Comparative Analysis on the Performance of Bluetooth 3.0 and Bluetooth 4.0 in the monitoring system of Toddler Growth

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***Abstract*— The development of this toddler growth recorder was designed using HC 05 (bluetooth 3.0) module. Meanwhile, the development of the bluetooth protocol has reached bluetooth 4.0, one of the tools used by Bluno Nano board. This study aims to compare the performance of communication devices using HC 05 module (bluetooth 3.0) with Bluno Nano board (bluetooth 4.0). The data were collected through a number of tests with calculations using electrical formulas. The results obtained from the performance of these two tools showed that Bluno Nano (bluetooth 4.0) board had more advantages compared to HC 05 module.**

Keywords— HC 05; Bluno Nano;Bluetooth;Performance Comparison

I. INTRODUCTION

In this industrial era of 4.0, the transition of physical data to digital ones comes to be something highly needed. In digital era, electronic archive management has become a trend as well as a focus for management development in many institutions [1]. The main objectives of digitizing data include maintaining the data integrity and gaining an insight or knowledge in making a decision.

Along with technology development, any efforts in data digitization can be simply conducted by combining the embedded devices with a data transmission module to make the data obtained able to be sent to other devices for reading and, later on, can be sent to the server. One form of implementation utilizing a transmission module for data transmission is the Toddler Growth Recording device. The aim of developing this device is to design an automation system for sending data of body mass and height of toddlers from the device to the smartphone to be monitored and again seen by the toodler's parents [2].

Bluetooth technology has become a protocol commonly used for data communication. The development of Bluetooth technology has reached bluetooth 5.0. However, the use of bluetooth 3.0 and bluetooth 4.0 is still more often used in the development of existing devices considering its affordable price of bluetooth 3.0 module. Meanwhile, the use of bluetooth 4.0 devices is quite stable and reliable to meet data exchange needs [3].

In choosing the right protocol in hardware development, several aspects are important to consider, particularly for communication devices. One of the aspects is *watt* (W) required by the device to work, *scope* (S) of a protocol and the last one is *waiting time* for sending data. A study compared the Bluetooth protocol and Zigbee in a journal entitled *Comparison of Zigbee and Bluetooth Wireless Technologies Survey*. In this journal the author discussed about the comparison of protocols using several parameters such as maximum data transmission speed, network coverage, and security [4]

Another study compared Timeout and Latency from the *Bluetooth Classic* and *BLE* protocols [5]. In this study, the author discussed the comparison of the performance of Bluetooth Classic with BLE developed in community, and it has resulted in a comparison as presented in Table 1 below.

Table 1 Specification of *Bluetooth Classsic* and *BLE*

No	Item	Value	
		Classic	**BLE**
1	Frequency (GHz)	2.4	
2	Number of channels	79	40
3	Standard maximum speed (Mbps)	1	1
4	Effective maximum speed (Mbps)	0.7	0.27
5	Maximum transmission power (mW)	100	10
6	Pairing	Required	Option
7	Broadcast when disconnected	impossible	possible
8	Maximum packet size (Byte)	1021	47

In the development of Toddler Scale as previously mentioned above, it still uses HC 05 (Bluetooth 3.0) module as a device to communicate data. Due to the development of Bluetooth, which has reached Bluetooth 5.0, the researcher intended to develop the existing device by replacing the components of HC 05 module using bluetooth 3.0 technology with Board Bluno Nano (Bluetooth 4.0). Further, a comparative analysis was carried out on the performance of the two devices to be used as an evaluation material in the development of a toddler growth recording device.

II. RESEARCH METHOD

In the development of automation system for the toddler growth recording device, there are three main aspects of system sustainability. These three aspects include the hardware for measuring the baby's weight and height, the smartphone device used to read the value of the measurement

data provided by the measurement device sent via bluetooth and the last one is the web server used to process and store data sent via internet network. Thus, overall, it can be described in the scheme illustrated in Figure 1 and Figure 2.

