

A SYSTEM AND METHOD FOR MONITORING RESIDENTIAL ENERGY CONSUMPTION

Field of the Invention

5 This invention relates to a system and a method for monitoring residential energy consumption remotely. Particularly, this invention relates to a system and a method for obtaining data associated to energy consumption from distribution board and one or more sockets in a monitored premise and analysing the data both locally and remotely, for user visualisation.

Prior Art

10 Smart plugs are currently available for monitoring and controlling of energy consumption of appliances connected to it. In order to monitor all sockets, each socket has to be attached with a smart plug. The smart plug has to be individually configured so
15 that a user is able to identify the socket that is monitored. Thus, a user has to repeat the same setup procedures multiple times.

 The smart plug has to be within a wireless network range in order for the smart plug to be communicatively connected to the home network. Hence, wireless repeaters may be required to extend the wireless network range in order smart plug to be
20 communicatively connected to the home network. This increases the costs of monitoring energy consumption since external devices are required to ensure the smart plugs are communicatively connected to the home network.

 In order to use a smart plug, it has to be directly inserted into an existing socket. This creates an unsightly protrusion and may require re-arrangement of existing furniture
25 to accommodate the protrusion.

 Therefore, those skilled in the art are striving to provide an improved and integrated system and method of monitoring energy consumption.

Summary of the Invention

The above and other problems are solved and an advance in the art is made by a system and method in accordance with this invention. A first advantage of the system and method in accordance with this invention is that the system and method enables early detection of anomalies in the electrical appliances. A second advantage of the system and method in accordance with this invention is that the system and method can be used to monitor the energy consumption trend over a number of residential premises, allowing additional information, such as the energy profiles of household appliances to be derived for ease of future identification. A third advantage of the system and method in accordance with this invention is that the system and method would allow for the switching on or off of the household appliances in the event of any scenario/abnormalities, facilitating the possibility of demand response and/or load curtailment. The fourth advantage of this system and method in accordance with this invention is that the form factor of the equipment associated with the invention is physically integrated by design, without the need to function as an externally plugged device.

A first aspect of the disclosure describes a residential energy consumption monitoring system. The system comprises a smart distribution board (DB) and at least one smart socket outlet. The smart DB comprises a metering board having a number of metering channel, each metering channel is connected to one of a miniature circuit breakers (MCBs) and configured to obtain frequency (Hz), current (A), and voltage (V), a DB processing unit configured to receive data from the metering device and a direct current power supply for driving the processing unit. The at least one smart socket outlet comprises a live inlet connected to one of the MCBs, a neutral inlet, metering device configured to obtain frequency (Hz), current (A), and voltage (V) from the live and neutral inlets, an outlet processing unit configured to receive data from the metering device and

transmit a data package comprising the data from the metering devices to the DB processing unit. The outlet processing unit is communicatively connected to the DB processing unit. One skilled in the art will recognise that the metering board may further be configured to obtain other parameters such as active power, reactive power, power factor, harmonics, etc without departing from the invention.

In accordance with an embodiment of the first aspect, one of the MCBs connected to the live inlet further connects to a live inlet of a conventional socket outlet.

In accordance with an embodiment of the first aspect, the DB processing unit comprises a DB processor, a DB memory and DB instructions stored on the memory and executable by the DB processor to: receive a signature list containing electric load signatures of top N number of common appliances from a main server; store the signature list in the DB memory; and commence data collection from metering board and the at least one smart socket outlet.

In accordance with an embodiment of the first aspect, the DB instruction to commence data collection from metering board and the at least one smart socket outlet comprises DB instructions to: establish connection with the at least one the smart socket outlet; update details in a configuration file stored on the DB memory containing information with respect to connected smart socket outlet, the details being the type of connectivity to connect with the at least one smart socket outlet; obtain data from the metering board, the data comprising frequency, voltage, and current; and receive a data package from the at least one smart socket outlet, the data package comprising frequency, voltage, and current.

In accordance with an embodiment of the first aspect, the configuration file further comprises a protection threshold AC voltage, a protection threshold current and a protection threshold temperature.

In accordance with an embodiment of the first aspect, the smart DB further comprises on/off switch for switching on or off each of the MCBs, and the DB instruction

to commence data collection from metering board and the at least one smart socket outlet further comprises DB instructions to: switch off the MCB in response to one of the rules comprising: AC voltage being above the protection threshold AC voltage, current being above protection threshold current and temperature being above the protection threshold temperature.

In accordance with an embodiment of the first aspect, the DB instruction to commence data collection from metering board and the at least one smart socket outlet further comprises DB instructions to: identify a type of load drawing from the MCBs and smart socket outlet by matching the electric load signatures in the signature list with an electric signature generated by the load drawing through the MCBs and/or smart socket outlet; and transmit a DB data package to the main server, the DB data package comprising the data obtained from the at least one smart socket outlet and/or the metering board wherein the identified type of load is indicated to the respective MCBs and smart socket outlet.

In accordance with an embodiment of the first aspect, the system further comprises the main server. The main server comprises a processor, a memory and instructions stored on the memory and executable by the processor to: receive the DB data package from the smart DB; determine a type of load in response to receiving an undetermined load from the DB data package; and store the DB data package and update a data structure associated to the smart DB and wherein the memory further comprises a signature list containing electric load signatures of a plurality of appliances.

In accordance with an embodiment of the first aspect, the instruction to determine the type of load in response to receiving the undetermined load from the DB data package comprises instructions to: compare an electric load signature of the undetermined load with the electric load signatures in the signature list; in response to a match, identify the appliance associated to the matched electric load signature and send a notification to the user to confirm the identified appliance; and in response to receiving a

confirmation from the user, transmit an updated signature list to the smart DB, the revised signature list containing the electric load signatures of top N number of common appliance and the identified appliance.

5 In accordance with an embodiment of the first aspect, the instructions of the main server further comprise instructions to: receive a request to amend a data structure associated to one of a plurality of smart DB; amend the data structure according to the request; and store the amended data structure.

10 In accordance with an embodiment of the first aspect, the instruction to amend the data structure according to the request further comprises instructions to: in response to the request to include a new appliance to a connected load, amend the data structure associated to the smart DB to include the new appliance against the MCBs or smart socket outlet accordingly.

15 In accordance with an embodiment of the first aspect, the instruction to amend the data structure according to the request further comprises instructions to: amend the signature list to include an electric load signature associated to the new appliance.

In accordance with an embodiment of the first aspect, the instruction to amend the data structure according to the request further comprises instructions to: update an order of the electric load signatures in the signature list.

20 In accordance with an embodiment of the first aspect, the instruction to update an order of the electric load signatures in the signature list comprises instructions to: update a score to each electric load signature, the score being the number of data structures containing the same electric load signature; and arrange the electric load signatures in ascending order where the highest score will be arranged at the top and the lowest score will be arranged at the bottom of the signature list.

25 In accordance with an embodiment of the first aspect, the outlet processing unit comprises an outlet processor, an outlet memory and outlet instructions stored on the outlet memory and executable by the outlet processor to: establish connection with the

smart DB; obtain data from the metering device, the data comprising frequency, voltage, current, and temperature; and transmit an outlet data package to the smart DB, the outlet data package comprising the data obtained from the metering device.

In accordance with an embodiment of the first aspect, the smart socket outlet further comprises: an on/off button configured to switch the outlet processing unit between a smart mode and a conventional mode; a reset button configured to activate a hardware reset to the outlet processing unit; a pairing button configured to activate a pairing between the outlet processing unit with the DB processing unit; a connectivity indicator to indicate whether the outlet processing unit is in communication with the DB processing unit; and an alarm indicator to indicate whether there is an issue with the outlet processing unit.

