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(54) **SYSTEMS AND METHODS FOR PROVIDING RETROACTIVE WIRELESS CONNECTIVITY TO HVAC SYSTEMS**

(71) Applicant: **Rheem Manufacturing Company**, Atlanta, GA (US)

(72) Inventors: **Michael John Knieser**, Fishers, IN (US); **Raheel Ashraf Chaudhry**, Frisco, TX (US)

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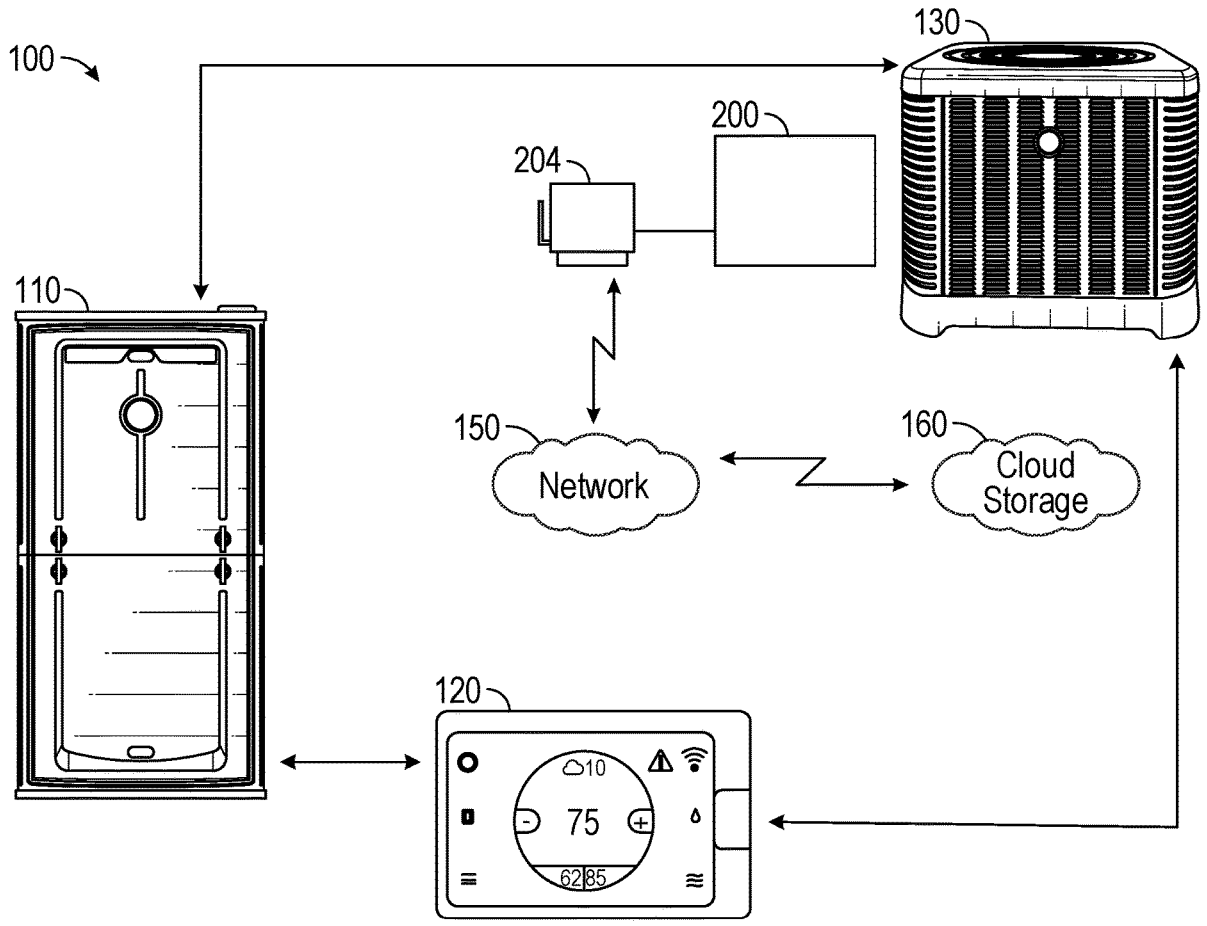
(52) **U.S. Cl.**

CPC ***F24F 11/56*** (2018.01); ***F24F 11/32*** (2018.01); ***F24F 11/57*** (2018.01); ***F24F 11/58*** (2018.01)

(57) **ABSTRACT**

The present disclosure is directed to systems and methods for providing wireless connectivity to a system, e.g., an HVAC system, having at least one non-communicating unit, e.g., an outdoor unit such as an HVAC unit and/or an indoor unit such as an air handler or a furnace. The system may include a wireless connectivity device that may be mechanically and operatively coupled to or otherwise integrated with the non-communicating unit, to thereby provide communication capabilities to the non-communicating unit. Accordingly, via the wireless connectivity device, the non-communicating unit may communicate information with additional components of the system including, e.g., a communicating unit, a thermostat, and/or cloud storage for providing access to third parties.



