Comparison of Wireless Technologies for the Application to the Smart Helmet Project

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Analytical Analysis

Team: C4
Name: Smart Helmet

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Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design II
March 1, 2019

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1 BACKGROUND

1.1 Introduction

After the smart helmet team met with the client, a greater understanding of the client requirements was understood. A major client requirement for the project is the ability to transmit the data from the sensors to a mobile device. One wat to transmit the data is to connect the sensors to a phone using Bluetooth. Bluetooth is widely used today for connecting multiple Bluetooth capable devices to one another and allow them to communicate with each other. There are many other forms of wireless connections between devices such as ZigBee, and Wi-Fi. Implementing one of these technologies would allow for machine to machine (M2M) communication. ZigBee are currently used in Commercial Applications for sensing and monitoring. The main feature of ZigBee is its design for low power consumption allowing for long device battery life. Wi-Fi is another form of connecting electronic devices and are commonly used in laptops, smartphones, and smart devices. A wireless router is used as a communication hub and due to the low power of transmissions, connected devices need to be in a close proximity to the router.

1.2 Problem Definition

This analytical analysis communicates the research done on wireless connections between devices and which technology would be the best fit for the smart helmet project. It will compare the technologies on their ability to transmit sensor data from the helmet to a wireless connected device. The issue being addressed is collecting the data from the sensors, the smart helmet project is addressing the issue by collecting the data wirelessly.

2 ASSUMPTIONS

2.1 Values

In analyzing wireless transmission technologies, there are very few values to be considered. The main values to be aware of are the range, transmission power, and costs. Since the smart helmet project is currently based around the football helmet, the team decided a range of about 50 meters is the goal. The team chose the distance because the maximum distance between a helmet user and the sensor data analyst will never exceed 50 meters. The team also decided the goal transmission power to be less than 500 mW since the Arduino voltage outputs are 5V and 3.3V. The goal cost for the technology chosen is to be under $30 to implement into the project since the related parts for the Arduino has all been under that cost.

2.2 Equations and Variables

The first equation will be the equation used in the analysis of the three wireless connectivity technologies. The equation will use researched values found for the three technologies.

$$\%difference = \left(\frac{C-B}{B}\right) * 100\% \qquad (1)$$

The percent difference will represent the difference when comparing the two wireless transmitting technologies values C to the Bluetooth values B. Bluetooth was arbitrarily chosen as the technology to compare the other technologies to. The percent difference equation 1 will be used to show the increase or decrease of improvement of the technologies from the Bluetooth. The values that will be compared are the power, range, and cost of the technologies.

3 PHYSICAL MODELING

The team will use Arduino compatible parts for these technologies since the sensors and coding is currently being done on Arduino. For all three of the wireless technologies, a module is needed to enable the Arduino to transmit data. Below in Figure 1.1 shows an example of an Arduino compatible Bluetooth module. The four pins represent the voltage, ground, transmit, and receive pins that will connect to the Arduino board. The voltage pin on the module will be connected to the 5V pin on the board, the ground will connect to the board ground. For the transmitting and receiving pins, they will be connected to their opposing counterpart on the board. The transmit pin on the module will connect to the receiving pin on the board, and the receiving pin on the module will connect to the transmitting pin on the board. The reason for the pins to be connected to their opposing counterpart is so the board and the module can communicate with each other. The Wi-Fi and ZigBee Arduino module follow the same principle as the Bluetooth module.

