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A Novel Energy Management of Smart Home with Multi Knapsack Load Monitoring Analysis

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Abstract:
The paper presents Home Energy Management System (HEMS) obtained from smart grid for residential consumers. The system integrates conventional source of supply from grid with renewable energy resources of solar system .The paper provides with the method of obtaining meter reading, total load consumed as well as individual load consumed and about load demand in a particular time of interval. The paper describes the IEEE 802.15.4 standard protocol wireless sensor network technology. Zigbee technology uses these standards which is an application software module using small, low power and data rate communication technique enabling to monitor and control the home appliances. Further the paper describes the use of web services and smart phone to monitor and control the load appliances. Lab view software is used for simulating home energy management centre and study the results. The microcontroller interface linked with Zigbee transceiver which uses standard RS 232 protocol/ interface bus for pc communication. In addition wireless protocol is used for communication with Android gadgets.

Key words*: home energy management system, power measurement, multi knapsack, android*

1. Introduction

The industrial development has lead to load shedding and blackouts arising due to a wide gap between demand and supply of electricity. While the fossil fuel demand is alarmingly rising, their availability is very limited leading to worse in fourth coming years. Hence alternative non conventional renewable energy resources are tapped out to reduce the dependence on fossil fuels. One such is a solar is a proven non conventional source of energy used to generate electricity through the photovoltaic system.

In spite of various similar measures undertaken the deficiency has not decreased and black outs have become a common factor .In order to avoid black outs the electric power supplier has to undertake many load shedding schedules. This is becoming a global phenomenon and the developing countries are most affected due to increasing energy demand substantially in many folds, while generation is growing at a relatively lower phase. This along with incorporation of latest gadgets has affected residential consumers.

Smart HEMS is a fastest developing methodology in power grid system that uses either analogue or digital or both combined together which act on information regarding electricity supplied by conventional grid to utility consumer. These in turn automatically use to improve efficiency, economic, reliability and sustain generation and distribution .

The Home Energy Management System (HEMS) plays a vital role in distributing electricity obtained either from existing power grid system, and or home level PV system using optimized methodology. This involves arriving at the data obtained from PV system and distributing this power to the load system enabling reduced grid power consumption.

At present, the home power system involves analogue or digital kWh meters indicating the total no of units consumed by the end user. This meter doesn't give any information to user regarding independent consumption details by individual loads. Hence the consumer cannot control load consumption properly. With the present energy billing systems by government, which results in higher tariff structures for higher unit consumed has lead consumer to rethink about the reduced usage of load. Hence the consumer has to decide the type of load to be used classifying them as critical, non critical and time dependant loads. This paper analyses the unit consumption pattern by the three types of load used at a particular time of interval.

For a consumer, it is necessary to know additional information like the consumption of particular load and time of requirement.

2. Back Ground Technologies

This paper utilizes various basic technologies which are briefly discussed as under.

2.1. Zigbee

IEEE 802.15.4 is a standard set by IEEE New standards committee (Nescom) for a low-rate wireless personal area network (LR-WPAN). Based on this in 2003, Zigbee alliance introduced Zigbee standard protocol.

Zigbee protocol as shown in Fig. 1 stack has four layers namely the physical (PHY) layer, the media access control (MAC) layer, the network (NWK) layer, and the application (APL) layer.

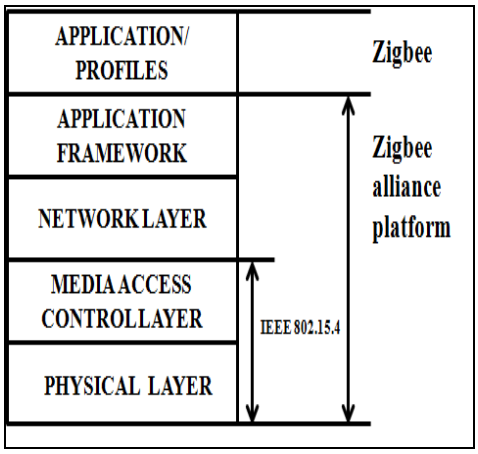

Figure 1: Zigbee Layers Module

With the present day power demand the need for communication has increased in both physical as well as wireless communications. The development of internet and intranet multi pc connectivity has lead to low cost home automation, energy conservation and security.

