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(54) METHOD FOR VALIDATION AND INTRODUCTION OF ONE OR MORE FEATURES IN ELECTRICALLY POWERED SYSTEM

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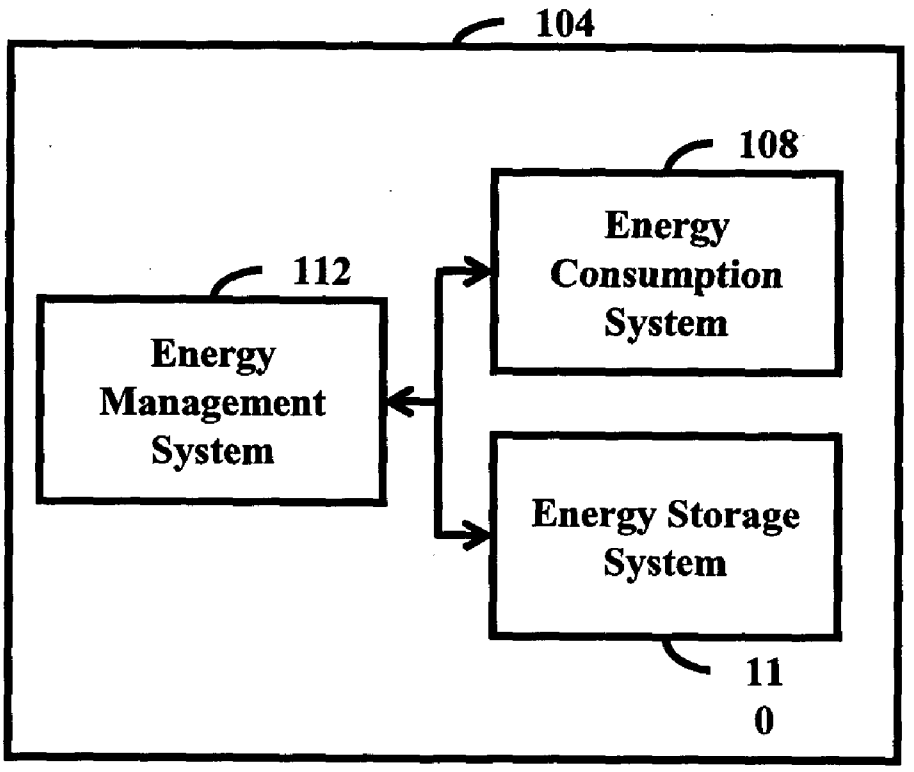
(57) **ABSTRACT**

A method and a system for facilitating validation of introduction of one or more features in a variant of an electrically powered system are provided. The method includes, introducing the features in plurality of electrically powered systems which are at least partially powered by electricity. Thereafter, data is collected, corresponding to at least one of the energy storage system and the energy consumption system of each of the plurality of electrically powered systems, based on the data required for validating the features introduced in the electrically powered system. The collected data corresponding to the energy storage system and the energy consumption system is transmitted to a remote location, thereby enabling analysis of the data, at the remote location, for validating introduction of the at least one feature in the variant of the electrically powered system.



