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**Wagner et al.**

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(54) **SYSTEMS AND METHODS FOR DISTRIBUTED CONTROL**

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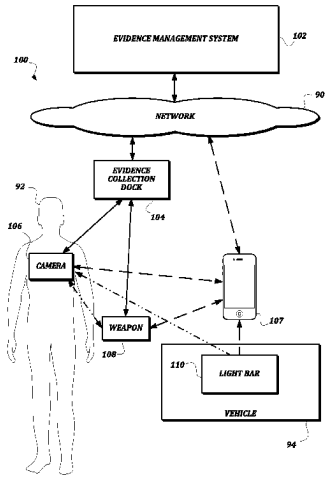
(57) **ABSTRACT**

Systems involving distributed control functions are described herein. Each member or device within the system has responsibility for controlling part of the system's behavior, and includes logic to determine what action, if any, will follow as a response to determining information or receiving information from other members or devices within the system. A change of status of one member of a system may provide a basis for action by another member of the system. Status may be the result of sensing a condition of the environment, sensing the condition of a component, receiving the output of a conventional sensor, and/or sensing the condition of a link between components. In some embodiments, action taken by a member of the system may include collecting data during law enforcement activities.

**20 Claims, 13 Drawing Sheets**



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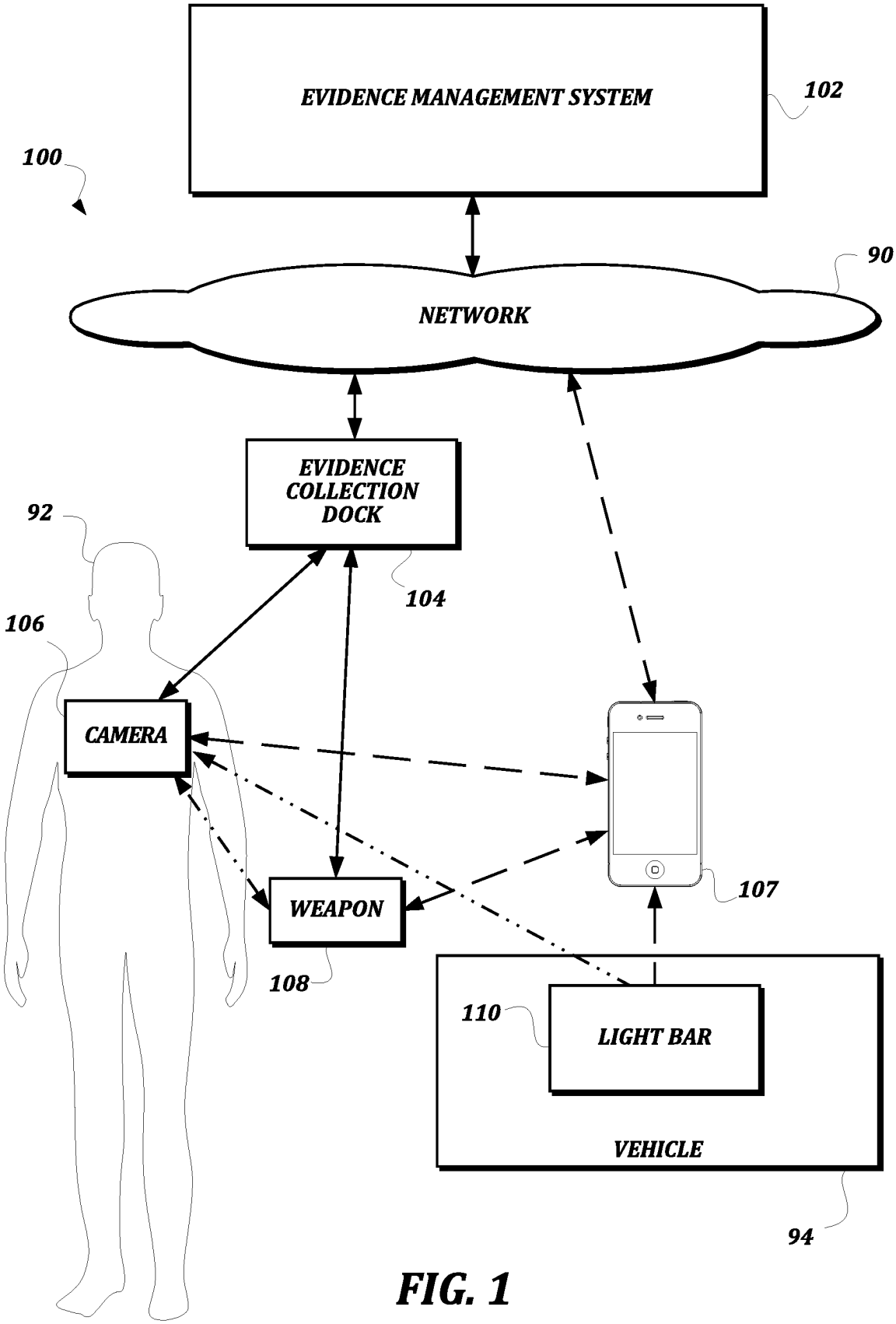
EVIDENCE MANAGEMENT SYSTEM
102
100
90
NETWORK
EVIDENCE COLLECTION DOCK
92
104
106
CAMERA
107
WEAPON
108
110
LIGHT BAR
VEHICLE
94

FIG. 1

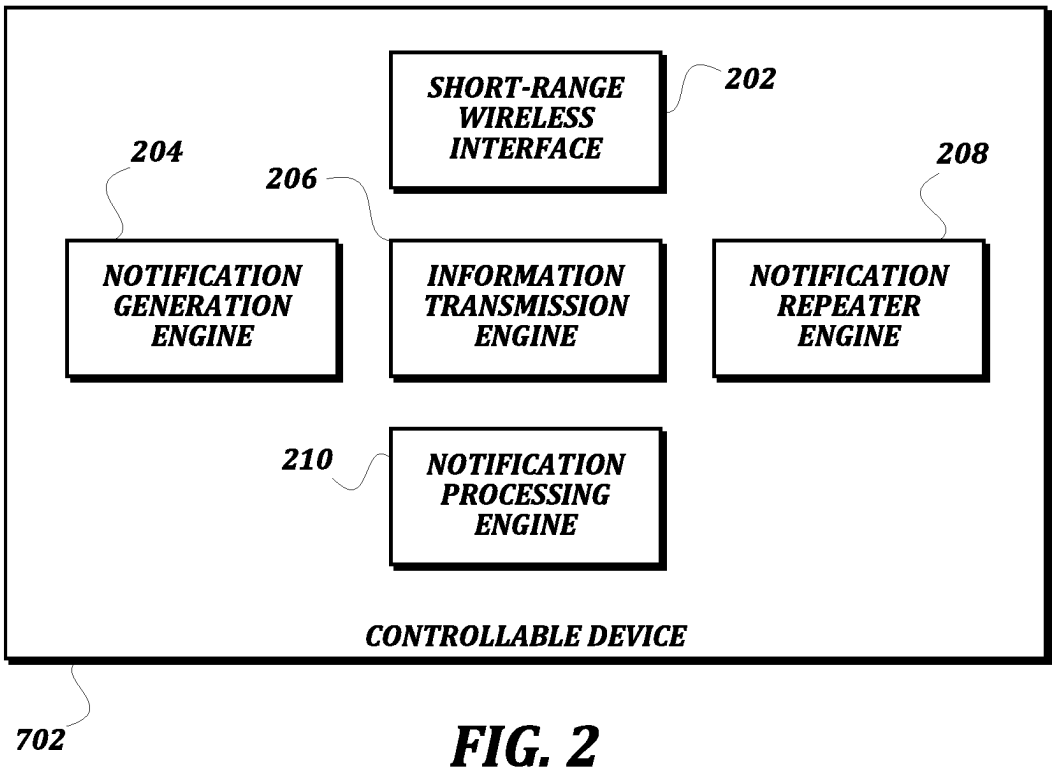
SHORT-RANGE WIRELESS INTERFACE
202
204
206
208
NOTIFICATION GENERATION ENGINE
INFORMATION TRANSMISSION ENGINE
NOTIFICATION REPEATER ENGINE
210
NOTIFICATION PROCESSING ENGINE
CONTROLLABLE DEVICE
702

FIG. 2

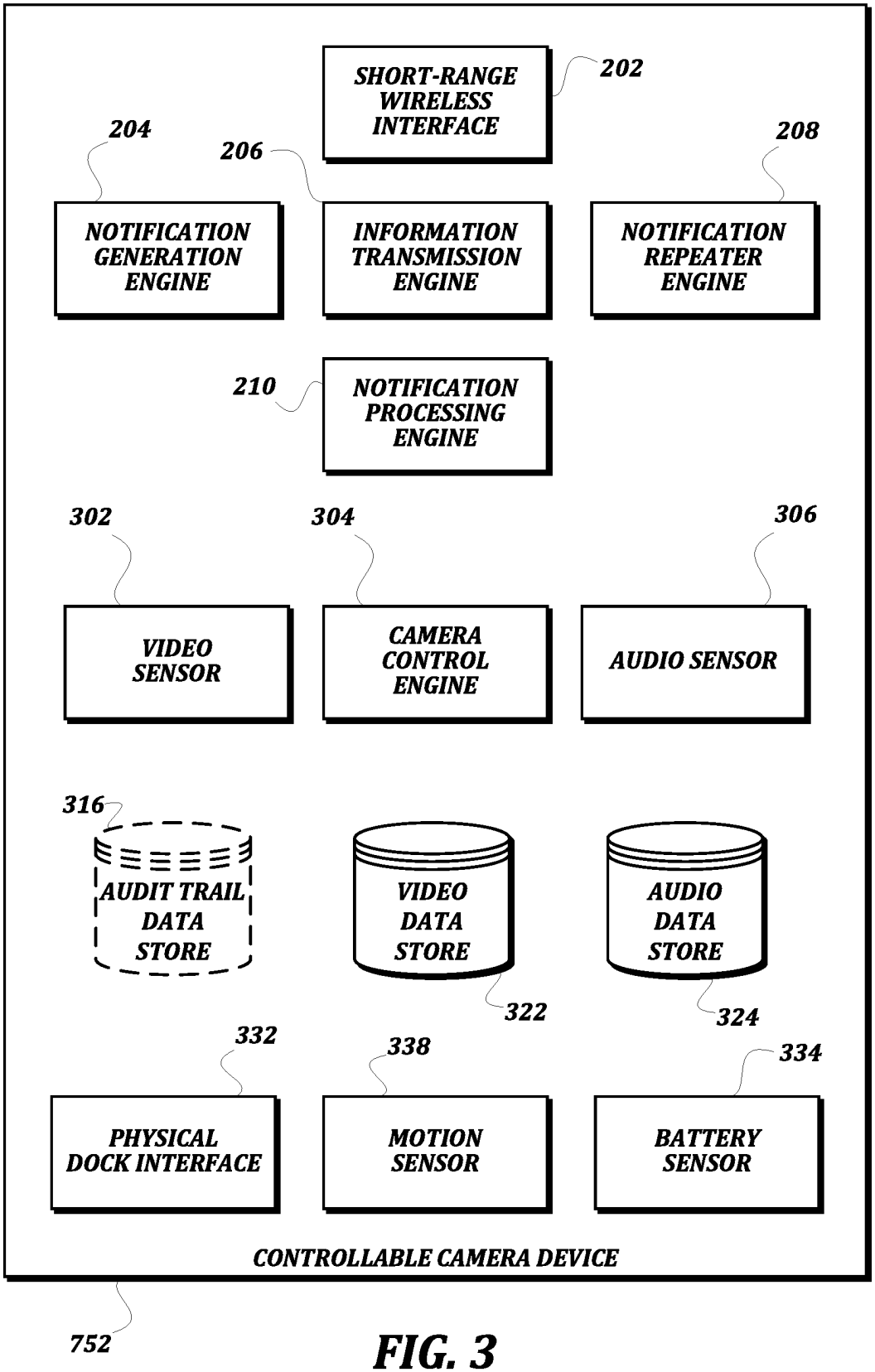
SHORT-RANGE WIRELESS INTERFACE
202
204
206
208
NOTIFICATION GENERATION ENGINE
INFORMATION TRANSMISSION ENGINE
NOTIFICATION REPEATER ENGINE
210
NOTIFICATION PROCESSING ENGINE
302
304
306
VIDEO SENSOR
CAMERA CONTROL ENGINE
AUDIO SENSOR
316
AUDIT TRAIL DATA STORE
VIDEO DATA STORE
AUDIO DATA STORE
322
324
332
338
334
PHYSICAL DOCK INTERFACE
MOTION SENSOR
BATTERY SENSOR
CONTROLLABLE CAMERA DEVICE
752

FIG. 3

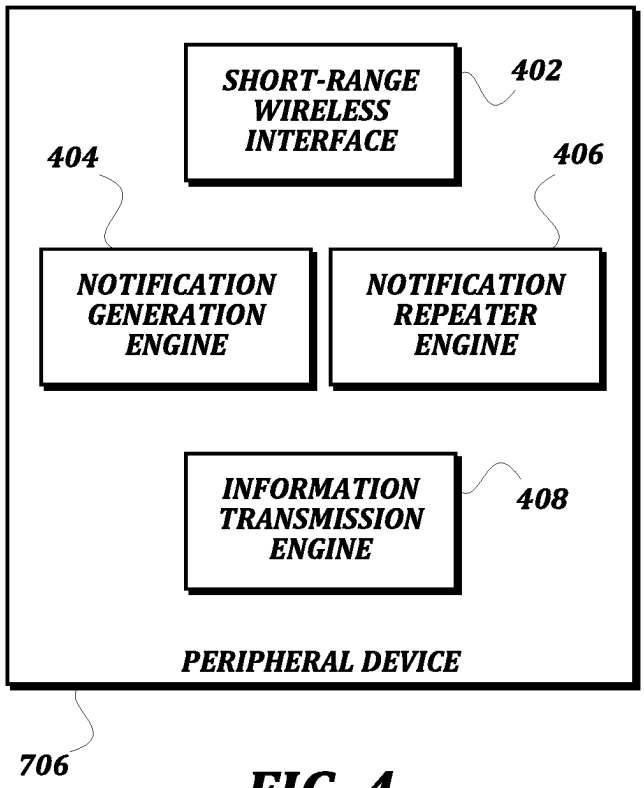
SHORT-RANGE WIRELESS INTERFACE
402
404
406
NOTIFICATION GENERATION ENGINE
NOTIFICATION REPEATER ENGINE
INFORMATION TRANSMISSION ENGINE
408
PERIPHERAL DEVICE
706

