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(71) Applicant: **THOMSON LICENSING** [FR/FR]; 1-5 rue Jeanne d'Arc, 92130 Issy-les-Moulineaux (FR).

(72) Inventors: **GAYRARD, Didier**; c/o Technicolor Connected Home Rennes, 975, avenue des Champs Blancs, CS17616, 35576 Cesson-Sévigné Cedex (FR). **LE LOUET, Arnaud**; c/o Technicolor Connected Home Rennes, 975, avenue des Champs Blancs, CS17616, 35576 Cesson-Sévigné Cedex (FR).

(74) Agents: **HUCHET, Anne** et al.; 1-5 rue Jeanne d'Arc, 92130 Issy-les-Moulineaux (FR).

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(54) Title: METHOD FOR NON-INTRUSIVE DETERMINING A POWER CONSUMPTION FOR A PLURALITY OF APPLIANCES, CORRESPONDING ELECTRONIC DEVICE, SYSTEM, COMPUTER READABLE PROGRAM PRODUCT AND COMPUTER READABLE STORAGE MEDIUM

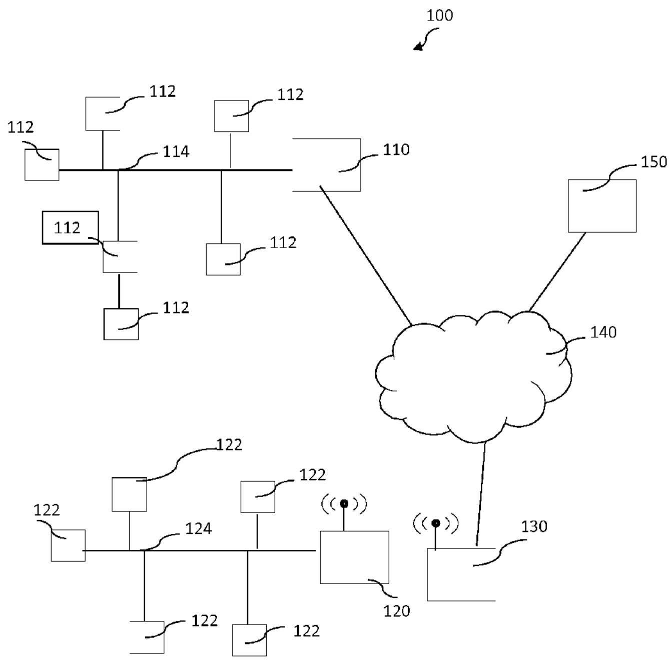

Figure 1

(57) Abstract: A non-intrusive method and corresponding apparatus, system for determining a power consumption for a plurality of appliances comprises measuring aggregate power consumption of the plurality of appliances during a time interval P for N sliding windows of a duration M and a temporal distance D between successive sliding windows; selecting a number Q sliding windows from the N sliding windows according to a selection criterion for selecting sliding windows with a sum S of power consumption representative for a power consumption layer defined according to appliance use; and calculating an average power consumption per power consumption layer over the time interval P, based on the aggregate power consumption measured over the time interval P for the Q selected sliding windows.

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Method for non-intrusive determining a power consumption for a plurality of appliances, corresponding electronic device, system, computer readable program product and computer readable storage medium

1. Technical field

The present disclosure relates to the field of analyzing consumption of resources, for instance consumption of resources (utilities) like water or energy, notably the analyzing of a global consumption of a plurality of appliances, in a non-intrusive way and more specifically, to methods aiming at detecting anomalies or deviation related to the global consumption of a plurality of appliances, notably in a domestic environment.

2. Background art

Nowadays, the daily human activity is getting more and more related to energy consumption. In the European Union, the residential sector alone accounts for 30% of electricity usage. This is a growing concern as energy resources are limited and it is predicted that global energy demands will double by the end of year 2030.

A house may comprise more than twenty electrical appliances: laptops, smart phones, washing machines, ovens, radiators...

Forgetting to shut down one appliance, an electricity cut off, a door of a freezer being left opened, or usage like keeping all lights on in a house, are probable cases that may impact the daily energy consumption of a house and may make the energy bills higher. Therefore, with the increased electricity consumption, the interest for energy conservation has increased in order to save energy and costs. To achieve this, research efforts have led to the development of Appliance Load Monitoring (ALM) methods to perform detailed energy sensing and to provide information on the breakdown of the energy spent.

ALM can be divided in two major approaches: namely Intrusive Load Monitoring (ILM) and Non-Intrusive Load Monitoring (NILM) technology. In order to perform ALM, ILM techniques require at least one sensor per appliance, whereas NILM techniques require only a single meter per house. Thus, even if ILM methods are more accurate in measuring appliance-specific energy consumption, ILM techniques are more costly than NILM techniques. Furthermore, the configuration of multiple sensors is difficult and the complexity of the needed installation is very high, thus favouring the use of NILM techniques.

Many techniques have been used to solve NILM problems. They usually involve an energy disaggregation between each appliance of the set of appliances monitored. The anomaly detection is tackled after identifying each appliance’s signature. Those techniques are based on pattern recognition of each appliance and require labeled data sets built during an initial instrumentation, such requiring extra cost and human effort. Furthermore, those techniques are not adapted for identifying new appliances that were not included in the initial instrumentation.

Moreover, the task of energy disaggregation is laborious and therefore, the system is complex. Besides, identifying each appliance’s signal is not always accurate enough, which may directly impact the detection of abnormal behaviors.

So, there’s a need to provide a solution that leads to a non-intrusive analysis of a global consumption of a plurality of appliances that is less complex to perform.

3. Summary of the present disclosure.

The present disclosure enables some of the above discussed disadvantages to be resolved by proposing a non-intrusive method for determining a power consumption for a plurality of appliances.

According to an embodiment of the present disclosure, the method comprises measuring aggregate power consumption of the plurality of appliances during a time interval P for N sliding windows of a duration M and a temporal distance D between successive sliding windows; selecting a number Q sliding windows from the N sliding windows according to a selection criterion for selecting sliding windows with a sum S of power consumption representative for a power consumption layer defined according to appliance use; and calculating an average power consumption per power consumption layer over the time interval P, based on the aggregate power consumption measured over the time interval P for the Q selected sliding windows.