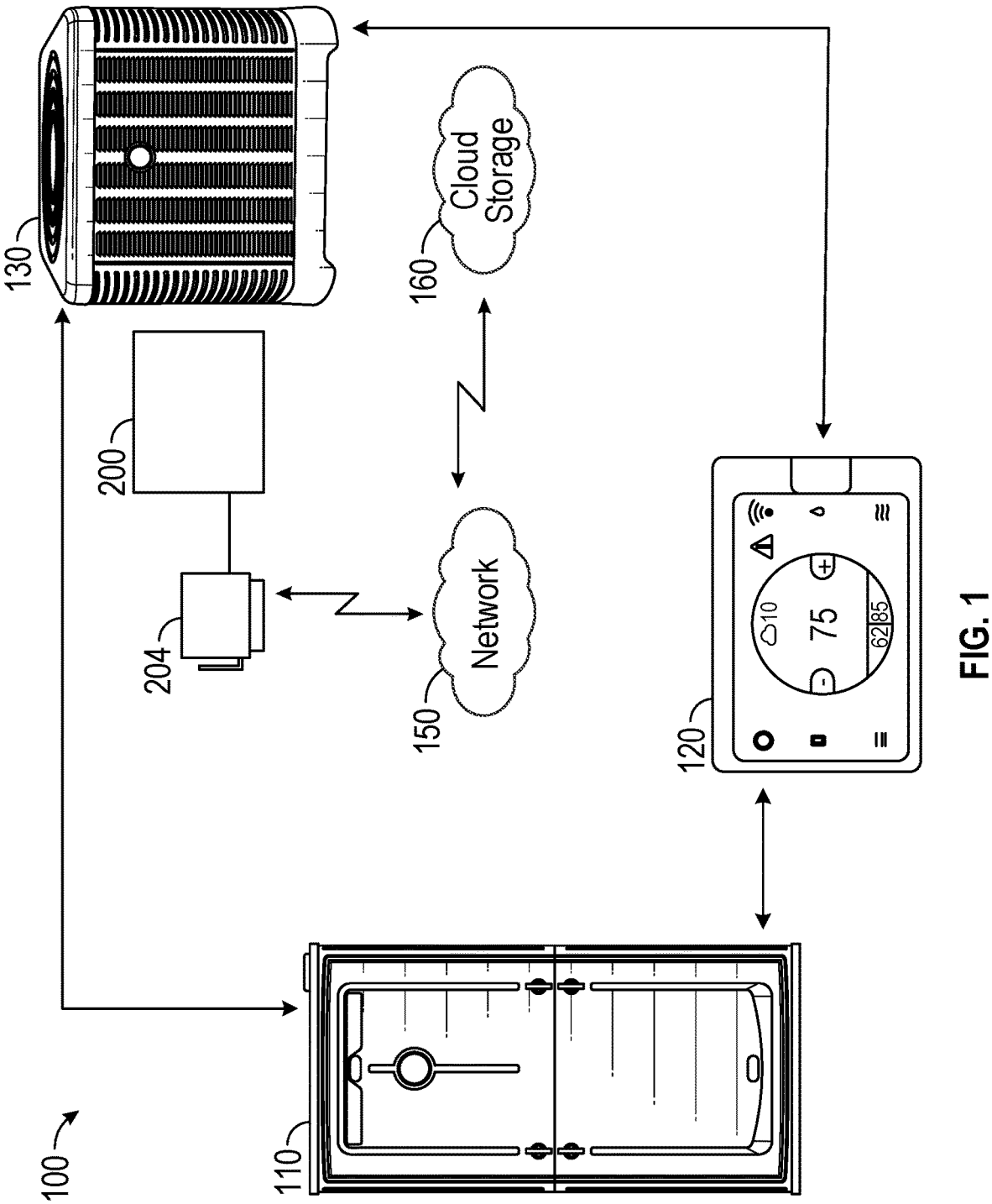

130
160
Cloud Storage
200
204
Network
150
120
75
62
85
10
110
100

FIG. 1

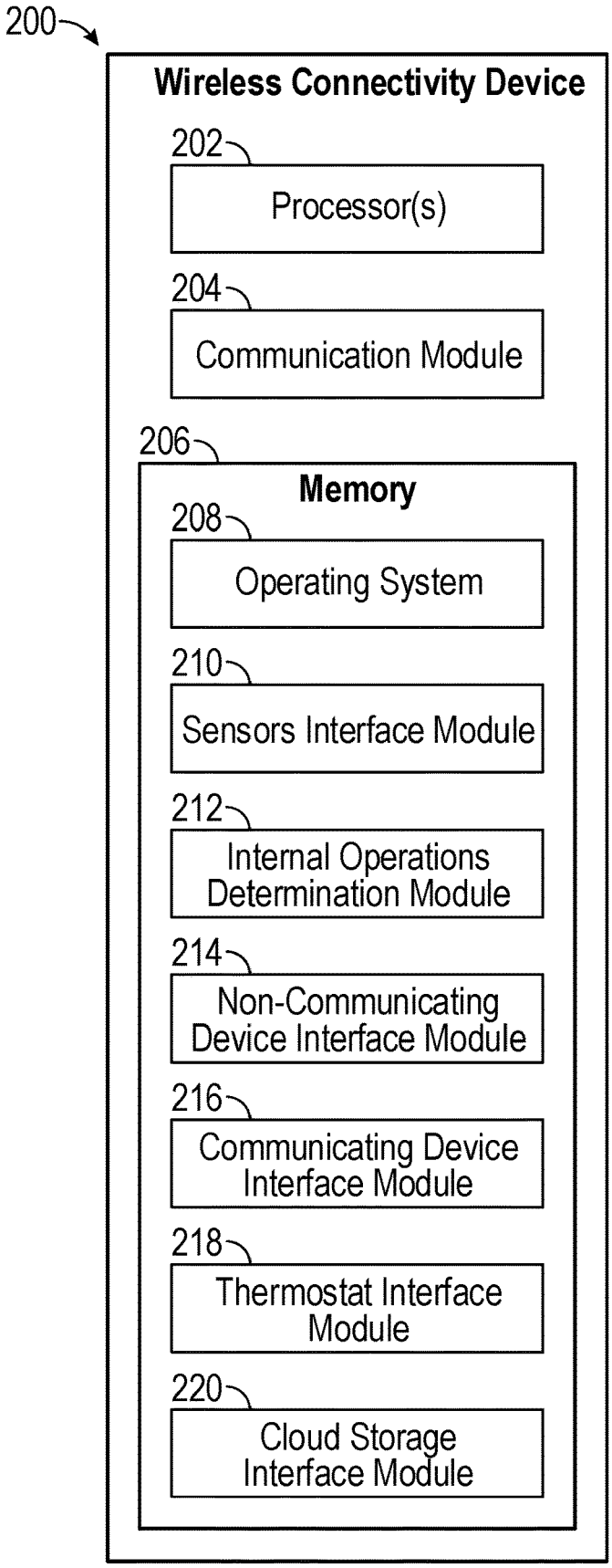

200
Wireless Connectivity Device
202
Processor(s)
204
Communication Module
206
Memory
208
Operating System
210
Sensors Interface Module
212
Internal Operations Determination Module
214
Non-Communicating Device Interface Module
216
Communicating Device Interface Module
218
Thermostat Interface Module
220
Cloud Storage Interface Module