In general IEEE defines the characteristics of PHY (physical layer and MAC (media access control) layer for LR-WPANs and Zigbee which is developed based on standard defines the network layer specifications and provides the frame work for application programming in the application layer.

PHY layer functionalities involve relay switching, data measurement and load assessment functions involving energy deduction having following features.

- Low rate of 816/915 PHY can be transferred in to better sensitivity and large coverage area which reduce the number of nodes.
- 24 GHz PHY uses to attain higher throughput and lower latency.
- The layer also determines lower duty cycle.

MAC layer involves storage of data, input/output data, pc interface and provides two service access points namely one MAC data services accessed through the MAC common part sub layer data SAP and the second one is MAC management service access through MLME-SAP and layer has following features

- Association and disassociation
- Acknowledged frame delivery
- Channel access mechanism
- Frame validation
- Guaranteed time slot management
- Beacon management

Network layer derives at

- Network information and address assignment
- Routing and route discovery.

Application layer comprises

- Application object and application profile.
- Zigbee device object and device profile.

Zigbee network shown in Fig. 2 comprises of three device types namely

- Zigbee end device
- Zigbee router
- Zigbee co-ordinator

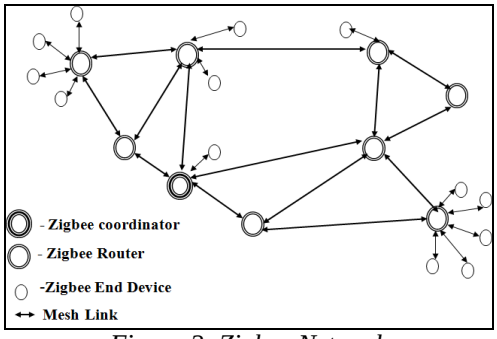

Figure 2: Zigbee Network

2.2. Home Area Network

Home Area Network (HAN) is just a Local Area Network (LAN) with multimedia applications which communicates with digital devices such as personal computers, mobile computing devices, mobile phones and digital TVs etc. In the home, HAN acts as a subsystem of smart grid with energy efficiency and demand response. Further it minimizes the power requirements, leading to cost benefits.

HAN is designed as two categories namely wired and wireless HANs. While the wired HANs utilize telephone, power line , Ethernet and IEEE 1394, whereas wireless HANs utilize wireless LAN, Home RF, Hyper LAN, Bluetooth, UWB (ultra wide band) and Zigbee , mobile devices.

2.3. Conversion of Solar Energy

The photovoltaic cells convert the sunlight into electricity. The arrays of photovoltaic cells are designed to obtain the required operating voltage. The voltage obtained from array of pv cells is unregulated DC. This DC electrical energy is stored in battery and it is converted to desired AC voltage by using inverter and integrated with conventional grid system. The block diagram of above conversion of solar energy using photovoltaic cell is shown in Fig. 3.

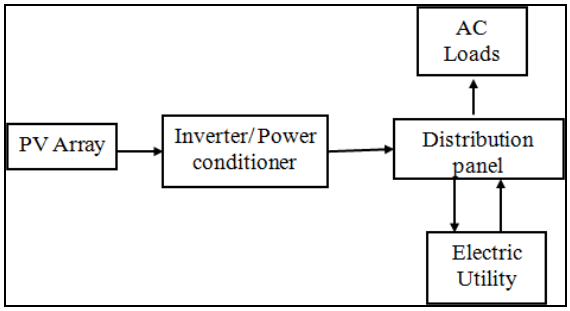

Figure 3: Grid Connected Solar PV System

3. Proposed Method

The basic block diagram of proposed method is shown in Fig. 4. Aim of the work is to determine a model for home energy management system and for a load network control. The model provides visual interface to monitor which enables to control the loads. The model also integrates with additional non conventional source of energy to overcome certain circumstances.