In accordance with an embodiment of the first aspect, the smart socket outlet further comprises a configuration file having a protection threshold AC voltage, a protection threshold current and a protection threshold temperature.

In accordance with an embodiment of the first aspect, the outlet instruction to obtain data from the metering device further comprises outlet instructions to: switch the on/off switch to off in response to one of the rules comprising: AC voltage being above the protection threshold AC voltage, current being above protection threshold current and temperature being above the protection threshold temperature.

In accordance with an embodiment of the first aspect, the metering device is one of or a combination of voltmeter, ammeter, power energy meter and thermistor.

Brief Description of the Drawings

The above and other features and advantages in accordance with this invention are described in the following detailed description and are shown in the following drawings:

Figure 1 illustrating an overview of the network infrastructure for the system in accordance with an embodiment of this disclosure;

Figure 2 illustrating a front view of a smart DB in accordance with an embodiment of this disclosure;

5 Figure 3 illustrating a side, front and rear views of a smart socket outlet in accordance with an embodiment of this disclosure;

Figure 4 illustrating a block diagram of components in the smart DB in accordance with an embodiment of this disclosure;

10 Figure 5 illustrating a block diagram of components in the smart socket outlet in accordance with an embodiment of this disclosure;

Figure 6 illustrating a processing unit of a main server in accordance with an embodiment of this disclosure;

Figure 7 illustrating a process flow for testing a smart DB in accordance with an embodiment of this disclosure;

15 Figure 8 illustrating a process flow for setting up a smart DB in accordance with an embodiment of this disclosure;

Figure 9 illustrating a process flow performed by the smart socket outlet in accordance with an embodiment of this disclosure;

20 Figure 10 illustrating a process flow performed by the smart DB in accordance with an embodiment of this disclosure;

Figure 11 illustrating a timing diagram on the information flow among the smart DBs, main server, third party server and mobile device DB in accordance with an embodiment of this disclosure; and

25 Figure 12 illustrating a process flow performed by the main server in accordance with an embodiment of this disclosure.

Detailed Description

This invention relates to a system and a method for monitoring and control of residential energy consumption remotely. Particularly, this invention relates to a system and a method for obtaining data associated to energy consumption from distribution board and one or more sockets in a monitored premise and analysing the data locally or
5 remotely.

It is envisioned that a system and a method in accordance with embodiments of this invention may be used for remote monitoring and obtaining information on the energy consumption of a residential premise. The system and method according to this invention provides the ability of monitoring energy consumption of a residential premise
10 continuously so that any abnormalities can be easily flagged up as soon as possible. The system and method according to this invention also provides the ability to remotely switch off the appliance if connected to smart socket outlet. The system and method comprises 2 parts, namely, data collection and analysis.

The data collection part comprises smart distribution board (DB) and smart
15 sockets to obtain information pertaining to the energy consumption and other pertinent information from the smart DB and smart sockets. Data from other sensors, such as smoke detector and motion sensor, can also be collected through the smart DB which may be used to switch off the connected appliance(s). All the information is transmitted to a main server for collection, analytics, and other processing procedures including user
20 visualisation/interfacing.

The analysis part comprises processes to reading the data collected and stored on the main server and providing an analysis accordingly. The analysis may also be performed by the smart DB. The processes include determining anomaly such as power trip or surge, energy consumption, appliances in use, etc. A detailed description of the
25 system and/or method in accordance with embodiments of this invention will now be described as follows.

Figure 1 illustrates an overview of the system 100 for performing the processes in accordance with this invention. The system 100 includes a smart DB 110, smart socket outlet 120, conventional socket outlet 150, main server 160, third party server 180 and mobile device 190.

Each residential premise will be provided with a smart DB 110, a number of smart socket outlets 120 and a number of conventional socket outlets 150. As shown in figure 1, the smart and conventional socket outlets 120 and 150 are distributed in the bedroom 131, living room 132, and kitchen 133. In particular, one smart socket outlet 120 and one conventional socket outlet 150 are provided in the bedroom 131 which are connected to a first circuit breaker in the smart DB 110; one smart socket outlet 120 and two conventional socket outlets 150 are provided in the living room 132 which are connected to a second circuit breaker in the smart DB 110; and one smart socket outlet 120 and two conventional socket outlets 150 are provided in the kitchen 133 which are connected to a third circuit breaker in the smart DB 110. One skilled in the art will recognise that the arrangement of the smart socket outlets 120 and conventional socket outlets 150 as shown in figure 1 is meant to be illustrative only and other arrangement may be implemented without departing from the invention. For example, two circuit breakers may be allocated to living room 132 where three conventional sockets 150 and one smart socket outlets 120 may be connected to one of the circuit breakers while two conventional sockets 150 and one smart socket outlets 120 may be connected to the other circuit breaker. Further, it is common that some circuit breakers are dedicated power lines where only one socket is connected to one circuit breaker. Such dedicated circuit breaker will not require a smart socket since the appliance connected to the conventional socket outlet 150 can be monitored directly from the smart DB. Importantly, each non-dedicated circuit breaker in the smart DB should be connected to at least one smart socket outlet 120 and at least one conventional socket outlet 150. One skilled in the art will also recognise that although one smart DB 110 is shown in figure 1, a number of smart DBs

110 may be provided to monitor a number of residential premises without departing from the invention. For example, a residential estate may comprise several residential units and one smart DB may be allocated to each residential unit so that granular energy consumption up to the residential unit can be monitored. Further, each smart socket outlet 120 may introduce resonance which may affect the electrical grid or interfere with the home network. Hence, the implementation of a smart DB and smart socket outlets can avoid affecting the electrical grid or interfering with the home network. Further details pertaining to the smart DB 110 and the smart socket outlet 120 will be described further below.

The main server 160 and third party server 180 are typical processing systems such as a desktop computer, laptop computer, or other computer terminal capable of handling large data storage and processing need. Main server 160 and third party server 180 are communicatively connected to network 170 via either a wired or wireless connection to retrieve data from smart DB 110 and/or mobile device 190. One skilled in the art will recognise that more than one server 110 and one third party server 180 may be used without departing from the invention. Further details of the server 110 and third party server 180 will be described below.

Smart DB

The smart DB 110 has a communication interface to allow transferring and receiving of information over a wired or wireless connection to allow the smart DB 110 to be communicatively connected to the main server 160 via a network 170. The smart DB 110 may be connected to the network 170 directly or via a home network. Figure 2 shows a possible arrangement of the components in the smart DB 110 while figure 4 shows the block diagram of the smart DB 110. The smart DB 110 comprises a processing unit 210, DC power supply 220, fuse 230, module board B 240, metering board 250, incoming miniature circuit breaker (MCB) 260, Residual Current Device (RCD) 270 and outgoing MCB 280.

The smart DB 110 can receive and transmit data, execute software applications. The processing unit 210 comprises a processor 410, memory 420, network device 430, and input/output ports 440. The processing unit 210 is powered by the DC power supply 220 which draws directly from the one of the outgoing MCB 280. Fuse 230 is connected
5 between DC power supply 220 and the outgoing MCB 280.

The processor 410 is a processor, microprocessor, microcontroller, application specific integrated circuit, digital signal processor (DSP), programmable logic circuit, or other data processing device that executes instructions to perform the processes in accordance with the present invention. The processor 410 has the capability to execute
10 various applications that are stored in the memory 420.

The memory 420 may include read-only memory (ROM), random-access memory (RAM), electrically erasable programmable ROM (EEPROM), flash cards, or any memory commonly used for computers.

