Multimedia Transmission over Interworking of Bluetooth WPAN and IEEE 802.11g WLAN Networks

M. R. Ahmad, T. A. Rahman
Wireless Communication Centre (WCC)
Faculty of Electrical Engineering
University of Technology Malaysia
81310 Skudai, Johor, Malaysia
Email: {riduan, tharek}@fke.utm.my

***Abstract* – Multimedia services, which are the topic of this research, audio-video conferencing and video streaming, have gained much popularity in last years. This has been enabled by the high increase of computing power in home Personal Computers (PCs), which allows usage of very efficient video compression technologies. Motion Picture Experts Group (MPEG) 1, 2 and 4, Real Video can reduce the size of video clip by a factor of 200 – 1000 thus making it possible to put such transmission into regular computer networks, including wireless. This research focuses on testing the possibilities of multimedia transfer given by two of the most promising wireless technologies, which are Bluetooth and Wireless Local Area Network (WLAN) located in Wireless Communication Centre (WCC) building. Speeds up to 721 kilobit per second (kbps) allow not only transmission of the web pages, e-mail, chat but also conferencing with video and audio or streaming of live shows like sports matches or movies. This research discusses possibilities of audio and video transmission over Bluetooth Wireless Personal Area Network (WPAN) and IEEE 802.11g WLAN links: which scenarios are possible, what kind of software may be used and where is the actual limit of the Bluetooth speed, i.e. how much of the bandwidth is actually available for the transmission. The reliability of Bluetooth WPAN is then estimated under the stated conditions and scenarios.**

I. INTRODUCTION

Wireless connectivity has become the buzzword in today's networks. As a result, intense research activities around wireless networks and mobile networking led to the introduction of several technologies. Bluetooth was introduced as the new wireless standard for low cost, low power and local radio communications. This technology is designed to be small enough to fit inside any electronic device, hence revolutionizing wireless connectivity by enabling many new and innovative services for its users. Several usage models and applications are already being identified for various Bluetooth wireless mobile devices such as headsets, phones, computers, modems, and so forth.

Bluetooth also offers wireless access to Local Area Network (LAN), global Internet and the mobile phone network for a host of home appliances and portable handheld interfaces [1].

In this paper, we focus on the development of an IEEE 802.15.1 Bluetooth Wireless Personal Area Network (WPAN) that provides Internet and WLAN access to Bluetooth devices within the WPAN. The Bluetooth WPAN consists of three Bluetooth devices, where one Bluetooth device will act as the Network Access Point (NAP), while the other two Bluetooth devices as the Personal Area Network User (PANU). The NAP will provide the PANU in the Bluetooth WPAN the ability of accessing the WLAN and Internet without the need for any fixed Bluetooth access point. Then, we focus on the transmission of video streaming and conferencing services over developed Bluetooth WPAN. Extensive measurement has been done to validate the reliability of Bluetooth WPAN to carry multimedia contents.

II. BLUETOOTH WPAN INTERWORKING WITH IEEE 802.11g WLAN

The Bluetooth 1.1 specification was released in February 2001 [2]. The standard is developed around the Industrial, Scientific and Medical (ISM) band using the frequency-hopping system [3]. The hopping rate is 1600 hops per second. The operating frequency band is divided into 1 MHz spaced channels; each supporting data rate of 1 MHz. frequency hopping is used to minimize the effect of interference from other users within the same band.

The Bluetooth architecture defines a small cell, called a piconet, and identifies four states for the stations: master (M), slave (S), standby (SB), and parked or hold (P) [4]. Each station can be in the master or slave state. Slave stations can participate in one or more piconets. A master station can handle seven simultaneously links, and up to 200 active slaves in a piconet [4]. If access is not possible, a station enters the standby mode, waiting to join a piconet, but keeping its media-access control address. A station can be in the parked mode – that is, in a low power connection. But in this case, it must release its media-access control address. Up to 10 piconets can operate in one area [4].

The Bluetooth specification also provides mechanisms for Bluetooth devices to discover each other, exchange identities and establish communications with each other, all without prior

1-4244-0000-7/05/$20.00 ©2005 IEEE.

knowledge of each other. This is referred to as ad hoc networking. Security is also an important issue. Therefore, for the purpose of security and privacy, encryption is used as a safeguard against eavesdropping, and authentication is used for verification of identity.