According to an embodiment of the present disclosure, appliance use is one of: standby state; producing cold; producing heat; or other.

According to an embodiment of the present disclosure, the power consumption layer is one of:

- a base layer representing a minimum aggregate power consumption of always on applicances and of appliances in standby state;
- a cold production layer representing aggregate power consumption of appliances producing cold;
- a heat production layer representing aggregate power consumption of appliances producing heat;
- a miscellaneous layer representing aggregate power consumption of appliances in none of the layers.

According to an embodiment, for the base layer the selection criterion comprises selecting, from the N sliding windows, the Q sliding windows with a lowest aggregate power consumption. For the heat production layer, the selection criterion comprises selecting, from the N sliding windows, the Q sliding windows with a highest aggregate power consumption. For the cold production layer, the selection criterion comprises selecting, from the N sliding windows, the Q sliding windows with an aggregate power consumption between the lowest aggregate power consumption and the highest aggregate power consumption. For the miscellaneous layer, the selection criterion comprises selecting, from the N sliding windows, the Q sliding windows with an aggregate power consumption not in any of the previous layers.

According to an embodiment, the duration M and the temporal distance D are specific to each power consumption layer.

According to an embodiment, the method further comprises generating at least one indicator of an power consumption behavior of at least one of the plurality of appliances based on at least one of the at least one calculated average power consumption per power consumption layer.

According to an embodiment, the method further comprises generating an alert according to a criterion of proximity between the indicator and a determined indicator.

According to an embodiment, the method further comprises rendering the indicator on a user interface of a device.

The present principles also comprise an electronic device for non-intrusive a power consumption for a plurality of appliances, the device comprising a processor configured to measure aggregate power consumption of the plurality of appliances during a time interval P for N sliding windows of a duration M and a temporal distance D between successive sliding windows; to select a number Q sliding windows from the N sliding windows according to a selection criterion for selecting sliding windows with a sum S of power consumption representative for a power consumption layer defined according to appliance use; and to calculate an average power consumption per power consumption layer over the time interval P, based on the aggregate power consumption measured over the time interval P for the Q selected sliding windows.

While not explicitly described, the electronic device of the present disclosure may be adapted to perform the analyzing method of the present disclosure in any of its embodiments.

According to another aspect, the present disclosure relates to a system for non-intrusive determining a power consumption for a plurality of appliances, wherein the system comprises a server and at least one device, the at least one device comprising a processor configured to: measure aggregate power consumption of the plurality of appliances during a time interval P for N sliding windows of a duration M and a temporal distance D between successive sliding windows; to select a number Q sliding windows from the N sliding windows according to a selection criterion for selecting sliding windows with a sum S of power consumption representative for a power consumption layer being defined according to appliance use; and to calculate an average power consumption per power consumption layer over the time interval P, based on the aggregate power consumption measured over the time interval P for the Q selected sliding windows.

While not explicitly described, the present embodiments related to an analyzing method or to the corresponding electronic device or system may be employed in any combination or sub-combination. For example, some embodiments may involve a calculating of a layer consumption comprising a defining of at least one sliding window, a selecting of at least one defined sliding window and an assessing on a layer consumption value, and a generating at least one indicator of an energy consumption behavior of the plurality of appliances based on at least one of the at least one calculated layer energy consumption.

According to another aspect, the present disclosure relates to a non-transitory program storage device, readable by a computer. According to an embodiment of the present disclosure, the non-transitory computer readable program product tangibly embodies a program of instructions executable by a computer to perform the analyzing method described above, in any of its embodiments.

According to another aspect, the present disclosure relates to a computer readable storage medium carrying a software program comprising program code instructions for performing the analyzing method of the present disclosure, in any of its embodiments, when the non transitory software program is executed by a computer.

As will be appreciated by one skilled in the art, aspects of the present disclosure can be embodied as a system, method, or computer readable medium. Accordingly, aspects of the present disclosure can take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, and so forth), or an embodiment combining software and hardware aspects that can all generally be referred to herein as a “circuit”, module” or “system”. Furthermore, aspects of the present disclosure can take the form of a computer readable storage medium. Any combination of one or more computer readable storage medium(s) may be utilized.

A computer readable storage medium can take the form of a computer readable program product embodied in one or more computer readable medium(s) and having computer readable program code embodied thereon that is executable by a computer. A computer readable storage medium as used herein is considered a non-transitory storage medium given the inherent capability to store the information therein as well as the inherent capability to provide retrieval of the information therefrom. A computer readable storage medium can be, for example, but is not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. It is to be appreciated that the following, while providing more specific examples of computer readable storage mediums to which the present disclosure can be applied, is merely an illustrative and not exhaustive listing as is readily appreciated by one of ordinary skill in the art: a portable computer diskette: a hard disk, a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a portable compact disc read-only memory (CD-ROM), an optical storage device; a magnetic storage device, or any suitable combination of the foregoing.

Thus, for example, it will be appreciated by those skilled in the art that the block diagrams presented herein represent conceptual views of illustrative system components and/or circuitry of some embodiments of the present disclosure. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may be substantially represented in computer readable storage media and so executed by a computer or processor, whether or not such computer or processor is explicitly shown.

4. List of figures.

The present disclosure will be better understood, and other specific features and advantages will emerge upon reading the following description, the description making reference to the annexed drawings wherein:

Figure 1 shows an example of a system according to a particular embodiment of the present disclosure;

Figure 2 is a functional diagram that illustrates a particular embodiment of the analyzing method of the present disclosure, compatible with the embodiment illustrated by figure 1.

Figure 3 illustrates an electronic device adapted to at least one particular embodiment of the present disclosure.

It is to be noted that the drawings only serve an illustrative purpose and that the embodiments of the present disclosure are not limited to the illustrated embodiments.

5. Detailed description of the embodiments.

At least one embodiment of the present disclosure offers a new way of analyzing the utility consumption behavior of a plurality of appliances, for example a plurality of domestic appliances, without the need of disaggregating the global consumption for said plurality of appliances between each appliance of the plurality of appliances monitored. The consumption may notably relate to a resource or utility like water or like any kind of energy (for instance power, gas, petrol...).

