the system **200** is implemented within a store, shopping center or other building, and specified manufacturers, wholesalers or other suppliers are granted permission to use the system **200** to promote specific items that they provide. In this embodiment, the supplier signs into system **200** using its provided credentials, references a desired product (e.g., by its UPC code) and submits a promotion with respect to such product.

In the preferred implementation, if the promotion and/or the supplier has been preapproved by the administrator **70**, the promotion is automatically integrated into the message broadcast schedule of system **200**. Otherwise, it is automatically submitted for review by the administrator **70** and, only when approved (e.g., as to content and/or timing), is it integrated into the message broadcast schedule. In either case, such integration often will involve server **205** or computer **65** automatically modifying and/or supplementing the submitted promotion, e.g., based on the location of the product within the retail space and/or other location-specific information.

By providing such access to system **200**, suppliers can directly communicate with their end customers, e.g., guiding potential customers to certain areas for them to scan the subject product from their phones **20** (or other user devices). At the same time, by charging a fee for such access, retailers also can benefit. Computer **65** or server **205** preferably is configured to present a user interface to administrator **70**, providing administrator **70** with significant flexibility in granting or conditioning access rights (e.g., by supplier, by product and by message) so that the corresponding retailer can have as much or as little involvement in the ongoing message broadcasts as it wants.

Tracking and Location Monitoring

In the embodiments discussed above, a network of spatially dispersed messaging units **52** is used for delivering spatially relevant communications. A similar network of messaging units can be used for tracking and/or monitoring the locations of one or more people or items. Such a system can be valuable, e.g.: (1) in a workplace setting for helping management to better understand how resources currently are being deployed, in real time, and how they might be deployed in the future to improve efficiency; (2) in a public or semi-public space for efficiently deploying security personnel; or (3) for coordinating the activities of robots and/or other fully or partially automated devices.

In any of these additional embodiments, the messaging units **52** can be arranged, e.g., as illustrated in FIG. **9** or **10**. When used for tracking or monitoring people, a user device **10** or **20**, as discussed above, often will be used as a receiving unit within a tracking and/or location-monitoring system according to the present embodiments. However, any of a variety of other types of receiving units instead can be used.

In this regard, FIG. **11** is a block diagram of a representative receiving unit **250** according to the present invention. Included within the receiving unit **250** is one or more sensors **252** for receiving signals broadcast by the messaging units **52** (typically in the form of visible, infrared or ultraviolet light) and converting such received signals into electrical signals. As indicated above, for user devices **10** or **20**, one or more built-in cameras can function as sensor(s) **252**. Alternatively, e.g., sensor(s) **252** can be implemented as simple light-intensity sensors, such as one or more phototransistors. In any event, the electrical signals output from sensor(s) **252** are provided to a processor **254** which, as discussed in greater detail below, is configured to process such signals in order to obtain more useful information, to store such signals and/or information into memory **255** and/or to cause the transmission of such signals and/or information to one or more other devices, e.g., using a radio transmitter **257** (for radio broadcasts) and/or one or more LEDs or other light sources **258** (for light-based broadcasts). A monitor **260** optionally may be included within, or as part of, receiving unit **250** (e.g., for user devices **10** or **20**) for displaying the current location and/or orientation of the receiving unit **250**, any other information that is based on such location and/or orientation information, and/or other type of information.

Similar to some of the previous embodiments, each of the messaging units **52** preferably is configured to continually broadcast one or more messages. In certain embodiments the different messaging units broadcast different messages that include different corresponding "location codes", e.g., where each such location code can be used to identify the location of the corresponding messaging unit **52**. For this purpose, each such location code can, e.g., either directly specify the location of the messaging unit **52** or can identify the messaging unit **52** so that its location can be determined (e.g., using a lookup table). In certain embodiments, the location code is a CDMA code that the messaging unit **52** utilizes to encode its transmission, thereby allowing the receiving units **250** to distinguish transmissions from different messaging units **52**. In addition, or instead, the substance of the message that is broadcast by a messaging unit **52** can include its location code. In certain preferred embodiments, each messaging unit **52** continually and repeatedly broadcasts the same message, such that each essentially serves as a reliable location beacon.

In some embodiments, in order to permit the receiving units **250** to distinguish the different messaging units **52** and/or to provide information that can be used in determining the location of the receiving unit **250**, the broadcasts of the different messaging units **52** are coordinated as part of an overall system. For instance, different messaging units **52** might broadcast at different frequencies or otherwise have different pulse patterns, as well as (or instead of) using different CDMA codes. In one set of embodiments, the pulses broadcast by spatially adjacent messaging units **52** are time-division multiplexed.

FIG. **12** is a flow diagram illustrating a process **270** performed by a receiving unit **250** within an overall tracking and/or monitoring system according to a representative embodiment of the present invention. Ordinarily, process **270** is performed by processor **254** reading a corresponding set of computer-readable/executable process steps out of memory **255** and then executing them.

Initially, in step **271** the receiving unit **250** receives one or more digital messages that have been broadcast by one or more corresponding messaging units **52** within the network. As noted above, the receiving unit **250** can include just a single omni-directional (at least within a 180° range, e.g., only front-facing or rear-facing) sensor **252** for this purpose, as often would be the case for many user devices **10** or **20**, or potentially even plural such sensors **252** (e.g., one on the front and one on the back of such a user device **10** or **20**).

Alternatively, the receiving unit **250** can include two or more directional sensors **252**, such as directional sensor **300** (shown in FIG. **13**). Sensor **300** mainly includes a phototransistor **302** that senses light intensity and also includes at least one lens **304** above its light-sensing element for providing the desired directionality. In alternate embodiments, other optical arrangements, such as mirrors or combinations of lenses and mirrors can be used to provide such desired directionality. In any event, a directional sensor according to the preferred embodiments exhibits its a highest signal gain in one particular direction, and its signal gain decreases the more the angle of the light source varies from that maximum-gain direction. Although directional sensor **300** sometimes is used as an example in the following discussion, references to it may be replaced with references to any other type of directional optical sensor.

The use of plural directional sensors **300**, pointed in different directions, generally results in two or more distinct electrical signals for each optical signal that is received. One example of such a sensor arrangement is embodied in sensor assembly **320** (shown in FIG. **14**), which includes four dif-

ferent sensors **321-324** pointed in four different directions **326-329**, respectively. That is, each of the sensors **321-324** has a direction or angle of maximum signal gain (or sensitivity) **326-329**, respectively, and as the angle between a light source and the subject sensor diverges from this maximum-sensitivity angle, the gain or sensitivity decreases (i.e., for a given light intensity, the signal level that is detected decreases as this angle increases).

In addition, as noted above but not shown in FIG. **14**, sensor assembly **320** preferably includes a processor **254**, memory **255** and a transmitter (**257** and/or **258**), together with a battery, capacitor or other element for storing and then providing electrical energy, so that assembly **320** is an entirely self-contained unit in a relatively small package. In alternate embodiments, in order to power assembly **320**, sensors **321-324** can be implemented as photovoltaic cells, separate photovoltaic cells can be included on assembly **320**, and/or any other type of electrical-energy-generating device (e.g. generating electricity from motion, changes in temperature, etc.) can be provided on assembly **320**, so that assembly **320** can be used continuously without battery replacement or recharging from an external source. It is noted that assembly **320** can be implemented as a single integrated circuit (IC), as a single circuit board, or in any other (preferably small) package.