FIG. 4

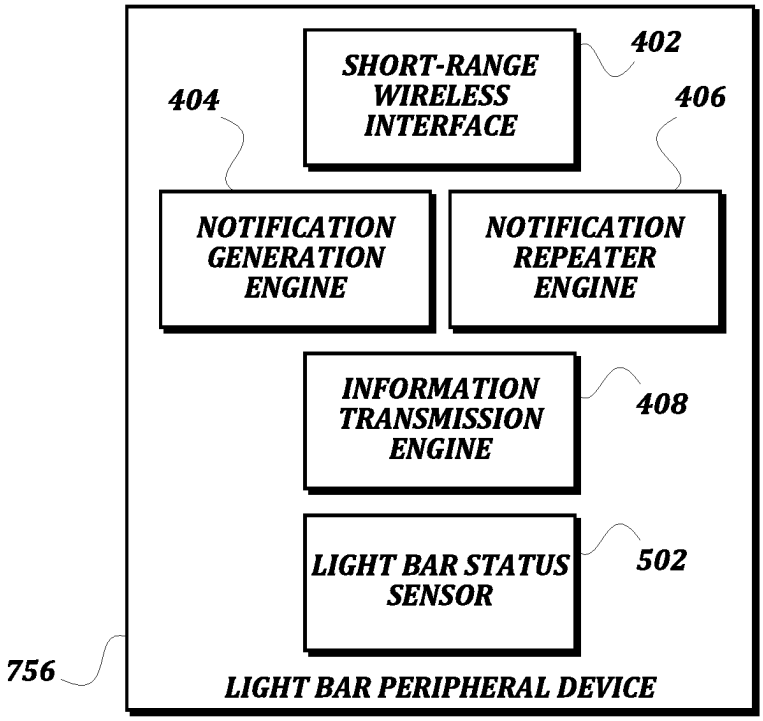
SHORT-RANGE WIRELESS INTERFACE
402
404
406
NOTIFICATION GENERATION ENGINE
NOTIFICATION REPEATER ENGINE
INFORMATION TRANSMISSION ENGINE
408
LIGHT BAR STATUS SENSOR
502
756
LIGHT BAR PERIPHERAL DEVICE

FIG. 5

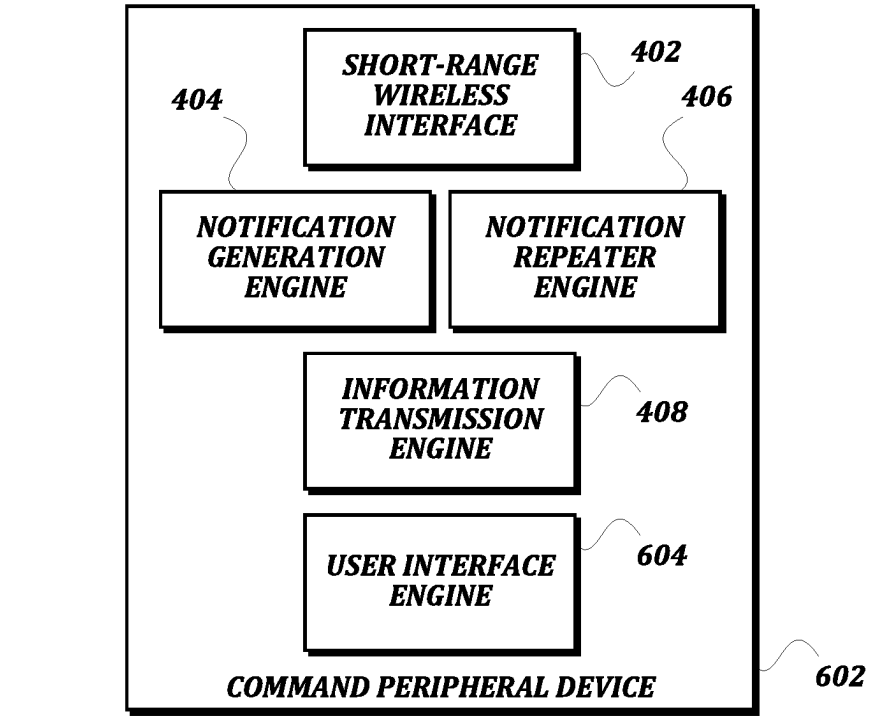
SHORT-RANGE WIRELESS INTERFACE
402
404
406
NOTIFICATION GENERATION ENGINE
NOTIFICATION REPEATER ENGINE
INFORMATION TRANSMISSION ENGINE
408
USER INTERFACE ENGINE
604
COMMAND PERIPHERAL DEVICE
602

FIG. 6

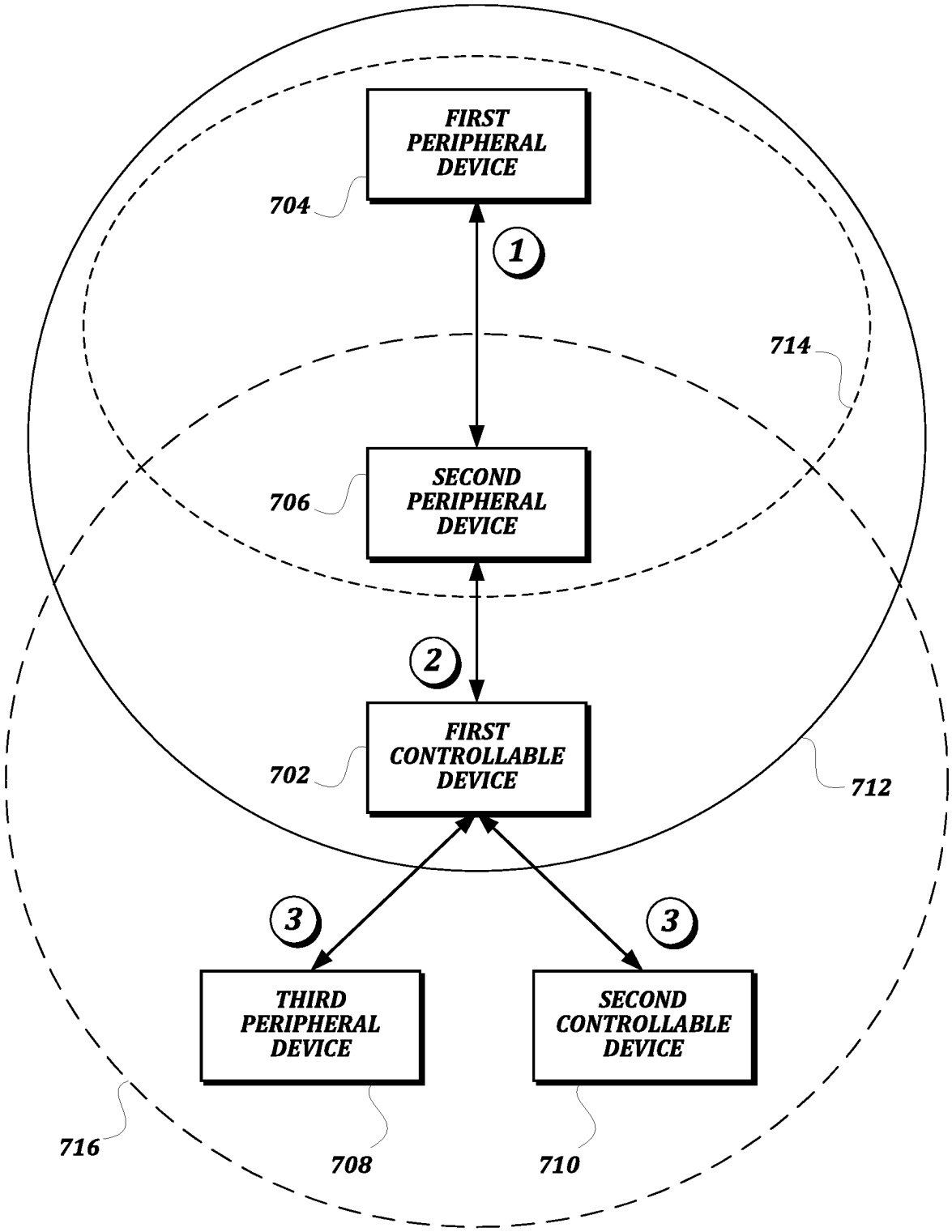
FIRST PERIPHERAL DEVICE
704
1
714
SECOND PERIPHERAL DEVICE
706
2
FIRST CONTROLLABLE DEVICE
702
712
3
3
THIRD PERIPHERAL DEVICE
SECOND CONTROLLABLE DEVICE
716
708
710

FIG. 7A

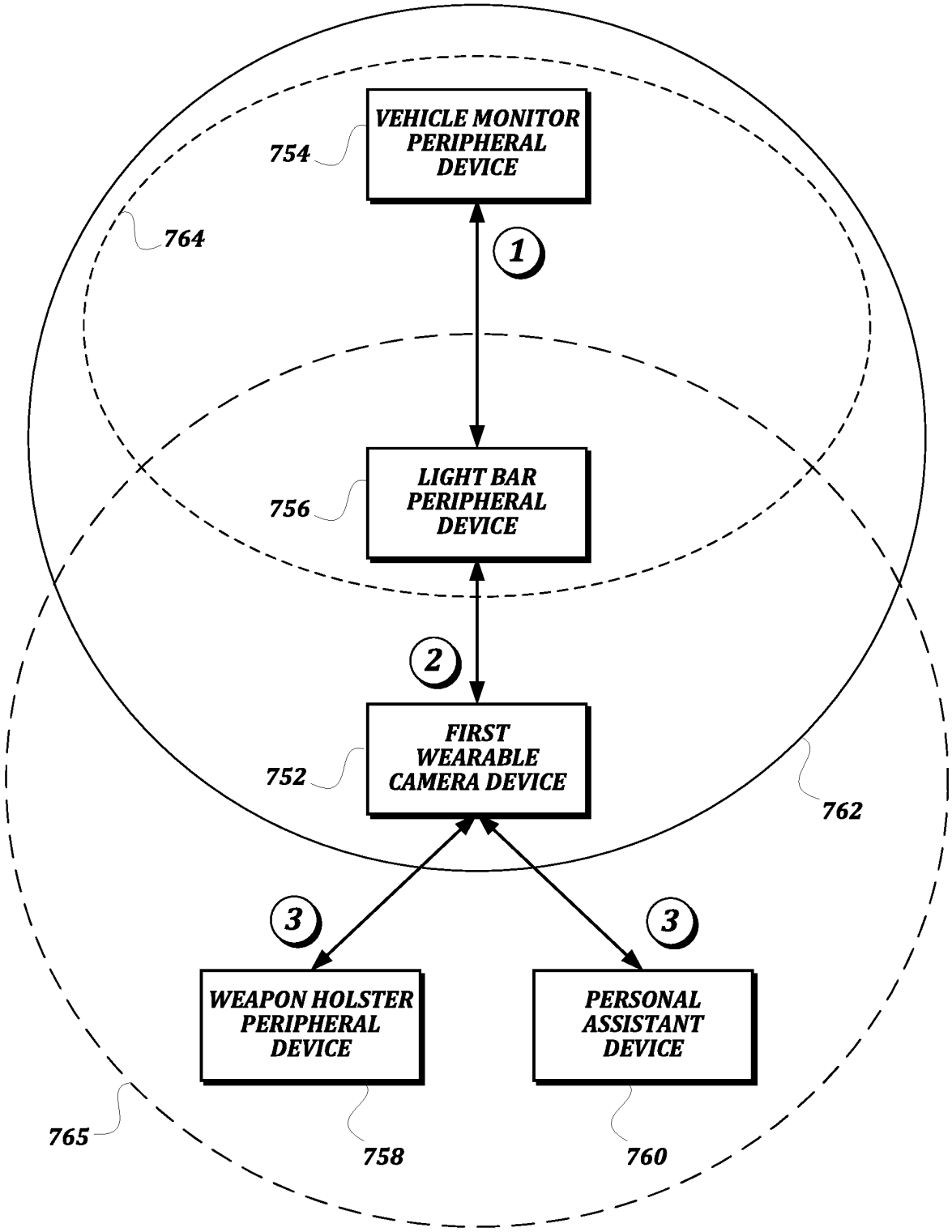
VEHICLE MONITOR PERIPHERAL DEVICE
754
764
1
LIGHT BAR PERIPHERAL DEVICE
756
2
FIRST WEARABLE CAMERA DEVICE
752
762
3
3
WEAPON HOLSTER PERIPHERAL DEVICE
PERSONAL ASSISTANT DEVICE
765
758
760