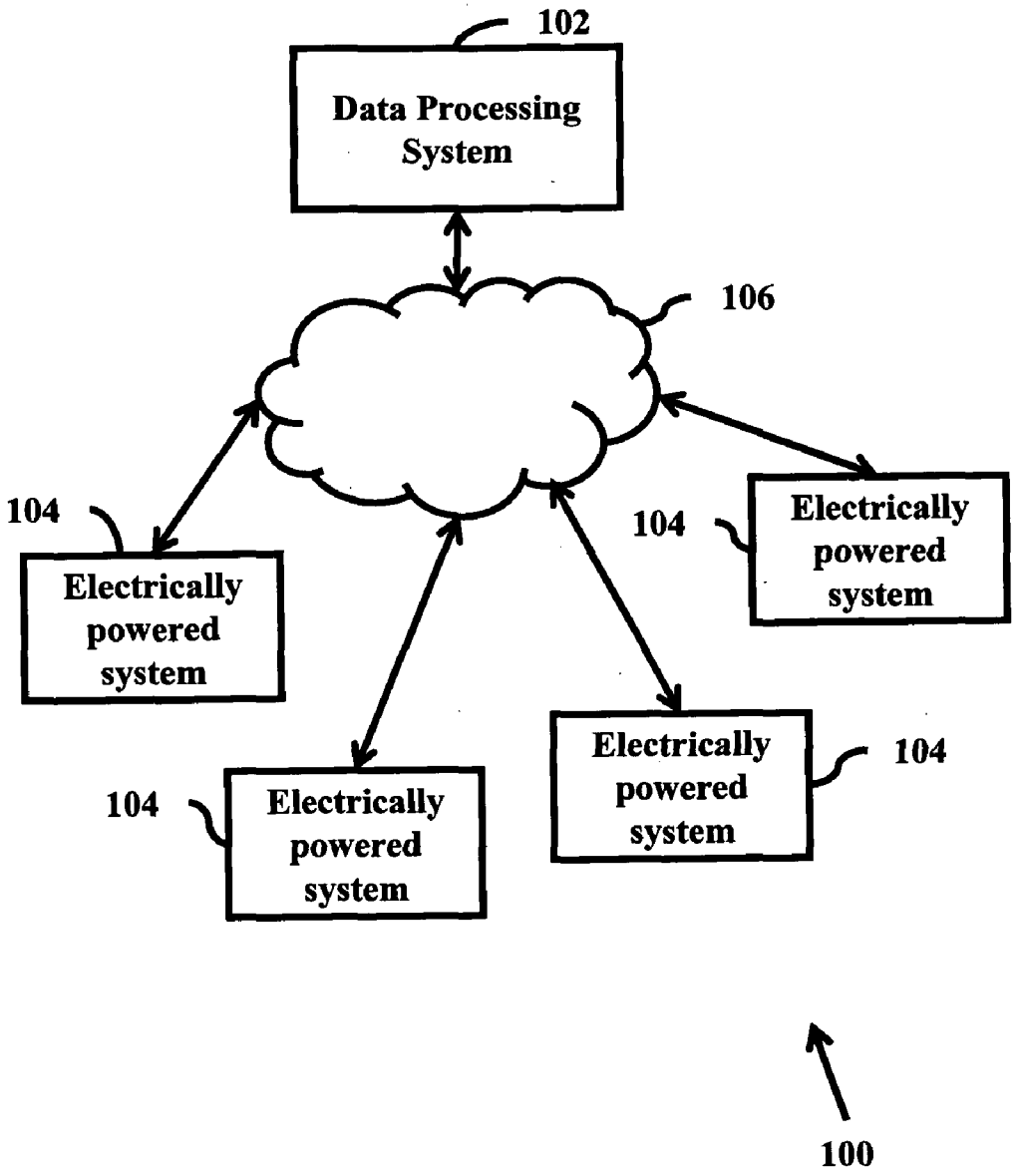

102
Data Processing System
106
104
Electrically powered system
104
Electrically powered system
104
Electrically powered system
104
Electrically powered system
100

FIG. 1

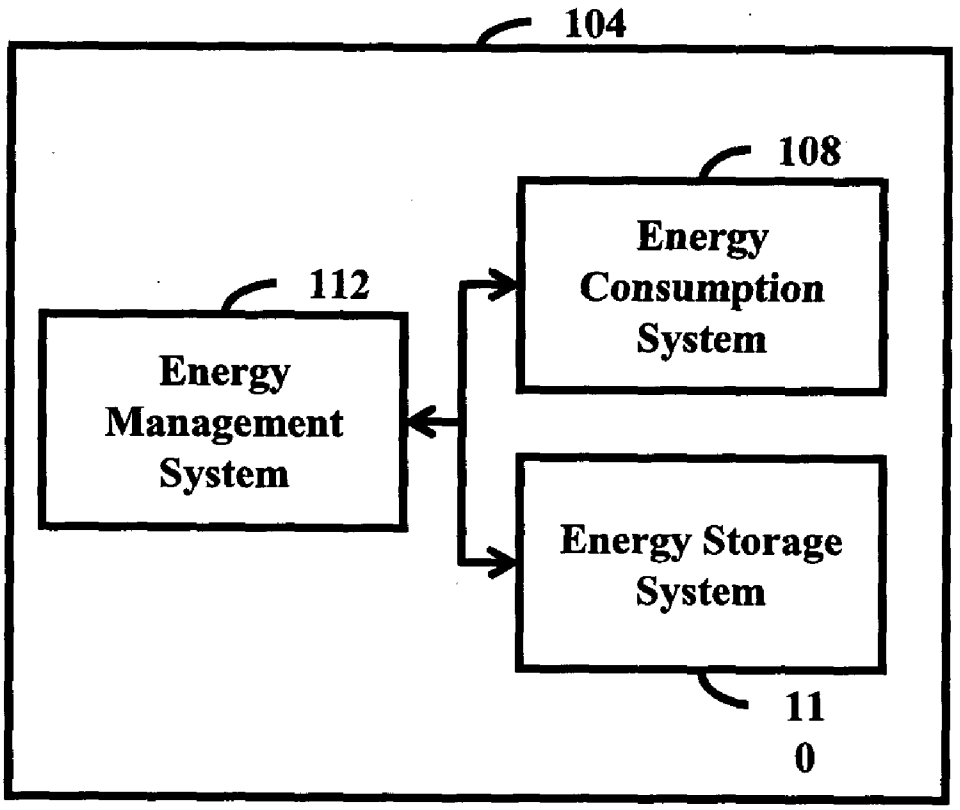

104
108
Energy Consumption System
112
Energy Management System
Energy Storage System
11
0