FIG. 2

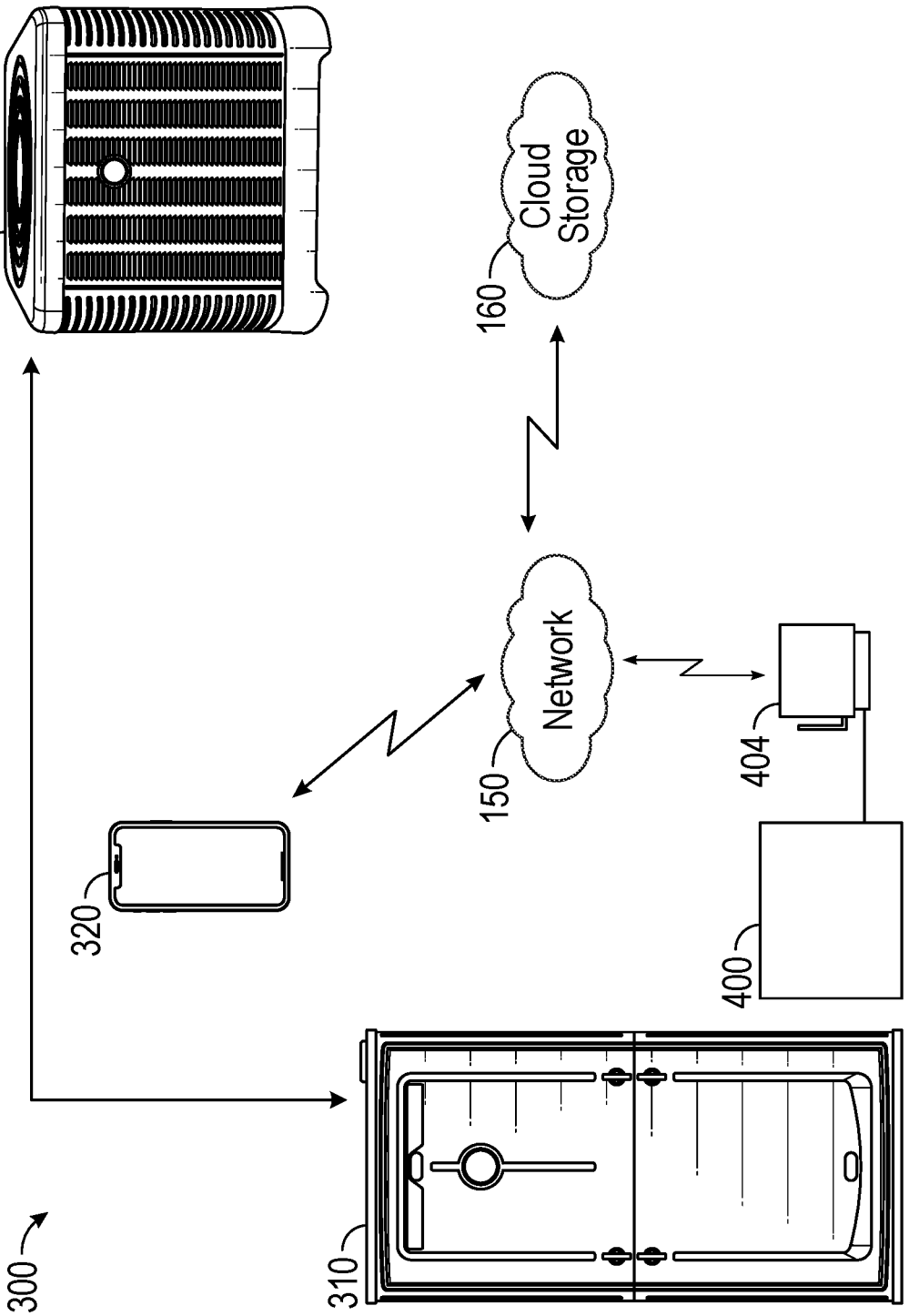


FIG. 3

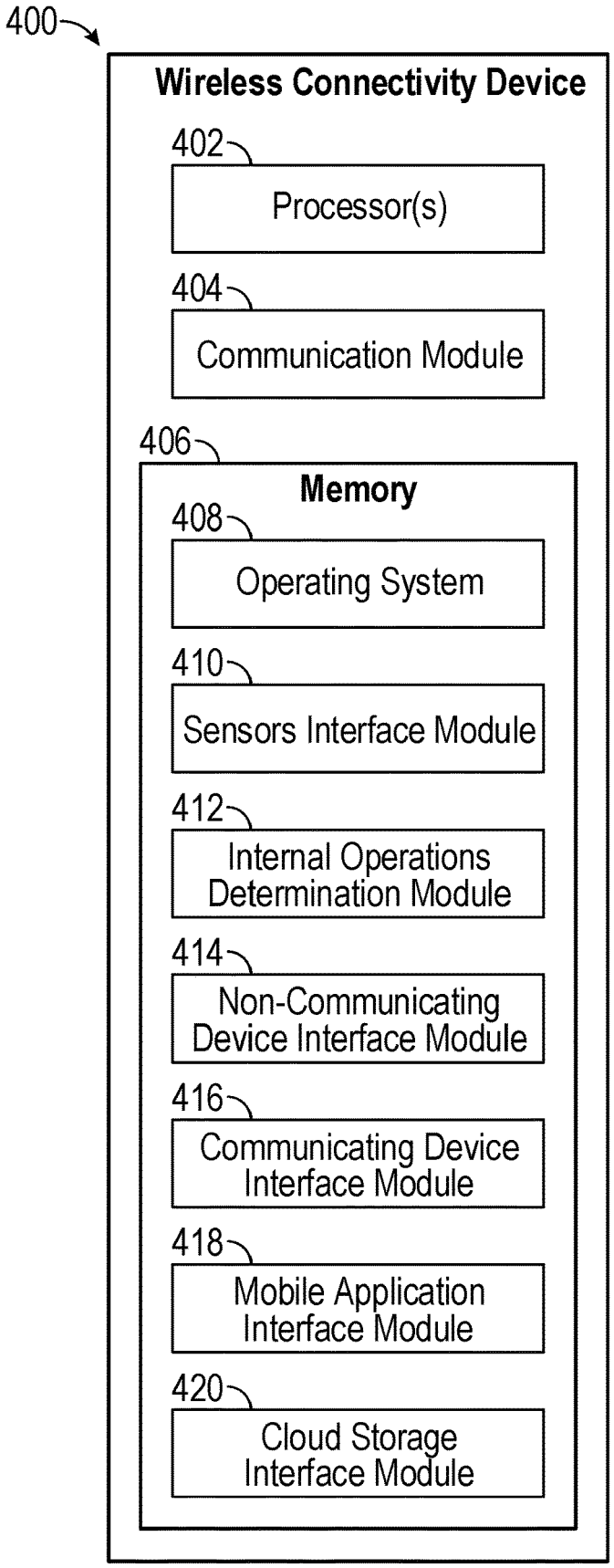

400
Wireless Connectivity Device
402
Processor(s)
404
Communication Module
406
Memory
408
Operating System
410
Sensors Interface Module
412
Internal Operations Determination Module
414
Non-Communicating Device Interface Module
416
Communicating Device Interface Module
418
Mobile Application Interface Module
420
Cloud Storage Interface Module

FIG. 4

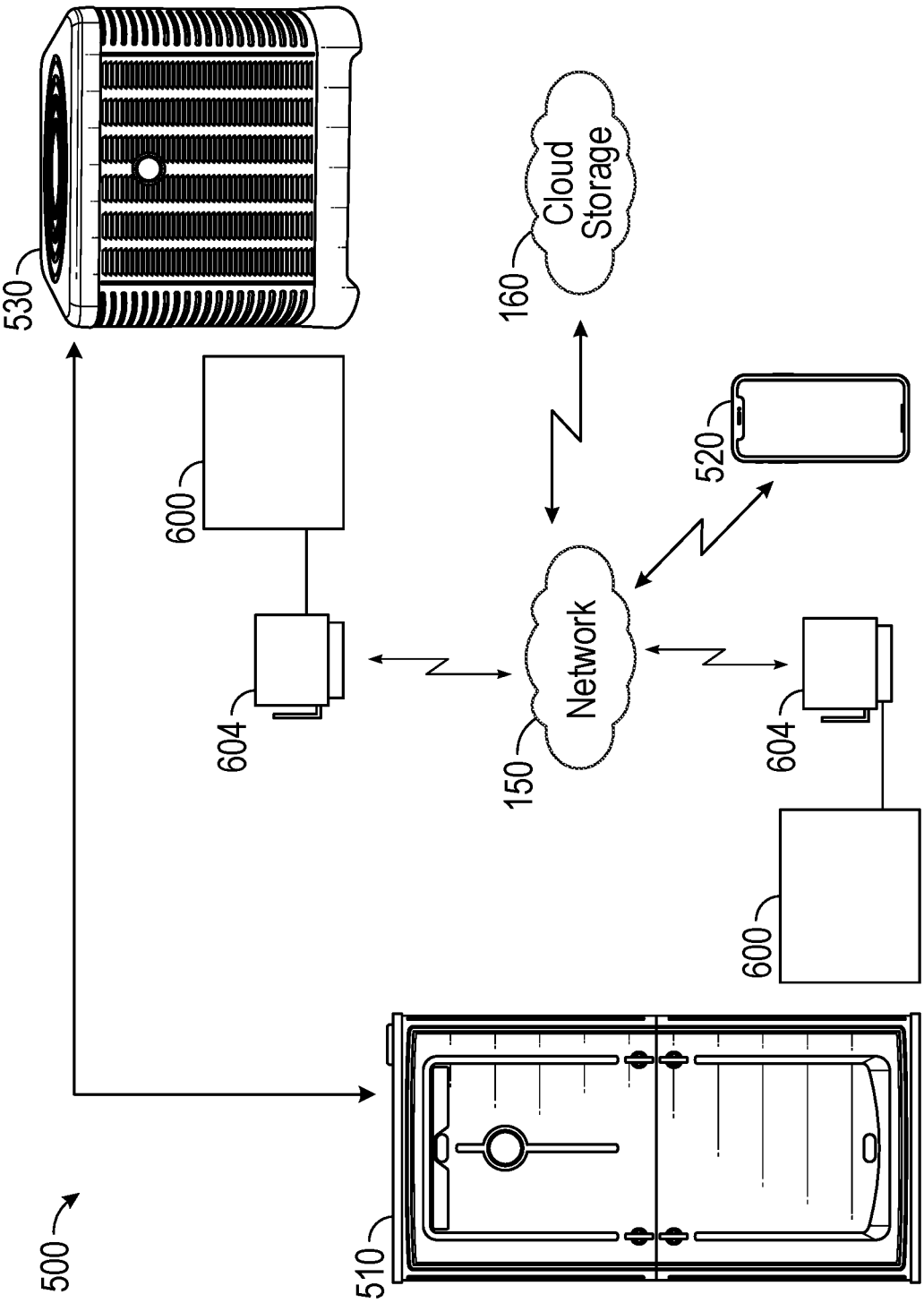


FIG. 5

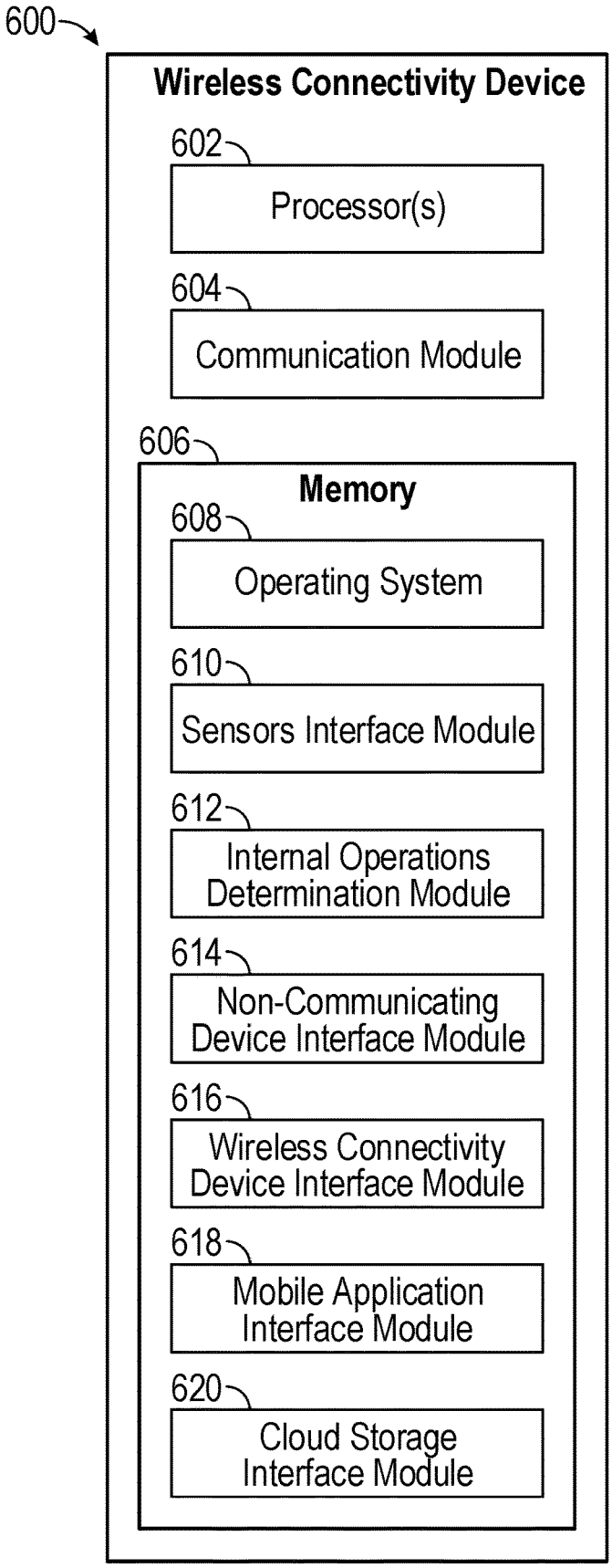

600
Wireless Connectivity Device
602
Processor(s)
604
Communication Module
606
Memory
608
Operating System
610
Sensors Interface Module
612
Internal Operations Determination Module
614
Non-Communicating Device Interface Module
616
Wireless Connectivity Device Interface Module
618
Mobile Application Interface Module
620
Cloud Storage Interface Module

FIG. 6

SYSTEMS AND METHODS FOR PROVIDING RETROACTIVE WIRELESS CONNECTIVITY TO HVAC SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and benefit of U.S. provisional patent application No. 63/445,495 filed Feb. 14, 2023, which is herein incorporated by reference.