Network device 430 connects processor 310 to a network for transmission of data
15 to and from other processing systems. The network device 330 is communicatively connected to the main server 160 via the network 170. To minimise cost, the network device 430 is communicatively connected to a home network which in turn is connected to the network 170. This means that additional wirings are not required since the data can be transmitted to the network device 430 of processing unit 210 via the power lines. In
20 another embodiment, network device 430 uses wired communication means such as dedicated Lan cables to connect network device 430 to home network and/or network device 530. In yet another embodiment, network device 430 uses wireless communication means such as Wireless Fidelity (Wi-Fi), Zigbee, and Bluetooth to communicate with home network and/or network device 530. In yet another embodiment,
25 network device 430 comprises both wired and wireless communication means to communicate with home network and/or network device 530.

The processing unit 120 is configured to obtain readings from the metering board 250 that is connected to the MCBs and the thermistor and transmit the readings to the main server. The network device 430 is also communicatively connected to the smart socket outlets 120 to obtain data package from the respective smart socket outlets 120.

5 One or more input/output (I/O) ports 440 can be configured to allow the processor 410 to communicate with and control from various I/O devices. Peripheral devices that may be connected to smart DB 110 via the I/O ports 440 include a USB storage device, an SD card or other device for relaying information to or from the smart DB 110. In addition to updating applications stored on memory 420 or installing new applications
10 onto the memory via the network device 430, a user may alternatively install new applications or update applications on the memory 420 through a user interface such as a USB via the I/O ports 440. I/O ports 440 also include necessary connectors to connect to a plurality of devices for monitoring energy consumption drawn from the outgoing MCB 280. This includes an analog-to-digital converter (ADC) 441, metering devices 250,
15 thermistor 443 and relay on/off switch 444. Other peripheral devices that may be connected to smart DB 110 via the I/O ports 440 include smoke detectors, door sensors or other sensors that may be used for monitoring a residential premise. This allows the owner of the residential premise to consolidate the data collection from various peripheral devices via the smart DB 110.

20 One skilled in the art will recognize that other features may be included in the processing unit 210. Further, the components in processing unit 210 may be replaced by other components that perform similar functions. In brief, the processing unit 210 as shown in figure 4 is considered merely illustrative and non-limiting. Essentially, the processing unit 210 is a multi-input data acquisition module, configured to obtain
25 measurements from the distribution board.

Briefly, the analogue signals received from the metering board 250 and thermistor 443 are converted to digital signals by the ADC 441. The digital signals are then received by the processor 410 via the I/O ports.

The metering board 250 is connected to the outgoing MCBs. Specifically, the metering board 250 comprises metering devices and each metering device is connected to each outgoing MCB. The metering device is configured to obtain the frequency, current, and voltage and any other pertinent information of the load drawing from the smart socket outlet. Some examples of metering device are voltmeter, ammeter, power energy meter, etc. This allows the processing unit to obtain the frequency, current, voltage, active power, reactive power, apparent power and any other information that are being drawn out from each outgoing MCBs 280. As mentioned above, each non dedicated outgoing MCB is connected to the live inlet of one smart socket outlet and at least one conventional socket outlet. In one embodiment, the metering board is a current transformer (CT) board. The thermistor 443 is connector to a temperature sensor such as a thermometer to obtain the temperature within the housing of the smart DB 110.

Each processing unit 210 is required to send a data package to the main server 160. The data package contains frequency, current, voltage, active power, reactive power, temperature and a time stamp. Specifically, the data package may in the following format, $[MF_{1...n}, MI_{1...n}, MV_{1...n}, MP_{1...n}, MQ_{1...n}, MT, SF_1, SI_1, SV_1, SP_1, SQ_1, ST_1, SF_2, SI_2, SV_2, SP_2, SQ_2, ST_2, SF_3, SI_3, SV_3, SP_3, SQ_3, ST_3, XXXXDDDDDD]$, where MF refers to frequency from the smart DB, MI refers to current from the Smart DB, MP refers to active power consumption in load from the smart DB, MQ refers to reactive power consumption in load from the smart DB, MV refers to voltage from the smart DB, MT refers to temperature from the smart DB, SF refers to frequency from the respective smart socket outlet 120, SI refers to current from the respective smart socket outlet 120, SV refers to voltage from the respective smart socket outlet 120, SP refers to active power consumption in load from the respective smart socket outlet 120, SQ refers to reactive

power consumption in load from the respective smart socket outlet 120, ST refers to temperature the respective Smart socket outlet 120, XXXX refers to time in 24 hours format and DDMMYY refers to day month and year, n refers to the number of metering devices 442. One skilled in the art will recognise that other any other information that may
5 be being drawn out from each outgoing MCBs 280, through the metering board such as a CT board, may be transmitted to the server without departing from the disclosure. Hence, the data package as described above is non-exhaustive and further information may be included.

Smart socket outlet

10 The smart socket outlet 120 has a communication interface to allow transferring and receiving of information over a wired or wireless connection to allow the smart socket outlet 120 to be communicatively connected to the smart DB 110. Figure 3 shows the side 370, front 380 and back 390 view of the smart socket outlet 120 and the relevant components while figure 5 shows the block diagram of the communication interface of the
15 smart socket outlet 120. The smart socket outlet 120 comprises a processing unit 310, conventional earth 320, live 330 and neutral 340 inlet, on/off button 311, reset button 312, paring button 313, connectivity indicator 314, alarm indicator 315, and on/off indicator 316. The earth inlet 320, live inlet 330 and neutral inlet 340 operate as conventional 3 pins socket in accordance to the Singapore Standard (SS) SS-145. One skilled in the art
20 will recognise that although the description describes 3 pins socket, it would be plausible for those skilled in the art to implement the smart socket outlet 120 based on 2 pins socket such as the CEE 7/3 socket. Importantly, only the live inlet 330 would be relevant to the disclosure as the metering device is connected to the live inlet 330 to obtain the power consumption of the load drawing power from the smart socket outlet 120.

25 The smart socket outlet 120 can receive and transmit data, execute software applications. The processing unit 310 comprises a processor 510, memory 520, network device 530, and input/output ports 540. The processing unit 510 is powered by the DC

power supply 550 which draws directly from the live and neutral inlet 330 and 340. The processing unit 310 acts as the communication interface of the smart socket outlet 120.

The processor 510 is a processor, microprocessor, microcontroller, application specific integrated circuit, digital signal processor (DSP), programmable logic circuit, or other data processing device that executes instructions to perform the processes in accordance with the present invention. The processor 510 has the capability to execute various applications that are stored in the memory 520.

The memory 520 may include read-only memory (ROM), random-access memory (RAM), electrically erasable programmable ROM (EEPROM), flash cards, or any memory commonly used for computers.

Network device 530 connects processor 310 to a network for transmission of data to and from other processing systems. The network device 530 is communicatively connected to the network device 430 of processing unit 210. To minimise cost, the network device 530 uses broadband over power lines (BPL) communication. This means that additional wirings are not required since the data can be transmitted to the network device 430 of processing unit 210 via the power lines. In another embodiment, dedicated lines such as Lan cables may be provided to connect network device 530 and network device 430. In yet another embodiment, network device 530 uses wireless communication means such as Wireless Fidelity (Wi-Fi), Zigbee, and Bluetooth to communicate with network device 430. In yet another embodiment, network device 530 comprises both wired and wireless communication means to communicate with network device 430. Network device 530 allows transmission of data package containing pertinent information to the network device 430, and receives instructions from the network device 430. This enables a user to locally monitor and control the smart socket outlet 120 via mobile device via a trusted application (or web-based browser), in the absence of internet connectivity within the residential premise. If internet connectivity is available, a user is

able to remotely monitor and control the smart socket outlet 120 via mobile device via a trusted application (or web-based browser).

The processing unit 310 is configured to obtain readings of a connected load from the smart socket outlet 120 and transmit a data package containing the readings to the smart DB 110. The data package includes frequency (Hz), current (A), voltage (V), temperature (°C), Power (W), and Energy Consumption (kWh). One skilled in the art will recognise that the data package may contain other information depending on the type of metering device used to obtain information from the live inlet.

