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(54) **CALCULATION OF AUXILIARY VALUE BASED ON METER DATA FROM NON-SMART ELECTRONIC UTILITY METER**
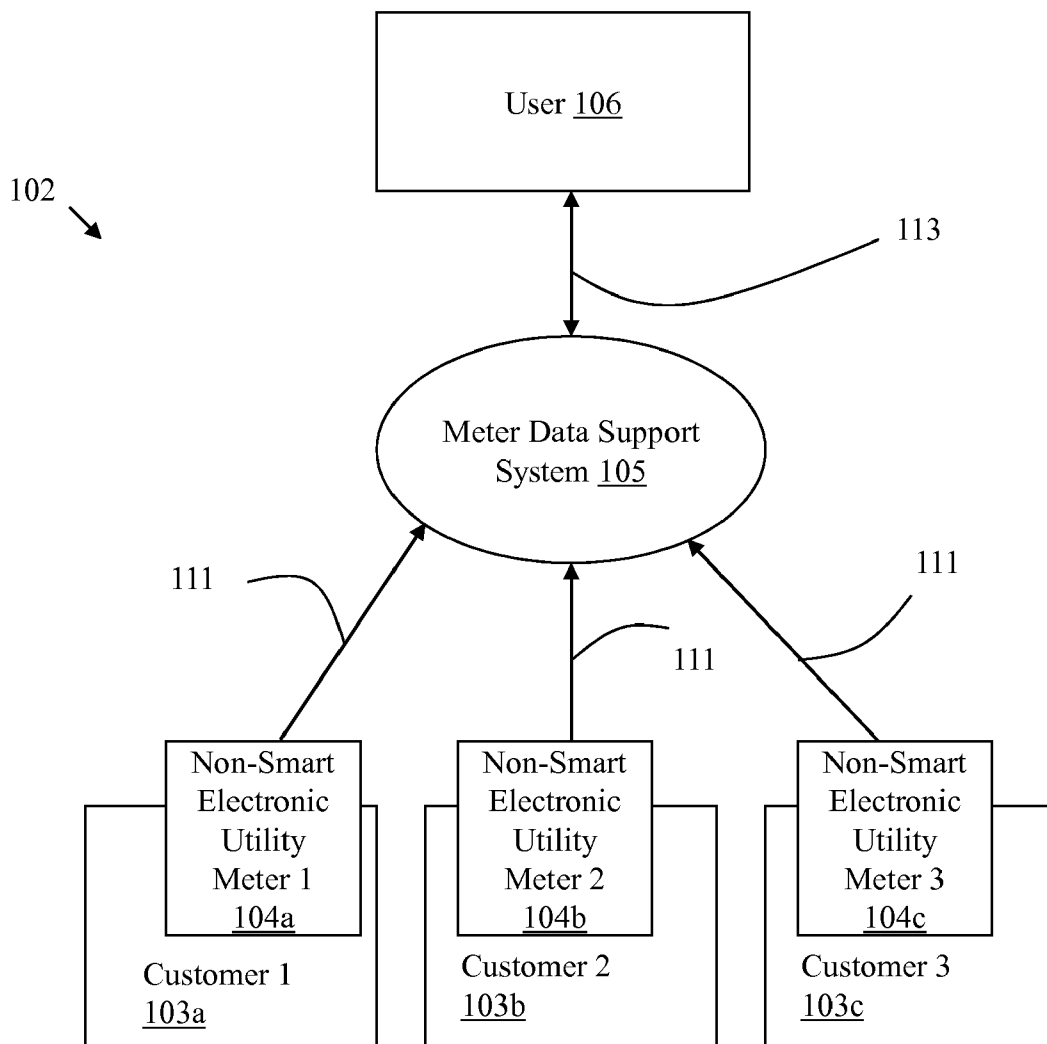
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(57) **ABSTRACT**

A system, including a meter data support system on a computer device configured to: receive raw meter data from a plurality of non-smart electronic utility meters that are each restricted to one way outbound communication, calculate an auxiliary value for each non-smart electronic utility meter using the raw meter data from each respective non-smart electronic utility meter, and provide access to the auxiliary value to at least one of a user and a customer.

