

SMART ENERGY MANAGEMENT BASED ON WIFI AND INTERNET TECHNOLOGY

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Abstract: This project introduces a wireless solution based on Internet protocol to manage the power source of Electrical machines and appliances. Based on this approach, a smart energy management system with the implementation of related software and hardware to manage power source on real time power demand of each power consuming systems.

1. Introduction

The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure[1-5].

The diminishing fossil fuels and increasing carbon emissions triggered the development of energy efficient appliances and smart products. Electricity prices rising proportionally as high as demand supply gap increases. This led to quest to focus on utilizing Renewable Energy sources as primary power source, which kept growing with pace. Also the Residential, Industrial and Commercial demand an un-interrupted power supply and their investment on backup system is expanded three-fold in last decade. Energy demand has been steadily increasing in recent years[6-10].

The concept of Smart Units and Smart Controller is introduced in this project. Low cost WiFi Module is used to build Smart Units. It provides the control capability of power consuming systems. Smart Controller is responsible for the management of Smart Units using the embedded software algorithms. Smart sensor unit is used to measure the power line states and electrical equipment power demand and transmit back to the Smart Controller. Smart Controller analysis the power demand from various such electrical power

consuming units and based on the configuration and preferences associated with it; Smart Controller command the Smart Switch to connect the power line to the respective source[11-17].

2. Existing Method

Smart home has become more and more popular in recent years. It aims at helping people manage the home appliance freely and build an autonomous environment in home or work area. A wireless solution based on Internet protocol to manage the smart home units. Based on this approach, People can use smart phones or tablets to control or monitor the home appliances both locally and remotely[18-24].

It is expected that IoT devices will be integrated into all forms of energy consuming devices (switches, power outlets, bulbs, televisions, etc.) and be able to communicate with the utility supply company in order to effectively balance power generation and energy usage. Such devices would also offer the opportunity for users to remotely control their devices. Besides home based energy management, the IoT is especially relevant to the Smart Grid since it provides systems to gather and act on energy and power-related information in an automated fashion with the goal to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity[25-30].

3. Proposed Method

The concept of Smart Units and Smart Controller is introduced in this project. Low cost WiFi Module is used to build Smart Units. It provides the control capability of power consuming systems. Smart Controller is responsible for the management of Smart Units using the embedded software algorithms.

The Smart Units consist of Smart Sensors and Smart Switches with WiFi Networking. Smart sensor unit is used to measure the power line states and electrical equipment power demand and transmit back to the Smart Controller. Smart Controller analysis the power demand from various such electrical power consuming units and based on the configuration and

preferences associated with it; Smart Controller command the Smart Switch to connect the power line to the respective source.

4. System Architecture

Figure 3 -shows the main architecture of the proposed smart home system. The home local network is organized by the central router by which the WLAN can access the internet. Smart units (such as smart switch, smart sensors etc.) equipped with special Wi-Fi module can be configured to join the given home wireless network. Power Consuming Electronics are easy to be equipped with the Wi-Fi module which makes them having the wireless connection ability. There are no complex hardwired arrangements to build this system. The system supports to dynamically add or remove the smart units by user control platform. All the smart units are connected together in the home local network working cooperatively. A Smart Controller is used in the local wireless network to manage the connected smart units. The Smart Controller is an embedded control board with custom operating system. It can search the online smart units and communicate with them. The phones or tablets joining in the local network can control the smart units and receive the feedback with the specific app. The communication protocol is designed and applied to this system. The other important function of the Smart Controller is that it can implement the remote communication with remote users outside the local network. Here remote server is configured and XMPP protocol is used for the remote communication. Smart Controller can login into the server when home router has the internet access thus having the ability to push environment message or get remote control from remote users. Then remote user can use the phone or tablets with specific app to login into the server to send control message to the Smart Controller or get feedback from the home proxy. The remote server not only serves the communication between one remote user and one Smart Controller, it is multi-systems oriented. One user can register for different Smart Controller and a Smart Controller can be associated with multi-users which means that the server is a public service provider and can provide this kind of service for millions of homes and offices. The remote server need to supply a management for the enormous information for the users and a secure database management system is used.