*FIG. 7B*

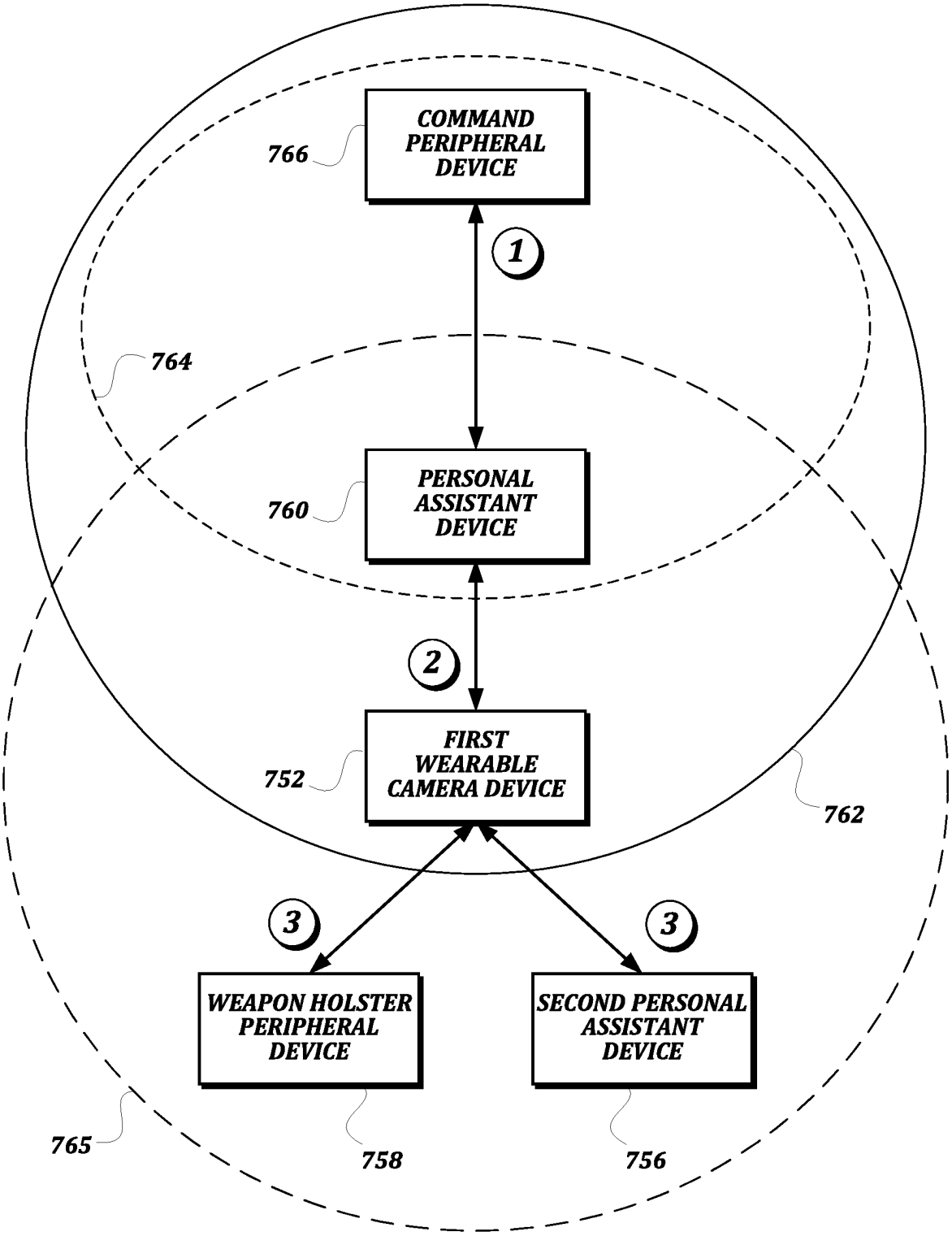
COMMAND PERIPHERAL DEVICE
766
1
764
PERSONAL ASSISTANT DEVICE
760
2
FIRST WEARABLE CAMERA DEVICE
752
762
3
3
WEAPON HOLSTER PERIPHERAL DEVICE
SECOND PERSONAL ASSISTANT DEVICE
765
758
756

FIG. 7C

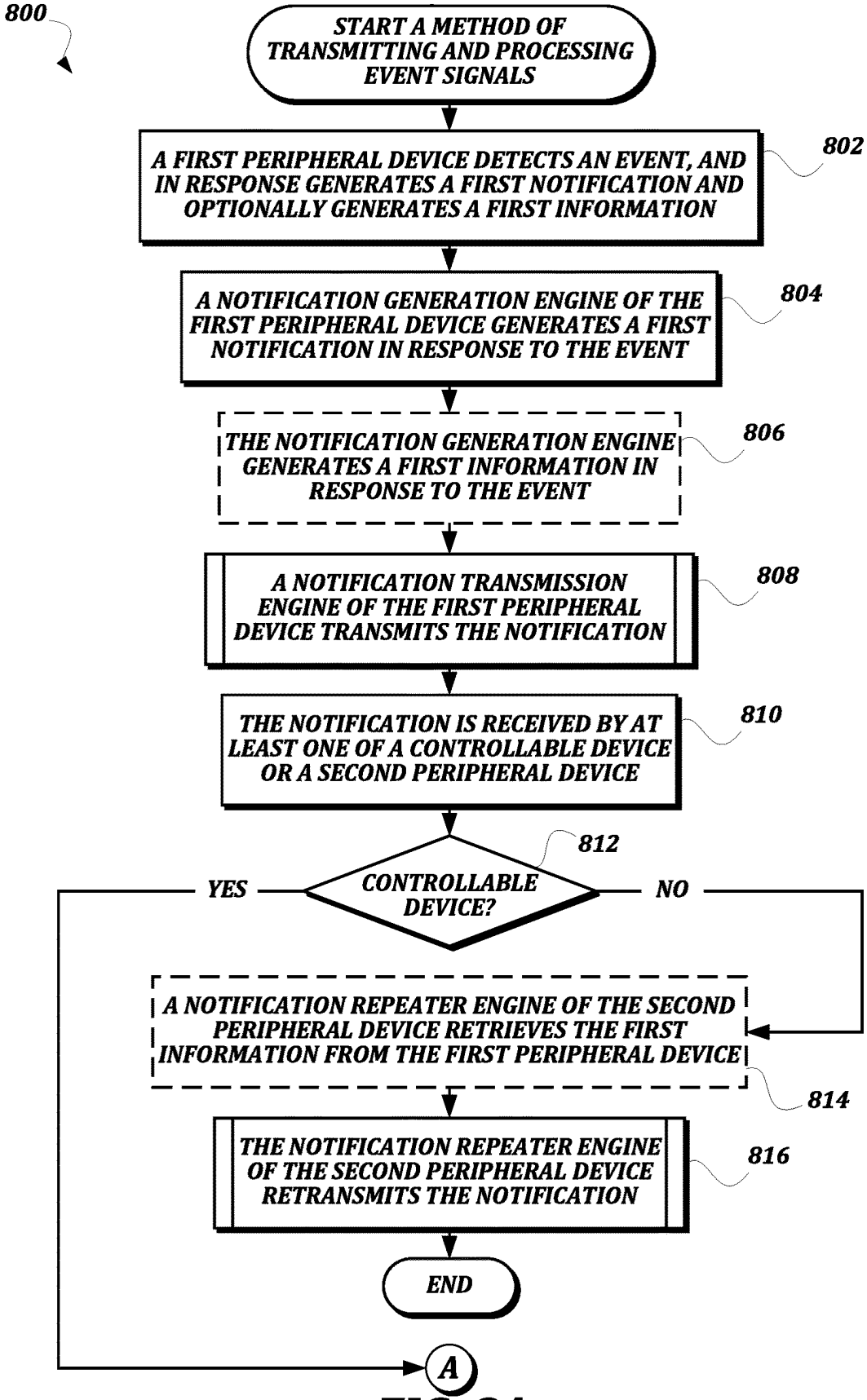
800
START A METHOD OF TRANSMITTING AND PROCESSING EVENT SIGNALS
A FIRST PERIPHERAL DEVICE DETECTS AN EVENT, AND IN RESPONSE GENERATES A FIRST NOTIFICATION AND OPTIONALLY GENERATES A FIRST INFORMATION
802
A NOTIFICATION GENERATION ENGINE OF THE FIRST PERIPHERAL DEVICE GENERATES A FIRST NOTIFICATION IN RESPONSE TO THE EVENT
804
THE NOTIFICATION GENERATION ENGINE GENERATES A FIRST INFORMATION IN RESPONSE TO THE EVENT
806
A NOTIFICATION TRANSMISSION ENGINE OF THE FIRST PERIPHERAL DEVICE TRANSMITS THE NOTIFICATION
808
THE NOTIFICATION IS RECEIVED BY AT LEAST ONE OF A CONTROLLABLE DEVICE OR A SECOND PERIPHERAL DEVICE
810
812
CONTROLLABLE DEVICE?
YES
NO
A NOTIFICATION REPEATER ENGINE OF THE SECOND PERIPHERAL DEVICE RETRIEVES THE FIRST INFORMATION FROM THE FIRST PERIPHERAL DEVICE
814
THE NOTIFICATION REPEATER ENGINE OF THE SECOND PERIPHERAL DEVICE RETRANSMITS THE NOTIFICATION
816
END
A

FIG. 8A

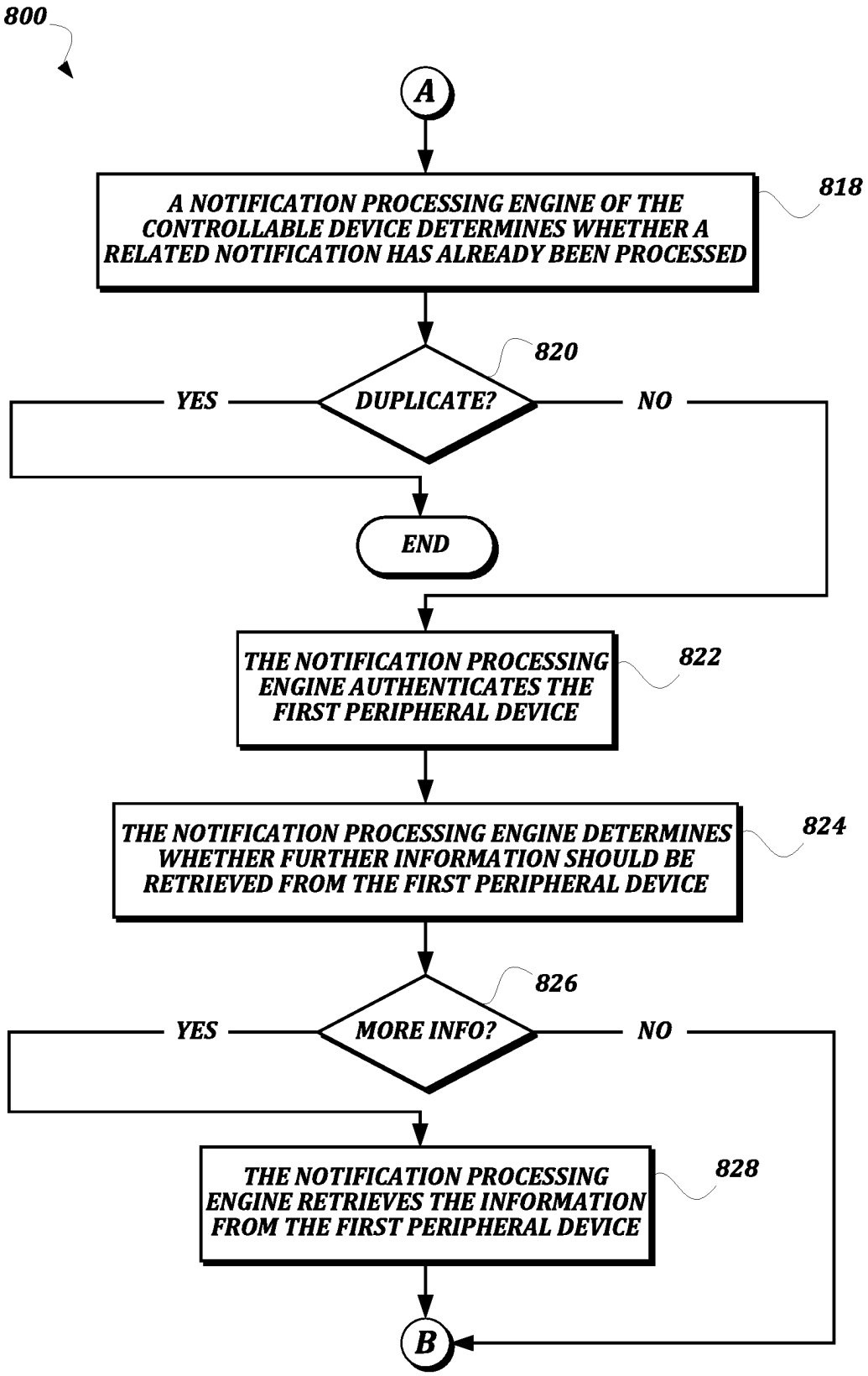
800
A
A NOTIFICATION PROCESSING ENGINE OF THE CONTROLLABLE DEVICE DETERMINES WHETHER A RELATED NOTIFICATION HAS ALREADY BEEN PROCESSED
818
820
DUPLICATE?
YES
NO
END
THE NOTIFICATION PROCESSING ENGINE AUTHENTICATES THE FIRST PERIPHERAL DEVICE
822
THE NOTIFICATION PROCESSING ENGINE DETERMINES WHETHER FURTHER INFORMATION SHOULD BE RETRIEVED FROM THE FIRST PERIPHERAL DEVICE
824
826
MORE INFO?
YES
NO
THE NOTIFICATION PROCESSING ENGINE RETRIEVES THE INFORMATION FROM THE FIRST PERIPHERAL DEVICE
828
B

FIG. 8B

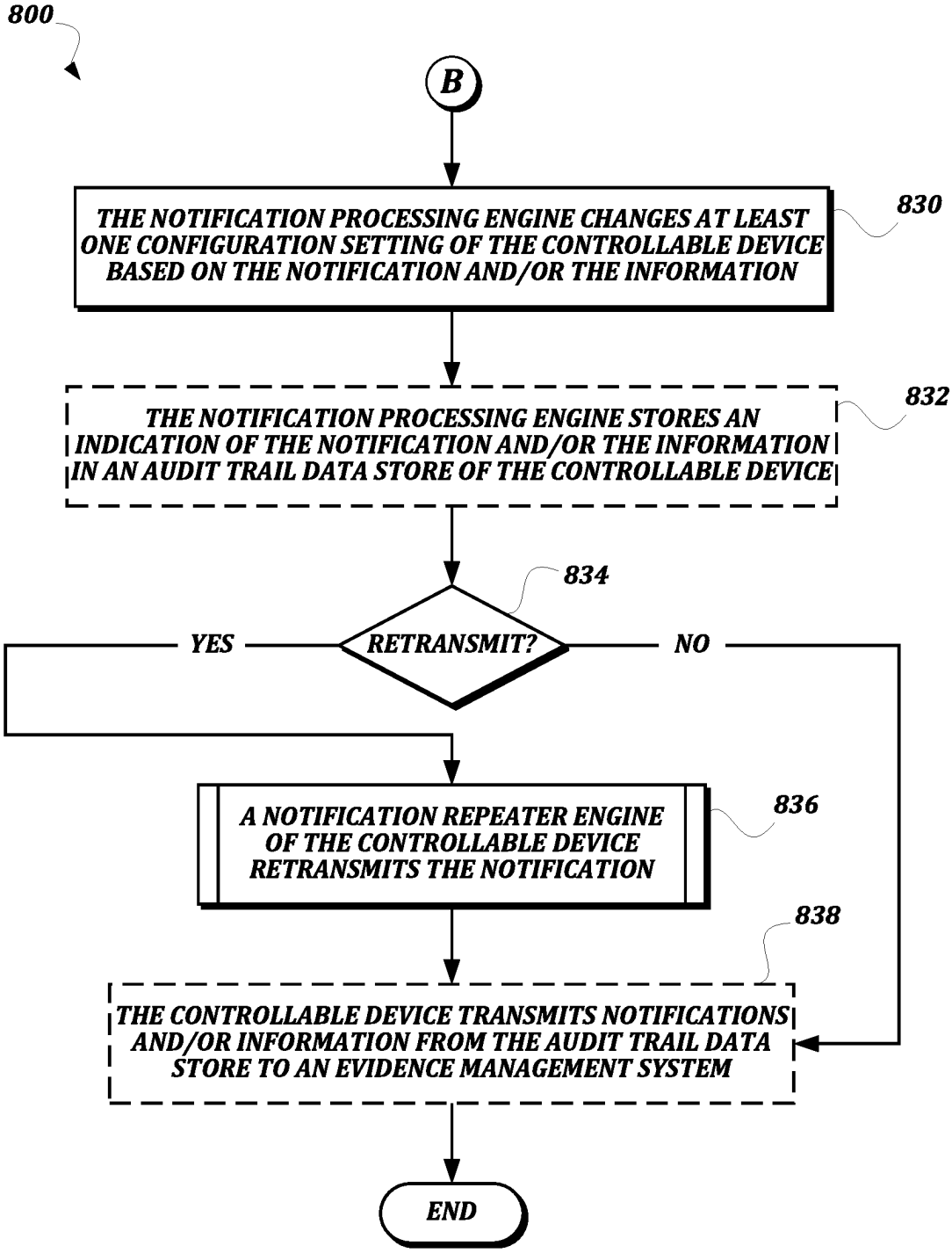
800
B
THE NOTIFICATION PROCESSING ENGINE CHANGES AT LEAST ONE CONFIGURATION SETTING OF THE CONTROLLABLE DEVICE BASED ON THE NOTIFICATION AND/OR THE INFORMATION
830
THE NOTIFICATION PROCESSING ENGINE STORES AN INDICATION OF THE NOTIFICATION AND/OR THE INFORMATION IN AN AUDIT TRAIL DATA STORE OF THE CONTROLLABLE DEVICE
832
834
RETRANSMIT?
YES
NO
A NOTIFICATION REPEATER ENGINE OF THE CONTROLLABLE DEVICE RETRANSMITS THE NOTIFICATION
836
838
THE CONTROLLABLE DEVICE TRANSMITS NOTIFICATIONS AND/OR INFORMATION FROM THE AUDIT TRAIL DATA STORE TO AN EVIDENCE MANAGEMENT SYSTEM
END

