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4K UHD Live Streaming Using 802.11ad AT Millimeter Wave Spectrum

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Abstract:
In this work, real time experiments evaluation of the 60 GHz 802.11ad live streaming was conducted. An error free 4k live transmission over 802.11ad up to distance of 22 m which is more than double the 802.11ad standard specification (10 m) was reported. Investigating in real time the effect of polarization on multi- channel transmission over this band and standards, using three different settings t o provide 18 configurations shows that 60 GHz bands has the potential of supporting applications that requires ultra-high speed wireless links. A multimedia communications system using 802.11ad in the 60 GHz band for achieving data rate of about 2.59 Gbps per link and over 7.7 Gbps for three channels, with high feasibility of getting tens of Gbps throughput if routers for this standard are commercially available for link aggregation of several channels is proposed. Packet loss is zero since the requested packets are wholly received at the receiving end of the transmission, there is no co-channel interference resulting from reliable polarization of the docks. The reliability and the efficiency of the system thus increased considerably because theoretically, more or a larger percentage of the transmitter energy will be focused or directed to the direction of the receiver thereby eliminating energy leakages to unintended clients. In addition, the video quality is stable with no jitter effect during streaming of uncompressed high definition video resulting in high-quality live streaming without retransmission.

Keyword: *Millimetre wave, polarization. 4k UHD, Gigabytes, compute unified device architecture (CUDA), Shutter time, Frame*

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I. Introduction

The efficient transmission of uncompressed video signals between devices requires the use of high definition multimedia interface (HDMI) cable. High Definition Multimedia Interface HDMI is a specification that combines video and audio into a single digital interface for use with digital versatile disc (DVD) players, digital television (DTV) players, set-top boxes, and other audio visual devices [1]. The choice for its use is based on the high bandwidth digital content protection (HDCP) and the core technology of digital visual interface (DVI). The use of HDMI 2.0 which is the latest iteration of the HDMI specification is due to its capability to increase bandwidth up to 18 Gbps and supports 4k UHD at 50 or 60 fps, with 12-bit 4:2:2 colour. The existing HDMI 1.4 standard is capable of delivering 4k video but has the limitation of not able to go above 30 fps (30 Hz). They are capable of carrying much higher information than standard A/V cables and their image is sharper and clearer than the A/V cable. The choice of HDMI channels for transmission of FHD video is now a common practice in the industry while the available version as at the time this experiment was conducted was HDMI 1.4 [2]. Considering the amount of data involved in transmitting an uncompressed 4k UHD video, the 60 GHz wireless technology seems to be the perfect choice for wireless transfers since it guarantees both high-speed, large bandwidth and uncongested frequency bands (57-66 GHz). According to [3], two of the standards operating on 60 GHz: WirelessHD and 802.15.3c, validate successful transmission of uncompressed 1080p video at high refresh rates. Moreover, these standards support uncompressed 4k UHD video, but in practice, it is very difficult if not impossible to realize as a result of inter connectivity between capture, storage devices and hardware interfaces of the standards. This problem can be overcome by deploying 802.11ad based WLAN to transmit uncompressed 4k UHD video making wireless video transmission highly desirable and efficient cable replacement option [3][4]. This work evaluates the potential of communication system operating on mmWave bands to provide high quality video and other wireless computer displays. Packet loss can be problematic, as it causes error propagation to dependent frames.

In this work, packet loss was negligible since the processed, and received frames fully satisfied number of frames requested. To this end, analytical and experimental techniques were employed using the IEEE 802.11ad WLAN provide proof of this concept and demonstrate the challenges faced in deployment of 4k UHD streaming over an IEEE 802.11ad WLAN. While effect of varying packet size on frame rate in a multi- channel system, evaluation and analysis of experimental results were the focus of this work.

