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# Performance Analysis of 60 Ghz Wireless Communications For Wigig Networks

**S.Praveen Chakkravarthy, V.Arthi, Leeban Moses**

***Abstract: The demand for faster wireless connectivity and uses of high definition multimedia content has increased the scope of research in wireless communication. To meet the requirements of future wireless networks, in terms of high speed connectivity and provisioning, WiGig networks are considered. A 60 GHz mm wave band paves a road to the future wireless ecosystem. To cater the infotainment choices to the consumer, WiGig Standard has been proposed. The work concentrates on analyzing the propagation time delay, path loss with respect to T-R separation and received power. With the advantage of the propagation characteristics of the 60GHz spectrum, WiGig will certainly provide high data connectivity and provisioning with minimum modifications in the RF front end receiver.***

***Keywords: WiGig networks, 60GHz spectrum, propagation time delay, path loss.***

## I. INTRODUCTION

Wi Fi can be used in a room environment and large volume of data cannot be transferred in a very short time period. A solution for the same is IEEE 802.11ad, WiGig. WiGig use the spectrum at frequency around 60 GHz along with high throughout.WiGig uses the microwave section of the spectrum and is a promising next generation wireless communication technology[1]. The microwave spectrum usage allows the system to provide high throughput with the use of wide bandwidth and even good reuse of spectrum is possible with very minimum interference.In order to achieve high data rate and better mobile experiences in the future network it has been enabled to enhance the broadband services for 5G networks. As the customers and mobile devices are increasing to share the high definition multimedia as well as live video conferencing the mobile networks are facing demand for mobile data[3]. Due to the higher advancements in mobile devices by using higher resolution cameras and high definition videos increases the need for higher data rate. As per a recent survey conducted the mobile traffic by 2021 is expected to grow approximately 50 Gigabytes per month and this represents the massive growth rate of mobile communication and the needs of higher data rate[4].To achieve multi gigabits/s data rate for next generation wireless systems, 60GHz WiGig is a promising candidate. Increased channel capacity and ultra-wide band spectrum of mm wave bands offer numerous advantages to cater the needs of wireless communication users[5].

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WiGig Technology is based on IEEE 802.11 ad specification that can support data transfer rate up to 7Gbps. WiGig operates in 60GHz frequency band. It defines high performance wireless implementation of widely used computer interfaces over 60GHz. It also enables multi giga – bit wireless connectivity between any two devices as shown in the figure 1.

WiGig users can perform high speed multimedia file transfer between mobile devices without fixed network infrastructure, instant wireless synchronization and wireless cable replacement to connect wireless displays of high definition[7].

The advantage of using 60 GHz band in Wi Gig technology include large spectrum, small antenna separation, easy beamforming, low Interference, inherent security and high-power transmission.

The significant features of wireless HD include 60 GHz wireless standard to connect television, displays to laptops, Blu-ray players etc. It also includes design for high quality uncompressed video (2560 x 1440 pixels) with 4K resolution for smart phones and Tablets.

The oxygen absorption of 15dB/km affects 60 GHz signals [9].The antenna beamforming technique Steers the antenna for WiGig communications by using different varieties of codebook techniques in order to overcome these harsh channel conditions [10]. Beamforming training technique is included along with exhaustive search algorithm is being standardized by WiGig network standards for constructing the data links of WiGig network [7],[8].

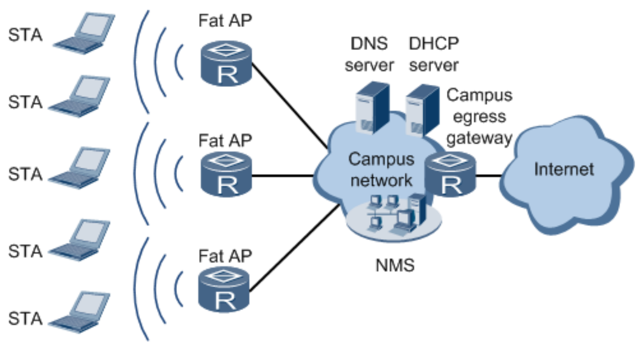


**Figure (1). Architecture of an NMS in Wigig network**

AP- Access point; STA – Station; DNS – Domain Name System; STA – Station; NMS – Network management system; DHCP – Dynamic host configuration protocol. By using exhaustive search technique along with beamforming algorithm it highly complicates the construction of the WiGig links due to its large overhead.

