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Cameron et al.

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(54) **UTILITY METER REPORTING NETWORK**

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(51) **Int. Cl.**

| | |
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| ***H04Q 9/00*** | (2006.01) |
| *G08B 5/22* | (2006.01) |
| *G08B 21/00* | (2006.01) |
| *G08C 19/04* | (2006.01) |
| *H04L 12/28* | (2006.01) |
| *H04M 11/00* | (2006.01) |

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

CPC .......... ***H04Q 9/00*** (2013.01); *H04Q 2209/40* (2013.01); *H04Q 2209/60* (2013.01)

(58) **Field of Classification Search**

CPC ...................... H04Q 2209/40; H04Q 2209/60

USPC ............... 340/870.02, 7.1, 870.11; 370/392; 455/405

See application file for complete search history.

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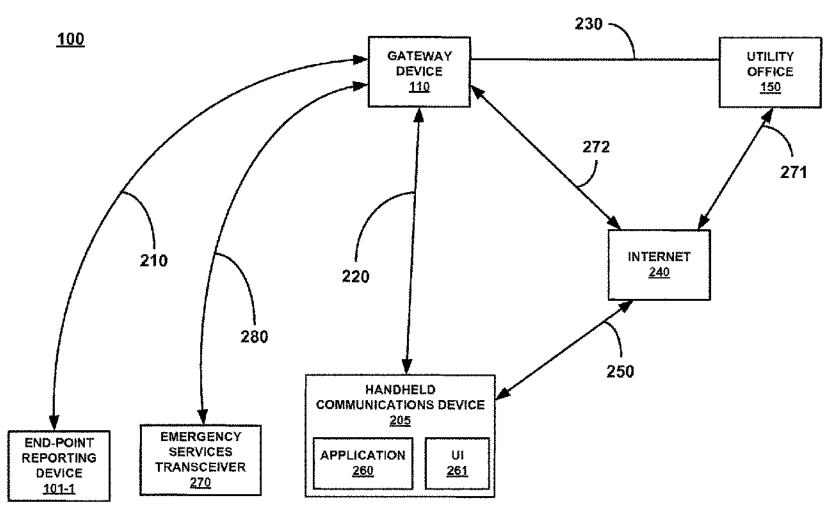
(57) **ABSTRACT**

A utility meter reporting network is disclosed. In one embodiment, an end-point reporting device is configured to collect utility usage data and to convey the utility usage data to a gateway device via a first Industrial, Scientific, and Medical (ISM) radio communication link using a first ISM transceiver operable in the 902 MHz to 928 MHz range. The network further comprises a gateway device comprising a second ISM transceiver for receiving the utility usage data from the end point and a wireless transceiver which is configured to send the utility usage data via an Institute of Electrical and Electronics Engineers (IEEE) 802.11 compliant wireless communication link. The network further comprises a utility office which receives the utility usage data from said gateway device via said IEEE 802.11 compliant wireless communication link.

**22 Claims, 6 Drawing Sheets**



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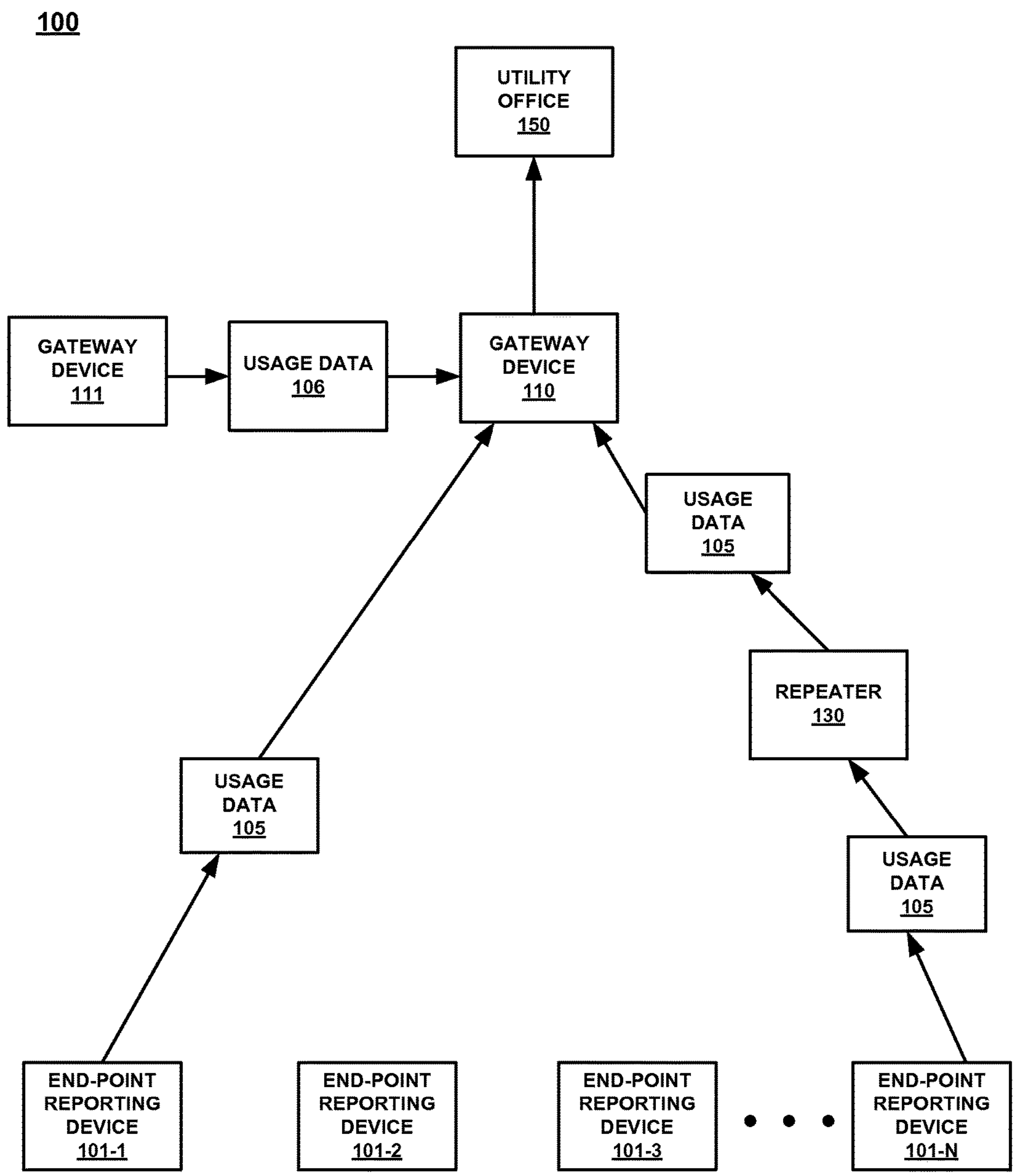
100
UTILITY OFFICE 150
GATEWAY DEVICE 111
USAGE DATA 106
GATEWAY DEVICE 110
USAGE DATA 105
REPEATER 130
USAGE DATA 105
USAGE DATA 105
END-POINT REPORTING DEVICE 101-1
END-POINT REPORTING DEVICE 101-2
END-POINT REPORTING DEVICE 101-3
END-POINT REPORTING DEVICE 101-N