More precisely, according to at least one embodiment, the global consumption of a monitored plurality of appliances is collected during at least one given duration (for instance during a time interval having a duration of several hours, a day, a week, a month,…). The samples collected are assessed in order to calculate a layer consumption for at least one layer, amongst a plurality of energy layers. At least one of the calculated layer consumption may then be used for generating an indicator of the energy consumption behavior of the plurality of appliances.

A detailed embodiment will now be presented in relation with figures 1 to 3. In the detailed embodiment, the monitored resource is electrical power. Of course, other embodiments may monitor other resources/utilities, like water.

Figure 1 illustrates an example of a system according to a particular embodiment of the present disclosure. According to the embodiment of figure 1, the system comprises at least one electronic device (110, 120, 130, 150) adapted to implement at least one embodiment of the analyzing method of the present disclosure.

The electronic device may notably be adapted to collect the global power consumption of a plurality (112, 122) of electrical appliances. The plurality of appliances may comprise all the electrical appliances present in a domestic environment for instance.

In some embodiments, such an electronic device (110, 120) may be adapted to measure the global power consumption of the plurality of appliances. It may for instance be a smart meter (110, 120) of a house. In other embodiments, it may be a standalone device (130, 150) equipped with means for obtaining the global energy consumption of a plurality of appliances. Such means for obtaining the global energy consumption may include acquiring means, like a probe for acquiring the global power consumption as evaluated by a meter, or communication means, notably a LAN (for Local Area Network) or WAN (for Wide Area Network) interface, adapted for receiving a measured global power consumption from a smart meter 120.

In some embodiments, the device 130 may be located in the domestic environment of the plurality of appliances and comprises a communication interface with a domestic network (for instance a WIFI® interface) in order to communicate with a meter 120.

The electronic device (110, 130) may further exchange data with a distant server, thanks to a wide area network 140, for instance a broadband network, in order to obtain reference data, notably reference data related to the power consumption of other plurality of appliances.

In other embodiments, the device 150 may also be situated at a distant location and comprises a communication interface with a WAN network, for instance a broadband communication interface, in order to collect the global power consumption of pluralities of appliances measured by a meter 110, 120.

The electronic device may for instance be a personal computer, a laptop, a tablet, a smartphone, a gateway, a smart meter, a server, or a set top box.

Figure 2 illustrates the analyzing method 200 of the present disclosure.

As illustrated, the analyzing method comprises collecting 210 power consumption samples during a determined time interval and calculating 220 a power consumption for at least one layer belonging to a plurality of energy layers.

Depending on embodiments, a power consumption value assigned to a layer may be calculated once the analyzed time interval is elapsed, or after several iterations (for example periodically) during the analyzed time interval.

In the particular embodiment detailed, where the monitored energy is electric power, the plurality of energy layers may for instance be constituted of the following layers:

- a “base” layer;
- a “cold production” layer;
- a "high power" layer;
- a "miscellaneous" layer.

In the particular detailed embodiment, the base layer may be considered as representative of the minimum power consumption of the monitored plurality of appliances. Indeed, the power consumption of all the appliances in a house for instance, will generally be not zero, even during night time, because devices are in a standby state, or because devices are permanently in use (such as servers, ADSL portals, electrical alarm clocks, . ..). Thus, the base layer notably includes the parasitic consumption of the plurality of appliances.

In the particular described embodiment, the “cold production” layer may enable to take into account energy consumption linked to a periodic activity of cyclic appliances, notably the cold-related part of the monitored plurality of appliances (freezers, refrigerators, etc. ...).

In the particular described embodiment, the "high power" layer comprises high “peaks” of power consumption. Such peaks may be due to appliances like electric heating appliances (often called "white" appliances), ovens and other products of high consumption (irons, ovens ...).

In the particular described embodiment, another layer, herein called "miscellaneous" layer, may represent the entire power consumption related to appliances used during a user’s everyday life, that do not operate continuously. Such appliances include devices (also called "grey" devices) like TV sets, computers,... They may also include lighting, Small Power Appliances, etc.

Of course, depending upon embodiments, different layers and/or more or less layers may be defined.

According to the illustrated embodiment, the calculation 220 of a power consumption related to a layer comprises defining 222 at least one sliding window inside the analyzed time interval. Each sliding window may be assigned a power consumption value being the sum of collected power samples related to its time interval.

Depending upon embodiments, defining a sliding window may take into account different definition criterions, notably:

- a determined duration (or size) of a sliding window for said layer;
- a determined temporal distance between the lowest time limits of two successive sliding windows;
- an exceeding of a determined threshold of energy consumption by each sample related to at least one part of a sliding window;
- an exceeding of a determined threshold of energy consumption by a sum of samples related to at least one part of a sliding window ;
- the duration of the analyzed time interval.

Those definition criterions (notably the size of the sliding windows, the determined distance between sliding windows, or a threshold value) may depend upon the considered layer.

Depending upon embodiments, two sliding windows may temporally overlap or be temporally disjoint.

In the particular embodiment described, the calculating 220 also comprises selecting 224 sliding windows amongst the defined sliding windows.

Depending upon embodiments, the selecting of a sliding window may take into account different selection criterions, notably:

- an exceedingof a determined threshold of energy consumption by each sample related to at least one part of a defined sliding window;
- an exceedingof a determined threshold of energy consumption by a sum of samples related to at least one part of a defined sliding window ;
- a determined number Q of defined sliding windows to be selected;
- a criteria of minimizing or maximizing a sum and/or a variance of the power consumption values assigned to all selected sliding windows;

Those selection criterions (notably the number of defined sliding windows to be selected or the threshold value) may differ according to the layer that is considered.

In the particular embodiment described, the calculating 220 also comprises assessing 226 a power consumption value in association with the layer, called herein layer power consumption value, the assessing taking into account the power consumption samples collected during the selected sliding windows of the layer. The assessing results in an obtaining of a calculated layer consumption.

Depending upon embodiments, a layer power consumption may be calculated for all the layers of the plurality of layers, or for at least one of those layers.

In the illustrated embodiment of figure 2, an iteration 221 of the calculating is performed for each layer, the layer power consumption values being for instance calculated sequentially, one by one.

In other embodiments, the calculating of the layer power consumption values may be performed concurrently. For instance, the defining of sliding windows may be first performed for all the layers to be considered, followed by the selecting of sliding windows for all the layers to be considered, followed by the assessing of power consumption values for each layer to be considered.