II. Related Work

Some research works on video coding aim to transmit multimedia data over bandwidth-limited wireless links are available in [5][6]. Nevertheless, transmission of uncompressed video seems impossible in the widely used 2.4 GHz or 5 GHz unlike at 60 GHz mm Wave according to [3][7]. The work in [8] demonstrated the feasibility of streaming ultra-high definition video content over wireless network in real time, using a PC platform, compute unified device architecture (CUDA), assisted GPU and commercial-of-the shelf (COTS) wireless HD boxes, with no virtual impairments. The study [9] described system level design proof of concept demonstration of 2-Gbps uncompressed HDTV transmission using a 60 GHz SiGe radio chipset. The research work in [10] studied the link-level performance of state-of-the-art 60 GHz radios in the context of robustness to obstructions and sensitivity to antenna array orientation. The IEEE 802.11ad standard divides the available bandwidth into 2.16 GHz wide sub-channels, each of which is capable of supporting uncompressed HD video transmission in 4k UHD TV. [11] delivers four times the picture resolution of 1080p full high definition (HD) which is eight million pixels contrary to two million pixels in 1080p. Technically, 4k requires at least 4000 horizontal pixels, but the most common and current trend in the A/V industry is to offer display with resolutions of 3840×2160. This resolution was originally called Quad Full HD because it is exactly four times the resolution of 1080p. In October 2012, the consumer electronics association introduced the term Ultra-High Definition or Ultra HD in describing any display device having minimum of 3840 horizontal pixels, 2160 vertical pixels and aspect ratio of 16:9. 4k UHD is thus a derivation of the 4k digital cinema standard, local multiplex shows images in native 4096 × 2160 with new consumer format 3840×2160. Thus, 60 GHz frequency band is a top priority for transmission of high-definition (HD) video over wireless networks while most of the wireless HD video transmission is compressed using H.264 standard [12].

III. Material and Methods

The experimental setup in Fig 1 shows the 60 GHz wireless link between WiGig 802.11ad access point (A.P) and latitude 6430u as the transmitter (Tx). HDMI 1.4 connects the A.P with the high definition television HDTV. The required minimum bandwidth for 4k UHD 23Hz 8-bit video is 2.29 Gbpsbyusingequation(1)adaptedfrom[13].

$$B = R * FHZ * S \qquad (1)$$

where B represent the bitrate, F*HZ* is frame rate, R is the resolution of the video image per frame and S depicts chroma sub-sampling. Thus, maximum data rate of 3.850 Gbps between the A.P and Tx is greater than what is required for live streaming of 4k UHD video. The PC that serves as Tx in the experiment is a high speed computer Intel i5 central processing unit (CPU) operating at 1.90 GHz with installed memory of 4.0 GB. A camera model Flea 3 FL3-U3-88S2C equipped with FlyCapture software development kit (SDK) provides a common software interface to control and acquire real time images from point grey USB 3.0 camera using the same application program interface (API) under 64-bit window. Its GigE image filter driver is to reduce latency and dropped frames, and maximized bandwidth. 4k live streaming from the camera serves as input to latitude.

