

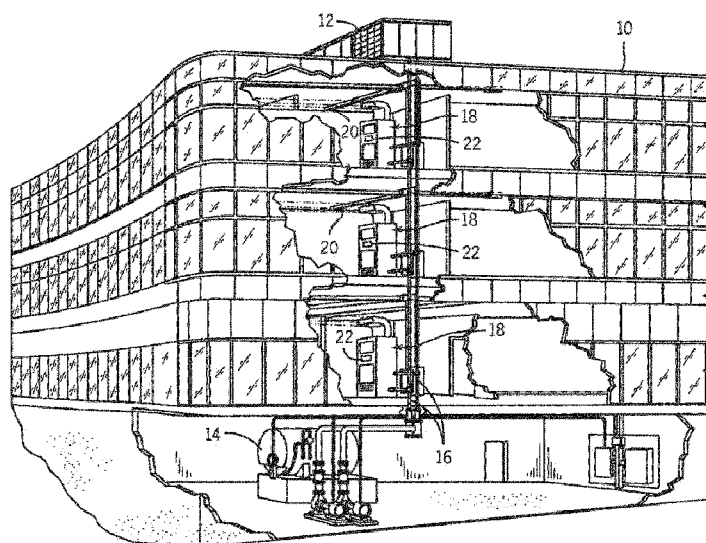


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(54) Title: THERMOSTAT WITH OCCUPANCY DETECTION, NFC COMMUNICATION, AND USER INTERFACE FEATURES

FIG. 1



(57) Abstract: A thermostat for a building space. The thermostat includes a user interface configured to display information to a user and receive input from the user. The thermostat also includes a processing circuit configured to identify the user and adjust the information displayed in the user interface based on the identity of the user.



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THERMOSTAT WITH OCCUPANCY DETECTION, NFC COMMUNICATION, AND USER INTERFACE FEATURES

CROSS-REFERENCE TO RELATED PATENT APPLICATION

[0001] This application claims the benefit of and priority to U.S. Provisional Patent Application No. 62/217,788 filed September 11, 2015, U.S. Provisional Patent Application No. 62/217,789 filed September 11, 2015, U.S. Provisional Patent Application No. 62/217,790 filed September 11, 2015, U.S. Provisional Patent Application No. 62/217,791 filed September 11, 2015, U.S. Provisional Patent Application No. 62/367,597 filed July 27, 2016, U.S. Provisional Patent Application No. 62/367,315 filed July 27, 2016, U.S. Provisional Patent Application No. 62/367,614 filed July 27, 2016, U.S. Provisional Patent Application No. 62/367,297 filed July 27, 2016, U.S. Provisional Patent Application No. 62/367,621 filed July 27, 2016, U.S. Provisional Patent Application No. 62/367,291 filed July 27, 2016, U.S. Provisional Patent Application No. 62/247,672 filed October 28, 2015, U.S. Provisional Patent Application No. 62/275,711 filed January 6, 2016, U.S. Patent Application No. 15/260,293 filed September 8, 2016, U.S. Patent Application No. 15/260,294 filed September 8, 2016, U.S. Patent Application No. 15/260,295 filed September 8, 2016, U.S. Patent Application No. 15/260,297 filed September 8, 2016, U.S. Patent Application No. 15/260,298 filed September 8, 2016, U.S. Patent Application No. 15/260,299 filed September 8, 2016, and U.S. Patent Application No. 15/260,301 filed September 8, 2016. The entire disclosure of each of these patent applications is incorporated by reference herein.

BACKGROUND

[0002] The present disclosure relates generally to thermostats and more particularly to the improved control of a building or home's heating, ventilating, and air conditioning (HVAC) system through occupancy detection.

[0003] A thermostat is, in general, a component of an HVAC control system. Thermostats sense the temperature of a system and control components of the HVAC in order to maintain a desired setpoint. A thermostat can control a heating or cooling system or an air conditioner. Thermostats are manufactured in many ways, and use a variety of sensors to measure temperature and other desired parameters.

[0004] Conventional thermostats are configured for one-way communication to connected components, and control HVAC systems by turning on or off certain components or regulating flow. Each thermostat may include a temperature sensor and a user interface. The user interface typically includes a display for presenting information to a user and one or more user interface elements for receiving input from a user. To control the temperature of a building or home, a user adjusts the temperature setpoint via the thermostat's user interface.

SUMMARY

[0005] One implementation of the present disclosure is a thermostat for a building space. The thermostat includes a user interface and a processing circuit. The user interface is configured to display information to a user and receive input from the user. The processing circuit is configured to identify the user and adjust the information displayed in the user interface based on the identity of the user.

[0006] In some embodiments, the processing circuit is configured to determine whether the user is within a proximity of the user interface and change the information displayed in the user interface to a set of information corresponding to the identity of the user when the user is within the proximity of the user interface.

[0007] In some embodiments, the processing circuit is configured to generate a profile for the user after the user is identified for a first time. In some embodiments, the processing circuit is configured to update the profile based on interactions between the user and the thermostat after the user is first identified.

[0008] In some embodiments, the information displayed in the user interface is a combination of user interface items. The user interface items may include a relative humidity value, a temperature value, a temperature setpoint, a time and date, a user interface background and color scheme, a set of user interface buttons, a time to setpoint, and thermostat faults.

[0009] In some embodiments, the processing circuit is configured to communicate with a user device via near field communication. The user device may be associated with the user and the processing circuit may communicate with the user device when the user device is used to check in with the thermostat via near field communication.

[0010] In some embodiments, the processing circuit is configured to identify the user based on an identity of the user device that is used to check in with the thermostat via near field communication.

[0011] In some embodiments, an occupancy sensor is configured to detect the user and provide sensor data associated with the detected user. The occupancy sensor may include a camera, a microphone, and a motion detector. The processing circuit may be configured to identify the user by performing digital image processing on an input received from the camera. The processing circuit may be configured to performing speaker recognition on an input received from the microphone. The processing circuit may be configured to detect motion based on an input received from the motion detector.

[0012] In some embodiments, performing digital image processing includes identifying the user based on a physical characteristic of the user. The physical characteristic may include a face of the user and a height of the user.

[0013] In some embodiments, performing speaker recognition includes using a text dependent voice recognition technique to identify words spoken to the thermostat and compare the spoken words to a database of words and phrases associated with the user. In some embodiments, a text independent voice recognition technique includes pattern matching of stored voice biometrics associated with the user to identify the user.

[0014] In some embodiments, detecting motion includes registering a plurality of hand waves detected by the motion detector, identifying a number of hand waves registered, and identifying a user associated with the identified number of hand waves registered.

[0015] In some embodiments, the processing circuit is configured to communicate with a voice-controlled smarthome controller via at least one of the Internet, Bluetooth, Wi-Fi, and Zigbee. In some embodiments, the voice-controlled smarthome controller identifies the user and communicates the identity of the user to the thermostat via at least one of the Internet, Bluetooth, Wi-Fi, and Zigbee.

[0016] Another implementation of the present disclosure is a near field communication enabled thermostat for a building space. The thermostat includes a user interface configured to display information to a user and receive input from the user. The thermostat includes a near field communication module configured to communicate with a user device. The thermostat includes a processing circuit configured to identify the user based on communications with the user device via the near field communication module and automatically display the custom user interface associated with the identified user.

[0017] In some embodiments, the processing circuit is configured to detect the user within the building space with an occupancy sensor including at least one of a motion detector, a microphone, and a camera. In some embodiments, the processing circuit is configured to receive a custom user interface and a custom heating and cooling schedule associated with the identified user and automatically run the custom heating and cooling schedule associated with the user when the user is identified.

[0018] In some embodiments, the processing circuit is configured to identify the user in response to receiving a detection signal from the occupancy sensor.

[0019] In some embodiments, identifying the user includes performing digital image processing on an input received from the camera. In some embodiments, identifying the user includes performing speaker recognition on an input received from the microphone. In some

embodiments, identifying the user includes detecting motion based on an input received from the motion detector.

[0020] In some embodiments, the processing circuit is configured to communicate with a voice-controlled smarthome controller via at least one of the Internet, Bluetooth, and Zigbee. The voice-controlled smarthome controller may identify the user and communicate an identity of the user to the thermostat.

[0021] Another implementation of the present disclosure is a method for operating a thermostat. The method includes displaying information to a user and receiving input from the user through a user interface. The method includes detecting an identity of the user within a building space and displaying information in the user interface. The information displayed is associated with an identity of the user.

[0022] In some embodiments, detecting the identity of the user within the building space is based on sensor data collected from an occupancy sensor. In some embodiments, detecting the identity of the user includes identifying at least one physical characteristic of the user with digital image processing when the occupancy sensor is a camera.

[0023] In some embodiments, detecting the identity of the user within the building space is based on sensor data collected from an occupancy sensor and includes performing a text independent voice recognition technique when the occupancy sensor is a microphone. In some embodiments, the text independent voice recognition technique uses pattern matching to determine voice biometrics associated with the user.

[0024] In some embodiments, detecting the identity of the user within the building space is based on sensor data collected from an occupancy sensor. In some embodiments, detecting the identity of the user includes registering a plurality of hand waves detected by the occupancy sensor when the occupancy sensor is a motion sensor. In some embodiments, detecting the identity of the user includes identifying a number of hand waves registered by the motion sensor. In some embodiments, detecting the identity of the user includes identifying a user associated with the number of hand waves registered by the motion sensor.

[0025] Another implementation of the present disclosure is a thermostat for a building space. The thermostat includes a communications interface configured to engage in bidirectional communications with heating, ventilation, or air conditioning (HVAC) equipment and to receive an indication of a current heating or cooling load from the HVAC equipment. The thermostat includes a processing circuit configured to determine an occupancy of the building space based on the indication of the current heating or cooling load received from the HVAC equipment and operate the HVAC equipment based on the determined occupancy of the building space.

[0026] In some embodiments, the processing circuit is configured to determine load metrics. In some embodiments, the load metrics include a time to setpoint calculated from known capabilities of the HVAC equipment, the heating and cooling load, a time of day, weather conditions, and historical equipment data.

[0027] In some embodiments, the communications interface is further configured to communicate with a fitness tracker. The indication of the current heating and cooling load may be further received from the fitness tracker.

[0028] In some embodiments, the indication of the current heating and cooling load received from the fitness tracker is based on the physical activity of a user wearing the fitness tracker.

[0029] In some embodiments, the thermostat includes a user interface configured to display dealer information. In some embodiments, the processing circuit is further configured to update the dealer information. In some embodiments, the processing circuit updates the dealer information in response to a determination that a predetermined amount of time has passed since the dealer information was last updated, the thermostat is in a commissioning mode, a dealer contract has started, and a dealer contract has ended.

[0030] In some embodiments, a user interface is configured to display dealer information. In some embodiments, the processing circuit is configured to cause the user interface to display the dealer information in response to detecting one or more thermostat events. Thermostat events may be a determination that a predetermined amount of time has passed, detecting a system fault,

and a determination that a user is adjusting settings in the thermostat for a time longer than a predetermined amount of time.

[0031] In some embodiments, a user interface is configured to display dealer information. In some embodiments, the processing circuit is further configured to hide the dealer information in response to receiving a notification to hide the dealer information. The notification may be received by the communications interface.

[0032] In some embodiments, the notification received by the communications interface includes a notification that the dealer is late on a payment or a notification that the dealer has canceled a contract.

[0033] In some embodiments, the thermostat includes a user interface configured to display dealer information. In some embodiments, the processing circuit is configured cause the user interface to display the dealer information when a fault is detected. In some embodiments, the dealer information includes least a button to contact the dealer, a dealer phone number, a dealer address, and dealer store hours.

[0034] Another implementation of the present disclosure is a method for operating a bidirectional thermostat. The method includes determining a time to setpoint for a building space and displaying the time to setpoint on a user interface.

[0035] In some embodiments, the method further includes determining load metrics. The load metrics may include the time to setpoint. The time to setpoint may be calculated from known capabilities of the HVAC equipment, the heating and cooling load, time of day, weather conditions, and historical equipment data.

[0036] In some embodiments, the method includes causing the user interface to display a recommendation for achieving a requested setpoint. The recommendation may include waiting a predetermined amount of time before attempting the requested setpoint, closing shades in a zone of a building, and turning on a fan in the zone of the building.

[0037] In some embodiments, the method includes determining if a requested setpoint is achievable based on comparing a first time to setpoint for a first zone of a building space and a second time to setpoint for a second zone of the building space.

[0038] In some embodiments, the method includes determining the amount of time required to reach the requested setpoint when the requested setpoint is determined to be achievable.

[0039] Another implementation of the present disclosure is a thermostat for a building space. The thermostat includes a communications interface and a processing circuit. The communications interface is configured to engage in bidirectional communications with heating, ventilation, or air conditioning (HVAC) equipment and to receive an indication of a current heating or cooling load from the HVAC equipment. The processing circuit is configured to determine if a requested setpoint is achievable based on the load.

[0040] In some embodiments, the processing circuit is configured to determine if the requested setpoint is achievable further based on factors. The factors may include a status of an electrical grid, weather conditions, and a time of day.

[0041] In some embodiments, the processing circuit is further configured to determine an amount of time required to reach the requested setpoint when the requested setpoint is determined to be achievable.

[0042] In some embodiments, the processing circuit is further configured to determine an amount of time required to reach the requested setpoint based on factors. The factors may include a status of an electrical grid, weather conditions, and historical data associated with the HVAC equipment.

[0043] In some embodiments, the processing circuit is configured to determine if a requested setpoint is achievable further based on comparing a first time to setpoint for a first zone of the building space and a second time to setpoint for a second zone of the building space.

[0044] In some embodiments, the processing circuit is further configured to cause a user interface to display a recommendation for achieving the requested setpoint. The recommendation

may include waiting a predetermined amount of time before attempting the requested setpoint, closing shades in a zone of the building, and turning on a fan in the zone of the building.

[0045] Another implementation of the present disclosure is a thermostat for a building space. The thermostat includes a network communication module and a processing circuit. The network communication module is communicatively coupled to at least one of one or more social media servers and one or more calendar servers. The processing circuit is configured to receive at least one of social media activity, social media events, and calendar events associated with a user via the network communication module. The processing circuit is further configured to determine an expected occupancy of the building based on at least one of the social media events and the calendar events. The processing circuit is further configured to adjust a setpoint of the thermostat based on at least one of the expected occupancy and the social media activity.

[0046] In some embodiments, the social media events include a social media event location, a social media event start time, and a social media event end time. In some embodiments, the calendar events include a calendar event location, a calendar event start time, and a calendar event end time.

[0047] In some embodiments, the expected occupancy of the building space includes a number of occupants of the building space at each of a plurality of times.

[0048] In some embodiments, the social media activity associated with the user includes at least one of a private message sent via a social media platform, a public comment via the social media platform, a public post via the social media platform, a private comment via the social media platform, and a private post via the social media platform.

[0049] In some embodiments, the processing circuit is further configured to adjust a setpoint of the thermostat based on the social media activity. The social media activity may include a command to perform at least one of raising the setpoint and lowering the setpoint.

[0050] In some embodiments, the command includes social media activity directed to the thermostat and social media activity monitored by the thermostat.

[0051] In some embodiments, the processing circuit is further configured to determine a plurality of times at which the building space will be occupied and unoccupied based on the expected occupancy. In some embodiments, the processing circuit is configured to determine a time required to reach the setpoint based on factors. The factor may include a setpoint target, weather conditions, and equipment functionality. In some embodiments, the processing circuit is further configured to preemptively adjust the setpoint of the building space before the building space is unoccupied based on the determined time required to reach the setpoint and preemptively adjust the setpoint of the building space before the building space is occupied based on the determined time required to reach the setpoint.

[0052] In some embodiments, the processing circuit is configured to adjust the setpoint of the thermostat based on the expected occupancy by lowering the setpoint by a calculated amount in response to a determination that the building space is unoccupied and the thermostat is in a heating mode, raising the setpoint by the calculated amount in response to a determination that the building space is occupied and the thermostat is in the heating mode, raising the setpoint by the calculated amount in response to a determination that the building space is unoccupied and the thermostat is in a cooling mode, and lowering the setpoint by the calculated amount in response to a determination that the building space is occupied and the thermostat is in the cooling mode.

[0053] In some embodiments, the processing circuit is further configured to send a query to the social media servers and receive the social media activity and the social media events associated with the user of the thermostat and send a query to the calendar servers and receive the calendar events associated with the user.

[0054] In some embodiments, the processing circuit is further configured to send a social media notification via the network communication module to the user, the social media notification including thermostat information.

[0055] Another implementation of the present disclosure is a method for adjusting a setpoint of a thermostat for a building space. The method includes receiving event data via a network communication module of the thermostat. The event data includes at least one of social media

events and calendar events associated with a user. The method further includes determining an expected occupancy of the building space based on the event data and adjusting the setpoint of the thermostat for the building space based on the expected occupancy of the building space.

[0056] In some embodiments, receiving event data via the network communication module of the thermostat includes subscribing to social media servers and receiving the social media events associated with the user of the thermostat when social media activity occurs. In some embodiments, receiving event data via the network communication module of the thermostat includes subscribing to calendar servers and receiving the calendar events associated with the user when the calendar events are added by the user.

[0057] In some embodiments, determining the expected occupancy of the building space based on the event data includes identifying locations of one or more events associated with the user, identifying start times of the events and end times of the events, and identifying a number of occupants of the building space between the start times of the events and the end times of the events.

[0058] In some embodiments, adjusting the setpoint includes determining an amount by which to adjust the setpoint based on the expected occupancy of the building space, a temperature of the building space, and a time required to reach the setpoint based on the temperature of the building space and the expected occupancy.

[0059] In some embodiments, adjusting the setpoint of the thermostat for the building space based on the expected occupancy of the building space includes lowering the setpoint by a calculated amount in response to a determination that the building space is unoccupied and the thermostat is in a heating mode, raising the setpoint by the calculated amount in response to a determination that the building space is occupied and the thermostat is in the heating mode, raising the setpoint by the calculated amount in response to a determination that the building space is unoccupied and the thermostat is in a cooling mode, and lowering the setpoint by the calculated amount in response to a determination that the building space is occupied and the thermostat is in the cooling mode.

[0060] In some embodiments, the method further includes determining a plurality of times at which the building space will be occupied and unoccupied based on the expected occupancy. In some embodiments, the method further includes determining a time required to reach the setpoint based on factors. The factors may include a setpoint target, weather conditions, and equipment functionality. The method may further include preemptively adjusting the setpoint of the building space before the building space is unoccupied based on the time required to reach the setpoint and preemptively adjusting the setpoint of the building space before the building space is occupied based on the time required to reach the setpoint.

[0061] Another implementation of the present disclosure is a social media enabled thermostat. The thermostat includes a network communication module communicatively and a processing circuit. The network communication module is coupled to one or more social media servers. The processing circuit is configured to receive at least one of social media activity and social media events associated with a user via the network communication module, generate social media notifications and serve the notifications to the user via the network communication module, determine an expected occupancy of the building based on the social media events, and adjust a setpoint of the thermostat based on at least one of the expected occupancy and the social media activity.

[0062] In some embodiments, the social media events include a social media event location, a number of social media event attendees, a social media event start time, and a social media event end time.

[0063] In some embodiments, the processing circuit is configured to receive at least one of the social media activity and the social media events associated with the user via the network communication module by subscribing to the social media servers and receiving the social media activity and the social media events associated with the user of the thermostat when the social media activity occurs.

[0064] In some embodiments, the processing circuit is configured to adjust the setpoint of the thermostat based on at least one of the expected occupancy and the social media activity. The

social media activity may include a command to perform at least one of raising the setpoint and lowering the setpoint.

[0065] Another implementation of the present disclosure is a thermostat for a building space. The thermostat includes a near field communications module and a processing circuit. The near field communication module is configured to communicate with a user device via near field communication. The processing circuit is configured to send data to the user device via the near field communications module and receive data from the user device via the near field communication module and process the received data. The processed data identifies the user or a user type.

[0066] In some embodiments, the processing circuit is further configured to automatically set settings of the thermostat to user settings associated with the user, automatically generate average user settings by averaging a plurality of user settings associated with a plurality of users, and automatically set the thermostat settings to the average user settings when the plurality of users check in with the thermostat.

[0067] In some embodiments, the data received from the user device includes a password and the processing circuit is further configured to lock the thermostat with the password.

[0068] In some embodiments, the processing circuit is further configured to make the user a master of the thermostat and allow the user control over thermostat settings when the user checks in with the thermostat and the thermostat is in an unlocked state.

[0069] In some embodiments, the processing circuit is further configured to prompt the user to install an application for interacting with the thermostat on the user device when the user checks in with the thermostat for a first time.

[0070] In some embodiments, the application for interacting with the thermostat receives thermostat settings from the user and transmits the settings to the thermostat through near field communication.

[0071] In some embodiments, the processing circuit is configured to generate a performance report, determine whether the user associated with the user device is authorized to receive the

performance report, and cause the near field communications module to send the performance report to the user device when the user device checks in with the thermostat and in response to a determination that the user is authorized to receive the performance report.

[0072] In some embodiments, the performance report includes at least one of: an energy management report, a system state, temperature setpoint, and a current temperature.

[0073] In some embodiments, the processing circuit is further configured to apply a dealer configuration to the thermostat when the user device checks in with the thermostat, the user device transmits the dealer configuration and a command to apply the dealer configuration to the thermostat, and the user device is a dealer authorized device.

[0074] In some embodiments, the processing circuit is further configured to cause the near field communications module to send a command to the user device causing the user device to generate an email, the email including fault information.

[0075] In some embodiments, the processing circuit is further configured to detect faults in at least one of the thermostat and equipment connected to the thermostat, generate a faults report including the detected faults, and transmit the faults report to the user device through near field communication.

[0076] In some embodiments, the processing circuit is further configured to cause the near field communications module to send trouble shooting information for a thermostat fault to the user device in response to a determination that the user device is an authorized dealer device.

[0077] In some embodiments, the trouble shooting information includes a command to retrieve troubleshooting information from a network.

[0078] Another implementation of the present disclosure is a method including sending data to a user device via a near field communications module, receiving data from the user device via the near field communication module and processing the received data, and checking in a user with the thermostat. The user is associated with the user device.

[0079] In some embodiments, the method further includes automatically changing settings of the thermostat to user settings associated with the user when the user checks in with the thermostat, automatically generating average user settings by averaging a plurality of user settings associated with a plurality of users, and automatically changing the thermostat settings to the average user settings when the plurality of users check in with the thermostat.

[0080] In some embodiments, checking in the user with the thermostat includes making the user a master of the thermostat when the thermostat is in an unlocked state.

[0081] In some embodiments, the method further includes applying a dealer configuration to the thermostat when the user device checks in with the thermostat, the user device transmits the dealer configuration and a command to apply the dealer configuration to the thermostat, and the user device is a dealer authorized device.

[0082] In some embodiments, the method further includes detecting faults in at least one of the thermostat and equipment connected to the thermostat, generating a faults report including the detected faults, and transmitting the faults report to the user device through near field communication.

[0083] In some embodiments, sending data to the user device via the near field communications module includes sending trouble shooting information when the user device is an authorized dealer device.

[0084] Another implementation of the present disclosure is a thermostat for a building space. The thermostat includes a near field communications module and a processing circuit. The near field communications module is configured to communicate with a user device via near field communication. The processing circuit is configured to receive data from the user device through the near field communication module and process the data.

[0085] Another implementation of the present disclosure is a thermostat for a building space. The thermostat includes a user interface configured to serve notifications to a user and receive input from the user. The thermostat includes a communications interface configured to perform bidirectional data communications with HVAC equipment controlled by the thermostat. The

communications interface is configured to receive performance information for the HVAC equipment. The thermostat includes a processing circuit configured to provide control signals to the HVAC equipment to achieve a setpoint for the building space, evaluate the performance information for the HVAC equipment to determine a recommendation for improving HVAC equipment performance, and automatically adjust at least one of the setpoint and the control signals provided to the HVAC equipment based on the recommendation for improving HVAC equipment performance.

[0086] In some embodiments, the processing circuit is further configured to receive a target bill amount from the user interface of the thermostat, determine optimal setpoints for the building space based on the performance information and the target bill amount, and present the optimal setpoints to the user through the user interface.

[0087] In some embodiments, the processing circuit is further configured to determine whether the HVAC equipment has taken longer than a threshold time to achieve the setpoint based on the performance information and generate a new setpoint for the building space in response to a determination that the HVAC equipment has taken longer than the threshold time to achieve the setpoint. In some embodiments, the processing circuit calculates the new setpoint such that the HVAC equipment reaches the new setpoint within the threshold time.

[0088] In some embodiments, the processing circuit is further configured to generate a report from the performance information and serve the report to the user through the user interface. The report may include at least one of an energy usage of the HVAC equipment, an energy usage for a plurality of operating parameters of the HVAC equipment, runtime costs of a plurality of stages of the HVAC equipment, and equipment replacement suggestions for the HVAC equipment.

[0089] In some embodiments, the processing circuit is further configured to log the energy usage of the HVAC equipment over time, determine historical energy usage from the logged energy usage, identify a current energy usage of the HVAC equipment, and provide an equipment replacement suggestion in response to a determination that the current energy usage of the HVAC equipment exceeds the historical energy usage by a predetermined amount.

[0090] In some embodiments, the processing circuit is further configured to transmit the performance information to an analytics service and receive a report generated by the analytics service from the performance information.

[0091] In some embodiments, the processing circuit is further configured to automatically generate multiple different sets of thermostat settings for operating the HVAC equipment, automatically use each set of the thermostat settings to operate the HVAC equipment at different times, determine an energy usage of the HVAC equipment resulting from each set of the thermostat settings based on the performance information, and notify the user of the set of thermostat settings that results in a lowest energy usage through the user interface.

[0092] In some embodiments, the processing circuit is further configured to receive information for a plurality of neighborhood buildings from a data analytics service. The information may include at least one of setpoints of the neighborhood buildings, monthly energy bills of the neighborhood buildings, and equipment used in the neighborhood buildings.

[0093] In some embodiments, the processing circuit is further configured to suggest setpoints to the user based on the setpoints of the neighborhood buildings and the monthly energy bills of the neighborhood buildings. In some embodiments, the processing circuit is further configured to suggest equipment purchases to the user based on the equipment used in the neighborhood buildings.

[0094] Another implementation of the present disclosure is a method for a thermostat with bidirectional communication. The method includes serving notifications to a user and receiving input from the user through a user interface and performing bidirectional data communications with HVAC equipment controlled by the thermostat. The thermostat receives performance information for the HVAC equipment through a communications interface. The method further includes evaluating the performance information for the HVAC equipment and determining a recommendation for improving HVAC equipment performance.

[0095] In some embodiments, the method further includes generating a report and serving the report to the user through the user interface. The report may include at least one of an energy

usage of the HVAC equipment, an energy usage for a plurality of operating parameters of the HVAC equipment, runtime costs of a plurality of stages of the HVAC equipment, and equipment replacement suggestions for the HVAC equipment.

[0096] In some embodiments, the method further includes generating equipment replacement suggests by logging energy usage of the HVAC equipment over time. In some embodiments, the energy usage is determined from the performance information. The method may further include determining historical energy usage from the logged energy usage and determining an equipment replacement suggestion in response to a determination that current energy usage of the HVAC equipment exceeds the historical energy usage by a predetermined amount.

[0097] In some embodiments, the method further includes determining energy efficient settings by automatically generating multiple different sets of thermostat settings for controlling the HVAC equipment, automatically using each set of the thermostat settings to control the HVAC equipment at different times, determining a plurality of energy usage amounts of the HVAC equipment resulting from each set of the thermostat settings based on the performance information, and notifying the user of the set of thermostat settings that results in a lowest energy usage through the user interface.

[0098] In some embodiments, the method further includes receiving a target bill amount from the user interface of the thermostat, determining optimal setpoints for a building space based on the performance information and the target bill amount, and presenting the optimal setpoints to the user through the user interface.

[0099] Another implementation of the present disclosure is a thermostat for a building space with bidirectional communication. The thermostat includes a user interface configured to serve information to a user and receive input from the user and a communications interface configured to perform bidirectional data communications with HVAC equipment controlled by the thermostat. The communications interface is configured to receive performance information for the HVAC equipment. The processing circuit is configured to make suggestions for replacing HVAC equipment based on the performance information for the HVAC equipment, receive a target bill amount from a user through the user interface and make HVAC equipment setting

suggestions to the user through the user interface that achieve the target bill amount, and generate a thermostat report and serve the report to the user through the user interface.

[0100] In some embodiments, the performance information for the HVAC equipment includes runtime information of the HVAC equipment and error codes of the HVAC equipment.

[0101] In some embodiments, the processing circuit is further configured to automatically generate multiple different sets of thermostat settings for operating the HVAC equipment, automatically use each set of the thermostat settings to operate the HVAC equipment at different times, determine an energy usage of the HVAC equipment resulting from each set of the thermostat settings based on the performance information, and notify the user of the set of thermostat settings that results in a lowest energy usage through the user interface.

[0102] In some embodiments, the processing circuit is further configured to determine whether the HVAC equipment has taken longer than a threshold time to achieve a setpoint based on the performance information and generate a new setpoint for the building space in response to a determination that the HVAC equipment has taken longer than the threshold time to achieve the setpoint. The processing circuit may calculate the new setpoint such that the HVAC equipment reaches the new setpoint within the threshold time.

[0103] In some embodiments, the report includes at least one of an energy usage of the HVAC equipment, an energy usage for a plurality of operating parameters of the HVAC equipment, runtime costs of a plurality of stages of the HVAC equipment, and equipment replacement suggestions for the HVAC equipment.

[0104] In some embodiments, the processing circuit is further configured to receive information for a plurality of neighborhood buildings from a data analytics service. The information may include at least one of setpoints of the neighborhood buildings, monthly energy bills of the neighborhood buildings, and equipment used in the neighborhood buildings.

[0105] Another implementation of the present disclosure is a thermostat for a building space. The thermostat includes an electronic display, a frame, a touch-sensitive interface having a first portion that overlays the electronic display and a second portion that overlays the frame, and a

processing circuit. The touch-sensitive interface is configured to receive touch-based input via both the first portion and the second portion. The processing circuit is configured to define one or more locations within the second portion that correspond to touch-sensitive buttons. The locations of the touch-sensitive buttons are customizable and can be changed by a user. At least one of a sticker and a skin covers at least part of the second portion and visually marks the locations of the touch-sensitive buttons.

[0106] In some embodiments, the processing circuit is configured to define the one or more locations within the second portion that correspond to the touch-sensitive buttons by receiving the one or more locations from the user.

[0107] In some embodiments, the locations of the touch-sensitive buttons are changed by the user through at least one of a web-based application and a mobile application. The web-based application and the mobile application may be communicatively coupled to the processing circuit.

[0108] In some embodiments, the web-based application and the mobile application are configured to generate a digital file including a design for at least one of the sticker and the skin that mark the location of the touch-sensitive buttons.

[0109] In some embodiments, the processing circuit is further configured to generate a digital file including a design of at least one of the sticker and the skin.

[0110] In some embodiments, the processing circuit is further configured associate the touch-based input to the location of the touch sensitive-button when the touch sensitive-button receives the touch-based input.

[0111] In some embodiments, the touch-sensitive buttons are configured to receive at least one of a direct touch and a touch movement.

[0112] In some embodiments, touch movement include at least one of a swipe up, a swipe down, a swipe right, and a swipe left.

[0113] In some embodiments, the sticker and skin include symbols that mark the location of the touch-sensitive buttons. The symbols may include at least one of a button symbol, a user defined symbol, and a manufacturer defined logo.

[0114] Another implementation of the present disclosure is a method for sensing touch-based input with a thermostat. The method includes receiving the touch-based input via both a first portion of a touch-sensitive interface and a second portion of the touch-sensitive interface. The first portion overlays an electronic display of the touch-sensitive interface and the second portion overlays a frame of the touch-sensitive interface. The method further includes defining one or more locations of touch-sensitive buttons within the second portion of the electronic display. The locations of the touch-sensitive buttons are customizable and can be changed by a user. The method further includes visually marking the locations of the touch-sensitive buttons on the second portion of the touch-sensitive interface using at least one of a sticker and a skin.

[0115] In some embodiments, defining the one or more locations within the second portion of the electronic display corresponding to touch-sensitive buttons include at least one of receiving the locations from the touch-sensitive interface, receiving the locations from a mobile application, and receiving the locations from a web-based application.

[0116] In some embodiments, receiving the touch-based input via the second portion of the touch-sensitive interface includes associating the touch-based input to the touch sensitive-button.

[0117] In some embodiments, the touch-sensitive buttons are configured to detect at least one of a direct touch and a touch movement.

[0118] In some embodiments, the method further includes detecting a touch movement. The touch movement may include at least one of a swipe up, a swipe down, a swipe right, and a swipe left.

[0119] Another implementation of the present disclosure is a thermostat for a building space. The thermostat includes an electronic display, a frame, a touch-sensitive interface having a first portion that overlays the electronic display and a second portion that overlays the frame. The touch-sensitive interface is configured to receive touch-based input via both the first portion and

the second portion. A skin covers at least part of the second portion and visually marks locations of one or more touch-sensitive buttons on the second portion. The processing circuit is configured to define one or more locations within the second portion that correspond to the touch-sensitive buttons and detect at least one of a direct touch and a touch movement based on user input provided via the second portion of the touch-sensitive interface.

[0120] In some embodiments, the processing circuit is further configured to associate touch-based input of the touch sensitive-button to the location of the touch sensitive-button.

[0121] In some embodiments, the touch movement includes at least one of a swipe up, a swipe down, a swipe right, and a swipe left.

[0122] In some embodiments, the processing circuit is configured to define the one or more locations within the second portion that correspond to the touch-sensitive buttons by receiving the locations of the touch-sensitive buttons from at least one of the touch-sensitive interface, a mobile application, and a web-based application.

[0123] In some embodiments, at least one of the web-based application and the mobile application are configured to generate a digital file includes a design for the skin.

[0124] In some embodiments, the skin includes symbols that visually mark the location of the touch-sensitive buttons. The symbols may include at least one of a button symbol, a user defined symbol, and a manufacturer defined logo.

[0125] Another implementation of the present disclosure is a thermostat for a building space. The thermostat includes a communications interface, an electronic display, and a processing circuit. The communications interface is configured to receive service provider information via a network connection. The electronic display includes a user interface configured to display the service provider information. The processing circuit is configured to determine when to display service provider information on the electronic display by monitoring thermostat events.

[0126] In some embodiments, the processing circuit is further configured to receive the service provider information from a dealer associated with the thermostat, receive new service provider information from a second dealer when the dealer associated with the thermostat changes from a

first dealer to the second dealer, and display the new service provider information via the electronic display in response to a determination that the dealer associated with the thermostat has changed from the first dealer to the second dealer.

[0127] In some embodiments, the processing circuit is further configured to receive the service provider information via the communications interface when the thermostat is first installed in the building space.

[0128] In some embodiments, service provider information includes customized branding. The customized branding may include at least one of a dealer phone number, a dealer address, dealer store hours, a dealer RSS feed, and a dealer logo.

[0129] In some embodiments, the processing circuit is further configured to receive the service provider information via the communications interface when a dealer creates new branding and serves the new branding to the thermostat via the communications interface.

[0130] In some embodiments, the processing circuit is further configured to cause the electronic display to display a button to contact a dealer, detect a user pressing the button, place a call to the dealer through voice over Internet in response to detecting the user pressing the button, and transmit communications between the user and the dealer using at least one of a microphone and a speaker of the thermostat.

[0131] In some embodiments, the processing circuit is configured to determine when to display dealer information on the electronic display by monitoring thermostat events. The thermostat events may include at least one of a fault occurring in the thermostat, a fault occurring in equipment connected to the thermostat, detecting that maintenance is due for the thermostat, detecting that maintenance is due for the connected equipment, determining that a threshold time has passed since the dealer information was last displayed, and determining that a user is adjusting settings in the thermostat for a time longer than a predetermined amount of time.

[0132] In some embodiments, the service provider information includes advertisements. In some embodiments, the processing circuit is configured to select the advertisements based on at least one of a schedule of the thermostat and an ambient temperature.

[0133] In some embodiments, the processing circuit is further configured to collect revenue information and serve the revenue information to a dealer via the communications interface. The revenue information may include at least one of number of service calls placed, number of technician visits to the building, advertising revenue, and equipment and parts purchased.

[0134] Another implementation of the present disclosure is a method for operating a network branded thermostat. The method includes receiving customized branding via a network connection of the thermostat, determining when to display the customized branding on the electronic display by monitoring thermostat events, and displaying the customized branding on an electronic display of the thermostat in response to detecting one or more of the thermostat events.

[0135] In some embodiments, the method further includes receiving the customized branding via the network connection when the thermostat is first installed in a building space.

[0136] In some embodiments, the method further includes receiving new customized branding from a second dealer when a dealer associated with the thermostat changes from a first dealer to the second dealer.

[0137] In some embodiments, the customized branding includes at least one of a dealer phone number, a dealer address, dealer store hours, a dealer RSS feed, and a dealer logo.

[0138] In some embodiments, the method further includes receiving customized branding via the network connection when a dealer creates new branding and serves the new branding to the thermostat via the network connection.

[0139] In some embodiments, the method further includes collecting revenue information and serving the revenue information to a dealer via the network connection. The revenue information may include a number of service calls placed, a number of technician visits to the building, an advertising revenue, and equipment and parts purchased.

[0140] Another implementation of the present disclosure is a dealer configured thermostat for a building space. The thermostat includes a communications interface configured to receive dealer information via a network connection, an electronic display including a user interface configured

to display the dealer information, a processing circuit configured to determine when to display the dealer information on the electronic display by monitoring events of the thermostat.

[0141] In some embodiments, the dealer information includes at least one of a dealer phone number, a dealer address, dealer store hours, a dealer RSS feed, and a dealer logo.

[0142] In some embodiments, the processing circuit is further configured to cause the electronic display to display a button to contact a dealer, detect a user pressing the button, place a call to the dealer through voice over Internet in response to detecting the user pressing the button, and transmit communications between the user and the dealer using at least one of a microphone and a speaker of the thermostat.

[0143] In some embodiments, the processing circuit is further configured to collect revenue information and serve the revenue information to a dealer via the communications interface. The revenue information may include number of service calls placed, number of technician visits to the building, advertising revenue, and equipment and parts purchased.

[0144] In some embodiments, the processing circuit is further configured to receive customized branding from a dealer associated with the thermostat, receive new customized branding from a second dealer when the dealer associated with the thermostat changes from a first dealer to the second dealer, and display the new customized branding via the electronic display in response to a determination that the dealer associated with the thermostat has changed from the first dealer to the second dealer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0145] Implementations of the inventive concepts disclosed herein may be better understood when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings, which are not necessarily to scale, and in which some features may be exaggerated and some features may be omitted or may be represented schematically in the interest of clarity. Like reference numerals in the figures may represent and refer to the same or similar element, feature, or function. In the drawings:

[0146] FIG. 1 is an illustration of a commercial or industrial HVAC system that employs heat exchangers, according to an exemplary embodiment.

[0147] FIG. 2 is an illustration of a residential HVAC system that employs heat exchangers, according to an exemplary embodiment.

[0148] FIG. 3 is a block diagram of a HVAC system that employs a control device such as a thermostat, according to an exemplary embodiment.

[0149] FIG. 4 is a block diagram of a prior art system for controlling the temperature of a building space using a wall-mounted thermostat, according to an exemplary embodiment.

[0150] FIG. 5 is a flowchart of a prior art process for controlling the temperature of a building space using a wall-mounted thermostat, according to an exemplary embodiment.

[0151] FIG. 6 is a block diagram of a thermostat with which a user may control the temperature of a building space according to an exemplary embodiment.

[0152] FIG. 7 is a system block diagram of a processing circuit of a thermostat and a remote data storage location according to an exemplary embodiment.

[0153] FIG. 8 is a drawing of a thermostat and its user interface elements according to an exemplary embodiment.

[0154] FIG. 9 is a drawing of the various user interfaces through which a user may control a thermostat according to an exemplary embodiment.

[0155] FIG. 10A is a drawing of various skins and configurations of the user interface of a thermostat according to an exemplary embodiment.

[0156] FIG. 10B is a drawing of a process in which user interface elements of a thermostat may be relocated or redefined according to an exemplary embodiment.

[0157] FIG. 11A is a drawing of a process in which a thermostat detects occupancy according to an exemplary embodiment.

[0158] FIG. 11B is a flowchart of the process shown in FIG. 11A according to an exemplary embodiment.

[0159] FIG. 11C is a drawing of a process for identifying a user and adjusting settings and user interface items, according to an exemplary embodiment.

[0160] FIG. 11D is a drawing of a configurable user interface, according to an exemplary embodiment.

[0161] FIG. 11E is a table of example configurations of a user interface for multiple users, according to an exemplary embodiment.

[0162] FIG. 12A is a flowchart of a process in which a thermostat uses schedule data to determine occupancy according to an exemplary embodiment.

[0163] FIG. 12B is a drawing of various applications and their user interfaces through which a thermostat may obtain schedule data and determine occupancy according to an exemplary embodiment.

[0164] FIG. 12C is a drawing of a scheduling screen of a thermostat, through which the process of handling multiple occupancy homes is shown according to an exemplary embodiment.

[0165] FIG. 13 is a drawing of a process in which a thermostat system adjusts the temperature of a home to a user's preferences prior to her arrival at home according to an exemplary embodiment.

[0166] FIG. 14 is a drawing of a process in which a thermostat system adjusts compressor staging using occupancy according to an exemplary embodiment.

[0167] FIG. 15A is a drawing of a process in which a thermostat communicates with a user's personal electronic device via NFC according to an exemplary embodiment.

[0168] FIG. 15B is a flowchart of the process described in FIG. 15A according to an exemplary embodiment.

[0169] FIG. 16A is a system diagram of the flow of information between a network, a thermostat, and a user's personal electronic device via NFC according to an exemplary embodiment.

[0170] FIG. 16B is a system diagram of the flow of information between a network, a thermostat, and a user's personal electronic device via NFC according to another exemplary embodiment.

[0171] FIG. 17 is a drawing of a process in which a thermostat prepares an analytic report in advance of receiving a request via NFC for the report according to an exemplary embodiment.

[0172] FIG. 18 is a drawing of a process in which a thermostat is locked and unlocked via NFC according to an exemplary embodiment.

[0173] FIG. 19 is a drawing of a process in which a thermostat changes operation of a system using location data obtained via NFC according to an exemplary embodiment.

[0174] FIG. 20 is a drawing of a process in which a thermostat changes operation of a system using feedback from a user obtained via NFC according to an exemplary embodiment.

[0175] FIG. 21 is a drawing of the flow of fault information between a piece of equipment, a thermostat, and a device via NFC according to an exemplary embodiment.

[0176] FIG. 22A is a drawing of a process in which a thermostat modifies its user interface and available features using user identification data obtained via NFC according to an exemplary embodiment.

[0177] FIG. 22B is a drawing of a process in which a thermostat modifies its user interface and available features using user identification data obtained via NFC according to another exemplary embodiment.

[0178] FIG. 23 is a drawing of a process in which a thermostat obtains equipment-specific information via NFC according to an exemplary embodiment.

[0179] FIG. 24 is a drawing of the devices with which a thermostat may communicate according to an exemplary embodiment.

[0180] FIG. 25A is a flowchart detailing the flow of information between a thermostat, HVAC equipment, a network, and network-connected devices and services according to an exemplary embodiment.

[0181] FIG. 25B is a block diagram illustrating the flow of information between a thermostat, social media servers, and calendar servers, according to an exemplary embodiment.

[0182] FIG. 25C is a flowchart of a process in which a thermostat queries a social media server, a mobile application server, and a calendar server and receives occupancy information, according to an exemplary embodiment.

[0183] FIG. 25D is a flowchart of a process in which a thermostat subscribes to a social media server, a mobile application server, and a calendar server and is pushed occupancy information, according to an exemplary embodiment.

[0184] FIG. 26A is a drawing of user interfaces through which a thermostat may display reports which compare and contrast a user's energy consumption and behavior with other similar systems according to an exemplary embodiment.

[0185] FIG. 26B is a drawing of processes through which a thermostat may interact with a user to affect the energy consumption and energy bill of a building space according to an exemplary embodiment.

[0186] FIG. 26C is a flowchart detailing process of testing new settings automatically according to an exemplary embodiment.

[0187] FIG. 26D is a drawing of a process in which a thermostat alerts users that it is unable to reach a setpoint according to an exemplary embodiment.

[0188] FIG. 27 is a drawing of various methods which a user may use to provide input to a thermostat according to an exemplary embodiment.

[0189] FIG. 28 is a drawing of a process in which a thermostat receives a command from a user through text message according to an exemplary embodiment.

[0190] FIG. 29 is a drawing of a method which a thermostat may utilize social media to determine occupancy according to an exemplary embodiment.

[0191] FIG. 30 is a drawing of a thermostat and its user interface through which a brand may promote itself according to an exemplary embodiment..

[0192] FIG. 31 is a drawing of the social media presence of a thermostat according to an exemplary embodiment.

[0193] FIG. 32 is a drawing of the analytics a thermostat may provide according to an exemplary embodiment.

[0194] FIG. 33 is a drawing of a thermostat and an external accessory according to an exemplary embodiment.

[0195] FIG. 34 is a flowchart of a process for determining if a setpoint is achievable, determining the time to reach a setpoint for an achievable setpoint, and serving notifications to a user, according to an exemplary embodiment.

[0196] FIG. 35 is a flowchart of a process for determining if a system fault can be fixed by a homeowner, according to an exemplary embodiment.

[0197] FIG. 36 is a flowchart of a process for determining if setpoints selected by a user are efficient and suggesting energy efficient setpoints to the user, according to an exemplary embodiment.