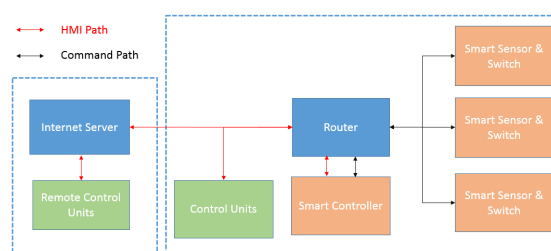


Figure 1. System Architecture

Hardware

Router

Router establishes the home wireless environment. Nowadays wireless routers are common devices for most families so this requirement for the system is easy to be satisfied. Standard home wireless network can be used to construct the smart home system which is free of establishing another specific wireless network. The smart home system can be regarded as an evaluation of our old WLAN. Common wireless routers provide alternative security mechanisms which are mature and reliable. On the other hand, home router is responsible for the internet access which can be implemented by different ways such as ADSL, VDSL.

Smart Units

Nowadays uart-wifi module has been widely used to help traditional industry adapted to IOT. It is a low cost module to make traditional appliances wireless enable. With the help of this kind of module we propose our smart units such as smart sensors, smart switch, etc. Figure 3 -2 is an ordinary block diagram of uart-wifi module. Use this module to make these units have the wireless function. Smart units can report their states and get commands wirelessly. Smart sensors report the data to the Smart Controller and can act following the instructions from the Smart Controller. Smart switches can be controlled wirelessly by wireless commands. Smart Controller can easily control the switch(On/Off/timing). Both Smart Sensor and Smart Switch is required component for a Smart Unit to build Smart Energy Management System where both sensing and switching is required otherwise any one can independently forms as Smart Unit as necessary. Smart Sensor is capable of measuring the electrical power demand from the electrical systems and transmit the information to the Smart Controller and Smart switch is capable of switching the power line between the available power sources. Smart sensor is alone enough to know the power line state so such units does not required Smart switch as part of Smart Unit.

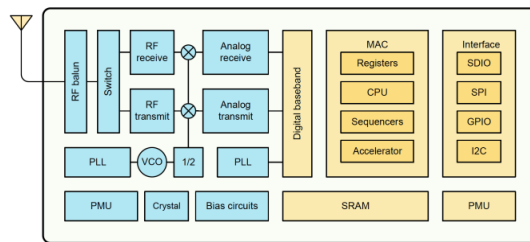


Figure 2. ESP8266 Block Diagram.

Usually this kind of module has two different working mode: AP (Access Point) and STA (Station). Thus the smart units equipped with the module have these two kind of modes. In AP mode, the smart units establish a specific wireless network which enables other devices safely connect to it. The module server is established in specific local IP and port and the user can configure this module by communicating with this server using AT commands. By configuring the module to STA mode and setting the specific parameters (home wireless network's name, encryption method and password), the smart units restart to work in STA mode and connect the home wireless network. Then smart units can cooperate with each other and can communicate with the Smart Controller. Smart Controller is an embedded board with any light weight OS. Smart Controller software is installed and set to be run at boot time.

Smart Controller

Smart Controller is responsible for the management of the masses of Smart Units. It collects and stores the information including states and configurations. For the local network control, Smart Controller is a manager transmitting the message between user control ends and smart units. For the remote control, Smart Controller can connect to the remote server so that it can communicate with the remote control ends that can access the internet. In this situation it works just as a proxy in home getting and analyzing the message between home wireless network and the outside Internet. Smart Controller will report the state of smart units to the remote server and the server will notify all the users who are bound with this Smart Controller. For remote control implementation, XMPP is used.

Remote Server

The architecture of Remote server deployment is shown in Fig. 4. Remote server can be a windows server equipped with relative software. We use Openfire to support XMPP protocol and MySQL to supply DBMS. Remote server is a critical factor to implement remote control. The main functions of the remote server are as follows: Device registration, Remote Message Transmission, Data Management. The control units (such as users phone, tablets) and Smart Controller

should register on the server first before they can use the remote message transmission utility. After registration the control units can be bound with specified home proxies. Then Smart Controller can communicate remotely with bound phones or tablets. A phone can be bound with more than one Smart Controller which means that user use a phone to control multiple smart energy management systems is possible. The MAC address of the control unit is used for registering server. Reliable data management is supplied for registration info and smart energy management system info. The remote server also can be deployed on clusters which supply more powerful service ability. Unlike the traditional experiment systems in which a home server is supplied to implement the remote access, our plan is more market oriented and is more feasible to be promoted.