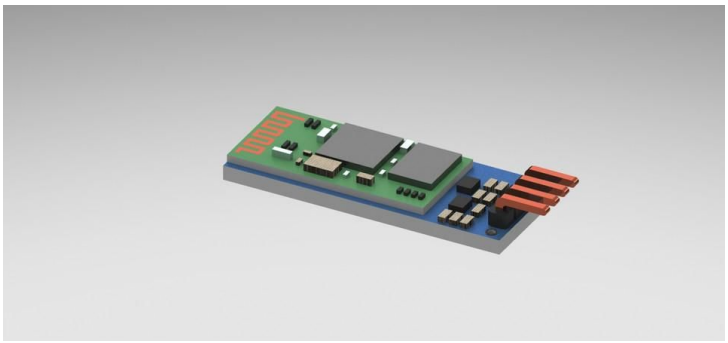

Figure 1.1: Arduino Bluetooth Module

4 DIAGRAMS/RESULTS AND DISCUSSION

A plot of the Bluetooth enabled devices over the years is shown below in figure 1.2. Many smart devices come standard with Bluetooth capabilities built in. Many smart devices with Bluetooth

capabilities also have Wi-Fi connectivity capabilities. ZigBee technology enabled devices are much lower than the Bluetooth and Wi-Fi enabled devices.

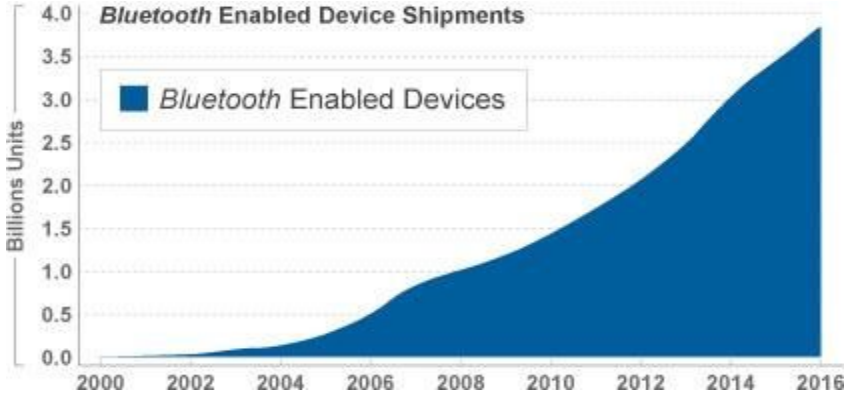

Figure 1.2: Bluetooth Devices vs. Years

In order to communicate using ZigBee and Wi-Fi, Routers are needed to connect multiple devices to each other. Figure 1.3 shows a diagram of how ZigBee devices are connected to one another using ZigBee routers.

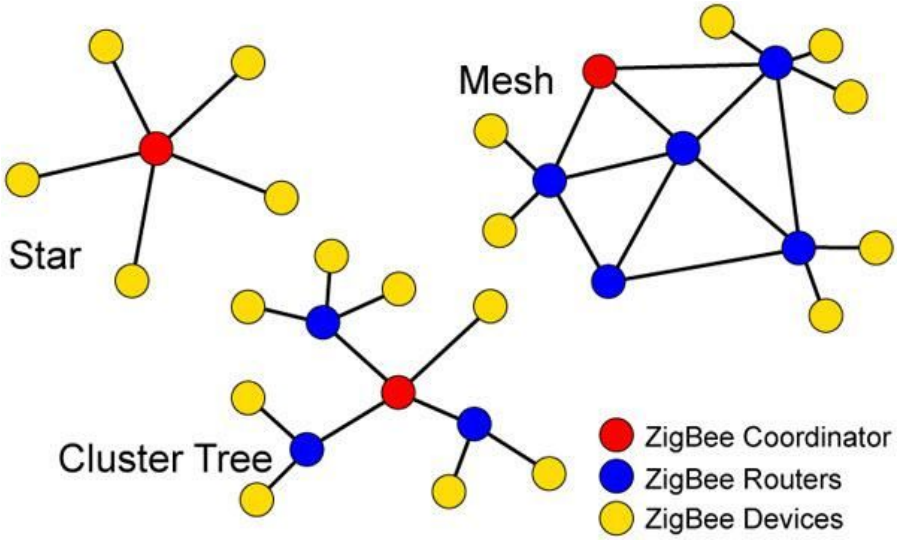

Figure 1.3: ZigBee Technology Diagram

Bluetooth devices come in class 1, 2 and 3. The transmission power and range vary between the classes as shown in Figure 1.4. The different classes are made for different applications, the class that will be considered in this analysis will be class 1 due to the project needing to transmit at a range of at least 50 meters.

