WiMedia UWB Product Testing Report

Lebing Liu and Xiaodai Dong

Wireless and Networking Research Lab
Electrical and Computer Engineering
University of Victoria

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University of Victoria

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ABSTRACT

As all kinds of "next generation wireless network" technologies have emerged in the past few years, ultra-wideband (UWB) certainly caught everybody's eye with its high speed wireless connectivity and its potential for transferring full-high definition (HD) quality video over the air. This paper examines two commercial UWB products, ZeroWire Mini-PCI and ZeroWire HDMI from TZero Technologies Inc., through comprehensive evaluation tests in office and residential environments. These products conform to WiMedia's multi-band orthogonal frequency division multiplexing (MB-OFDM) specification. Detailed throughput versus range measurements and visual testing of TZero's wireless HDMI solution demonstrate the impressive performance of these UWB modules for high speed HD video distribution.

1. INTRODUCTION

In recent years, the rapidly growing arena of personal communication technology has enabled a new digital home lifestyle filled with various consumer electronic devices, such as personal computers, PDAs, HDTV and DV cameras. Meanwhile, an ever increasing number of households have a broadband connection to outdoor public telecommunication and broadcasting networks for home entertainment and data.

Instead of having all home digital electronics running as separate appliances, there is a growing demand for a more effectively integrated home digital environment. Furthermore, wireless connection is the preferred choice in such a home environment. Several requirements are critical for the adoption of a wireless technology supporting an entertainment and computing network [1]:

- **Throughput:** High throughput is needed to support both streaming data and file transfer.
- **Quality of Service:** Unlike standards such as 802.11 which are intended specifically as a wireless replacement for wired local area networks, new wireless standards must support QoS requirements such as jitter, latency and guaranteed bandwidth.
    - **Flexibility:** The capacity to handle different kinds of data transfer.
    - **Real-time features:** Supporting real-time and continuous data transmission for streaming-type data of audio and video entertainment.
- **Easy operation:** Easy to operate and allow hot connection and disconnection by simple plug-and-play.
- **Economy:** Reasonable cost and small size applied even to handheld sets.
- **High reliability:** Frequent people activity and movement are inevitable in the

home environment. Special attention to the shadowing impact of the human body should be paid for system reliability and service quality.

In this paper, we evaluate a reference design module based on TZero Technologies' WiMedia UWB chipset and TZero's off-the-shelf wireless video product, to see if this new technology has delivered the promise of transmitting hundreds of megabits per second while maintaining a satisfactory QoS. In other words, after years of talk, can UWB deliver on its promise?

The test was organized by Professor Xiaodai Dong and her team at the University of Victoria. The reference design evaluation kit under test was purchased directly from TZero Technologies Inc. TZero's ZeroWire HDMI product was built and supplied by an offshore manufacturer in China[1]. Both the module and the HDMI product are FCC, TELEC and ETSI certified. As part of this study, TZero provided support for operating the evaluation kit. The commercially-available ZeroWire HDMI product operated out of the box and needed no support.

2. BACKGROUND

2.1 Ultra-wideband

The FCC allocated 7.5 GHz of spectrum to ultra-wideband in 2002. Other regulatory regimes, including Japan and the European Union, have also allocated spectrum to UWB. This state-of-the-art technology presents itself as one of the most innovative and promising wireless technologies to enable high-speed data transmission. That promise comes from a basic relationship in communication theory known as the Shannon capacity theorem:

$$C = BW \log_2\left(1 + \frac{S}{N}\right)$$

where C is the channel capacity, BW is the channel bandwidth and S/N is the signal-to-noise ratio. This relationship shows that the maximum achievable channel capacity is proportional to the channel bandwidth. On the other hand, the capacity only increases in proportion to the logarithm of the signal power. Thus, increasing bandwidth is the most effective route to increasing capacity. The wide bandwidth of

[1] The unit we evaluated is a pre-production model of the product sold by Gefen Incorporated: http://www.gefen.com/kvm/dproduct.jsp?prod_id=4318

UWB takes direct advantage of this fact to provide higher throughput.

What's more, UWB also has the potential for high resilience to multipath fading and high immunity to interference because of its inherent frequency diversity.

The FCC not only allocates the operating frequency range for UWB, but also regulates the transmit power to a very low level. Figure 1 illustrates the very wide operating frequency range for UWB (from 3.1 GHz up to 10.6 GHz) and the very low power spectral density. Because of its low power spectral density, UWB devices can co-exist with traditional wireless service without causing interference. On one hand, this low power constraint protects the existing wireless service; on the other hand, it limits the transmitting range of UWB down to about 10 meters.

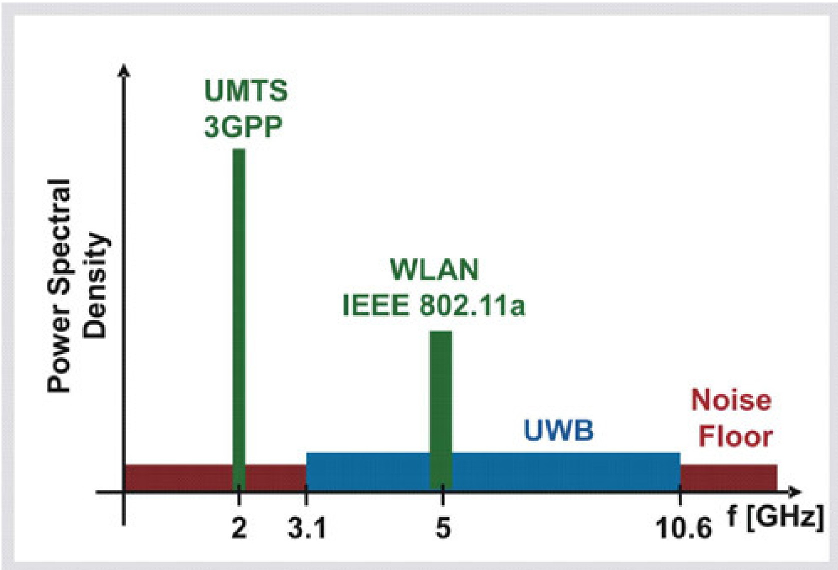

Figure 1. Allocated spectrum for UWB [2]

Although several competing approaches to UWB have been proposed, only the WiMedia physical layer (PHY) and medium access (MAC) layer specifications have been adopted as an industry-wide standard. Any PHY and MAC layers can be implemented for UWB as long as it meets the FCC spectrum mask and 500MHz minimum bandwidth requirement. The WiMedia UWB technology which is based on multi-band orthogonal frequency division multiplexing (MB-OFDM) grew out of the IEEE 802.15.3a high-speed personal area network working group which was abandoned in January 2006. Most companies that originally supported multi-band OFDM in the IEEE 802.15.3a working group afterwards joined the WiMedia Alliance which created its own UWB PHY and MAC standard. WiMedia's standard was later adopted by ECMA as the ECMA-368 Standard. Thus, WiMedia UWB has, in a sense, become a de-facto industry standard built outside of IEEE.

