

IoT based Residence Energy Control System

Kavitha A.B¹, S. Srividhya²

¹Student, Information Science & Engineering Department, BNM Institute of Technology, VTU, Karnataka, India

²Assistant Professor, Information Science & Engineering Department, BNM Institute of Technology, VTU, Karnataka, India

Abstract - In the past decade most of the Natural Resources are nearing to exhaustion. It is the duty of every human to make an attempt to save energy and to make a better future. This paper provides one such attempt to save energy consumed by the house hold electrical appliances. The energy control system is an effective method to save energy as it prevents users from letting their home electrical devices consume more energy with or without their notice. Currently, there are multiple commercial products which aim to save energy, but not all systems prove to be effective, efficient and user friendly. This paper provides one such energy saving system which proves to be intelligent as it makes use of IoT and wireless sockets that work with embedded systems to minimize the consumption of energy of home appliances. It also provides feasibility to user to decide and set limits based on the usage of energy. This system also provides different control modes to be chosen by the user.

Key Words: Neural Network, Zigbee, Smart Socket, Sensors, Internet of Things, Serial port Interface, ELC (Energy Control Limit)

1. INTRODUCTION

Natural Resources are one of the most important aspects for the human livelihood. It is important to save such resources. The greenhouse effect is increasing rapidly in today's world which makes it difficult to save energy and is the critical issue to design electronic appliances. In the present era the concept of smart house that are equipped with lightning systems, advanced temperature control systems, advanced security systems in in urge and are increasing day by day. These systems are in need of energy efficient management in their construction. Hence there is an urge for the development of system that can efficiently manage and control energy and its usage in such smart residences. On the other hand, internet of things should be used to develop a smart home to save more energy. A versatile system that includes IoT embedded in to the network along with the appliances and the necessary network management tools and devices is to be developed. A good number of projects to reduce wasting of energy do exist. With the current methodology, anyone will be allowed to set his own limits for the reduction of energy wastage. The limit can be set along with time using an energy controller unit to provide all the usage details of residence appliances. The purpose is to bring awareness for consumer's energy consumption by getting users to be aware of their wastage and use of energy.

2. RELATED STUDIES

There are a huge number of case studies with respect to energy control for residence and here are few relatively mentioned. V. W. Wong [1] presents a methodology to normalize energy usage of home appliances through gaming technique. However, user's satisfaction degree for efficient task scheduling was not considered. Home appliances with storage devices which are to optimally scheduled has been discussed in [2], aiming to monitor the total cost minimization. These techniques seemed to make use of Meta heuristic methods for their optimization of energy, yet the ease and placate of a person in the home was not considered for the process of price negotiation. A numeral nonlinear encoding replica for controlled power consumption with in a house was developed by Anvari Moghaddam et al. [3] for attaining equilibrium amid user living manner and the power reduction. It incorporated a varied intent task below user preferences and also different system constraints. The algorithm presented reduced utility bills, home based power consumption and promised a finest assignment development along with good placate for any user. Also, if internet of things could get a place in the above mentioned system the power saving will be increased.

The wireless sensor networks along with the IoT found novel methods energy monitoring in home. These situations had a non variable protocol with a faster connection to contact the unit for remote monitoring and functioning. Appliances by Yeoh et al [4] used emails as the communication medium called e2Home alliance that enabled people from elsewhere to monitor electrical devices at home through notifications on email. This facilitated users to establish an effective management of home appliances with a normal speed internet. But it is not easy to construct this system with complex email services. A rational agent was created by Das et al [5] that acted as a home servant in a versatile manner and aimed to provide high comfort and low maintenance cost for users. An involuntary procedure for residence monitor by Choi et al [6] was developed. It was a context-aware middleware to provide users with their preferences. The intermediate makes use of OSA by the structure of the residence internet, and predicts the user's first choice on house hold devices by employing collected statistics. The kind of data sensed contained timing, position of devices with its movements, thump, humidity and temperature.

