УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ” - ШТИП
ФАКУЛТЕТ ЗА ИНФОРМАТИКА

ISSN:1857-8691

ГОДИШЕН ЗБОРНИК
2016/2017
YEARBOOK
2016/2017

ГОДИНА 5 **VOLUME V**

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За издавачот:
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С О Д Р Ж И Н А

SERVICE FOR CONTROLLING HOUSEHOLD ELECTRICAL DEVICES THROUGH THE INTERNET

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Abstract. This paper provides description of service which offers controlling household electrical devices through the Internet, remotely. The concept of the service in this format is designed as a student's project and it gives the basic idea which can be improved.
At the beginning, importance of the problem of electrical energy consumption is explained. Some illustrative examples for improving energy consumption of the devices are given. The idea of IoT (Internet of Things) internetworking is analyzed as potential solution for the problem. Our service is based on the IoT and it is combination of some simple hardware and software components which are specified and explained separately. The business potential of developing service of this kind is mentioned. Finally, we summarize the benefits that users can obtain by implementing this system in their households.

Keywords: service, electrical energy, IoT, devices, system, remote control

1. Introduction

One of the mainstream problems of today's society is the electricity efficiency. In today's world when we are always connected to the internet, we use all kind of devices that are charged every day or permanently plugged in, so the electricity is the driving force that keeps them running. Most devices are always drawing power, even if they are in idle power mode. They can be turned off and on by switchers or using power strip to group appliances. We are witnessing everyday innovations in different fields which are focused on improving existing and creating new solutions which will reduce the consumption of electric energy.

The idea of IoT (Internet of Things) is connecting multiple devices together in a network, enabling data transfer between them. [1] This kind of interconnection can be utilized for making smart organisation of our devices. With implementation of IoT internetworking we can engineer systems which will be energy efficient//will improve the energy consumption in our homes.

As a potential solution to this problem we are proposing a service which would provide precise and permanent control over the consumption of household electric energy remotely (through the Internet), even when we are not at home. Moreover, users of this service would get lot of other benefits. For example, they can turn on the water heater when they are at work, and when they arrive at home, they will not have to wait. There are lot of examples like this, which confirm the great potential of implementing the IoT systems in people's everyday lives. Modified version of this systems can also be implemented in other industrial buildings. However, we will only pay attention of designing and implementing a service which uses system of this kind in the homes. The target group are all family members and the service is designed to meet their needs.

From a business standpoint, we can define the service as company responsible for installing and maintenance of the system. The consumers will have to pay their bills/debts on a monthly basis. The costs for the installation and maintenance are relatively low.