TECHNICAL FIELD

[0002] The present disclosure is generally in the field of wireless communication systems for providing wireless connectivity to non-communicating HVAC systems.

BACKGROUND

[0003] Heating, ventilation, and air conditioning (HVAC) systems may be communicating or non-communicating. In a non-communicating system, the thermostat acts as a switch, and completes a circuit to deliver voltage to a component of the HVAC system, e.g., an indoor unit such as an air handler or furnace, and/or an outdoor unit such as an air conditioning (AC) unit, to cause the component to turn on or off until a temperature set point is reached. Typically, HVAC systems run on a 24 Volt power supply. In a communicating system, the thermostat may search for components of the HVAC system, e.g., via a Bluetooth connection, and once paired with the component, the component may communicate its capabilities and/or internal operations parameters, which may allow for optimal performance of the HVAC system. Currently, non-communicating components may not communicate with communicating components.

[0004] The foregoing background information is provided to reveal information believed by the applicant to be of possible relevance to the present disclosure. No admission is necessarily intended, nor should be construed, that any of the preceding information constitutes prior art against the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** illustrates a wireless communication system for providing wireless connectivity between a communicating indoor unit and a non-communicating outdoor unit constructed in accordance with the principles of the present disclosure.

[0006] FIG. **2** illustrates some example components that may be included in the wireless connectivity device of the system of FIG. **1** in accordance with the principles of the present disclosure.

[0007] FIG. **3** illustrates a wireless communication system for providing wireless connectivity between a non-communicating indoor unit and a communicating outdoor unit constructed in accordance with the principles of the present disclosure.

[0008] FIG. **4** illustrates some example components that may be included in the wireless connectivity device of the system of FIG. **3** in accordance with the principles of the present disclosure.

[0009] FIG. **5** illustrates a wireless communication system for providing wireless connectivity between a non-communicating indoor unit and a non-communicating outdoor unit constructed in accordance with the principles of the present disclosure.

[0010] FIG. **6** illustrates some example components that may be included in the wireless connectivity device of the system of FIG. **5** in accordance with the principles of the present disclosure.

DETAILED DESCRIPTION

[0011] The present disclosure is directed to systems and methods for providing wireless connectivity to a system, e.g., an HVAC system, including at least one non-communicating unit, e.g., an outdoor unit such as an AC unit or heat pump and/or an indoor unit such as an air handler or a furnace (as well as any other type of HVAC unit). A non-communicating unit does not have electronic communication capabilities and thus cannot communicate data to other units in the HVAC system. Instead, the non-communicating unit may simply be instructed to turn on or off. For example, a circuit electrically coupled to the non-communicating unit may be completed, e.g., via a command signal transmitted by a thermostat, such that voltage may be transmitted to the non-communicating unit to power on. Moreover, the circuit may be broken to cease delivery of voltage to thereby power off the non-communicating unit. In some digital systems, the command signals further may include a temperature set point along with the on/off command. For example, the indoor unit may send a command signal to the outdoor unit instructing the outdoor unit to turn on and to operate in a manner to achieve a predetermined temperature, such as by providing air conditioned to a certain temperature, etc. In contrast, a communicating unit may have the capability to measure and communicate data, e.g., data indicative of its capabilities and/or internal operations parameters, to facilitate optimization of the HVAC system.

[0012] In accordance with the principles of the present disclosure, the systems described herein may include a wireless connectivity device that may be mechanically and operatively coupled to or otherwise integrated with the non-communicating unit, to thereby provide communication capabilities to the non-communicating unit. Beyond simply providing basic communication to the non-communicating unit, the wireless connectivity device may further be used to determine or monitor system operation and diagnostic services. Moreover, the wireless connectivity device may provide demand response interactions between third party utility providers and the HVAC system. For example, state and/or local regulations may at times require limitations of electricity usage, such as by prohibiting thermostats from being lowered beyond a predetermined temperature, and utility providers may provide incentives to homeowners in exchange. Through the wireless connectivity device, with permission, utility providers may access data indicative of internal operations of the HVAC system, and send appropriate commands to devices of the HVAC system to automatically limit usage.

[0013] Therefore, the use of the wireless connectivity device improves upon conventional HVAC systems by providing for remote monitoring and control of HVAC systems including non-communicating units, which would otherwise be impossible in such conventional systems. As one example, a homeowner may use an application of a mobile device (such as a smartphone, laptop computer, tablet, etc.) that is connected to the Internet to view data about the non-communicating unit or control the non-communicating unit. Continuing the same example, the homeowner may be

able to remotely control the operation of a legacy HVAC unit that would otherwise not have communication capabilities to set a temperature within a home (reference to a home is only exemplary and other types of buildings may also be applicable) via the application. As another example, a technician may be provided diagnostic information about the non-communicating HVAC unit and may be able to remotely diagnose the non-communicating unit before arriving at the location of the home. In some instances, the technician may be able to send a signal to resolve an issue with the unit or, at the very least, may have knowledge of the issue with the unit prior to arriving at the location of the home such that the technician may arrive at the home with the correct tools and/or parts to perform maintenance on the unit. As yet another example, if a home includes non-communicating units and one of the units is replaced with a newer communicating unit, a wireless connectivity device may be provided in the non-communicating unit to allow the homeowner to control both the new unit and the older non-communicating unit.

[0014] Some representative embodiments will be described more fully hereinafter with example reference to the accompanying drawings that illustrate embodiments of the disclosure. Embodiments may take many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those appropriately skilled in the art.

[0015] In accordance with one aspect of the present disclosure, a wireless connectivity device for an HVAC system is provided. The wireless connectivity device may include one or more sensors that may be operatively coupled to a non-communicating unit of the HVAC system, and to measure one or more internal operations parameters of the non-communicating unit, a communication module, such as a cellular module, that may wirelessly communicate data between the wireless connectivity device and the HVAC system, at least one processor, and memory having instructions that, when executed by the at least one processor, causes the at least one processor to determine a state of internal operations of the non-communicating unit based on the measured one or more internal operations parameters, e.g., the real-time operating conditions of the non-communicating unit based on at least one of, for example, current, pressure, temperature, vibration, or noise associated with the non-communicating unit.

[0016] For example, the wireless connectivity device may be configured to be mechanically and operatively coupled to the non-communicating unit, e.g., via a wired connection or wireless connection. Alternatively, the wireless connectivity device may be integrated with the non-communicating unit, e.g., built into the hardware of the non-communicating unit at the time of manufacture. The communication module may communicate data between the wireless connectivity device and the HVAC system via at least one of a WiFi, Bluetooth, or cellular connection. The communication module may include a wired communication bus, or alternatively, a wireless communication bus.

[0017] The processor may be programmed to determine the state of internal operations of the non-communicating unit by comparing the measured one or more internal operations parameters with one or more baseline internal operations parameters. Accordingly, the processor may be programmed to adjust operations of the non-communicating unit if the measured one or more internal operations parameters is outside of a predetermined threshold range of the one or more baseline internal operations parameters. The one or more sensors may include at least one of a current sensor that may measure current associated with the non-communicating unit, a pressure sensor that may measure pressure associated with the non-communicating unit, a temperature sensor that may measure temperature associated with the non-communicating unit, an accelerometer that may measure vibration associated with the non-communicating unit, or an audio sensor that may measure noise associated with the non-communicating unit.

[0018] The wireless connectivity device may be communicatively coupled to a cloud storage for storing information indicative of the state of internal operations of the non-communicating unit received from the wireless connectivity device. The cloud storage may share the information indicative of the state of internal operations of the non-communicating unit with one or more third parties, e.g., the manufacturer of the non-communicating unit, or an HVAC contractor or other persons with permission to access the data including the user/homeowner. Accordingly, the wireless connectivity device may control operations of the non-communicating unit responsive to one or more commands received from the one or more third parties. In some embodiments, the non-communicating unit may be an outdoor unit, and the wireless connectivity device may be communicatively coupled to, e.g., a thermostat, which may in turn be communicatively coupled to a mobile application for receiving user input. Alternatively, the wireless connectivity device may be communicatively coupled to the mobile application. In some embodiments, the non-communicating unit may be an indoor unit, and the wireless connectivity device may be communicatively coupled to, e.g., a mobile application programmed to communicate user input to the wireless connectivity device. Moreover, the non-communicating unit may be communicatively coupled to a thermostat. Alternatively, the wireless connectivity device further may include a thermostat communicatively coupled to the mobile application.

