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Wideband Millimetre Wave OFDM Uplink with Hybrid Receiving

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ABSTRACT

The main aim of this project is to develop a system which can help us to know more about millimeter-wave orthogonal frequency division multiplexing (OFDM) uplink transmission with hybrid receiving and with a wide bandwidth. By considering the spatial- and frequency-wideband effects in the channel model, the spectral efficiency of the system is analyzed. The analysis and the simulation results show the beam squint effect caused by the wideband effects. Moreover, the impacts of the bandwidth and the number of subcarriers on the beam squint effect are revealed.

Keywords - Millimetre-wave (mm-wave), wideband, beam squint, orthogonal frequency division multiplexing (OFDM), hybrid.

I. INTRODUCTION

This paper investigates the beam squint effect in millimeter-wave (mm Wave) communication systems, where a large antenna array and wide bandwidth are utilized to enhance data transmission rates. In such systems, the delay encountered by each signal path at the base station (BS) antennas not only introduces phase differences between antennas but also induces significant delays in the channel impulse response due to the wide bandwidth. This phenomenon, referred to as the spatial-wideband effect, leads to the beam formed by the BS pointing in different directions for different frequencies. The paper aims to analyse and understand this beam squint effect in depth.

The beam squint effect in wideband millimeter-wave (mm Wave) systems has been addressed in previous works, specifically in, where channel estimation approaches were proposed. In addition, the transmission issues associated with the beam squint effect were discussed in. However, the spectral efficiency of wideband mm Wave systems employing hybrid receiving has not been thoroughly analysed in these papers. While analyzes the signal-to-interference-plus-noise ratio (SINR) in wideband mm Wave systems and investigates the impacts of array dimension and bandwidth on the beam squint effect, the analysis does not consider the dual-wideband effects, namely the spatial- and frequency-wideband effects.

On a different note, the spectral efficiency of mm Wave systems has been studied in. However, these analyses have not specifically addressed the beam squint effect in wideband mm Wave systems.

It presents an analysis of the spectral efficiency in wideband millimeter-wave (mm Wave) orthogonal frequency division multiplexing (OFDM) uplink transmission systems employing hybrid receiving. The focus is on a base station (BS) equipped with a large antenna array and utilizing a hybrid receiving structure. The channel model accounts for the dual-wideband effects.

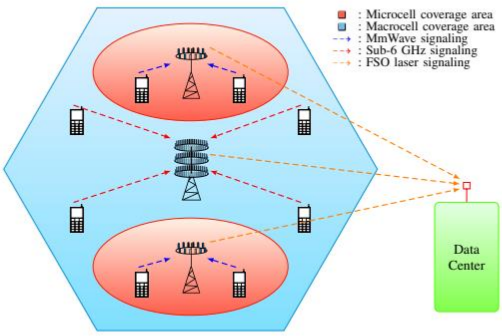

Fig 1. This study focuses on an outdoor heterogeneous mm Wave cellular relay network with FSO backhaul. Base stations act as relays to improve coverage. Sub-6 GHz communication occurs in macro cells requiring high power for reliable links. In microcells, mm Wave signalling supports high data rates reliably.

By examining the norm of the beam space channel, the paper derives the spectral efficiency of the system, demonstrating the degradation caused by the beam squint effect. Additionally, the impact of bandwidth and the number of subcarriers on the beam squint effect is investigated through an analysis of the spectral efficiency. These findings offer valuable insights for system design considerations.

Overall, wideband mm Wave OFDM uplink with hybrid receiving is an advanced technique that use the unique properties of mm Wave frequencies to achieve fast and reliable wireless communication. It is important for next-generation wireless networks with high data capacity and better user experiences.

II. LITERATURE SURVEY

This section we will give a brief introduction of the latest methods for comparison of OFDM and FDMCM uplink hybrid receiving. And some strategies are used for reference in our model

1. OFDM millimeter-wave communication for future wireless systems by Singh, M., Jindal, M., & Gupta, A. (2017): This paper is centered around the utilization of OFDM (Orthogonal Frequency Division Multiplexing) for millimeter wave communication in upcoming wireless systems. It examines the benefits of employing OFDM in dealing with frequency-selective channels, reducing the impact of multipath fading, and achieving remarkable spectral efficiency in millimeter wave OFDM systems. The references provided encompass a wide array of subjects related to millimeter wave OFDM, encompassing channel modeling, analysis of system performance, beamforming techniques, and evaluating the feasibility of millimeter wave communication for future wireless systems. These references can serve as an initial reference point for further exploration.

2. Millimeter wave frequencies for 5G cellular communication by Rappaport et al. (2013), is discussed. The authors highlight the benefits and obstacles associated with millimeter waves and emphasize the practicality of millimeter wave orthogonal frequency-division multiplexing (OFDM) for achieving high-speed wireless communication.