FIG. 1

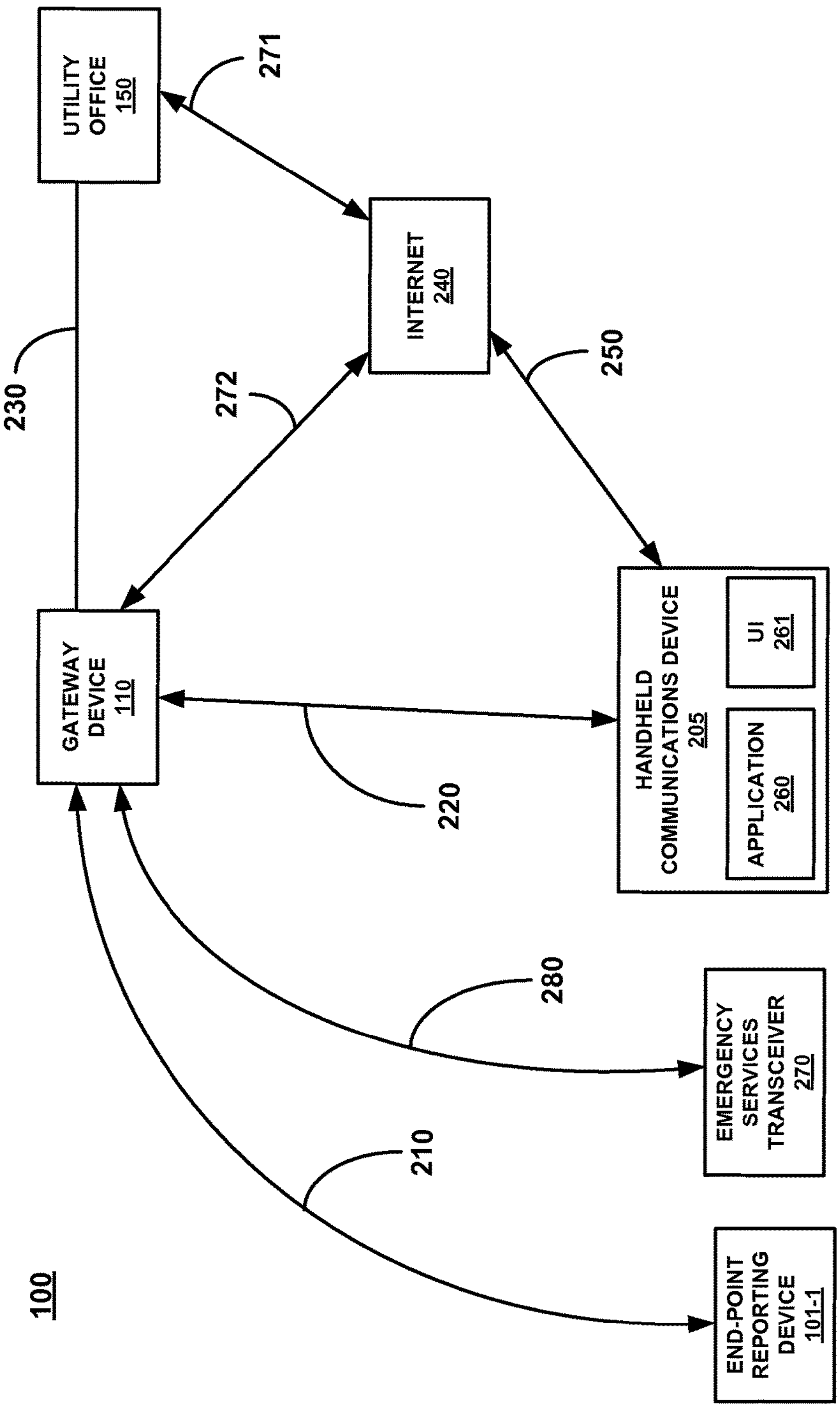
100
UTILITY OFFICE 150
INTERNET 240
GATEWAY DEVICE 110
HANDHELD COMMUNICATIONS DEVICE 205
UI 261
APPLICATION 260
EMERGENCY SERVICES TRANSCEIVER 270
END-POINT REPORTING DEVICE 101-1
230
271
272
250
220
280
210

FIG. 2

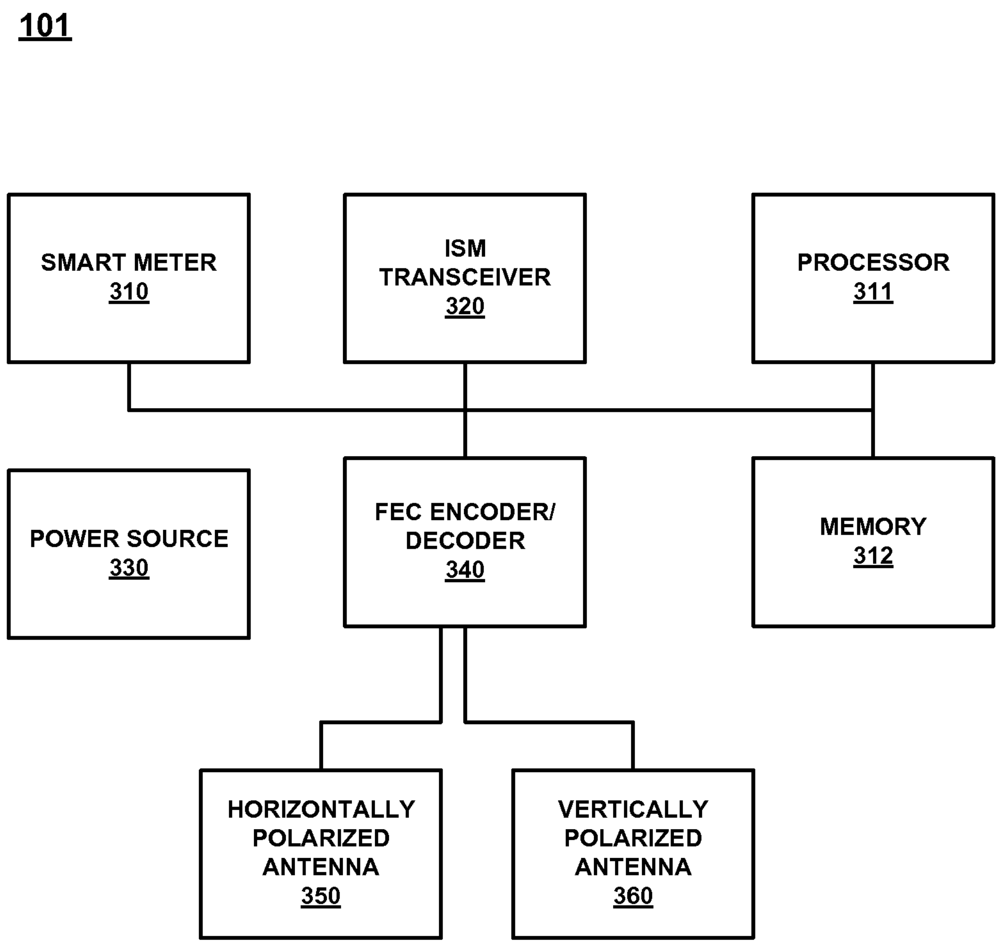
101
SMART METER
310
ISM
TRANSCEIVER
320
PROCESSOR
311
POWER SOURCE
330
FEC ENCODER/
DECODER
340
MEMORY
312
HORIZONTALLY
POLARIZED
ANTENNA
350
VERTICALLY
POLARIZED
ANTENNA
360