One or more input/output (I/O) ports 540 can be configured to allow the processor 510 to communicate with and control from various I/O devices. Peripheral devices that may be connected to smart socket outlet 120 via the I/O ports 540 include a USB storage device, an SD card or other storage device for transmitting information to or receiving information from the smart socket outlet 120. In addition to updating applications stored on memory 520 or installing new applications onto the memory via the network device 530, a user may alternatively install new applications or update applications on the memory 520 through a user interface such as a USB via the I/O ports 540. I/O ports 540 also include necessary connectors to connect to a plurality of devices for monitoring energy consumption drawn from the live 330 and neutral 340 power lines. This includes an analog-to-digital converter (ADC) 541, metering devices 542, thermistor 543, on/off button 311, reset button 312, pairing button 313, connectivity indicator 314, alarm indicator 315, and on/off indicator 316. I/O ports 540 also include relay On/Off switch 544 to switch on or switch off the socket.

The on/off button 311 allows a user to enable/disable the processing unit 310 between smart and conventional mode. When the conventional mode is activated, the smart features of the smart socket outlet be deactivated. The reset button 312 allows a user to activate a hardware reset to the processing unit 310. The pairing button 313 allows a user to activate a pairing between the processing unit 310 with the processing unit 210

of the smart BD 110. The connectivity indicator 314 indicates whether the processing unit 310 is in communication with the processing unit 210 of the smart DB 110. The alarm indicator 315 indicates whether there is an issue with the processing unit 310. The on/off indicator 316 indicates whether the processing unit 310 is in the smart or conventional mode.

One skilled in the art will recognize that other features may be included in the processing unit 310. Further, the components in processing unit 310 may be replaced by other components that perform similar functions. In brief, the processing unit 310 as shown in figure 5 is considered merely illustrative and non-limiting. Essentially, the processing unit 310 is a multi-input data acquisition module, configured to obtain measurements from the distribution board.

Briefly, the analogue signals received from the metering devices 542 and thermistor 543 are converted to digital signals by the ADC 541. The digital signals are then received by the processor 510 via the I/O ports.

The metering devices 542 are connected to the live 330 outlet. The metering devices are configured to obtain the frequency, current, and voltage and any other pertinent information of the load drawing from the smart socket outlet. Some examples of metering devices are voltmeter, ammeter, power energy meter, etc. This allows the processing unit to obtain the frequency, current, and voltage that are being drawn out from the live 330 outlet. The thermistor 543 is connector to a temperature sensor such as a thermometer to obtain the temperature within the housing of the smart socket outlet 120.

The processing unit 310 is required to send a data package to the smart DB 110. The data package contains frequency, current, voltage, active power, reactive power, and temperature. Specifically, the data package may in the following format, $[SF_s, SI_s, SV_s, SP_s, SQ_s, ST_s]$.

The smart socket outlet 120 shall also meet the following requirements:

1. Rated 13A or 15A, 230VAC @ 50Hz.

2. Include an overload and overheat protection function.

3. Manual switch 351 for switching on and off of the device. The manual switch 351 may be a mechanical switch which is either single-pole or double-pole to effect switching of the line current.

4. A British Standard (BS) 1 Gang Type. The exterior front plate shall be based on SS-145 requirements with an estimated dimension of 86X86mm.

5. Suitable for mounting onto a standard BS 1 Gang Metal/Plastic Flush Box with estimated dimensional sizes of: 70(Length) x 70(Breadth) x 38(Depth) mm.

6. Suitable for existing wiring practice in a fixed installation (i.e. Ring or Radial electrical wiring circuit)

7. Each smart socket outlet operates independently.

One skilled in the art will recognise that the above requirements are based on standards approved by the relevant regulators. Hence, the requirements as stated above are not meant to be limiting and is meant to be illustrative only and other requirements may be implemented without departing from the invention.

Server

Processes stored as instructions in a media that are executed by a processing system in main server 160 or third party server 180 provides the method and/or system in accordance with this invention. The instructions may be stored as firmware, hardware, or software. Figure 6 illustrates processing system 600 or a virtual machine running on the processing system 600 in main server 160 or third party server 180 that execute the instructions to perform the processes for providing a method and/or system in accordance with this invention. One skilled in the art will recognize that the exact configuration of each processing system may be different and the exact configuration of the processing system in each device may vary. Thus, processing system 600 shown in Figure 6 is given by way of example only.

Processing system 600 includes Central Processing Unit (CPU) 605. CPU 605 is a processor, microprocessor, or any combination of processors and microprocessors that execute instructions to perform the processes in accordance with the present invention. CPU 605 connects to memory bus 610 and Input/ Output (I/O) bus 615. Memory bus 610 connects CPU 605 to memories 620 and 625 to transmit data and instructions between the memories and CPU 605. I/O bus 615 connects CPU 605 to peripheral devices to transmit data between CPU 605 and the peripheral devices. One skilled in the art will recognize that I/O bus 615 and memory bus 610 may be combined into one bus or subdivided into many other busses and the exact configuration is left to those skilled in the art.

A non-volatile memory 620, such as a Read Only Memory (ROM), is connected to memory bus 610. Non-volatile memory 620 stores instructions and data needed to operate various sub-systems of processing system 600 and to boot the system at start-up. One skilled in the art will recognize that any number of types of memory may be used to perform this function.

A volatile memory 625, such as Random Access Memory (RAM), is also connected to memory bus 610. Volatile memory 625 stores the instructions and data needed by CPU 605 to perform software instructions for processes such as the processes required for providing a system in accordance with this invention. One skilled in the art will recognize that any number of types of memory may be used as volatile memory and the exact type used is left as a design choice to those skilled in the art.

I/O device 630, keyboard 635, display 640, memory 645, network device 650 and any number of other peripheral devices connect to I/O bus 615 to exchange data with CPU 605 for use in applications being executed by CPU 605. I/O device 630 is any device that transmits and/or receives data from CPU 605. Keyboard 635 is a specific type of I/O that receives user input and transmits the input to CPU 605. Display 640 receives display data from CPU 605 and display images on a screen for a user to see.

Memory 645 is a device that transmits and receives data to and from CPU 605 for storing data to a media. Network device 650 connects CPU 605 to a network for transmission of data to and from other processing systems such as smart DB 110 and mobile device 190.

Mobile device

5 Mobile devices 190 may be a mobile phone, a personal digital assistant (PDA), a portable computer, a tablet or other similar mobile device without departing from the invention. The mobile device 190 is equipped with telecommunication network interface in order to communicate with the main server 160, third party service providers 180 and the home network to access the smart DB 110 and smart socket outlet 120. Essentially,
10 the mobile device 190 is a device to allow a user to access the data from the main server 160, third party 180 and smart DB 110. Hence, mobile device 190 may not be restricted to portable devices. Instead, mobile device 190 may also include desktop computer. Essentially, mobile device 190 allows a user to access data at the monitored residential premise or from a remote location.

15 Mobile device 190 includes a processor, a radio transceiver, an image capturing device, a display, a keypad, a memory, an audio module, a Near Field Communication (NFC) module, and an I/O device. The radio transceiver, image capturing device, display, keypad, memory, audio module, NFC module, I/O device and any number of other peripheral devices connect to processor to exchange data with processor for use in
20 applications being executed by processor.

 The radio transceiver is connected to an antenna which is configured to transmit outgoing voice and data signals and receive incoming voice and data signals over a radio communication channel. The radio communication channel can be a digital radio communication channel such as a CDMA, GSM, LTE channel or any other subsequent
25 generations of telecommunication network channels (such as 5G network) that employs both voice and data messages in a conventional technique.