III. Multimedia Streams Standards

A. Video Conferencing

There are two video conferencing standards; H.261 and H.263. H.261 standard refers to the visual and audio part of the conference. This standard has been in existence for a number of years and any system complying with it will at least be able to see and hear people using another compliant system. Only H.263 affects Desktop Video Conferencing. H.263 is supposed to link together different software standards by setting factors such as voice and picture syncing. This is not well implemented. The different interpretation of the standard means that if using a desktop system, to guarantee success, the equipment and software at both the send and receive site must be identical. This rule holds even if both systems say are comply with H.263.

B. Video Streaming

Transmissions of video streaming are resource intensive even when the video is compressed using sophisticated algorithms like MPEG and H.26. The delay requirement is a critical traffic component to real-time interactive streaming video for reliable services. However, non-interactive video streaming services such as video cast and video-on-demand (VOD) have some longer delay tolerance compared to interactive streaming services. This tolerance allows the non-interactive video streaming sender to smooth out the quantity of packets generated at the encoder. A common feature of conventional video coding schemes, MPEG and H.263, is that bit streams are generated through compression algorithms using variable-length codes (VLC) and the temporal predictive coding method.

Streaming protocols may be divided into 2 groups; delivery of the content and acquiring (ordering) the transmission. Multimedia stream is carried usually by the Real-Time Protocol stack (RTP/RTCP). It is being used by most of the solutions, including QuickTime, vic, rat and is also part of H.323 protocol stack used by Microsoft Netmeeting. The advantages of this protocol are its simplicity and flexibility. In IP domain, it is carried over simple and effective User Datagram Protocol (UDP).

IV. Testing Scenario

This section will present the scenarios of the multimedia transmission over Bluetooth WPAN tests. First is video streaming test and second is the video conferencing test. For both the video streaming and video conferencing tests, bandwidth consumption data had been collected and analyzed. All the tests were carried out at the Mobile Lab in Wireless Communication Center (WCC), Universiti Teknologi Malaysia. A simple floor plan for the Mobile Lab is shown in Fig. 1. As shown in Fig. 1, the distance between PANU 1 and NAP, distance between PANU 1 and NAP, distance between PANU 1 and PANU 2 are the same in length (d). Both tests had been carried out at each PANU for the distance of d=2m and d=5m using Line Of Sight (LOS) path and obstructed path. For both test, the obstacle used is a white board with the length of 2.5m and the height of 1m. The obstacle is located at the middle distance (d/2) between each PANU and the NAP. The WLAN IEEE 802.11g access point labeled as AP operates at 2.4GHz using channel 6. There were ten another access points that operate at the same frequency and using same channel in the building in radius about 50 meters from AP.

Basically, for video streaming, the video are being streamed from the local server connected to the switch and the quality of the streamed video is being observed. Then, the bandwidth consumption is being plot. Video streaming is the most demanding service tested in this work. Professional video streaming may demand as much bandwidth as 40 Mbps (HDTV MPEG-2 stream), but lower speeds are also possible. Bluetooth offers speeds up to 721 Kbps, so the streams tested in range 450 Kbps. Prepared stream has been uploaded to the content directories of the available streaming server which is Real Server. Real Server with Real Player from Real Networks is one of the most popular solutions for streaming multimedia in internet. By default, they use PNM protocol for transmission, but RTSP/RTP companion has been implemented in both server and player for compatibility with other solution.

