The IP Cameras Performance in IEEE 802.11n Devices Implemented on WLAN Robot Version 2 for Moving Bomb in Thailand

SANON CHIMMANEE  
Msitm-online, IT Faculty  
Rangsit University  
52/234 Rangsit University, Muang-Ake, Paholyothin Rd., Pathumthani 12000  
THAILAND  
schimmanee@yahoo.com, sanon.s@rsu.ac.th

Abstract: - the WLAN robot v.2 for moving bomb away from crowd in the three southern provinces of Thailand needs two IP cameras. In this paper, the throughput of the video transmission from two IP cameras is observed. In IEEE802.11n, the maximum throughput can reach up to 600Mbps with 4 spatial streams by using MIMO technology and many other features which improve the performance sharply. Thus, the performance of two IP camera transmissions over 802.11n implemented on the proposed robot is investigated. The performance comparison of IEEE802.11 devices is also presented. The experimental results show the limitation of using IEEE 802.11g and 802.11n devices in the remote controlling robot.

Key-Words: - IEEE802.11g, IEEE802.11n, IP camera, WLAN, Robot, QoS

1 Introduction
IEEE 802.11n (draft 3.0) proposes the potential of throughputs beyond 200 Mbps, based on physical layer (PHY) data rates up to 600Mbps [1]. Marcelo Atenas et al. [2] tested the performance of the IPTV over IEEE 802.11n, which can be used for IPTV service provider. In an IPTV network, the video and audio streams are sent in MPEG through Real-time Transport Protocol (RTP). Haifeng Zheng et al. [3] investigated the performance of video transmission over IEEE 802.11n using frame aggregation mechanism. A. Matsumoto et al. [4] tested the throughput performance and the coverage range of IEEE 802.11n devices in vehicular networks. Syh-Shihu Yeh et al. [5] proposed the comparison between ZigBee and IEEE 802.11g and then implemented ZigBee on the rescue robot in order to transmit data over longer distances. Markus Johansson et al. [6] implemented the Intelligent ZigBee and WLAN enabled robot car. ZigBee was used for transferring of the robot car controlling commands while WLAN was used for in-car image transmission to the controlling computer. Christof Rohrig, and Frank Kunemund [7] presented a method to estimate position and heading of mobile robot in an indoor scenario, which this method for localizing the mobile robot is based on the use of receive signal strengths value of WLAN access point.

The previous work is a robot version 1 presented in a proceeding of Inceb’08 [8], which is a WLAN robot. This robot does not use ZigBee to transfer the robot controlling commands like [5-6] since both video streams and the robot command are sent via WLAN IEEE 802.11g. This results in reducing a complexity of both hardware devices and software for the remote robot control. It should be noted that the robot controlling command of the robot v.1 consumes a very low bandwidth since it is based on the Telnet protocol. The robot version 2 is developed to solve limitations of the robot v.1 [9]. IEEE 802.11n is implemented on the robot v.2. This paper presents the IP cameras performance over IEEE 802.11n that is implemented on WLAN Robot Version 2 for moving bomb crowd in the three southern provinces of Thailand. The performance comparisons of IEEE 802.11 devices are also investigated, especially focusing on remote robot control by using two IP cameras. Additionally, the performance comparisons of IEEE 802.11g and IEEE 802.11n is studied. From experiment result, it is found that the remote robot control at 140 meters is possible with a high QoS of video transmission from two IP cameras.

The rest of this paper is organized as follows: Section 2 gives the related works. In section 3, the experimental configuration is presented. Performance evaluation is proposed in the section 4. And the conclusion is introduced in the section 5.
2 Related Works

2.1 WLAN Robot
The previous work as shown in Fig. 1 is a robot Version 1 presented in a proceeding of Inceb’08 [1], which is a WLAN robot implemented 802.11g.

Fig. 1 The robot version 1 which is equipped with four wheels and IEEE802.11g presented in [8].

