

# Smart Electrical Energy Saver using Grove Sensor with Arduino Microcontroller (SEES-GM)

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**Abstract**– The idea makes use of IoT and machine learning concepts to solve the problem of human power interaction. It involves the installation of smart electric meter at homes which links all the electrical appliances. The smart electric meter produces the individual power consumption of each appliances linked to it over a period of time. These power consumption details of the electrical appliances are then fed to the mobile application through the Grove sensors, Arduino board and the EB data parser. The mobile application will monitor the power consumption of each appliance based on the basic power consumption details that are preset and provide the awareness for conservation of power. The application generates the electricity bill for each day based on the tariff pattern. Suggestions are provided to the user through the mobile application based on the power consumptions of individual appliances. The application can intimate the user about the faulty appliances that consume more power. There is a great utilization of power since the user can monitor the electricity bill everyday and reduce the usage of appliance that consumes more power and replace that are faulty.

## 1. INTRODUCTION

Electricity consumption has significantly increased during the past two decades in India due to the availability of electrical appliances at an affordable cost. Hence, electricity generation has to keep up pace in order to meet the electricity demand of the entire nation. India's electricity generation from 1950 to 1985 was very low when compared to developed nations. Since 1990, India has recorded faster growth in electricity generation. India is the world's third largest producer and fourth largest consumer of electricity. Though the electrical energy production is tremendous, it is not being utilized with proper care to save energy. The existing conventional online application [1] generates electricity bill based on the units consumed for every two months for each customer. It provides a single value for the units consumed with the corresponding cost. With this value alone, it is not possible to understand the pattern of energy consumption by different electrical appliances. However, such an understanding will lead to an increased awareness of the power usage and subsequently may have a significant influence on using the appliances prudently in order to reduce the bill amount. Further, at present it is not possible to detect a faulty electrical appliance which might possibly inflate the bill. Most importantly, the current system does not provide an itemized electricity bill based on the current tariff. This information, if it is provided, would definitely be a motivating factor for the consumers to save energy. This in turn would reduce the burden on the country in terms of electricity generation, thus leading to an improved economy.

With this in mind, the objective of this project is to develop a novel system named “SEES-GM: Smart Electrical Energy Saver using Grove Sensor with Arduino Microcontroller” to increase the awareness of electricity usage leading to savings in energy. This system intends to

- Provide the number of units and the cost consumed for every heavy-duty electrical appliance
- Detect faulty electrical appliances and issue alerts
- Generate and display intermediate electricity bill using the current tariff.

Currently, our country is generating electricity from both conventional and renewable sources including wind, solar, bio mass and bio gas. An average amount of 5 crore is spent for generating 1 Mega Watt electricity. While this is very expensive, people use this energy indiscreetly unmindful of the cost involved without any awareness. Such an irresponsible usage would only backfire on the public in the form of additional tax. Hence, it is essential to utilize this electrical energy in a prudent manner. To address this concern, a system named SEES-GM has been proposed to create sufficient awareness for the consumers regarding the usage of electrical energy.

## 2. LITERATURE SURVEY

Weiss, M., Helfenstein, A., Mattern, F., and Staake, T.,<sup>[1]</sup>

**Leveraging smart meter data to recognize home appliances:**

This Journal which was published in the year 2012 has nearly met all the findings of the implementation and usage of the smart meter and its collaboration with the smart phones as it is being the era of smartphones, but in a simulation environment. This journal majorly discusses how to leverage the information

from the smart meter to find the home appliances based on the simulated database to provided. Our proposed system makes use of the AppliSense algorithm to analyse and recognize the electrical appliances based on the data collected from the smart energy meter and makes use of the android application to process the data and makes use of the linear regression algorithm to provide suggestions regarding the power consumptions of the individual appliances. In the long term, we would like to investigate the possibility of building a larger appliance signature base. In addition, we are considering methods to derive occupancy state from electricity and appliance use data, in order to use this information in a smart heating control strategy.

