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(54) **Title**: A METHOD OF PROVIDING SMART GRID SERVICES SECURELY VIA SHARED METERING DEVICES AND A SYSTEM DERIVED THEREOF

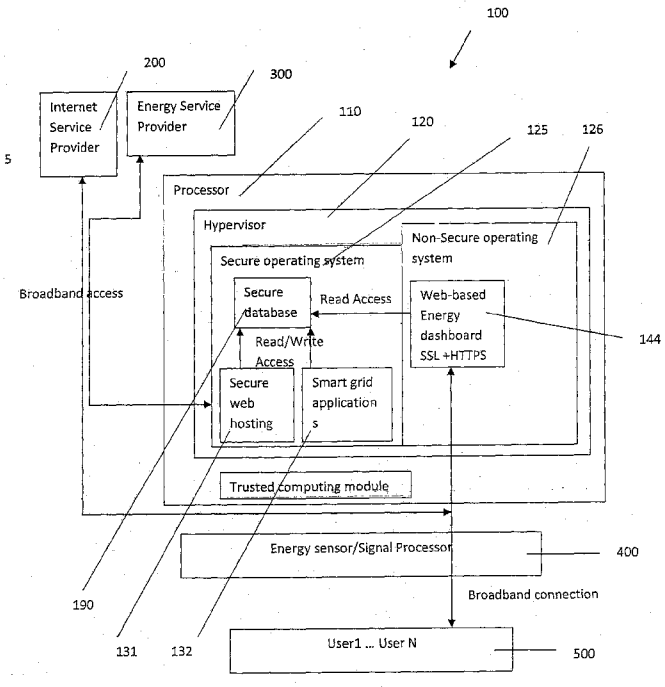

Figure 2

(57) **Abstract**: A metering device (100) of electricity utility equipped with capability of providing internet access comprises a first sensors (400) capable of real-time measuring utility data of a first recipient (500) and the utility data is acquired as analog signal; a processor (110) connected to the first sensors (400) via a signal processing unit, which process and convert the analog signal to digital signal, to obtain the measured utility data for analysis through instructions from one or more software applications; a hypervisor (120) coupled to the processor (1 10) allowing the processor (110) to host a first (126) and a second operating system (125) forming a first subnet and a second subnet thereon; and a communication module coupled to the processor (110) and adapted to provide internet access to the first recipient (500) via a first domain connected to the first subnet and send the utility data to a billing server via a second domain connected to the second subnet.

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A METHOD OF PROVIDING SMART GRID SERVICES SECURELY VIA SHARED METERING DEVICES AND A SYSTEM DERIVED THEREOF

FIELD OF INVENTION

The present invention relates to a method of sharing a metering device for a community of customers while providing smart grid services and internet services securely through a hybrid of power line communication (PLC) and a system capable of implementing the disclosed method. More specifically, the present invention uses a single power metering devices to run one or more virtual machines to cater the publicly shared internet services to one or more recipients, preferably household or office units, while using one or more virtual machines to provide parallel secure network and services available only for the energy provider for secure smart grid applications such as remote electricity cut-off, automated billing etc. The invention also shows a system that allows the energy and internet service providers to offer cloud computing securely to metering devices.

BACKGROUND OF THE INVENTION

Power line communication has been used to provide broadband internet access. Through the readily available power line network infrastructure, PLC is able to provide internet service to residents located in remote area without incurring much cost for equipment and utility investment. The PLC also facilitates electricity service provider to perform auto-billing via remote billing server in communication with power metering devices constantly monitoring electricity consumption of a recipient. For example, in International Patent with publication no. 2006/028275, an automatic meter reading method and apparatus utilizing a microprocessor and a bi-directional broadband connection to access Internet are disclosed. The disclosed invention claims to have integrated utility infrastructure and communication equipment into a data transmission network without requiring additional cost to deploy new equipment or establishment.

Another International patent with publication no. 2006/017094 describes a system used for metering electrical power utility services to residential homes and combining electrical usage and other utility metering function of multiple end user. Thus, the system eliminates the need for an individual electric metering device for each end user. The system serves as a single metering data collection point for multiple users and facilitates interactive communication between the utility service delivery points and utility users. Broadband signal may be impressed onto the service conductors from multiple broadband sources in this invention.

Though the above mentioned prior arts can provide internet services and automatic meter reading through the single network joining the recipients of the utility, the meter reading is not feasible if the utility user does not subscribe for the internet service. Moreover, single network design in the prior arts may subject automatic meter reading to an unexpected disruption when the internet services providers facing substantial downtime. The utility provider may suffer incorrect billing caused by such downtime, particularly during data transmission. Further, sharing the same network for non-secure internet service expose server of the utility provider from being hacked. Therefore, it is more preferred to have a more secure and reliable PLC system to facilitate both meter reading and broadband service offering functions that disruption in one operation causes no effect to another. Other existing metering infrastructures available in the market use separate metering devices, energy dashboards and PLC repeaters to provide different types of services. For example, metering devices provides metering, automated meter reading, electricity theft detection applications, and energy dashboards provide charts to analyze energy consumption data etc. Integration of different components in many of these proposed smart grid fail to deliver a clear economic justification. The benefits delivered by these products cannot significantly outweigh the costs for implementing the infrastructures. To find wider deployment, the smart grid establishment must deliver either more benefits or at lower project costs, preferably both.

SUMMARY OF THE INVENTION

The present invention aims to offer an utility metering device which is shared by a community of users, energy and internet service providers securely. However, sharing a metering device by different parties present many security and technical challenges, the invention provides an approach to realize sharing of the the utilities metering device while meeting performance, real time and technical requirements. Importantly, sharing the network establishment of the connected metering device by different parties reduces the total number of metering devices required for a deployment in an apartment, office buildings etc. Another central feature of the utility metering device is to cater internet access and metering the utility consumption. More specifically, the metering device has a communication module to permit data transmission in between multiple utility users and a broadband service provider. Therefore, multiple utilities users can share the utility metering device.

