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(54) **MONITORING OF FILTERS**

(71) Applicants: **John P. Sanroma**, Billerica, MA (US); **Michael J. Gambuzza**, Boston, MA (US); **Jason M. Sanroma**, Billerica, MA (US)

(72) Inventors: **John P. Sanroma**, Billerica, MA (US); **Michael J. Gambuzza**, Boston, MA (US); **Jason M. Sanroma**, Billerica, MA (US)

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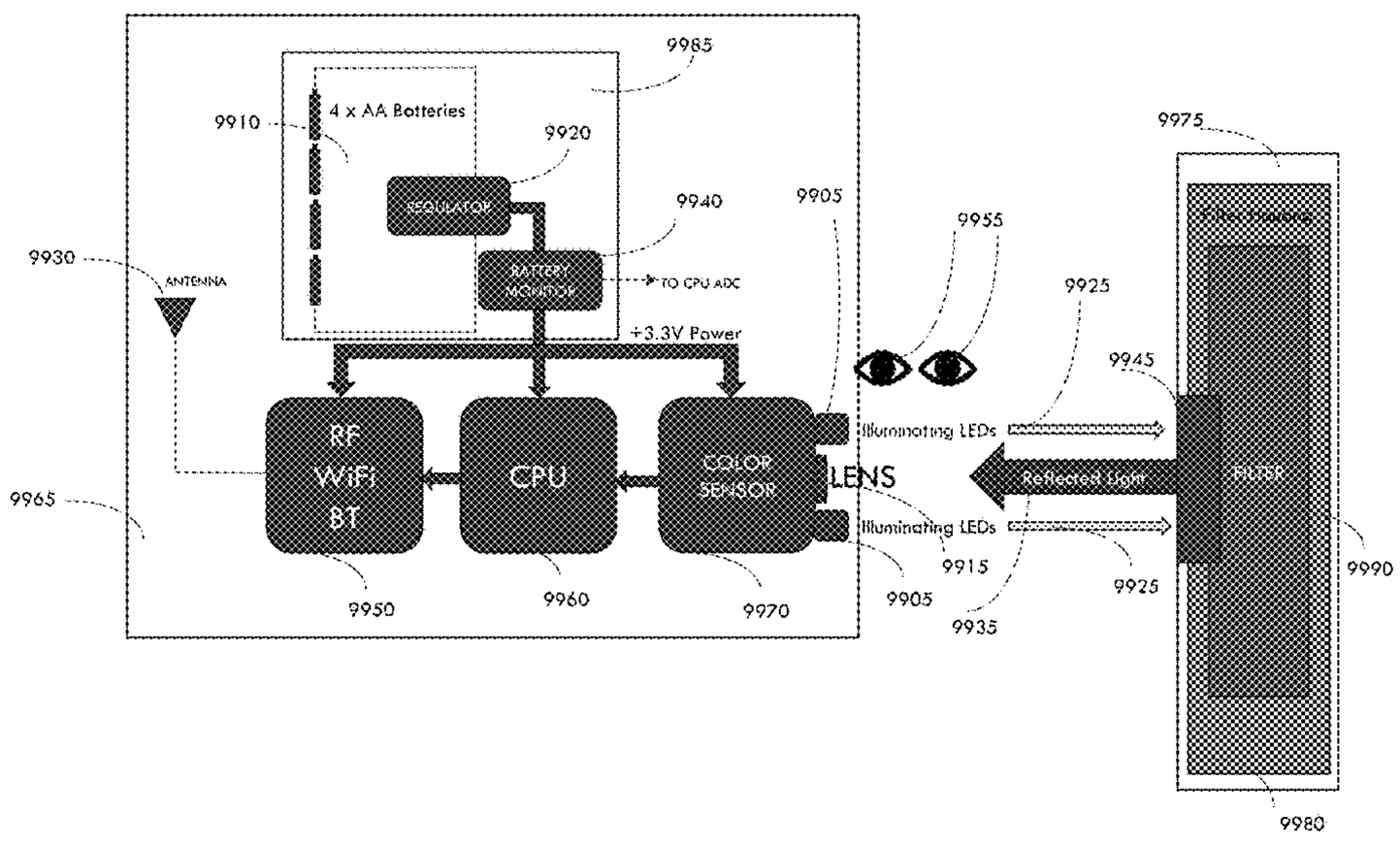
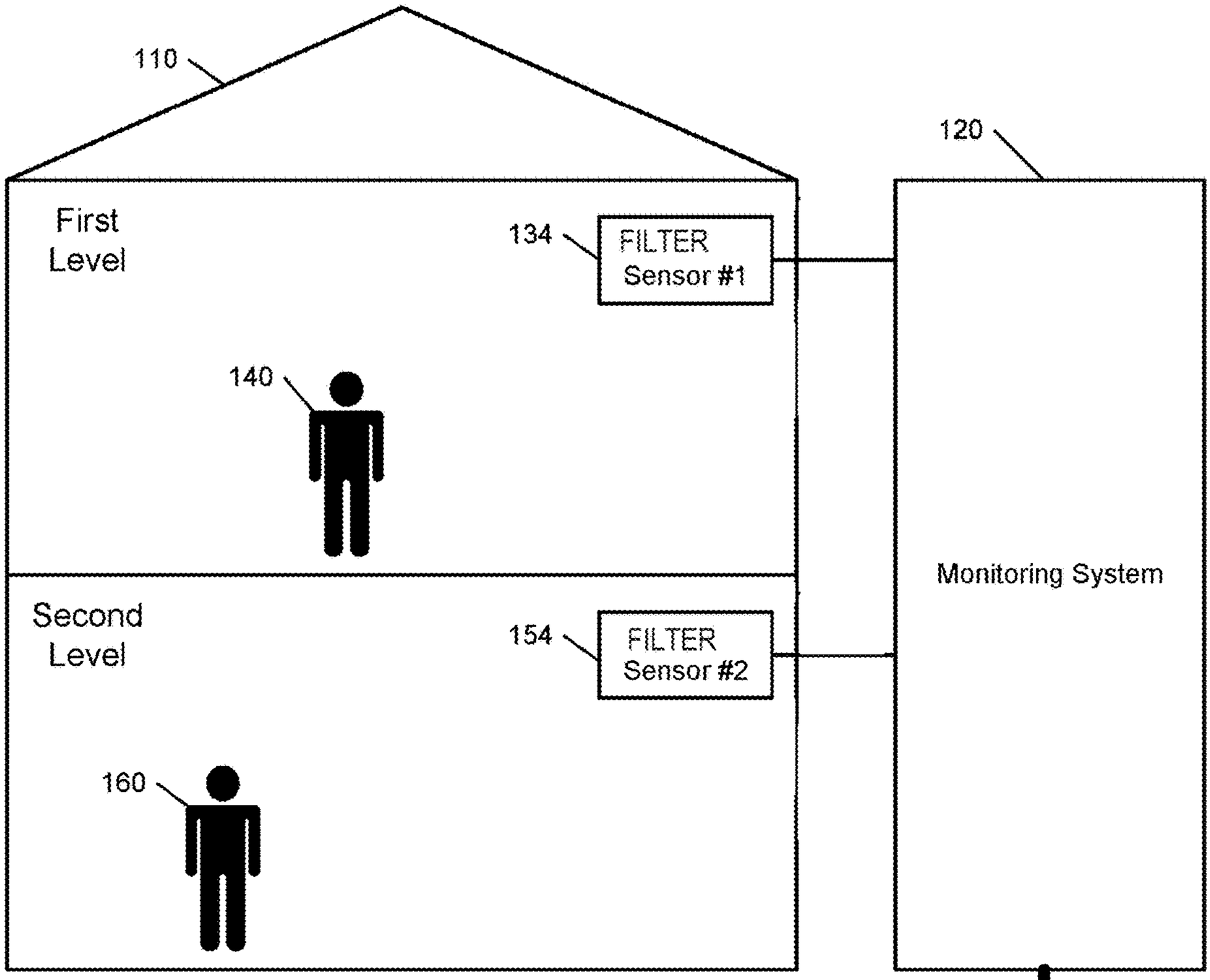
(57) **ABSTRACT**

Filters are monitored. Color data is determined for a filter. A filter status for the filter is derived from the color data. An action is taken based on the filter status. The filter status may include a dirty status or an empty status for the filter. The action may include alerting a user based on the filter status. The filter may be illuminated prior to the determining of the color data for the filter.





Device	Status
FILTER Sensor #1	DIRTY
FILTER Sensor #2	NOT DIRTY

FIG. 1

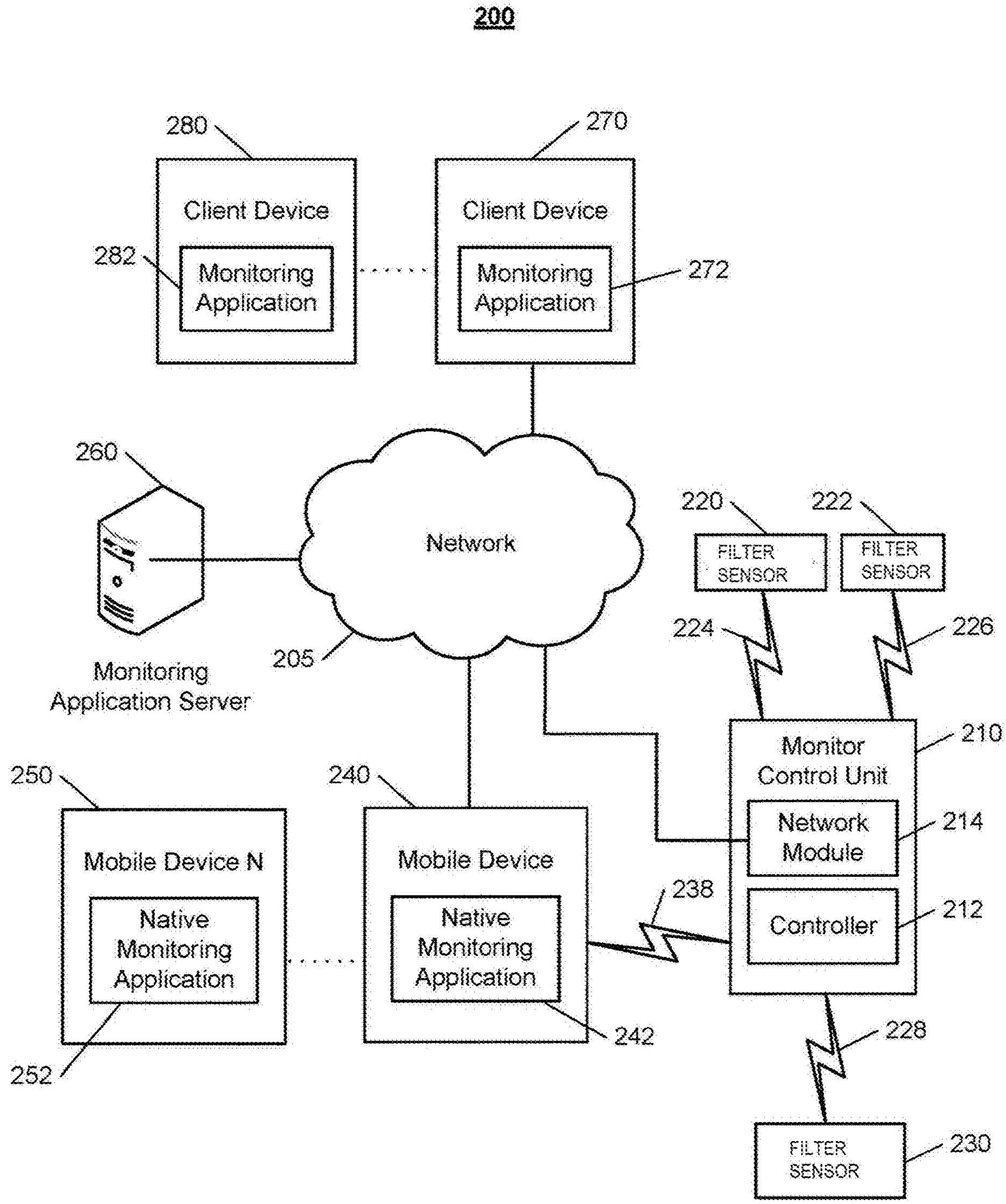

200
280
270
Client Device
Client Device
282
Monitoring Application
Monitoring Application
272
260
Network
220
222
FILTER SENSOR
FILTER SENSOR
224
226
205
Monitoring Application Server
210
Monitor Control Unit
250
240
Network Module
214
Mobile Device N
Mobile Device
238
Native Monitoring Application
Native Monitoring Application
Controller
212
242
228
252
FILTER SENSOR
230

