Active Node Based Sensor Wireless Network for Energy Management

S. S. H. Rizvi, M. Z. Ahmad, J. Ahmed and A. Karim

***Abstract*—Nowadays electricity is the prime source of energy around the world for domestic and industrial applications. Our lifestyle revolves around electrical appliances and devices which make it a core necessity. However there is a shortage of this very important source of energy, especially in country like Pakistan where the overall life and building pattern is highly energy inefficient. Furthermore, energy prices soar due to different reasons; more building owners and operators are turning to energy management to reduce their overall operating costs by using efficient and reliable energy management systems and techniques. Generally this is achieved by improving the energy efficiency of building systems and energy conservation. In this paper, an active node based wireless network is proposed and implemented for energy management in a typical Pakistani environment. The proposed system is primarily based on the assumptions that most of the energy is wasted unintentionally in domestic applications and industrial processes.**

***Index Terms*—Energy efficiency, energy management, wireless sensor network.**

I. Introduction

Energy consumption is increasing day by day. If effective energy generating and saving policies are not adopted, energy crises would get worse and it is well established that the country like Pakistan will suffer more. As a matter of fact, energy crisis is considered as the greatest barrier and bottle neck in the economic growth. It has been observed that in Pakistan most of the buildings including hospitals, institutions, industry, home etc are energy inefficient. This means, a large part of energy is being wasted unintentionally. The ultimate results are heavy electricity bill and load shading due to dearth of electricity. This problem can be solved up to some extend by the application of latest technology like wireless sensor networks [1]. This would help in increasing energy efficiency. Generally a wireless sensor network is made of a large number of sensor nodes, which are densely deployed and connected through each others. The emergence of wireless sensor networks has enabled new applications in several fields such as distributed control [2]-[3], tracking and inventory [4], structural monitoring [5], fire-safety [6], habitat monitoring [7]-[8] and building management systems (BMS) [9] etc. In this paper, preliminary results for an integrated wireless sensor active node based system for increasing energy efficiency are reported. This system is currently under development at Iqra University, Karachi, Pakistan.

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II. Proposed Research Model

The proposed model is the combination of wireless sensor network (WSN) and electrical system with intelligent routing technique. For the energy management, it is a unique system. The system has active nodes with a feedback system. The nodes can transmit power parameters like power consumption, power factor, device status etc. to the remote control terminal using existing TCP/IP protocol. Ethernet, Bluetooth and ZigBee are used to transfer the information in this system [10]. Normally, the data is acquired by smart terminal. It can also be propagated to any remote location. Smart terminal serves as an expert system that acquires data from all remote sensors. Then it makes decision based on gathered information for effective use of valuable energy resource to make effective and efficient energy management system. In addition to this, it also logs the data for historical trends. In the proposed model, daily power utilization of each location is recoded. The expert system remotely shutoff some of the devices depending on the rule base, if the measured power utilization is greater than the expected utilization. The measurement propagation is based on new routing algorithm (RDBSR) (Relative Direction Based Sensor Routing). The scheme divides the targeted area into sectors and locates for a manager node in each sector. The manager node receives collected data from sensor devices of corresponding sector and then transfers it to the base station through the shortest path of 2-dimensional (x, y) coordinates. That results energy-efficient data delivery to the base station [11]. As a case study; the architecture of IQRA University is considered for the implementation of our proposed model as shown in Fig. 1.

The salient features of the proposed model are as under:
Effective and efficient utilization of resources

- Optimum power consumption
- Effective power scheduling and management
- Power reconciliation
- Real time data logging
- Forecasting of power utility
- Remote switching control
- Intelligent Load shading