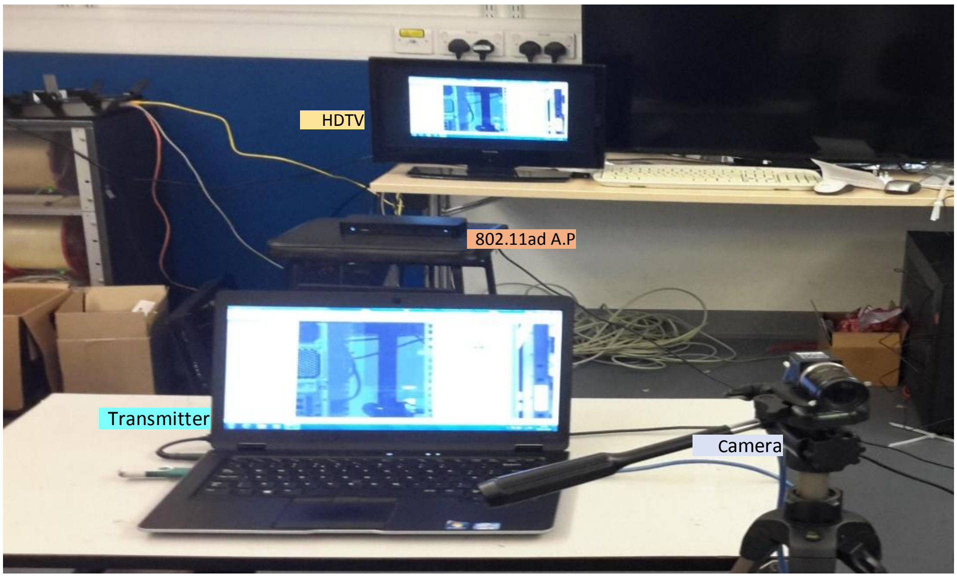

Fig 1: 4K UHD streaming over 802.11ad single channel

Fig 2 shows pictorially, three 60 GHz wireless connection between wireless WiGig docks (802.11ad A.P) D1, D2 D3 and transmitter 1, 2, 3 and Fig 3 is the real application setup of the links for the determination of the estimated bandwidth for different packet sizes and frame rates, processed frames, displayed frames, requested frames and received frames. The experimental evaluation of 60 GHz IEEE 802.11ad live streaming, error free 4k ultra-high definition (UHD) transmission over 22 m range exceeding the 10 m 802.11ad specification was presented.

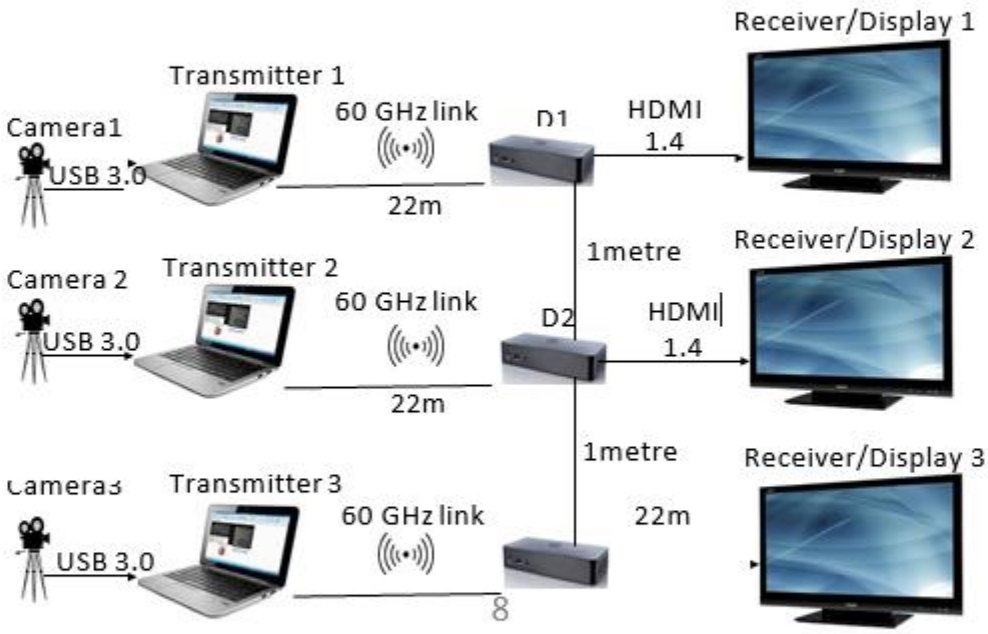

Fig 2: Pictorial Diagram of 4K UHD streaming over multi-channel 802.11ad

Fig 3: 4K UHD streaming over multi-channel 802.11ad

The docking stations DI, D2, and D3, can operate on any of the three available 60 GHz bands: Channel 1 58.32 GHz , Channel 2 60.48 GHz and Channel 3 62.64 GHz as shown in the docking status. Maximum separating distance between the docks is 1 m. Each of the three settings consists of six configurations as shown in table 1 where x presents different channel without polarization, y is polarization on different channel and z depicts same channel polarized. The specification about the camera used is given in table 2,