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## II. SYSTEM MODEL

A millimeter wave can easily penetrate into different materials of building parts, moving objects and stationary environment and can propagate over very few distances in the desired frequency. The millimeter waves are highly directional and can be propagated over few kilometers and they are affected by reflection, diffraction and scattering.

To achieve higher data rates the gains of the directional antenna must be considered. To establish link between two different beamforming protocols and different devices directional communication must be established. Time division multiple access technique is used for the allocation of contention based access.

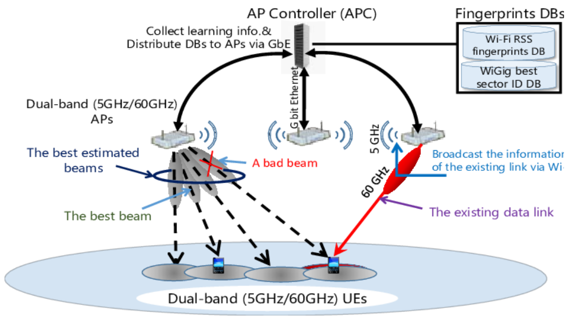


**Figure (2) . Frame work of beam forming architecture in WiGig networks.**

The short training field and channel estimation field it is used to to predict the channel characteristics for the decoder, estimates the frequency offset and provide synchronisation, provides training for automatic gain control and it helps in signal acquisition. Golay codes are used in short training field and channel estimation field. The PLCP indicates the modulation structure of the packets and also provides the size of the packet.

Until beam forming is done, devices do not know the right direction to use for communication with each other. There arises a need to provide a mode that compensates for the lack of antenna gain, so that the devices can, at a minimum, discover each other. Beam forming can be done at or after discovery as shown in figure (2), which is aa test case scenario.

The beam forming enables the MAC/PHY to meet the requirements of all usage models and support all device types. It allows modular design and supports pre-network entry and post-network beam forming. The technique is capable of post beam forming link re-establishment and tracking.

The proposed beam forming link re-establishment and tracking is a novel beam forming training technique. The best beam angle pair will be obtained in a few packets by steering their angles in a training packet simultaneously and by coding multiple beam angles in a training packet.

### 2.1 Exhaustive in-packet training

The in-packet training technique reduces the overheads in header and preamble sections by using different searching techniques that is very feasible. By using the in-packet training technique the number of training package can be reduced. for instance if the training packet in the transmitter is 16, by using exhaustive in packet training technique the training packet Can be reduced to 4.

### 2.2 Rx beam forming

In receiver beamforming the transmitter sends its packet 4 times, while the receiver sends its packet one by one. The receiver is able to identify the best beam pair as (3,2) From the beam pair (3,2) and (2,4) In which both are aligned as a>1. The receiver beamforming training technique does not involve any explicit feedback.

### 2.3 Feedback in-packet training

In order to improve the training time of receiver beamforming, the access point can be used to piggyback the intermediate training results by sending the association request for the receivers to associate with the access point.

The transmitted beam is initially trained by using the process of exhaustive in packet training and the receiver beam is steering at all its directions simultaneously.

The received signal obtained will be y (t)=(a, 1, 0, 0) and this represents the amplitude of the received the signal at the transmitted field. The transmitted beam is chosen as 2 because the value of a is greater than 1. The obtained information is then feedback to the transmitter because it sense at raining packet through its beam to stage 3. The receiver detects the received beam 3 as the best receiver beam because the receiver varies its beam direction within the packet.