In many of the embodiments discussed above, a relatively costly multipurpose user device **10** or **20** is used as a receiving unit **250**. However, as indicated by the example of assembly **320** above, a simpler special-purpose device instead can be used, e.g., a device that includes just one or more sensors **252**, a processor **254** (such as a microcontroller), a small amount of memory **255** (which can be included on the same IC as the processor), and a LED or other type of transmission device **257** or **258**. Such a simpler, lower-cost, special-purpose device **320** can be particularly advantageous when tracking or monitoring a large number of people, pets, objects, machines or anything else, and is discussed in greater detail below.

Returning to FIG. **12**, in step **272** the receiving unit **250** (e.g., user device **10** or **20**, or assembly **320**) identifies location information based on the messages received in step **271**. This location information can be nothing more than the signal(s) received (e.g., at each of the sensors **321-324**). Alternatively, such location information can be generated by processing of the received signals to varying degrees. For example, the receiving unit's processor **254** might identify the messaging unit(s) **52** from which it has received a broadcast message, e.g., in any of the ways discussed above in connection with step **162**, such as by using time-division selectivity or code-division selectivity or, even more simply, by detecting an identification code (e.g., a unique code) that has been broadcast by each such messaging unit. Still further, more precise location information (and, potentially, even orientation information) can be generated by: (1) comparing the sensor-generated signals for individual messaging units **52** to determine the angles to such messaging units **52** (as described in greater detail below), and then triangulating to establish a position (or location) for, and/or an orientation of, the receiving unit **250**; (2) comparing relative timing of pulses received from multiple different messaging units **52** (particularly where such messaging units **52** have different pulse frequencies or other differences in their pulse characteristics) in order to identify distances to such messaging units **52**, and then triangulating; or (3) using any combination of the foregoing techniques and/or any other light-based direction-measuring or distance-measuring technique(s). Generally speaking, the amount of processing used to generate the location information in this step **272** will depend upon the processing-power of the receiving unit **250**.

Next, in step **274** the receiving unit **250** transmits (e.g., using transmitter **257** or light source **258**) and/or stores (e.g., into memory **255**) the location information identified in step **272**. Often, the receiving unit **250** will store the location information if it is a multipurpose device (such as a tablet or smart phone) and, therefore, will be able to use its current location in connection with other (e.g., higher-level) processing. On the other hand, for the simpler sensor assembly **320**, the receiving unit **250** often will simply transmit the location information on to another device, e.g., for additional processing to identify the location of the receiving unit **250** and/or to use such location information for any of a variety of different purposes. In many cases, transmission will be desirable whether or not the location information is stored for use by the receiving unit **250**, so that other systems and/or devices will have access to it. Such transmission, for instance, can be optical (e.g., using its own LED **258**) or can use radio waves (e.g., Bluetooth, near-field communications or Wi-Fi).

Thus, in certain embodiments the receiving unit **250** itself identifies its location and/or uses that location information locally for its own processing purposes (e.g., to assist its user or for autonomous navigation). In other embodiments, either or both of such tasks is/are performed by a separate monitoring/tracking device or system, in order to limit the processing load on the receiving unit **250**. In either event, at some point the location of the receiving unit **250** is identified (e.g., using any of the techniques discussed above in connection with step **272**) based on the location information collected or generated by the receiving unit **250**.

The simplest way to determine location is to identify the messaging unit(s) **52** from which messages were received in step **271** and then retrieve the location(s) of such messaging unit(s) **52**, e.g., using a lookup table. If messages were received from more than one messaging unit **52**, a simple average of their positions can be calculated to determine a coarse location. Alternatively, a weighted average, e.g., based on the signal strength received from each, can be calculated, and in many cases will provide a better estimation of location.

On the other hand, if plural directional sensors were used by the receiving unit **250**, then a corresponding plurality of signals will be received for each messaging unit **52**, and the broadcast from each messaging unit **52** ordinarily will be received at a different signal strength at each such sensor (assuming the sensors have different directionalities). Comparing and/or processing these differing signal strengths, e.g., using known techniques, can provide a more precise location.

FIG. **15** illustrates this concept, showing a sensor assembly **320** with two sensors **321** and **323** and their respective reception beam center directions **326** and **328**. Light coming from a direction **336** that is directly perpendicular to sensor assembly **320** is approximately 30° offset from each of the center directions **326** and **328**. Accordingly, sensors **321** and **323** would detect such light at approximately the same signal level. On the other hand, light coming from the direction **337**, which roughly coincides with direction **326** and is approximately 60° offset from directions **328**, would be detected at a much stronger level by sensor **321** then by sensor **323**. Similarly, light coming from the direction **338**, which roughly coincides with direction **328** and is approximately 60° offset from directions **326**, would be detected at a much stronger level by sensor **323** then by sensor **321**.

In other words, by comparing the signal strengths detected at sensors **321** and **323** (e.g., using a lookup table or a pre-stored formula for that models the gain profiles of the sensors **321** and **323**) from a single source, it is possible to fairly accurately identify the position of the source relative to the sensor assembly **320**. One way to compare such signal

strengths is to calculate a ratio of their magnitudes; then that ratio can be mapped directly (e.g., using a lookup table or a formula) to an angle at which the light is incident upon the sensor assembly **320**. One advantage of employing such a ratio is that doing so eliminates any effects of intensity variation from the source (i.e., messaging units **52**). However, other ratios (e.g., power ratios or the like) or other comparison metrics instead (or also) can be used. Also, the mapping of the comparison metric value to an angle can be predetermined based on the physics of the sensor assembly **320** or can be determined empirically (e.g., calibrated). Use of additional sensors (resulting in additional signals for characterizing each messaging unit **52** or other source) and/or generating and then processing signals based on the broadcasts received from different messaging units **52** (e.g., resulting in angles to other known points) can provide additional information that can be used to more precisely determine the location and/or orientation of the sensor assembly **320**, as well as to identify and correct potential errors (e.g., caused by differential shading of different portions of the sensor assembly **320**).

Another technique referenced above involves the calculation of distances based on differences in the pulse characteristics for different messaging units **52**. For instance, if two messaging units **52** transmit pulses at different frequencies, then the phase shift between their corresponding signals received by a given sensor **252** will provide an indication of their relative distances. By using coordinated sequences of different frequencies for two or more different messaging units **52**, and then calculating phase-shift information from multiple different messaging units **52**, actual distances (to these known points) can be determined by taking into account the speed of light and using straightforward mathematics. Then, the location and/or orientation of the receiving unit **250** can be calculated using triangulation.

As noted above, each individual source (i.e., messaging units **52**) might be identified, e.g., by decoding the received signals using different CDMA codes for the different sources (in which case the CDMA codes themselves function as identification codes that can be used to determine the locations of the corresponding messaging units **52**) or in any other manner in which the individual messaging units **52** broadcast different identification (or, equivalently, location) codes. As indicated in the preceding sentence, a unique identification code, or a non-unique identification code in combination with other information (e.g., past location history that indicates a general current location) that together uniquely identify a messaging unit **52**, can be easily mapped to the known location of the messaging unit, so that the terms "identification code" and "location code" often can be used interchangeably. By using multiple directional sensors **300** and/or identifying the positions of multiple signal sources (e.g., messaging units **52**), it can be possible to very precisely identify the location and the orientation of the sensor assembly **320** (or other receiving unit **250**).

FIG. **16** is a flow diagram illustrating a representative process **360** performed by a location-monitoring and/or location-tracking device in response to the transmission of location information in step **274**. As indicated above, in certain embodiments, such a device is included in the overall system. For example, with reference to system **50** or system **200**, described above, this device might be central computer **65** or server **205**. In any event, the following process steps preferably are implemented as computer-executable process steps, which are read out of memory or any other storage device and then executed by one or more computer processors.