#### **S. Elakshumi, A. Ponraj<sup>[2]</sup> - A Server Based Load Analysis of Smart Meter Systems:**

Energy meters are gradually being replaced by accurate electronic meters. As huge revenue is lost to power theft, incorrect meter reading and billing, the use of smart meter analysis eliminates this issue. Furthermore, it will improve metering, billing efficiency and accuracy, thereby contributing the energy in a maintainable way. Also, making it possible to use energy resources more efficiently and providing real-time data useful for balancing electric equipment or loads and reducing energy outages. Consumers can easily understand their power consumption by this means. Advance metering infrastructure proposed gives way to Smart Grid Technology very soon in near future. The Power Line communication modems is been used as a dedicated devices in achieving the desired goals. But PLC is not so powered due to high cost required to design transceivers at each station. Here the challenge is to lower the cost so enjoy a more efficient and cheapest media of communication. Clustering in high dimensions has been an open problem all these years. Recent research show that it is preferable to use dimensionality reduction techniques before clustering than clustering in the high dimension directly. Thus there is a need for good-quality, fast clustering algorithms for low-dimensional data.

#### **Olivier Steiger, Mauricio Garcia Avendano, Yannick Maret<sup>[3]</sup> - A mobile app for reporting damaged electrical equipment:**

A mobile app has been presented for collecting data about damaged electrical equipment. This is an essential stage of reliable, coordinated and fast power outage management. The app has been implemented on an Android tablet computer, and it has been found easy to use even for first-time users. Feedback obtained from a test panel of 17 people has pinpointed some aspects that are in need of improvement. Notably, the equipment localization map and the navigation bar have been found to lack intuitiveness. Beside these specific improvements, the app shall be ported to other devices and operating systems (e.g. iOS) in the future. Another useful

feature that shall be investigated is the verification, in terms of quality and suitability, of pictures prior to transmission. In fact, uneducated users may generate irrelevant data that can be filtered out that way, thus saving bandwidth and reducing clutter received by the utility. Basic solutions include checking the picture for proper exposure and contrast. More advanced systems could further assess content adequacy, e.g. by making sure that the images shows the proper electrical components.

#### **Kant Suwansit, BootsabakornKonsombut, PeeraphatHankongkaew, ThitinanTantidham, PMA<sup>[4]</sup> - Power Monitoring Application for Android:**

In this work, they develop the system to monitor AC power usage of an electric device via the CT sensor coupled with a bridge circuit attached to the Arduino board. Our Arduino board, CT Sensor and the circuit are designed and put in a box with AC power connection between an AC outlet and monitored device which is easy to be installed and implemented. Power monitoring values are recorded on database server side and can be handled in real time and for historical log usage. It also allows users to manipulate name of each monitored device according its location on Android devices. The power consumption can be displayed in different time scales of each device and comparison among different devices like real-time, daily, monthly, yearly graph as well as statistical history upon user desires. Users need to connect their android system to the server to retrieve the power consumption data for displays . . However, User cannot monitoring whenever the network of Android is not on the same the server.

#### **M. Amir Hamzah M.Isa, MohdFuad Abdul Latip, NorlizaZaini, Yasin Fitri Alias,<sup>[5]</sup> - Android-based Application for Real Time Energy Monitoring of Domestic Electricity:**

This paper presents about the development of a system called the Android-based Application for Real Time Energy Monitoring for Domestic Electricity (SEES-GM). This system consists of two main parts. The first part is an online database used to store electricity consumption data recorded by the smart meter at a particular house. The second part is an Android application used to view and monitor the power consumption of different areas (rooms) in a house and their respective costs. The system was successfully developed and tested. The objectives were achieved where the system allows the users to be more aware of their power consumption in the house, up to the identification of which area in the house or which equipment that consume the most energy, leading to the highest cost. By knowing such information, the user can save money by trying to minimize utilization of electricity in the identified area or the related equipment. In addition, future extension of SEES-GM may include a feature to capture abnormal activity that lead to a rise in power consumption value. Besides that, SEES-GM can also be enhanced with alerts

to users when the maximum usage of electricity is reached, optionally with automatic supply cut.

### 3. PROPOSED SYSTEM

The architecture of the proposed SEES-GM shown in Figure 1, consists of a group of grove electricity sensors, an arduino microcontroller and a **EB Data Processor**. Basically, grove electricity sensors are used to measure the alternating currents consumed by the appliances and arduino controller is utilized to preprocess the data. The EB Data Processor is responsible for storing the EB data in database and detecting the power consumed by different appliances. Further, most importantly, it also provides different useful views about the consumption of users in order to create an awareness of their usage of electrical energy.

