A Robust Approach for Power Monitoring and Device Management

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Abstract
Wireless Sensor Networks (WSNs) have become increasingly important because of their ability to monitor and manage situational information for various intelligent services. Due to these advantages, WSNs has been applied in many fields, such as the military, industry, environmental monitoring, and healthcare. As the power consumption varies as per the uses it is necessary to reduce the power usage and manage the total power consumption. To do so we propose a design for wireless sensor based embedded system for monitoring and controlling of remotely electrical appliances. Smart monitoring and controlling system will calculate the total power consumption of electrical appliances. The system uses genetic algorithm which helps in the optimization of the system performance. Thus, the GUI is developed to show the status and consumption of electrical appliances which in turn help the user to manage the appliances wirelessly.

Keywords
WSN, Intelligent Services, Power Consumption, Smart Monitoring, Control System, Genetic Algorithm, Optimization, GUI, Wireless Sensor, Embedded System

I. Introduction

Wireless Sensor Networks (WSNs) have become an attractive technology for the research community, particularly with the rapid increase in Micro-Electro-Mechanical Systems technology which has facilitated the development of smart sensors [3]. Typically, a WSN is a distributed system that is composed of autonomous units with sensing capabilities (sensor nodes), interconnected by wireless communication system. This network offers an optimized and potentially low-cost solution to several problems [4-8] including military target tracking, health care services monitoring, environment control systems, animal monitoring, and smart Homes. In recent years, the introduction of network enabled devices into the home environment has proceeded at a remarkable rate. Moreover, with the rapid growth of the Internet, there is the requirement for the control and monitoring of such network enabled devices remotely. However, the new and exciting opportunities to increase the connectivity of devices within the home for home automation remain largely undeveloped.

Nowadays home and building automation systems are used more and more. On the one hand, they provide increased comfort especially when employed in a private home. A smart environment is a physical world that is interconnected through a continuous network abundantly and invisibly with sensors, actuators and computational units, embedded seamlessly in the everyday objects of our lives [1]. A smart home is a residence in which computing and information technology apply to expect and respond to the occupiers' needs and can be used to enhance the everyday life at home. Potential applications for smart homes can be found in these categories: welfare, entertainment, environment, safety, communication, and appliances [2]. Some of the important communication technologies employed by today's home automation system cover Wi-MAX, Bluetooth, Wireless LAN (Wi-Fi), Zig-bee, and Global System for Mobile Communication (GSM). Nagender Kumar Suryadevara [1] proposed the idea of design and development of smart monitoring and controlling system for electrical appliances in real time using Zigbee module connected in a mesh topology such that the adjacent Zigbee node is less than 10m away to have a reliable data reception at centralized Zigbee coordinator. Ahmed ElShafee, Karim Alaa Hamed [2] in his paper presents a design and prototype implementation of new home automation system that uses Wi-Fi technology as a network infrastructure connecting its parts. Manivannam M, Kumaresan N [9] in this paper approaches the design and development of online Interactive Data Acquisition and control System (IDACS) using ARM based embedded web server. The paper presented by Huo Ching Sun, Yann-Chang Huang [12], describes the study to improve the efficiency of appliances of energy management in smart homes. The paper reviews various methods of energy optimization including fuzzy logic, neural networks, heuristic methods and evolutionary algorithms. Also, the paper presented by Adnan Ahmad, Nadeem Javaid, et al [13], proposed the system to handle the problem of cost minimization as an optimization problem, and household appliances in response to the real-time pricing of the electricity market. The constrained optimization is mathematically formulated and then solved by using the genetic algorithm.

This paper 'A Robust Approach for Power Monitoring and Device Management' discusses the base idea of WSN which uses the RF module for communication between the systems. I have developed an embedded system which is used for connecting various load and a GUI is built on MATLAB which helps the user to monitor the power consumption by each load. User can also control connected electrical loads through buttons on GUI. Thus, power is monitored and logged in a file for records.

II. Web Based Automation

This paper explains the two major parts in the application.

- Hardware implementation
- Algorithm development for statistical analysis

In the developed application, the basic idea of wireless communication is used. Wireless communication is basically a transmission of data wirelessly to any location. Systems using wireless communication can be made by linking up standalone appliances that are present at home or in office and integrating to form a cooperating network.

Another concept used is algorithm which is basically a genetic algorithm for statistical analysis of received data. This algorithm works for the optimization of the system performance results. The received data is analysed and displayed graphically on GUI. GUIs (also known as graphical user interfaces or UIs) are created in MATLAB and provide the control of software applications, eliminating the need to learn a language or type commands in order to run the application. A GUI typically contains controls such as menus, toolbars, buttons, and sliders. Many MATLAB products,

such as Curve Fitting Toolbox™, Signal Processing Toolbox™, and Control System Toolbox™ include apps with custom user interfaces. You can also create your own custom apps, including their corresponding UIs, for others to use.

III. Block Diagram

In fig. 1, the block diagram is shown in which the embedded system consisting the major elements are:

1. **Electric load:** For processing the electric watts which is the real-time input.
2. **Micro-controller:** For sending commands to the software system.
3. **RF module:** To establish the wireless communication.
4. **MATLAB based GUI:** It is a software system to control the electric devices connected to the hardware system according to the algorithm.

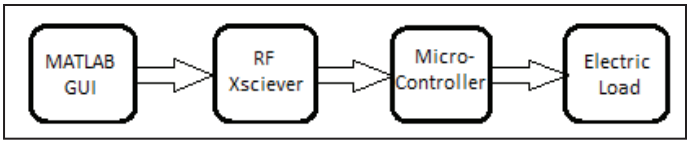

Fig. 1: Block Diagram

The algorithm for the above proposed system is as explained below.

- Connect the loads through relay module.
- Connection with the microcontroller to any one the ports is done.
- Establish the wireless communication using RF module with the software system.
- Run the system using normal operation or GA based operation for the results on GUI.
- Notify the user with the system status.
- Display of the present status of the power consumption by the loads connected and expected bill amount.
- Sending commands to the controller wirelessly for desired action to be taken.
- Controller controls the load by sending commands to the relay module.

IV. Methodology

This project is developed for automation of homes. With the increase in consumption of energy and population, there is a great need to conserve energy in every possible way. The inability to access and control the appliances from remote locations is one of the major reasons for energy loss. For ATmega16 to interact with the electric loads with varying watts, the load/s is connected to the relay module. With the help of this data is passed between the load/s connected and micro-controller.

As soon as the connection is established the intent is registered and application starts. The user can connect load or loads of varying watts to the input terminals of relay module. LEDs are connected to the relay module which shows the status of the relay. The load connected to the relay module is ultimately gets connected to the port of ATmega16 microcontroller. As the load is connected to the micro-controller, the controller sends this information to the processor of the system. CC2500 is the communication module used for wireless communication between the systems.