Other approaches proposed in the now defunct IEEE 802.15.3a working group included spread-spectrum UWB (sponsored by Motorola and its subsequent spin-off XtremeSpectrum) and pulse-based UWB sponsored by Pulse-LINK.

2.1.1 WiMedia

The WiMedia specification divides the whole 7.5 GHz frequency range into 5 band groups[2] with 14 sub-bands. Time Frequency Codes (TFC) are used for frequency hopping within a band group in the data transmission, which allows the instantaneous transmitted power to be increased even while the power spectral density stays the same. This is because the FCC sets a maximum output power limit at -41.3 dBm/MHz as measured by an RMS detector with a 1 millisecond time constant. Since the duration of a symbol is only 312.5 ns, the RMS detector will measure the power averaged over three consecutive symbols. Thus, at each 1 MHz frequency interval that is being measured, the actual detected power will be the instantaneous transmitted power times the duty-cycle of the signal at that frequency.

WiMedia OFDM provides PHY data rates of 53.3Mbps, 80Mbps, 106.6Mbps, 160Mbps, 200Mbps, 320Mbps, 400Mbps, and 480Mbps. Significantly, the WiMedia MAC was designed with QoS in mind and supports guaranteed reservations in a TDMA framework (as well as CSMA/CA contention access).

2.1.2 Impulse based UWB

Impulse UWB uses very short duration impulses to create the wide bandwidth signal. For example, the impulse UWB technology originally developed by time-domain corporation [3] uses baseband pulses with duration on the order of 1nS or smaller to create a signal bandwidth of hundreds of megahertz.

2.1.3 Spread-spectrum based UWB

Spread-spectrum based UWB uses pseudo-random noise sequences to dither the information bit stream in order to generate the wide bandwidth.

[2] In order to avoid interfering with Wi-Fi at 5.8 GHz, most WiMedia products operate avoid Band Group 5. For best performance, operation in Band Group 1, which is from 3.1GHz to 4.8GHz. is preferred.

2.2 UWB Applications

With its promising high data rate transmission capability, UWB technology can enable a vast variety of wireless personal area networks (WPAN) applications, such as high-speed wireless universal serial bus (W-USB) and delivery of high definition video over the air. WiMedia companies have focused on both applications as well as standard wireless Ethernet applications.

TZero Technologies Inc., founded in 2003, is a fabless semiconductor provider of CMOS, high-performance ultra wideband chipsets. Its goal is to provide consumer electronics manufacturers a standards-based solution that can deliver high definition content to any display by using wireless links [4]. Its ZeroWire chipset and its recently introduced ZeroWire HDMI product are evaluated in this paper.

3. TEST

We tested two major products from TZero Technologies Inc.: the ZeroWire reference design module in a Mini-PCI type 3A form factor and the ZeroWire HDMI end-user product. We evaluated the reference module from a data throughput point of view and the wireless HDMI product from an end-user, video quality point of view.

The ZeroWire module is a FCC (US) and ETSI (European Union) certified mini-PCI card with integrated TZero UWB chipset and two RF connectors for attaching the antennas. This card can be plugged in any standard mini-PCI slot for evaluation or design purposes. Moreover, the built-in ubiquitous IP network protocol for connectivity enables multiple peer-to-peer connections over industry-standard protocols.

The ZeroWire HDMI product is FCC, ETSI and TELEC (Japan) certified and comes as a ready-to-use wireless high definition video system powered by TZero's ZeroWire chipset. Users can easily connect their HD video source to the ZeroWire HDMI server, and stream full HD quality video to a TV connected to the ZeroWire HDMI client.

The ZeroWire products operate in the 3.1 GHz to 4.8 GHz portion of the UWB spectrum. Detailed descriptions and specifications of ZeroWire Mini-PCI and ZeroWire HDMI can be found in the Tzero's official website http://www.tzerotech.com/products/literature/. We tested several TFCs and found a fairly narrow range of performance differences among the TFCs. The hopping codes, because of their higher transmit power, gave somewhat better results. The data that follows was collected for TFC1 (three-band hopping) and TFC8 (two-band hopping).

3.1 ZeroWire Mini-PCI

TZero provided two ZeroWire Mini-PCI cards loaded with TZero's core software and the cards came with the Mini-PCI to standard PCI interface. We installed the cards on two Shuttle boxes. The Shuttle box is a small computer running on the CentOS 4.7 operating system. One Omron S1 antenna is used at the server and two identical antennas are used at the client as shown in Figure 2. The ZeroWire Mini-PCI card software interface allowed us to select the time frequency code (TFC), physical (PHY) data rate, multiple antenna processing ON/OFF, and acknowledgement (ACK) ON/OFF.

Figure 2. The server station (right) and client station (left)

3.1.1 Throughput vs Distance Test, Office Building Environment

The objective of this test is to evaluate the ZeroWire Mini-PCI's throughput versus distance performance in the office building environment.

Test setup and procedures

The ZeroWire Mini-PCI throughput versus distance measurements was performed in the hallway of an office building at the University of Victoria, Victoria, BC, Canada, as shown in Figure 3 and Figure 4. The hallway is 2.35 meter wide with sections of concrete walls and drywalls. There are metal and wood doors, displaying window and metal shutters along the sides of the hallway. We measured the UDP throughput from the server to the client using Iperf at different distances, and gathered the throughput results. The average throughput (over 100 seconds) from each distance check point showed the supportable range for different PHY data rate settings.

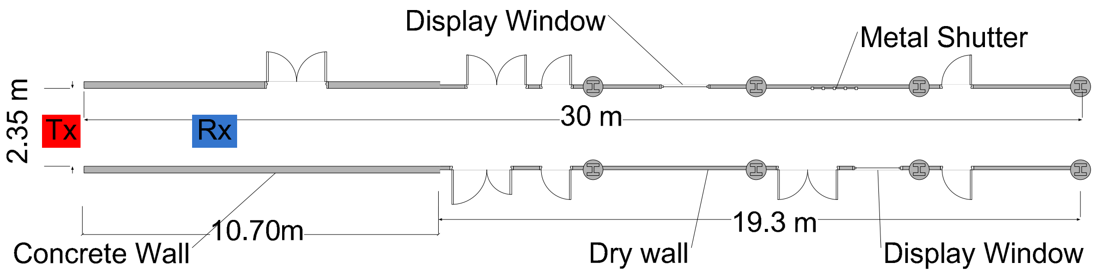

Figure 3. Hallway floor plan. Location of the server (transmitter) was fixed and the client (receiver) was moved along the hallway.