[0019] In accordance with another aspect of the present disclosure, an HVAC system is provided. The HVAC system may include an indoor unit, an outdoor unit, and a wireless connectivity device that is operatively coupled to at least one of the indoor unit or the outdoor unit. The wireless connectivity unit may include one or more sensors that may measure one or more internal operations parameters of the at least one of the indoor unit or the outdoor unit, and a communication module that may wirelessly communicate data between the wireless connectivity device and the HVAC system. The HVAC system further may include at least one processor, and memory having instructions that, when executed by the at least one processor, causes the at least one processor to determine a state of internal operations of the at least one of the indoor unit or the outdoor unit based on the measured one or more internal operations parameters.

[0020] The processor may be programmed to adjust operations of the at least one of the indoor unit or the outdoor unit if the measured one or more internal operations parameters is outside of a predetermined threshold range. The wireless connectivity device may be communicatively coupled to a cloud storage for storing information indicative of the state

of internal operations of the non-communicating unit received from the wireless connectivity device. The cloud storage may share the information indicative of the state of internal operations of the at least one of the indoor unit or the outdoor unit with one or more third parties. Accordingly, the wireless connectivity device may control operations of the non-communicating unit responsive to one or more commands received from the one or more third parties.

[0021] The indoor unit may include at least one of an air handler or a furnace, and the outdoor unit may be an air conditioning unit or heat pump. In some embodiments, the indoor unit is communicating and the outdoor unit is non-communicating. Accordingly, the wireless connectivity device may be operatively coupled to the outdoor unit, and the processor may be programmed to determine a state of internal operations of the outdoor unit based on one or more measured internal operations parameters associated with the outdoor unit. Alternatively, the outdoor unit may be communicating and the indoor unit may be non-communicating. Accordingly, the wireless connectivity device may be operatively coupled to the indoor unit, and the processor may be programmed to determine a state of internal operations of the indoor unit based on one or more measured internal operations parameters associated with the indoor unit. In some embodiments, the outdoor unit is non-communicating and the indoor unit is non-communicating. Accordingly, the wireless connectivity device may be operatively coupled to the indoor unit and a second wireless connectivity device is operatively coupled to the indoor unit, such that the second wireless connectivity device is communicatively coupled to the wireless connectivity device.

[0022] While reference is made herein to HVAC systems, similar wireless connectivity may also be provided to systems that include other types of units, such as water heaters, for example.

[0023] Referring now to FIG. **1**, an HVAC system with wireless connectivity capabilities is provided. System **100** may include communicating indoor unit **110**, controller **120**, non-communicating outdoor unit **130**, wireless connectivity device **200**, and/or cloud storage **160**. Indoor unit **110**, controller **120**, wireless connectivity device **200**, and/or cloud storage **160** may all be communicatively coupled via, e.g., network **150**. Network **150** may include any one, or a combination of networks, such as a local area network (LAN), a wide area network (WAN), a telephone network, a cellular network, a cable network, a wireless network, and/or private/public networks, such as the Internet. For example, network **150** may support communication technologies, such as TCP/IP, Bluetooth, cellular, near-field communication (NFC), WiFi, WiFi direct, machine-to-machine communication, man-to-machine communication, and/or visible light communications. Although only one network **150** is shown in FIGS. **1**, **3**, and **5**, as will be understood by a person having ordinary skill in the art, network **150** may encompass various communication networks for communication between different components of the systems described herein. As an example, the controller, e.g., thermostat, may communicate with the indoor unit, e.g., an air handling unit and/or furnace, via a WiFi connection over network **150**, and the system components, e.g., the wireless communication device and/or other components with communications capabilities, may communicate with cloud storage **160** via a cellular connection over network **150**, or alternatively, over a WiFi connection over network **150**.

[0024] Indoor unit **110** may be, e.g. an air handling unit that regulates and circulates air as part of an HVAC system, and/or a furnace that generates heat from fuel source such as natural gas, oil, or electricity. For example, indoor unit **110** may include a filter, a blower, a heating element, and/or a cooling element for ventilating, heating, and/or cooling air. Indoor unit **110** generally may be disposed within a home, e.g., in a basement or attic or other appropriately sized location. Indoor unit **110** may be fluidicly coupled to outdoor unit **130** via, e.g., a duct system that permits air flow therebetween.

[0025] Controller **120**, e.g., a thermostat, may be communicatively coupled to communicating indoor unit **110** for transmitting commands to indoor unit **110** and/or receiving data from indoor unit **110**, e.g., data indicative of the capabilities and/or internal operation parameters of indoor unit **110**. For example, controller **120** may be a smart thermostat such as an EcoNet® Smart Thermostat. Alternatively, controller **120** may be a standard programmable thermostat. Controller **120** may communicate with indoor unit **110** via a wired connection, or alternatively, via a wireless connection, e.g., WiFi or Bluetooth, over network **150**.

[0026] In some instances, the controller **120** may be configured to auto-poll the wireless connectivity device **200** to obtain data about the non-communicating outdoor unit **130**. For example, the controller **120** may request data from the wireless connectivity device **200** periodically at pre-determined intervals. This not only allows for data about the non-communicating outdoor unit **130** to be automatically obtained but also prevents data transmission bandwidth from being used when it is desired for such bandwidth to be used for data communications between other devices.

[0027] Outdoor unit **130** may be, e.g., an AC unit that cools air by removing heat from the air for circulation via, e.g., the blower of indoor unit **110**. Outdoor unit **130** generally may be disposed outside a home, and may be operatively coupled to indoor unit **110** and/or controller **120** via a wired connection. Unlike traditional HVAC systems where a non-communicating outdoor unit may only be instructed by the HVAC system to turn on or off, e.g., via a 24 Volt power supply, system **100** further includes wireless connectivity device **200** that provides wireless communication capabilities to a non-communicating unit, e.g., outdoor unit **130**. Accordingly, wireless connectivity device **200** may be mechanically and operatively coupled to, or otherwise integrated with outdoor unit **130**. Moreover, wireless connectivity device **200** may be electrically powered, e.g., via an electric outlet and/or internal battery.

[0028] In addition, wireless connectivity device **200** may include one or more sensors that may measure one or more parameters associated with outdoor unit **130**, e.g., internal operations parameters such as current, pressure, and temperature. For example, wireless connectivity device **200** may include three temperature sensors, two pressure sensors, and one current sensor. As will be understood by a person having ordinary skill in the art, wireless connectivity device **200** may include less or more than three temperature sensors, less or more than two pressure sensors, and less or more than one current sensor. In some embodiments, the one or more sensors further may include one or more accelerometers that

may measure vibration, and/or one or more audio sensors that may detect noises associated with component parts of outdoor unit **130**. Accordingly, additional internal operations parameters associated with outdoor unit **130** that may be measured by the one or more sensors include vibration and noise.

[0029] In some instances, the one or more sensors may be in electrical communication with the wireless connectivity device **200** such that the one or more sensors may be provided at various locations within the HVAC system physically separate from the wireless connectivity device **200**. For example, the wireless connectivity device may be provided in a portion of the HVAC system including electronics used by the HVAC system and the one or more sensors may be provided proximate to components that the sensors are measuring.

[0030] The wireless connectivity device **200** may also be used to supplement an existing sensor suite of an HVAC system. For example, an HVAC system may already have temperature sensors used to capture temperature data for the HVAC system, but may not have a current sensor. The wireless connectivity device **200** may be provided with a current sensor to supplement the temperature sensors are capture additional information about the HVAC system.

[0031] As shown in FIG. **1**, wireless connectivity device **200** may include communication module **204**, e.g., a wireless transceiver, that may connect to and communicate data over network **150**. Communication module **204** may provide any combination of, e.g., WiFi, Bluetooth, or cellular connections or any other wireless connections supported by network **150** described above, between wireless connectivity device **200** and the components of system **100**. For example, communication module **204** may provide at least one of WiFi, Bluetooth, ZigBee, NFC, WiMAX, LTE, HSPA, EV-DO, UMTS, earlier 3G standards, satellite services, etc. In some embodiments, communication module **204** may include a wired communication bus, such as EcoNet®. Additionally or alternatively, communication module **204** may include wireless communication bus such as Bluetooth. Accordingly, communication module **204** may connect wireless connectivity device **200** with the other components of system **100**, e.g., indoor unit **110**, controller **120**, and cloud storage **160**, such that data may be communicated therebetween.

[0032] Moreover, in some embodiments, wireless connectivity device **200** may leverage an existing WiFi connection, e.g., a homeowner's WiFi internet network, to connect to cloud storage **160**, rather than connecting via the cellular network of communication module **204**, which may have associated costs such as monthly fees, and may be slower than the WiFi connection. Similarly, components of system **100** such as indoor unit **110** and/or controller **120**, may wirelessly communicate via a homeowner's WiFi internet network, and may use the cellular network of communication module **204** as a backup if the WiFi internet network is unable to connect to cloud storage **160**.