In the particular embodiment described, the analyzing method further comprises generating 230 an indicator of an energy consumption behavior of the plurality of appliances. This indicator may vary upon embodiments. For instance, it may be equal or proportional to the layer power consumption calculated for one layer. It may also be a ratio between one of the layer power consumption calculated and the global power consumption of the plurality of appliances, or a ratio between at least two of the layer power consumption calculated, or an indicator based on several ratios, notably ratios between each of the layer power consumption calculated and the global power consumption of the plurality of appliances.

In the particular embodiment described, the analyzing method further comprises comparing 240 the generated indicator with a determined indicator, for instance an indicator having a pre-determined value stored during the configuration of the electronic device or a value obtained from a distant server, or a former value of the indicator related to the same plurality of appliances (for example the latest former value generated for the indicator), or an average value of the indicator during a determined time period, for instance a time interval greater than the analyzed time interval. It may also be a reference value of the indicator obtained from another device, for instance a distant server, and related to at least one other plurality of appliances. The reference indicator may relate to the same analyzed time interval as the generated indicator, to a different time interval of the same duration, or to a different time interval of different duration.

This comparing step 240 is an optional one. Notably, in some embodiments where the method further comprises rendering/presenting 260 the generated indicator on a user interface of the device, no comparing may be performed by the device. In other embodiments, the generated indicator may be transmitted to another device, for instance a distant server, for further processing.

In some embodiments, the method may also comprise generating 250 an alert, the generating depending on a criteria of proximity between the generated indicator and the determined indicator. For instance, an alert may be generated when the difference between both indicators is greater that a given threshold. This generating is optional.

In the illustrated embodiment, the method further comprises rendering/presenting 260 the generated indicator on a user interface of the device. The rendering/presenting may also comprise a rendering/presenting of the determined indicator. The rendering/presenting may notably involve a display of the generated indicator and/or determined indicator through graphics. For instance, series of layer consumption values may be displayed on weekly or monthly basiss, for showing the weekly or monthly evolution of the indicator.

Examples of the calculating 220 of a layer power consumption in a particular embodiment of the present disclosure will now be described for several layers.

Indeed, calculating 220 a layer power consumption for the base layer, may comprise defining 222 sliding windows having a determined size (or duration) of several minutes, for instance a size between 1 to 5 minutes, for example 3 minutes. A determined number N of sliding windows may be defined, with N having a value between 1 to 5, for instance 2.

In the particular embodiment described, the calculation 220 of the layer power consumption of the base layer may notably comprise selecting 224 a determined number Q of defined sliding windows. This determined number Q may notably have a value between 1 to 20, for instance 10.

Notably, the Q sliding windows may be selected according a selection criteria related to the sum S and/or the variance V of all candidate Q–tuples formed by power consumption values of the N defined sliding windows.

The selection criterion may for instance be a criterion of minimization of the sum S and the variance V of candidates Q–tuples. Such a criterion may enable selection of only the sliding windows that are relative to the minimum power consumption of all the plurality of appliances, while not taking into account a power cut incident.

The calculation 220 of the base layer may for instance comprise an assessing 226 taking into account the power consumption values of the selected sliding windows, the size of the sliding windows and/or the duration of the analyzed time interval.

For instance, in the particular embodiment described, the layer power consumption of the base layer may be expressed as the power consumption (in Wh) PC_base:

$$PC\_base = (S * \frac{P}{Q * M})$$

Where:

- P is the duration of the analyzed time interval in minutes (for instance 4320 minutes);
- M is the determined size of the defined sliding windows;
- Q is the number of selected sliding windows;
- S is the sum of the power consumption values of the Q selected sliding windows, expressed in Watt/hour (Wh).

Calculating 220 a layer power consumption for the cold production layer may comprise defining 222 sliding windows having a determined size M of 90 to 150 minutes, for instance 120 minutes, with a determined distance D between the lowest time value of two successive sliding windows having a value between 20 to 40 minutes, for instance 30 minutes.

Furthermore, in the exemplary embodiment, each defined sliding window for the cold production layer is defined so that no collected power consumption sample related of the defined sliding window has a value being above a given threshold, called herein “cold threshold”.

Such a threshold may depend of the plurality of appliances monitored (notably, it may depend of the number of cold production appliances belonging to the plurality of appliances). It may be chosen for instance as an instant power value between 300 W to 500 W (or a power consumption value between 6 to 8 Wh per minute).

In the particular embodiment described, the calculation 220 of the layer power consumption related to the cold production layer may notably comprises selecting 224 a determined number Q of defined sliding windows. This determined number Q may notably have a value between 1 to 10, for instance 5.

Notably, the Q sliding windows may be selected according a selection criterion related to the sum S and/or the variance V of all candidate Q–tuples formed by power consumption values of the N defined sliding windows.

The selection criterion may for instance be a criterion of minimization of the sum S and the variance V of candidates Q–tuples.

The calculation 220 of the layer power consumption of the cold production layer may for instance comprise an assessing 226 taking into account the power consumption values of the selected sliding windows, the size of the sliding windows and/or the duration for the analyzed time interval.

For instance, in the particular embodiment described, the layer power consumption of the cold production layer may be expressed as the power consumption (in Wh) PC_cold:

$$PC\_cold = PC\_cold\_raw - PC\_base$$

Where PC_base is the base layer power consumption expressed in Wh, and:

$$PC\_cold\_raw = (S * \frac{P}{Q * M})$$

Where:

- P is the duration of the analyzed time interval in minutes (for instance 4320 minutes);
- M is the size of the defined sliding windows;
- Q is the number of selected sliding windows;
- S is the sum of the power consumption values of the Q selected sliding windows, expressed in Wh.

Calculating 220 a layer power consumption value for the high power layer, may comprise defining 222 sliding windows, with a determined distance D between the lowest time value of two successive sliding windows having a value between 0 to 5 minutes, for instance 3 minutes. Each sliding window may have a determined size of less than 5 minutes, for instance 3 minutes.

In the particular embodiment described, the number N of defined sliding windows for the high power layer may notably depend of the duration P of the analyzed time interval and of the determined distance D between two sliding windows. For instance, the number N of defined sliding windows may be close or equal to P/(D -1).

In the exemplary embodiment, the calculation of the layer power consumption of the high power layer may also comprise selecting some defined sliding windows.