Initially, in step **362** the location information that was transmitted by the receiving unit **250** is received. This step can be accomplished in a variety of different ways, typically depending upon the manner in which the location information has been transmitted. For instance, if the message had been transmitted by the receiving unit **250** flashing a LED or other light source **258**, it might initially be received by a sensor **58** and then forwarded to the subject monitoring and/or tracking device (e.g., over Wi-Fi, over a LAN or using a direct hardwired connection). On the other hand, if the message had been transmitted via a radio signal, it might initially be received by a nearby messaging unit **52** via its antenna **54**, and then forwarded to the subject monitoring and/or tracking device (e.g., over Wi-Fi, over a LAN or using a direct hardwired connection). In any event, the corresponding signal is coupled to the processor for the monitoring and/or tracking device (e.g., either directly or placed in storage for subsequent access by such device).

In step **363**, the current location of the receiving unit **250** is identified and/or updated, e.g., in a stored database associated with the subject monitoring and/or tracking device. The processing performed in this step **363** preferably depends upon the format of the received location information. For instance, if the received location information already identifies the location of the subject receiving unit **250**, then ordinarily that information is simply stored and/or used (e.g., by another application running on the monitoring and/or tracking device or on any other device coupled to it). On the other hand, in many cases, particularly where the receiving unit **250** has limited processing capacity and/or limited energy resources for performing processing, the location information provided by the receiving unit **250** will include just exactly or essentially what was received by it from the messaging unit(s) **52**. In these latter cases, additional processing is first performed in this step **363**, e.g., as described above in connection with step **272** and elsewhere, in order to identify an actual physical location for the messaging unit **250**.

Depending upon the particular embodiment, just the current location of the receiving unit **250** is stored and/or used, or a history of where the receiving unit **250** has been over some period of time (e.g., during at least the past 5 minutes, 15 minutes, 30 minutes, one hour, two hours, four hours, eight hours, one day, three days or one week) is stored and/or used. Similarly, although a single receiving unit **250** is referenced above, in many embodiments the physical locations for a plurality of such receiving units are monitored, tracked, stored and/or used, such as at least 25, 50, 100, 200, 500, 1,000, 5,000 or 10,000 such receiving units. The more data points that are collected and stored, the more useful information that can be generated. For example, by tracking multiple receiving units **250**, it can be possible to identify foot traffic patterns and/or bottlenecks and, as a result, to design more efficient floor plans and/or business processes.

Security Systems

As noted above, a system according to the present invention can be implemented in a variety of different kinds of spaces and for a variety of different purposes. One set of embodiments includes security-system and/or access-control functionality. A block diagram of one such exemplary system **400** is illustrated in FIG. **17**. As shown, system **400** includes a messaging unit **52**, a receiving unit **250** and an access-control unit **410**. Examples of hardware configurations for the messaging unit **52** and the receiving unit **250** have been described above. However, as discussed in greater detail below, in the present embodiments, these components are again configured somewhat differently from the other sets of embodiments discussed above, e.g., using different sets of computer-executable process steps (or software).

In the preferred embodiments, access-control unit **410** functions as, or at least controls, a gateway to a resource, such as stored information, one or more physical items or a physical space. Preferably, access-control unit **410** includes two main subcomponents: (1) an access-control component **412**, which typically includes a processor, memory and/or other type of storage device, and which is the main processing component of access-control unit **410**, performing the processing steps ascribed to access-control unit **410** below; and (2) one or more user interfaces, such as (a) a keyboard **414**, a keypad (not shown), a touchscreen (not shown) or any other interface for entering information manually, (b) a radio receiver **416**, an optical sensor (not shown) for receiving light-based communications, or any other interface for receiving information wirelessly, and/or (c) a physical port (not shown) for receiving a wired connection with receiving unit **250**. In the discussion below, references to keyboard **414** can be replaced with references to any other interface(s) for entering information manually, and references to radio receiver **416** can be replaced with references to any other interface(s) for receiving information wirelessly.

A description of how the foregoing components interact with each other within a system **400** according to certain representative embodiments of the present invention is now described with reference to FIG. **18**. More specifically, FIG. **18** shows an overall process **430** in which some of the individual process steps are executed by the messaging unit **52**, some are executed by the receiving unit **250**, and some are executed by the access-control unit **410**, as described in greater detail below. As will become apparent, although in some cases the individual process steps may be based on, or triggered by, manual input, such process steps preferably are mainly or substantially automated, being stored as computer-executable process steps, and executed by the processor associated with the corresponding device.

Initially, in step **431** a request is submitted by the receiving unit **250** and then received by the messaging unit **52** or by any other device that is in communication with access-control unit **410**. In the preferred embodiments, this request signals a desire by the user **60** or the receiving unit **250** to have access to a protected resource. It can, for example, be transmitted wirelessly (e.g., via radio signals using radio transmitter **257** or via modulated broadcasts of light using LEDs or other light sources **258**), entered manually (e.g., via keyboard interface **414**), or submitted via a wire or cable connection. In any event, the request can be generic and/or can include information identifying the user **60** and/or the receiving unit **250**. However, as discussed below, in certain embodiments, this step **431** is omitted.

In step **432**, a digital message is broadcast by messaging unit **52**. This step **432** can be triggered by the receipt of a request in step **431** or else, e.g., where step **431** is omitted, it can be performed periodically (e.g., continuously at intervals not greater than 1, 5 or 10 seconds), or it can be performed based on any other triggering condition (e.g., attempted access of the certain webpage, physical motion within a particular space, detection of a person in a particular location, and/or detection of a particular type of electronic device in a particular location). In any event, the digital message preferably is broadcast by flashing the light source **55** on and off, e.g., in any manner described above, and includes a secret (e.g., randomly or pseudo-randomly generated) code. Such a code can be generated independently or can be generated (e.g., using encryption and/or hashing) based on information (if any) within the request received in step **431** (e.g., information identifying the user **60** and/or the receiving unit **250**).

In step **434**, the receiving unit **250** receives the digital message that was broadcast in step **432** via its sensor(s) **252**, which typically converts the light-based signal into an electrical signal. This electrical signal is then coupled to the processor **254** of the receiving unit **250**.

In step **435**, based on the message received in step **434**, receiving unit **250** transmits or displays certain related information. In certain embodiments, the information transmitted or displayed in this step **435** is just the same information (e.g., code) received in step **434**. In other embodiments, the received information is supplemented with information associated with the user **60** or the receiving unit **250**, such as a personal password of the user **60**, a code generated from a biometric scan of user **60** (e.g., a fingerprint or thumbprint, or a photograph of the user **60** or some feature of the user **60**), a unique identification code for receiving unit **250**, or any combination of the foregoing. Preferably, one or more of such codes is used as, or is used as the basis for, an encryption code to encrypt one or more of such other codes. In any event, the result preferably is a code indicating that the user **60** and/or the user's receiving unit **250** currently is in the vicinity of messaging unit **52**. Such information can be transmitted, e.g., by modulating one or more light sources **258** or via a radio transmitter **257**. Alternatively, such information can be simply displayed on a monitor **260** (e.g., in alphanumeric form or other format that is easily readable by a human, or in a more computer-friendly format, such as a QR code).

In step **437**, an access code is received by access-control unit **410**. If the information in step **435** had been transmitted, and then such information is received by an appropriate sensor or receiver (e.g., radio receiver **416**) and the access code is derived therefrom in this step **437**. Alternatively, if the information had been displayed in step **435**, then, e.g., in this step **437**: (1) it could be read optically (e.g., by having an optical sensor directly read the display from monitor **260**); or (2) it could have been read by the user **60** who then inputs it (or a code based on the displayed information) manually (e.g., via keyboard **414**).