102

User 106

113

Meter Data Support System 105

111

111

111

Non-Smart Electronic Utility Meter 3 104c

Customer 3 103c

Non-Smart Electronic Utility Meter 2 104b
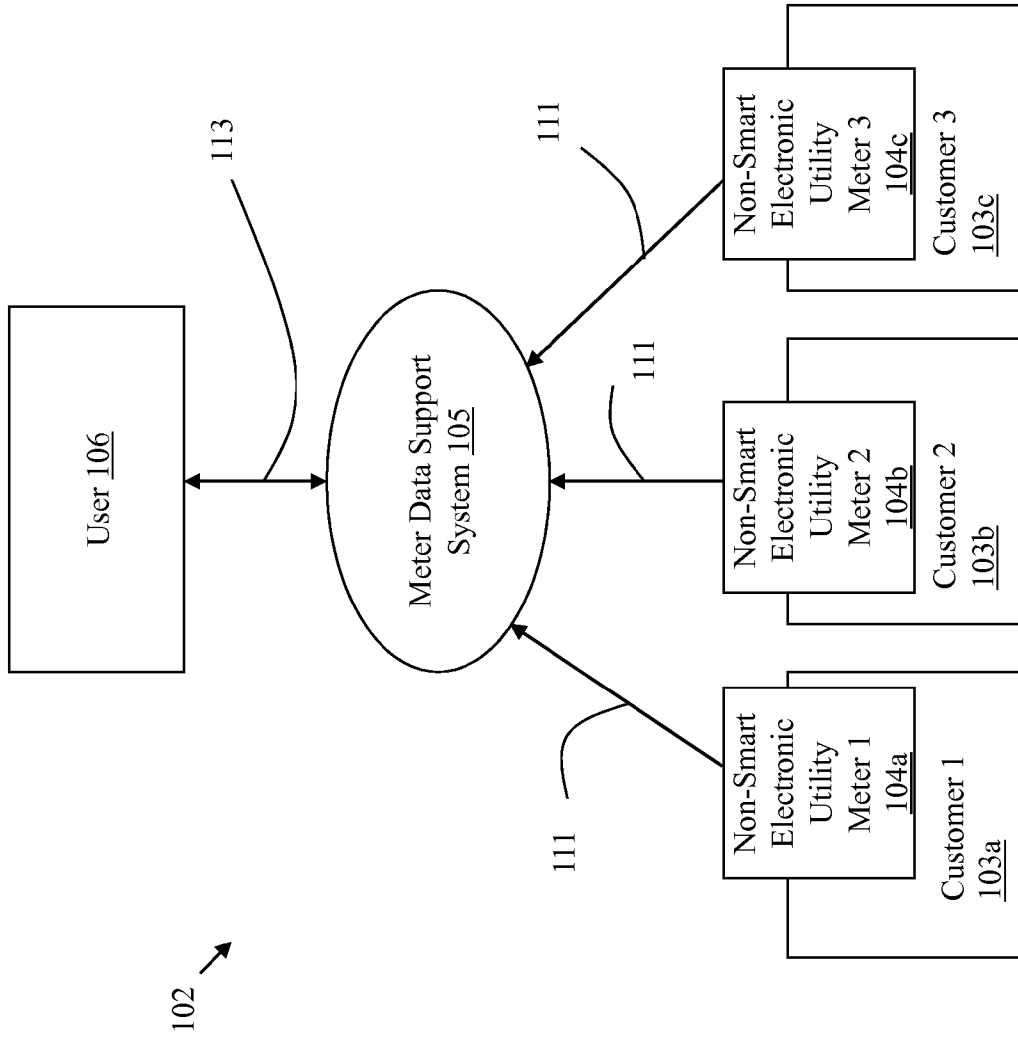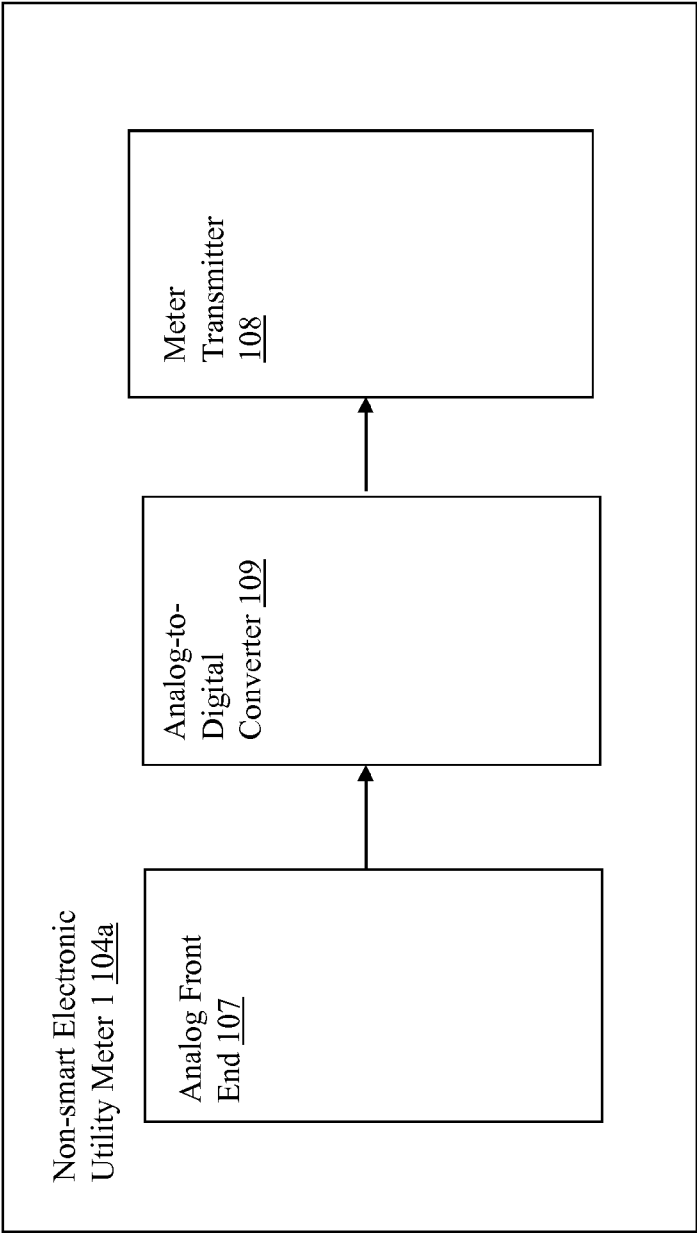
Customer 2 103b

Non-Smart Electronic Utility Meter 1 104a

Customer 1 103a

FIG. 1

FIG. 2

FIG. 3

FIG. 4

S1 receiving a first communication signal

S2 calculating auxiliary value from the raw meter data

S3 providing access to auxiliary value and/or raw meter data

S4 sending a second communication signal

FIG. 5

CALCULATION OF AUXILIARY VALUE BASED ON METER DATA FROM NON-SMART ELECTRONIC UTILITY METER

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to electronic utility meters and more particularly to calculation of an auxiliary value based on meter data from a non-smart electronic utility meter.