[0198] FIG. 37 is a flowchart of a process for updating and displaying a dealers contact information, according to an exemplary embodiment.

[0199] Those skilled in the art will appreciate that the summary is illustrative only and is not intended to be in any way limiting. Other aspects, inventive features, and advantages of the devices and/or processes described herein will become apparent in the detailed description set forth herein and taken in conjunction with the accompanying drawings.

DETAILED DESCRIPTION

[0200] Before describing in detail the inventive concepts disclosed herein, it should be observed that the inventive concepts disclosed herein include, but are not limited to, a novel structural combination of data/signal processing components, sensors, and/or communications circuits, and not in the particular detailed configurations thereof. Accordingly, the structure, methods, functions, control and arrangement of components, software, and circuits have, for the most part, been illustrated in the drawings by readily understandable block representations and schematic diagrams, in order not to obscure the disclosure with structural details which will be readily apparent to those skilled in the art, having the benefit of the description herein. Further, the inventive concepts disclosed herein are not limited to the particular embodiments depicted in the exemplary diagrams, but should be construed in accordance with the language in the claims.

[0201] Referring generally to the FIGURES, systems and methods for a thermostat are shown according to various exemplary embodiments. The thermostat may include a communications interface and a processing circuit. The communications interface may be configured to engage in bidirectional communications with heating, ventilation, or air conditioning (HVAC) equipment and to receive an indication of a current heating or cooling load from the HVAC equipment. The processing circuit may be configured to determine an occupancy of the building space based on the indication of the current heating or cooling load received from the HVAC equipment. The processing circuit may be further configured to operate the HVAC equipment based on the determined occupancy of the building space. In some embodiments, the thermostat determines occupancy and/or identifies occupants from data received from sensors. In some embodiments, the thermostat configures itself based on the occupants identified. In some embodiments, the thermostat communicates to other devices through NFC. In some embodiments, the thermostat communicates to social media servers, mobile applications servers, and calendar servers. In some embodiments, the thermostat has user interface features such as stickers and skins. In some embodiments, the thermostat receives customized branding and displays the branding.

Building With HVAC System and Thermostat

[0202] FIG. 1 illustrates an exemplary application, in this case an HVAC system for building environmental management that may be a communicating system employing one or more control devices (e.g., thermostats) functioning as system controllers. A building 10 is cooled by a system that includes a chiller 12 and a boiler 14. As shown, chiller 12 is disposed on the roof of building 10 and boiler 14 is located in the basement; however, the chiller and boiler may be located in other equipment rooms or areas next to the building. Chiller 12 is an air cooled or water cooled device that implements a refrigeration cycle to cool water. Chiller 12 may be a stand-alone unit or may be part of a single package unit containing other equipment, such as a blower and/or integrated air handler. Boiler 14 is a closed vessel that includes a furnace to heat water. The water from chiller 12 and boiler 14 is circulated through building 10 by water conduits 16. Water conduits 16 are routed to air handlers 18, located on individual floors and within sections of building 10.

[0203] Air handlers 18 are coupled to ductwork 20 that is adapted to distribute air between the air handlers and may receive air from an outside intake (not shown). Air handlers 18 include heat exchangers that circulate cold water from chiller 12 and hot water from boiler 14 to provide heated or cooled air. Fans, within air handlers 18, draw air through the heat exchangers and direct the conditioned air to environments within building 10, such as rooms, apartments, or offices, to maintain the environments at a designated temperature. A control device 22, shown here as including a thermostat, may be used to designate the temperature of the conditioned air. Control device 22 also may be used to control the flow of air through and from air handlers 18 and to diagnose mechanical or electrical problems with the air handlers 18. Other devices may, of course, be included in the system, such as control valves that regulate the flow of water and pressure and/or temperature transducers or switches that sense the temperatures and pressures of the water, the air, and so forth. Moreover, the control device may communicate with computer systems that are integrated with or separate from other building control or monitoring systems, and even systems that are remote from the building.

[0204] FIG. 2 illustrates a residential heating and cooling system. The residential heating and cooling system may provide heated and cooled air to a residential structure, as well as provide

outside air for ventilation and provide improved indoor air quality (IAQ) through devices such as ultraviolet lights and air filters. In general, a residence 24 will include refrigerant conduits 26 that operatively couple an indoor unit 28 to an outdoor unit 30. Indoor unit 28 may be positioned in a utility room, an attic, a basement, and so forth. Outdoor unit 30 is typically situated adjacent to a side of residence 24 and is covered by a shroud to protect the system components and to prevent leaves and other contaminants from entering the unit. Refrigerant conduits 26 transfer refrigerant between indoor unit 28 and outdoor unit 30, typically transferring primarily liquid refrigerant in one direction and primarily vaporized refrigerant in an opposite direction.

[0205] When the system shown in FIG. 2 is operating as an air conditioner, a coil in outdoor unit 30 serves as a condenser for recondensing vaporized refrigerant flowing from indoor unit 28 to outdoor unit 30 via one of the refrigerant conduits 26. In these applications, a coil of the indoor unit, designated by the reference numeral 32, serves as an evaporator coil. Evaporator coil 32 receives liquid refrigerant (which may be expanded by an expansion device, not shown) and evaporates the refrigerant before returning it to outdoor unit 30.

[0206] Outdoor unit 30 draws in environmental air through its sides as indicated by the arrows directed to the sides of the unit, forces the air through the outer unit coil using a fan (not shown), and expels the air as indicated by the arrows above the outdoor unit. When operating as an air conditioner, the air is heated by the condenser coil within the outdoor unit and exits the top of the unit at a temperature higher than it entered the sides. Air is blown over indoor coil 32 and is then circulated through residence 24 by means of ductwork 20, as indicated by the arrows entering and exiting ductwork 20. The overall system operates to maintain a desired temperature as set by system controller 22. When the temperature sensed inside the residence is higher than the set point on the thermostat (plus a small amount), the air conditioner will become operative to refrigerate additional air for circulation through the residence. When the temperature reaches the set point (minus a small amount), the unit will stop the refrigeration cycle temporarily.

[0207] When the unit in FIG. 2 operates as a heat pump, the roles of the coils are simply reversed. That is, the coil of outdoor unit 30 will serve as an evaporator to evaporate refrigerant

and thereby cool air entering outdoor unit 30 as the air passes over the outdoor unit coil. Indoor coil 32 will receive a stream of air blown over it and will heat the air by condensing a refrigerant.

[0208] FIG. 3 is a block diagram of an HVAC system 42 that includes the control device 22, indoor unit 28 functioning as an air handler, and outdoor unit 30 functioning as a heat pump. Refrigerant flows through system 42 within a closed refrigeration loop 44 between outdoor unit 30 and indoor unit 28. The refrigerant may be any fluid that absorbs and extracts heat. For example, the refrigerant may be hydrofluorocarbon (HFC) based R-410A, R-407C, or R-134a.

[0209] The operation of indoor and outdoor units 28 and 30 is controlled by control circuits 48 and 46, respectively. The control circuits 46 and 48 may execute hardware or software control algorithms to regulate the HVAC system. According to exemplary embodiments, the control circuits may include one or more microprocessors, analog to digital converters, non-volatile memories, and interface boards. In certain embodiments, the control circuits may be fitted with or coupled to auxiliary control boards that allow conventional 24 VAC wiring to be controlled through serial communications.

[0210] The control circuits 46 and 48 may receive control signals from control device 22 and transmit the signals to equipment located within indoor unit 28 and outdoor unit 30. For example, outdoor control circuit 46 may route control signals to a motor 50 that powers a fan 52 and to a motor 54 that powers a compressor 56. Indoor control circuit 48 may route control signals to a motor 58 that powers a fan 60. The control circuits also may transmit control signals to other types of equipment such as valves 62 and 64, sensors, and switches.

[0211] According to exemplary embodiments, control device 22 may communicate with control circuits 46 and 48 by transmitting communication packets over a serial communication interface. Control device 22 may function as the master system controller while control circuits 46 and 48 operate as slave devices. In certain embodiments, control device 22 may send a ping message to discover connected slave devices and their properties. For example, control circuits 46 and 48 may transmit an acknowledgement message in response to receiving a ping message from control device 22. Control circuits 46 and 48 also may transmit information, in response to requests from control device 22, identifying the type of unit and specific properties of the unit.

For example, control circuit 46 may transmit a signal to control device 22 indicating that it controls a two-stage heat pump with auxiliary heat and a bonnet sensor. Control circuits 46 and 48 also may transmit signals identifying terminal connections and jumper settings of the control circuits.

[0212] Control device 22 may operate to control the overall heating and cooling provided by indoor and outdoor units 28 and 30. Indoor and outdoor units 28 and 30 include coils 66 and 32, respectively, that both operate as heat exchangers. The coils may function either as an evaporator or a condenser depending on the heat pump operation mode. For example, when heat pump system 42 is operating in cooling (or “AC”) mode, outside coil 32 functions as a condenser, releasing heat to the outside air, while inside coil 66 functions as an evaporator, absorbing heat from the inside air. When heat pump system 42 is operating in heating mode, outside coil 32 functions as an evaporator, absorbing heat from the outside air, while inside coil 66 functions as a condenser, releasing heat to the inside air. A reversing valve may be positioned on closed loop 44 to control the direction of refrigerant flow and thereby to switch the heat pump between heating mode and cooling mode.

[0213] Heat pump system 42 also includes two metering devices 62 and 64 for decreasing the pressure and temperature of the refrigerant before it enters the evaporator. The metering devices also regulate the refrigerant flow entering the evaporator so that the amount of refrigerant entering the evaporator equals, or approximately equals, the amount of refrigerant exiting the evaporator. The metering device used depends on the heat pump operation mode. For example, when heat pump system 74 is operating in cooling mode, refrigerant bypasses metering device 62 and flows through metering device 64 before entering inside coil 66, which acts as an evaporator. In another example, when heat pump system 42 is operating in heating mode, refrigerant bypasses metering device 64 and flows through metering device 62 before entering outside coil 32, which acts as an evaporator. According to other exemplary embodiments, a single metering device may be used for both heating mode and cooling mode. The metering devices typically are thermal or electronic expansion valves, but also may be orifices or capillary tubes.

[0214] The refrigerant enters the evaporator, which is outside coil 32 in heating mode and inside coil 66 in cooling mode, as a low temperature and pressure liquid. Some vapor refrigerant also may be present as a result of the expansion process that occurs in metering device 62 or 64. The refrigerant flows through tubes in the evaporator and absorbs heat from the air changing the refrigerant into a vapor. In cooling mode, the indoor air flowing across the multichannel tubes also may be dehumidified. The moisture from the air may condense on the outer surface of the multichannel tubes and consequently be removed from the air.

[0215] After exiting the evaporator, the refrigerant flows into compressor 56. Compressor 56 decreases the volume of the refrigerant vapor, thereby, increasing the temperature and pressure of the vapor. The compressor may be any suitable compressor such as a screw compressor, reciprocating compressor, rotary compressor, swing link compressor, scroll compressor, or turbine compressor.

[0216] From compressor 56, the increased temperature and pressure vapor refrigerant flows into a condenser, the location of which is determined by the heat pump mode. In cooling mode, the refrigerant flows into outside coil 32 (acting as a condenser). Fan 52, which is powered by motor 50, draws air across the tubes containing refrigerant vapor. According to certain exemplary embodiments, the fan may be replaced by a pump that draws fluid across the multichannel tubes. The heat from the refrigerant is transferred to the outside air causing the refrigerant to condense into a liquid. In heating mode, the refrigerant flows into inside coil 66 (acting as a condenser). Fan 60, which is powered by motor 58, draws air across the tubes containing refrigerant vapor. The heat from the refrigerant is transferred to the inside air causing the refrigerant to condense into a liquid.

[0217] After exiting the condenser, the refrigerant flows through the metering device (62 in heating mode and 64 in cooling mode) and returns to the evaporator (outside coil 32 in heating mode and inside coil 66 in cooling mode) where the process begins again.

[0218] In both heating and cooling modes, motor 54 drives compressor 56 and circulates refrigerant through reversible refrigeration/heating loop 44. The motor may receive power either directly from an AC or DC power source or from a variable speed drive (VSD). The motor may

be a switched reluctance (SR) motor, an induction motor, an electronically commutated permanent magnet motor (ECM), or any other suitable motor type.

[0219] The operation of motor 54 is controlled by control circuit 46. Control circuit 46 may receive control signals from control device 22. In certain embodiments, control device may receive information from a sensor 68 that measures the ambient indoor air temperature. Control device 22 then compares the air temperature to the temperature set point (which may be input by a user) and engages compressor motor 54 and fan motors 50 and 58 to run the cooling system if the air temperature is above the temperature set point. In heating mode, control device 22 compares the air temperature from sensor 68 to the temperature set point and engages motors 50, 54, and 58 to run the heating system if the air temperature is below the temperature set point.

[0220] The control circuit 46 and control device 22 also may initiate a defrost cycle when the system is operating in heating mode. When the outdoor temperature approaches freezing, moisture in the outside air that is directed over outside coil 32 may condense and freeze on the coil. Sensors may be included within outdoor unit 30 to measure the outside air temperature and the temperature of outside coil 32. These sensors provide the temperature information to the control circuit 46 which determines when to initiate a defrost cycle.

[0221] Referring now to FIG. 4, a system 400 for monitoring and controlling the temperature of a building space is shown, according to an exemplary embodiment. System 400 is shown to include a thermostat 404 installed within a building space 402. Typically, thermostat 404 is mounted on a wall within building space 402. Thermostat 404 is shown to include user interface 406 and a temperature sensor 408. User interface 406 includes an electronic display for presenting information to a user 410 and one or more physical input devices (e.g., a rotary knob, pushbuttons, manually-operable switches, etc.) for receiving input from a user 410. Temperature sensor 408 measures the temperature of building space 402 and provides the measured temperature to user interface 406.

[0222] Thermostat 404 communicates with a controller 412. In various embodiments, controller 512 may be integrated with thermostat 404 or may exist as a separate controller (e.g., a field and equipment controller, a supervisory controller, etc.) that receives input from thermostat

404. Thermostat 404 may send temperature measurements and user-defined temperature setpoints to controller 412. Controller 412 uses the temperature measurements and the setpoints to generate a control signal for HVAC equipment 414. The control signal causes HVAC equipment 414 to provide heating and/or cooling for building space 402.

[0223] Referring now to FIG. 5, a process 500 for monitoring and controlling the temperature of a building space is shown, according to an exemplary embodiment. Process 500 may be performed by system 400, as described with reference to FIG. 4. In process 500, thermostat 404 measures the temperature of building space 402 (step 502). User 410 views the measured temperature and adjusts the temperature setpoint via user interface 406 of thermostat 404 (step 504). Thermostat 404 sends the measured temperature and the setpoint to controller 412 (step 506). Controller 412 uses the measured temperature and the setpoint to generate and provide a control signal to HVAC equipment 414 (step 508). HVAC equipment 414 operates in accordance with the control signal to provide heating/cooling to building space 402 (step 510).

Occupancy Based Control and Operation

[0224] In FIG. 6, a block diagram of thermostat 600 is shown to include sensors 602, 604, and 606, processing circuit 608, data communications interface 610, and user interface 612. In some embodiments, sensors 602-606 are used to detect occupancy (i.e., occupancy sensors). It is contemplated that sensors 602-606 could be, in some embodiments, motion sensors, cameras, microphones, capacitive sensors, or any number of other sensors. Sensors 602-606 could be any number of sensors. Sensors 602-606 could be cameras which detect heat signatures in some embodiments. Sensors 602-606 may detect separate objects and distinguish between humans and other objects. Sensors 602-606 could be any transducers which detect some characteristic of their respective environment and surroundings.

[0225] Still referring to FIG. 6, thermostat 600 is capable of bi-directional communication with equipment through data communications interface 610. Thermostat 600 may communicate to a network or the Internet through the data communications interface 610. In some embodiments, data communications interface 610 is a network interface for thermostat 600. In some embodiments, the networks include at least one of a wireless Zigbee network, a Bluetooth

connection, Ethernet, Wi-Fi, and any other such network. In some embodiments, the data communications interface 610 includes a near field communication module configured to interact with near field communication enabled devices. In some embodiments, the near field communication module is configured to exchange information in a peer-to-peer connection with a user device. The user device may be a plurality of user devices with nearfield communication enabled. In some embodiments, the user devices are a smartphone, a laptop, a tablet, or any other user device with nearfield communication enabled. In some embodiments, thermostat 600 may be able to communicate with a variety of devices through a network. For example, thermostat 600 may be able to communicate with other network enabled appliances and systems in a user's home such as a security system or a refrigerator or light system. In other embodiments, thermostat 600 may be able to communicate directly with devices.

[0226] Now referring to FIG. 7, processing circuit 608 is shown to include a processor 702 and memory 704. Processor 702 may be a general purpose or specific purpose processor, an application specific integrated circuit (ASIC), one or more field programmable gate arrays (FPGAs), a group of processing components, or other suitable processing components. Processor 702 is configured to execute computer code or instructions stored in memory 704 or received from other computer readable media (e.g., CDROM, network storage, a remote server, etc.).

[0227] Memory 704 may include one or more devices (e.g., memory units, memory devices, storage devices, etc.) for storing data and/or computer code for completing and/or facilitating the various processes described in the present disclosure. Memory 704 may include random access memory (RAM), read-only memory (ROM), hard drive storage, temporary storage, non-volatile memory, flash memory, optical memory, or any other suitable memory for storing software objects and/or computer instructions. Memory 704 may include database components, object code components, script components, or any other type of information structure for supporting the various activities and information structures described in the present disclosure. Memory 704 may be communicably connected to processor 702 via processing circuit 134 and may include computer code for executing (e.g., by processor 702) one or more processes described herein. When processor 702 executes instructions stored in memory 704 for completing the various

activities described herein, processor 702 generally configures thermostat 600 (and more particularly processing circuit 134) to complete such activities.

[0228] Memory 704 is shown to include occupancy detector 706, occupancy identifier 708, occupancy predictor 710, data analyzer 712, system analyzer 714, and voice recognition module 716. Occupancy detector 706 processes data received from sensors 602-606 to determine whether occupancy has been detected. Occupancy identifier 708 processes occupancy data collected to determine which user or users are home. Occupancy predictor 710 processes calendar and scheduling data to determine when a user or users will be home, which user or users will be home, and the appropriate course of action when overlap and conflicting preferences occur.

[0229] Processing circuit 608 is shown to include a control circuit 722 which includes a controller 724, and a scheduler 726. Controller 724 may be an embodiment of controller 512, and is able to communicate with and send commands to connected equipment. Scheduler 726 is a module which is configured to receive calendar and schedule data to organize and send commands to connected equipment.

[0230] Processing circuit 608 is also shown to include a data logger 720. System 700 is shown to include remote data storage 718. In some embodiments, remote data storage 718 is at least one of RAM, ROM, EPROM, EEPROM, CD-ROM or other optical disk storage, hard drive, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store data. Data logger 720 may record data in memory 704 and the remote data storage 718. In some embodiments, processing circuit 608 may store data in remote data storage 718. In some embodiments, remote data storage 178 is located inside processing circuit 608. In some embodiments, remote data storage 718 is outside processing circuit 608 but is located inside thermostat 600. While storing data locally may reduce access time, the cost of providing suitable storage space may discourage user adoption. Remote data storage 718 is remote from processing circuit 608 and may be accessed through any number of communications protocols.

[0231] Referring now to FIG. 8, thermostat 600 is shown to have a display 802 and a frame 804. In some embodiments, display 802 is touch-sensitive, and may be a capacitive LCD screen.

In some embodiments, frame 804 is touch-sensitive. In some embodiments, a capacitive layer may extend from display 802 out over frame 804. Thermostat may be configured to have buttons 806-812 on frame 804. Buttons 806-812 on frame 804 are touch sensitive buttons. Buttons 806-812 are not physical buttons, and cannot be seen. Buttons 806-812 are predefined areas of the capacitive layer which extends over frame 804. In some embodiments, buttons 806-812 are associated with large areas of frame 804 and are not finely sensitive. In some embodiments, buttons 806-812 are configured to receive touch-based input. Buttons 806-812 may use any amount of the available size of frame 804 and may be configured in any shape. In some embodiments, the shapes may be circular, square, rectangular and any other shape that can be used as a button. In some embodiments, the button shapes and sizes are selected for a direct touch from the user. In some embodiments, the button shapes and sizes are selected for registering a swipe on frame 804. In some embodiments, buttons 806-812 are configured to register a direct touch. In some embodiments, buttons 806-812 are configured to register a swipe.

[0232] Referring now to FIG. 9, exemplary user interfaces 902, 904, and 908 are shown. User interfaces 902-908 are used to interact with and control thermostat 600. User interface 902 is an exemplary embodiment of a mobile application user interface which can be used on personal electronic devices such as smartphones or tablets. User interface 904 is an exemplary embodiment of user interface 612, and is physically integrated with thermostat 600. User interface 908 is an exemplary embodiment of a web-based application user interface which can be accessed through any device connected to the Internet. In some embodiments, a network-based application may be used instead of a web-based application, and may allow users to control thermostat 600 through any device which is connected to a local area network (LAN), regardless of Internet connectivity. It is understood that the embodiments described and shown in FIG. 9 are only a few of many different possibilities. In some embodiments, it is possible for a user to queue commands through user interfaces 902-908 to send to thermostat 600. In some embodiments, any combination of the above mentioned methods may be available options to control thermostat 600.

[0233] Referring now to FIG. 10A, different skins 1002, 1004, 1006, and 1008 are shown. Skins may change the look, feel, and functionality of thermostat 600. Skins may be used to tailor functionality and complexity of operation to a user's preference and comfort level. Skins may be software configurations which dictate the appearance of user interface 612 of thermostat 600. Skins 1002 and 1006 are exemplary embodiments of software configuration skins. Skin 1002 is an exemplary embodiment of a skin created for a user who wishes to be able to access and use all features of their thermostat 600. Skin 1006 is an exemplary embodiment of a skin created for a user who only wishes to control the temperature of their home, and does not wish to see any other options or controls.

[0234] Skins can be stickers which are applied to the outside of thermostat 600 to frame 804. It is understood that physical skins may be in the form of any physical applique and is not limited to stickers. The buttons shown on skins 1004 and 1008 are visible only on the physical skins, and are not visible or physical buttons on frame 804. In some embodiments, a wirelessly communicating tag, attached to the physical skin, interacts with thermostat 600 to configure the functionality of thermostat 600. For example, an RFID tag is attached to a skin sticker which dictates portions of frame 804 which correspond to buttons on the sticker.

[0235] Referring now to FIG. 10B, a process 1050 through which a skin may be customized is shown. Users may be able to download an application or use a web-based application, embodied in FIG. 10B as 1052, to customize skins to their preferred settings. Users may be able to change the placement and priority of certain features of user interface 612 of thermostat 600. Users may be able to move icons, screens, or buttons on display 802. It is shown that the movement of button icons 1060, 1062, and 1062 in web-based application 1052 correspond to movement of touch-sensitive buttons 1054, 1056, and 1058 on thermostat 600. The movement of screens 1070 and 1072 in web-based application 1052 is shown to correspond to movement of screens 1066 and 1068 on thermostat 600. Changes which could be made to user interface 612 of thermostat 600 include backgrounds, icons, macros, scenes, etc. In some embodiments, skins may change the sound settings of thermostat 600. It is conceivable that any setting on thermostat 600 may be

adjusted by a user through the use of skins. There could be any number of skins, which may be user customizable.

[0236] In some embodiments, users may be able to design their own physical skin and print it out at a location with a suitable fabrication center. In another embodiment, users may need to send their designs to the manufacturer or a dealer to fabricate. In some embodiments, any combination of the above mentioned methods of customization may be available to users.

[0237] Determining the occupancy of a home allows thermostat 600 to make energy efficient operating decisions by reducing conditioning and power consumption when a home is unoccupied. User comfort may be increased when thermostat 600 is able to anticipate occupancy and condition the home to user preferences by the time the home is occupied. Occupancy based operation and control of an HVAC system allows users to conserve energy and arrive home to a comfortable environment without requiring a large amount of effort on the part of the user.

[0238] Referring now to FIG. 11A, an exemplary situation 1100 in which thermostat 600 detects occupancy of a home is shown. Thermostat 600 may detect occupancy through sensor 1102, which may be an embodiment of sensors 602-606. In some embodiments, thermostat 600 may detect occupancy through communication with external object 1104. Object 1104 may be any device. In some embodiments, object 1104 is an electronic device capable of communicating with thermostat 600. In various embodiments, object 1104 may be a user's cellphone, laptop, tablet, or any portable electronic device. In some embodiments, object 1104 is a dongle which may be compatible with thermostat 600 or any other objects which may communicate with thermostat 600. In some embodiments, object 1104 is a wearable object such as a necklace, a watch, or a fitness tracker. Object 1104 may be a business card or an RFID card. In some embodiments, object 1104 is an NFC enabled device. In some embodiments, the NFC enabled device is associated with a user. When the user interacts with thermostat 600 via the NFC enabled device, thermostat 600 may be able to identify the user that interacts with thermostat 600. Thermostat 600 may detect the time at which occupancy is detected. In some embodiments, thermostat 600 time-stamps logged data to be used in later analysis.

[0239] FIG. 11B describes an exemplary process 1150 in which thermostat 600 may detect occupancy and alter operations of a connected system. Thermostat 600 waits for an input to be received at sensor 1102 (step 1152). In step 1154, an input is received. The input may be a noise, a movement, a heat signature, or a communication signal. Once the input is received, it must be processed by occupancy detector 706 of memory 704 in step 1156. In step 1157, a determination is made whether occupancy has been detected. If occupancy has been detected, an operation command is issued from thermostat 600 to the connected system (step 1158). If occupancy has not been detected, the process repeats, and thermostat 600 waits for an input to be received in step 1152. In some embodiments, thermostat 600 may receive a communication signal from object 1104, which may be through NFC, WiFi, Bluetooth, or any other communication protocol. In some embodiments, occupancy is determined through NFC. Further, a user identity may be determined through NFC when a user checks in with thermostat 600 via an NFC enabled device that is associated with a user.

[0240] Referring now to FIG. 11C, process 1160 for identifying a user and adjusting settings of thermostat 600 is described according to an exemplary embodiment. Sensors 602-604 are configured to receive input (step 1162) when occupancy detector 706 detects an occupant with sensors 602-604. Sensors 602-604 may include one or more microphones, one or more cameras, and/or one or more motion detectors. Thermostat 600 uses the input from sensors 602-604 to determine user identity (step 1165) with occupancy identifier 708. The identity of the user is linked to user preferred settings. The user preferred settings may be interface configurations, schedules, setpoints, and any other configurable setting or process. Thermostat 600 adjusts its settings based on the preferred settings of the identified user (step 1166).

[0241] In some embodiments, the occupancy identifier 708 receives sensor input from sensors 602-604 where at least one of sensors 602-604 is a camera. In the event that occupancy detector 706 detects one or more users, occupancy identifier 708 can perform digital image processing to identify the one or more users based on the digital images received from the camera of sensors 602-604. In some embodiments, digital image processing is used to identify the faces of the one or more users, the height of the one or more users, or any other physical characteristic of the one

or more users. In some embodiments, the digital image processing is performed by image analysis tools such as edge detectors and neural networks. In some embodiments, the digital image processing compares the physical characteristics of the one or more users with physical characteristics of previously identified users stored by data logger 720 in the remote data storage 718. In some embodiments, the data logger 720 may store the physical characteristics of the previously identified users in the remote data storage 718.

[0242] In some embodiments, the occupancy identifier 708 is configured to capture video data from a camera and perform pre-processing. In some embodiments pre-processing may be compressing the video data, converting the video data into an appropriate format, and any other pre-processing action necessary. The occupancy identifier 708 may be configured to transmit the captured spoken video data to a server via data communications interface 610. Data communications interface 610 may be configured to transmit the video data to the server via wireless Zigbee network, a Bluetooth connection, Ethernet, Wi-Fi, the Internet, and any other such network.

[0243] In some embodiments, data communications interface 610 is configured to receive an identified user from a server. In some embodiments, the data communications interface 610 is configured to transmit video data to the server. The server may be configured to perform digital image processing to identify the speaker. In some embodiments, the server transmits the identity of the speaker to data communications interface 610.

[0244] In some embodiments, the occupancy identifier 708 receives sensor input from sensors 602-604 where at least one of the sensors 602-604 is a motion detector. The motion detector may be at least one of a passive infrared (PIR) sensor, a microwave sensor, an ultrasonic sensor, a tomographic motion detector, or a camera configured to detect motion. In some embodiments, the motion detector is configured to identify a unique gesture linked to a user. In some embodiments, the link between the gesture and the user is stored by data logger 720 in remote data storage 718. In an event that occupancy detector 706 detects one or more users by the motion detector of sensors 602-604, occupancy identifier 708 determines which user is present based on the link between the user and the gesture. For example, user Dan is identified by the

occupancy identifier 708 when the motion detector of sensors 602-604 registers three hand waves each occurring within a set amount of time. User Phil is identified by the occupancy identifier 708 when the motion detector of sensors 602-604 registers 2 hand waves each occurring within the set amount of time. In some embodiments, the gesture is a plurality of hand waves or other such gestures. In some embodiments, the hand gestures are registered based on types of motion. The types of motion may be vertical waves, horizontal waves, circular waves, or any other movement which the motion detector of sensors 602-604 can register.

[0245] In some embodiments, the occupancy identifier 708 receives sensor input from sensors 602-604 where at least one of the sensors 602-604 is a microphone. The microphone can have any of a plurality of microphone types. The microphone types include, for example, a dynamic microphone, a ribbon microphone, a carbon microphone, a piezoelectric microphone, a fiber optic microphone, a laser microphone, a liquid microphone, and an audio speaker used as a microphone. In some embodiments, the voice recognition module 716 analyzes the audio data received from the microphone of sensors 602-606 in the event that occupancy detector 706 detects one or more users by the microphone of sensors 602-604. In some embodiments, the voice recognition module 716 identifies the one or more users based on voice biometrics of the audio received from sensors 602-606. Voice biometrics are the unique characteristics of a speaker's voice. Voice biometrics include voice pitch or speaking style that result from the anatomy of the speaker's throat and mouth. In some embodiments, the voice recognition module 716 uses a text dependent voice recognition technique. In some embodiments, the voice recognition module 716 uses a text independent voice recognition technique to identify the one or more users detected by occupancy detector 706.

[0246] In some embodiments, the voice recognition module 716 uses the text dependent voice recognition technique to identify the one or more users based on a password or particular phrase spoken by one of the users. For example, the user may speak a phrase such as "This is Felix, I am home." The voice recognition module 716 can perform speech recognition to determine the spoken phrase "This is Felix, I am home" from the audio data received from the microphone of sensors 602-604. In some embodiments, the voice recognition module 716 uses one or a

combination of a hidden Markov models, dynamic time warping, and a neural networks to determine the spoken phrase. The voice recognition module 716 compares the determined spoken phrase to phrases linked to users stored by the data logger 718 in remote data storage 718. If the phrase, “This is Felix, I am home” matches a phrase linked to a user Felix stored by the data logger 718, the voice recognition module 716 identifies the user as Felix.

[0247] In some embodiments, the voice recognition module 716 uses the text independent voice recognition technique to identify one or more users based on particular voice biometrics of the user. The text independent voice recognition technique performs a pattern recognition technique to identify the particular voice biometrics of the speaker from the audio data received from the microphone of sensors 602-604. The voice biometrics include voice pitch and speaking style. In some embodiments, a plurality of techniques are used to identify the voice biometrics of the user. The techniques include frequency estimation, hidden Markov models, Gaussian mixture models, pattern matching algorithms, neural networks, matrix representation, Vector Quantization, and decision trees.

[0248] In some embodiments, the voice recognition module 716 is configured to capture audio data from one or more users and perform pre-processing. In some embodiments pre-processing may be compressing the audio data, converting the audio data into an appropriate format, and any other pre-processing action necessary. The voice recognition module 716 may be configured to transmit the captured spoken audio data to a server via data communications interface 610. Data communications interface 610 may be configured to transmit the audio to the server via wireless Zigbee network, a Bluetooth connection, Ethernet, Wi-Fi, the Internet, and any other such network.

[0249] In some embodiments, data communications interface 610 is configured to receive an identified user from a server. In some embodiments, the data communications interface 610 is configured to transmit audio data to the server. The server may be configured to perform at least one of text dependent and/or text independent voice recognition to identify the speaker. In some embodiments, the server transmits the identity of the speaker to data communications interface 610.

[0250] In some embodiments, the thermostat 600 receives an automatic command to display a particular user interface when a user is detected and identified. In some embodiments, the user is identified through NFC or through sensors 602-604. In some embodiments, the user creates a unique user interface for thermostat 600 and thermostat 600 links the unique user interface to the user. The user can create a user interface displaying a combination of user interface items. The user interface items include at least one of a relative humidity value, a temperature value, a temperature setpoint, a time and date, a user interface background, a set of user interface buttons, a user interface color scheme, a time to setpoint and other such user interface items. In some embodiments, the thermostat 600 is configured to run a heating or cooling schedule or adjust a heating or cooling setpoint to a preference unique to the user. In some embodiments, the user creates a unique heating and cooling schedule for thermostat 600 and thermostat 600 links the unique heating and cooling schedule to the user. In some embodiments, the unique heating and cooling schedule contains the desired temperature setpoints of the user. In some embodiments, thermostat 600 sends a setpoint to controller 412 based the heating and cooling preferences of the identified user. Controller 412 sends a control signal to HVAC equipment 414 commanding the HVAC equipment 4147 to heat or cool the building space 402 based on the preferences of the detected and identified user. In some embodiments, the heating and cooling setpoint preferences, the unique user interface items, and the heating and cooling schedules of the identified user are stored by the data logger 720 in the remote data storage 718.

[0251] In some embodiments, the thermostat 600 is configured to learn information about an identified user. The thermostat 600 can identify a user and then track and store the interactions of the user with the thermostat 600. For example, thermostat 600 identifies a user Frank for a first time. Thermostat 600 creates a profile for Frank and records historical information regarding Frank with data logger 720 and stores the historical information regarding Frank in remote data storage 718. The profile includes a historical link between the profile and the user Frank. For example, thermostat 600 identifies Frank for the first time on February 11th. On February 11th, Frank changes a heating setpoint of thermostat 600 to 72 degrees. If thermostat 600 identifies Frank on February 17th, the thermostat may automatically adjust the setpoint of thermostat 600 to 72 degrees Fahrenheit. In some embodiments, thermostat 600 may also monitor the user

interface preferences of Frank. For example, whenever Frank interacts with thermostat 600, Frank views a faults (e.g. operational errors) screen of thermostat 600. Thermostat 600 uses this historical data to automatically display the faults screen whenever Frank is identified by thermostat 600.

[0252] In some embodiments, the occupancy identifier 708 receives information regarding the identity of one or more users from a user device. In some embodiments, the information is received from the data communications interface 610. The data communications interface 610 may receive information from the user device. In some embodiments, the user device is at least one of a cell phone, a personal computer, a voice-controlled smarthome controller, or any other such voice controlled device. In some embodiments, occupancy identifier 708 may identify the user based on a Bluetooth signal from a user device (e.g., a cell phone) when the user device is connected to thermostat 600 via a Bluetooth communications link. Thermostat 600 may use the RSSI signal strength of the signal from the user device to make a prediction regarding how close the user is to thermostat 600. In some embodiments, the voice-controlled smarthome controller is an Amazon Echo, an ivee, a cubic, a Athom Homey or any other such voice-controlled smarthome controller. In some embodiments, the voice-controlled smarthome controller identifies the user interacting with the voice-controlled smarthome controller and communicates the identified user to the thermostat 600 via the data communications interface 610 over at least one of Wi-Fi, Bluetooth, Zigbee, Ethernet, or any other communication protocol.

[0253] Referring now to FIG. 11D, a configurable user interface 1170 is shown according to an exemplary embodiment. Thermostat 600 can be configured by a user so that whenever the user is identified by thermostat 600, thermostat 600 displays the configurable user interface 1170. In some embodiments, the user interface 612 is configured to displayed the configurable user interface 1170. In some embodiments, user interface 1170 is a screen on an application running on a mobile device. In FIG. 11D, user interface has a configurable setpoint up button 1172 and a configurable setpoint down button 1174. Setpoint up button 1172 and setpoint down button 1174 can be configured to be displayed or hidden. Setpoint up button 1172 and setpoint down button 1174 can also be located in different places on configurable user interface 1170. Configurable

user interface 1170 also includes a setpoint value 1176 and room temperature 1178. Setpoint value 1176 and room temperature 1178 can be configured to display in degrees Fahrenheit, degrees Celsius, and degrees Kelvin. Configurable user interface 1170 may also be configured to display buttons. In FIG. 11D, configurable user interface 1170 is configured to display a settings 1180 button and a runtime report button 1182. The locations of the said buttons can be adjusted according to user preference. Configurable user interface 1170 can also include readouts such as fault status 1184 and the date 1186. These readouts can be adjusted and configured to user preference. In some embodiments, configurable user interface 1170 includes any user interface button, readout, text, and value that can be configured. In some embodiments, configurable user interface 1170 is configured through a smartphone application. In some embodiments, configurable user interface 1170 is configured through the user interface 612 of thermostat 600.

[0254] Referring now to FIG. 11E, table 1190 of example configurations of configurable user interface 1170 for multiple users is shown according to an exemplary embodiment. Table 1190 includes rows 1191-1193, each row corresponding to user preferences for configurable user interface 1170. Columns 1194-1198 include the user preferences for a particular setting. Column 1194 contains the preferred setpoints for the users. The setpoints are 78 degrees Fahrenheit, 75 degrees Fahrenheit, and 70 degrees Fahrenheit. Column 1195 contains the preferred units for each user. In some embodiments, the preferred units are the units for ambient temperature and/or setpoints displayed on configurable user interface 1170. Column 1196 contains the settings button location for the users. In some embodiments, any configurable button can have location preferences for a user. Column 1197 contains the faults preferences of the users. The fault preferences are not displayed, highest priority fault, and scroll. Highest priority fault may cause thermostat 600 to display the most critical fault on configurable user interface 1170. Scroll may cause faults to be displayed sequentially on configurable user interface 1170. Column 1198 contains the date format of the users. The date format for user 1 and user 2 is MM-DD-YYYY. The date format for user 3 is YYYY-MM-DD. Any configurable setting of thermostat 600 can be recorded and stored for a particular user. In some embodiments, the configurable user interface 1170 has an information field for displaying information. The information field displays information according to the detected user. For example, a configuration for one user may place

weather forecast information (downloaded from a web source) in the information field while a configuration for another user may place schedule information for the user in the information field. Other types of information to be displayed in the information field include sports scores, Face Book notifications for the user, particular HVAC characteristics (energy consumption, humidity, temperature (inside and outside), fault records. In some embodiments, when a maintenance personnel is identified as approaching the user interface the configurable user interface 1170 displays fault codes or fault messages in the information field.

[0255] In some embodiments, when thermostat 600 detects and identifies a user, the corresponding row of settings is applied. For example, if thermostat 600 detects and identifies user 3, thermostat 600 applies all the settings in row 1193. In some embodiments, if multiple users are detected and identified by thermostat 600, the settings are voted and/or averaged. For example, when thermostat 600 detects and identifies user 2 and user 3, thermostat 600 averages the preferred setpoints and sets the setpoint of thermostat 600 to the average value of user 2 and user 3. In some embodiments, the settings in rows 1191-1193 are received from user input into user interface 1170. In some embodiments, the settings in rows 1191-1193 are received from a mobile device. The mobile device may be at least one of a smartphone, a laptop, and a tablet. In some embodiments, each user is associated with a preferred schedule. When a user is identified, thermostat 600 runs the preferred schedule associated with the identified user.

[0256] In some embodiments, thermostat 600 may grant priority to one identified user over other identified users. For example, thermostat 600 may identify Charles and Thomas in Zone A. Thomas and Charles may both have respective preferred setpoints, preferred user interfaces, and/or other preferences. Thermostat 600 may be configured to implement the preferences of Thomas since Thomas has a higher priority level than Charles. In some embodiments, thermostat 600 may configure zones based on the identified occupants of a zone. For example, a building space has Zone A and Zone B. Charles may be identified in Zone A while Thomas may be identified in Zone B. Thermostat 600 may be configured to implement the preferences of Charles in Zone A while implementing the preferences of Thomas in Zone B.

[0257] Referring now to FIG. 12A, thermostat 600 may determine occupancy based on a schedule or calendar. In some embodiments, a user is able to input a schedule directly to the thermostat. In other embodiments, thermostat 600 may support integration with existing calendar applications. In step 1202, occupancy predictor 710 of memory 704 receives calendar data or a schedule from a user. Occupancy predictor 710 then determines when the user does not have any events scheduled in step 1204. In some embodiments, thermostat 600 may allow a user to input a schedule of times when she expects to be home. The periods of time identified in step 1204 are then stored as predicted periods of occupancy (step 1206). In some embodiments, thermostat 600 may store the predicted occupancy periods in remote data storage 718. In other embodiments, thermostat 600 may store the predicted occupancy periods locally in memory 704. In step 1208, operation commands are issued from thermostat 600 to the connected system based on the occupancy periods stored and the associated user's preferences.

[0258] In FIG. 12B, an exemplary embodiment of methods with which users may input calendar data is shown. Existing calendar application 1240 accessed on a mobile device with user Jack's schedule is shown. Existing calendar application 1242 accessed via a browser with user Jill's schedule is shown. In some embodiments, thermostat 600 may communicate with Jack or Jill's Google, iOS, or Outlook calendar and determine when he or she will be home or to determine expected occupancy based upon the appointment and event information obtained. Thermostat 600 may decide that a user will be home whenever he does not have an appointment scheduled. In some embodiments, thermostat 600 may be programmed to assume that a user will not be home on weekdays during the work day, in addition to appointments and engagements outside of those hours. Thermostat 600 may be able to determine when a user will be home based upon location information associated with events in his calendar. In some embodiments, thermostat 600 determines that Jill is having a party at her home and determines what time the party is at and how many attendees will be at the party by communicating with calendar application 1242. In some embodiments, thermostat 600 may be able to detect the network connectivity of a user's personal device – whether it is connected – to determine occupancy. In some embodiments, thermostat 600 may be able to detect the network connectivity of a user's personal device to determine what area of the home the user is in. Thermostat 600 may be able to

control conditioning to different areas, or zones, of a home depending on the duct and flow work. The network 1244, to which Jack is connected, may be identified and used to determine that he is in zone 1 of the home. The network 1246, to which Jill is connected, may be identified and used to determine that she is in zone 2 of the home.

[0259] In a multiple occupancy home, thermostat 600 may be able to make operating decisions based on occupancy. Thermostat 600 may be able to operate on different schedules for different detected users. In one embodiment, users may each enter their own schedule to thermostat 600 directly. In other embodiments, thermostat 600 may be able to communicate with external calendars and applications to determine a user's schedule. Thermostat 600 may be able to detect which user is home and adjust the operating schedule to accommodate that user's preferences. For example, in a home with multiple occupants and different schedules to keep to, thermostat may detect which user is home, and make operating decisions based on that user's settings and schedule. It is possible that thermostat 600 may have a different setting for guests or periodic visitors such as a housekeeper or a nanny. For example, thermostat 600 may operate at lower capacity when only the housekeeper is in the home, as opposed to when the entire family residing in the home is present.

[0260] In some embodiments, thermostat 600 may use data gathered from calendar application 1242 to adjust scheduling, adjust temperature setpoints, determine expected occupancy at a plurality of times, preemptively adjust conditioning, preemptively adjust heating and cooling setpoints, and preemptively adjust temperature setpoints. In some embodiments, expected occupancy is the occupancy of a building that will occur at a plurality of times based on data gathered from calendar application 1242. Thermostat 600 may determine that a user will not be home because they will be at an event at a location which is not home and adjust conditioning, adjust heating, and adjust temperature setpoints to operate more efficiently until it is anticipated that the user will return home. In some embodiments, adjusting temperature setpoints includes raising the temperature setpoints and/or lowering the temperature setpoints. For example, a user may have a dining event on calendar application 1242 from 19:00 until 22:00 one evening. Thermostat 600 may reduce conditioning or adjust temperature setpoints at 19:00 and, depending

on the expected time to the setpoint, may begin to preemptively increase conditioning or preemptively adjust temperature setpoints an appropriate amount at a time prior to 22:00. In some embodiments, thermostat 600 determines that an event on calendar application 1242 is occurring at home and adjust scheduling and occupancy accordingly. In some embodiments, thermostat determines that no users will occupy the premises during a particular time and will turn off air conditioning or increase the setpoint temperature a threshold number of minutes (e.g., 10 minutes) before all occupants are expected to be out of the house. The threshold can be programmable in some embodiments.

[0261] In a multiple occupancy home, it is common for users to have different schedules. Referring now to FIG. 12C, thermostat 600 is shown making operating decisions based on the intersection of schedules of the occupants. Thermostat 600 may use calendar information to determine how many users are home and adjust operation accordingly. Thermostat 600 may make decisions on operating procedure when more than one user is home. In one embodiment, thermostat 600 may compromise when users with different preferences are home. The process described in FIG. 12A may be adapted for situations in which conflicting preferences exist for multiple occupancy homes. Thermostat 600 may receive the schedule of two occupants of the home. Thermostat 600 compares the calendars detect occupancy based on when either occupant does not have an event scheduled. Thermostat 600 could create a merged calendar of the free times of the users. If only one user is home, his settings are applied, as shown in thermostat 600 schedule block 1274. Thermostat 600 determines an overlap in occupancy has been detected. For example, if one user prefers the home to be at 72 °F while another user prefers the home to be at 68 °F, and both users are home, thermostat 600 may compromise and set the temperature to 70 °F as shown in thermostat 600 schedule block 1272. In another embodiment, there may be a master user whose settings will override other users' settings. For example, one user prefers the home to be at 72 °F while another user prefers the home to be at 68 °F; however, the first user is the master user, so her settings are conveyed to the equipment as shown in thermostat 600 schedule block 1276. In another embodiment, if a user is already at home but the master user is detected afterward, her settings may be applied automatically upon her detection. In yet another

embodiment, thermostat 600 may keep an existing user's preferences until the master user commands an update.