In step **438**, access-control unit **410** determines whether the received access code is correct (e.g., corresponds to a reference code that is based on the digital message broadcast by the messaging/modulation controller and/or matches an expected code for an authorized user **60** or an authorized receiving unit **250**). If so, then processing proceeds to step **440** in which access to the desired resource is granted. If not, then processing proceeds to step **441** in which access is denied. In this regard, the granting of access may involve, e.g., providing access to restricted portions of a website, providing access (e.g., read, write or both) to any other restricted data, opening an electromechanical lock to permit access to a restricted location or space, making available certain restricted electronically-implemented or electronically-controlled functionality, opening restricted communication channels, or providing access to any other restricted physical, virtual or intangible resource.

Light-Based Communications Based on Characterization Information

Generally speaking, the embodiments discussed above concern systems, methods and techniques for communicating with a variety of users **60** within a particular space, such as customers within a retail or other commercial space. Such communications can be based on any of a variety of different factors. For example, in most of the previous embodiments, the communications are based on the current locations of the individual users **60** and, in some cases, based on the previous locations or movements of such users **60**. Furthermore, in some of the previously discussed embodiments, the commu-

nications also (or instead) are based on individual characteristics or other previous activities of the users **60** and/or other individuals within the covered space. The present embodiments include additional options for providing user-specific communications, particularly for communicating based on the end-user's, the recipient's and/or their companions' individual characteristics.

The present embodiments can operate within the context of a variety of different systems, such as system **50** or system **200**, described above. One such system **470** (which otherwise could have structure of system **50** or system **200**) is illustrated in FIG. **19**. As shown, system **470** has a central server **475** which can include, e.g., computer **65**, server **205** or a combination of the two. Central server **475** preferably receives information **477** from various sources (such as those noted below) and then processes such information **477** to create or identify messages **478** to be broadcast or otherwise sent (and subsequently received and displayed by the user devices **10** or **20** of individual users **60**) based on such information **477**. More preferably, central server **475** causes the identified messages **478** to be distributed to the appropriate messaging/modulation controllers (e.g., controllers **56**), which in turn output control signals **479** to the light sources **55**, causing them to broadcast such messages **478** by modulating their light output **480** (e.g., using a selected encoding technique so that they can be received by the appropriate user devices **10** or **20**).

Information **477** preferably pertains to the individual users **60** and, in some cases, also pertains to other people within the covered space (e.g., as described in greater detail below). As noted above, such information **477** can be collected in any of a variety of different ways, using a variety of different system components. For example, the user **60** might submit information about, or a profile of, himself or herself through a user device **10** or **20**, or through a different computer or device. In addition, or instead, one or more sensors (e.g., sensors **75** or sensors on the user devices **10** or **20**) can be used to automatically collect information regarding the users **60** and/or such other people. Still further, information **477** may be manually input by a different person, such as an associate **73** using a device **72**. Generally speaking, such information-collection approaches can be divided into substantially automated approaches using sensors or substantially manual approaches using input devices, although hybrid devices that permit a combination of such approaches also (or instead) may be employed.

As to the use of automated sensors **75**, many options are available. For example, cameras can be used to capture still images or video, which can then be stored for future reference and also manually examined and/or automatically processed using available algorithms to identify any desired information, such as approximate age and gender, height, facial characteristics, or other biometric information, which then can be used to recognize, or to confirm the identities of, individual people. RFID sensors, operating in conjunction with RFID tags on individual items, can be used to determine, e.g., what objects an individual picks up and/or how long he/she holds them. Infrared sensors can be used to detect individual people. Laser range finders can be used in conjunction with cameras or other sensors to identify locations of people. Radio receivers (e.g., having scanning directional antennas) can be used to locate individuals using wireless devices, e.g., including those who are not communicating within a system according to the present invention. Information **477** from multiple different sensors **75** (e.g., any of the foregoing sensors) can be used by central server **475** to triangulate the locations of individual people. In certain embodiments, e.g., using any of the techniques described herein, the central server **475** tracks the locations of the users **60** and, in some cases, other individuals as well.

Sensors on the user **60**'s device **10** or **20** (e.g., under control of a user app for communicating within the present system **470**) can obtain information regarding, e.g., movements made by the user **60**, Web browsing history, texting history, e-mailing history, telephone use history and various other previous explicit uses of the device **10** or **20** by the user **60**, as well as the times and locations of such uses. Then, the user app causes such information (or information derived from such information, e.g., to protect the user **60**'s privacy) to be transmitted along with the other information **477** to the central server **475**.

As noted above, the central server **475** preferably implements a tracking system that tracks locations of users **60** and, in some cases, of the people within the covered space. Typically, such a tracking system inputs sensor data (discussed above) and then combines such data using available techniques (such as triangulation, Kalman filtering, etc.) to generate the tracking information.

Such tracking information is then combined with all of the other collected information **477** to identify or obtain the messages **478** that are directed to individual users **60**, e.g., using collaborative filtering, neural-network processing, clustering algorithms and/or any of the other techniques described herein or otherwise available for identifying effective messages, particularly available techniques for targeting advertising messages. The combination of long-term data (such as gender and age) and temporary data (such as an assessment of the user **60**'s current mood) often can provide for much better message targeting that is available conventionally. In addition, the combination of automatically collected data and real-time input from human observers can further improve such targeting. Still further, use of current information regarding a user **60**'s companions, as well as information regarding the user **60** himself or herself, often can provide even more relevant message targeting, e.g., by taking into account any influences such companions are likely to have on the user **60**'s purchasing decisions and/or any distractions such companions are causing user **60**.

With respect to manual input, clustering, machine-learning and other statistical techniques can be used to evaluate and weight the inputs from different associates **73**, either on an overall basis or on a characteristic-by-characteristic basis. For example, one associate **73** might be very good at estimating the ages of users **60**, while another might be good at assessing a user **60**'s current mood. By statistically correlating such assessments over a large number of characteristics and individual users **60**, correlation strengths can be determined so that future assessments can be weighted more or less heavily based on who the associate **73** is and what the specific characteristic is.

For the foregoing purposes, the raw information **477** provided by sensors **75**, provided by sensors on the user devices **10** or **20**, input by the users **60** themselves, input by an associate **73**, or obtained in any other way may be directly used by the central server **475** or may be first processed to obtain more relevant derivative information that is then used in constructing or identifying effective messages. In the preferred embodiments, the particular information to use is identified based on statistical evaluations of the types of information that are most relevant to achieving a particular defined goal or subgoal.

In this regard, the goals sought to be achieved by a system **470** according to the present embodiments can include, e.g., motivating the user **60** to: move to a different location within the covered space, purchase or at least examine or consider a

particular item, engage in a game or contest, participate in some other group activity, or communicate with friends or family by telephone or electronic messaging. Once a particular goal has been identified (e.g., by a manager or other individual associated with the system **470**), the particular messages **478** preferably are selected by the central server **475** so as to maximize the likelihood that the users **60** will take the corresponding action. In addition, the same user-specific information-based approach can be used to first identify subgoal(s) that are likely to cause individual users **60** to take the action associated with the main goal and then to communicate messages **478** that are likely to cause the individual users **60** to engage in the action(s) corresponding to such subgoal(s).

As noted above, the information **477** also can be input manually, either by the user **60** or by other individuals, such as one or more associates **73**. In the former case, the information **477** generally is input when the user **60** manually creates a profile, which is then transmitted to central server **475**. In the latter case, associate device **72** preferably provides a dedicated user interface for inputting information regarding the user **60** and, in certain cases, other individuals as well. Pages **500**, **530** and **580**, taken from one example of such a user interface, are illustrated in FIGS. **20-22**, respectively.

