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The Implementation of Internet of Things Using Test Bed in the UKMNET Environment

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Abstract:
The Internet of Things (IoT) is one of the most important components for the 4.0 industrial revolution. Among today's problems of computing is the need for high power consumption and considerable space and equipment usage. Therefore, a small-sized technology and requires only low power to operate is necessary. A study has been conducted to study the implementation of IoT within the UKM network environment known as UKMNet. Furthermore, a test bed is developed using an Arduino Uno board as the IoT Hardware. To test the performance of the connection between the Arduino board and the server, the iPerf software is use. As a result, we find that Arduino Uno is suitable for use as the IoT hardware for this scenario. Performance tests for Arduino board also meet the requirements for the implementation of IoT where the data transmission rate is between 3.483 Mbps up to 3.563 Mbps. The jitter value for this connection is also lower than 1.80 milliseconds to 1.85 milliseconds while the packet loss rate recorded is 0% to 0.59% for 10 seconds of data transmission. In conclusion, by using Arduino Uno as an IoT hardware is suitable to implement in the UKMNet.

***Keywords**: : 4IR, Arduino Uno, iPerf software, UKMNet*

Introduction:

The Internet of Things (IoT) is a new evolution of the Internet which encompass different objects with different abilities, which has the same way to communicate to enable the transfer of information, where this information is understood by two or more objects to make the process more efficient, where it will reduce human involvement and interaction. Numerous researches have been conducted about IoT to prove the huge need in developping new platforms for this technology [1].

Examples of these objects are detectors or electronic devices such as computers, smartphones, televisions, machines and robots [2]. Innovations in the manufacture of detectors and small electronic equipment have led to the use of IoT, besides the cost factor of small devices that become cheaper and accessible to anyone. In addition, internet usage rates worldwide have also contributed to the increase in the use of IoT devices worldwide [3].

The 4.0 Industrial Revolution (4IR) brings paradigm changes in the economy, social life, health, education, lifestyle, employment and skills development [4]. One of the important components in today's 4IR warmly talked about the world is IoT. According to Klaus Schwab [5], in his book entitled 'The Fourth Industrial Revolution', he explains that 4IR is run by three major domains of physical, digital and biological, in which the domain is supported by nine major pillars; IoT, computer simulation, virtual reality, system integration, cyber security, cloud computing, manufacturing, three-dimensional printing and robotic automation. Figure 1 shows a major pillar in the 4.0 Industrial Revolution.

The word IoT has been used since 1997 by British technology leader, Kevin Ashton [6], in describing

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where a physical object can be connected to the Internet which involves a lot of use of the detector. He has used the Radio Frequency Identification tag (RFID) to detect and calculate the quantity of an item without involving human interaction [7]. According to Rafique et al. [8], RFID is an automated identification system that can identify objects via radio waves in their network without interruption. RFID also uses radio frequencies to identify target objects and gather relevant information such as identity, status and location. The RFID consists of three components: tag, reader and antenna [9].

According to Miraz et al. [10], IoT consists of five main components: detectors, nodes, receivers, movers and devices. According to Ranjan [11], IoTis a transformation process for connecting smart devices and objects to the network to perform certain tasks efficiently and can be achieved remotely. This statement is supported by Hassan et al. [12], where IoT have become a smart concept for the Internet, as all objects around us can be connected to the Internet and have the ability to exchange information, organize data and work efficiently. However, this Internet network is vulnerable to some attacks that cause severe direct impacts on networks, such as sabotage, breaking networks and stealing information [13]-[14].

This study was conducted to examine the suitability of the implementation of IoT in the UKMNet environment as UKMNet has a unique network connection. For starters, researchers used detectors to measure the current and voltage connected to the IoT test site and then measure the network performance for this device connection to UKMNet. It involves the connectivity of fiber optic technology connected by using switches from the AVAYA model or now known as Extreme Networks as the main pulse of UKMNet. These switches are divided into categories of main switches, distribution switches and access switches where the number of switches connected in UKMNet is over 573 units [15]. Figure 2 shows the UKMNet network involving connections to several campus locations and research centers.

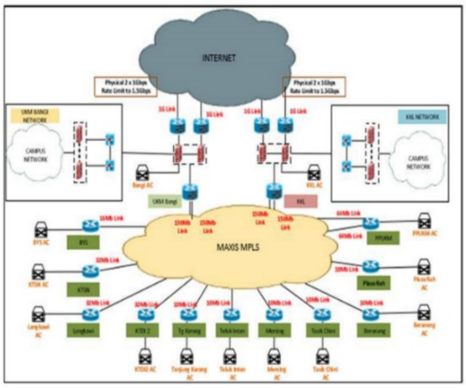

Fig. 1. UKMNET network

In order to ensure that this study is working successfully, selecting the appropriate IoT hardware used in the UKMNet environment must be carefully crafted as it definitely has different impacts and outcomes Therefore, we chose to use Arduino Uno as a component of this IoT drive. This is because the price is cheap, popular and easy to find. A study of appropriate performance metrics and software is also implemented. The iPerf software is chosen because it is easy to get on the Arduino board and it meets the metrics you want to measure data rates, packet loss and packet loss rates.

1 RESEARCH METHOD

The first phase in this research methodology is a statement of the problem in which the researcher understands the problem first by finding the basics in the relevant field. In the second phase, researchers conduct literary studies to deeply understand IoT. In this phase, researchers are reviewing the relevant studies that have been conducted. As a result, a design proposal for this study was developed as one of the processes in the third phase. The fourth phase shows how the implementation was implemented.

Finally, in the fifth phase, performance assessments are evaluated. In the third step, a proposed design was developed to build a test site for the IoT study that put into the UKMNet environment. Test site using Arduino Uno boards as an IoT platform connected with YHDC detector. The

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IoT platform is then connected to an UKMNet network where a server is used to function as an interface media for data storage to a database. This data is received from Arduino Uno boards that receive current and voltage information from the YHDC detector. Figure 3 shows the connection design of the developed test site.

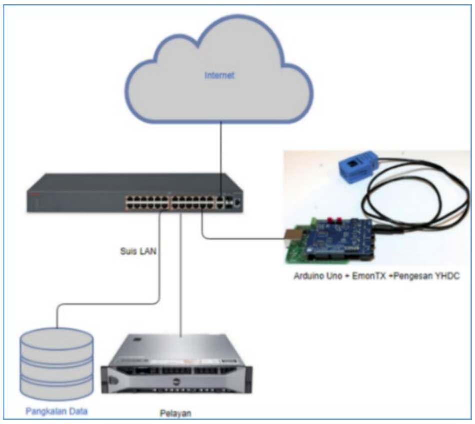

Fig. 2. Test site design

2 RESULTS AND DISCUSSIONS

This test site was taken during January 2019 to obtain results from the YHDC detector installed on the test site located at the Data Center, Center of Information Technology, UKM. This YHDC detector is set to send data to the server every 15 seconds. Therefore, the readings recorded in the database are the average readings for each day. Figure 3 shows the result of the current reading value in the ampere of the four detectors placed at the test site. Figure 4 shows the result of the voltage readings in volt for the four sensors placed at the test site. Figure 5 shows the trend of the temperature reading value in degrees Celsius which represents one case only as the readings are the same for the four cases.

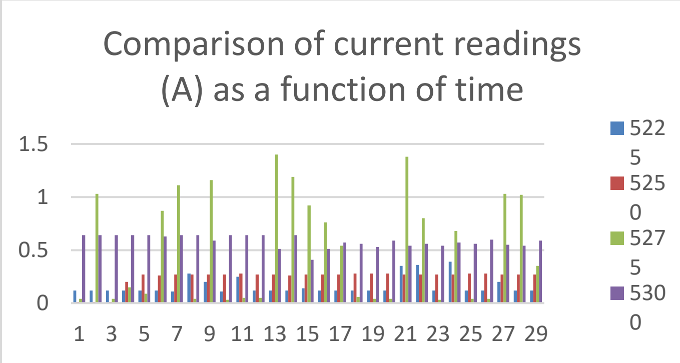

Fig. 3. Comparison of current readings as a function of time

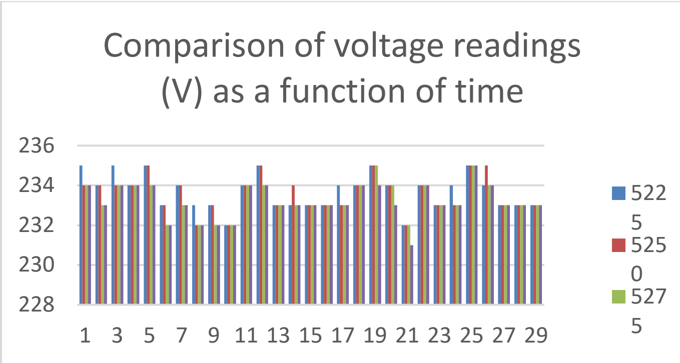

Fig. 4. Comparison of voltage readings as a function of time

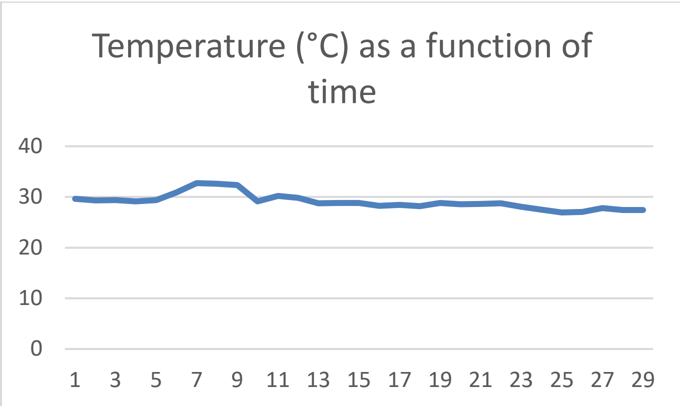

Fig. 5. Temperature (°C) as a function of time

As a result of the current and voltage information obtained from the detector, the server translates the value to the use of electrical power generated by the electrical apparatus measured at the test site. Figure 6 shows the distribution of the average power value generated by the electrical apparatus.

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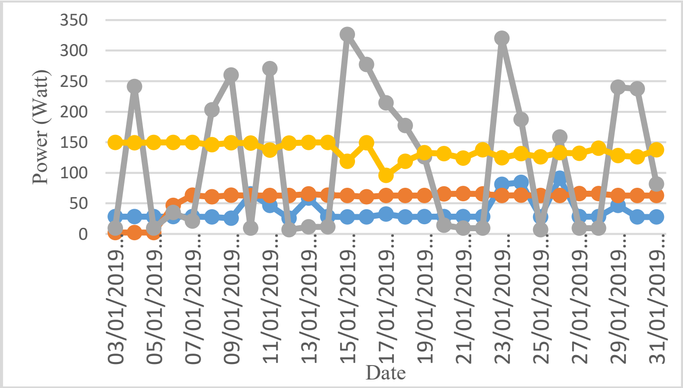


Fig. 6. Average electricity consumption for January 2019

2.1 Data Transmission Rate

Data transmission rates are measured to test the rate of transmission of data from Arduino boards and computers within the same network. To ensure the validity and accuracy of the results, the test was conducted several times and this study lists three test results that have been implemented. Table 1 shows the results that have been recorded from the three tests performed. Figure 7 shows the comparison between the tests.

Table 1. Tests result

Time (second)	Data Transmission Rate (Mbps)		
	Test 1	**Test 2**	**Test 3**
10	3.76	3.77	3.45
20	3.58	3.59	3.58
30	3.28	3.37	3.39
40	3.55	3.56	3.38
50	3.65	3.66	3.51
60	3.63	3.65	3.62
70	3.34	3.54	3.58
80	3.43	3.42	3.51
90	3.36	3.69	3.45
100	3.25	3.38	3.39
Average	**3.483**	**3.563**	**3.486**

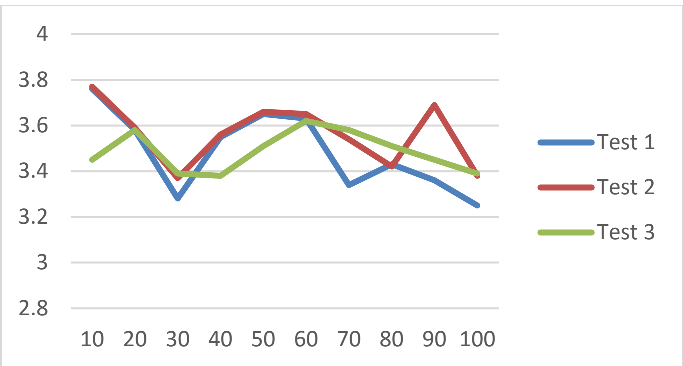
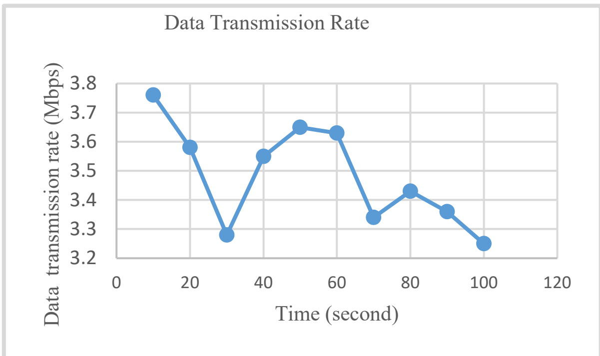


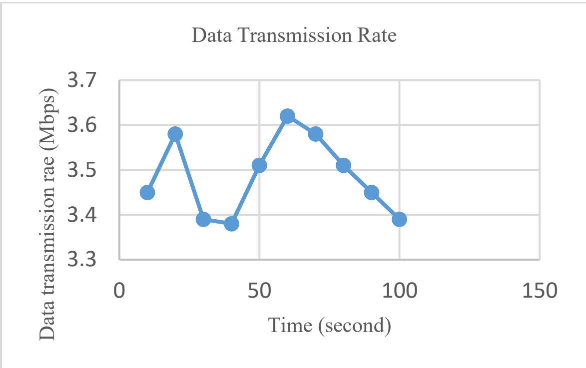
Fig. 7. Tests comparison as a function of time

Figure 8 shows three plots that have been plotted for performance metric test for the rate of data transmission. Based on the plotted tables and graphs, it is obtained on average, the data transmission rate for this Arduino board is between 3.483 Mbps and 3.563 Mbps. This data rate is sufficient for small data transmission because the Internet only involves sending small data.



(a)

(b)



(c)

Fig. 8. Decision graph: (a) Test 1, (b) Test 2 and (c) Test 3

2.2 Jitter

Jitter is the space of time between one data packet with another data packet. From the results of the performance tests that have been performed, a table of results as in Table 2 has been recorded. Based on the test results that have been made, it is found that the resulting gain is between 1.80ms up to 1.85ms. This value is small and does not give a significant difference because the data transmission of any Internet tool only involves a small data packet.

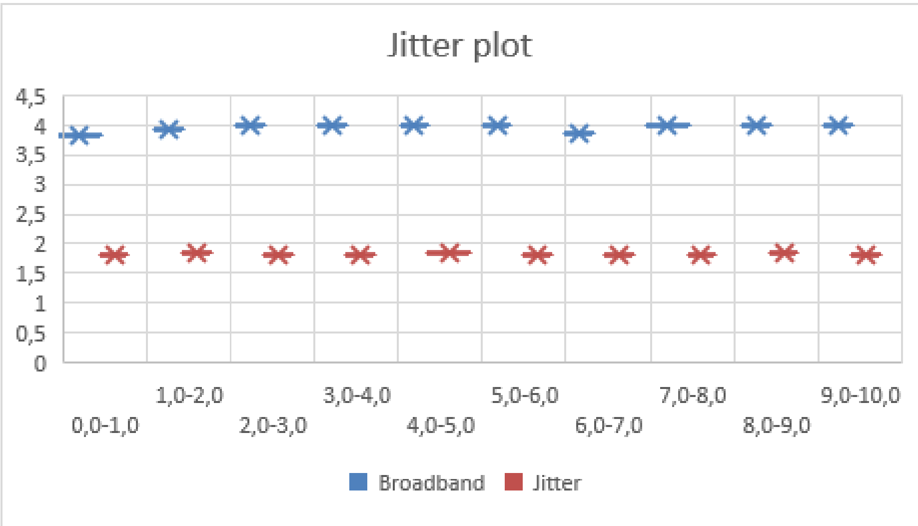


Fig. 9. Jitter plot

2.3 Loss of Packet

To ensure good link quality, package loss should not exceed 1%. High packet loss rates result in a large number of re-transmission of TCP segments that affect broadband. Table 2 records the number of packets transmit and the number of packets missing for the packet loss data. Based on the results, the percentage of data packet loss is very small, less than 1% where the average packet loss is between 0% and 0.59%.

Table 2. Number of packets transmit and the number of packets missing for the packet loss data

Time (second)	Broadband (Mbps)	No. of packets loss	Total of packets transmit	Percentage of packets loss
0.0-1.0	3.84	0	837	0.00%
1.0-2.0	3.94	5	850	0.59%
2.0-3.0	3.98	2	851	0.24%
3.0-4.0	4.00	0	850	0.00%
4.0-5.0	3.98	1	850	0.12%
5.0-6.0	4.00	0	851	0.00%
6.0-7.0	3.87	1	755	0.13%
7.0-8.0	4.00	0	850	0.00%
8.0-9.0	4.00	0	850	0.00%
9.0-10.0	4.00	0	851	0.00%

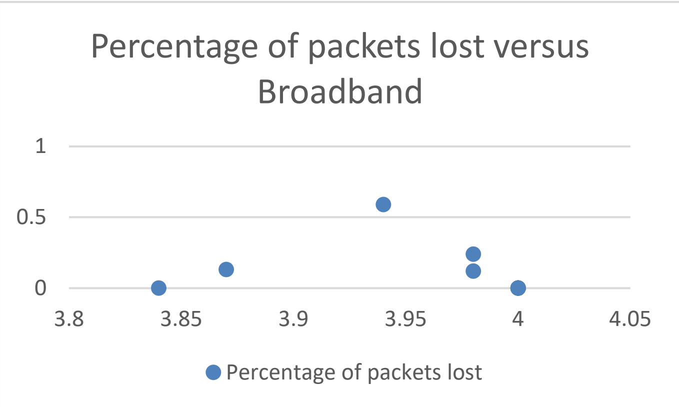


Fig. 10. Percentage of packets lost as a function of the broadband

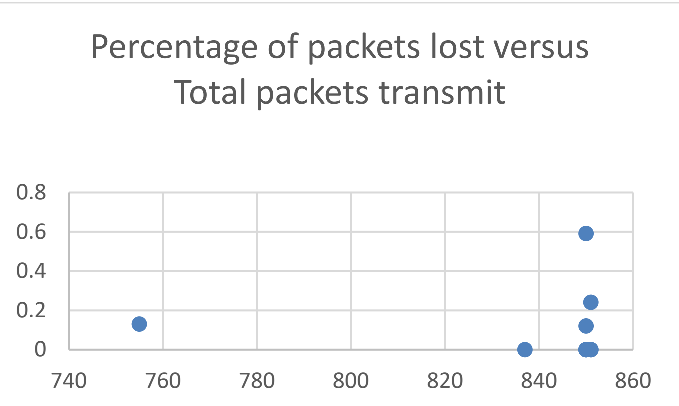


Fig. 11. Percentage of packets lost as a function of the total packets transmit

CONCLUSION

As a result of some of the tests and studies conducted, researchers found that Arduino Uno boards were suitable for use as IoT hardware in the UKMNet environment. Based on the research on the results of the Arduino Uno board performance test in the UKMNet environment, researchers found that data transmission rate performance was low but it was in line with the goals and uses of IoT which only meant for transmission of small data blocks. Performance test on this hardware found that the value of data transmission rates from Arduino boards to servers was between 3.483 Mps and 3.563 Mbps. The jitter test is between 1.80 milliseconds and 1.85 milliseconds while packet loss rates are between 0% and 0.59% for transmission of one block of data for 10 seconds. In conclusion, IoT using Arduino Uno as IoT hardware is best implemented in the UKMNet environment.

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