FIG. 3

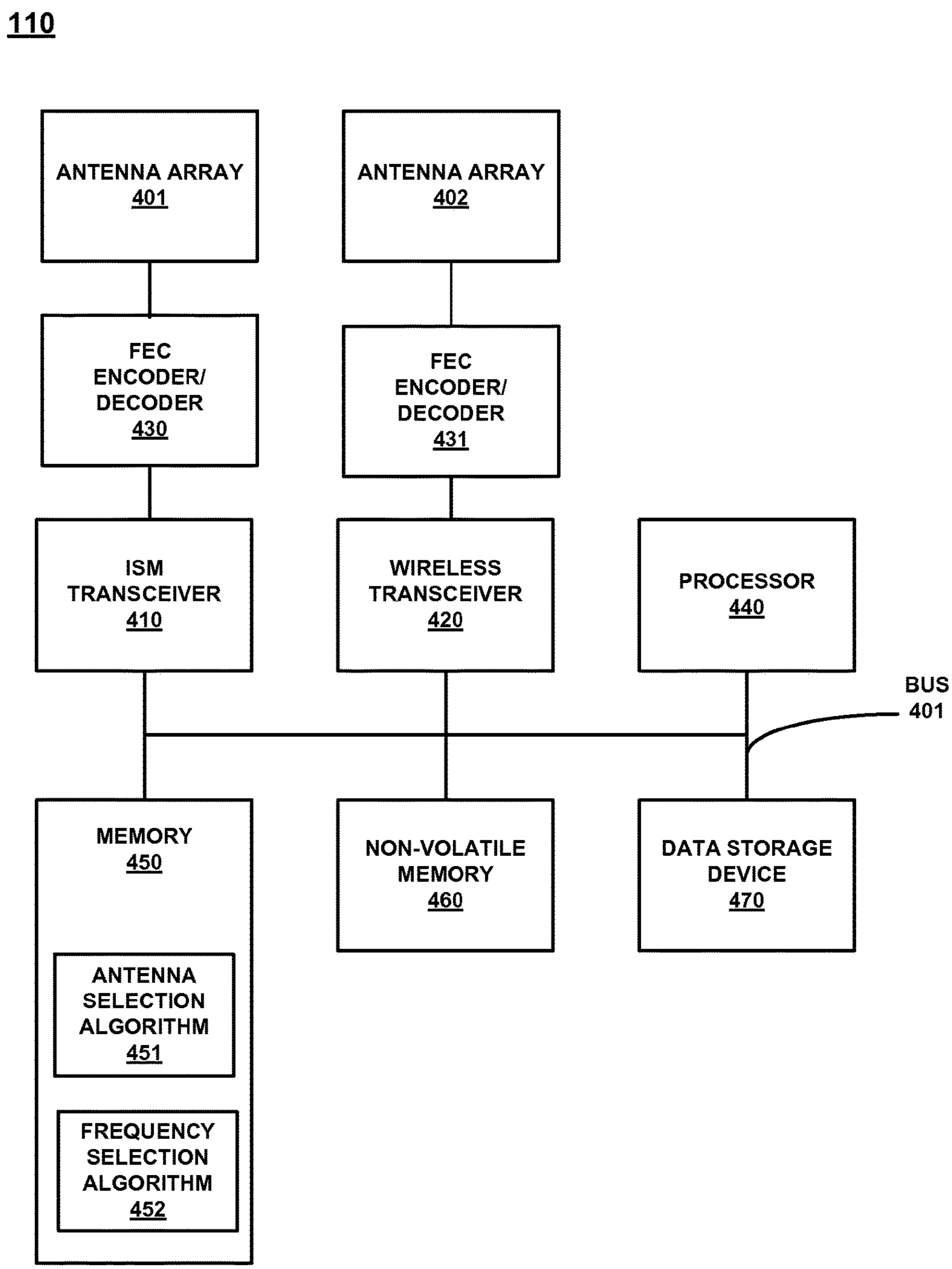
110
ANTENNA ARRAY 401
ANTENNA ARRAY 402
FEC ENCODER/ DECODER 430
FEC ENCODER/ DECODER 431
ISM TRANSCEIVER 410
WIRELESS TRANSCEIVER 420
PROCESSOR 440
BUS 401
MEMORY 450
ANTENNA SELECTION ALGORITHM 451
FREQUENCY SELECTION ALGORITHM 452
NON-VOLATILE MEMORY 460
DATA STORAGE DEVICE 470

FIG. 4

500

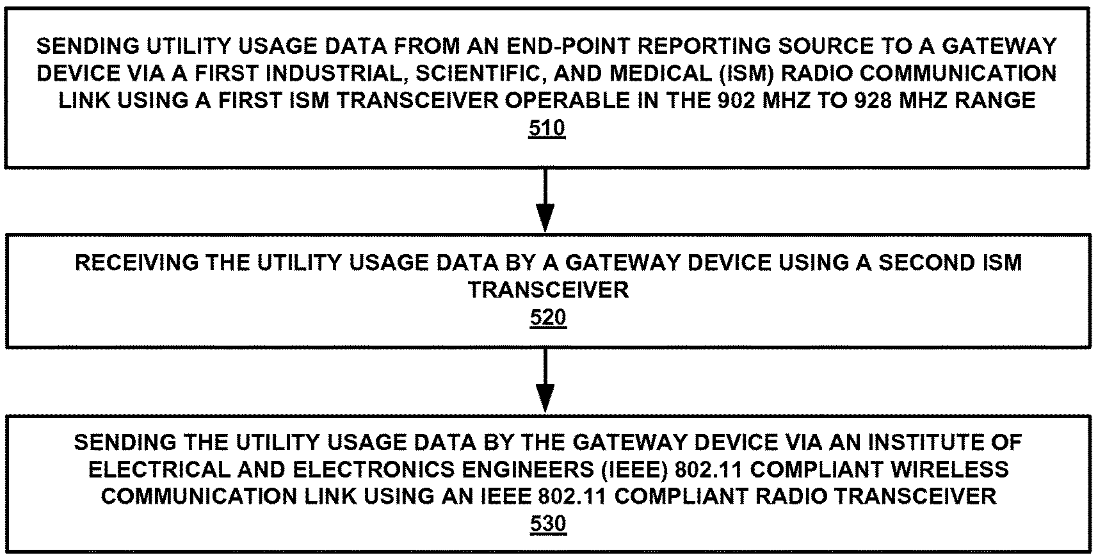
SENDING UTILITY USAGE DATA FROM AN END-POINT REPORTING SOURCE TO A GATEWAY DEVICE VIA A FIRST INDUSTRIAL, SCIENTIFIC, AND MEDICAL (ISM) RADIO COMMUNICATION LINK USING A FIRST ISM TRANSCEIVER OPERABLE IN THE 902 MHZ TO 928 MHZ RANGE
510
RECEIVING THE UTILITY USAGE DATA BY A GATEWAY DEVICE USING A SECOND ISM TRANSCEIVER
520
SENDING THE UTILITY USAGE DATA BY THE GATEWAY DEVICE VIA AN INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE) 802.11 COMPLIANT WIRELESS COMMUNICATION LINK USING AN IEEE 802.11 COMPLIANT RADIO TRANSCEIVER
530

FIG. 5

600

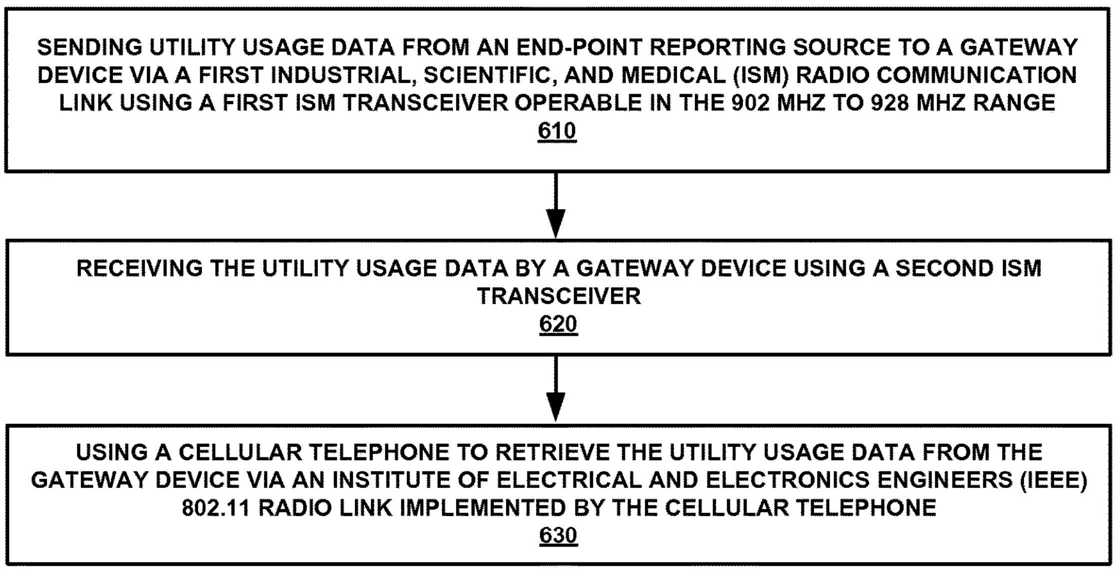
SENDING UTILITY USAGE DATA FROM AN END-POINT REPORTING SOURCE TO A GATEWAY DEVICE VIA A FIRST INDUSTRIAL, SCIENTIFIC, AND MEDICAL (ISM) RADIO COMMUNICATION LINK USING A FIRST ISM TRANSCEIVER OPERABLE IN THE 902 MHZ TO 928 MHZ RANGE
610
RECEIVING THE UTILITY USAGE DATA BY A GATEWAY DEVICE USING A SECOND ISM TRANSCEIVER
620
USING A CELLULAR TELEPHONE TO RETRIEVE THE UTILITY USAGE DATA FROM THE GATEWAY DEVICE VIA AN INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE) 802.11 RADIO LINK IMPLEMENTED BY THE CELLULAR TELEPHONE
630