FIG. 2

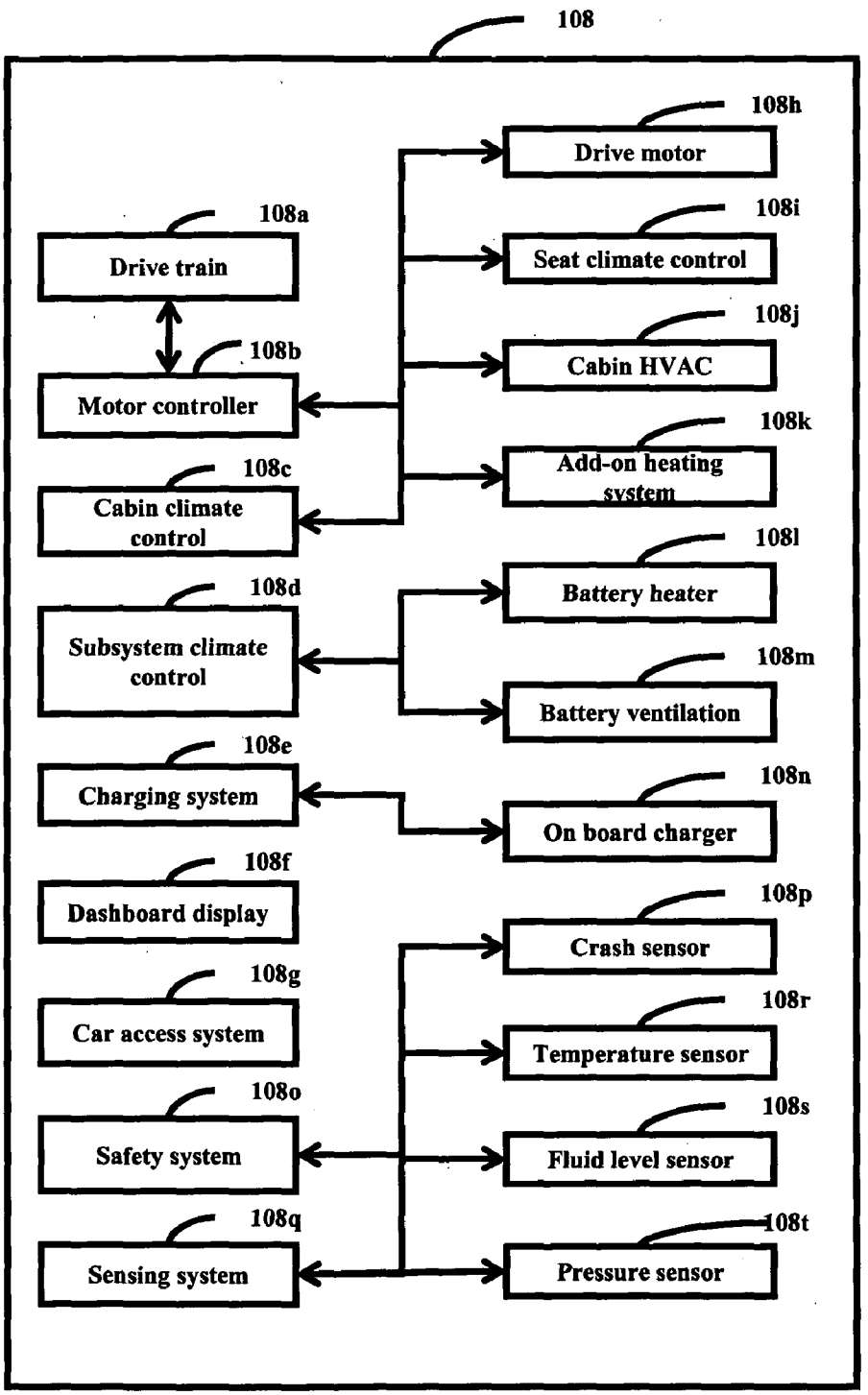

108
108a
Drive train
108b
Motor controller
108c
Cabin climate control
108d
Subsystem climate control
108e
Charging system
108f
Dashboard display
108g
Car access system
108o
Safety system
108q
Sensing system
108h
Drive motor
108i
Seat climate control
108j
Cabin HVAC
108k
Add-on heating system
108l
Battery heater
108m
Battery ventilation
108n
On board charger
108p
Crash sensor
108r
Temperature sensor
108s
Fluid level sensor
108t
Pressure sensor

