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ORIGINAL CONTRIBUTION

The Real-Time Power Monitoring in Building Using IoT Sensing Method and Knowledge Management Approach

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***Abstract*— The objective of this research is from overpower consumption problem in the organization by combining the concept of IoT sensing method, which provides online data to a website with the KM-specific technologies. Using knowledge management process is the primary approach to work as the knowledge accumulated, and knowledge distribution method to manipulate power usage procedure in the organization according to data from the monitoring system. Data will collect through in and out the time of staff compared with power using period. The real-time electricity monitoring system determines data as daily, weekly, and monthly. The system installed into two large offices most occupied rooms and also provided statistically calculated to define the hourly energy consumption. The statistical result of the monitoring system is used to one of the factors to create resource planning which is one of knowledge management processes by providing a conceptualized platform for ideas of working without over power consumption limit in the workplace. The result is also valuable to the further analysis of office working hours for each department in the organization. The study shows the efferent data illustration by using the online platform to be one of the driving factors for the working activity development which controlled by knowledge management process to overcome one of the specific problems.**

***Index Terms*— Power monitoring, Sensor network, Sensor grid, IoT, Office power data, Working environment**

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I. INTRODUCTION

Power management is one of the most complicated to deal with the organization. Working as a big term brings more variety of power demand among the working hour. In order to understand the problem, identify the source of the problem is required. There are many ways of monitoring building power consumption, such as human inspection, video surveillance, or automate sensor monitoring [1].

Obviously, the effective method is the automated method. The method relied on real-time sensor monitoring using an online sensor network. The sensor network can always help gather data and create a data log of power consumption behavior. Numerous behavioral questions can be responded by the analysis of the data log to create the behavior pattern and understand the meaning of each result pattern.

The sensor network for power monitoring is consists of two types, an invasive sensor, and a non-invasive sensor [2]. The first invasive sensor requires the additional installation to the building's power grid. This type of sensor will place in the main consumer box of each room by a serial link in the main power line. However, the invasive sensor will handle an enormous amount of power load for a whole room electricity usage. Consequently, a more expensive and bigger sensor than standard will necessitates performing this inspection. The other type is a non-invasive power sensor. This sensor uses electromagnetic conduction with the sensor's induction coil and reads the amount of electricity from the sensor. This method doesn't require modifying any current or wiring in order to sensor installing. Simply clip it around the current source line, and it can be used to detect a current of up to 100A, maximum. In terms of efficiency and cost ratio, the non-invasive sensor has been chosen to implement in the study.

The data acquired by the sensor is transmitted by the building's Wi-Fi network, using an HTTP request to upload data into the server. This way is a good way for budget-saving overusing a classical wide area network connection.

Although the knowledge sharing process to comply with the management rule of using power in the office building is the next step of using data from the monitoring system [3]. The knowledge management process is very important to understand and transform data patterns result from the system into understandable knowledge. The working policy has concluded base on the knowledge, and use it to reduce unnecessary working process. When complete this study this monitoring system can enable more power usage efficiency based on the working pattern from the monitoring data.

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II. WIRELESS SENSOR FOR BUILDING MONITORING

Pinter-Wollman [4] informed that the complex system modeling examining and investigating the relationship between the collective behaviors and system associated with the environment can be described by the behavioral working stages. The sensor programmed by the C++ programmable ESP8266 board and Wi-Fi (IEE802.11n) data transfer including I2C data bus as an internal data link. It is designed to capture the power fluctuation in the main power line.

Torfs et al. [5] introduce wireless sensor network what designed for monitoring buildings to assess earthquake damage using wireless sensor then transmitted data on-demand from the base station. The study is to use a pattern of data from accelerometers to measure the seismic response of the building. This explains why this method is wildly used and produces precise data monitoring in the same working domain.