FIG. 6

# UTILITY METER REPORTING NETWORK

## BACKGROUND

In many areas, utility companies use wireless technology to facilitate automatic collection of utility use data. For example, a wireless transceiver and antenna can be coupled with a meter and the utility use data can be read using a handheld device which directly contacts the wireless transceiver coupled with the meter. As a result, the collection of billing data can be performed more quickly and reliably than when a person had to manually access the meter and record the utility use data. Alternatively, the wireless transceiver can periodically send the utility use data to, for example, a pole-mounted (e.g., a utility pole or the like) radio transceiver. The pole-mounted transceiver then sends the utility use data to a utility office using a cellular telephone connection.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of this application, illustrate embodiments of the subject matter, and together with the description of embodiments, serve to explain the principles of the embodiments of the subject matter. Unless noted, the drawings referred to in this brief description of drawings should be understood as not being drawn to scale.

FIG. **1** is a diagram of a utility meter reporting network in accordance with one embodiment.

FIG. **2** shows communication links used in a utility meter reporting network in accordance with an embodiment.

FIG. **3** is a block diagram of an end-point reporting device in accordance with an embodiment.

FIG. **4** is a block diagram of a gateway device in accordance with an embodiment.

FIG. **5** is a flowchart of a method for collecting utility usage data in accordance with an embodiment.

FIG. **6** is a flowchart of a method for collecting utility usage data in accordance with an embodiment.

## DESCRIPTION OF EMBODIMENTS

Reference will now be made in detail to various embodiments, examples of which are illustrated in the accompanying drawings. While the subject matter will be described in conjunction with these embodiments, it will be understood that they are not intended to limit the subject matter to these embodiments. On the contrary, the subject matter described herein is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope as defined by the appended claims. In some embodiments, all or portions of the electronic computing devices, units, and components described herein are implemented in hardware, a combination of hardware and firmware, a combination of hardware and computer-executable instructions, or the like. Furthermore, in the following description, numerous specific details are set forth in order to provide a thorough understanding of the subject matter. However, some embodiments may be practiced without these specific details. In other instances, well-known methods, procedures, objects, and circuits have not been described in detail as not to unnecessarily obscure aspects of the subject matter.

FIG. **1** is a diagram of a utility meter reporting network **100** in accordance with one embodiment. In FIG. **1**, utility meter reporting network **100** comprises a plurality of end-point reporting devices (e.g., **101-1**, **101-2**, **101-3** . . . **101**-N) which are communicatively coupled with a gateway device **110**. As will be described in greater detail below, end-point reporting devices **101-1** to **101**N are configured to collect utility usage data **105** and to send that data to gateway device **110** using a wireless communication link. As an example, end-point reporting devices **101-1** to **101**N can be configured to collect and report utility usage data **105** in conjunction with a water meter, a natural gas meter, or an electric meter. It is noted that embodiments are not limited to reporting data from a utility meter alone. However, the present discussion will be directed to utility usage reporting for the purpose of clarity.



As will be discussed in greater detail below, in one embodiment, end-point reporting devices **101-1** to **101**N convey utility usage data **105** wirelessly to gateway device **110** using an Industrial, Scientific, and Medical (ISM) radio transceiver (e.g., ISM transceiver **320** of FIG. **3**) which operates in the 902-928 MHz frequency range. In accordance with various embodiments, end-point reporting devices **101-1** to **101**N can report utility usage data **105** to gateway device **110** at pre-determined time intervals, continuously, or in response to a message generated by gateway device **110**.

In FIG. **1**, a repeater **130** is shown. Repeater **130** is used in instances when a signal from end-point reporting devices **101-1** to **101**N is blocked with reference to gateway device **110**. For example, end-point reporting device **101**-N may be disposed behind a wall, or other obstacle, which degrades the reception of signals received at gateway device **110**. Repeater **130** can be placed at a location which has better signal reception from end-point reporting device **101**-N. Repeater **130** receives utility usage data **105** sent by end-point reporting device **101**-N and forwards that data wirelessly to gateway device **110**. In accordance with one embodiment, repeater **130** comprises an ISM transceiver (not shown) and generates a message using the ISM transceiver conveying the utility usage data **105** to gateway device **110**. However, it is noted that the message conveying utility usage data **105** to gateway device **110** can use a separate radio transceiver operable at a different radio frequency than the ISM radio band. For example, in one embodiment repeater **130** comprises a second transceiver which operates an implementation of the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standards for Wi-Fi networks.

In accordance with various embodiments, gateway device **110** is configured to receive and store utility usage data **105** from end-point reporting devices **101-1** to **101**N and to forward that data to utility office **150**. In accordance with various embodiments, gateway device **110** comprises an ISM transceiver (e.g., **410** of FIG. **4**) for receiving utility usage data **105** from end-point reporting devices **101-1** to **101**N and/or repeater **130**. Gateway device further comprises a wireless transceiver (e.g., **420**) for conveying the utility usage data **105** to utility office **150**, or to other devices which are authorized to communicate with gateway device **110**. It is noted that gateway device **110** is not limited to wireless communications alone when communicating with utility office **150**. For example, gateway device **110** can also be configured with a wired communication interface (not shown) such as an Ethernet cable, fiber-optics cable, or the like to convey the utility usage data **105** to utility office **150** via a wired communication link. Additionally, gateway device **110** can utilize a cellular communications device (not shown) to convey the utility usage data **105** to utility office **150** via a cellular communications network. As discussed above, gateway device **110** can receive utility usage data **105** from end-point reporting devices **101-1** to **101**N at pre-determined time intervals. These intervals can be hourly, daily, weekly, etc. Alternatively, the time interval can change throughout a given time period. For example, during peak usage hours, a customer, or utility office **150**, may desire a more detailed representation of utility usage. Thus, during peak usage hours, the reporting interval for sending utility usage data **105** can be 1 minute, while the non-peak hours reporting interval can be every 10 minutes. In one embodiment, gateway device **110** can generate a message to end-point reporting devices **101-1** to **101**N to increase or decrease the time interval for sending utility usage data **105**. For example, if it is suspected that there is a water-main break, a command can be forwarded via gateway device **110** to provide continuous reporting of utility usage data **105** to gateway device **110**. As will be discussed in greater detail below, this facilitates determining if unusually high rates of utility usage are occurring, or if there is a problem with end-point reporting device **101** itself.

In accordance with an embodiment, gateway device **110** can also receive utility usage data (e.g., **106** of FIG. **1**) from a second gateway device (e.g., **111** of FIG. **1**) which is communicatively coupled with a respective end-point reporting device(s) (not shown) in a separate network. In other words, second gateway device **111** can receive utility usage data **106** from one or more end-point reporting devices of a respective reporting network using, for example, an ISM radio transceiver **410** of FIG. **4**. Then, second gateway device **111** can forward utility usage data **106** to gateway device **110** using, for example, a wireless transceiver **420** of FIG. **4**. Gateway device **110** is configured to store utility usage data **106** (e.g., in volatile memory **450**, or data storage device **470**) and to forward utility usage data **106** to utility office **150**. The forwarding of utility usage data **105** and **106** can be according to a pre-determined time schedule, in response to a message from utility office **150**, or when communications are established, or re-established, with utility office **150**. In accordance with one embodiment, utility usage data **105** and **106** will be retained (e.g., in volatile memory **450**, or data storage device **470**) of gateway device **110** and/or second gateway device **111** until utility office **150** generates a message confirming the reception of utility usage data **105** and/or **106**. In one embodiment, utility usage data **105** and/or **106** can be erased from storage upon gateway device **110** in response to a confirmation message from utility office **150** indicating that utility usage data **105** and/or **106** have been received. In another embodiment, utility usage data **106** is erased from storage upon gateway device **110** in response to a confirmation message from utility office **150** indicating that utility usage data **106** has been received. However, utility usage data **105** will still be stored by gateway device **110** for a pre-determined time period (e.g., 30 days, 60 days, etc.) for each end-point reporting device **101-1** to **101**N with which it is communicatively coupled. In one embodiment, gateway device **110** is configured to generate a message to second gateway device **111** indicating that utility usage data **106** has been received by utility office **150**. In response, second gateway device **111** can delete utility usage data **106** from memory, or store utility usage data **106** as described above with reference to gateway device **110**.