The present invention also aims to provide an utility metering device offering a secure network virtually separated from the broadband or internet service network for the utility provider to provide a number of smart grid services such as automatic meter reading and billing via a remote billing server, remote electrical switches, theft detection and prevention etc. These services may be performed automatically through the software installed at the billing server or the metering device itself, or it can be performed and intervened by authorized personnel from the energy service provider.

Another object of the present invention is to disclose a system for providing internet access to recipient connected to a power line network via a metering device functioning as the router and repeater. Particularly, a base station of the internet service provider connects to the power line network in between the transformer and the metering devices.

Still another object of the present invention is to offer a system architecture that is a hybrid of power line communication which virtually forms at least two or more different networks, preferably a non-secure domain for providing internet service and another secured domain

accessible only by the utility service provider for smart grid services like, but not limited to, retrieving billing information.

The system follows the basic concept of a N-tier web architecture, in which a web architecture is virtually partitioned into a sub-system for web hosting, and a secure sub-system for database and other high privilege services. For the partition that runs the secure operating system, at least one of the preceding objects is met, in whole or in part, by the present invention, in which one of the embodiments of the present invention is a metering device of electricity utility equipped with capability of providing internet access comprising a first sensors capable of real-time measuring utility data of a first recipient and the utility data is acquired as analog signal; a processor connected to the first sensors via a signal processing unit, which processes and converts the analog signal to digital signal, to obtain the measured utility data for analysis through instructions from one or more software applications; a hypervisor coupled to the processor allowing the processor to host a first and a second operating system forming a first subnet and a second subnet thereon; and a communication module coupled to the processor and adapted to provide internet access to the first recipient via a first domain connected to the first subnet and send the utility data to a billing server via a second domain connected to the second subnet.

In another aspect, the metering device may comprise a second sensor capable of real-time measuring utility data of a second recipient and is connected to the processor via the signal processing unit to obtain the measured utility data of the second recipients for analysis through instructions from one or more software applications that the utility data of the second recipient is sent through the second domain connected to the second subnet and the first domain connected to the first subnet allows the second recipient to access internet.

A storage device maybe incorporated to communicate with the processor for recording utility data and/or information of the analysis and providing the recorded information to the processor or the billing server upon through the secure operating system upon proper

authentication. With the right authentication, the authorized application running on the secure operating system may update the secure database with energy consumption data, latest billing information, theft detection and other data that are accessible only with the right authentication.

Still another aspect of the invention is a system of providing internet service via a power line network comprising a plurality of power metering devices distributed in the power line network that each power metering device connects to at least one recipients, more preferably multiple recipients, and a computing processor is housed within each power metering device and is virtually partitioned by a hypervisor to host a first and a second operating systems forming a first and a second subnets via a communication module, wherein the first subnet connects to a first domain providing access to Internet to the recipient connected to the power metering device and the second subnet connects to a second domain accessible by service provider of the power line for retrieving billing information of the recipient connected to the power metering device. More preferably, the first subnet and the second subnet are virtually separated.

In order to avoid disruption in the automatic meter reading process, the second domain is run on the secure operating system that supports secure means of secure network which only accessible by the utility provider to extract utility data from the metering device.

In one embodiment, the power metering device comprises a plurality of sensors capable of real-time measuring consumption data of the power used by the plurality of recipients that each sensor is responsible for measuring consumption rate of one recipient of the power; and the processor in communication with the plurality of sensors to obtain the measured consumption data for analysis through instructions from one or more software applications in the secure operating system.

In a preferred embodiment, trusted computing platform technologies and practices and virtual private network are applied to provide more secure computing and networking environment between the Energy service provider and the secure operating system. Specifically, the secure operating system applies trusted computing hardware module to prevent unauthorized software applications from tempering the operating system.

In another embodiment, the secure operating system may run an application that controls schedule-based remote electrical switches. An authorized person that is authenticated by the secure operating system may remotely access the secure database to change the "Active?" parameter in figure 3. The database may be made flexible by including the feature similar to an alarm clock. A web-based interface hosted by the web server of the secure operating system will be available to the authorized user to schedule a period of time and certain days in a week that the metering device cuts electricity supply to irresponsible customers.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram showing the connection of various elements in the disclosed system;

Figure 2 is a schematic diagram detailing the flow a N-tier web architecture for a metering device of the present invention through the established secure and non-secure network;

Figure 3 is possible user interface used by the power service provider for multiple meter reading and billing through a secure network;

Figure 4 is exemplary presentation of one user interface for customer meter reading from a remote PC connected to the billing server, and

Figure 5 shows the structure of Power Line Communication network can be used in the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The most preferred embodiment of the invention is now described herein with reference to the figures, where like reference numbers indicate identical or functionally similar elements. While specific configurations and arrangements are discussed, it should be understood that this is done for illustrative purposes only. A person skilled in the art will recognize that the other configurations and arrangements can be used without departing from the scope of the invention.

The terms "energy service provider", "utility provider", "power service provider" and "utility service provider" are used interchangeable in the description herein.

One embodiment of the present invention is a metering device (100) of electricity utility equipped with capability of providing internet access comprising a first sensors (400) capable of real-time measuring utility data of a first recipient (500) and the utility data is acquired as analog signal; a processor (110) connected to the first sensors (400) via a signal processing unit, which process and convert the analog signal to digital signal, to obtain the measured utility data for analysis through instructions from one or more software applications; a hypervisor (120) coupled to the processor (110) allowing the processor (110) to host a first (126) and a second operating system (125) forming a first subnet and a second subnet thereon; and a communication module coupled to the processor (110) and adapted to provide internet access to the first recipient (500) via a first domain connected to the first subnet and send the utility data to a billing server via a second domain connected to the second subnet.