[0033] The use of the wireless connectivity device allows for the formation of a mesh network including both communicating units and non-communicating units in the HVAC system. This allows for multiple different types of units to communicate via a single shared network. This also allows for the communication range of units in the network to be increased. For example, a first non-communicating unit may include a wireless connectivity device **200** that allows the first non-communicating unit to communicate with other units via short-range wireless communications. A second unit may be within a distance of the first non-communicating unit allowing the first non-communicating unit to communicate with the second unit. However, a third unit may be a distance from the first non-communicating unit that is too far for the short-range wireless communications to be performed between the first non-communicating unit and the third unit. With the existence of the mesh network, the second unit may be able to relay messages between the first non-communicating unit and the third unit to allow for communications to be performed between the two units. Furthermore, the use of the mesh network allows for communications to be re-routed via other units if one of the units experiences a failure that prevents that particular unit from performing communications.

[0034] Controller **120** further may be communicatively coupled to wireless connectivity device **200** over network **150** for communicating with outdoor unit **130**. Accordingly, controller **120** may transmit commands to wireless connectivity device **200** to thereby provide instructions to outdoor unit **130**, and/or receive data from wireless connectivity device **200**, e.g., data indicative of the capabilities and/or internal operations parameters of outdoor unit **130** measured by the one or more sensors of wireless connectivity device **200** operatively coupled to outdoor unit **130**.

[0035] Moreover, controller **120** may include a user interface for receiving user input, e.g., a command to turn indoor unit **110** and/or outdoor unit **130** on or off and optionally a temperature set point, and generate and transmit one or more command signals indicative of the user input to indoor unit **110** and/or wireless connectivity device **200**, e.g., via a WiFi connection over network **150**. In some embodiments, controller **120** may be communicatively coupled to a mobile application running on a mobile device, e.g., via a WiFi or Bluetooth connection over network **150**, such that controller **120** may receive user input via the mobile application. Accordingly, controller **120** may be operatively coupled to one or more temperature sensors that may measure temperature, e.g., within a room of a home, such that temperature may be monitored by controller **120**, and controller **120** may instruct indoor unit **110** and/or outdoor unit **130** to operate until the temperature set point is achieved in accordance with the user input.

[0036] In addition, controller **120** and/or wireless connectivity device **200** may optimize performance of system **100** by taking into account capabilities and internal operations parameters of indoor unit **110** and/or outdoor unit **130**. For example, controller **120** and/or wireless connectivity device **200** may take into account device capabilities including, but not limited to, max blower speed, max heating/cooling temperature, and/or power usage of indoor unit **110**, and max cooling temperature and/or power usage of outdoor unit **130**. Accordingly, controller **120** and/or wireless connectivity device **200** may adjust operations of indoor unit **110** and/or outdoor unit **130** responsive to the internal operations parameters of indoor unit **110** and/or outdoor unit **130**, while considering the respective device capabilities.

[0037] Moreover, controller **120** may record and share internal operations parameters of indoor unit **110** and/or outdoor unit **130** with a third party, e.g., via cloud storage **160**, which may be indicative of one or more operating issues of indoor unit **110** and/or outdoor unit **130**, necessitating repair or replacement. The data may be reviewed

remotely by a professional for identifying potential issues, thereby saving time otherwise required for the professional to conduct a home visit in order to identify the issue. In some embodiments, controller **120** may process the recorded data and execute diagnostic functions to identify potential issues associated with the operation of indoor unit **110** and/or outdoor unit **130**. Moreover, controller **120** may communicate an alert to the user, e.g., by displaying the alert via the user interface of controller **120** or a mobile application communicatively coupled to controller **120**, and/or share data indicative of the identified issues, e.g., via cloud storage **160**.

[0038] Information shared between indoor unit **110**, controller **120**, and/or wireless connectivity device **200** may be stored on cloud storage **160** and may be bi-directional in nature. For example, in one case, information indicative of internal operations parameters associated with indoor unit **110** and/or outdoor unit **130** may be transferred from wireless connectivity device **200** to cloud storage **160**. Such information stored on cloud storage **160** may be subsequently accessed and used by the components of system **100** and/or a third party.

[0039] Referring now to FIG. **2**, components that may be included in wireless connectivity device **200** are described in further detail. Wireless connectivity device **200** may include one or more processors **202**, communication module **204**, and memory **206**. As described above, communication module **204** allows wireless connectivity device **200** to communicate with indoor unit **110**, controller **120**, and cloud storage **160** over one or more communication networks of network **150**. Communication module **204** may use any of various communication formats, such as, for example, an Internet communications format, or a cellular communications format.

[0040] Memory **206**, which is one example of a non-transitory computer-readable medium, may be used to store operating system (OS) **208**, sensors interface module **210**, internal operations determination module **212**, non-communicating device interface module **214**, communicating device interface module **216**, thermostat interface module **218**, and cloud storage interface module **220**. The modules are provided in the form of computer-executable instructions that may be executed by processor **202** for performing various operations in accordance with the disclosure. Memory **206** may include any one memory element or a combination of volatile memory elements (e.g., random access memory (RAM, such as DRAM, SRAM, SDRAM, etc.)) and non-volatile memory elements (e.g., ROM, hard drive, tape, CDROM, etc.). In the context of this document, a "non-transitory computer-readable medium" may be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device.

[0041] Sensors interface module **210** may be executed by processor **202** for receiving and processing data measured by the one or more sensors of wireless connectivity device **200** operatively coupled to outdoor unit **130**. For example, sensors interface module **210** may receive and process data indicative of at least one of current associated with outdoor unit **130** from one or more current sensors, e.g., current of the motor of outdoor unit **130**, pressure associated with outdoor unit **130** from one or more pressure sensors, e.g., fluid pressure within the coils of outdoor unit **130**, temperature associated with outdoor unit **130** from one or more temperature sensors, e.g., ambient temperature and/or temperature of electronic components of outdoor unit **130**, vibration associated with outdoor unit **130** from one or more accelerometers, e.g., movement of mechanical components of outdoor unit **130**, or noise associated with outdoor unit **130** from one or more audio sensors, e.g., noise emitted from the electronic and/or mechanical components of outdoor unit **130**.

[0042] Internal operations determination module **212** may be executed by processor **202** for analyzing the data obtained and processed by sensors interface module **210** to determine the state of internal operations of outdoor unit **130**, e.g., the real-time operating conditions of outdoor unit **130** based on at least one of current, pressure, temperature, vibration, or noise associated with outdoor unit **130**. For example, based on the current data, internal operations determination module **212** may determine the amount of current outdoor unit **130** consumes, and compare it with a baseline and/or predetermined threshold amount associated with the baseline stored in memory **206** to determine if outdoor unit **130** is drawing less or more current than under normal and/or tolerable operating conditions. For example, if internal wires are broken and/or the motor of outdoor unit **130** is not working, the current data would indicate that outdoor unit **130** is drawing zero current. Moreover, if a rotor of outdoor unit **130** is locked, e.g., due to damage by a fallen tree on outdoor unit **130**, the current data may indicate that outdoor unit **130** is drawing more current than expected.

[0043] Based on the pressure data, alone or in combination with the current data, internal operations determination module **212** may determine if refrigerant is leaking or overcharged. For example, internal operations determination module **212** may compare fluid pressure and/or current data with one or more baselines and/or predetermined thresholds stored in memory **206** to determine whether the fluid within the coil lines of system **100** is within an acceptable amount. Although the pressure data alone may be indicative of whether the fluid pressure levels within the coils are acceptable, as the fluid pressure within the coils may be different depending on whether outdoor unit **130** is running or not, the current data in combination with the pressure data may provide more information than pressure data alone. Based on the temperature data, internal operations determination module **212** may determine the ambient temperature based on temperature measurements obtained from both the low pressure side and the high pressure side of outdoor unit **130**. The temperature data in combination with the pressure and/or current data may provide even more information that may be useful to, e.g., a contractor, to identify potential operational issues.

[0044] In addition, based on the vibration data, internal operations determination module **212** may determine whether outdoor unit **130** is vibrating more or less than under normal operating conditions by comparing the vibration data with a baseline and/or predetermined threshold amount stored in memory **206**. Additionally, based on the audio data, internal operations determination module **212** may determine whether outdoor unit **130** emitting noise indicative of a potential issue, e.g., if the motor of outdoor unit **130** is making unusual sounds, by comparing the audio data with a baseline and/or predetermined threshold amount stored in memory **206**.