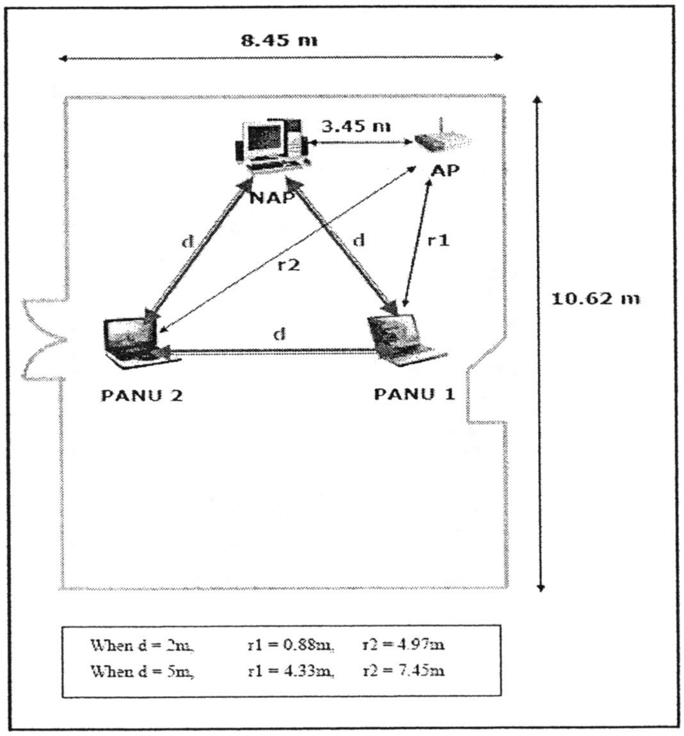

Fig. 1. The simple floor plan for mobile lab

Audio-video transmission may be used to create a conference with users spread across the globe. A product has been selected for evaluation which is MBONE tools (vic/rat). Vic and rat are tools widely used in the University environment for conferencing. They support various codec and work on practically all platforms.

Both the conferencing and streaming sessions has been established between laptop ACER and local server HP as shown in Fig. 2. Bandwidth consumption data collected at laptop ACER which represents the bandwidth utilization over Bluetooth WPAN and then the data analyzed. Two scenarios have been developed. First scenario is laptop ACER located 2 meters distance from the gateway (DWEN) with LOS and OLOS condition. Second scenario is laptop ACER located 10 meters distance from the gateway with LOS and OLOS condition.

V. Results and Discussion

A. Video Conferencing

From the Fig. 3 and Fig. 4, the bandwidth consumption for LOS is about 380 kHz while for OLOS is about 370 kHz. Both of the conditions occur even at the peaks when high motion occurred in front of the camera. Although there is only a difference of 10 kHz in bandwidth consumption of the LOS and OLOS but it is obvious that the obstructed path had contributed to the distortion of signals.

Although the bandwidth consumption for both the LOS and OLOS for the distance of 2 meters is about 10 kHz difference but the picture quality from experiment clearly shows that the picture quality of LOS is much better than OLOS. As a whole, from the observation during the testing, the picture quality for both is considered as excellent as there is no drop of signal during the testing.