In order to eliminate the limitations of the robot v.1 [8], the robot v.2 [9] is established as shown in a Fig. 2. One of major problems of the robot v.1 is that when two IP cameras are enabled simultaneously, the remote controlling robot is possible in a short distance. Thus, IP cameras performance over IEEE 802.11 is needed to be investigated in order to realize the robot to remotely control in a long distance by using IP cameras.

Fig. 2 displays the proposed robot v.2 carrying the object, which is published in [9].

2.2 IEEE 802.11n
IEEE 802.11n (draft 3.0) introduces the potential of throughputs beyond 200 Mbps, based on physical layer (PHY) data rates up to 600Mbps [1]. There are many researches about the performance evaluation of IEEE 802.11 [2-6]. However, the IP cameras performance on the robot is still open to study.

3 Experimental Setup

3.1 Experiment 1
The robot v.2 as shown in Fig. 2 has two IP cameras. Fig. 3 displays the C# program that is used to remotely control the robot via IEEE802.11. In this form program, there are 4 windows for displaying the video from two IP cameras.

Fig. 3 C# windows application that is used to remotely controlling robot via WLAN, which is divided into 4 windows.

Fig. 4 Two video streams loaded on the two windows form. The control buttons are not loaded.
An objective of this experiment is to investigate bandwidth usage from enabling IP cameras for four steps. The result of this section can be found in section 4.1.

3.2 Experiment 2
In this experiment, there are also four tests as the subsection 3.1. An objective of this experiment is to observe the effect of RTT ping packets on the variable distance. The factor distance is in a range of 1-40 meters. This experiment is done on September 28, 2012 at Prachanivate 2 village as displayed in Fig. 8.

3.3 Experiment 3
A target of this experiment is to study the remote control using the remote controlling notebook via WLAN. The performance comparison of several access point implemented on the robot are presented. Fig. 9 shows three IEEE802.11g devices as follows 1) Linksys WRT54 G, 2) Linksys WRT54 G with two Linksys 7 dB antennas, and 3) Linksys WRT54Gx ver.2 that is MIMO technology with three antennas. Fig. 10 displays two IEEE802.11n devices as follows: Linksys WRT320N and Linksys WAP4410N that has three antennas. The outcome of this experiment can be found in subsection 4.3.
Fig. 9 Three IEEE802.11g devices implemented on the robot as follows: 1) Linksys WRT54 G, 2) Linksys WRT54 G with two Linksys 7 dB antennas, and 3) Linksys WRT54Gx ver.2 that is MIMO technology with three antennas.

Fig. 10 Two IEEE802.11g devices as follows: 1) Linksys WRT320N and 2) Linksys WAP4410N that has three antennas.

3.4 Experiment 4
A target of this experiment is to observe the performance comparison of RTT ping packets between IEEE802.11g and IEEE 802.11n. The effect of RTT ping packets on variable distance is studied. The outcome of this experiment can be found in the subsection 4.4.

4 Experimental result

4.1 Experimental Result 1
From the experiment 3.1, the average of throughput is needed for supporting QoS.

Table 1. Average of the Bandwidth usage of IP cameras.

<table>
<thead>
<tr>
<th>Distance from the robot (Meter)</th>
<th>one camera (Mbps)</th>
<th>One camera and control (Mbps)</th>
<th>Two cameras (Mbps)</th>
<th>Two cameras and controls (Mbps)</th>
</tr>
</thead>
</table>

4.2 Experimental Result 2
From the experiment 3.2, the effect of RTT ping packets on variable distance is lists in Table 2.

