Home Automation System by Using Smart Devices
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Abstract. This paper presents a home automation system by using smart devices. This system used the embedded system and ZigBee technologies to overcome the drawbacks of traditional systems. It could be installed and used in many places, conveniently. The proposed system has been tested at the Smart Home Laboratory. The result of this study indicated that the automatic controlling function is the most effective feature in reducing the energy consumption. Consequently, the performance indicators analysis revealed that the proposed system could reduce the power consumption in the home was equal to 20.03%.

Introduction

With the continuous development of an economy, the electrical energy demand of both society and household increasing at present. The conflict between supply and demand becomes more and more serious. In recent years, along with advanced technology in communication, information, and control penetrating into the aspect of the human life, it gets more and more important to change the long-formed bad habits of energy waste and make use of the advanced technology mentioned above to manage energy consumption scientifically, and it has been a hot focus in energy supply field. Now, the intelligent electric networks are developed rapidly, obviously, based on the construction of intelligent electric networks, meeting the requirements of management on the demand of energy and improving the service and its intelligent level, then we can realize the social idea like low carbon, energy conversation, environment protection, as well as a new lifestyle. Recently, the technology of home automation system has expanded for the purpose of reducing energy consumption. Home automation system involves any device or product that can analyze energy consumption, control and monitor home electrical appliances [1]. The home automation systems are installed with the intention of providing the user with easier access and more control over the devices in the home. The user will be able to monitor and control devices at home locally as well as remotely via the internet provided the user has a device with the compatible web browser. Generally, home automation systems can be implemented within any physical structure provided that limitations of the technology are taken into account before installation. A complete home automation system consists of a Wi-Fi router or an internet connection, a gateway and multiple nodes. These systems can commonly be installed in standard homes without much hassle, making the homes smart. Several researchers have proposed home automation systems based on the wireless communication technology. Han et al. [2] presented a home automation system using ZigBee technology to reduce the standby power. The proposed system consists of an automatic standby power cut off the outlet, a ZigBee hub, and a server. Gill et al. [3] proposed a ZigBee-based home automation system. This system consists of a home network unit and a gateway. The core part of this system is the interoperability of different networks in the home environment. Pan et al. [4] proposed a WSN-based intelligent light control system for indoor environments, such as a home for a reduction in energy consumption. In this system, wireless sensors are responsible for measuring current illuminations and the lights are controlled by applying the model of user’s actions and profiles. Song et al. [5] projected a home monitoring system using hybrid sensor networks. The concept of this system is a roaming sensor that moves the appropriate location and participates in the network when the network is disconnected. Suh et al. [6] presented an intelligent home control system based on a wireless sensor network with a link quality indicator based routing.
protocol to enhance network reliability. The above mentioned home automation systems have limitations with respect to true home automation such as, energy control is based on fixed threshold power consumption, which may not be applicable to different consumers. In this paper, it is shown that the use of smart devices incorporating power management features can substantially reduce the power consumption of a home and this paper used ZigBee to communicate to devices within the home.

**Wireless Communication Technologies**

Data collection process can be performed with wired or wireless methods in home automation systems. Often people do not want to see piles of cables in their homes and they want to provide solutions in terms of cost with low prices. Nowadays, the most commonly used short-range wireless networks are ZigBee, Wi-Fi and Bluetooth technology. These three protocols are compared in Table 1.

<table>
<thead>
<tr>
<th>Feature</th>
<th>ZigBee</th>
<th>Wi-Fi</th>
<th>Bluetooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus area</td>
<td>monitoring and control</td>
<td>Web, mail, video</td>
<td>instead of cable</td>
</tr>
<tr>
<td>Transmission rate (kb/s)</td>
<td>20-250</td>
<td>54000+</td>
<td>720-3000</td>
</tr>
<tr>
<td>Mesh size (piece)</td>
<td>2^m</td>
<td>32+</td>
<td>7</td>
</tr>
<tr>
<td>Range (Meter)</td>
<td>1-1600</td>
<td>1000+</td>
<td>1-10</td>
</tr>
<tr>
<td>Complexity</td>
<td>simple</td>
<td>too complex</td>
<td>complex</td>
</tr>
<tr>
<td>Successful features</td>
<td>endurance, low costs, low power consumption</td>
<td>speed, flexibility</td>
<td>low costs, easiness</td>
</tr>
</tbody>
</table>

ZigBee is a wireless personal area network (WPAN) standard based on an IEEE 802.15.4. It is used in a network that requires low data rate, i.e., up to 250 kb/s, and long battery life, i.e., up to 10 years. A typical ZigBee transmission range can be up to 100 meters depending on power output and environmental characteristics. This distance can be extended up to 1,600 meters with ZigBee-Pro. As seen in Table 1, the technology defined as the ZigBee protocol is intended to be simpler and less expensive than other wireless networks such as Wi-Fi or Bluetooth. This paper used the ZigBee technology for networking and communication because it has low power and low cost characteristics, which enable it to be widely used in home and building environments [8].