It is important to be noted that the metering device (100) of the present invention can be configured to connect and communicate with multiple recipients (500) rather than just a single recipient. The processor (110) in the metering device (100) can simultaneously

perform meter reading and provide internet access to multiple recipients (500) as shown in figure 1. Particularly, the metering device (100) further comprises a second sensor (400) capable of real-time measuring utility data of a second recipient (500) and is connected to the processor (110) via the signal processing unit to obtain the measured utility data of the second recipient (500) for analysis through instructions from one or more software applications that the utility data of the second recipient (500) is sent through the second domain connected to the second subnet and the first domain connected to the first subnet allows the second recipient (500) to access internet. More specifically, in this embodiment, a plurality of sensors (400) are connected to a single processor (110) that each sensor (400) is responsible for utility measurement for one recipient. Further, the plurality of recipients connected to the single processor (110) are allowed to access internet service through the non-secure first subnet managed by the internet service provider (200) while the utility consumption information is delivered in between the billing server and the metering device via the secure second subnet running in parallel in the processor of the metering device. In contrast to the conventional technologies which requires metering device (100) to be typically installed for every recipient such as housing units of an apartment, office unit of an office building and the like. Every metering device (100) in the conventional system is costly as it at least includes a current and voltage interface transducer, an analogue to digital converter, digital signal processing and energy computation function, and an optional communication module.

According to the preferred embodiment, the sensor (400) is installed to a point, of the power line network, which the electrical current passes through before being supplied to each receipt unit or recipient. Thus the amount of utility passed through the point can be measured. The sensor in the present invention only measures the real time volume or amount of the utility without further processing or recording the measured amount. More preferably, in metering and billing consumption of electricity, the sensor (400) can be current and/or voltage transducer. The transducer continuously generates an analog signal that the amplitude of the analog signal is direct proportion to the current and/or voltage passed through. The amplitude

of the measured analog signal is sent to the signal processing unit and processor for further process and use. It is important to be noted that metering, recording, analysis and so on are not conducted at the recipient level. The sensor (400) installed at each receipt unit feeds the measured signal to a signal processing unit that the signal processing unit is shared by multiple recipients and receives the measured analog signal from different sensors of multiple recipients. Consequently, in the embodiment where the metering device (100) is connected to multiple recipients, the sensor and the processor of the present invention may not share a single housing while the sensors are positioned much away from the processor at the downstream of the power line network to measure the utility data.

One of the preferred embodiment, which a plurality of recipients (500) connected to a single metering device (100), may not have the processor (110) continuously received measurement from all the connected sensors. Preferably, a flexible algorithm and electronics circuit sample measurement of the utility consumption from the certain number of sensors (400) installed at the recipients (500) for the processor (110) to compute the amount of consumed utility. For example, sampling of current and voltage value using one or more multiplexer in an electricity distribution network is one feasible way to carry out such embodiment. More specifically, the input power transmission line of each recipient has one current and one voltage sensor for energy consumption measurement. The processor (110) has the flexibility to choose which sensor (400) to read by selecting one input of the multiplexer. For example, if there was N number of recipients (500) to be read, the processor (110) samples only the N number of current and voltage sensors using a time division method. However, there may be more than one multiplexer to process multiple number of current and voltage sensors. For example, certain energy measurement chips can measure 2 or 4 housing units simultaneously. Therefore, there may more than one multiplexer and ADC for tens of recipients (500). The processor (110) computes the consumed amount of the utility using the sampled current and voltage values. In more specific, the disclosed metering device comprises a multiplexer disposed in between the connection of the processor (110) and the plurality of sensors (400) prior to the signal processing unit that the multiplexer samples measurement of consumption

data from each sensor (400) to the processor (110) at a predetermined duration. The sampling rate may be in the scale of micro second.

Pursuant to another embodiment, the communication module allows the metering device (100) to transmit data to or from one or more remote server through the power line network. The remote servers, according to the preferred embodiment, are particularly billing server of the utility provider (300) and/or server in a base station of the internet service provider. The communication module includes both hardware and software establishment. The hardware part mainly refers to repeater receiving modulated carrier signal transmitted in the power line, and further amplifying, reshaping and/or retiming the received signal the recipients. Yet the software part has instructions installed to drive the repeater to process the signal for amplifying, reshaping and/or retiming. The repeater of the communication module in the present invention can be a standalone device coupled to the processor, or forming parts of the processor. Apart being an intermediate point to retransmit the signal, the communication module may include as well modulator and demodulator to permit utility data to be sent and received in between the metering device and the connected billing server through the power line communication. Information delivered from the billing server can be extracted for further process via the demodulator, while utility data can be impressed and sent to the billing server as well through the modulator. These modulated and demodulated data deliveries only happens in the secured second subnet. The communication module allows the billing server communicate remotely to the metering device via the secure second subnet for automated billing, theft detection, commodity demand management and so on.

