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The Solution for Efficient Electricity Management through Wireless Sensor Network

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Abstract - In the new paradigm of Internet of Things (IoT), many objects will be on the network having capability of sensing, computing and communicating with each other directly or indirectly. The most important aspect of it is that, such network will be invisible but intelligent to complete the entire task through Internet. Utilization of such efficient ubiquitous network will have number of applications like in social, industrial, entertainment, health care etc. The efficient electricity management is the major need to be considered due to limited natural resource of energy generation. The major issue in not to generate the resource but to handle the generated resource efficiently. In this paper we have proposed the solution for electricity management through Wireless Sensor Network (WSN) in the IoT paradigm, where the sensing nodes deployed on the high electricity consumption devices will monitor the daily consumption and update it through smart device on the Internet for reference. Smart electric devices can be controlled to leave in dormant state when not needed. This will help to budget the need of electricity planning at a large scale automatically.

Keywords - *WSN, IoT , Electricity Management.*

1. Introduction

In the developing countries, the major issue which arises is, to manage the supply and demand of resources like electricity for industrial and domestic areas. The aspects of development based on the appropriate utilization of advance technology and managing the things continuously without interruption will be very required. As stated previously, generating and managing the utilization of electricity is a big task. Figure 1 shows the generalized block diagram of electricity management scenario.

As seen in Fig 1, the actual working functionality will consist of wireless sensor network and utilization of Internet to manage the things. The Internet of Things can be viewed into two perspectives: either Internet-centric or Thing-Centric [1][7]. Within this paper, the concept is visualized as Thing-Centric.

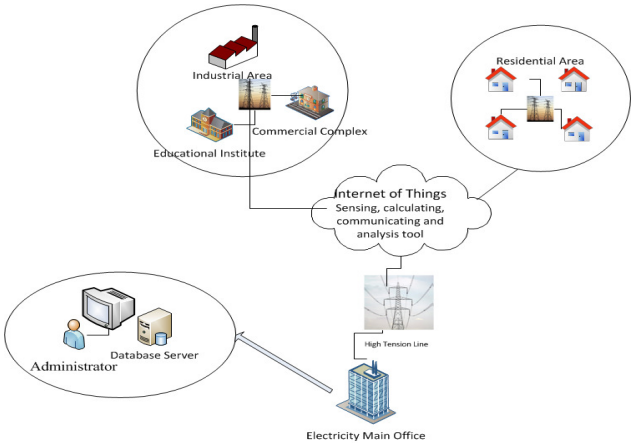

Figure 1. Generalized block diagram for electricity management through IoT

To work towards the implementation of the concept, the total area under the supply of one high tension electricity line is categorized as residential area, industrial area and commercial area. The categorization is essential as looking after the huge difference in utilization; working hours and rates applied for billing are different. Each area need to be covered under deployment of embedded wireless sensor network. The role of the wireless sensor network will be to calculate the electricity consumption of each device continuously and send the real time information wirelessly to the sink node which is acting as coordinator for that particular area using different routing, communicating algorithms. Each device is assigned a unique IP, working as its identification mark. The commutative report generated by each device or section is used to calculate the daily need of that area. With the daily report it will become easy to make a decision about need of usage cut down, when and how to

be done. In this way the efficient handling of electricity can be achieved [2][3].

2. Wireless Sensor Network and IoT components

A wireless sensor network is comprised of sensing, computing and communicating elements. A different data dissemination model allows reacting on the monitored phenomenon in the right way at right time. The expected communication is wireless, thus it will utilize technologies like ZigBee, Wi-Fi. The coordinating node is required to collect the data from each sensing node and exchange control signals [8][9]. The topology selection is based on the location of device and overall infrastructure. Selections of range of wireless connectivity, fading, absorption are again points which should be taken under consideratiom. The major issue comes in picture while handling the sensor located in the area beyond the frequent reach for maintenance for the purpose of battery replacement. The implementation of wireless sensor network will comprise of:

a. Usage of a 16 bit microcontroller with in-built memory, Analog to Digital converter (ADC) and ZigBee like wireless communication approach which are available to be utilized as a wireless sensor nodes with appropriate sensors.

b. Deployed sensing nodes need to communicate with each other and a coordinator/sink node for the exchange of data as well control or updating information. The topology cannot be fixed or predefined; they normally will work in an ad hoc passion. The routing and MAC layer issues need to be managed efficiently depending on factors like scalability.

c. An interface between the WSN and Internet is a crucial factor for design as it will help the WSN to be accessible to large number of Internet users as per the IoT. To exchange the information between these two different types of network following different protocol stacks, it is extremely essential to perform the utilization of dual stack approach which is capable to communicate with each other.

d. Lastly, on the Internet side, the existing Internet functionality will have to represent the information to its users by using a Graphical User Interface. While displaying the information on the GUI, readability should be taken into consideration as any type of user even one without any technical background/novice user should be able to operate it, this is very important, as system is to be deployed considering social aspect also.

e. So identify each 'Object' on IoT it is essential to have a unique identification of it. The advance approach is assignment of an IP address to each Object for its direct and efficient tracking so that each object will communicate with Internet with its specific identity. Assigning an IP address for each object triggers the need of IPv6 for huge address space availability.

f. But, utilizing the unique IP concept for simple things seems to be inappropriate due to resource required. The better option would be using few smart devices in the network to have an access to Internet directly, so few will communicate through the smart devices.

