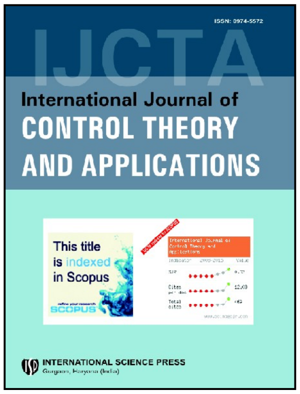

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Design and Implementation of Monitoring and Control Algorithm for Energy Conservation in Building

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Abstract: Today's buildings are becoming most advanced in order that the demands are increasing. Complex prerequisites needed in apartments, hospitals, multistoried buildings with power saving technology. This involves the need of advanced automation in buildings with wireless sensor networks (WSN). This proposed research work analyzed how to benefit power saving from the occupancy based power utilization. Power savings can be achieved by monitoring and control the electrical devices based on the human occupancy in the buildings and rooms. Based on our simulation results, it shows that the real-time occupancy information collected through the regular monitoring thus saves significant amount of electrical energy. In the first phase of the work, the power saving is achieved by using general data collection by forming clusters among sensors. In the second phase of the work, the fuzzy rules are used to optimize the controlling mechanism of electrical device in order to reduce the power utilization for lighting, fan, and air conditioning based on human presence inside the room, temperature (T), ventilation (V_L) and day light (D_L) brightness (B). Electrical power utilization updated by smart meter (S_M) and the readings are transferred to the electricity board main server also human presence data's transferred to the local server.

Keywords: Electrical Devices, Monitor, Fuzzy Rules, Controller, Energy consumption

INTRODUCTION

At present scenario, reducing electricity power usage in home and buildings are the vital role of our society, because buildings are one of the core contributors to demand electricity. Due to electric power utilization reduction in building electric cost will be saved for building owners. Thus it improves electrical device life time by controlling continues operation. Indian buildings are an interesting environment nowadays. Due to recent economic gains it brings many changes in living standards, which could affect high electricity usage in buildings. This is the time to study about the relations between electrification and electricity utilization in developing countries. In recent times, researcher aims their interest to expand suitable global electrical power consumption model in buildings to reduce electric bill amount.

In our everyday life, due to lot of timeless activities, occupants need of reliable lighting, AC and fan control mechanism. Depends on day light (D_L) brightness and various climatic conditions electrical device operations need to be adjust automatically. Currently, due to the limitation of electricity usage (150 units /month then cost will change) so that cost of electricity will increase. Thus, it is very much important to take effective solution to optimize utilization of electrical power by many electrical appliances in buildings. Residential consumes sufficient amount of electricity, which is concerning three times higher than commercial buildings based on the reviews of the central electricity Authority. The ultimate reason behind on this is, the area of residential building is seven times greater than the commercials. In order that the domestic products usage increased, thus raises electricity consumption. In future, electricity consumption in India is expected to rise around 2280BkWh in 2021-22 and 4500BkWh in 2031-32. In that electrical devices used maximum electrical power.

In this paper, the main key issues are concerned with the development of monitoring and controlling electrical appliances like lights (L), fan (F), air condition (AC). By applying simple fuzzy decision rules using sensors connected with the electrical devices control the operations. In real time, by monitoring the environmental changes, simultaneously control the operation of lights, AC and fan based on D_L and V_L using sensors reduces electrical power usage. In further special consideration is used to evaluate the effectiveness of the proposed control strategies using cluster formation among sensors. To manage all the dissimilar devices, wide-ranging sensors (S) needed and it act as intelligent controller.

All the ventilation devices and lights connected inside the room along with S that provides a power control system. Sensors have been employed to monitor a variety of physical activities, like T, pressure, flow rate, humidity, acoustics, vibrations (V) even pollution levels. In WSN large number of sensors placed where each light, fan, AC to detect physical changes such as D_L and V_L to adjust device activities.

The rest of this paper is organized as follows: in Section 2, the review of the related works has been deliberated. Section 3 deals with DDMCA implementation steps. Section 4 describes the results and discussions. Finally, the article is successfully concluded in section 5.