Control Units

Control units can be mobile phones or tablets. Based on the architecture and communication protocol we developed android software which makes user easy to control the system. This also can be implemented on other platforms. Mobile apps control for the system implements local control and remote control. The control flow will be presented in system implementation

Software

Smart Controller

This section will describe the design for the management software on the Smart Controller and the control software on mobile phones. The control software can be implemented on different platforms based on the design. The workflow of the Smart Controller software is shown in Figure 3 -3. The operating system of the Smart Controller embedded board is custom OS. The program is running as a service of the operating system. Broadcast receiver is registered and once the system is started, the booting signal is captured and the Smart Controller service starts to run. At first, Smart Controller will connect into the home wireless network. Then it will periodically search the available smart units in home wireless network. A dynamic smart units table will be maintained. Then the Smart Controller will establish connection with the available units, actively polling the states or receiving the state change or the alert report. The information of the smart units can be collected and pushed to the control units including control units in home wireless network and the outside remote users mobile phones. The remote push is implemented through the remote server using XMPP protocol. The local push is based on wireless broadcast. The Smart Controller will keep connected with the remote server so that it can get the latest message from the remote users thus implementing remote control.

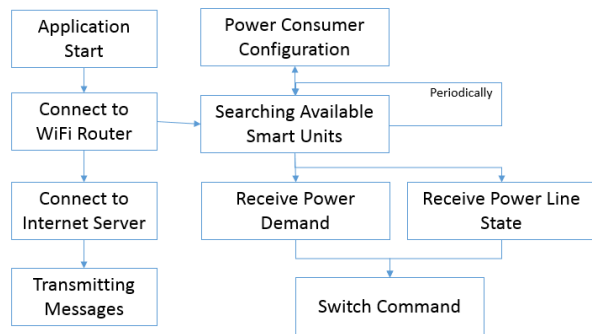


Figure 3. Smart Controller Workflow

Smart sensor unit is used to measure the power line states and electrical equipment power demand and transmit back to the Smart Controller. Smart Controller analysis the power demand from various such electrical power consuming units and based on the configuration and preferences associated with it; Smart Controller command the Smart Switch to connect the power line to the respective source.

Control Unit

The app workflow of the control units is shown in Figure 3 -4. At the start time, the synchronization of configuration file will be processed. The configuration file describes the user customized information of the smart units and UI layouts. The software generates the UI based on the configuration file which is specific and unique in different smart home system. We use the latest modification time of the configuration file as the timestamp. By comparing this timestamp of the file in phone with that one in Smart Controller, we can get the newest one. Then the phone decides to upload the new one to the Smart Controller or download the new one. Given that a second user is coming to a configured system, the app starts and synchronizes with the Smart Controller. Then it will download the configuration file in the Smart Controller. So the second user is easy to get into the control stage. The app generates the UI and is ready for working. After configuration (which is used when new smart units are added) and synchronization, the app can get the states from the Smart Controller and control the system through the Smart Controller. Software implements Remote control and local control. The app will detect whether it is in home wireless network. For local control which means the phone is in home wireless network, it is easy to be done by the Smart Controller transition. For remote control, if the phone has the access of the internet, it will login into the remote server and make remote XMPP connection with the Smart Controller. The remote phone must be configured before in local environment which means the phone has registered for the Smart Controller, otherwise the remote control is denied.

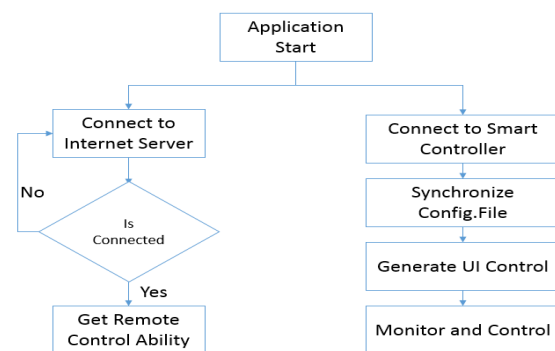


Figure 4. Control Unit Workflow

5. Conclusion

Controlling the equipment's is not just smart enough, this project introduce the concept of controlling the equipment's and switches its power source based on its power demand and available power source. This system is more useful where renewable resource such as solar power cannot be connected to grid but effectively utilize the power when available. Low cost smart energy management system based on Internet and WiFi. We come up with the concept of Smart Units and Smart Controller. The remote server and Smart Controller is a new scheme for remote control in which XMPP is used. Low cost WiFi module is used to make smart units. Relative apps based on different platforms can be developed and android app is used to demonstrate the system. We use Smart Controller to solve the synchronization problem and the system supports multiuser. Also one phone can register different Smart Controllers, thus one phone can control more than one smart energy management system. So the remote server can provide services for different homes and offices and the system is more likely to be promoted.

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