A grove electricity sensor [2] is a small sized, highly accurate device to measure the alternating current from any electrical appliance generating upto a maximum of 5A. The SEES-GM considers a sample group of four appliances connected to grove electricity sensors. Basically, these sensors measure the alternating currents consumed by the appliances periodically. The SIG pins of these sensors provide the alternating voltages based on the alternating currents measured from appliances. These values are passed to the arduino microcontroller for preprocessing them to corresponding amplitude currents. The timestamp, amplitude current and the appliance will be sent to the **EB Data Parser** available in the **EB Data Processor**. The EB Data Parser finds the power corresponding to the appliance and records it in the EB database by applying the following formula.

$$P = I_A / V, \quad [1]$$

where  $I_A$  – Alternating current consumed by the appliance A &  $V = 240$

Table 1 Threshold of Appliances

SNo.	Appliances	Power consumed in Amps per hour	Power consumed in Watts per hour	Power consumed in Kilo Watts
1	Air Conditioner (1 ton)	5.83	1400	1.4
	Air Conditioner (1.5 ton)	8.75	2100	2.1
2	Refrigerator	0.42	100	0.1

3	(165 Litres)			
	Refrigerator (310 Litres)	1.67	400	0.4
	Washing Machine (top load)	1.04	250	0.25
	Washing Machine (front load)	3.12	750	0.75
4	Water Heater	4.12	1000	1

Consequently, **Home Appliance Electricity Detector** utilizes Applisense algorithm to detect the power consumed by different appliances. This detector considers the aggregated electricity for a particular period of time for the detection. In order to detect a particular appliance, threshold database shown in Table 1 is considered. Generally, each appliance has the power capacity in watts per hour. Based on this power, the appliances will draw respective currents. The commonly used appliances, their power capacity and the expected current to be drawn are given in this threshold table. Whenever the significant change in load curve is detected, it computes the difference between the consecutive levels. This difference in power will be compared with the known threshold database shown in Table 1 to map with the respective appliance.

**EB Data Processor** generates three views. The first view consists of appliance, power consumed in units and cost in rupees. In order to generate this view, this processor considers the EB database which has power consumed by the appliances in watts. From this, power consumed by a particular appliance for a period of time (may be weekly) will be found by using a proper sql filter command. However, this has to be converted into power consumption in units in order to calculate the respective cost. The power in units [4] can be calculated by applying the following formulae

$$\text{Daily Units} = (\text{Power in watts} * \text{Usage hours per day}) / 1000 \quad [2]$$

$$\text{Weekly Units} = \text{Daily Units} * 7 \quad [3]$$

During the detection of the appliances, if the power consumed by an appliance is more than its expected power consumption, it is classified as a faulty device and this information is provided to the user. Based on the above-mentioned information, the second view is generated. This view consists of appliance, power consumed by that particular appliance in general, the current consumption of that appliance and the status of the device.

The present electricity bill does not provide any information to the consumers regarding the basis in which the bill has been generated. Hence, the **EB Data Processor** will also generate a third view to display the electricity bill which details the generation of bill based on the current tariff for the total number of units consumed..