FIG. 2

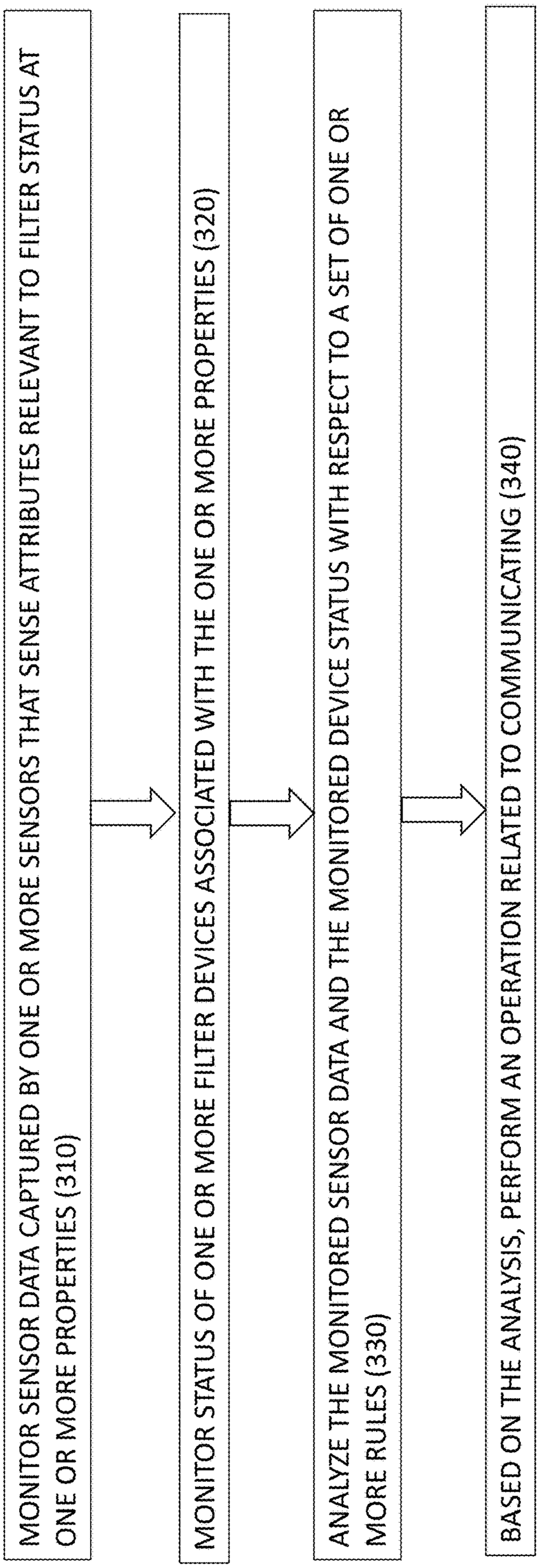

300
MONITOR SENSOR DATA CAPTURED BY ONE OR MORE SENSORS THAT SENSE ATTRIBUTES RELEVANT TO FILTER STATUS AT ONE OR MORE PROPERTIES (310)
MONITOR STATUS OF ONE OR MORE FILTER DEVICES ASSOCIATED WITH THE ONE OR MORE PROPERTIES (320)
ANALYZE THE MONITORED SENSOR DATA AND THE MONITORED DEVICE STATUS WITH RESPECT TO A SET OF ONE OR MORE RULES (330)
BASED ON THE ANALYSIS, PERFORM AN OPERATION RELATED TO COMMUNICATING (340)

FIG. 3

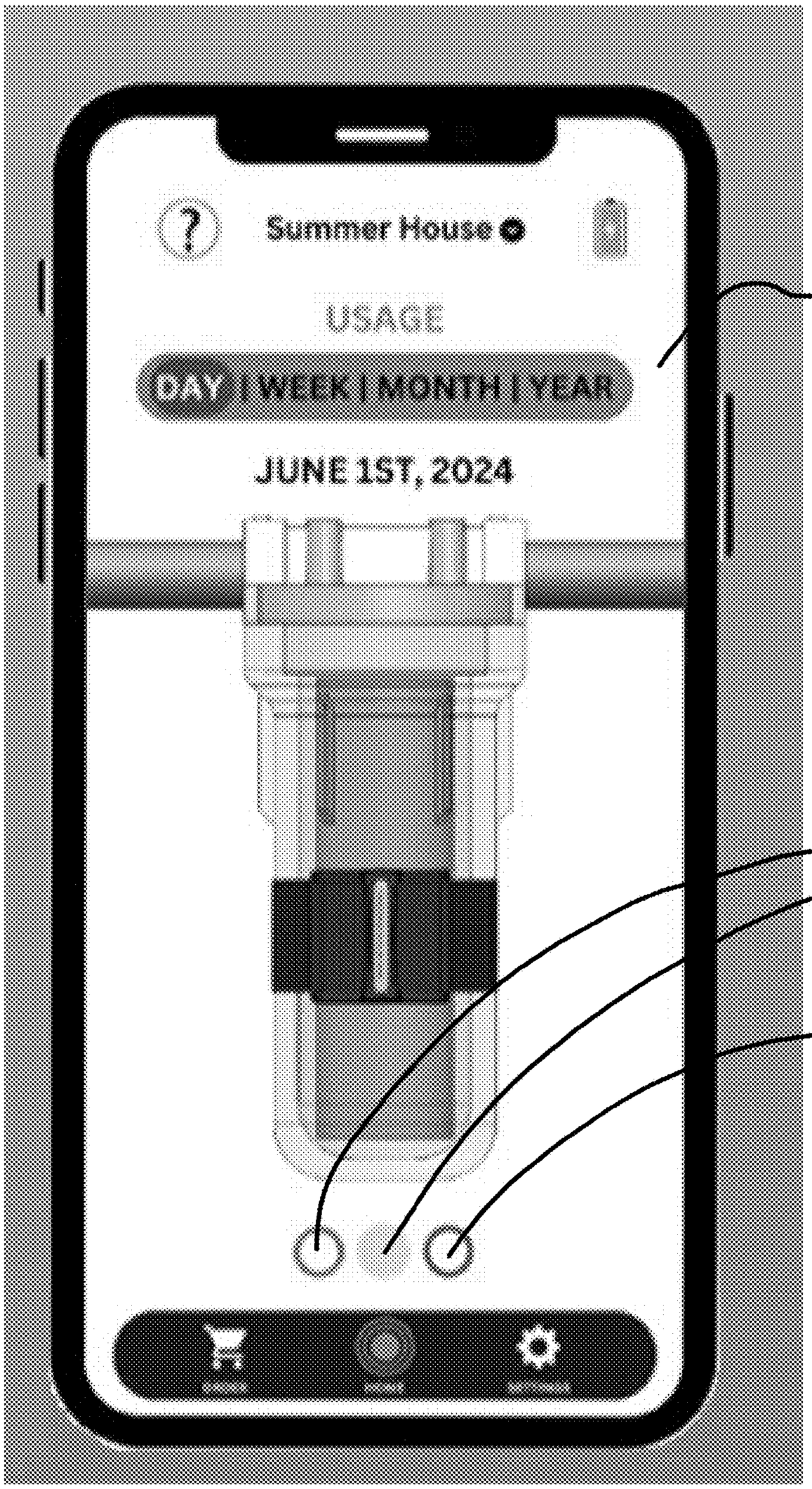

Summer House
USAGE
DAY | WEEK | MONTH | YEAR
JUNE 1ST, 2024
500
510
520
530

FIG. 4

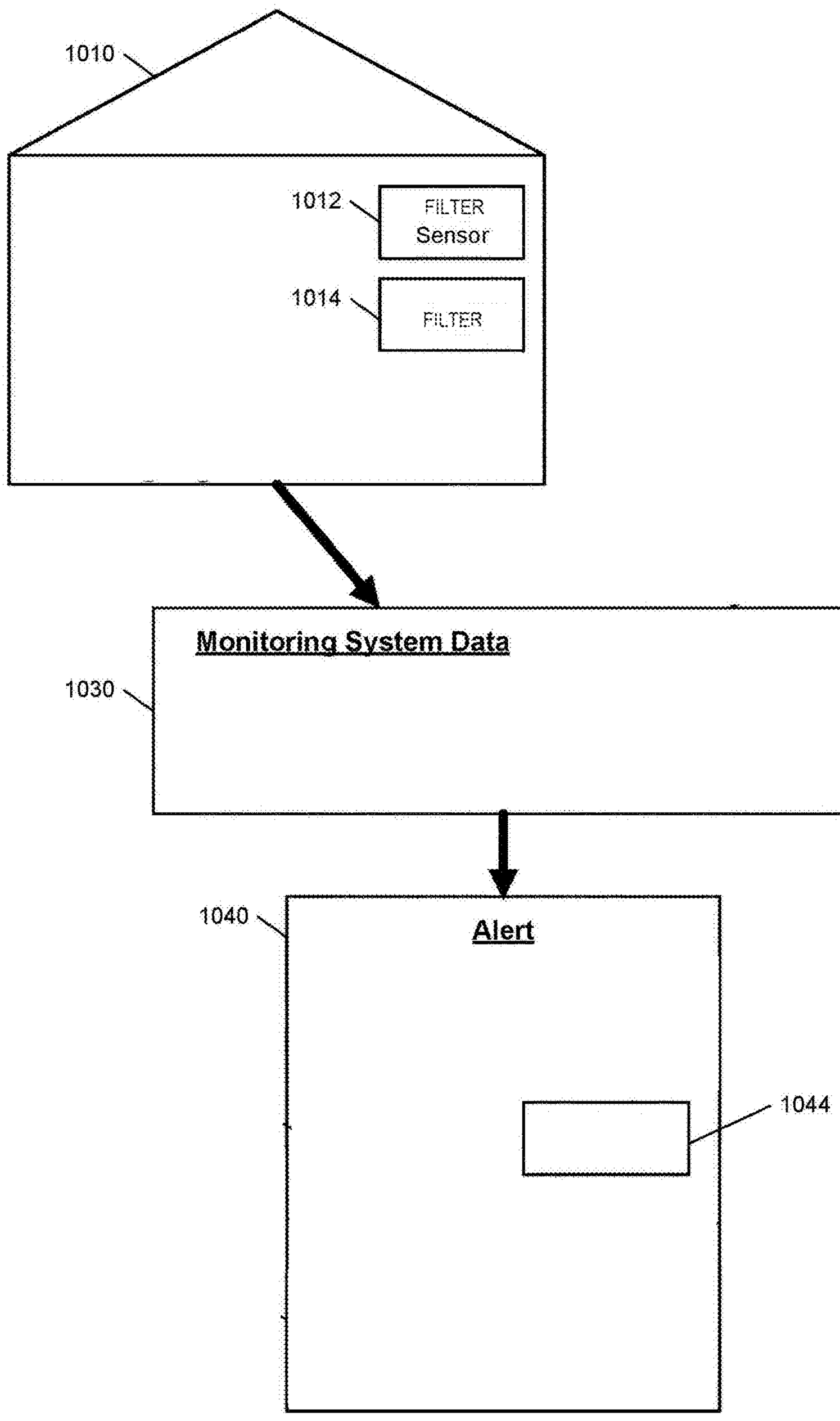

1010
1012
FILTER
Sensor
1014
FILTER
Monitoring System Data
1030
1040
Alert
1044

FIG. 5

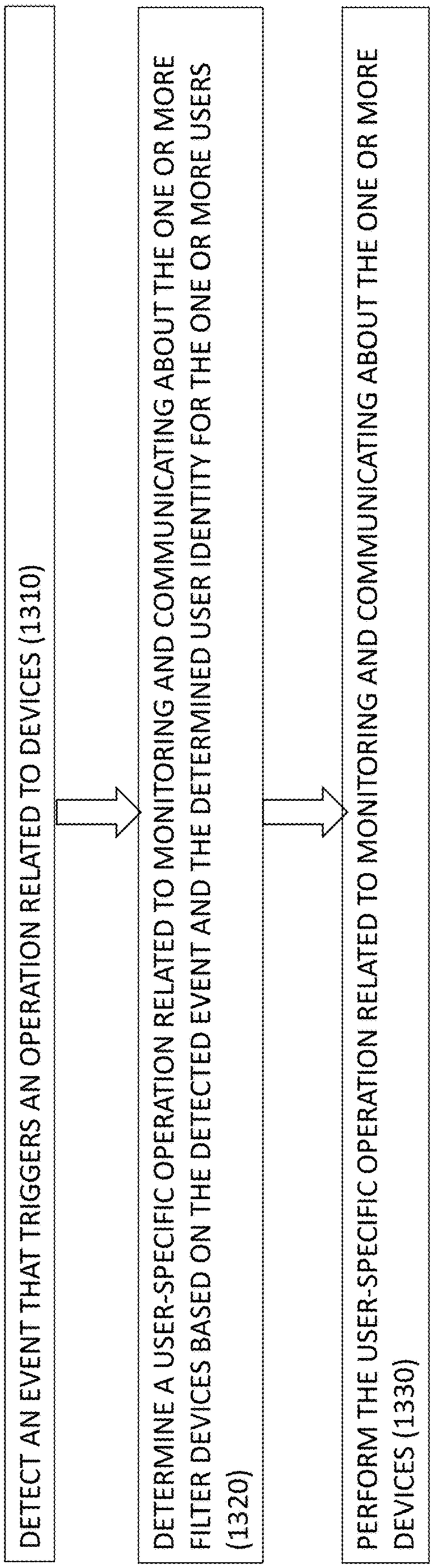

1300
DETECT AN EVENT THAT TRIGGERS AN OPERATION RELATED TO DEVICES (1310)
DETERMINE A USER-SPECIFIC OPERATION RELATED TO MONITORING AND COMMUNICATING ABOUT THE ONE OR MORE FILTER DEVICES BASED ON THE DETECTED EVENT AND THE DETERMINED USER IDENTITY FOR THE ONE OR MORE USERS (1320)
PERFORM THE USER-SPECIFIC OPERATION RELATED TO MONITORING AND COMMUNICATING ABOUT THE ONE OR MORE DEVICES (1330)