FIG. 3

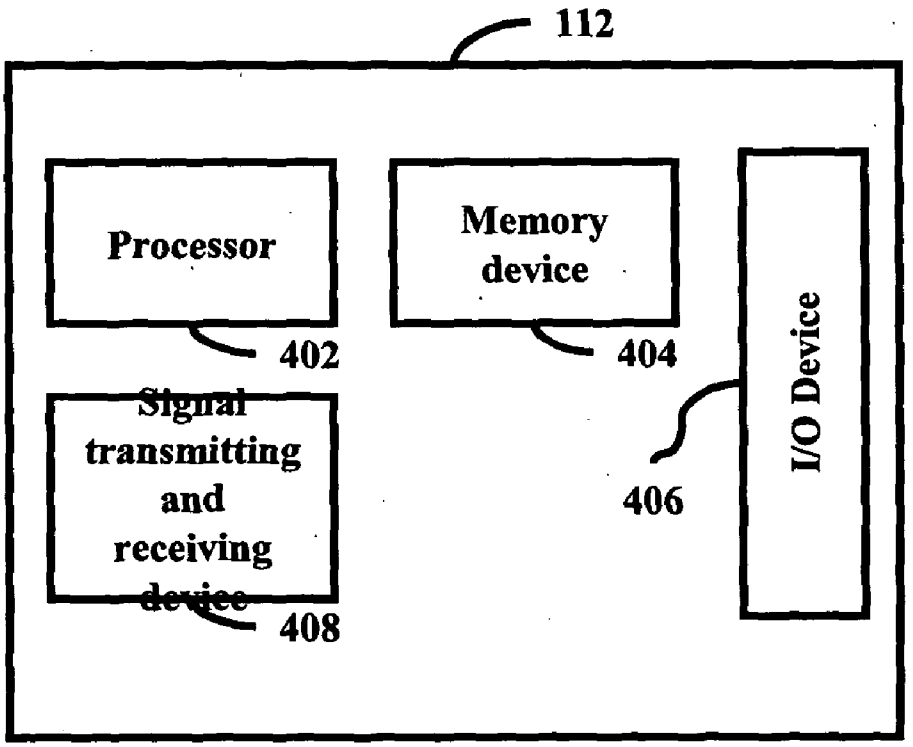

112
Processor
402
Memory device
404
I/O Device
406
Signal transmitting and receiving device
408

FIG. 4

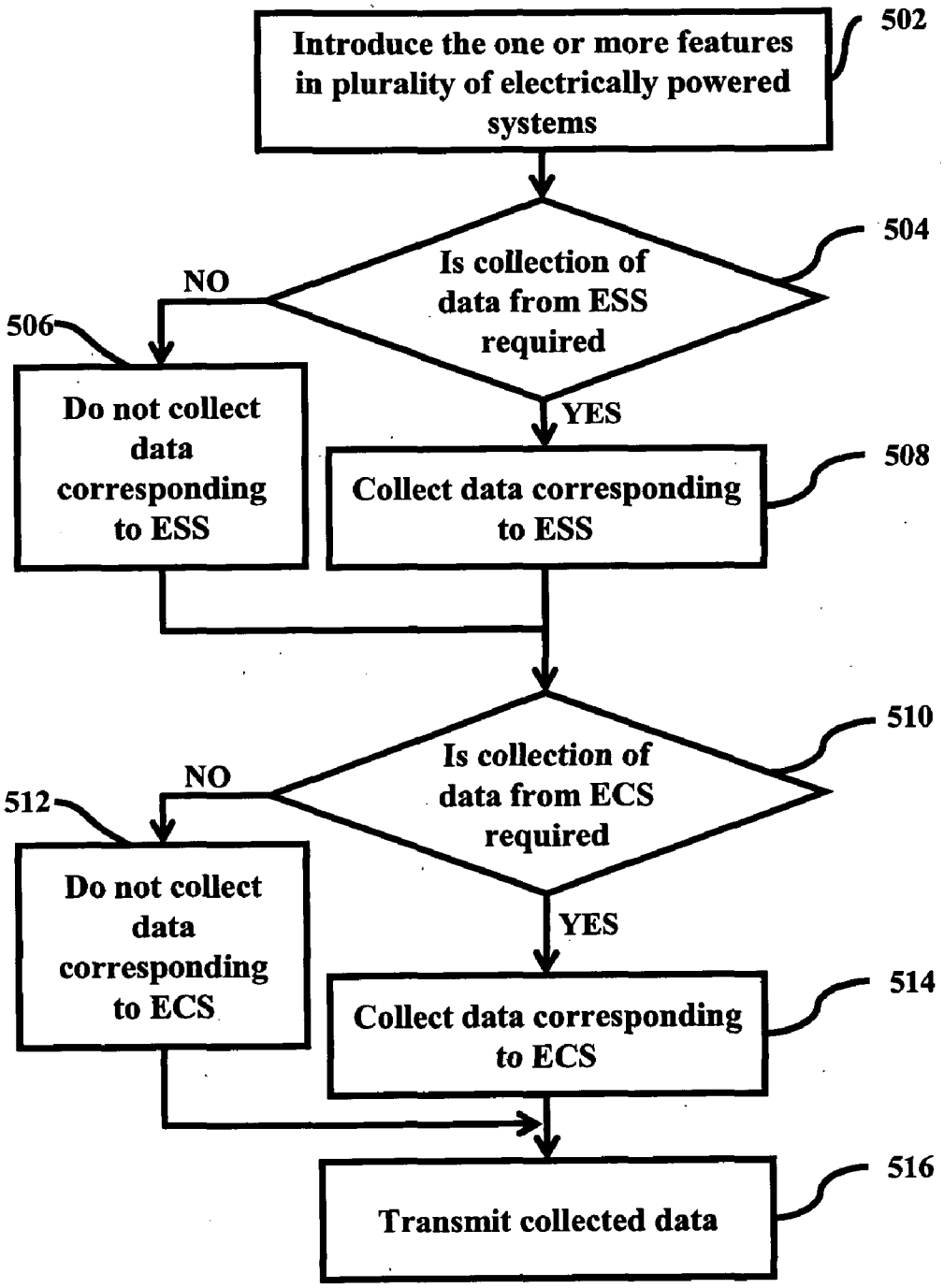

Introduce the one or more features in plurality of electrically powered systems
502
Is collection of data from ESS required
504
NO
506
Do not collect data corresponding to ESS
YES
Collect data corresponding to ESS
508
Is collection of data from ECS required
510
NO
512
Do not collect data corresponding to ECS
YES
Collect data corresponding to ECS
514
Transmit collected data
516