[0045] Non-communicating device interface module **214** may be executed by processor **202** for communicating data between wireless connectivity device **200** and the non-communicating unit of system **100** that wireless connectivity device **200** is coupled to, e.g., outdoor unit **130**. For example, non-communicating device interface module **214** may transmit commands to outdoor unit **130**, e.g., to cause outdoor unit **130** to turn on or off and/or to operate until a temperature set point is achieved, responsive to user input. Moreover, non-communicating device interface module **214** may optimize operation of outdoor unit **130** by taking into account internal operations parameters of outdoor unit **130** as determined by internal operations determination module **212**. For example, if a potential issue is identified by internal operations determination module **212**, e.g., based on one or more of current, pressure, temperature, vibration, or audio measurements associated with outdoor unit **130**, non-communicating device interface module **214** may adjust the operating parameters of outdoor unit **130**, and/or cause outdoor unit **130** to power off until the potential issue is resolved. Moreover, based on known operational characteristics of outdoor unit **130**, internal operations determination module **212** may cause outdoor unit **130** to operate in a manner such that the temperature set point is achieved in an energy efficient manner.

[0046] Communicating device interface module **216** may be executed by processor **202** for communicating data between wireless connectivity device **200** and a communicating unit of system **100**, e.g., indoor unit **110**. For example, communicating device interface module **216** may receive information indicative of the capabilities and/or internal operations parameters of indoor unit **110**, such that cloud storage interface module **220** may communicate the information to cloud storage **160** for storage, as described in further detail below.

[0047] Thermostat interface module **218** may be executed by processor **202** for communicating data between wireless connectivity device **200** and controller **120**, e.g., a thermostat. For example, thermostat interface module **218** may receive commands from controller **120**, e.g., to power outdoor unit **130** on or off, such that non-communicating device interface module **214** may instruct outdoor unit **130** to turn on or off in accordance with the received commands.

[0048] Cloud storage interface module **220** may be executed by processor **202** for communicating data between wireless connectivity device **200** and cloud storage **160**. For example, cloud storage interface module **220** may communicate information indicative of the capabilities and/or internal operations parameters of indoor unit **110** received by communicating device interface module **216**, and/or information indicative of the internal operations parameters of outdoor unit **130** received and processed by sensors interface module **210** to cloud storage **160** for storage. As described above, the components of system **100** may subsequently access and receive data stored in cloud storage **160**, e.g., via cloud storage interface module **220** and communication module **204**.

[0049] Moreover, a third party with permission to access cloud storage **160** may access and download information stored in cloud storage **160**. For example, a contractor may download information indicative of potential issues determined by internal operations determination module **212**, and/or information indicative of the internal operations parameters of outdoor unit **130** received and processed by sensors interface module **210** such that the contractor may identify potential issues manually. Accordingly, the contractor may be made aware of potential issues prior to conducting an in-person inspection, and additionally may identify requisite repair tools and/or replacement parts prior to conducting the in-home visit for the repair and/or replacement, which will save valuable time and costs.

[0050] Referring now to FIG. **3**, an alternative HVAC system with wireless connectivity capabilities is provided. System **300** may include non-communicating indoor unit **310**, controller **320**, communicating outdoor unit **330**, wireless connectivity device **400**, and/or cloud storage **160**. Indoor unit **310**, controller **320**, wireless connectivity device **400**, and/or cloud storage **160** may all be communicatively coupled via, e.g., network **150**. Like indoor unit **110** of system **100**, indoor unit **310** may be, e.g., an air handling unit that regulates and circulates air as part of an HVAC system, and/or a furnace that generates heat from fuel source such as natural gas, oil, or electricity, and like outdoor unit **130** of system **100**, outdoor unit **330** may be, e.g., an AC unit that cools air by removing heat from the air for circulation. As described above, outdoor unit **330** may be operatively coupled to indoor unit **310** via a wired connection. Unlike system **100** where the indoor unit is communicating and the outdoor unit is non-communicating, in system **300**, outdoor unit **330** is communicating and indoor unit **310** is non-communicating. Accordingly, outdoor unit **330** may communicate information indicative of its capabilities and internal operations parameters to the components of system **300**, e.g., via a wired connection or wireless connection over network **150**, whereas indoor unit **310** may be mechanically and operatively coupled to wireless connectivity device **400** to communicate with the components of system **300**.

[0051] Wireless connectivity device **400** may constructed similar to wireless connectivity device **200**, such that one or more sensors of wireless connectivity device **400** may be operatively coupled to indoor unit **310** to measure internal operations parameters of indoor unit **310**, and communication module **404** of wireless connectivity device **400** may communicate information indicative of the internal operations parameters of indoor unit **310** to the components of system **300**. For example, communication module **404** may provide any combination of, e.g., WiFi, Bluetooth, or cellular connections between wireless connectivity device **400** and the components of system **300**. Unlike wireless connectivity device **200**, which is operatively coupled to an outdoor unit, as wireless connectivity device **400** may be operatively coupled to indoor unit **310**, wireless connectivity device **400** may function as a thermostat without the need for a separate thermostat.

[0052] As shown in FIG. **3**, the thermostat functions of wireless connectivity device **400** may be controlled via controller **320**, e.g., a mobile application running on a mobile device, communicatively coupled to wireless connectivity device **400** via a wireless connection such as WiFi or Bluetooth over network **150**. Accordingly, wireless connectivity device **400** may receive user input via controller **320**. Controller **320** further may provide commands to outdoor unit **330**, and receive information from outdoor unit **330**, wireless connectivity device **400**, and cloud storage **160**. Moreover, by coupling the one or more sensors of wireless connectivity device **400** to indoor unit **310**, additional internal operations parameters of indoor unit **310** may be monitored, and thus more diagnostics may be provided by

system **300**. For example, wireless connectivity device **400** may monitor the cooling coils of indoor unit **310**, and provide defrost control diagnostics.

[0053] Referring now to FIG. **4**, components that may be included in wireless connectivity device **400** are described in further detail. As described above, wireless connectivity device **400** may be constructed similar to wireless connectivity device **200**. For example, wireless connectivity device **400** may include one or more processors **402**, communication module **404**, and memory **406**, which correspond with one or more processors **202**, communication module **204**, and memory **206**. Accordingly, communication module **404** allows wireless connectivity platform **400** to communicate with outdoor unit **330**, controller **320**, and cloud storage **160**. Moreover, like memory **206**, memory **406** may be used to store operating system (OS) **408**, sensors interface module **410**, internal operations determination module **412**, non-communicating device interface module **414**, communicating device interface module **416**, and cloud storage interface module **420**. As outdoor unit **330** is the communicating unit in system **300**, communicating device interface module **416** may communicate with outdoor unit **330**.

[0054] Unlike memory **206**, memory **406** may include mobile application interface module **418** instead of thermostat interface module **218**. As the thermostat may be integrated with wireless connectivity device **400** that may be controlled via controller **320**, e.g., a mobile application, mobile application interface module **418** may be executed by processor **402** for communicating data between wireless connectivity device **400** and controller **320**. For example, mobile application interface module **418** may receive commands from controller **320**, e.g., to power indoor unit **310** on or off, such that non-communicating device interface module **414** may instruct indoor unit **310** to turn on or off in accordance with the received commands.

[0055] Moreover, as described above, internal operations determination module **412** may provide additional diagnostic capabilities based on the received and processed data from sensors interface module **410** indicative of the state of internal operations of indoor unit **310**. For example, by comparing the current and/or temperature data associated with indoor unit **310** with one or more baselines and/or predetermined thresholds associated therewith, internal operations determination module **412** may determine that indoor unit **310** is overcharged and that the cooling coils of indoor unit **310** are frozen, such that indoor unit **310** is unable to blow air, e.g., due to ice within indoor unit **310**, to thereby provide indoor AC coil defrost control. In addition, based on at least the pressure data associated with indoor unit **310**, internal operations determination module **412** may provide duct pressure monitoring, and/or detect a dirty filter, etc.

[0056] Referring now to FIG. **5**, another alternative HVAC system with wireless connectivity capabilities is provided. System **500** may include non-communicating indoor unit **510**, controller **520**, non-communicating outdoor unit **530**, one or more wireless connectivity devices **600**, and/or cloud storage **160**. Controller **520**, one or more wireless connectivity devices **600**, and/or cloud storage **160** may all be communicatively coupled via, e.g., network **150**. Like indoor unit **110**, **310**, indoor unit **510** may be, e.g., an air handling unit that regulates and circulates air as part of an HVAC system, and/or a furnace that generates heat from fuel source such as natural gas, oil, or electricity, and like outdoor unit **130**, **330**, outdoor unit **530** may be, e.g., an AC unit that cools air by removing heat from the air for circulation. As described above, outdoor unit **530** may be operatively coupled to indoor unit **510** via a wired connection. Unlike systems **100**, **300**, both indoor unit **510** and outdoor unit **530** are non-communicating. Accordingly, both indoor unit **510** and outdoor unit **530** may each be mechanically and operatively coupled to or otherwise integrated with a wireless connectivity device, e.g., wireless connectivity device **600**, to communicate with the components of system **500**.