In order to share a metering device to a number of users (500), internet (200) and energy service providers (300), a physical processor (110) is virtually partitioned to run a number of operating systems (125 and 126) using a hypervisor (120) as in figure 2. In the simplest design, the hypervisor (120) partitions the processor (110) to run one secure operating system (125) and one non-secure operating system (126). However, it is possible to run more than one secure, or one non-secure operating system, or different combination of operating

systems. It is intention of the inventors of the present invention to offer a secure network (131) or line for the utility provider (300) to perform utility billing, automatic meter reading and the like without being influenced by the concurrently broadband service offered in the same power line network. With the hypervisor (120) coupled to the processor (110), multiple operating systems, preferably the first (126) and the second operating systems (125), can be host in the metering device (100) each performing virtually separated tasks, namely automatic meter reading and internet data transmission. The first operating system (126) connects to the first domain via the first subnet and acquires data transmitted from/to the internet service provider (200), while the data related to utility consumption and billing is delivered through the second subnet connected to the second domain managed by the second operating system (125). The second subnet in the present invention is preferably secured network (131) that only accessible by utility service provider (300). A secure operating system (125) is employed to run the tasks and applications set in the metering device (100) via the secure second subnet. The secure operating system (125) requires user to provide the right authentication information using the secure and encrypted networking technologies such as SSL, VPN etc before the use is actually connected to the second subnet. Upon verification, the user may have access and capable of intervening the tasks carried out in the metering device at certain levels to perform appropriate smart grid services (132) securely to the power service provider (300). Moreover, in the present invention, the metering device (100) also function as router to interchange traffic in between two subnets to ensure proper data deliveries. With virtualization of the hardware in the metering device (100) using the hypervisor (120), the present invention creates two or more parallel data transmission lines in a single power line network connected to equal number of subnets sharing the identical routing prefix. There are many methods to implement secure and non-secure subnets. For example, SSL and HTTPS stack are applicable in the present invention to achieve different subnets. The secure operating system (125) may host a secure database (120) and run a number of secure smart grid services (132). During the system setup, the Ethernet port that is connected to the secure operating system (125) obtain one fix IP address with a set of user account for the energy service provider (300). The secure operating system (125) allows

encrypted authentication for authorized personnel from the energy service provider (300) using HTTPS stack and full SSL handshake. On the other hand, the non-secure operating system (126) hosting a web server (144) also implements a HTTPS and SSL stack for authenticating a different set of user accounts. The user accounts are allocated to authenticate the users of the metering device to read energy consumption graphs, payment details etc. Therefore, two different sets of user accounts are allocated for secure operating system (125) and non-secure operating system (126). Only trusted personnel from the energy service provider (300) is provided with the account information for the secure operating system and the account information may be changed from time to time. For a more secure network, virtual private network may be setup between the secure operating system (125) and energy service provider (300).

In respect to another embodiment, the metering device (100) further comprises a storage device integrated and in communication with the processor for recording utility data and/or information of the analysis and providing the recorded information to the processor (110) upon request. The data stored utility data is transmitted to the billing server of the utility provider (300) for further billing and analysis through the secured second subnet. In order to transmit the stored data to the billing server via the power line, a modulator may attached thereto to impress data into the frequency carrier signal followed by decryption at the end of the billing server and stored thereto. Besides, the operating system, the software instruction or the firmware are kept in the storage device as well to drive the processor to perform various tasks. Firmware or software to be run in the processor can be updated by the utility provider via PLC empowered second subnet. The software applications operated in the metering device via the secure operating system and network have the privilege to update the information in the billing server. The software applications may provide many smart grid services such as automated meter reading, theft detection and prevention, remote electrical cut-off and so on.

In further embodiment, the metering device (100) may have an interface or display to show utility data and/or analysis information recalled from the storage device and/or the billing server of the utility provider (300). Preferably, the information display is limited to data transmitted in the secured second subnet and not involves the first subnet to ensure subnet security and avoid data collision. The display unit in the disclosed device maybe a flat panel display which is able to simultaneously display multiple meter readings of the utility of different recipients (500). More preferably, the flat panel display of the present invention shows virtual representation of the actual electric meters and readings for at least two recipients on the screen, more preferably with label to indicate the identity of the recipient. The flat panel display is preferably positioned at a place in the building where users can easily access to. A touch screen panel may be used in the present invention that an input means and the display unit are integrally fabricated as a single unit to enhance interaction in between the user and the utility provider. Using the display, the disclosed metering device also permits the utility provider to make announcement using the display unit. More particularly, the announcement is sent from the billing server through the second subnet to the processor for further display on the display unit.

Another embodiment of the present invention is a system of providing internet service via a power line network comprising a plurality of power metering devices (100) distributed in the power line network that each power metering device (100) connects to at least one recipients (500), and a computing processor (110) is housed within each power metering device (100) and is virtually partitioned by a hypervisor (120) to host a first (126) and a second operating systems (125) providing a first and a second subnets, wherein the first subnet connects to a first domain providing access to Internet to the recipient (500) connected to the power metering device (100) and the second subnet connects to a second domain accessible by utility service provider (300) of the power line for retrieving billing information of the recipient (500) connected to the power metering device (100). Preferably, the metering device (100) described above is used in the disclosed system to carry out the preferred embodiments. Likewise, using the mentioned metering device (100) allow multiple recipients (500) to be

connected via a single metering device (100). More specifically, the metering device (100) may comprise a plurality of sensors (400) capable of real-time measuring consumption data of the power used by the plurality of recipients (500) that each sensor (400) is responsible for measuring consumption rate of one recipient of the power; and the processor (110) in communication with the plurality of sensors (400) to obtain the measured consumption data for analysis through instructions from one or more software applications. Preferably, the first subnet and the second subnet are virtually separated.

