An Internet of Things Application through GPRS

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ABSTRACT

The Internet of Things (IoT) is an integration of information technology, communication and Internet technology in order to connect things to a systems and then peoples. These physical things surrounding us, are increasingly connected to the internet through sensors rendering them virtual. They can, hence, be monitored or controlled remotely. However, the internet connection is not available in all geographical areas. However, mobile wireless networks have better geographical coverage. In this work we present a way to connect the "things" to the Internet through the wireless technology General Packet Radio Service (GPRS) which covers wider geographical area and it can provide cellular internet network. We suggest an architecture for this application using a mobile phone, on the user side, with a specific application developed for the system and a GPRS modem, on the "thing" side, (here a lamp). The advantage of this architecture, from the automation aspect, with respect to a GSM automation, is that the latter consumes SMS for any command sent to or acknowledgments received from the "thing". While the proposed system uses data transmission which can be unlimited for a given period depending on the commercial offers by the Internet Service Providers (ISPs).

Keywords: IoT, Modem, GPRS, Remote controlling.

1. INTRODUCTION

The internet of things can be defined as connecting and exchanging data between smart objects to make new forms of communication and control [1]. To establish a connection, a gateway between the Internet connection and the wired or wireless connection to the "thing" is needed. Many wireless approaches have been used such as Bluetooth, RFID and ZigBee. The Bluetooth connection has a low range coverage and unable to remotely control from distances greater than 100 meters [2] [5]. The gateway itself is also connected wirelessly or in a wired way to the Internet.

In certain geographical areas the internet coverage is not insured. However, wireless mobile is widely spread. The GSM solution to remotely control and monitor devices [4] have been used for home automation purposes. However, this is not an IoT application since the internet is not involved. The only way to communicate is through sending and receiving SMS messages, which is not at all cheap especially in case of relatively big amount of data and repeated requests.

The second generation of the mobile communication networks known as General Packet Radio Service (GPRS) provides a relatively low data rate communication.

This can be used for connecting things with low data rate needs like monitoring a temperature sensor periodically or controlling a bulb or a motor remotely. The IoT architecture for this system can then be built in two ways: either through a server on the cloud where the gateway of the “thing” can send data to and receive data from it, or by using a fixed IP for the GPRS modem where the client can directly send or receive data from the “thing”.

This project will focus on making an IoT automation system that can control and monitor a bulb light using the internet of things paradigm with GPRS network. The implementation consists in two major parts; the first one is on the user end where he/she can control and monitor the objects using a mobile application. The second part is a GPRS modem, with a microcontroller based board for the application layer implementation, on the “things” side. The “thing” will be controlled and linked to the microcontroller.

Some similar automation projects can be found in the literature. In [3] an Internet-Based Geographical Information System GIS has been suggested to monitor a house wirelessly by using a GPRS modem. In the project sensors are sensing different data parameters from the home surroundings. If there were any unwanted data or data above a chosen threshold, a micro-GPRS modem will send a message which includes the status of the sensed parameters to an internet based server. Then the server sends an SMS (short message service) to the owner of the house and the changes can be observed on the owner’s mobile phone. The system also sends the status of all the sensors and their parameter values if the user wanted to know by sending a message to the modem. In addition the system provides another functionality which tells the user the exact location of the houses in the system using a GIS software.

In [6] the authors use GSM/GPRS transmission to monitor the mechanical parameters of a small wind turbine. The mobile wireless is used to transmit two information: the tower vibration and a brake pad wear, from a small turbine of 10 KW. The sensors sense the data and send it to the GSM/GPRS modem to sends the acquired data through the cellular network to a remote modem which receives the acquired data. The latter will broadcasts the data on the remote side using a data supervision software. GPRS combined with GPS is used in Passenger Information System for Public Transportation in smart city applications of IoT [7]. A new a new narrow band radio-access technology is suggested for internet of things [8] NB-IoT is recently suggested. It is backward compatible with the existing devices like GSM, GPRS and LTE.The rest of the paper is organized as follows: In section 2, we clarify the problem statement followed by the possible architectures to obtain an IoT system in section 3. Then we explain, in section 4 the operation of the suggested solution with fixed IP through the activity diagram. Finally, in section 5 we present the implementation of the architecture followed by the testing and results in section 6. We conclude the work in section 7.

2. PROBLEM STATEMENT

In any IoT system the internet access is required from both sides: the "thing" side and the people side. Some geographical areas are not served by wired or wireless 3G internet connection. The deployment of such facilities may take time in these areas or may not at all be installed for economic reasons. Other solutions should be found to extend IoT applications to them. The 2G wireless connection is available in most areas. Hence, building an IoT system for connecting and automating objects, with relatively low data rate to send to and receive from is possible, using 2G wireless mobile network (GPRS).

3. PROBLEM STATEMENT

Two system architectures are possible to implement an IoT application using wireless networks. We present them in this section.

The first system architecture can be compared with a classical client-server with a dynamic IP as shown in **Error! Reference source not found.**. It consists of two parts: one of them is using a server to perform the communications. The second approach is by using a static IP to perform the communication directly between the two ends of the system as shown in **Error! Reference source not found.**.

In both cases the system consists of two ends: one of them is users that can control and monitor an object which are linked to the system and the other end is the object that we want to have access to it remotely.

On the user end in case of first system architecture, a PC or smart phones can be used to access a website on a server as it has shown in the right side of the architecture in **Error! Reference source not found.**. The other end, the sensors or objects are connected to an SIM900 GPRS modem that is placed on an Arduino Uno board. The microcontroller periodically reads the status of the objects connected to it and send it through internet using GPRS cellular network to the server. In this way, the status of the "things" are sent periodically to the server. On the other side when users want to check the status of the connected objects they check the status with the server. In order to control the objects, the user sends a command to the server and on the object side the microcontroller uses the GPRS shield to check the server for any command sent by the user. According to the data (status) obtained for each object the microcontroller decides to take action accordingly. The data can be logged and saved on the sever side for monitoring and future consultation.

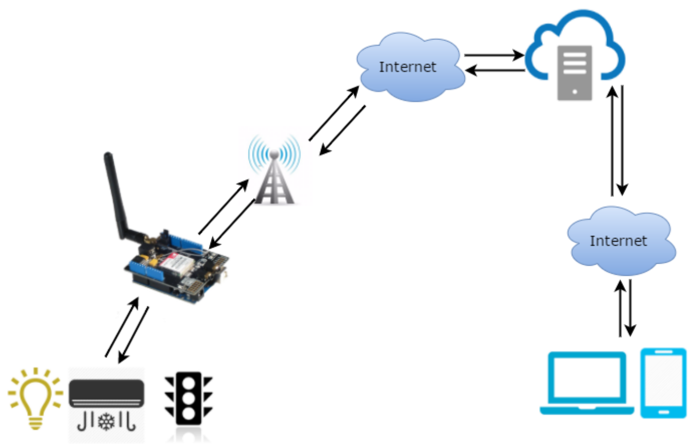

FIGURE 1. System Architecture without fixed IP

The second architecture case is when the career companies provide a static IP address for the GPRS module. In this case some changes could be done in the system that makes it more cost effective and faster: if we have a SIM card with a fixed IP then the communication will be direct through TCP/IP connection and the system architecture is as in **Error! Reference source not found.**.

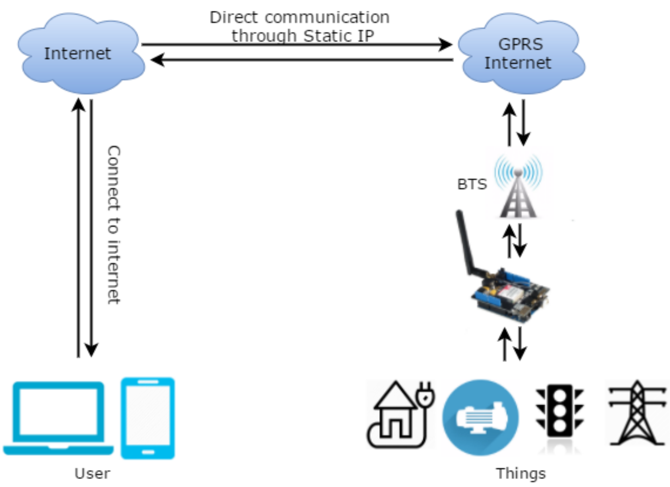

FIGURE 2. System architecture with fixed IP

There are two ends of the communication; one of them is the user who controls and monitors the objects, the other end is the GPRS modem with a SIM card and a microcontroller to respond to the user commands and acknowledge. When the user wants to take action on a device firstly he/she connects to the internet then a direct TCP/IP communication will be initiated through the fixed IP. After that the user can send commands to the GPRS modem which receives the commands and perform the required action. In this way only the system becomes active when the user wants to communicate therefore the cost and the power consumption will be reduced compared to other approaches. In this work, we will implement this architecture as shown in the following section.

4. ACTIVITY DIAGRAM OF THE SYSTEM

In this system the microcontroller acts as a server and communicates with the user through the GPRS modem using AT commands. **Error! Reference source not found.** shows the activity diagram of the system using the static IP. Firstly, when the system starts the GPRS modem waits for connection requests through TCP/IP communication protocol. In other words it waits for the user to launch a connection request. If the user didn't initiate a connection it keeps its state as it was which was listening. If the user sent a request then the server responds back and a TCP/IP communication will be established. After that the server waits for commands to be sent by the user. If the user did not send any commands it keeps its state as it was till the user launches a command. In contrast if the user send a command then the server will take action according to the received command. For example if the command was to turn OFF/ON a light, then the microcontroller do the required action (this can be done through relays connected to the microcontroller) and acknowledge back the user about the status of the device or object. In next stage if the user did not exit or close the connection then it goes back and still wait for the commands but if the user closed the connection it will go back to the first stage and the connection gets terminated.

5. IMPLEMENTATION

The implementation of the activity diagram in the previous section needs an interface on the user side and a microcontroller based GPRS modem. This is explained in the following two subsections.

5.1 MOBILE APPLICATION DEVELOPMENT

The mobile application provides a user interface to start a session and send a command or receive a status. The development environment “android studio” is used which is the official integrated development environment (IDE) for Android platform. Its language is java based so for the implementation of the software java language and android studio is used. The application consists of two forms, one of them is the sign in tab and the other one is the home tab as shown in **Error! Reference source not found.**.

5.2 MICRO-CONTROLLER AND GSM/GPRS MODEM INTERFACING

A microcontroller and a GPRS modem are used to establish the communication with the client on the object side. For this we use an Arduino Uno board with the GPRS shield as shown in **Error! Reference source not found.**.

The key point for enabling the serial communication between the Arduino and the GSM/GPRS shield is the receiver (Rx) and transmitter (Tx) pins which they are responsible for sending and receiving data or in other words the Arduino uses these pins to send AT commands through the transmitter and get the response through the receiver pin. To allow serial communications through these pins, the mode of the modem should be changed to software serial which is by choosing the communication ports properly using jumper on the GPRS board. After these modifications the Arduino and the modem can communicate serially and they are ready to be programmed to perform different tasks.

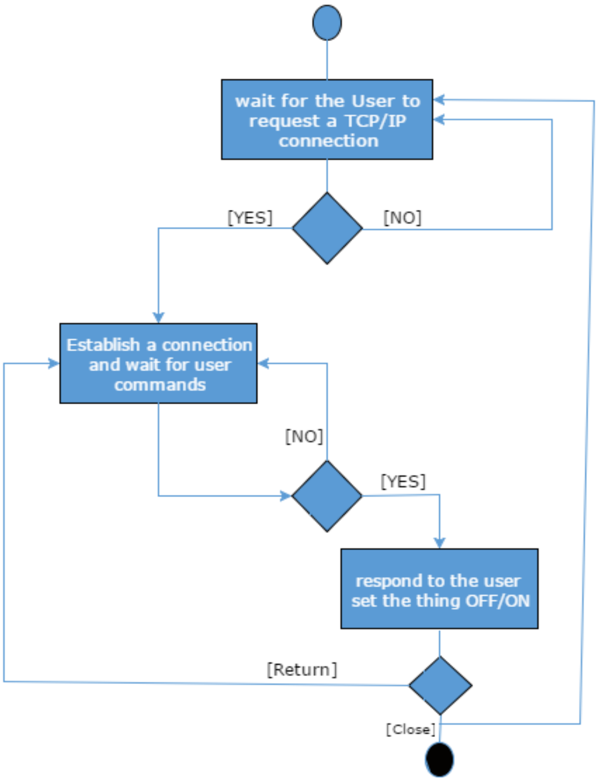

FIGURE 3. Activity diagram of the system using 2nd architecture

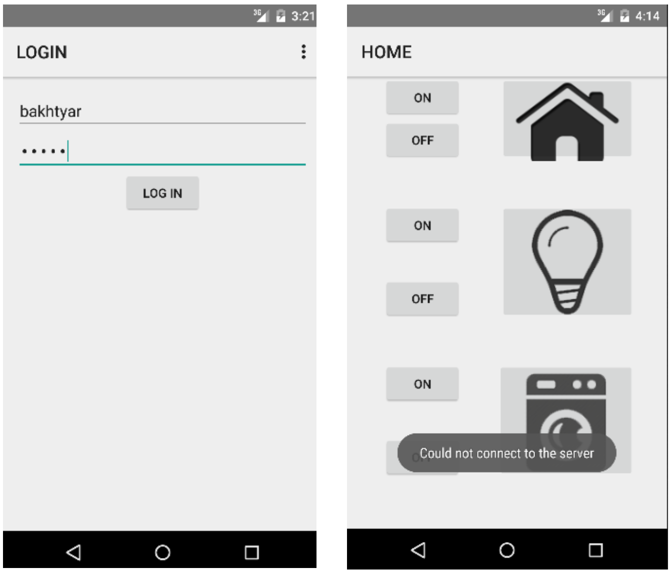

FIGURE 4. User interface application

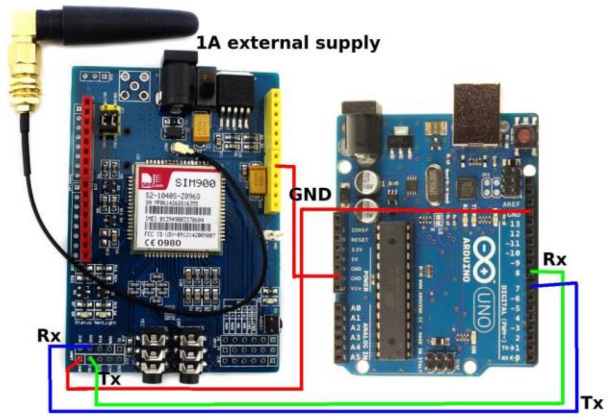

FIGURE 5. Microcontroller and GPRS shield in the object side (client).

The overall system can be seen as shown in the **Error! Reference source not found.**

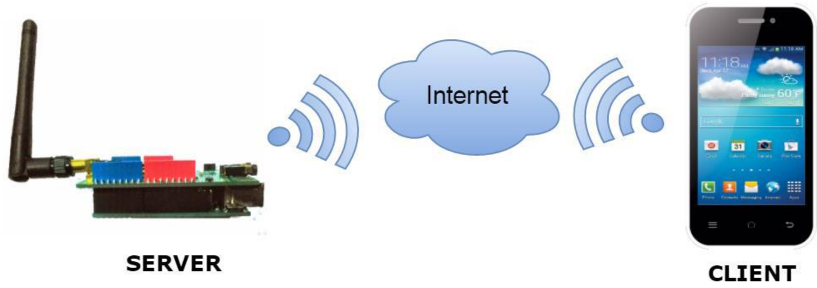

FIGURE 6. The overall system

6. TESTING AND RESULTS

The performance of the system means how often the server is getting ready to accept the client connection in different kind of situations or in other words, does the system always responds to the client requests for connection establishment? To answer this question some tests have been done on the server side to make the client sure that whenever the server has power supply it connects to the internet and it waits for the client's request for communication. The server side turns on automatically whenever it has a power supply. Many trails have been done to test this server readiness when the power is on. The result was positive all the time. After the power is on the serve will wait for the client to connect to it. The server was accepting the client connections each time the client initiated a connection.

To test the client side we used the HyperTerminal software read the information from the server side. It shows how reliably the client can connect to the server when the server is available and ready to accept the client connections. We tried to connect to the server five times and all the times the connection succeeded. The results are shown in **Error! Reference source not found.** which is used to read the AT commands from the Arduino board (server side). As it is shown that the IP address of the client has changed in the 3rd iteration which means that in the test we disconnected the client to get a different public and private IP, yet the connection still succeeded.

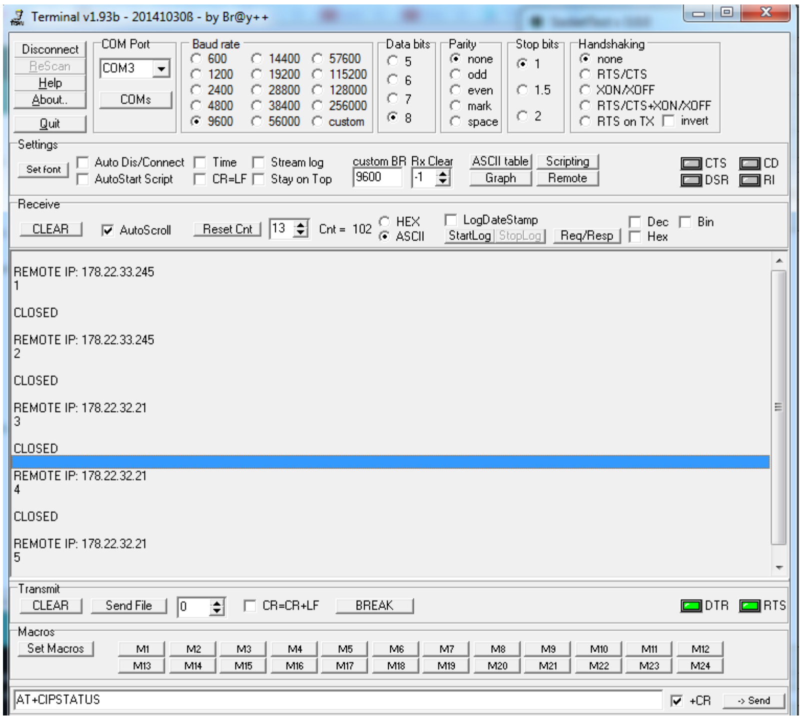

FIGURE 6. Software to test the client connection to the server

To test the data exchange from the client to the server (commands), after the client to the server connection has been established, different types of data has been sent as shown in **Error! Reference source not found.**.

To receive monitoring data on the client side the test was not valid. This is because the ISP has some security firewall in that direction from the sever side to the internet. This issue should be discussed with the ISP in order to relax this security measure in case of real applications.

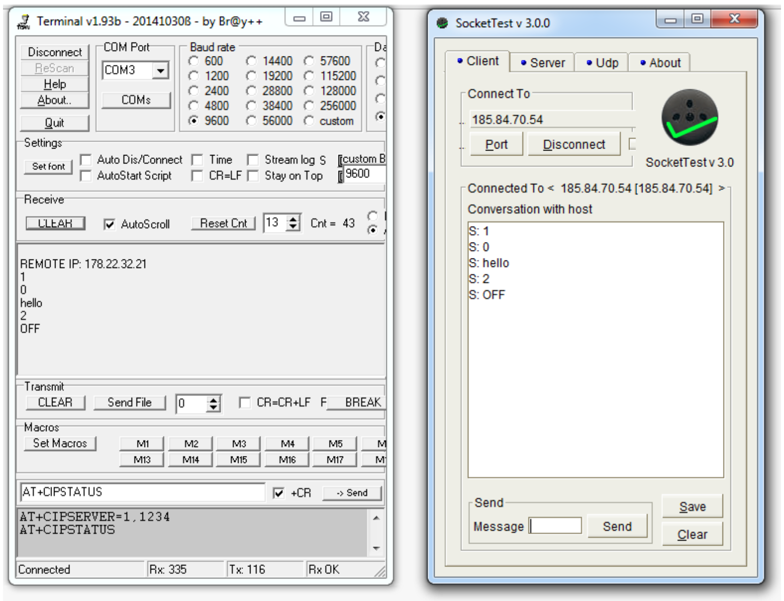

FIGURE 7. Command sent from the client side (right) and received on the server side (left)

7. CONCLUSION

It is shown that remotely controlling and monitoring essential devices “things” is possible through a GPRS modem and IP address. This system can have applications in many areas such as agriculture, weather data collection for forecasting and other systems. A low cost IoT system was built with an Arduino Uno and a GPRS shield with a SIM card which has a static IP address on the server “thing” side. An android mobile application on the client side with an easy is user friendly. The communication between the client and server occurs efficiently in a reactive manner. The tests on a light bulb showed that the system performance is reliable. The acknowledgment from the “thing” side, to the commands sent, is not possible because of the restriction from the ISPs in our region and this problem can be fixed if the companies support this project. Further works needed to evaluate the performance of the system; parameter like end-to-end delay can be monitored and evaluated. The delay time is critical for some applications, especially when using the architecture with server.

ACKNOWLEFGMENTS

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