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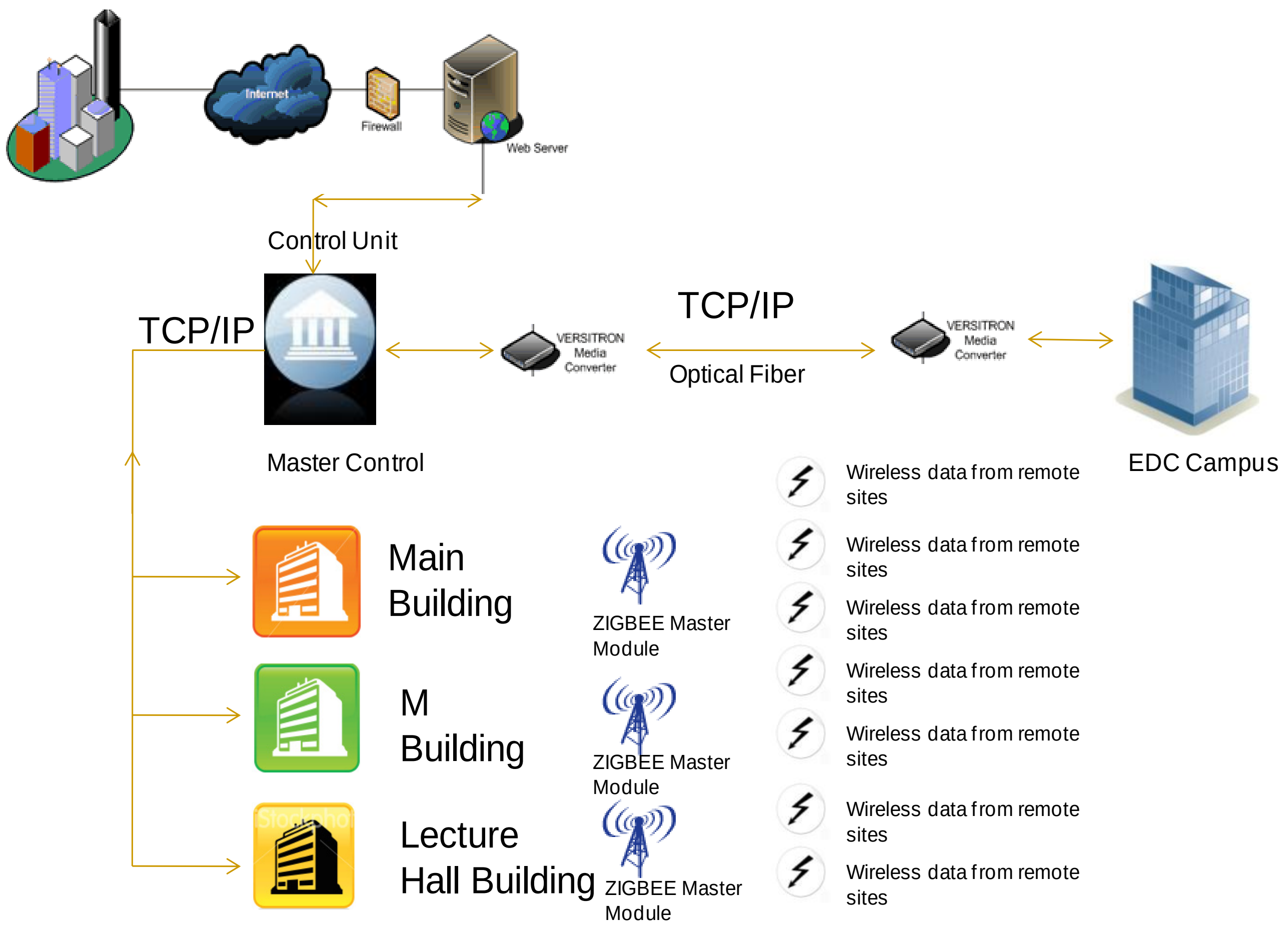

Fig. 1. Proposed model

III. Implementation of SOP

To develop an understanding between items and their power consumptions, we should gather the detail knowledge of quantities as well as the number of items that is shown in Fig. 2. It is shown that tube lights, desktop computers and CRT/LCD monitors are the largest amount in quantity. Now as the number of items is known we may build a relation between power consumption of each group as in Fig. 3. This relation points out that the major power consumption items are air-conditioner, chiller, desktop computers and CRT/LCD monitors. We then focused to these areas and develop a strategy that by giving trainings to our peons that when to start the air conditions and when to use the tube lights, where the misuse of lights is taking place and how to control them. We educate people to use air-conditioner at 26 ℃ that will provide same magnitude of cooling with one third less amount of electrical energy consumption.