[0262] Referring now to FIG. 13, thermostat 600 may be able to determine the operating conditions needed to reach a user's desired settings by the time they arrive. In one embodiment, thermostat 600 allows a user to program directly into thermostat 600 when she expects to be home and what settings she would like it to be. In another embodiment, thermostat 600 may access a user's external calendar and determine when she will be home as shown in thermostat 600 schedule block 1302. For example, if Jill is scheduled to be home at 1700 and would like her home to be at 72 °F when she arrives, thermostat 600 may begin to cool her home from a starting point of 76 °F at 1600, as shown in situational snapshot 1304. By 1630, as Jill is travelling, thermostat 600 has already cooled her home to 74 °F as shown in situational snapshot 1306. When Jill arrives home at 1700, her home is already at 72 °F, as shown in situational snapshot 1308. In another embodiment, thermostat 600 may be able to receive communication from a user while they are away to set their home at a certain temperature, which thermostat 600 may immediately command.

[0263] Thermostat 600 may be able to determine what kind of activities are occurring in the home and change operation based on occupancy level. In some embodiments, thermostat 600 is able to detect separate occupants of the home. In other embodiments, thermostat 600 determines occupancy level based on communication with connected equipment. For example, thermostat 600 may be able to estimate occupancy based on assumed load seen by the AC unit. In another embodiment, thermostat 600 may obtain activity information from a fitness tracker to determine the amount of activity related to a specific user. In yet another embodiment, thermostat 600 may use sensor 1102 to detect the amount of movement or activity occurring. For example, thermostat 600 may determine that a user is currently occupying a room, but that there is a low level of activity. Thermostat 600 may determine that the user is sleeping, and adjust conditioning accordingly. Thermostat 600 may determine that many people are in one room, and that there is a high level of activity, and increase conditioning accordingly.

[0264] Referring now to FIG. 14, thermostat 600 may adjust compressor staging in a connected AC unit based on occupancy. In one embodiment, thermostat 600 may detect a change in occupancy and adjust compressor staging accordingly. For example, thermostat 600 may detect that more motion is occurring, and increase staging to maintain temperature. In another embodiment, thermostat 600 may analyze the occupancy and activity level of the home and determine an appropriate staging progression. For example, there may currently be one person detected by thermostat 600, as shown in snapshot 1402. The compressor is currently operating in stage 1, as there is low occupancy. In snapshot 1404, thermostat 600 may detect from the home network that there are five people in the home, and command the compressor, currently at stage 1, to go through stages 2, 3, and 4 to stage 5. Thermostat 600 may then detect that there are ten people in the home, and command the compressor, currently at stage 1, to go directly to stage 5.

[0265] Thermostat 600 may be able to determine with some granularity where in the home a user is. In some embodiments, thermostat 600 communicates with a user's personal device 1104 and obtains GPS data to determine whether a user is home, and if so, where he is. In some embodiments, thermostat 600 uses a geofencing to determine what zone or room of the home a user is in and adjusts operation accordingly. Geofencing allows a boundary to be defined based on locational information. Thermostat 600 may adjust operation based on detected occupancy and location. For example, if a user is detected on the upper floor of a home, thermostat 600 may increase conditioning on the upper floor. Thermostat 600 could detect that there are no occupants on the lower floor and decrease conditioning to the lower floor.

[0266] Thermostat 600 may allow users to set their occupancy status through an application or as an input to thermostat 600. In some embodiments, a user may input their occupancy status through an object 1104 such as a cellphone. For example, Jill may set her status as "away." In some embodiments, different users may have different settings, and thermostat 600 may determine the level of occupancy from the status information received. In some embodiments, thermostat 600 is able to automatically update a user's status based on the connectivity of an object 1104 which, in some embodiments, is a cellphone.

[0267] In some embodiments, thermostat 600 may send push notifications to a user's cellphone 1104 depending on their detected location. For example, if Jill is detected to have left her home, thermostat 600 may display a prompt asking if she would like to set her status as "away." In some embodiments, when a user is away, the system associated with thermostat 600 goes into an energy efficient state which may not be comfortable to occupants remaining in the home. Thermostat 600 may allow a master user to override all commands given to thermostat 600 from other users. In some embodiments, if a master user is away, the system will go into an energy efficient state despite the occupancy of the home by other users. Thermostat 600 may display a warning to the master user that another user is still home, and ask whether she would still like to set her status as "away." For example, if Jill is the master user and is detected leaving her home, thermostat 600 may ask whether she would like to set her status to "away." If she chooses "Yes", thermostat 600 may warn her that Jack is still home, and that the system will go into an energy efficient state despite his occupancy. Thermostat 600 may ask whether a user is sure she wishes to change her status. If a user selects "Yes", the system will execute whatever command is associated with no occupancy.

[0268] Thermostat 600 may detect a user's location based on a zone sensor which may communicate through any communications protocol. For example, the zone sensor may use Bluetooth, NFC, WiFi, or any other communications protocol. In some embodiments, thermostat 600 may indicate the success or failure of detection of a user through the playing of a sound. In some embodiments, the sound may be unique for success or for failure. In some embodiments, an accompanying indicator may be displayed. For example, a message may be displayed, warning the user that they were not authenticated. The indicator may be as simple as a flashing LED.

[0269] Thermostat 600 may be adjust its communication behavior based on detected occupancy. In one embodiment, thermostat 600 may determine that a user is in the kitchen while thermostat 600 is in the living room. Thermostat 600 may attempt to communicate any changes in operation to the user through a speaker in the kitchen, or through the user's portable electronic device since the user cannot see the screen of thermostat 600.

[0270] Thermostat 600 may be able to learn from user behavior, and store data to adapt operation and better serve users. In one embodiment, thermostat 600 may analyze the location data obtained and determine the location in which a user spends a majority of his time in. Thermostat 600 may set that location as a priority to condition over all locations in the home. In another embodiment, thermostat 600 may allow users to set their preferred priority space.

[0271] Thermostat 600 may be able to learn from outside sources how to adjust operation. In some embodiments, thermostat 600 stores the date and time at which occupancy is being detected. Thermostat 600 may determine, based on the season, what an appropriate conditioning command might be. Thermostat 600 may be able to learn what an appropriate adjustment to standard operating conditions might be based on historical data collected from the home.

[0272] Thermostat 600 may make adjustments to standard operating condition based on the frequency at which occupancy is detected. A user is detected at one time. Some amount of time later, the user is detected again. Thermostat 600 will make an operating decision based on the time in between detections. In one embodiment, sensors 602-606 are one motion sensor and thermostat 600 detects occupancy purely on motion. For example, a pet cat may walk past the sensor several times a minute, causing thermostat 600 to detect “high occupancy.” However, thermostat 600 may have a threshold frequency past which it decides that it should not be considering each detection as a separate event. In another embodiment, thermostat 600 may detect a user’s device connecting to the home network at a high frequency, possibly due to faulty components. Thermostat 600 may decide that the high level of activity is not genuine, and cancel adjustments accordingly.

[0273] Thermostat 600 may receive identifying information when detecting occupancy. In one embodiment, thermostat 600 may use sensors 602-606, in one embodiment, a plurality of cameras, to detect and identify separate users. In another embodiment, thermostat 600 may receive user information from the user’s portable electronic device. In yet another embodiment, thermostat 600 may communicate with the network to receive user information from devices connected to the network. Thermostat 600 may store personalized settings and control configurations for each associated device. Thermostat 600 may load settings from the network to

adjust the user interface in accordance with the user detected. For example, a user may prefer to have a user interface with only temperature adjustment, whereas another user may prefer to have a user interface which allows her to access every option available. Thermostat 600 may allow users to create a personalized home screen which displays information the user is most interested in.

[0274] Thermostat 600 may display different information based on the user detected. In some embodiments, thermostat 600 is able to distinguish between occupants based on information received from sensors 602-606. One of sensors 602-606 may be a camera, a motion sensor, a microphone, or any other conceivable sensor which could be used to detect occupancy. Thermostat 600 may only display the current temperature if a child or a pet is detected. In some embodiments, thermostat 600 may detect and identify the user based on their identifiable personal device, and display a screen of her choice. For example, if a user prefers to see how long it will take to reach her settings, she can select that screen as the default screen when she is detected in the home. In another embodiment, thermostat 600 may display the most used screen. For example, if the temperature screen is used the most out of all screens available, thermostat 600 may display the temperature screen whenever occupancy is detected.

Near Field Communication Based Control and Operation

[0275] Thermostat 600 may be able to base control and operation decisions on data obtained through near field communication (NFC). In one embodiment, a user brings personal electronic device 1502 within range of an NFC transmitter integrated with thermostat 600, as shown in FIG. 15A. This may be referred to as “checking in.” In some embodiments, the NFC uses one or more of a set of communication protocols that enable the thermostat 600 and the electronic device 1502 to establish communication by bringing them within less than 10 cm (about 4 cm (2 in)) of each other. Other distances can be available using NFC depending upon application parameters and design criteria. The NFC can use electromagnetic induction between loop antenna disposed on the thermostat 600 and the electronic device 1502. In some embodiments, the electronic device 1502 is a mobile device such as a smartphone or a tablet that is NFC enabled. In some embodiments, the electronic device 1502 is a key fob.

[0276] With reference to FIG. 15B, a process 1550 is shown according to an exemplary embodiment where thermostat 600 issues an operation command in response to NFC. In step 1552, thermostat 600 may receive identifying information through NFC. This information may include preferred settings for thermostat 600. Upon authentication and identification of the user through electronic device 1502, thermostat 600 is receptive to commands (step 1554). In some embodiments, thermostat 600 may provide an audible indication that the scan has occurred. For example, thermostat 600 may beep to let users know that scanning has been completed. In other embodiments, thermostat 600 may provide visual feedback that scanning has occurred. For example, thermostat 600 may flash display 802. In another embodiment thermostat 600 may communicate to device 1502 to provide an indication, such as beeping, flashing, or vibrating, that scanning has occurred. Thermostat 600 may alert the user that scanning has occurred in any number of ways not limited to those enumerated. Upon receiving a command in step 1556, thermostat 600 then transmits the command to connected equipment (step 1558).

[0277] Still referring to FIG. 15B, the operation command can be a command to adjust setpoints, fan settings and any other setting of the connected equipment (step 1558). In some embodiments, the operation command adjusts the settings of the connected equipment to settings associated with a user. In some embodiments, the issued command is a command to make changes to the user interface 612 of thermostat 600. The changes may be backlight settings, sound settings, schedule settings, banner settings, language settings, temperature scale settings, branding settings, and current time. In some embodiments, the issued command may be a temporary command based on a user's preference. For example, Steve may want all thermostat sounds to be off when he is checked into thermostat 600. Steve checks into thermostat 600 with user device 1502 and a command is issued to turn off all sound on thermostat 600. However, when another user Karen checks into thermostat 600, the sound is turned back on. In some embodiments, settings of thermostat 600 are updated or synchronized. For example, Daniel checks in with thermostat 600 with user device 1502. Thermostat 600 may receive the current time from user device 1502 and synchronize the time held on thermostat 600 with the time on user device 1502.

[0278] In some embodiments, thermostat 600 may detect that no users have been associated, and may display a prompt on display 802 or on device 1502 with a tutorial on how to set up thermostat 600. For example, if thermostat 600 has just been installed and has no associated users and detects Jill's phone, thermostat 600 may display a message on Jill's phone asking whether she would like a tutorial of how to set up thermostat 600, or if she would like a walkthrough of any of the features of thermostat 600.

[0279] In multiple occupancy homes, thermostat 600 may allow multiple users. In some embodiments, a user may designate themselves as the master user, and may be able to override all commands to thermostat 600 from other users. In some embodiments, a new master user may be designated through an NFC check in based on the identifying information received by thermostat 600. For example, master user Jill may leave for work early in the morning while Jack remains at home until the afternoon. Jack may be able to check in and become the new master. In some embodiments, when a master checks into thermostat 600, the settings of thermostat 600 may be adjusted to the preferred settings of the master even if other users are checked into thermostat 600. For example, Jack checks into thermostat 600 and changes the temperature setpoint to 70 degrees Fahrenheit. Andre, the current master of thermostat 600, checks into thermostat 600 and has a default setpoint of 75 degrees Fahrenheit. Thermostat 600 automatically changes the setpoint from 70 degrees Fahrenheit to 75 degrees Fahrenheit since Andre is the master of thermostat 600.

[0280] In some embodiments, thermostat 600 may automatically execute commands communicated through NFC. Users may be able to queue commands to thermostat 600 on their electronic device and transmit them through the use of NFC. In some embodiments, a user may send commands directly through user interface 612. In other embodiments, a user may send commands through electronic device 1502. For example, an application made by Johnson Controls Inc. for interacting with thermostat 600 may be available for download to a user's device. In some embodiments, if a user has not downloaded the application, thermostat 600 may be able to detect this and activate a prompt which asks the user if they would like to install the application. Thermostat 600 may be able to communicate with the network and initiate the

installation process for the application. In other embodiments, a web-based application may be available for use with thermostat 600. For example, Johnson Controls Inc. may create an application which users can access from any device with network connectivity.

[0281] In FIG. 16A, thermostat 600 is communicating with network 1602 to receive information which thermostat 600 then transmits to device 1502. In some embodiments, network 1602 is a cloud storage service. In other embodiments, network 1602 may be a LAN or any other type of network, and may allow access to the Internet.

[0282] Referring now to FIG. 16B, thermostat 600 communicates over NFC with device 1502 which communicates with the network. Thermostat 600 may command device 1502 to retrieve information from network 1602 instead of transmitting the data over NFC. This embodiment and the previous embodiment are critically different in the flow of information.

[0283] Thermostat 600 may be able to receive billing information from device 1502. A user may wish to analyze their usage and their bill to make decisions regarding their behavior moving forward. In some embodiments, a user may be able to bring device 1502 within range of thermostat 600 and transmit bill information to thermostat 600. In some embodiments, the information is transferred over NFC after authentication of the user and device 1502. In other embodiments, the user and device 1502 are authenticated over NFC, and a command is sent to thermostat 600 to retrieve bill information from the network. The information retrieved may be in the form of Excel data, an XML file, a .txt file, any file type with tags, or any number of data formats. A user may be able to pay their bill over NFC through protocols such as Android Pay or Samsung Pay.

[0284] In FIG. 17, process 1700 is an exemplary method through which thermostat 600 may preprocess stored data in order to send performance reports to device 1502 almost instantaneously. In some embodiments, device 1502 is able to quickly pull raw data via NFC from thermostat 600 to generate performance reports on topics such as energy management. Thermostat 600 may store data within a memory integrated with the device itself. In some embodiments, thermostat 600 may store data in the network. In step 1702, thermostat 600 prepares reports for download by device 1502 in advance of a request for a report. Device 1502

checks in over NFC with thermostat 600 and is authenticated (step 1704). Once device 1502 is authorized to download reports from thermostat 600, the analytics are downloaded for immediate display in step 1706. The entire process is streamlined to provide users with quick updates of their system performance. In some embodiments, generated reports pertain to energy management. In other embodiments, reports pertain to system operating parameters and performance metrics such as time-to-setpoint. In some embodiments, reports may be sent to a different authorized device after check in and specification by the user. The state and operation parameters of an HVAC system are constantly changing. In some embodiments, placing device 1502 on thermostat 600 provides a user with a snapshot of the system which includes information such as the system state, setpoint, current temperature.

[0285] Referring now to FIG. 18, the process of locking thermostat 600 over NFC is shown. A user (in this exemplary process, Jill) may check in with thermostat 600 with device 1802 and send the command to lock operation. Thermostat 600 receives the command and locks operation until another command is received. All attempts to input commands from other users (device 1806), pets, or small children (baby 1804) will be denied. Upon check in from the same user's device, cellphone 1802, which locked thermostat 600 and receiving the unlock command, thermostat 600 may resume operation and become receptive to commands from other users. In some embodiments, thermostat 600 may be commanded to allow other authorized users who check in to unlock operation. For example, Jill could send a command authorizing Jack to unlock operation – no one but Jack and Jill can unlock thermostat 600. In other embodiments, a user may be able to lock thermostat 600, but a master user may be able to unlock thermostat 600 without specifically being authorized to do so. For example, Jack may lock thermostat 600 without designating anyone else as an authorized user; because Jill is a master user, Jill can unlock thermostat 600. In some embodiments, a user may have more than one device associated with him and thermostat 600 may recognize all devices and allow him to lock and unlock devices with different devices associated with him. In some embodiments, a password or PIN is set for thermostat 600 via device 1802. For example, Jill may check in with thermostat 600 with device 1802 and set a PIN for the thermostat 600. Thermostat 600 can then be locked or unlocked with the PIN that Jill has set via device 1802.

[0286] Referring now to FIG. 19, an exemplary process 1900 for changing zones based on the user is shown. It is contemplated that there are multiple conditioning zones in a home, and that an NFC tag or sensor may be installed in each. Depending on the zone in which a user checks in, thermostat 600 may automatically receive commands to adjust settings for that zone. Jack, a user is shown checking in with an NFC tag on the first floor, or zone 1, of his home in step 1092.

Once Jack's device 1502 is authenticated, thermostat 600 receives an automatic command to adjust settings of zone 1 to Jack's preferences in step 1904. Jack is then shown to check in on the second floor of his home in step 1906. Once Jack's device 1502 is authenticated, thermostat 600 receives an automatic command to adjust settings of zone 2 to Jack's preferences in step 1908. In a multiple occupancy home, thermostat 600 may support multiple settings for each zone. In some embodiments, thermostat 600 may adjust each zone to a different user's preferences. In other embodiments, thermostat 600 may decide that zones in which a user has not checked in are not occupied, and therefore adjust or reduce conditioning in those zones. A user may be able to save preferred zones as part of their settings. For example, if a home is divided into zones such that there is one zone for each room, a user may save their bedroom as their preferred zone. Upon check in at any of the NFC sensors in the home, settings for their preferred zone will be communicated to thermostat 600, which will control the appropriate connected equipment. In some embodiments, multiple users can check into a zone. For example, Felix, Mark, and Jack all check into zone 1 in step 1902. Thermostat 600 receives an automatic command to adjust setting of zone 1 according to Felix, Mark, and Jack's preferences in step 1502. In some embodiments, thermostat 600 averages the setting of Felix, Mark, and Jack. In some embodiments, thermostat 600 identifies one of Felix, Mark, and Jack as a master and sets the preferences of zone 1 to the master's preferences.

[0287] In some embodiments, the thermostat 600 receives an automatic command to display a particular user interface when Jack checks in with the NFC tag in zone 1 or zone 2. In some embodiments, the NFC tag in zone 1 and zone 2 is the thermostat 600 and/or a remote NFC tag communicably coupled to thermostat 600. In some embodiments, Jack creates a custom user interface for thermostat 600. The custom user interface can include a set of interface items which have been selected by Jack for inclusion in the custom user interface. In other words, Jack can

create a custom user interface displaying Jack's selected user interface items. The user interface items can include, for example, a relative humidity value, a temperature value, a temperature setpoint, a time and date, a user interface background, a set of user interface buttons, a user interface color scheme, and/or other items which can be displayed via the user interface. In some embodiments, the thermostat 600 is configured to run a heating or cooling schedule specific to Jack in zone 1 when Jack checks in with the NFC tag in zone 1. Similarly, the thermostat 600 can be configured to run a heating or cooling schedule specific to Jack in zone 2 when Jack checks in with the NFC tag in zone 2. As Jack moves from zone to zone, Jack can check in with the NFC tag in each zone to cause his user-specific heating or cooling schedule to follow him from zone to zone.

[0288] Referring now to FIG. 20, an exemplary process 2000 for adjusting conditioning when a user is between zones is shown. In many homes, the only thermocouples or other temperature sensors are the ones integrated with the thermostats. In step 2002, thermostat 600 may detect that a user is not in just one zone. Thermostat 600 sends a prompt to be displayed on user's device 1502 which asks whether it is cool enough. If the user feels that it is not cool enough, despite the thermostat's sensor reporting that the desired temperature has been reached, he may choose to say "No." Thermostat 600 then adjusts the operating conditions of one of the zones the user is between. Once the conditions have stabilized, thermostat 600 sends another prompt to be displayed on user's device 1502 which asks whether it is cool enough (step 2004). If the user still feels that it is not cool enough, in step 2006, thermostat 600 adjusts the operating conditions of another zone the user is between. Thermostat 600 repeats this process until the user responds in the affirmative. This process could be used for heating, for adjusting humidity, etc. and is not limited to cooling.

[0289] Referring now to FIG. 21, thermostat 600 may be able to detect faults or receive messages reporting faults from connected equipment. When a fault is detected, thermostat 600 may alert users by sending a prompt to the users' devices when the user checks into the thermostat 600 through NFC. In some embodiments, the fault displayed on device 1502 includes information describing the fault. In some embodiments, the information includes the time at

which the fault occurred, the runtime of the equipment, the last mode of operation, the stage, maintenance information, the name of the fault, the fault code, and any other information related to describing the fault. For example, if a compressor is not functioning correctly and this malfunction is detected, thermostat 600 may send a prompt to device 1502 notifying the user that the compressor is not performing as expected. In some embodiments, thermostat 600 may contain contact information for the dealer or an authorized repair company. Thermostat 600 may include the contact information in the prompt, or provide it when a user indicates that they would like to call for help. For example, thermostat 600 may ask a user if they would like to contact the dealer, and offer to dial the dealer's number if a user chooses to accept. In some embodiments, thermostat 600 uses NFC to send the dealer's number to the user's phone when the user places his phone on thermostat 600. In some embodiments, thermostat 600 may generate an estimate for repair costs based on historic data. In other embodiments, thermostat 600 may receive communication from the dealer with an estimate of the repair based on the information transmitted.

[0290] Still referring to FIG. 21, device 1502 may be prompted to email a document to the dealer or authorized repair company when device 1502 checks in with thermostat 600 and thermostat 600 has a fault. In some embodiments, the document is an attachment to an email. In some embodiments, the document is the text body of the email. The email can include information relating to the system and a description of the fault so that the fault can be diagnosed. The description of the fault can be a fault code or a fault name. The information relating to the system can include equipment runtime, last mode of operation, stage at which fault occurred, superheat/subcool information, voltage, current, power, maintenance information, fault/event log, and any other such information that is related to the fault. In some embodiments, the email is automatically populated with the thermostat serial number as the subject line of the email.

[0291] Thermostat 600 may be able to provide different user interfaces and make different options available depending on the user. As shown in FIG. 22A, thermostat 600 may have an operating mode targeted to dealers which allows for configuration of thermostat 600 before

purchase by the end user. A technician is shown to use dealer authorized device 2202. In some embodiments, thermostat 600 in dealer mode will allow a dealer to apply a custom configuration specific to their dealership. The dealer may program in their contact information to be displayed when a fault is detected. The dealer may choose to include their logo, custom messages, and specific settings for system parameters. The dealer may configure any aspect of the thermostat. In some embodiments, the dealer may contact the customer before purchase and configure the settings to the customer's specifications. The dealer may be able to include fault suppression rules, such that minor faults are not displayed to the user to prevent undue concern. For example, faults related to energy efficiency may not be displayed to the user. In some embodiments, the dealer may be able to demote faults to prompts such that a user remains informed, but does not become distressed. For example, if a user's AC unit is not functioning as efficiently as it could, the dealer may demote the fault to a prompt which notifies the user that current outside conditions make it difficult to operate at maximum efficiency. In some embodiments, dealers may edit the language of the faults. For example, if a catastrophic failure of the system occurs, a dealer may change the language of the fault notification to a less panic inducing message.

[0292] Referring now to FIG. 22B, thermostat 600 may follow different procedures for reporting faults when a dealer is the user checked in. Information may be transmitted to the dealer or repairman over NFC. In some embodiments, the information itself is not sent – instead, a key or command is sent to the device to retrieve the information from the network. In some embodiments, thermostat 600 is able to send the dealer or repairman to the appropriate troubleshooting page for the specific model of equipment being worked on. Troubleshooting techniques and common problems and their solutions may be displayed. In some embodiments, thermostat 600 may communicate where variations in the system and most commonly identified trouble junctions are during installation. Thermostat 600 may store performance data and fault data. In some embodiments, this data is stored in memory integrated with thermostat 600. In other embodiments, this data is stored in the network and accessed by thermostat 600 when needed. Thermostat 600 may be able to produce a system performance history report. In some embodiments, thermostat 600 may produce a fault history report or any number of analytic reports on the operation of the system.

[0293] Referring now to FIG. 23, equipment connected to thermostat 600 may include RFID tags which can be scanned by thermostat 600 or the device of an installer. AC unit 2302 and furnace 2304 are shown to include RFID tags. The RFID tags may contain identifying information such as the serial number, model, and install date. For ease of installation, the RFID tags may link to installation instructions unique to the model of equipment being installed. In some embodiments, other information such as wiring diagrams and set-up guides may be available upon scanning the RFID tag of the respective piece of equipment. Thermostat 600 may send a key to access the information over NFC along with a command to retrieve the information from the network. The information may be displayed on dealer authorized device 2202 or another authorized device. In some embodiments, the information may be displayed on display 802 of thermostat 600. In some embodiments, dealers may be able to input the warranty information for the system to be made available to the user if requested from thermostat 600. In some embodiments, the warranty information and period may be automatically applied during installation via NFC. In some embodiments, a user is able to retrieve warranty information from thermostat 600 via NFC by placing device 1502 on thermostat 600.

[0294] It should be noted that some or all of the features disclosed above described with respect to advanced functions and modes available to dealers and installers may also be available to end users, if desired.

Smart Thermostat and Equipment Communications

[0295] Most commercial thermostats available to consumers are only capable of uni-directional communication: switching on or off connected equipment. Thermostat 600 is capable of bi-directional communication with connected equipment in the system. Referring to FIG. 24, it is shown that thermostat 600 is capable of communicating with a variety of devices, such as light system 2404, refrigerator 2406, security system 2408, blinds or windows 2410, door 2412, or fitness tracker or other wearable 2414, either directly or through an intermediary. Thermostat 600 may communicate directly with connected HVAC equipment 2420. Thermostat 600 may communicate with services such as weather service 2416, utility provider 2418, network 2422, or server 2424. In some embodiments, thermostat 600 communicates with devices through router

2402 to which the devices are connected. In other embodiments, thermostat 600 communicates with devices through network 2422 with which the devices are connected. User owned portable electronic devices with which thermostat 600 may communicate include device 1502, laptop 2426, or tablet 2428. It is understood that the resources with which thermostat 600 is shown to be connected are not meant to be limiting, and that thermostat 600 may be connected with any number of devices, services, and systems. Communication may occur over any of a number of protocols: communication may occur over wired or wireless venues. Communication may occur over WiFi, Bluetooth, LAN, TCP/IP, etc.

[0296] Referring now to FIG. 25A, thermostat 600 is able to receive information used to calculate metrics such as assumed load and current energy consumption due to its bi-directional communication abilities. Thermostat 600 is shown to be connected with network 2422, through which thermostat 600 may communicate with dealer 2502, weather service 2416, analytics service 2504, or utility provider 2418. Thermostat 600 is shown to be communicating directly with HVAC equipment 2420. It is understood that the resources with which thermostat 600 is shown to be connected are not meant to be limiting, and that thermostat 600 may be connected with any number of devices, services, and systems. The history of the system, including equipment operating performance, can be stored either in memory integrated with thermostat 600 or in network 2422 for later access.

[0297] Thermostat 600 may analyze the data through analytics service 2504. Analytics service 2504 may be an embodiment of analyzer 712 of memory 704, which is integrated with thermostat 600, or may be a remote module able to communicate with thermostat 600 in any of the ways in which thermostat 600 is able to communicate: through wired or wireless protocols. Thermostat 600 and analytics service 2504 may be able to use historical data from the system with which it is associated as well as other systems connected to the network which are similar in size and equipment configuration. Thermostat 600 may be able to use local equipment history or history stored in network 2422 of similar equipment to educate a user on the capabilities of his system. Analytics service 2504 may have algorithms available to it, as well as a store of historical calculations and analysis from which it may provide informed estimates. Thermostat

600 may receive basic operational data from connected equipment which it then transmits to analytics service 2504. Analytics service 2504 may use feedback from connected equipment to make accurate estimates and to detect faults. For example, analytics service 2504 may determine that despite the AC unit operating at maximum settings for the past 20 minutes, no change in temperature has been detected. Analytics service 2504 may then generate an error message for thermostat 600 to communicate to a user. Analytics service 2504 may also be able to detect problems such as capacity incongruences and staging malfunctions. It is understood that analytics service 2504 is not limited to detecting problems explicitly enumerated.

[0298] Thermostat 600 may connect with a commercial energy management software which provides tools to users. These tools may allow users to create reports using variables in which they are interested. In some embodiments, thermostat 600 may transmit all data received to the commercial energy management software for processing and presentation to a user. Thermostat 600 may receive results and reports from the energy management software for display to a user on a portable device or on display 802. In some embodiments, thermostat 600 may generate the results and reports and display the results and reports to the user on portable device 1502 or on display 802. In some embodiments, the report includes the energy usage of HVAC equipment connected to thermostat 600. In some embodiments, the report includes operating parameters of the HVAC equipment and the associated energy usage for the operating parameters. In some embodiments, the report includes runtime costs for different stages of the HVAC equipment. In some embodiments, the report include equipment replacement suggestions. In some embodiments, thermostat 600 generates the results and reports and display the results and reports to the user on portable device 1502 or on display 802. Advantages of not processing data locally include reduced cost of units for consumers and simplicity of updating or patching functionality. Thermostat 600 may be compatible with a plug in which communicates with thermostat 600 and a standalone program. The plug in may detect parameters such as current draw, and may be able to detect actions of the system early through monitoring current draw or other such parameters.

[0299] Analytics service 2504 may combine a user's energy usage data with their energy bill to report on the fiscal effects of a user's behavior. Thermostat 600 is able to communicate with a

user's device which may authorize thermostat 600 to receive billing information. In some embodiments, thermostat 600 may help a user reduce their energy bill by integrating demand-response information into the report. In some embodiments, thermostat 600 is able to develop a cost analysis of a user's energy behavior. For example, thermostat 600 may be able to receive demand-response feedback from a utility provider or smart meter which can be analyzed along with a user's energy usage to inform the user of the effects of their usage behavior.

[0300] In some embodiments, thermostat 600 may alert a user of the overall health of HVAC equipment 2420 connected to thermostat 600. The health of HVAC equipment 2420 may be determined by monitoring the HVAC equipment 2420 connected to thermostat 600. In some embodiments, thermostat 600 may monitor vital system components such as a compressor, an outdoor fan, an accumulator, and any other piece of HVAC equipment. In some embodiments, thermostat 600 may use temperatures and pressures of the HVAC equipment 2420 obtained through thermistors and pressure transducers to identify any impending issues with the HVAC equipment. The impending issues may also be identified through infrared thermal imaging. Infrared sensors may monitor components of the HVAC equipment 2420 and identify any abnormalities in the heat signatures of the HVAC equipment 2420. In some embodiments, HVAC equipment 2420 sends fault information to HVAC equipment 2420.

[0301] In some embodiments, thermostat 600 displays a status indicator on user interface 612 associated with the overall health of the HVAC equipment 2420. The status may also indicate the current health of thermostat 600. The status indicator may be a small flashing circle on user interface 612, a colored button on user interface 612, or any other user interface item used to display the health of connected HVAC equipment 2420. Thermostat 600 may display a green status indicator when there are no faults and no impending issues are detected. The green status indicator may be displayed when the HVAC equipment 2420 is fully functional. The HVAC equipment 2420 may be determined to be fully functional when the HVAC equipment 2420 operates at a defined system health level. Thermostat 600 may display a yellow status indicator when maintenance is needed on the HVAC equipment 2420, a minor fault has been identified, and/or the HVAC equipment 2420 is operating below the defined performance level. In some

embodiments, the yellow status indicator may be displayed along with a suggestion to perform maintenance on the HVAC equipment. The maintenance may be cleaning an air filter, checking pipes for leaks and/or checking pipes for blockage. Thermostat 600 may identify that a user has attempted the suggested maintenance and can perform a full system check to determine if the health of HVAC equipment 2420 has increased. In some embodiments, thermostat 600 may display a red status indicator when the HVAC equipment and/or thermostat 600 have stopped working and/or encountered a major system fault. Thermostat 600 may prompt the user to call a technician by displaying a technician or dealer number on the user interface 612 of thermostat 600 when the red status indicator is displayed.

[0302] In some embodiments, thermostat 600 automatically configures settings based on the connected HVAC equipment 2420. Thermostat 600 may be preprogrammed with the square footage of the building it is located in, receive the square footage from analytics service 2504, receive the square footage from HVAC equipment 2420, and/or receive the square footage through user interface 612. Thermostat 600 can use the square footage of the building it is located in and relevant information received from HVAC equipment 2420 to identify setpoints that are achievable and do not use excessive amounts of energy. Setpoints that do not use excessive amounts of energy may result in reduced equipment runtime and cost savings for a user. For example, thermostat 600 may communicate to HVAC equipment 2420 and learn ratings of the HVAC equipment 2420. One rating may be a BTU rating. Setpoints may be chosen based on the BTU rating of the HVAC equipment 2420 and the square footage of the building thermostat 600 is located in to eliminate excess energy consumption. In some embodiments, setpoint suggestions may be made to a user through interface 612. The setpoint suggestions may be setpoints that do not consume excessive amounts of energy.

[0303] In some embodiments, thermostat 600 determines the energy consumption of HVAC equipment 2420. Thermostat 600 may display a report to a user through user interface 612 identifying how setpoints, schedules, and/or system overrides affect energy consumption. In some embodiments, thermostat 600 generates the report based on power consumption of HVAC equipment 2420. A power meter may be used to measure the power consumption of HVAC

equipment 2420. In some embodiments, the power meter is a combination of a volt meter and an amp clamp. In some embodiments, each piece of HVAC equipment has its own power meter. The report may identify the power consumption of each piece of HVAC equipment individually.

[0304] In some embodiments, thermostat 600 may adjust settings of HVAC equipment 2420 when the HVAC equipment has reached an ideal condition. An ideal condition may be achieving a requested setpoint. Thermostat 600 may adjust the settings of HVAC equipment 2420 such that excessive starting and/or stopping of HVAC equipment 2420 is avoided. Thermostat 600 may change fan speeds, temperature setpoints, and/or any other applicable setting that will avoid excessive starting and stopping of the HVAC equipment 2420. Avoiding starting and stopping may result in lower energy costs and may increase the life span of HVAC equipment 2420.

[0305] Referring now to FIG. 25B, thermostat 600 is able to receive information that can be used to determine expected occupancy. Thermostat 600 is shown to be connected to the network 2422, through which thermostat 600 communicates to one or more social media servers 2506, one or more mobile application servers 2507, and/or one or more calendar servers 2508. It is understood that the resources with which thermostat 600 is shown to be connected are not meant to be limiting, and that thermostat 600 may be connected with any number of devices, services, and systems. In FIG. 25B, user 2510 is connected to network 2422 via a user device 2512 with which the user can communicate to the social media server 2506, the mobile application server 2507, and/or the calendar server 2508. In some embodiments, user device 2512 includes a plurality of devices. In some embodiments, the devices include a cellphone (e.g. smartphone), a laptop computer, a tablet, a desktop computer, and any other such computing device. In some embodiments, the network 2422 is the Internet and thermostat 600 may communicate to the Internet via data communications interface 610. Data communications interface 610 can connect the thermostat 600 to the Internet via Wi-Fi, Bluetooth, Zigbee, Ethernet, and any other communication method enabling thermostat 600 to connect to the Internet.

[0306] In FIG. 25B, the social media servers 2506 are a plurality of social media servers. The social media servers 2506 can include Facebook, MySpace, Twitter, Tumbler, Snapchat, and Instagram. It is understood that the social media servers 2506 with which thermostat 600 is

connected are not meant to be limiting, and that thermostat 600 may be connected with any number of social media servers 2506. The mobile application server 2507 can include a server for any application running on user device 2512 that utilizes user device 2512 location or a GPS built into user device 2512. In some embodiments the servers include a Pokemon Go server, a Google maps server, an Apple maps server, and any other such server running an application that user the GPS of user device 2512. The calendar servers 2508 include a plurality of calendar servers. The calendar servers 2508 can include at least one of Google Calendars, iOS Calendars, Outlook Calendars, and iCal. It is understood that the calendar servers 2508 with which thermostat 600 is connected are not meant to be limiting, and that thermostat 600 may be connected with any number of calendar servers. User 2510 can have accounts on the social media servers 2506 and the calendar servers 2508. In some embodiments, the social media data or calendar data is stored on user device 2512, and the thermostat 600 receives the social media data or calendar data from the user device 2512 directly using point to point communication or via the network 2422.

[0307] Referring now to FIG. 25C, a process 2520 for thermostat 600 is described according to an exemplary embodiment. Thermostat 600 is configured to query the social media servers 2506, the mobile application servers 2507, and/or the calendar servers 2508 for information (step 2522). In some embodiments, the information includes occupancy of a building at a plurality of times, a geolocation of user 2510, any other information that can be used to determine occupancy of a building, and a command to change a setpoint. The social media server 2506, the mobile application servers 2507, and the calendar servers 2508 respond accordingly to each query of thermostat 600 by sending thermostat 600 the requested information via the network 2422 (step 2524). The thermostat 600 uses the information received from the social media servers 2506, the mobile application servers 2507, and the calendar servers 2508 to determine the expected occupancy of the building at a plurality of times (step 2526). In some embodiments, the thermostat 600 determines the number of occupants of a building, the length of time the occupants will be in the building, and when the occupants are in the building. The thermostat 600 adjusts setpoints and heating and cooling of the building based on the user occupancy (step 2528) determined in step 2526. In some embodiments, the thermostat 600 receives private

messages, public social media posts, private social media posts, and post comments that command setpoint changes. In some embodiments, the commands are directed to the thermostat. For example, Philip may send a direct message to thermostat 600 reading, "Raise the temperature setpoint in here!". In some embodiments, the thermostat 600 monitors Philips social media activity.

[0308] Referring to FIG. 25D, the thermostat 600 is subscribed to social media server 2506, mobile application servers 2507, and calendar servers 2508 (step 2532). When new information is entered into the servers associated with the user 2510 or there is activity associated with the user 2510 on the servers, the servers are configured to push information to the thermostat 600 (step 2534). In some embodiments, the information includes occupancy of a building at a plurality of times, a geolocation of user 2510, any other information that can be used to determine expected occupancy of a building, and a command to change a setpoint. In some embodiments, the thermostat 600 determines the number of occupants of a building, the length of time the occupants will be in the building, and when the occupants are in the building from the information pushed to thermostat 600 (step 2534). The thermostat 600 adjusts the setpoints and the heating and cooling of the building based on the expected occupancy (step 2538). In some embodiments, the thermostat 600 increases a setpoint or decreases a setpoint based on the expected occupancy. For example, the thermostat 600 receives information regarding Charles' schedule from calendar server 2508. Calendar server indicates that Charles will be in the building at 7:00 P.M. Thermostat 600 adjusts the setpoints at 7:00 P.M. to setpoints which Charles has identified as his preferred setpoints

[0309] Referring now to FIG. 26B, several processes through which a user can control her energy usage and resulting energy bill are shown. In process 2602, display 802 of thermostat 600 is shown. Thermostat 600 may suggest setpoints to help a user reach her target bill amount. In step 2604, a user is asked to input her current monthly energy bill and their current setpoints. For example, Jill may currently be paying \$350 a month in energy bills by keeping her setpoints at 68 °F in the summer and 76 °F in the winter. In step 2606, the user is asked to input her target bill amount. Jill may wish to reduce her bill to \$250 a month. In some situations, the target bill

amount is not possible. Thermostat 600 may display a warning to the user that her target is unachievable under the current operating conditions. For example, it is the coldest winter in Jill's area in 100 years. In order to keep temperatures at a livable level and prevent damage to the plumbing, the temperature needs to be kept at or above 65 °F. In another situation, it is the hottest summer in Jill's area in 100 years. The units in Jill's home are not equipped to efficiently cool a house of that size to a livable temperature. Thermostat 600 is unable to save enough energy to reduce Jill's monthly bill to \$250 and when she inputs her target payment as \$250, thermostat 600 may flash a message which reads "Current operating temperatures prevent me from reaching your target bill amount. We are on track to having a bill of \$300 this month." When the target bill amount is possible, thermostat 600 may change the setpoints to the setpoints suggested to the user. In one embodiment, a user may input her own preferred setpoints to see what her monthly bill may be if she does not make changes to her energy usage. In step 2608, for example, Jill may input her preference for 70 °F and 74°F. Thermostat 600 may determine that based on local historical equipment data, Jill's monthly bill with her current settings will be \$230. In some embodiments, thermostat 600 may use data from the history stored in network 2422. Thermostat 600 may communicate the need to have the data analyzed by data analytics service 2504. Thermostat 600 may communicate with other devices connected to network 2422 and display information on connected devices. In some embodiments, thermostat 600 may display all data and communications on a user device 1502.

[0310] Still referring to FIG. 26B, in process 2624, thermostat 600 may allow a user to track their usage relative to their target. In step 2626, thermostat 600 shows on display 802 a user's energy usage relative to their goal payment for the month. For example, Jill would like to pay \$100 for the month of July. It is the 13th, and she is already halfway through her target payment. This allows Jill to make an informed decision on whether she would like to adjust her usage habits or receive a larger bill. In some embodiments, thermostat 600 may provide a report of different operating parameters and their respective energy usage. In step 2628, the runtime of each stage of the compressor is shown. In step 2630, the calculated cost associated with the runtimes of each stage is shown. This comparison informs users of their usage habits and allows users to decide whether and how to make adjustments to affect their monthly bill. In some

embodiments, thermostat 600 may use data from the history stored in network 2422. Thermostat 600 may communicate the need to have the data analyzed by data analytics service 2504. Thermostat 600 may communicate with other devices connected to network 2422 and display information on connected devices. In some embodiments, thermostat 600 may display all data and communications on a user device 1502.

[0311] Still referring to FIG. 26B, thermostat 600 may make changes to setpoints automatically (process 2650). In step 2652, display 802 of thermostat 600 is shown to inform a user that his setpoint has been raised by 2 °F. For example, Jack may have had his setting at 72 °F and over the course of a few hours, thermostat 600 may have raised the temperature to 74 °F. Thermostat 600 may inform Jack that his setpoint was increased, and ask whether he had noticed a difference in comfort or whether he would like to keep the change made. If a user chooses to accept the change, thermostat 600 may display the projected savings resulting from the change (step 2654). In some embodiments, this is a monthly savings. Thermostat 600 may be able to estimate the savings for just one day, or for a year. This feature may help users save energy by making adjustments and showing them how even a small change can result in savings. In some embodiments, thermostat 600 may use data from the history stored in network 2422. Thermostat 600 may communicate the need to have the data analyzed by data analytics service 2504. Thermostat 600 may communicate with other devices connected to network 2422 and display information on connected devices. In some embodiments, thermostat 600 may display all data and communications on a user device 1502.

[0312] Still referring to FIG. 26B, thermostat 600 may compare a home's system with systems in the surrounding area or neighborhood (process 2674). In some embodiments, thermostat 600 receives information regarding the systems in the surrounding area from data analytics service 2504. In some embodiments, only homes with similar settings and equipment will be shown. In other embodiments, all homes will be shown regardless. In step 2676, thermostat 600 may show on display 802 statistics on setpoints being used by neighbors. This allows users to compare their usage habits with users in similar environmental conditions. For example, Jack and Jill live in Mr. Roger's Neighborhood. Thermostat 600 shows that 40% of homes have setpoints at 72 °F

and 72 °F (meaning that they keep 72 °F as the setpoint year round). In step 2678, thermostat 600 may show the average monthly bill for the set of homes included in the report. Thermostat 600 may ask users if they would like to try the settings, allowing users to make budget and energy conscious decisions without undue effort. In some embodiments, thermostat 600 may use data from the history stored in network 2422. Thermostat 600 may communicate the need to have the data analyzed by data analytics service 2504. Thermostat 600 may communicate with other devices connected to network 2422 and display information on connected devices. In some embodiments, thermostat 600 may display all data and communications on a user device 1502.

[0313] Thermostat 600 may make comparisons of the connected system to similar systems connected to the network. System analyzer 714 may find a subset of systems connected to the network which are similar to the system connected to thermostat 600. Similar systems may be determined based on equipment configurations, size of home, location, climate, and various other factors or any combination of the previously mentioned factors. Thermostat 600 may send a request for a report to be generated by analytics service 2504, which may retrieve data, from the subset of similar systems determined by system analyzer 714, from the network. Reports may be generated which analyze energy usage of the occupants of a home. As shown in FIG. 26A, thermostat 600 may display reports on a user's device 1502 to compare and contrast a user's energy consumption and behavior with other similar systems. Thermostat 600 may also show comparison reports on display 802. For example, thermostat 600 may display reports comparing John's usage with his neighbors – Jack and Jill's – usage.

[0314] In other embodiments, thermostat 600 may find systems which are similar with respect to many parameters, although not necessarily geographically close. Thermostat 600 may be able to notify a user of their ranking in terms of energy usage. For example, thermostat 600 may inform a user that their energy usage is above average among similar systems. This allows users to evaluate their energy usage behavior and decide whether they value efficiency, comfort, or a compromise. In some embodiments, number ranks could be given, encouraging users to experiment with thermostat 600 and its settings in order to be more efficient. It is contemplated that users can post their rank and their settings on social media to share with others and to create

a sense of competition. For example, a user may post their settings on a social media website with the message “My conditioning system is running 10% more efficiently this month and saved \$15 on my electricity bill! Thanks Johnson Controls Inc.!”