Table 2. Average of ping packets with size 256 bytes at distance from the robot to the remote controlling notebook in a range of 1 to 40 meters

<table>
<thead>
<tr>
<th>Distance from the robot (Meter)</th>
<th>one camera (Msec)</th>
<th>One camera and control (Msec)</th>
<th>Two cameras (Msec)</th>
<th>Two cameras and controls (Msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Meter</td>
<td>4.424</td>
<td>4.621</td>
<td>6.422</td>
<td>6.425</td>
</tr>
<tr>
<td>10 Meter</td>
<td>9.803</td>
<td>21.913</td>
<td>53.309</td>
<td>57.130</td>
</tr>
<tr>
<td>20 Meter</td>
<td>21.609</td>
<td>108.625</td>
<td>121.483</td>
<td>147.946</td>
</tr>
<tr>
<td>30 Meter</td>
<td>82.097</td>
<td>112.667</td>
<td>175.898</td>
<td>252.901</td>
</tr>
<tr>
<td>40 Meter</td>
<td>87.716</td>
<td>123.687</td>
<td>221.028</td>
<td>271.959</td>
</tr>
</tbody>
</table>

Fig. 11 Representation of the Table 2 in terms of the graph.
From Table 2 and Fig. 11, it is found the slope of the two cameras and controls is the highest. When the distance is on increase linearly, the RTT ping packets are also increasing linearly.

**4.3 Experimental Result 3**  
From the experiment 3.3, the acceptable distance that allows the robot to able to control is listed.

**Table 3.** Performance comparison in the remote robot control via WLAN using the remote controlling notebook.

<table>
<thead>
<tr>
<th>Distance (Meter)</th>
<th>SRX (802.11g) Msec</th>
<th>WAP4410N (802.11n) Msec</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Meter</td>
<td>8.178</td>
<td>7.371</td>
</tr>
<tr>
<td>20 Meter</td>
<td>8.477</td>
<td>7.213</td>
</tr>
<tr>
<td>30 Meter</td>
<td>9.797</td>
<td>6.842</td>
</tr>
<tr>
<td>40 Meter</td>
<td>7.898</td>
<td>6.892</td>
</tr>
<tr>
<td>50 Meter</td>
<td>13.456</td>
<td>7.128</td>
</tr>
<tr>
<td>60 Meter</td>
<td>20.080</td>
<td>8.108</td>
</tr>
<tr>
<td>70 Meter</td>
<td>15.127</td>
<td>6.562</td>
</tr>
<tr>
<td>80 Meter</td>
<td>15.334</td>
<td>6.139</td>
</tr>
<tr>
<td>90 Meter</td>
<td>15.338</td>
<td>8.309</td>
</tr>
<tr>
<td>100 Meter</td>
<td>15.249</td>
<td>5.063</td>
</tr>
<tr>
<td>110 Meter</td>
<td>9.727</td>
<td>5.091</td>
</tr>
<tr>
<td>120 Meter</td>
<td>11.612</td>
<td>7.021</td>
</tr>
<tr>
<td>130 Meter</td>
<td>17.985</td>
<td>13.392</td>
</tr>
<tr>
<td>140 Meter</td>
<td>16.909</td>
<td>11.448</td>
</tr>
</tbody>
</table>

From this table, it is found that IEEE802.11n (WAP4410N) enables the robot to remotely control at long distance about 140 meters with a high QoS.

**4.4 Experimental Result 4**  
From the experiment 3.4, the performance comparison of the long distance control between three antenna device of IEEE802.11g (SRX) and IEEE802.11n (WAP4410N) is listed.

From this table, it is found that IEEE802.11n (WAP4410N) gives a better performance of average RTT than IEEE802.11g (SRX) up to 47.83 %.

**5 Conclusion**  
This paper presents the performance comparison of the long distance control for the proposed robot. The proposed robot is possible to control at distance 140 meter by using IEEE 802.11n. For enabling two IP cameras, when the distance is on increase linear, the RTT ping packets is also increase linear. Based on three antennas of the access point, it is found that WAP4410N introduces a better performance of RTT ping packet than SRX up to nearly 40%. The longer distance and more times for testing will be extended in the further work.
References:


