Literature review on measuring the energy consumption and utilization in commercial devices using sensors

Dishita Barai, Naren Tada

_____

***Abstract*: The rise in use of commercial appliances in large scale also results in large amount of power draw and hence huge amount of electricity bills to be paid. This results in a large difference between their power draw from the mains and the actual utilization as some amount of this energy is bound to be wasted in some form of energy. In this paper, various techniques that have been implemented previously for measuring the difference between the actual power draw and the utilized power draw, the steps to reduce the amount of power draw and hence saving the energy costs are mentioned.**

Keywords: Power consumption, energy consumption, utilization, wireless sensor network
_____

I. INTRODUCTION

The use of commercial devices like desktop computers, LCD displays, etc. and also the home appliances like oven, refrigerators, etc. are increasing day by day. Hence the energy utilization keeps on increasing day by day which also effects on the electricity bills every month. But the matter of concern is that the amount of energy consumed is not totally utilized for the devices. Some amount of energy is bound to be wasted in some other form of energy. Hence it should be made aware to the users about how much energy is wasted, how much amount of energy is actually utilized. The difference between the values of the amount of energy drawn and amount of energy utilized by any commercial device defines the efficiency of the commercial device, in terms of the power draw.

In this paper, various techniques that have been implemented to measure this difference are being focused upon. PowerNet [1], a hybrid sensor network, monitors the power and utilization of the computing systems on the basis of a large scale deployment. SmartMeter.KOM [2], combines the abilities of taking measurements of the electric current flow, switching the mains connection of the attached load, etc. Another project, Supero [3], designed a power usage monitoring systems in home appliances to measure the real-time total household power consumption. In their work, [4], Faycal and Davood have presented a system that combine the derived data to improve the devices' performance and increase users' awareness.

The deployment of these projects have been done using wireless sensor network technology. Wireless sensor nodes are tiny computers that are designed to perform a specific task with very high efficiency in terms of power usage. Lower the usage — longer the life. This technology can be applied in a variety of applications like security, maintenance observation, agricultural, traffic monitoring and many more. WSN is a collection numerous tiny devices with low cost and low power equipment.[5].

In these projects, the data of the amount of power consumed and its utilization is collected by the sensor node to be attached to or placed nearby the device and then the data is transmitted over the wireless network to the base station using some routing protocols.

II. PROJECT POWERNET

The PowerNet project [1], is a hybrid sensor network developed for computing the power consumption and utilization of various systems in a large academic building. It comprised of approximately 140 wired and wireless meters and almost 23 software sensors that monitored PCs, laptops, LCD screens, etc. This project was active for 14 months and the wireless meters for 3 months. The deployment environment had a large number of diverse set of devices that had large variations in workload and configuration. To improve the efficiency of this type of computing system needs the detailed and accurate data of energy consumption and energy waste.

The overall design of the PowerNet deployment that measures the power usage and utilization of individual devices and also transmitting the data over the network to store on a central server is as shown in Fig. 1.

Two types of meters were used to deploy the project i.e. 1) Wired meters 2) Wireless meters.

The commercially available Watts-Up.NET meters were used as wired meters. Certain issues like non-reprogrammable proprietary software, size of the meter, overhead of installing meters within the building network etc. resulted in replacement of wired Watts-Up.NET meters by the wireless meters.

The wireless meters were based on the ACme design, i.e. the AC meter switch configured within the Epic Core Mote, with certain modifications like a switch from solid-state relay to a mechanical one, or to add an expansion port with a range of serial interfaces, to support new sensors and the added storage.

Fig. 1 Deployment of PowerNet [1]

The protocol used for transmitting the data collected by the individual sensor nodes to the central server was the Collection Tree Protocol which was known to be robust and efficient routing protocol in the TinyOs for the deployment of sensor network.

The following figure 2 shows the data of power consumption and CPU utilization measured for almost a week.
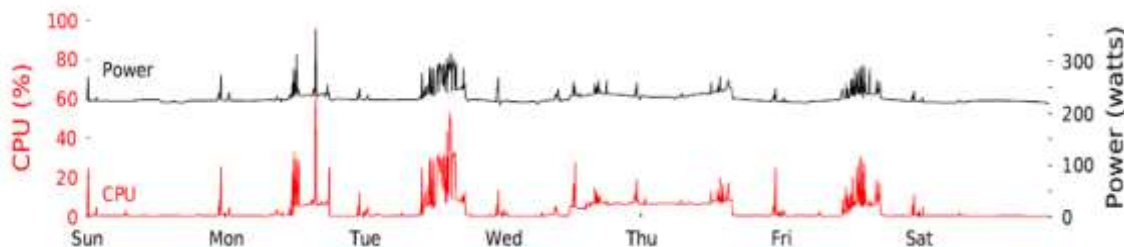

Fig. 2 A week long observation of PowerNet [1]

In spite of all these quantitative analysis, the future work of the PowerNet project has a focus on qualitative analysis as well as in improving the performance of CTP during the business hours.

III. PROJECT SMARTMETER.KOM

The SmartMeter.KOM project [2], is a combination of the abilities to take high resolution measurements of the electric current flow, switching the mains connection of the attached load, and a wireless communication device to exchange readings with other nodes in the sensor networks. [2]. These devices have the capability to deactivate the devices when the users are absent, the generation of events when operating modes change, or the automatic disconnection of faulty devices.

To deploy this system, the sensor used is Allegro Microsystems, AC5712, a precise, low offset current sensor based on Hall effect. As a communication device, MicroChip MRP24J4DMA is used as it combines a radio transceiver chip with an onboard antenna and all required external components on a single circuit board. These devices are located in always a position where connection to the mains is available.

Architecture of the SmartMeter.KOM device is as shown in the following figure 3.
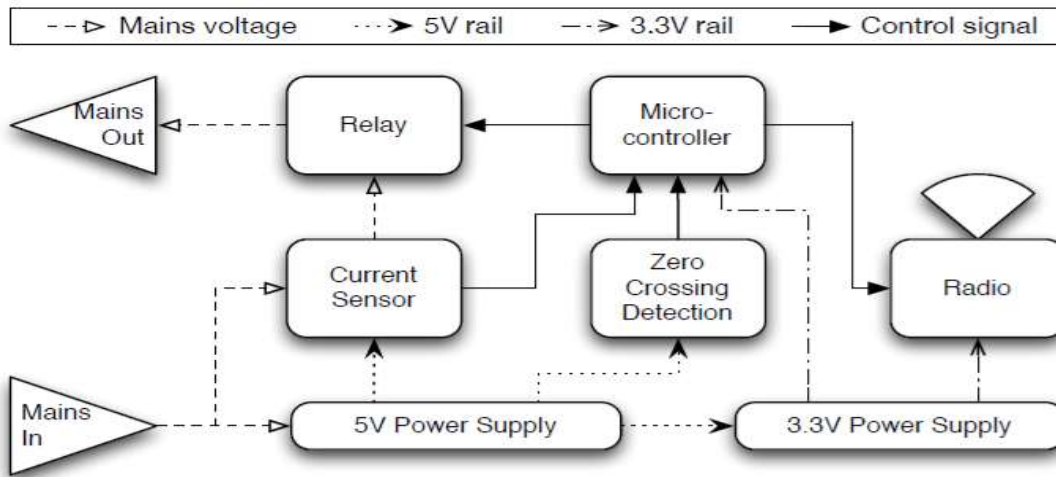
Fig. 3 Architecture of SmartMeter.KOM [2]

In near future, the indoor deployment of power metering nodes at large scale is being planned in this project.

IV. PROJECT SUPERO:

The project Supero, [3], aims to design a residential power usage monitoring system that uses only inexpensive and easy to install sensing devices and can be deployed by non-professional users with straightforward instructions. [3]. Real-time power consumption is measured using a smart meter in this system. It uses a multi-sensor fusion to correlate data collected by power, light, and acoustic sensors and reduce possible sensing errors. The sensor nodes protoyped in Supero are TelosB/Iris sensor nodes and a smart meter.

Here the base station is a telosB mote that is connected to a laptop computer. The power measurements are done through a Kill-A-Watt meter. With the integration of Zigbee radios, the efficiency of a power meter is determined and hence provides ground truth power usage data of the individual appliances. The architecture of the project Supero is as shown in the following figure 4.
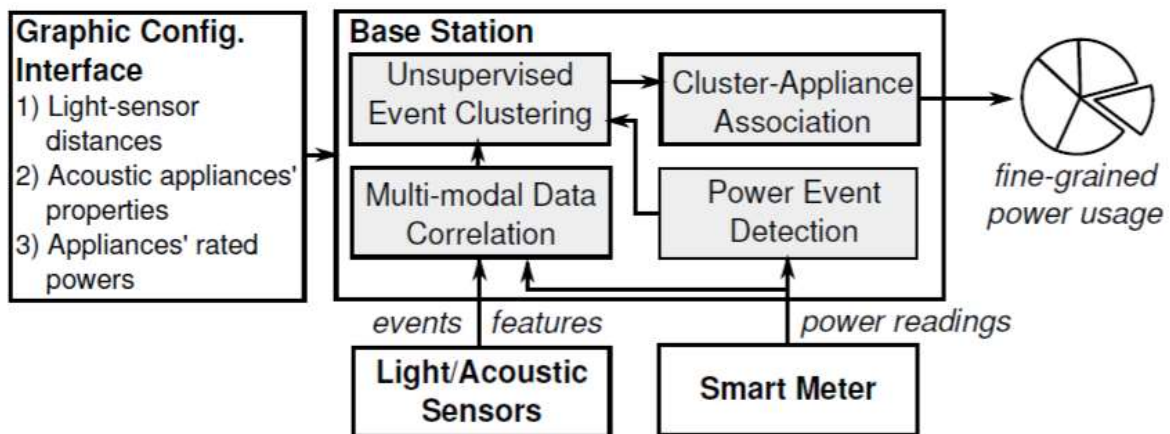