FIG. 5

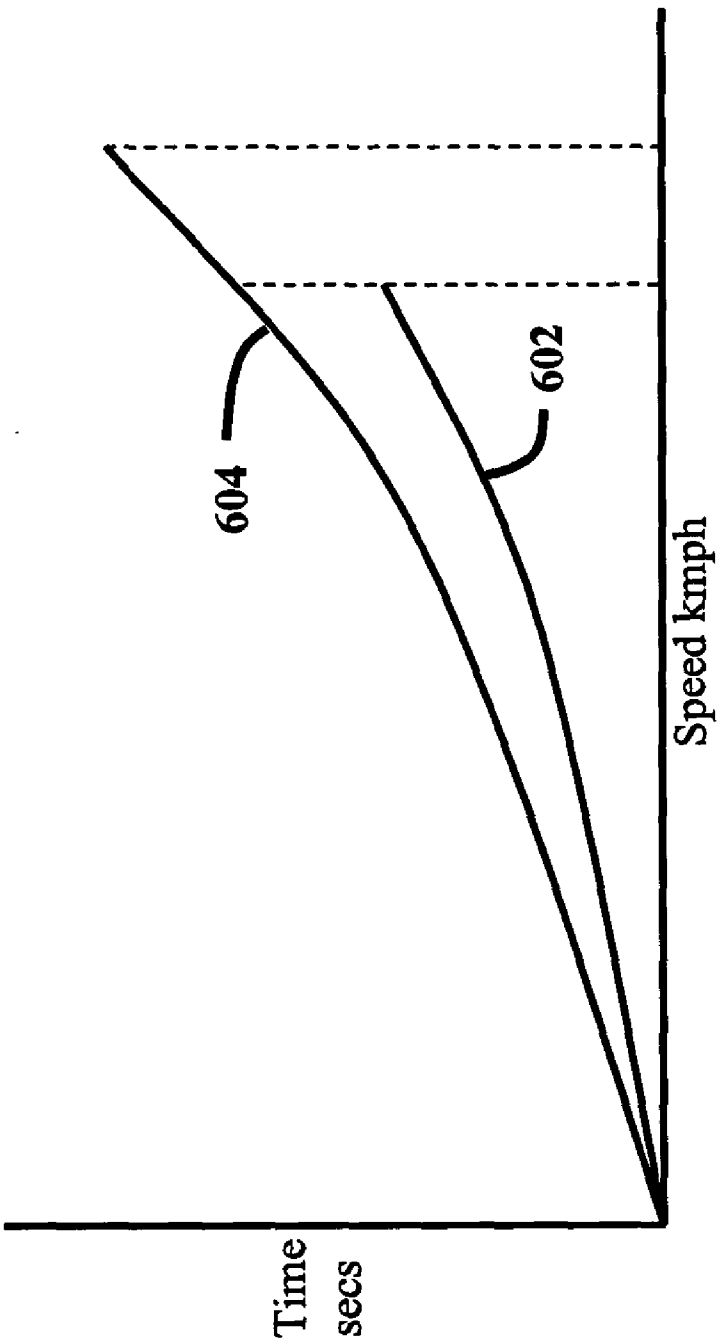


FIG. 6

METHOD FOR VALIDATION AND INTRODUCTION OF ONE OR MORE FEATURES IN ELECTRICALLY POWERED SYSTEM

[0001] This disclosure relates to systems which are at least partially powered by electricity, and more particularly but not exclusively to, a technique for validating introduction of new features in the systems which are at least partially powered by electricity.

BACKGROUND

[0002] It is a common practice in business to introduce variants of a product in Which features different from the existing model of the product are introduced. For example, a variant of an electric car model can be introduced to the market, in which the variant has an energy storage system, such as a battery, made of chemistry which is different from the chemistry of an energy storage system in an existing model of the electric car. Generally, before introducing a variant, the new feature to be introduced is validated to ascertain safety, performance, and durability of the product, among other reasons.

[0003] Traditionally, validation of introduction of a new feature can be performed by making prototypes of the product with the new feature, and testing the product under various operating conditions. For example, if a new feature, such as a new charge profile for a battery of an electric car, has to be introduced, then the same is validated using various test electric cars. To validate this feature, the manufacturer of the electric car deploys the test electric cars in various geographic locations to ascertain the performance of the electric car in light of the newly introduced feature. The deployment of the test electric cars in various geographic locations will enable the manufacturer to validate the new feature under different weather conditions. For example, a newly introduced feature might work well in locations such as India which has moderate climate, whereas it might not work well in Alaska which has extremely challenging climatic conditions. Such deployment of the product across various geographic locations can increase the cost of validating the new feature. Further, the high cost of introducing test products just for the sake of validating might lead to using fewer test products for validating. Using fewer test products for validating might decrease the reliability of validation. Further, introducing products solely for validation purposes and collecting data relating to the test products might also increase the time required for validation. Alternatively, manufacturers may use facilities that simulate various operating conditions to validate introduction of new features. However, building such facilities or renting such facilities may increase the cost of validation. Additionally, it may be difficult to find a facility which is capable of simulating all the desired types of operating conditions.

Statement of Invention

[0004] Accordingly, an embodiment provides a method for facilitating validation of introduction of one or more features in a variant of an electrically powered system, which is at least partially powered by electricity. The electrically powered system includes, an energy storage system adapted to store electric energy, an energy consumption system configured to at least partially consume electric energy from the energy storage system, and an energy management system configured to at least manage the energy storage system and the energy consumption system. The method includes introducing the features in a plurality of electrically powered systems which are at least partially powered by electricity. Thereafter, data is collected, corresponding to at least one of the energy storage system and the energy consumption system of each of the plurality of electrically powered systems, based on the information required for validating the features introduced in the electrically powered system. The collected data corresponding to the energy storage system and the energy consumption system is transmitted to a remote location, thereby enabling analysis of the data at the remote location for validating introduction of the at least one feature in the variant of the electrically powered system.

[0005] There is also provided a system for facilitating validation of introduction of one or more features in a variant of an electrically powered system which is at least partially powered by electricity. The system includes, a plurality of electrically powered system and a data processing system. Each of the plurality of electrically powered systems is configured to enable introduction of the features in them. Each of the electrically powered systems includes an energy storage system adapted to store electric energy, an energy consumption system configured to at least partially consume electric energy from the energy storage system, and an energy management system configured to collect data from the energy storage system and the energy consumption system, send instructions to the energy storage system and the energy consumption system, and transmit data to a remote location. The data processing system located at the remote location is configured to communicate with the electrically powered systems, thereby enabling the data processing system to receive transmitted data and further enabling analysis of the data at the remote location for validating introduction of the at least one feature in the variant of the electrically powered system.

[0006] These and other aspects of the embodiments disclosed herein will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings. It should be understood, however, that the following descriptions, while indicating preferred embodiments and numerous specific details thereof, are given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the embodiments disclosed herein without departing from the spirit thereof, and the embodiments disclosed herein include all such modifications.

BRIEF DESCRIPTION OF FIGURES

[0007] Embodiments are illustrated in the accompanying drawings, throughout which like reference letters indicate corresponding parts in the various figures. The embodiments disclosed herein will be better understood from the following description with reference to the drawings, in which:

[0008] FIG. **1** is a block diagram illustrating a system **100** for facilitating validation of introduction of one or more features in a variant of an electrically powered system, in accordance with an embodiment;

[0009] FIG. **2** is a block diagram illustrating an electrically powered system, in accordance with an embodiment;

[0010] FIG. **3** is a block diagram illustrating an energy consumption system, in accordance with an embodiment;

[0011] FIG. **4** is a block diagram illustrating an energy management system, in accordance with an embodiment;

[0012] FIG. **5** is a flowchart illustrating a method for facilitating validation of introduction of one or more features in a variant of an electrically powered system, in accordance with an embodiment; and

[0013] FIG. **6** is a graph illustrating drive profiles of an electric vehicle, in accordance with an embodiment.

DETAILED DESCRIPTION

[0014] The embodiments disclosed herein and the various features and advantageous details thereof are explained more fully with reference to the non-limiting embodiments that are illustrated in the accompanying drawings and detailed in the following description. Descriptions of well-known components and processing techniques may be omitted so as to not unnecessarily obscure the embodiments disclosed herein. The examples used herein are intended merely to facilitate an understanding of ways in which the embodiments disclosed herein may be practiced and to further enable those of skill in the art to practice the embodiments disclosed herein. Accordingly, the examples should not be construed as limiting the scope of the embodiments disclosed herein.