FIG. 8C

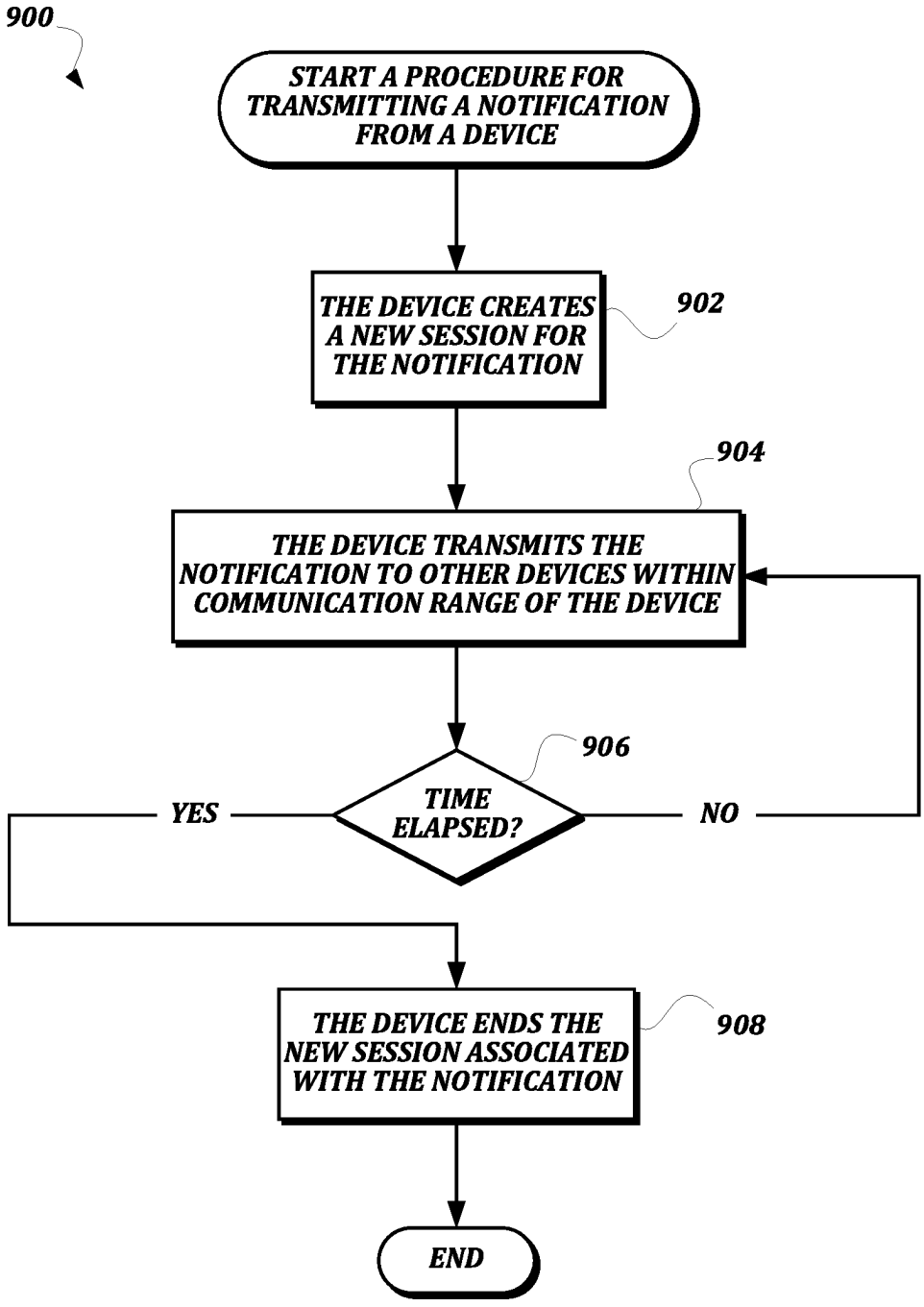
900
START A PROCEDURE FOR TRANSMITTING A NOTIFICATION FROM A DEVICE
THE DEVICE CREATES A NEW SESSION FOR THE NOTIFICATION
902
904
THE DEVICE TRANSMITS THE NOTIFICATION TO OTHER DEVICES WITHIN COMMUNICATION RANGE OF THE DEVICE
906
TIME ELAPSED?
YES
NO
THE DEVICE ENDS THE NEW SESSION ASSOCIATED WITH THE NOTIFICATION
908
END

FIG. 9

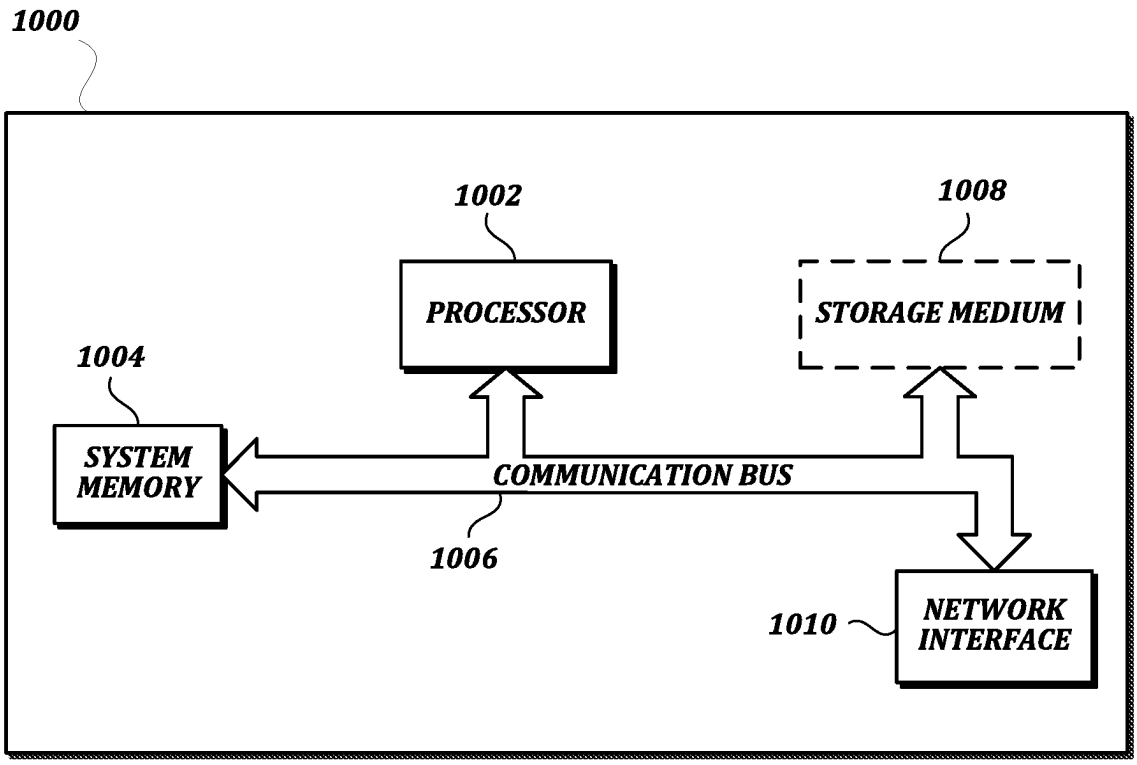
1000
1002
PROCESSOR
1008
STORAGE MEDIUM
1004
SYSTEM MEMORY
COMMUNICATION BUS
1006
1010
NETWORK INTERFACE

FIG. 10

# SYSTEMS AND METHODS FOR DISTRIBUTED CONTROL

## CROSS-REFERENCES TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 18/149,632, filed Jan. 3, 2023, which is a continuation of U.S. application Ser. No. 17/157,720, filed Jan. 25, 2021, which is a continuation of U.S. application Ser. No. 16/508,105, filed Jul. 10, 2019, which is a continuation of U.S. application Ser. No. 14/918,392, filed Oct. 20, 2015, which claims the benefit of Provisional Application No. 62/066,083, filed Oct. 20, 2014, and Provisional Application No. 62/192,466, filed Jul. 14, 2015, the entire disclosures of which are hereby incorporated by reference herein.

## BACKGROUND

Existing techniques for controlling devices in a system, such as wearable cameras operating in a law enforcement context, have various shortcomings. For example, some existing systems require a recording state of a camera to be manually changed by its user. This can lead to video not being recorded for important incidents because a user is too distracted by urgent events that require attention to operate the camera, or for other reasons. What is needed are effective systems and methods for distributed control of wearable cameras and other controllable devices that do not require manual control by a user, but instead allow settings on the controllable devices to be changed in response to events that can automatically be detected.

## SUMMARY

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

In some embodiments, a system comprising a first peripheral device and a controllable device is provided. The first peripheral device is configured to broadcast a first notification indicating an availability of first information generated by the first peripheral device, and to transmit the first information in response to a request for the first information. The controllable device is configured to receive the first notification from the first peripheral device; in response to the first notification, transmit a request for the first information to the first peripheral device; and in response to the first information received from the first peripheral device, change at least one setting of the controllable device based on the first information.

In some embodiments, a controllable device is provided. The controllable device comprises a short-range wireless interface and a notification processing engine. The notification processing engine is configured to receive a first notification from a first peripheral device via the short-range wireless interface; and in response to a determination that the controllable device should process the first notification, change at least one setting of the controllable device based on the first notification.

In some embodiments, a method of processing received signals for control of a controllable device is provided. The method comprises receiving, by the controllable device, a first notification from a first peripheral device; and in response to determining that the controllable device should process the first notification, changing at least one setting of the controllable device based on the first notification.



## DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a high-level schematic diagram that illustrates communication between various components of an exemplary embodiment of a system according to various aspects of the present disclosure;

FIG. **2** is a block diagram that illustrates an exemplary embodiment of a controllable device according to various aspects of the present disclosure;

FIG. **3** is a block diagram that illustrates components of an exemplary embodiment of a controllable camera device according to various aspects of the present disclosure;

FIG. **4** is a block diagram that illustrates an exemplary embodiment of a peripheral device according to various aspects of the present disclosure;

FIG. **5** is a block diagram that illustrates a light bar peripheral device according to various aspects of the present disclosure;

FIG. **6** is a block diagram that illustrates an exemplary embodiment of a command peripheral device according to various aspects of the present disclosure;

FIGS. **7A-7C** are high-level schematic diagrams of exemplary embodiments of communication between devices according to various aspects of the present disclosure;

FIGS. **8A-8C** are a flowchart that illustrates an exemplary embodiment of a method of transmitting and processing event notifications according to various aspects of the present disclosure;

FIG. **9** is a flowchart that illustrates a procedure for transmitting a notification from a device according to various aspects of the present disclosure; and

FIG. **10** is a block diagram that illustrates aspects of an exemplary computing device appropriate for use as a computing device of the present disclosure.

## DETAILED DESCRIPTION

In a system involving central control functions, the central (or federated) part of the system issues commands to other parts of the system and those parts take action in accordance with the received commands. The part that makes decisions and issues commands may be referred to as the master. The part or parts that perform commands may be referred to as slaves. By contrast, in a system involving distributed control functions such as the systems described herein, each member or device within the system that has responsibility for controlling part of the system's behavior includes logic to determine what action, if any, will follow as a response to determining information (e.g., passage of time, results of computation) or receiving information (e.g., one or more notice(s) of change(s) in status(es)). In systems that involve distributed control functions, a change of status of one member of a system may provide a basis for action by another member of the system. Status may be the result of sensing a condition of the environment, sensing the condition of a component, receiving the output of a conventional sensor, and/or sensing the condition of a link between components. When a member of a system receives an

indication that status has changed, action taken in response may be determined by logic implemented in that member of the system.

A condition of a component may include a physical condition including but not limited to temperature, physical location or movement, configuration, capacity to perform, response time, forecast of capability, operating mode, faults encountered, inputs received, received messages, and results of computation. A condition of a link between components may include but is not limited to an operating electrical parameter, a description of establishing connection, a disconnection, a mode of communication, a network capacity, a latency, a description of a queue or buffer, a description of message routing, an extent of noise, a time allotment, and a description of a node (e.g., control, dormant, active, in range).

In some embodiments, recorded data is collected during law enforcement activities (e.g., traffic stops, incidents where police are dispatched to investigate or enforce the law, unmanned traffic monitoring). This class of embodiments will be used below to describe systems, methods, and communication that may be implemented in an analogous manner in a system used for other purposes, for example, any quantity of users who desire to record data during their chosen activities (e.g., first responders, surgical teams, sports teams, military operatives, security officers, social event managers, news reporting, film production, music production, classroom instruction, consumer surveys, group interviews). An officer is a user as discussed below.