[0002] Residential and commercial customers may receive a utility from a utility distribution network. In an electrical distribution network, for example, residential and commercial customers may be connected via secondary phase distribution lines with a secondary step-down transformer, the secondary step-down transformer receiving power from primary phase distribution lines. An electronic utility meter meters the utility usage of the residential or commercial customer. Electrical distribution network may also include, for example, a generating station, a generator step-up transformer, high voltage transmission lines, and substation step-down transformers.

[0003] In recent years, electronic utility meters have become smart meters and may be equipped with three broad categories of components. First, an analog front end (AFE) for the purpose of metering utility usage. Second, a computer device that stores, processes, and calculates an auxiliary value based on the utility meter data at the meter. Third, equipment for two-way communication with a head end server within an advanced metering infrastructure (AMI) and/or with appliances within a home appliance network (HAN) of a customer. In order for the smart meter to do this, the electronic utility meter requires additional hardware such as processors, memory, integrated chips, printed circuit boards, and larger power supplies thereby increasing, for example, cost, power consumption, complexity, and weight of the electronic utility meter.

[0004] The AMI may include a head end server—a computer device that may include a software application that manages the timely collection, initial validation, and storage of data received from smart electronic utility meters.

SUMMARY OF THE INVENTION

[0005] A first aspect of the invention includes a system, comprising: a meter data support system on a computer device configured to: receive raw meter data from a plurality of non-smart electronic utility meters that are each restricted to one way outbound communication, calculate an auxiliary value for each non-smart electronic utility meter using the raw meter data from each respective non-smart electronic utility meter, and provide access to the auxiliary value to at least one of a user and a customer.
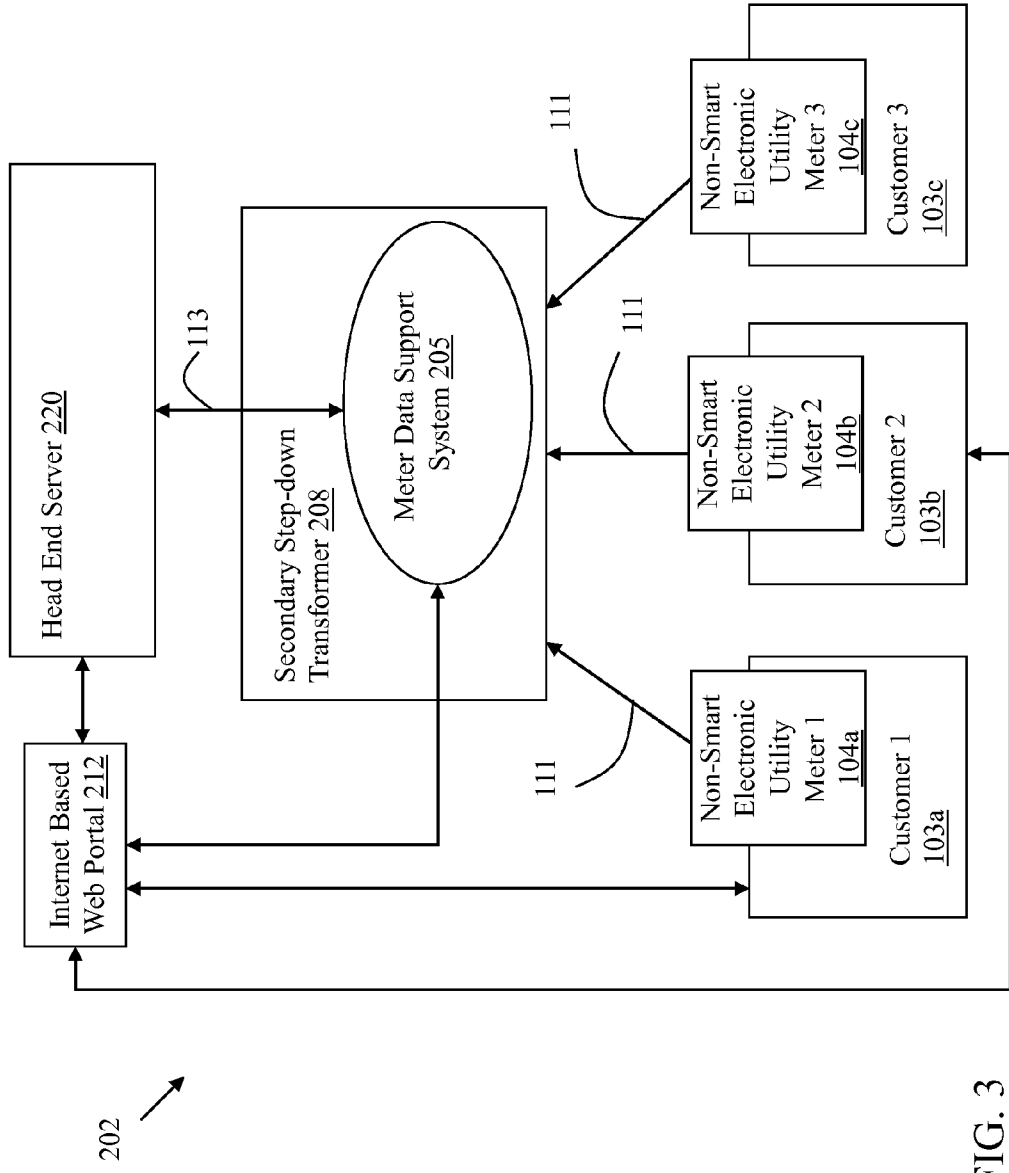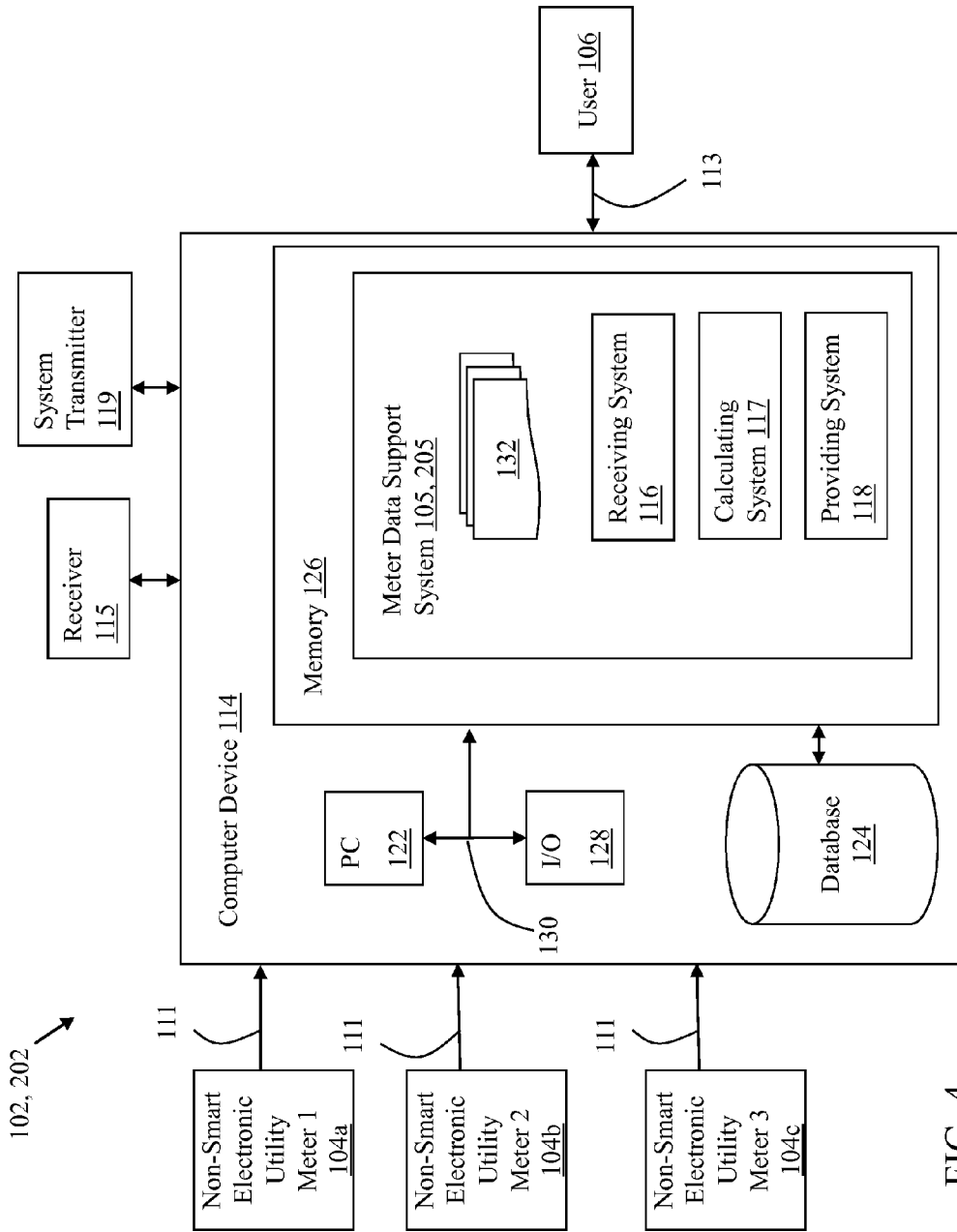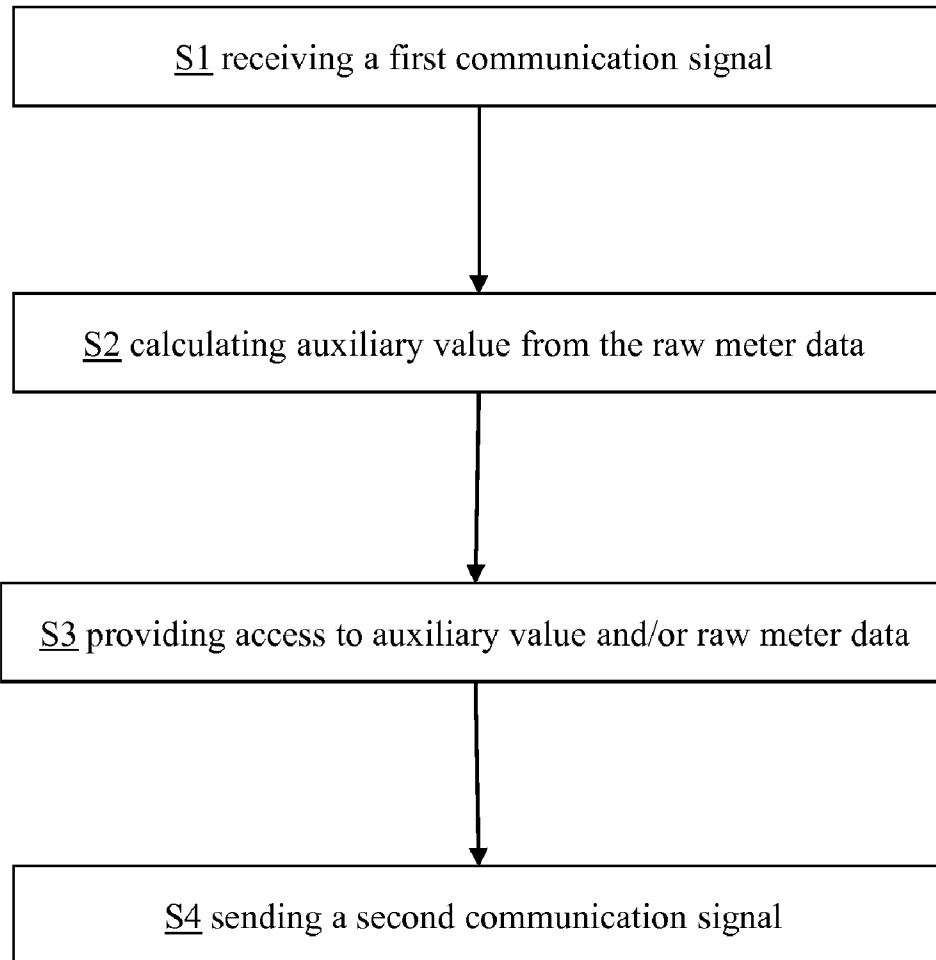
[0006] A second aspect of the invention includes a system, comprising: a meter data support system on a computer device configured to: receive raw meter data from a plurality of non-smart electronic utility meters that are each restricted to one way outbound communication, calculate an auxiliary value for each electronic utility meter using the raw meter data from each respective non-smart electronic utility meter, and provide access to the auxiliary value to at least one of a user and a customer; and a head end server configured to receive the auxiliary value from the meter data support system.