[0015] The embodiments disclosed herein facilitate validation of introduction of one or more features in a variant of an electrically powered system. To introduce one or more features in a variant of an electrically powered system, such as an electric vehicle, the introduction of the features are validated. For example, if a new feature is to be introduced in a variant of an electric car, the introduction of the feature in the variant has to be validated. To validate the introduction of the feature, the feature is introduced in several electric cars and data is collected from the electric cars. The collected data is analyzed to make a decision on introduction of the feature in a variant of the electric car that may be released in the market at a later date. Referring now to the drawings, and more particularly to FIGS. **1** through **6**, where similar reference characters denote corresponding features consistently throughout the figures, there are shown preferred embodiments.

System Description

[0016] FIG. **1** is a block diagram illustrating a system **100** for facilitating validation of introduction of one or more features in a variant of an electrically powered system, in accordance with an embodiment. The system **100** includes multiple electrically powered systems (EPSs) **104** and a data processing system (DPS) **102**. EPS **104** is a system which is at least partially powered by electric energy. Examples of EPSs **104** include, but are not limited to, electric vehicles, hybrid electric vehicles, and uninterruptible power supply systems. A DPS **102** can be configured to receive and process data from an EPS **104**. In some embodiments, one or more of the EPSs **104** are wirelessly connected to the DPS **102**, which is located at a location which is remote to the location of the EPSs **104**. The EPSs **104** can be connected to the DPS **102** through a telecommunication network **106**. The EPSs **104** can communicate with the DPS **102** using any other data transfer technique.

Data Processing System

[0017] The DPS **102** can include one or more memory devices connected to one or more processing units. The one or more processing units can include, for example, a general-purpose microprocessor, an application-specific integrated circuit, a field-programmable gate array, another device capable of manipulating data, or a combination of devices. In certain embodiments, at least some of the one or more memory devices are integrated with at least one of the processing units. In an embodiment, the DPS **102** is a dedicated computer capable of wirelessly communicating over the network **106**. In other embodiments, the DPS **102** may be a discrete set of components that perform the functions as a DPS **102** as described herein.

Electrically Powered System

[0018] FIG. **2** is a block diagram illustrating an EPS **104**, in accordance with an embodiment. EPS **104** includes an energy storage system (ESS) **110**, an energy consumption system (ECS) **108**, and an energy management system (EMS) **112**. The ESS **110** can include a battery pack capable of storing electricity, one or more capacitors, a thermal storage device, a chemical storage device, a fuel tank, an energy conversion system, other energy storage devices, or a combination of devices. For example, the ESS **110** may comprise one or more of a lead-acid battery, a gel battery, a lithium ion battery, a lithium ion polymer battery, a NaS battery, a nickel-iron battery, a nickel metal hydride battery, a nickel-cadmium battery, and capacitors, among others. The electric energy and/or other forms of energy stored in the ESS **110** can be at least partially consumed by one or more sub-systems of the ECS **108**.

Energy Consumption System

[0019] The ECS **108** may include one or more subsystems that use energy stored in the ESS **110**. FIG. **3** is a block diagram illustrating an energy consumption system **108**, in accordance with an embodiment. For example, the ECS **108** can include sub-systems such as, a drive train **108***a*, a motor controller **108***b*, a cabin climate control **108***c*, a subsystem climate control **108***d*, a charging system **108***e*, a dashboard display **108***f*, a car access system **108***g*, a drive motor **108***h*, a seat climate control **108***i*, a cabin HVAC **108***j*, an add-on heating system **108***k*, a battery heater **108***l*, battery ventilation **108***m*, an on board charger **108***n*, a safety system **108***o*, a crash sensor **108***p*, a sensing system **108***q*, a temperature sensor **108***r*, a fluid level sensor **108***s*, a pressure sensor **108***t* and other subsystems, or a combination of subsystems. The one or more subsystems of the ECS **108** are capable of at least partially consuming electric energy stored in the ESS **110**. In some embodiments, the distribution of electric energy stored in the ESS **110** to the sub-systems of the ECS **108** is at least partially managed by the EMS **112**.

Energy Management System

[0020] FIG. **4** is a block diagram illustrating an EMS **112**, in accordance with an embodiment. The EMS **112** can include components configured to perform one or more of the following functions: managing the distribution of energy stored in the ESS **110**, receiving instructions for managing the distribution of energy, and providing information about the distribution of energy. In some embodiments, the EMS **112** comprises a processor **402**, a memory device **404**, an input and output (I/O) device **406**, and a signal transmitting and receiving device **408**. In certain embodiments, the processor **402** is capable of receiving and processing data obtained from the I/O device **406**, the signal transmitting and receiving device

408, and the memory device **404**. Further, the processor **402** can be configured to send data to the memory device **404** for storage. Additionally, the processor **402** can be configured to send commands to the I/O device **406**, which can communicate the commands to systems and sub-systems associated with the I/O device **406**. Further, the processor **402** can be configured to send data to the signal transmitting and receiving device **408** for transmitting the data to the DPS **102** and the like. In an embodiment, the processor **402** is made of electronic circuits comprising commercially available general purpose microcontroller chips. The memory device **404** may comprise a combination of volatile and non volatile memory chips that can store information in digital form. The I/O device **406** can comprise sets of output lines, each of which is individually connected to the processor **402**. These output lines may include analog inputs, analog outputs, digital inputs, digital outputs, pulse/frequency outputs and data lines, or a combination of line types. The data lines can be connected to the external world through the signal transmitting and receiving device **408**.