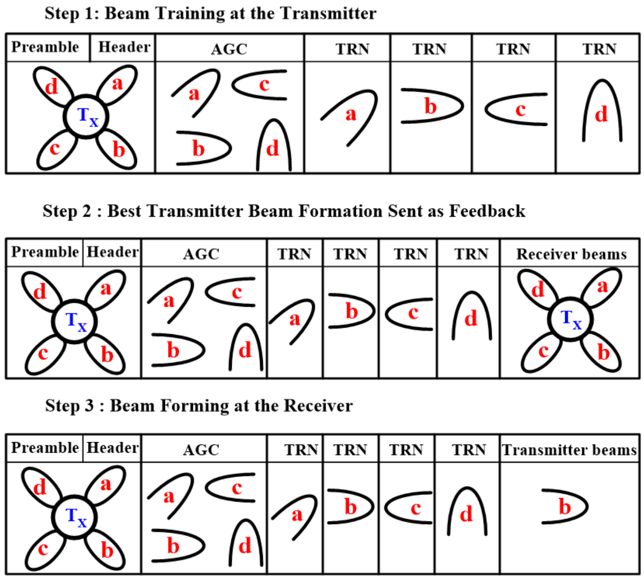


**Figure.3 Stage by stage training at transmitter and receiver.**

AGC- Automatic gain control; TRN - Training

The exhaustive search process gives an inbound knowledge to set the platform for simulation scenario.

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## III. RESULTS AND DISCUSSIONS

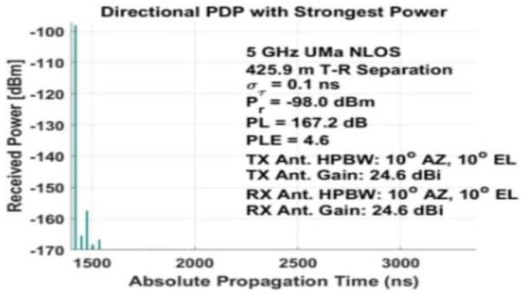


**Figure 4. Determination of Path loss**

Simulation scenario:

- Barometric Pressure: 1013.25 mbar
- Humidity: 50%
- Temperature: 20◦C
- Rate of Rain: 0 mm/hr
- Number of TX Antenna Elements Nt: 2
- Number of RX Antenna Elements Nr: 2
- Number of TX Antenna Elements Per Row Wt: 2
- Number of RX Antenna Elements Per Row Wr: 2
- TX Antenna Azimuth HPBW: 10◦
- TX Antenna Elevation HPBW: 10◦
- RX Antenna Azimuth HPBW: 10◦
- RX Antenna Elevation HPBW: 10◦

and assuming the frequency interval between adjacent sub-carriers is 500 kHz, which corresponds to 800 MHz/500 kHz = 1600 sub-carriers, we perform 100 simulation runs (i.e., set the number of RX locations to 100) to emulate 100 random MIMO channel realizations with the input parameters described below.

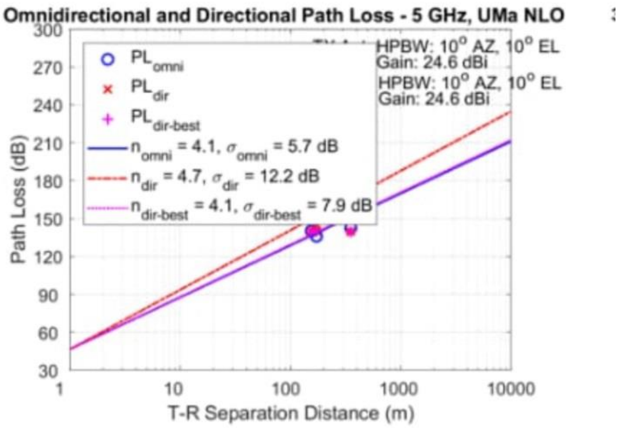


**Figure 5. Determination of power spectrum with respect to received power provides minimum fluctuations.**

Consider RF bandwidth of 800 MHz, with LOS environment and a transmit power of 30 dBm, the pathloss variation for a gain of 24.6 dbi is found to be optimum and is inline with the receiver characteristics. This implies that frequent resetting of AGC is not required.