Table 1: Channel configuration settings

	Settings	x		Settings	y		Settings	z	
I	1	2	3	1	2	1	1	1	2
II	2	3	1	1	3	1	1	1	3
III	3	1	2	2	1	2	2	2	1
IV	2	1	3	2	3	2	2	2	3
V	1	3	2	3	1	3	3	3	1
VI	3	2	1	3	2	3	3	3	2

Table 2: Camera Specification

Type	FlyCapture 2 camera selection 2.5.3.4
Model	Flea 3FL3-U3-88S2C
Resolution	3840 ×2160
Interface	USB 3.0
Megapixels	8.8 MP
ADC	12-bit
Gain Range	0 dB to 24 dB

The live streaming was conducted using 18 different channel settings based on the three configurations. All radio antennas transmit or receive signals from a particular polarization not being sensitive to the orthogonal polarizations. Symmetrically, an antenna that lies wholly in a plane which also includes the observer can only have its polarization along the direction of that plane. The same frequency channel can be used for two signals broadcast in opposite polarizations, this is achieved by adjusting the receiving antenna for one or the other polarization, any of the signals can be selected without interference [14]. According to table 1, the arrangement and orientation of the 802.11ad A.Ps (D1, D2, D3) is as shown, settings x shows six different configurations in which we ensure that same channel (1, 2, or 3) are not placed side by side. Again, settings y equally has six different arrangements in which same channel were placed on either end of another channel. Lastly, settings z shows same channel placed side by side. The polarity of the antenna in settings z was arranged such that the docks alignments are different.

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IV. Results and Discussion

The experimental results as shown in Fig 4 reveals the reliability and feasibility of using 802.11ad to produce a high-quality live streaming with no packet loss and thus no need for retransmission. The QoS is very good as depicted in fig 4 since human perception cannot see any difference by the viewers.

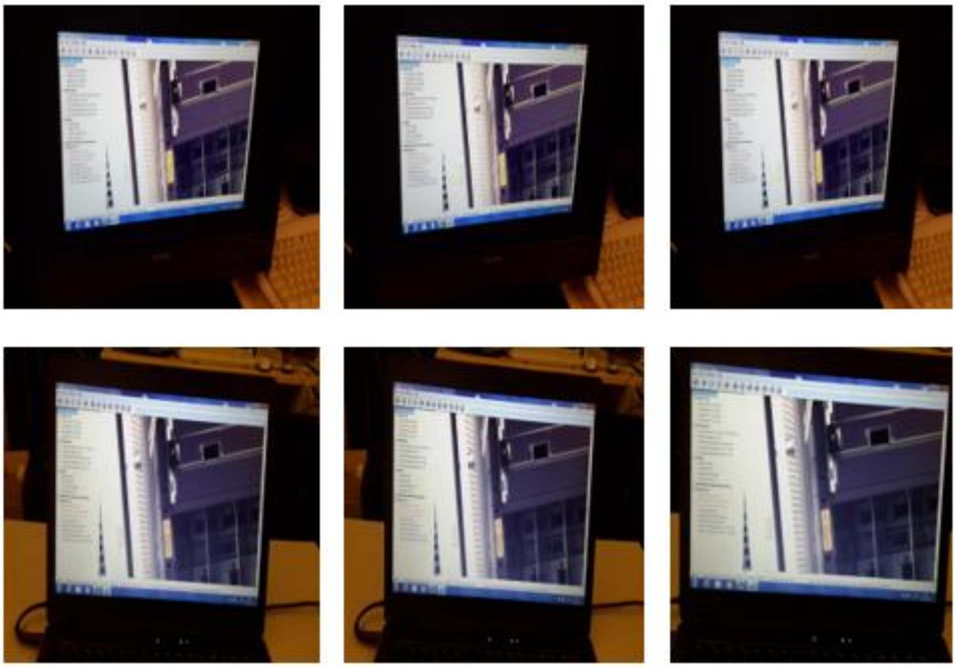

Fig 4: Receiver and output 4k display.