[0315] Referring now to FIG. 26C, users may be able to indicate their preference to thermostat 600, which may use the preference to make operation decisions. When comparing systems according to process 2680, thermostat 600 may determine whether settings of other systems can impact a user’s energy usage. In step 2681, system analyzer 714 may find a subset of systems connected to the network which are similar to the system connected to thermostat 600. Similar systems may be determined based on equipment configurations, size of home, location, climate, and various other factors or any combination of the previously mentioned factors. Thermostat 600 may find that a neighboring home of a similar size with a similar system is using much less energy (step 2682). If the user has indicated that they value energy efficiency, thermostat 600 may notify the user that potentially more efficient settings have been found (step 2683). In some embodiments, thermostat 600 may automatically test-run settings which have been identified as potentially impacting a user’s energy usage. For example, thermostat 600 may run settings of a potentially more efficient system while a user is not home and report the results of the test when the user returns (step 2684).

[0316] In some embodiments, thermostat 600 may display a prompt with the identified potentially impactful settings and allow a user to decide which settings to test. For example: a system identical in equipment and area serviced is identified as operating 10% more efficiently than Jill’s system. Thermostat 600 may display “According to information stored in the cloud, you may be able to increase efficiency by increasing your fan speed to HIGH. Would you like to increase your fan speed from MEDIUM to HIGH? To accept this change, please select Yes. To reject this change, please select No.” Depending on Jill’s selection, thermostat 600 would either adjust fan speed or dismiss the prompt. In some embodiments, an issue may occur when a setting does not produce expected results. For example, the blower of a system is too small to operate any more efficiently at higher speeds. A compressor may be broken and consequently produces no better results when staging is altered. Thermostat 600 may identify the source of these issues

and evaluate what the problem is (step 2685). Thermostat 600 may then display a prompt to the user asking whether she would like to call her dealer or a technician to repair the identified source of the problem (step 2686). For example, if a furnace is connected to thermostat 600, thermostat 600 can communicate with the furnace and determine that there is a problem with the airflow of the furnace. Thermostat 600 can use information gathered from the furnace to identify that an air filter of the furnace needs to be changed. Thermostat 600 can then display a prompt to the user identifying the issue as a bad air filter. In some embodiments, the information regarding identified problems are sent directly to the user and the technician via an email or text message.

[0317] Thermostat 600 is able to provide a clear and up-to-date report of a home's energy usage. Thermostat 600 is able to communicate with a wide variety of devices, and the communication allows greater detail when creating a usage report. Whereas a monthly bill from a utility provider merely shows the total usage, analytics service 2504 offers key information such as the time of use and the piece of equipment associated with the usage. For example, thermostat 600 may display an energy usage report which shows that for the past two days, the dishwasher has been using more than twice the amount of energy it has been using for the three years it has been in the home. Thermostat 600 may detect the discrepancy and notify a user that the dishwasher may be malfunctioning. Thermostat 600 may display an energy report which shows that the AC system is using less energy than a user had previously thought. Thermostat 600 may display an energy report that shows that the washing machine is using energy even when it is not being used. This information may help a user decide that it is time to replace old, inefficient appliances. Thermostat 600 may connect to older, existing equipment in a home to improve efficiency over previous performance using a conventional thermostat. In some embodiments, thermostat 600 applies changes to the equipment operating parameters using metering over time.

[0318] Thermostat 600 may be able to use analytics service 2504 to calculate the time needed to reach the setpoint commanded by the user. In some embodiments, this calculation is done locally. In other embodiments, thermostat 600 may transmit the data to analytics service 2504 which may transmit the results back to thermostat 600 or a user device 1502 for display. For

example, thermostat 600 may receive a command to condition a home to 72 °F when the outside temperature is 80 °F and there is low humidity. Thermostat 600 transmits the current operating conditions and the command to analytics service 2504. Analytics service 2504 determines, from current operation conditions, feedback from the equipment, and historical data, that the system will be able to reach the setpoint specified in half an hour. Analytics service 2504 transmits this information to thermostat 600, which then displays a message to the user notifying her that the system will reach the setpoint in half an hour. In some embodiments, based on certain outside conditions, the system may be under an unusual amount of load. Analytics service 2504 may recognize this when comparing system performance with similar systems and adjust the time estimate. In some embodiments, analytics service 2504 may add an offset to the standard time estimate. It is contemplated that analytics service 2504 is able to perform this function for more optimal conditions as well, and subtract an offset from the standard time estimate.

[0319] Referring now to FIG. 26D, thermostat 600 may be able to notify a user of the ability of the system to reach the setpoint specified by the user. For example, thermostat 600 may receive a command to condition a large home to 77 °F when the outside temperature is 105 °F. Thermostat 600 sends the current operating conditions and the command to analytics service 2504. Analytics service 2504 may determine, from current operation conditions, feedback from the equipment, and historical data, that due to the high humidity and the size of the AC unit installed relative to the size of the home, the system is unable to reach the setpoint. Analytics service 2504 may determine this by using data points from current operation to extrapolate future temperatures. Analytics service 2504 may use historical data points to determine setpoint limits under the current operating conditions. Analytics service 2504 transmits this information to thermostat 600, which then displays a message to the user notifying her that the system is unable to reach a setpoint.

[0320] When this situation arises, thermostat 600 may be able to notify the user in any number of different ways. Thermostat 600 may display an indicator such as a flashing message on display 802, transmit a message to user device 1502 to vibrate and alert the user that the setpoint is unattainable, play a sound, or any number of other methods of notifying the user. Thermostat

600 may display a message with more information about the situation, such as the factors contributing to the inability of the system to reach the setpoint. It is contemplated that thermostat 600 may notify users of any condition and provide additional information, and that this feature is not limited to when the system cannot reach the specified setpoint. In some embodiments, thermostat 600 may be able to calculate the maximum or minimum setpoint which can be achieved based on the current operating conditions, feedback from equipment, and historical performance data. In some embodiments, thermostat 600 uses historical data to determine that a system was previously able to reach a setpoint, but is now unable to do so. In some embodiments, thermostat 600 monitors the time it takes the system to reach a setpoint and compares it to a threshold time. For example, if a system that historically takes 15 minutes to reach 65 degrees Fahrenheit when the temperature is 70 degrees Fahrenheit takes 30 minutes to reach 65 degrees Fahrenheit, the thermostat 600 can identify a decrease in performance. In some embodiments, thermostat 600 determines a new setpoint such that the time required to reach the setpoint is equal or less than the threshold time. In some embodiments, thermostat 600 may advance a time of a setpoint change to allow for the increased time required to reach the setpoint and enable the setpoint to be reached at the desired time. This decrease in performance may be due to degradation of components in the system, and thermostat 600 may display a prompt telling the user that a piece of equipment may be broken or damaged. Thermostat 600 may ask a user if they would like to call their dealer or a technician to have the system repaired. In some embodiments, thermostat 600 does not reach the setpoint due to weather conditions and operating limitations of the equipment. In some embodiments, thermostat 600 serves a notification to the user that the setpoint is unattainable.

[0321] Thermostat 600 may be able to offer an alternative when the setpoint cannot be reached. In some embodiments, analytics service 2504 may be able to find a solution in which the system can sacrifice certain parameters in order to achieve the user's desired setting. For example, thermostat 600 may be able to achieve the specified setting, if the user is willing to pay more in electricity, decrease the lifespan of components, wait for a longer period of time, or turn off another appliance. It is understood that there are other tradeoffs which could be made to achieve

a desired thermostat setting. The choice is offered to the user, who will then be able to decide between energy saved and time lost.

[0322] Thermostat 600 may display the appropriate setpoint limit depending on whether a user is decreasing the setpoint (the minimum) or increasing the setpoint (the maximum). In some embodiments, thermostat 600 is able to detect when to show the setpoint limit, depending on the user's commands. For example, if a user is repeatedly inputting commands at user interface 612 of thermostat 600, thermostat 600 may display the setpoint limit. In other embodiments, thermostat 600 may go directly to the limit after predetermined conditions have been met. For example, if a user is inputting commands at user interface 612 of thermostat 600 and holds down a button for a certain amount of time, thermostat 600 may interpret the input as a command to set the system to the respective limit. In some embodiments, if a system is already at its limit when a user tries to command the system to move farther in the direction of the extreme, thermostat 600 may display a notification on display 802 to inform the user that the system is already at its limit, and that their request cannot be fulfilled under the current conditions.

[0323] Thermostat 600 may be able to show a user the efficiency or comfort consequences of their commands. Thermostat 600 may receive a command on a hot day to condition a home to 2 °F lower than it currently is. Thermostat 600 may transmit the current operating conditions and the command to analytics service 2504. Analytics service 2504 may determine, from current operation conditions, feedback from the equipment, and historical data, the additional costs associated with the 2 °F decrease as well as the additional energy used based on billing history associated with the home, billing data of similar systems connected to the network, and algorithms for determining energy consumption. Thermostat 600 may be able to perform these calculations for any increase, decrease, or lack of change in the setpoint. The calculated energy consumption and additional costs may be used by analytics service 2504 to provide suggestions to users about their usage behavior. For example, thermostat 600 may display a message explaining that turning up the setpoint on a hot day by 2 °F may save a user as much as \$3.00 that day. Thermostat 600 may provide tips for conserving energy such as reducing load by turning off high-energy devices such as dryers, or by better insulating the home by closing

windows. Thermostat 600 may provide suggestions of energy or money saving features not recently used.

[0324] Analytics service 2504 may be able to determine from comparing current performance with historical performance whether a piece of equipment is functioning correctly. For example, analytics service 2504 may determine that if a connected unit is malfunctioning, analytics service 2504 may transmit an error code to thermostat 600, which then displays an error code to the user. In some embodiments, thermostat 600 may display the error code on display 802. In other embodiments, thermostat 600 may display the error code on a user's device 1502 or in a web-based application connected to the system.

[0325] If a fault is detected, standard staging progressions or operating procedures may be altered to provide the best experience for the user. For example, an AC unit may normally transition from stage to stage without skipping stages. If thermostat 600 has detected that a fault has occurred somewhere within the system, thermostat 600 may command the compressor to skip the lower stages and go straight to the upper stages in order to maintain performance. In another example, thermostat 600 may receive information from the flow system that a pipe has been clogged somewhere in the system, and that airflow has been greatly diminished. In order to maintain performance, thermostat 600 may command an increase in airflow to compensate for the blockage.

[0326] Thermostat 600 may alter staging, airflow, or other system parameters based on historical performance. In some embodiments, analytics service 2504 may search through historical data to find periods of operation which match conditions and select the settings and commands which produced the most desirable result according to the user's preferences.

[0327] Thermostat 600 may alter staging progressions or other operating parameters based on other factors, such as weather conditions and forecasts. Thermostat 600 may be able to receive weather information from a weather service, the network, or a device with which thermostat 600 can directly or indirectly communicate. In some embodiments, thermostat 600 is able to receive a weather forecast and make operating decisions based on that forecast. For example, thermostat 600 may receive information one balmy night that the next morning will be below freezing.

Thermostat 600 may command the system to go to 100% operating power without transitioning through lower stages. In some embodiments, thermostat 600 may change the setpoint from the user defined setpoint using the weather information received.

[0328] Thermostat 600 may alter staging progressions or other operating parameters based on factors such as user demand or level of activity. In some embodiments, thermostat 600 adjusts operating parameters when a user commands a sudden and significant change in temperature. For example: it is below freezing outside and a user has returned home after vacation; the HVAC system is suddenly powered on and commanded to heat the home to 72 °F; thermostat 600 commands all equipment to operate at maximum capacity in order to reach the setpoint as soon as possible. In other embodiments, thermostat 600 detects the level of occupancy and activity, and adjusts operating parameters accordingly. For example: there is a party in the home and there are many people dancing; thermostat 600 detects the high level of occupancy and activity and commands all equipment to operate at maximum capacity in order to maintain the setpoint. It is understood that thermostat 600 may detect that there is low or no occupancy or activity and adjust operating conditions accordingly. For example, thermostat 600 may detect that there is little activity and command equipment to operate at low capacity and as efficiently as possible. In some embodiments, thermostat 600 may detect that there is no occupancy and that the outside conditions are acceptable and turn off all equipment in order to save energy.

Thermostat UI Features, Integration, Branding, and Social Media

UI Features

[0329] Referring again to FIG. 8, thermostat 600 is shown to have a display 802, and a frame 804. Display 802 and frame 804 may both be touch-sensitive, and accept user input as commands to thermostat 600.

[0330] Referring now to FIG. 27, a variety of ways to provide input to thermostat 600 are shown. Buttons 2702, 2704, 2706, and 2708 may be embodiments of buttons 806-812. Buttons 2704 and 2708 are shown in dashed outlines to clarify that they are not visible or physical buttons. Buttons 2702 and 2706 are shown in solid outlines, and are an exemplary embodiment

of buttons printed on and defined by a physical skin. In some embodiments, hidden buttons are placed around frame 804. Having the option of providing input through the frame allows users to control thermostat 600 without obscuring display 802. In some embodiments, users are able to provide a direct touch to buttons 2704 and 2708 in the form of a button push and/or button tap. In some embodiments, users are able to provide a direct touch to buttons 2704 and 2708 in the form of a button push. In some embodiments, users are able to provide input in the form of touch movement on frame 804. For example, a user may be able to swipe up or down to scroll, or left or right to move through screens. Input method 2712 is an exemplary method of interaction with the touch-sensitive buttons on frame 804. Thermostat 600 may recognize voice commands. Input method 2714 is an exemplary method of interacting with thermostat 600 via voice commands. Thermostat 600 may recognize input through the use of sensors 602-606. One of sensors 602-606 may be a camera, a motion sensor, a microphone, a capacitive sensor, or any other conceivable sensor. In some embodiments, sensors 602-606 are embodied as a microphone and voice recognition module 716 of memory 704 processes input locally. In other embodiments, the voice input may be sent to network 2422 and processed by a separate module. In some embodiments, a user gives voice commands to their personal device 1502 which processes the input and transmits the command to thermostat 600. Thermostat 600 may be programmed with a specific voice command that will not be commonly or accidentally said to enter dealer or advanced mode. For example, the phrase “advanced dealer mode 23” may be said to enter dealer mode when making a house call.

[0331] Thermostat 600 may recognize gesture controls through the use of sensors 602-606. For example, a user may perform a certain gesture to indicate returning to the menu, increasing the temperature, decreasing the temperature, or locking thermostat 600. Many types of gestures of varying complexity may be accepted as input to thermostat 600. For example, a user may swipe up or down to scroll. In some embodiments, gesture input is processed locally by a memory module gesture processor. In other embodiments, gesture input is received by thermostat 600 and sent to a processor connected to the network. The command is then transmitted to thermostat 600. In some embodiments, a specific gesture may put thermostat 600 in dealer or advanced

mode. For example, an uncommon gesture such as making two circles may be used by a dealer when making a house call to put thermostat 600 into dealer mode.

[0332] Users may add customizable skins to thermostat 600 to alter its functionality and appearance. Skins may be physical appliques similar to stickers, or they may be a certain selection of settings. In some embodiments, skins have buttons printed in various locations. In some embodiments, the buttons are circles, squares, arrows or any other shape. In some embodiments, the buttons are customized images such as a dealer logo. In some embodiments, the buttons are custom images selected by a user. Skins may transmit the location of these buttons relative to frame 804 such that a touch of the button on the skin will register as an input associated with that location on frame 804. Users can design their own skins with their preferred button placement to apply to thermostat 600. In some embodiments, users may use an application (web-based, mobile application, or otherwise) or user interface 612 of thermostat 600 to define button placement on the frame and generate a digital file of a design for the customized skin. In some embodiments, the web-based application and/or the mobile application communicate with thermostat 600 via a network (e.g. the Internet) through data communications interface 610. The web-based application and/or the mobile application can communicate the location of buttons to thermostat 600. Users may be able to define the functionality of buttons on the frame. In some embodiments, user created skins may be printed out by sending the digital file of the customized skin to a dealer. In other embodiments, custom skins can be sent to the manufacturer (e.g., Johnson Controls Inc.) to be printed. Skins may be created and applied to thermostat 600 prior to delivery. In some embodiments, users may design their own skin for thermostat 600 at the time of ordering. For example, Jack may wish to purchase a thermostat 600 for their grandmother who cannot see very well and does not want to use every feature of thermostat 600; he creates a skin with large, clearly printed buttons and simplified menus when ordering thermostat 600. In other embodiments, skins are created for dealers and applied prior to sale. Dealer created skins may include a dealer's logo, custom button configurations, unique settings, and contact information. For example, a dealer may program their information in as the contact when a fault requiring repair occurs. In some embodiments, skins may include 3D features such as braille to assist a

visually impaired user to interface with the device. One of the 3D features may indicate a command to the device to read at least some of the information displayed over the speaker.

[0333] Skins may easily be shared over social media. Users may post designs for physical skins as well as the actual configuration skin. In some embodiments, other users can select skins to try on their respective thermostat 600. Users may share results of their detailed energy usage reports to foster a sense of competition and to encourage others to be conscious of their energy usage. For example, a user may post their new configuration skin with the message “Went up by 1 degree and saved \$5 this month! #1degreeatatime #jci #savingtheworld #fahrenheit #imperialsystem4ever.”

[0334] Many screens are available within user interface 612 which allow the user to control and interact with thermostat 600. In some embodiments, thermostat 600 is able to learn from user input and behavior. Thermostat 600 may store frequency of screen visits, and automatically open to the most viewed screen. Thermostat 600 may allow users to select their favorite screen to be displayed first whenever user interface 612 is viewed. Buttons 806-812 can be used to interact with display 802. In some embodiments, editing the placement of the buttons and the set-up of the screens shown on display 802 can be done through an application on thermostat 600 or user device 1502.

[0335] Referring now to FIG. 28, an exemplary process 2800 of controlling thermostat 600 by sending it text messages is shown. Thermostat 600 may have its own unique number at which it can receive messages through the cellular network. In step 2802, a user opens the messaging app of their cellphone and selects thermostat 600. In step 2804, a user sends thermostat 600 the message “72” and thermostat 600 acknowledges. Depending on the settings selected by the user, thermostat 600 will interpret the number received as either degrees Fahrenheit or degrees Celsius. In some embodiments, thermostat 600 will be able to detect, based on which user is sending the command, which units are being specified. Thermostat 600 may determine that the command received is either degrees Fahrenheit or degrees Celsius based on predetermined limits, as there is little chance that a user would like for their home to 25 °F or 72 °C. In step 2806, thermostat 600 adjusts operation in accordance with the target temperature received in the

previous step. Thermostat 600 may receive commands from any source. It is contemplated that thermostat 600 may receive commands from an email, a phone call, a video message, a social media message, or any other form of communication.

[0336] Referring now to FIG. 29, thermostat 600 may connect to social media servers 2506 to gather event data. Thermostat 600 may use the gathered data to adjust scheduling, adjust temperature setpoints, determine expected occupancy at a plurality of times, preemptively adjust conditioning, preemptively adjust heating and cooling setpoints, and preemptively adjust temperature setpoints. In some embodiments, expected occupancy is the occupancy of a building that will occur at a plurality of times based on social media activity. In some embodiments, thermostat 600 is connected to calendar servers 2508 to gather event data. Thermostat 600 may determine that a user will not be home because they will be at an event at a location which is not home and adjust conditioning, adjust heating, and adjust temperature setpoints to operate more efficiently until it is anticipated that the user will return home. In some embodiments, adjusting temperature setpoints includes raising the temperature setpoints and/or lowering the temperature setpoints. For example, a user may accept an invitation to dinner at a restaurant from 19:00 until 22:00 one evening. Thermostat 600 may reduce conditioning or adjust temperature setpoints at 19:00 and, depending on the expected time to the setpoint, may begin to preemptively increase conditioning or preemptively adjust temperature setpoints an appropriate amount of time prior to 22:00. In some embodiments, thermostat 600 may determine that an event is occurring at home and adjust scheduling and occupancy accordingly. For example, FIG. 29 shows that seven people are attending a hype club for Thermostat (possibly thermostat 600) at Jack and Jill's house. Thermostat 600 determines that Jack and Jill's house is home, and that occupancy will be seven people on August 17th from 16:30 to 20:30. Thermostat 600 will preemptively adjust conditioning, scheduling, temperature setpoints, and occupancy on August 17th to accommodate the high occupancy and the scheduled event so that the home will be conditioned by the time the event starts. There are situations in which a user may wish to delay scheduled events or the programmed schedule for thermostat 600. In some embodiments, thermostat 600 may communicate with a user's calendar application or clock application so that when the user chooses to "snooze", thermostat 600 will delay scheduling by the amount that the snooze is set

for. For example, if thermostat 600 is scheduled to reduce heating when Jack is at work from 09:00 until 17:00 on a winter day, but Jack has a late morning meeting he would like to get more sleep for, he can hit snooze for 30 minutes in the alarm app on his phone and rest easy knowing that thermostat 600 will not suddenly leave him freezing while he is getting ready.

[0337] In some embodiments, thermostat 600 is configured to raise and lower the temperature setpoints based on expected occupancy and in accordance with thermostat 600 being in a heating and cooling mode. In some embodiments, thermostat 600 facilitates a heating or cooling mode as explained in FIG. 1. In some embodiments, thermostat 600 determines an appropriate amount to adjust the heating and cooling setpoints. The appropriate amount can be determined from event data gathered from social media servers 2506 and/or calendar servers 2508, a temperature of a building, and a time to setpoint. In some embodiments, the event data is used to determine the number of occupants. In some embodiments, thermostat 600 is configured to lower a temperature setpoint by an appropriate amount in response to a determination that the building space is unoccupied and the thermostat is in a heating mode. In some embodiments, thermostat 600 is configured to raise the temperature setpoint by the appropriate amount in response to a determination that the building space is occupied and the thermostat is in the heating mode. In some embodiments, the thermostat 600 is configured to raise the temperature setpoint by the appropriate amount in response to a determination that the building space is unoccupied and the thermostat is in a cooling mode. In some embodiments, thermostat 600 is configured to lower the temperature setpoint by the appropriate amount in response to a determination that the building space is occupied and the thermostat is in the cooling mode.

Integration of Other Systems/Cloud

[0338] As shown in FIG. 24, thermostat 600 is capable of communicating with many devices. Thermostat 600 may receive data from various sensors around the home to use when making operating decisions. Thermostat 600 may be able to determine occupancy without the use of an integrated sensor if sensors in places such as windows and doors are installed and connected to thermostat 600 or the network. For example, thermostat 600 may determine that the home is occupied upon activation of the front door sensor and begin conditioning the home based on the

master user's preferences. Thermostat 600 may detect that a window or door is open and display a message on display 802 or in some embodiments on device 1502 warning a user that a window or door is open and may cause an increase in energy consumption and a decrease in efficiency. Thermostat 600 may also determine that the home is no longer occupied upon a second activation of the front door sensor and begin reducing conditioning of the home. It is understood that more sophisticated algorithms for determining occupancy may be used to prevent issues such as a guest entering a home, letting a pet outside, or other such situations. Thermostat 600 may communicate with users' personal devices, such as cellphones, heartrate trackers, fitness trackers, or any of a variety of personal devices. In one embodiment, thermostat 600 may determine level of activity based on information from a user's heartrate or fitness tracker and adjust conditions accordingly.

[0339] In some embodiments, a user may interact with thermostat 600 via a mobile application and can select an override mode for thermostat 600. The modes may be "Away", "Home", "Party", "Cooking/Baking", "Workout", "Sleeping", "Housework", a custom mode, and any other such mode for thermostat 600. Each mode may be configured to adjust settings of thermostat 600 to account for the activity of a user. Each mode may have a setpoint and a time duration determined by the user. For example, a user may be going to sleep and may press the sleep button associated with the "Sleeping" mode on the mobile application. Thermostat 600 may receive command from the mobile application to enter the "Sleeping" mode. Thermostat 600 may change the setpoint to 65 degrees Fahrenheit for 8 hours. 65 degrees Fahrenheit may be the preferred sleeping temperature of the user. When a user makes changes to an operating mode or creates a new operating mode via the mobile application, the operating mode may be created and/or updated on the mobile application running on a mobile device, a server hosting information pertaining to the mobile application, and/or thermostat 600.

[0340] In some embodiments, a fitness tracker may interface with the mobile application and may identify that the user associated with the fitness tracker is moving rapidly. Thermostat 600 may receive a command to enter "Workout" mode from the mobile application when the fitness tracker identifies rapid movement. In some embodiments, the mobile application is interfaced

with a user calendar. The user may have calendar events scheduled on the calendar such as “Cleaning time”, “Half hour workout”, and/or “Birthday Party”. Thermostat 600 may receive a command from the mobile application to run a mode appropriate for each of the calendar events.

[0341] In some embodiments, thermostat 600 may be connected to thermal sensors. In some embodiments, thermal sensors are infrared temperature sensors. The thermal sensor may be located in different rooms of a building. Thermostat 600 may use information received from the thermal sensors to determine what rooms are occupied and/or unexpected temperature increases in a room. For example, thermal sensors may identify that an individual is exercising in Room A and thus lower the temperature setpoint in Room A to keep the individual exercising comfortable. In some embodiments, thermostat 600 may identify that a room in the building is much hotter than other rooms. For example, thermostat 600 may identify that Room B is warmer than Room A based on information received from the thermal sensors. Thermostat 600 may identify that there is a problem with HVAC equipment in Room B based on this comparison. In some embodiments, when thermostat 600 identifies an unexpected temperature increase, thermostat 600 tells a user to have thermostat 600 and/or HVAC equipment connected to thermostat 600 serviced. In some embodiments, thermostat 600 may give the user specific instructions through user interface 612 for improving the performance of thermostat 600 and/or the HVAC equipment connected to thermostat 600. For example, the specific instructions may be changing air filters, checking for blocked duct pipes, closing windows or curtains in certain rooms, and/or any other method that can be used to prevent the HVAC system from becoming damaged and/or using excessive amounts of energy.

[0342] Thermostat 600 may have control over other systems in the home, such as the lighting system or the security system. In some embodiments, when occupancy is detected, thermostat 600 may turn on lights where a user is determined to be. For example, if Jill comes home, checks in, and proceeds to her bedroom, thermostat 600 may turn on the lights on the way from the door to Jill’s bedroom. In other embodiments, thermostat 600 may be able to turn off lights when occupancy is no longer detected. Thermostat 600 may enable the security system when occupancy is no longer detected. For example, if Jack leaves for work but forgets to set the

alarm, thermostat 600 may arm the security system after failing to detect occupancy in the entire home for 30 minutes. In some embodiments, thermostat 600 may be able to disarm the security system if occupancy is detected. For example, if Jill comes home and checks in, thermostat 600 may disarm the security system. It is understood that more sophisticated algorithms may be used to prevent issues associated with the turning on of lights in rooms where a user may be sleeping or enabling the alarm system while users are still home. Thermostat 600 may be able to control systems such as blinds, windows, and doors. Thermostat 600 may be able to draw blinds or close doors or windows when occupancy changes, or in order to improve efficiency or performance of the system.

[0343] Thermostat 600 may receive data from a weather service, as mentioned previously. In some embodiments, thermostat 600 may show the forecast on display 802. Thermostat 600 may be able to send the forecast to a user's phone on a schedule or upon check-in with thermostat 600.

[0344] Thermostat 600 may communicate with commercial storage solutions such as Dropbox, Google Docs, or Amazon Cloud. Thermostat 600 may store data in such places in order to record trends and make data and analytic reports more accessible to users. Storing data in places other than local memory will also reduce the cost of thermostat 600 as a unit and promote sales.

[0345] Thermostat 600 may communicate with the network to receive firmware updates. In some embodiments, the firmware updates are for connected equipment. For example, thermostat 600 may receive a notification that the AC unit has an available firmware update. Thermostat 600 may show a prompt on display 802 with a message such as: "A firmware update is available for your AC unit. Would you like to call your dealer to schedule a home visit?"

[0346] Thermostat 600 may communicate with a user's utility provider. System performance data may be integrated with utility data in order to monitor a home's level of energy usage and inform users of their usage habits.

Branding

[0347] The appearance of thermostat 600 can easily be changed to a dealer or end user's preference. This flexibility provides many opportunities for marketing and promotion of a brand. Dealers may choose to use custom branding in order to familiarize consumers with their business. Dealers may be provided with skin templates to choose from which will change the user interface or the physical appearance of thermostat 600; these skin templates may be further customizable. For example, dealers may be presented with three or four skin templates for the user interface of thermostat 600.

[0348] An application may allow a dealer to customize the color scheme of his chosen template. In some embodiments, this application is a stand-alone application to be accessed through a computing device such as a laptop or smartphone. In other embodiments, this application is a web-based application which may be accessed through any network connection. Dealers may be able to customize the fonts used in the user interface or on the physical skin. In some embodiments, dealers may choose from a selection of chosen font pairs which go well together. In some embodiments, the skin created with such a branding design tool may be applied, prior to sale, to all thermostats a dealer sells. In some embodiments, the branding is dealer information. Dealer information may include a dealer phone number, a dealer address, dealer store hours, a dealer RSS feed, and a dealer logo. In some embodiments, thermostat 600 is branded at installation. In some embodiments, a skin template may be available which is tailored to meet the Americans with Disabilities Act (ADA) specifications. Color schemes, font size and choice and animations may be customized to meet ADA specifications. Features such as ADA compliant sounds or other feedback may be made available through the branding tool. Dealers may wish to use a more subtle method of branding; for example, using only the logo or icon without the brand name attached.

[0349] As shown in FIG. 22A, a dealer can program their contact information into thermostat 600 to be made available to an end user whenever service or advice is needed or maintenance is required. In some embodiments, the maintenance is needed for thermostat 600. In some embodiments, the maintenance is needed for equipment connected to thermostat 600. In some embodiments, the dealer can program the dealer's address and store hours into thermostat 600. In

some embodiments, thermostat 600 includes a microphone and a speaker. Dealers may choose to customize a physical skin which will provide a button for a user to press which will call the dealer when pressed. The call may be placed as a Voice over Internet Protocol call. The call can utilize a microphone and speaker of thermostat 600. In some embodiments, thermostat 600 will communicate with the user's cellphone and automatically place the call.

[0350] In some embodiments, dealer information and/or dealer branding may be shown on user interface 612 of thermostat 600. The dealer branding may be displayed at a first rate such as twice an hour when the HVAC system is operating normally, and may be displayed at a second rate higher than the first rate, such as 12 times an hour (or continuously), when the HVAC system is not operating normally or optionally if a setpoint cannot be achieved. In some embodiments, the thermostat 600 may include a camera module. If a camera module is present, the thermostat may choose to display the dealer branding if a user is in the vicinity of the thermostat 600.

[0351] Referring now to FIG. 30, thermostat 600 may include unobtrusive dealer specified content on certain screens. In some embodiments, this may include an RSS feed of the dealer's website to keep the end user apprised of activity relating to the dealer. For example, thermostat 600 may include a news screen at the bottom of which exists a window which shows an RSS of a dealer's website. In other embodiments, this may include advertisements for dealer services and specials in which an end user has indicated an interest. Advertisements for partner companies and services may also be shown. In some embodiments, advertisement selection may be based on information made available to thermostat 600. For example, if a user has no events schedule and it is a hot summer day, advertisements for a water park owned by a partner company may be selected for display to that user. In one embodiment, advertisements may be based on events scheduled for the user; for example, advertisements for partnered hotels may be selected if a user is scheduled to travel.

[0352] Thermostat 600 may communicate with the network, and as such, may be updated remotely. In some embodiments, changes to a skin may be made after purchase. For example, a user may purchase thermostat 600 from a first dealer who is then bought out by a second dealer.

The second dealer may decide to rebrand thermostat 600 so that end users have updated contact information on hand for when they need assistance. The updated information also brings more awareness to the new owners, possibly generating more revenue.

[0353] Referring now to FIG. 31, thermostat 600 is shown to have a social media presence. Thermostat 600 may have social media profiles on different social media networks. In some embodiments, users may choose to post reviews, comments, skins, and settings for thermostat 600.

[0354] Thermostat 600 may include the Johnson Controls Inc. logo in all skins, settings, and configurations. The new slogan of Johnson Controls Inc. may be incorporated and featured in order to highlight changes and refresh impressions of the brand in a user's mind.

[0355] Thermostat 600 may communicate valuable data and feedback to a dealer. Thermostat may record and report how many service calls were provided or how many home visits were saved as a result of thermostat 600's features. In some embodiments, thermostat 600 records and reports the amount of advertisement revenue to the dealer. In some embodiments, thermostat 600 records any parts and equipment purchased through and/or for thermostat 600. In some embodiments, thermostat 600 reports any new equipment or parts purchased to the dealer. Thermostat 600 may provide a dealer with analysis of increased revenue and business as a result of thermostat 600. For example, each thermostat installed reports data which is aggregated by a revenue analyzer connected to the network. At the end of the fiscal year, a report is transmitted to the dealer detailing the revenue generated as a result of thermostat 600. The report may highlight that as a result of advertisements and direct dealer contact information made available by thermostat 600, 1000 more customers have been reached per month – an estimated \$100,000 increase in revenue.

[0356] In some embodiments, thermostat 600 may automate maintenance scheduling and consumables ordering. For example, filters may be ordered from the dealer automatically and delivered to a user when a filter change is needed. Thermostat 600 may prompt the user to call their dealer and schedule a maintenance appointment if the user wishes. In some embodiments, thermostat 600 may notify a user that it is time to schedule a maintenance appointment or to

order consumables, giving users control over whether they wish to make any purchases or appointments.

[0357] Thermostat 600 may analyze a dealer's revenue and provide information and feedback targeted to improving performance and generating more business. For example, each thermostat installed by a particular dealer transmits dealer-relevant data to the network to be analyzed by a dealer performance analyzer. The results, showing that his customer base has not expanded in the last year, are sent to the dealer. The performance analyzer has discovered that the dealer has not been entering his contact information or using customized skins advertising his brand.

[0358] In some embodiments, thermostat 600 provides many opportunities for partnerships over social media platforms. Thermostat 600 may allow users to command changes from social media posts. For example: Jill tweets privately at thermostat 600: @thermostat100 72, and thermostat 600 tweets back: @jillandjack Command received. Thermostat 600 may have a unique Twitter handle. It is understood that any social media platform may be used to post changes to thermostat 600. Social media platforms can include Facebook, MySpace, Twitter, Tumblr, Snapchat, and Instagram. In some embodiments, the thermostat 600 monitors private messages, public social media posts, private social media posts, and post comments to command changes. In some embodiments, the commands are directed to the thermostat. For example, Philip may send a direct message to thermostat 600 reading, "Raise the temperature setpoint in here!". In some embodiments, the thermostat 600 monitors Philips social media activity. For example, Philip may post on Facebook, "It is really cold out today." Thermostat 600 can monitor and analyze this public or private post and raise the temperature setpoint. Philip could also post on Facebook, "It is really hot out today!" Thermostat 600 can analyze this public or private post or message and lower the temperature setpoint. In some embodiments, thermostat 600 may allow actions specific to a social media platform to command changes. For example: Jack likes system settings for a thermostat which Jill has posted on Facebook. Thermostat 600 detects this action and applies the settings. In some embodiments, companies or dealers may promote well-tested and popular settings for users to try in order to increase traffic to their website or related products. In some embodiments, partnered companies may create skins for users to download or

purchase and apply. For example: a fitness tracker manufacturer may create a health-centric skin which collects data from a connected fitness tracker and provides tips and suggestions for healthy living.

[0359] In some embodiments, thermostat 600 generates social media notifications and serves the notifications to the user 2510 via social media. In some embodiments, the notification includes thermostat information. The thermostat information includes building temperature, temperature setpoints, schedule information, faults, and any other such information relating to thermostat 600. For example: Jack receives a Facebook message from thermostat 600. The message reads, “Thermostat 600 has encountered a fault with occupancy sensor 1.” Jack views this message via user device 2510. Jack may respond to thermostat 600. Jack may respond with a message reading, “Call a repair man.” It is understood that the notifications thermostat 600 can send to the user 2510 via the social media servers 2506 are not meant to be limiting, and that thermostat 600 may be configured to send any number of social media notifications to user 2510.

Algorithms/Analytics

[0360] Processing of data is done by memory module analytics service 2504. In some embodiments, thermostat 600 sends the data to be analyzed to the network, which transmits the data to a data analyzer 712 remote from thermostat 600. Thermostat 600 may receive input from a user to determine what analysis or algorithm is applied to the data or to a controller for a connected component.

[0361] Referring now to FIG. 32, thermostat 600 is able to graph power usage of a home. Thermostat 600 may process data periodically in order to display results instantaneously when requested by a user. Thermostat 600 may filter data based on user inputs, or thermostat 600 may offer several predetermined filters. In one embodiment, thermostat 600 is able to determine and display system energy usage per compressor stage, fan speed, or any quantifiable metric, allowing a user to make informed decisions regarding her energy usage habits. For example, thermostat 600 may analyze data from the past month and report that Jill has been using 20% more energy by setting the compressor to run in stage 3 instead of stage 2. This increase in

energy over the 10 days the system has been at stage 3 has resulted in a net increase of \$5 over Jill's standard energy bill. With this information, Jill may decide whether she prefers efficiency or comfort, and adjust (or not) her usage accordingly.

[0362] Referring again to FIG. 32, thermostat 600 is able to compare one home's energy usage with another home of similar size and setup. For example, thermostat 600 may identify homes of similar square footage and equipment configuration which are located in a similar climate for comparison with the home it belongs to. In some embodiments, users may elect to view comparisons of their usage with that of a dissimilar home. For example, users may wish to estimate their energy usage with an addition to their current home or in a new home they plan to buy.

[0363] Referring now to FIG. 33, thermostat 600 may be compatible with external accessories. Thermostat 600 is shown to include port 3302. Thermostat 600 may contain multiple ports. Port 3302 may be compatible with USB, Thunderbolt, HDMI, Ethernet, 3.5mm, or any other communications standards, and may be used to communicate tabulated, visual, audio, or any other type of data. FIG. 33 is shown to include external accessory 3304. In one embodiment, external accessory 3304 is exclusively compatible with thermostat 600. In some embodiments, external accessory 3304 is compatible with a variable of devices, and can transfer data between thermostat 600 and another device compatible with external accessory 3304. For example, external accessory is a USB dongle which can store data to be analyzed from thermostat 600 and transfer the data to a laptop. The results of the analysis, including any visual representations, may be transferred to thermostat 600 for display. In some embodiments, external accessory 3304 is able to communicate with user device 1502 and may be used during installation for troubleshooting. For example, external accessory 3304 may be a phone dongle which assists a technician in troubleshooting wiring installation such as a Cat5e tester.

[0364] In some embodiments, thermostat 600 is able to analyze data transferred from another source through external accessory 3304 and generate a report for display. For example, thermostat 600 may receive billing data from external accessory 3304 and integrate billing data with usage and operational data to generate a report correlating a user's usage habits and

behavior with their energy cost. External accessory 3304 may provide additional capabilities to thermostat 600. External accessory 3304 may contain a data analyzer 712 or a data mapping module. In some embodiments, external accessory 3304 contains communications means which thermostat 600 does not otherwise have. For example, thermostat 600 may only have communications electronics which are configured for Bluetooth communications. External accessory 3304 contains communications electronics which allow thermostat 600 to communicate over WiFi, expanding the network of devices and applications with which thermostat 600 can interact. In one embodiment, a previous model of thermostat may be retrofit with external accessory 3304 to gain functionality of features of thermostat 600.

[0365] Thermostat 600 may analyze system performance to determine and monitor system health. Thermostat 600 may compare current performance with historical data to determine whether each piece of equipment or component of the system is fully functional. For example, thermostat 600 can log the energy usage of HVAC equipment. Thermostat 600 can identify the current energy usage of the HVAC equipment and compare the current energy usage of the HVAC equipment to the historical energy usage of the HVAC equipment. In another example, thermostat 600 logs the energy usage of HVAC equipment. Thermostat 600 identifies the current energy usage of the HVAC equipment and compares the current energy usage of the HVAC equipment to the historical energy usage of the HVAC equipment. In another example, thermostat 600 may find that the compressor has been on the same stage for a week, but system performance has decreased in the past two hours. Thermostat 600 may determine that the compressor is no longer functioning correctly, and prompt the user to call the dealer to schedule an appointment. Thermostat 600 may be able to provide an estimate of the lifetime of consumables based on historical service and operating condition data. For example, thermostat 600 may estimate that the air filter will need to be replaced in 10 days due to records that it had last been replaced 40 days ago during a service call, and that the system is operating at high capacity because it is summer. Thermostat 600 may prompt the user to order a new filter, automatically order a new filter, or ask the user if he would like to schedule a maintenance appointment.

[0366] Thermostat 600 is able to provide tips and suggestions to users based on analysis of their usage and habits. Thermostat 600 may allow users to input preferences with regards to efficiency or comfort. Thermostat 600 may allow users to input a target energy bill amount. With these guidelines, thermostat 600 may be able to suggest setpoints within a reasonable range of a user's current setpoint which may help the user to achieve their goal payment. For example: Jack wishes to reduce his monthly electricity bill from \$300 to \$250. It is August, and Jack currently sets his thermostat to 66 °F. Thermostat 600 may analyze billing data and system performance from the past two Augusts to determine and propose a new setpoint. Thermostat 600 may suggest to Jack that moving the setpoint up by just two degrees to 68 °F may lower his electricity bill to \$275, and that moving the setpoint up to 70 °F may allow him to reduce his electricity bill to \$250. This situation gives Jack options and provides a middle ground choice if he wants to make a compromise.

[0367] Thermostat 600 may give users tips based generally on their indication of preference for either comfort or efficiency. In some embodiments, thermostat 600 may be able to draw from a preformed pool of general tips relating to either increased user comfort or increased energy efficiency. This prepopulated source of tips allow thermostat 600 to quickly provide simple tips to a user. For example, if Jill has indicated that she prefers efficiency to comfort, thermostat 600 may periodically display tips for reducing energy usage, such as raising the setpoint on a hot day, closing the windows when running the conditioning system, or choosing conservative stage progressions for a compressor. It is understood that many other tips may be given, and that tips of similar weight are given for users who indicate a preference for comfort. In some embodiments, general tips may be correlated with actions a user is currently taking. For example, if a user, who has indicated a preference for efficiency, is lowering the setpoint on a hot day, thermostat 600 may display a prompt informing the user that their current course of action will result in a decrease in energy efficiency.

[0368] Thermostat 600 may offer suggestions to a user based on his history of energy consumption and system settings. For example, thermostat 600 may analyze Jack's energy consumption from the past year, as well as his operational settings. He has increased fan speed,

increasing energy usage, but has not seen any changes in performance. Thermostat 600 may alert Jack that he can reduce his energy usage without sacrificing comfort.

[0369] Thermostat 600 settings may be shared with other users. In one embodiment, thermostat 600 may communicate with other thermostats connected to the network to find similar homes with similar settings. When system with settings that match closely to that with which thermostat 600 is associated is found, and that system is performing better in the area of a user's preference, either efficiency or comfort, thermostat 600 may suggest changing current settings to match those of the other system exactly.

[0370] Thermostat 600 may be able to provide a user with a suggested operation procedure or stage progression based on the cost determined per stage as well as the estimated time to reach a setpoint. In one embodiment, a user indicates her preference for comfort, and thermostat 600 offers staging suggestions based on her calculated cost per stage to increase efficiency. Staging suggestions include which stages to proceed to or to skip, and how long it will take for the system to reach the setpoint. Several options with varying total times and energy consumption may be offered.

[0371] Thermostat 600 may analyze the performance of a system and make recommendations to assist a user in meeting their goals and maintaining functionality of their system. In some embodiments, thermostat 600 may offer a suggestion on whether a home should run on gas or electricity. In other embodiments, thermostat 600 may communicate with a user maintenance portal. The maintenance portal may be a web-based application or a stand-alone application. The maintenance portal allows users to schedule seasonal check-ups and make appointments for house calls. Memory 704 of thermostat 600 may contain a schedule analyzer. The schedule analyzer may select time slots during which a user is not scheduled for any events and suggest those time slots as appointment times in the maintenance portal. In some embodiments, the maintenance portal automatically creates reminders for necessary maintenance based on service records. In other embodiments, users create reminders to schedule maintenance and review service records. Thermostat 600 may determine that a piece of equipment is running for a longer amount of time than usual to achieve the same results. In some embodiments, thermostat 600

may suggest to a user that the equipment may need repairs in order to increase efficiency and comfort, and offer to call the dealer.

[0372] Referring now to FIG. 34, a process 3400 for determining a time to setpoint for HVAC equipment 2420 and making recommendations with thermostat 600 is shown, according to an exemplary embodiment. The time to setpoint can be an amount of time required to reach the setpoint based on current or predicted environmental conditions and the capability of the HVAC system operated by the thermostat. In FIG. 34, thermostat 600 is configured to receive a requested setpoint (step 3402). In some embodiments, the setpoint is a temperature setpoint, a humidification/dehumidification setpoint, and/or any other environmental setpoint. In some embodiments, the setpoint request is made through user interface 612 of thermostat 600. In some embodiments, the setpoint request is made through social media activity. In some embodiments, the setpoint request is made through a wireless connection such as wifi, Bluetooth, or NFC. when a user checks into thermostat 600. Thermostat 600 is configured to determine if the setpoint requested in step 3402 is achievable (step 3404). Thermostat 600 makes the determination that the setpoint is achievable based on a plurality of factors. The factors can include a thermal load, a time of day, a connected electrical grid status, agreements to not operate equipment such as at certain times of the day, weather conditions, historical data, equipment status and functionality and any other factor that affects the ability of the HVAC equipment 2420 to reach the requested setpoint. In some embodiments, the thermostat, monitors the change in temperature with respect to time and adjusts continually adjusts the set point in response to the change in temperature with respect to time. In some embodiments, a level of occupancy can be inferred from the thermal load derived time to setpoint data.