Method for Facilitating Validation of Introduction of One or More Features in a Variant of an Electrically Powered System

[0021] FIG. **5** is a flowchart illustrating a method for facilitating validation of introduction of one or more features in a variant of an electrically powered system, in accordance with an embodiment. To facilitate validation of introduction of the features, at step **502**, the features are introduced in multiple EPSs **104**. The EPSs **104** into which the features are introduced can include EPSs **104** used in the field, EPSs **104** used in a controlled test environment, a fleet of EPSs **104** used in a similar situation or setting, EPSs **104** used in a variety of different situations or settings, or a combination of EPSs **104** in controlled and uncontrolled environments. For example, the EPSs **104** into which the features are introduced can include EPSs **104** which have been sold to customers, and which are being used by the customers. Hence, it may be noted that, usage of EPSs **104** which are solely meant for validation may not be required. For example, for validating introduction of a new feature in a variant of an electric car that may be released in the market at a later stage, the feature can be introduced in existing models of electric cars which are currently being used by customers.

[0022] In an embodiment, the EPSs **104** in which the features are introduced may be located in distinct geographic locations. For example, the EPSs **104** may be located in places which have distinct weather conditions, terrain conditions and traffic conditions, among others. In effect, the EPSs **104** in which the features are introduced may be experiencing distinct operating conditions. The introduction of features in EPSs **104** which are experiencing distinct operating conditions enables collection of data from the EPSs **104** that enables understanding of performance of the EPSs **104** in light of the introduced features under various operating conditions.

[0023] In an embodiment, variations of the features may be introduced in one or more EPSs **104**. Introduction of variations of the features enables understanding of performance of the EPSs **104** with each of the feature variations. For example, if introduction of new charge profile for a battery of an electric car is to be validated, then variations of the new charge profile can be introduced in different EPSs **104**. Introducing variations of the charge profile can enable understanding of battery or ESS **110** behavior with different charge profiles. Measuring the results of the introduction of these variations can also enable selecting the most feasible charge profile that may be introduced in a variant of an electric car that may be released in the market at a later stage.

[0024] In an embodiment, when introducing multiple features that are to be validated, all or a combination the features that are to be validated can be introduced in each of the EPSs **104**. Alternatively, one or more features may be introduced in each of the EPSs **104**. In certain embodiments, one or more features are introduced into one or more subsets of the EPSs **104**.

[0025] In an embodiment, based on the feature to the introduced, the EMS **112** of the EPS **104** in which the feature is being introduced may be reprogrammed. In an embodiment, the reprogramming can be carried out from a remote location wirelessly over a telecommunication network. In an embodiment, DPS **102** which is located at a remote location reprograms the EPS **104** over the network **106**.

[0026] In an embodiment, the EMS **112** may be connected to the DPS **102** using tangible connection to enable reprogramming of the EMS **112**. Any other data communication technique can be used to transfer data, software, programming, or instructions between the DPS **102** and the EPS **104**. In some embodiments, the EMS **112** is reprogrammed by any one data communication technique or by a combination of data communication techniques.

[0027] In another embodiment, where a feature cannot be introduced by only reprogramming of the EMS **112**, the feature can be introduced in the EPS **104** by introducing one or more components in the EPS **104**. For example, if introduction of a battery of certain chemistry has to be validated, then the battery of that chemistry is introduced in the EPSs **104**.

[0028] Subsequent to introduction of the features in the EPSs **104**, data corresponding to one or more of the ESS **110** and the ECS **108** is collected. The collected data can include data that is required for validation of introduction of the features, other data, or a combination of required data and other data. In some embodiments, at step **504**, processor **402** of the EMS **112** checks whether data corresponding to the ESS **110** is required for validation of introduction of the features. In an embodiment, DPS **102** updates the EMS **112** regarding the data that is required for validation of introduction of the features. If data corresponding to the ESS **110** is required, then the same is collected from the ESS **110** at step **508**. Further, the processor **402**, at step **510**, checks whether data corresponding to ECS **108** is required for validation of introduction of the features. If data corresponding to ECS **108** is required, then the same is collected from the ECS **108**, at step **514**.

[0029] In an embodiment, data is collected only from those sub-systems of the ECS **108** which are required for validation of introduction of the features. While the embodiment illustrated in FIG. **5** indicates that data is not collected if it is not required, in alternative embodiments, data that is not necessarily required (including, for example, optional data, metadata, other data, or a combination of data) may be collected in addition to any required data. Further, in some embodiments, the method includes collecting some or all data that is available for collection. In certain circumstances, at least some data that is typically required for validation of introduction of one or more features may not be available (due to, for example, a system fault or measurement error). In certain embodiments, data may be collected even when certain required data is not available.

[0030] At step **516**, the data collected by the processor **402** is transferred to the DPS **102**. The transfer of data can be accomplished by any suitable technique. For example, the data collected by the processor **402** can be transmitted to a remote location. The data collected by the processor **402** may be stored in the memory device **404** and transmitted by the signal transmitting and receiving device **408**. In an embodiment, the data is transmitted to the remote location periodically by retrieving the required data from the memory device **404**. In an embodiment, the data collected is partially transmitted to the remote location. Alternatively, all the collected data may be transmitted. In an embodiment, the processor **402** processes the collected data before transmitting. Alternatively, a part of the collected data may be processed by the processor **402** before transmitting. Alternatively, the data may be transmitted without being processed before transmitting.

[0031] In an embodiment, the transmitted data is received at the remote location by the DPS **102**

[0032] The various actions in above method may be performed in the order presented, in a different order or simultaneously. Further, in some embodiments, some actions listed in the method may be omitted.

[0033] The data received by the DPS **102** can be analyzed to validate the introduction of features.

EXAMPLES

[0034] In an embodiment, system **100** is used to validate introduction of a heating feature in a variant of electric vehicles. To validate the introduction, the heating feature is introduced into existing electric vehicles. In an embodiment, the heating feature is introduced by integrating required components in the vehicles. Subsequently, data corresponding to performance of the vehicle in light of the introduced feature is collected. The collected data is used to validate the introduction of the feature.