The delay associated with packet size is shown in figure 5, while Figs 6 and 7 are plots of frames rate against packet sizes. The evaluation of the device antenna omnidirectional pattern as shown Fig 8 shows the reliability and the potential of 802.11ad systems to always maintained wireless connection. It is good to note that the devices maintained wireless link up to 22 m which is more than double the 10 m 802.11ad specification, maximum link speed was 3850 Mbps as shown from the docking status which validates the fact that it does support data rates needed for uncompressed video streaming such as 4k UHD as depicted in Figs 9-11 for the three channels while Fig 12 is a combined curve for the three channels for the purpose of comparison

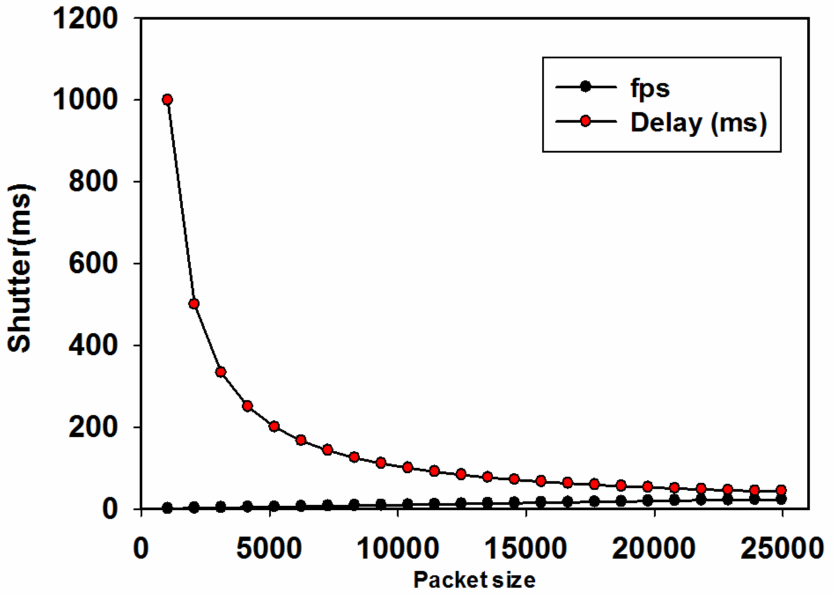

Fig 5: Shutter time and corresponding packet size

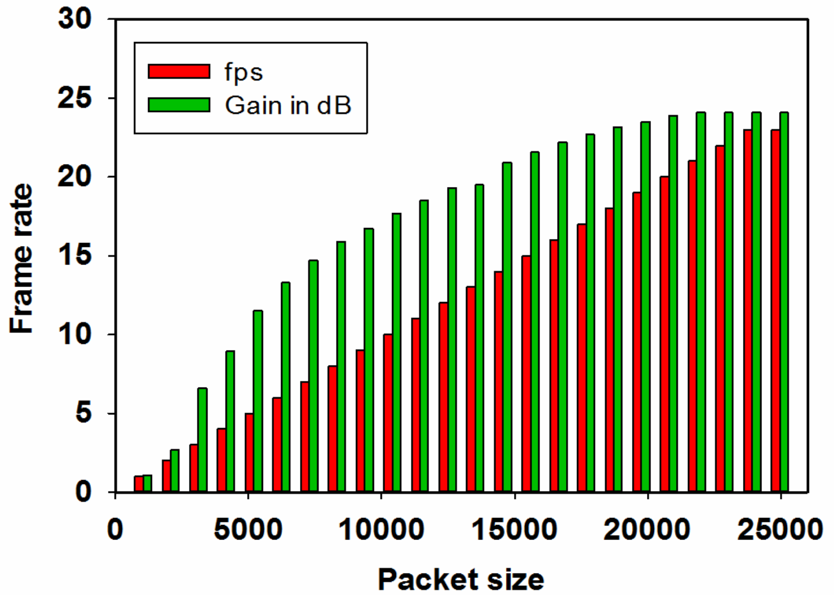

Fig 6: Frame rate and packet size

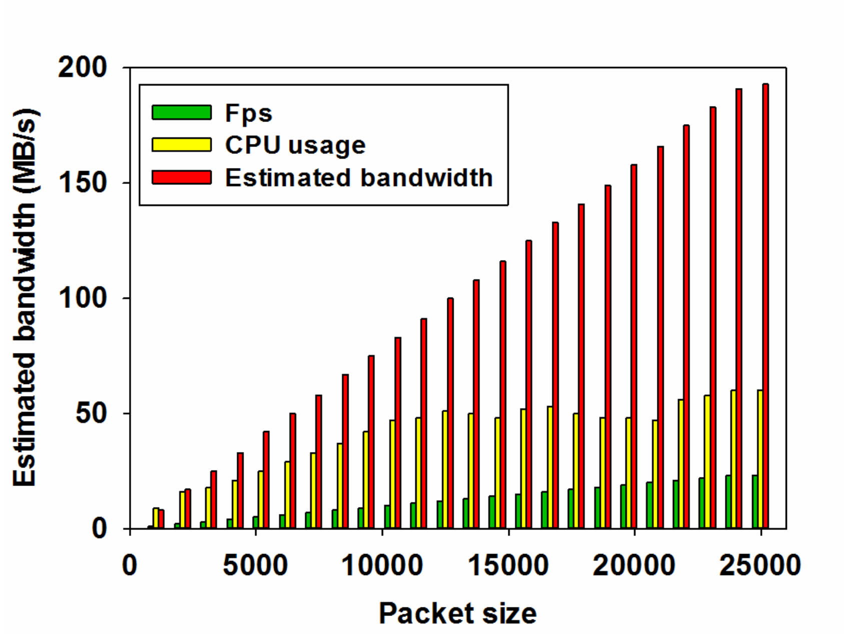

Fig 7: Estimated bandwidths and packet size

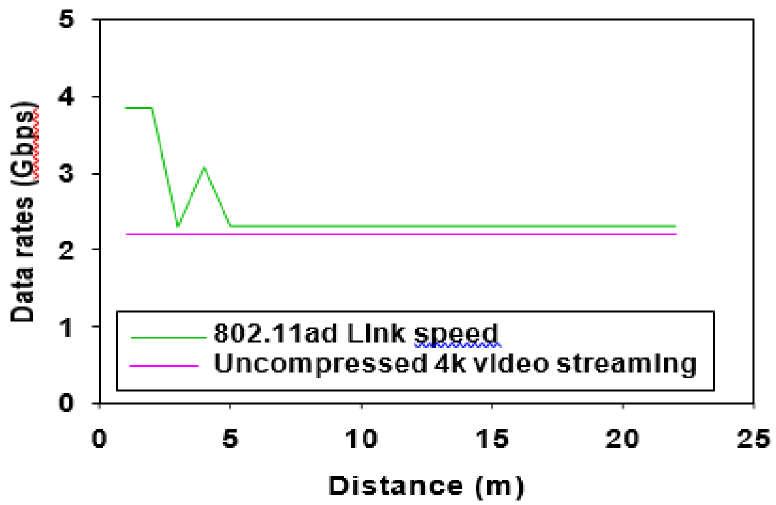

Fig 8: Uncompressed 4k UHD live transmission using 802.11ad WLAN.