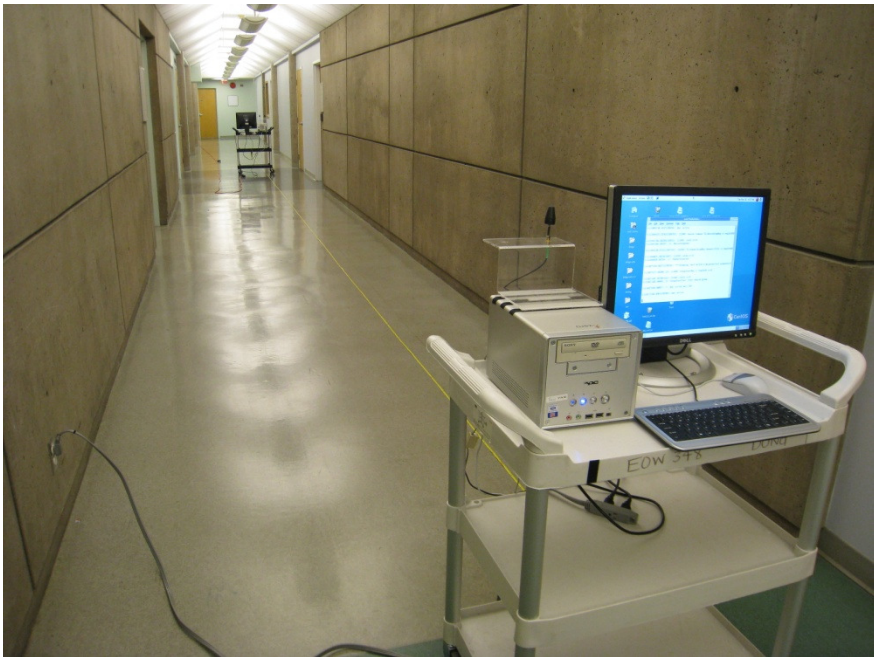

Figure 4. Throughput measurement test setup in the hallway of an office building

Since UWB devices mainly target indoor office and home uses, people activities have to be taken into account in our measurements. Besides the regular line of sight (LOS) throughput versus distance test, we also measured throughput at different distances with people blocking in the middle between the server and the client. This non-line of sight (NLOS) test gives us very important information about how the WiMedia products perform in a variety of realistic environment.

Test results

The results presented in this section are obtained with auto rate setting, multiple antenna processing and ACK ON. ZeroWire Mini-PCI auto rate setting adapts the PHY rate based on the channel condition to obtain close to zero packet error rate (PER) with ARQ. For the LOS environment, the ZeroWire Mini-PCI throughput held at around 200 Mbps up to 7 meters and dropped slightly to about 150 Mbps from 8 meters to 15 meters as shown in Figure 5. After 15 meters, the throughput reached about 100 Mbps and this was maintained up to 20 meters. To our surprise, the throughput bounced back to about 150 Mbps around 25 meters, and back to about 100 Mbps around 30 meters, at which point we ran out of the test space. This could be caused by the changes in building material and fixtures along the two sides of the hallway.

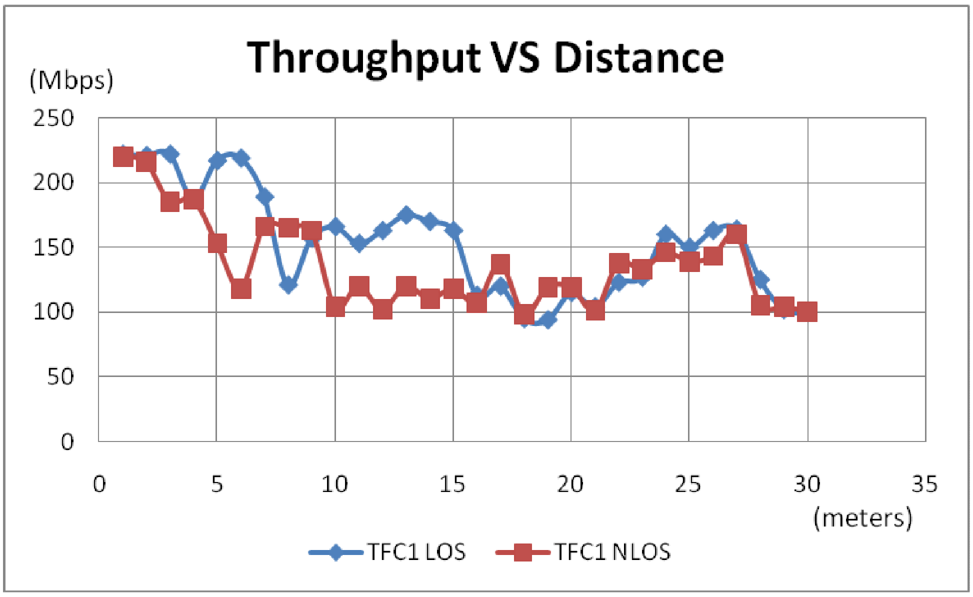

Figure 5. Hallway throughput measurement test with TFC1

When there are people blocking in between the server and client, the throughput decreased in most distance points. However, we still can see some NLOS results were better than the LOS results at the same distance, and this situation occurred more frequently at further distances. This is due to the fact that further distances are more sensitive to multiple path components and depend less on the LOS path. This is a testament to TZero's receiver algorithms (both its multiple antenna implementation which allows gathering spatially diverse multipath components and its receiver signal processing techniques which enable gathering the multipath energy constructively). Figure 6 shows similar results when the measurement test used TFC8 as its time frequency hopping pattern.

An interesting aspect of these curves is that, even in the LOS case, the throughput changes gradually rather in steps as the PHY rate changes. This is due to TZero's automatic rate adaptation algorithm which selects the PHY rate and layer-2 PER and number of re-tries to maximize the application layer throughput.