Device Class	Transmit Power	Intended Range
Class 3	1 mW	Less than 10 meters
Class 2	2.5 mW	10 meters, 33 feet
Class 1	100 mW	100 meters, 328 feet

Figure 1.4: Comparison of Bluetooth Classes

Table 1: Comparison of Transmission Technologies

	Wi-Fi	ZigBee	Bluetooth
Transmit Power	100 mW	1 mW	100 mW
Range	30-100m	10-30 m	10-100 m
Cost	$8.39	$21.95	$6.95

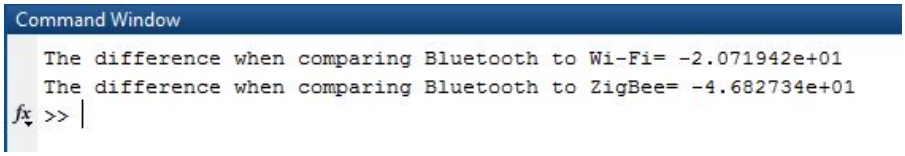

Figure 1.5: MATLAB Output

The values that were used to compare the three technologies their transmission power, range, and cost. The values are presented above in table 1 and were found from online journal articles and websites that are cited in the reference section. A MATLAB code was written using equation 1 to compare the researched values. Figure 1.5 shows the output from the MATLAB code which shows that the Wi-Fi had about a two percent decrease and ZigBee had about a four percent decrease when compared to the Bluetooth. The percentages were a sum of the differences for each variable being compared between the two technologies. The MATLAB code is presented in Appendix 7.1. From these calculations, the Bluetooth technology shows to be two percent better than Wi-Fi, and also four percent better than ZigBee when comparing transmission power, range, and cost.

5 CONCLUSIONS

This analysis is applicable to the smart helmet project because it compares Bluetooth, Wi-Fi, and ZigBee technologies with each other so the team can decide on the best technology for the project. The team wanted a technology that can transmit at least 50 meters, have a transmission power of less than 500 mW, and cost less than 30 dollars. These technologies satisfied these parameters, but the best technology that satisfied the parameters is Bluetooth. Due to the analysis between technologies, there were no equations found when researching them so this analysis used the values that were found through research to compare them. Also there are many other factors such as the amount of enabled devices for these technologies and Bluetooth was found to be standard in lots of devices. Wi-Fi and ZigBee also require a certain configuration of routers and repeaters to extend the signal to connect multiple devices where Bluetooth only requires Bluetooth capabilities between devices to communicate with each other. After

this analysis Bluetooth will be used for the remainder of this project to satisfy the client need of transmitting the sensor data from the Arduino board to a Bluetooth enabled device such as a smartphone.

6 REFERENCES

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7 APPENDICES

7.1 Appendix A: Matlab Code

```
%Race Oshiro
clear; clc; close all;

%Values
Bp=100;   %mW
Br=100;  %m
Bc=6.95; %dollars
Cwp=100; %mW
Cwr=100; %m
Cwc=8.39; %dollars
Czp=1; %mW
Czr=30; %m
Czc=21.95; %dollars

%Calculations
Bw=((Bp-Cwp)/Bp)*100+((Br-Cwr)/Br)*100+((Bc-Cwc)/Bc)*100; %percent
Bz=((Bp-Czp)/Bp)*100+((Br-Czr)/Br)*100+((Bc-Czc)/Bc)*100; %percent

%Output
fprintf('The difference when comparing Bluetooth to Wi-Fi= %d\n',Bw);
fprintf('The difference when comparing Bluetooth to ZigBee= %d\n',Bz);
```