Interface page **500**, shown in FIG. **20**, displays a section **501** of the space covered by a LiFi system **470** (e.g., configured as system **50** or **200**) according to the present invention. The particular section **501** illustrated on page **500** is identified in box **502**. When the down arrow **503** is touched or clicked, a drop-down list is displayed and a different section of the covered space may be selected for illustration. Alternatively, a graphical user interface page that displays the entire covered space, divided into sections, may be displayed so that the associate **73** has the ability to select or designate the section that is desired to be displayed. In fact, such an overall map of the entire covered space may be presented initially for the associate **73** to select the desired section to view. However, in the preferred embodiments, the current location of associate **73** is tracked by central server **475** and the section corresponding to associate **73**'s current location is displayed by default, with the displayed section automatically changing as associate **73** moves through the covered space, using either predefined sections or ad hoc sections, based on associate **73**'s current location (as to the latter, e.g., with the currently displayed section being centered at associate **73**'s location).

In the present example, the covered space is a commercial space, such as a retail store or a mall, and the illustrated section **501** includes shelves **232**. To further assist the associate **73** (in this example, typically a salesperson or sales associate), the shelves or any other areas of the displayed section **501** optionally are labeled with the types of items that are located in that subsection or with any other information that can provide the associate **73** with visual context.

In any event, the locations of some or all of the users **60** are designated by icons **505** (in the present example, black dots). In the present embodiment, the icons **505** are displayed only for registered users **60** whose user devices **10** or **20** are on and are in bidirectional communication with the system **470** (e.g., those transmitting signals from their user devices **10** or **20** to the central server **475** through the LiFi network, a Wi-Fi network or in any other manner). As a result, e.g., using any of the techniques discussed herein, a fairly precise location of each such user **60** typically can be obtained. By displaying such locations in this way, it is possible for an associate **73**, operating an associate device **72**, to easily match up individuals he or she sees within section **501** with the icons **505** that are displayed on interface page **500**. Optionally, the location of associate device **72** also is displayed on page **500**, e.g., to even better assist associate **73** in matching customers or other users **60** to the displayed icons **505**.

Then, touching or clicking on one of the icons **505** preferably causes a new user-interface page to be displayed, e.g., one that permits information about the corresponding user **60** to be input and/or that displays information already known about such user **60**. An example is page **530**, shown in FIG. **21**.

In the preferred embodiments, page **530** is pre-populated by the central server **475** with information it has previously obtained. More preferably, information that has been previously input by the current associate **73** (e.g., the logged-in user on the device **72** on which page **530** currently is being displayed) is highlighted (e.g., displayed in bold, in a different color, or in some other distinguishing manner) as compared to information obtained by central server **475** in other ways. In the current embodiment, the associate **73** has the ability to modify (e.g., update) or supplement any of the displayed (e.g., pre-populated) information.

In addition, in some cases it will be apparent that the information previously obtained does not correspond to the actual user **60** that the associate **73** is observing. This might be because, e.g., a single user device **10** or **20** is shared by two or more people (such as a husband and a wife). In that case, arrow buttons **532** and **533** can be used to navigate backward or forward, respectively, among the various individuals who previously have been associated with the current user device **10** or **20** or with the current login information for the user **60**, e.g., with each click or touch of one of the arrow buttons **532** or **533** bringing up a page **530** that has been pre-populated with personal characteristic information corresponding to a different individual who has previously been observed in connection with the present user device **10** or **20** or the present login information, as applicable. If none of these previously observed individuals seem to match the present individual, "New" button **535** can be touched or clicked to bring up a blank page **530** for inputting information about the current individual.

A variety of different types of information can be input and/or can be pre-populated and displayed within page **530**. In addition, although only a single such page is discussed, multiple different information pages can be provided for each individual. The specific information shown on page **530** includes a designation of gender (selectable by clicking on one of the radio buttons **537**), one or more photographs that are displayed in region **538**, age field **540**, name field **545** and a field **546** for any additional notes. However, these types of information are merely exemplary. Fields, buttons or any other user interface elements for any of a variety of other kinds of information about the user **60** may also (or instead) be included, typically depending upon what information is deemed most useful for the desired purposes. Examples include: current manner of dress (e.g., business professional, business casual, recreational, trendy or urban), ZIP code or other indication of the user's neighborhood of residence, interests, social media friends or contacts, or any other personal or demographic information.

On the other hand, a great deal of information **477** may be collected by the central server **475**, while only a portion of it is displayed on page **530**. Typically, it will be most desirable to include on page **530** information types that either: (1) are only (or at least best) capable of being personally observed and/or (2) would be useful to an associate **73** in talking to or otherwise personally interacting with the corresponding user **60**. Also, in certain embodiments the fields and/or choices displayed on page **530** are varied dynamically based on pre-

viously input or otherwise obtained information, such as different choices for mood buttons **543** depending upon the user **60**'s age and gender.

Generally, unless there is an indication that the determination was made by an automated process, once one of the male/female radio buttons **537** has been selected it will not be subsequently changed by the current associate **73**. However, in certain cases, e.g., where gender has been machine-designated based on captured video(s) or image(s), the associate **73** might change the initial designation.

In any event, to assist the associate **73** in confirming that the current user **60** is the same individual whose information is being presented on the current page **530**, in certain embodiments previously taken photographs are displayed in region **538** (e.g., along with navigation arrows if more than one).

Once an estimated age has been entered into the field **540** (or subsequently updated), the central server **475** preferably automatically updates it in response to the passage of time. Also, multiple different age estimates (e.g., from different associates **73** or input at different times) may be combined (e.g., averaged) together, for purposes of pre-populating field **540** on this page **530** and/or for use in other ways by the central server **475**.

A set of buttons **543** permits the associate **73** to select the currently perceived mood of the user **60**. In the preferred embodiments, any number of applicable labels may be selected. However, in alternate embodiments, buttons **543** are radio buttons so that only one may be selected. As discussed in greater detail below, this information can be particularly useful in directing messages to the user **60**, and it is the type of information that is typically very difficult to determine through automated analysis.

Field **545** displays the name of the user **60**, if previously obtained, or allows the associate **73** to enter a name, e.g., if he or she learns it during a conversation with user **60**. Again, this information preferably is highlighted to indicate whether the current associate **73** previously was told the user's name or whether it was obtained in some other manner. Alternatively, such information might not even be displayed to the current associate **73** unless the same individual previously entered it. The main reason for these displays features is that many users **60** (e.g., customers) might feel uncomfortable if someone he or she has not previously spoken with addresses him or her by name.

Field **546** permits entry and display of additional information (e.g., arbitrary or unformatted notes) about the user **60**. Similar to buttons **543**, field **546** permits inputting of personal observations about the user **60**. However, the information in notes field **546** typically will be most useful to the associates **73** themselves, e.g., in providing cues about how to approach the user **60** and/or about what to say to user **60**. At the same time, available automated tools often will be able to extract meaning from these notes **546** and then use such information in directing messages or other communications to the user **60** (or at least suggesting such messages). Once again, for reasons similar to those mentioned above, the notes **546** that previously have been input by the current associate **73** preferably are highlighted. In the particular illustrated example of field **546**, each individual note is designated by a separate bullet. In addition, each note could be accompanied by metadata, indicating, e.g., who input it and/or the date and time it was entered.