FIG. **1** is a high-level schematic diagram that illustrates communication between various components of an exemplary embodiment of a system according to various aspects of the present disclosure. In some embodiments, the system **100** is configured to allow for distributed control of various devices within the system **100**.

In general, a user **92**, such as a law enforcement officer, may be associated with one or more devices. The devices may include, but are not limited to, a camera **106**, a weapon **108**, and various devices associated with a vehicle **94** such as a light bar device **110**. The camera **106** may be, for example, a wearable camera that records video and/or audio data when activated. The weapon **108** may be, for example, a conducted energy weapon (CEW) that transmits notifications regarding events such as firing events, cartridge loading, holster removal, and/or the like. The light bar device **110** may detect changes in state such as activation of the light bar on the vehicle **94**, which is usually associated with an emergency situation. Other devices, such as a dashboard camera, a heart rate sensor device, a holster sensor device, and/or the like may also be included in the system **100** but are not illustrated in FIG. **1**.

In some embodiments, at least some of the devices may have limited communication functionality. For example, devices may have short-range wireless communication abilities, but some devices may only be able to perform a direct long-range transmission or reception of information, such as to an evidence management system **102**, when physically connected to an evidence collection dock **104** that communicates with the evidence management system **102** via a broadband network **90** such as a LAN, a WAN, and/or the Internet. Accordingly, technical problems arise when attempting to control the devices in an automated manner, at least in that no reliable communication path from a central control device to the controllable devices is available. In some embodiments, a personal assistant computing device **107** is provided. The personal assistant computing device **107** is illustrated as a smartphone computing device, but in some embodiments may be a laptop computing device, a tablet computing device, or any other suitable computing device capable of being carried by the user **92** or a vehicle **94** associated with the user **92** and capable of performing the actions described herein. The personal assistant computing device **107** may be capable of short-range communication with the other devices in the system **100**, and may also be capable of long range communication with the evidence management system **102**, a dispatch system, or any other system. In some embodiments, the personal assistant computing device **107** has the components and capabilities of a peripheral device **706** and/or a controllable device **702** as discussed below. Further aspects of these devices and their capabilities will be discussed below.

FIG. **2** is a block diagram that illustrates an exemplary embodiment of a controllable device according to various aspects of the present disclosure. As illustrated, the controllable device **702** includes a short-range wireless interface **202**. The short-range wireless interface **202** may be configured to use any suitable wireless networking technology capable of wirelessly exchanging data with other devices within range of the controllable device **702**, including but not limited to Bluetooth (including Bluetooth Low Energy), ZigBee, NFC, and/or the like.

As illustrated, the controllable device **702** also includes a notification generation engine **204**, an information transmission engine **206**, a notification repeater engine **208**, and a notification processing engine **210**. In general, the term "engine" as used herein refers to logic embodied in hardware or software instructions, which can be written in a programming language, such as C, C++, COBOL, JAVA™, PHP, Perl, HTML, CSS, JavaScript, VBScript, ASPX, Microsoft .NET™ languages such as C#, and/or the like. An engine may be compiled into executable programs or written in interpreted programming languages. Engines may be callable from other engines or from themselves. Generally, the engines described herein refer to modules that can be merged with other engines to form a single engine, or can be divided into multiple sub-engines. The engines may be embodied in any type of circuit such as an FPGA or an ASIC; and/or may be stored in any type of computer-readable medium or computer storage device and be stored on and executed by one or more general purpose computers, thus creating a special purpose computer configured to provide the engine. Accordingly, the devices and systems illustrated herein include one or more computing devices configured to provide the illustrated engines, though the computing devices themselves have not been illustrated in every case for the sake of clarity.

In some embodiments, the notification generation engine **204** is configured to create and transmit new notifications based on information obtained by components of the controllable device **702**. In some embodiments, the information transmission engine **206** is configured to respond to requests for information associated with notifications after notifications have been transmitted by the notification generation engine **204** and received by other devices. In some embodiments, the notification repeater engine **208** is configured to create and transmit notifications based on notifications received by the controllable device **702** from other devices. In some embodiments, the notification processing engine **210** is configured to analyze notifications received from other devices via the short-range wireless interface **202**, and to determine whether a setting of the controllable device **702** should be changed in response to the notifications. In some embodiments, the notification processing engine **210** is also configured to filter notifications for selective retransmission.

Further description of the configuration of and actions performed by these components is provided below.

One of ordinary skill in the art will recognize that, though components common to all controllable devices are illustrated in FIG. **2**, in some embodiments, particular controllable devices may include additional components. For example, FIG. **3** is a block diagram that illustrates components of an exemplary embodiment of a controllable camera device according to various aspects of the present disclosure. In some embodiments, the controllable camera device **752** is a wearable camera that provides a point of view associated with the user **92**. In some embodiments, the controllable camera device **752** may be attached to another device carried by the user **92**, such as a weapon.

Because the controllable camera device **752** is a type of controllable device **702**, it includes a short-range wireless interface **202**, a notification generation engine **204**, an information transmission engine **206**, a notification repeater engine **208**, and a notification processing engine **210** as described above. Further, as with any camera, the controllable camera device **752** includes at least a video sensor **302**, and may also include an audio sensor **306**. Data collected by the video sensor **302** and the audio sensor **306** may be stored in a video data store **322** and an audio data store **324**, respectively, though in some embodiments the audio and video information is stored together in a single data store and/or in a combined data file. One example of an appropriate video sensor is a charge-coupled device (CCD), though any other digital image sensor, such as a complementary metal-oxide-semiconductor (CMOS) sensor, an active pixel sensor, or any other type of digital image sensor could be used instead. Any type of microphone may be used as an audio sensor **306**.

As understood by one of ordinary skill in the art, a "data store" as described herein may be any suitable device configured to store data for access by a computing device. One example of a data store suitable for use with the high capacity needs of the evidence management system **102** is a highly reliable, high-speed relational database management system (RDBMS) executing on one or more computing devices and accessible over a high-speed network. However, any other suitable storage technique and/or device capable of quickly and reliably providing the stored data in response to queries may be used, such as a key-value store, an object database, and/or the like. Further, for the evidence management system **102**, the computing device providing the data store may be accessible locally instead of over a network, or may be provided as a cloud-based service. A data store may also include data stored in an organized manner on a computer-readable storage medium, as described further below. One example of a data store suitable for use with the needs of the controllable camera device **752**, which includes reliable storage but also low overhead, is a file system or database management system that stores data in files (or records) on a computer-readable medium such as flash memory, random access memory (RAM), hard disk drives, and/or the like. One of ordinary skill in the art will recognize that separate data stores described herein may be combined into a single data store, and/or a single data store described herein may be separated into multiple data stores, without departing from the scope of the present disclosure.

The controllable camera device **752** also includes a camera control engine **304**. The camera control engine **304** is configured to change settings of the controllable camera device **752** and thereby cause the controllable camera device **752** to perform camera functions. For example, the camera control engine **304** may cause the video sensor **302** and audio sensor **306** to begin obtaining data, and may cause the video and/or audio data to be saved in a video data store **322** and/or audio data store **324** after receiving it from the sensor. The camera control engine **304** may receive commands to start, pause, or stop the video recording from a physical user interface device of the controllable camera device **752**, or may automatically start, pause, or stop the video recording in response to an instruction received from, for example, the notification processing engine **200** related to a notification received via the short-range wireless interface **202**. The camera control engine **304** may also change settings on the video sensor **302** and/or audio sensor **306** in response to such instructions, such as an image quality, a white balance setting, a gain, and/or any other video or audio recording setting. Starting video recording may include transitioning from a pre-trigger mode, wherein video data and/or audio data is saved in a pre-trigger buffer such as a ring buffer, to a post-trigger mode wherein video data and/or audio data is saved in the video data store **322** and/or the audio data store **324**. Likewise, stopping video recording may include transitioning from the post-trigger mode to the pre-trigger mode.

In some embodiments, the camera control engine **304** may record events relating to starting, pausing, or stopping the video recording, as well as the settings for the video sensor **302** and audio sensor **306**, in an audit trail data store **316**. In some embodiments, the camera control engine **304** may embed the sensor configuration information in the data stored in the video data store **322** and/or audio data store **324**, along with other information about the state of the controllable camera device **752**. The notification processing engine **210** may likewise store records of received notifications and/or information, and the notification generation engine **204** may likewise store records of generated notifications and/or information, in the audit trail data store **316**, the video data store **322**, and/or the audio data store **324**.

The controllable camera device **752** may also include a number of general components, including a motion sensor **338**, a physical dock interface **332**, and a battery sensor **334**. The motion sensor **338**, such as a multi-axis accelerometer, produces information that may be used by other components. For example, the notification generation engine **204** may use the motion sensor **338** to detect a certain types of motion, such as running, falling, and/or the like, and to generate notifications announcing when particular types of motion are detected.

The physical dock interface **332** is configured to mate with a physical connector on the evidence collection dock **104**. In some embodiments, the physical dock interface **332** may include a female 2.5 mm socket, which mates with a male 2.5 mm plug of the evidence collection dock **104**. Once docked, the controllable camera device **752** may then transfer data to the evidence management system **102** via the connection using any suitable data transmission protocol. In some embodiments, power may be transferred to the controllable camera device **752** via the physical dock interface **332** instead of or in addition to the data transfer. In some embodiments, other connection hardware that can provide both power and data connectivity may be used, such as a USB connector, a USB Type-C connector, a Firewire connector, and/or the like.

The battery sensor **334** is another example of an internal system that may generate events that are monitored by the notification generation engine **204** for the generation of notifications. For example, the battery sensor **334** may detect a low battery state, a battery overheating state, and/or the like, and may provide alerts to the notification generation engine **204** for the generation of notifications. Other well-

known internal device systems, such as a file system controller, a free-fall sensor, and/or the like, may similarly provide alerts to the notification generation engine **204**, but are not illustrated here.

FIG. **4** is a block diagram that illustrates an exemplary embodiment of a peripheral device according to various aspects of the present disclosure. As illustrated, the peripheral device **706** includes a short-range wireless interface **402**, a notification generation engine **404**, a notification repeater engine **406**, and an information transmission engine **408**. One of ordinary skill in the art will recognize that these components are similar to the short-range wireless interface **202**, notification generation engine **204**, notification repeater engine **208**, and information transmission engine **206** illustrated and described above with respect to the controllable device **702**. As such, a detailed description of the similar components in the peripheral device **706** is not provided here for the sake of brevity.

The peripheral device **706** and the controllable device **702** have some overlapping capabilities (as discussed in more detail below), and so include similar components. However, the peripheral device **706** is generally used as a source of notifications based on events detected by or generated by components of the peripheral device **706**, and is not generally controllable based on received notifications. Accordingly, the peripheral device **706** is missing the notification processing engine **210** that is present in the controllable device **702**. This allows for the simplification of the hardware used in a peripheral device **706**, thus reducing cost and improving battery life.

One of ordinary skill in the art will recognize that, though components common to all peripheral devices are illustrated in FIG. **4**, in some embodiments, particular peripheral devices may include additional components. As one example, FIG. **5** is a block diagram that illustrates a light bar peripheral device **756** according to various aspects of the present disclosure. The light bar peripheral device **756** is suitable for associating with a light bar **110** of a vehicle **94**, and will help make information about the status of the light bar **110** available within the system **100**. The light bar peripheral device **756** is a type of peripheral device **706**, and so it includes a short-range wireless interface **402**, a notification generation engine **404**, a notification repeater engine **406**, and an information transmission engine **408** as described above.

The light bar peripheral device **756** also includes a light bar status sensor **502**. The light bar status sensor **502** is configured to determine at least a state of the lights on the light bar **110** and/or the status of any other hardware associated with the light bar **110**, including but not limited to a siren, a camera, and/or the like. The light bar status sensor **502** detects when a state of the light bar **110** changes (e.g., the lights are turned on or off), and is configured to transmit alerts regarding the state changes to the notification generation engine **404**. In some embodiments, the notification generation engine **404** receives the alerts from the light bar status sensor **502** and generates notifications when appropriate. The content of the notification generated by the notification generation engine **404** may merely indicate that the status of the light bar **110** has changed, as opposed to also including an indication of the actual status. In response to receiving such a notification, another device may request information that includes the actual status of the light bar **110** from the light bar peripheral device **756**. To respond to the request, the information transmission engine **408** may use the light bar status sensor **502** to determine the state of the light bar **110** (e.g., lights on, lights off, a particular pattern being displayed by the lights, and/or the like) for transmission as information associated with the notification.

As will be recognized by one of ordinary skill in the art, although a light bar peripheral device **756** is illustrated and described in FIG. **5**, many other types of peripheral devices **706** and controllable devices **702** not illustrated in the drawings may be used within the system **100**. These devices will include the common features of the peripheral device **706** and/or the controllable device **702**, as well as additional sensors appropriate for detecting relevant statuses of the components of the particular device.

For example, in some embodiments, a weapon peripheral device may be provided. A weapon provides force for self-defense, defense of others, and/or defense of property. For example, a weapon may include conventional circuits and/or mechanisms for cutting (e.g., hand knife, jaws of life), propelling a projectile (e.g., hand gun, shotgun), releasing noxious material (e.g., pepper spray), and/or causing involuntary muscle contractions (e.g., conducted electrical weapons (CEWs) such as those marketed by TASER International Inc.). A weapon peripheral device may include sensors for determining a change in status of a safety device, detecting a discharge of the weapon, detecting a change in loading status of the weapon, and/or the like. As a similar example, a weapon holster peripheral device may be provided. The weapon holster may be configured to carry a weapon when not in use, and the weapon holster peripheral device may include a sensor configured to detect when the weapon is placed into or removed from the holster.

As another example, in some embodiments, a personal assistant device may be configured as a peripheral device. A personal assistant device, such as the personal assistant device **107** illustrated in FIG. **1**, may include any personal computer system that performs user-selected programs and supports communication with other officers (e.g., officers not co-located with the officer, officers operating dispatch or inventory functions, and/or the like) and/or communicates with other members of the system (e.g., forwards notices, batches notices to forward, derives a new notice from one or more other notices). For example, a personal assistant may be packaged as or with the functions of a laptop computing device, a wrist-worn computing device, a tablet computing device, a body-worn computing device, a smartphone, and/or the like. Communication may include any conventional technologies (e.g., cellular phone service, text and data messaging, email, voice over IP, push-to-talk, video over cellular, video over IP, and/or the like). Communication may use conventional public or private media (e.g., public cellular phone service, local area service, reserved channels, private trunk service, emergency services radio bands, and/or the like). In some embodiments, the personal assistant device may be configured as a controllable device, as opposed to a peripheral device.