FIG. 6

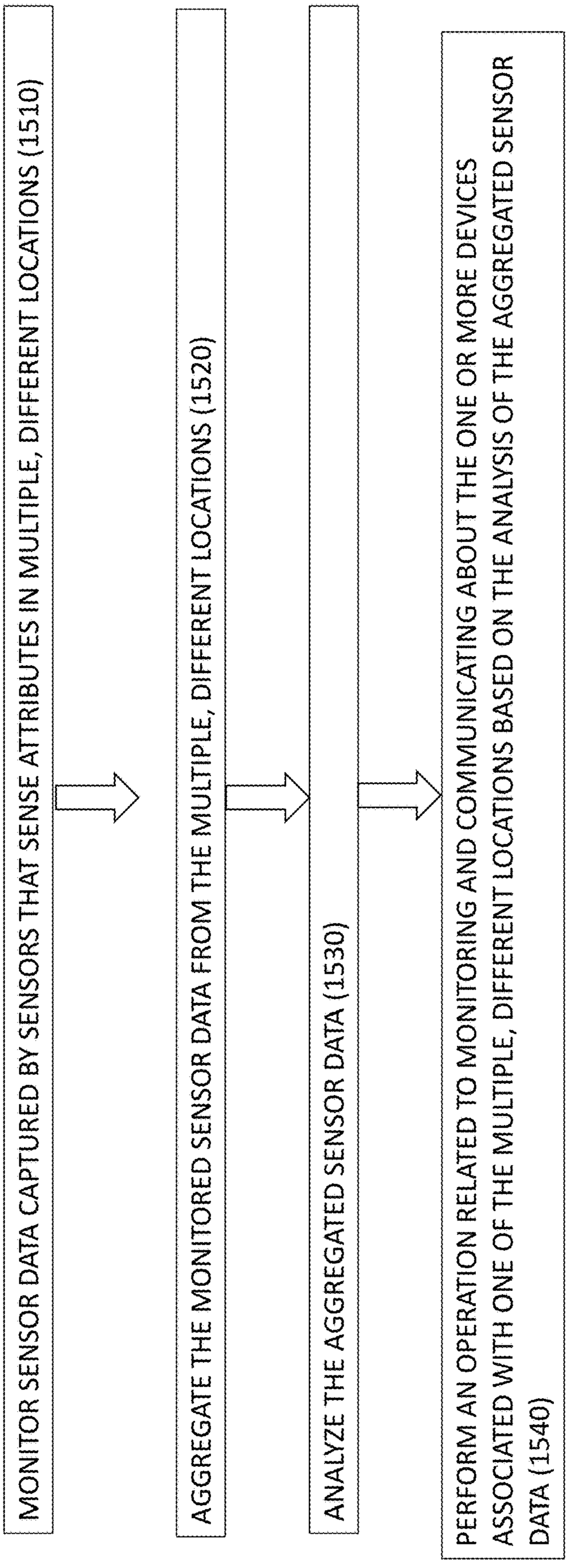

1500
MONITOR SENSOR DATA CAPTURED BY SENSORS THAT SENSE ATTRIBUTES IN MULTIPLE, DIFFERENT LOCATIONS (1510)
AGGREGATE THE MONITORED SENSOR DATA FROM THE MULTIPLE, DIFFERENT LOCATIONS (1520)
ANALYZE THE AGGREGATED SENSOR DATA (1530)
PERFORM AN OPERATION RELATED TO MONITORING AND COMMUNICATING ABOUT THE ONE OR MORE DEVICES ASSOCIATED WITH ONE OF THE MULTIPLE, DIFFERENT LOCATIONS BASED ON THE ANALYSIS OF THE AGGREGATED SENSOR DATA (1540)

FIG. 7

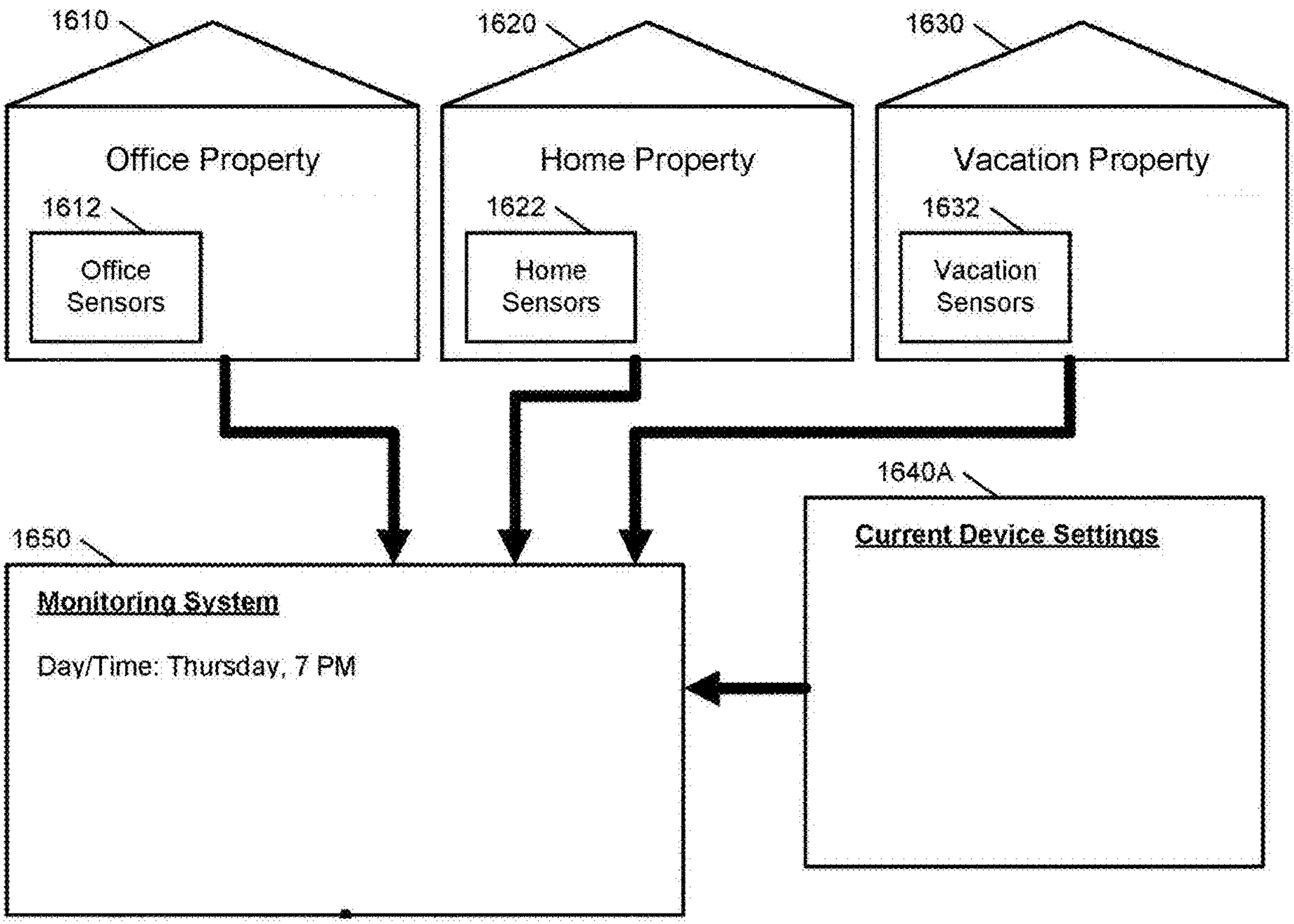

1610
Office Property
1612
Office Sensors
1620
Home Property
1622
Home Sensors
1630
Vacation Property
1632
Vacation Sensors
1640A
Current Device Settings
1650
Monitoring System
Day/Time: Thursday, 7 PM

FIG. 8

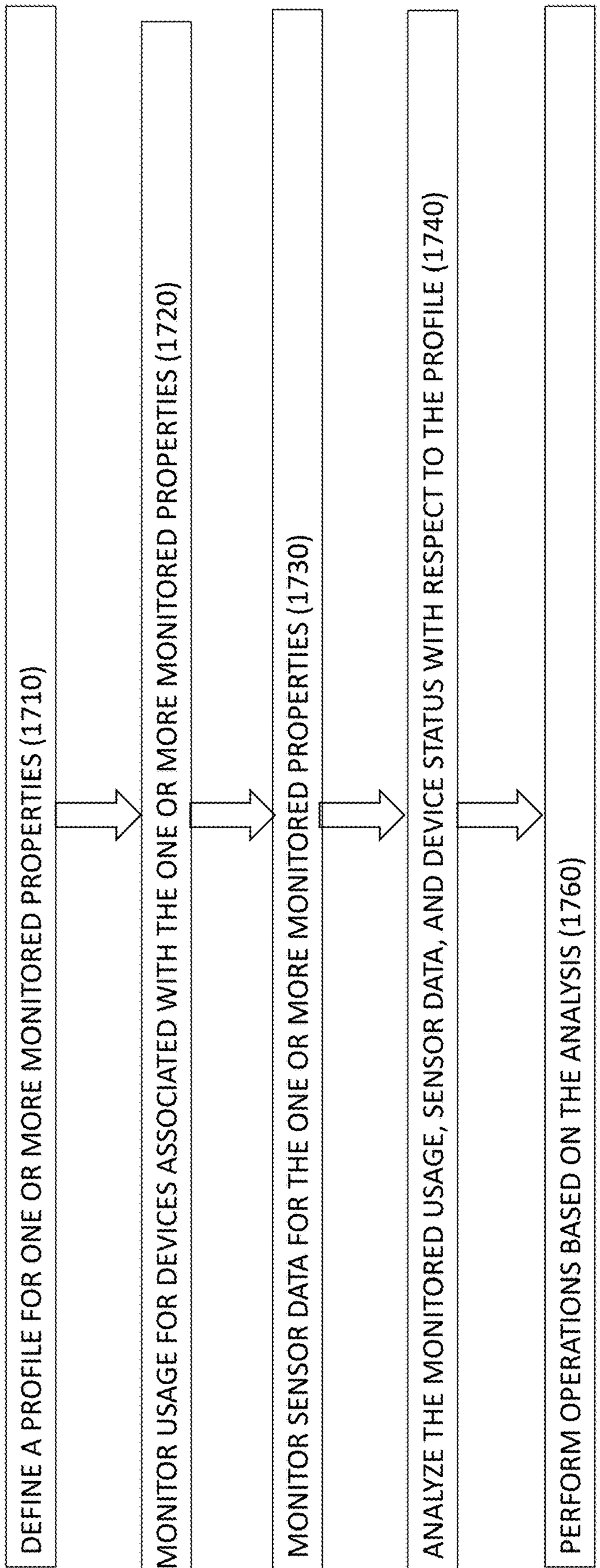

1700
DEFINE A PROFILE FOR ONE OR MORE MONITORED PROPERTIES (1710)
MONITOR USAGE FOR DEVICES ASSOCIATED WITH THE ONE OR MORE MONITORED PROPERTIES (1720)
MONITOR SENSOR DATA FOR THE ONE OR MORE MONITORED PROPERTIES (1730)
ANALYZE THE MONITORED USAGE, SENSOR DATA, AND DEVICE STATUS WITH RESPECT TO THE PROFILE (1740)
PERFORM OPERATIONS BASED ON THE ANALYSIS (1760)