For any of the fields displayed on page **530** (e.g., any of fields **540**, **545** or **546**), information preferably can be entered or altered using any available user interface mechanisms, such as clicking or touching within the field and then typing in order dictating the information. For tablets and similar touch-screen devices, touching within any such field preferably results in the display of a pop-up numeric keypad or alpha-numeric keyboard, as applicable, for entering the corresponding information.

As discussed above, user-interface elements **532**, **533** and **535** are for associating different individuals with a single user login and for navigating among those different individuals. In addition, the user **60** often will have other individuals with him or her, such as family members, friends or other companions. For those situations, in the present embodiment, clicking or touching the Companions button **548** causes a new page to be displayed, preferably identical to page **530** but for specifying and viewing information pertaining to the main user **60**'s individual companions. In this new page: arrow buttons **532** and **533** can be used for selecting from among different individuals who previously were identified as companions for user **60**; button **535** can be used to create a new record for, and input information regarding, a new companion; and button **548** (preferably now labeled "Back", "Device Owner" or "Registered User") returns the associate **73** back to page **530**, showing information for the user **60**.

The preceding discussion generally describes an embodiment in which information presented to the associate **73** can include, in addition to information originally input by that particular associate **73** himself or herself, other information that was input by other associates **73** and/or obtained in other ways. This ordinarily will be the preferred mode, so that each associate **73** has access to all or almost all available information that either would be useful to him/her in his/her interactions with the users **60** or would allow him/her to avoid having to input information that has already been input by another associate or obtained in some other way. However, in the current embodiment, the associate **73** has the option of selecting button **552** to display information in the "system" mode (in which such information is displayed irrespective of how it was obtained, as generally discussed above) or button **553** for the "personal" mode (in which only information previously input by the present associate **73** is displayed). In alternate embodiments, only the personal mode is available (i.e., so that the associate **73** does not have a choice).

Finally, clicking or touching the "clear" button **555** clears all information from page **530**, clicking or touching the "revert" button **556** reverses the last change made by associate **73**, and clicking or touching the "done" button **557** saves the current information to the central server **475** and returns the user interface to page **500**.

In addition to displaying other information about the user **60**, page **530** (or any other page of the user interface) optionally can display a variety of different kinds of messaging information. For instance, it could display any or all of: proposed messages for sending to this particular user **60**, which the associate **73** can then accept, reject or modify; or messages that were previously sent to the user **60**, e.g., together with the date and time they were sent, so that the associate **73** can be better informed when speaking with or otherwise interacting with the user **60**.

In the preceding embodiments, the central server **475** only tracks the positions of registered users **60** whose user devices **10** or **20** are on and are in bidirectional communication within the system **470**. However, in alternate embodiments sensors **75** (e.g., cameras or infrared sensors to detect the individuals themselves or radio receivers to obtain locations based on the transmissions from people's wireless devices) are used to track the locations of other individuals within the covered space, i.e., those were not communicating within the system **470**. As result, it often will be the case that less is known about these individuals.

For such an embodiment, rather than using page **500**, page **580** (shown in FIG. **22**) is used to display a selected portion **501** of the covered space. In page **580**, the user **60** who are in bidirectional communication with the system are designated with black dots **505**A-C and the other detected individuals within the space are designated with open circles **581-587**. In addition to the functionality described above in connection with page **500**, page **580** also provides the following functionality. Touching or clicking on any of the open circles **581-587** causes an information page **530** for that individual to be displayed, although in many cases, without some ability to store identifying information for such individuals, it might be difficult to store and retrieve information for a single individual from one visit to the next. Facial recognition or other biometrics may be used for this purpose. Also, or instead, as indicated above, previous designations as a companion of a user **60** can be used in maintaining the identity of such non-registered individuals.

In this regard, page **580** provides the associate **73** with the ability to designate which of the other detected individuals appears to be with a particular user **60**. Such functionality is initiated by touching or clicking on the "group" button **590**. Once this has been done, touching or clicking individual icons (e.g., any of icons **505**A-C and/or icons **581-587**), rather than bringing up information pages **530**, instead causes such icons to be highlighted indicating that they are a group of people who are together. Thus, for example, in FIG. **22**, the associate **73** has touched icons **505**A and **582** (as indicated by the fact that they are now highlighted), meaning that associate **73** believes them to be together. At the same time, the individual corresponding to icon **581**, although in close proximity to this group, has not been highlighted as being with them. Alternatively, rather than (or in addition to) designating companions individually, associate **73** can click or touch "area" button **591** and then draw an area, causing all icons within that area to be highlighted as being together. Once all members of a particular group have been highlighted in either manner, the "done" button **592** is touched or clicked to save the information to the central server **475** and return page **580** to its default state (i.e., no highlighting of the icons). This procedure can be repeated as many times as desired, in order to identify any number of groups of people who appear to be together.

OTHER EXEMPLARY EMBODIMENTS

As will be readily apparent, the present invention is ideally suited to any environment in which a high level of spatially dependent messaging is desired. In addition, because the systems of the present invention can integrate with, and use much of the same infrastructure as, energy-efficient LED and other lighting, such systems can be extremely cost-efficient as well as energy-efficient.

One application of a system according to the present invention is in education, such as primary-level and secondary-level classrooms (e.g., elementary schools, middle schools and high schools). However, any other educational setting could benefit from such a system. For example, with such a system an instructor can divide the class into different groups, e.g., with each group learning different material, or learning the same material but at different speeds. Then, messaging units **52** in the different locations, corresponding to the different groups, can be used to communicate different content that is relevant to each individual group's particular focus. Such groups can be made as large or as small as desired, even to the point that each "group" can consist of just a single student (e.g., by using desk lamps as the light sources **55** for the messaging units **52**), so that individualized communications are possible. In addition, or instead, each classroom can be designated as a different group, receiving different messages than the other classrooms. Also, rather than designating groups, an instructor can designate different "learning stations" where different material is taught, explored or practiced, with the students moving among such different stations.

Similar communications/messaging can be used in connection with less-formal educational settings, such as museums, galleries, displays, exhibitions or tourist sites. Here, the same light source that is used to illuminate a particular exhibit or other item of interest also can be used to communicate information regarding that exhibit or item and/or to communicate information about any similar or related exhibits or items.

Other locations in which systems according to the present invention can be beneficial include hospitals, urgent-care centers and other medical facilities. Here, the messaging units **52** preferably broadcast information that is relevant to their corresponding physical locations, such as information (e.g., medical history, current medical condition, personal preferences or other personal information) regarding a patient within that patient's room or within an operating room into which a patient has been or will be moved.

Still further, a system according to the present invention can utilize (e.g., work in conjunction with) any existing or future public, municipal, commercial or other lighting system or set of individually controlled lights. In one embodiment, traffic lights are used to broadcast information, such as information pertaining to events or conditions within the local vicinity (e.g., traffic, road conditions, detours, local events or traffic-light timing) or even information pertaining to businesses or other commercial activities (e.g., to generate revenues for the corresponding municipality). In more-specific embodiments, a sensor within a smartphone or within a user's automobile receives traffic-light timing information in this manner, and then an associated processor retrieves and uses GPS, traffic and/or vehicle speedometer information, in conjunction with such traffic-light timing information, to generate messages that advise the driver: whether he/she is safe to proceed, whether to speed up in order to make it through the intersection before the light turns red, or whether to prepare to stop because it is not possible to make it through the intersection safely or legally. Because traffic signals are directional, different information can be broadcast to drivers based on the direction in which they currently are traveling. In addition, through integration with the vehicle's or smartphone's GPS, the incoming information from the traffic light can be filtered and/or used based on relevance to the user's current route or relevance to the user in any other way. Still further, streetlights and/or illuminated commercial signs can be configured to broadcast any desired information to drivers, bicyclists, pedestrians, etc.