2.1 Energy Control System

Making use of too many sensors to detect or sense user activities is not efficient or worthy as sensors also consume good amount of power. Hence less priced and an effective system is to be used. The project uses a smart methodology which is called Residence Energy Control System (RECoS for short), is introduced for decreasing the power wastage in a residence through the devices put to monitor with sensor less system. This system called RECoS makes use of back propagation algorithm to monitor user activities and automatically shut down the device that collaborate with the system in instances of idle energy found. Experiments conducted using this system can reduce energy of about 41% of the total used.

ZigBee will be utilized for the transfer of information with respect to power and energy of home appliances. For monitoring the solar panels, power line communication is utilized. This protocol establishes the wireless network, based on the Kruskal's algorithm value measured from the RF radio.

3. SYSTEM ARCHITECTURE

The RECoS system is made up of different modes to monitor the start and stop of the devices that. The IoT configuration is very simple and works in collaboration with smart sockets connected to home gateway which use Zigbee and internet for communication. Above all, the RECoS doesn't use sensors and works even on vintage devices which do not have any privilege for connectivity of internetwork. The back propagation algorithm enhances the intelligent learning phase and is able to achieve a good amount of energy saved. RECoS is able to save about 45% of energy per week from the experimental results and this energy is the idle energy. Other appliances can also save some amounts of energy.

The project mainly consists of wireless socket, electrical devices with current and voltage sensor. The Wireless socket is a combination of relay and zigbee. The electrical device is connected to relay. Current and voltage sensors will collect the instantaneous values of voltage and current. This system will manage the power consumption whenever power exceeds the threshold by switching off/on the appliances. The current sensor senses the ac or dc current in the wires and produces output according to it. The output data of sensors is analog in nature and will be provided to the ADCs (analog to digital convertor). The ADCs will sample the analog values in its internally defined voltage levels. The ADC will convert the matched level into a digital output which will be equivalent to that level in the form of BCDs to the microcontroller. The complete architecture of the system along with the Hardware setup is represented in Figure 3.1. The microcontroller will convert the data of ADC into decimal values and then the controller will also send the data to the server wirelessly using Zigbee modules. Zigbee is interfaced with the microcontroller through serial port and transmit data serially. It can also use the TTL logic method to directly connect with the ports.

4. IMPLEMENTATION

The electricity measures such as current, voltage, power and frequency are measured automatically by the RECoS system. An experiment which considered a frequency of 10 readings per second was performed. Later the data so collected was sent to the home gateway for every 10 minutes which is controlled by action trigger. This means that 6000 readings in total were sent (10 mins*60sec/min*10/sec). This in turn means 6000 times of data transfer was done. Yet there was no congestion in the network of data transfer as ZigBee is an efficient transceiver. The system is made to transfer the average readings of data values, be it power, frequency or voltage (that is average energy consumed is the time*avg power) to the control unit. Example, if data 144 is sent to the control unit by the powered device, then that means 144 values are read which is 24 hours of value reading and 6 values per hour. The control unit further sends all the received information by the sockets to the controller through an Internetwork facility. All the learnt and calculated information or values are saved in the cloud within the heuristic tables created earlier.

4.1 Smart Learning

The system mentioned so far makes use of the back propagation neural network (BPNN) algorithm in order to monitor everyday energy consumption of a residence. BPNN algorithm establishes an energy usage model for each residence on availability of the historic data of that home energy consumption. The historic data is collected in the learning phase. This algorithm takes data from i/p layer, processes it in the intermediate layer and shows result in the o/p layer. This system takes i/p from the control unit i.e. the power usage value of the real time devices with respect to