[0373] In some embodiments, thermostat 600 is configured to determine if a setpoint is unachievable based on a comparison of zones in a home. In some embodiments, there may be a plurality of zones in a home. Each zone may be heated and conditioned to a different temperature. In some embodiments, thermostat 600 controls multiple zones. For example, thermostat 600 may be cooling zones Zone A and Zone B to 65 degrees Fahrenheit. Thermostat 600 may identify that Zone A reaches 65 degrees Fahrenheit from a room temperature of 80

degrees Fahrenheit in 10 minutes. Thermostat 600 may identify that Zone B has taken 25 minutes to reach 75 degrees Fahrenheit from a room temperature of 80 degrees Fahrenheit. In some embodiments, thermostat 600 may be configured to determine that Zone B cannot reach 65 degrees Fahrenheit.

[0374] In some embodiments, when a zone cannot reach a setpoint based on a zone comparison, thermostat 600 identifies possible reasons why the zone cannot reach the setpoint. In some embodiments, the thermostat 600 may identify the time of day and the location of the zones. For example, at 6:30 P.M., thermostat 600 may identify that one zone on the west side of the home is not reaching its setpoint as compared to another zone on the east side of the home. Thermostat 600 may provide recommendations to the user (step 3408) that are the result of the zone comparison. For example, thermostat 600 may notify a user that he or she should wait until the sun goes down before attempting to request a low setpoint and/or may tell a user to close his shades. For example, thermostat 600 may be configured to tell a user “In three hours it will be dark outside, you should wait three hours before attempting this setpoint.”

[0375] In some embodiments, thermostat 600 may be configured to monitor and/or operate dampers and fans. In some embodiments, thermostat 600 may make a comparison between the two zones based on the differences between the zones such as a ceiling fan running, dampers being open or closed, a stove generating heat, and any other piece of equipment thermostat 600 may be able to monitor and compare between two zones. For example, thermostat 600 may determine that Zone A is reaching a temperature of 65 degrees Fahrenheit from a room temperature of 80 degrees Fahrenheit but Zone B reaches a temperature of 75 degrees Fahrenheit from a room temperature of 80 degrees Fahrenheit over the course of an hour. Thermostat 600 may identify that Zone A has a fan running and Zone B is a kitchen and has a stove turned on and a fan turned off. Thermostat 600 can provide recommendations to the user (step 3408) such as, “You have a stove running, you won’t be able to reach the setpoint” and/or “Turn on the fan in Zone B”.

[0376] Still referring to FIG. 34, when thermostat 600 determines that the setpoint is not achievable (step 3404), thermostat 600 informs the user that the setpoint is not achievable (step

3408). Thermostat 600 can inform the user that the setpoint is not achievable in a number of ways. In some embodiments, the thermostat 600 displays a notification to the user through user interface 612. In some embodiments, the thermostat 600 sends a notification to the user that the setpoint is not achievable when the user checks in with thermostat 600 via NFC. In some embodiments, the thermostat 600 sends a notification to the user that the setpoint is not achievable by generating a social media notification.

[0377] Still referring to FIG. 34, thermostat 600 is configured to make suggestions when thermostat 600 determines that the requested setpoint is not achievable (step 3408). In some embodiments, the suggestion includes a plurality of suggestions that can be served to a user through NFC, a social media notification, and thermostat 600's user interface 612. In some embodiments, suggestions include closing drapes, closing windows, closing dampers to unused spaces, and turning on fans. In some embodiments, the suggestions can be implemented by HVAC equipment 2420. In some embodiments, the suggestions include a plurality of recommended setpoints and a time to setpoint for each setpoint. Thermostat 600 can determine the time to setpoint for each time to setpoint by using a plurality of factors. The factors can include thermal load, time of day, electrical grid status, weather, historical equipment data, and equipment functionality.

[0378] Still referring to FIG. 34, thermostat 600 is configured to control HVAC equipment 2420 to the requested setpoint when thermostat 600 determines that the requested setpoint is achievable. Thermostat 600 serves a notification to the user of what the time to setpoint is for the requested setpoint. In some embodiments, thermostat 600 displays the time to setpoint on user interface 612. In some embodiments, thermostat 600 sends a notification to a user device via NFC when a user checks in with thermostat 600. In some embodiments, thermostat 600 sends a notification to a user through a social media notification.

[0379] In some embodiments, thermostat 600 displays the time to setpoint on user interface 612. Thermostat 600 may display the time to setpoint in a number of graphical forms. In some embodiments, thermostat 600 displays the countdown timer as a ticking countdown clock which may be refreshed periodically. In some embodiments, the graphical form may be an hour glass.

The hour glass may change based on changes in the time to setpoint. In some embodiments, a percentage bar is the graphical form that thermostat 600 displays time to setpoint.

[0380] In some embodiments, thermostat 600 determines the time to setpoint for a requested setpoint and preemptively adjusts the setpoints based on expected occupancy for a building. In some embodiments, thermostat 600 identifies an expected occupancy of a building from scheduler 726, social media server 2506, calendar server 2508, and mobile application server 2507. For example, a building may be unoccupied at 1:00 P.M. Thermostat 600 identifies that Tom will be in the building at 2:00 P.M. based on a social media message he sent to Joe. The social media message may read, “I will be at the building at 2:00 P.M.”. The thermostat 600 knows that Tom likes a setpoint of 70 degrees Fahrenheit. Thermostat 600 determines that it will take 10 minutes to reach a setpoint of 70 degrees Fahrenheit. Thermostat 600 waits until 1:50 P.M. and then adjusts the set point to 70 degrees Fahrenheit. The building reaches a temperature of 70 degrees Fahrenheit at 2:00 P.M. when Tom reaches the building.

[0381] Referring now to FIG. 35, a process 3500 for identifying if a fault can be serviced by a homeowner and suggestions to clear the fault are shown, according to an exemplary embodiment. In FIG. 35, thermostat 600 is configured to detect and identify faults (step 3502). Thermostat 600 may receive fault information from HVAC equipment through bidirectional communication as described in FIG. 21. Thermostat 600 may use the fault codes of the identified faults to determine possible solutions to the fault. If thermostat 600 identifies that the faults identified can be serviced and fixed by a homeowner (step 3504), thermostat 600 can display fault information and instructions to fix the fault on the user interface 612 of thermostat 600 (step 3506).

[0382] In some embodiments, thermostat 600 may ask the user if the user would like to perform the instructions to fix the fault or if the user would like to immediately call a dealer. The instructions may be to power cycle a breaker, check filters for derbies, check registers for blockage, or any other instruction that a homeowner could perform. Thermostat 600 can then check if the fault has been cleared (step 3508). If the fault has been cleared, the thermostat 600 can resume the operation of the HVAC equipment (step 3510). If the thermostat determines that

the fault has not been cleared, the thermostat is configured to display dealer information on the user interface 612 of thermostat 600. The dealer information may include an address of contact information for the dealer. In some embodiments, the thermostat 600 prompts the user to directly contact the dealer from thermostat 600. In some embodiments, thermostat 600 may automatically contact the dealer. In some embodiments, thermostat 600 may request permission before contacting the dealer

[0383] Referring now to FIG. 36, a process 3600 for determining if setpoints selected by a user are energy efficient and suggesting energy efficient setpoints to the user is shown according to an exemplary embodiment. Thermostat 600 can be configured to receive setpoints from a user (step 3602). Thermostat 600 can be configured to identify energy efficient setpoints that are within an offset value from the received setpoint (step 3604). The energy efficient setpoints are setpoints that thermostat 600 determines will use less energy. In some embodiments, thermostat 600 uses historical data gathered and logged from HVAC equipment connected to thermostat 600 to determine energy efficient setpoints. In some embodiments, the historical data is gathered through bidirectional communication between thermostat 600 and the connected HVAC equipment. In some embodiments, the historical data includes information regarding the connected HVAC equipment. The information can include equipment tonnage, runtime of the HVAC equipment, compressor speed, and any other relevant information about the connected HVAC equipment. In some embodiments, thermostat 600 gathers the current equipment performance from the connected HVAC equipment through bidirectional communication and uses the current information to determine energy efficient setpoints. In some embodiments, the thermostat 600 identifies energy efficient setpoints further based on indoor/outdoor temperature. In some embodiments, the energy efficient setpoint may be calculated on a remote server and communicated to thermostat 600.

[0384] In some embodiments, thermostat 600 displays the energy efficient setpoints to the user along with a calculated cost of each setpoint (step 3606). In some embodiments, thermostat 600 may display a cost comparison between multiple setpoints. In some embodiments, thermostat 600 uses past energy bills to determine the cost of running each energy efficient setpoint.

Thermostat 600 is configured to receive a command from a user to either accept one of the energy efficient setpoints or reject the energy efficient setpoints (step 3608). If the user accepts one of the energy efficient setpoints, thermostat 600 implements the energy efficient setpoint selected (step 3612). If the user rejects the energy efficient setpoint, thermostat 600 does not change the setpoint (step 3610).

[0385] Referring now to FIG. 37, process 3700 for updating and displaying a dealers contact information and/or branding is shown according to an exemplary embodiment. In some embodiments, process 3700 is executed on one or more processors or other circuits configured to execute process 3700. In some embodiments, thermostat 600 receives the updates from a network connection, the Internet, a transfer of data via NFC, and/or any other method for updating thermostat 600. Thermostat 600 is configured to determine when to update a dealer's information and/or branding (step 3702). In some embodiments, the dealer's information and/or branding along with dealer related settings are stored on thermostat 600 in remote data storage 718. In some embodiments, thermostat 600 is connected to the internet and/or any other network and can retrieve dealer information and/or branding from a web server. In some embodiments, thermostat 600 is configured to update the dealer's information and/or branding when a set amount of time has passed. In some embodiments, thermostat 600 is configured to update the dealer's information and/or branding when thermostat 600 enters a commissioning mode. In some embodiments, thermostat 600 is configured to update or change the dealer's information, related settings, and/or branding when a contract between a third party and the dealer has started or ended. In some embodiments, thermostat 600 is configured to receive new branding when a dealer updates their branding, the dealer associated with the thermostat changes from a first dealer to a second dealer, and/or thermostat 600 is installed for a first time. In some embodiments, the dealer pays the third party to have the dealer's information stored and advertised on thermostat 600. In some embodiments, the dealer's information and any relevant settings must be updated according to the status of the contract (e.g. payments being on time or late). In some embodiments, relevant settings are the frequency at which thermostat 600 displays the contact information of the dealer.

[0386] Still referring to FIG. 37, thermostat 600 is configured to update the dealer's information and/or branding (step 3704). In some embodiments, thermostat 600 receives dealer information items which include an address of the dealer, a phone number of the dealer, a web address of the dealer, a configurable branding, and any other information the dealer wants to display on user interface 612 of thermostat 600. In some embodiments, thermostat 600 receives dealer related settings. The settings may include a frequency at which thermostat 600 displays the dealer information. In some embodiments, the settings include a confirmation that the dealer has made advertising payments on time to the third party. In some embodiments, there is a setting which stops the display of the dealer's contact information when the dealer has not made payments on time and/or the dealer has cancelled a contract with the third party. In some embodiments, the dealer information may change to default dealer settings if the contract with the original dealer is cancelled. In some embodiments, the settings include what combination of dealer information items to display in a certain circumstance. For example, there may be a setting which causes thermostat 600 to display the dealer's logo every 20 minutes. There may also be a setting which causes thermostat 600 to display the dealer's phone number when thermostat 600 has a fault. In some embodiments, thermostat 600 receives custom branding associated with a dealer.

[0387] Still referring to FIG. 37, thermostat 600 decides when it should display the dealer information (step 3706). In some embodiments, thermostat 600 monitors thermostat 600 events and displays the dealer information when an event occurs. In some embodiments, the event is that a set amount of time has passed since thermostat 600 last displayed the dealer information. Thermostat 600 may determine that a set amount of time has passed and that it is appropriate to advertise the dealer information to the user via the user interface 612 of thermostat 600. In some embodiments, thermostat 600 displays the dealer's information when thermostat 600 identifies that there is a system fault. In some embodiments, thermostat 600 displays the dealer information and a service notification when thermostat 600 determines that the thermostat 600 and any equipment connected to thermostat 600 needs a maintenance check. In some embodiments, the dealer information is displayed as a result of a maintenance schedule or a determination by thermostat 600 that there may be a potential issue with thermostat 600 or any equipment

connected to thermostat 600. In some embodiments, thermostat 600 displays the dealer's contact information when thermostat 600 identifies that a user has been looking through thermostat 600 settings or configurations through the user interface 612 of thermostat 600 for a time longer than a threshold time. For example, if a user has spent 20 minutes looking through thermostat 600 settings, thermostat 600 may display a customer service number for the user to dial and receive help in whatever task the user is trying to complete with thermostat 600.

[0388] Still referring to FIG. 37, thermostat 600 displays dealer information on the user interface 612 of thermostat 600 (step 3708). In some embodiments, thermostat 600 displays the phone number of a dealer, the address of a dealer, a dealer logo and/or name, or any other information that the dealer wants to display. In some embodiments, thermostat 600 displays a button which allows a user to directly contact the dealer through thermostat 600. In some embodiments, thermostat 600 displays a notification that a dealer technician is located within a set distance from thermostat 600. For example, thermostat 600 determines that there is a fault with equipment connect to thermostat 600. Thermostat 600 determines that a dealer technician is in the neighborhood of the house where the thermostat 600 is located. Thermostat 600 displays a notification that a dealer technician is in the area and has time to stop by and take a look at the fault displayed on thermostat 600. In some embodiments, a button may be displayed on user interface 612. Pushing the button on the thermostat 600 may cause a smartphone of the user to make a call to the dealer. In some embodiments, thermostat 600 may pass contact information to the smartphone via a wireless connection. In some embodiments, the smartphone may use a camera to collect the contact information presented on the thermostat 600. The contact information may be presented on the display or encoded in a barcode or Q code which may be presented on the display.

[0389] Referring again to FIG. 24, thermostat 600 is capable of communicating with a variety of devices, and entities, including utility providers. In some embodiments, thermostat 600 may control connected systems. Thermostat 600 may analyze energy usage and billing data from the utility provider and make decisions on which connected appliances or pieces of equipment can be controlled to control load. In some embodiments, thermostat 600 may communicate with a

smart meter and adjust load according to time-of-use rates or demand-response feedback. Thermostat 600 may analyze all data from the system and integrate energy usage to build efficient control algorithms, make more informed decisions, or provide more effective suggestions and tips. In some embodiments, thermostat 600 tailors all derived content to a user's preferences and past actions and decisions.

[0390] Thermostat 600 may adjust existing and create new control algorithms based on parameters such as time constraints, user preferences, and occupancy detected. In some embodiments, thermostat 600 may skip compressor stages in staging progressions when there is a limited amount of time available for the system to reach the setpoint. For example: Jill is hosting a party, which begins at 1800, today. There is only an hour until the party begins, but the system is expected to transition from 72°F to 68 °F. Thermostat 600 may determine that there is not enough time for the standard staging progression, and skip from a low stage to a high stage in order to meet the deadline for reaching the setpoint.

[0391] Thermostat 600 may adjust control algorithms based on a user's indicated preference for comfort or efficiency. In some embodiments, thermostat 600 participates in demand-response based on occupancy levels, appropriately restricting or permitting energy usage depending on detected occupancy. Thermostat 600 may determine occupancy from inputs received and command more efficient scheduling when no occupancy is detected. In some embodiments, thermostat 600 may lengthen run times when a home is unoccupied. Thermostat 600 may adjust scheduling and operations based on detected activity levels within the home. Thermostat 600 may detect that a user is not home if she has been tagged in an event hosted in a location different from home. For example, if Jill has been tagged in an event at George's house, thermostat 600 may determine that Jill is not home, and that the home is unoccupied. In some embodiments, thermostat 600 may determine that a user is not home if any social media platform has indicated that they are in a location other than home.

[0392] Thermostat 600 may receive weather input upon which a portion of system controls decisions are based. Thermostat 600 may communicate with a weather station, a weather service, or a network from which weather data can be retrieved. In some embodiments, thermostat 600

may adjust scheduling based on weather forecasts in order to better prepare for the upcoming operating conditions. Thermostat 600 may adjust defrosting operations based on the forecast. In some embodiments, thermostat 600 may detect the minimum temperature which will keep pipes from freezing while a home is unoccupied in the winter. Thermostat 600 may receive data from local sensors outside of the home and adjust conditions based on outdoor conditions. For example: a desert environment experiences a large range of temperatures every day; thermostat 600 may preempt steep temperature changes by anticipating the schedule of the changes and adjusting operation accordingly. Thermostat 600 may detect outdoor conditions and command the condenser to adjust the volume of air drawn from the outside to increase efficiency.

Configuration of Exemplary Embodiments

[0393] The construction and arrangement of the systems and methods as shown in the various exemplary embodiments are illustrative only. Although only a few embodiments have been described in detail in this disclosure, many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.). For example, the position of elements may be reversed or otherwise varied and the nature or number of discrete elements or positions may be altered or varied. Accordingly, all such modifications are intended to be included within the scope of the present disclosure. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. Other substitutions, modifications, changes, and omissions may be made in the design, operating conditions and arrangement of the exemplary embodiments without departing from the scope of the present disclosure.

[0394] The present disclosure contemplates methods, systems and program products on any machine-readable media for accomplishing various operations. The embodiments of the present disclosure may be implemented using existing computer processors, or by a special purpose computer processor for an appropriate system, incorporated for this or another purpose, or by a hardwired system. Embodiments within the scope of the present disclosure include program products comprising machine-readable media for carrying or having machine-executable

instructions or data structures stored thereon. Such machine-readable media can be any available media that can be accessed by a general purpose or special purpose computer or other machine with a processor. By way of example, such machine-readable media can comprise RAM, ROM, EPROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to carry or store desired program code in the form of machine-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer or other machine with a processor. Combinations of the above are also included within the scope of machine-readable media. Machine-executable instructions include, for example, instructions and data which cause a general purpose computer, special purpose computer, or special purpose processing machines to perform a certain function or group of functions.

[0395] Although the figures show a specific order of method steps, the order of the steps may differ from what is depicted. Also two or more steps may be performed concurrently or with partial concurrence. Such variation will depend on the software and hardware systems chosen and on designer choice. All such variations are within the scope of the disclosure. Likewise, software implementations could be accomplished with standard programming techniques with rule based logic and other logic to accomplish the various connection steps, processing steps, comparison steps and decision steps.

WHAT IS CLAIMED IS:

1. A thermostat for a building space, the thermostat comprising:
a user interface configured to display information to a user and receive input from the user; and
a processing circuit configured to identify the user and adjust the information displayed in the user interface based on the identity of the user.
2. The thermostat of Claim 1, wherein the processing circuit is further configured to:
determine whether the user is within a proximity of the user interface; and
change the information displayed in the user interface to a set of information corresponding to the identity of the user when the user is within the proximity of the user interface.
3. The thermostat of Claim 1, wherein the processing circuit is further configured to:
generate a profile for the user after the user is identified for a first time; and
update the profile based on interactions between the user and the thermostat after the user is first identified.

4. The thermostat of Claim 1, wherein the information displayed in the user interface is a combination of user interface items comprising at least one of:
- a relative humidity value;
 - a temperature value;
 - a temperature setpoint;
 - a time and date;
 - a user interface background and color scheme;
 - a set of user interface buttons;
 - a time to setpoint; and
 - thermostat faults.
5. The thermostat of Claim 1, wherein the processing circuit is further configured to communicate with a user device via near field communication;
- wherein the user device is associated with the user and the processing circuit communicates with the user device when the user device is used to check in with the thermostat via near field communication.
6. The thermostat of Claim 5, wherein the processing circuit is further configured to identify the user based on an identity of the user device that is used to check in with the thermostat via near field communication.
7. The thermostat of Claim 1, further comprising an occupancy sensor configured to detect the user and provide sensor data associated with the detected user, wherein the occupancy sensor comprises at least one of a camera, a microphone, and a motion detector;
- wherein the processing circuit is configured to identify the user by at least one of:
- performing digital image processing on an input received from the camera;
 - performing speaker recognition on an input received from the microphone; and
 - detecting motion based on an input received from the motion detector.

8. The thermostat of Claim 7, wherein performing digital image processing comprises identifying the user based on a physical characteristic of the user, wherein the physical characteristic comprises at least one of a face of the user and a height of the user.

9. The thermostat of Claim 7, wherein performing speaker recognition comprises at least one of:

using a text dependent voice recognition technique to identify words spoken to the thermostat and compare the spoken words to a database of words and phrases associated with the user; and

using a text independent voice recognition technique comprising pattern matching of stored voice biometrics associated with the user to identify the user.

10. The thermostat of Claim 7, wherein detecting motion comprises:

registering a plurality of hand waves detected by the motion detector;

identifying a number of hand waves registered; and

identifying a user associated with the identified number of hand waves registered.

11. The thermostat of Claim 1, wherein the processing circuit is further configured to communicate with a voice-controlled smarthome controller via at least one of the Internet, Bluetooth, Wi-Fi, and Zigbee;

wherein the voice-controlled smarthome controller identifies the user and communicates the identity of the user to the thermostat via at least one of the Internet, Bluetooth, Wi-Fi, and Zigbee.

12. A near field communication enabled thermostat for a building space, the thermostat comprising:

a user interface configured to display information to a user and receive input from the user;

a near field communication module configured to communicate with a user device; and

a processing circuit configured to:

identify the user based on communications with the user device via the near field communication module; and

automatically display the custom user interface associated with the identified user.

13. The thermostat of Claim 12, wherein the processing circuit is further configured to:

detect the user within the building space with an occupancy sensor comprising at least one of a motion detector, a microphone, and a camera;

receive a custom user interface and a custom heating and cooling schedule associated with the identified user; and

automatically run the custom heating and cooling schedule associated with the user when the user is identified.

14. The thermostat of Claim 13, wherein the processing circuit is further configured to identify the user in response to receiving a detection signal from the occupancy sensor.

15. The thermostat of Claim 14, wherein identifying the user comprises at least one of:

performing digital image processing on an input received from the camera;

performing speaker recognition on an input received from the microphone; and

detecting motion based on an input received from the motion detector.

16. The thermostat of Claim 12, wherein the processing circuit is further configured to communicate with a voice-controlled smarthome controller via at least one of the Internet, Bluetooth, and Zigbee;

wherein the voice-controlled smarthome controller identifies the user and communicates an identity of the user to the thermostat.

17. A method for operating a thermostat, the method comprising:

displaying information to a user and receiving input from the user through a user interface;

detecting an identity of the user within a building space;

displaying information in the user interface, wherein the information is associated with an identity of the user.

18. The method of Claim 17, wherein detecting the identity of the user within the building space is based on sensor data collected from an occupancy sensor and comprises identifying at least one physical characteristic of the user with digital image processing when the occupancy sensor is a camera.

19. The method of Claim 17, wherein detecting the identity of the user within the building space is based on sensor data collected from an occupancy sensor and comprises performing a text independent voice recognition technique when the occupancy sensor is a microphone;

wherein the text independent voice recognition technique uses pattern matching to determine voice biometrics associated with the user.

20. The method of Claim 17, wherein detecting the identity of the user within the building space is based on sensor data collected from an occupancy sensor and comprises:

- registering a plurality of hand waves detected by the occupancy sensor when the occupancy sensor is a motion sensor;
- identifying a number of hand waves registered by the motion sensor; and
- identifying a user associated with the number of hand waves registered by the motion sensor.

21. A thermostat for a building space, the thermostat comprising:

- a communications interface configured to engage in bidirectional communications with heating, ventilation, or air conditioning (HVAC) equipment and to receive an indication of a current heating or cooling load from the HVAC equipment; and

- a processing circuit configured to:
 - determine an occupancy of the building space based on the indication of the current heating or cooling load received from the HVAC equipment; and
 - operate the HVAC equipment based on the determined occupancy of the building space.

22. The thermostat of Claim 21, wherein the processing circuit is further configured to determine load metrics based, wherein the load metrics comprise a time to setpoint calculated from at least one of:

- known capabilities of the HVAC equipment;
- the heating and cooling load;
- a time of day;
- weather conditions; and
- historical equipment data.

23. The thermostat of Claim 21, wherein the communications interface is further configured to communicate with a fitness tracker, wherein the indication of the current heating and cooling load is further received from the fitness tracker.

24. The thermostat of Claim 23, wherein the indication of the current heating and cooling load received from the fitness tracker is based on the physical activity of a user wearing the fitness tracker.

25. The thermostat of Claim 21, further comprising a user interface configured to display dealer information;

wherein the processing circuit is further configured to update the dealer information in response to a determination that at least one of:

- a predetermined amount of time has passed since the dealer information was last updated;
- the thermostat is in a commissioning mode;
- a dealer contract has started; and
- a dealer contract has ended.

26. The thermostat of Claim 21, further comprising a user interface configured to display dealer information;

wherein the processing circuit is configured to cause the user interface to display the dealer information in response to detecting one or more thermostat events comprising at least one of:

- a determination that a predetermined amount of time has passed;
- detecting a system fault; and
- a determination that a user is adjusting settings in the thermostat for a time longer than a predetermined amount of time.

27. The thermostat of Claim 21, further comprising a user interface configured to display dealer information;

wherein the processing circuit is further configured to hide the dealer information in response to receiving a notification to hide the dealer information, wherein the notification is received by the communications interface.

28. The thermostat of Claim 27, wherein the notification received by the communications interface comprises at least one of:

- a notification that the dealer is late on a payment; and
- a notification that the dealer has canceled a contract.

29. The thermostat of Claim 21, further comprising a user interface configured to display dealer information;

wherein the processing circuit is further configured cause the user interface to display the dealer information when a fault is detected, the dealer information comprising at least one of:

- a button to contact the dealer;
- a dealer phone number;
- a dealer address; and
- a dealer store hours.

30. A method for operating a bidirectional thermostat, the method comprising:
determining a time to setpoint for a building space; and
displaying the time to setpoint on a user interface.

31. The method of Claim 30, wherein the method further comprises determining load metrics, wherein the load metrics comprise the time to setpoint calculated from at least one of:

known capabilities of the HVAC equipment;

the heating and cooling load;

time of day;

weather conditions; and

historical equipment data.

32. The method of Claim 30, further comprising causing the user interface to display a recommendation for achieving a requested setpoint, wherein the recommendation comprises waiting a predetermined amount of time before attempting the requested setpoint, closing shades in a zone of a building, and turning on a fan in the zone of the building.

33. The method of Claim 30, further comprising determining if a requested setpoint is achievable based on comparing a first time to setpoint for a first zone of a building space and a second time to setpoint for a second zone of the building space.

34. The method of Claim 30, further comprising determining the amount of time required to reach the requested setpoint when the requested setpoint is determined to be achievable.

35. A thermostat for a building space, the thermostat comprising:

a communications interface configured to engage in bidirectional communications with heating, ventilation, or air conditioning (HVAC) equipment and to receive an indication of a current heating or cooling load from the HVAC equipment; and

a processing circuit configured to determine if a requested setpoint is achievable based on the load.

36. The thermostat of Claim 35, wherein the processing circuit is configured to determine if the requested setpoint is achievable further based on factors comprising:

- a status of an electrical grid;
- weather conditions; and
- a time of day.

37. The thermostat of Claim 35, wherein the processing circuit is further configured to determine an amount of time required to reach the requested setpoint when the requested setpoint is determined to be achievable.

38. The thermostat of Claim 35, wherein the processing circuit is further configured to determine an amount of time required to reach the requested setpoint based on factors comprising:

- a status of an electrical grid;
- weather conditions; and
- historical data associated with the HVAC equipment.

39. The thermostat of Claim 35, wherein the processing circuit is configured to determine if a requested setpoint is achievable further based on comparing a first time to setpoint for a first zone of the building space and a second time to setpoint for a second zone of the building space.

40. The thermostat of Claim 35, wherein the processing circuit is further configured to cause a user interface to display a recommendation for achieving the requested setpoint, wherein the recommendation comprises waiting a predetermined amount of time before attempting the requested setpoint, closing shades in a zone of the building, and turning on a fan in the zone of the building.

41. A thermostat for a building space, the thermostat comprising:
- a network communication module communicatively coupled to at least one of one or more social media servers and one or more calendar servers; and
 - a processing circuit configured to:
 - receive at least one of social media activity, social media events, and calendar events associated with a user via the network communication module;
 - determine an expected occupancy of the building based on at least one of the social media events and the calendar events; and
 - adjust a setpoint of the thermostat based on at least one of the expected occupancy and the social media activity.
42. The thermostat of Claim 41, wherein:
- the social media events comprise a social media event location, a social media event start time, and a social media event end time; and
 - the calendar events comprise a calendar event location, a calendar event start time, and a calendar event end time.
43. The thermostat of Claim 41, wherein the expected occupancy of the building space comprises a number of occupants of the building space at each of a plurality of times.
44. The thermostat of Claim 41, wherein the social media activity associated with the user comprises at least one of:
- a private message sent via a social media platform;
 - a public comment via the social media platform;
 - a public post via the social media platform;
 - a private comment via the social media platform; and
 - a private post via the social media platform.

45. The thermostat of Claim 41, wherein the processing circuit is further configured to adjust a setpoint of the thermostat based on the social media activity;

wherein the social media activity comprises a command to perform at least one of raising the setpoint and lowering the setpoint.

46. The thermostat of Claim 45, wherein the command comprises at least one of:
social media activity directed to the thermostat; and
social media activity monitored by the thermostat.

47. The thermostat of Claim 41, wherein the processing circuit is further configured to:
determine a plurality of times at which the building space will be occupied and unoccupied based on the expected occupancy;

determine a time required to reach the setpoint based on factors comprising a setpoint target, weather conditions, and equipment functionality;

preemptively adjust the setpoint of the building space before the building space is unoccupied based on the determined time required to reach the setpoint; and

preemptively adjust the setpoint of the building space before the building space is occupied based on the determined time required to reach the setpoint.

48. The thermostat of Claim 41, wherein the processing circuit is configured to adjust the setpoint of the thermostat based on the expected occupancy by:

lowering the setpoint by a calculated amount in response to a determination that the building space is unoccupied and the thermostat is in a heating mode;

raising the setpoint by the calculated amount in response to a determination that the building space is occupied and the thermostat is in the heating mode;

raising the setpoint by the calculated amount in response to a determination that the building space is unoccupied and the thermostat is in a cooling mode; and

lowering the setpoint by the calculated amount in response to a determination that the building space is occupied and the thermostat is in the cooling mode.

49. The thermostat of Claim 41, wherein the processing circuit is further configured to:

send a query to the social media servers and receive the social media activity and the social media events associated with the user of the thermostat; and

send a query to the calendar servers and receive the calendar events associated with the user.

50. The thermostat of Claim 41, wherein the processing circuit is further configured to send a social media notification via the network communication module to the user, the social media notification comprising thermostat information.

51. A method for adjusting a setpoint of a thermostat for a building space, the method comprising:

receiving event data via a network communication module of the thermostat, the event data comprising at least one of social media events and calendar events associated with a user;

determining an expected occupancy of the building space based on the event data; and

adjusting the setpoint of the thermostat for the building space based on the expected occupancy of the building space.

52. The method of Claim 51, wherein receiving event data via the network communication module of the thermostat comprises:

subscribing to social media servers and receiving the social media events associated with the user of the thermostat when social media activity occurs; and

subscribing to calendar servers and receiving the calendar events associated with the user when the calendar events are added by the user.

53. The method of Claim 51, wherein determining the expected occupancy of the building space based on the event data comprises:

identifying locations of one or more events associated with the user;

identifying start times of the events and end times of the events; and

identifying a number of occupants of the building space between the start times of the events and the end times of the events.

54. The method of Claim 51, wherein adjusting the setpoint comprises determining an amount by which to adjust the setpoint based on:

the expected occupancy of the building space;

a temperature of the building space; and

a time required to reach the setpoint based on the temperature of the building space and the expected occupancy.

55. The method of Claim 51, wherein adjusting the setpoint of the thermostat for the building space based on the expected occupancy of the building space comprises:

lowering the setpoint by a calculated amount in response to a determination that the building space is unoccupied and the thermostat is in a heating mode;

raising the setpoint by the calculated amount in response to a determination that the building space is occupied and the thermostat is in the heating mode;

raising the setpoint by the calculated amount in response to a determination that the building space is unoccupied and the thermostat is in a cooling mode; and

lowering the setpoint by the calculated amount in response to a determination that the building space is occupied and the thermostat is in the cooling mode.

56. The method of Claim 51, the method further comprising:

determining a plurality of times at which the building space will be occupied and unoccupied based on the expected occupancy;

determining a time required to reach the setpoint based on factors comprising a setpoint target, weather conditions, and equipment functionality;

preemptively adjusting the setpoint of the building space before the building space is unoccupied based on the time required to reach the setpoint; and

preemptively adjusting the setpoint of the building space before the building space is occupied based on the time required to reach the setpoint.

57. A social media enabled thermostat, the thermostat comprising:
a network communication module communicatively coupled to one or more social media servers; and
a processing circuit configured to:
receive at least one of social media activity and social media events associated with a user via the network communication module;
generate social media notifications and serve the notifications to the user via the network communication module;
determine an expected occupancy of the building based on the social media events; and
adjust a setpoint of the thermostat based on at least one of the expected occupancy and the social media activity.

58. The thermostat of Claim 57, wherein the social media events comprise:
a social media event location;
a number of social media event attendees;
a social media event start time; and
a social media event end time.

59. The thermostat of Claim 57, wherein the processing circuit is configured to receive at least one of the social media activity and the social media events associated with the user via the network communication module by:
subscribing to the social media servers; and
receiving the social media activity and the social media events associated with the user of the thermostat when the social media activity occurs.

60. The thermostat of Claim 57, wherein the processing circuit is configured to adjust the setpoint of the thermostat based on at least one of the expected occupancy and the social media activity;

wherein the social media activity comprises a command to perform at least one of raising the setpoint and lowering the setpoint.

61. A thermostat for a building space, the thermostat comprising:

a near field communications module configured to communicate with a user device via near field communication; and

a processing circuit configured to:

send data to the user device via the near field communications module; and

receive data from the user device via the near field communication module and process the received data, wherein the data identifies the user or a user type.

62. The thermostat of Claim 61, wherein the processing circuit is further configured to:

automatically set settings of the thermostat to user settings associated with the user;

automatically generate average user settings by averaging a plurality of user settings associated with a plurality of users; and

automatically set the thermostat settings to the average user settings when the plurality of users check in with the thermostat.

63. The thermostat of Claim 61, wherein the data received from the user device comprises a password and the processing circuit is further configured to lock the thermostat with the password.

64. The thermostat of Claim 61, wherein the processing circuit is further configured to make the user a master of the thermostat and allow the user control over thermostat settings when the user checks in with the thermostat and the thermostat is in an unlocked state.

65. The thermostat of Claim 61, wherein the processing circuit is further configured to prompt the user to install an application for interacting with the thermostat on the user device when the user checks in with the thermostat for a first time.

66. The thermostat of Claim 65, wherein the application for interacting with the thermostat receives thermostat settings from the user and transmits the settings to the thermostat through near field communication.

67. The thermostat of Claim 61, wherein the processing circuit is configured to:
generate a performance report;
determine whether the user associated with the user device is authorized to receive the performance report; and
cause the near field communications module to send the performance report to the user device when the user device checks in with the thermostat and in response to a determination that the user is authorized to receive the performance report.

68. The thermostat of Claim 67, wherein the performance report comprises at least one of:
an energy management report;
a system state;
temperature setpoint; and
a current temperature.

69. The thermostat of Claim 1, wherein the processing circuit is further configured to apply a dealer configuration to the thermostat when:
the user device checks in with the thermostat;
the user device transmits the dealer configuration and a command to apply the dealer configuration to the thermostat; and
the user device is a dealer authorized device.

70. The thermostat of Claim 61, wherein the processing circuit is further configured to cause the near field communications module to send a command to the user device causing the user device to generate an email, the email comprising fault information.

71. The thermostat of Claim 61, wherein the processing circuit is further configured to:
detect faults in at least one of the thermostat and equipment connected to the thermostat;
generate a faults report comprising the detected faults; and
transmit the faults report to the user device through near field communication.

72. The thermostat of Claim 61, wherein the processing circuit is further configured to cause the near field communications module to send trouble shooting information for a thermostat fault to the user device in response to a determination that the user device is an authorized dealer device.

73. The thermostat of Claim 72, wherein the trouble shooting information comprises a command to retrieve troubleshooting information from a network.

74. A method for nearfield communication with a thermostat, the method comprising:
sending data to a user device via a near field communications module;
receiving data from the user device via the near field communication module and
processing the received data; and
checking in a user with the thermostat, wherein the user is associated with the user device.

75. The method of Claim 74, wherein the method further comprises:
automatically changing settings of the thermostat to user settings associated with the user when the user checks in with the thermostat;
automatically generating average user settings by averaging a plurality of user settings associated with a plurality of users; and
automatically changing the thermostat settings to the average user settings when the plurality of users check in with the thermostat.
76. The method of Claim 74, wherein checking in the user with the thermostat comprises making the user a master of the thermostat when the thermostat is in an unlocked state.
77. The method of Claim 74, the method further comprising applying a dealer configuration to the thermostat when:
the user device checks in with the thermostat;
the user device transmits the dealer configuration and a command to apply the dealer configuration to the thermostat; and
the user device is a dealer authorized device.
78. The method of Claim 74, wherein the method further comprises:
detecting faults in at least one of the thermostat and equipment connected to the thermostat;
generating a faults report comprising the detected faults; and
transmitting the faults report to the user device through near field communication.
79. The method of Claim 74, wherein sending data to the user device via the near field communications module comprises sending trouble shooting information when the user device is an authorized dealer device.

80. A thermostat for a building space, the thermostat comprising:
a near field communications module configured to communicate with a user device via near field communication; and
a processing circuit configured to receive data from the user device through the near field communication module and process the data.
81. A thermostat for a building space, the thermostat comprising:
a user interface configured to serve notifications to a user and receive input from the user;
a communications interface configured to perform bidirectional data communications with HVAC equipment controlled by the thermostat, wherein the communications interface is configured to receive performance information for the HVAC equipment; and
a processing circuit configured to:
provide control signals to the HVAC equipment to achieve a setpoint for the building space;
evaluate the performance information for the HVAC equipment to determine a recommendation for improving HVAC equipment performance; and
automatically adjust at least one of the setpoint and the control signals provided to the HVAC equipment based on the recommendation for improving HVAC equipment performance.
82. The thermostat of Claim 81, wherein the processing circuit is further configured to:
receive a target bill amount from the user interface of the thermostat;
determine optimal setpoints for the building space based on the performance information and the target bill amount; and
present the optimal setpoints to the user through the user interface.

83. The thermostat of Claim 81, wherein the processing circuit is further configured to:
determine whether the HVAC equipment has taken longer than a threshold time to achieve the setpoint based on the performance information; and
generate a new setpoint for the building space in response to a determination that the HVAC equipment has taken longer than the threshold time to achieve the setpoint, wherein the processing circuit calculates the new setpoint such that the HVAC equipment reaches the new setpoint within the threshold time.
84. The thermostat of Claim 81, wherein the processing circuit is further configured to generate a report from the performance information and serve the report to the user through the user interface, the report comprising at least one of:
an energy usage of the HVAC equipment;
an energy usage for a plurality of operating parameters of the HVAC equipment;
runtime costs of a plurality of stages of the HVAC equipment; and
equipment replacement suggestions for the HVAC equipment.
85. The thermostat of Claim 84, wherein the processing circuit is further configured to:
log the energy usage of the HVAC equipment over time;
determine historical energy usage from the logged energy usage;
identify a current energy usage of the HVAC equipment; and
provide an equipment replacement suggestion in response to a determination that the current energy usage of the HVAC equipment exceeds the historical energy usage by a predetermined amount.

86. The thermostat of Claim 81, wherein the processing circuit is further configured to:
transmit the performance information to an analytics service; and
receive a report generated by the analytics service from the performance information.
87. The thermostat of Claim 81, wherein the processing circuit is further configured to:
automatically generate multiple different sets of thermostat settings for operating the HVAC equipment;
automatically use each set of the thermostat settings to operate the HVAC equipment at different times;
determine an energy usage of the HVAC equipment resulting from each set of the thermostat settings based on the performance information; and
notify the user of the set of thermostat settings that results in a lowest energy usage through the user interface.
88. The thermostat of Claim 81, wherein the processing circuit is further configured to receive information for a plurality of neighborhood buildings from a data analytics service, the information comprising at least one of setpoints of the neighborhood buildings, monthly energy bills of the neighborhood buildings, and equipment used in the neighborhood buildings.
89. The thermostat of Claim 88, wherein the processing circuit is further configured to:
suggest setpoints to the user based on the setpoints of the neighborhood buildings and the monthly energy bills of the neighborhood buildings; and
suggest equipment purchases to the user based on the equipment used in the neighborhood buildings.

90. A method for a thermostat with bidirectional communication, the method comprising:
serving notifications to a user and receiving input from the user through a user interface;
performing bidirectional data communications with HVAC equipment controlled by the thermostat, wherein the thermostat receives performance information for the HVAC equipment through a communications interface; and
evaluating the performance information for the HVAC equipment and determining a recommendation for improving HVAC equipment performance.
91. The method of Claim 90, the method further comprising generating a report and serving the report to the user through the user interface, the report comprising at least one of:
an energy usage of the HVAC equipment;
an energy usage for a plurality of operating parameters of the HVAC equipment;
runtime costs of a plurality of stages of the HVAC equipment; and
equipment replacement suggestions for the HVAC equipment.
92. The method of Claim 90, the method further comprising generating equipment replacement suggests by:
logging energy usage of the HVAC equipment over time, wherein the energy usage is determined from the performance information;
determining historical energy usage from the logged energy usage; and
determining an equipment replacement suggestion in response to a determination that current energy usage of the HVAC equipment exceeds the historical energy usage by a predetermined amount.

93. The method of Claim 90, the method further comprising determining energy efficient settings by:

automatically generating multiple different sets of thermostat settings for controlling the HVAC equipment;

automatically using each set of the thermostat settings to control the HVAC equipment at different times;

determining a plurality of energy usage amounts of the HVAC equipment resulting from each set of the thermostat settings based on the performance information; and

notifying the user of the set of thermostat settings that results in a lowest energy usage through the user interface.

94. The method of Claim 90, the method further comprising:

receiving a target bill amount from the user interface of the thermostat;

determining optimal setpoints for a building space based on the performance information and the target bill amount; and

presenting the optimal setpoints to the user through the user interface.

95. A thermostat for a building space with bidirectional communication, the thermostat comprising:

- a user interface configured to serve information to a user and receive input from the user;
- a communications interface configured to perform bidirectional data communications with HVAC equipment controlled by the thermostat, wherein the communications interface is configured to receive performance information for the HVAC equipment; and
- a processing circuit configured to perform at least one of the following operations:
 - make suggestions for replacing HVAC equipment based on the performance information for the HVAC equipment;
 - receive a target bill amount from a user through the user interface and make HVAC equipment setting suggestions to the user through the user interface that achieve the target bill amount; and
 - generate a thermostat report and serve the report to the user through the user interface.

96. The thermostat of Claim 95, wherein the performance information for the HVAC equipment comprises:

- runtime information of the HVAC equipment; and
- error codes of the HVAC equipment.

97. The thermostat of Claim 95, wherein the processing circuit is further configured to:
automatically generate multiple different sets of thermostat settings for operating the HVAC equipment;
automatically use each set of the thermostat settings to operate the HVAC equipment at different times;
determine an energy usage of the HVAC equipment resulting from each set of the thermostat settings based on the performance information; and
notify the user of the set of thermostat settings that results in a lowest energy usage through the user interface.
98. The thermostat of Claim 95, wherein the processing circuit is further configured to:
determine whether the HVAC equipment has taken longer than a threshold time to achieve a setpoint based on the performance information; and
generate a new setpoint for the building space in response to a determination that the HVAC equipment has taken longer than the threshold time to achieve the setpoint, wherein the processing circuit calculates the new setpoint such that the HVAC equipment reaches the new setpoint within the threshold time.
99. The thermostat of Claim 95, wherein the report comprises at least one of:
an energy usage of the HVAC equipment;
an energy usage for a plurality of operating parameters of the HVAC equipment;
runtime costs of a plurality of stages of the HVAC equipment; and
equipment replacement suggestions for the HVAC equipment.
100. The thermostat of Claim 95, wherein the processing circuit is further configured to receive information for a plurality of neighborhood buildings from a data analytics service, the information comprising at least one of setpoints of the neighborhood buildings, monthly energy bills of the neighborhood buildings, and equipment used in the neighborhood buildings.

101. A thermostat for a building space, the thermostat comprising:
an electronic display;
a frame;
a touch-sensitive interface having a first portion that overlays the electronic display and a second portion that overlays the frame, wherein the touch-sensitive interface is configured to receive touch-based input via both the first portion and the second portion;
a processing circuit configured to define one or more locations within the second portion that correspond to touch-sensitive buttons, wherein the locations of the touch-sensitive buttons are customizable and can be changed by a user; and
at least one of a sticker and a skin that covers at least part of the second portion and visually marks the locations of the touch-sensitive buttons.
102. The thermostat of Claim 101, wherein the processing circuit is configured to define the one or more locations within the second portion that correspond to the touch-sensitive buttons by receiving the one or more locations from the user.
103. The thermostat of Claim 102, wherein the locations of the touch-sensitive buttons are changed by the user through at least one of a web-based application and a mobile application, wherein the web-based application and the mobile application are communicatively coupled to the processing circuit.
104. The thermostat of Claim 103, wherein the web-based application and the mobile application are configured to generate a digital file comprising a design for at least one of the sticker and the skin that mark the location of the touch-sensitive buttons.