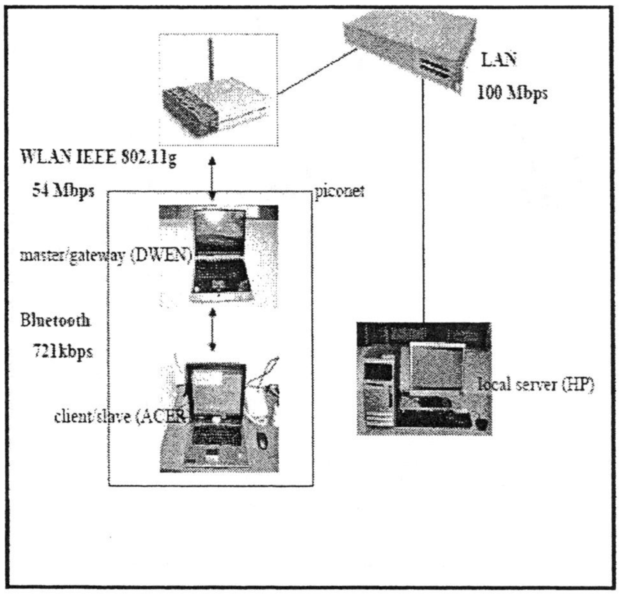

Fig. 2. Video conferencing and streaming test-bed

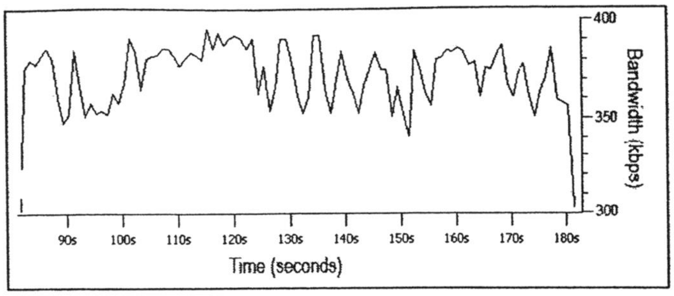

Fig. 3. Bandwidth uilization for 2 meters LOS scenario

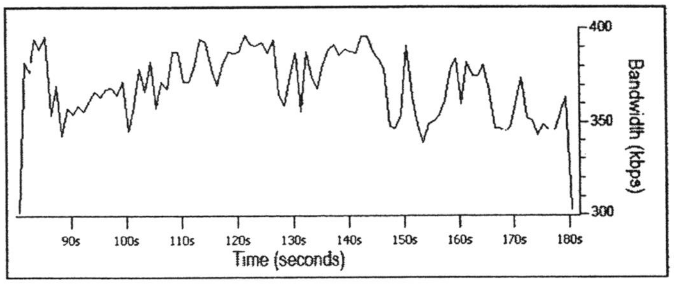

Fig. 4. Bandwidth uilization for 2 meters OLOS scenario

From Fig. 5 and Fig. 6, as for the distance of 10 meters LOS and OLOS, the bandwidth consumption drop only to half if were to compared to the bandwidth consumption of 2 meters LOS and OLOS. For LOS, the bandwidth consumption is about 160 kHz while for OLOS; the bandwidth consumption is about 130 kHz. The picture quality was not as good as those in the 2 meters but the motion was still very clear and there is no drop of signals for both the condition of LOS and OLOS.

Basically, for the distance of 10 meters, the video conferencing application can still be carried out but the picture quality is very bad. For 10 meters LOS, the picture can still move considerably smooth but for 10 meters OLOS, the picture do not move smoothly and it result in very poor picture quality. This mentioned scenario is for single user. As for multiple users, the link might not get the top quality. Then they can try to reduce the size of the captured video or agree to get some errors on the video, which may not disturb the conversation at all. Picture in the conference is usually only augmenting the sound and it is the sound that carries most important information. Audio is transmitted at 5.4 kHz by default and its quality should not suffer even at the highest congestion.

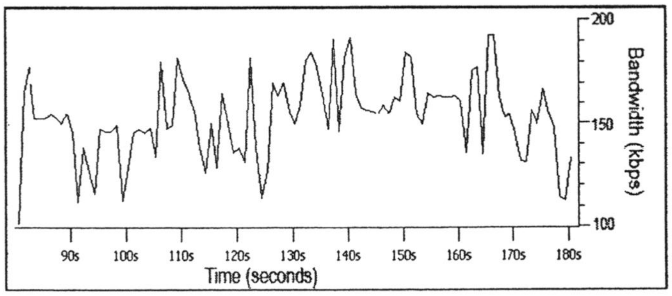

Fig. 5. Bandwidth utilization for 10 meters LOS scenario

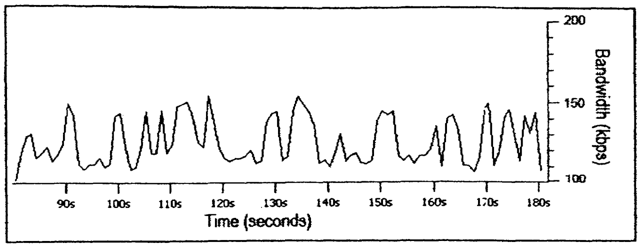

Fig. 6. Bandwidth utilization for 10 meters OLOS scenario

B. *VIDEO STREAMING*

Fig. 7 and Fig. 8 illustrate the bandwidth consumption for streaming of video files from the internet for the short distance of 2 meters. As observed from the graph shown, the bandwidth consumption is merely from the range of 450 kHz to 500 kHz. This means that it is still way off the Bluetooth speed of 721 kHz. From the observation during the testing, the sound and picture quality of the streamed videos are very good as well. They movie is as though we are watching directly from a broadcast television while the sound is crystal clear. From Fig. 9 and Fig. 10, the bandwidth consumption drop to less than 100 kHz. The picture quality of the streamed video is also very weak. Although the audio is still considered to be clear but the picture starts to lag.