3. Proposed Structure for Electricity Management

The area where we can mitigate the electricity utilization is corporate buildings and industrial areas in comparison to home automation. Figure 2 shows the conceptual diagram of electricity management in a corporate office through Wireless Sensor Network [5].

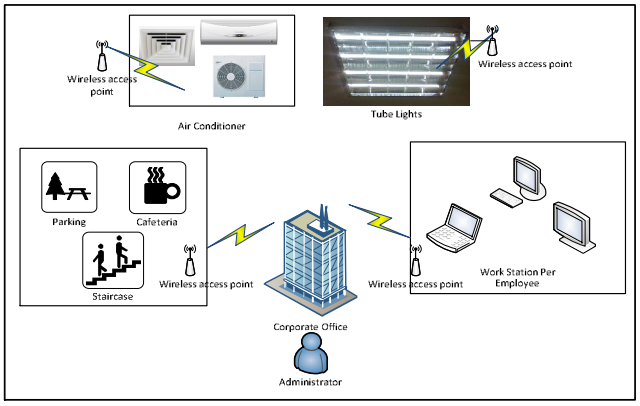

Figure 2 . Electricity management in Corporate Office through Wireless Sensor Network

The concept gives stress on managing the electricity through controlling lights and air conditioner (AC) usage in the office. While observing maintenance factors like light and air conditioner for the corporate offices the survey shoes result as in Figure 3.

Here, the graphical result of electricity utilization for high rise office building with assumption: 25,000 square feet in summer days, timing 7.00 am to 6.00 pm. Monday to Friday in Chicago is shown.

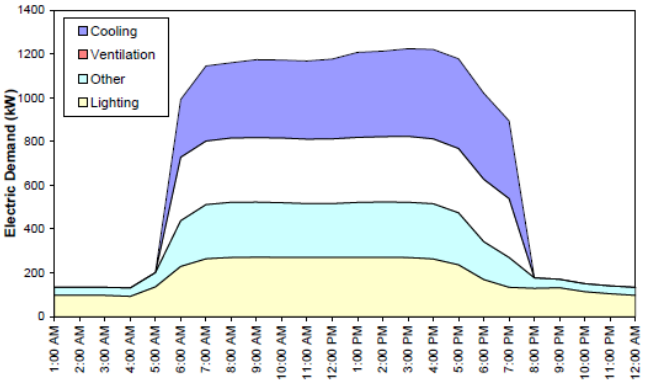

Figure 3. Typical office building daily load scenario

With the help of lighting and air conditioner related electricity management the load scenario could shows the result as in Figure 4 and 5 [10] [11].

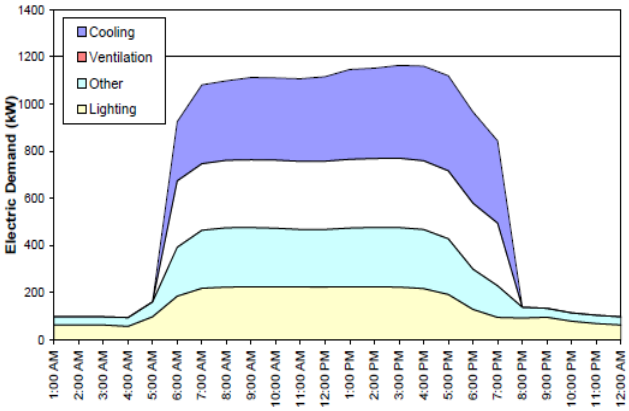

Figure 4. Load profile with lighting measure

The result shows the variation in the requirement of electricity using light maintenance. As seen, 3 % saving of consumption through it can be achieved.