2. RELATED WORKS

Building and plant modeling approaches are theoretically compatible. Central to the model is its customized matrix equation processor which is designed to accommodate variable time-stepping, complex distributed control and treatment of stiff systems (i.e. systems with a large range of time constants) [1]. The Huanxiajindian subproject includes multi-story and mid-rise apartment buildings. The apartment buildings and additional public buildings are served by one substation, which is a part of a large hot water district heating system supplied by a combined heat and power plant [2]. The latest trend that is dramatically impacting our industry is that of controlling and monitoring building automation controls over IP networks [3].

The intent of this research is to provide documented evidence and build tools that can be used to educate and influence end-users, building owners, architects, and contractors that a “greener building” can be achieved using intelligent technology, and will provide a tangible and significant return on investment [4]. All these changes, as discussed in the following, will affect the grid in terms of reliability of power transfer, stability of the overall system and safety for the grid components and, more importantly, for the people nearby grid facilities [5]. This work pretends to take advantage of powerful capabilities of computational intelligence to improve the actual features of modeling, prognosis, diagnosis and optimization of load demand for EMS [6]. Reliable spatially resolved occupancy data are not available in most buildings. Many modern buildings include motion detectors, and temperature and CO2 sensors for light and air flow management, but these sensors present some limitations [7].

Wireless Sensor Network (WSN) which consists of dense sensor nodes that continuously observe physical phenomenon provides an opportunity for building monitoring [8]. Implementing a WSN-based distributed control system requires an efficient means of sharing information between devices [9]. The Wireless Sensor Networks (WSNs) technology is one of the promising information technologies developed in the last decades, and it has the potential to be used in improving buildings' energy efficiency [10]. Metering management will no longer be limited to manual reading. Instead, it is evolving from Automated Metering Reading (AMR) to Advanced Metering Infrastructure (AMI)[12]. The magnitude of the savings depends on the type of feedback or information offered, cost of power, interface type and format, and other social and economic factors [13].

Building Energy Management Systems (BEMS) is one of the best known solutions in improving building operation [14]. A BAS for small/medium-sized buildings should be able to monitor and control major end-uses (such as, heating, ventilation and air conditioning systems (HVAC); exhaust fans and interior and exterior lighting systems) from anywhere in coordinated way (web, smart phones or desktop computers) [15]. The best choice in order to obtain a more relevant and stable energy saving is to adopt a totally automated Building Management System (BMS) [16]. Such systems can revolutionize the way we live and work therefore in this project we want to use WSN technology to control and manage energy in building [17].

In contrast, Digital environmental home energy management system (DEHEMS) uses wireless sensor monitoring network to control home appliances according to user profiles [18]. A prototype automation system for monitoring and controlling in multi-storey building with more than thirty sensor nodes and controlling nodes has been developed and tested successfully in the IU-Building [19]. The utilization of ZigBee WSNs outperforms traditional techniques in providing a low power-cost and fully distributed building environment monitoring methodology [20]. There is a strong need for an open standard interface in the software layer for BMS which a) supports the import, and deployment of control and FDD algorithms, and b) facilitates the use of simulation models for building operation [21]. Therefore, the informational data of "operating situations" and "usage" of individual property have to be collected and analyzed [22].

3. IMPLEMENTATION OF DDMCA PROTOCOL

3.1. Network Setup

Sensors control electrical devices programmatically, through the detection of human occupancy in buildings. It can sense high accuracy environmental status. Initially electrical devices are connected to the sensors to control its operation via the protocol in network. Sensors deployed with IEEE 802.15.4 radio and 125-meter coverage built in antenna, if obstacles are presents such as doors and walls, their radius changes as 20 to 30 meters. All electrical devices connected with smart meters, it evaluates the power consumption in home and buildings, very