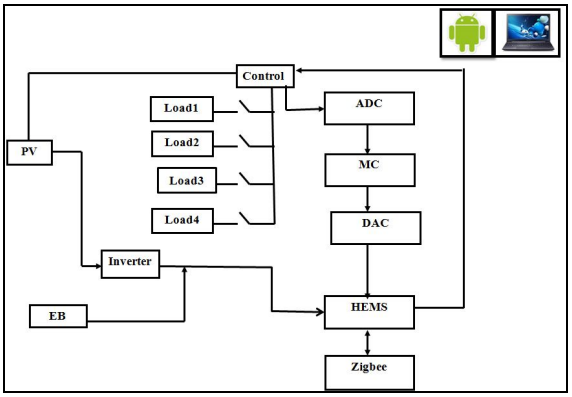

Figure 4: Block Diagram of Proposed HEM System

For the study purpose, a typical Indian house with minimum utilities is taken as an example which has following three types of loads.

- Critical loads having food processor and food grinding, kitchen lights, refrigerator etc...
- Non critical loads are as washing machine, television and entertainment system etc...
- Time dependant equipments such as water heater, air conditioner, water pumps etc are used in particular interval of time.

These loads are individually treated as single knapsack and collectively as multiple knapsacks method. The house receives electricity from grid connected to distributed standard generating sources which is considered as a main source while the alternative is the supply from solar PV source.

3.1. Home Energy Management System (HEMS)

HEMS consists of following functional blocks namely

- HEMS software
- Home Energy Management Centre (HEMC)
- Load scheduler

HEMS proposed in this paper comprises of HEMC and load scheduler. HEMC provides a user friendly graphical representation to the residential consumer, which assist customer to control the various loads as and when required using load scheduler.

HEMC software uses the Lab view developer tool provided by National Instruments (NI) and this communicates to human using zigbee protocol to collect information required. It has two selectors namely Home Tab (Fig. 5) and Data tab (Fig. 6).

Home tab provides details about the line voltage, load control and on /off control. In addition the alarm indicates any mal functioning of hardware or false operation and On / Off control is used for switching sequences. Data tab displays the timely data logging of voltage ,current with a time and date representation which also displays XY graph plotted shown in Fig. 6.

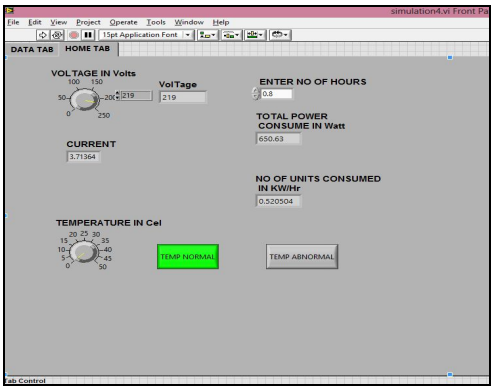

Figure 5: Home Tab

A load scheduler considers multiple knapsacks which is an accumulation of various single knapsacks. Due to this, consumer will be able to understand peak load along with time and period of occurrence. A load scheduler determines essence of critical load like, refrigerators, lights etc...Non critical loads like washing machine along time dependent loads like geysers, water pump.

Apart from this a bypass arrangement is provided to control various loads as and when required on an emergency requirement. Energy costing function for 24 hours days of electricity consumption is studied and recorded. Costing function is also obtained as an user friendly graphical output.