In most of the embodiments described above, the messaging units **52** are in fixed locations. However, in certain embodiments messaging units **52** are mobile. For example, in one alternate embodiment one or more automobiles (and/or other transportation vehicles, such as trucks, buses, streetcars, other modes of public transit, motorcycles or bicycles) are configured so as to provide the functionality of messaging units **52**, e.g., with their headlights, taillights and/or any other already-existing or additional add-on lights functioning as the light sources **55**. In these embodiments, the vehicles preferably broadcast information regarding themselves, such as their current route information (e.g., obtained from an onboard GPS system or via a Bluetooth or other wireless connection to a smartphone implementing a navigation system), their current speed or location, whether they are about to

break or accelerate (e.g., when coupled to an automated driving system), whether the driver's foot is positioned on or above the accelerator or the brake, and/or even vehicle or driver identification information (e.g., for reception and use by police cars). Any or all of this information can be received by other vehicles for use in automatically controlling the driving or operation of such other vehicles and/or for providing alerts to the drivers of such other vehicles. In addition, or instead, such information can be received by traffic sensors for use in controlling or guiding overall traffic flow and/or by any other sensors for any other purposes.

In still further embodiments, mobile messaging units **52** are implemented as flashlights, cellphone lights (e.g., light sources **14**), keychain lights or any other portable lights. In the preferred embodiments, such mobile messaging units **52** are configured to broadcast information about the corresponding user, which information is then received and used for any of a variety of purposes, such as security, identification and/or team coordination. For instance, a properly configured keychain light or other flashlight can be used, not only to provide illumination, but also to broadcast a code that unlocks a home or automobile lock. A police or firefighter's flashlight can be configured to also broadcast a code identifying the officer or firefighter to his or her colleagues and/or to provide other immediately relevant information, such as a live video from the individual's helmet cam for coordinating the activities of multiple individuals. Similar light-based messaging also can be employed by automated and/or robotic devices at an emergency scene, e.g., for similar purposes.

Also, in the embodiments discussed above, the user device **10** or **20** generally is a smartphone, tablet or other portable handheld electronic device. However, user device **10** or **20** instead could be implemented as any other kind of device, or any combination of devices. For instance, the sensor portion **12** for receiving light-based messages can be implemented as an eyeglass camera, such as currently is implemented in the Google Glass product, or any other type of wearable sensor. The light source portion **14** for broadcasting light-based messages can be implemented as a light on a handheld device, a wearable light source or any other kind of light. Still further, the sensor **12**, light source **14** and processor **254** can be included within a single device or provided with in multiple different devices that are coupled to each other.

In short, communication systems according to the present invention can involve any mixture of fixed and mobile messaging units **52** and user devices **10** or **20**. Both the messaging units **52** and the user devices **10** or **20** can take on any of a variety of different forms, for any of a variety of different purposes.

In each of the foregoing embodiments, not only are highly specific location-based communications facilitated, but such communications can be very secure. On that basis, systems of the present invention can be distinguished from Wi-Fi networks and other radio-frequency-based communications in which the communications signals penetrate walls and other structures and are, therefore, more easily monitored by others than are light-based communications according to the present invention.

Finally, in any of the embodiments discussed herein that refer to light-based or LiFi communications, it should be understood that the referenced communications can be performed exclusively using such light-based or LiFi approaches. Alternatively, any of such communications instead can be performed in part using such light-based or LiFi approaches and in part using any other (preferably wireless) communications systems, such as Wi-Fi, cellular-based, Bluetooth or near-field communications. Similarly, in any embodiment according to the present invention, the referenced light-based or LiFi approaches can be used in conjunction with one or more other communications systems, such as where the light-based or LiFi approach is used for the final link in communicating with an end user and one or more other additional communications systems are used to reach a desired server.

System Environment.

Generally speaking, except where clearly indicated otherwise, all of the systems, methods, functionality and techniques described herein can be practiced with the use of one or more programmable general-purpose computing devices. Such devices (e.g., including any of the electronic devices mentioned herein) typically will include, for example, at least some of the following components coupled to each other, e.g., via a common bus: (a) one or more central processing units (CPUs); (b) read-only memory (ROM); (c) random access memory (RAM); (d) input/output software and circuitry for interfacing with other devices (e.g., using a hardwired connection, such as a serial port, a parallel port, a USB connection or a FireWire connection, or using a wireless protocol, such as radio-frequency identification (RFID), any other near-field communication (NFC) protocol, Bluetooth or a 802.11 protocol); (e) software and circuitry for connecting to one or more networks, e.g., using a hardwired connection such as an Ethernet card or a wireless protocol, such as code division multiple access (CDMA), global system for mobile communications (GSM), Bluetooth, a 802.11 protocol, or any other cellular-based or non-cellular-based system, which networks, in turn, in many embodiments of the invention, connect to the Internet or to any other networks; (f) a display (such as a cathode ray tube display, a liquid crystal display, an organic light-emitting display, a polymeric light-emitting display or any other thin-film display); (g) other output devices (such as one or more speakers, a headphone set and/or a printer); (h) one or more input devices (such as a mouse, touchpad, tablet, touch-sensitive display or other pointing device, a keyboard, a keypad, a microphone and/or a scanner); (i) a mass storage unit (such as a hard disk drive or a solid-state drive); (j) a real-time clock; (k) a removable storage read/write device (such as a flash drive, any other portable drive that utilizes semiconductor memory, a magnetic disk, a magnetic tape, an opto-magnetic disk, an optical disk, or the like); and/or (l) a modem (e.g., for sending faxes or for connecting to the Internet or to any other computer network). In operation, the process steps to implement the above methods and functionality, to the extent performed by such a general-purpose computer, typically initially are stored in mass storage (e.g., a hard disk or solid-state drive), are downloaded into RAM, and then are executed by the CPU out of RAM. However, in some cases the process steps initially are stored in RAM or ROM and/or are directly executed out of mass storage.

Suitable general-purpose programmable devices for use in implementing the present invention may be obtained from various vendors. In the various embodiments, different types of devices are used depending upon the size and complexity of the tasks. Such devices can include, e.g., mainframe computers, multiprocessor computers, one or more server boxes, workstations, personal (e.g., desktop, laptop, tablet or slate) computers and/or even smaller computers, such as personal digital assistants (PDAs), wireless telephones (e.g., smartphones) or any other programmable appliance or device, whether stand-alone, hard-wired into a network or wirelessly connected to a network.

In addition, although general-purpose programmable devices have been described above, in alternate embodiments

one or more special-purpose processors or computers instead (or in addition) are used. In general, it should be noted that, except as expressly noted otherwise, any of the functionality described above can be implemented by a general-purpose processor executing software and/or firmware, by dedicated (e.g., logic-based) hardware, or any combination of these approaches, with the particular implementation being selected based on known engineering tradeoffs. More specifically, where any process and/or functionality described above is implemented in a fixed, predetermined and/or logical manner, it can be accomplished by a processor executing programming (e.g., software or firmware), an appropriate arrangement of logic components (hardware), or any combination of the two, as will be readily appreciated by those skilled in the art. In other words, it is well-understood how to convert logical and/or arithmetic operations into instructions for performing such operations within a processor and/or into logic gate configurations for performing such operations; in fact, compilers typically are available for both kinds of conversions.