**System Description**

The proposed system has been designed and implemented for home automation system as shown in Fig. 1. The purpose of a smart gateway in a home automation system is to enable bridging between different technologies. It also acts as a means to connect the home automation system to external services and vice versa with the help of a router. Sensors can be used to relay information on certain aspects from within or outside the home to enable the system to adapt to the occurring changes. Sensors communicate directly with the smart gateway and feed the system information with regards to light intensity inside a particular room and temperature inside the home. A home automation system should be able to automatically turn off the air-conditioning unit and smart systems that control lighting systems allow just enough light wherever and whenever the user requires it. This is done with the help of sensors that relay information regarding the intensity of the light inside and/or outside the house, allowing the system to decide if the lights should be turned off, or the blinds should be lifted a certain amount to allow an ideal amount of light to flood the room. Three type sensors are included in the proposed system: light, temperature and motion sensors. A user can access the home automation system through a smart phone in the remote area and turn off unnecessarily turned on household appliances.
Implementation Results

Experimental Setting

We designed several conditions which could be used to demonstrate the energy management system of a home automation system by using smart devices. Smart devices are installed in the Smart Home Laboratory and operated. The total hours that an appliance is turned on or off during the period of four months. The experiment was conducted to measure the energy consumption of each device within the home for when the home automation system was turned on and for when it was turned off. We started by measuring the total amount of energy consumed in a day with the home automation system disabled to give an accurate measurement for the usage of electricity in a home. Next, we measure the total amount of energy required in a day for a home with the smart gateway turned on.

Experimental Results

Smart devices are installed in the Smart Home Laboratory have many benefits in term of control. Due to a better and more controlled use of the device, they also tend to have a longer life span and would be less prone damage owing to accidents when operating the devices. We took a grate deal of information in our efforts to table the results as shown in Table 2.

Table 2 shows the energy consumed in a four month period for when the home automation system is disabled and when it is actively monitoring and making minute changes to the states of the devices in the network across a particular section of the house. We calculated the power that would be saved simply by installing the home automation system in a home environment. As can be seen from Table 2, there can be substantial savings over the period of four months in a standard home by implementing the home automation system and the total energy consumption without the smart control enabled, with the smart control enabled, differences between both cases.
Table 2. Comparison of energy consumption.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Without smart control (kWh)</th>
<th>With smart control (kWh)</th>
<th>Difference (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living room</td>
<td>354.50</td>
<td>283.60</td>
<td>70.90</td>
</tr>
<tr>
<td>Kitchen</td>
<td>59.60</td>
<td>45.80</td>
<td>13.80</td>
</tr>
<tr>
<td>Master bedroom</td>
<td>173.80</td>
<td>140.70</td>
<td>33.10</td>
</tr>
<tr>
<td>Children’ bedroom I</td>
<td>128.10</td>
<td>102.50</td>
<td>25.60</td>
</tr>
<tr>
<td>Children’ bedroom II</td>
<td>53.50</td>
<td>42.80</td>
<td>10.70</td>
</tr>
<tr>
<td>Bathroom</td>
<td>31.20</td>
<td>24.50</td>
<td>6.70</td>
</tr>
<tr>
<td>Others</td>
<td>22.50</td>
<td>18.40</td>
<td>4.10</td>
</tr>
<tr>
<td>Total</td>
<td>823.20</td>
<td>658.30</td>
<td>164.90</td>
</tr>
</tbody>
</table>

The performance indicators analysis of the energy management system is given by

\[
\%E_{\text{reduce}} = \frac{E_{\text{before}} - E_{\text{after}}}{E_{\text{before}}} \times 100
\]

where

Figure 2. Screenshots of the home automation control application.

Figure 3. Lighting sensor iOS application.

Figure 4. Temperature sensor iOS application.

The performance indicators analysis of the energy management system is given by

\[
\%E_{\text{reduce}} = \frac{E_{\text{before}} - E_{\text{after}}}{E_{\text{before}}} \times 100
\]

where
%\%{E_{reduce}}\% the percentage decrease in energy consumption.
\[ E_{\text{before}} \] total energy consumption without the smart control.
\[ E_{\text{after}} \] total energy consumption with the smart control.

From Table 2, the performance indicators analysis revealed that the proposed system could reduce the power consumption in the home was equal to 20.03%. The proposed system is evaluated by investigating the overall satisfaction of the users of the system. The users were generally happy with the integration and savings obtained by enabling the proposed system and provided positive experiences as well as several suggestions for improving the system further. The screenshots of the home automation app are shown in Fig. 2 while the lighting sensor iOS app and the temperature sensor iOS app are shown in Fig. 3 and Fig. 4, respectively.

Conclusion

This paper proposes a home automation system by using smart devices. This system used the embedded system and ZigBee technologies to overcome the drawbacks of traditional systems. The proposed system effectively monitors and controls the electrical appliance usages at an elderly home and the real-time monitoring of the electrical appliances can be viewed through a smart phone. The proposed system is robust and flexible in operation and the performance indicators analysis revealed that the proposed system could reduce the power consumption in the home was equal to 20.03%. This paper suggested to future study, the system will be integrated with hybrid systems like smart home inhabitants behavior recognition systems to determine the wellness of the inhabitant in terms of energy consumption.

Acknowledgment

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References