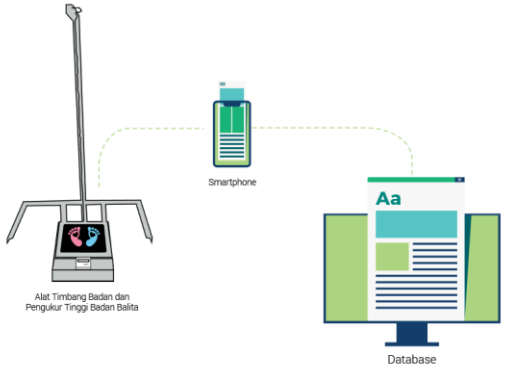

Figure 1. The Scheme of Automation System of Toodler Growth Recording Device

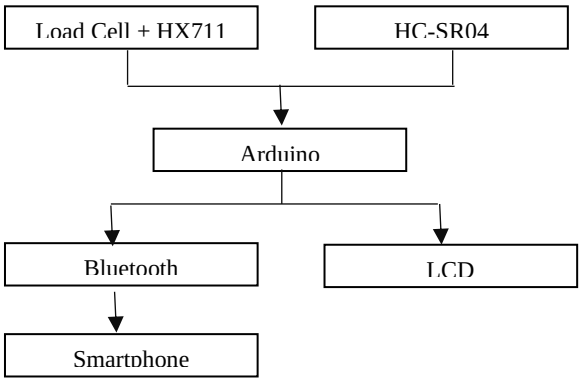

Figure 2. Flow Chart of Automation System of Toodler Growth Recording Device

In this study, the author focused on the data communication component as a discussion by comparing the performance of HC 05 module used based upon the design of the Toddler Growth Recording device using Bluno Nano board.

A. Toddler Growth Recording Device

This device consists of three input hardware components (a Load Cell connected to HX711 and two HC-SR04 ultrasonic proximity sensors), which are processed by the microcontroller in stages, and then it is displayed by the output hardware component (16x2 LCD) and the data used received by the microcontroller will then be sent to the smartphone via the bluetooth component (HC-05) as illustrated in Figure 3 block diagram.

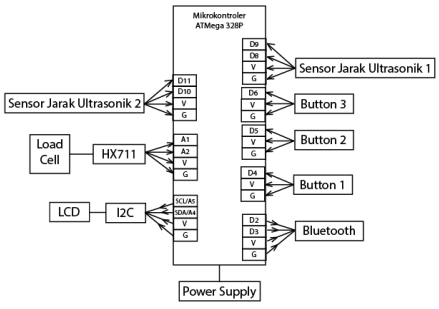

Figure 3 Hardware Block Diagram

B. HC 05 (Bluetooth 3.0)Module

HC-05 Bluetooth is a component that will process the communication between the device and the data receiver. The HC-05 component has 6 pins, but in its use only 4 pins are used as in presented in Table 2 describing the interface of HC-05 component.

Table 2 Specification of HC 05 Module [5]

Specification	**Remarks**
Bluetooth Version	3.0
Frequency	2.4 GHz
Scope	<10 m
Power Supply	3.3 V / 5V
Ampere	30 mA
Baud Rate Support	9600,19200,38400,57600,115200,230400,460800
Size	26.9 mm * 13 mm * 2.2 mm
Weight	10 grams

Table 3 Interface of HC 05 Module

No	**Interface of HC-05 Pin**	**Interface of Arduino Pin**
1	VCC	5V
2	GND	GND
3	TX	D2
4	RX	D3

C. Board Bluno Nano (Bluetooth 4.0)

Bluno Nano is a board as a product of DFRobot Bluno Family. This board is equipped with a Bluetooth 4.0 technology device module, known as BLE (Bluetooth Low Energy) on the 2.4 GHz frequency. The specification of this board is presented in Table 4.