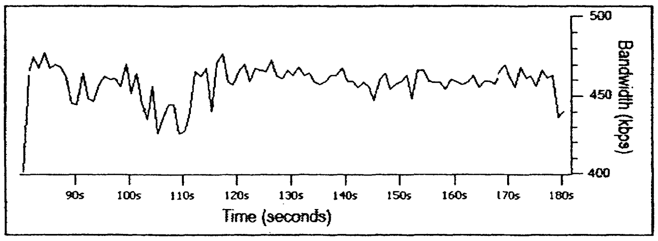

Fig. 7. Bandwidth utilization for 2 meters LOS scenario

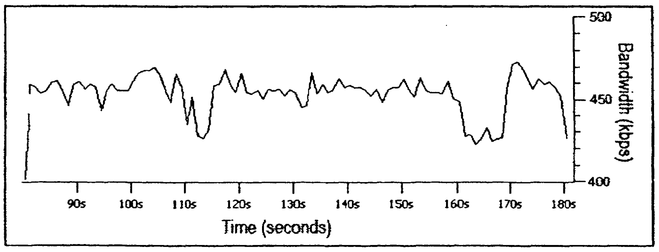

Fig. 8. Bandwidth utilization for 2 meters OLOS scenario

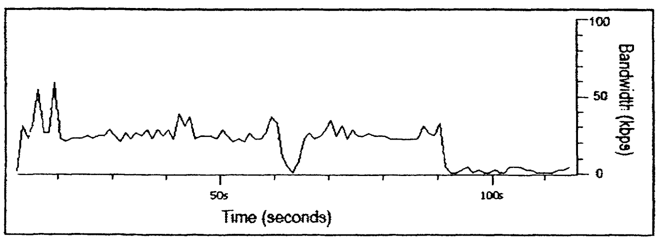

Fig. 9. Bandwidth utilization for 10 meters LOS scenario

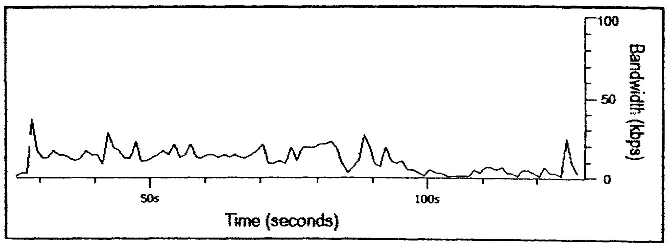

Fig. 10. Bandwidth utilization for 10 meters OLOS scenario

VI. CONCLUSION

Audio-video transmission performed with multimedia testing tools occupied up to 50% of the Bluetooth WPAN link, even with highest motion in front of the web camera. In the end, client/server architecture from Real Networks has been evaluated, providing answer to the question how much bandwidth in the Bluetooth WPAN link is actually available for the transmission.

The conclusion from the tests can be drawn that Bluetooth link is very suitable for multimedia transmission, as long as appropriate compression technologies are used. Distance between master and slaves and external interference from WLAN access points have contribute to the Bluetooth WPAN performance significantly for multimedia transmission. The size of the picture and frame rate also has to be somehow limited, but still providing very high quality.

REFERENCES

[1] R. Nicolas and H. Eric, "BWIG: Bluetooth Web Internet Gateway," in *IEEE Proc. 7th International Symposium in Computers and Communications, ISCC'02.*

[2] Ericsson Bluetooth Specification Version 1.1, Bluetooth SIG 2001.

[3] J. Y. Khan, J. Wall, M. A. Rashid, "Bluetooth-based Wireless Personal Area Network for Multimedia Communication," in *IEEE Proc. 1st International Workshop on Electronic Design, Test and Applications*, pp. 47-51, 2002.

[4] R. Jordan, C. T. Abdallah, "Wireless Communications and Networking: An Overview," IEEE Antenna's and Propagation Magazine, vol. 44, no. 1, pp. 185-193, 2002.

[5] M. C. Carlos, A. Sachin, T. Rishi and P. A. Dharma, "A Novel Architecture and Coexistence Method to Provide Global Access to/from Bluetooth WPANs by IEEE 802.11 WLANs," IEEE Journal 2003.

[6] A. Markus, F. Matthias, M. Peter, S. Markus, V. Asko and W. Andre, "IP Services over Bluetooth: Leading the Way to a New Mobility," IEEE Journal.

[7] K. Rolf, "Bluetooth Based Wireless Internet Applications for Indoor Hotspots: Experience of a Successful Experiment during CeBIT 2001," IEEE Journal 2001.

[8] I. Vilovic and B. Z. Cihlar, "Performance of the Bluetooth-based WPAN for Multimedia Communication," in 4th EURASIP Conference in Video and Image Processing and Multimedia Communications, 2-5 July 2003, Zagreb, Croatia.

[9] S. G. Miaou, C. Y. Huang, K. J. Ho and M. C. Tu, "Quality Degradation and Improvement of H.263 Video Transmitted in Bluetooth Packets under the Interference of Wireless LAN," IEEE Journal 2002.