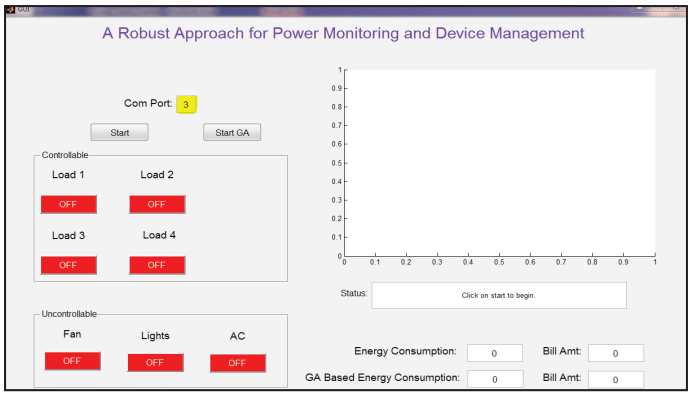

Fig. 2(a): Initial System Status

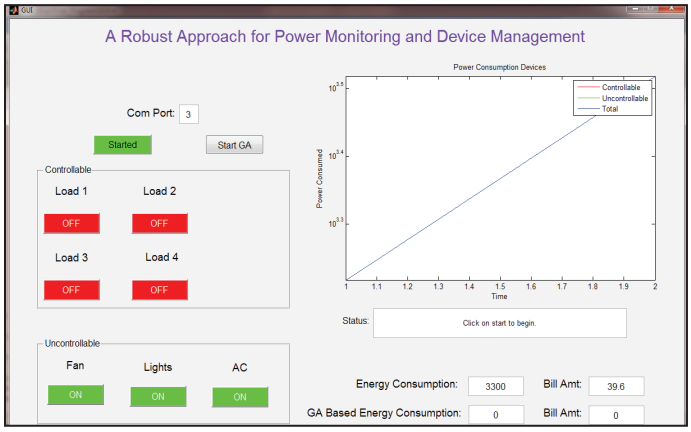

Fig. 2(b): Initial System GUI

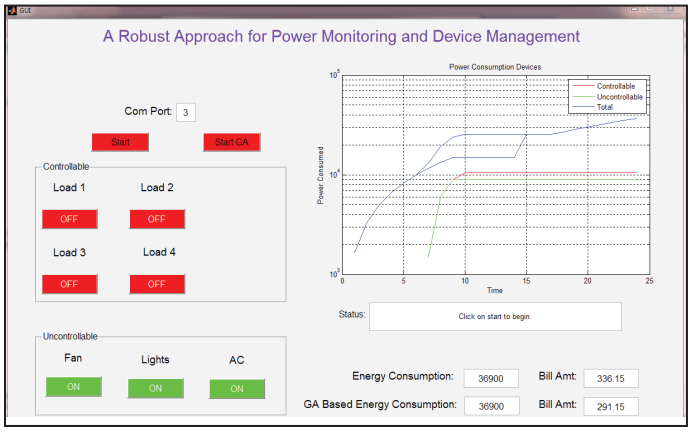

Fig. 2(c): System Status After Command

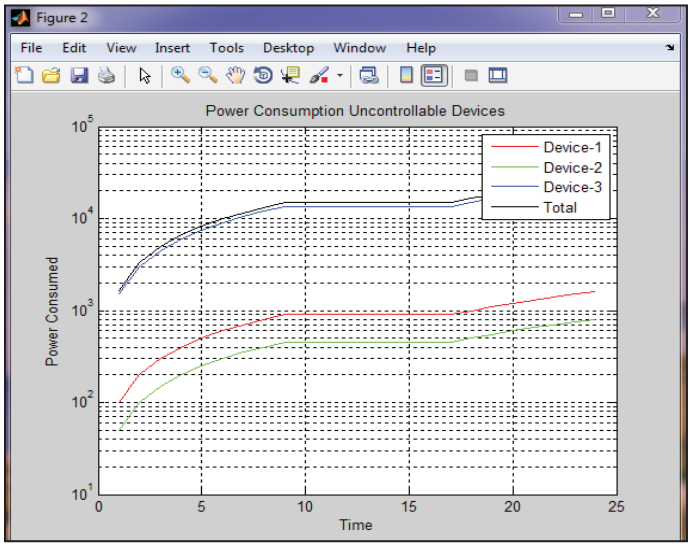

Fig. 2(d): Power Consumption GUI for Uncontrollable Devices

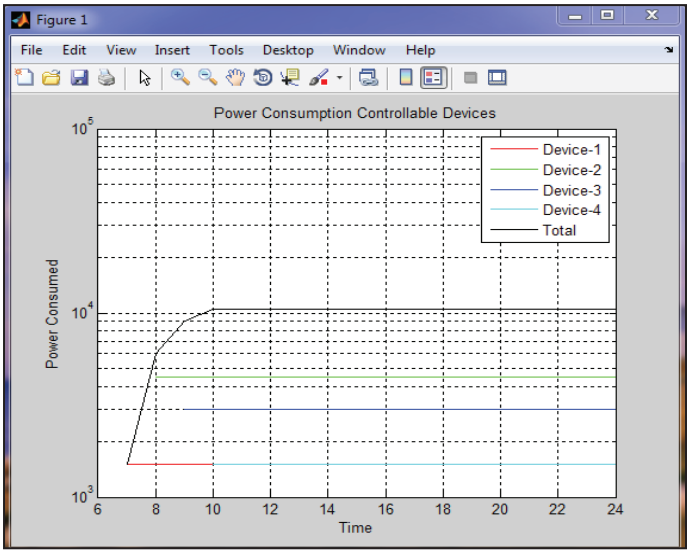

Fig. 2(e): Power Consumption GUI for Controllable Devices

A GUI is developed on MATLAB platform. This GUI shows the present status of the loads connected. It also shows various parameters such as COM port used, buttons for starting the system using normal method or using algorithm, status of the controllable and uncontrollable devices, graphical scales for real time data monitoring and numerical value displaying energy consumption using both the methods. Numerical values are also displayed on the GUI showing energy consumption and billing amount for both normal operation of the system and using GA as well.

When the system starts, GUI is updated showing device status, graphical scale with respect to time and labels showing colored graph for each load connected. As the user commands to start the system using either normal mode or using GA, the graph updates the points on the scale. The system starts run considering the performance of the system for 24 hours. The algorithm then works on the loads showing the result as total power consumed by the system and expected bill amount. We can see the difference in the system performance using two different methods. A considerable result is obtained using GA on the system.

As soon as the user commands the system to switch the system operation method, this information is transferred to the RF module connected to the controlling system. As soon as the command is received by the RF module, it transfers to the micro-controller which directs the relay module to act as required.

The proposed system run using both the methods shows the difference between the results. We can see optimization is done by the GA based algorithm and bill amount is significantly reduced. The comparative results of the system show that when the system was tested using normal mode of operation the energy consumption is 36900 units. For this, the billing amount came out as 336.15 INR. But when the system was operated using GA, though the energy consumption units were same i.e. 36900, the billing amount reduced to 291.15 INR. This shows that, with the use of genetic algorithm the optimization is done on the system and the result is reduction in billing amount by approximately 13%.

A log file also gets created and maintained with the real-time data of power consumption by each device and total watts consumed for both normal and GA based operation. This helps the user to keep the record and track in case of faults occurred in the system.

A	B	C	D	E
0	0	0	5600	5600
0	0	0	5700	5700
0	0	0	5800	5800
0	0	0	5900	5900
0	0	0	6000	6000
10	0	0	6100	6110
20	0	0	6200	6220
30	0	0	6300	6330
40	0	0	6400	6440
50	0	0	6500	6550
60	0	0	6600	6660
70	0	0	6700	6770
80	0	0	6800	6880
90	0	0	6900	6990
100	0	0	7000	7100
110	0	0	7100	7210
120	0	0	7200	7320
130	0	0	7300	7430
140	0	0	7400	7540
150	0	0	7500	7650
160	0	0	7600	7760
170	0	0	7700	7870
180	0	0	7800	7980
190	0	0	7900	8090
200	0	0	8000	8200

Fig. 3: Log File

V. Future Work

- To develop algorithm for optimization of power and lowering the price points.
- To add voice controlled features.
- To implement the system using internet server with security features.

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