As in the foregoing description, the sensor (400) is installed to a point, of the power line network, which the electrical current passes through and measured before being supplied to each receipt unit or recipient (500). The sensor (400) can be current and/or voltage transducer. The transducer continuously generates an analog signal that the amplitude of the analog signal is direct proportion to the current and/or voltage passed through. The sensor (400) installed at each receipt unit (500) feeds the measured signal to a signal processing unit that the signal processing unit is shared by multiple recipients and receives the measured analog signal from different sensors (400) of multiple recipients (500). Additionally, in the disclosed system, a flexible algorithm and electronics circuit may be incorporated to the processor to sample the utility consumption from the certain number of sensors (400) installed at the recipients (500) for the processor (110) to compute the amount of consumed utility. More than one multiplexer can be employed to process multiple number of current and voltage sensors. For example, the disclosed system has a multiplexer disposed in between the connection of the processor (110) and the plurality of sensors (400) prior to the signal processing unit that the multiplexer samples measurement of consumption data from each sensor to the processor at a predetermined duration.

The communication module of the disclosed system allows the data to be transmitted through the power line network using the metering devices. In one embodiment, the hardware part of the communication module refers to repeater receiving modulated carrier signal transmitted in the power line, and further amplifying, reshaping and/or retiming the received signal the

recipients. Moreover, the software part has instructions installed to drive the repeater to process the signal for amplifying, reshaping and/or retiming. Modulator and demodulator may form parts of the communication module to permit utility data to be sent and received in between the metering device and the connected billing server through the disclosed system. Nevertheless, the modulated and demodulated data may only perform in the secured second subnet. With the communication module, the disclosed system assists the utility provider to remotely retrieve information from to the metering device for automated billing, theft detection, commodity demand management and so on. The instructions of one or more software applications installed may be used for consumption data recording, signal processing, automated metering, theft detection, demand management or any combination thereof and the common display is able to simultaneously show analysis information and/or reading of the automated metering of at least two recipients. The information stored in the billing server may be accessible by the recipients (500) via the non-secure first subnet through an user interface, for example as shown in Figure 4. Illustrated in figure 4 is another interface may be employed by the energy service provider (300) through a web-based user interface (144) to read and update various parameters of the meter reading in the metering device. The energy service provider (300) must log in to the secure operating system.

As illustrated in figure 5, the plurality power metering devices (100) of the system are connected to a base station of an Internet service provider (200) for accessing the internet. Data is modulated and demodulated at the base station to deliver data to the recipients (500) and extracting data uploaded by the recipients. The base station serves as the intermediate point joining a backbone telecommunication network of the internet service provider (200) and the power line network. Data derived from the backbone telecommunication network of the service provider is impressed to a modulated carrier signal at a preferred frequency to be transmitted along the disclosed system together with the electricity to the metering device. The metering device (100) receives the carrier signal and retransmit the carrier signal to the recipient that the signal is decrypted at the recipient end to be used. The retransmitted signal may be amplified, reshaped and/or retimed at the metering devices.

Further embodiment of the disclosed invention relates to a method of providing internet access to a plurality of recipients (500) located in a power line network. The disclosed method can be incorporated into the above mentioned system and use with the disclosed metering device (100). Preferably, it comprises the steps of connecting the at least one recipient to a power metering device (100), incorporated with a computing processor (110), located in the power line network, and providing internet access service to the connected recipient (500) via the power metering device (100), wherein the computing processor (110) is virtually partitioned by a hypervisor (120) to host a first (126) and a second operating systems (125) providing a first and a second subnets that the first subnet connects to a first domain providing access to Internet to the recipient connected to the power metering device and the second subnet connects to a second domain accessible by service provider of the power line for retrieving billing information of the recipient connected to the power metering device. Another embodiment of the present invention have the power metering device (100) communicated with a plurality of sensors (400) capable of real-time measuring consumption data of the power used by the plurality of recipients (500) that each sensor (400) is responsible for measuring consumption rate of one recipient (500) of the power; and the processor (110) in communication with the plurality of sensors (400) to obtain the measured consumption data for analysis through instructions from one or more software applications. The software applications operated in the metering device (100) via the secure operating system (125) and network have the privilege to update the information in the billing server. The software applications may provide many smart grid services such as automated meter reading, theft detection and prevention, remote electrical cut-off and so on.

To secure the automatic meter reading process and other smart grid services, the first subnet and the second subnet are virtually separated and the second subnet is a secured network accessible only by the utility provider. The secure operating system (125) requires user connected to the second subnet, secured network, to provide the right authentication information using the secure and encrypted networking technologies such as SSL, VPN etc. Once a device from the utility service provider (300) is authorized with the right

authentication, the device can have certain levels of access to the database (190) to provide appropriate smart grid services (132) securely to the utility service provider (300).

The present disclosure includes as contained in the appended claims, as well as that of the foregoing description. Although this invention has been described in its preferred form with a degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangements of parts may be resorted to without departing from the scope of the invention.

Claims

1. A metering device (100) of electricity utility equipped with capability of providing internet access comprising

a first sensors (400) capable of real-time measuring utility data of a first recipient (500) and the utility data is acquired as analog signal;

a processor (110) connected to the first sensors (400) via a signal processing unit, which process and convert the analog signal to digital signal, to obtain the measured utility data for analysis through instructions from one or more software applications;

a hypervisor (120) coupled to the processor (110) allowing the processor (110) to host a first (126) and a second operating system (125) forming a first subnet and a second subnet thereon; and

a communication module coupled to the processor (110) and adapted to provide internet access to the first recipient (500) via a first domain connected to the first subnet and send the utility data to a billing server via a second domain connected to the second subnet.

2. A power metering device according to claim 1, further comprising a second sensor capable of real-time measuring utility data of a second recipient (500) and is connected to the processor (110) via the signal processing unit to obtain the measured utility data of the second recipient (500) for analysis through instructions from one or more software applications that the utility data of the second recipient (500) is sent through the second domain connected to the second subnet and the first domain connected to the first subnet allows the second recipient to access internet.

3. A power metering device according to claim 1 or 2 further comprising a storage device in communication with the processor (110) for recording utility data and/or information of the analysis and providing the recorded information to the processor (110) upon request.