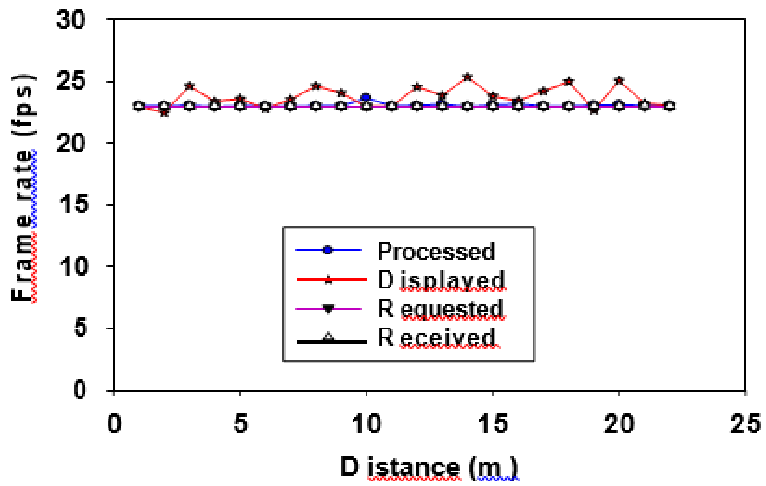

Fig 9: Frame rate against distance for channel 1

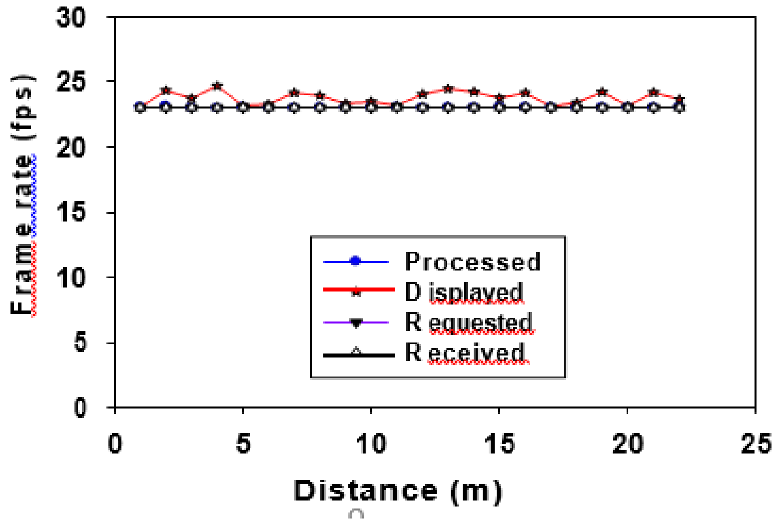

Fig 10: Frame rate against distance for channel 2.

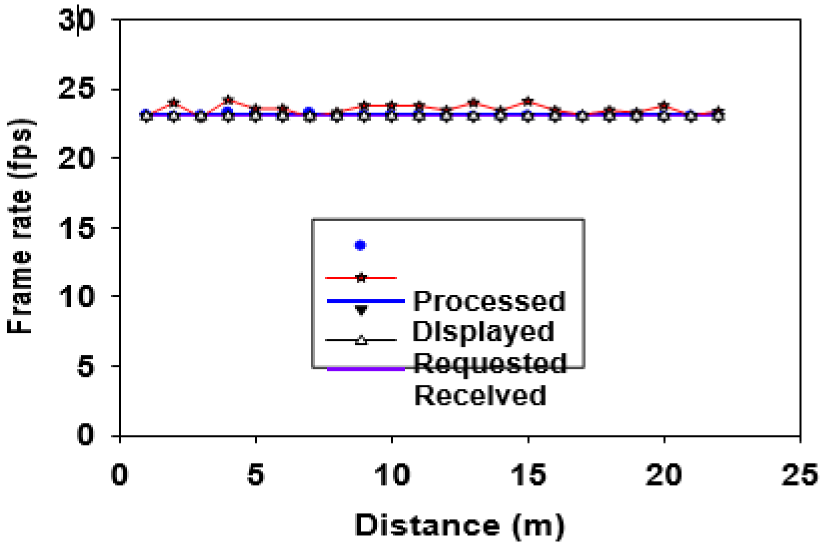

Fig 11: Frame rate against distance for channel 3.