As yet another example, a personal monitor peripheral device may be provided. A personal monitor peripheral device may include any apparatus for monitoring and/or recording physical and biological aspects of the user **92** (e.g., location, orientation, position, acceleration, ambient temperature, body temperature, voice, heart rate, indications of stress, and/or the like). Sensors that generate inputs to a personal monitor peripheral device may be of any conventional technology (e.g., analog voltage or current, frequency, pulse position, optical transducers, hall effect, magnetic induction, acceleration, temperature, audio, and/or the like). In some embodiments, a personal monitor peripheral device permits assessment of a user's present level of physiological stress, psychological stress, and/or capacity to perform his or

her duties within the policies and procedures prescribed by his or her superiors. A personal monitor peripheral device may be packaged to be worn on the wrist, chest, waist, and/or head. A personal monitor peripheral device with separable components may communicate among its components using conventional short range communication technology (e.g., Bluetooth, Zigbee, and/or the like).

As still another example, a vehicle monitor peripheral device may be provided. A vehicle monitor peripheral device includes any apparatus for monitoring and/or recording physical aspects of a vehicle (e.g., location, orientation, position, acceleration, ambient temperature, speed, direction, engine performance, supplies of consumables, operating temperature, emissions, operation of integral and accessory equipment, and/or the like). Sensors that generate inputs to a vehicle monitor peripheral device may be of any conventional technology (e.g., analog voltage or current, frequency, pulse position, optical transducers, hall effect, magnetic induction, acceleration, temperature, audio, and/or the like). Any conventional integrated or after-market installation for sensing, monitoring and recording technologies may be used. Some operating mode sensors may include a light bar operating mode sensor be packaged with a light bar; a siren operating mode sensor packaged with a siren; a combined siren and light bar operating mode sensor (if the siren and light bar themselves are combined; vehicle lighting operating mode sensor(s) (e.g., head lights, tail lights, directional and emergency flashers, passenger compartment lighting) packaged with suitable lighting assemblies and/or subassemblies; engine operating mode sensors integrated with engine controls such as ECMs; and/or the like.

In some embodiments, vehicle environment monitors may be provided as peripheral devices or controllable devices. A vehicle environment monitor may include enhanced monitoring and/or recording sensors that expands an unaided user's awareness (e.g., night vision cameras, ultrasound detecting microphones, gunshot detection/location sensor, and/or the like). Other types of sensors that may be provided by a vehicle environment monitor include, but are not limited to: scanners for hidden weapons; sensors for illegal substances such as drugs; breathalyzer devices; still cameras for capturing portraits, scenes, documents, licenses, contraband, or counterfeit goods; video cameras adapted for investigations of particular areas (e.g., under-car or confined space cameras); explosives sensors; and/or the like. Some vehicle environment monitors may also provide analyzed data that goes beyond mere recording. Analysis may include recognition, correlation, and/or prediction based on information monitored or recorded from any source, such as other sensors within the system **100**. Analysis of video or still photographs may be used for recognition of car make and model and identification of the owner of the vehicle and owner of the vehicle license. Analysis of audio and video may be used for recognition and identification of voices, faces, body dimensions, birth marks, tattoos, clothing, currency, drivers' licenses, and/or documents. Predictions may include conventional algorithms for the prediction of crime, for example, predictions based on locations of persons, locations of vehicles, recent dispatches, and recent sniffed, snooped, or analyzed network packets.

In some embodiments, some peripheral devices may be configured to generate notifications as desired by a user, as opposed to automatically in response to data generated by a sensor. As an example, FIG. **6** is a block diagram that illustrates an exemplary embodiment of a command peripheral device **602** according to various aspects of the present disclosure. Again, the command peripheral device **602** is a type of peripheral device **706**, and so it includes a short-range wireless interface **402**, a notification generation engine **404**, a notification repeater engine **406**, and an information transmission engine **408** as described above. In contrast to the above, the command peripheral device **602** includes a user interface engine **604**. The user interface engine **604** is configured to generate a user interface for accepting commands from a user intended for a controllable device. In this way, notifications may be generated within the system **100** that are not in response to a sensed status change, but are instead intentionally created by a user. When a command is received by the user interface engine **604**, the notification generation engine **404** generates a notification and optionally generates information for propagation through the system **100** in a manner similar to other notifications and information.

In some embodiments, the command peripheral device **602** may be an interactive device carried by the user **92** or the vehicle **94**, such as a smart phone, a tablet computing device, a laptop computing device, and/or the like. In some embodiments, the command peripheral device **602** may be a desktop computing device or a server computing device located remotely from the user **92** and operated by a dispatcher or other such user. In such embodiments, the command peripheral device **602** may include a long-range network interface, such as a wired network interface, a WiFi network interface, an LTE network interface, and/or the like. The notification in such embodiments would be sent in a targeted manner to another device with a long-range network interface, such as the personal assistant device **107**, which may then propagate the notification and/or information throughout the rest of the system **100** as any other notification and/or information is propagated.

FIGS. **7A-7C** are high-level schematic diagrams of exemplary embodiments of communication between devices according to various aspects of the present disclosure. In FIG. **7A**, a setting is changed on a first controllable device **702** in response to a notification generated on a first peripheral device **704**. The first peripheral device **704** detects an event that causes a notification to be generated. At a first point in a communication sequence, the first peripheral device **704** generates a notification and transmits the notification to one or more devices within a short-range wireless communication range **714** of the first peripheral device **704**. As illustrated, a second peripheral device **706** is within the communication range **714**, but the first controllable device **702** is not. As discussed in further detail below, the notification may include all of the information needed to describe the event, or the second peripheral device **706** may, upon receiving the notification, request further information from the first peripheral device **704**.

At a second point in the communication sequence, the second peripheral device **706** retransmits the notification originally generated by the first peripheral device **704** to other devices within a communication range **712** of the second peripheral device **706**. For example, the first controllable device **702** is within the communication range **712** of the second peripheral device **706**. Accordingly, the first controllable device **702** receives the notification from the second peripheral device **706**. As discussed in further detail below, in some embodiments the notification transmitted by the second peripheral device **706** may be the same notification as that originally transmitted by the first peripheral device **704** and so appears to the first controllable device **702** as having been transmitted by the first peripheral device **704**. In some embodiments, the second peripheral device **706** may generate a new notification based on the notification

received from the first peripheral device **704**, and transmit that new notification to the first controllable device **702**. As above, all of the information needed by the first controllable device **702** to change its setting may be included in the notification, or the first controllable device **702** may request further information from the second peripheral device **706** upon receiving the notification. In the second case, the second peripheral device **706** may respond to the request for further information with the information it retrieved from the first peripheral device **704**. The first controllable device **702** may then change one or more of its settings based on the notification and/or the information.

At a third point in the communication sequence, the first controllable device **702** may itself retransmit the notification in order to ensure the broadest possible propagation of the notification despite only using short-range wireless technology. Accordingly, the notification retransmitted by the first controllable device **702** may be received by other devices within a communication range **716** of first controllable device **702**, such as a third peripheral device **708** and a second controllable device **710**. As described above, the retransmitted notification could match the original notification, or could be a new notification based on the original notification. In some embodiments, any retransmitted notification is ignored by the original peripheral device or controllable device, even if the original device is within communication range and receives the retransmitted notification. This may help to avoid exponential growth of transmitted notifications, and may save battery life on the original device by not having to fully process as many incoming notifications.

As stated above, any suitable short-range wireless communication technology may be used for the communication. In some embodiments, if Bluetooth or Bluetooth Low Energy is used, the devices may form piconets and scatternets. For example, the communication range **714** may represent a piconet comprising the first peripheral device **704** and the second peripheral device **706**, communication range **712** may represent a piconet comprising the second peripheral device **706** and the first controllable device **702**, and communication range **716** may represent a piconet comprising the first controllable device **702**, the third peripheral device **708**, and the second controllable device **710**. As such, communication ranges **712**, **714**, and **716** may be joined by their common devices to form a scatternet.

In FIG. **7**A, generic peripheral devices and controllable devices are discussed in order to illustrate the general types of communication that occur in some typical embodiments. FIG. **7**B illustrates a similar communication topology, but describes the participating devices with more particularity in order to demonstrate a practical example of communication according to various aspects of the present disclosure. In FIG. **7**B, an event is detected by a vehicle monitor peripheral device **754**. For example, the vehicle monitor peripheral device **754** may be installed in a vehicle **94**, and may include a sensor that monitors the state of the trunk of the vehicle **94**. Upon detecting that the trunk has been opened from a closed state, the vehicle monitor peripheral device **754** generates a notification.

At the first point in the communication sequence, the vehicle monitor peripheral device **754** transmits the notification to devices within its communication range **764**, including light bar peripheral device **756** (but not first wearable camera device **752**). Once the light bar peripheral device **756** receives the notification, it may request further information from the vehicle peripheral device **754** based on the content of the notification. In some embodiments, the notification may simply be an alert similar to a "door ajar" warning, and so a type included in the notification indicating the "door ajar" alert may be adequate for controllable devices to make decisions regarding what settings to change. However, in some embodiments, more information may be made available by the vehicle monitor peripheral device **754** to indicate, for example, which component of the vehicle **94** is ajar and generating the alert. If the light bar peripheral device **756** determines from the notification that further information is available, then it retrieves the information from the vehicle monitor peripheral device **754**.

The first wearable camera device **752** may not be within the communication range **764** of the vehicle monitor peripheral device **754** for a variety of reasons. For example, the user **92** may have travelled away from the vehicle **94**, and therefore may not be close enough to the vehicle monitor peripheral device **754**. As another example, a line of sight between the vehicle monitor peripheral device **754** and the first wearable camera device **752** may be blocked by the seats of the vehicle **94**, the engine of the vehicle **94**, or by some other item that blocks low-powered short-range wireless communication between the devices despite their relatively close proximity.

At a second point in the communication sequence after the light bar peripheral device **756** has received the notification, it retransmits the notification to other devices within its communication range **762**, such as the first wearable camera device **752**. As before, the first wearable camera device **752** may request further information from the light bar peripheral device **756** if it is available. Thereafter, the first wearable camera device **752** may check or change a recording state of its camera in response to the received notification. For example, opening the trunk may indicate that the user **92** is retrieving a weapon, a testing kit, or other items used when responding to an incident that should be recorded. As such, the first wearable camera device **752** may begin recording if recording was not already happening. As another example, closing the trunk may indicate that the items have been replaced by the user **92** and the incident is over, and so the recording could be stopped.

At a third point in the communication sequence, the first wearable camera device **752** itself retransmits the notification to other devices within its communication range **765**. These devices may include a weapon holster peripheral device **758** and/or a personal assistant device **760**. The notification is not itself relevant to the weapon holster peripheral device **758**, but it provides the weapon holster peripheral device **758** the opportunity to retransmit the notification. Likewise, the personal assistant device **760** may not change a setting based on the notification, but it may record the notification, retransmit the notification via a wide-area network in order to notify a dispatch system of the event, ignore the notification completely, or take any other appropriate action.

FIG. **7**C illustrates another similar communication topology, in order to describe communication between other particular participating devices as another practical example of communication according to various aspects of the present disclosure. In FIG. **7**C, a command peripheral device **766** receives an input via a user interface that causes a notification and optionally information to be generated representing a command. For example, a dispatcher may be sending a user **92** to the scene of an incident, and using the user interface engine of the command peripheral device **766**, the dispatcher causes the notification and optionally information to be generated that will cause the camera **752** of the user **92** to be activated.

At the first point in the communication sequence, the command peripheral device **766** transmits the notification and optionally the information to the personal assistant device **760** of the user **92**. The communication range **764** of the command peripheral device **766** may indicate a wireless communication range in which the personal assistant device **760** is reachable, or it may indicate a network connection between the command peripheral device **766** and the personal assistant device **760** that traverses two or more networking technologies. For example, the command peripheral device **766** may transmit the notification to the personal assistant device **760** over a wide area network such as the Internet. The command peripheral device **766** may be connected to the Internet via a wired network, and the personal assistant device **760** may be connected to the Internet via WiFi, 3G, 4G, LTE, or any other suitable long-range wireless networking technology.

From this point, the notification propagates similar to the notifications in the previously described examples. At the second point in the communication sequence, the personal assistant device **760** acts as a peripheral device or a controllable device, and transmits the notification to devices within a communication range **762** of the personal assistant device **760**, such as the first wearable camera device **752**. If the first wearable camera device **752** determines that there is further information associated with the notification, it retrieves the information from the personal assistant device **760**. The first wearable camera device **752** then changes a setting based on the notification and/or the information. If the notification is as described above and associated with a command to start recording, the first wearable camera device **752** will start recording based on the notification and/or the information.

At a third point in the communication sequence, the first wearable camera device **752** may retransmit the notification to other devices within a communication range **765** of the first wearable camera device, such as a weapon holster peripheral device **758** and/or a second personal assistant device **756** associated with another user. In some embodiments wherein the original notification was addressed specifically to the first wearable camera device **752**, the first wearable camera device **752** may not retransmit the notification because it is only relevant to the first wearable camera device **752**. Even in such embodiments, other peripheral devices **706** or controllable devices **702** may be able to take action in response to the start of recording if the first wearable camera device **752** generates and transmits a new notification related to its own change in recording state.

FIGS. **8**A-**8**C are a flowchart that illustrates an exemplary embodiment of a method of transmitting and processing event notifications according to various aspects of the present disclosure. From a start block, the method **800** proceeds to block **802**, where a first peripheral device **704** detects an event. As discussed above, a wide variety of events may be detected by peripheral devices, depending on the type of peripheral device. For example, a safety sensor of a weapon peripheral device may detect changes in state of a weapon safety. As another example, a light bar sensor of a vehicle monitor peripheral device may detect a change in state of the light bar as an event. As yet another example, a command peripheral device may detect an event based upon an entry received by its user interface engine. As will be understood by one of ordinary skill in the art, other types of events may also be detected by the peripheral devices described above or by other types of peripheral devices.

At block **804**, a notification generation engine **404** of the first peripheral device **704** generates a first notification in response to the event. In some embodiments, the first notification includes a header having a standard layout that includes at least some information relating to the event and/or the first peripheral device **704**, such as one or more of a session identifier (described further below); information identifying a type, manufacturer, model, and/or serial number of the first peripheral device **704**; information identifying a type of the event; and/or an indication regarding whether more information will be made available. In some embodiments, the first notification may also include a payload with more data based on the type of the event.