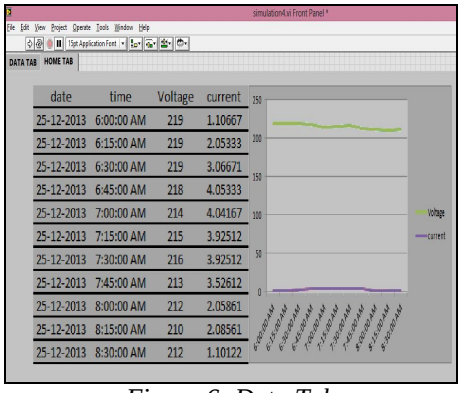

Figure 6: Data Tab

3.2. Operation

The electricity required to run the multi knapsack system is measured using transducers which converts digital signals using ADC converter. The converted signals are fed to microcontroller which analyses and stores the data. These analyzed data are fed to personal computer which acts as a home energy management centre. These data are processed using Labview software and simulations are executed. Simulated results are obtained in the form of graphical view which can be interpreted easily. Also the month wise power consumption of individual loads is displayed as in graph shown in Fig . 7

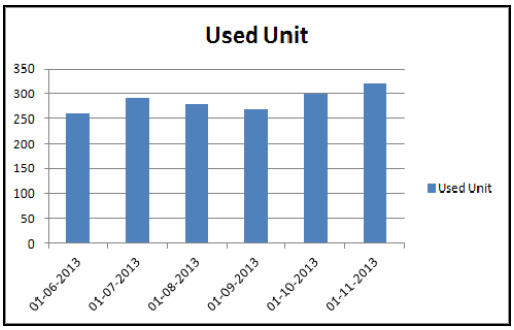

Figure 7: Forecasted Graph

Using wireless technology such as Wi-Fi, Bluetooth pc communicates with Android mobiles. Android mobiles are synchronized with Lab view using dash board software.

4. Proposed Hardware

The proposed hardware for implementation of HEMS comprises of

- Load Management Centre (LMC)
- Load Network

4.1. Load Management Centre (LMC)

The connection of HEMS (Home Energy Management System) software and the load network is done by LMC. The functional components of LMC are PIC18f4520 microchip family and Zigbee transceiver of MC12311. The interface of the microcontroller with the Zigbee transceiver is done using Standard RS232 bus. The status of the loads on a custom LCD of lines 16x2 is known from the module since the load network sends the data to the module.

LMC algorithm is shown in Fig. 8 All the modules are first initialized and status of the hardware is checked. The different load transmits data to the Data tab for analyzing and scheduling the energy consumption.

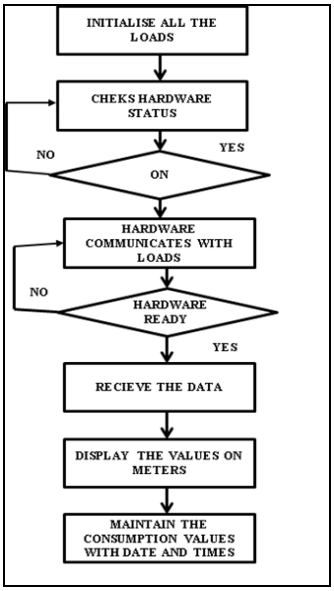

Figure 8: LMC Algorithm

4.2. Load Network

It contains voltage ant current sensor, zigbee interface and load control circuit. The conversion of the system voltage to a lower voltage is done by using potential transformer .This proportionate low voltage is converted to DC voltage by using appropriate bridge rectifier circuits

By using ACS712 Fully Integrated, Hall-Effect-Based Linear Current Sensor. AC current into DC voltage. Then the PIC controller changes the voltage into digital form.

If the load current of light and other load is too low, it is difficult to apply in PIC for digital conversion. So a precision rectifier is designed which can change the AC and DC signals. Then the digital format current data is transmitted to LMC. In LMC for this purpose zigbee interface and free scale PIC is used.

The microcontroller PIC communicates with zigbee using standard RS232 interface. Zigbee receives data from the microcontroller and is transferred to LMC.

The control of the load is done by the load control circuit because it is attached to the microcontroller PIC. This circuit uses the 5V DC SONGLE Power Relay SRD-5VDC-SL-C PCB Type which will control the high voltage electrical equipments (maximum 250v). The algorithm of load network is shown in Fig. 9.