FIG. 9

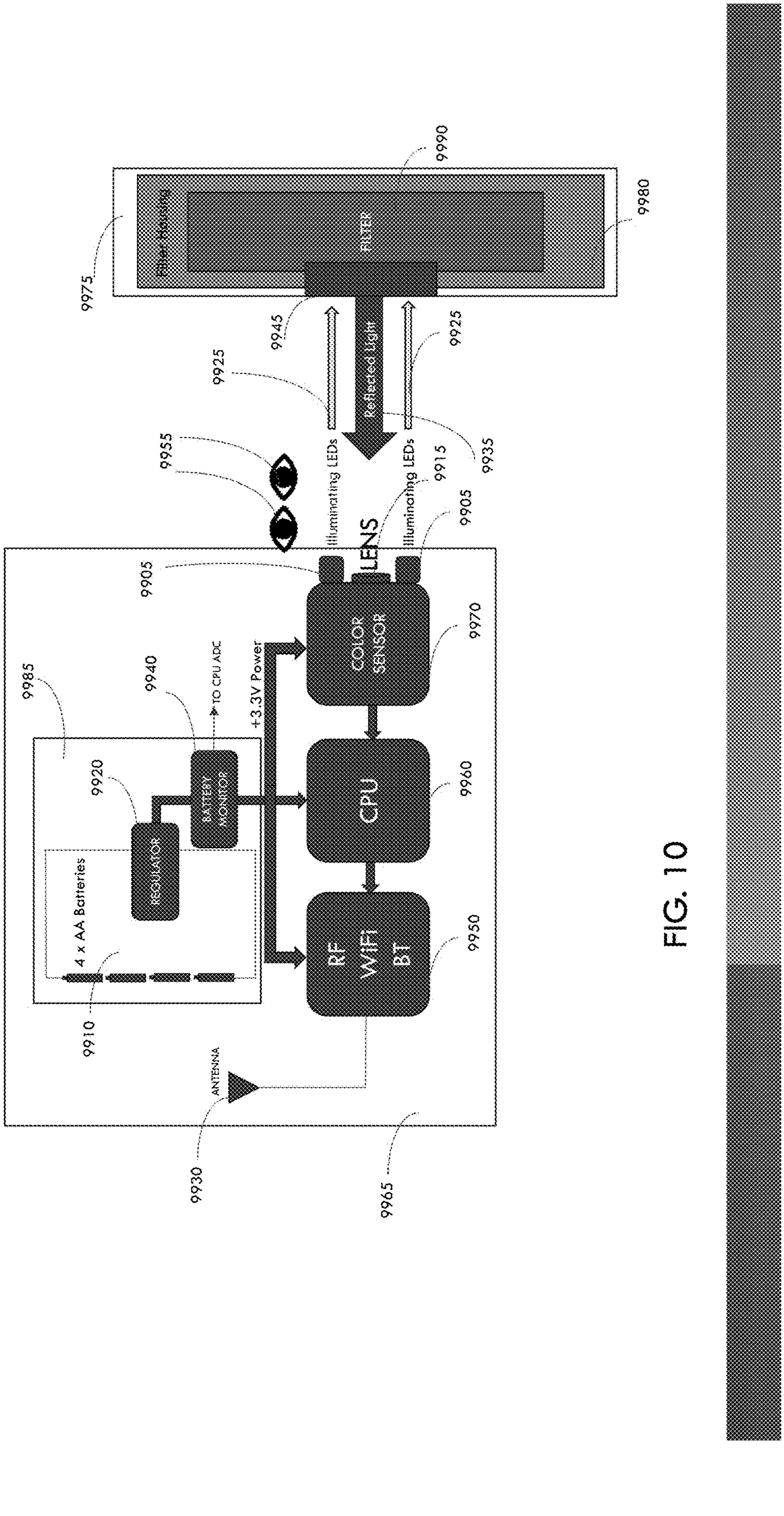

9990
9980
9975
Filter Housing
FILTER
9945
9925
9925
Reflected Light
9955
Illuminating LEDs
Illuminating LEDs
9915
9935
LENS
9905
9905
9985
9940
TO CPU ADC
+3.3V Power
COLOR SENSOR
9970
9920
BATTERY MONITOR
REGULATOR
CPU
9960
4 x AA Batteries
RF
WiFi
BT
9950
9910
ANTENNA
9930
9965

FIG. 10

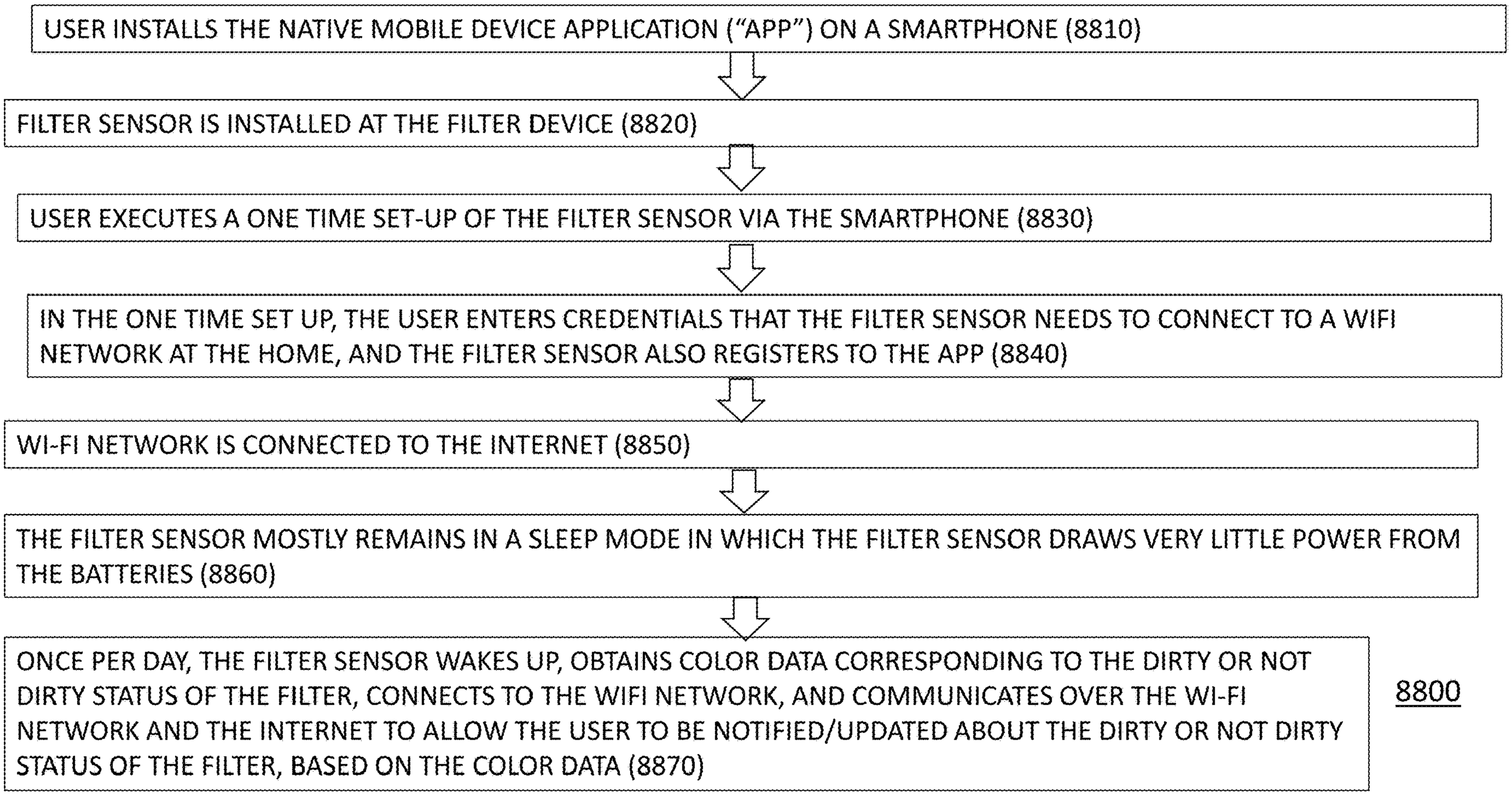

USER INSTALLS THE NATIVE MOBILE DEVICE APPLICATION ("APP") ON A SMARTPHONE (8810)
FILTER SENSOR IS INSTALLED AT THE FILTER DEVICE (8820)
USER EXECUTES A ONE TIME SET-UP OF THE FILTER SENSOR VIA THE SMARTPHONE (8830)
IN THE ONE TIME SET UP, THE USER ENTERS CREDENTIALS THAT THE FILTER SENSOR NEEDS TO CONNECT TO A WIFI NETWORK AT THE HOME, AND THE FILTER SENSOR ALSO REGISTERS TO THE APP (8840)
WI-FI NETWORK IS CONNECTED TO THE INTERNET (8850)
THE FILTER SENSOR MOSTLY REMAINS IN A SLEEP MODE IN WHICH THE FILTER SENSOR DRAWS VERY LITTLE POWER FROM THE BATTERIES (8860)
ONCE PER DAY, THE FILTER SENSOR WAKES UP, OBTAINS COLOR DATA CORRESPONDING TO THE DIRTY OR NOT DIRTY STATUS OF THE FILTER, CONNECTS TO THE WIFI NETWORK, AND COMMUNICATES OVER THE WI-FI NETWORK AND THE INTERNET TO ALLOW THE USER TO BE NOTIFIED/UPDATED ABOUT THE DIRTY OR NOT DIRTY STATUS OF THE FILTER, BASED ON THE COLOR DATA (8870)
8800

FIG. 11

MONITORING OF FILTERS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/446,832, filed Feb. 18, 2023, which is incorporated by reference herein in its entirety.

FIELD

[0002] This disclosure relates to monitoring of filters.

BACKGROUND

[0003] The present invention is of particular utility in the field of monitoring of filters, for example, fluid filters or with respect to domestic water supply, although various aspects of the invention may be exploited to advantage in other fields. It is desirable to have impurities removed from fluids, and to have water of good taste, high purity, and low hardness for drinking and cooking.

[0004] Filtration systems generally comprise multiple cartridge filters located within corresponding filter housings, and fluids to be filtered (influents) are supplied to the filter housings for the removal of debris, contaminants and particles. These cartridge filters generally have a cylinder shape with a hollow core. Influents are supplied to the hollow core and flowing outwards through the media of the cartridge filters, leaving debris, contaminants and particles at the surface of the media. After conducting such fluid processing for a period of time, the debris and particles will accumulate and clog the filter media, causing the drop of filter efficiency. Therefore, the cartridge must be replaced after a period of operation. The replacing of a cartridge generally involves shutting down the filtration operation and removing the cartridge and inserting a new cartridge.

[0005] Many people equip homes and businesses with water filters to provide increased water purity for their homes and businesses. In general, a water filter is a device for removing impurities in the domestic water supply.

[0006] Heretofore ion-exchange type water softeners have been the principal devices used domestically to upgrade water quality. They do so by removing the dissolved solids causing water hardness. One characteristic of ion exchange units is that they must be frequently replaced, which presents the home owner with a continuing maintenance problem.

[0007] Another type of filter system is a sediment filter system that includes a sediment filter. The sediment filter may be replaceable and is preferably a woven or non-woven fabric, more preferably a non-woven fabric having micropores. The sediment filter ensures filtration of particles generally above 3 microns.

[0008] A person replaces a water filter on a predetermined schedule or when the person perceives that the water filter is no longer capable of removing impurities, e.g., because the filter is full of impurities already removed from the water supply (i.e., the filter is "dirty"). The person may determine that the filter is dirty by visually inspecting the filter.

[0009] Another type of filter operates to control, limit, or regulate output of materials.

[0010] For example, a tube birdfeeder operates as a filter by controlling, limiting, or regulating the output of birdseed from the tube birdfeeder. Tube birdfeeders are hollow, cylindrical tubes, often made of plastic, and have multiple feeding stations spaced along the length of the tube. Typically, feeding stations include both a seed port and an adjacent perch to provide the feeding bird with a place to alight. The interior of the tube birdfeeder may have one color when the tube birdfeeder is full of birdseed, and may have a second color when the tube birdfeeder is empty of birdseed.

[0011] In another example, the interior of a liquid soap dispenser may have one color when the dispenser is full of soap, and may have a second color when the dispenser is empty of soap.

SUMMARY

[0012] Systems and methods are described for use in monitoring of filters.

[0013] Filters are monitored. Color data is determined for a filter. A filter status for the filter is derived from the color data. An action is taken based on the filter status.

[0014] Implementations of the described techniques may include hardware, a method or process implemented at least partially in hardware, or a computer-readable storage medium encoded with executable instructions that, when executed by a processor, perform operations.

[0015] The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The present invention(s) is/are illustrated by way of example and is/are not limited by the accompanying figures, in which like references indicate similar elements. Elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale.

[0017] FIGS. **1-2**, **4-5**, **8**, **10** are diagrams depicting examples of systems for use in monitoring of filters, according to some embodiments.

[0018] FIGS. **3**, **6-7**, **9**, **11** are flowcharts of methods for use with one or more of the example systems of FIGS. **1-2**, **4-5**, **8**, **10**, according to some embodiments.

DETAILED DESCRIPTION

[0019] A water filter is usually installed by or for a homeowner to help produce clean water for household use. Dirty water flows into the water filter and cleaner water flows out of the water filter. Impurities removed from the dirty water by the water filter accumulate in the water filter. At some point the water filter needs to be replaced because the water filter becomes full of impurities and therefore becomes ineffective at cleaning the dirty water flowing in. The homeowner can determine that the water filter needs to be replaced by viewing the color of the water filter. The water filter has one color (typically a light color) when the water filter is new, and then the color of the water filter changes (typically darkens) over time due to the accumulation of impurities in the filter.

[0020] The homeowner must check the color of the water filter frequently in order to detect when the water filter needs to be replaced. In many cases the water filter is installed in a remote area of the home, such as a basement corner, and therefore the homeowner must make a special trip to the remote area each time to check the color of the water filter. The special trip is not convenient for the homeowner, and

therefore the homeowner is prone to failing to check the color of the water filter frequently enough to make sure that the water filter is replaced often enough to ensure effective cleaning of the dirty water. The homeowner may forget to check the color of the water filter, or may find that checking the color of the water filter is too inconvenient to perform frequently enough to be effective.

[0021] Techniques are described herein for use in monitoring of filters, e.g., for providing remote water filter monitoring. The techniques may combine water purity efforts with user convenience and may provide remote monitoring that improves water purity while providing an enhanced level of convenience to users.

[0022] In some implementations, a native mobile device application enables use of a mobile device to monitor one or more water filters in a home, business, vacation or other property from anywhere. The native mobile device application provides alerts related to water filter status and events that may impact user decision on water filter replacement.

[0023] FIG. **1** illustrates an example of monitoring sensor data and device status. As shown, a property **110** is monitored by a monitoring system **120**. The property **110** may be a residence, an office building, or any other type of property that is capable of being monitored by the monitoring system **120**. The monitoring system **120** may be a local monitoring system that is located at the property and monitors device status at the property **110** through one or more sensors. The monitoring system **120** also may be remote from the property **110** and receive, over a network, sensor data from one or more sensors located at the property **110**. The monitoring system **120** further may include both local components that are located at the property **110** and remote components that are located separate from the property **110** at another property.

[0024] In the example shown in FIG. **1**, the property **110** includes first and second levels suitable to accommodate the presence of persons **140**, **160** respectively. The first level has a first filter sensor **134**. The monitoring system **120** receives sensor data from the first sensor **134**.

[0025] Similar to the first level, the second level has a second filter sensor **154**. The monitoring system **120** also receives sensor data from the second sensor **154**.

[0026] In the example shown in FIG. **1**, the monitoring system **120** sets status data **170**A based on the status in the property **110** sensed by the sensors. The device status data **170**A includes a device column **172** and a status column **174**. As shown in the example of FIG. **1**, the monitoring system **120** may detect that the first sensor **134** detected a dirty filter (e.g., based on the presence of a dark color of the filter) and the second sensor **154** detected a not dirty filer (e.g., based on the presence of a light color of the filter).

[0027] FIG. **2** illustrates an example of an electronic system **200** configured to provide remote sensor monitoring using devices. System **200** may be the same as, or may comprise, or may be comprised within, system **120** of FIG. **1**. The electronic system **200** includes a network **205**, a monitoring system control unit **210**, one or more mobile devices **240**, **250**, a monitoring application server **260**, and one or more client devices **270**, **280**. In some examples, the network **205** facilitates communications between the monitoring system control unit **210**, the one or more mobile devices **240**, **250**, the one or more client devices **270**, **280**, and the monitoring application server **260**.

[0028] The network **205** is configured to enable exchange of electronic communications between devices connected to the network **205**. For example, the network **205** may be configured to enable exchange of electronic communications between the monitoring system control unit **210**, the one or more mobile devices **240**, **250**, the one or more client devices **270**, **280**, and the monitoring application server **260**. The network **205** may include, for example, one or more of the Internet, Wide Area Networks (WANs), Local Area Networks (LANs), analog or digital wired and wireless telephone networks (e.g., a public switched telephone network (PSTN), Integrated Services Digital Network (ISDN), a 5G network, a cellular network, a WiFi network, and Digital Subscriber Line (DSL)), radio, television, cable, satellite, or any other delivery or tunneling mechanism for carrying data. Network **205** may include multiple networks or subnetworks, each of which may include, for example, a wired or wireless data pathway. The network **205** may include a circuit-switched network, a packet-switched data network, or any other network able to carry electronic communications (e.g., data or voice communications). For example, the network **205** may include networks based on the Internet protocol (IP), asynchronous transfer mode (ATM), the PSTN, packet-switched networks based on IP, X.25, or Frame Relay, or other comparable technologies and may support voice using, for example, VoIP, or other comparable protocols used for voice communications. The network **205** may include one or more networks that include wireless data channels and wireless voice channels. The network **205** may be a wireless network, a broadband network, or a combination of networks including a wireless network and a broadband network.

[0029] The monitoring system control unit **210** includes a controller **212** and a network module **214**. The controller **212** is configured to control a monitoring system that includes the monitoring system control unit **210**. In some examples, the controller **212** may include a processor or other control circuitry configured to execute instructions of a program that monitors. In these examples, the controller **212** may be configured to receive input from sensors **220**, **222**, **230** included in the system. For example, the controller **212** may be configured to control operation of the network module **214** included in the monitoring system control unit **210**.

[0030] The network module **214** is a communication device configured to exchange communications over the network **205**. The network module **214** may be a wireless communication module configured to exchange wireless communications over the network **205**. For example, the network module **214** may be a wireless communication device configured to exchange communications over a wireless data channel and a wireless voice channel. In this example, the network module **214** may transmit sensor data over a wireless data channel and establish a two-way voice communication session over a wireless voice channel. The wireless communication device may include one or more of a GSM module, a 5G module, a WiFi unit, a radio modem, cellular transmission module, or any type of module configured to exchange communications in one of the following formats: GSM or GPRS, CDMA, EDGE or EGPRS, EVDO or EVDO, UMTS, or IP.

[0031] The network module **214** also may be a wired communication module configured to exchange communications over the network **205** using a wired connection. For

instance, the network module **214** may be a modem, a network interface card, or another type of network interface device. The network module **214** may be an Ethernet network card configured to enable the monitoring system control unit **210** to communicate over a local area network and/or the Internet. The network module **214** also may be a voiceband modem configured to enable communication over the telephone lines of Plain Old Telephone Systems (POTS).

[0032] The monitoring system that includes the monitoring system control unit **210** includes one or more sensors. For example, the monitoring system may include multiple sensors. The sensors may include an optical sensing device configured to capture colors for filters in a property monitored by the monitoring system.

[0033] The monitoring system control unit **210** communicates with filter sensors **220**, **222**, **230** to perform monitoring of filters. One or more of sensors **220**, **222**, **230** may be the same as, or may comprise, or may be comprised within, one or more of sensors **134**, **154** of FIG. **1**. Filter sensor **220** is connected to one or more filters and is configured to help monitor dirty/not dirty status of filters. Filter sensor **220** may directly measure filter color. Filter sensor **220** may communicate filter color information to the monitoring system control unit **210**.

[0034] Filter sensors **220**, **222**, **230** communicate with the controller **212** over communication links **224**, **226**, **228**. The communication links **224**, **226**, **228** may be a wired or wireless data pathway configured to transmit signals from the filter sensors **220**, **222**, **230** to the controller **212**. The filter sensors **220**, **222**, **230** may continuously transmit sensed values to the controller **212**, periodically transmit sensed values to the controller **212**, or transmit sensed values to the controller **212** in response to a change in a sensed value.

[0035] The monitoring application server **260** is an electronic device configured to provide monitoring services by exchanging electronic communications with the monitoring system control unit **210**, the one or more mobile devices **240**, **250**, and the one or more client devices **270**, **280** over the network **205**. For example, the monitoring application server **260** may be configured to monitor events generated by the monitoring system control unit **210**. In this example, the monitoring application server **260** may exchange electronic communications with the network module **214** included in the monitoring system control unit **210** to receive information regarding water filter events detected by the monitoring system control unit **210**. The monitoring application server **260** also may receive information regarding events from the one or more mobile devices **240**, **250**.

[0036] The monitoring application server **260** may store filter sensor data received from the monitoring system and perform analysis of sensor data received from the monitoring system. Based on the analysis, the monitoring application server **260** may communicate with and control aspects of the monitoring system control unit **210**, the one or more mobile devices **240**, **250**, or the one or more client devices **270**, **280**.

[0037] The one or more mobile devices **240**, **250** are devices that host and display user interfaces and that host one or more native applications (e.g., the native monitoring application **242**, **252**). The one or more mobile devices **240**, **250** may be cellular phones or non-cellular locally networked devices with displays. The one or more mobile devices **240**, **250** may include a cell phone, a smart phone, a tablet PC, a personal digital assistant ("PDA"), or any other portable device configured to communicate over a network and display information. For example, implementations may also include smartphone-type devices, iPhone-type devices (e.g., as provided by Apple), other communication devices, and handheld or portable electronic devices for communications, and/or data organization. The one or more mobile devices **240**, **250** may be the same or may include mobile devices of different types. The one or more mobile devices **240**, **250** may perform functions unrelated to the monitoring system, such as placing personal telephone calls, playing music, playing video, displaying pictures, browsing the Internet, maintaining an electronic calendar, etc.

[0038] The one or more mobile devices **240**, **250** communicate with and receive monitoring system data from the monitoring system control unit **210** using communication link **238**. For instance, the one or more mobile devices **240**, **250** may communicate with the monitoring system control unit **210** using various local wireless protocols such as WiFi, Bluetooth, zwave, zigbee, HomePlug (ethernet over powerline), or wired protocols such as Ethernet and USB, to connect the one or more mobile devices **240**, **250** to local equipment. The one or more mobile devices **240**, **250** may connect locally to the monitoring system and its sensors and other devices. The local connection may improve the speed of status communications because communicating through the network **205** with a remote server (e.g., the monitoring application server **260**) may be significantly slower.

[0039] Although the one or more mobile devices **240**, **250** are shown as communicating with the monitoring system control unit **210**, the one or more mobile devices **240**, **250** may communicate directly with the sensors **220**, **222**, **230** and other devices controlled by the monitoring system control unit **210**. In some implementations, the one or more mobile devices **240**, **250** replace the monitoring system control unit **210** and perform the functions of the monitoring system control unit **210** for local monitoring and long range/offsite communication.

[0040] In other implementations, the one or more mobile devices **240**, **250** receive monitoring system data captured by the monitoring system control unit **210** through the network **205**. The one or more mobile devices **240**, **250** may receive the data from the monitoring system control unit **210** through the network **205** or the monitoring application server **260** may relay data received from the monitoring system control unit **210** to the one or more mobile devices **240**, **250** through the network **205**. In this regard, the monitoring application server **260** may facilitate communication between the one or more mobile devices **240**, **250** and the monitoring system.

[0041] In some implementations, the one or more mobile devices **240**, **250** may be configured to switch whether the one or more mobile devices **240**, **250** communicate with the monitoring system control unit **210** directly (e.g., through link **238**) or through the monitoring application server **260** (e.g., through network **205**) based on a location of the one or more mobile devices **240**, **250**. For instance, when the one or more mobile devices **240**, **250** are located close to the monitoring system control unit **210** and in range to communicate directly with the monitoring system control unit **210**, the one or more mobile devices **240**, **250** use direct communication. When the one or more mobile devices **240**, **250** are located far from the monitoring system control unit

210 and not in range to communicate directly with the monitoring system control unit **210**, the one or more mobile devices **240**, **250** use communication through the monitoring application server **260**.

[0042] Although the one or more mobile devices **240**, **250** are shown as being connected to the network **205**, in some implementations, the one or more mobile devices **240**, **250** are not connected to the network **205**. In these implementations, the one or more mobile devices **240**, **250** communicate directly with one or more of the monitoring system components and no network (e.g., Internet) connection or reliance on remote servers is needed.

[0043] In some implementations, the one or more mobile devices **240**, **250** are used in conjunction with only local sensors and/or local devices in a house. In these implementations, the system **100** only includes the one or more mobile devices **240**, **250** and the filter sensors **220**, **222**, and **230**. The one or more mobile devices **240**, **250** receive data directly from the filter sensors **220**, **222**, and **230** and sends data directly to the filter sensors **220**, **222**, and **230**. The one or more mobile devices **240**, **250** provide the appropriate interfaces/processing to provide monitoring information, generate alerts, and modify settings, etc.

[0044] In other implementations, the system **200** further includes network **205** and the filter sensors **220**, **222**, and **230** are configured to communicate sensor data to the one or more mobile devices **240**, **250** over network **205** (e.g., the Internet, cellular network, etc.). In yet another implementation, the filter sensors **220**, **222**, and **230** (or a component, such as a bridge/router) are intelligent enough to change the communication pathway from a direct local pathway when the one or more mobile devices **240**, **250** are in close physical proximity to the filter sensors **220**, **222**, and **230** to a pathway over network **205** when the one or more mobile devices **240**, **250** are farther from the filter sensors **220**, **222**, and **230**. In some examples, the system leverages GPS information from the one or more mobile devices **240**, **250** to determine whether the one or more mobile devices **240**, **250** are close enough to the filter sensors **220**, **222**, and **230** to use the direct local pathway or whether the one or more mobile devices **240**, **250** are far enough from the filter sensors **220**, **222**, and **230** that the pathway over network **205** is required. In other examples, the system leverages status communications (e.g., pinging) between the one or more mobile devices **240**, **250** and the filter sensors **220**, **222**, and **230** to determine whether communication using the direct local pathway is possible. If communication using the direct local pathway is possible, the one or more mobile devices **240**, **250** communicate with the filter sensors **220**, **222**, and **230** using the direct local pathway. If communication using the direct local pathway is not possible, the one or more mobile devices **240**, **250** communicate with the filter sensors **220**, **222**, and **230** using the pathway over network **205**.

[0045] The one or more mobile devices **240**, **250** each include a native monitoring application **242**, **252**, respectively. The native monitoring application **242**, **252** refers to a software/firmware program running on the corresponding mobile device that enables the user interface and features describe below. The one or more mobile devices **240**, **250** may load or install the native monitoring application **242**, **252** based on data received over a network or data received from local media. The native monitoring application **242**, **252** runs on mobile devices platforms, such as iPhone, Google Android, Windows Mobile, etc.

[0046] The native monitoring application **242**, **252** monitors filter sensors in a home, business, vacation or other property from anywhere. The native monitoring application **242**, **252** enables users to easily monitor how dirty their filters are.

[0047] In some implementations, the native monitoring application **242**, **252** enables the mobile device to connect to a filter sensor remotely and provide a user real-time, remote indication of filter status in a building. For example, a user may take the user's mobile device on a business trip out of town. While the user is out of town, the filter at the user's home becomes unexpectedly dirty, and the user is alerted automatically. The user may communicate separately with someone near the home to replace the filter.

[0048] The native monitoring application **242**, **252** also may alert the user during time frames when it is convenient or appropriate for the user, so user can take action through the native monitoring application **242**, **252**. For instance, the native monitoring application **242**, **252** may receive information related to convenient or appropriate times from the monitoring application server **260**, from another source on the Internet, or from a user entering information related to convenient times. The native monitoring application **242**, **252** may store the convenient time information for use in alerting the user. The native monitoring application **242**, **252** may periodically update the convenient time information. In using the convenient time information to alert the user, the native monitoring application **242**, **252** may provide an alert to the user when the user is likely awake and not busy, but determine not to provide an alert to the user when the user is likely to be asleep or busy.

[0049] The native monitoring application **242**, **252** may include detailed and summary filter status reports to show users how dirty or not dirty the filters are.

[0050] The native monitoring application **242**, **252** also may implement a permission system that provides a different level of access for different users. For instance, landlord users may have full access to the monitoring system and a tenant user may have limited access (e.g., the tenant user may be able to see the status of a filter in the tenant's home in an apartment building, but may not be able to see the status of other filters in the apartment building). The permission system may be implemented based on user-specific passcodes or particular mobile devices may be assigned to particular users.

[0051] The one or more client devices **270**, **280** may be any type of client devices (e.g., personal computers) that are capable of performing operations similar to those described as being performed by the one or more mobile devices **240**, **250**. The one or more client devices **270**, **280** operate a monitoring application **272**, **282** either locally or over a network. The monitoring application **272**, **282** may be similar to the native monitoring application **242**, **252** operated by the one or more mobile devices **240**, **250**.

[0052] FIGS. **3**, **6-7**, **9**, **11** illustrate example processes. The operations of the example processes are described generally as being performed by the system **200**. The operations of the example processes may be performed by one of the components of the system **200** (e.g., the monitoring application server **260**) or may be performed by any combination of the components of the system **200**. In some

implementations, operations of the example processes may be performed by one or more processors included in one or more electronic devices.

[0053] FIG. **3** illustrates an example process **300** for performing an operation related to communicating filter status based on monitored sensor data and monitored device status. The system **200** monitors sensor data captured by one or more sensors that sense attributes relevant to filter status at one or more properties (**310**). For example, the system **200** receives, either directly or via a network, data communications from sensors included in a monitoring system that are configured to sense physical attributes of the physical world at the one or more properties. The sensor data may include color sensor data, radio frequency identification (RFID) sensor data (e.g., RFID tags may be applied to filter devices and RFID sensors may detect presence of the filter devices), or any other sensor data related to physical attributes capable of being monitored using sensor technology.

[0054] The system **200** may monitor the received sensor data for single detected events (e.g., a single reading of filter status) or a series of detected events (e.g., a pattern of multiple readings of filter status and an RFID tag identification). In addition, the sensor data may be direct data captured by the sensors or may be processed prior to being received by the system **200**. The sensor data may processed by performing statistical calculations on the sensor data to identify trends within the data.

[0055] The system **200** monitors status of one or more filter devices associated with the one or more properties (**320**). For example, the system **200** may receive, either directly or via a network, data communications from one or more filter devices located at the one or more properties. In this example, the system **200** may receive the data communications directly from the one or more filter devices or from a controller (e.g., a zwave controller) added to the one or more filter devices. The system **200** may process the data communications to determine a state of a device (e.g., whether the filter is dirty or not dirty). The system **200** also may process the data communications to determine filter status of the one or more filter devices. The system **200** may track device status patterns for the one or more filter devices and track filter use through operation of the one or more filter devices.

[0056] The system **200** analyzes the monitored sensor data and the monitored device status with respect to a set of one or more rules (**330**) and performs an operation related to communicating based on the analysis (**340**). For instance, the system **200** analyzes events detected using the sensor data in relation to device status information to perform communication regarding the one or more filter devices. The system **200** may analyze single detected events and take action according to single detected events. For instance, when the system **200** determines that all of the filters at a property are dirty, the system **200** may communicate the need to replace the filters at the property.

[0057] The system **200** also may analyze patterns of the sensor data and device status and take action according to the patterns. For instance, the system **200** may determine a pattern that relates to when filters are typically dirty in a property. The system **200** also may determine a device usage pattern. After determining the device usage pattern, the system **200** may compare the device usage pattern with another pattern. For example, the system **200** may determine that devices typically become dirtier during particular times of day or week or month or year. In this example, the system **200** may suggest adjustment to a filter replacement schedule to more closely match another pattern such as a work schedule or when a user is expected to be present at the property.

[0058] In addition, the system **200** may monitor filter status at the property and use the monitored filter status to determine which types of communication operations to perform. For instance, when filter status has been measured to be dirty at a relatively high level for a time period, the system **200** may increase or otherwise change the communications to the user.

[0059] FIG. **4** illustrates an interface **500** that enables user control over the monitoring of devices and communication about devices from a remote location. The interface **500** may be presented by one or more of mobile devices **240**, **250** of FIG. **2**. The interface **500** may be presented over a network (e.g., as a webpage on a personal computer) or may be displayed by an application that operates on a device (e.g., displayed by a native monitoring application on a mobile device). The interface may have indicators **510**, **520**, **530** to indicate to the user how dirty the water filter is. For example, if interface **500** highlights indicator **510**, it is indicated that the water filter is not dirty. In another example, if interface **500** highlights indicator **530**, it is indicated that the water filter is dirty and needs to be replaced.

[0060] FIG. **5** illustrates an example of performing an operation related to communicating in a manner that accounts for filter status. As shown, a property **1010** is monitored by a monitoring system. The property **1010** includes a sensor **1012**. Sensor **1012** may be the same as, may comprise, or may be comprised within one or more of sensors **220**, **222**, **230** of FIG. **2** and sensors **134**, **154** of FIG. **1**. The monitoring system monitors sensor data from the sensor **1012** and monitors the state of filter **1014**.

[0061] In the example shown in FIG. **5**, the monitoring system analyzes color data captured by sensor **1012** and detects a dirty status of filter **1014** within the property **1010** based on the analysis of the color data. The monitoring system accumulates all this monitored data in monitoring system data **1030**. As shown, the monitoring system data **1030** indicates that the filter **1014** is operating with a dirty status.

[0062] The monitoring system analyzes the monitoring system data **1030** with respect to one or more rules and determines that an action is needed based on the monitored attributes stored in the monitoring system data **1030**. As shown, the monitoring system determines that an alert **1040** should be sent to one or more users associated with the property **1010** based on the sensor data and the monitored device status. The alert **1040** may be the same as, may comprise, or may be comprised within, interface **500** of FIG. **4**. The alert **1040** provides a message indicating current values for the sensed activity with the property **1010** to enable the one or more users to assess the potentially unhealthy situation for the filter and take action accordingly.

[0063] The alert **1040** includes multiple options for a user to respond to the situation. For example, the alert **1040** includes an input control **1044** that enables a user to receive more detailed information related to the filter. A user may activate the input control **1044** to see more detailed filter information and attempt to assess the likelihood of the filter being placed in unhealthy situation.

[0064] An example process accounts for geographic location data in performing an operation related to monitoring and communicating about one or more filter devices. The system **200** monitors geographic location data of one or more users associated with one or more monitored properties. For example, the system **200** determines a geographic location of one or more users associated with a monitored property. In this example, the system **200** may determine geographic location using any type of mechanism for determining a geographic location of a user. For instance, the system **200** may use GPS data to determine a geographic location, may use cell tower triangulation to determine a geographic location, or may use an IP address of a device being operated by the user to determine a geographic location. The system **200** may determine and monitor a geographic location of one or more users relative to a geographic location of a monitored property (e.g., within a particular number of miles).

[0065] In some examples, the system **200** may perform one or more operations related to preparing a monitored property for anticipated occupation when the inferred future occupancy suggests that the monitored property will be occupied in a relatively short period of time. These operations may include automatically prompting the user to replace the water filter to prepare the property for occupation.

[0066] FIG. **6** illustrates an example process **1300** for accounting for user identity in performing an operation related to monitoring and communicating about filter devices. The system **200** detects an event that triggers an operation related to devices (**1310**). For instance, the system **200** determines that monitored attributes described throughout this disclosure (e.g., sensor data, device status, etc.) indicate performance of an action defined by a rule.

[0067] In some implementations, the event may be a standalone event that triggers an operation. In these implementations, the event may be a sensor detecting dirty status of a filter.

[0068] In some examples, the event may be part of a string of multiple events that trigger an operation. In these examples, the event may be part of a pattern of events that is detected by the system **200**. When the system **200** detects the pattern of events, the system **200** triggers an operation based on the pattern of events.