Table 4 *Board* Bluno Nano[5] Specification

Specification	**Remarks**
Bluetooth Version	4.0 (*Bluetooth Low Energy*)
Frequency	2.4 GHz
Scope	< 15 meter
Power Supply	5 V
Ampere	15 mA
Baud Rate Support	9600,19200,38400,57600,115200,230400,460800
Size	53 mm * 19 mm * 12 mm

Weight	20 grams

D. Research Subject

In this research, the researcher aimed to measure and compare the performance of a component in the system [2]. The component used as the research object was the HC-05 bluetooth module device. Here, the researcher replaced the HC 05 module component using *bluetooth 3.0* technology with Bluno Nano board component using *bluetooth 4.0* technology.

Maximum Distance *Scope* (S) was the first subject used as the consideration of performance comparison. The maximum scope measured in this experiment was also related to the ability of the module device to serve or work.

The second subject to be concerned tention to was the voltage value (V), affecting the power required by the device to carry out its work. Voltage is one of the important variables as it is one of the values that will affect the amount of power used by the device to run its work.

Finally, the third subject observed by the researcher was the delay or length of time required for a protocol to send its data to the target device.

E. Measurement Devices

To get the test data, the researcher used five tools for measuring the variables that can be measured including battery, ubec, cable, multimeter and smartphone.

Multimeter was the first tool that can measure several values of electrical quantities such as voltage (V), current strength (I) and resistance (Ω).

Figure 4 Multimeter

The smartphone was used to read and accommodate the data sent by the Toddler Growth Recording device via a bluetooth device. In addition, it was also used to record the length of time sent by the system by comparing the timing between transmissions from Bluetooth devices to smartphones. The smartphone devices used were those that have used Bluetooth 4.0 technology.

Figure 5 *Smartphone*

UBEC (Universal Battery Elimination Circuit) was used to adjust the amount of voltage from the battery to HC 05 and Bluno Nano devices to adjust the maximum voltage load (5 volts) that can be received by each device.

Figure 6 *UBEC*

Furthermore, the tool used was a battery. The specification of battery used in this experiment was a Lippo battery with the ampere of 2200 mAh. The last thing that was used as a tool was the micro USB cable to connect the power to the tested hardware component.

Figure 7 battery

Figure 8 USB Cable

F. Data Collecting Method

To get the results of the device's performance, the researcher conducted the following treatments:

1. Each of devices, HC 05 and Bluno Nano, was connected in series to the battery via ubec as shown in Figure 8.

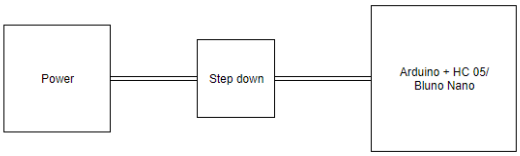

Figure 8 Scheme of the Testing Sequence towards HC 05 & Bluno Nano

2. The initial voltage (V) subsequently was measured and recorded before the two devices were connected to a power source and worked.
3. After working for an hour, it was continued with the measurement of final voltage (V) of both HC 05 module and the Bluno Nano board in idle mode for one hour.
4. Then, measurement and recording of the initial voltage (V) was again performed prior to connect the two devices to the power source for work.
5. The measurement and record of final voltage (V) of HC 05 module and the Bluno Nano board were carried out after working for one hour.
6. Furthermore, the testing of data transmission was carried out using three distance variations: 1 meter, 5

meters, and 10 meters. At each distance, measurement was made towards the pause of data transmission.

III. Results and Discussion

This chapter will discuss the results of the testing and comparison of HC 05 module and Bluno Nano. The two devices were assembled using a 2200-mAh Lippo battery. The first thing to do was to measure the distance range as shown in Table 5 on both devices.