The algorithm initializes the loads and receives the data from the loads. If data is received, displayed in controller board and sends the data to HEMS. Depending on the data, input is controlled by the user and the consumption values are maintained with date and time.

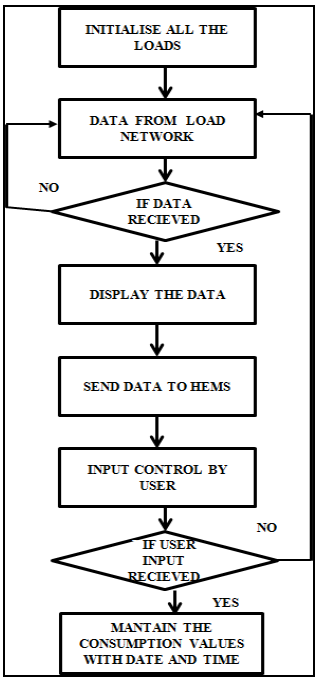

Figure 9: Load Network Algorithm

5. Results and Discussion

For case study, a residential home which is shown in Fig. 10 is considered.

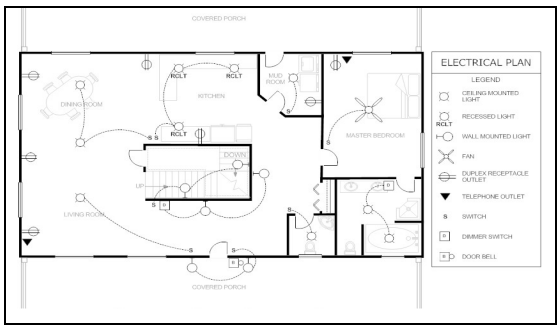

Figure 10: Electrical Plan of House

Data's of the electrical house is fed in to HEMS software. The readings and results are observed during the period between 6.00 AM to 8.30AM, which is normally a peak hour energy consumption at home. The readings are taken on a integrated time cycle of 15 minutes duration. From the results plotted, the following observations are made

When the load in the grid increases, the voltage obtained is dropped down.

When the voltage drops down the current consumption tends to increase.

Manually non essential loads could be avoided at particular time duration to boost the voltage level thereby decreasing the current drawn which leads to better efficiency.

Similarly time scheduling is done depending on the load type.

6. Conclusion

This paper presents an intelligent home energy management system and an algorithm for managing and scheduling the loads. The proposed HEMS can effectively control and manage the loads and ends at reduction in consumption of power which has been successfully implemented and tested. Due to different load scheduling method, the electric tariff tends to decrease and the energy consumption is also reduced.

Proposed method is effective in which consumer can easily control the loads with visual view of graphical interface and its consumption is stored in a file. So the user can notice the profile in day by day basis and makes the power profile more reliable. Load scheduler tells about the load commitment and the unit consumed by the loads. An additional non conventional source of energy is integrated to meet the demand.

7. References

1. Zigbee Alliance, "Zigbee Smart Energy Profile Specification," revision 15, Dec. 2008.
2. Carles Gomez and Josep Paradells, "Wireless Home Automation Networks," IEEE Communication Magazine, June. 2010.
3. Soyoung Hwang and Donghui Yu, "Remote Monitoring and Controlling System Based on Zigbee Networks," International Journal of Software Engg., and its Applications., vol. 6, No. 3, July, 2012.
4. F. Baig, A. Mahmod, and N. Javaid, "Smart Home Energy Management System for Monitoring and Scheduling of Home Appliances Using Zigbee," J.Basic.Appl . Sci. Res., 2013.
5. Manisa Pipattanasomporn, Murat Kuzlu, and Saifur Rahman, "An Algorithm for Intelligent Home Energy Management and Demand Response Anlysis," IEEE Trans. Smart Grid, 2012.
6. "The Home Area Network," Trialliant.
7. Dae-Man Han and Jae-Hyun Lin, "Design and Implementation of Smart Home Energy Management