 The image capturing device is any device capable of capturing still and/or moving images. The display receives display data from processor and display images on a screen for a user to see. The keypad receives user input and transmits the input to

processor. In some embodiments, the display may be a touch sensitive surface that functions as a keypad to receive user input.

The memory is a device that transmits and receives data to and from processor for storing data to a memory. The audio module may include a microphone, an earpiece and a headset. A microphone is a device that transmits audio data to processor. An earpiece is a device that receives audio data from the processor. The headset is a device that transmits and receives audio data to and from the processor. The NFC module is a module that allows device to establish radio communication with another similar device by touching them together or by bringing the devices within a close proximity. The NFC module enables the mobile device 190 to make contactless communication with another mobile device 190, smart DB 110 or smart socket outlet 120.

Other peripheral devices that may be connected to processor include a Bluetooth transceiver, a Wi-Fi transceiver and a Global Positioning System (GPS).

The processor is a processor, microprocessor, or any combination of processors and microprocessors that execute instructions to perform the processes in accordance with the present invention. The processor has the capability to execute various application programs that are stored in the memory. These application programs can receive inputs from the user via the display having a touch sensitive surface or directly from a keypad. Some application programs stored in the memory that can be performed by the processor are application programs developed for iPhone, Android, Windows Mobile, Blackberry or other mobile platforms.

Setup procedure

Before the smart DB can be used, a testing procedure will be executed to ensure the smart DB conforms to certain standards. Figure 7 illustrates a process 700 of a process flow for testing a smart DB. Process 700 begins with step 705 by ensuring that the supply at the meter board is switch off. This cuts off supply from the meter board to the smart DB.

In step 710, ensures that all incoming and outgoing supply is switched off. Specifically, the incoming MCB 260, ELCB 270 and outgoing MCB 280 are switched off.

In step 715, ensures that the 2A fuse carrier 230 for isolation of ELV components is opened.

In step 720, a qualified technician performs the necessary testing of the incoming submain and outgoing cables. The test includes megger test and polarity test. One skilled
5 in the art will recognise that other test may be required which is dependent on the requirements from the relevant agency. Importantly, test on the smart DB commences after the necessary switches are switched off.

After tests are completed, the 2A fuse carrier 230 for isolation of ELV components is closed in step 725.

10 In step 730, all incoming and outgoing supply is switched on. Specifically, the incoming MCB 260, RCD 270 and outgoing MCB 280 are switched on.

In step 735, the supply at the meter board is switched on. Then a certification will be issued and process 700 ends. The certification includes IEC 61439-3, IEC 60255-1 and IEC 61869-1&2.

15 After certifying the smart DB, a user has to register and setup the smart DB 110 and the connected smart socket outlet 120. Figure 8 illustrates a process 800 of a process flow for setting up the smart DB and smart socket outlets. The process 800 is executable via a mobile application. Process 800 begins with step 805 by connecting the mobile device to the smart socket outlets. This can be achieved by entering the
20 registration number printed on the smart socket outlet. The registration number may be represented by a QR code. If a QR code is available, a user may simple activate the camera of the mobile device to capture the QR code instead of entering the registration number. The application will execute the necessary processes in order to connect the mobile phone to the smart socket outlet using the registration number. The registration
25 number is stored in the memory. This step is repeated for all smart socket outlets that are connected to a smart DB so that the registration numbers of all the smart socket outlets are stored in the memory.

In step 810, process 800 connects the mobile device to the smart DB. Similar to connecting to the smart socket outlet, this can be achieved by entering the registration number printed on the smart DB. The registration number may be represented by a QR code. If a QR code is available, a user may simple activate the camera of the mobile device to capture the QR code instead of entering the registration number. The application will execute the necessary processes in order to connect the mobile phone to the smart DB using the registration number.

In step 815, process 800 connects the smart DB and the smart socket outlets based on the registration numbers of the smart socket outlets stored in the memory. A configuration file in the memory of the smart DB will be updated to register the connected smart socket outlet.

In step 820, process 800 connects the smart DB to the internet via a local network. Specifically, the mobile device scans for available local network and prompt the user to select the local network and enter the password. Once the name of the local network and password are entered, the name of the local network and password are transmitted to the smart DB and in turn the smart DB will attempt to connect to the internet via the selected local network using the name of the local network and password.

After the smart DB connects to the internet via the local network, process 800 obtains setup information in step 825. Specifically the user will be required to enter the address and an identification number such as mobile number and a password in step 825. The address, identification number, registration number and password will be transmitted to the main server in step 830 so that a new data structure can be created.

In step 835, in response to receiving the address, identification number, registration number and password, the main server creates a new data structure for the smart DB. The new data structure comprises the information described in table 1 below. The main server would thereafter transmit a success message with a signature list containing the electric load signature of top N number of common appliances. The electric

load signature is based on a combination of voltage, current and frequency readings produced by each appliance. Data collection will commence after creation of the data structure for the smart DB. Process 800 ends after step 835. The process 800 is executable via a mobile application developed by a developer that manages the main server. To allow flexibility, the mobile application may contain an option to the user to select a third party server. This allows a user to select a third party to collect data instead of the default main server. For example, the default main server may be a public database that is available to the public while the third party server may be a secured server that is not available to the public. Hence, allowing users to store their data privately.

Data collection and processes performed by the Smart socket outlet

Figure 9 illustrates a process 900 of a process flow performed by the processing unit 310 upon powering up by way of the on/off button 331. Process 900 begins with step 902 by pairing the smart socket outlet 120 with a connected smart DB 110.

After the smart socket outlet 120 is paired with the smart DB 110, process 900 proceeds to step 905 to determine whether a signal is received from the reset button. If a signal is received, process 900 proceeds to step 910. Otherwise, process 900 proceeds to step 915.

In step 910, process 900 resets a configuration file to default data. The default configuration file is as follows:

Name: Smart socket 1

Rating of voltage: 195 VAC ~ 265 VAC

Rating of frequency: 50Hz

Rating of current: 13A

Protection Threshold voltage: 274 VAC

Protection Threshold Current: 14A

Protection Threshold temperature: 85°C

Password: 123456

The configuration file contains the information required to perform the processes executable by the processing unit 310. One skilled in the art will recognise that the above parameters (other than name and password) are based on standards approved by the relevant regulators. Hence, the parameters (other than name and password) as stated above are not meant to be limiting and is meant to be illustrative only and other parameters may be implemented without departing from the invention.

In step 915, process 900 determines whether an instruction is received from an external device such as mobile device 190 or a mobile device to configure the smart socket outlet 120. If an instruction is received from an external device, process 900 proceeds to step 920. Otherwise, process 900 proceeds to step 930.

In step 920, process 900 will act according to instructions received from the external device after the external device provides a password that corresponds to the password in the configuration file. The instructions may include changing the parameters in the configuration file, receiving the data from the metering devices and thermistor, or switching on or off the socket by triggering the on/off switch 544. If the instruction is to change the parameters in the configuration file, the process will receive the changes from the external device and amend the configuration file according to the changes received. For example, if the changes received include change of name, the process will amend the configuration file to include the new name received from the external device. The rating of voltage, frequency and current; protection threshold voltage, current and temperature; and password can be amended by a user via the external device. The switching on or off the socket by triggering the on/off switch 544 allows the flexibility to the user to remotely switch on or off appliance. Steps 905 and 915 are essentially interrupts that pause the data collection of the smart socket outlet to reconfigure the configuration file and act according to instructions received from user respectively. It should be noted that steps 905 and 915 are instructions received from external device such as mobile device 190 via

local network or short range network. If the mobile device 190 is at a remote location, the mobile device 190 has to send instructions to the smart socket outlet via the smart DB. For example, if the mobile device 190 wishes to switch off a smart socket outlet, the mobile device 190 has to send instruction to the smart DB which in turn relays the instruction to the smart socket outlet to switch off the socket by triggering the on/off switch 544.