4. A power metering device according to claim 1 or 2 further comprising an interface to show utility data and/or analysis information.

5. A system of providing internet service via a power line network comprising
a plurality of power metering devices (100) distributed in the power line network that each power metering device (100) connects to at least one recipients (500), and
a computing processor (110) is housed within each power metering device (100) and is virtually partitioned by a hypervisor (120) to host a first (126) and a second operating systems (125) forming a first and a second subnets through a communication module,
wherein the first subnet connects to a first domain providing access to Internet to the recipient connected to the power metering device (100) and the second subnet connects to a second domain accessible by service provider of the power line for retrieving billing information of the recipient (500) connected to the power metering device (100).

6. A system according to claim 5, wherein the power metering device comprises a plurality of sensors (400) capable of real-time measuring consumption data of the power used by the plurality of recipients (500) that each sensor (400) is responsible for measuring consumption rate of one recipient (500) of the power; and the processor (110) in communication with the plurality of sensors (400) to obtain the measured consumption data for analysis through instructions from one or more software applications.

7. A system according to claim 5, wherein the first subnet and the second subnet are virtually separated.

8. A system according to claim 5, wherein the second subnet is a secured network.

9. A system according to claim 5, wherein the plurality power metering devices (100) are connected to a base station of an Internet service provider for accessing the internet.

10. A method of providing internet access to a plurality of recipients (500) located in a power line network comprising the steps of connecting the at least one recipient (500) to a power metering device (100), incorporated with a computing processor (110), located in the power line network, and

providing internet access service to the connected recipient (500) via the power metering device (100), wherein the computing processor (110) is virtually partitioned by a hypervisor (120) to host a first (126) and a second operating systems (125) forming a first and a second subnets via a communication module that the first subnet connects to a first domain providing access to Internet to the recipient (500) connected to the power metering device (100) and the second subnet connects to a second domain accessible by utility service provider (300) of the power line for retrieving billing information of the recipient connected to the power metering device (100).

11. A method of claim 10, wherein the power metering device comprises a plurality of sensors (400) capable of real-time measuring consumption data of the power used by the plurality of recipients (500) that each sensor (400) is responsible for measuring consumption rate of one recipient (500) of the power; and the processor (110) in communication with the plurality of sensors (500) to obtain the measured consumption data for analysis through instructions from one or more software applications.

12. A method of claim 10, wherein the first subnet and the second subnet are virtually separated.

13. A method of claim 10, wherein the second subnet is a secured network.

14. A method of claim 10, wherein the plurality power metering devices are connected to a base station of an Internet service provider for accessing the internet.

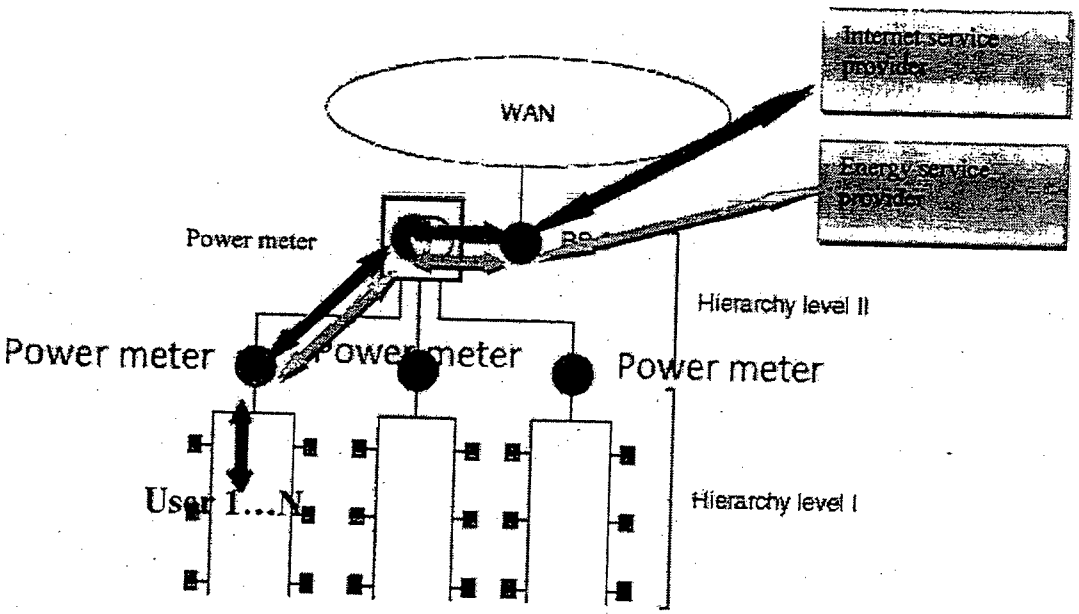
WAN
Internet service provider
Energy service provider
Power meter
Hierarchy level II
Power meter
Power meter
Power meter
User 1...N
Hierarchy level I