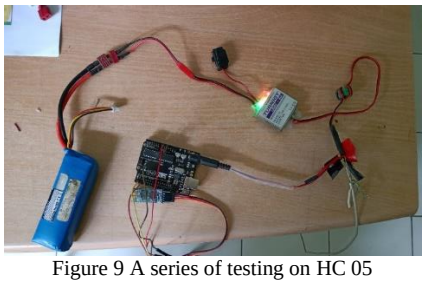

Figure 9 A series of testing on HC 05

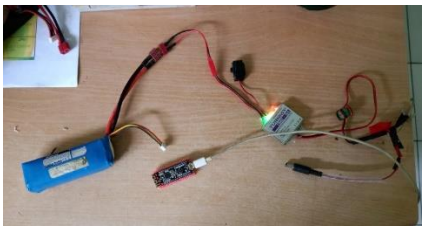

Figure 10 a series of testing on Bluno Nano

For devices using HC 05 module, the limit for data communication could reach 10m, while the Bluno Nano could reach 20m. The HC 05 range itself only reached a distance of 10 m because it used the Bluetooth 3.0 protocol. Whereas, Bluno Nano could reach a distance of 20 m because it used the Bluetooth 4.0 protocol with a range of up to 20m. Table 5 shows the results of the comparison of the distance test.

Table 5 Results of the Testing on Distance

No	Distance	Hardware	
		HC 05	Bluno Nano
1	1 m	Sent	Sent
2	2 m	Sent	Sent
3	5 m	Sent	Sent
4	10 m	Sent	Sent
5	15 m	Not	Sent
6	20 m	Not	Sent
7	25 m	Not	Not

Table 6 furthermore shows the results obtained for the battery used to know the power consumption of the current contained in each device. After getting the results as shown in Table 6, the measurement of the amount of power consumed by the two devices in performing work was carried out in accordance with the formula of power measurement as written below.to measure the power used by the device.

$$P = V.I \quad (1)$$

- P = *Watt*
- V= *Volt*
- I = Ampere

As shown in Table 6, the voltage value on each device after being measured in doing its work was found. Then, the battery specifications used had the ampere of 2200 mA or 2.2 Amp. Thus, the results obtained are as follows:

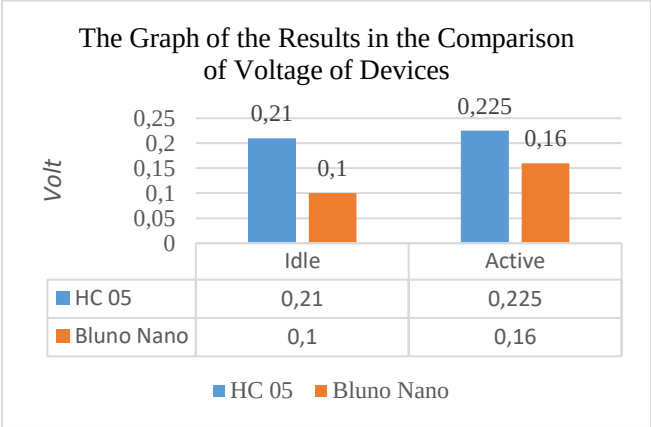

Figure 11 The Graph of Comparison in the Voltage Test

Table 6 The Results of the Voltage Reduction Measurement

No	Condition	Voltage (*V*)	
		HC 05	Bluno Nano
1	*Idle Device*	0.21 Volt	0.10 Volt
2	Active	0.255 Volt	0.16 Volt

The result of this first power calculation was when HC 05 module was in idle state and in active state:

The results can be seen in Figure 12 showing the Comparison Chart of Calculating Device Power Consumption. In HC 05 device, the power consumed when the module was only turned on without doing any activity was approximately 0.462 Watt and when transferring Data it was found at approximately 0.561 Watt. Whereas, for the Bluno Nano device, the power spent in idle state was 0.22 Watts and to send the data, it consumed approximately 0.352 Watts. The results of the measurements can be seen in Figure 12 showing the Comparison Result Graph of Device Power Consumption.

Based on the measurement results obtained from the power calculations of both HC 05 and Bluno Nano module, the Bluno Nano device consumed 52% of the power at the idle state and 37% when the device transferred the existing data. For overall measurement related to the power efficiency, the consumption by Bluno Nano against HC 05 module reached 44%.