FIG. **2** shows communication links used in a utility meter reporting network **100** in accordance with an embodiment. In FIG. **2**, end-point reporting device **101-1** is communicatively coupled with gateway device **110** via an ISM radio link **210**. The ISM radio frequency bands (e.g., 902 MHz-928 MHz) are increasingly used for short-range radio communications. In a typical utility reporting scenario, a user or vehicle is equipped with a dedicated meter-reading device which uses an ISM transceiver to receive utility usage data from a meter equipped with a, ISM transceiver. However, many companies do not want to spend the extra money to equip devices, such as data collectors or the like, with ISM circuitry, especially in devices which may have shipped with integrated Wi-Fi capabilities. For example, many companies, including utility companies, provide their field technicians with cellular telephones having integrated Wi-Fi and GNSS position determination capabilities. Thus, by implementing utility reporting network **100**, a company can take advantage of existing equipment being issued to field technicians without the added cost of providing ISM communication capabilities as well. However, the user of handheld communication device **205** does not preclude a user equipped with an ISM transceiver from communicating directly with end-point reporting device **101**.

In accordance with various embodiments, users of utility meter reporting network **100** can use a handheld communications device (e.g., **205** of FIG. **2**) to receive utility usage data **105**. In one embodiment, handheld communications device **205** is a cellular telephone. Currently, many cellular telephones come equipped with Wi-Fi circuitry embedded. Thus, there is no extra cost associated with adding ISM circuitry to handheld communications device **205**. It is noted that while the present discussion will specifically cite cellular telephones, that there are a wide variety of handheld devices such as laptop computers, tablet computers, personal digital assistants (PDAs), and handheld data collectors which are also equipped with Wi-Fi capability and which can be used as handheld communications device **205**. In one embodiment, handheld communications device **205** can establish communications with gateway device **110** via a Wi-Fi communication link **220** to retrieve utility usage data **105** from gateway device **110**. Thus, instead of directly communicating with end-point reporting device **101**, handheld communications device **205** receives utility usage data **105** from gateway device **110**. It is noted that gateway device **110** can send utility usage data **105** to utility office **150** via a Wi-Fi communications link **230**, via a cellular telephone link (not shown), or via a wired data connection (not shown) as well.

In accordance with various embodiments, handheld communication device **205** can establish communications with gateway device **110** via the Internet **240** using communication link **250**. For example, a cellular telephone can connect with the Internet **240** using either mobile broadband services, or Wi-Fi communication links. In accordance with various embodiments, communications link **250** is a Wi-Fi link to a Wi-Fi hotspot which allows handheld communications device **205** to connect with Internet **240**. In one embodiment, handheld communications device **205** connects with utility office **150** via Internet **240** and communications link **271**. Then, via utility office **150**, handheld communications device **205** is communicatively coupled with gateway device **110** via communications link **230**. It is noted that Service Set Identification (SSID) security measures can be implemented such as a user identification and password to permit accessing gateway device **110** using handheld communications device **205**. A user can log-in to a webpage, or into gateway device **110** directly using handheld communications device **205** to access data stored thereon, or to interact with end-point reporting device **101**. For example, a user of handheld communications device **205** can retrieve utility usage data **105** from gateway device **110** rather than directly from end-point reporting device **101** via communications link **220**. In one embodiment, when handheld communications device **205** retrieves utility usage data **105** from gateway device **110**, utility usage data **105** can be deleted or over-written. In another embodiment, handheld communications device **205** connects with Internet **240** via communications link **250** and in turn connected with gateway device **110** via communications link **272**.

In one embodiment, a custom user interface **261** can be downloaded onto handheld communications device **205** to facilitate interacting with gateway device **110**. In another embodiment, a custom application **260** can be downloaded onto handheld communications device **205** to configure it as a utility usage data collection device. In one embodiment, the geographic position of handheld communications device **205** can assist in determining which gateway device (e.g., **110**, or **111** of FIG. **1**) is to be contacted. For example, using GNSS circuitry embedded in handheld communications device **205**, its geographic location can be determined. In one embodiment, handheld communications device **205** can use this information to determine which gateway device **110** is closest in order to retrieve the utility usage data **105** of each end-point reporting device which reports to gateway device **110**. In one embodiment, a look-up table can be accessed to correlate the current geographic position of handheld communications device **205** with the nearest gateway device **110**. The operator of handheld communications device **205** can then select which gateway device (e.g., **110** of FIG. **1**) to establish communications with, or alternatively, gateway device **110** can be automatically selected based upon its proximity to the current position of handheld communications device **205**.

As discussed above, gateway device **110** is communicatively coupled with utility office **150** via a Wi-Fi communication link **230** (e.g., in the 2.4 GHz and/or 5 GHz frequency band). In one embodiment, Wi-Fi communication link **230**, as well as wireless communication links with other gateway devices such as second gateway device **111**, is compliant with the IEEE 802.11 protocols such as the 802.11.g protocol, or the 802.11.n protocol. By implementing a Wi-Fi network within utility reporting network **100**, gateway devices (e.g., **110** and **111** of FIG. **1**) can be meshed into a network with store and forward capabilities. In one embodiment, utility reporting network **100** can also be utilized to provide bandwidth to other services. For example, unused bandwidth in utility reporting network **100** can be sold to Internet providers in areas where wireless Internet service is not provided. Additionally, excess bandwidth of utility reporting network **100** can be reserved for emergency services such as police, fire, or ambulances to provide Internet connectivity in remote areas where radio or cellular coverage is not possible. In one embodiment, part of the radio spectrum used by wireless transceiver **420** is reserved for use by emergency responders. In FIG. **2**, an emergency services transceiver **270** is communicatively coupled with gateway device **110** via Wi-Fi communications link **280**. In accordance with various embodiments, emergency services transceiver **270** comprises a vehicle-mounted or handheld device (e.g., a cellular telephone, tablet computer, laptop computer, etc.) used by emergency services personnel such as police, firefighters, ambulance, or hazmat crews. In so doing, emergency service personnel can communicate via utility meter reporting network **100**. This is advantageous in areas in which dedicated cellular or Wi-Fi network coverage is irregular or non-existent. Thus, rather than having to install dedicated communication networks, emergency responders can share the bandwidth of utility meter reporting network **100** and perhaps underwrite some of the costs for installing and maintaining the network.

FIG. **3** is a block diagram of an end-point reporting device **101** in accordance with an embodiment. In the embodiment of FIG. **3**, end-point reporting device **101** comprises a smart meter **310** which comprises a processor **311** for processing information and instructions and a memory **312** for storing information and instructions for processor **311**. End-point reporting device **101** further comprises an ISM transceiver **320** which operates in the 900 MHz ISM band using the 902-928 MHz frequency range. In FIG. **3**, ISM transceiver **320** is coupled with a horizontally polarized antenna **350** and a vertically polarized antenna **360**. In accordance with various embodiments, horizontally polarized antenna **350** and vertically polarized antenna **360** can be disposed in separate enclosures, or in the same enclosure. One example of a vertically polarized antenna used in accordance with at least one embodiment is described in U.S. patent application Ser. No. 13/691,358 filed Nov. 30, 2012, titled Ruggedized Electronic Enclosure for In-ground Installation, by John F. Cameron, Larry Collins, and Daniel Shane Fitzgibbons, which is assigned to the assignee of the present application which is incorporated by reference in its entirety herein. In FIG. **3**, end-point reporting device **101** further comprises power source (e.g., a battery) **330** and a Forward Error Correction (FEC) encoder/decoder **340**. Forward error correction is a technique which is known in the communication arts which implements error control in communications by sending redundant data in a message. The receiver can detect errors in the original message and, in some cases, correct the error without the necessity of re-sending the original data. In accordance with various embodiments, forward error correction can increase the range of transmissions by end-point reporting device **101** by a factor of 4.