IV. Results and Discussion

In order to gather the requisite data for analysis; we recorded the consumptions (and ON/OFF status) of each electrical load (installed in IQRA University) throughout a month shown in figure 4. We divided the loads into 24 categories. It was found that the top four loads (with respect to power consumption) were air conditioners/Chiller, desktop computers (CPU), CRT/LCD monitors, and Tube-lights. By applying Pareto rule, we only attempted to manage these bulk loads out of 24 types of loads. For the management of these loads we developed standard operating procedure (SOP) to operate them on need bases. After implementing the SOP throughout a month, once again we recorded the readings of the loads for complete month. Result shows that 11% of the energy can be saved by practicing the SOP on these four loads only shown in Fig. 5. Note that the SOP operation was manual and it was implemented only on 4 loads; however if an automated procedure is implemented on all of the loads we may save around 25-30% of the energy per month. Fig. 2 represents devices and their quantity while Fig. 3 represents power consumption of each device.

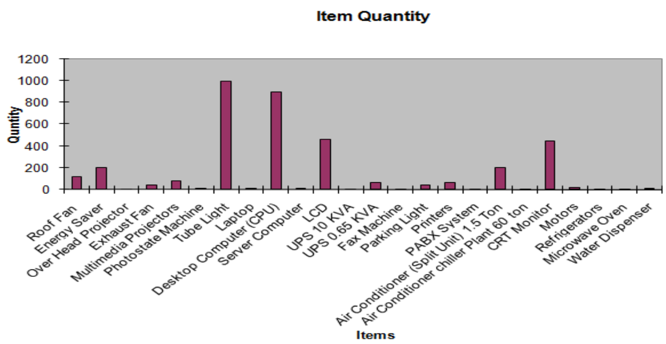

Fig. 2. Quantity Wise Items

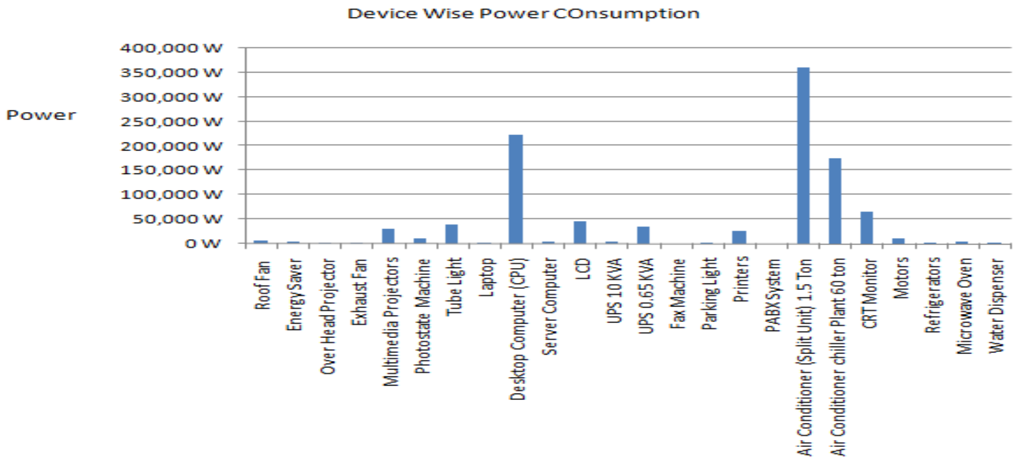

Fig 3. Device wise power consumption

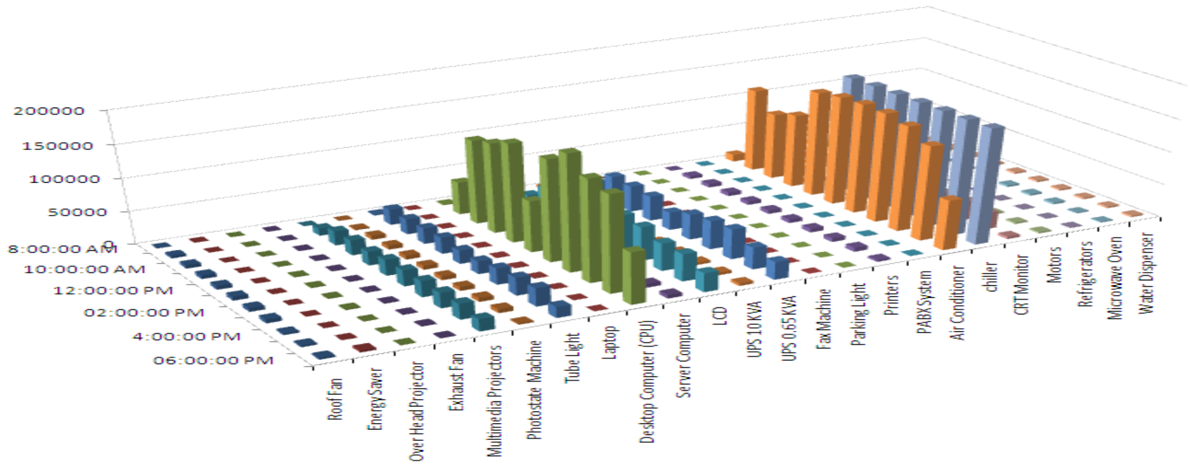

Fig. 4. Hourly power consumption device wise

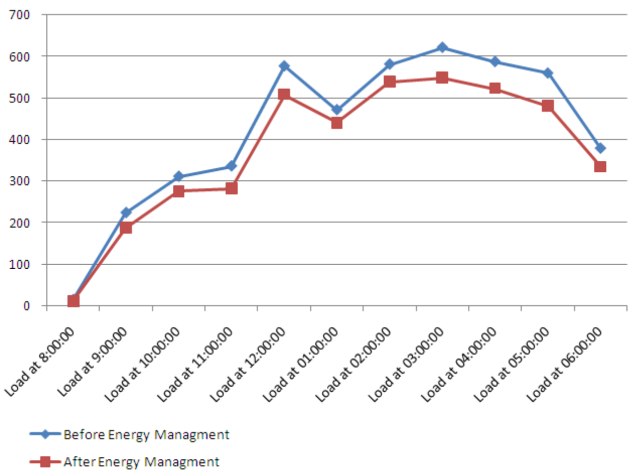