In the particular embodiment described, the defined sliding windows may be selected according a selection criterion taking account of a given threshold, called herein “high power threshold”, being greater than the cold threshold. For instance, the selection criterion may be a power consumption value associated with a defined sliding window being greater than M * HPT (with M being the size of the sliding windows and HPT being the High Power Threshold value) The value of the high power threshold may depend of the plurality of appliances monitored and notably of the number of high power appliances belonging to the plurality of appliances. The high power threshold may be notably an instant power between 1000 W to 1500 W, for instance 1200 W (or a power consumption value between 16 to 25 Wh per minute, for instance 20 Wh per minute).

Depending upon embodiments, the high power threshold may be given a static value or may be assigned a dynamic value.

The calculation of the layer power consumption of the high power layer may for instance comprise an assessing 226 taking into account the power consumption values of the selected sliding windows, the size of the sliding windows and/or the duration for the analyzed time interval.

For instance, in the particular embodiment described, the layer power consumption of the high power layer may be expressed as the power consumption (in Wh) PC_high:

$$PC\_high = S - (PC\_cold\_raw * \frac{Q * M}{P})$$

Where:

- P is the duration of the analyzed time interval in minutes (for instance 4320 minutes);
- M is the size of the defined sliding windows;
- Q is the number of selected sliding windows;
- S is the sum of the power consumption values of the Q selected sliding windows, expressed in Wh;
- PC_cold_raw represents the sum of the layer power consumptions of the cold layer and of the base layer.

In the described embodiment, the plurality of layers achieves a partition of the power consumption samples collected. Thus, the layer power consumption of the miscellaneous layer may be calculated as the remaining power consumption once subtracted to the global power consumption of the analyzed time interval the power consumption values related to all the other layers (namely in the particular embodiment described, the base layer, the cold production layer and the high power layer).

For instance, the power consumption of the miscellaneous layer CL may be expressed as

$$CL = PC\_global - PC\_high - PC\_cold - PC\_base$$

Where:

- PC_global is the global power consumption on the analyzed time interval;
- PC_high is the power consumption of the “high power” layer on the analyzed time interval;
- PC_cold is the layer power consumption of the “cold production” layer on the analyzed time interval;
- PC_base is the layer power consumption of the “base” layer on the analyzed time interval;

Depending upon embodiments, the values of the thresholds, for instance the cold threshold and/or the high power threshold, may be defined statically (for instance they may be arbitrary values defined by an operator, for instance an authorized supervisor, or by an inhabitant of the house of instance, or they may be obtained by self-learning). For instance, a threshold may be calculated from statistical data (either related to the power consumption of the same plurality of appliances, on a long term period (like a year for instance), or to a given set of pluralities of appliances).

In the described embodiment, the distribution of the global power consumption between the different layers and the ratio between the calculated layer power consumption values enables to obtain an idea of the impact of groups of appliances of the monitored plurality of appliances associated with layers.

In a variant, a layer may itself be cut in several classes, or sub-layers, and the layer power consumption of a given layer may further be split between several power consumption values, each related to a class of the given layer.

For instance, in the particular embodiment described, several classes may be defined for the "high power" layer:

- a pulse class;
- a “no periodic flat” class;
- a “periodical flat” class.

The "pulse" class may notably comprise periodic peaks and dips of power consumption being close to each other, with alternation, so that the nature of these oscillations may present some fundamental frequencies. The time period associated to the “pulse” class may for instance be a period of one minute, a few minutes (for instance 2 to 6 minutes), less than 10 minutes etc… The ”pulse” class may be related to central vapor irons, autonomous heating, or ovens, for instance.

The "No periodical flat" class may relate to power consumption values linked to phases of continuous consumption over duration greater than the period defined for the “pulse” class. For instance, if the pulse class is associated to pulses of less than 5 minutes, the “no periodical flat” class may be associated with phases of continuous consumption having a duration comprised between 5 minutes to one or two hours.

The "No periodical flat" class may be related to devices whose use is controlled manually by a user (thanks to a manual switch for instance) or by a timer, like auxiliary heating, hairdryer, "white" appliances such as tumble dryers, washing machines, and so on

The "periodical flat" class may relate to power consumption linked to periodical power consumption with a period greater than the duration of pulse class, (for instance a period of N minutes, with N greater than 5) with a given duty cycle of less than 30 to 50% may be chosen. The "periodical flat" class may be related to devices like electric heaters (either heaters programmed centrally or individual electric heaters, notably individual heaters provided with a regulation from a programming hysteresis temperature).

Figure 3 now describes the structure of an electronic device 30, as the electric devices 110, 120, 130, 150 illustrated by figure 1. This device may notably be a smart meter 110, 120, a standalone device 130, located either near a meter, or a distant server 150. In the particular embodiment of figure 3, the electronic device 30 comprises following modules, link together via a data and address bus 300, which may also carry a timer signal:

- a micro-processor 31 (or CPU) ;
- a graphic card 32 (depending on embodiments, such a card may be optional);
- at least one Input/ Output module 34, (like a keyboard, a mouse, a webcam, a probe, a microphone, a loud-speaker, a probe for acquiring a power consumption from a meter, and so on);
- a ROM (or « Read Only Memory ») 35 ;
- a RAM (or « Random Access Memory ») 36 ;
- a communication interface 37 configured for the reception and/or transmission of data, for example via a wireless connection (notably of type WIFI® or Bluetooth);
- a communication interface 38 with a broadband network;
- a power source 39.

In some embodiments, the electronic device 30 may also comprise, or be connected to, a display module 33, for instance a display screen, directly connected to the graphic card 32 by a dedicated bus 330. In a variant, the display module may be external to the electronic device 30. In some embodiments, the electronic device 30 may communicate with the display module 33 thanks to wireless means. In other embodiments, the electronic device 30 may communicate with the display module thanks to wired means, like a cable transmitting display signals. The electronic device 30 may comprise a connector (not illustrated) or other means for transmitting adapted to transmit a display signal to an external display apparatus like an LCD or plasma screen or a video projector.

Each of the mentioned memories may comprise at least one register, that is to say a memory zone of low capacity (a few binary data) or high capacity (with a capability of storage of a whole program or of all or part of data representative of data to be calculated or displayed).