In accordance with various embodiments, ISM transceiver **320** can implement a variety of signal modulation techniques including, but not limited to, Gaussian minimum shift keying (GMSK), phase-shift keying (PSK), and 4-level frequency shift keying (4-level FSK). It is noted that, depending upon the signal modulation technique used, a particular method of performing forward error correction (FEC) may be implemented. In one embodiment, the data rate from end-point reporting device **101** is intentionally slowed to generate more energy per bit transmitted. For example, the transmission range for a message generated at a 25 kilobits/second data rate is not as great as the transmission range for a message generated at a 10 kilobits/second data rate. Thus, by intentionally selecting a lower data rate, the transmission range of end-point reporting device **101** can be extended. In accordance with various embodiments data encryption is used to protect the data from unauthorized access. Data encryption algorithms used in accordance with various embodiments include, but are not limited to, the advanced encryption standard (AES) for data encryption.

FIG. **4** is a block diagram of a gateway device **110** in accordance with an embodiment. In FIG. **4**, gateway device **110** comprises a processor **440**, a memory **450**, a non-volatile memory **460**, and a data storage device **470**. In accordance with various embodiments, processor **440** is for processing information and instructions. In one embodiment, memory **450** comprises random access memory (RAM) for storing information and instructions for processor **440**. In one embodiment, non-volatile memory **460** comprises read only memory (ROM) for storing static information and instructions for processor **440**. In various embodiments, data storage device **470** (e.g., a magnetic or optical disk and disk drive) is for long-term storage of data such as utility usage data **105** as well as for storing information and instructions. In one embodiment, data storage device **470** stores utility usage data **105** for each end-point reporting device (e.g., **101-1** to **101**N) in a local network. In accordance with various embodiments, data storage device **470** stores utility usage data **105** for each end-point reporting device for a pre-determined period such as one month, two months, etc. In one embodiment, data storage device **470** can over-write older utility usage data per end-point reporting device. Also, in response to a command from processor **440**, data storage device **470** can erase utility usage data **105** for a given end-point reporting device **101**, or for all end-point reporting devices **101**, such as when utility usage data **105** has been successfully received at utility office **150**.

In FIG. **4**, gateway device **110** further comprises an ISM transceiver **410** and a wireless transceiver **420**. ISM transceiver **410** is configured for communicating with end-point reporting devices in the 900 MHz ISM frequency range (e.g., 902 MHz-928 MHz). It is noted that ISM transceiver **410** can also communicate with other ISM-equipped devices such as a dedicated utility usage data collector (not shown). Wireless transceiver **420** is configured for communicating in Wi-Fi networks in the 2.4 GHz and/or 5 GHz frequency ranges. In the embodiment of FIG. **4**, ISM transceiver **410** is coupled with antenna array **401** via a FEC encoder/decoder **430**. As described above, forward error correction is a well known error correction technique used in communications which can also extend the range of transmissions. In accordance with various embodiments, FEC encoder/decoder **430** is used in conjunction with ISM transceiver **410** to extend the range of transmissions to and from end-point reporting devices **101-1** to **101**N. Similarly, wireless transceiver **420** is coupled with antenna array **402** via FEC encoder/decoder **431**. FEC encoder/decoder **431** is used in conjunction with wireless transceiver **420** to implement forward error correction with, for example, utility office **150**, Internet **240**, handheld communications device **205**, and emergency services transceiver **270**. It is noted that there is no requirement that ISM transceiver **410** and/or wireless transceiver **420** routes messages through FEC encoder/decoders **430** and **431** respectively in accordance with various embodiments. In accordance with various embodiments, wireless transceiver **420** can implement a variety of signal modulation techniques including, but not limited to, Gaussian minimum shift keying (GMSK), phase-shift keying (PSK), and 4-level frequency shift keying (4-level FSK). It is noted that, depending upon the signal modulation technique used, a particular method of performing forward error correction may be implemented.

As described above, FEC encoder/decoder **430** is communicatively coupled with antenna array **401**. In accordance with various embodiments, antenna array **401** is matched with ISM transceiver **410** to match the range limits afforded by a 1 watt Effective Isotropic Radiated Power (EIRP). Similarly, antenna array **402** is matched with wireless transceiver **420** to match the range limits afforded by a 1 watt EIRP as well. In accordance with at least one embodiment, antenna array **401** and antenna array **402** comprise one of a circularly polarized antenna, a vectored antenna array, or another gained antenna to realize greater transmission ranges. For example, it is likely that gateway device **110** will be mounted to a structure (e.g., a building, power/telephone pole, etc.) well above ground level (e.g., 20-30 feet). Therefore, it is not likely that gateway device **110** will be receiving signals from end-point reporting devices **101**, or other gateway devices (e.g., **111** of FIG. **1**) that originate above the height at which gateway device **110** is disposed, or from the horizon down to the ground. Therefore various embodiments select antenna gain to focus energy to and from known points where signals are sent or received. For example, in one embodiment, antenna array **401** can be a circularly polarized antenna which is aimed downwards to receive signals in the area. In another embodiment, antenna array **401** comprises a vectored antenna array which divides the coverage area of gateway device **110** into multiple vectors of coverage. As an example, antenna array **401** can comprise 3 antenna banks which each cover an arc of 120 degrees and which are selectively energized to increase antenna gain. Again, as gateway device **110** is operating within the constraints of 1 watt of EIRP transmission power, antenna gain is implemented to extend the range of radio transmissions in utility meter reporting network **100**. This can be further aided with the knowledge of exactly where end-point reporting devices **101**, repeaters **130**, and other gateway devices (e.g., **111** of FIG. **1**) are located. In addition, if gateway device **110** implements a schedule in which the time transmissions to/from a particular device (e.g., an end-point reporting device **101**, repeater **130**, gateway device **111**, or utility office **150**) will be transmitting, gateway device **110** can selectively energize one of the antenna banks to increase antenna gain in a particular direction. It is noted that while specific radio frequencies have been discussed above, various embodiments can utilize other radio frequencies as well. For example, the Federal Communications Commission is proposing wider availability to unused portions of the radio spectrum (e.g., referred to as "white space") to provide greater availability for wireless devices. This includes licensed commercial frequencies and ISM frequencies. Thus, in various embodiments ISM transceiver **410** and/or wireless transceiver **420** can be configured to search for frequencies (e.g., using frequency selection algorithm **452**) which are outside of the frequencies cited above in compliance with emerging FCC regulations.

In accordance with one embodiment, gateway device **110** implements an antenna selection algorithm **451** resident in memory **450**. In one embodiment, gateway device **110** can initiate a process with a given end-point reporting device **101** to determine which of horizontally polarized antenna **350** and vertically polarized antenna **360** provides the best signal quality at a particular time. Depending upon local conditions, signal degradation can come from various interference sources which may be moving through the area and are not persistent. In one embodiment, gateway device **110** can measure signal strength, signal-to-noise-ratio, or another metric indicative of signal quality when end-point reporting source **101** transmits data using horizontally polarized antenna **350** and vertically polarized antenna **360** and determine which antenna provides better signal quality. Gateway device **110** will then generate a message to end-point reporting device **101** instructing it as to which antenna is to be used to transmit utility usage data **105**. It is noted that the selection of which of horizontally polarized antenna **350** and vertically polarized antenna **360** is to be used is a dynamic selection based upon current conditions and can change with each successive transmission of utility usage data **105**.

In accordance with one embodiment, gateway device implements a frequency selection algorithm **452** resident in memory **450**. It is noted that the implementation of frequency selection algorithm **452** can be performed independently, or in conjunction with antenna selection algorithm **451**. Furthermore, antenna selection algorithm **451** can be performed independently as well. In accordance with various embodiments, frequency selection algorithm **452** is used to determine which particular frequency provides the best signal quality at a particular time. As with antenna selection, the local conditions when a usage report are transmitted can change dynamically so that a particular frequency in the 902 MHz-928 MHz frequency range provides better signal quality than others. For example, in one embodiment, gateway device **110** can initiate a process with an end-point reporting device **101** in which end-point reporting device sends multiple messages on respective frequencies (e.g., 902 MHz, 904 MHz, 906 MHz, etc.) to determine which frequency in the 902 MHz-928 MHz frequency range provides the best signal quality. Again, gateway device **110** can measure signal strength, signal-to-noise-ratio, or another metric indicative of signal quality when end-point reporting source **101** transmits data using each particular frequency and determine which frequency provides the best signal quality. Gateway device **110** will then generate a message instructing end-point reporting device **101** to use that frequency when transmitting utility usage data **105**. In accordance with various embodiments, gateway device **110** can use a predetermined schedule in which the transmission times of utility usage data **105** from each end-point reporting device **101** are known to determine the best frequency and/or antenna selection to use when transmitting utility usage data **105** from a given end-point reporting device **101**

FIG. **5** is a flowchart of a method **500** for collecting utility usage data in accordance with an embodiment. In operation **510** of FIG. **5**, utility usage data **105** is sent from an end-point reporting device **101** to a gateway device **110** via first Industrial, Scientific, and Medical (ISM) radio communication link (e.g., **210** of FIG. **2**) using a first ISM transceiver operable in the 902 MHz to 928 MHz range (e.g., **320** of FIG. **3**).

In operation **520** of FIG. **5**, the utility usage data **105** is received by a gateway device **110** using a second ISM transceiver (e.g., **420** of FIG. **4**). As described above, in one embodiment repeater **130** can be used to convey the data from end-point reporting device **101** to gateway device **110**. Additionally, gateway device **110** is configured to implement a frequency selection algorithm **452** which permits gateway device **110** to select which channel within the 902 MHz to 928 MHz frequency range is to be used to convey utility usage data **105**. As described above, gateway device **110** can initiate a process in which end-point reporting device **101** sends a plurality of messages, each using a different channel or frequency within the 902 MHz to 928 MHz frequency range, to determine which channel provides the best signal quality. Gateway device **110** will then indicate to end-point reporting device **101** which channel is to be used when end-point reporting device **101** sends utility usage data **105**. Similarly, gateway device **110** is configured to implement antenna selection algorithm **451** which permits gateway device **110** to indicate to end-point reporting device **101** which of a horizontally polarized antenna **350** and a vertically polarized antenna **360** is to be used to convey utility usage data **105**. Again, gateway device **110** can initiate a process in which end-point reporting device **101** sends a first message using vertically polarized antenna **360** and a second message using horizontally polarized antenna **350** and determine which message has the best signal quality. Gateway device **110** will then send a message to end-point reporting device **101** which indicates whether to use horizontally polarized antenna **350** or vertically polarized antenna **360** when sending utility usage data **105**. It is again noted that gateway device **110** utilizes a controlled gain antenna (e.g., **401** of FIG. **4**) when communicating with end-point reporting device **101** and/or handheld communication device **205** and utility office **150**. It is noted that end-point reporting device **101** and gateway device **110** can implement forward error correction of ISM messages (e.g., ISM radio communication link **210** of FIG. **2**) using respective FEC encoder/decoders (e.g., **340** of FIGS. **3** and **430** of FIG. **4** respectively).

In operation **530** of FIG. **5**, the utility usage data **105** is sent by the gateway device **110** via a Institute of Electrical and Electronics Engineers (IEEE) 802.11 compliant wireless communication link (e.g., **220**, **230**, or **272** of FIG. **1**) using an IEEE 802.11 compliant radio transceiver (e.g., wireless transceiver **420** of FIG. **4**). As described above, in one embodiment, Wi-Fi communications link **230** comprises an IEEE 802.11.g compliant communications link. Alternatively, Wi-Fi communications link **230** comprises an IEEE 802.11.n compliant communications link in accordance with another embodiment. In at least one embodiment, gateway **110** can receive a second set of utility usage data **106** from a second gateway device **111**. In accordance with various embodiments, gateway device **110** can store and/or forward the second set of utility usage data **106** for second gateway device **111**. In accordance with various embodiments, gateway device **110** can forward utility usage data **106** (e.g., to utility office **150** via Wi-Fi communications link **230**, or to handheld communications device **205** via Wi-Fi communications links **220** or **272**) and send a message to second gateway device **111** indicating that utility usage data **106** has been received. Additionally, handheld communication device **205** can access gateway device **110** via the Internet using wireless communication link **250** which can be implemented using a Wi-Fi communication link, or broadband services via a cellular communication link.

FIG. **6** is a flowchart of a method **600** for collecting utility usage data in accordance with an embodiment. In operation **610** of FIG. **6**, utility usage data **105** is sent from an end-point reporting device **101** to a gateway device **110** via a first Industrial, Scientific, and Medical (ISM) radio communication link (e.g., **210** of FIG. **2**) using a first ISM transceiver (e.g., **320** of FIG. **3**) operable in the 902 MHz to 928 MHz range.

In operation **620** of FIG. **6**, the utility usage data **105** is received by the gateway device **110** using a second ISM transceiver (e.g., **420** of FIG. **4**). In accordance with various embodiments, gateway device **110** uses ISM transceiver **410** to communicate with end-point reporting device **101**.

In operation **630** of FIG. **6**, a cellular telephone (e.g., **205** of FIG. **2**) is used to retrieve the utility usage data **105** from the gateway device **110** via an Institute of Electrical and Electronics Engineers (IEEE) 802.11 radio link (e.g., **220**, or **250** of FIG. **2**) implemented by the cellular telephone **205**. In one embodiment, a cellular telephone (e.g., **205** of FIG. **2**) can communicate directly with gateway device **110** using a Wi-Fi communications link (e.g., **220** of FIG. **2**). It is noted that in one embodiment, communication links **250** and **272** of FIG. **2** are Wi-Fi links compliant with the IEEE 802.11.g specification or the IEEE 802.11.n specification. In accordance with one embodiment, a cellular telephone (e.g., **205** of FIG. **2**) can connect with the Internet **240** using either mobile broadband services, or Wi-Fi communication links. In accordance with various embodiments, a cellular telephone **205** can thus be used to collect utility usage data directly from gateway device **110** for one or more end-point reporting devices **101**. This can be beneficial in that a user does not have to visit the location of each end-point reporting device **101** to collect utility usage data for a region covered by gateway device **110**. Additionally, gateway device **110** can be accessed by an emergency services transceiver **270** via Wi-Fi communications link **280**. This can be used as a back-up source of communications for emergency responders, or to provide Internet and network communications in regions in which cellular or wireless Internet access is irregular or non-existent.

Embodiments of the present technology are thus described. While the present technology has been described in particular embodiments, it should be appreciated that the present technology should not be construed as limited to these embodiments alone, but rather construed according to the following claims.

What is claimed is:

**1**. A utility meter reporting network comprising:

an end-point reporting device configured to collect utility usage data and to convey said utility usage data to a gateway device via a first Industrial, Scientific, and Medical (ISM) radio communication link using an ISM transmitter operable in the 902 MHz to 928 MHz range, said end-point reporting device including a vertically polarized antenna and a horizontally polarized antenna;

said gateway device comprising an ISM receiver for receiving said utility usage data from said end-point reporting device, a storage for storing said utility usage data, and a wireless transceiver configured to send said utility usage data via an Institute of Electrical and Electronics Engineers (IEEE) 802.11 compliant wireless communication link, wherein said gateway device is configured to implement a frequency selection algorithm in conjunction with an antenna selection algorithm, wherein:

said frequency selection algorithm includes said end-point reporting device sending multiple messages at three different frequencies in the 902 MHz to 928 MHz range to said gateway device to determine which of the three different frequencies provides the highest signal-to-noise ratio as measured by said gateway device, and thereafter said gateway device generates a message instructing said end-point reporting device to use the frequency providing the highest signal-to-noise ratio when transmitting said utility usage data; and

said antenna selection algorithm includes said end-point reporting device sending a first message using said vertically polarized antenna and a second message using said horizontally polarized antenna to determine which antenna provides the highest signal-to-noise ratio as measured by said gateway device, and thereafter said gateway device generates a message instructing said end-point reporting device to use the antenna providing the highest signal-to-noise ratio when transmitting said utility usage data; and

a remote device configured to receive said utility usage data from said gateway device via said IEEE 802.11 compliant wireless communication link;

wherein said gateway device is configured to erase said utility usage data from said storage upon receipt of a confirmation of said utility usage data from said remote device;

wherein said gateway device receives said utility usage data from said end-point reporting device at a first rate when a utility malfunction is not suspected;

wherein said gateway device receives said utility usage data from said end-point reporting device at a second rate when said utility malfunction is suspected, said first rate being a periodic rate and said second rate being a continuous rate.

**2**. The utility meter reporting network of claim **1** further comprising:

a second gateway device configured to wirelessly receive a second set of utility usage data from a second end-point reporting device via a second ISM radio communication link and to convey said second set of utility usage data to said gateway device via said IEEE 802.11 compliant wireless communication link.

**3**. The utility meter reporting network of claim **1** further comprising:

a wireless repeater configured to receive said utility usage data from said end-point reporting device and to forward said utility usage data to said gateway device using a second ISM radio communication link.

**4**. The utility meter reporting network of claim **1** wherein said remote device is configured to access said gateway device via the Internet and to retrieve said utility usage data from said gateway device via the Internet.

**5**. The utility meter reporting network of claim **1** wherein said IEEE 802.11 compliant wireless communication link is compliant with the IEEE 802.11.g communication standard.

**6**. The utility meter reporting network of claim **1**, wherein said gateway creates a schedule by implementing said frequency selection algorithm and said antenna selection algorithm at various transmission times and tracking one or more transmission times providing the highest signal-to-noise ratios.

**7**. The utility meter reporting network of claim **1** wherein said gateway device is configured to control the gain of an antenna coupled with said ISM receiver when receiving a message from said end-point reporting device.

**8**. The utility meter reporting network of claim **1** wherein said remote device is configured to directly communicate with said gateway device via a second IEEE 802.11 compliant wireless communication link and retrieve said utility usage data from said gateway device.

**9**. The utility meter reporting network of claim **1** wherein said end-point reporting device further comprises a Forward Error Correction (FEC) encoder/decoder coupled with said ISM transmitter and wherein said gateway device further comprises a second FEC encoder/decoder coupled with said ISM receiver.

**10**. A method for collecting utility usage data, said method comprising:

sending utility usage data from an end-point reporting device to a gateway device via a first Industrial, Scientific, and Medical (ISM) radio communication link using an ISM transmitter operable in the 902 MHz to 928 MHz range, said end-point reporting device including a vertically polarized antenna and a horizontally polarized antenna;

receiving said utility usage data by said gateway device using an ISM receivers;

implementing a frequency selection algorithm in conjunction with an antenna selection algorithm, wherein:

said frequency selection algorithm includes said end-point reporting device sending multiple messages at three different frequencies in the 902 MHz to 928 MHz range to said gateway device to determine which of the three different frequencies provides the highest signal-to-noise ratio as measured by said gateway device, and thereafter said gateway device generates a message instructing said end-point reporting device to use that frequency when transmitting said utility usage data; and

said antenna selection algorithm includes said end-point reporting device sending a first message using said vertically polarized antenna and a second message using said horizontally polarized antenna to determine which antenna provides the highest signal-to-noise ratio as measured by said gateway device, and thereafter said gateway device generates a message instructing said end-point reporting device to use the antenna providing the highest signal-to-noise ratio when transmitting said utility usage data; and

sending said utility usage data by said gateway device to a remote device via an Institute of Electrical and Electronics Engineers (IEEE) 802.11 compliant wireless communication link using an IEEE 802.11 compliant radio transceiver;

wherein said gateway device comprises a storage for storing said utility usage data;

wherein said gateway device is configured to erase said utility usage data from said storage upon receipt of a confirmation of said utility usage data from said remote device;

wherein said gateway device receives said utility usage data from said end-point reporting device at a first rate when a utility malfunction is not suspected;

wherein said gateway device receives said utility usage data from said end-point reporting device at a second rate when said utility malfunction is suspected, said second rate being higher than said first rate.

**11**. The method of claim **10** further comprising:

implementing a wireless communication link which is compliant with the IEEE 802.11.g communication standard to send said utility usage data from said gateway device.

**12**. The method of claim **10** further comprising:

receiving at a second gateway device a second set of utility usage data from a second end-point reporting device via a second ISM radio communication link; and

conveying said second set of utility usage data to said gateway device via said IEEE 802.11 compliant wireless communication link.

**13**. The method of claim **10** further comprising:

receiving said utility usage data from said end-point reporting device at a wireless repeater; and

forwarding said utility usage data from said wireless repeater to said gateway device using a second ISM radio communication link.

**14**. The method of claim **10** further comprising:

creating a schedule by implementing said frequency selection algorithm and said antenna selection algorithm at various transmission times and tracking one or more transmission times providing the highest signal-to-noise ratios.

**15**. The method of claim **10** further comprising:

controlling the gain of an antenna coupled with said ISM receiver by said gateway device when receiving a message from said end-point reporting device.

**16**. The method of claim **10** further comprising:

communicating directly with said gateway device via a second IEEE 802.11 compliant wireless communication link using said remote device; and

receiving said utility usage data from said gateway device by remote device via said IEEE 802.11 compliant wireless communication link.

**17**. The method of claim **10** further comprising:

wirelessly accessing said gateway device via the Internet using said remote device; and

receiving said utility usage data from said gateway device via the Internet using said remote device.

**18**. The method of claim **10** further comprising:

implementing Forward Error Correction (FEC) using a first FEC encoder/decoder coupled with said ISM transmitter of said end-point reporting device and a second FEC encoder/decoder coupled with said ISM receiver of said gateway device.

**19**. The method of claim **10** further comprising:

accessing said gateway device using a second IEEE 802.11 compliant wireless communication link using an emergency services transceiver.

**20**. A method for collecting utility usage data, said method comprising:

sending utility usage data from an end-point reporting device to a gateway device via a first Industrial, Scientific, and Medical (ISM) radio communication link using an ISM transmitter operable in the 902 MHz to 928 MHz range, said end-point reporting device including a vertically polarized antenna and a horizontally polarized antenna;

receiving said utility usage data by said gateway device using an ISM receivers;

implementing a frequency selection algorithm in conjunction with an antenna selection algorithm, wherein:

said frequency selection algorithm includes said end-point reporting device sending multiple messages at three different frequencies in the 902 MHz to 928 MHz range to said gateway device to determine which of the three different frequencies provides the highest signal-to-noise ratio as measured by said gateway device, and thereafter said gateway device generates a message instructing said end-point reporting device to use that frequency when transmitting said utility usage data; and

said antenna selection algorithm includes said end-point reporting device sending a first message using said vertically polarized antenna and a second message using said horizontally polarized antenna to determine which antenna provides the highest signal-to-noise ratio as measured by said gateway device, and thereafter said gateway device generates a message instructing said end-point reporting device to use the antenna providing the highest signal-to-noise ratio when transmitting said utility usage data; and

using a remote device to receive said utility usage data from said gateway device via an Institute of Electrical and Electronics Engineers (IEEE) 802.11 radio link;

wherein said gateway device comprises a storage for storing said utility usage data;

wherein said gateway device is configured to erase said utility usage data from said storage upon receipt of a confirmation of said utility usage data from said remote device;

wherein said gateway device receives said utility usage data from said end-point reporting device at a first rate when a utility malfunction is not suspected;

wherein said gateway device receives said utility usage data from said end-point reporting device at a second rate when said utility malfunction is suspected, said second rate being higher than said first rate.

**21**. The method of claim **20** further comprising:

wirelessly accessing said gateway device via the Internet using said remote device; and

receiving said utility usage data from said gateway device via the Internet using said remote device.

**22**. The method of claim **20** further comprising: accessing said gateway device using a second IEEE 802.11 compliant wireless radio link implemented by an emergency services transceiver.

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