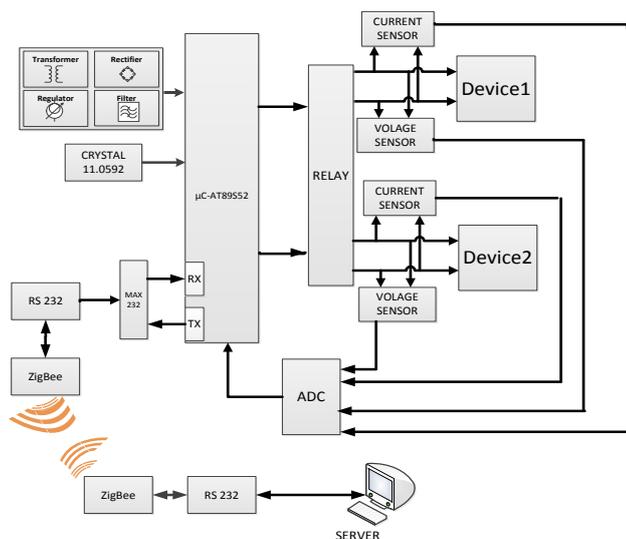


Figure 3.1: Block diagram of RECoS Architecture

time. These values are provided by algorithm. e.g., one month is divided into week and weekend days and 4 values are considered as TP_i , and the days represented as Di . All the values in the week day vary from that from the weekend values. This facilitates the correctness of calculated values for energy control. The calculated prophecy values are the outputs from the algorithm used.

4.2 Back Propagation Neural Network algorithm:

The algorithm accepts unprocessed data as intake into its first layer. A copy of the data is made and original data does not undergo any change. The replicated value from the first layer is sent down to next layer nodes for processing. All the values from first layer are accepted by the second layer. There are certain pre existing weights that are termed values in the second layer and these values are used by the second layer to process the values received from the first layer. The values thus obtained are transmitted to the last layer. This value further undergoes modification by the pre existing values in the third layer. Thus processed values are termed to be final values as output and are checked by the launch utility.

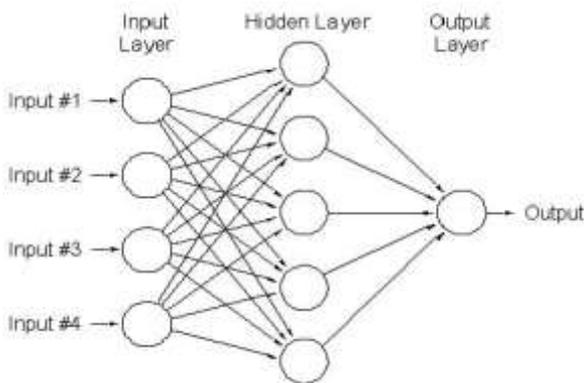


Figure 4.1: Architecture of a Neural Network

Figure 4.1 shows a simple NN architecture. The nodes in all the three layers are connected to the node below in the below layer. Every node has a value fixed to it with every connection a node has with the other node.

4.3 Information/Command Transceiver Module

Home gateway is connected to this module through the internet or any other network in order to transfer data from the socket along with user commands to control unit. Once in every ten minutes, the module begins with a signal received. A request on information is sent to the control unit after the mode begins. The Transmitter model is represented in Figure 4.2. With the response taken, collected information is being saved in the cloud along with device ID's.

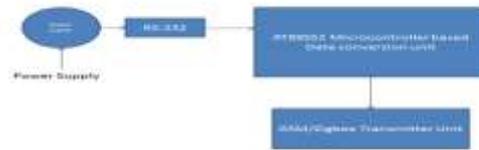


Figure 4.2: RECoS Transmitter Model

The data requests are sent to the home gateway by the above module through the transmitter and the receiver receives the information and stores it in the memory with the respective socket ID's.

The data flow at the initial level with the control transfer is the flow of control from one module to another can be seen. The control begins from the device under test and moves to smart socket which is later received by RECoS system with in which the algorithm runs to fetch the expected outcome of particular device.

When a limit for power usage is set, the system goes into energy limit mode and takes control. When users set the energy limit for a period of one month (considering power usage in the previous month), the energy limit of control is estimated by the same module along with the parameters, which also provides historic data of power used. The module is also responsible to provide details such as the date id and the precedence of the devices. The parameter indicating the power used is the real time energy consumed by a particular device for the corresponding id. The factor which indicates a threshold by user is the expected energy consumption for the rest of the days in a month and turns out to be 91 percent of the complete energy for that month.