[0007] A third aspect of the invention includes a system, comprising: a plurality of non-smart electronic utility meters, wherein each non-smart electronic utility meter is devoid of smart meter functioning with respect to calculating an auxiliary value, and wherein each non-smart electronic utility meter is restricted to one way outbound communication; a meter data support system on a computer device configured to: receive raw meter data from the plurality of non-smart electronic utility meters, calculate the auxiliary value for each non-smart electronic utility meter using the raw meter data from each respective non-smart electronic utility meter, and provide access to the auxiliary value to at least one of a user and a customer; a secondary step down transformer for providing stepped down electricity to the plurality of non-smart electronic utility meters and the computer device; and a head end server configured to receive the auxiliary value from the meter data support system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] These and other features of this invention will be more readily understood from the following detailed description of the various aspects of the invention taken in conjunction with the accompanying drawings that depict various embodiments of the invention, in which:

[0009] FIG. 1 shows a block diagram of one embodiment of a system in accordance with the invention.

[0010] FIG. 2 shows a block diagram of one embodiment of a non-smart electronic utility meter in accordance with the invention.

[0011] FIG. 3 shows a block diagram of one embodiment of a system in accordance with the invention.

[0012] FIG. 4 shows a block diagram depicting a system in accordance with one embodiment of the invention.

[0013] FIG. 5 shows a flow diagram representing an embodiment of a method of calculation for non-smart electronic utility meters.

[0014] It is noted that the drawings of the invention are not to scale. The drawings are intended to depict only typical aspects of the invention, and therefore should not be considered as limiting the scope of the invention. In the drawings, like numbering represents like elements between the drawings.

DETAILED DESCRIPTION

[0015] Referring to FIG. 1, a schematic view of one embodiment of a system 102 in accordance with the invention is shown. As more fully described herein, system 102 reduces the computing and communication requirements of electronic utility meters allowing use of non-smart electronic utility meters ("non-smart meters") 104a-c. A plurality of non-smart meters 104a-c is shown in one-way outbound communication using a first communication signal 111 with meter data support system 105. Each non-smart meter 104a-c is associated with one of a plurality of customers 103a-c. Plurality of customers 103a-c may include residential and/or commercial customers. Each non-smart meter 104 may meter the utility usage of one of the plurality of customers 103a-c. Meter data support system 105 is shown in two-way communication using a second communication signal 113 with a user 106.

[0016] Referring to FIG. 2, a schematic view of one embodiment of non-smart meter 104a in accordance with the invention is shown. Non-smart meter 104a may include an

analog front end (AFE) **107** and a meter transmitter **108**. AFE **107** may meter utility usage and may be restricted to measuring the amount of a utility used, for example in the case of electricity—measuring kilowatt hours. In other words, the non-smart electronic utility meter is devoid of structure and functionality to calculate an auxiliary value using raw meter data. "Raw meter data" may include direct measurements of values, for example, kilowatts used, time, date, battery status, and meter number. For example, raw meter data may include, a kilowatt usage measured (by AFE **107**), a date, a time, a meter number, and a battery status. "Auxiliary value" may include new values calculated from raw meter data for additional information about utility usage. Auxiliary value may include, for example, present demand, an unbilled amount, a maximum demand, a today's usage, a load disconnect, and a unit price per kilowatt hour. A person skilled in the art will readily recognize that an auxiliary value may include a variety of new values. The type of raw meter data and auxiliary values included may vary with the type of utility being metered, for example, measurements of gas usage or water usage may differ from measurements of electricity usage. Further, non-smart meter **104a** may include an analog-to-digital converter (ADC) **109**. A person skilled in the art will readily recognize that ADC **109** may be a part of AFE **107** or may be a separate component. After AFE **107** collects raw meter data in analog format, ADC **109** may convert raw meter data to a digital format.

[0017] Referring again to FIG. **1**, each non-smart meter **104a-c**, using meter transmitter **108** (FIG. **2**), may send first communication signal **111** containing raw meter data to meter data support system **105**. Each non-smart meter **104a-c** may be restricted to one-way outbound communication, i.e., from non-smart meter **104a-c** to meter data support system **105**. Including only AFE **107** (FIG. **2**) and the restricted to one-way outbound communication capability in each non-smart meter **104a-c** reduces the need to store, process, and calculate an auxiliary value based on raw meter data at each non-smart meter **104a-c**. This, in turn, may reduce the associated need for additional equipment at each non-smart meter **104a-c** thereby reducing, for example, the cost, size, weight, electronic complexity, and power demand of each non-smart meter **104a-c**. Meter data support system **105** may be configured to receive raw meter data from non-smart meters **104a-c**. Transmission of first communication signal **111** includes one-way outbound communication from non-smart meter **104** to meter data support system **105**. Each non-smart meter **104** may be equipped to measure utility usage as raw meter data and to transmit raw meter data only. Meter data support system **105** may receive raw meter data from a plurality of non-smart meters **104** where auxiliary value may be calculated from the raw meter data for transmission in second communication signal **113** to user **106**. Transmission of first communication signal **111** and second communication signal **113** may include the following formats: power line carrier (PLC), radio frequency (RF), cellular transmission, and general packet radio service (GPRS). These formats are well known to a person skilled in the art.

[0018] Referring to FIG. **3**, block diagram of one embodiment of system **202** in accordance with the invention is shown. A secondary step down transformer **208** may receive electricity from primary phase distribution lines and reduce, i.e. "step down," the voltage for distribution to a group of residential and/or commercial customers. Secondary step down transformer **208** typically may serve a group of resi-

dential and/or commercial customers and, consequently, may provide the group of residential and/or commercial customers meter data management with system **202**. Meter data support system **205** may be included with a secondary step down transformer **208**. Secondary step down transformer **208** may provide power to meter data support system **205**. Secondary step down transformer **208** may provide enclosure to meter data support system **205**. Meter data support system **205** is a separate component from any smart device that may be included with secondary step down transformer **208**. In one embodiment, a user **106** (FIG. **1**) may take the form of a head end server **220** within the AMI of a distribution network. Head end server **220** may display auxiliary value and/or raw meter data on an Internet based web portal **212** where auxiliary value and/or raw meter data may be accessed by each customer **103a-c** and/or head end server **220** (user **106** FIG. **1**). In another embodiment, meter data support system **202** may display auxiliary value and/or raw meter data on an Internet based web portal **212** where auxiliary value and/or raw meter data may be accessed by each customer **103a-c** and/or head end server **220** (user **106** FIG. **1**).

[0019] Meter data support system **205** is a separate component from non-smart electronic utility meter **104a-c** and a separate component from head end server **220**. Implementation of meter data support system **205** may allow the continued use of existing non-smart electronic utility meters thereby reducing expense of replacement. Meter data support system **205** is a separate component from any smart device located within the electrical distribution network. As discussed, FIG. **3** shows meter data support system **205** included as part of secondary step-down transformer **208**. However, meter data support system **205** may be included as part of any node or line in the electrical distribution network, except at head end server **220** or non-smart electronic utility meter **104a-c**, including, for example the generating station, the generator step-up transformer, the high voltage transmission lines, the substation step-down transformers, the primary phase distribution lines, and the secondary phase distribution lines.

[0020] Referring to FIG. **4**, a block diagram of one embodiment of system **102, 202** in accordance with the invention is shown. System **102, 202** may include a receiver **115**, a system transmitter **119**, and a computer device **114**. Receiver **115** and system transmitter **119** may include any known or to be developed receiving and/or transmission device that may be configured to receive and/or transmit first communication signal **111** and/or second communication signal **113** in the following formats: power line carrier (PLC), radio frequency (RF), cellular transmission, and general packet radio service (GPRS). Computer device **114** may include meter data support system **105, 205** which makes computer device **114** operable to receive raw meter data, calculate an auxiliary value, and provide access to the auxiliary value. As indicated in FIG. **4**, a receiving system **116**, a calculating system **117**, and a providing system **118** may be optional components (or, modules) in meter data support system **105, 205**. Alternatively, receiving system **116**, calculating system **117**, and providing system **118** may be part of an external system which may perform the functions described herein.

[0021] Computer device **114** is shown in communication with user **106**. User **106** may be a human, for example, a programmer or operator and/or a computerized system interacting with system **102, 202** and meter data support system **105, 205**. Communications between user **106** and computer

device **114** can be implemented using any solution, such as a graphical interface, an application programming interface (API), and/or the like. Furthermore, communications can utilize any combination of public and/or private networks. Additionally, computer device **114** is shown in communication with each customer **103***a-c*. Computer device **114** is shown including a processing component **122** (e.g., one or more processors), a database **124**, a memory **126**, an input/output (I/O) component **128** (e.g., one or more I/O interfaces and/or devices), and a communications pathway **130**. In one embodiment, processing component **122** executes program code, such as meter data support system **105, 205**, which is at least partially embodied in memory **126**. While executing program code, processing component **122** can process data, which can result in reading and/or writing the data to/from database **124**, memory **126** and/or I/O component **128** for further processing. Communications pathway **130** provides a communications link between each of the components in computer device **114**. I/O component **128** can comprise one or more human I/O devices or storage devices, which enable user **106** and/or customer **103***a-c* to interact with computer device **114** and/or one or more communications devices to enable user **106** and/or customer **103***a-c* to communicate with computer device **114** using any type of communications link. To this extent, meter data support system **105, 205** can manage a set of interfaces (e.g., graphical user interface(s), application program interface, and/or the like) that enable human and/or system interaction with system **102, 202** and meter data support system **105, 205**.

[0022] In any event, computer device **114** can comprise one or more general purpose computing articles of manufacture (e.g., computing devices) capable of executing program code installed thereon. As used herein, it is understood that "program code" means any collection of instructions, in any language, code or notation, that cause a computing device having an information processing capability to perform a particular function either directly or after any combination of the following: (a) conversion to another language, code or notation; (b) reproduction in a different material form; and/or (c) decompression. To this extent, meter data support system **105, 205** can be embodied as any combination of system software and/or application software. In any event, the technical effect of computer device **114** is to receive raw meter data, calculate an auxiliary value, and provide access to the auxiliary value.

[0023] Further, meter data support system **105, 205** can be implemented using a set of modules **132**. In this case, a module **132** can enable computer device **114** to perform a set of tasks used by meter data support system **105, 205**, and can be separately developed and/or implemented apart from other portions of meter data support system **105, 205**. Meter data support system **105, 205** may include modules **132** which comprise a specific use machine/hardware and/or software. Regardless, it is understood that two or more modules, and/or systems may share some/all of their respective hardware and/or software. Further, it is understood that some of the functionality discussed herein may not be implemented or additional functionality may be included as part of computer device **114**.

[0024] When computer device **114** comprises multiple computing devices, each computing device may have only a portion of meter data support system **105, 205** embodied thereon (e.g., one or more modules **132**). However, it is understood that computer device **114** and meter data support system **105, 205** are only representative of various possible equivalent computer devices that may perform a process described herein. To this extent, in other embodiments, the functionality provided by computer device **114** and meter data support system **105, 205** can be at least partially implemented by one or more computing devices that include any combination of general and/or specific purpose hardware with or without program code. In each embodiment, the hardware and program code, if included, can be created using standard engineering and programming techniques, respectively.

[0025] Regardless, when computer device **114** includes multiple computing devices, the computing devices can communicate over any type of communications link. Further, while performing a process described herein, computer device **114** can communicate with one or more other computer devices using any type of communications link. In either case, the communications link can comprise any combination of various types of wired and/or wireless links; comprise any combination of one or more types of networks; and/or utilize any combination of various types of transmission techniques and protocols.

[0026] As discussed herein, meter data support system **105, 205** enables computer device **114** to receive raw meter data, calculate an auxiliary value, and provide access to the auxiliary value. Meter data support system **105, 205** may include logic, which may include the following functions: receiving system **116**, calculating system **117**, and providing system **118**. In one embodiment, meter data support system **105, 205** may include logic to perform the below-stated functions. Structurally, the logic may take any of a variety of forms such as a field programmable gate array (FPGA), a microprocessor, a digital signal processor, an application specific integrated circuit (ASIC) or any other specific use machine structure capable of carrying out the functions described herein. Logic may take any of a variety of forms, such as software and/or hardware. However, for illustrative purposes, meter data support system **105, 205** and logic included therein will be described herein as a specific use machine. As will be understood from the description, while logic is illustrated as including each of the above-stated functions, not all of the functions are necessary according to the teachings of the invention as recited in the appended claims.

[0027] In one embodiment, the invention provides a computer program embodied in at least one computer-readable storage medium, which when executed, enables a computer device (e.g., computer device **114**) to receive raw meter data, calculate an auxiliary value, and provide access to the auxiliary value. To this extent, the computer-readable storage medium includes program code, such as meter data support system **105, 205**, which implements some or all of a process described herein. It is understood that the term "computer-readable storage medium" comprises one or more of any type of tangible medium of expression capable of embodying a copy of the program code (e.g., a physical embodiment). For example, the computer-readable storage medium can comprise: one or more portable storage articles of manufacture; one or more memory/storage components of a computing device; paper; and/or the like. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a nonexhaustive list) of the computer readable storage medium

would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0028] In another embodiment, the invention provides a method of providing a copy of program code, such as meter data support system **105**, **205**, which implements some or all of a process described herein. In this case, a computer device can generate and transmit, for reception at a second, distinct location, a set of data signals that has one or more of its characteristics set and/or changed in such a manner as to encode a copy of the program code in the set of data signals. Similarly, an embodiment of the invention provides a method of acquiring a copy of program code that implements some or all of a process described herein, which includes a computer device receiving the set of data signals described herein, and translating the set of data signals into a copy of the computer program embodied in at least one computer-readable medium. In either case, the set of data signals can be transmitted/received using any type of communications link.

[0029] In still another embodiment, the invention provides a method of generating a system for receiving raw meter data, calculating an auxiliary value, and providing access to the auxiliary value. In this case, a computer device, such as computer device **114**, can be obtained (e.g., created, maintained, made available, etc.) and one or more modules for performing a process described herein can be obtained (e.g., created, purchased, used, modified, etc.) and deployed to the computer device. To this extent, the deployment can comprise one or more of: (1) installing program code on a computing device from a computer-readable medium; (2) adding one or more computing and/or I/O devices to the computer device; and (3) incorporating and/or modifying the computer device to enable it to perform a process described herein.

