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# Bluetooth Range Expansion: Using Bluetooth Module and Arduino Microcontroller in Exchanging Messages

**Aira Marie Miranda [1], Claire D. Cabrillos [2], Jayhan V. Sapu-an [3], Jinalyn M. Domingo [4], John Kevin S. Panaguiton [5], Robert T. Narciso [6]**

**Abstract:** Bluetooth is a widely used technology in today's mobile phones. It enables a device to communicate wirelessly without being in line of sight of another device, but Bluetooth has its own shortcomings, such as being only applicable between two Bluetooth-enabled devices at a time and its range being limited. Thus, this study aims to overcome these disadvantages by proposing a new innovation called Bluetooth range expansion that can pair two devices over a longer distance. The proposed Bluetooth range expansion utilizes two hardware devices, namely a Bluetooth module and a microcontroller, but the testing is limited to an open area. The level of acceptability of the prototype is also determined based on its design, functionality, and performance.

**Keywords:** Bluetooth range expansion, Microcontroller, Bluetooth module, Prototype

## 1. Introduction

Nowadays, most of our devices, from mobile phones to personal computers or laptops, are equipped with Bluetooth technology, which replaces infrared technology. In addition to reducing desktop clutter, Bluetooth can also be used to connect a few computers, cellphones, and other mobile devices to sync and swap files. Bluetooth refers to a short-range wireless technology that is generally used for exchanging data between fixed and mobile devices over short distances as well as in building ad hoc personal area networks (PANs) [1][2]. Its range is usually limited to ten meters, or approximately 33

[1] College of Computer Studies, University of Antique, Sibalom, Antique, Philippines
Email: airamarie.miranda@antiquespride.edu.ph
[2] College of Computer Studies, University of Antique, Sibalom, Antique, Philippines
Email: claire.cabrillos@antiquespride.edu.ph
[3] College of Computer Studies, University of Antique, Sibalom, Antique, Philippines
Email: jhayhanviosapuan@antiquespride.edu.ph
[4] College of Computer Studies, University of Antique, Sibalom, Antique, Philippines
Email: jinalyn.domingo@antiquespride.edu.ph
[5] College of Computer Studies, University of Antique, Sibalom, Antique, Philippines
Email: johnkevin.panaguiton@antiquespride.edu.ph
[6] College of Computer Studies, University of Antique, Sibalom, Antique, Philippines
Email: robert.narciso@antiquespride.edu.ph

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feet, and its transmission power is limited to 2.5 milliwatts [3]. As an alternative to wired network connections, Bluetooth is very useful for exchanging files over mobile devices over short distances. For example, the use of music players and mobile phones with wireless headphones.

Currently, Bluetooth is managed by the Bluetooth Special Interest Group (SIG), which manages the development of the specification, manages the qualification program, and protects the trademarks [4][5]. Bluetooth technology is very useful in today's high-tech world; it can be used for transferring files from one device to another; however, the transfer is always limited by its range. When enabled, Bluetooth continually scans for signals, looking for new devices to connect with, using energy in the process; thus, it slowly drains the battery of the mobile device.

The main purpose of this study is to design a Bluetooth Range Expansion prototype that can expand the range of exchanging messages via Bluetooth using the Bluetooth module and an Arduino microcontroller [6][7]. This prototype is designed to expand the range of Bluetooth and has the capability to connect over longer distances. It also attempts to execute the following objectives:

1. To determine the range of the prototype with regards to the distance between laptop to tablet and laptop to cellphone.
2. To determine the level of acceptability of the prototype as to design, functionality, and performance between laptop to tablet and laptop to cellphone.
3. To determine if there is a significant difference in the range of the prototype in the distance between laptop to tablet and laptop to cellphone as to its functionality and performance.
4. To determine if there is a significant difference in the average acceptability of the prototype with regards to design.

The remainder of this paper is organized as follows: Section 2 outlines the methodology in the development and evaluation of the Bluetooth Range Expansion prototype; Section 3 details the results and discussion; and Section 4 concludes the study.

## 2. Methodology

### 2.1 Prototype Design

A prototype for Bluetooth range expansion is developed with the use of a Bluetooth module and an Arduino programmable microcontroller. Figure 1 shows the operational process of the prototype.

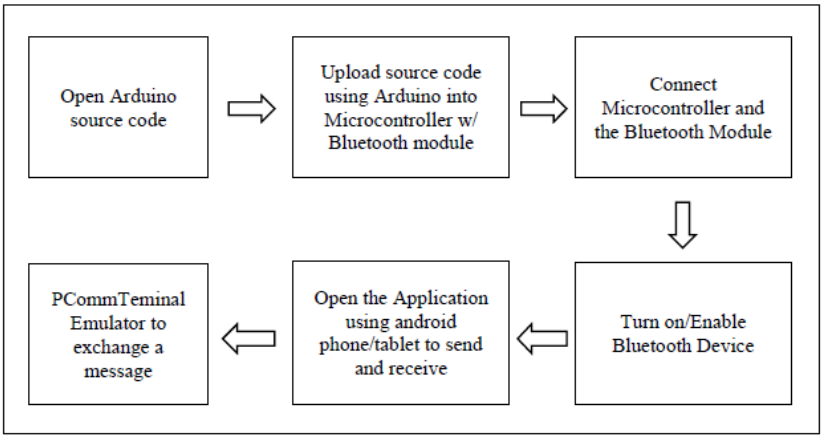


**Figure 1.** Operational Process of the Bluetooth Range Expansion Prototype

Figure 1 shows that the Arduino source code must first be opened to start the prototype's operation. The user is then required to check the serial port and select the microcontroller board Gizduino (mini) ATmega328 to start uploading the source code. Next, the microcontroller will be connected to the Bluetooth module and enable the Bluetooth devices. The PComm Terminal Emulator will be used to exchange the messages via Bluetooth with an Android application.

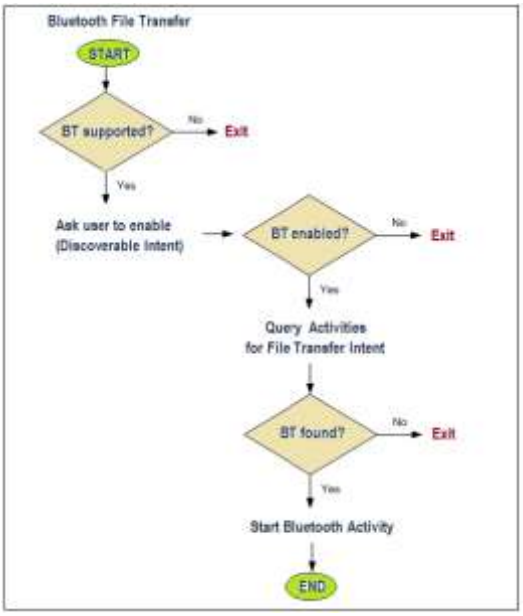


**Figure 2.** Process using Bluetooth File Transfer

Figure 2 shows the process of transferring files via Bluetooth, which starts with opening the Bluetooth discoverable intent and choosing among the displayed device names. If it is enabled, start sending and receiving the file being transferred.

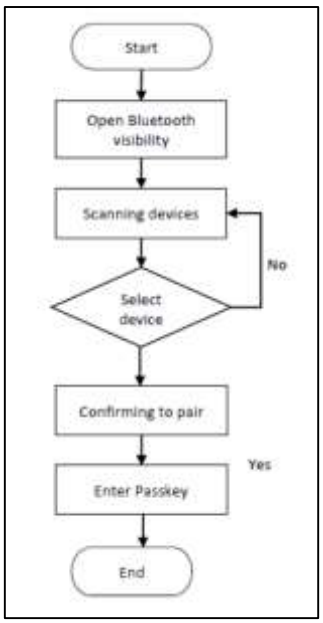


**Figure 3.** Bluetooth Setup Process

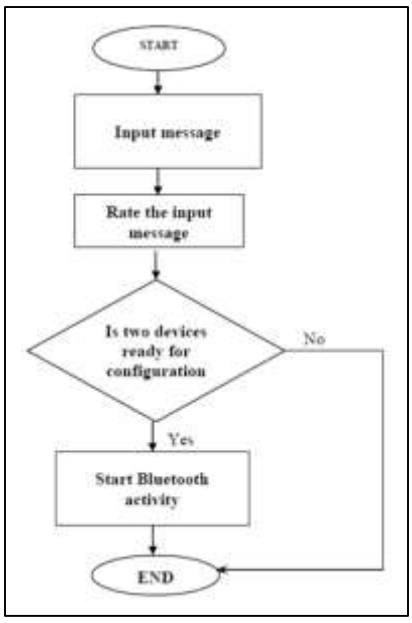


**Figure 4.** Bluetooth Configuration Process

Figure 3 shows that the process of setting up Bluetooth starts with opening the Bluetooth device. Next, scan the device name, select confirming to pair, and enter a passcode to continue processing.

Figure 4 shows the Bluetooth configuration process to get the devices ready for exchanging messages or having a conversation.

### 2.2 Prototype Implementation

The installation process for the Arduino microcontroller depends on your operating system. The device needs to meet the system requirements of the prototype. When installing, it is always a good idea to first close or disable the programs that are running. It also takes time to install. After installing the prototype, reboot the device if necessary. Figure 5 shows the initial steps in installing the Arduino microcontroller on your device.


**Figure 5.** Locate and Run the Arduino Executable File

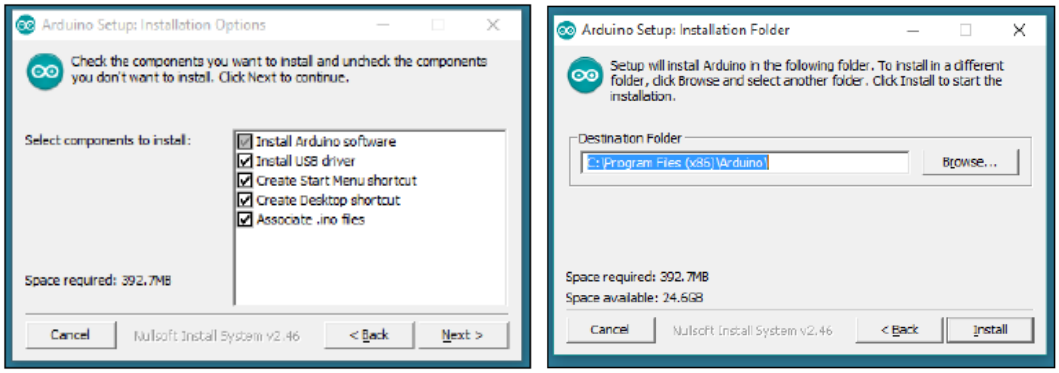


**Figure 6.** Arduino Setup: Components and Installation Folder

Installing the Arduino microcontroller also allows the driver installation process; thus, check the components that are required in the installation, as shown in Figure 6. Setup the Arduino installation folder where the Arduino application files will be located. The Arduino installation extracts and installs all the required files in this folder. After installing the Arduino application, upload the source code of the Bluetooth Range Expansion prototype, and your device will be ready to use and run the program, as shown in Figure 7.


**Figure 7.** Uploading of BTExpansion Source Code

When the source code is successfully uploaded, configure the port number to be used by the Bluetooth Range Expansion prototype in exchanging messages, as shown in Figure 8.

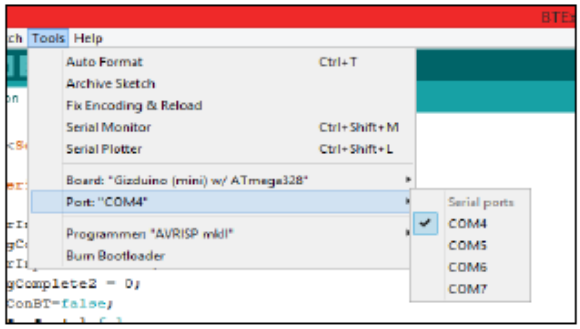


**Figure 8.** Port Selection

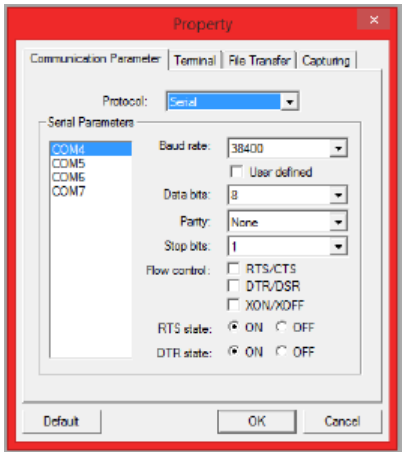


**Figure 9.** Baud Rate configuration

The properties of communication will then be configured through the PComm Terminal Emulator. The COM4 port baud rate is set to 38400 for a continuous process, as shown in Figure 9. Once the configuration is done, your device is now ready to exchange messages via the Bluetooth terminal, as shown in Figure 10.


**Figure 10.** Receiving Messages through Bluetooth Terminal

### 2.3 Prototype Evaluation

The prototype will be evaluated by twenty selected students, ten from the Bachelor of Science in Computer Science (BSCS) and ten from the Bachelor of Science in Information Technology (BSIT).

The level of acceptability of the Bluetooth Range Expansion prototype will be measured based on its performance, functionality, and design. The scores for the prototype's performance will be interpreted as follows: 1 - Low performance; 2 - Good performance; 3 - Very Good performance; and 4 - Extremely Good performance. For its functionality, the scores will be interpreted as follows: 1 – Poor; 2 – Good; 3 - Very Good; and 4 - Excellent. For the prototype's design, the scores are interpreted as follows: 1 - Not Acceptable; 2 – Satisfactory; 3 - Very Satisfactory; 4 - Extremely Satisfactory.

The statistical technique used in scrutinizing and construing the data and testing was the T-test to determine the range of the prototype on the distance between laptop to tablet and laptop to cellphone, as shown in Equation 1.

$$t = \frac{x_1 - x_2}{\sqrt{\frac{{sd_1}^2}{n_1} - \frac{{sd_2}^2}{n_2}}} \quad (1)$$

where:

$x_1$ = stands for the mean of the first variable

$x_2$ = stands for the mean of the second variable

$sx_1^1$ = variance of $x_1$

$sx_2^2$ = variance of $x_2$

$n_1$ = total number of operations of the first variable

$n_2$ = total number of the operations of the second variable

## 3. Results and Discussion

The various steps involved in the Bluetooth Range Expansion prototype's operations follow the First-In-First-Out algorithm, which includes the following: (1) initialize the Bluetooth terminal between devices; (2) set the input between devices; (3) create messages to be transferred between devices; (4) rate the input message; (5) start the configuration; and (6) display the output.

Figure 11 shows that this algorithm includes the initialization of the Bluetooth terminal between devices and setting the input between devices. Once the devices are ready for configuration, the rating of the created message starts in order to check if the first letter or word to be transferred will be the first to display on the output device.

```
void loop() {
    if (BTSerial.available()) {   Serial.write(BTSerial.read());  }

    // READ Arduino Serial Monitor and WRITE to HC-05
    if (Serial.available())   {  BTSerial.write(Serial.read());  }

    serialEvent();

    // send to bluetooth when a newline arrives:
    if (stringComplete1==1) {
        if (stringComplete2 == 3) {   //print in new line if enter was not pressed.
            strInput1 = ( "\r\n" + strInput1);
            string Complete2 = 0;
            strInput2=" > ";
        }
        BTSerial.print(strInput1);
        strInput1 = " > ";
        string Complete1 = 0;
    }

    // send to serial when a newline arrives:
    if (stringComplete2==2) {     //print in new line if enter was not pressed.
        if (stringComplete1 == 3) {
            strInput2 = ( "\r\n" + strInput2);
            string Complete1 = 0;
            strInput1=" > ";
        }
        Serial.print(strInput2);
        strInput2 = " > ";
        string Complete2 = 0;
    }
}


void serialEvent() {   //Controller.
    while (Serial.available()) {
        char inChar1 = (char)Serial.read();
        strInput1 += inChar1;
        string Complete1 = 3;
        if (inChar1 == '\n') {
            string Complete1 = 1;
        }
    }
    while (BTSerial.available()) {
        char inChar2 = (char)BTSerial.read();
        strInput2 += inChar2;
        string Complete2 = 3;
        if (inChar2 == '\n') {
            string Complete2 = 2;
        }
    }
}
```

**Figure 11.** Source Code of the Underlying Algorithm

In this algorithm, the BTSerial initializes the Bluetooth terminal, the words Owners1 and Owners2 are displayed when connecting to a laptop or tablet, the StringInput1 and StringInput2 are initializations of the variables, the Void loop is used for the looping process, the SerialEvent rate the input, and StringComplete1 and StringComplete2 determine whether the process is from a laptop or tablet.

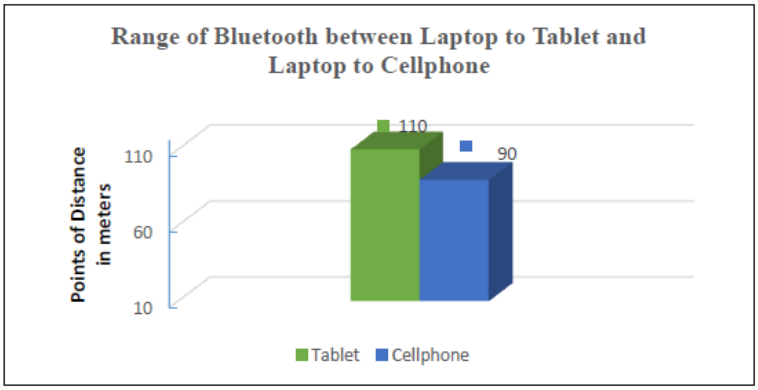


**Figure 12.** Distance of Two Devices (Tablet and Cellphone)

Figure 12 shows that it is more applicable to expanding the Bluetooth range using a tablet as compared with a cellphone; that is, with a tablet, it can expand the range from 10 to 110 meters, while with a cellphone, the range can only be expanded from 10 to 90 meters.

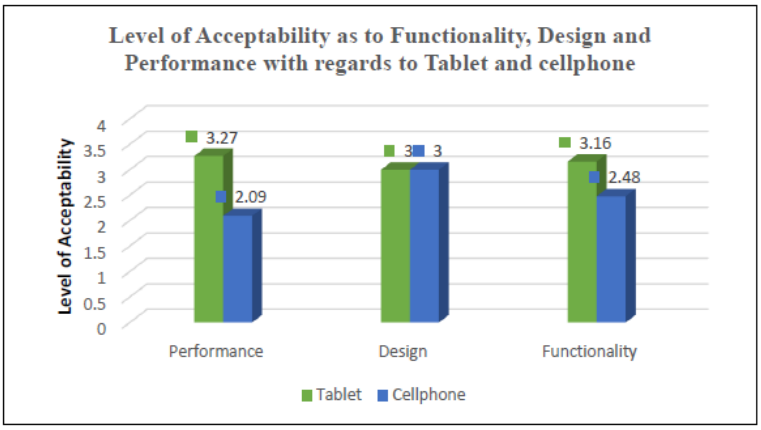


**Figure 13.** Level of Acceptability as to performance, Functionality and Design

In determining the level of acceptability of the Bluetooth Range Expansion prototype based on its functionality, performance, and design, a connection between laptop to tablet and laptop to cellphone has been established.