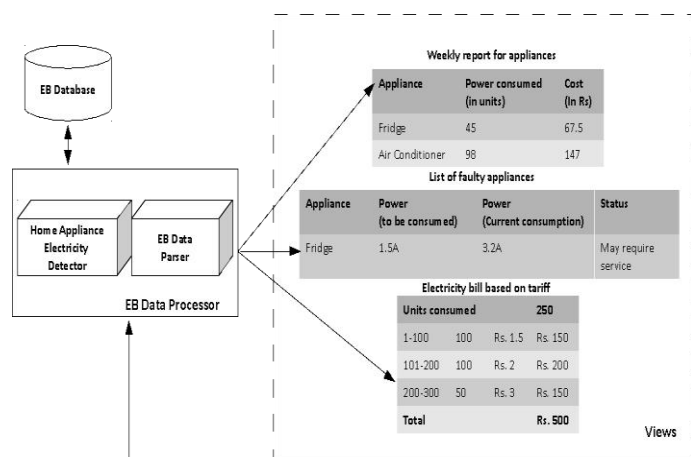


Figure 1. Design of proposed system SEES-GM

Figure 2: Design of android application for SEES-GM

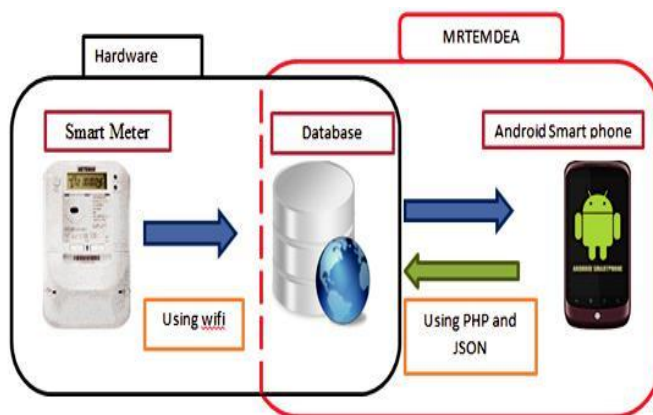
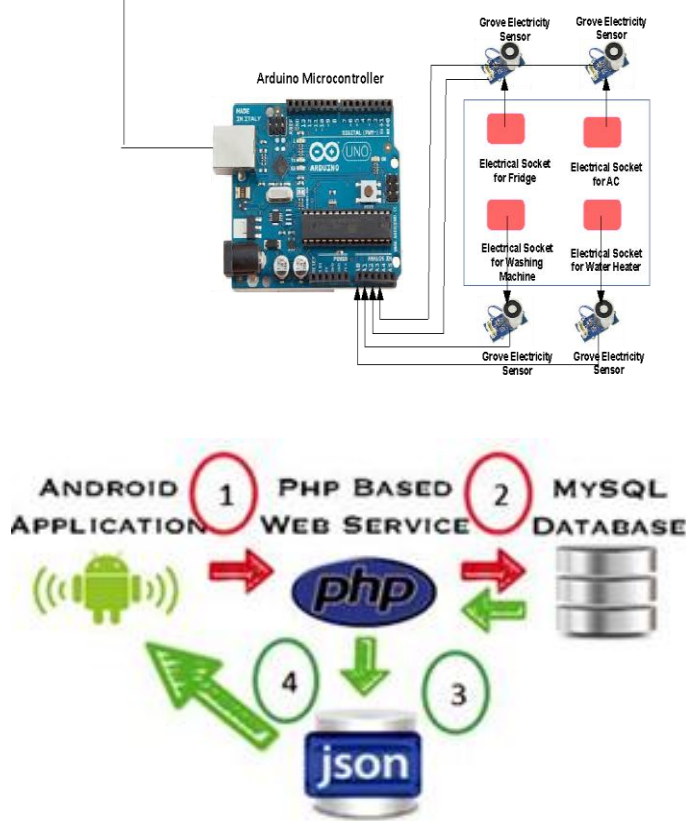
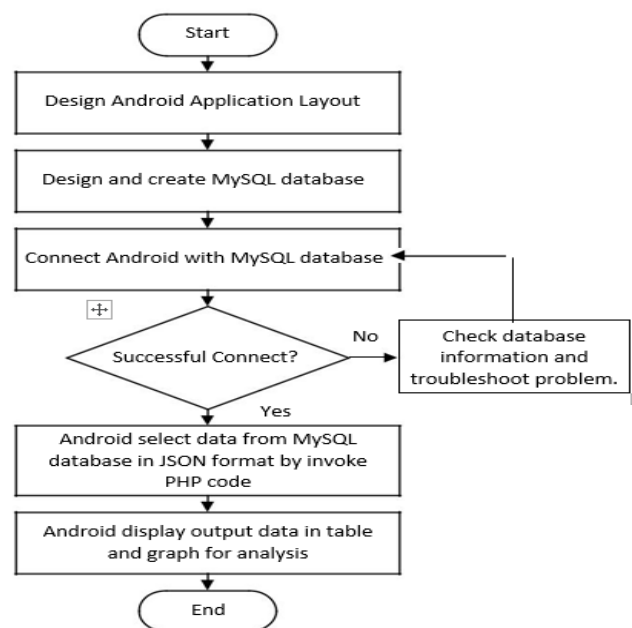


Figure 3: Overall architecture of the SEES- GM



#### 4. METHODOLOGY

In the initial stage of the work, we aimed to develop an Android-based application that will be able to provide a friendly user interface to display the electricity consumption of a house in terms of voltage, current, power and also monetary value. The electricity consumption in each different area of the house will be displayed so that the user can determine which



part of the house is consuming the largest amount of energy. The motive for having the mobile application, specifically on Android platform is simply due to the advantages it offers, where the mobile phone is portable and always handy with the

user. So by having the application installed on the phone, the user is free to launch the application and monitor the electricity consumption analysis at anywhere and anytime easily.