The most challenge of management in an organization is to clarify the relation of organizational practices with their contribution to organizational performance [6]. Gray[7] investigates inspection data to introduce the proposed framework of problem-solving perspective on knowledge management practices. In Peter's framework has defined the meaning that detecting the problem is an opportunity to discover to improve the working performance. Fig. 1 describes the problem-solving process in the knowledge management practices framework [7, 8, 9]. The framework illustrates the connection between decision-making and knowledge management. The decision-making is the origin of problem recognition which requires knowledge capturing and knowledge transforming from the derivation domain into the computing domain [10], and the process will define be our designed monitoring system from a wireless network sensor. Once they completed the problem recognition the next step will proceed to the problem-solving process, by performing the knowledge creation. In this process, the monitoring data will transform to pattern then rule base to understand power using habit in computing term. The pattern is enabling to define normal working habits out of abnormal working habits from the monitored data.

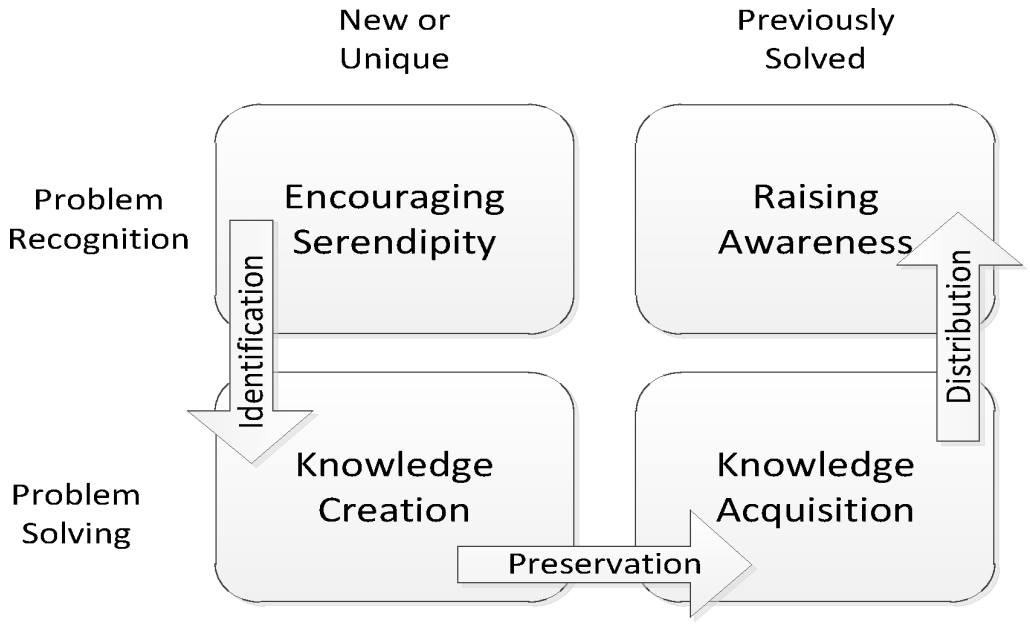

Fig. 1. Problem-solving process using knowledge management practices

The knowledge acquisition is the result of knowledge creation [11], the result is ruled base that can conclude the problem-solving strategy. In this stage, the level of problem is defined and report as statistical data.

Then distribution to raising awareness is the after problem solved state. In this process, the rule base has transformed into policy and enforce member to follow then observe that the particular problem has reduced or not tend to happen in the future.

The weekly result can provide a wider assumption of the power usage event that happens in a week's time [12]. From Fig. 4 display totals of activities that sensor number 3 has fewer uses in this room and sensor number 4 mostly uses of the week. This statistical data shows how often each device has been turning on in the period.

Form this data there are clear in management level that the office worker normally stays and work in a spot of air-condition number 2 and 4 the data can compare to observation method to understand the condition of air-condition number 2 and 4 that how could reduce the number of these air-condition by the group this worker in the same year and use only single air condition at a time, for example.

III. EXPERIMENT

Two most frequent activity rooms were chosen to install the sensor. At this first step, the most significant power usage device in the room is the air condition. The sensor has installed in every air condition's main power line in the room. The sensor design to pick up the ampere in the power line, for example, there will be the low ampere running in the line while no one in the room has turned on the air condition, then the ampere will significantly go up when the air-conditioner has turned on. The monitoring system will be able to record this activity and report as a graph display.