105. The thermostat of Claim 101, wherein the processing circuit is further configured to generate a digital file comprising a design of at least one of the sticker and the skin.

106. The thermostat of Claim 101, wherein the processing circuit is further configured associate the touch-based input to the location of the touch sensitive-button when the touch sensitive-button receives the touch-based input.

107. The thermostat of Claim 101, wherein the touch-sensitive buttons are configured to receive at least one of a direct touch and a touch movement.

108. The thermostat of Claim 107, wherein touch movement comprises at least one of:
a swipe up;
a swipe down;
a swipe right; and
a swipe left.

109. The thermostat of Claim 101, wherein the sticker and skin comprise symbols that mark the location of the touch-sensitive buttons, the symbols comprising at least one of:
a button symbol;
a user defined symbol; and
a manufacturer defined logo.

110. A method for sensing touch-based input with a thermostat, the method comprising:
- receiving the touch-based input via both a first portion of a touch-sensitive interface and a second portion of the touch-sensitive interface, wherein the first portion overlays an electronic display of the touch-sensitive interface and the second portion overlays a frame of the touch-sensitive interface;
 - defining one or more locations of touch-sensitive buttons within the second portion of the electronic display, wherein the locations of the touch-sensitive buttons are customizable and can be changed by a user; and
 - visually marking the locations of the touch-sensitive buttons on the second portion of the touch-sensitive interface using at least one of a sticker and a skin.
111. The method of Claim 110, wherein defining the one or more locations within the second portion of the electronic display corresponding to touch-sensitive buttons comprises at least one of:
- receiving the locations from the touch-sensitive interface;
 - receiving the locations from a mobile application; and
 - receiving the locations from a web-based application.
112. The method of Claim 110, wherein receiving the touch-based input via the second portion of the touch-sensitive interface comprises associating the touch-based input to the touch sensitive-button.
113. The method of Claim 110, wherein the touch-sensitive buttons are configured to detect at least one of a direct touch and a touch movement.

114. The method of Claim 110, wherein the method further comprises detecting a touch movement, the touch movement comprising at least one of:

- a swipe up;
- a swipe down;
- a swipe right; and
- a swipe left.

115. A thermostat for a building space, the thermostat comprising:

- an electronic display;
- a frame;
- a touch-sensitive interface having a first portion that overlays the electronic display and a second portion that overlays the frame, wherein the touch-sensitive interface is configured to receive touch-based input via both the first portion and the second portion;
- a skin that covers at least part of the second portion and visually marks locations of one or more touch-sensitive buttons on the second portion; and
- a processing circuit configured to:
 - define one or more locations within the second portion that correspond to the touch-sensitive buttons; and
 - detect at least one of a direct touch and a touch movement based on user input provided via the second portion of the touch-sensitive interface.

116. The thermostat of Claim 115, wherein the processing circuit is further configured to associate touch-based input of the touch sensitive-button to the location of the touch sensitive-button.

117. The thermostat of Claim 115, wherein the touch movement comprises at least one of:
a swipe up;
a swipe down;
a swipe right; and
a swipe left.
118. The thermostat of Claim 115, wherein the processing circuit is configured to define the one or more locations within the second portion that correspond to the touch-sensitive buttons by receiving the locations of the touch-sensitive buttons from at least one of:
the touch-sensitive interface;
a mobile application; and
a web-based application.
119. The thermostat of Claim 118, wherein at least one of the web-based application and the mobile application are configured to generate a digital file comprising a design for the skin.
120. The thermostat of Claim 115, wherein the skin comprises symbols that visually mark the location of the touch-sensitive buttons, wherein the symbols comprise at least one of:
a button symbol;
a user defined symbol; and
a manufacturer defined logo.

121. A thermostat for a building space, the thermostat comprising:
- a communications interface configured to receive service provider information via a network connection;
 - an electronic display comprising a user interface configured to display the service provider information; and
 - a processing circuit configured to determine when to display service provider information on the electronic display by monitoring thermostat events.
122. The thermostat of Claim 121, wherein the processing circuit is further configured to:
- receive the service provider information from a dealer associated with the thermostat;
 - receive new service provider information from a second dealer when the dealer associated with the thermostat changes from a first dealer to the second dealer; and
 - display the new service provider information via the electronic display in response to a determination that the dealer associated with the thermostat has changed from the first dealer to the second dealer.
123. The thermostat of Claim 121, wherein the processing circuit is further configured to receive the service provider information via the communications interface when the thermostat is first installed in the building space.
124. The thermostat of Claim 121, wherein the service provider information comprises customized branding, the customized branding comprising at least one of:
- a dealer phone number;
 - a dealer address;
 - dealer store hours;
 - a dealer RSS feed; and
 - a dealer logo.

125. The thermostat of Claim 121, wherein the processing circuit is further configured to receive the service provider information via the communications interface when a dealer creates new branding and serves the new branding to the thermostat via the communications interface.

126. The thermostat of Claim 121, wherein the processing circuit is further configured to:
cause the electronic display to display a button to contact a dealer;
detect a user pressing the button;
place a call to the dealer through voice over Internet in response to detecting the user pressing the button; and
transmit communications between the user and the dealer using at least one of a microphone and a speaker of the thermostat.

127. The thermostat of Claim 121, wherein the processing circuit is configured to determine when to display dealer information on the electronic display by monitoring thermostat events; wherein the thermostat events comprise at least one of:
a fault occurring in the thermostat;
a fault occurring in equipment connected to the thermostat;
detecting that maintenance is due for the thermostat;
detecting that maintenance is due for the connected equipment;
determining that a threshold time has passed since the dealer information was last displayed; and
determining that a user is adjusting settings in the thermostat for a time longer than a predetermined amount of time.

128. The thermostat of Claim 121, wherein the service provider information comprises advertisements;

wherein the processing circuit is configured to select the advertisements based on at least one of:

a schedule of the thermostat; and
an ambient temperature.

129. The thermostat of Claim 121, wherein the processing circuit is further configured to collect revenue information and serve the revenue information to a dealer via the communications interface, the revenue information comprising at least one of:

number of service calls placed;
number of technician visits to the building;
advertising revenue; and
equipment and parts purchased.

130. A method for operating a network branded thermostat, the method comprising:
receiving customized branding via a network connection of the thermostat;
determining when to display the customized branding on the electronic display by monitoring thermostat events; and
displaying the customized branding on an electronic display of the thermostat in response to detecting one or more of the thermostat events.

131. The method of Claim 130, wherein the method further comprising receiving the customized branding via the network connection when the thermostat is first installed in a building space.

132. The method of Claim 130, the method further comprising receiving new customized branding from a second dealer when a dealer associated with the thermostat changes from a first dealer to the second dealer.

133. The method of Claim 130, wherein the customized branding comprising at least one of:
a dealer phone number;
a dealer address;
dealer store hours;
a dealer RSS feed; and
a dealer logo.

134. The method of Claim 130, further comprising receiving customized branding via the network connection when a dealer creates new branding and serves the new branding to the thermostat via the network connection.

135. The method of Claim 130, the method further comprising collecting revenue information and serving the revenue information to a dealer via the network connection, the revenue information comprising:
number of service calls placed;
number of technician visits to the building;
advertising revenue; and
equipment and parts purchased.

136. A dealer configured thermostat for a building space, the thermostat comprising:
- a communications interface configured to receive dealer information via a network connection;
 - an electronic display comprising a user interface configured to display the dealer information; and
 - a processing circuit configured to determine when to display the dealer information on the electronic display by monitoring events of the thermostat.
137. The thermostat of Claim 136, wherein the dealer information comprises at least one of:
- a dealer phone number;
 - a dealer address;
 - dealer store hours;
 - a dealer RSS feed; and
 - a dealer logo.
138. The thermostat of Claim 136, wherein the processing circuit is further configured to:
- cause the electronic display to display a button to contact a dealer;
 - detect a user pressing the button;
 - place a call to the dealer through voice over Internet in response to detecting the user pressing the button; and
 - transmit communications between the user and the dealer using at least one of a microphone and a speaker of the thermostat.

139. The thermostat of Claim 136, wherein the processing circuit is further configured to collect revenue information and serve the revenue information to a dealer via the communications interface, the revenue information comprising:

- number of service calls placed;
- number of technician visits to the building;
- advertising revenue; and
- equipment and parts purchased.

140. The thermostat of Claim 136, wherein the processing circuit is further configured to:

- receive customized branding from a dealer associated with the thermostat;
- receive new customized branding from a second dealer when the dealer associated with the thermostat changes from a first dealer to the second dealer; and
- display the new customized branding via the electronic display in response to a determination that the dealer associated with the thermostat has changed from the first dealer to the second dealer.

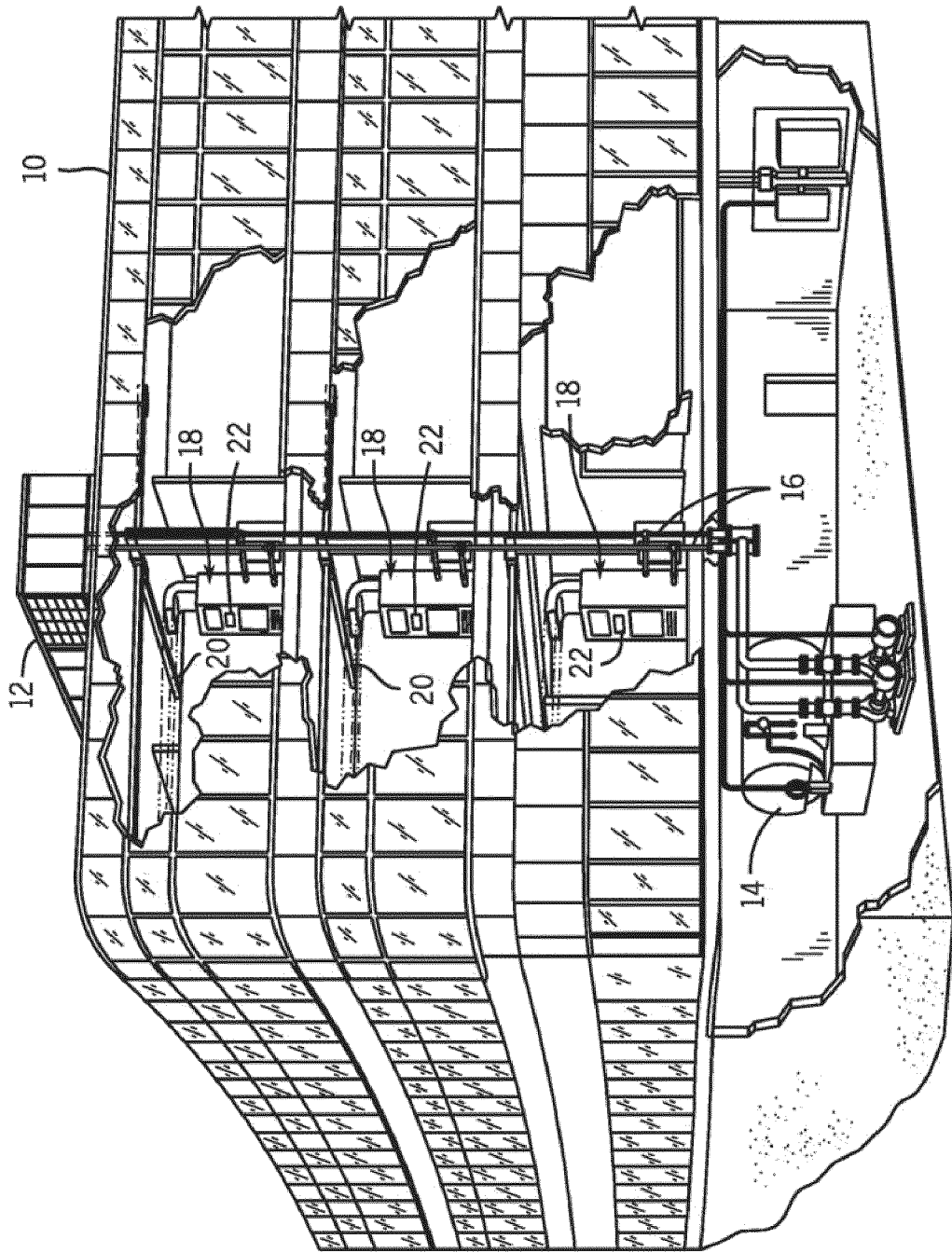


FIG. 1

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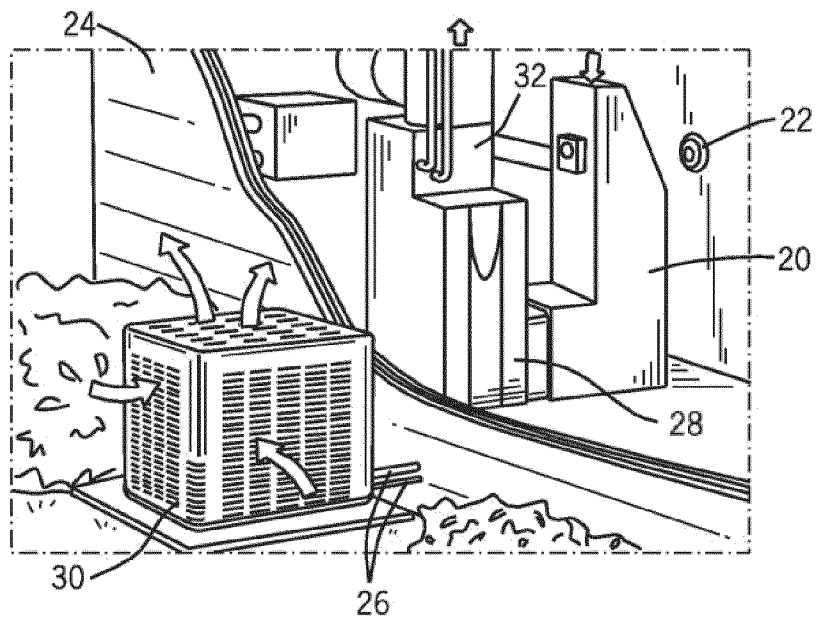


FIG. 2

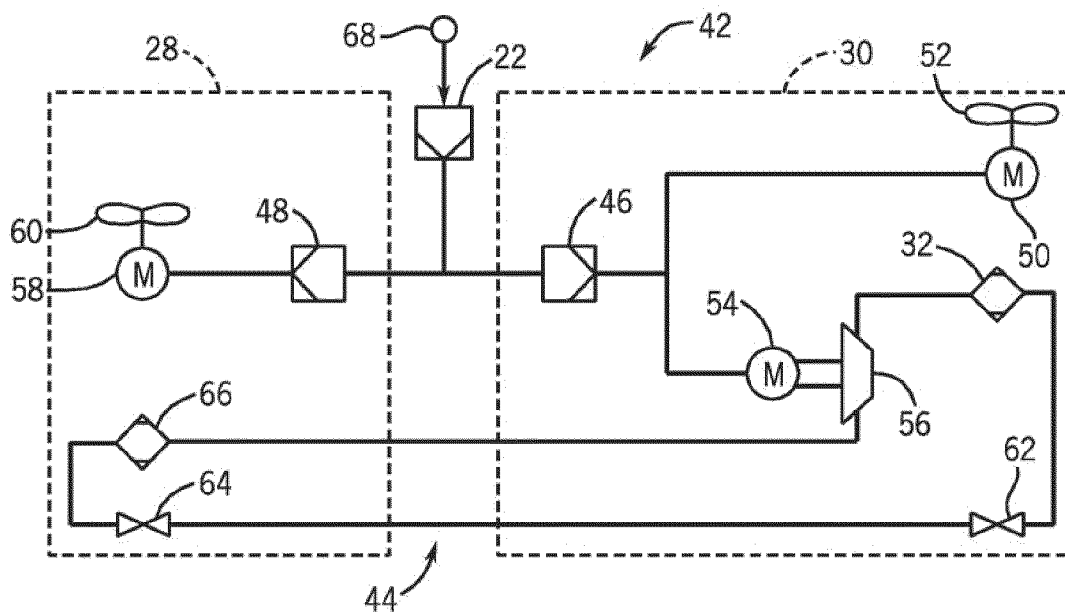
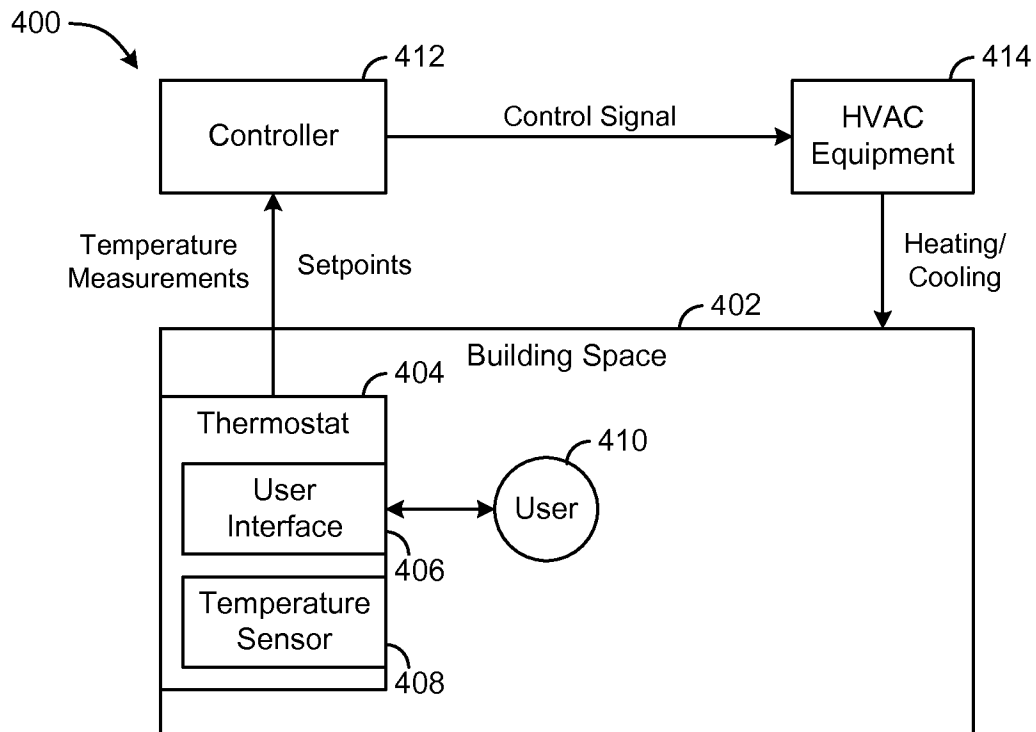
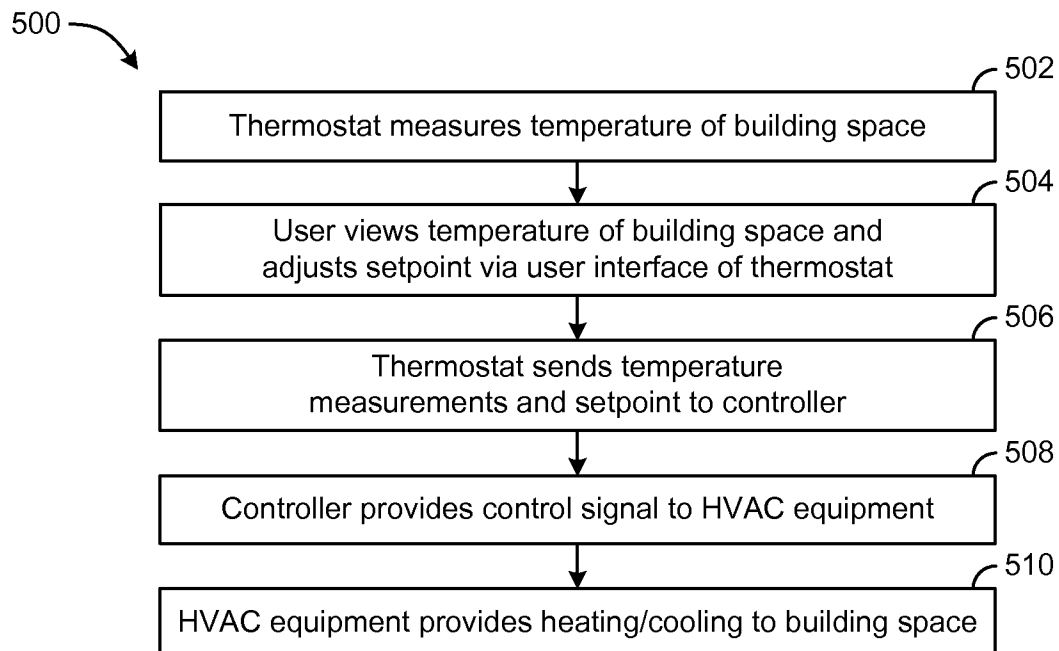


FIG. 3

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**FIG. 4****FIG. 5**

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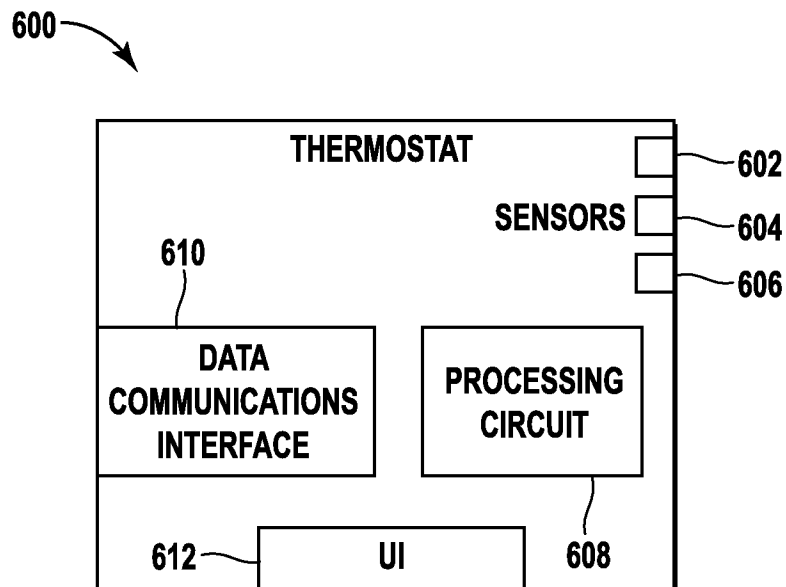


FIG. 6

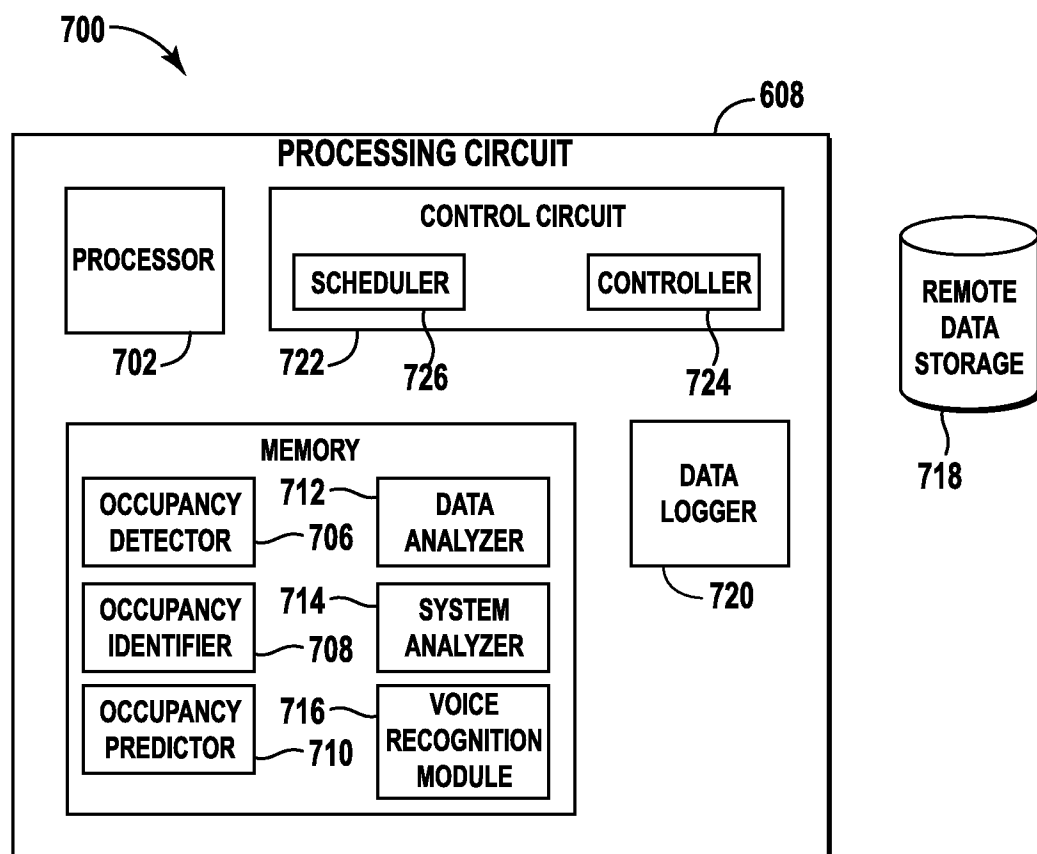


FIG. 7

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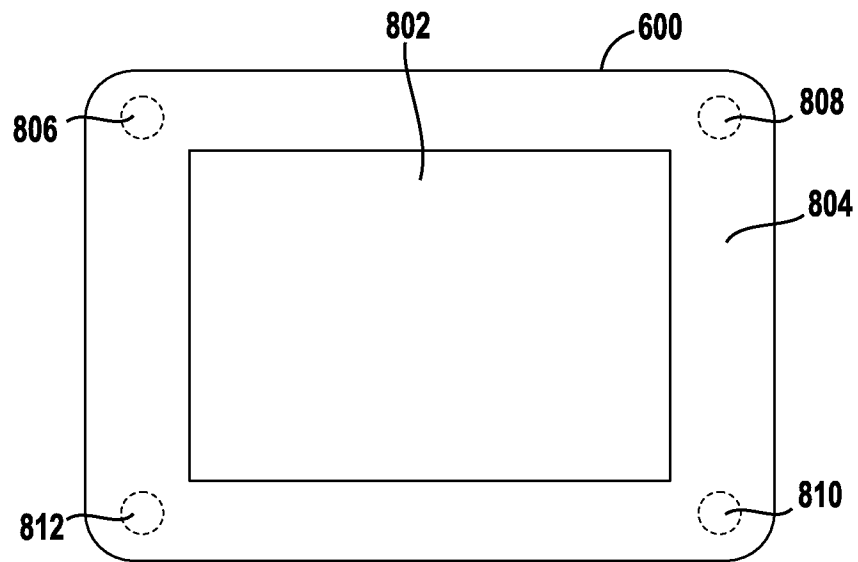


FIG. 8

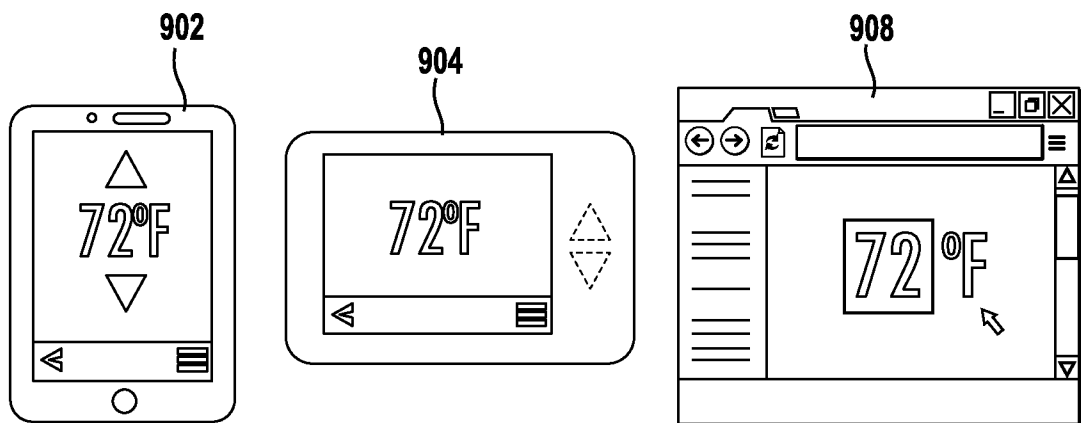


FIG. 9

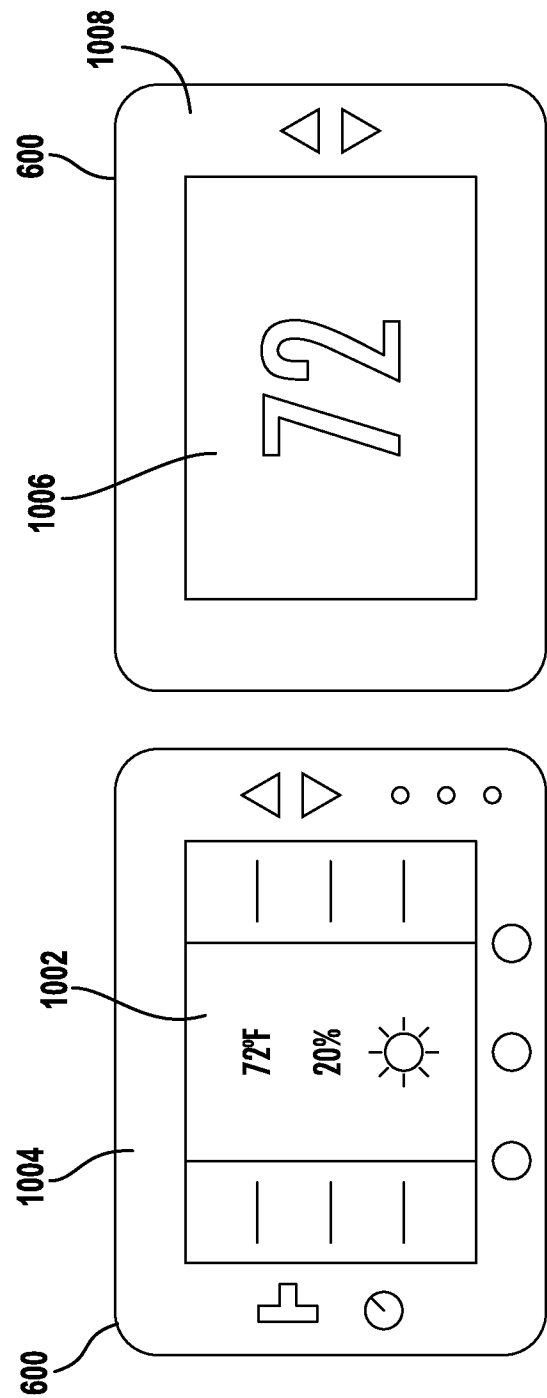
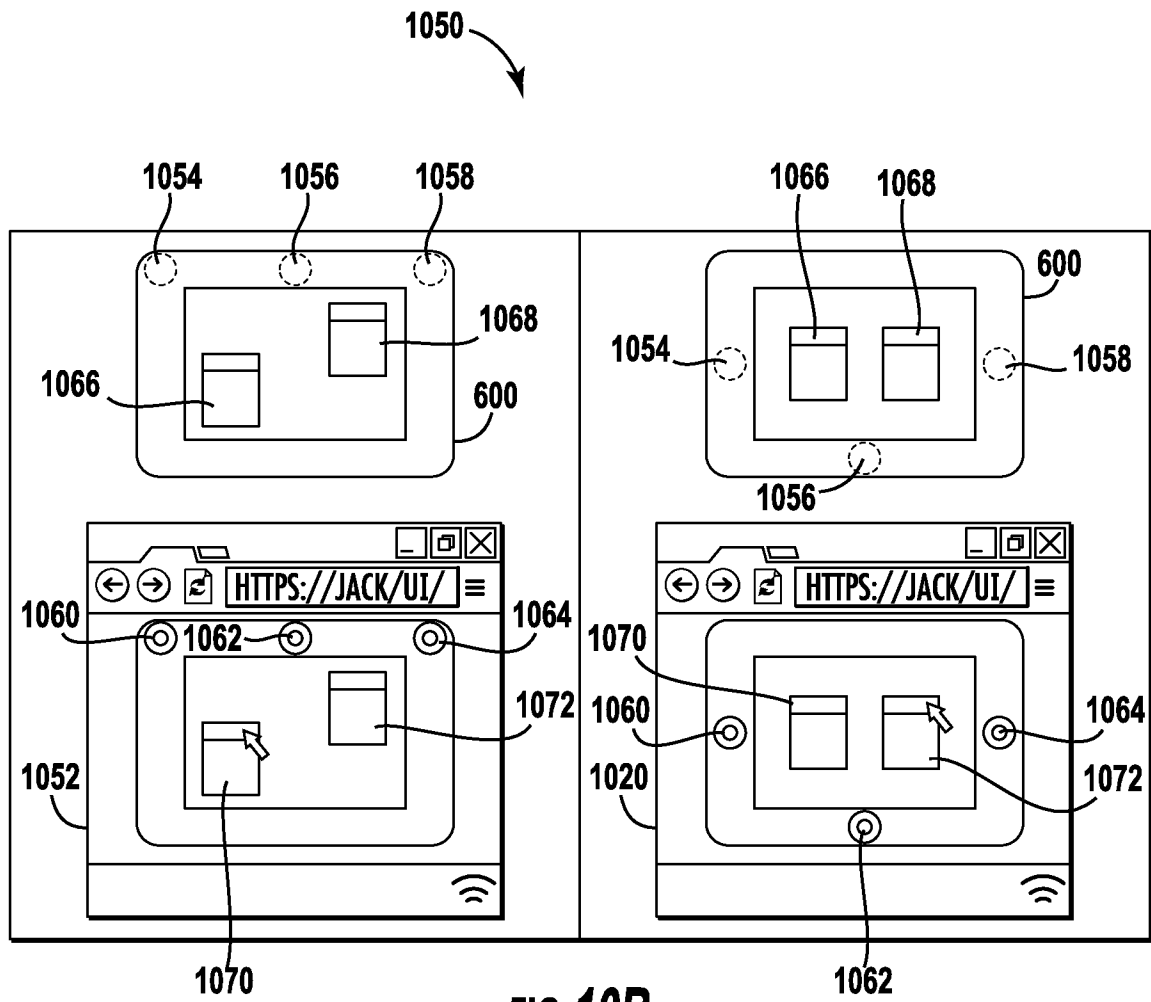


FIG. 10A

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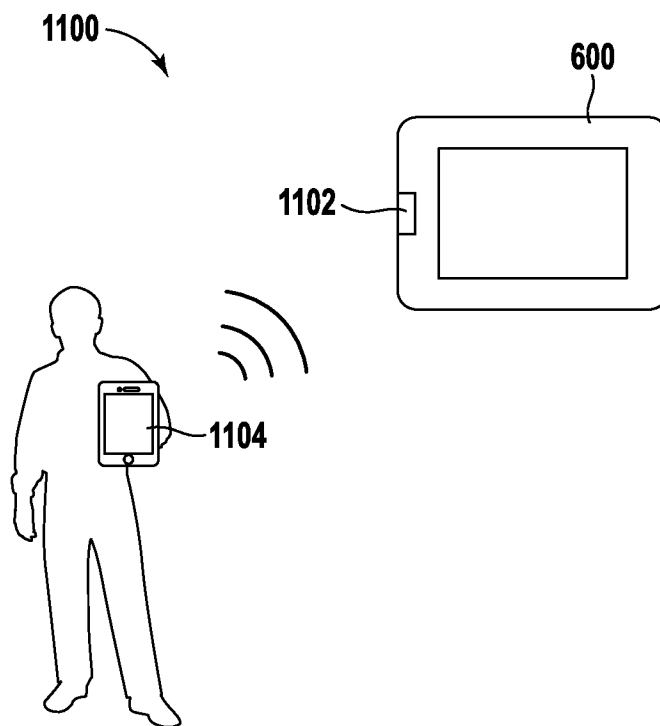


FIG. 11A

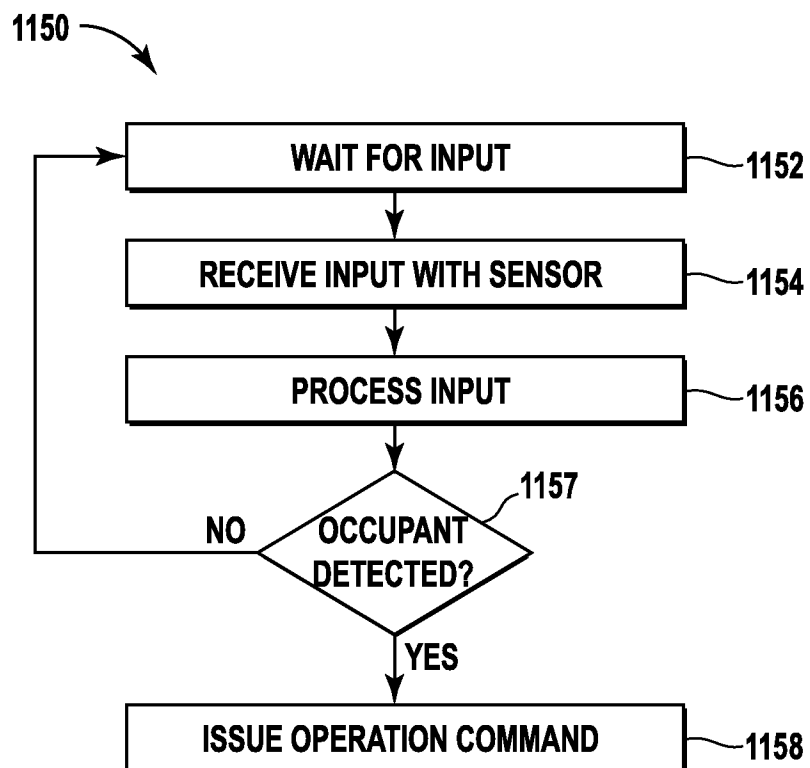


FIG. 11B

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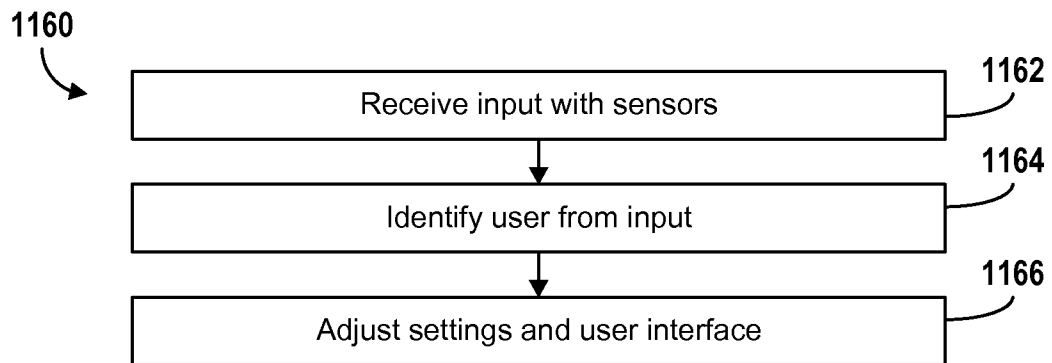


FIG. 11C

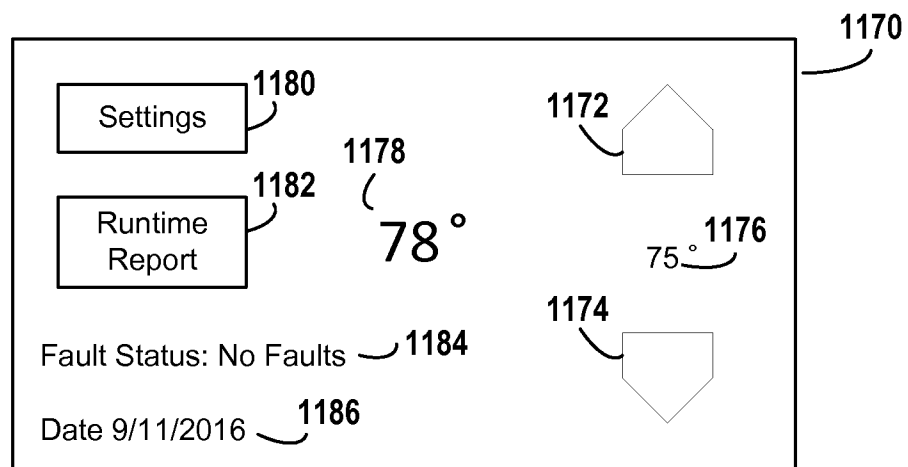


FIG. 11D

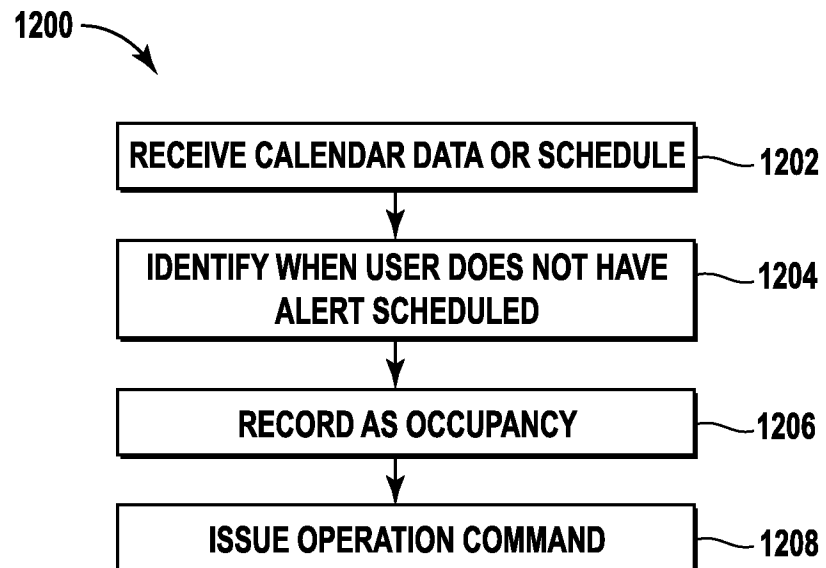
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1190

	1194	1195	1196	1197	1198	
1191	Preferred setpoint	Preferred units	Settings button location	Faults preferences	Date format	
1192	User 1	78F	Celsius	Upper left side of screen	Not displayed	MM-DD-YYYY
1193	User 2	75F	Fahrenheit	Middle of screen	Highest priority fault	MM-DD-YYYY
	User 3	70F	Kelvin	Bottom right side of screen	Scroll	YYYY-MM-DD

FIG. 11E

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**FIG. 12A**

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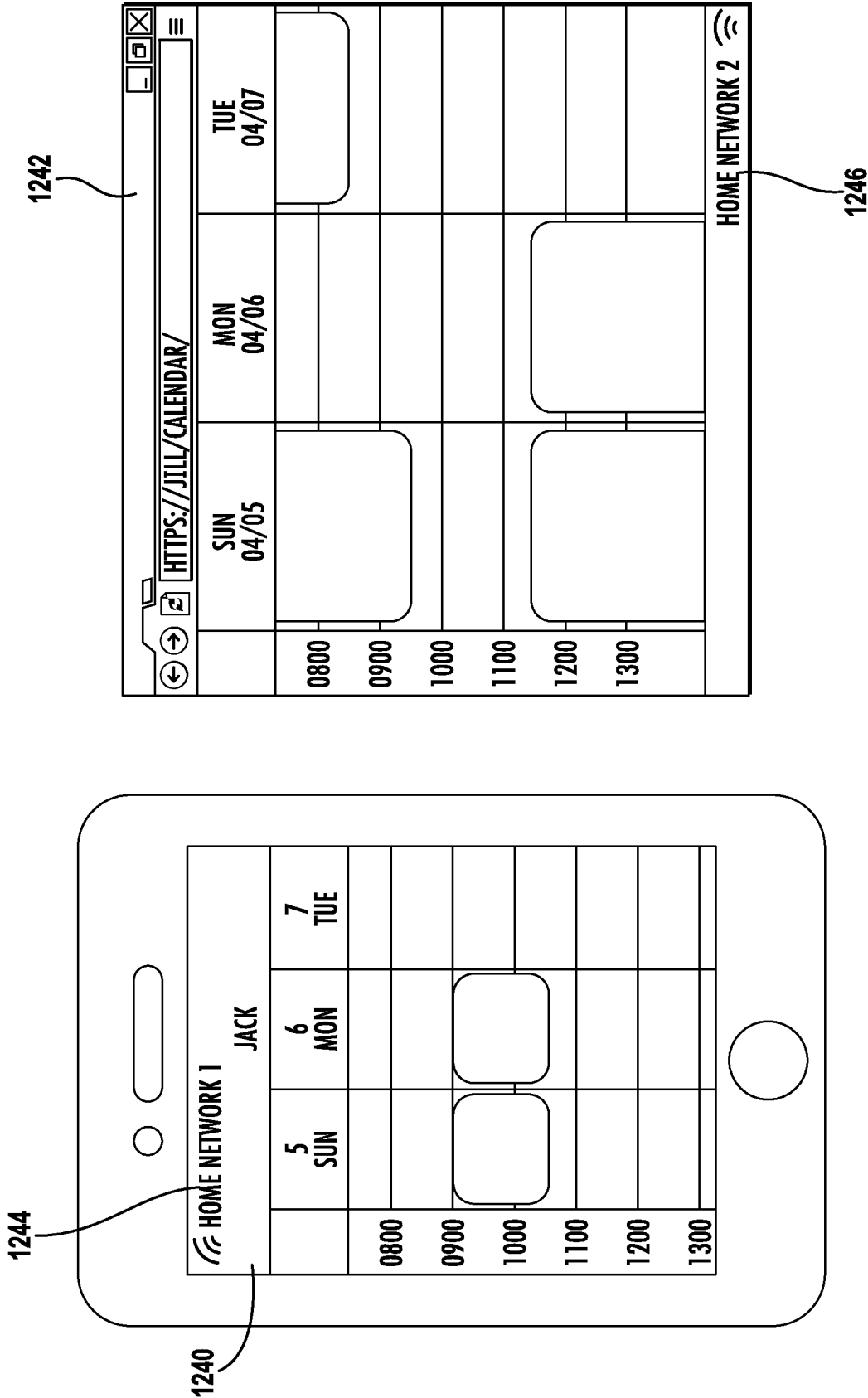