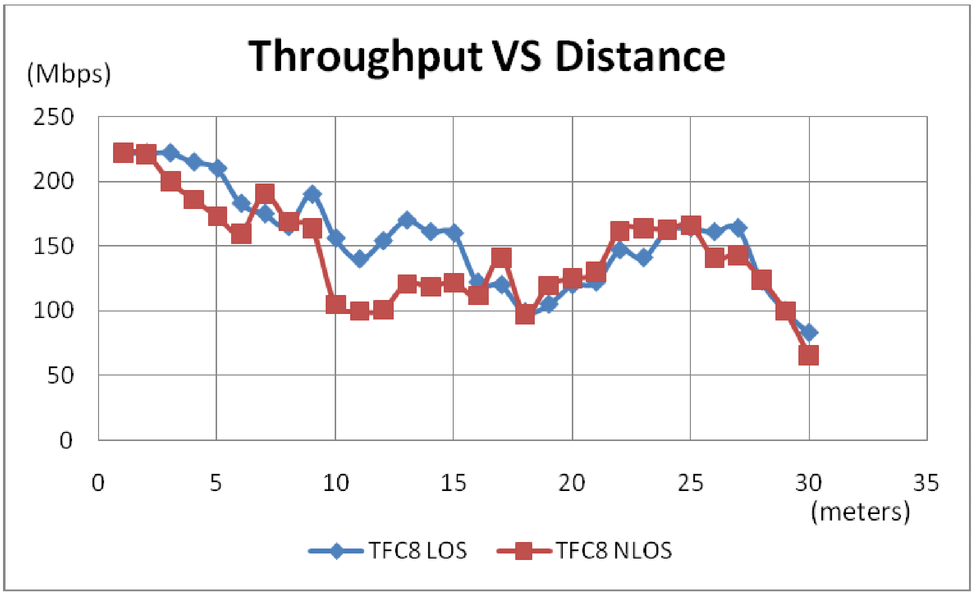

Figure 6. Hallway throughput measurement test with TFC8

The measurement test results were good in that ZeroWire Mini-PCI was able to maintain a high data rate throughput about 150 Mbps up to 13 meters distance. Even with people blocking the LOS path, the throughput was still maintained above 100 Mbps. Note that a real-time compressed HD video stream requires as much as 80 Mbps for visually loseless playback, and ZeroWire Mini-PCI shows us its capability for delivering such throughput. Furthermore, the throughput results at long distance (up to 30 meters) were surprising, as high as around 100 Mbps even with people blocking in between. We surmise that the multiple antenna technology coupled with the adaptive optimization of TZero's receiver to the channel conditions enables this extended range performance.

3.1.2 Block-ACK Simulation Test, Office Building Environment

The block-ACK mechanism allows acknowledgement of a group of frames (packets) instead of every single frame (packet), significantly improving MAC efficiency. Although ZeroWire Mini-PCI did not come with this feature, we were informed by TZero that block-ACK has been implemented in hardware but with no software support yet. Therefore, we can simulate the block-ACK mode to see the possibility of very high throughput once block-ACK is fully implemented.

Test setup and procedures

The test was performed in the same office building hallway. In order to make one acknowledgement frame correspond to more than one data frame, we manually changed the frame length and inter-frame spacing in a way that acknowledgement frames are sent slower than data frames. PHY rate is set at 480 Mbps, multiple antenna processing is on and regular ACK is turned off, which means there is no ACK in the test.

Test results

The simulated block-ACK throughput reached 324 Mbps at the distances up to 5.65 meters with TFC 1 and 5.55 meters with TFC 8, while maintaining the packet error rate (PER) less than 1%. These data indicate that as soon as the real block-ACK mode is supported in software, with all the packet error recovery mechanisms enabled, the overall performance of ZeroWire Mini-PCI will be even better than that reported in this paper.

3.1.3 Throughput Measurement Test, Home Environment

We also tested ZeroWire Mini-PCI in a home environment since the TZero targets the market of home applications.

Test setup and procedures

In the home environment throughput measurement test, we placed the server and client pair in different locations in a two-level house. The results are shown in the following figures and tables. All the tests were carried out with auto rate setting, TFC1, multiple antenna processing and ACK ON.

Test Results

As demonstrated by Figures 7-10 and Tables 1-4, ZeroWire Mini-PCI performed well in a home environment which has all kinds of obstacles such as furniture, electronic devices, appliances and so on. Most scenarios tested in the house are NLOS where the server and client are separated by walls and structures. This is what we call hard NLOS. Only people blocking the LOS path can be considered as soft NLOS. In the hard NLOS case, we still tested the scenario where a person stood in front of the server or client, and the throughput data are shown in Tables 1-4.

As an aside, we noted that TZero's wireless performance was unaffected by our wireless LAN and cordless phone. We also tried turning on our microwave oven which also had no perceptible impact on the performance.