Figure 1

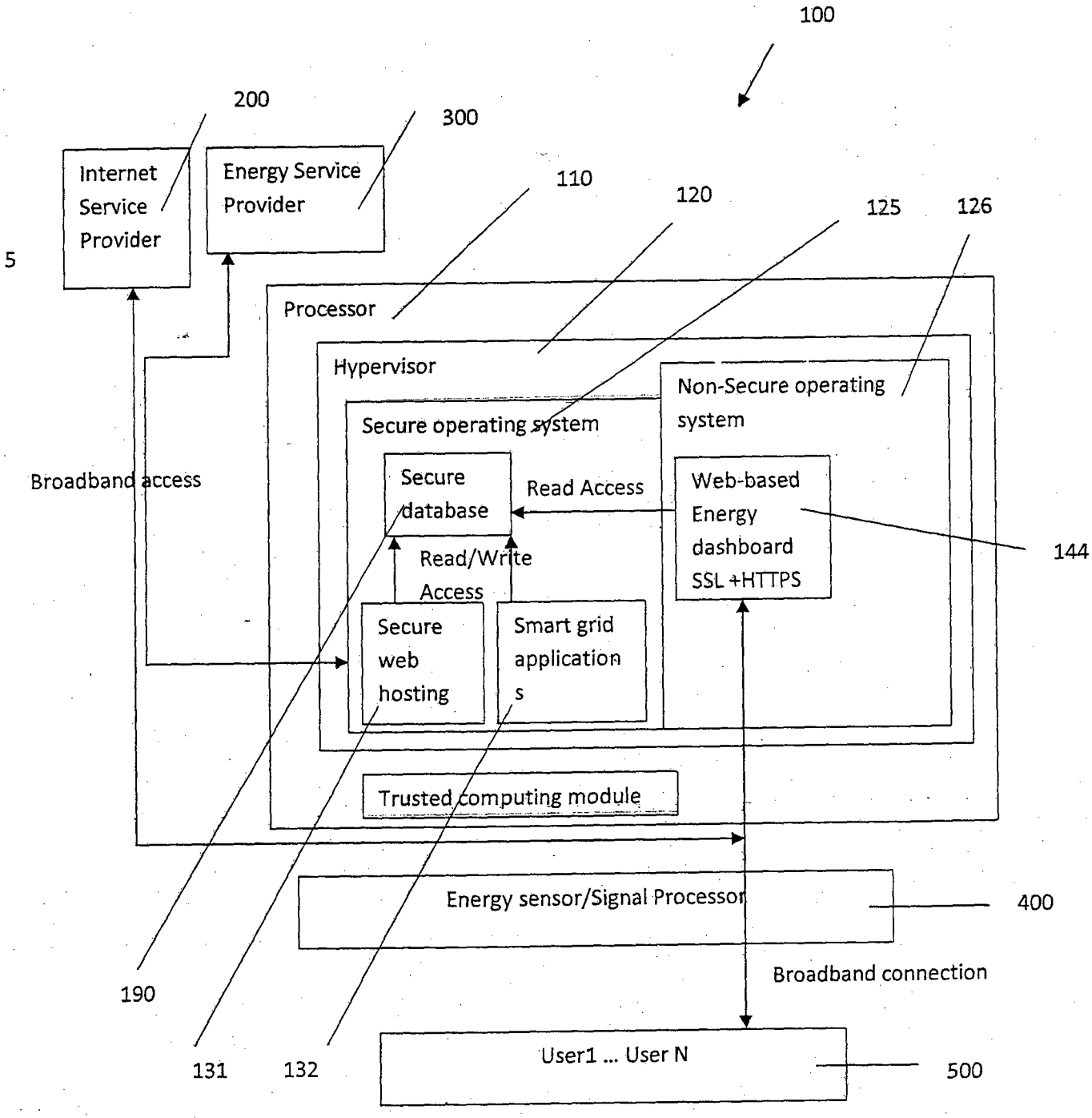
100
200
300
Internet Service Provider
Energy Service Provider
110
120
125
126
5
Processor
Hypervisor
Non-Secure operating system
Secure operating system
Broadband access
Secure database
Read Access
Web-based Energy dashboard SSL +HTTPS
144
Read/Write Access
Secure web hosting
Smart grid applications
Trusted computing module
Energy sensor/Signal Processor
400
Broadband connection
190
131
132
User1 ... User N
500

Figure 2

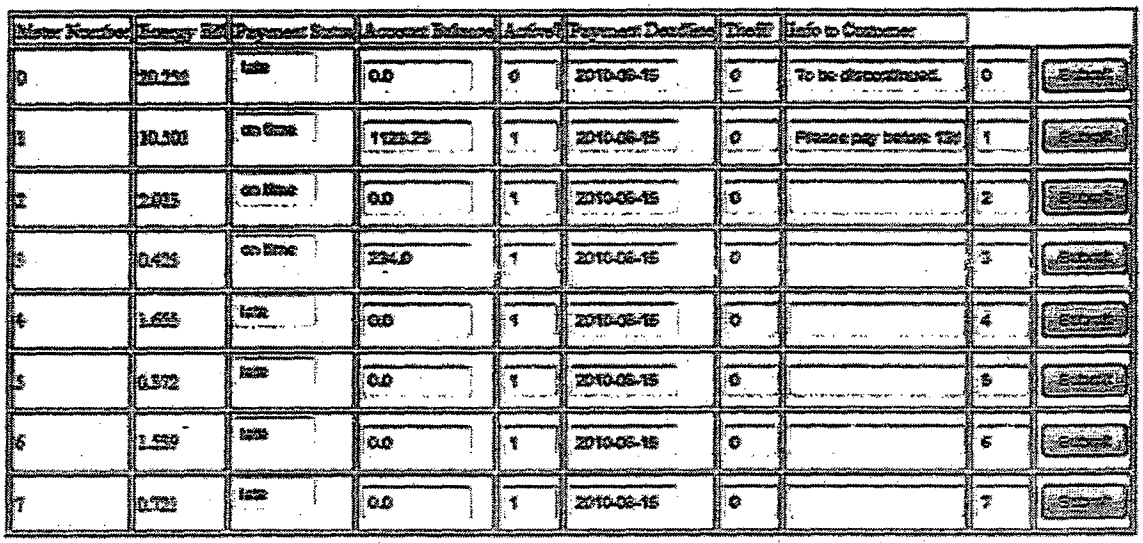
Meter Number
Energy (kWh)
Payment Status
Account Balance
Active?
Payment Deadline
Tariff
Info to Customer
0
1
2
3
4
5
6
7
0.0
1125.25
234.0
2010-06-15
To be disconnected.
Please pay before 12/
Submit