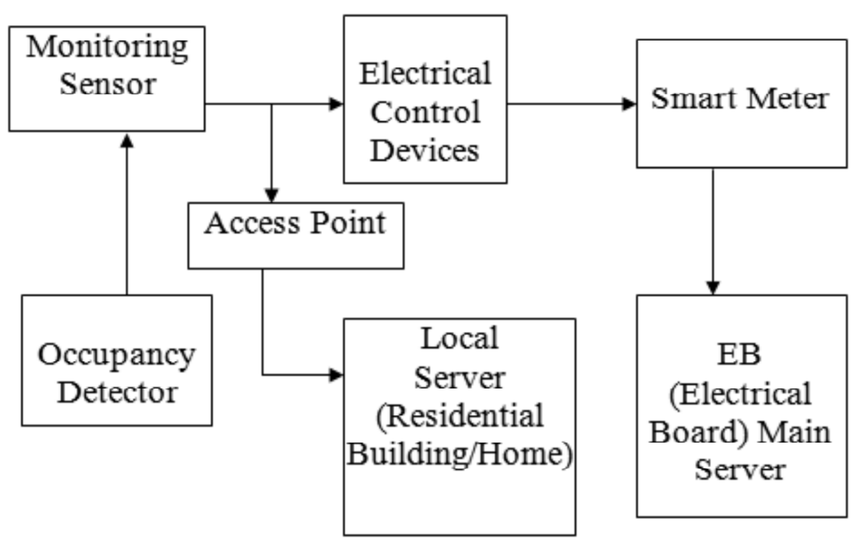

Figure 1: Network model

often smart meter converse that information for billing purpose to the electricity main server for the balanced management of power consumption in buildings. Smart meter outlet observes each appliance power usage. Also one local server connected in network to collect data about human occupancy and electrical usage. The efficiency of the new algorithm formed by fuzzy controller that reduces electrical power consumption by adjusting device operations based on occupant presence.

The electrical power consumption of individual household equipment computed as total power consumption of the home or building. The consumption of power is an important feature has been slowly changeable day to day. Variations of power consumption may happen because of the weather conditions or avoidable operation of electrical power by more number of household appliances and careless handling by not switching OFF the lights or AC and fan. These factors may show superior impacts of power usage.

If the room T is lower than the sensor detection threshold (T_{Thresh}), heat control devices (H_{CD}) AC, fan speed will be reduced by sensor when occupants stayed inside the room based on their moving speed (M_S) and V. H_{CD} allows small amount of air inside to the room so that T may adjust inside the room. The accuracy of changes computed using fuzzy logic with Inputs of L V, and distance (d_{sj}), output produced as control voltage (C_v)

Whereas room T increases S compares current T with T_{Thresh} and allow maximum amount of air inside room. Thus increases additional cooling effect in the room. In general twenty four hours time duration programmed to cover complete day device monitoring. Automatic switch off is also used in timers to set at pre-determined time period. but the switch ON only by the manual operation.

```
If (AC_S== 1) && (Fan_S == 1)
S Monitors current room T
If  T < TempThresh
Air Circulation -- ;
If T > Detection Thresh
Air Circulation++;
```

In fuzzy estimation input membership functions which is ranges from 0 to 1 based on the crisp output value is converted and range is selected heuristically, because in the specific day light (DL) room the value of brightness (B) remains within this above range compared to the B when the room is illuminated by artificial L. The second input vibration on the room membership functions ranging also from 0 to 1 as per the vibration value of room surfaces. The output C_v has membership functions ranging from 0 to 1 based on which the fuzzy conclusions are converted to their corresponding accurate outputs. The rules are created based on the knowledge of the real system, that what level dimming required for the current B and V_L need from AC and fan.

In Fuzzy Logic Inference (FIS) structure it predicts the output, written in the lookup table. The output membership function related to any random inputs, one from B and other from vibration obtained from matrixes which are fuzzification of inputs and the defuzzification of outputs to get accurate values. The output value generated by the FIS is used to control the L, AC and fan.

3.2 Neighbor set creation: When S $\mathbf{n_i}$ received HELLO message from its neighbors $\mathbf{n_j}$ with their ID, time (T_s) and current energy (C_E), $\mathbf{n_i}$ creates neighbor list (N_L) to store the received information. $\mathbf{n_i}$ also broadcast an HELLO message with its ID, T_s and CE, all receiving $\mathbf{n_j}$ neighbors (N) update $\mathbf{n_i}$ as their N in N_L. Finally the complete sensor in the network constructs 1 hop N_L and all sensors forms network connectivity.