In step 930, process 900 obtains data from the metering devices and thermistor. After the data is obtained from the metering devices and thermistor, process 900 determines whether the current, voltage, and temperature are above protection threshold current, voltage and temperature. If any one of the current, voltage, and temperature is above protection threshold current, voltage and temperature, process 900 will activate the alarm indicator and turn off the switch by triggering the on/off switch 544.

In step 935, process 900 generates and transmits data package to the smart DB 110. The data package includes frequency, current, voltage, and temperature.

Process 900 repeats from step 905 after step 935. However, if the connection between the smart DB and the smart socket outlet is broken and process 900 is unable to transmit data package to the smart DB 110, process 900 repeats from step 902 to re-establish connection with the smart DB.

While process 900 describes a process executable by the smart socket outlet 120 and in communication with the smart DB 110, one skilled in the art will recognise that it would be possible to configure the smart socket outlet 120 to be in direct communication with a mobile device 190 so that a user can amend the configuration file or read current data obtained from metering devices and thermistor. However, such connectivity between the smart socket outlet 120 and mobile device 190 is available via short range network such as WiFi, Bluetooth, etc.

Data collection and processes performed by the Smart DB

Figure 10 illustrates a process 1000 of a process flow performed by the processing unit 210 upon powering up to commence data collection or act according to instructions received from user. It should be noted that after setting up the smart DB and smart socket outlets as described in process 800, the configuration file for the smart DB would be stored on the memory of the smart DB. Further, a signature list containing electric load signatures of top N number of common appliances received from the main server would be stored on the memory of the smart DB. It should be noted that the smart DB is not meant to solely collect data and transmit the data to the main server. Rather, the smart DB functions as an edge computer to collate data from a residential premise; and perform certain analysis such as identifying appliance based on electric load signature obtained from the MCBs and smart socket outlets, and determining anomalies in the power drawn by the same load over a predetermined time period.

Process 1000 begins with step 1002 by pairing the smart DB 110 with connected smart socket outlet 120 listed in the configuration file under connected smart socket outlet. It should be noted that in the event the smart socket outlets only implements wireless connectivity, smart socket outlets that may be out of the wireless communication range may be connectable to the smart DB via relay from smart socket outlet that is within the wireless communication range of both out of range smart socket outlet and smart DB. In another embodiment where smart socket outlets contain both wireless and wire communication protocol, the smart DB may automatically select wire communication with smart socket outlet that is out of the wireless communication range or with poor wireless signal. After the smart DB 110 is paired with smart socket outlet 120, process 1000 updates the details pertaining to the connected smart socket outlet in the configuration file and commence receiving data packages from the connected smart socket outlet. For example, the details to be updated in the configuration file may be the type of connectivity.

In step 1005, process 1000 determines whether an instruction is received from an external device such as mobile device 190 or a mobile device to configure the smart DB 110. If an instruction is received from an external device, process 1000 proceeds to step 1010. Otherwise, process 1000 proceeds to step 1020. Step 1005 is essentially an interrupt that pause the data collection of the smart DB to act according to instructions received from user.

In step 1010, process 1000 will act according to instructions received from the external device after the external device provides a password that corresponds to the password in a configuration file stored on the memory 420. Briefly, some form of authentication is required before a user can access or amend the data associated to a smart DB. The instructions may include changing the parameters in the configuration file, receiving the data from the metering devices and thermistor directly from the smart DB 110 and connected smart socket outlets 120, or switching off one or more MCBs by triggering the on/off switch 444. If the instruction is to receive the data from the metering devices and thermistor, step 1025 will be required to transmit data package to main server and the external device. If the instruction is to change the parameters in the configuration file, the process will receive the changes from the external device and amend the configuration file according to the changes received. The details in the configuration file stored on the memory 420 are as follows:

Name: Smart DB 1

Password: 123456

Connected Smart socket outlet: Smart socket 1, Smart socket 2, Smart socket 3

Circuit breakers: 16

Rating of voltage: 230 VAC

Voltage range: 46 VAC ~ 250 VAC

Rating of circuit breaker current: 6A/20A/32A/40A

Power consumption: <1w/2VAC

Rating of frequency: 50Hz

One skilled in the art will recognise that the above parameters (other than name, password, connected smart socket outlet) are based on standards approved by the relevant regulators. Hence, the parameters (other than name, password, connected smart socket outlet) as stated above are not meant to be limiting and is meant to be illustrative only and other parameters may be implemented without departing from the invention.

The configuration file will be used for preparing a data structure as shown in table 1 below. If the instruction is to switch on or off one of the MCBs, the smart DB will trigger the relevant on/off switch 444 to switch off the relevant MCB. This allows the flexibility to the user to remotely switch on or off sockets drawing from the relevant MCB..

In step 1020, process 1000, process 1000 updates the details pertaining to the connected Smart socket outlet in the configuration file and commence receiving data packages from the connected smart socket outlet. For example, the details to be updated in the configuration file may be the type of connectivity. Thereafter, process 1000 proceeds to step 1020 to obtain data from the metering devices and thermistor.

In step 1020, after the data is obtained from the metering devices and thermistor, process 1000 determines whether the AC voltage, impulse AC voltage, current and temperature are above protection threshold AC voltage, threshold impulse AC voltage, threshold current and threshold temperature. If any one of the AC voltage, impulse AC voltage, current and temperature is above protection threshold AC voltage, impulse AC voltage, current and temperature, process 1000 will turn off the DB by triggering the on/off switch 444. In this step, smart DB will also identify the type of load by comparing the signature list containing electric load signatures with the electric signature generated by the connected loads.

In step 1025, process 1000 generates and transmits data package to the main server 160 via the home network. The data package comprises the data obtained from the smart socket outlets and the metering board. Further, identified loads are indicated to

the respective MCBs and smart socket outlets. Process 1000 repeats from step 1005 after step 1025.

The smart DB also performs certain analysis after data from smart socket outlets and metering board is collected for a predetermined period. In order for the analysis to be meaningful, at least one week of data is required. The analysis performed by the smart DB includes monitoring of anomalies of identified load over a period of time. Appliances typically draw power in a consistent manner. Hence, the electric load signature of the identified load should not deviate by more than a predetermined percentage. Therefore, the smart DB analyses the electric load signature of each identified load over a period of time. If any of the electric load signatures deviate from the electric load signature by more than the predetermined percentage, the smart DB will send a notification to the mobile device of the user directly. Alternatively, the notification will be sent to the user indirectly via the main server.

Data analysis and processes performed by the main server

Figure 11 illustrates a timing diagram 1100 on the information flow among the smart DB 110, the main server 160, third party server 180 and mobile device 190.

In step 1105, transmits the signature list to the smart DB.

In step 1110, smart DBs 110 will transmit data package to the main server 160. In response to receiving the data package, the main server 160 stores the data package on the memory in a data structure according to the identity of the smart DB 110. The table 1 below illustrates an example of a data structure in accordance with an embodiment of this disclosure.