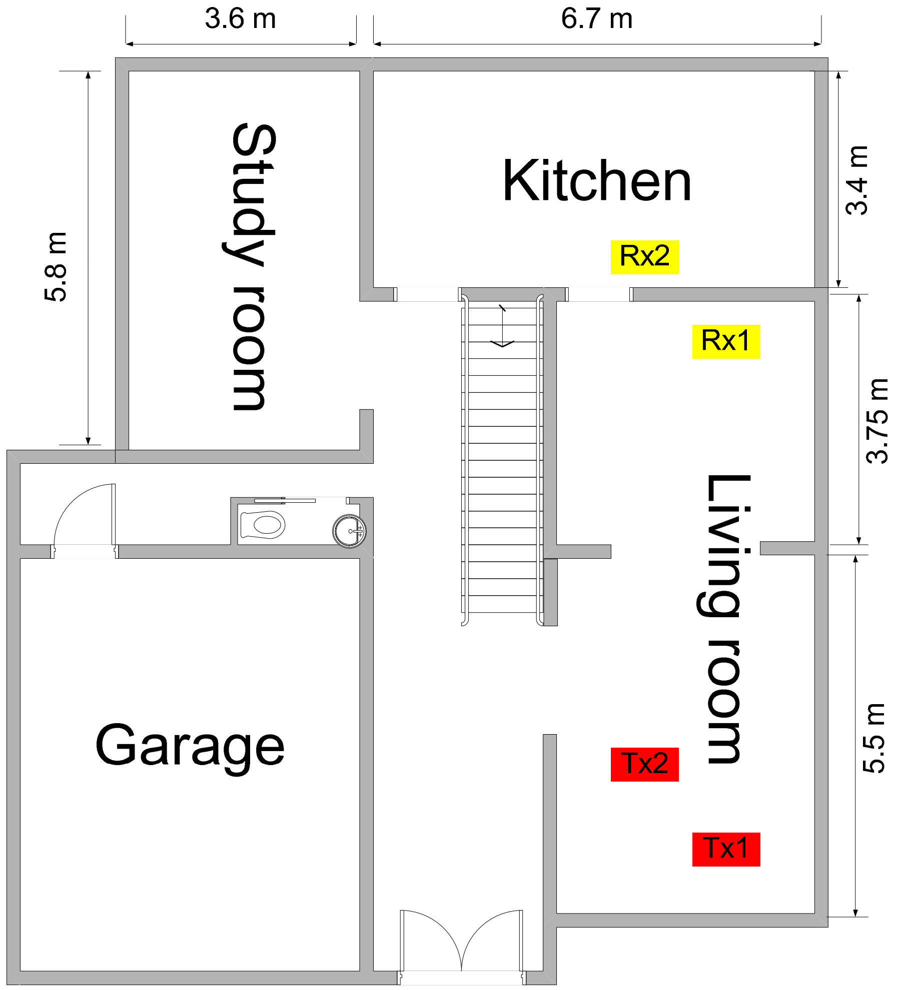

Figure 7. Locations of the server (Tx) and client (Rx) on the 1st floor

Table 1. Throughput measurement test in the living room

Locations	**Distance from Tx1**	**Throughput without people blocking**	**Throughput with people blocking**
Rx1	6.00 m	192 Mb/s	168 Mb/s
Locations	**Distance from Tx2**	**Throughput without people blocking**	**Throughput with people blocking**
Rx2	6.00 m	103 Mb/s	100 Mb/s

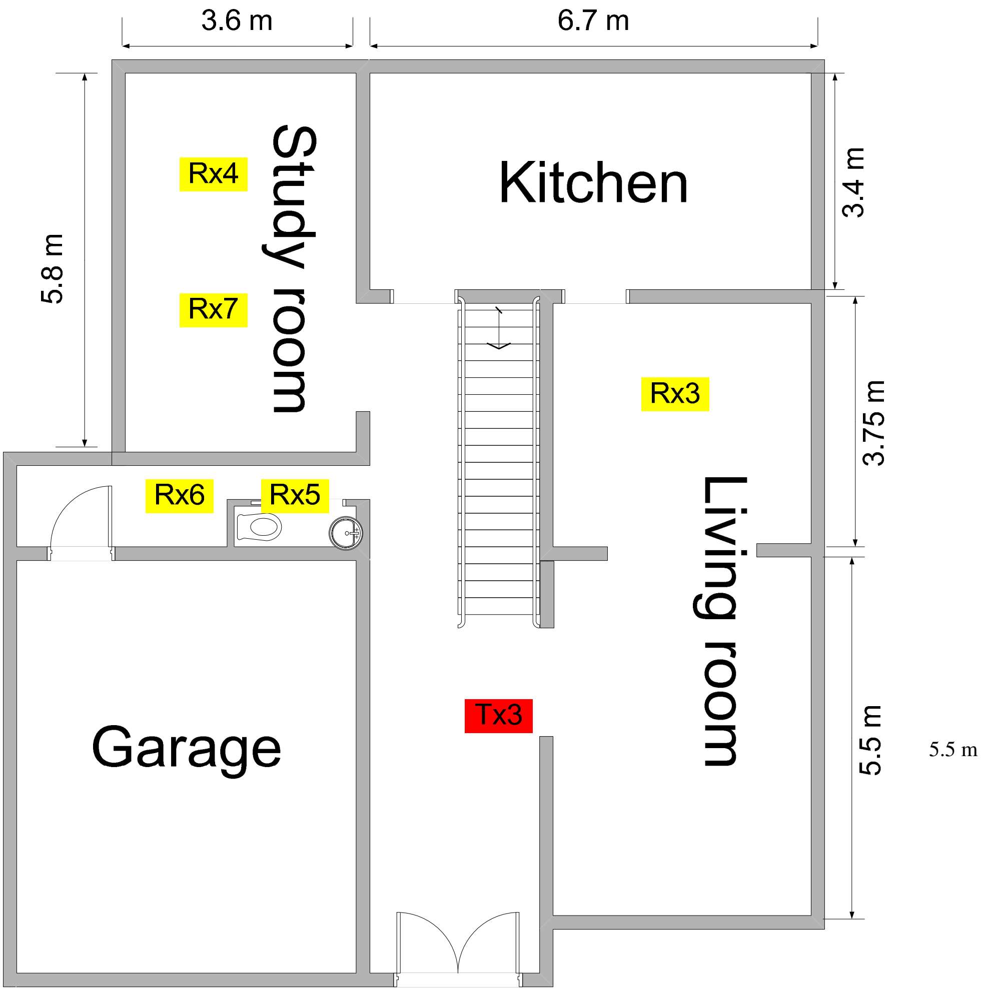

Figure 8. Locations of the server (Tx) and client (Rx) on the 1st floor

Table 2. Throughput measurement test with the 3rd server location on the 1st floor

Locations	Distance from Tx3 (in meter)	Throughput without people blocking	Throughput with people blocking
Rx3	5.00 m	78 Mb/s	69 Mb/s
Rx4	8.06 m	39 Mb/s	39 Mb/s
Rx5	4.14 m	172 Mb/s	101 Mb/s
Rx6	4.92 m	70 Mb/s	45 Mb/s
Rx7	7.21 m	53 Mb/s	39 Mb/s