[0069] The system **200** determines a user-specific operation related to monitoring and communicating about the one or more filter devices based on the detected event and the determined user identity for the one or more users (**1320**) and performs the user-specific operation related to monitoring and communicating about the one or more devices (**1330**). The system **200** may determine and perform several different, types of operations related to monitoring and communicating about the one or more devices based on the detected event and the determined user identity for the one or more users. For example, the system **200** may automatically, without user intervention, communicate about the one or more devices based on the determined user identity for the one or more users. In another example, the system **200** may send alerts or display suggested changes to an identified user based on the determined user identity for the one or more users.

[0070] FIG. **7** illustrates an example process **1500** for accounting for sensor data from multiple, different locations in performing an operation related to monitoring and communicating about the one or more devices. The system **200** monitors sensor data captured by sensors that sense attributes in multiple, different locations (**1510**). For instance, the system **200** may use techniques similar to those discussed above with respect to reference numeral **310** to sense attributes. The system **200** may sense attributes in multiple, different locations. The system **200** may monitor sensor data from multiple, different areas within a single monitored property (e.g., sensor data from different levels or rooms within a house) or may monitor sensor data from multiple, different monitored properties (e.g., sensor data from a first filter at a home residence and sensor data from a second filter at a vacation residence).

[0071] The system **200** aggregates the monitored sensor data from the multiple, different locations (**1520**). For example, the system **200** combines the monitored sensor data from the multiple, different locations to enable the combined data to be analyzed for events occurring in each of the different locations. In this example, the combined or aggregated data may reflect activity in each of the different locations and, as such, may provide insights as to the relative usage patterns of the different locations.

[0072] The system **200** analyzes the aggregated sensor data (**1530**) and performs an operation related to monitoring and communicating about the one or more devices associated with one of the multiple, different locations based on the analysis of the aggregated sensor data (**1540**). For instance, the system **200** analyzes events detected using the sensor data at the multiple, different locations. The system **200** may analyze patterns of the sensor data at the different locations and take action according to the relative overlap in the patterns of activity at the different locations.

[0073] FIG. **8** illustrates examples of performing an operation related to monitoring and communicating about the one or more devices associated with a monitored property based on sensor data aggregated for multiple, different properties. As shown in FIG. **8**, a monitoring system **1650** monitors sensed data and communicates about the one or more devices at each of an office property **1610**, a home property **1620**, and a vacation property **1630**. Monitoring system **1650** may be the same as, may comprise, or may be comprised within, one or more of system **120** of FIG. **1** and system **200** of FIG. **2**. The office property **1610** includes sensors **1612** at the office property **1610**, the home property **1620** includes sensors **1622** at the home property **1620**, and the vacation property **1630** includes sensors **1632** at the vacation property **1630**. One or more of sensors **1612**, **1622**, **1632** may be the same as, may comprise, or may be comprised within, one or more of sensor **1012** of FIG. **5**, sensors **220**, **222**, **230** of FIG. **2**, and sensors **134**, **154** of FIG. **1**. The monitoring system **1650** may communicate, over a network, to receive sensor data from sensors included in the corresponding system. The office property **1610**, the home property **1620**, and the vacation property **1630** are all associated with (e.g., owned by) a single user.

[0074] In the example shown in FIG. **8**, the current device settings **1640**A show the status of devices at each of the office property **1610**, the home property **1620**, and the vacation property **1630** on a Thursday at seven in the evening. At this time, the monitoring system **1650** detects filter status at the office property **1610**, the home property **1620**, and the vacation property **1630**. From past monitored sensor data for the office property **1610**, the home property

1620, and the vacation property **1630**, the monitoring system **1650** has derived a relative filter status pattern.

[0075] FIG. **9** illustrates an example process **1700** for performing operations related to monitoring and communicating about the one or more devices based on a profile. The system **200** defines a profile for one or more monitored properties (**1710**). For example, the system **200** receives user input describing one or more goals or rules that a user would like to set. In this example, the system **200** uses the one or more goals or rules to define a profile for the user, which is used to monitor and communicate about the one or more devices at one or more properties associated with the user.

[0076] The profile may include various dirty filter thresholds that define when it is and is not appropriate to replace a filter. The profile may define the thresholds for the one or more monitored properties in terms of a budget. The profile may define how much control the user would like to give the system **200** in meeting the various thresholds and budgets defined in the profile. An example profile is shown in FIG. **18** and described in more detail below.

[0077] The system **200** monitors usage for devices associated with the one or more monitored properties (**1720**). The system **200** may measure filter use by a single device or collectively measure filter use by several (e.g., all) devices at one or multiple properties.

[0078] The system **200** monitors sensor data for the one or more monitored properties (**1730**). For instance, the system **200** may use techniques similar to those discussed above with respect to reference numeral **310** to monitor sensor data for the one or more monitored properties.

[0079] The system **200** analyzes the monitored usage, sensor data, and device status with respect to the profile (**1740**) and performs operations based on the analysis (**1760**).

[0080] FIG. **10** illustrates an example embodiment of circuitry and components of filter sensor **9965** at filter device **9975**. Filter sensor **9965** may be the same as, may comprise, or may be comprised within, one or more of filter sensors **1612**, **1622**, **1632** of FIG. **8**, sensor **1012** of FIG. **5**, sensors **220**, **222**, **230** of FIG. **2**, and sensors **134**, **154**. The filter device **9975** includes a filter **9990** encompassed by a filter housing **9980**. Filter device **9975** may be the same as, may comprise, or may be comprised within, filter **1014** of FIG. **5**, The filter sensor **9965** is placed in close proximity to the filter device **9975**. In at least one embodiment, the filter sensor **9965** is physically attached to the outside of the filter housing **9980**. At least one area (e.g., window **9945**) of the filter housing **9980** is transparent or translucent enough such that in at least the one area, the filter housing allows light from outside the filter housing **9980** to enter the filter housing **9980** and reach the filter **9990** and then reflect off the filter **9990** and back out of the filter housing **9980**, as reflected light **9935**. In at least one embodiment, the reflected light **9935** is intense enough to be visible to human eyes **9955**. In at least one embodiment, the light from outside the filter housing may be ambient light and/or light **9925** generated by illuminating LEDs **9905** of the filter sensor **9965** that are positioned so that such generated light is able to penetrate the at least one area of the filter housing **9980** and reach the filter **9990**.

[0081] The reflected light **9935** enters a lens **9915** leading to a color sensor device **9970**. In at least one embodiment, the reflected light **9935** is intense enough to pass through the lens **9915** and be detected and processed by the color sensor device **9970**. The color sensor device **9970** derives color data from the reflected light **9935**. The color data indicates the color of the reflected light **9935**. In at least one embodiment, the color data includes numerical values for red, green, and blue components of the reflected light **9935**.

[0082] The color data is provided from the color sensor device **9970** to a processor device (CPU) **9960** of the filter sensor **9965**. The CPU **9960** controls the operation of the filter sensor **9965**. The filter sensor **9965** also has a data communication device **9950** that allows the CPU **9960** to communicate with external computing devices outside the filter sensor **9965**. The filter sensor **9965** may also have an antenna **9930** connected to the data communication device **9950** to help enable this communication.

[0083] In at least one embodiment, the filter sensor **9965**, including the data communication device **9950**, the CPU **9960**, the color sensor device **9970**, and the illuminating LEDs **9905**, are powered by a power supply device **9985** included with or attached to the filter sensor **9965**. In at least one embodiment, the power supply device **9985** includes batteries **9910** and a regulator **9920**. From electricity provided by the batteries **9910**, the regulator **9920** derives electrical power to be provided to the filter sensor **9965**, including the data communication device **9950**, the CPU **9960**, the color sensor device **9970**, and the illuminating LEDs **9905**. In at least one embodiment, the power supply device **9985** also includes a battery monitor **9940** that provides the CPU **9960** with battery data. From the battery data, the CPU **9960** derives battery power information indicating how much energy remains stored in the batteries **9910**.

[0084] Using the data communication device **9950**, the CPU **9960** can communicate filter sensor information to the external computing devices. In at least one embodiment, the filter sensor information may include the color data and/or the battery power information, and/or information derived from the color data and/or the battery power information.

[0085] FIG. **11** illustrates an example process **8800** wherein, in at least one embodiment, the monitoring system operates as follows. The user installs the native mobile device application ("app") on a smartphone (**8810**). The filter sensor is installed at the filter device (**8820**), for example in a home. The user executes a one time set-up of the filter sensor via the smartphone (**8830**). In the one time set up, the user enters credentials that the filter sensor needs to connect to a WiFi network at the home, and the filter sensor also registers to the app (**8840**). The Wi-Fi network is connected to the internet (**8850**). Normal operation is as follows: The filter sensor mostly remains in a sleep mode in which the filter sensor draws very little power from the batteries (**8860**). Once per day, the filter sensor wakes up, obtains color data corresponding to the dirty or not dirty status of the filter, connects to the WiFi network, and communicates over the Wi-Fi network and the internet to allow the user to be notified/updated about the dirty or not dirty status of the filter (e.g., by updating the app), based on the color data (**8870**).

[0086] In at least one embodiment, with further reference to FIG. **10**, the device **9965** includes at least one light source **9905** and color sensor **9970**. Preferably, each light source **9905** may be a single white light emitting diode (LED) or a plurality of individual color LEDs. The color sensor **9970** may be a color sensing chip, photodiode or photo integrated circuit (photo IC). In one embodiment, a photo IC sensitive

to red (λ=615 nm), green (λ=540 nm) and blue (λ=465 nm) regions of the color spectrum may be used. In particular embodiments, detected signals may be serially output as 12-bit digital data. Thus, the photo IC may comprise three 12-bit digital registers allowing simultaneous measurement of three colors (red, green and blue). In alternative embodiments, smaller or larger digital data bit sizes may be used, depending on the resolution or number of colors that needs to be detected.

[0087] The light source **9905** and color sensor **9970** of the device **9965**, are purposefully placed such that when the filter **9990** is inserted into the filter housing **9980**, the light source **9905** is able to shine light on the filter **9990** while the sensor **9970** detects wavelengths reflected and/or refracted from the filter **9970**. In particular, the filter **9990** substantially fills the filter housing **9980** so that the light source **9905** is able to shine light on the filter **9990**, and the sensor **9970** is able to detect the resulting wavelengths, regardless of the filter's orientation in the device. The light source **9905** and color sensor **9970** are operatively coupled to a printed circuit board (PCB) so as to be electrically coupled with other electrical components of the device **9965**.

[0088] In particular embodiments, the filter **9990** is separately encased within the filter housing **9980** to form a fluid-tight seal around the filter **9990** to protect device components, such as the light source **9905** and sensor **9970**, from contacting any fluid escaping from the filter housing. Accordingly, window **9945** may be formed on a wall of the filter housing **9980** separating the filter **9990** from the light source **9905** and sensor **9970**, as shown in FIG. **10**. This allows the light source **9905** to shine light on the filter **9990** within the filter housing **9980** and the sensor **9970** to detect the reflected and/or refracted wavelengths from the housing **9980** while being protected from any harmful fluid. Preferably, the window **9945** is made of a polycarbonate material. Moreover, the sensor **9970** is capable of detecting the wavelengths through the window **9945** regardless of the window being distorted or dirty.

[0089] In another embodiment, the window **9945** is not used. Rather, a wall of housing **9980** separating the filter **9990** from the light source **9905** and sensor **9970** is a translucent material of the filter housing **9980**, which allows light to pass through. In this embodiment, the source **9905** is able to shine light onto the filter **9990**, and the sensor **9970** is capable of detecting the reflected light **9935** through the translucent wall to detect the color of the filter **9990**. In alternative embodiments, other case colored materials may be used, as long as they do not interfere with the ability to detect and determine the color.

[0090] The device **9965** further includes CPU **9960** operatively coupled to the sensor **9970** via the PCB, for example. In particular, CPU **9960** is programmed with control algorithms to receive output data from the sensor **9970** to determine a specific color of the filter **9990**. For instance, the control algorithms used for detecting the color of the filter **9990** when utilizing the above-stated translucent material may be different from the control algorithms used when a clear window is utilized. Additionally, in particular embodiments, the device **9965** has an opaque housing, although in alternative embodiments, the housing may be translucent. The control algorithms used for detecting the color of the filter **9990** when the housing **9980** is opaque may be different from the control algorithms used when the housing is translucent.

[0091] In one embodiment, different colors of the filter **9990** correspond to different impurities or impurity concentrations, respectively. Accordingly, if the CPU **9960** enables determination that the filter **9990** is a dark brown color, it can then enable detection that the filter **9990** is dirty and needs replacing.