Identity number	Socket number	Data	Location	Load
DB1	DB1,S1	SF ₁ , SI ₁ , SV ₁ , SP ₁ , SQ ₁ , ST ₁ XXXXDDDDDD	Bedroom	Unknown

	DB1,S2	SF ₂ , SI ₂ , SV ₂ , SP ₂ , SQ ₂ , ST ₂ , XXXXDDDDDD	Living room	Television, router
	DB1,S3	SF ₃ , SI ₃ , SV ₃ , SP ₃ , SQ ₃ , ST ₃ , XXXXDDDDDD	Kitchen	Oven
	DB1,B1	MF ₁ , MI ₁ , MV ₁ , MP ₁ , MQ ₁ , MT, XXXXDDDDDD	Bedroom	Unknown
	DB1,B2	MF ₂ , MI ₂ , MV ₂ , MP ₂ , MQ ₂ , MT, XXXXDDDDDD	Living room	Air-conditioner
	DB1,B3	MF ₃ , MI ₃ , MV ₃ , MP ₃ , MQ ₃ , MT, XXXXDDDDDD	Kitchen	Refrigerator
DB2	DB2,S1	SF ₁ , SI ₁ , SV ₁ , SP ₁ , SQ ₁ , ST ₁ , XXXXDDDDDD	Living room	Unknown
	DB2,S2	SF ₂ , SI ₂ , SV ₂ , SP ₂ , SQ ₂ , ST ₂ , XXXXDDDDDD	Bedroom	Computer
	DB2,B1	MF ₁ , MI ₁ , MV ₁ , MP ₁ , MQ ₁ , MT, XXXXDDDDDD	Living room	Refrigerator
	DB2,B2	MF ₂ , MI ₂ , MV ₂ , MP ₂ , MQ ₂ , MT, XXXXDDDDDD	Bedroom	Unknown
	DB2,B3	MF ₃ , MI ₃ , MV ₃ , MP ₃ , MQ ₃ , MT, XXXXDDDDDD	Bedroom	Air-conditioner

Table 1

A user can register with the main server 160 via his mobile device 190 or computer through an application. Details of the registration via the application are omitted for brevity as the processes for registration are commonly known processes. Essentially, after the user completes the registration, the user is able to amend the details of the location in the data structure. This allows the user to identify which smart socket(s) are in used. Table 1 above shows a data structure containing details of two connected smart

DBs 110 (DB1 and DB2). DB1 includes 3 smart socket outlets (S1-S3) and 3 circuit breakers (B1-B3). DB2 includes 2 smart socket outlets (S1-S2) and 3 circuit breakers (B1-B3). The second rightmost column indicates the location of the socket outlets which is provided by the user. For DB1, the residential unit has at least a bedroom, living room and a kitchen. DB1 has at least three circuit breakers and each circuit breaker is connected with one smart socket outlet. Similarly for DB2, the residential unit has at least a bedroom, living room and a kitchen. However, DB2 has at least three circuit breakers and two of the circuit breakers are each connected with one smart socket outlet. This is because circuit breaker 3 (B3) may be a dedicated circuit breaker for air conditioner. Hence, a smart socket outlet is not required for B3. The rightmost column indicates the type of load drawing power from the socket. The information on the load may be indicated by the user or via a data analytics by comparing known electric load signatures. One skilled in the art will recognise that the data structure as presented in table 1 above is for illustrative purposes only. Other information such as rule based notifications may be included without departing from the disclosure. For example, the data structure may include a rule based notification to trigger an alert to the user when the energy consumption of a particular circuit breaker or a smart socket outlet exceeds certain limits. In another example, the data structure may include a rule based notification to trigger an alert to the user when the overall energy consumption exceeds certain limits. Essentially, steps 1105 and 1110 relate to commencement of collecting and storing of data on the main server.

A user may monitor the energy consumption in real time or the energy consumption over a period of time. Further, a user may also amend the location of the sockets. Still further, a user may wish to remotely switch on or off an appliance. This is achieved by communicating directly to the main server 160 or the smart DB 110 depending on the type of requests from the user. Specifically, in step 1120, mobile device 190 may request for information or amend the location of the sockets. Such requests are

transmitted to the main server 160. In response to the request, main server 160 retrieves and transmits the requested information to the mobile device 190 in step 1125. The requested information may be energy consumption in real time or the energy consumption over a period of time. If the request is an amendment to the location of the sockets, the main server 160 will amend the data structure accordingly and transmit an acknowledgement to confirm the changes in step 1125. In another type of request, in step 1120, mobile device 190 may request to switch off an appliance. Such request is transmitted to the smart DB 110. In response to the request, the smart DB 110 switches off the relevant MCB to cut of power supply to the appliance. If the appliance is connected to a smart socket outlet, the smart DB 110 will instruct the smart socket outlet to switch off power supply to the appliance. A confirmation on switching off the appliance will be transmitted back to the mobile device 190 in step 1125. In short, steps 1120 and 1125 illustrates that the mobile device 190 is able to access and amend the data structure from the main server 160, or to remotely switch on or off appliance via the smart DB.

A user may monitor the energy consumption based on actual pricing. In such circumstances, the user requests for pricing rate from the relevant third party server 180 in step 1130. In response to the request, the third party server 180 transmits the pricing rate to the mobile device 190 in step 1135.

Figure 12 illustrates a process 1200 of a process flow performed by the main server. Process 1200 begins with identifying the source of the data received. If the data is received from the smart DB, process 1200 proceeds to step 1210. If the data is received from a mobile device 190, process 1200 proceeds to step 1215.

In step 1210, process 1200 stores the data received from the smart DB in the memory and updates the data structure associated to the smart DB. Specifically, the data structure associated to the smart DB is retrieved and the data structure is appended to include the data received from the smart DB. Before appending the data structure, process 1200 may determine the type of connected undetermined load by comparing the

data received with the electric load signatures stored on the signature list. More specifically, the electric load signature of the undetermined load from the data package is compared with the electric load signatures in the signature list. If there is a match, the main server appends the rightmost column to indicate the appliance associated to the matched electric load signature and waits for the user to confirm load. If the user confirms the appliance, the main server would send an updated signature list. If the identified appliance is not in the top N number of common appliance, the updated signature list contain the electric load signature of top N number of common appliances and the electric load signature of the new appliance.

In step 1215, process 1200 determines the type of data received from the mobile device. If the data received from the mobile device is a request to amend the data structure, process 1200 proceeds to step 1220. If the data received from the mobile device is a request to retrieve information, process 1200 proceeds to step 1225.

In step 1220, process 1200 retrieves the data structure associated to the mobile device, which is associated to a smart DB, and amends the data structure accordingly. In this step, if the request from the user is to add a new appliance to a connected but undetermined load, process 1200 amends data structure to include the new appliance against the MCBs or smart socket outlet accordingly. The electric load signature of the new appliance will also be added to the signature list. Each appliance has a certain energy consumption signature. Hence, the storing of electric load signature of appliances from multiple users allow the server to build up an electric load signature list so that the main server is able to identify unknown appliances drawing energy from the grid. The main server is also able to prompt the user to confirm an unverified appliance based on matching of the electric load signature of connected appliance to that in the electric load signature data structure.

In step 1225, process 1200 retrieves the data structure associates to the mobile device and transmits the data structure to the mobile device.

The main server also periodically updates the signature list to better reflect the top N number of common appliance. For example, at predetermined time interval, the main server will update a score to each electric load signature. The score being the number of data structures, each data structure corresponds to a smart DB, containing the same electric load signature. The electric load signatures will then be arranged in ascending order where the highest score will be arranged at the top and the lowest score will be arranged at the bottom of the signature list.

Similar to the analysis performed by the smart DB, the main server also performs certain analysis after collating the data from various smart DB for a predetermined period.

In order for the analysis to be meaningful, at least one week of data per smart DB is required. The analysis performed by the main server includes monitoring of anomalies of identified load over a period of time. Appliances typically draw power in a consistent manner. Hence, the electric load signature of the identified load should not deviate by more than a predetermined percentage. Therefore, the main server analyses the electric load signature of each identified load over a period of time. If any of the electric load signatures deviate from the electric load signature by more than the predetermined percentage, the main server will send a notification to the mobile device of the user directly.