At optional block **806**, the notification generation engine **404** generates a first information in response to the event. The first information is kept separate from the first notification, and is stored by the first peripheral device **704** until it is requested by a device that receives the first notification. The actions of optional block **806** may be performed in embodiments wherein more information is needed to describe the event than will fit in a single notification packet; in embodiments wherein the information is desired to be communicated via a secure channel instead of via a public broadcast; in embodiments wherein the size of the first notification is intended to be minimized; or in any other suitable embodiment. The actions of block **806** are optional because in some embodiments, none of these goals is desired, and all of the data needed to adequately describe the event fits in the first notification. For example, if the first peripheral device **704** is a heartrate monitor device, a value indicating a current heartrate or heartrate range would not be sensitive information and would likely fit within the notification packet, and so the actions of optional block **806** may not be necessary.

Next, at procedure block **808**, a notification transmission engine **404** of the first peripheral device **704** transmits the notification. In some embodiments, the transmission may be a broadcast receivable by any devices within communication range of the first peripheral device **704**. In some embodiments, the transmission may be directed to one or more particular devices by virtue of a previously configured setting such as a pairing between the particular devices and the first peripheral device **704**. Any suitable procedure for transmitting the notification may be used, including the procedure **900** illustrated in FIG. **9** and described in further detail below.

At block **810**, the notification is received by at least one of a controllable device **702** or a second peripheral device **706**. The method **800** then proceeds to a decision block **812**, after which the remainder of the method **800** changes based on whether the notification was received by a controllable device **702** or a second peripheral device **706**. The remainder of method **800** assumes that the notification was received by exactly one controllable device **702** or second peripheral device **706** for case of discussion only. One of ordinary skill in the art will recognize that, in some embodiments, the same transmitted notification could be received by both a controllable device **702** and a second peripheral device **706**, could be received by multiple controllable devices **702**, or could be received by multiple other peripheral devices **706**, and that portions of the remainder of the method **800** may therefore be conducted concurrently by multiple receiving devices.

If the notification was received by a second peripheral device **706**, then the result of the decision block **812** is NO, and the method **800** proceeds to optional block **814**. At optional block **814**, a notification repeater engine **406** of the second peripheral device **706** retrieves the first information from the first peripheral device **406**. The actions of block

814 are optional because, in some embodiments, there may not be first information to retrieve from the first peripheral device 406. In some embodiments, the notification repeater engine 406 will request information from the first peripheral device 704 regardless of whether information is present to be retrieved. In some embodiments, the notification repeater engine 406 may determine whether or not to request information from the first peripheral device 406 based on the first notification. For example, the notification repeater engine 406 may check for an explicit indication regarding the presence or absence of information to be retrieved in the first notification, may check a type of the first notification, may check a type of device that transmitted the first notification, and/or may use any other suitable technique.

At procedure block 816, the notification repeater engine 406 of the second peripheral device 706 retransmits the notification. Again, any suitable transmission technique may be used, including the procedure 900 described in further detail below. In some embodiments, the notification repeater engine 406 may create a new notification, and the original notification and information may be retrievable from the second peripheral device 706 as further information associated with the new notification. In some embodiments, the notification repeater engine 406 may retransmit the notification that matches the first notification, either exactly or with enough alterations such that a receiving device will contact the second peripheral device instead of the first peripheral device for the further information. The method 800 then proceeds to an end block and terminates.

Returning to decision block 812, if the first notification was received by a controllable device 702, then the result at decision block 812 is YES, and the method 800 proceeds to a continuation terminal ("terminal A"). From terminal A (FIG. 8B), the method 800 proceeds to block 818, where a notification processing engine 210 of the controllable device 702 determines whether a related notification has already been processed. In some embodiments, the controllable device 702 is likely to receive duplicate notifications, because the notifications may be transmitted repeatedly for the same event to help overcome intermittent losses in connectivity (as discussed further below). To detect duplicate notifications, the controllable device 702 may save session identifiers that have previously been processed and ignore notifications after the first for a given session identifier; the controllable device 702 may ignore all notifications from a given device for a predetermined amount of time after processing a first notification; the controllable device 702 may create a fingerprint of each processed notification to compare to newly received notifications; or may use any other suitable technique.

At decision block 820, the method 800 branches based on the determination regarding whether a related notification had already been processed. If a related notification had been processed, then the received notification is a duplicate and the result of the determination at decision block 820 is YES. Thereafter, the method 800 proceeds to an end block and terminates. Otherwise, if no related notification had been processed, then the received notification is not a duplicate and the result of the determination at decision block 820 is NO. The method 800 then proceeds to block 822, where the notification processing engine 210 authenticates the first peripheral device 704. Authentication of the first peripheral device 704 is desirable in order to avoid allowing unauthorized malicious notifications to cause unwanted changes in settings of the controllable device 702.

Any suitable technique for authentication may be used. In some embodiments, the controllable device 702 stores a whitelist of serial numbers or other identifiers of peripheral devices 706 for which notifications will be processed, and authentication comprises ensuring that the peripheral device 706 is on the whitelist. In some embodiments, the controllable device 702 may establish an encrypted connection with the peripheral device 706 using any suitable cryptographic communication technique, including but not limited to a Diffie-Hellman elliptical curve technique and/or the like. The controllable device 702 may assume that, if the peripheral device 706 implements the cryptographic communication technique and can establish the encrypted connection, then the peripheral device 706 is authenticated. In some embodiments, this encrypted connection or tunnel may be used to exchange further information between the peripheral device 706 and the controllable device 702. In some embodiments, a digital signature or other certificate stored on the peripheral device 706 is checked by the controllable device 702 for validity in order to authenticate the peripheral device.

Assuming the first peripheral device 704 was properly authenticated, the method 800 proceeds to block 824, where the notification processing engine 210 determines whether further information should be retrieved from the first peripheral device 704. Similar to the discussion above with respect to the actions of the notification repeater engine 406 of the second peripheral device, the notification processing engine 210 may use any suitable technique for determining whether further information should be retrieved from the first peripheral device 704. In some embodiments, the notification processing engine 210 will request information from the first peripheral device 704 regardless of whether information is present to be retrieved. In some embodiments, the notification processing engine 210 may determine whether or not to request information from the first peripheral device 704 based on the first notification. For example, the notification processing engine 210 may check for an explicit indication regarding the presence or absence of information to be retrieved in the first notification, may check a type of the first notification, may check a type of device that transmitted the first notification, and/or may use any other suitable technique. In some embodiments, the notification processing engine 210 may check a whitelist of devices from which information will be requested. The whitelist may define one or more "sets" of devices to which the controllable device 702 belongs, such as a user or officer set, a vehicle set, a group set, a station set, and/or the like.

At decision block 826, the method 800 branches based on the determination regarding whether further information should be retrieved from the first peripheral device 704. If it had been determined that further information should be retrieved from the first peripheral device 704, then the result of the determination at decision block 826 is YES, and the method 800 proceeds to block 828. At block 828, the notification processing engine 210 retrieves the information from the first peripheral device 704 using any suitable technique. In some embodiments, the notification may be a Bluetooth Low Energy advertisement message, and the notification processing engine 210 may retrieve the information by transmitting a scan request packet to the first peripheral device 704. In some embodiments, a tunnel may be established between the first peripheral device 704 and the controllable device 702, and the further information may be retrieved using a serial transmission protocol. The method 800 then proceeds to a continuation terminal ("terminal B"). Returning to decision block 826, if it had been determined that further information should not be retrieved from the first peripheral device 704, then the result of the

determination at decision block **826** is NO, and the method **800** proceeds directly to terminal B.

From terminal B (FIG. **8**C), the method **800** proceeds to block **830**, where the notification processing engine **210** changes at least one configuration setting of the controllable device **702** based on the notification and/or the information. As one example, if the controllable device **702** is a controllable camera device **752**, then the notification processing engine **210** may cause the camera control engine **304** to change a recording state of the video sensor **302** and/or audio sensor **306** to start, pause, or stop recording based on the notification and/or the information. As another example, if the controllable camera device **752** is equipped with or can otherwise access a long-range wireless interface, the notification processing engine **210** may cause transmission of a live video or audio stream from the controllable camera device **752** to the evidence management system **102** or other remote device to be started or stopped.

Further, in some embodiments changing a configuration setting may include storing or transmitting data associated with the notification and/or the information. For example, if the controllable device **702** includes a long-range wireless interface, the notification processing engine **210** may cause the controllable device **702** to transmit an SMS, an email, an API call, or any other data transmission based on the notification and/or the information to a remote device. As another example, the notification processing engine **210** may record and aggregate metadata based on the received notifications and/or information, including but not limited to identities of users associated with the notifications (in order to be able to count a total number of users within the system's communication range); a type of the peripheral device that transmitted the notification and its status (in order to be able to count, for example, a total number of activated cameras or weapons drawn in an area); a distance of the peripheral device from the controllable device **702** based on the signal strength; and or the like.

Also, though single notifications are described above, in some embodiments the notification processing engine **210** may use multiple notifications and/or multiple pieces of retrieved information to make the decision regarding the change in a setting. For example, if the notification and information indicate that the trunk of a vehicle **94** associated with the user **92** is open, the notification processing engine **210** may cause other information to be retrieved to determine whether the light bar or siren is active, or whether the vehicle **94** is moving, before causing a change in video or audio recording state. As another example, if several notifications and/or pieces of retrieved information indicate that a weapon has been removed from a holster and the trunk is open, then the video recording state may not be changed (due to the likelihood that the user **92** is merely placing the weapon in the trunk as opposed to using the weapon to apply force. As still another example, if several notifications and or pieces of retrieved information indicate that the user **92** has returned to the driver's seat of the vehicle **94** and that the user's holster is empty, then the notification processing engine **210** may cause a warning message to be transmitted or displayed.

At optional block **832**, the notification processing engine **210** stores an indication of the notification and/or the information (depending on whether additional information was retrieved) in an audit trail data store **316** of the controllable device **702**. The actions at block **832** are optional because not all embodiments of a controllable device **702** will include an audit trail data store **316**, but may instead apply the configuration setting change without storing a record of the change, the notification, or the information. In some embodiments, instead of storing the notification and/or the information in an audit trail data store **316**, the notification processing engine **210** may add data from the notification and/or the information to data recorded by the controllable device **702** or metadata associated with data recorded by the controllable device **702**, including but not limited to metadata associated with video data or audio data.

The method **800** then proceeds to decision block **834**, where a determination is made regarding whether the controllable device **702** should retransmit the notification and/or the information. In some embodiments, the controllable device **702** may retransmit all notifications, as does the peripheral device **706**. In some embodiments, the controllable device **702** may filter some notifications and may not retransmit them. For example, in some embodiments, the notification processing engine **210** may detect that a notification was addressed specifically to the controllable device **702**, and may therefore not retransmit it because it will not be relevant to other devices. As another example, in some embodiments, the notification processing engine **210** may not retransmit notifications of certain types or from certain types of devices.

If the determination at decision block **834** is that the controllable device **702** should retransmit the notification, then the result of decision block **834** is YES, and the method **800** proceeds to procedure block **836**, where a notification repeater engine **208** of the controllable device **702** retransmits the notification. Again, any suitable transmission technique may be used, including the procedure **900** described in further detail below. In some embodiments, the notification repeater engine **208** may create a new notification, and the original notification and information may be retrievable from the controllable device **702** as further information associated with the new notification. In some embodiments, the notification repeater engine **208** may retransmit the notification that matches the first notification, either exactly or with enough alterations such that a receiving device will contact the first peripheral device instead of the controllable device **702** for the further information. The method **800** then proceeds to optional block **838**. Returning to decision block **834**, if the determination is that the controllable device **702** should not retransmit the notification, then the result of decision block **834** is NO, and the method **800** proceeds directly to optional block **838**.

At optional block **838**, the controllable device **702** transmits notifications and/or information from the audit trail data store **316** to an evidence management system **102**. The information may be transmitted from the audit trail data store **316** to the evidence management system **102** using any suitable technique, including via an evidence collection dock **104** or via an ad-hoc wireless communication path. In some embodiments, urgent notifications and/or information may be transmitted to the evidence management system **102** via the ad-hoc wireless communication path, including via a coordinator computing device, as soon as possible after the receipt of the notification and/or information whether or not it is stored in the audit trail data store **316**. The actions described at block **838** are optional because not all embodiments transmit information to an evidence management system **102**, nor do all embodiments include an audit trail data store **316**. The method **800** then proceeds to an end block and terminates.

FIG. **9** is a flowchart that illustrates a procedure for transmitting a notification from a device according to various aspects of the present disclosure. As discussed above, the procedure **900** is suitable for use by a peripheral device

706 or a controllable device 702, as discussed in blocks 808, 816, and 836 of the method 800 described above. Because similar steps would be performed by either device at any of these blocks 808, 816, and 836, separate descriptions of each block are not provided.

The technique described in the procedure 900 has many advantages. For example, the procedure 900 can overcome issues with intermittent connectivity, which may be caused by an intermittent lack of line of sight between devices, devices intermittently moving out of communication range of each other, and/or the like. For example, if a low-power short-range wireless communication technique is used, the line of sight may be blocked by the user's body, the frame of a vehicle, and/or the like. As another example, the devices may travel into and out of range of each other during an activity such as a foot pursuit, a traffic stop, and/or the like. As another example of an advantage, the short periods for which notifications are transmitted helps to strike a balance that reduces power consumption and thereby increases battery life. As yet another example of an advantage, the use of sessions (as described below) may help allow receiving devices to ignore duplicate notifications, thereby further reducing processing and power drains.

From a start block, the procedure 900 advances to block 902, where the device creates a new session for the notification. In some embodiments, the new session is identified by a session identifier. In some embodiments, creating the new session may simply increment a session identifier value based on a previous session identifier value for the device. In some embodiments, the device may randomly choose a session identifier or use an unpredictable but deterministic sequence of session identifier values, such as the output of a pseudo-random number generator for a given seed, so that a receiving device can compare the session identifier value to an expected next session identifier value for authentication purposes.