[0057] Wireless connectivity device **600** may constructed similar to wireless connectivity device **200**, **400**. For example, one or more sensors of the wireless connectivity device coupled to indoor unit **510** may be operatively coupled to indoor unit **510** to measure internal operations parameters of indoor unit **510**, and the corresponding wireless communication module, e.g., communication module **604**, of the wireless connectivity device may communicate information indicative of the internal operations parameters of indoor unit **510** to the components of system **500**. Moreover, one or more sensors of the wireless connectivity device coupled to outdoor unit **530** may be operatively coupled to outdoor unit **530** to measure internal operations parameters of outdoor unit **530**, and the corresponding wireless communication module, e.g., communication module **604**, of the wireless connectivity device may communicate information indicative of the internal operations parameters of outdoor unit **530** to the components of system **500**. For example, communication modules **604** may provide any combination of, e.g., WiFi, Bluetooth, or cellular connections between wireless connectivity devices **600** and the components of system **500**.

[0058] Like wireless connectivity device **400**, the wireless connectivity device operatively coupled to indoor unit **510** may function as a thermostat without the need for a separate thermostat. Accordingly, controller **520**, e.g., a mobile application running on a mobile device, may be communicatively coupled to wireless connectivity devices **600** over network **150**. Accordingly, controller **520** may transmit data indicative of user input to wireless connectivity devices **600**, and information to cloud storage **160** for storage, and further may receive information from wireless connectivity devices **600** and cloud storage **160**. Moreover, like wireless connectivity device **400**, the wireless connectivity device operatively coupled to indoor unit **510** may monitor additional internal operations parameters of indoor unit **510**, and thus provide more diagnostic capabilities.

[0059] Referring now to FIG. **6**, components that may be included in wireless connectivity device **600** are described in further detail. As described above, wireless connectivity device **600** may be constructed similar to wireless connectivity device **200**, **400**. For example, wireless connectivity device **600** may include one or more processors **602**, communication module **604**, and memory **606**, which correspond with one or more processors **202**, **402**, communication module **204**, **404**, and memory **206**, **406**. Accordingly, communication module **604** allows wireless connectivity platform **600** to communicate with another wireless connectivity device in system **500**, controller **520**, and cloud storage **160**. Moreover, like memory **406**, memory **606** may store operating system (OS) **608**, sensors interface module **610**, internal operations determination module **612**, non-

communicating device interface module **614**, and cloud storage interface module **620**.

[0060] Sensors interface module **610** and internal operations determination module **612** of the wireless connectivity device coupled to indoor unit **510** may operate in a similar manner to sensors interface module **410** and internal operations determination module **412**, respectively, of wireless connectivity device **400** coupled to non-communicating indoor unit **310**. Moreover, non-communicating device interface module **614** of the wireless connectivity device coupled to indoor unit **510** may communicate data between the wireless connectivity device and indoor unit **510**, and non-communicating device interface module **614** of the wireless connectivity device coupled to outdoor unit **530** may communicate data between the wireless connectivity device and outdoor unit **530**. Unlike memory **206**, **406**, memory **606** may include wireless connectivity device interface module **616** instead of communicating device interface module **216**, **416**. Wireless connectivity device interface module **616** may be executed by processor **602** for communicating data between one wireless connectivity device and another wireless connectivity device within system **500**.

[0061] As described above, by coupling any of the wireless connectivity devices described herein to a non-communicating indoor unit, a non-communicating outdoor unit, or both, the wireless connectivity device may provide demand response interactions between third party utility providers and the HVAC system, such that the third party may effectively control the indoor unit and/or the outdoor unit. Accordingly, the third party may send commands to the one or more wireless connectivity devices to power on or off the associated indoor unit and/or outdoor unit to limit usage thereof, e.g., in accordance with state and/or local regulations.

[0062] Modifications and variations of the methods and devices described herein will be obvious to those skilled in the art from the foregoing detailed description. Such modifications and variations are intended to come within the scope of the appended claims.

We claim:

1. A wireless connectivity device for a Heating, Ventilation, and Air Conditioning (HVAC) system, the wireless connectivity device comprising:

one or more sensors configured to be operatively coupled to a non-communicating unit of the HVAC system, and to measure one or more internal operations parameters of the non-communicating unit;

a communication module configured to wirelessly communicate data between the wireless connectivity device and the HVAC system;

at least one processor; and

memory having instructions that, when executed by the at least one processor, causes the at least one processor to determine a state of internal operations of the non-communicating unit based on the measured one or more internal operations parameters.

2. The wireless connectivity device of claim **1**, wherein the wireless connectivity device is configured to be mechanically and operatively coupled to the non-communicating unit.

3. The wireless connectivity device of claim **1**, wherein the wireless connectivity device is configured to be integrated with the non-communicating unit.

4. The wireless connectivity device of claim **1**, wherein the communication module is configured to communicate data between the wireless connectivity device and the HVAC system via at least one of a WiFi, Bluetooth, or cellular connection.

5. The wireless connectivity device of claim **1**, wherein the processor is configured to determine the state of internal operations of the non-communicating unit by comparing the measured one or more internal operations parameters with one or more baseline internal operations parameters.

6. The wireless connectivity device of claim **5**, wherein the processor is configured to adjust operations of the non-communicating unit if the measured one or more internal operations parameters is outside of a predetermined threshold range of the one or more baseline internal operations parameters.

7. The wireless connectivity device of claim **1**, wherein the one or more sensors comprises at least one of a current sensor configured to measure current associated with the non-communicating unit, a pressure sensor configured to measure pressure associated with the non-communicating unit, a temperature sensor configured to measure temperature associated with the non-communicating unit, an accelerometer configured to measure vibration associated with the non-communicating unit, or an audio sensor configured to measure noise associated with the non-communicating unit.

8. The wireless connectivity device of claim **1**, wherein the wireless connectivity device is configured to be communicatively coupled to a cloud storage for storing information indicative of the state of internal operations of the non-communicating unit received from the wireless connectivity device.

9. The wireless connectivity device of claim **8**, wherein the cloud storage is configured to share the information indicative of the state of internal operations of the non-communicating unit with one or more third parties, wherein the wireless connectivity device is configured to control operations of the non-communicating unit responsive to one or more commands received from the one or more third parties.

10. The wireless connectivity device of claim **1**, wherein the non-communicating unit comprises an outdoor unit, and wherein the wireless connectivity device is configured to be communicatively coupled to a thermostat.

11. The wireless connectivity device of claim **1**, wherein the non-communicating unit comprises an indoor unit, and wherein the wireless connectivity device is configured to be communicatively coupled to a mobile application configured to communicate user input to the wireless connectivity device.

12. The HVAC system of claim **11**, wherein the wireless connectivity device further comprises a thermostat communicatively coupled to the mobile application.

13. An HVAC system comprising:

an indoor unit;

an outdoor unit;

a wireless connectivity device configured to be operatively coupled to at least one of the indoor unit or the outdoor unit, the wireless connectivity unit comprising one or more sensors configured to measure one or more internal operations parameters of the at least one of the indoor unit or the outdoor unit, and a communication

module configured to wirelessly communicate data between the wireless connectivity device and the HVAC system;

at least one processor; and

memory having instructions that, when executed by the at least one processor, causes the at least one processor to determine a state of internal operations of the at least one of the indoor unit or the outdoor unit based on the measured one or more internal operations parameters.

14. The HVAC system of claim **13**, wherein the processor is configured to adjust operations of the at least one of the indoor unit or the outdoor unit if the measured one or more internal operations parameters is outside of a predetermined threshold range.

15. The HVAC system of claim **13**, wherein the wireless connectivity device is configured to be communicatively coupled to a cloud storage for storing information indicative of the state of internal operations of the non-communicating unit received from the wireless connectivity device.

16. The HVAC system of claim **14**, wherein the cloud storage is configured to share the information indicative of the state of internal operations of the at least one of the indoor unit or the outdoor unit with one or more third parties, wherein the wireless connectivity device is configured to control operations of the non-communicating unit responsive to one or more commands received from the one or more third parties.

17. The HVAC system of claim **13**, wherein the indoor unit comprises at least one of an air handler or a furnace, and wherein the outdoor unit comprises an air conditioning unit or heat pump.

18. The HVAC system of claim **13**, wherein the indoor unit is communicating and the outdoor unit is non-communicating, wherein the wireless connectivity device is operatively coupled to the outdoor unit, and wherein the processor is configured to determine a state of internal operations of the outdoor unit based on one or more measured internal operations parameters associated with the outdoor unit.

19. The HVAC system of claim **13**, wherein the outdoor unit is communicating and the indoor unit is non-communicating, wherein the wireless connectivity device is operatively coupled to the indoor unit, and wherein the processor is configured to determine a state of internal operations of the indoor unit based on one or more measured internal operations parameters associated with the indoor unit.

20. The HVAC system of claim **13**, wherein the outdoor unit is non-communicating and the indoor unit is non-communicating, wherein the wireless connectivity device is operatively coupled to the indoor unit and a second wireless connectivity device is operatively coupled to the indoor unit, and wherein the second wireless connectivity device is communicatively coupled to the wireless connectivity device.

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