It should be understood that the present invention also relates to machine-readable tangible (or non-transitory) media on which are stored software or firmware program instructions (i.e., computer-executable process instructions) for performing the methods and functionality of this invention. Such media include, by way of example, magnetic disks, magnetic tape, optically readable media such as CDs and DVDs, or semiconductor memory such as various types of memory cards, USB flash memory devices, solid-state drives, etc. In each case, the medium may take the form of a portable item such as a miniature disk drive or a small disk, diskette, cassette, cartridge, card, stick etc., or it may take the form of a relatively larger or less-mobile item such as a hard disk drive, ROM or RAM provided in a computer or other device. As used herein, unless clearly noted otherwise, references to computer-executable process steps stored on a computer-readable or machine-readable medium are intended to encompass situations in which such process steps are stored on a single medium, as well as situations in which such process steps are stored across multiple media.

The foregoing description primarily emphasizes electronic computers and devices. However, it should be understood that any other computing or other type of device instead may be used, such as a device utilizing any combination of electronic, optical, biological and chemical processing that is capable of performing basic logical and/or arithmetic operations.

In addition, where the present disclosure refers to a processor, computer, server, server device, computer-readable medium or other storage device, client device, or any other kind of apparatus or device, such references should be understood as encompassing the use of plural such processors, computers, servers, server devices, computer-readable media or other storage devices, client devices, or any other such apparatuses or devices, except to the extent clearly indicated otherwise. For instance, a server generally can (and often will) be implemented using a single device or a cluster of server devices (either local or geographically dispersed), e.g., with appropriate load balancing. Similarly, a server device and a client device often will cooperate in executing the process steps of a complete method, e.g., with each such device having its own storage device(s) storing a portion of such process steps and its own processor(s) executing those process steps.

As used herein, the term "coupled", or any other form of the word, is intended to mean either directly connected or connected through one or more other elements or processing blocks.

Additional Considerations.

In the event of any conflict or inconsistency between the disclosure explicitly set forth herein or in the attached drawings, on the one hand, and any materials incorporated by reference herein, on the other, the present disclosure shall take precedence. In the event of any conflict or inconsistency between the disclosures of any applications or patents incorporated by reference herein, the more recently filed disclosure shall take precedence.

In certain instances, the foregoing description refers to clicking or double-clicking on user-interface buttons (typically in reference to desktop computers or laptops), touching icons (typically in reference to devices with touchscreens), dragging user-interface items, or otherwise entering commands or information via a particular user-interface element or mechanism and/or in a particular manner. All of such references are intended to be exemplary only, it being understood that each such reference, as well as each other aspect of the present invention as a whole, encompasses entry of commands or information by a user in any of the ways mentioned herein or in any other known manner, using the same or any other user-interface mechanism, with different entry methods and different user-interface elements being most appropriate for different types of devices and/or in different situations. In addition, or instead, any and all references to inputting commands or information should be understood to encompass input by an automated (e.g., computer-executed) process.

In the above discussion, certain methods are explained by breaking them down into steps listed in a particular order. However, it should be noted that in each such case, except to the extent clearly indicated to the contrary or mandated by practical considerations (such as where the results from one step are necessary to perform another), the indicated order is not critical but, instead, that the described steps can be reordered and/or two or more of such steps can be performed concurrently.

References herein to a "criterion", "multiple criteria", "condition", "conditions" or similar words which are intended to trigger, limit, filter or otherwise affect processing steps, other actions, the subjects of processing steps or actions, or any other activity or data, are intended to mean "one or more", irrespective of whether the singular or the plural form has been used. For instance, any criterion or condition can include any combination (e.g., Boolean combination) of actions, events and/or occurrences (i.e., a multi-part criterion or condition).

Similarly, in the discussion above, functionality sometimes is ascribed to a particular module or component. However, functionality generally may be redistributed as desired among any different modules or components, in some cases completely obviating the need for a particular component or module and/or requiring the addition of new components or modules. The precise distribution of functionality preferably is made according to known engineering tradeoffs, with reference to the specific embodiment of the invention, as will be understood by those skilled in the art.

In the discussions above, the words "include", "includes", "including", and all other forms of the word should not be understood as limiting, but rather any specific items following such words should be understood as being merely exemplary.

Several different embodiments of the present invention are described above, with each such embodiment described as including certain features. However, it is intended that the features described in connection with the discussion of any single embodiment are not limited to that embodiment but

may be included and/or arranged in various combinations in any of the other embodiments as well, as will be understood by those skilled in the art.

Thus, although the present invention has been described in detail with regard to the exemplary embodiments thereof and accompanying drawings, it should be apparent to those skilled in the art that various adaptations and modifications of the present invention may be accomplished without departing from the spirit and the scope of the invention. Accordingly, the invention is not limited to the precise embodiments shown in the drawings and described above. Rather, it is intended that all such variations not departing from the spirit of the invention be considered as within the scope thereof as limited solely by the claims appended hereto.

What is claimed is:

1. A messaging system, comprising:

a plurality of messaging units disposed at different locations within a space, each of said messaging units including at least one light source;

at least one messaging/modulation controller coupled to the light sources and configured to turn the light sources on and off so as to broadcast input digital messages;

a central server coupled to the at least one messaging/modulation controller and configured to selectively provide messages to said at least one messaging/modulation controller for broadcast by different ones of said messaging units; and

an associate device coupled to the central server and configured to: (a) display a user interface for manually inputting information about individuals within the space and (b) provide said information to the central server,

wherein the central server selects messages to be broadcast by individual ones of the messaging units based on the information received from said associate device.

2. A messaging system according to claim **1**, further comprising at least one receiver that receives transmissions from user devices within the space.

3. A messaging system according to claim **2**, wherein the central server selects messages to be broadcast by individual ones of the messaging units also based on said received transmissions.

4. A messaging system according to claim **1**, further comprising a tracking system that tracks locations of individuals within the space and provides said location information to the central server.

5. A messaging system according to claim **4**, wherein the central server selects messages to be broadcast by individual ones of the messaging units also based on said location information.

6. A messaging system according to claim **4**, wherein the tracking system tracks the locations of the individuals based on broadcasts from user devices carried by said individuals.

7. A messaging system according to claim **1**, further comprising a sensor that: (a) monitors and obtains observation information about individuals within the space and (b) provides said observation information to the central server, and wherein the central server selects messages to be broadcast by individual ones of the messaging units also based on said observation information.

8. A messaging system according to claim **7**, wherein said sensor comprises a camera.

9. A messaging system according to claim **1**, wherein said user interface displays a map of at least a portion of the space and displays icons indicating locations of individuals within the space.

10. A messaging system according to claim **9**, wherein designating one of the icons causes the user interface to display an information page for a corresponding one of the individuals.

11. A messaging system according to claim **9**, wherein said user interface permits designation of plural icons to indicate that the corresponding individuals are with each other.

12. A messaging system according to claim **1**, wherein said user interface also displays previously collected information about the individuals within the space.

13. A messaging system according to claim **1**, wherein said associate device comprises a wireless handheld device.

14. A messaging system according to claim **1**, wherein said associate device comprises a tablet computer.

15. A messaging system according to claim **1**, wherein the at least one light source in each of a plurality of said messaging units includes a light-emitting diode (LED).

16. A messaging system according to claim **1**, wherein the user interface includes a page that: (1) displays an area comprising at least a section of the space, and (2) permits an associate using said associate device to designate a location of an individual about whom the associate wishes to at least one of input or view information.

17. A messaging system according to claim **16**, wherein the area displayed on said page is automatically selected based on a current location of the associate using said associate device.

18. A messaging system according to claim **1**, wherein upon designation of a specific individual, the user interface displays a page for inputting information about said specific individual.

19. A messaging system according to claim **18**, wherein said page is pre-populated with second information that was previously obtained about said specific individual.

20. A messaging system according to claim **18**, wherein said page includes fields for inputting personally observed information.

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