When the electronic device is powered on, the microprocessor 31 loads and executes the program instructions 360 contained in a register of the RAM 36, and notably the algorithms needed of performing at least one embodiment of the analyzing method described herein.

According to a variant, the electronic device 30 comprises several microprocessors.

According to another variant, the power source 39 is external to the electronic device 30.

In the particular embodiment illustrated in figure 3, the microprocessor 31 may be configured for analyzing a global consumption of a plurality of appliances.

In this illustrated embodiment, the microprocessor is notably configured to measure aggregate power consumption of the plurality of appliances during a time interval P for N sliding windows of a duration M and a temporal distance D between successive sliding windows; to select a number Q sliding windows from the N sliding windows according to a selection criterion for selecting sliding windows with a sum S of power consumption representative for a power consumption layer defined according to appliance use; and to calculate an average power consumption per power consumption layer over the time interval P, based on the aggregate power consumption measured over the time interval P for the Q selected sliding windows.

CLAIMS

1. A method for non-intrusive determining a power consumption for a plurality of appliances, said method comprising:

measuring aggregate power consumption of said plurality of appliances during a time interval P for N sliding windows of a duration M and a temporal distance D between successive sliding windows;

selecting (224) a number Q sliding windows from said N sliding windows according to a selection criterion for selecting sliding windows with a sum S of power consumption representative for a power consumption layer defined according to appliance use;

calculating (226) an average power consumption per power consumption layer over the time interval P, based on said aggregate power consumption measured over said time interval P for said Q selected sliding windows.

2. The method according to claim 1 wherein said appliance use is one of:

standby state;
producing cold;
producing heat; or
other.

3. The method according to claim 1 or 2 wherein said power consumption layer is one of:

a base layer, representing a minimal aggregate power consumption of always on appliances and of appliances in standby state;

a cold production layer, representing aggregate power consumption of appliances producing cold;

a heat production layer, representing aggregate power consumption of appliances producing heat;

a miscellaneous layer, representing aggregate power consumption of appliances in none of the previous layers.

4. The method according to claim 3 wherein:

for said base layer said selection criterion comprises selecting, from the N sliding windows, the Q sliding windows with a lowest aggregate power consumption;

for said heat production layer, said selection criterion comprises selecting, from the N sliding windows, the Q sliding windows with a highest aggregate power consumption;

for said cold production layer, said selection criterion comprises selecting, from the N sliding windows, the Q sliding windows with an aggregate power consumption between said lowest aggregate power consumption and said highest aggregate power consumption;

for said miscellaneous layer, said selection criterion comprises selecting, from the N sliding windows, the Q sliding windows with an aggregate power consumption not in any of the previous layers.

5. The method according to any of claims 1 to 4 wherein said duration M and said temporal distance D are specific to each power consumption layer.

6. Analyzing method according to any of claims 1 to 5 wherein said method further comprises generating at least one indicator of an power consumption behavior of at least one of said plurality of appliances based on at least one of said at least one calculated average power consumption per power consumption layer.

7. Analyzing method according to any of claims 1 to 6 wherein said method further comprises generating an alert according to a criterion of proximity between said indicator and a determined indicator.

8. Analyzing method according to any of claims 1 to 7 wherein said method further comprises rendering said indicator on a user interface of a device.

9. An electronic device for non-intrusive a power consumption for a plurality of appliances, wherein said device comprises a processor configured to:

measure aggregate power consumption of said plurality of appliances during a time interval P for N sliding windows of a duration M and a temporal distance D between successive sliding windows;

select a number Q sliding windows from said N sliding windows according to a selection criterion for selecting sliding windows with a sum S of power consumption representative for a power consumption layer defined according to appliance use;

calculate an average power consumption per power consumption layer over the time interval P, based on said aggregate power consumption measured over said time interval P for said Q selected sliding windows.

10. A system for non-intrusive determining a power consumption for a plurality of appliances, wherein said system comprises a server and at least one device, said at least one device comprising a processor configured to:

measure aggregate power consumption of said plurality of appliances during a time interval P for N sliding windows of a duration M and a temporal distance D between successive sliding windows;

select a number Q sliding windows from said N sliding windows according to a selection criterion for selecting sliding windows with a sum S of power consumption representative for a power consumption layer being defined according to appliance use;

calculate an average power consumption per power consumption layer over the time interval P, based on said aggregate power consumption measured over said time interval P for said Q selected sliding windows.

11. A non-transitory computer readable program product, characterized in that it comprises program code instructions for performing the method according to any of claims 1 to 8, when said non-transitory computer readable product is executed by a computer.

12. Computer readable storage medium carrying a software program comprising program code instructions for performing the method according to any of claims 1 to 8, when said non transitory software program is executed by a computer.