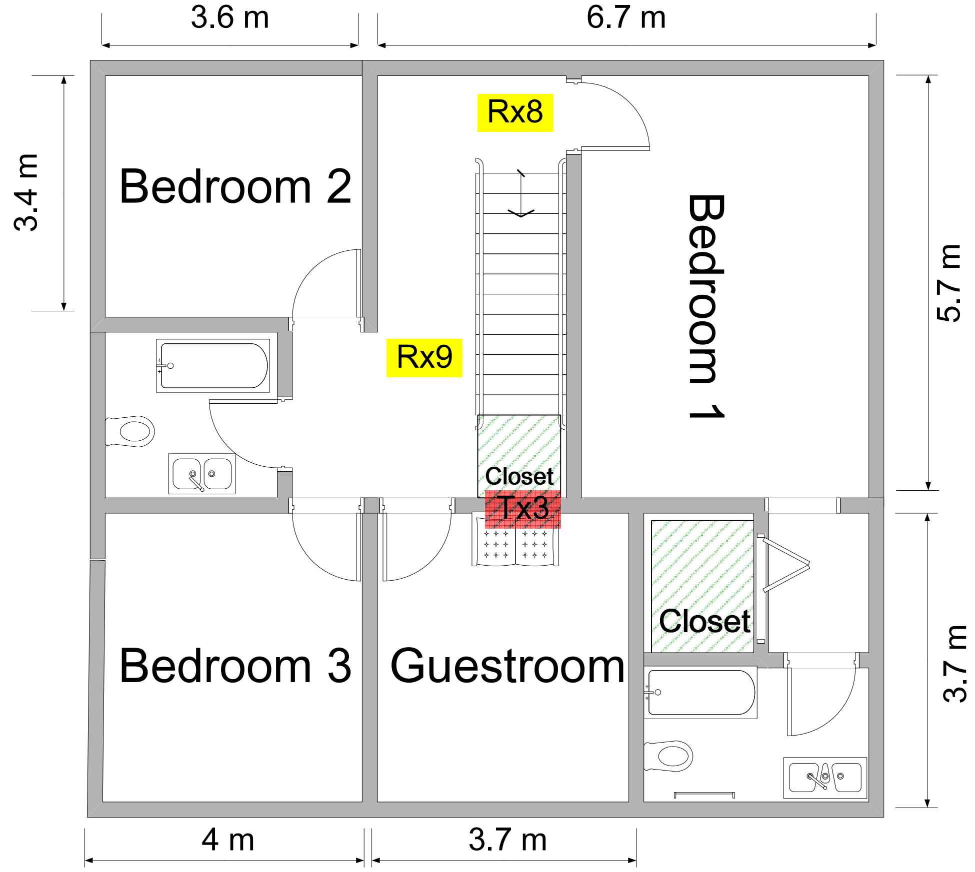

Figure 9. Locations of the server (Tx) and client (Rx). Note that Tx3 is placed on the 1st floor while Rx8 and Rx9 are on the 2nd floor

Table 3. Throughput measurement test between-two-floors

Locations	Distance from Tx3	Throughput without people blocking	Throughput with people blocking
Rx8	5.80 m	221 Mb/s	168 Mb/s
Rx9	3.60 m	73 Mb/s	n/a

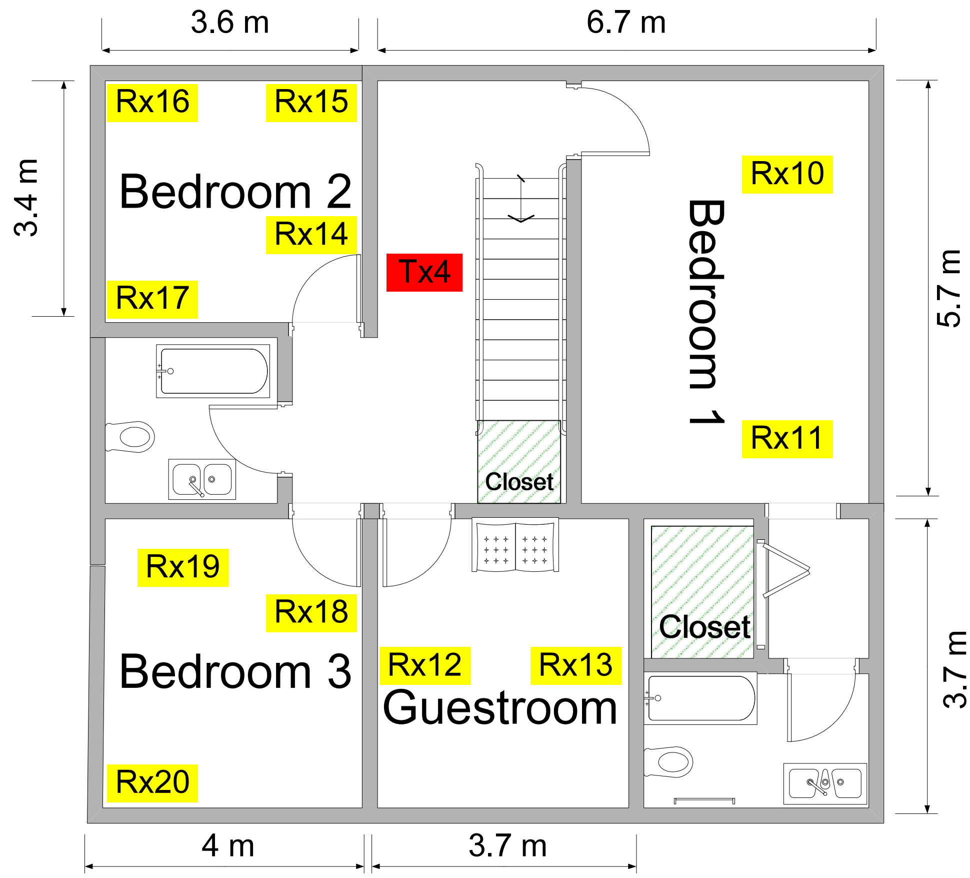

Figure 10. Locations of the server (Tx) and client (Rx) on the 2nd floor

Table 4. Throughput measurement test on the 2nd floor

Locations	Distance from Tx4	Throughput without people blocking	Throughput with people blocking
Rx10	4.61 m	202 Mb/s	101 Mb/s
Rx11	4.92 m	216 Mb/s	122 Mb/s
Rx12	5.00 m	222 Mb/s	206 Mb/s
Rx13	5.39 m	72 Mb/s	50 Mb/s
Rx14	1.41 m	222 Mb/s	165 Mb/s
Rx15	2.70 m	187 Mb/s	107 Mb/s
Rx16	3.91 m	195 Mb/s	120 Mb/s
Rx17	4.00 m	221 Mb/s	185 Mb/s
Rx18	4.12 m	185 Mb/s	115 Mb/s
Rx19	4.30 m	73 Mb/s	71 Mb/s
Rx20	7.13 m	63 Mb/s	45 Mb/s

3.1.4 Gateway Simulation Test, Home Environment

Potentially, the high speed wireless connectivity of the WiMedia devices can provide wireless HD video, gaming and normal data networking simultaneously from a single WiMedia UWB gateway. To explore this possibilty we tried to locate such spot for a gateway (transmitter) that could cover the whole floor as much as possible while maintaining a satisfactory data rate and QoS.

Test setup and procedures

We performed the simulation test in the 1st floor of the house, and several potential locations shown in Figure 11 are tested for data throughput by Iperf. The location that provided the overall best throughput for the entire 1st floor was selected as the "gateway spot".