### A. Development of SEES-GM

In general, the overall system is divided into two main parts, specifically the data collector (hardware) component and the mobile application component. At one end, the recorded electricity usage data will be uploaded by the smart meter microcontroller to an online database. While at the other end of the system, these data will then be available for the Android application to absorb via a PHP-based web service powered by JavaScript Object Notation (JSON) function. Figure 1 shows the general interactions between these different components.

Figure 2 illustrates the sequence of activities carried out in developing the mobile Android application and the online database.

#### 1) Proses 1- Interaction between Android and PHP:

The interaction between Android application and PHP involves the actions of “add-room”, “edit-room”, “get-list” and “delete-room”. The Android application sends such request actions based on user’s command to web-based PHP to execute. For every request of adding a new room, the user must insert the room name, hardware identity and the description of the area (or room), for which the electricity consumption readings will be recorded. The codes as in Code 1 represents the request of adding a room (coded in Java) sent by the Android application to the online PHP.

Figure 7: Flowchart of activities on Android and online database.

#### 2) Proses 2- Interaction between PHP and MySQL database:

Once the PHP script received an incoming request from the Android application, it will redirect the request to the online database. This is shown in Code 2, which is used to insert the incoming information about the newly added area (or room) into the database. Such updates about the areas to be monitored in the house are required to allow the real time monitoring of electricity utilization for each different area in the house. For this system, MySQL database is employed, which is a flexible storage to drive dynamic data handling. This allows the user to edit previously stored information, e.g. to rename the area (room) name, hardware ID or the description. For editing and deleting process, the same SQL query is used by changing the keyword of “INSERT INTO” to “UPDATE” and “DELETE”. While, for viewing data on MySQL database the keyword that must be changed to “SELECT”. Based on the created area (room) data in the database, the electricity usage of that particular area in the form of current, voltage, power and monetary value is auto inserted by hardware (microcontroller) by using wireless sensor to the online MySQL database.

#### 3) Proses 3- Interaction between PHP and JSON:

In order to return data to the requesting Android application, the online PHP script will need to encode the required data in JSON format. Code 1 shows the example of data encoded into JSON format by the PHP script. This code will be used for interaction with the Android application.

```
$d["areaName"] = $aa["areaName"]
$d["hdID"] = $aa["hdID"]
```

Code1

#### 4) Proses 4- Interaction between JSON and Android:

In the fourth process, JSON encoded data sent by the online PHP script will be received by the Android application and need to be decoded.

### B. Implementation of SEES-GM

Figure 3 shows the overall layout on how real time energy monitoring system for domestic electricity is being deployed. In general, the system can be classified into two parts, i.e. the first one is the hardware component and while the second part is the mobile-based android application. The database acts as a medium of storage, i.e. to collect data recorded by the smart meter (hardware) and also to allow access to the Android application. By having the Android application installed on their phone, the user will be able to access details of their home electricity consumption at anywhere and anytime.

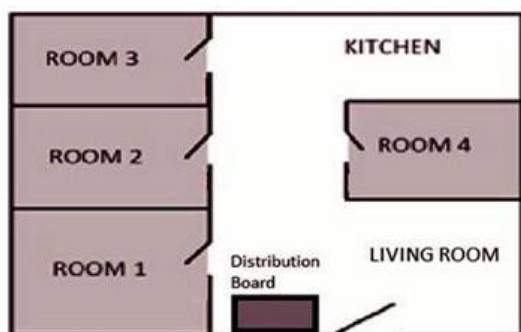


Figure 4: Example of a house layout

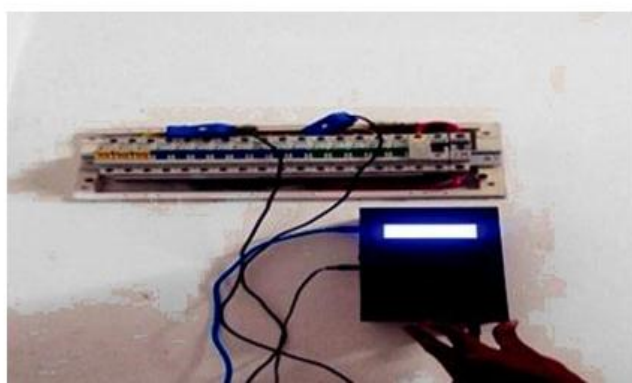


Figure 4 illustrates the layout of a house and the location of a main distribution board. As shown in the layout, there are 4 rooms, 1 living hall and 1 kitchen. Figure 5 shows the installation of smart meter at the main distribution board, where the energy consumption are measured based on different areas in the house. One area may cover more than one room.