[0092] It is contemplated that any number of colors may be used in accordance with embodiments of the present invention to arbitrarily correspond to a respective level of dirtiness of the filter **9990**. Moreover, the embodiments of the present invention are not limited to colors in the visible spectrum. It is contemplated that the filter **9990** may also be of an infrared or ultraviolet color, the wavelengths of which are detectable by the sensor **9970**.

[0093] In other embodiments, different colors of the filter **9990** may indicate other information such as impurity type, amount of impurity contained in the filter **9990**, proper insertion of the filter **9990**, or the like. Thus, upon the CPU **9960** enabling detection of this information, the CPU **9960** may operate the device **9965** according to the information.

[0094] In particular embodiments, the relationship between an arbitrary color and corresponding information (e.g., impurity type etc.) is previously known (e.g., by the device **9965**) and may be stored in a memory (not shown) (e.g., of the device **9965**). The device memory may be preloaded with such information during manufacture of the device. Alternatively, the user may download such information onto the device memory from an external source.

[0095] In one embodiment, information deduced from the detected color may be communicated to a user via a display of the device **9965**. For example, when the color of the filter **9990** is detected by the sensor **9970**, the control algorithms of the device **9965** may first enable detection of the type of impurity contained in the filter, and convey this information to the user. The user is then able to visually confirm whether the currently connected filter **9990** contains the expected impurity to receive. The information may also be communicated to other devices such as a controller or remote monitor.

[0096] In an example method of operation of the device **9965**, under an embodiment, the device **9965** operates as follows. The device **9965** has firmware based upon an operating system such as Linux, for example, but is not so limited. Specialized software or applications along with this operating system provides the services, API and functionality for set up and use of the device **9965** features in concert with cloud infrastructure and mobile and web applications.

[0097] During the user's initial setup of device **9965**, the following tasks are performed by the firmware:

[0098] a. The device **9965** firmware boots.

[0099] b. Since no existing device information is present, the device **9965** creates a Wi-Fi access point for setup functions.

[0100] c. User launches the mobile application and after creating an account using their information begins the setup process.

[0101] d. User connects to device **9965** Wi-Fi access point and submits Wi-Fi credentials for their home network.

[0102] e. The device **9965** attempts to connect with the home network using the provided Wi-Fi credentials.

[0103] f. The device **9965** registers itself to cloud backend, associates with the current user and attempts to open ports on the user's Internet router (for incoming connections) using Universal Plug and Play (UPNP) or Network

Address Translation (NAP) Port Mapping Protocol (PMP), depending on the type of router present.

[0104] g. Once fully connected, the device **9965** turns off its Wi-Fi access point and begins normal operation.

[0105] h. In the cases where a new Wi-Fi router is present, the device **9965** has moved to a new environment, or connectivity to the existing router fails, the device **9965** can accept new Wi-Fi credentials in a similar fashion to the initial setup process.

[0106] In at least one other embodiment, device **9965** and filter device **9975** may be at least partially integrated physically. For example, at least a portion of device **9965** may be built into or physically integrated with filter housing **9980**.

[0107] Embodiments described herein include a setup or enrollment process that comprises determining geolocation of the monitoring unit during installation at the premises. The monitoring unit of an embodiment incorporates a WiFi module (processor and radio (802.11)), and during enrollment the monitoring unit puts the WiFi module into 'Access Point mode'. The mobile device running the mobile application described in detail herein enrolls as a WiFi client to the monitoring unit access point. The mobile application then provides new WiFi credentials (e.g., service set identification (SSID), password (optional), etc.) to the monitoring unit via the WiFi access point; subsequently, the mobile application automatically switches the mobile device over to the same WiFi SSID, or the user manually switches the mobile device to that SSID using a network configuration utility. Upon receipt of the new WiFi credentials, the monitoring unit automatically switches its WiFi processor to enroll as a client at the new SSID (using the optional password). Either the monitoring unit or the mobile application initiates a process to store the WiFi credentials on a remote server or other remote device. The monitoring unit of an embodiment restores the WiFi credentials from a remote server, but the remote server of an alternative embodiment initiates restoration of the WiFi credentials of the monitoring unit.

[0108] The mobile application of an embodiment provides numerous operations, but is not so limited. For example, the mobile application provides a user interface that enables a user to switch the monitoring unit to the access point mode in order to change the SSID. The mobile application provides authentication directly to the camera (e.g. username, password, etc.). Alternatively, the mobile application provides authentication against a remote server.

[0109] The mobile application provides to one or more monitoring units location information corresponding to the monitoring unit installation, where the location information corresponding to the monitoring unit is location data determined at the mobile device. The monitoring unit then provides its location data to the remote server. Alternatively, the mobile application provides the location data of the monitoring unit installation directly to a remote server or other remote device. The monitoring unit of an embodiment includes an administrative tool that provides information about numerous monitoring units and their respective physical locations.

[0110] In an alternative embodiment the monitoring unit is temporarily coupled or connected via a physical connector (e.g., USB cable) to a mobile device running the mobile application. In this embodiment the mobile application delivers the Wifi SSID and password over the wired connection, and the monitoring device then switches to the Wifi access point as described above.

[0111] Generally, the monitoring unit's operating state comprises but is not limited to the following:

[0112] a. Sensor polling is running and receiving raw data from sensors.

[0113] b. The rules engine is running and can interface with sensors.

[0114] c. The audio and video service and RTSP server are running and are ready to accept incoming connections, record footage in a loop and detect loud sounds.

[0115] d. The PIR motion sensor service is running and able to detect movement within the monitoring unit's FOV.

[0116] e. Automated tasks run at their pre-defined intervals and perform, but are not limited to, one or more of the following: maintain contact or communication between the monitoring unit and the cloud back-end and ensure incoming ports remain open on the user's Internet router; check for updates to the monitoring unit's firmware; post status updates about the current environment around the monitoring unit; post heartbeats periodically to inform the cloud backend of the monitoring unit's state.

[0117] The described systems, methods, and techniques may be implemented in digital electronic circuitry, computer hardware, firmware, software, or in combinations of these elements. Apparatus implementing these techniques may include appropriate input and output devices, a computer processor, and a computer program product tangibly embodied in a machine-readable storage device for execution by a programmable processor. A process implementing these techniques may be performed by a programmable processor executing a program of instructions to perform desired functions by operating on input data and generating appropriate output. The techniques may be implemented in one or more computer programs that are executable on a programmable system including at least one programmable processor coupled to receive data and instructions from, and to transmit data and instructions to, a data storage system, at least one input device, and at least one output device. Each computer program may be implemented in a high-level procedural or object-oriented programming language, or in assembly or machine language if desired; and in any case, the language may be a compiled or interpreted language. Suitable processors include, by way of example, both general and special purpose microprocessors. Generally, a processor will receive instructions and data from a read-only memory and/or a random access memory. Storage devices suitable for tangibly embodying computer program instructions and data include all forms of non-volatile memory, including by way of example semiconductor memory devices, such as Erasable Programmable Read-Only Memory (EPROM), Electrically Erasable Programmable Read-Only Memory (EEPROM), and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and Compact Disc Read-Only Memory (CD-ROM). Any of the foregoing may be supplemented by, or incorporated in, specially-designed ASICs (application-specific integrated circuits).

[0118] It will be understood that various modifications may be made. For example, in some implementations, the system **200** (e.g., one or more components of the system **200**) may implement a health calculator.

[0119] In some examples, the system **200** derives a health value for a monitored property.

[0120] In some implementations, the system **200** judges the efficiency of a water filter system at a property on a relative basis.

[0121] In some examples, the system **200** is a learning system. In these examples, the system derives insights from filter data and patterns of filter data over time.

[0122] The system **200** may constantly use its archive of information to learn over time, and the system **200** may dynamically and without user driven inputs, derive insights from filter data and patterns of filter data over time.

[0123] In embodiments based on a filter operating to control, limit, or regulate output of materials, such as a tube birdfeeder or a liquid soap dispenser, filter sensor **9965** (which may be the same as, may comprise, or may be comprised within, one or more of filter sensors **1612**, **1622**, **1632** of FIG. **8**, sensor **1012** of FIG. **5**, sensors **220**, **222**, **230** of FIG. **2**, and sensors **134**, **154**) may enable a detection or determination of "full" in place of "dirty" above, and/or a detection or determination of "empty" in place of "not dirty" above.

[0124] Other useful implementations could be achieved if steps of the disclosed techniques were performed in a different order and/or if components in the disclosed systems were combined in a different manner and/or replaced or supplemented by other components. Accordingly, other implementations are within the scope of the disclosure.

[0125] It should be understood that various operations described herein may be implemented in software executed by processing circuitry, hardware, or a combination thereof. The order in which each operation of a given method is performed may be changed, and various operations may be added, reordered, combined, omitted, modified, etc. It is intended that the invention(s) described herein embrace all such modifications and changes and, accordingly, the above description should be regarded in an illustrative rather than a restrictive sense.

[0126] The terms "tangible" and "non-transitory," as used herein, are intended to describe a computer-readable storage medium (or "memory") excluding propagating electromagnetic signals; but are not intended to otherwise limit the type of physical computer-readable storage device that is encompassed by the phrase computer-readable medium or memory. For instance, the terms "non-transitory computer readable medium" or "tangible memory" are intended to encompass types of storage devices that do not necessarily store information permanently, including, for example, RAM. Program instructions and data stored on a tangible computer-accessible storage medium in non-transitory form may afterwards be transmitted by transmission media or signals such as electrical, electromagnetic, or digital signals, which may be conveyed via a communication medium such as a network and/or a wireless link.

[0127] Unless stated otherwise, terms such as "first" and "second" are used to arbitrarily distinguish between the elements such terms describe. Thus, these terms are not necessarily intended to indicate temporal or other prioritization of such elements. The terms "coupled" or "operably coupled" are defined as connected, although not necessarily directly, and not necessarily mechanically. The terms "a" and "an" are defined as one or more unless stated otherwise. The terms "comprise" (and any form of comprise, such as "comprises" and "comprising"), "have" (and any form of have, such as "has" and "having"), "include" (and any form of include, such as "includes" and "including") and "contain" (and any form of contain, such as "contains" and "containing") are open-ended linking verbs. As a result, a system, device, or apparatus that "comprises," "has," "includes" or "contains" one or more elements possesses those one or more elements but is not limited to possessing only those one or more elements. Similarly, a method or process that "comprises," "has," "includes" or "contains" one or more operations possesses those one or more operations but is not limited to possessing only those one or more operations.

[0128] Although the invention(s) is/are described herein with reference to specific embodiments, various modifications and changes can be made without departing from the scope of the present invention(s), as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the present invention(s). Any benefits, advantages, or solutions to problems that are described herein with regard to specific embodiments are not intended to be construed as a critical, required, or essential feature or element of any or all the claims.

1. A method for use in monitoring of filters, comprising:
determining color data for a filter;
deriving, from the color data, a filter status for the filter; and
taking an action based on the filter status.

2. The method of claim **1**, wherein the filter status comprises a dirty status for the filter.

3. The method of claim **1**, wherein the filter status comprises an empty status for the filter.

4. The method of claim **1**, wherein the action comprises alerting a user based on the filter status.

5. The method of claim **1**, further comprising:
illuminating the filter prior to the determining of the color data for the filter.

6. The method of claim **1**, wherein the action comprises displaying the filter status at a location that is remote from the filter.

7. The method of claim **1**, wherein the filter comprises a water filter.

8. The method of claim **1**, wherein the filter status comprises a needs-replacing status for the filter.

9. The method of claim **1**, wherein the determining of the color data for the filter comprises using a color sensor to sense light from the filter.

10. The method of claim **1**, wherein the filter is disposed at least partially within a filter housing.

11. The method of claim **1**, wherein the color data is determined based on light traversing a filter housing containing the filter.

12. A system for use in monitoring of filters, comprising:
a color sensor determining color data for a filter;
a processor deriving, from the color data, a filter status for the filter; and
a communication system taking an action based on the filter status.

13. The system of claim **12**, wherein the filter status comprises a dirty status for the filter.

14. The system of claim **12**, wherein the filter status comprises an empty status for the filter.

15. The system of claim **12**, wherein the action comprises alerting a user based on the filter status.

16. The system of claim **12**, further comprising:

a light source illuminating the filter prior to the determining of the color data for the filter.

17. The system of claim **12**, wherein the action comprises displaying the filter status at a location that is remote from the filter.

18. The system of claim **12**, wherein the filter comprises a water filter.

19. The system of claim **12**, wherein the filter status comprises a needs-replacing status for the filter.

20. The system of claim **12**, wherein the color data is determined based on light traversing a filter housing containing the filter.

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