At block 904, the device transmits the notification to other devices within communication range of the device. In some embodiments, the notification may be a broadcast transmission or otherwise unaddressed, such that any device within communication range may receive and process the notification. In some embodiments, the notification may be addressed or otherwise directed to one or more particular devices, such as devices that had previously been paired to the transmitting device, devices that are the particular target of the notification, and/or the like. In some embodiments, the notification may be transmitted using a radio frequency communication technique. In some embodiments, the radio frequency used may be in the 2.4 GHz band in order to avoid interference with police bands used for other equipment. In some embodiments, the notification may be transmitted using a short-range wireless networking technology, such as Bluetooth or Bluetooth Low Energy. In some embodiments, wired communication and/or long-range wireless communication may be used to implement at least part of the communication path used to transmit the notification. For example, the transmitting device may be a command peripheral device 602 operated by a dispatcher on a wired network, and the notification may be addressed to a peripheral device 706 or a controllable device 702 in the field, such as a smart phone device or a controllable camera device 752 having a long-range wireless interface such as LTE or WiFi.

In some embodiments, the notification may be included in a Bluetooth Low Energy advertisement message as defined by the respective protocol. Some portions of the message format may be defined by the systems designer (e.g., the predefined sequence of information in the payload, the quantity of bits predefined to convey various information in the payload, and/or the like). In some embodiments, the format described below in Table 1 may be used. Other embodiments, according to various aspects of the present disclosure, may use a different sequence of information in the payload. Still other embodiments, according to various aspects of the present disclosure, use different quantities of bits for information in the payload. Shorter payloads permit more messages to be sent and received per unit time.

TABLE 1

| Bit Position | Name | Description and Alternatives |
|---|---|---|
| 1-8 | Preamble | Tunes receiver; defined by protocol |
| 9-40 | Access address | Distinguishes an intended message from noise; defined by protocol |
| 41-48 | Header | Packet type defined by protocol |
| 49-56 | Length | Number of bits in the Payload |
| 57-353 | Payload | See following rows |
| 57-88 | Sender manufacturer | A code number, a more meaningful coded text abbreviation |
| 89-100 | Sender model | A code number, a more meaningful coded text abbreviation |
| 101-148 | Sender serial number | A binary integer, a code comprising digits, a code comprising characters |
| 149-164 | Sender faults | A set of binary true/false values each conveying a predetermined fault condition in the transmitting device |
| 165-180 | Session identifier | A binary integer |
| 181-200 | Status | A set of bits providing data that carries status information regarding the device (or an event detected by the device) |
| 201-353 | reserved | May be omitted from the message |
| 353-376 | CRC | Cyclic redundancy check code for the message or for one or more suitable portions of the message (e.g., header, length, payload, portion of the payload) |

After transmitting the notification, the procedure 900 waits for a predetermined amount of time. The amount of time for which the procedure 900 waits may be configurable by an administrator or designer of the system in order to balance battery life with a likelihood of successful commu-

nication (shorter wait times increase the likelihood of successful communication, but reduce battery life). In some embodiments, the amount of time may be a value in the range of 1-10 seconds, such as 5 seconds. In some embodiments, an extra random delay interval between 0 and 10 ms may be added to the amount of time to help avoid collisions between notifications.

After waiting, the procedure **900** then proceeds to a decision block **906**, where a determination is made regarding whether a predetermined amount of time has elapsed since the creation of the new session. In some embodiments, the predetermined amount of time may be configurable by an administrator or designer of the system; in some embodiments, the predetermined amount of time may be a value in the range of 20-60 seconds, such as 30 seconds. Again, longer sessions increase likelihood of successful communication, but reduce battery life on both the transmitter and receiver.

If the predetermined amount of time has not elapsed since the creation of the new session, then the result of the determination at decision block **906** is NO, and the procedure **900** returns to block **904**. Otherwise, if the predetermined amount of time has elapsed, then the result of the determination at decision block **906** is YES, and the procedure **900** advances to block **908**, where the device ends the new session associated with the notification. Once the new session ends, no more transmissions will be made using the session identifier. In some embodiments, the end of a session also stops the transmission of further notifications until the procedure **900** is executed a subsequent time. In some embodiments, events other than the elapsing of the predetermined amount of time may cause session to end. For example, in some embodiments, a new event that supersedes the previous event, such as another change in camera or light bar state, or crossing an additional heart rate threshold, may cause the session to end so that a new session can be started. As another example, in some embodiments, a confirmed receipt by a targeted recipient device may cause the session to end.

The procedure **900** then proceeds to an end block and terminates.

FIG. **10** is a block diagram that illustrates aspects of an exemplary computing device appropriate for use as a computing device of the present disclosure. While multiple different types of computing devices were discussed above, the exemplary computing device **1000** describes various elements that are common to many different types of computing devices. While FIG. **10** is described with reference to a computing device that is implemented as a device on a network, the description below is applicable to servers, personal computers, mobile phones, smart phones, tablet computers, embedded computing devices, and other devices that may be used to implement portions of embodiments of the present disclosure. Moreover, those of ordinary skill in the art and others will recognize that the computing device **1000** may be any one of any number of currently available or yet to be developed devices.

In its most basic configuration, the computing device **1000** includes at least one processor **1002** and a system memory **1004** connected by a communication bus **1006**. Depending on the exact configuration and type of device, the system memory **1004** may be volatile or nonvolatile memory, such as read only memory ("ROM"), random access memory ("RAM"), EEPROM, flash memory, or similar memory technology. Those of ordinary skill in the art and others will recognize that system memory **1004** typically stores data and/or program modules that are immediately accessible to and/or currently being operated on by the processor **1002**. In this regard, the processor **1002** may serve as a computational center of the computing device **1000** by supporting the execution of instructions.

As further illustrated in FIG. **10**, the computing device **1000** may include a network interface **1010** comprising one or more components for communicating with other devices over a network. Embodiments of the present disclosure may access basic services that utilize the network interface **1010** to perform communications using common network protocols. The network interface **1010** may also include a wireless network interface configured to communicate via one or more wireless communication protocols, such as WiFi, 2G, 3G, LTE, WiMAX, Bluetooth, and/or the like. As will be appreciated by one of ordinary skill in the art, the network interface **1010** illustrated in FIG. **10** may represent one or more wireless interfaces or physical communication interfaces described and illustrated above with respect to particular components of the system **100**.

In the exemplary embodiment depicted in FIG. **10**, the computing device **1000** also includes a storage medium **1008**. However, services may be accessed using a computing device that does not include means for persisting data to a local storage medium. Therefore, the storage medium **1008** depicted in FIG. **10** is represented with a dashed line to indicate that the storage medium **1008** is optional. In any event, the storage medium **1008** may be volatile or nonvolatile, removable or nonremovable, implemented using any technology capable of storing information such as, but not limited to, a hard drive, solid state drive, CD ROM, DVD, or other disk storage, magnetic cassettes, magnetic tape, magnetic disk storage, and/or the like.

As used herein, the term "computer-readable medium" includes volatile and non-volatile and removable and non-removable media implemented in any method or technology capable of storing information, such as computer readable instructions, data structures, program modules, or other data. In this regard, the system memory **1004** and storage medium **1008** depicted in FIG. **10** are merely examples of computer-readable media.

Suitable implementations of computing devices that include a processor **1002**, system memory **1004**, communication bus **1006**, storage medium **1008**, and network interface **1010** are known and commercially available. For ease of illustration and because it is not important for an understanding of the claimed subject matter, FIG. **10** does not show some of the typical components of many computing devices. In this regard, the computing device **1000** may include input devices, such as a keyboard, keypad, mouse, microphone, touch input device, touch screen, tablet, and/or the like. Such input devices may be coupled to the computing device **1000** by wired or wireless connections including RF, infrared, serial, parallel, Bluetooth, USB, or other suitable connections protocols using wireless or physical connections. Similarly, the computing device **1000** may also include output devices such as a display, speakers, printer, etc. Since these devices are well known in the art, they are not illustrated or described further herein.

While illustrative embodiments have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

What is claimed is:

**1**. A system for changing configuration settings on controllable devices in response to automatically detected events, the system comprising:

a peripheral device comprising at least one sensor, a first processor, and a first short-range wireless interface, the first processor configured to perform first operations comprising:

detecting, via the at least one sensor, a change in a first status of the peripheral device via the at least one sensor;

automatically generating a first notification in response to detecting the change in the first status of the peripheral device, the first notification including information indicating that the first status of the peripheral device has changed; and

transmitting the first notification via the first short-range wireless interface;

a first controllable camera device comprising a first video sensor, a second processor, and a second short-range wireless interface, the second processor configured to perform second operations comprising:

collecting first video data via the first video sensor;

receiving the first notification from the peripheral device via the second short-range wireless interface;

making a first determination whether a first configuration setting of the first controllable camera device should be changed in response to the information indicating that the first status of the peripheral device has changed;

in accordance with the first determination indicating that the first configuration setting of the first controllable camera device should be changed, changing the first configuration setting of the first controllable camera device; and

based on the first notification, transmitting, via the second short-range wireless interface, a second notification, wherein the second notification includes the information indicating that the first status of the peripheral device has changed; and

a second controllable device comprising a third short-range wireless interface and a third processor, the third processor configured to perform third operations comprising:

receiving the second notification from the first controllable camera device via the third short-range wireless interface;

making a second determination whether a second configuration setting of the second controllable device should be changed in response to the information indicating that the first status of the peripheral device has changed; and

in accordance with the second determination indicating that the second configuration setting of the second controllable device should be changed, changing the second configuration setting of the second controllable device.

**2**. The system of claim **1**, wherein the second controllable device comprises a second controllable camera device comprising a second video sensor.

**3**. The system of claim **2**, wherein changing the second configuration setting of the second controllable device comprises changing a recording state of the second video sensor.

**4**. The system of claim **1**, wherein the second operations further comprise generating a new notification based on the first notification, and wherein transmitting the second notification comprises transmitting the new notification.

**5**. The system of claim **1**, wherein transmitting the second notification comprises retransmitting the first notification.

**6**. The system of claim **1**, wherein the first controllable camera device comprises a video data store; and

changing the first configuration setting of the first controllable camera device comprises causing the first video data to be saved in the video data store.

**7**. The system of claim **1**, wherein the first controllable camera device comprises a first long-range wireless interface; and

changing the first configuration setting of the first controllable camera device comprises:

starting transmission of a first live video stream from the first controllable camera device via the first long-range wireless interface; or

transmitting first data based on the information indicating that the first status of the peripheral device has changed from the first long-range wireless interface to a remote device.

**8**. The system of claim **1**, wherein the second operations further comprise:

receiving a third notification via the second short-range wireless interface;

detecting the third notification is a duplicate of the first notification; and

in accordance with detecting the third notification is the duplicate of the first notification, ignoring the third notification.

**9**. The system of claim **1**, wherein changing the first configuration setting comprises recording the first video data.

**10**. The system of claim **1**, wherein the peripheral device is one of a weapon peripheral device, a weapon holster peripheral device, a vehicle monitor peripheral device, and a personal monitor peripheral device.

**11**. The system of claim **1**, wherein each of the first notification and the second notification are unaddressed.

**12**. The system of claim **1**, wherein the first notification further comprises information identifying a type of the peripheral device;

making the first determination comprises making the first determination based on the information indicating that the first status of the peripheral device has changed and the information identifying the type of the peripheral device; and

making the second determination comprises making the second determination based on the information indicating that the first status of the peripheral device has changed and the information identifying the type of the peripheral device.

**13**. The system of claim **1**, wherein the peripheral device comprises a vehicle monitor peripheral device and the at least one sensor comprises an analog voltage sensor.

**14**. The system of claim **1**, wherein transmitting the first notification comprises repeatedly transmitting the first notification for a predetermined amount of time.

**15**. The system of claim **14**, wherein the first operations comprise generating a session identifier, the first notification includes the session identifier, and repeatedly transmitting the first notification includes repeatedly transmitting the session identifier in the first notification.

**16**. The system of claim **1**, wherein transmitting the first notification comprises:

repeatedly transmitting the first notification until a change in a second status is detected, wherein the change in the second status supersedes the change in the first status; and

ending a session during which the first notification is repeatedly transmitted, wherein ending the session comprises stopping transmitting of the first notification.

17. A method of distributed control performed by a peripheral device, a first controllable camera device, and a second controllable camera device, the method comprising:

detecting, by the peripheral device, a change in status of the peripheral device based on first data generated by one or more sensors of the peripheral device;

automatically generating, by the peripheral device, a first notification in response to detecting the change in the status of the peripheral device, wherein the first notification includes information indicating that the status of the peripheral device has changed;

transmitting, by the peripheral device, the first notification via a first short-range wireless interface of the peripheral device;

receiving, by the first controllable camera device, the first notification from the peripheral device via a second short-range wireless interface of the first controllable camera device;

determining, by a processor of the first controllable camera device, that a configuration setting of the first controllable camera device should be changed based on the information indicating that the status of the peripheral device has changed;

changing, by the processor of the first controllable camera device, the configuration setting of the first controllable camera device in response to determining by the processor of the first controllable camera device that the configuration setting of the first controllable camera device should be changed;

transmitting, by the first controllable camera device, a second notification via the second short-range wireless interface of the first controllable camera device;

receiving, by the second controllable camera device, the second notification from the first controllable camera device via a third short-range wireless interface of the second controllable camera device;

determining, by a processor of the second controllable camera device, that a configuration setting of the second controllable camera device should be changed based on the information indicating that the status of the peripheral device has changed; and

changing, by the processor of the second controllable camera device, the configuration setting of the second controllable camera device in response to determining by the processor of the second controllable camera device that the configuration setting of the second controllable camera device should be changed, wherein the peripheral device is one of a weapon peripheral device, a weapon holster peripheral device, and a vehicle monitor peripheral device.

18. The method of claim 17, wherein transmitting the second notification comprises retransmitting the first notification.

19. The method of claim 17, wherein changing of the configuration setting of the first controllable camera device comprises at least one of saving video data collected by a video sensor of the first controllable camera device in a data store of the first controllable camera device, starting transmission of a live video stream from the first controllable camera device via a first long-range wireless interface of the first controllable camera device, or transmitting first data based on the information indicating that the status of the peripheral device has changed from the first long-range wireless interface of the first controllable camera device to a remote device; and

changing of the configuration setting of the second controllable camera device comprises at least one of saving video data collected by a video sensor of the second controllable camera device in a data store of the second controllable camera device, starting transmission of a live video stream from the second controllable camera device via a second long-range wireless interface of the second controllable camera device, or transmitting second data based on the information indicating that the status of the peripheral device has changed from the second long-range wireless interface of the second controllable camera device to the remote device.

20. The method of claim 19, wherein the first notification includes a session identifier generated by the peripheral device and transmitting the first notification includes repeatedly transmitting the first notification comprising the session identifier for a predetermined amount of time.

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