Investigation of a New Technology of Controlling Electrical Apparatus Via a Smart Phone

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***Abstract*. This paper discusses the present possibilities for controlling electrical apparatus via smart phone and implementing newer technologies in this process.**

Keywords: proximity detection, BLE, beacon, RSSI, safety, Android, electrical apparatus, controlling.

I. INTRODUCTION

There are many possibilities for controlling an electrical apparatus via a smart phone. But all of them need custom applications for every type of device and special procedure for connecting with every device. This means that if user needs to control 20 different types of devices, it must have 20 different applications installed in his smart device. Also manufacturers must provide an application for every operating system. Using Google's Eddystone URL, Physical web and HTML 5 it is possible to build easy for use and application free control conception [1], [2], [3]. Manufacturers can use HTML 5, CSS and Java script to design a web based interface that can control user's smart device hardware. So it will be possible to write a script that connects a device to the electrical apparatus automatically if it is in range. Using Eddystone URL beacons and Physical web mean, that no other application is needed and the phone can decide which control HTML page to display depending on the closest URL beacon or electrical apparatus [5], [6].

II. DIFFERENT VARIANTS FOR CONTROLING ELECTRICAL APPARATUS VIA A SMART PHONE

Since the controlling device is a smart phone, there are 6 variants for communication, such as:

- GSM service based;
- Internet based;
- Wi-Fi based;
- Bluetooth based;
- Light emitting based;
- Sound based.

A. GSM service based communication variant.

In this case the microprocessor that controls the electrical apparatus must be connected to a GSM modem. The modem will receive the incoming calls and text messages. Depending of caller ID and the text of the SMS messages, it can perform a certain action.

As an example, controlling procedure of an automatic circuit breaker can be presented.

The tripping settings, status messages and controlling actions can be set directly or received via text messages. When an incoming text message occurs, the microcontroller must compare the caller ID with the set caller ID in the SIM card memory. If the caller ID is previously stored, safety check is passed and the incoming command can be decoded - Figure 1. The commands can be AT-based commands or just key words in English or other basic language. For example "Set_I1_130" can be used as command for setting overload protection at 130 Amps.

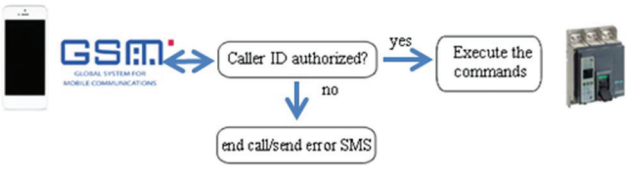

Fig. 1. Diagram of GSM based model operation.

This variant is useful when the electrical apparatus is mounted at inaccessible or dangerous place, but require a GSM network coverage and prepaid GSM service taxes. A specific application is not required, so the electrical apparatus can be controlled with every smart phone, no matter the operating system and built-in hardware.

B. Light emitting based communication variant.

In this case the electrical apparatus must be equipped with photo sensitive element and light emitting element. As photo sensitive element can be used a photo resistor and a LED can be used as light emitting element - Figure 2. On the phone's side, a display or flash light LED can be used as emitting

device and the camera can be used as photo sensitive device. A communication protocol must be developed. It can be based an Infrared remote control protocol for instance.

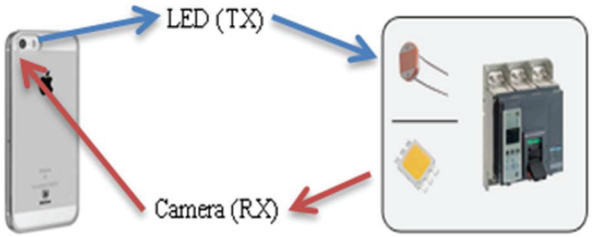

Fig. 2. Light emitting model diagram.

In this case a specific app is required. In it the user must be able to set the tripping settings of the circuit breaker. When everything is set, sending procedure can be started. The phone must be close to the controlled device, so that the light from its emitting device can reach the circuit breaker's sensitive element.

This method is suitable in those cases, where there is no space for input hardware on the electrical apparatus, or where unauthorized setting is not acceptable. Big disadvantages are the limited space between the devices, susceptibility to interference and the low communication speeds.

C. Sound based communication variant.

The difference between this and the previous method is that here sound is used for communication. Again a special application and communication protocol are required and the space between apparatus is limited. This method is not suitable in noisy places.

D. Wi-Fi based communication variant.

In this scenario a microcontroller is used to communicate with the Wi-Fi module, like ESP8266. The microcontroller set the module to broadcast a Wi-Fi network so that the smartphone can connect to it. Then the controller links a web server which hosts an interface page. The user must connect to the wireless network and tape server's address in the phone's browser. The interface page can contain information about the device, its wiring diagram and specification, current status information and control possibilities. In most wireless hot spots, a captive portal is used to redirect the user to authorization web interface. This means that every connected user will be automatically redirected to specific web page where he can login into his account. A captive portal can be used to redirect all connected users automatically to the control page's web address. In this case to control a wireless enabled electrical apparatus user need only to connect to the desired Wi-Fi network. It is possible for wireless enabled electrical apparatus to be connected to existing wireless network. In this case Service Set Identifier (SSID) and password of the network must be programmed in apparatus memory. This can be done by cell phone at firs use.

Example:

After pressing a button on the electrical apparatus a wireless network is created. When user connects his device to this network, it can control some of the variables like SSID to connect and Password for corresponding SSID. After a period of inactivity or by another pressing of the button, electrical apparatus is restarted and begin to connect to a desired Wi-Fi network - Figure 3. When successful connection is indicated user must connect his device in same Wi-Fi network in order to control the electrical apparatus.

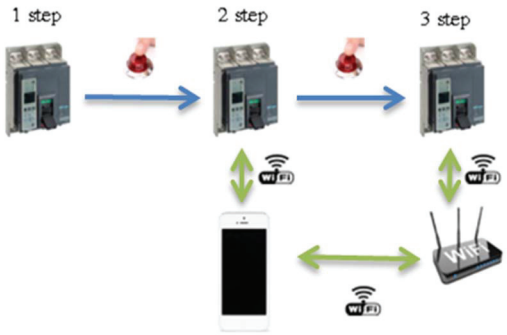

Fig. 3. Diagram of the steps of connection to Wi-Fi for programming.

In this case many electrical apparatus can be connected in one network and can be controlled easily without reconnecting. In such a network captive portal cannot be used. So another automatization method for connecting to a specific apparatus must be used. First variant is apparatus address to be printed on its cover. But it will be something like 192.168.0.134 or some text string. Both variants are inconvenient. Here a QR code can be printed on every electrical apparatuses case. QR code will force user's browser to automatically connect to corresponding IP address or host name - Figure 4. QR codes, or Quick-Response codes, are easily readable barcodes that when scanned with a QR decoder (usually available on smartphones) can translate the code into a URL, a telephone number, a bit of text, or other data.

Fig. 4. QR code scanning method diagram.

This method is useful where the electrical apparatus is mounted at dangerous or inaccessible places. It doesn't require an internet connection. The application needed to load control

page is a web browser so there is no need of special application or just QR code reader in extended variant. Also the operating system of the device is not important. The distance between the device and the smart phone is limited by the used hardware and the surrounding environment but is at least 10 meters.

E. Internet based communication variant.

Here the microcontroller is directly connected to the internet. This means that every Internet of Things (IoT) protocol can be used. The device can be provided with its own static IP address. When user loads this address in his web browser it will display web based interface hosted on the electrical apparatus web server. Other possibility is using a web database. The controller connects to the database hosted somewhere in the internet. In order to control this database, user must connect to a web page. This page will control the database and respectively the electrical apparatus - Figure 5.

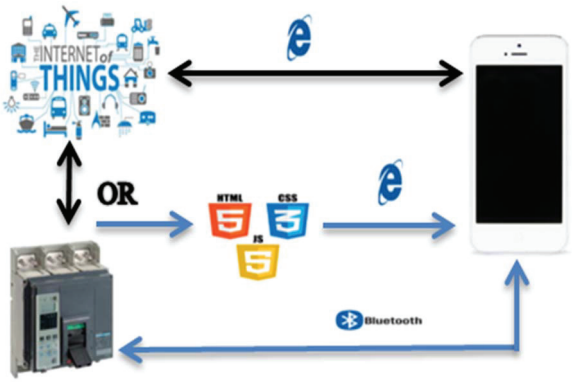

Fig. 5. IoT, Web application diagram.

In this case an internet connection and possibly static IP address is needed. This means that if the user or the electrical apparatus is not able to connect to the internet, a proper communication cannot be established. Also the response time is based on the internet connection's speed.

F. Bluetooth based communication variant.

Here there are two main variants.

The first is using Bluetooth classic. In this case, the microcontroller of the electrical apparatus communicates with a Bluetooth module, like HC6. User must find and connect to the corresponding Bluetooth device. After pairing, user is able to send and receive serial data. Again custom application is needed. Here there is no need of internet connection or GSM coverage. User can connect directly to the electrical apparatus. However, pairing is needed every time user connects to new device.

The second variant is to use Bluetooth Low Energy. This is new version of the protocol. It is more energy efficient and does not require pairing. Bluetooth Low Energy (BLE) has the ability to exchange data in one of two states: connected and advertising modes. Connected mode uses the Generic Attribute (GATT) layer to transfer data in a one-to-one connection. Advertising mode uses the Generic Access Profile (GAP) layer to broadcast data out to anyone who is listening. Advertising mode is a one-to-many transfer and has no guarantees about data coherence. Again a custom application is needed.

III. IMPLEMENTING EDDYSTONE URL, PHYSICAL WEB AND HTML 5

In all cases an Eddystone URL beacon is needed to be built into the device. The URL broadcasted by the device must be the URL of HTML 5 based web page. This page may use Apache Cordova plugin to control smart phone's built-in hardware [7-9]. So when user is near the electrical apparatus the control page will be automatically displayed and his device will eventually be connected do the corresponding electrical apparatus.

The main models are:

A. GSM service based model.

Here Eddystone URL is broadcasted. When user is near the electrical apparatus, his phone receives the signal and the Physical web browser displays the corresponding web page [3]. As it was mentioned, the page is able to control the user's smart phone hardware [4]. So it can send and receive text messages or open serial communication channel between the devices.

B. Light emitting based model.

Here the web page can control the phone's camera and display or a flash light. When the users set all of the variables and tap a send button, the sending procedure is started.

C. Sound based model.

Same procedure as above described, but with different hardware.

D. W-Fi based model.

Here there is no need the user to know the network's SSID or the server's IP address. They can be automatically set by the web page's script. So the user can be connected and redirected to electrical apparatus by a procedure built in the web server.

E. Internet based model.

In this case HTML 5 is not required. Here the user is redirected to a control page which interacts with the web database. So there is no need of controlling smart phone's hardware.

F. Bluetooth based model.

Again the user is redirected to HTML 5 based web page. The page can connect his smart phone to specific Bluetooth device or electrical apparatus or Bluetooth service.

It is possible to use beacons for automatically identify nearest electrical apparatus. Using these devices require a special application to be built for every type of device. The application will look for nearby beacons and will display a control panel for nearest for instance - Figure 6. It can use internal database or web based one. Also it can just display some messages depending of user's position.

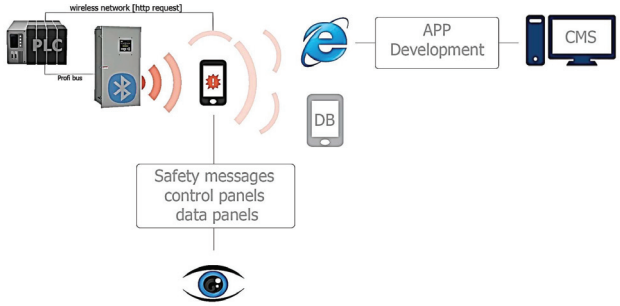

Fig. 6. Diagram explaining the using of beacons for controlling electrical apparatus.

IV. BEACONS

A. *How It Works?*

When the smart phone receives the radio signals from the beacon, it measures RSSI (Received Signal Strength Indicator). The RSSI is measured in dBm (decibel-milliwatt). When a user approaches to the beacon, this value increases. It can be calculated approximately by measure of how much the radio signal has decreased in power between the antennas. The path loss is related to the distance between beacon and smartphone and the signal wavelength.

According to [2] and [8] the following equation can be used to calculate distances in indoor environments.

$$d = 0.89976*(Prx/txPower)^{7.7095}+0.111$$

Where d is the distance between phone and beacon, Prx is the received power and txPower is value fixed by the manufacturer and corresponds to signal strength one meter from the device. For Eddystone txPower is the received power at 0 meters, in dBm, and the value ranges from -100 dBm to +20 dBm at a resolution of 1 dBm. In Eddystone specification there is a note for developers:

"*Note to developers:* the best way to determine the precise value to put into this field is to measure the actual output of your beacon from 1 meter away and then add 41 dBm to that. 41 dBm is the signal loss that occurs over 1 meter."

So Eddystone must use other equation.

B. *Compatible mobile devices:*

- iOS devices with Bluetooth 4.0 (iPhone 4S and later), iPad (3rd generation and later), iPad Mini (1st generation and later), iPod Touch (5th generation);
- Macintosh computers with OS X Mavericks (10.9) and Bluetooth 4.0;
- Android 4.3+ (e.g. Samsung Galaxy S3/S4, Samsung Galaxy Note 2/3, HTC One, Google/LG Nexus 7 2013 /Nexus 4/Nexus 5, OnePlus One, LG G3);
- Windows Phone devices with the Lumia Cyan update or above.

V. CONCLUSIONS

Often controlling electrical apparatus via smart phone require many steps for establish proper connection. Also different application is required for different operating systems and different device types. Using beacons and WEB applications connection to nearest device can be established automatically. The applications are cloud based WEB Apps so every smart phone can use them no matter the operating system. Also every application will be loaded only when there is need of it and will be deleted again after disconnection of the device. Choosing one of the mentioned methods for controlling electrical apparatuses depends on place of use, type of the controlled device and the budget for the project. All controlling variants are safe and reliable and can be password protected. The electromagnetic noise reduces the coverage and time for delivering the command but cannot cause delivering wrong command.

VI. REFERENCES

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