Figure 13 shows the level of acceptability of the Bluetooth Range Expansion prototype for both a laptop to tablet and a laptop to cellphone. As to the prototype's functionality, the connection to the tablet gets a score of 3.16, which is interpreted as "Very Good", its design gets a score of 3.00, which is interpreted as "Very Satisfactory", and its performance gets a score of 3.27, which is interpreted as "Very Good". On the other hand, the level of acceptability of the Bluetooth Range Expansion prototype when a laptop is connected to a cellphone is as follows: its functionality gets a score of 2.48, which is interpreted as "Good", its design gets a score of 3.00, which is interpreted as "Very Satisfactory", and its performance gets a score of 2.09, which is interpreted as "Good". In comparing the results of acceptability of the two devices, it shows that a tablet is more accessible than a cellphone in expanding the Bluetooth range for exchanging messages.

**Table 1.** T-test Results for between Cellphone and Tablet as to their Functionality and Performance

| Criteria | M | SD | t | df | Sig (2-tailed) |
|---|---|---|---|---|---|
| *Functionality* | | | | | |
| Tablet | 3.16 | .32 | -4.87 | 18 | .000 |
| Cellphone | 2.48 | .31 | | | |
| *Performance* | | | | | |
| Tablet | 3.27 | .40 | -7.00 | 18 | .000 |
| Cellphone | 2.09 | .34 | | | |

** significant at $\alpha$ = .05(p<0)*

The results in Table 1 show that there was a significant difference in the functionality of the prototype. The level of acceptability of the Bluetooth Range Expansion prototype between laptop and tablet as to functionality is 3.16, while laptop to cellphone is 2.48. Comparing the means using the laptop to tablet, it is significantly higher ($M$ = 3.16), as compared to using the laptop to cellphone ($M$ = 2.48). On the other hand, the level of acceptability of the prototype between laptop and tablet based on their performance is 3.27, while laptop to cellphone is 2.09.

**Table 2.** Difference on the Average Acceptability of the Prototype as to their Design

| Criteria | M | SD | t | df | Sig (2-tailed) |
|---|---|---|---|---|---|
| *Design* | | | | | |
| Tablet | 3.00 | .00 | | 18 | |
| Cellphone | 3.00 | .00 | | | |

The results in Table 2 show that there was no significant difference in the design between a tablet and a cellphone since they have the same mean value ($M$ = 3.00). The results show the level of acceptability of the prototype using a laptop to tablet as to design is the same as using a laptop to cellphone, which is interpreted as “Very Satisfactory”. Both the functionality and performance of the prototype using a laptop to tablet are interpreted as “Very Good”, while the functionality and performance of the laptop to cellphone are interpreted as “Good”.

## 4. Conclusion

Based on the results of the evaluation of the Bluetooth Range Expansion prototype, it is concluded that expanding the range of Bluetooth communication from laptop to tablet is more pertinent than expanding the range of Bluetooth communication from laptop to cellphone because tablets have greater capacity for accessing communication signals. The level of acceptance of the prototype in terms of functionality, performance, and design also reveals that the application of the prototype to expand the

range of exchanging messages between a laptop and tablet is more acceptable as compared with using a laptop and cellphone.

In the future, the prototype's capability can be enhanced to include the transmission of multimedia, such as videos, pictures, or audio files. The expansion range will also be improved with higher transmission speeds.

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