The sensor module packaged together with the ESP8266 Board which is Arduino compatible board with a Wi-Fi module. To reduce noise in the sensor reading the filtering algorithm is applied to the sensor module [13].

$$Eall = \sum_{i} \sum_{k} Ecomp_{i,k} + Ecomm_{i,k} \quad (1)$$

From the equation, k is the dispensation step, N_(i,k) byte of data from the sensor, ⟦Ecomp⟧_(i,k) is the amount of energy in a message at the node, and ⟦Ecomm⟧_(i,k) is the amount of energy the at the gateway.

Fig. 2 illustrates the workflow of the monitoring system. The process starts from searching for a Wi-Fi connection the sensor will not continue working without the connection. Then calibrating the sensor by reading and calculate for initial value then set the value to zero. Next is reding the amp value from the sensor and looking for the peak signal when the power consumption rate has gone up. The system uses the peak value as a condition to send a record to the server after detecting the over-threshold number. HTTP get request will send afterward to carry a number of ampere and DateTime of the detected event to record at the server.

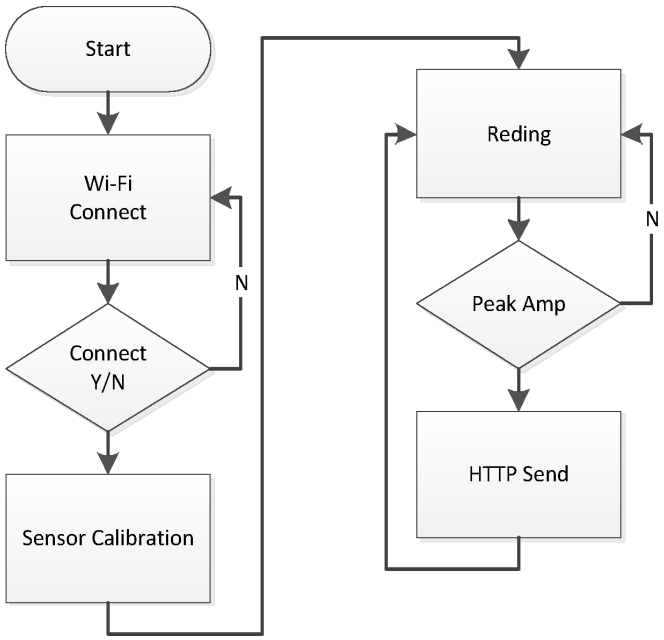

Fig. 2. Power monitoring system flowcharts

IV. RESULTS

Fig. 3 represents the result in scale day from the monitoring system. As shown in the picture three activities have been detected. The first two activities begin from 2 PM until 5 PM and the last activity started to form 3 PM until 5 PM. This data can show how the monitor system work and record statistical data. The assortment of monitoring nodes in each room can be assigned dynamically from the control station.

Fig. 3. Monitoring daily results

This permits for instance to disable the monitoring function on nodes that report unusually high numbers of false alarms. The weekly result can provide a wider assumption of the power usage event that happens in a week's time. From Fig. 4 display total of activities that sensor number 3 has fewer uses in this room and sensor number 4 mostly uses of the week. This statistical data shows how often each device has been turning on in the period.

Fig. 4. Monitoring weekly results

Form this data there are clear at the management level that the office worker normally stays and work in a spot of air-condition number 2 and 4 the data can compare to the observation method to understand the condition of air-condition number 2 and 4 that how the management term could reduce the number of these air-condition by the group this worker in the same year and use only single air condition at a time, for example.

V. CONCLUSION

This research investigates the distinguishing behaviors of a worker in relation to power consumption in the workplace. To reduce the problem of overpowering spending, the origin of the problem requires identifying; the monitoring system has shown that the automated method is one of the effective keys to handling this task. The knowledge management process is a distribution key which, extracts from the rule base using data from the monitoring system to create the solution policy to enforce workers to comply.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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