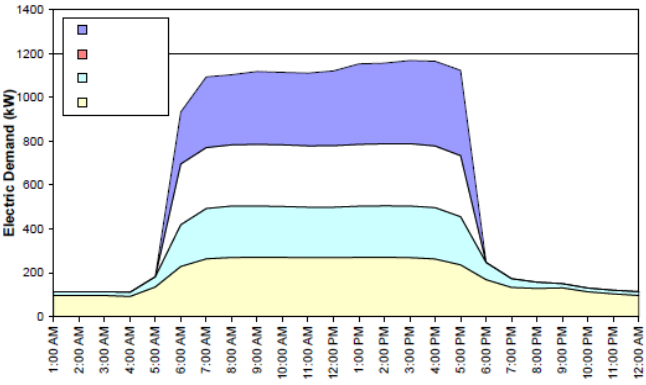

Figure 5. Load profile with Re-Commissioning Measures.

Figure 5 show the ample variation in electricity utilization with re-commissioning measures like optimized temperature set point, power management enabling for PC's, printer and copier, using energy star equipment. These solutions help out to reduce consumption by 13%. With reference to the survey strategy the proposed structure will utilize the different types of sensors like:

3.1 Light Control with PIR Motion Sensors

All the corporate offices utilizes the maximum lighting in areas such as parking, corridors, cafeteria , passages etc where the presence of users is just for a time being. Thus unnecessary lighting when not needed leads to wastage which we can minimize. With the help of a PIR motion sensor the presence/ absence of a person will be identified and lights within those areas will be turned ON/OFF.

3.2 Temperature & Humidity Sensors

Depending on surrounding weather conditions, it is essential to control the settings of the centralized air conditioner. For the same, with the help of temperature and humidity sensor, monitoring of said parameters will be done and information will be made available to maintenance department to do required settings accordingly to avoid wastage of electricity consumption due to wrong operating mode.

Thus, with the help of PIR motion sensor, temperature and humidity sensor it will become easy to monitor major resources of electricity consumption. Wireless PIR automated motion sensors will do the job automatically and monitor the location where they are implemented. The information about status of ON/ OFF condition of each light source indirectly calculates the consumed energy. In case of temperature and humidity sensors, they will collect information and instead of taking action directly will report the reading and send it to the coordinating node wirelessly using ZigBee. The cumulative information over day time will help out to maintain the setting of air conditioner.

4. Interconnection with IP for Remote Monitoring and Control

To achieve the remote monitoring of wireless sensor nodes from anywhere the 2 different approaches are:

- Each sensing node can be made IP – enabled, utilizing the concept of IPv6 in IoT.
- Coordinating node (Sink Node) will have IP to access information from all sensing nodes within its range.

To go with the concept of IoT , it will be essential to make use of IPv6 for addressing each sensing node with a unique IP address. With such technique each node can be observed through web/ smart devices running on user side along with IPv6 protocol.

Second approach will make use of a sink node which will work as a coordinator for all sensing nodes and communicate with the server for IP – enabled network. The underlying working is shown in Figure 6.

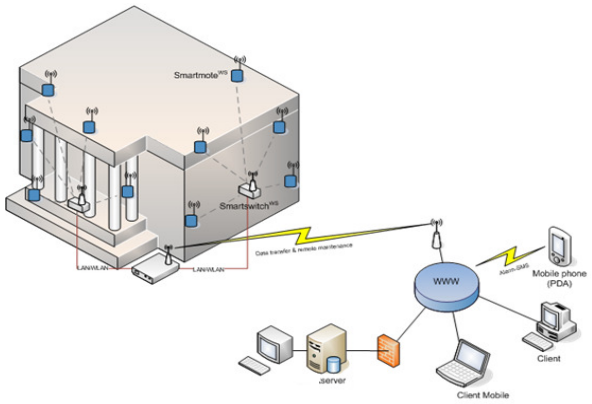

Figure 6. WSN over IP for Remote Monitoring and Control

For implementation of WSN over IP we will make use of a Web Server which will act as the interface between Internet users and the sink node in WSN. The web interface provided at the web server will allow users to view the data collected from different sensors in the WSN. The server mainly will consist of a database like MySQL/Oracle 10g for providing persistent storage of the data received from the sink node.[6] The server will run the IPv6 protocol, and communicate with the sink as soon as users request for data from nodes. The database will also have the mapping of IPv6 and WSN addresses being two different types of networks, for individual sensor nodes. The data from the sensor network node will be a hexadecimal code. Before it is stored in the database, the server will have to execute data conversion program to be displayed in an understandable way to Internet users. Therefore, the Internet users will be able to work on the sensor networks, observe its topology and properties, monitor and control the electricity usage parameters and readings, execute the required management tasks and download the logs of data collected.

5. Summary

From the survey and the proposed approach it will be possible to effectively control electricity utilization in residential / commercial areas. Use of wireless sensor network will enables remote monitoring and controlling the usage of electricity in an efficient and easy way. The IoT or IP-enabled approach helps to access information from individual sensor node any time from any location without the need of any external web interface to connect with internet. By using these measures for electricity management it will be possible to reduce the overall electricity consumption in commercial areas by 10 – 15 %.

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