Table 1
Fuzzy lookup table

S.no	*Fuzzy_input(L)*	*Fuzzy_input(v)*	*Fuzzy_Output*
1	Very_High	Very_High	Very_High
2	Very_High	High	High
3	Very_High	Medium	High
4	Very_High	Low	Medium
5	Very_High	Very_Low	Medium
6	High	Very_High	High
7	High	High	High
8	High	Medium	High
9	High	Low	Medium
10	High	Very_Low	Medium
11	Medium	Very_High	High
12	Medium	High	Medium
13	Medium	Medium	Medium
14	Medium	Low	Low
15	Medium	Very_Low	Low
16	Low	Very_High	Medium
17	Low	High	Medium
18	Low	Medium	Low
19	Low	Low	Low
20	Low	Very_Low	Low
21	Very_Low	Very_High	Medium
22	Very_Low	High	Medium
23	Very_Low	Medium	Low
24	Very_Low	Low	Low
25	Very_Low	Very_Low	Low

Neighbor Insert (ID, T_s, C_E)

3.3 Route Discovery: Network is deployed as a bound for graph (G), where defines the set of sensors $S = \{s_1, s_2 ......s_n\}, i \neq j$ where s_1 to s_n declares each sensor from group of sensors S in network. Set of N defined as $N = \{n_1, n_2 ......n_n\}$ here $n_1 to..n_n$ explains each neighbors of a S. Data transmission started by any source (S_N) and it may does not have any route to reach local server via access point (A_P) to send its detected information. Server starts beacon signal (B_{EA}) which is rebroadcasted by all S in the network through A_P. Periodically B_{EA} broadcasted through the medium of wireless channel with its ID and location through A_P. All S updated server ID and server location in its routing table. A_P Sends announcement of (A_{PA}) periodically about its presence with ID, location to all S. Which are the S under the coverage of A_P receives A_{PA} and update in its routing table. Each S replied with its N_L to server through A_P thus server constructs sensor list S_L. This list contains sensor ID, C_E, N_L and T_s of each S, sensing data about occupant staying time T_s inside the room, mode of electrical appliances' (M_{EA}) about its operation for building people knowledge.

Server Insert S_L (ID, T_s, C_E, N_L, M_{EA})

Regular electrical power utilization of entire home and building updated by smart meter (S_M). S_M wirelessly connected to the gateway (G_w) to electrical board server through internet. After deployment for easy transmission sensors build local clustering among its neighbors to form route to local server. After N_L construction each S starts cluster formation among its local N group by cluster message (C_M). When C_M received by S distance (d_{sj}) estimation computed with $\mathbf{n_j}$ using propagation layer. Let S and $\mathbf{n_j}$ have coordinate values X and y respectively as deployment coordinates. Compute d_{sj} of $\mathbf{n_j}$ towards server to find shortest distance path. d_{sj} between the sensors computed by.

Where X1 and X2 defines S coordinates and X2, Y2 defines nj coordinates. Energy consumption will vary based on sensor with its neighbor distance. So that energy consumption between sensors computed based on distance using receiving signal strength (R_{SS}). Actual power used as per distance inside the communication range computed as R_{SS}. S computes transmission power TxPr of the signal and receiving power RxPr computed by nj.

Here and refers the receiving power of node and transmission power of node. considered as system loss and is the wavelength of the signal. The two parameters C_E and strong R_{SS} nodes up to server chosen as cluster head (C_H). Chosen C_H broadcast its announcement (C_{HA}). If S receives C_{HA}, update as current C_H. While S_N sensed data, it transmits to local server via C_H to save energy and reduce hop count.

3.4 Occupancy Detection with Fuzzy Optimization: B, vibration and d_{sj} are the inputs to the fuzzifcation. Fuzzy computes consistent output which can be the results of indecision. These inputs to the fuzzification processed by comparing the boundary range are low, medium and high values. The fuzzified inputs are used to identify the current fuzzy rules and their performance can be adjusted by tuning the rules by various combinations of low, medium and high values. Three input parameters are aggregated by the triangular corner for 3 values. These values are computed in two formats as weighted sum and direct sum of input parameter. Let us state the inputs which are usually membership degrees of a fuzzy concept, , and the weights w1, w2, w3 the taken from [0, 1].

$$Sum = L1 \times V2 \times D3$$

The output of the system by discrete center of gravity defuzzification method.

$$Output = Sum \times \alpha$$

output of membership function estimate to adjust D_L and ventilation to operate light, fan and AC.