Figure 6 shows the flow chart of the Android application interfaces following the proposed navigation path. Four main features are supported by this Android application; i.e. i) view area (room) data, ii) add new area, iii) edit area information and iv) delete area. Figure 7 shows a sample snapshot of the Android application interface, where the user can select which area (room) from the list to view its energy consumption in the form of data voltage, current, power consumption, and monetary value of consumed electricity in a specified period.

This application is unique when compared to other power monitoring meter systems due to the fact that it can record and display the electricity usage based on minute, hour and day. The user will just need to specify the “from date” and “to date” to filter the electricity usage data for a specific period. The filtered data will then be plotted into a graph accordingly.

## 5. TECHNOLOGY STACK

- A. **Smart electric meter** - The smart electric meter to produce the daily consumptions of power by different appliances digitally is installed at home.
- B. **Grove electricity Sensor** -Grove electricity sensors are used to measure the alternating currents consumed by the appliances.
- C. **Android based mobile application** – A common android base mobile application is created to monitor the power consumption details. The readings from the Arduino microprocessor is fed as input to the mobile application.
- D. **Arduino Microcontroller** – Used to preprocess the data from the Grove electricity sensor.
- E. **MS Access** – It is used to keep the records of the smart meters readings and the power consumed by the individual appliances over a period of time.
- F. **EB data parser** - The EB Data Processor is responsible for storing the EB data in database and detecting the power consumed by different appliances.

## VI. ADVANTAGES

The proposed system will bring forward a lot of positive changes to the existing models.

- The excess power consumed by the faulty appliances can be eliminated. Users are now capable of smartly monitoring the daily power usage and therefore can reduce the unwanted consumption thus leading to the sustainable development.
- The human errors previously made by the existing systems can now be eliminated.
- A high level of energy can be saved and further the over used resources can be put to good use.

## 6. CONCLUSION

Thus it can be concluded that the proposed Smart Electrical Energy Saver using Grove Sensor with Arduino Microcontroller (SEES-GM) brings about a variety of improvements to the existing energy saving model and truly adds the “intelligence” factor to the existing models. We gave a detailed description and evaluation of a system that facilitates automatic recognition of switching events of electric appliances. In contrast to other existing approaches, our objective was to develop a system that achieves this by being unobtrusively integrated in users’ life and without requiring a complex system setup or training. We achieved this by interconnecting components that are becoming ubiquitous in home environments: a smart meter and a smartphone. This signature database is established over time and also allows introducing new devices, which is important in a fast changing home environment. In particular, we achieve this as a side effect of a smartphone application, which much simplifies the appliance signature acquisition for user. Applying data analytics to the gathered metering data allows the system to raise energy awareness by providing better tailored energy feedback without the need for special purpose hardware. In combination with actuation capabilities, we can foresee this information to be used to automatically optimize energy consumption and hence increase residential energy efficiency. Not least, appliance-level consumption information can give rise to new business models (e.g., providing cross-selling offers for non-energy-efficient devices). With a recognition rate of about 90% the results of our evaluation study confirm the suitability of the general scheme and encourage us to intensify further research.

## 7. AREAS FOR FURTHER RESEARCH

Future work consists of deploying the system in various households to gather real-world data that allows for more in-depth evaluation of. Based on these experiences, we plan to analyse the algorithm’s dependency on the number of manually recorded signatures and to implement

relevant refinements. This also includes accuracy improvements through the extension from one to three phases (which helps in case two appliances are turned on/off at the same time) and a module for auto-identification of hard-wired heating and cooling devices. In order to deal with edges detected in the load curve that do not yet correspond to an existing signature in the database, we focus on the application of clustering concepts that automatically classify these events (and once a certain probability is reached, verify the match by pushing a notification to the user interface). We also envision the possibility to upload appliance signatures to a community platform. In the long term, we would like to investigate the possibility of building a larger appliance signature base. In addition, we are considering methods to derive occupancy state from electricity and appliance use data, in order to use this information in a smart heating control strategy. The process of gathering the data from the users can be made automatic instead of manual labour through the use of cloud. Integration of smart billing system to further increase the efficiency.

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