FIG. 12B

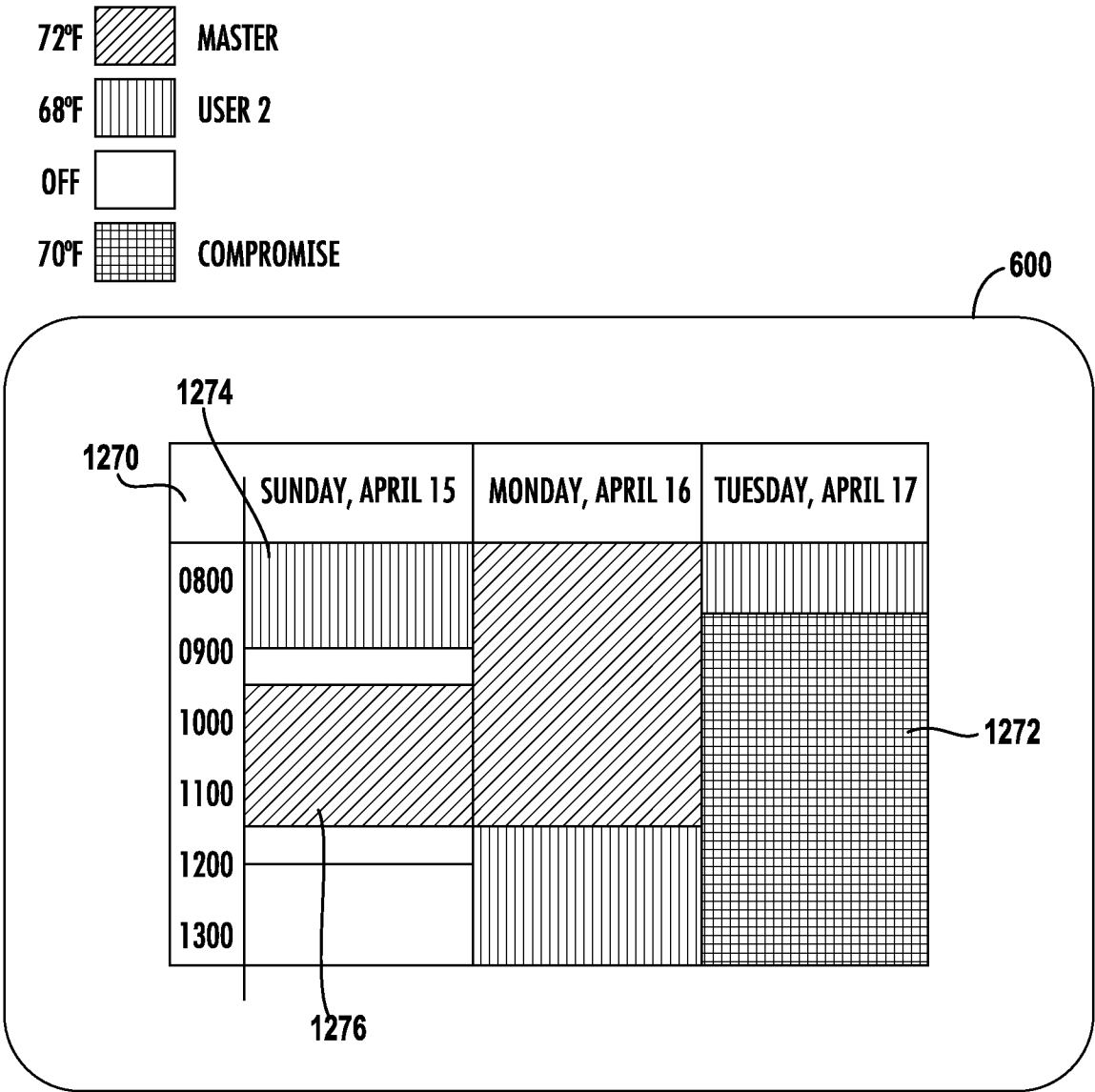
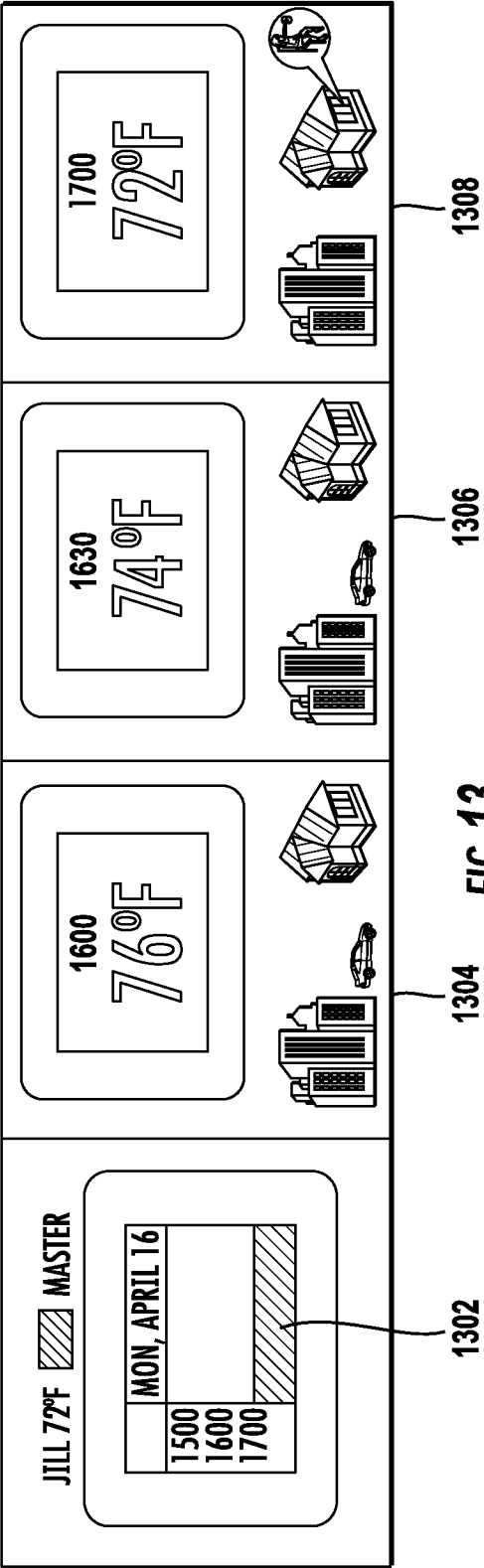
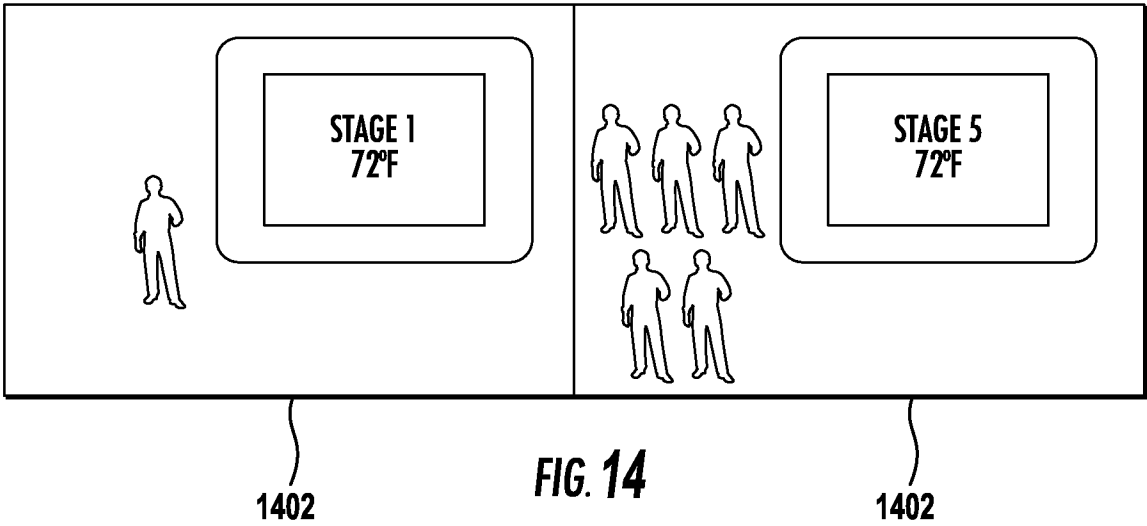
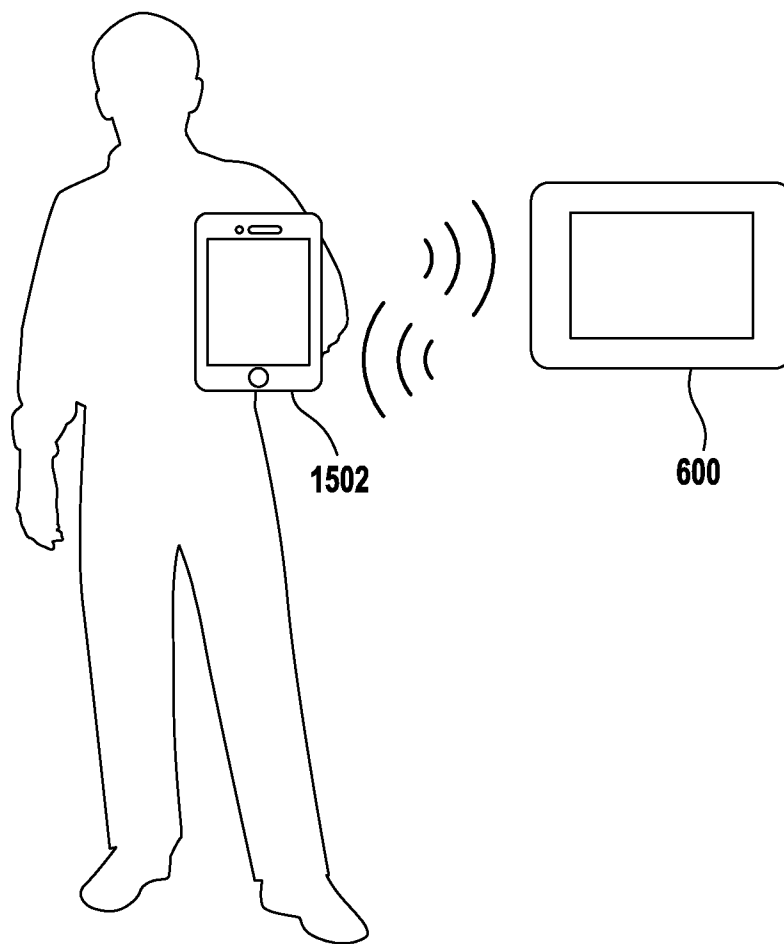


FIG. 12C

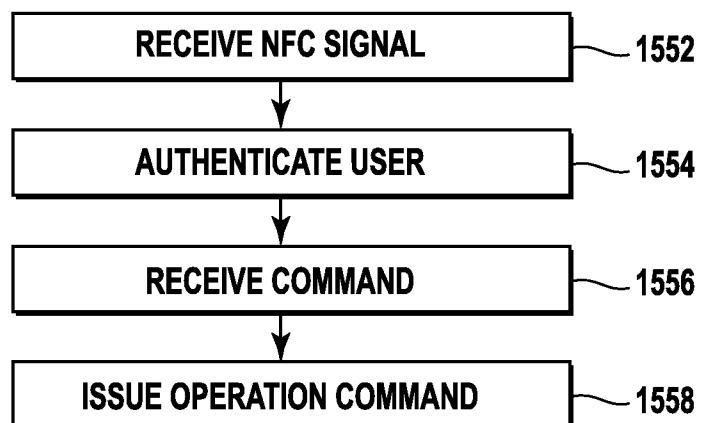




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**FIG. 15A**

1500

**FIG. 15B**

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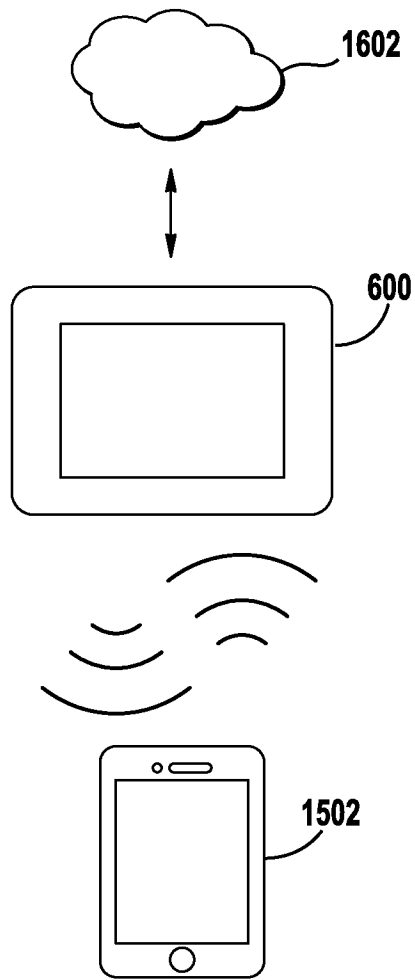


FIG. 16A

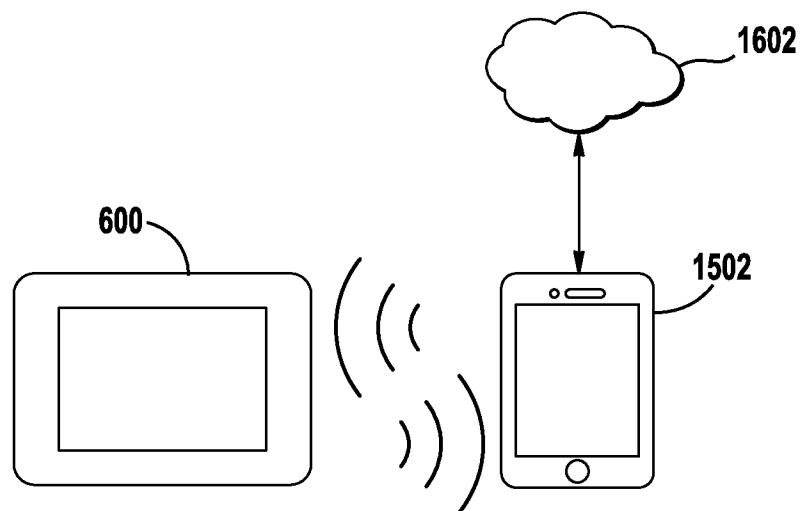
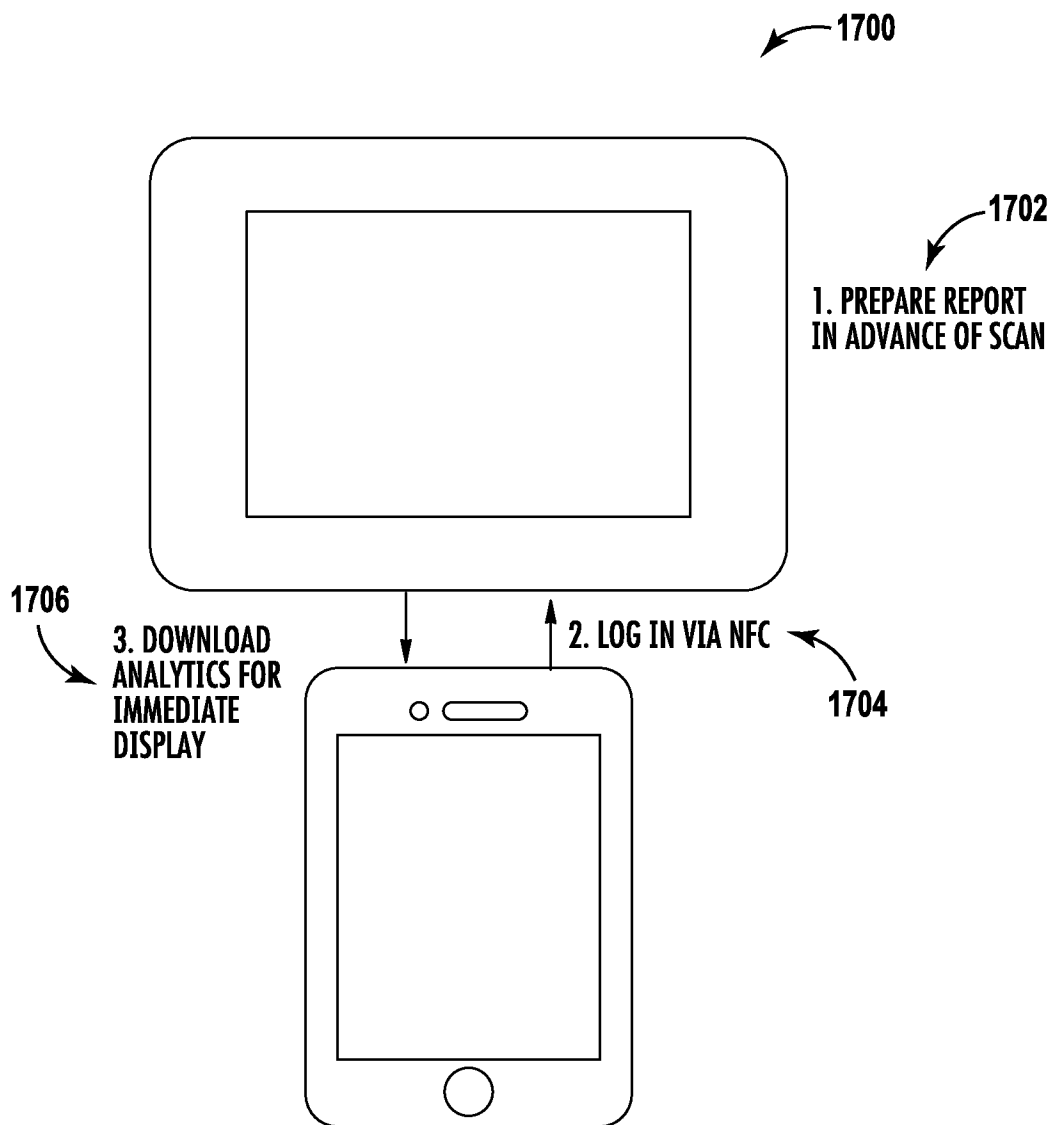


FIG. 16B

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**FIG. 17**

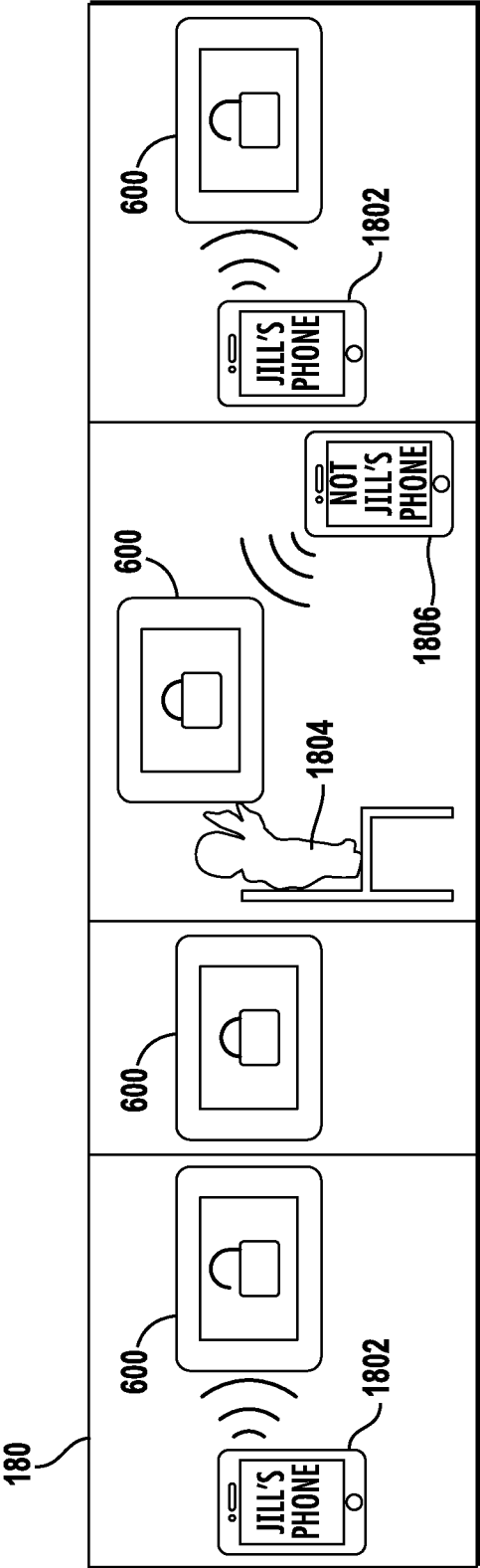


FIG. 18

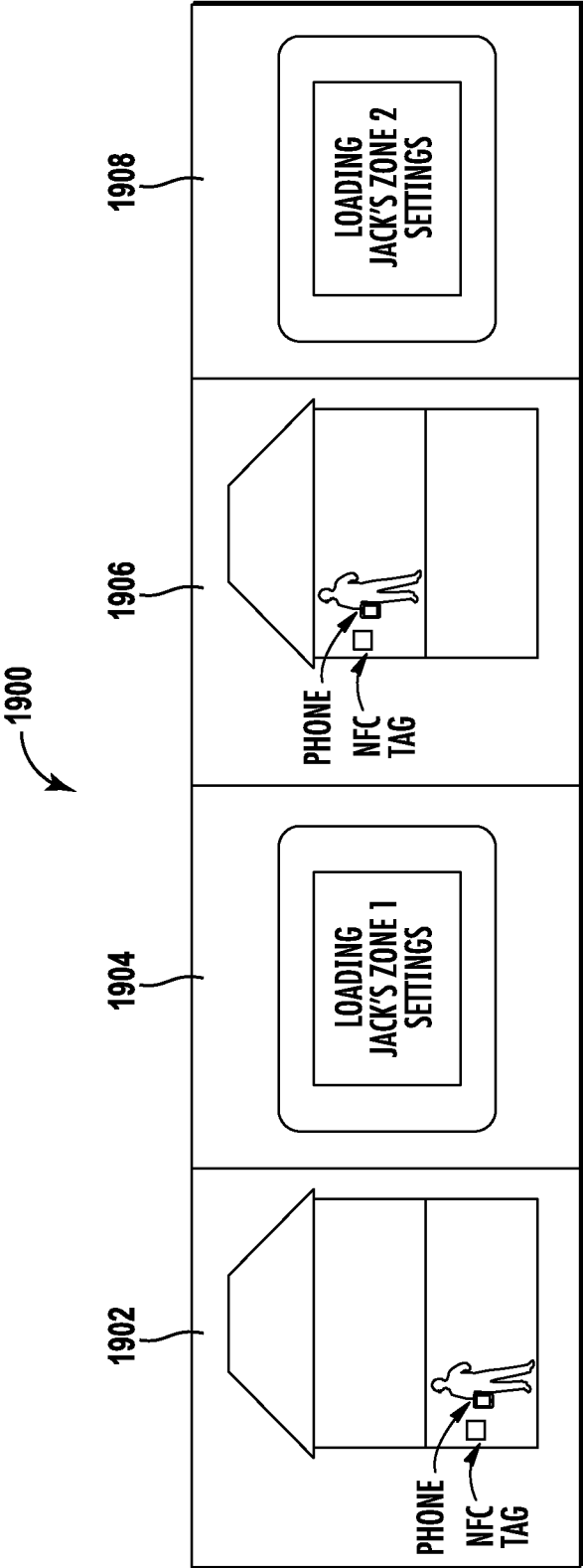


FIG. 19

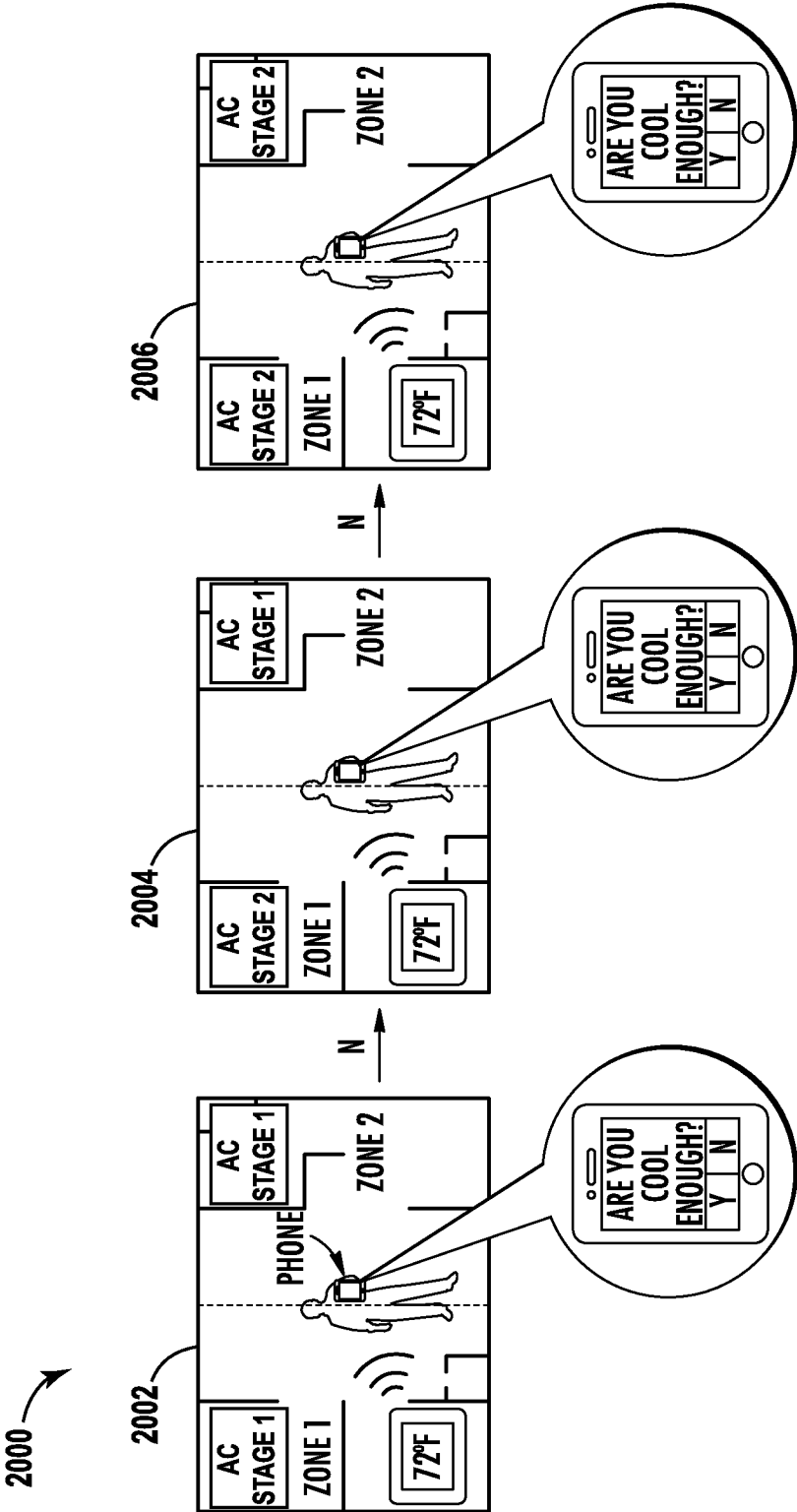


FIG. 20

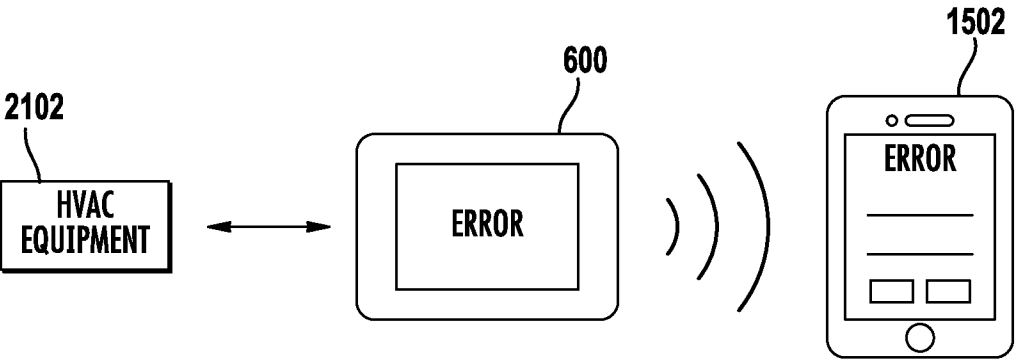


FIG. 21

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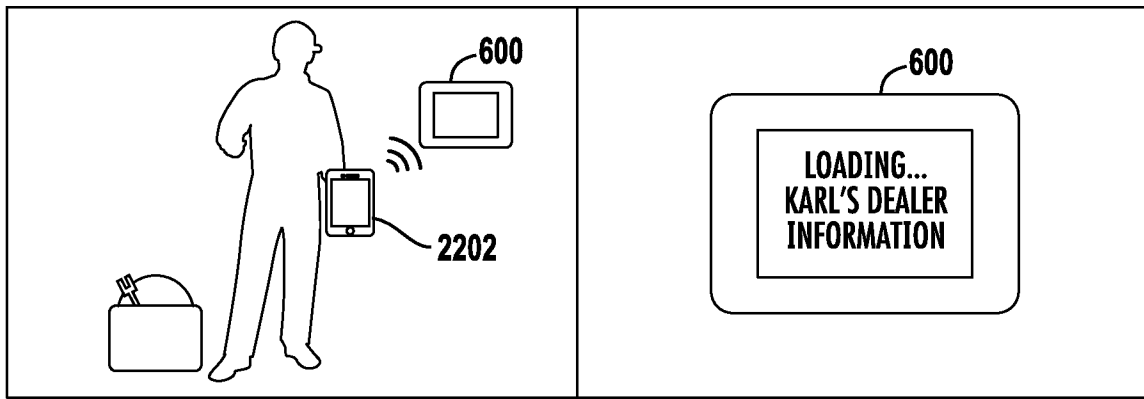


FIG. 22A

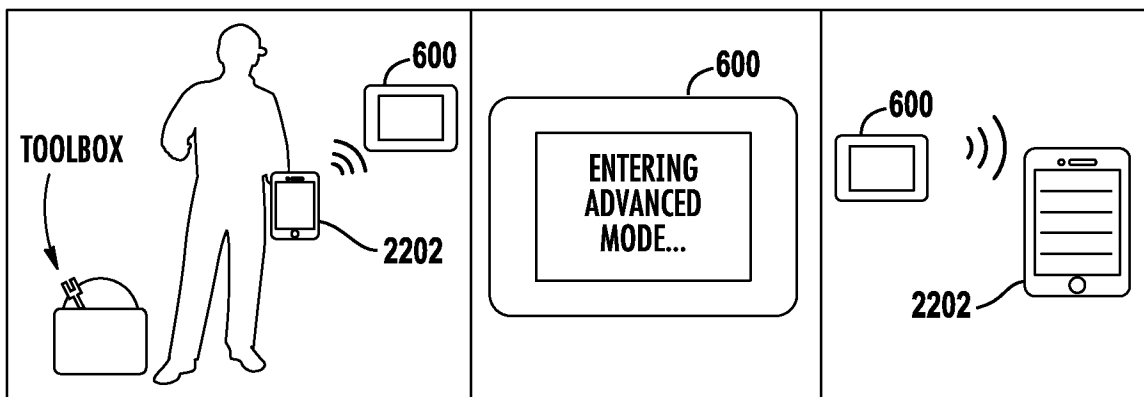
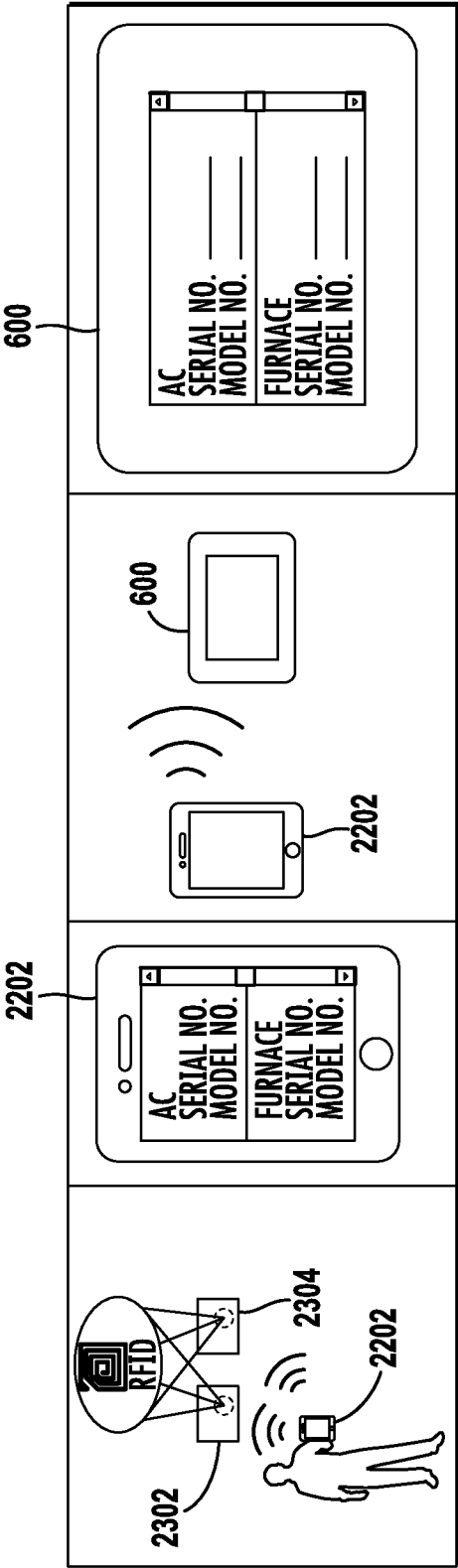


FIG. 22B



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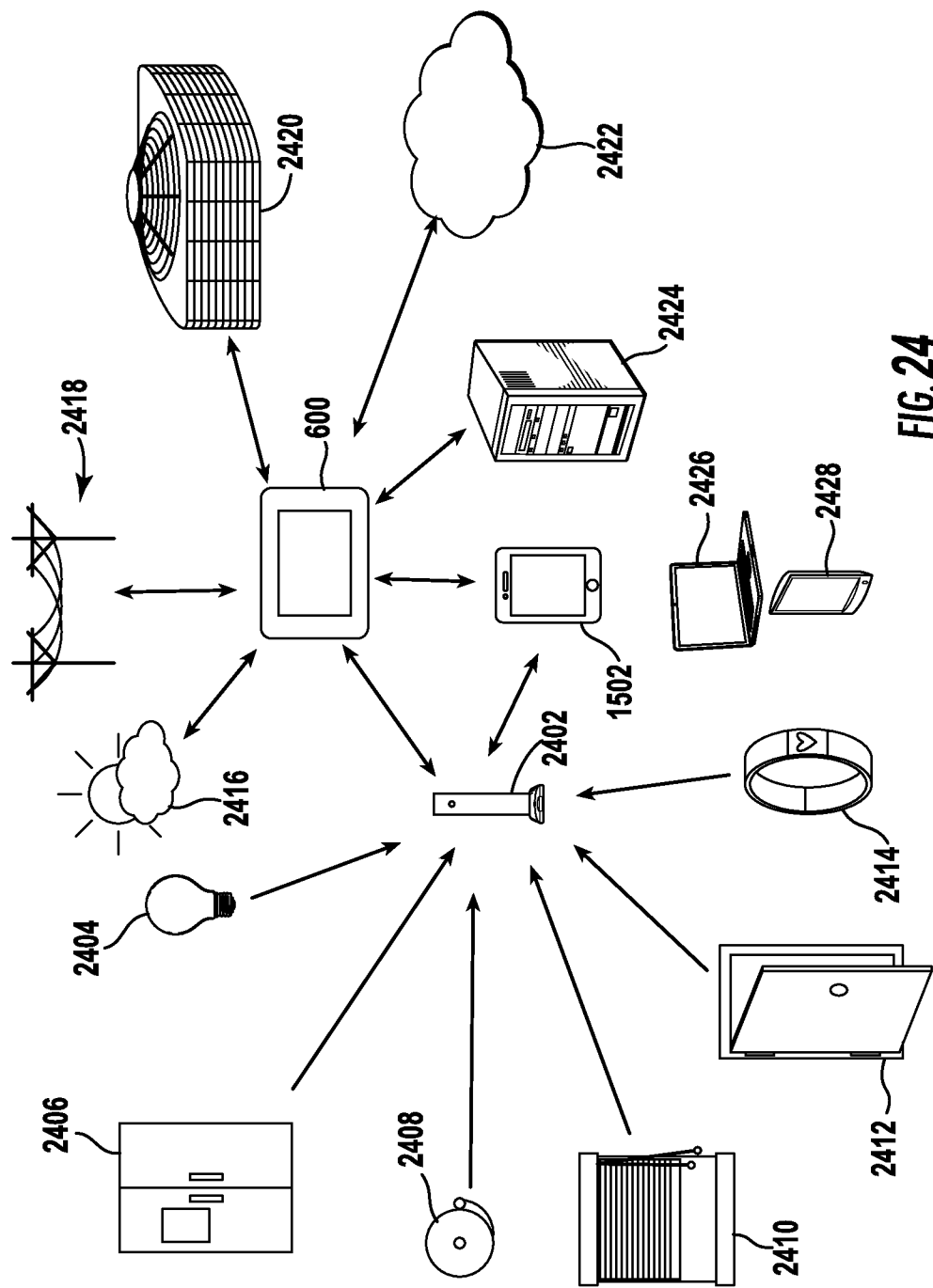
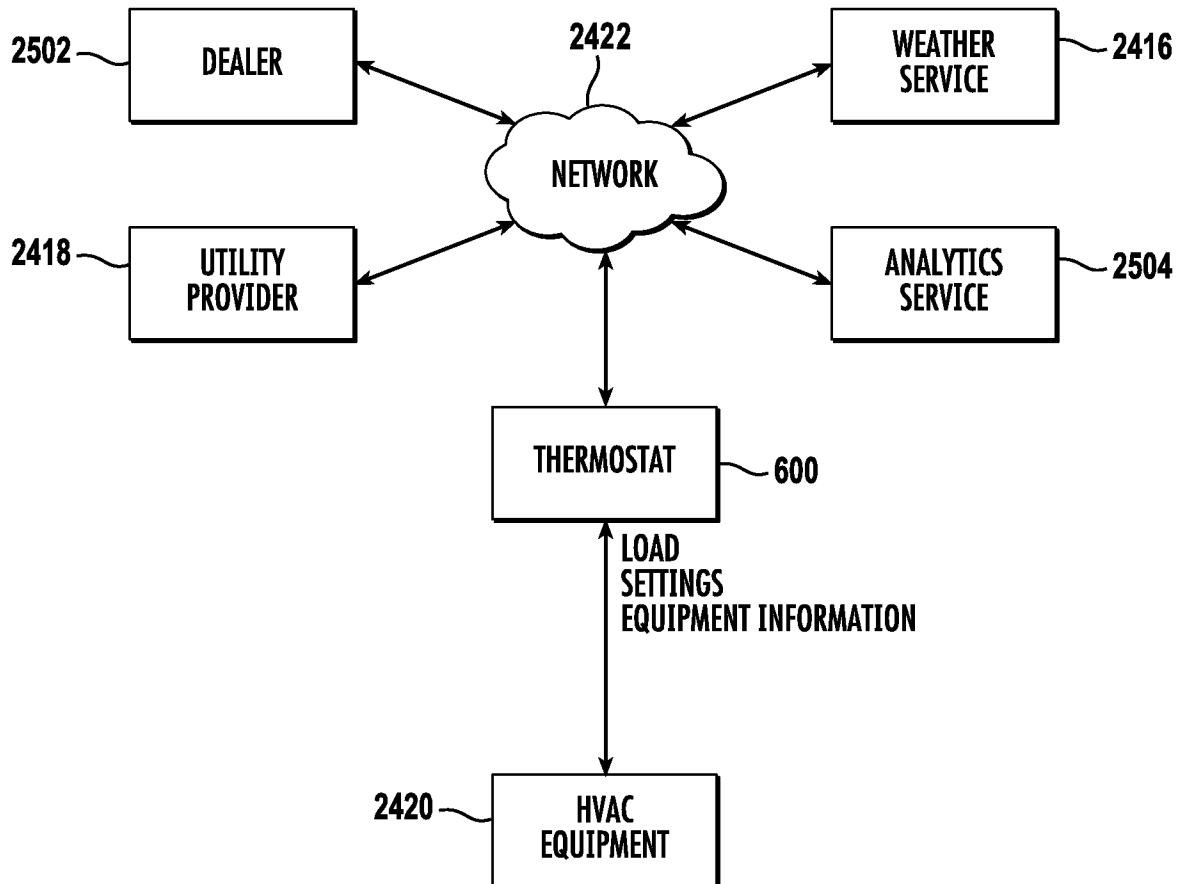


FIG. 24

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**FIG. 25 A**

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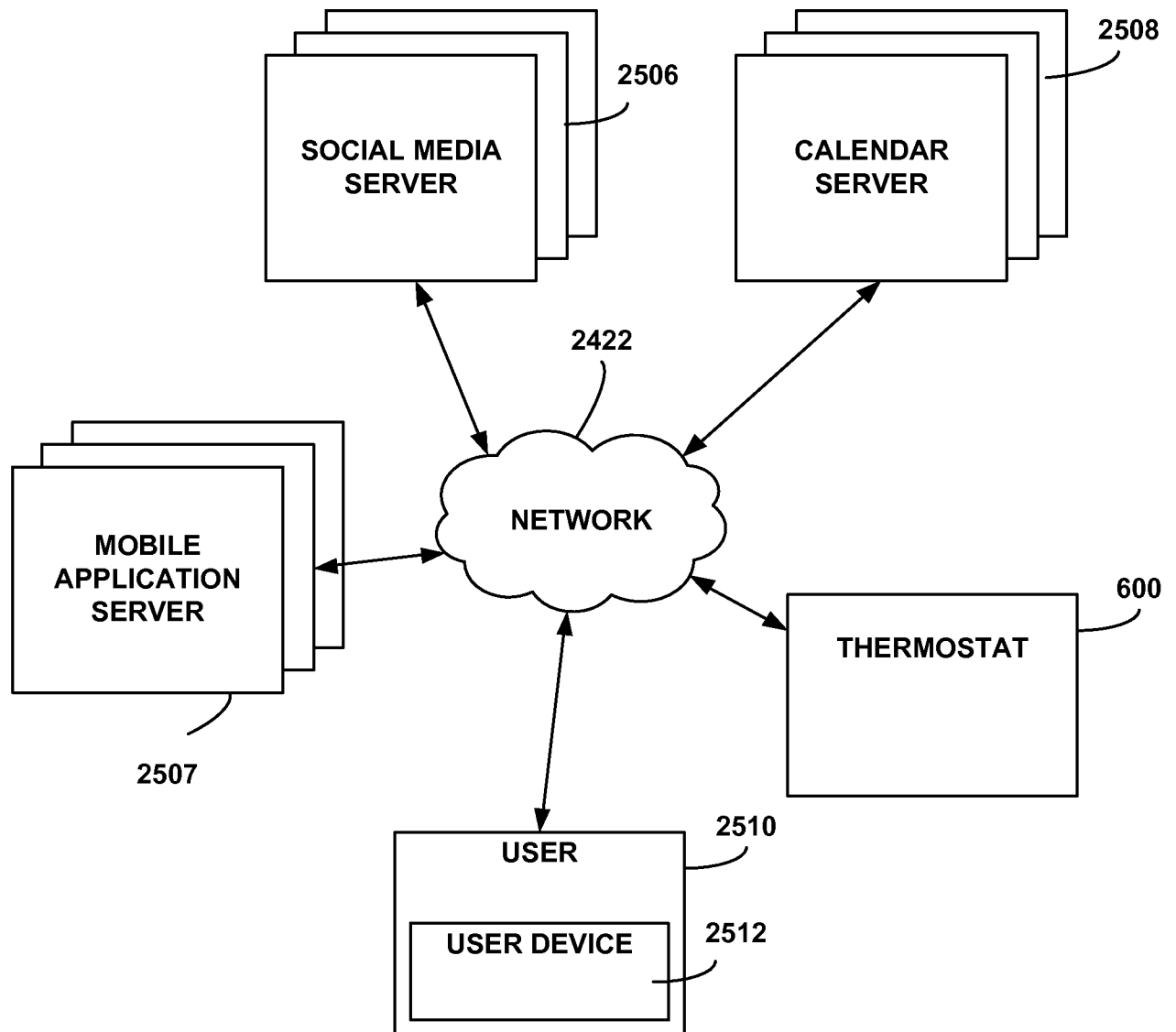
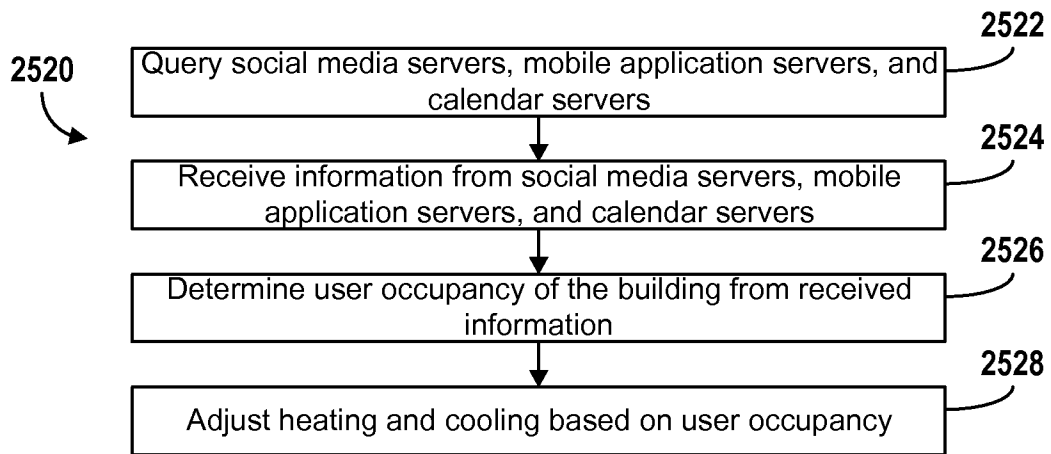
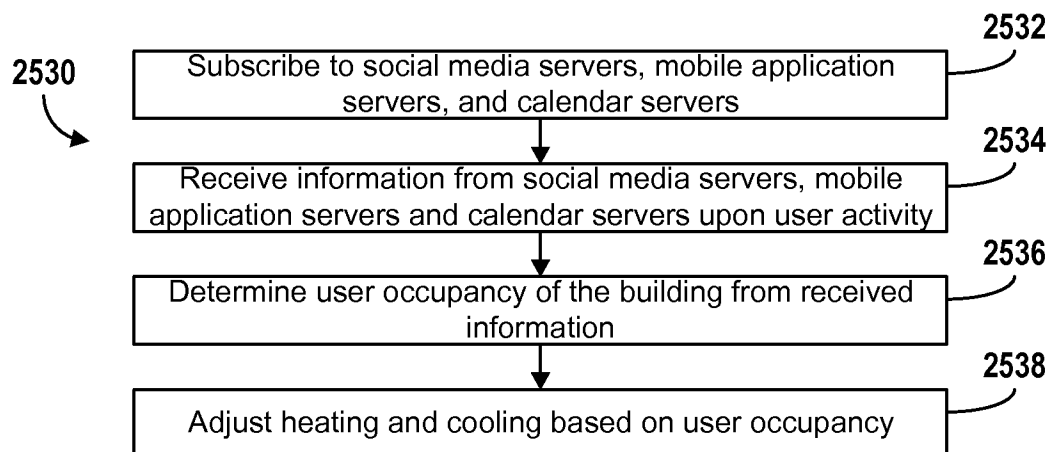