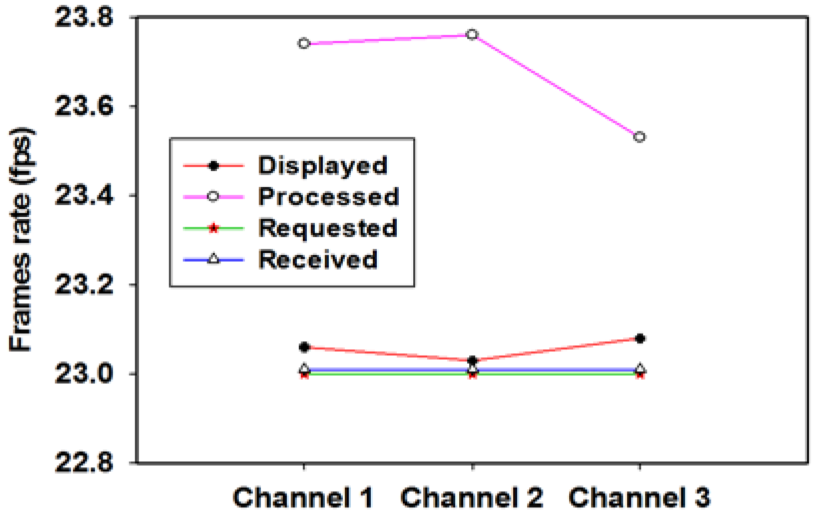

Fig 12: Frame rate against distance for the three channels

V. **Conclusion**:

A solution that demonstrates the possibility of transmitting uncompressed 4kUHD video sequences over a wireless network in real-time was provided, using three 60 GHz 802.11ad WiGig wireless for simultaneous transmission. It was found that provided a multi-gigabit data rate processing system served as the device inputting the stream to the wireless transmitters, uncompressed 4kUHD streaming was possible. Since the minimum bitrate required for a video sequence of that magnitude is a minimum of 2.39Gb/s, this was made possible.

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References

[1]. Adewale Abe and Stuart D. Walker "Multi-hop 802.11ad Wireless H.264 Video Streaming" IEEE 2016 94-99

[2]. S. Venuti, \Introducing hdmi 1.4 specification features," *Press Release*, 2009.

[3]. H. Singh, J. Oh, C. Kweon, X. Qin, H.-R. Shao, and C. Ngo, \A 60 ghz wireless network for enabling uncompressed video communication," *IEEE Communications Magazine*, (46) 12, 2008 71-78.

[4]. J. M. Gilbert, C. H. Doan, S. Emami, and C. B. Shung, \A 4-gbps uncompressed wireless hd a/v transceiver chipset,"*IEEEmicro*,(28)2,2008,56-64.

[5]. S. Colonnese, G. Panci, and G. Scarano, \Error resilient video coding for wireless channels," in *Personal, Indoor and Mobile Radio Communications, 2004. PIMRC 2004. 15th IEEE InternationalSymposiumon*,vol.4,2004,3040-30442004.

[6]. P. Havaldar and G. Medioni, *Multimedia systems: algorithms, standards, and industry practices*. Course Technology Press, 2009

[7]. Femi-Jemilohun O. J 1, Walker S. D "Performance Evaluation of 24GHz Spectrum Indoor Wireless Radio Links" International Journal of Emerging Technology and Advanced Engineering, 2014, 40-45

[8]. A. O. Ejeye and S. D. Walker, \Uncompressed quad-1080p wireless video streaming," in *Computer Science and Electronic Engineering Conference (CEEC), 2012 4th*, pp. 13{16, IEEE, 2012.

[9]. Y. Katayama, C. Haymes, D. Nakano, T. Beukema, B. Floyd, S. Reynolds, U. Pfeiffer, B. Gaucher, and K. Schleupen, \2-gbps uncompressed hdtv transmission over 60-ghz sige radio link," in *IEEE Consumer Commun. Networking Conf*, 2007, 12-16

[10]. X. Tie, K. Ramachandran, and R. Mahindra 60 ghz wireless link performance in indoor environments," in*International Conference on Passive and Active Network Measurement*, Springer, 2012, 147-157

[11]. I. Union, \Ultra high definition television: Threshold of a new age," 2012.

[12]. W. S. Version, \1.1 overview," *WirelessHD, Morgan Hill, CA, USA*, 2010.

[13]. C. Poynton, *Digital video and HD: Algorithms and Interfaces*. Elsevier, 2012.

[14]. T. S. Rappaport, R. W. Heath Jr, R. C. Daniels, and J. N. Murdock, *Millimeter wave wireless communications*. Pearson Education, 2014

Abe .A, et. al. "4K UHD Live Streaming Using 802.11ad AT Millimeter Wave Spectrum." *IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)* 17(2), (2022): pp 11-19.