[0035] In an embodiment, system **100** is used to validate introduction of new drive pattern in a variant of electric vehicles. For example, introduction of new drive profile in vehicles which may be used inside a college campus may be validated. It may be noted that vehicles which may be used only in the campus may be driven at speeds lower than that of vehicles driven on city roads. FIG. **6** is a graph illustrating drive profiles of an electric vehicle, in accordance with an embodiment. In light of the above observation, drive profiles of existing vehicles is changed from existing drive profile **604** to a new drive profile **602**. The new drive profile **602** provides higher acceleration and lower top speed as compared to existing drive profile **604**. After configuring the vehicles to follow the new profile **602**, data is gathered from the vehicles wirelessly to identify if there is any advantage, such as, increased drive range realized due to the new profile. In this case the new feature is introduced by reprogramming EMS **112** of each of the vehicles to follow the new profile **602**.

[0036] In an embodiment, the new feature may be introduced in the EPS **104** by introducing one or more components in the EPS **104**. For example, if introduction of a new type of battery in a variant of EPS **104** has to be validated, then the new type of battery is introduced in the existing EPS **104** for validation. Subsequently, data from the EPS **104** is collected wirelessly to validate introduction of the new type of battery.

[0037] The embodiments disclosed herein can be implemented through at least one software program running on at least one hardware device and performing network management functions to control the network elements. The network elements shown in FIG. **1** include blocks which can be at least one of a hardware device, or a combination of hardware device and software module.

[0038] The embodiment disclosed herein describes facilitating validation of introduction of one or more features in a variant of an electrically powered system. Therefore, it is understood that the embodiments disclosed include a program and a computer readable medium having data stored therein. The computer readable medium can contain program code for implementing one or more steps of the disclosed methods. The disclosed embodiments also include a server or any suitable programmable device configured to execute that program code. One or more of the disclosed methods can be implemented through or together with a software program written in, e.g., very high speed integrated circuit hardware description language (VHDL) or another programming language. Further, the disclosed methods can be implemented by one or more software modules being executed on at least one hardware device. The at least one hardware device can include any kind of portable device that can be programmed. The at least one hardware device may also include devices that can be programmed (e.g., a hardware device like an ASIC, a combination of hardware and software devices, such as an ASIC and an FPGA, or at least one microprocessor and at least one memory with software modules located therein). The methods described herein can be implemented partly in hardware and partly in software. Alternatively, embodiments may be implemented on different hardware devices, e.g. using a plurality of CPUs.

[0039] The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments disclosed herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation. Therefore, while the embodiments disclosed herein have been described in terms of preferred embodiments, those skilled in the art will recognize that the embodiments disclosed herein can be practiced with modification within the spirit and scope of the embodiments as described herein.

1. A method for facilitating validation of introduction of one or more features in a variant of an electrically powered system which is at least partially powered by electricity, the electrically powered system comprising an energy storage system adapted to store electric energy, an energy consumption system configured to at least partially consume electric energy from the energy storage system, and an energy management system configured to at least manage the energy storage system and the energy consumption system, the method comprising:

introducing the one or more features in a plurality of electrically powered systems which are at least partially powered by electricity;

collecting data corresponding to at least one of the energy storage system and the energy consumption system of each of the plurality of electrically powered systems, based on the data required for validating the features introduced in the electrically powered system; and

transmitting the data corresponding to at least one of the energy storage system and the energy consumption system to a remote location, thereby enabling analysis of the data, at the remote location, for validating introduction of the at least one feature in the variant of the electrically powered system.

2. The method according to claim **1**, wherein introducing the features in the plurality of systems comprises introducing the features in the systems which are currently used by consumers.

3. The method according to claim **1**, wherein one or more of the systems in which the features are introduced are located in distinct geographic locations.

4. The method according to claim **1**, wherein introducing the features in plurality of systems comprises, reprogramming the energy management system of each of the systems to introduce the features.

5. The method according to claim **4**, wherein reprogramming the energy management system comprises, reprogramming the energy management system using a wireless network.

6. The method according to claim **4**, wherein reprogramming the energy management system comprises, reprogramming the energy management system using a wired network.

7. The method according to claim **1**, wherein introducing the features in a plurality of systems comprises, introducing one or more components corresponding to the features, into each of the systems.

8. The method according to claim **1**, wherein introducing the features in plurality of systems comprises, introducing variations of the features in one or more of the plurality of systems.

9. The method according to claim **1**, further comprising processing collected data before transmitting.

10. The method according to claim **1**, wherein transmitting comprises, transmitting to the remote location using a wireless communication network.

11. A system for facilitating validation of introduction of one or more features in a variant of an electrically powered system which is at least partially powered by electricity, the system comprising:

a plurality of electrically powered systems, wherein each of the electrically powered systems are configured to enable introduction of the features thereto, wherein each of the electrically powered systems comprises,

energy storage system adapted to store electric energy;

an energy consumption system configured to at least partially consume electric energy from the energy storage system; and

energy management system configured to:

collect data from the energy storage system and the energy consumption system;

send instructions to the energy storage system and the energy consumption system; and

transmit data to a remote location; and

data processing system located at the remote location, said data processing system configured to communicate with the electrically powered systems at least for receiving transmitted data, thereby enabling analysis of the data at the remote location for validating introduction of the at least one feature in the variant of the electrically powered system.

12. The system according to claim **11**, wherein the electrically powered systems are currently used by consumers.

13. The system according to claim **11**, wherein the electrically powered systems are electric vehicles which are at least partially powered by electricity.

14. The system according to claim **11**, wherein the energy management system is configured to be reprogrammed to enable features in the electrically powered systems.

15. The system according to claim **14**, wherein the energy management system is configured to be reprogrammed over a wireless communication network.

16. (canceled)

17. (canceled)

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