When occupant enters the room based on sound and vibration, sensors start detecting the presence then using fuzzy controller monitor the current brightness in room. Depends on the brightness and ventilation room lighting mode changed as low brightness, medium brightness or full brightness and light starts ON state as per sensor detection according to D_L. Same way as per the ventilation and room temperature AC or fan adjust its speed of air circulation using fuzzy computation as low speed, medium speed or high speed. Lighting and ventilation adjustment can be computed from FIS system to make decisions for electrical device operation and the results can be seen in Table 1 In the proposed system, after occupant entrance inside the room, the sensor detects their presence through the vibration and sound then it computes

1. Brightness inside the room
2. Temperature
3. Object distance

Fuzzy divide the inputs into three low, medium and high linguistic modes and chooses triangular membership function to define them. Human occupancy information send to the local sever via C_H and A_P. Although S_M updates the current electrical utilization readings in its meter as units. Depends on the environmental current usage minimizes the power consumption and if occupants not present inside room sensors connected to the electrical devices does auto off after a waiting period. Further adjustment needed for occupants; manually they need to adjust to their own requirement.

Table 2
Power Utilization

Smart Meter (Reading)	*Number of Units*	*Cost*
8.74404	33.1161	4.02437
21.3506	52.026	4.29395
29.5031	64.2546	4.33795
34.8304	72.2456	8.21737
37.8093	76.7139	8.52277
43.1157	84.6736	8.52277
47.6182	91.4273	9.4907
51.7735	97.6602	9.83355
57.7667	106.65	9.87852
62.4072	113.611	9.83355
67.0074	120.511	10.1454
72.7609	129.141	13.5764
81.121	141.681	13.5764
83.6571	145.486	13.4979
90.5827	155.874	13.5764
94.6268	161.94	14.4555
103.089	174.633	14.5272
113.366	190.049	18.035
120.457	200.685	19.3141
127.854	211.781	19.4913
137.447	226.17	19.3141
144.844	237.266	19.4913
158.61	257.915	20.4182

4. RESULTS AND DISCUSSION

In order to calculate the performance of the **DDMCA**, we compare it with basic ESWSN protocol in NS-2. Network parameters are mentioned as: 2Mbps bit rate radio channel model and 100 meters' node coverage area assigned as its transmission range. In application layer sensing application developed to generate data's. So as per sense nature any node can send data to local server. with maximum 64 bytes per second as data size. The total simulation time is set as 200 seconds with the network area of 1000 X 1000 square meters.

Figure 2(a) &2(b) shows the energy consumption get increases with respect to time interval and packet size of both the protocols. As the energy get reduced in DDMCA protocol when compared with ESWSN protocol, because it optimized sensing with the support of fuzzy logic

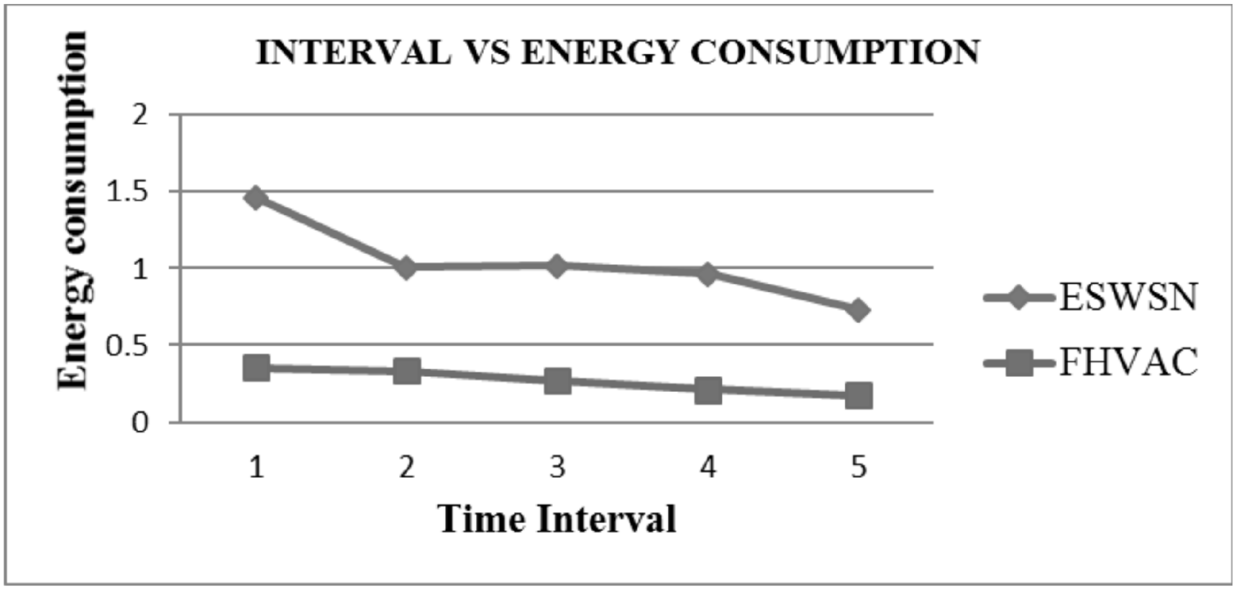

Figure 2(a): Interval Vs Energy consumption

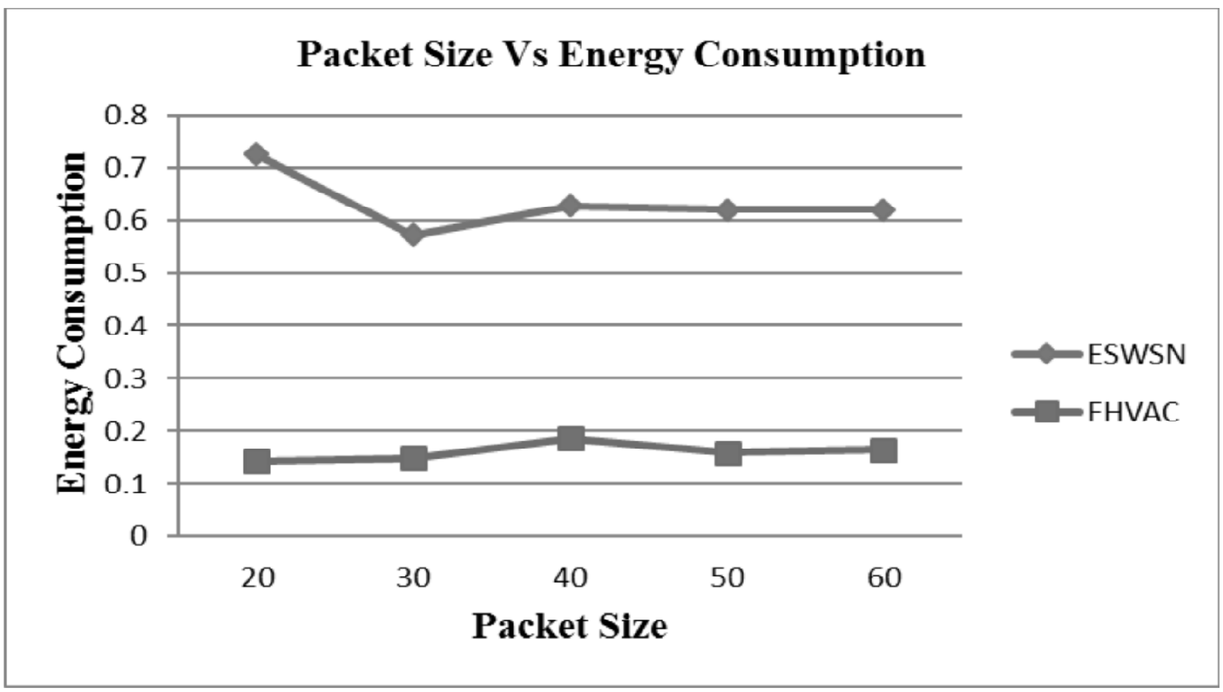

Figure 2(b): Packet Size Vs Energy consumption

5. CONCLUSION

This paper, we proposed monitoring and control power utilization in building based on occupant's presence. To control the routing power usage DDMCA proposed a fuzzy system to choose lights, fan, and AC operation. Also clustering provides stable path routing. Simulation results show that the proposed protocol generates less delay, so as it increases the PDR. The simulation output shows the DDMCA has best performance when the network is in high density with more number of packets.

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