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Smartphone's off grid communication network by using Arduino microcontroller and microstrip antenna

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ABSTRACT

After a major disaster, the present communication system fails in providing the services in the affected area. No means of communication proves to be more dangerous as the rescue and relief operations become more difficult. Our current research is about establishing a network in such a disaster-prone area, which would facilitate to communicate and carry out the rescue missions. This research project used Java to create a fire-chat application and used it with the smartphone android system. It used Bluetooth model HC-05 linked with Arduino UNO by the SPI interface to connect Arduino with the smartphone. The FR-model HCW69 connected with Arduino by using UART to transceiver the message. The microstrip antenna 915 MHz connected with the FR-model HCW69 to give us more distance. The maximum effective range of the transceiver was 1 kilometer, to communicate by forming a mesh network. This application is helpful in the case when the smartphone is out of service; it (smartphone) can be communicated connected to the other nearby users with a message.

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1. INTRODUCTION

Nowadays, there are diverse communication systems that provide efficient and quick communication. There are fixed wire networks, such as the telephone network, several mobile networks, satellite networks, and the internet [1]. In addition to these networks, there are more simple systems such as walkie-talkies [2], which allow for two-way wireless voice communication over shorter distances. Compared to the networks mentioned, walkie-talkies have more limited use, but at the same time does not require any infrastructure [3], [4]. Such wireless communication devices are often used when it is necessary to have a way of communicating without, or in addition to the infrastructure-based solutions, either for security reasons or for safety reasons [5]. In cases of emergency, mobile base stations may stop working due to external causes, or they may get overloaded by too much traffic [6], [7]. In these cases, it is necessary to have an alternative way of communicating to organize help and rescue the people involved [8]. In lesser demanding situations such as hiking or mountain climbing, an alternative way of communicating could also be a benefit.

In situations without network coverage systems such as an embedded computing systems (ECS), the internet of things (IoT), or mobile networks, it is important to have a reliable network and an infrastructure that has alternative network routes in case parts of the system stop working [9]. There are, however, places where it is not economically viable to build communication channels, and there are places isolated from the infrastructure-based wireless technologies [10]. This is when we need easy to deploy infrastructure-less communication systems, such as walkie-talkies [11]. This type of communication system may be useful when we are inside buildings or cellars with dense or reflective walls where there is weak or no mobile reception in rural areas without cellular coverage. This may be in mountains, forests or on the sea, in natural disaster situations where infrastructure may break or when the increased communication needs cannot be satisfied by standard communication channels, when mobile networks are down due to technical problems, in cases with high demands of data that needs alternative channels [12]. This may be the case for mobile computation or video streaming, and in crowded areas, such as concerts or football stadiums where existing communication channels may get overloaded.

A smartphone is a mobile phone able to perform many of the functions of a personal computer. Compared to a standard mobile phone, the smartphone has an operating system, a touchscreen, a global positioning system (GPS), a camera, Internet access capability, and much more [13]. Communication is typically done by voice calls or text messages through mobile networks, but can also be done through other wireless technologies such as wireless fidelity (Wi-Fi) and Bluetooth [14]. There are several apps (applications) for smartphones that can be used to communicate over shorter distances using Wi-Fi or Bluetooth [15]. Most of these apps work by creating wireless local area networks where one smartphone is the access point of communication. Every other device can connect to the access point and communicates with other connected smartphones through the access point [16]. This means that the range of the network is limited by the range of the connection to the access point.

This study focused on the use of smartphones as communication terminals without the use of mobile-cellular networks. It explained that smartphones could be used for communication in situations when the mobile network is out of range or not working [17]. These situations include emergencies in case of hurricanes or flooding, but also less demanding situations where alternative communication may be useful. Arduino microcontroller like Arduino UNO is used as a controller to process the transmitted and received data from the smartphone. Figure 1 shows the block diagram of the study. This system could potentially have a better chance of establishing communication to someone else when there is no mobile coverage.

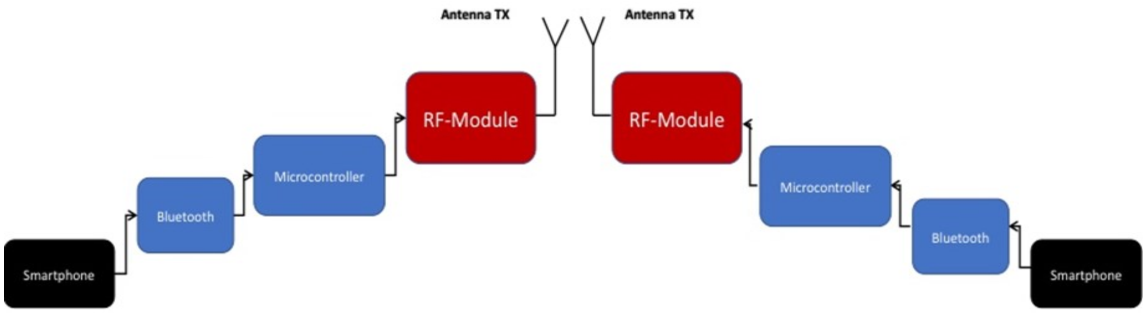

Figure 1. Block diagram of study using smartphone and Arduino with Bluetooth

2. RESEARCH METHOD

2.1. Arduino UNO

The Arduino an open-source platform which provides strong base for hardware and software [18]-[20]. Arduino Uno is a microcontroller board based on the AT mega 168 or 328. The Arduino Uno has 6 Analog I/O pins and 14 digital I/O pins. Here we use 8 to 13 pins for input/output. It needs 7 to 12V input voltage and 5V operating voltage. It simply connects with a DC battery to get started. It also has a reset button to reset all previous connections [21]. It has one USB port that can be connected to a computer for programming or connected to an Android USB port for serial communication (USB-to-serial communication). USB master capability is not supported on the Arduino Uno, but it can act as a USB slave. It has one input and one output pin for serial communication (one UART port) and several analogs and digital pins that can be connected to a radio module. The basic model of Arduino is shown in Figure 2.

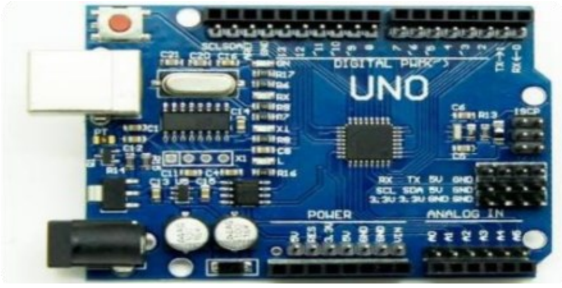

Figure 2. Arduino UNO module without connections

2.2. Bluetooth

The Bluetooth model has four important pins, virtual credit card (VCC), transmit (TX), receive (RX), and ground. TXD: the sender, usually expressed as a sender, normal communication must be connected to another device RXD. RXD: Receive-side, generally showed as the receiving end, the normal communication must be connected to another device TXD. Normally, the TXD is always connected to RXD of other equipment. Figure 3 shows the connection diagram of the Bluetooth model with Arduino. We linked the VCC of Bluetooth model with 5V in Arduino, the ground pin of the Bluetooth model joined with the ground pin of Arduino, TX pin of Bluetooth model joined with PIN 7 in Arduino and the RX of Bluetooth model connect with PIN 8 in Arduino, as shown in Figure 3.

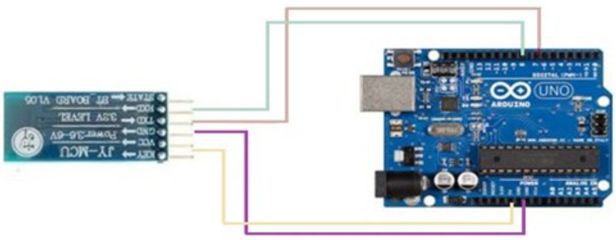

Figure 3. Connections of Bluetooth model with Arduino UNO

2.3. RFM69HCW wireless transceiver

This project used RF-Model69hcw as can show in Figure 4, Arduino feed RF-Model69hcw power and ground, The RFM69HCW is a transceiver module capable of operation over a wide frequency range, including the 315,433,868 and 915 MHz license-free industry scientific and medical (ISM) frequency bands. All major RF communication parameters are programmable, and most of them can be dynamically set. The RFM69HCW offers the unique advantage of programmable narrow-band and wide-band communication modes. The RFM69HCW is optimized for low power consumption while offering high RF output power and channelized operation [22]. The RFM69HCW employs an advanced power supply scheme, which provides stable operating characteristics over the full temperature and voltage range of operation. It includes the total output power of +20 dBm maintained from 2.4 to 3.6 V. The RFM69HCW can be powered from any low-noise voltage source via pins.

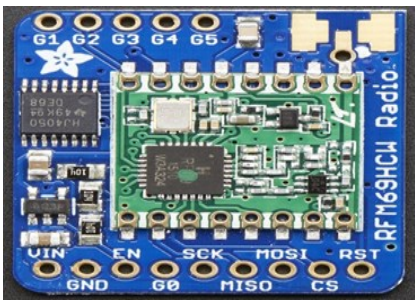

Figure 4. RFM69HCW wireless transceiver

2.4. Microstrip antenna

This article has used a microstrip patch high gain antenna that works during a natural disaster, and that operates on 915 MHz using air gap technic, as shown in Figure 5. The characteristics of the first antenna are determined by measuring the resonance frequency, return loss, and gain. The frequency and return loss value is measured by using vector analyzer equipment. From the experiment, the frequencies of the Antenna are 915 MHz, which have a return loss of -13.750 dB, respectively. To calculate the gain receiver of the antenna, power transmitter, distance of antenna, the tabular form of calibration report has used after calculating the gain obtained is 5.509 dB at frequency of 915 MHZ.

Figure 5. Microstrip patch antenna

2.5. Java programming

The design of the system software has made with the Java programming language. The Arduino environment itself was written in Java, communication to the serial port can be done via the Java library (RX, TX.) This library is quite similar to the Java API extension of communications. Internally the IDE remembers that port and baud rate you used last time. The internal implementation cannot be considered public API; the computer programmer will faithfully use it. Therefore, computer programmers can be got to keep their settings to remind them which COM ports their Arduino cards are using on the computer.

3. IMPLEMENTATION AND TESTING THE RF MODEL

For the RF telemetry links majority, line of sight is the primary mode of EM propagation wave, a direct, unobstructed path between the transmission antenna and receiving antennas [23]-[25]. Therefore, for one antenna, the maximum propagation path is limited by the distance to the RF horizon. According to the results from the in the first step, it covers a short distance, we designed an RF-model and linked it with the antenna that provides coverage give for more range. To overcome the distance issues, the second step of this project was to improve coverage between two smartphones so that it is more useful in an emergency. In this case, step antennas (915 MHz) is used and link it with the RF-model to give more distance combination of the antenna with RF-model gives a significant improvement in solving the distance issues. A class with the name ‘on Create’ was defined to control Bluetooth and enable communication with other devices. ‘setupChat1’ to initialize the modules. ‘Bluetooth Chat Service’ this chat service class does all the work for managing and setting up Bluetooth connections with other devices. It has a thread that listens for incoming connections, a thread for connecting with a device, and a thread for performing data transmissions when connected. In the Bluetooth Chat Service class, we create a constructor that prepares a new Bluetooth Chat session. For running the service, another class ‘Accept Thread’ was created, which contained new listening server, and listener to listen to the server socket if it’s connected or not connected. A class titled ‘Broadcast Receiver’ was developed to broadcast a signal.

4. RESULTS AND DISCUSSION

The characteristics of the antenna are determined by measuring the resonance frequency, return loss, and gain. Figure 6 shows the final prototype of the group items. The frequency and return loss value is measured by using vector analyser equipment. From the experiment, the frequencies of the antenna are 915 MHz, which have a return loss of -13.750 dB, respectively. To calculate the gain receiver of the antenna, power transmitter, distance of antenna and the Tabular form calibration report are used. After calculating, the gain obtained is 5.509 dB at frequency of 915 MHZ.

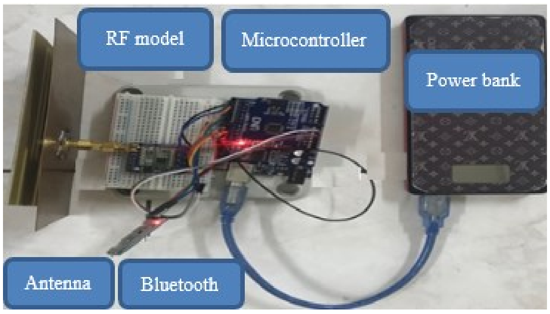

Figure 6. Final prototype, antenna with the RF-model

The maximum distance between smartphones in this project it is achieved to 1 kilometer, that is mean antenna gave distance around 900 meters, as we know the obstacles are affective and prevented the wave signals. We tried to send and receive the messages between the obstacles like (trees), the distance became around 500 meters less than before 1 kilometer the because of the obstacles. The testing for sending and receiving messages like (hi, hello) that is sent by Arduino without antennas by using Bluetooth chat application, the maximum distance between these two smartphones (android system) was 100 meters.

Actually, after linked antennas with RF-model and got around one-kilometers distance as shown in Figure 7, the power input that feeds RF-model 5v+ and the output power of FR-model is 20 dBm, after sent the message and received, I calculated the power receive of antenna for a different distance (100, 500, and 1000 m). As shows the equation in the Table 1 and Table 2 to show the power received. Figure 8 refers to the screen Bluetooth chat application; this application sent and received the message. Also, this Bluetooth chat application allows writing 200 letters in one message sending 200 letters enough to complete the statement.

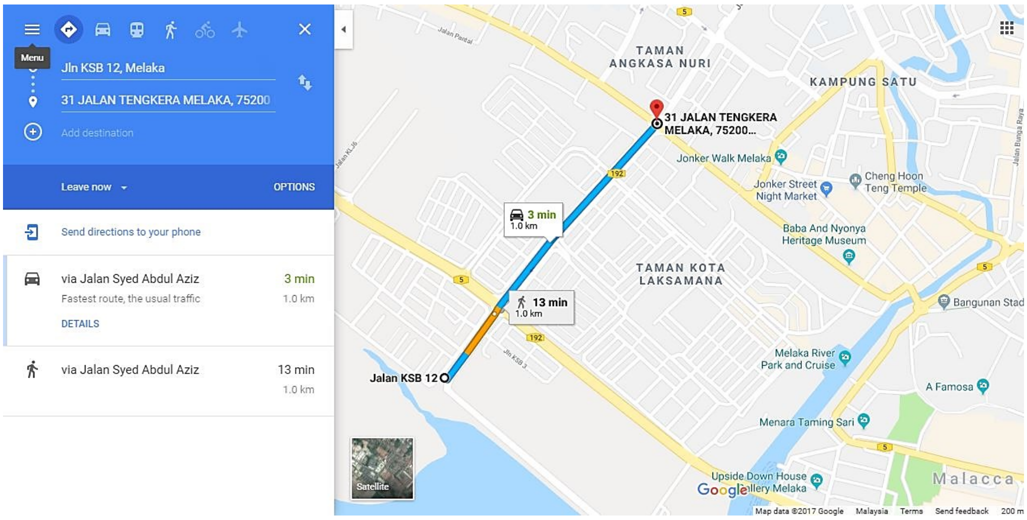

Figure 7. Google map to check the range

Table 1. Equations and calculations

Equation of (l_{pf})	Distance (m)	Result (dB)
$L_{pf} = 32.5 + 20 \log F_{MHz} + 20 \log R_{Km}$	100	71.72
	500	85.70
	1000	91.72
Equation of (L)	Distance (m)	Result (dB)
$L = L_{PF} - Gt - Gr$	100	58.52
	500	72.5
	1000	78.52
Equation of (P_{rdB})	Distance (m)	Result (w)
$L = L_{PF} - Gt - Gr$	100	$1.4*10^{-7}$
	500	$5*10^{-9}$
	100	$1*10^{-9}$

Table 2. Calculation of power receive

The distance (meter)	Power receive (dB)
100	-68.52
500	-82.5
1000	-88.52

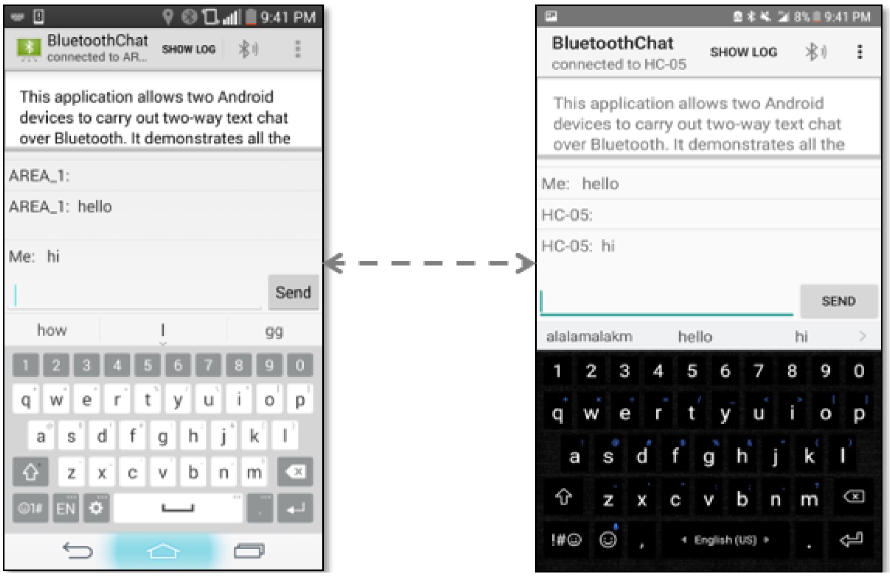

Figure 8. Communication testing

5. CONCLUSION

This study discussed the development of a system to explore the capability of smartphones for communication in situations when the mobile network is out of range or not working. A microcontroller and RF-model device which were connected to a smartphone proposed for the off-grid communication without using normal communication. It utilizes radiofrequency technology to send data even in the absence of telecommunication coverage by using Bluetooth chat application.

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