[0030] Referring to FIG. **5** (along with FIGS. **1-4**), a flow diagram of a method in accordance with one embodiment of the invention is shown. As shown in FIG. **5**, at **51**, receiving system **116** may receive first communication signal **111** containing raw meter data from at least one non-smart meter **104***a-c*. Raw meter data may include kilowatt usage, time of day and meter identification. At S2, calculating system **117** may calculate auxiliary value based on the raw meter data.

[0031] In one embodiment, at S3, providing system **117** may provide access to auxiliary value by user **106** and/or customer **103***a-c*. Providing access may include assigning a uniform resource locator to auxiliary value for providing an address to display auxiliary value on an Internet based web portal **212** (FIG. **3**). At S4, system transmitter **119** may send second communication signal **113** with auxiliary value to user **106** and/or customer **103***a-c*. Communication between user **106** and/or customer **103***a-c* and system **102** may be two-way communication. For example, user **106** and/or customer **103***a-c* may provide new instructions to meter data support system **105**, **205** for calculating auxiliary value. In one embodiment, user **106** may display auxiliary value and/or raw meter data for each non-smart meter **104***a-c* on Internet based web portal **212**. In one embodiment, system **102**, **202** may

display auxiliary value and/or raw meter data for each non-smart meter **104***a-c* on Internet based web portal **212**. Each user **106** and/or customer **103***a-c* may access Internet based web portal **212** to view auxiliary value and/or meter data for the non-smart meter associated with customer **103***a-c*. Security for accessing Internet based web portal **212** may include any known or to be developed method for securing access to Internet based web portal **212**.

[0032] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof

[0033] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A system, comprising:
a meter data support system on a computer device configured to:
receive raw meter data from a plurality of non-smart electronic utility meters that are each restricted to one way outbound communication,
calculate an auxiliary value for each non-smart electronic utility meter using the raw meter data from each respective non-smart electronic utility meter, and
provide access to the auxiliary value to at least one of a user and a customer.

2. The system of claim **1**, wherein each non-smart electronic utility meter is devoid of smart meter functioning with respect to calculating the auxiliary value.

3. The system of claim **1**, wherein the meter data support system is located between the plurality of non-smart electronic utility meters and a head end server.

4. The system of claim **1**, wherein the meter data support system is included with a secondary step-down transformer.

5. The system of claim **1**, further comprising:
a receiver and a transmitter, and
wherein the receiver and transmitter use one of the following formats: power line carrier (PLC), radio frequency (RF), cellular transmission, and general packet radio service (GPRS).

6. The system of claim **1**, wherein the meter data support system is further configured to transmit at least one of the auxiliary value and the raw meter data to a head end server.

7. The system of claim **1**, wherein the auxiliary value includes at least one of a present demand, an unbilled amount, a maximum demand, a today's usage, a load disconnect, and a unit price per kilowatt hour.

8. The system of claim **1**, wherein the providing access to the auxiliary value includes assigning a uniform resource location (URL) for linking access to an Internet based web portal.

9. The system of claim **6**, further comprising the head end server providing for display via an Internet based web portal at least one of the auxiliary value and the raw meter data.

10. A system, comprising:

a meter data support system on a computer device configured to:

receive raw meter data from a plurality of non-smart electronic utility meters that are each restricted to one way outbound communication,

calculate an auxiliary value for each electronic utility meter using the raw meter data from each respective non-smart electronic utility meter, and

provide access to the auxiliary value to at least one of a user and a customer; and

a head end server configured to receive the auxiliary value from the meter data support system.

11. The system of claim **10**, wherein the at least one non-smart electronic utility meter is devoid of smart meter functioning with respect to calculating the auxiliary value.

12. The system of claim **10**, wherein the meter data support system is located between the plurality of non-smart electronic utility meters and the head end server.

13. The system of claim **10**, wherein the meter data support system is included with a secondary step-down transformer.

14. The system of claim **10**, further comprising:

a receiver and a transmitter, and

wherein the receiver and transmitter use one of the following formats: power line carrier (PLC), radio frequency (RF), cellular transmission, and general packet radio service (GPRS).

15. The system of claim **10**, wherein the meter data support system is further configured to transmit at least one of the auxiliary value and the raw meter data to a head end server.

16. The system of claim **10**, wherein the auxiliary value includes at least one of a present demand, an unbilled amount, a maximum demand, a today's usage, a load disconnect, and a unit price per kilowatt hour.

17. The system of claim **10**, wherein the providing access to the auxiliary value includes assigning a uniform resource location (URL) for linking access to an Internet based web portal.

18. The system of claim **15**, further comprising the head end server providing for display via an Internet based web portal at least one of the auxiliary value and the raw meter data.

19. A system, comprising:

a plurality of non-smart electronic utility meters, wherein each non-smart electronic utility meter is devoid of smart meter functioning with respect to calculating an auxiliary value, and wherein each non-smart electronic utility meter is restricted to one way outbound communication;

a meter data support system on a computer device configured to:

receive raw meter data from the plurality of non-smart electronic utility meters,

calculate the auxiliary value for each non-smart electronic utility meter using the raw meter data from each respective non-smart electronic utility meter, and

provide access to the auxiliary value to at least one of a user and a customer;

a secondary step down transformer for providing stepped down electricity to the plurality of non-smart electronic utility meters and the computer device; and

a head end server configured to receive the auxiliary value from the meter data support system.

20. The system of claim **19**, wherein the meter data support system is located between the plurality of non-smart electronic utility meters and the head end server.

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