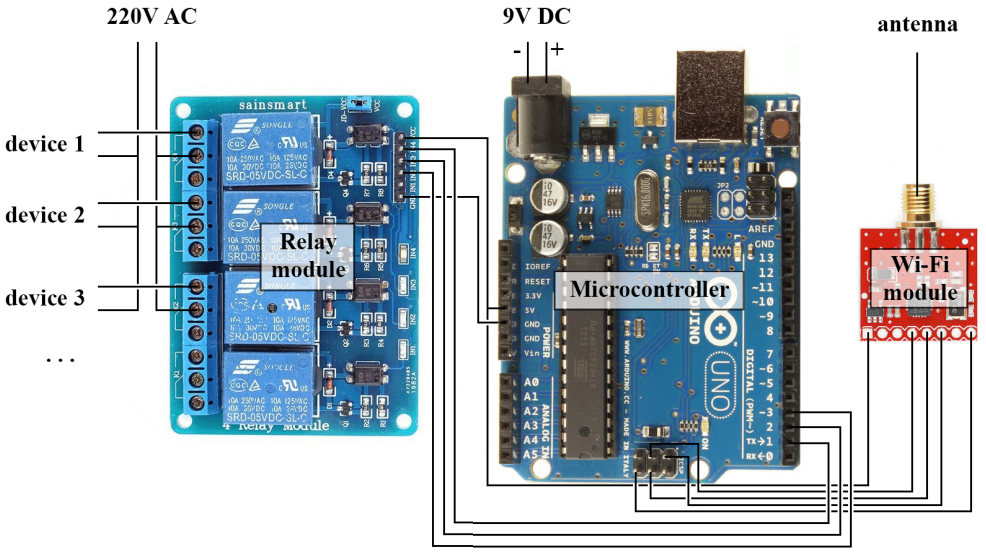
2. Materials and methods

By default, almost all of the household devices are connected to the main AC supply. With this method you can control the device in real time, if we are near the switch of that device. This can be restrictive. As a partial solution for this problem, timer relays are widely used. They can be set to automatically turn on and off the main power supply for device or devices in certain intervals. This also can be restrictive because it is hard to make changes in the timer intervals if there is no human factor to physically set the timer relay. The system we are talking about in this paper can be useful in situations like these.

2.1. Hardware

The technical aspect of the hardware is very simple. It is composed from microcontroller, as brain of the system which must be able to establish Internet connection through Wi-Fi module. The outputs of the microcontroller are connected with the inputs of the relay module. Every device is connected to the pinouts of certain relay or relays.

For non-commercial use and better explanation of the idea for the system, prototype can be built with electronics which are cheap and available. As a main electronic controller for the prototype, several types of electronic boards can be used, like Arduino UNO, Raspberry Pi, Omega, or some other board of this type. Any Wi-Fi module compatible with the microcontroller can be used. It is due to hold stable connection with the modem. Relay module contains one or more relays for every device. Typically, one relay can be used for simple devices like a lightbulb which can be only turned on and off. Some devices, like room heaters, can have more functionalities: one or more heating elements turned on, fan speed and water circulation control. More relays can be used for single device of this type in order to have full control of all functionalities.



Some parts which can be used for building the prototype are listed below.

Arduino UNO microcontroller. Arduino UNO is an open source electronics platform based on easy-to-use hardware and software. These boards are able to read inputs and react on them with pre-defined actions. They are inexpensive, cross-platform, open source, have extensible software and hardware and clear programming environment. [2]

Raspberry Pi microcontroller. The most famous and basically a credit-card-sized mini computer which can be used in all sorts of electronic projects is Raspberry Pi. [3]

Omega. The smallest Linux IoT computer, with Wi-Fi built-in is Omega. It combines the tiny form factor and power-efficiency of the Arduino, with the power and flexibilities of the Raspberry Pi. [4]

WiFi Module. NRF24l01 is a highly integrated, ultra low power (ULP) 2Mbps RF transceiver integrated circuit for the 2.4GHz ISM (Industrial, Scientific and Medical) band. [5]

Relay Module. Relay Module is a circuit board with relays and appropriate electronics for their control. Commonly, it has voltage regulator and one transistor for every relay. Relays are used to control

larger current flow using small amount of current. The current they use as input is completely isolated from the current which they are controlling.

WiFi shield is a powerful IoT shield that allows an Arduino board to connect to the internet using the 802.11 wireless specification (WiFi). [6]

Special circuit board must be designed for commercial implementation of this system. It should be able to perform all of the above features: establishing internet connection, processing the data and controlling the relays. Additional sensors for reading some parameters like current temperature or light intensity can be used as inputs for the microcontroller.

2.2. Software

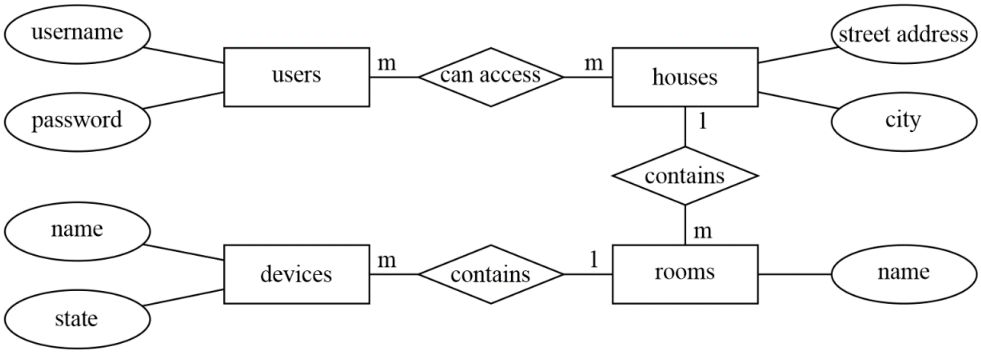
The hardware described above must be driven by appropriate software. Two types of software are needed for completeness of the system: application for driving the microcontroller and web application to provide interface for the users and do some logics.

Arduino has its own easy to use IDE for coding the microcontroller. The written program is called sketch and the IDE is used to upload it through one of the PC COM ports. In our case we wrote two sketches, one for the receiver and one for the transmitter side. The transmitting side was responsible for preparing the data in one array and sending it to the receiver using the Wi-Fi module as main component for communication between the two Arduino microcontrollers. Once the data reached the receiving part, it had to be checked for errors during the transmission and if there were none, the data was split into instructions for each relay that was attached on the Arduino microcontroller. This is not ideal way for realisation of this part of the system and there are many better ways this can be done with the some of the components stated above. This is the way how we did it in our prototype and it works well for small amount of devices connected to the electronics.

Omega 2 boards have almost all Arduino Uno functionalities. Additionally, it supports Linux operating system and it is mitigating circumstance. It means that server side application can be installed on the board and there is no need PC to run all the time.

Web application is designed to communicate with users of the service. They must be able to access it from multiple devices. It also provides some logical part as automatically changing the state (on or off) of the devices. All of the data is split across multiple tables which makes the system modular and easy to upgrade. Every user is part of one or more houses which contain all devices the user can control. For easier orientation, devices are grouped by rooms. Web application is able to read and write data, while the server side application should be able only to read the state of the devices from the database and send it to the microcontroller.

The system as a whole must provide maximum protection to the users and security should be a key point in designing this system. One way to achieve this is keeping the software up to date and using encryption keys and tokens for communication between the software API and the electronic devices and, as previously stated, not to depend on already available hardware components.



3. Results and discussion

Taking into account all of the functionalities of our system, we can assume that it represents a concept that has the possibility to grow into a business designed to benefit individuals or companies interested in utilization of its capabilities. The system has many advantages which are derived from its simplicity such as low costs, simple hardware, easy maintenance, flexible for upgrading and wide range of areas where it can be implemented.

Low costs for implementation. Costs for implementation of this system are extremely low, considering the fact that the electronics which would be used is cheap and simple. Installing the hardware for homes with existing electric installation can be done with special box for the new electronics. It is composed of separate hardware parts connected together with the devices which are controlled, using cables. It is possible to make separate modules of the hardware, communicating with each other via Wi-Fi connection.

Easy hardware and software maintenance. If there is a problem with a single hardware part of the system (for example burned out relay), replacing it is a simple and short job which would not cause serious obstacles and unavailabilities in the system if it is solved in a fast time. Also, the software parts with corrected bugs should be previously tested to keep the system error free after maintenance.

Flexible system for upgrading. The current version of the system can be upgraded with more specific functions depending on the need of the customers which will use them. Newer versions should be designed to support the old and the newly implemented hardware technologies, so the consumers would not have to replace their hardware parts. If there is a need for a new type of hardware or software part to be implemented, it will be in a complete collaboration with the existing parts.

Wide area of usage. The system is designed to be implemented in objects such as houses, backyards, workshops, garages, and small companies, but its benefits can also be utilized by schools and other forms of organizations. It can be integrated with an existing electrical installation or be built along with a new installation.

Controlling energy consumption. Usage of this service can directly affect the total household energy consumption. The customers could be able to do a supervision over the devices and be aware of their consumption of electrical energy.

4. Concluding remarks

With everything stated above, we can summarize that this service can be beneficial to many people interested in implementing it in their homes and other buildings. Its design primarily is focused to ease the controlling and supervising of devices from a distance using only an internet connection and a computer, tablet or smartphone, in order to reduce the energy consumption and to cut monthly bills for electricity, making the home energy efficient.

Another positive thing derived from the project is its flexibility and simplicity making it distinguished between similar technologies. There are endless variants of functionalities which can be integrated in our system according to the wishes and demands of the users and the newly invented technologies. Involving modern technology in all fields of life, our goal is to introduce this trend of smart homes and making it accessible and affordable for everyone.

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