Fig. 5. Comparison Chart

V. Load Prediction

As the proposed model is an expert system that is capable to predict load on the basis of past record; in our case study we take hourly reading before and after applying define SOP and it has been observed that both actual value and optimized value are non-proportional so in order to make prediction both quantities should be liberalized using linear programming.

Regression method is used as linearization tools where actual value is treated as one random variable *x* and optimized value is treated as another random variable *y*, so linear equation becomes

$$y = 0.907018x - 6.00598, \quad (1)$$

where

y = Optimized Load
x = Actual Load

Equation (1) is used to predict optimized load that can be achieved after applying SOP in our case study.

VI. Future Work

In the proposed model data is fetched from ZigBee, a wireless sensor network. Because sensor devices do not have sufficient computational ability and battery power, an energy-efficient sensor routing scheme is critical to send information to the base station [11]. Routing at physical layer enable communication more fast, reliable and secure as shown in Fig. 6 [11].

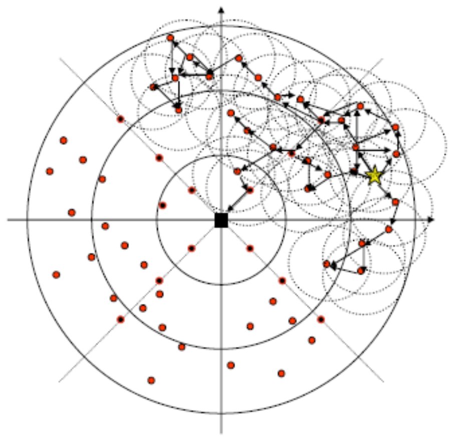

Fig. 6(a). Conventional routing schemes [11]

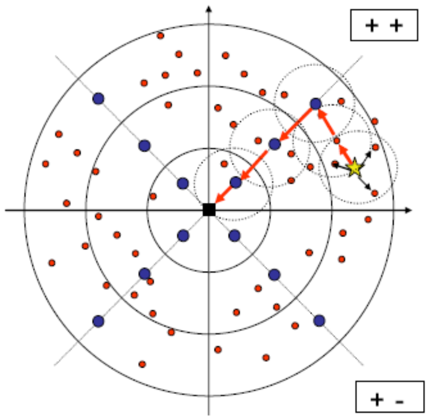

Fig. 6(b). Relative direction based sensor routing scheme [11]

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