The above is a description of exemplary embodiments of a system and method for monitoring energy consumption in a residential premise in accordance with this disclosure. It is foreseeable that those skilled in the art can and will design alternative systems and methods based on this disclosure.

Claims

1. A residential energy consumption monitoring system for monitoring energy consumption in a residential premise, the residential energy consumption monitoring system

5 comprising:

a smart distribution board (DB) comprising:

a plurality of miniature circuit breakers (MCBs);

a metering board having a plurality of metering devices, each metering device is configured to obtain data associated with energy consumption drawn from one of
10 the MCBs;

a DB processing unit configured to receive the data from the metering board;

and

a direct current power supply for driving the DB processing unit;

at least one smart socket outlet communicatively connected to the smart DB, the at

15 least one smart socket outlet comprising:

a live inlet connected to one of the MCBs;

a neutral inlet;

a metering device configured to obtain data associated with energy consumption drawn from the live and neutral inlets; and

20 an outlet processing unit configured to receive the data from the metering device of the at least one smart socket outlet and transmit a data package comprising the data from the metering device of the at least one smart socket outlet to the DB processing unit; and

at least one conventional socket outlet,

25 wherein at least one of the MCBs is connected to a live inlet of the at least one conventional socket outlet and the at least one smart socket outlet.

2. The residential energy consumption monitoring system according to claim 1, wherein the at least one conventional socket outlet and the at least one smart socket outlet that are connected to the at least one of the MCBs are provided in one location within the residential premise, wherein the one location is one of: a bedroom, a living room, and a kitchen.

5

3. The residential energy consumption monitoring system according to claim 1 or 2, wherein the DB processing unit comprises a DB processor, a DB memory and DB instructions stored on the DB memory and executable by the DB processor to:

receive a signature list containing electric load signatures of top N number of common

10 appliances from a main server;

store the signature list in the DB memory; and

commence data collection from the metering board and the at least one smart socket outlet.

15 4. The residential energy consumption monitoring system according to claim 3, wherein the DB instructions to commence data collection from the metering board and the at least one smart socket outlet comprises instructions to:

establish connection with the at least one smart socket outlet;

update details in a configuration file stored on the DB memory containing information

20 with respect to the at least one smart socket outlet that is connected, the details being a type of connectivity to connect with the at least one smart socket outlet;

obtain data from the metering board, the data comprising frequency, voltage, and current; and

receive a data package from the at least one smart socket outlet, the data package

25 comprising frequency, voltage, and current.

5. The residential energy consumption monitoring system according to claim 4, wherein the configuration file further comprises a protection threshold AC voltage, a protection threshold current and a protection threshold temperature.

6. The residential energy consumption monitoring system according to claim 5, wherein the smart DB further comprises on/off switch for switching on or off each of the MCBs, and the DB instructions to commence data collection from the metering board and the at least one smart socket outlet further comprises instructions to:

switch off the MCB in response to one of the rules comprising: AC voltage being above the protection threshold AC voltage, current being above the protection threshold current and temperature being above the protection threshold temperature.

7. The residential energy consumption monitoring system according to claim 4, wherein the DB instructions to commence data collection from the metering board and the at least one smart socket outlet further comprises instructions to:

identify a type of load drawing from the MCBs and smart socket outlet by matching the electric load signatures in the signature list with an electric signature generated by a load drawing from the MCBs and smart socket outlet; and

transmit a DB data package to the main server, the DB data package comprising the data obtained from the at least one smart socket outlet and the metering board wherein the identified type of load is indicated to the respective MCBs and smart socket outlet.

8. The residential energy consumption monitoring system according to claim 7, further comprising the main server, the main server having a processor, a memory and instructions stored on the memory and executable by the processor to:

receive the DB data package from the smart DB;

determine a type of load in response to receiving an undetermined load from the DB data package; and

store the DB data package and update a data structure associated to the smart DB and wherein the memory further comprises a signature list containing electric load signatures of a plurality of appliances.

5 9. The residential energy consumption monitoring system according to claim 8, wherein the instruction to determine the type of load in response to receiving the undetermined load from the DB data package comprises instructions to:

compare an electric load signature of the undetermined load with the electric load signatures in the signature list;

10 in response to a match, identify an appliance associated to the matched electric load signature and send a notification to a user to confirm the identified appliance; and

in response to receiving a confirmation from a user, transmit a revised signature list to the smart DB, the revised signature list containing the electric load signatures of top N number of common appliance and the identified appliance.

15

10. The residential energy consumption monitoring system according to claim 8, wherein the instructions of the main server further comprise instructions to:

receive a request to amend a data structure associated to one of a plurality of the smart DBs;

20 amend the data structure according to the request; and

store the amended data structure.

11. The residential energy consumption monitoring system according to claim 10, wherein the instruction to amend the data structure according to the request further comprises
25 instructions to:

in response to the request to include a new appliance to a connected load, amend the data structure associated to the smart DB to include the new appliance against the MCBs or the at least one smart socket outlet accordingly.

12. The residential energy consumption monitoring system according to claim 11, wherein the instruction to amend the data structure according to the request further comprises instructions to:

5 amend the signature list to include an electric load signature associated to the new appliance.

13. The residential energy consumption monitoring system according to claim 12, wherein the instruction to amend the data structure according to the request further comprises
10 instructions to:

 update an order of the electric load signatures in the signature list.

14. The residential energy consumption monitoring system according to claim 13, wherein the instruction to update an order of the electric load signatures in the signature list comprises
15 instructions to:

 update a score to each electric load signature, the score being the number of data structures containing the same electric load signature; and

 arrange the electric load signatures in ascending order where the highest score will be arranged at the top and the lowest score will be arranged at the bottom of the signature list.

20

15. The residential energy consumption monitoring system according to any one of claims 1 to 14, wherein the outlet processing unit of the at least one smart socket outlet comprises an outlet processor, an outlet memory and outlet instructions stored on the outlet memory and executable by the outlet processor to:

25 establish connection with the smart DB;

 obtain data from the metering device of the at least one smart socket outlet, the data comprising frequency, voltage, current, and temperature; and

transmit an outlet data package to the smart DB, the outlet data package comprising the data obtained from the metering device of the at least one smart socket outlet, wherein the metering device of the at least one smart socket outlet is further configured to obtain temperature.

5

16. The residential energy consumption monitoring system according to claim 15, wherein the at least one smart socket outlet further comprises:

an on/off button configured to switch the outlet processing unit between a smart mode and a conventional mode;

10 a reset button configured to activate a hardware reset to the outlet processing unit;

a paring button configured to activate a pairing between the outlet processing unit with the DB processing unit;

a connectivity indicator to indicate whether the outlet processing unit is in communication with the DB processing unit;

15 an alarm indicator to indicate whether there is an issue with the outlet processing unit;

and

an on/off switch configured to switch on or off the at least one smart socket outlet.

17. The residential energy consumption monitoring system according to claim 16, wherein
20 the at least one smart socket outlet further comprises a configuration file having a protection threshold AC voltage, a protection threshold current and a protection threshold temperature.

18. The residential energy consumption monitoring system according to claim 17, wherein
the outlet instruction to obtain data from the metering device of the at least one smart socket
25 outlet further comprises outlet instructions to:

switch the on/off switch to off in response to one of the rules comprising: AC voltage being above the protection threshold AC voltage, current being above protection threshold current and temperature being above the protection threshold temperature.

19. The residential energy consumption monitoring system according to claim 6 or 16, wherein the on/off switch of the smart DB or the on/off switch of the at least one smart socket outlet is configured to be switched on or off remotely by a user.

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20. The residential energy consumption monitoring system according to any one of claims 1 to 19, wherein the metering device is one of or a combination of voltmeter, ammeter, power energy meter and thermistor.