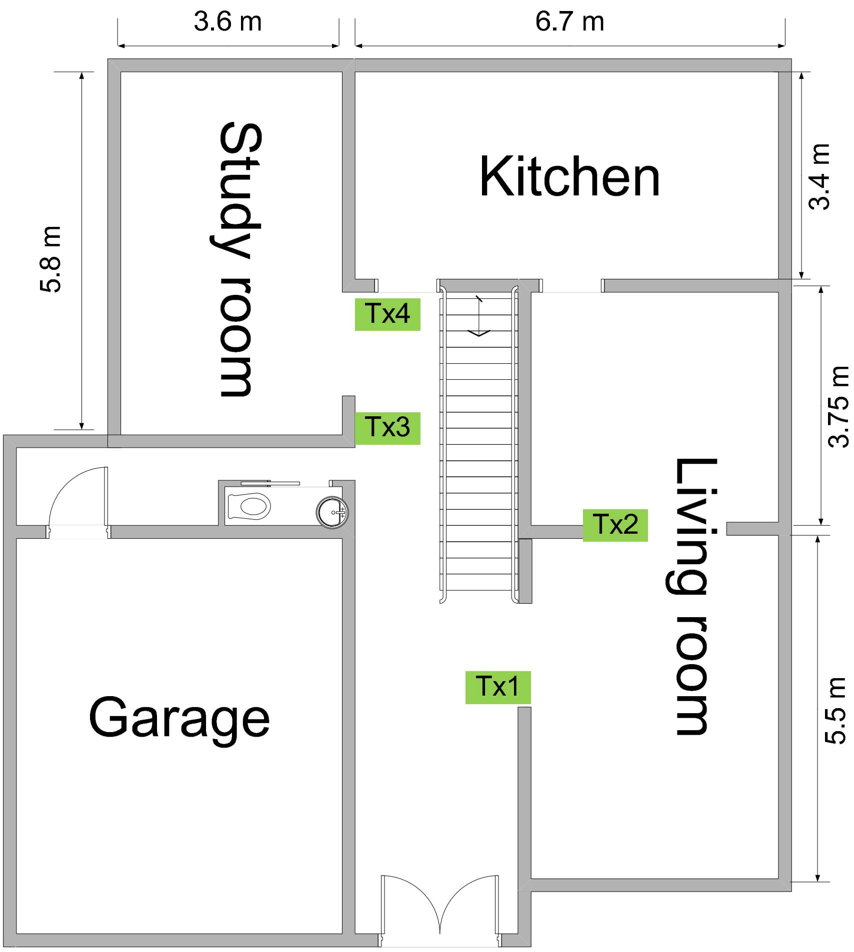

Figure 11. Potential gateway locations

Test results

After testing all 4 potential gateway locations labelled in Figure 11, we found that location Tx3 outperformed others in terms of overall coverage. For example, location Tx2 provided a very high data rate in the living room area, but it cannot cover the study room well. Location Tx4 offered high data throughput in the study room and the kitchen; however, it failed to support the farther away living room area. On the other hand, location Tx3 was identified as the spot which provided good coverage to living room, study room and the kitchen. Figure 12 and Table 5 show the corresponding data rates at different receiving locations with a gateway transmitting at Tx3.

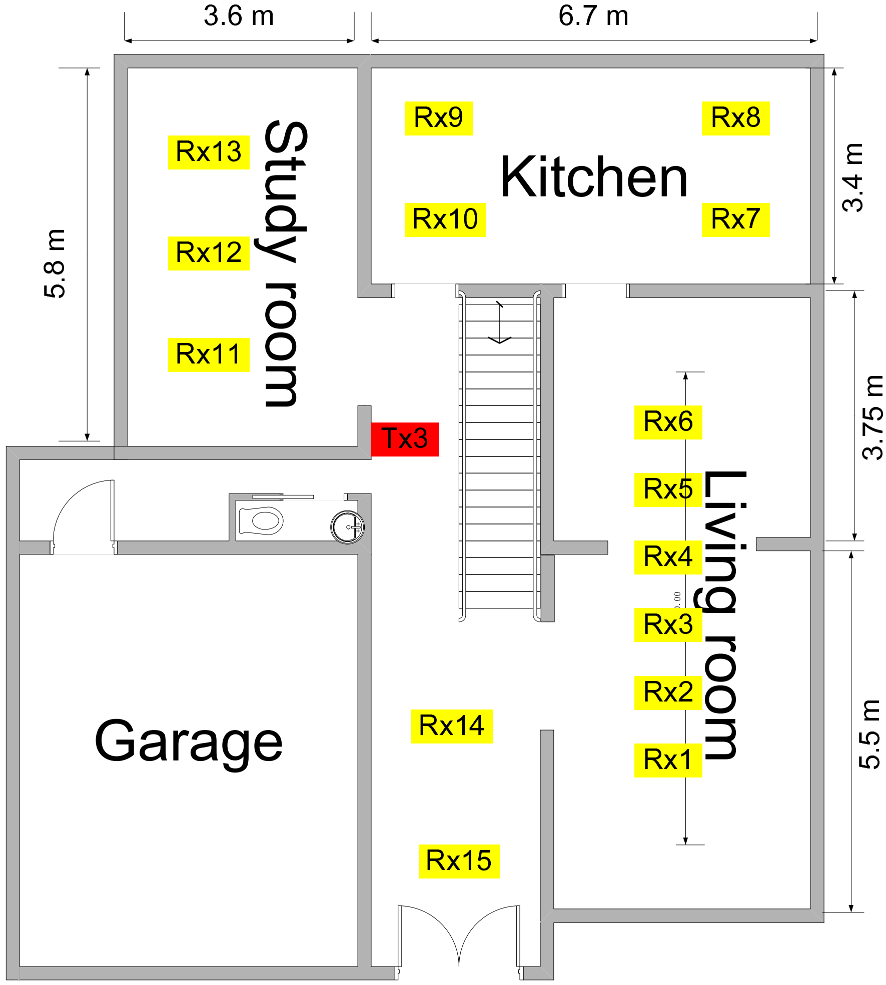

Figure 12. The selected gateway location (Tx3) and its various receiving locations

Table 5. Throughput for test locations in Figure 11

Locations	Throughput without people blocking	Corresponding Area
Rx1	60 Mb/s	Living room
Rx2	72 Mb/s	
Rx3	98 Mb/s	
Rx4	120 Mb/s	
Rx5	200 Mb/s	
Rx6	77 Mb/s	
Rx7	43 Mb/s	Kitchen
Rx8	44 Mb/s	
Rx9	215 Mb/s	
Rx10	221 Mb/s	
Rx11	222 Mb/s	Study room
Rx12	222 Mb/s	
Rx13	189 Mb/s	
Rx14	222 Mb/s	Hallway
Rx15	201 Mb/s	

We can see that the data throughput ranges from 60 Mbps to 222 Mbps in the area of the 1^{st} floor tested and the average value is 153 Mbps. The relatively low data rates in locations Rx1, Rx2, Rx3, Rx7 and Rx8 were due to the closet under the stairway in between the transceiver set.

This gateway simulation test, together with results in Table 4 and Figure 10, demonstrated that a sjngle ZeroWire Mini-PCI can successfully cover the majority of the floor area on the same level in the house tested while maintaining its promising high data rate and QoS.

3.2 ZeroWire HDMI

After examining the data throughput from the previous tests, we evaluated the ZeroWire HDMI set (Figure 13) for a more visualized user experience point of view. Similar to ZeroWire Mini-PCI, the server and client of ZeroWire HDMI have one and two antennas, respectively.