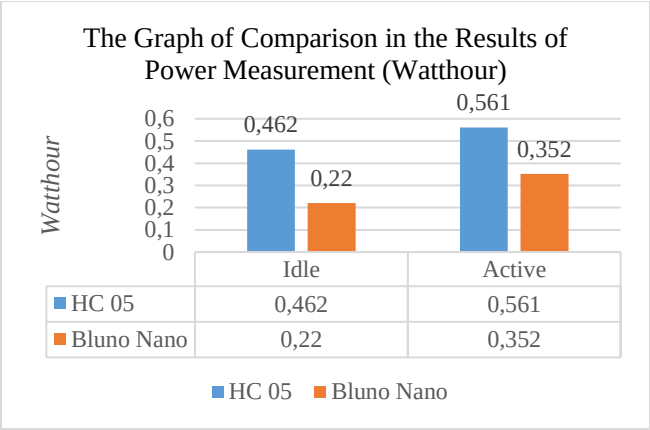

Figure 12 The Graph of Comparison in the Measurement of the Power Consumption of Devices

The bluno nano device could save the power consumption until 52% in silent mode for being supported by Bluetooth 4.0 protocol, which had an ability to minimize the power consumed when the device was in idling mode without doing any works. This was because Bluetooth 4.0 will only maintain pairing or connection with connected Bluetooth devices without broadcasting to make the power consumed was still little and more efficient. Meanwhile, HC 05 module using the bluetooth 3.0 protocol would continue to broadcast data even though no data were sent to maintain connection with other devices.

Meanwhile, the efficiency when working alone, there was no far difference between HC 05 module and Bluno Nano device; it was only approximately 37%. This was related to the Bluno Nano's ability, supported by the Bluetooth 4.0 protocol that was capable of minimizing the power consumed during pauses between transmissions.

Furthermore, there are three tables showing the results obtained after comparing the waiting time test of the two devices. In the waiting time test, the distance was tested at 1 meter, 5 meters, and 10 meters as shown in Table 7, 8 and 9.

Table 7 Result of Comparison in the test of waiting time test with 1-meter distance

Experiment	Device's Wating Time	
	HC 05	Bluno Nano
1	1.93 seconds	1.65 seconds
2	1.88 seconds	1.12 seconds
3	1.99 seconds	1.07 seconds
4	1.80 seconds	1.45 seconds
5	1.73 seconds	1.31 seconds
Average	1.866 seconds	1.32 seconds

In Table 7 the comparison of in the results of the waiting time test from both HC 05 and Bluno nano was not much different for a distance of about 1 meter. In this test, the results of the average waiting time of the two devices did not reach a difference of 1 second. Based on the results obtained, the Bluno Nano board device had a waiting time faster than HC 05 module. So here, it can be seen that Bluno Nano board was faster around 29% in a distance of 1 meter compared to HC 05 module.

Table 8 The Results of Comparison in Waiting Time Test in the 5-meter Distance.

Experiment	Device's Waiting Time	
	HC 05	Bluno Nano
1	2.5 seconds	1.11 seconds
2	3.42 seconds	1.5 seconds
3	2.7 seconds	1.51 seconds
4	2.15 seconds	1.14 seconds
5	3.71 seconds	1.61 seconds
Average	2.89 seconds	1.37 seconds

The results of the second distance test at a distance of 5 meters can be seen in Table 8. In testing the waiting time for a distance of 5 meters, Bluno Nano board still had an advantage over HC 05 module as seen from the average waiting time obtained with a difference of about 1.52 seconds. The Bluno Nano board device still had a fairly stable waiting time for a distance of 5 meters, still less than 1.5 seconds for the average sending time. In this test, the waiting time for Bluno Nano board was about 52% compared to HC 05 module.

Table 9 The Results of the Comparison in the Waiting Time Comparison at the distance of 10 meters.

Experiment	Device's Waiting Time	
	HC 05	Bluno Nano
1	2.72 seconds	1.1 seconds
2	2.5 seconds	1.57 seconds
3	3.7 seconds	1.15 seconds
4	2.91 seconds	1.92 seconds
5	2.82 seconds	1.35 seconds
Average	2.93 seconds	1.41 seconds

The third waiting time test was carried out at a distance of about 10 meters. At this distance, the waiting time for the HC 05 module was quite unstable with the average waiting time value of about 2.93 seconds. Meanwhile, Bluno Nano board for testing at a distance of 10 meters was still quite stable for the waiting time obtained and the average value generated in the 10- meter distance test was 1.41 seconds.

In testing the comparison of the waiting time for a distance of 10 meters, the difference in waiting time between HC 05 module and Bluno Nano board was found about 1.52 seconds in which Bluno Nano board was found more excellent.

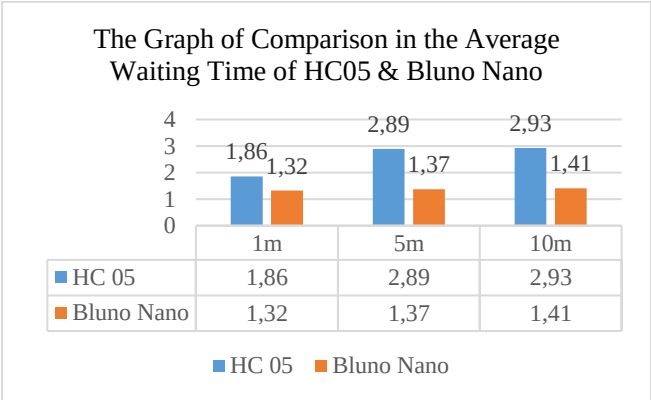

Figure 13 The Graph of the Comparison in the Waiting Time Test

Figure 13 shows the overall results of the waiting time test of the two devices. As seen in Figure 13, HC 05 device had a significant comparison of the waiting time for data transmission about 1 second when the distance of HC 05 module was close to the data receiving device.

Meanwhile, Bluno Nano board had a fairly stable average time for the three test distances with the average sending distance not more than 1.5 seconds of waiting time for sending. Figure 13 shows the test data for the overall comparison of the average time of the two devices in which Bluno Nano board device had an overall average time advantage of 1.2 seconds compared to HC 05 module.

From the results obtained by testing the distance, power and average waiting time of the two devices, it can be seen that the Bluno Nano board device had more advantages in the three tests conducted compared to HC 05 module.

Table 10 Results of Comparison in Completed Tests

No	Test	More Excellent Device	Results
1	Maximum Distance Scope	Bluno Nano	20 meters
2	Power (Idle/Active)	Bluno Nano	0.1/0.16 *WattHour*
3	Average Waiting Time (1m/5m/10m)	Bluno Nano	1.32/1.37/1.41 seconds

From the results of the distance and power testing of the two devices, it can be seen the advantages of Bluno Nano board, using the Bluetooth 4.0 protocol in which it had a fairly stable distance range and a more efficient working method in saving power used. Compared to the HC 05 device which used the bluetooth 3.0 protocol.

Furthermore, from the test results of the average waiting time of the two devices, it can be seen that the advantages of Bluno Nano board, using a bluetooth module directly attached to the device (inlane model), was more excellent in terms of data transmission compared to the HC 05 module which must be connected to main board such as Arduino.

IV. CONCLUSION

Based on the results of tests that have been carried out in comparing HC 05 module devices using the bluetooth 3.0 protocol with Bluno Nano board using the bluetooth 4.0 protocol on the Toddler Growth Measurement Tool, it can be concluded that:

1. Bluno Nano board had a longer scope compared to HC 05 module. Its reach was up to 20 meters.
2. The voltage drop from Bluno Nano board occurred at idle state and worked less than HC 05 module. Thus, when calculating the power consumption of Bluno Nano board, the power required by Bluno Nano board was less than HC 05 module.
3. Bluno Nano (bluetooth 4.0) board had a lower waiting time compared to HC 05 (bluetooth 3.0) module.
4. HC 05 module as a separate component from the board had an advantage in its design, because if there is a damage to one of the components it can reduce repair costs without any repairment for the whole system.

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