5. RESULTS

RECoS mainly operates on IoT which uses smart sockets to monitor energy values. The wireless communication module that connects the gateway of home to the socket is Zigbee that works on network and bluetooth. The whole system works on three important devices that is smart socket, energy controller and home gateway. The password enabled authentication ensures secure data transfer as mentioned earlier, there is no data loss due to the efficient usage of Zigbee. The Wifi module enables increased communication range between smart socket and home gateway. Energy controller unit measures the power consumption of the home appliances, store data into the memory and also displays the results on the user mobile app and the cloud server.

5.1 Power Monitoring

Remote monitoring of the power consumed by the sockets over the network is an additional advantage in this system

for any user. The whole system works on real time data, at the same time collecting and storing the historic data.

5.2 Electrical occurrence retort with time

The main characteristic of this system is the prospect is to end the power stream if an unusual activity is found earlier to the energy consumption begins or a break up happens at situations where in the controller does not select its respective mode with time. For the purpose of finding an exposure instance for any energy occurrence, hypothetical along with pragmatic examination to be conducted. The recognition instance is calculated for every case.

5.3 Recognition of Hardware period

The period which is necessary to fetch information on real time power usage can be dependent on the sensors alone. For an instance, by considering the historic data available about the power supply usage, the time which is necessary to read novel values of energy consumed is about 2 to 6 microseconds. The *trs*, which is defined as the time necessary for the relay to connect to the socket, was found to be 2ms after experimental analysis. This instance is recorded in the cloud server for further experiments and to calculate the probability of limit. If the time limit crosses the specified time, then a relay with higher speed is to be used. Every relay available varies with the time taken. But, the Zigbee compatible relay is the main factor to be considered.

Table -1: Weekly reading of Energy Consumed per socket

Sock_id	Smart_S 1	Smart_S 2	Smart_S 3	...	Smart_S n
Week_avg1	2.12	0.68	1.26	0.46
Week_avg2	3.55	1.14	1.63	0.73
Energy_limit	71.23	24.62	46.12	...	16.23
Week_quota1	2.31	0.99	2.13	...	0.59
Week_quota2	3.22	1.23	1.84	...	0.69

The devices in the system are monitored with Zigbee and Relay, For an instance, if *A*, is the energy limit set for a device *q* i.e, $q(A)$, then the limit for a particular time say for about a month by considering earlier read values of at least one month prior is estimated by the Limit module for *A* with time *t* for that particular day *x*. Also, the precedence of day *x*, if it is week day or weekend is also considered. Table 6.1 presents the instance of the energy-limit control, showing all the device energy used with time and day of the week. It also displays the limit set along with the complete energy fixed by the user. It is found that the predictable power usage for

almost a month is found to be 92% of the stored data of the previous month.



Figure 5.1: Energy usage data stored

The results are obtained by testing three different nodes such as Node 1, Node 2 and Node 3. Third node is the combination of the first and second. Different voltage electric bulbs are tested on the nodes and their power consumption in terms of voltage and current is read and transmitted via Zigbee to the interface where all the data is stored into the database. Figure 5.1 shows all the data related to energy consumed with the node details stored in the cloud. The user limit can be set by the user by logging in to the website either through mobile app or the website. Every time the load exceeds, a message is displayed on the website so that the user can decide which mode to set and the action to be performed. The interface also displays which node readings are being read and transmitted. When both the nodes are in use, the addition of the consumed power is read and transmitted. A time limit is also set so that a particular node automatically switches off after the time set is reached. When a particular node limit exceeds, the user can opt to turn off the device connected by himself by logging into the interface website. Figure 5.2 shows the snapshot of the display form which indicates the node under monitor along with its energy consumption details.

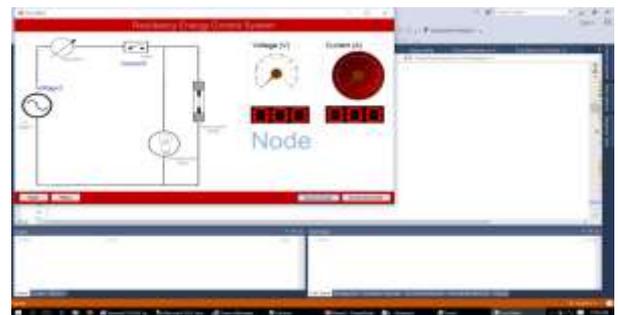


Figure 5.2: NODE Display Form

IRJET sample template format ,Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