Figure 13. ZeroWire HDMI set with Blu-Ray DVD player and HDTV

3.2.1 HD Video Test Setup and Procedures

The test was setup by connecting a SONY Blu-Ray DVD player to the transmitter side (server), and a 40 inch 1080p Toshiba HDTV to the receiving side (client). In order to have a convincing test result, we purchased the HQV Benchmark Blu-Ray DVD and used it as the media source. The video clip used for testing is the continuous playback of a ship slowly sailing across the sea (from the left to the right of the screen). There are clearly visible continuous movements of the ship and water while at the same time the overall video content does not change dramatically so that any small degradation in the video can be easily perceived. Please see http://www.hqv.com/benchmark.cfm for more information on HQV Benchmark Blu-Ray DVD. In addition, a 122 minute long Blu-ray DVD movie was used for a two-hour long test.

We performed the test in the living room of the same house where ZeroWire Mini-PCI was tested in the proceeding section. Figure 14 and Figure 15 show the test setup and test layout, respectively. The whole living room can be divided into two sections, and the 40 inch HDTV was placed in the first section with the client (receiver). The Blu-Ray DVD player was connected to the server (transmitter) and placed at several locations in the living room. Because ZeroWire HDMI markets its product for in-room HD video distribution, the largest room in the house, the living room, was selected for testing. We evaluated the ZeroWire HDMI set by comparing the video (1080p) quality on the HDTV received through ZeroWire HDMI with the video quality provided by a HDMI cable connection.

Figure 14. Test setup for the ZeroWire HDMI video test. Both the server and the client were placed 90 cm above the ground.

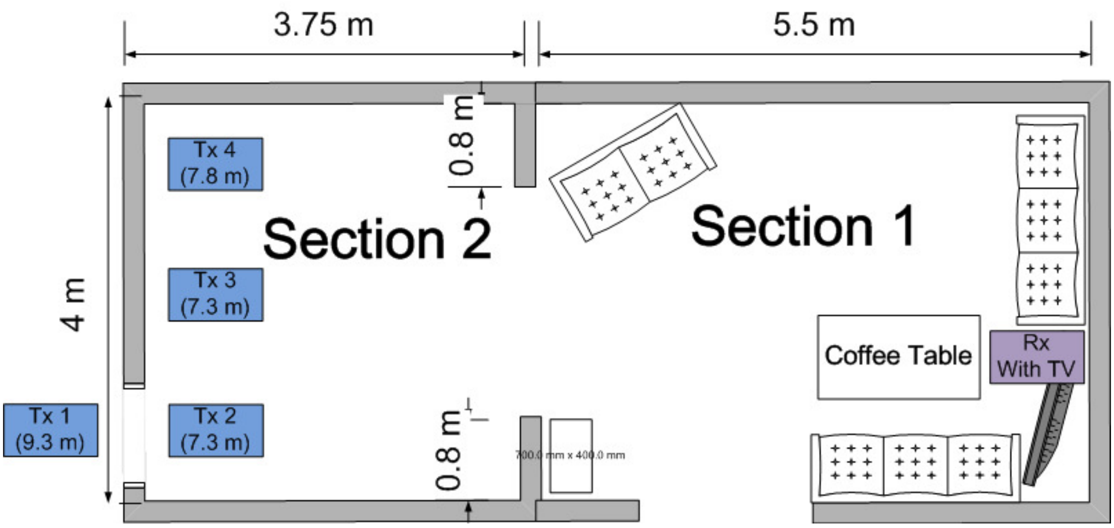

Figure 15. Video test layout and floor plan

3.2.2 HD Video Test Results

By using the HQV HD Benchmark Blu-Ray DVD, we found that the quality of the HD video received through ZeroWire HDMI was as good as using HDMI cable connection when the server (transmitter) was placed anywhere in Section 1. Even three people actively walking around in Section 1 did not affect the video quality.

When the transmitter was placed at the far end of Section 2 (Tx2-Tx4), the video quality was still fine and fulfilled the HD video requirements. If a person got in the way on the LOS path and stayed stationary, the video showed a transient interference effect and then returned to the fine quality as if there were no blocking. However, when there were dynamic people activities blocking the LOS path, noticeable video quality degradation appeared.

Playing the Blu-ray DVD movie showed better effect than playing HQV Benchmark DVD. The video quality matched that of cabled HDMI even at the far end of Section 2, with slight interruption only when constant intentional body movement blocked the LOS path within 1 meter in front of the server (Tx). In a realistic user viewing environment, such an artificial setting will be unlikely to happen. We enjoyed watching the 2-hour long movie transmitted through ZeroWire HDMI in the living room.

3.3 Results Analysis

According to TZero, the ZeroWire HDMI set we tested does not have the optimal rate adaption and multiple antenna processing algorithms which are currently being implemented in the new off-the-shelf ZeroWire HDMI product. Nonetheless, we were still impressed with the performance of TZero's product.

The overall performance is much better than that reported in [5], which claimed that WiMedia products can only achieve a throughput limited to approximately 30 to 40 Mbps with a distance limit of 0.5 meter. The low expectations in [5] might due to the fact that the WiMedia products examined in that report were still at a very early stage when [5] was published. We believe that the test results demonstrated by the TZero products in this report are far more representative of the capability of MB-OFDM technology. In comparison with the published results in [5] for the alternative, proprietary UWB technology from Pulse_LINK called CWave, the throughput of ZeroWire Mini-PCI is higher for ranges beyond 3-4 meters and robust for a long distance (at least 30 meters) for both LOS and NLOS. The tests in [5] only contain LOS results. The current generation of TZero products award significant confidence to WiMedia UWB for HD video distribution in terms of both data throughput versus range and real wireless HD video experience.

4. CONCLUSION

We have evaluated the performance of ZeroWire Mini-PCI and ZeroWire HDMI from TZero Technologies Inc. in terms of throughput versus range and visual experience. ZeroWire Mini-PCI achieves above 200 Mbps up to 7 meters and dropped slightly to about 150 Mbps from 8 meters to 15 meters. The throughput is maintained above 100 Mbps up to 30 meters we have tested. Future block-ACK feature can push the throughput to the 300+ Mbps range beyond 5 meters. ZeroWire HDMI achieves visually lossless HD video distribution performance in the home environment tested. These test results clearly reveal the true capability and potential of WiMedia UWB for delivering high speed HD video content in a home wireless network.

5. ACKNOWLEGEMENTS

We would like to thank TZero Technologies Inc. for providing support for their ZeroWire evaluation system. Special acknowledgement also goes to M.A.Sc. student Zhuangzhuang Tian in our team who provided much assistance in the testing.

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