To interpret the received power, the assumptions for simulation scenario include polarization: co-pol, Foliage loss : Nil, Tr& Rxr array type : ULA. It is evident that the received power is uniform.

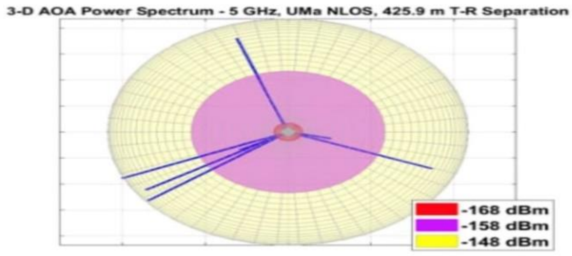


**Figure 6. Identification of received power (dBm)**

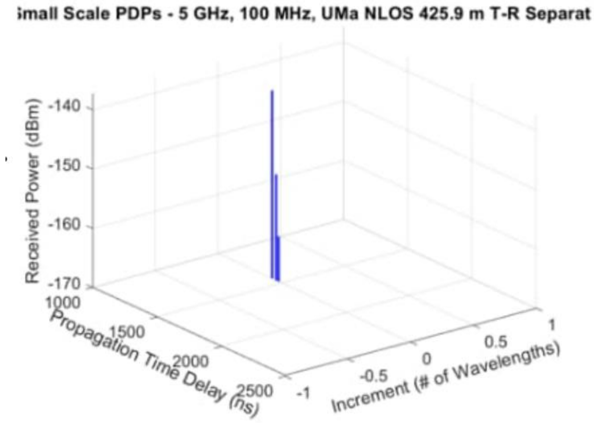


**Figure 7. Path loss considering directional and omni directional antenna**

The figure 7 depicts the path loss by considering Frequency as 28 GHz, Transmit antenna spacing 0.5 λ ,Receive antenna spacing 0.5 λ and number of receiver location is 100.

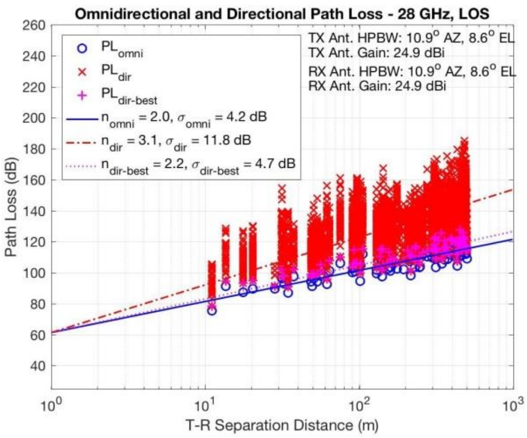


**Figure 8. Calculation of propagation time delay**

Considering the lower bound of T-R separation distance as 100m and upper bound of T-R separation distance as 100m, it is evident that propagation time delay and received power are optimum for some values of incremental wavelength.

## IV. CONCLUSION

A beam forming training packet structure for mm wave system with in -packet beam forming training is presented with a beam coding scheme.

Even though beam directions are varied within the packet, the optimum path loss and uniform receive power of the WiGig network, no extra resetting of AGC is required. With the flexibility provided by the in packet beamformng training, greatly reduce the beam forming training packet in 802.11 ad standard. This clearly depicts that only simple modification of mm wave RF front end to support the proposed beam coding scheme. The insight clearly concludes the fact that WiGig networks should be seriously considered for HD transmission.

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