6. CONCLUSIONS

The project speaks of the accomplishment of ZigBee with an intelligent control system which uses smart sockets to control and monitor the devices for their energy consumption. The efficiency and flexibility is achieved by providing different modes for the system so as to have remote control on devices, reduce leakage of current, detection of idle energy and also to achieve hindrance of electrical fires and shocks. The above mentioned system is achieved by performing real time experiments on residential devices by creating a separate control unit with a gateway for it. These experiments showed an outcome which has high efficiency and is worldwide accepted. The examination of results so obtained proved the system is highly efficient and flexible enough for any residence.

This system is worthy of enhancing the comfort level of living in a smart home by increasing the efficiency of the performances of electronic devices and reducing the wastage of energy, there by globally creating an awareness. The control of energy consumption takes place by the usage of smart socket collaborated with IoT. This system provides high user satisfaction as it provides four different modes of control based on the requirement and comfort of the user. This system uses a simple formation of internet of things that combines control unit, intelligent sockets, Zigbee and wifi. Above all, the efficiency level of the system with respect to energy used by the system is high as there are no sensors deployed.

In the near future, RECoS system can be made more reliable and cost effective and also predictive by making use of behavioral models to enable prediction of the system before using it. Besides, the user interface is very simple and further can be made personalized. A user form for knowledge of the system working manner is also created to reduce power wastage in a very smart way. Since the system makes use of data transmission on to the cloud, security becomes a concerned factor and encryption of the modes for control can be considered. These constitute the future studies.

ACKNOWLEDGEMENT

I gratefully acknowledge the role played by my guide Asst. Prof. Mrs. S. Srividhya during the course of this work. She has given me confidence to take up this project and guided me at all times of difficulty. I express my deep sense of gratitude to the Principal, Dr. K. N. Krishna Murthy for facilitating the resources and providing all the encouragement. I am indebted to my spouse his unconditional love and sacrifice made during all those long hours of neglect. They have all been a constant source of inspiration and motivation.

REFERENCES

- [1] A. H. Mohsenian-Rad, V. W. Wong, J. Jatskevich, R. Schober, and A. Leon-Garcia, "Autonomous Demand-side Management based on Game-theoretic Energy

Consumption Scheduling for the Future Smart Grid," IEEE Trans. on Smart Grid, vol. 1, no. 3, pp. 320-331, Dec. 2010.

- [2] A. Barbato, A. Capone, G. Carello, M. Delfanti, M. Merlo, and A. Zaminga, "House Energy Demand Optimization in Single and Multi-user Scenarios," in Proc. of IEEE Int'l Conf. Smart Grid Comm., Brussels, Belgium, pp. 345-350, Oct. 2011.
- [3] A. Anvari-Moghaddam, H. Monsef, and A. Rahimi Kian, "Optimal Smart Home Energy Management Considering Energy Saving and a Comfortable Lifestyle," IEEE Trans. on Smart Grid, vol. 6, no. 1, pp. 324-332, Jan. 2015.
- [4] C. M. Yeoh, H. Y. Tan, C. K. Kok, H. J. Lee and H. Lim, "e2Home: A Lightweight Smart Home Management System," in Proc. of Int'l Conf. on Convergence and Hybrid Information Technology, pp. 82-87, Busan, Nov. 2008.
- [5] S. K. Das, D. J. Cook, A. Battacharya, E. O. III, Heierman, and T. Y. Lin, "The Role of Prediction Algorithms in the MavHome Smart Home Architecture," IEEE Wireless Communications, vol. 9, no. 6, pp. 77-84, Dec. 2002.

BIOGRAPHIES



"**Kavitha A. B** received B.E degree from AleMS in 2014. She has worked in Mphasis Ltd, Siemens Pvt. Ltd. and is pursuing M.tech from BNMIT".



"**Mrs. S. Srividhya** working as Assistant Professor at BNMIT. She has received M.Tech and B.Tech degrees from Anna University. She is pursuing Ph.D in Computer Science from VTU".