FIG. 25B

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**FIG. 25C****FIG. 25D**

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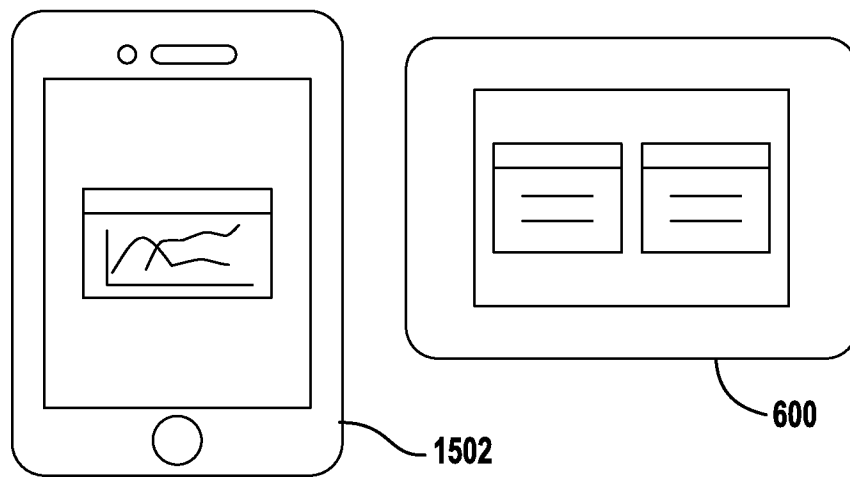


FIG. 26A

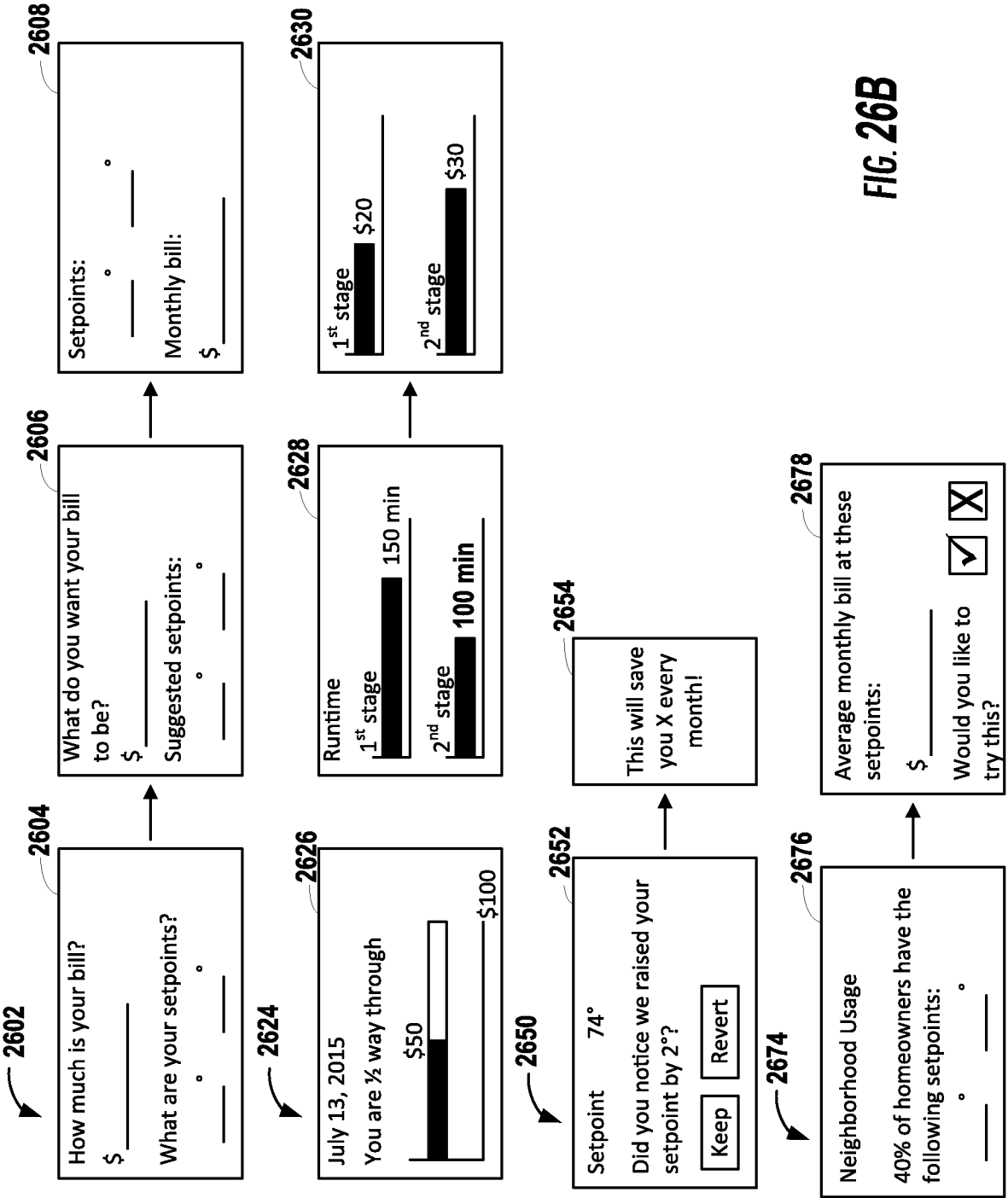
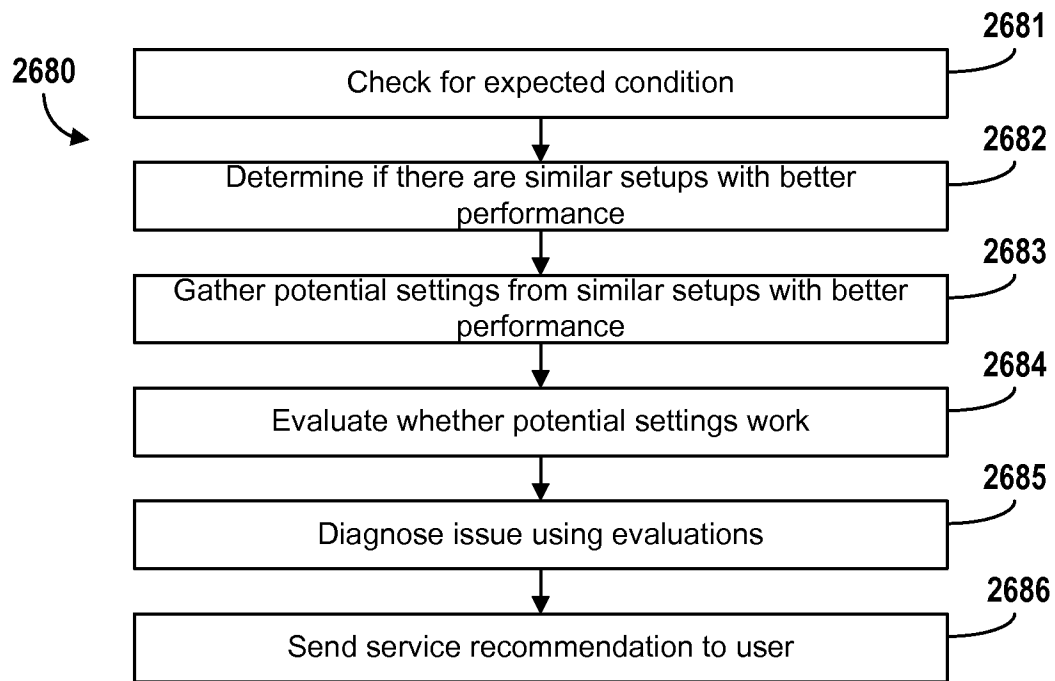
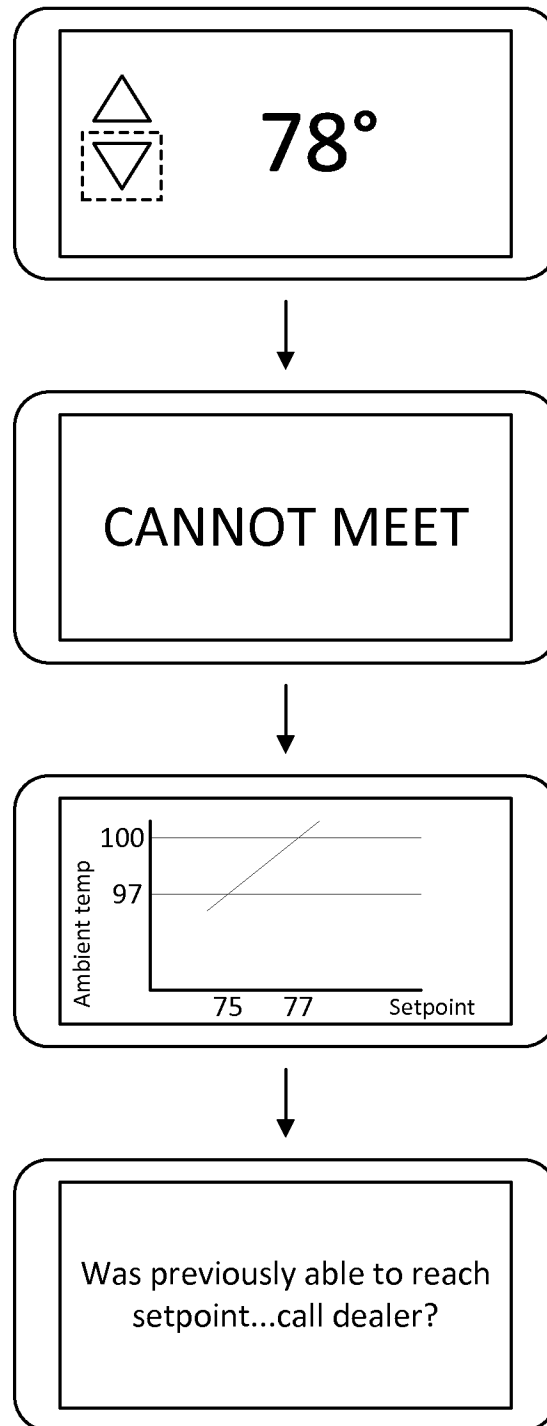


FIG. 26B

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**FIG. 26C**

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**FIG. 26D**

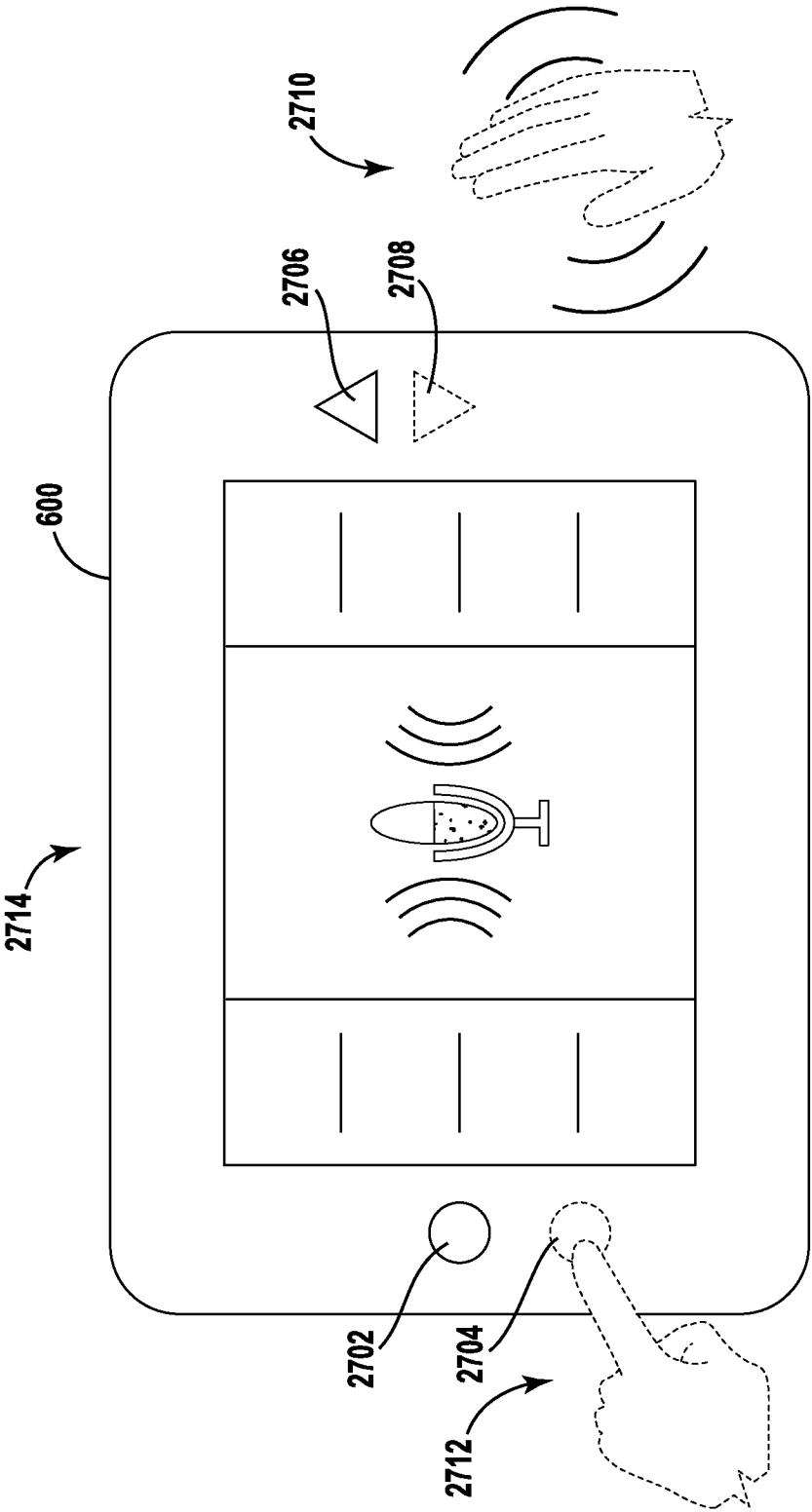


FIG. 27

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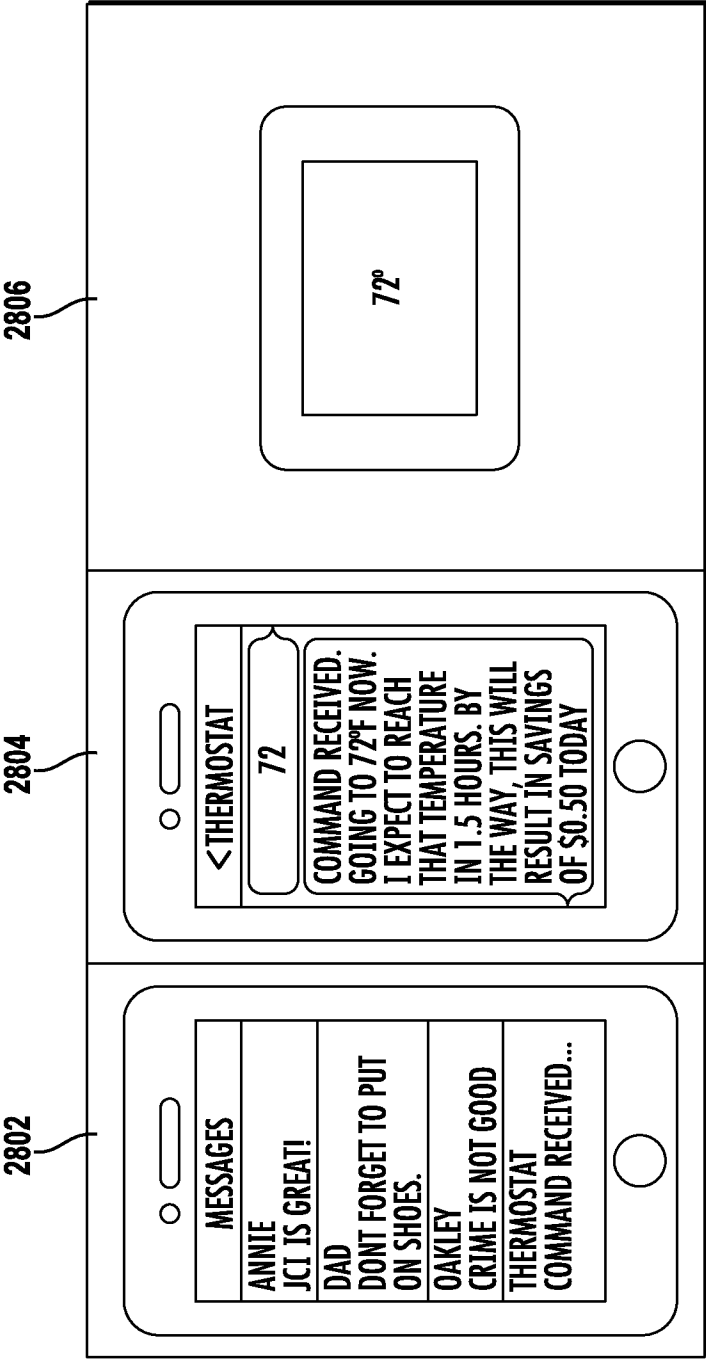


FIG. 28

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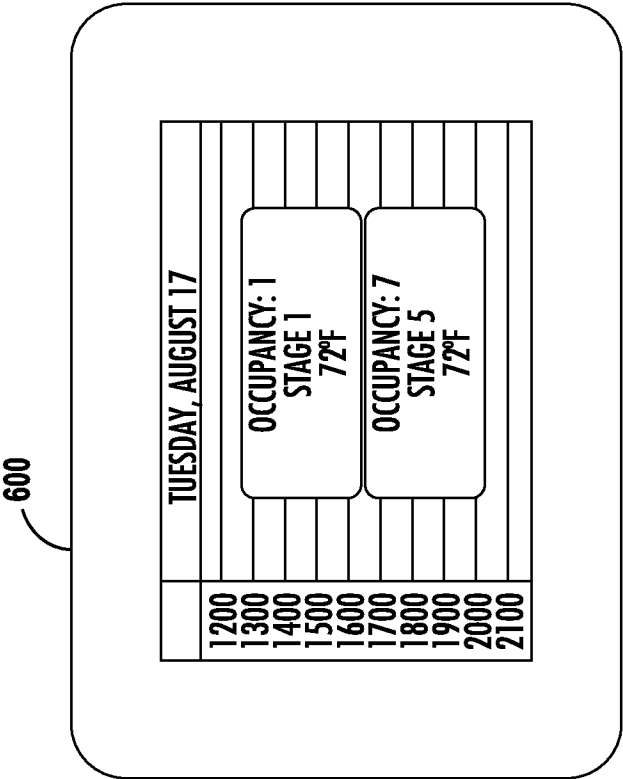
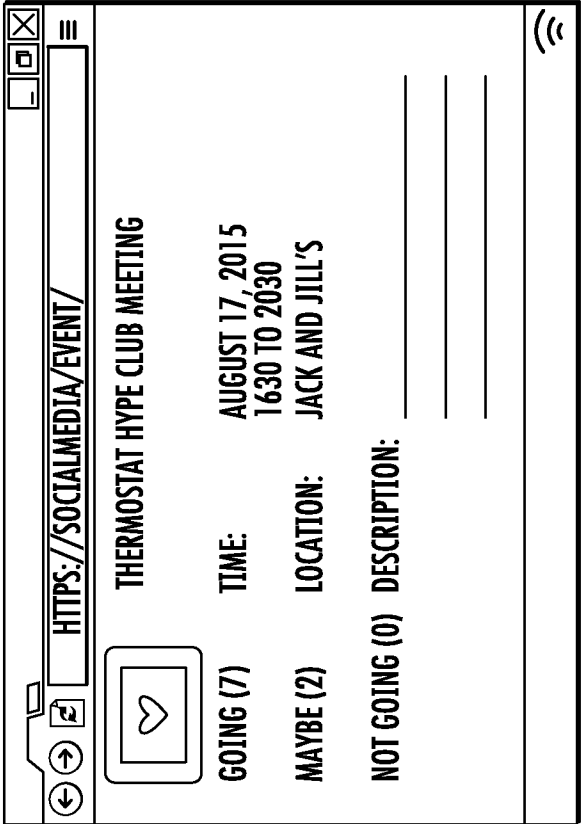


FIG. 29

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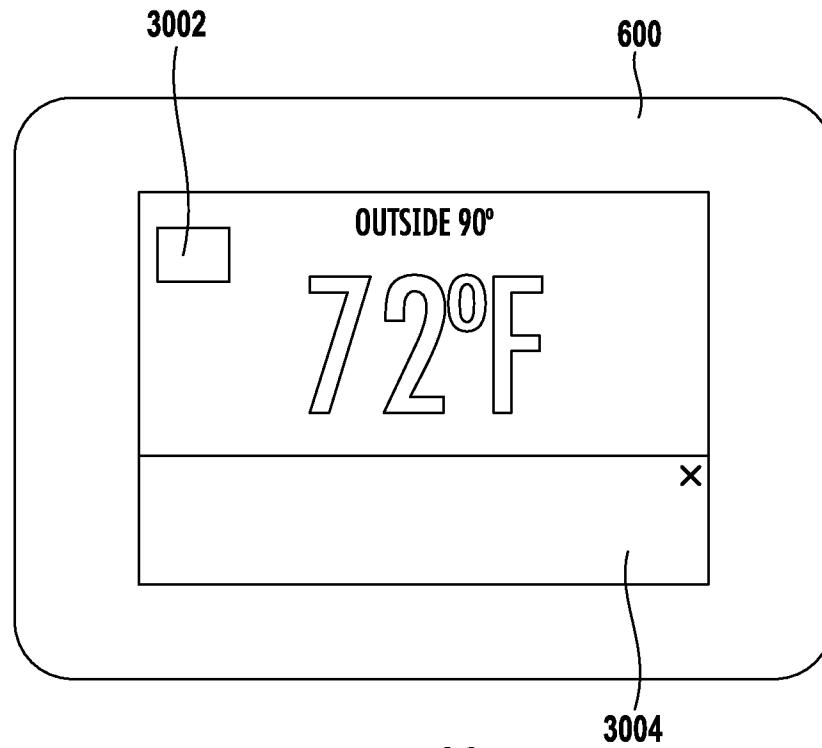


FIG. 30

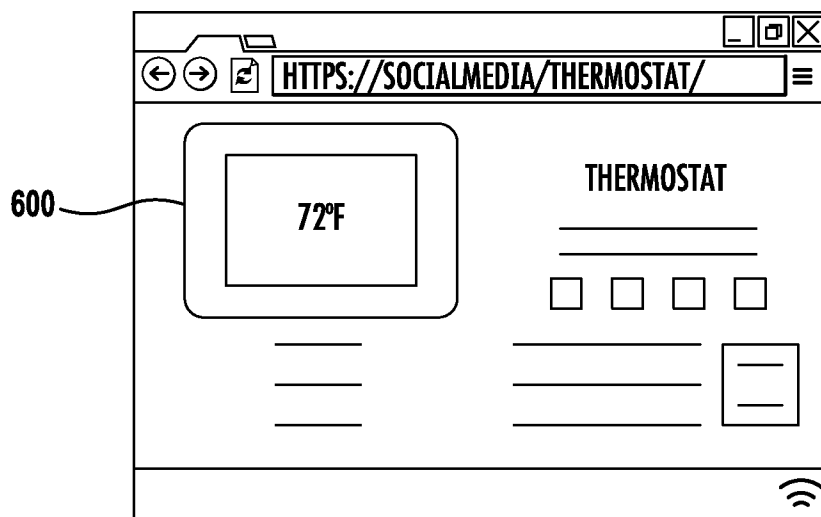


FIG. 31

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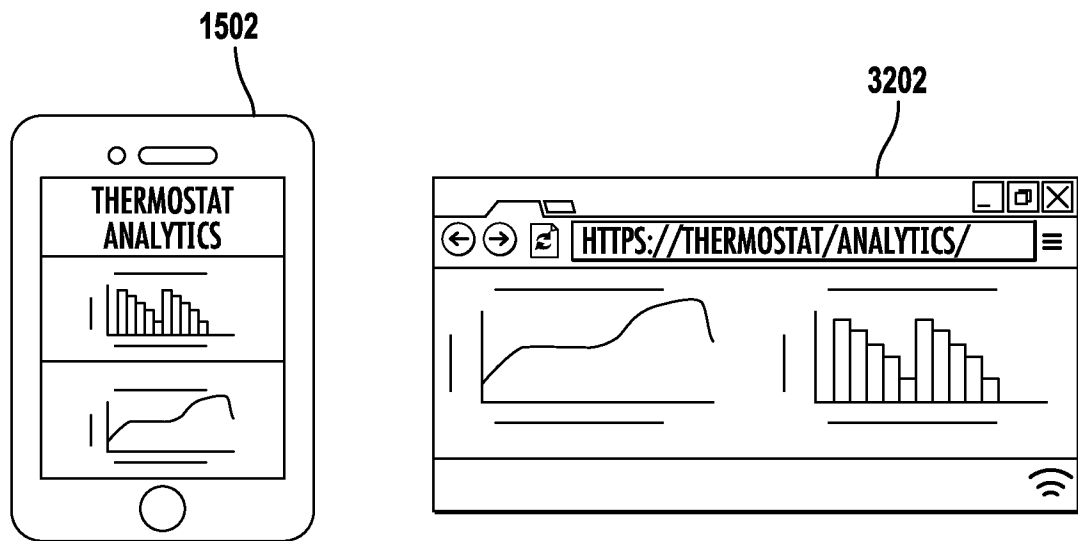


FIG. 32

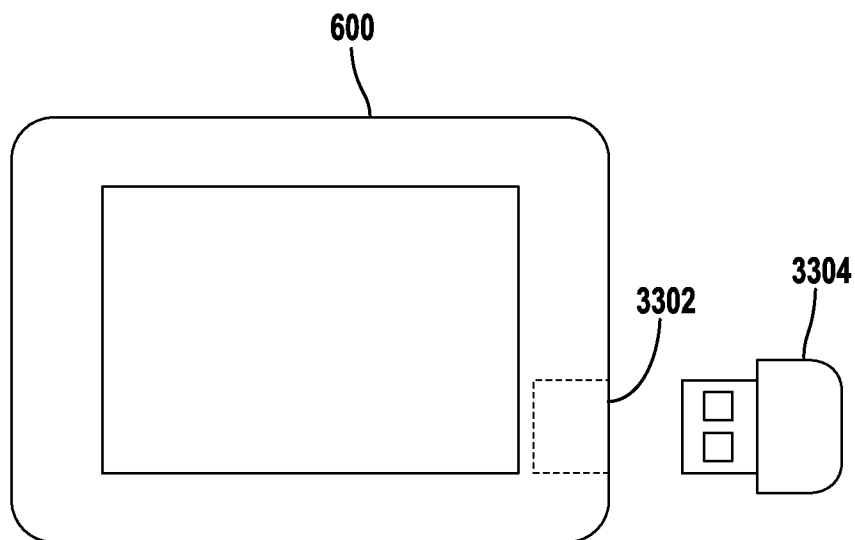
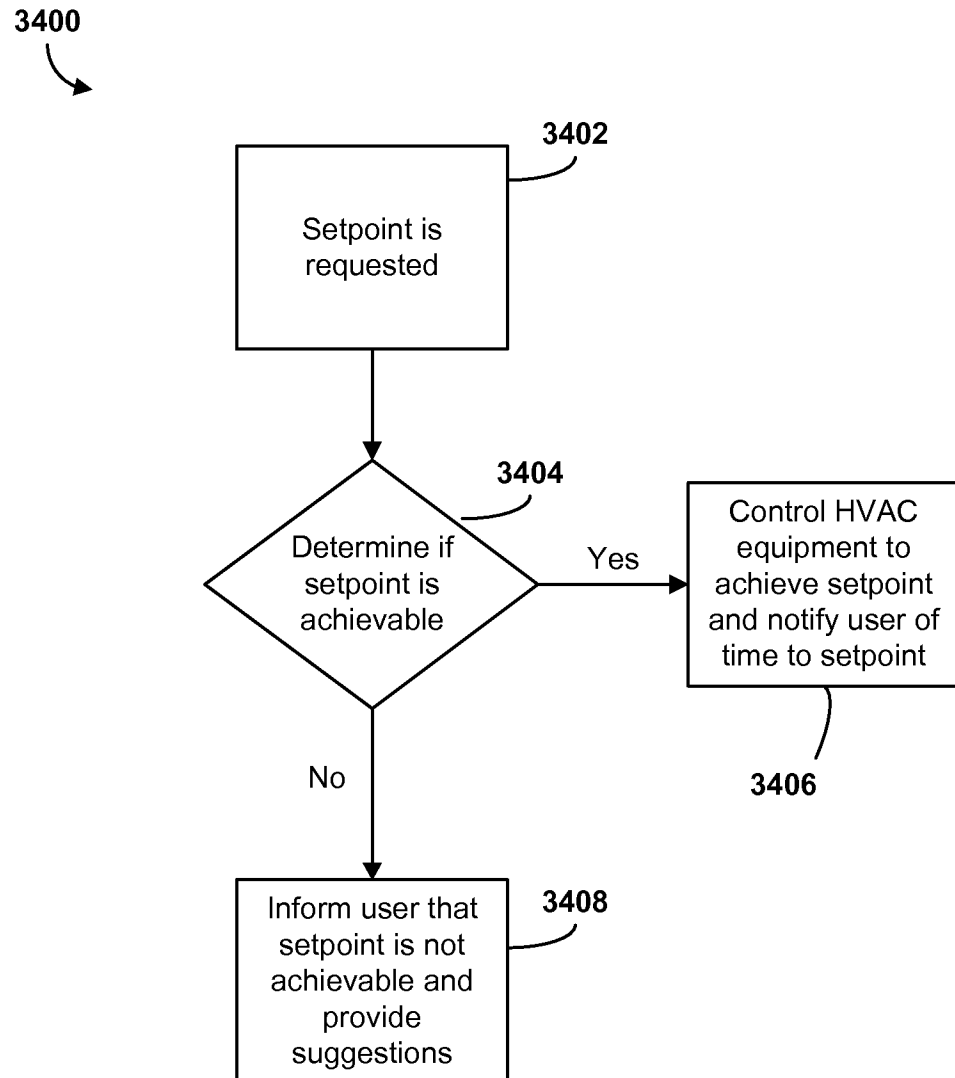
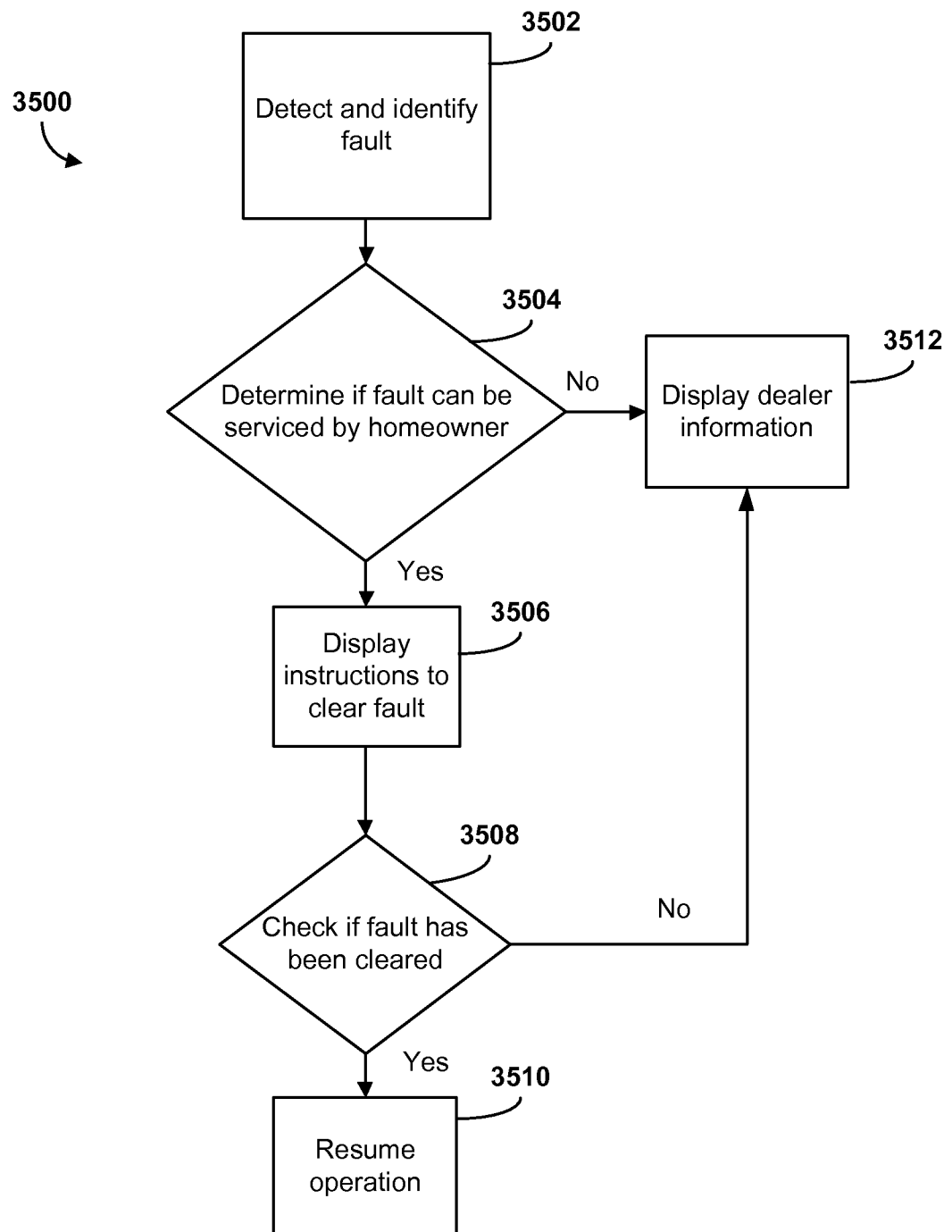


FIG. 33

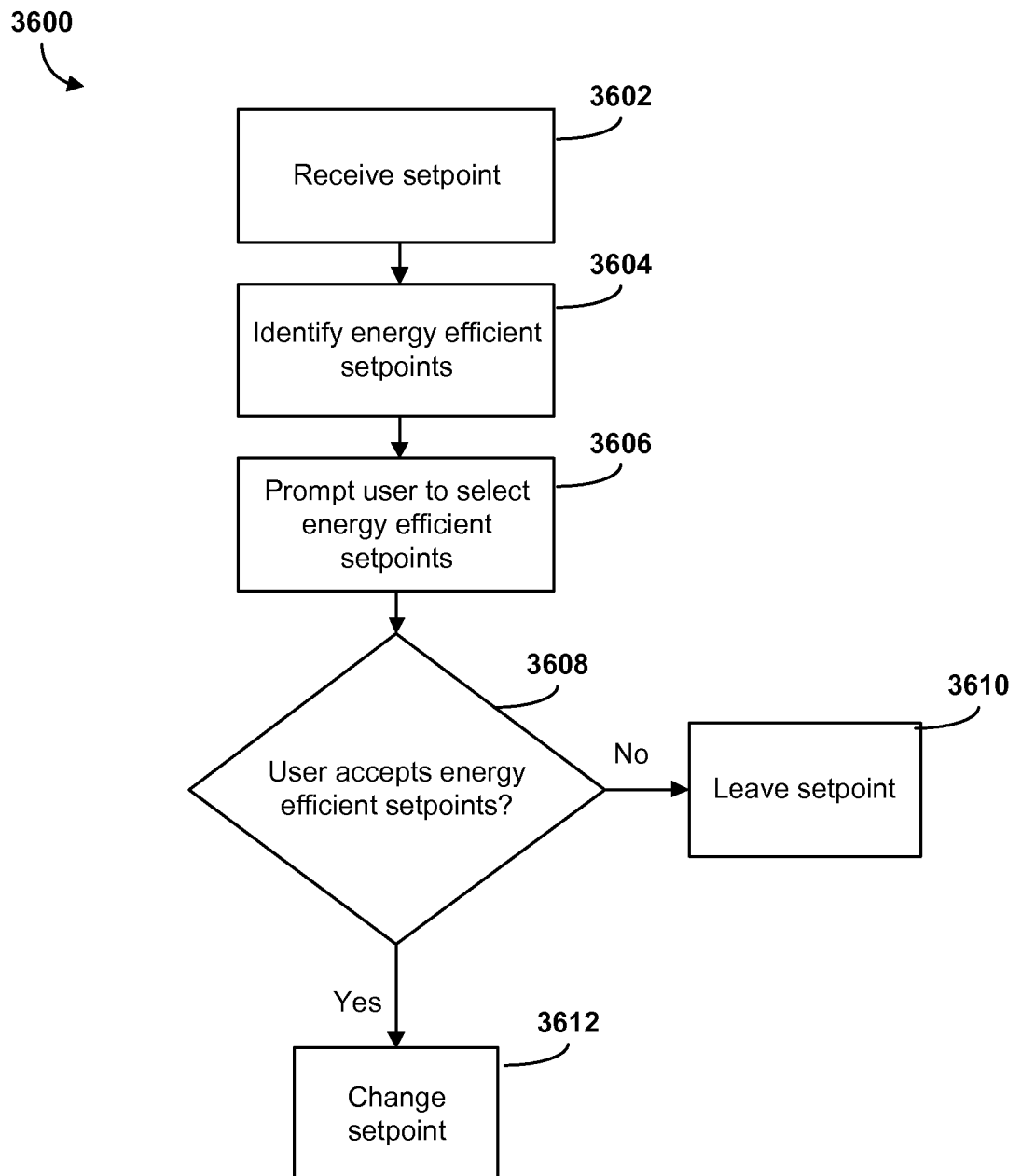
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**FIG. 34**

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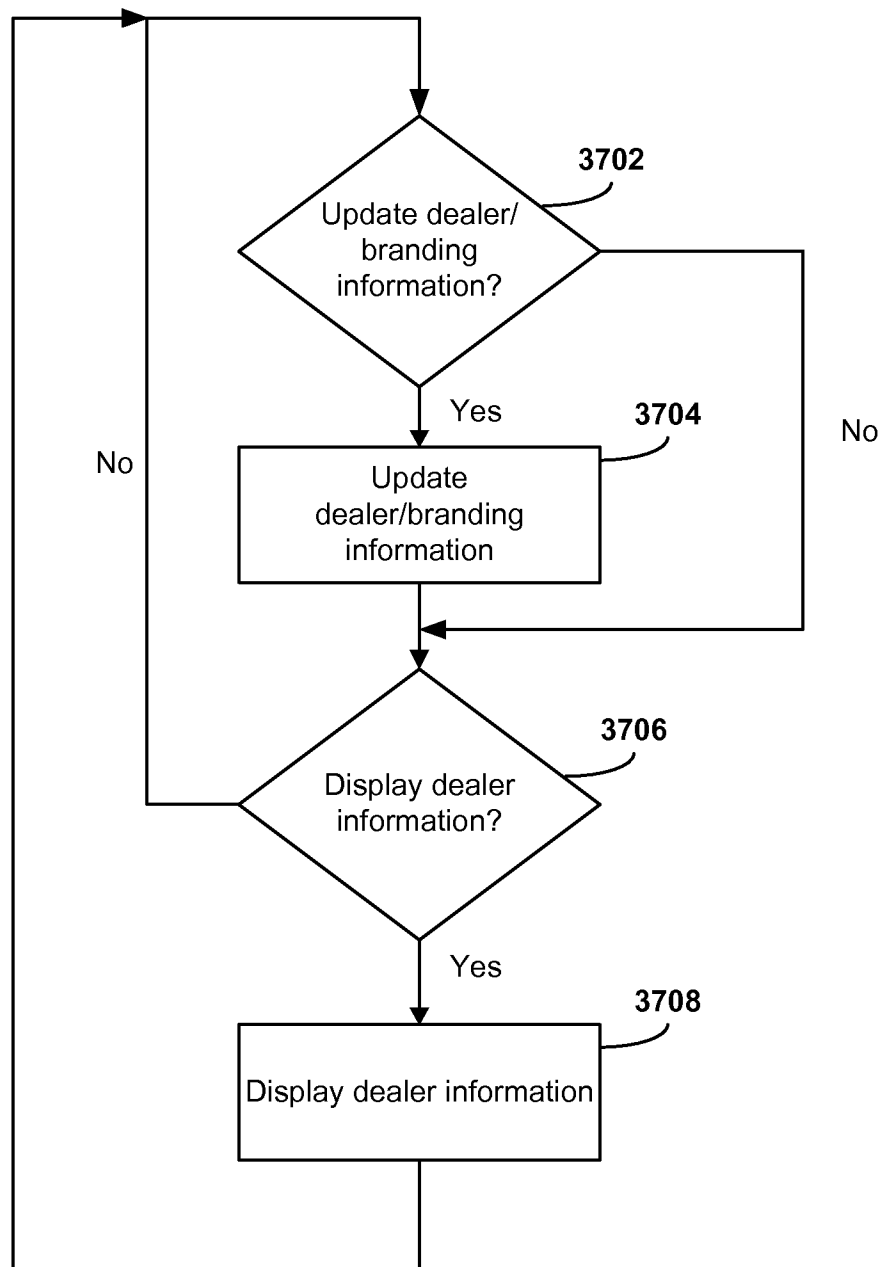
**FIG. 35**

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**FIG. 36**

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3700

**FIG. 37**

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/051176

A. CLASSIFICATION OF SUBJECT MATTER
INV. G05D23/19 F24F11/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24F G05D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2015/012449 A1 (LG ELECTRONICS INC [KR]) 29 January 2015 (2015-01-29) the whole document	1-9,11, 12,16-19 10, 13-15,20
X A	----- US 8 674 816 B2 (TRUNDLE STEPHEN SCOTT [US] ET AL) 18 March 2014 (2014-03-18) the whole document	1 2-20
Y	----- EP 2 738 478 A2 (LENNOX IND INC [US]) 4 June 2014 (2014-06-04) the whole document	13-15
	----- -/-	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

13 December 2016

Date of mailing of the international search report

16/02/2017

Name and mailing address of the ISA/

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Authorized officer

Thomann, Jérôme

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/051176

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EIJI HAYASHI ET AL: "Wave to me", HUMAN FACTORS IN COMPUTING SYSTEMS, ACM, 2 PENN PLAZA, SUITE 701 NEW YORK NY 10121-0701 USA, 26 April 2014 (2014-04-26), pages 3453-3462, XP058046577, DOI: 10.1145/2556288.2557043 ISBN: 978-1-4503-2473-1 the whole document	10,20
A	----- US 2013/332000 A1 (IMES KEVIN R [US] ET AL) 12 December 2013 (2013-12-12) the whole document	1-20
A	----- US 2012/046859 A1 (IMES KEVIN R [US] ET AL) 23 February 2012 (2012-02-23) the whole document	1-20
A	----- CA 2 818 696 A1 (NEST LABS INC [US]) 24 May 2012 (2012-05-24) the whole document -----	1-20

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/051176

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-20

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-20

reducing users' time for entering their input

2. claims: 21-29

diminishing wastes of energy in the building

3. claims: 30-40

providing visibility to a user about the time needed by the thermostat

4. claims: 41-60

providing adequate HVAC settings as soon as user enters building

5. claims: 61-80

restricting thermostat use for unauthorised users

6. claims: 81-100

scheduling maintenance of the HVAC equipment

7. claims: 101-120

increasing the aesthetics of the user interface

8. claims: 121-140

delivering service provider information to a user

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/051176

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