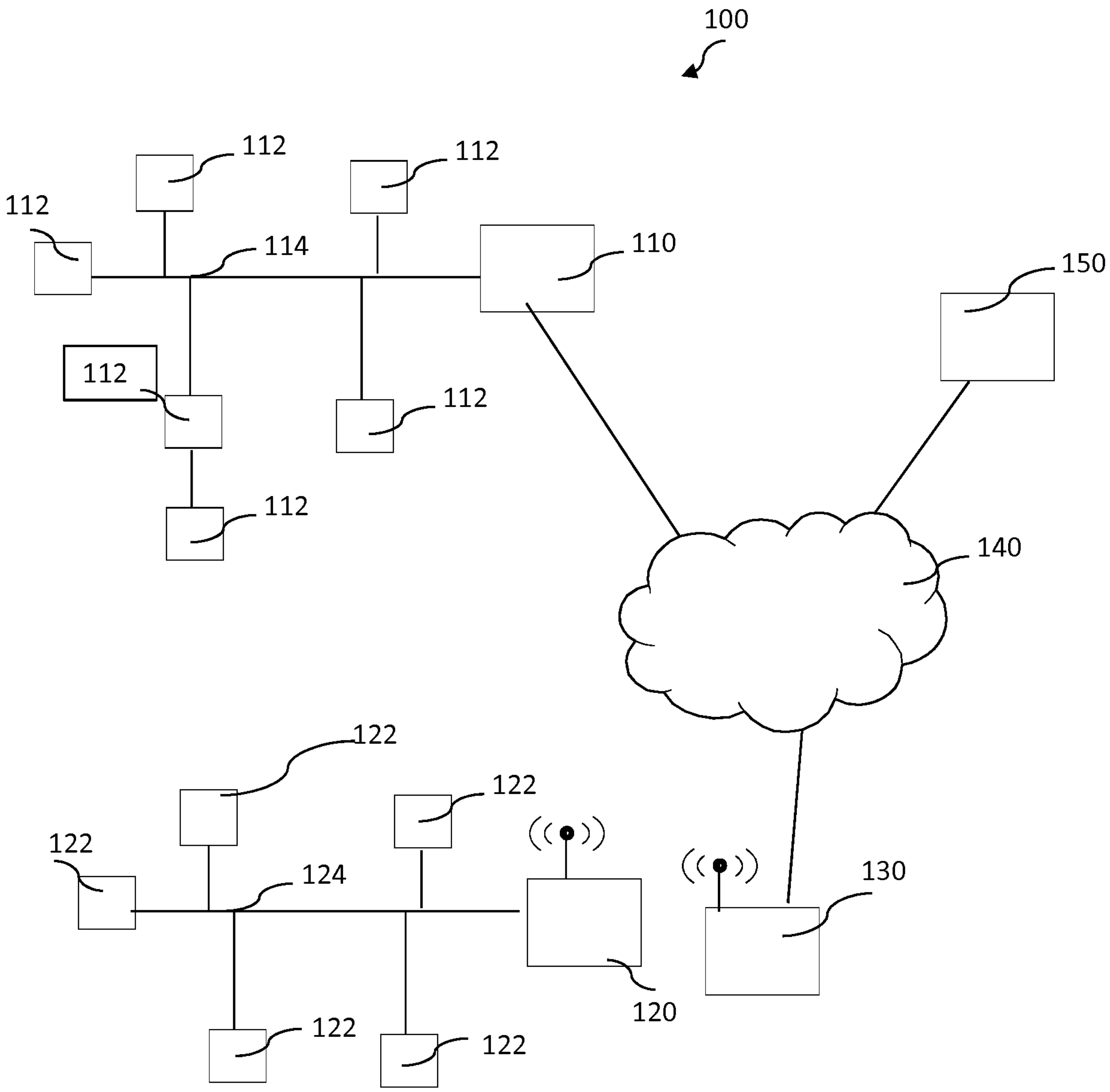
100
112
112
112
112
114
110
150
112
112
112
140
122
122
122
124
120
130
122
122

Figure 1

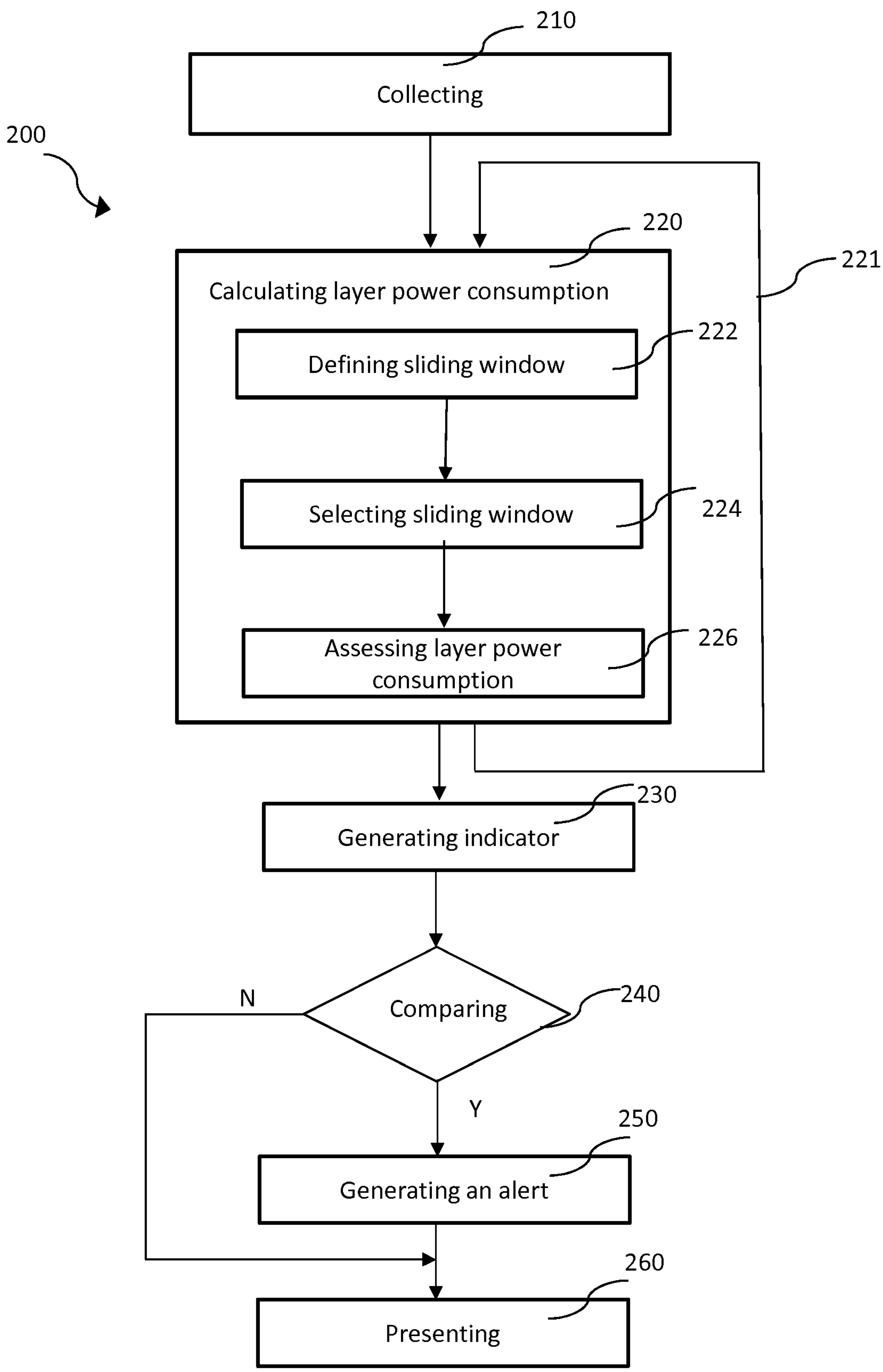
210
Collecting
200
220
221
Calculating layer power consumption
222
Defining sliding window
Selecting sliding window
224
Assessing layer power consumption
226
230
Generating indicator
N
Comparing
240
Y
250
Generating an alert
260
Presenting