Figure 3

Meter Number	Energy Bill	Payment Status	Account Balance
1	10.501	on time	1123.23
Active Status	**Payment Deadline**	**Theft?**	**Extra Infor**
1	2010-08-15	0	Please pay before 13th

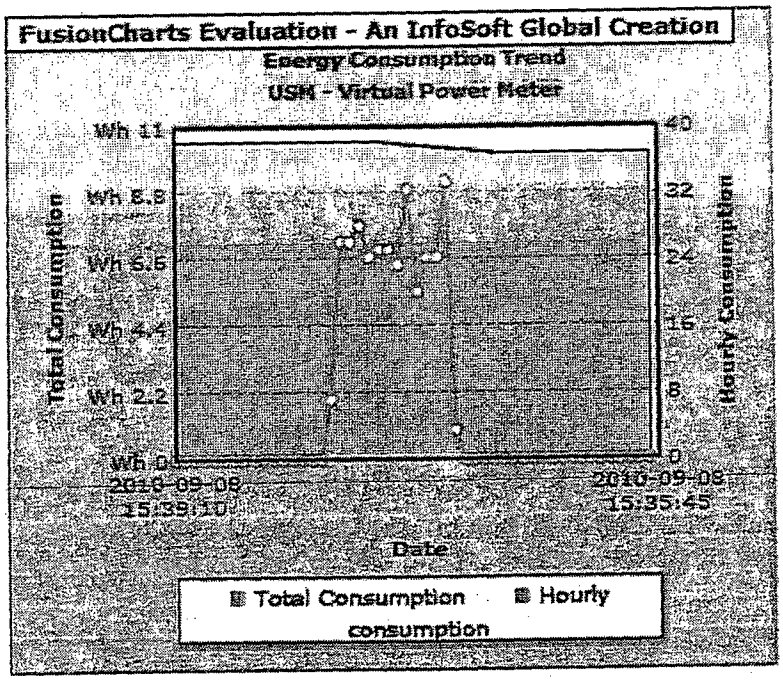

Figure 4

5

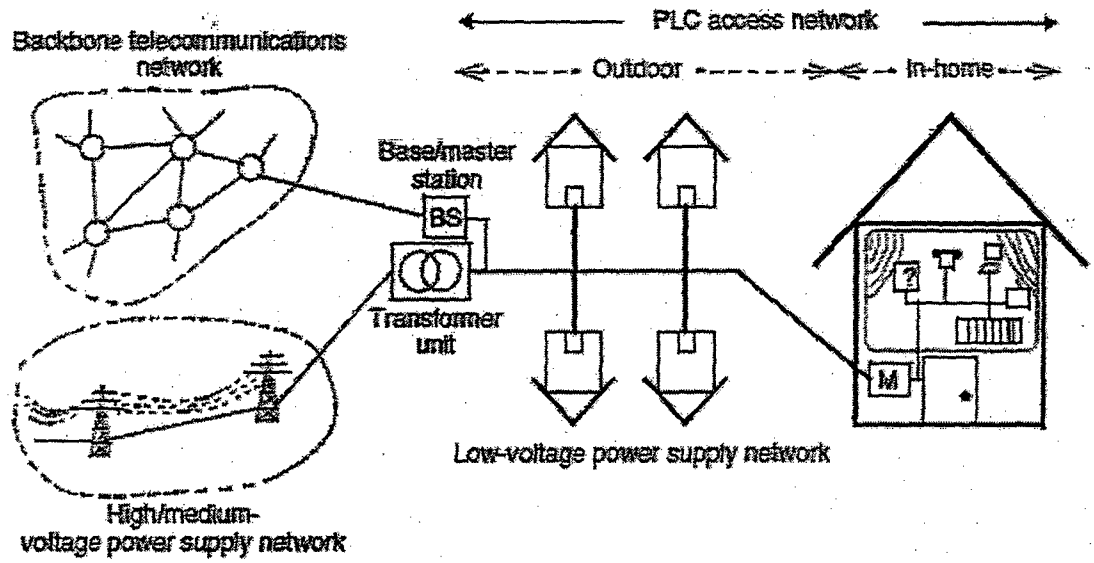
PLC access network
Outdoor
In-home
Backbone telecommunications network
Base/master station
BS
Transformer unit
Low-voltage power supply network
High/medium-voltage power supply network
M

Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/MY2011/000191

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

H04B 3/54 (2006.01) ***G01R 22/06*** (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPI, EPODOC, ESP@CE, USPTO and GOOGLE: Keywords (power, electricity, meter, power, line, communications, billing, internet, modem, network) and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/0114987 A1 (KAGAN) 24 May 2007 See abstract, paras 13, 28 – 32 and fig 1	1 – 14
A	WO 2006/017094 A1 (CENTERPOINT ENERGY, INC.) 16 February 2006 Abstract, para 9 and figures	
A	CN 2862220 Y (FUJIAN GREAT POWER PLC EQUIPME) 24 January 2007 See abstract in English sourced from the ESP@CE website	
A	CN 101237362 A (CITIWAY TECHNOLOGY BEIJING CO.) 6 August 2008 See abstract in English sourced from the ESP@CE website	

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:

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

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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 November 2011	28/11/2011
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. +61 2 6283 7999	Authorized officer **BEN TUOHY** AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6283 7918

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/MY2011/000191

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
US	2007114987	US	7554320	US	2009265124	US	8022690
WO	2006017094	US	2006007016				
CN	2862220	NONE					
CN	101237362	NONE					

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX