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Effect of Distance on the Maximum Data Transfer for Different Mounting Elevations of XBee Pro Module in Viral Advertisement System

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Abstract. This paper presents a study on the effect of distance between XBee Pro modules to the maximum data transfer for three different mounting elevations. The study has been conducted by using two units of XBee Pro modules which each represents a receiver and a transmitter. The transmitter is mounted in three different elevations which are 0.5, 1.5 and 2.5 meter from the ground while the receiver is fixed at the same elevation. When the transmitter continuously transmits the wireless signal carrying its particular address, the receiver will detect the signal address once the range of communication of both receiver and transmitter intersects. The results obtained are the values of data size, in bytes, with respect to the distance between receiver and transmitter for different mounting elevations of transmitter. These data are then converted into graph that illustrates the data size-distance characteristics for each mounting elevation. Finally, the best mounting elevation is to be identified based on the result obtained.

Keywords: XBee, wireless, advertisement

1. Introduction

In the development of advertisement system, the importance of having wireless technology is significantly increasing especially in the scenario where the information is dynamically changing over the time. This is because wireless advertisement allows the flexibility in sending and displaying the information as well as modifying it when necessary. Despite it also solves the environmental issue from the usage of papers which are going to be dumped later on.

There are several types of protocol that can be used for a viral advertisement system. The one that could be very common nowadays is Zigbee protocol. The information is wirelessly transmitted within the range of the XBee device. The size of the advertisement can be transmitted at a certain period of time is still a question needs to be figured out. This is because how far the information is being sent out will result in different effect. Hence this study is done to provide a better understanding in term of explaining the behavior of data size over the distance the data is transferred.

Previous researches have been done which employ Zigbee protocol in transferring data between different points. Researchers from Anna University of Technology have come out with their research regarding the study on Zigbee technology. The study discusses the characteristics of Zigbee like the power consumption, data rate, cost and time delay [1]. However the maximum data size of information over a distance did not come into consideration.

Another research was done by researchers from Akita, Japan regarding the flexible bus system using Zigbee as the communication medium. In their research, experiments were done to study the detection range as well as data transfer involved while the data being transferred was solely the bus routes and number of passengers [2]. Therefore, it is proven that Zigbee can be used in bus transportation system. This is a good motivation for a new research on the viral advertisement system which utilizes bus as the information carrier to spread out the advertisement.

In this paper, we will further discuss on the measuring principle in Section 2. Section 3 describes the experimental setup used for the data size measurement and finally in Section 4, we will thoroughly discuss the results obtained from the experiments

2. **Measuring Principle**

I. XBee Pro Module

XBee is a flexible wireless communication device that can be connected with microcontroller, computer or any system with serial communication. It is a product produced by Digi and can be divided into two types which are XBee and XBee Pro. Table 1 provides the differences between XBee and XBee Pro modules.

Table 1 XBee and XBee Pro comparisons

Specifications	**XBee**	**XBee Pro**
Indoor range(m)	30	100
Outdoor range(m)	100	1500
Power output(mW)	1	60
Supply voltage (V)	2.8 - 3.4	2.8 - 3.4
Receive current (mA)	50	55
Transmit current (mA)	45	270

From Table 1, it is proven that XBee Pro has more advantages in every specification compared to the normal XBee. That is the reason why XBee Pro is more preferable and has been chosen as the communication medium for this viral advertisement system. The outlook of the XBee Pro module is shown in Fig. 1

Fig. 1 XBee Pro

There are several types of XBee addressing mode for it to communicate with the other module. The one used in this project is the transparent mode. This connection mode only communicates two XBee modules by pairing its destination and its own address. For example, if there are two modules (XBee1 and XBee2), the DL (destination address) and MY (its own address) addressing are shown in Table 2.

Table 2 XBee addressing for Transparent Mode

Address	**MY**	**DL**
XBee1	1111	2222
XBee2	2222	1111

For the analysis of the system, transparent mode will be used because the experiment only involves two points and it supports the Zigbee point-to-point communication principle which is further discussed in the next part.

II. Zigbee Point-to-point Communication

A viral advertisement system for this project is accomplished by employing the point-to-point communication using Zigbee. In general, a point-to-point communication refers to the communication connection between only two networking nodes. Information transmitted by one node can be received by the other node, which is contrasted with a point-to-multipoint or broadcast communication where many nodes can receive the information.

In this viral advertisement system, the information transmitted and received is the advertisement ID itself. A bus plays the role as the information carrier that carries the advertisement ID and transmits it to the respective bus top. Note that the advertisement ID was sent from the mall to the bus beforehand. The scenario is illustrated in Fig. 2. In this case, the point-to-point communication is employed between the bus and the mall as well as the bus and the bus stop.

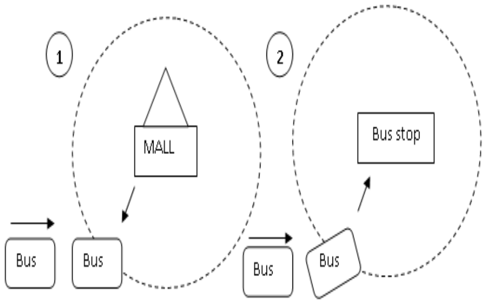

Fig. 2 Viral advertisement system

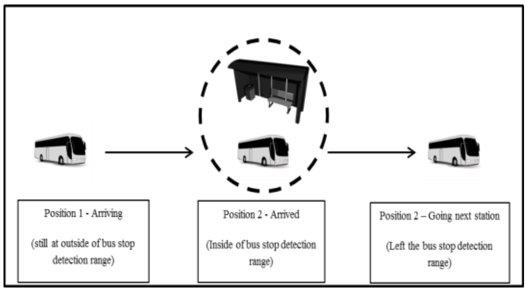

Fig. 3 Point-to-point communication between bus and bus stop

To further explain on the point-to-point communication, let us consider Scenario 2 from Fig. 2 only. It involves the communication between bus and bus stop as depicted in Fig. 3. The bus is now carrying the advertisement ID and approaching the bus stop but still in Position 1 which is outside the communication range. Once the bus entering the range as in Position 2, it will transmit the advertisement ID to the bus stop which is also equipped with computer and LCD monitor to display the information from the advertisement. The next experimental setup will only cover the measurement of data size transferred from bus to stop only in order to study the effect of distance on the maximum data size.

Each bus and bus stop is equipped with an XBee Pro module to support the Zigbee wireless protocol. The connection between the bus and the bus stop is accomplished right after the range of the module on the bus intersects with the range of the module at the bus stop. Each advertisement has its own unique ID which is recognized by the XBee module at the bus stop. Fig. 4 shows the flowchart of connection between the XBee module at the bus and XBee module at the bus stop.

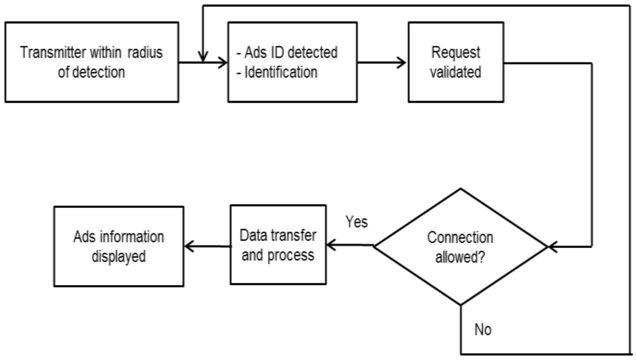

Fig. 4 Flowchart of connection between bus and bus station modules

3. Experimental Setup

An experiment is done to study the maximum data size that can be transferred in a certain time. As mentioned before, the measurement only covers the data transmitted from bus to bus stop only which is sufficient to study the data transfer behavior between two nodes. It is estimated that the time for a bus to pass a bus stop is 2 second without stop. For this reason, the data will be only sent within 2 second. Meanwhile each packet data size is 32 bytes because it is the estimate size for a simple advertisement. This experiment is done on a straight road by which the transmitter and the receiver are set in a line without any obstacle. Fig. 5 illustrates the flowchart of the experiment.

As known earlier, there are two nodes involved in this experiment which are the moving node (bus) and the stationary node (bus stop) as depicted in Fig. 6. The moving node will move towards the stationary node. The moving node will transmit the data and stationary node will loopback data received from moving node.

In this experiment, X-CTU software is used to monitor the data in two different computers. First computer is used with the transmitter while the other one with the receiver. That means each bus and bus stop is equipped with a computer having the X-CTU software for monitoring. The transmitter part and receiver part of the X-CTU are shown in Fig. 7 and Fig. 8, respectively.

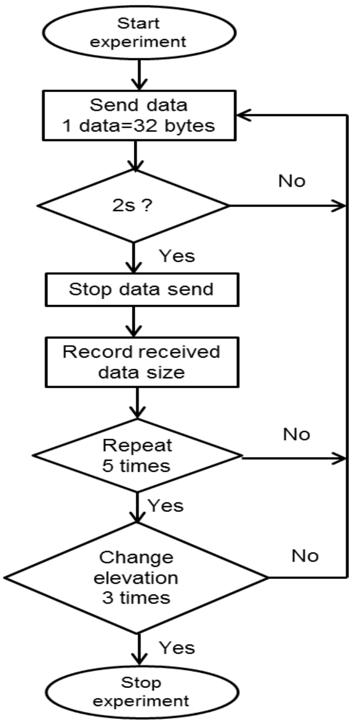

Fig. 5 Flowchart of experiment

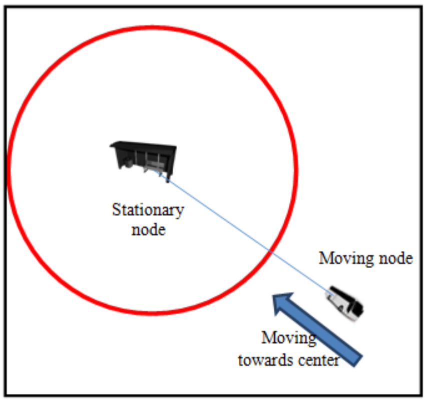

Fig. 6 Moving node and stationary node

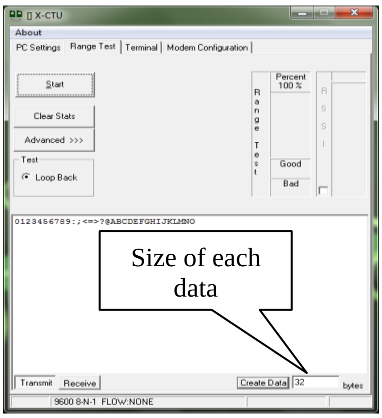

Fig. 7 X-CTU transmitter window

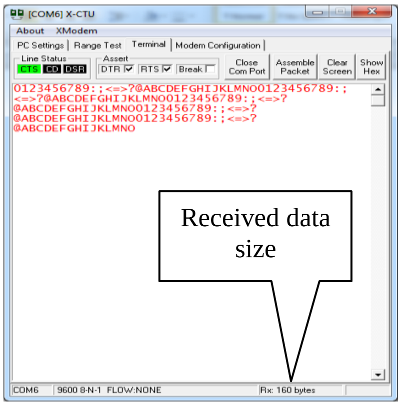

Fig. 8 X-CTU receiver window

The readings on how much the data size is received can be seen on the X-CTU receiver window as in Fig. 8. The readings are taken for different distance between the bus and the bus stop. For each distance, the mounting elevations of the XBee Pro module at the bus stop are set to be at 0.5 meter, 1.5 meter and 2.5 meter from the ground. Each point of elevation test is done to identify the best height for mounting the module at the bus stop.

4. Results and Analysis

Note that the experiment was done on the real road with a car used to represent the bus. The position where the bus stop located is fixed at the same point. To have more precise result, the data is measured in five trials for each distance and mounting elevation. The results are tabulated in Table 3 for different mounting elevations with average values of data size and finally converted into a graph as depicted in Fig. 9.

The graph shows the relationship between the data size (bytes) of advertisement to the distance of two XBee. From the datasheet, maximum effective range for XBee Pro is 1500 meter [3]. However from the experiment, we can send the data up to 1100 meter distance for each 2 second. We can see that the maximum data size can be transferred is up to 96 bytes.

Table 3 Measurement for different mounting elevations

Distance (meter)	Average Data Size (bytes)		
	0.5m	1.5m	2.5m
0	96	96	96
100	96	96	96
200	96	96	89.6
300	89.6	96	96
400	76.8	96	96
500	64	89.6	89.6
600	76.8	89.6	89.6
700	70.4	96	83.2
800	76.8	76.8	76.4
900	51.2	57.6	57.6
1000	51.2	44.8	44.8
1100	19.2	25.6	25.6

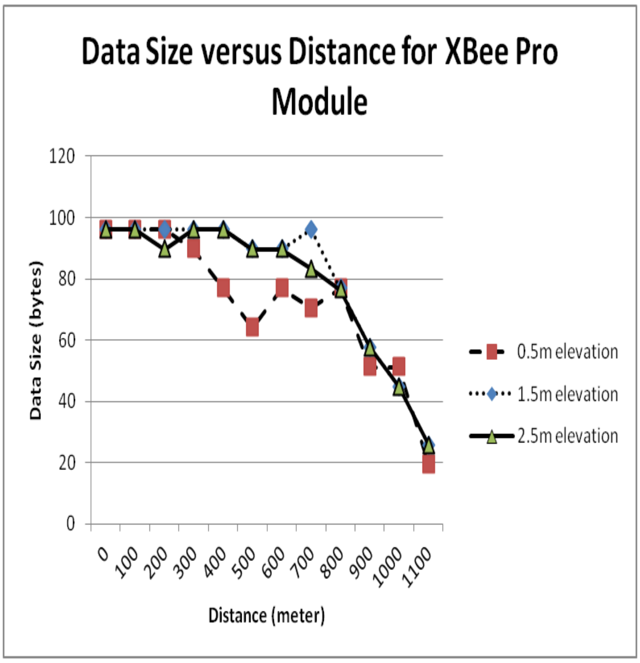

Fig. 9 Graph of data size versus distance for XBee Pro Module

As the distance increase, size of data received drops. It is hard to receive the maximum data in 2 second for a longer range. The data propagates more slowly due to long distance and energy of electromagnetic wave depleted as it propagates longer. Zigbee uses radio frequency to transmit and receive. Photons in the wave consist of energy that allows the radio wave to move, but the photon only has certain amount of energy. It only can propagate as long as the energy is sufficient [4]. This describes the general behavior of the graph in Fig. 9.

Among the three elevations, 2.5 meter seems to be the best position for the module to be mounted at the bus stop. The curve is almost stable showing that there is less disturbance effect from surrounding (vehicles on the road) when the module is mounted higher.

As we know the theoretical range of an XBee Pro module is 1500 meter in radius as from the datasheet, the efficiency of the module can be calculated.

$$Efficiency = \frac{Experimental\ radius\ coverage}{Theoretical\ radius\ coverage} x100\%$$

$$Efficiency = \frac{1100m}{1500m} \times 100\% = 73.33\%$$

Therefore the efficiency of the XBee Pro module used in this experiment is 73.33% compared to the distance range in the datasheet which is considerably high for the experiment in a real traffic environment.

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