Fig. 4 Architecture of project Supero [3]

In its future work, the project aims to explore the use of other sensing modalities i.e. infrared, seismic, magnetic, etc. to monitor other complex appliances and also to develop an easy to understand user manual to help non-professionals set up their sensor deployment eg. By video examples.

V. OTHER RELATED WORK

In the research work [4], the design of the energy monitoring system using TelosB mote and Contiki operating system is mentioned.

This system allows the user to monitor the energy usage at each appliance without any modification or physical contact with it or with its energy supply system.

The proposed platform in this project constituted of TelosB sensor mote, a current clamp on sensor based on hall effect and a signal amplifier. The architecture of such type of sensing platform is as shown in fig. 5.

VI. CONCLUSION:

From the review of these projects, we can conclude that more work need to be done for large scale deployments of projects [2,3,4] at process levels, for routing and data collection among the large number of sensor nodes. In [1], the qualitative analysis of the computing devices at a process level needs to be done. Also the performance of the CTP protocol i.e. the collection tree protocol needs to be improved during the business hours.
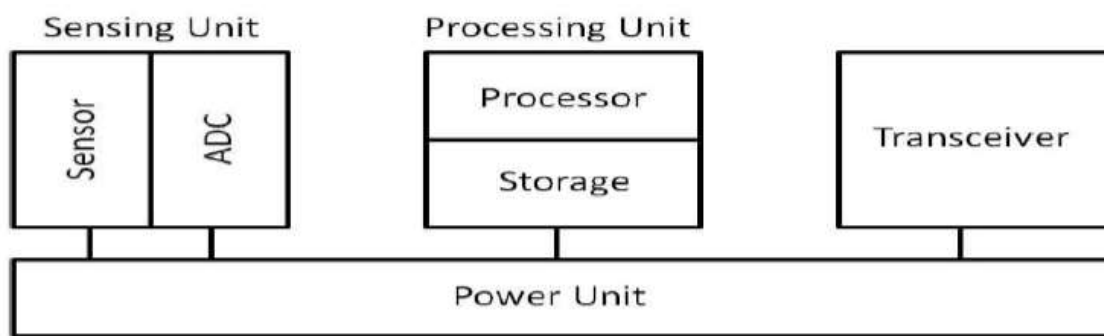

Fig. 5 Architecture for the proposed system in [4]

REFERENCES

1. Maria Kazandjieva, Omprakash Gnawali, Bradon Heller, Philip Levis, Christos Kozyrakis, "Identifying Energy Waste through dense power sensing and utilization monitoring", Stanford University, tech. rep. CSTR 2010-03, 2010.
2. Andreas Reinhardt, Dominic Burkhardt, Parag S. Mogre, Manzil Zaheer, Ralf Steinmetz. "SmartMeter.KOM: A low-cost wireless sensor for distributed power metering." In proceedings of 6th IEEE International Workshop on Practical issues in building sensor network applications, page 1044-1051, October 2011.
3. Dennis E. Phillips, Rui Tan, Mohammad Mahdi Moazzami, Guoliang Xing, Jinzhu Chen, David K. Y. Yau. "Supero: A sensor system for unsupervised residential power usage monitoring." 2013 IEEE International Conference on Pervasive Computing And Communications (PerCom), San Diego.
4. Faycal Bouhafs, Davood Rajabi. "Open sensing platform for home energy monitoring in the Internet of Things." The International Journal of engineering and sciences (IJES), volume 2, issue 1, pg 53-61,2013
5. Tejas Patalia, Naren Tada, Chirag Patel. "MEAL based routing in WSN." Springer International Publishing Switzerland 2016