Figure 2

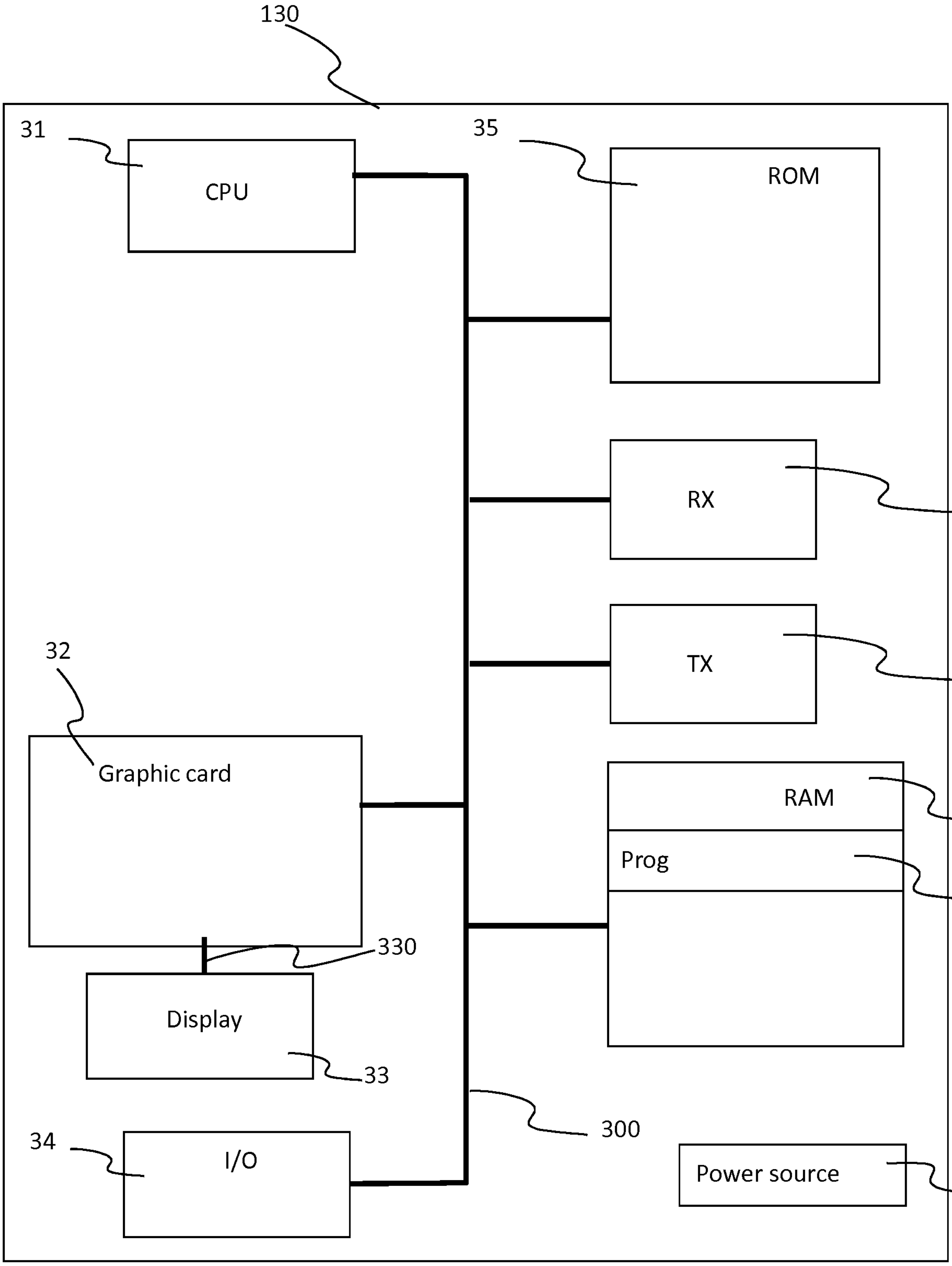
130
31
CPU
35
ROM
RX
37
TX
38
32
Graphic card
RAM
36
Prog
360
330
Display
33
300
34
I/O
Power source
39

Figure 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/079202

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06Q50/06
ADD.

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)
G06Q

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)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KAUSTAV BASU ET AL: "Load identification from power recordings at meter panel in residential households", ELECTRICAL MACHINES (ICEM), 2012 XXTH INTERNATIONAL CONFERENCE ON, IEEE, 2 September 2012 (2012-09-02), pages 2098-2104, XP032465003, DOI: 10.1109/ICELMACH.2012.6350172 ISBN: 978-1-4673-0143-5 the whole document -----	1-12

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[X] Further documents are listed in the continuation of Box C.

[X] 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
26 February 2016	15/03/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Neppel, Clara

1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BASU KAUSTAV ET AL: "Residential appliance identification and future usage prediction from smart meter", IECON 2013 - 39TH ANNUAL CONFERENCE OF THE IEEE INDUSTRIAL ELECTRONICS SOCIETY, IEEE, 10 November 2013 (2013-11-10), pages 4994-4999, XP032539405, ISSN: 1553-572X, DOI: 10.1109/IECON.2013.6699944 [retrieved on 2013-12-30] the whole document -----	1-12
X	GB 2 478 166 A (INTELLIGENT SUSTAINABLE ENERGY LTD [GB]) 31 August 2011 (2011-08-31) the whole document -----	1-12
X	MING DONG ET AL: "An Event Window Based Load Monitoring Technique for Smart Meters", 1 June 2012 (2012-06-01), IEEE TRANSACTIONS ON SMART GRID, IEEE, USA, PAGE(S) 787 - 796, XP011445358, ISSN: 1949-3053 the whole document -----	1-12

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2015/079202

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2478166 A	31-08-2011	AU 2011260098 A1	20-12-2012
		EP 2577576 A2	10-04-2013
		GB 2478166 A	31-08-2011
		JP 2013527542 A	27-06-2013
		US 2013204399 A1	08-08-2013
		WO 2011151622 A2	08-12-2011