3. "Broadband Wireless: The New Era in Communications," a paper published by Intel. It is highlighted that the world is rapidly transitioning to wireless connectivity at a faster pace than anticipated. The paper envisions billions of people gaining high-speed internet access wirelessly within the next decade. Intel predicts that various high-speed wireless technologies, such as 3G, Wi-Fi, WiMAX, and Ultra-Wideband, will coexist and work together to cater to the diverse needs of service providers and customers

in a connected world. No single technology will dominate, and the strongest wireless solutions will combine multiple technologies to enhance mobility and enable seamless roaming. Intel is actively driving this wireless revolution through leadership, technology development, and the introduction of innovative silicon products like Intel Centrino, WiMAX technology, and Intel PXA processors.

4. "Issues in deploying smart antenna in mobile radio networks" by Rameshwar Kawitkar, the focus is on discussing the challenges related to smart antenna implementation in mobile radio networks.

Khurram Sheikh et al. provide an overview of smart antenna (SA) applications in fixed broadband wireless access (BWA) networks. They describe various SA techniques, including the recent advancement of "spatial multiplexing," which greatly enhances the performance of BWA networks. The paper "Smart Antennas for Broadband Wireless Access Networks" examines the impact of SA techniques on the capacity and throughput of BWA networks.

5. "Channel Estimation and Hybrid Combining for mm Wave: Phase Shifters or Switches" by R. Mendez-Rial et al., presented in 2015, discusses how to improve communication in high-frequency wireless networks.

To solve this problem, the authors suggest using a combination of analog and digital techniques.

The paper explores two methods: phase shifters and switches. Phase shifters adjust the phase of the received signal, while switches select specific antennas for combining the signals. One important aspect of the research is channel estimation, which means figuring out the characteristics of the wireless channel.

By studying and analyzing the results, the authors provide insights into the advantages and disadvantages of using phase shifters and switches in mmWave networks. This information is valuable for improving the performance of these networks, enabling faster and more reliable wireless communication.

III. PROPOSED SYSTEM

OFDM

OFDM, or Orthogonal Frequency Division Multiplexing, is a fancy term for a method used in wireless communication systems to send lots of information at once. It's like having multiple lanes on a highway where each lane carries different data. This technique is used in things like Wi-Fi, 4G LTE, and digital broadcasting.

Here's how it works: Instead of sending all the data on one frequency, OFDM divides the frequency into many smaller ones called subcarriers. These subcarriers are carefully chosen to not interfere with each other. It's like having different musical notes that don't clash.

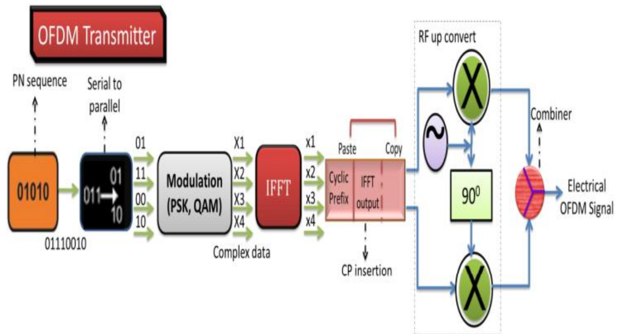

Fig 2. OFDM Transmission Process

MM waves, or millimeter waves, are a type of wireless technology that brings some cool benefits. They have a large bandwidth, which means they can carry a lot of information at once. Even though they have a big capacity, the components needed to use them are small in size.One great thing about MM waves is that they provide greater resolution, which helps with things like detailed imaging or precise measurements. They can also help reduce interference, so you get a more reliable and clearer signal.

Another advantage of MM waves is that they offer increased security. They operate at very high frequencies, making it harder for unwanted snoops to intercept or tamper with the signals.

Overall, MM waves are pretty awesome because they give us more speed, smaller devices, clearer signals, and better protection. That's why they're being used in a bunch of different wireless technologies to make our communication faster and more efficient.

A) LARGE BANDWIDTH

Microwave frequencies have a limit of 1 gigabit per second for data transfer rates. However, millimeter waves offer a larger bandwidth, allowing for better data transfer rates of about 10 gigabits per second. This means we can enjoy real-time gaming, high-quality video streaming, and other bandwidth-intensive applications more smoothly and without delays.

B) GREATER RESOLUTION

Millimeter waves help us achieve greater resolution because they can be focused into narrow beams, allowing for more precise and detailed imaging or measurements. Additionally, millimeter-wave equipment has small components, like tiny antennas, thanks to their high frequency. This small size is important and useful for various applications.

C) Low interference and increased security

Millimeter waves have low interference and increased security because their narrow and short-range beams are less likely to be affected by external signals or obstacles. This makes it harder for others to intercept or interfere with the signal, ensuring better security for our communication.

IV. SOFTWARE DETAILS

Using MATLAB software 2021 for the comparison of OFDM uplink with hybrid receiving. To avoid repetitive coding in MATLAB, you can create .m files, which can be either scripts or functions. Scripts act as an extended command line statement where variables are shared between the script and the workspace. They don't have input or output arguments.

On the other hand, functions have their own workspace and are typically called with input arguments and return output arguments. They are declared using the "function" keyword.

Creating a MATLAB script is straightforward. Open the MATLAB editor by typing "edit example_script.m" in the command window. Write your code lines and save the file in a location within the MATLAB search path. You can then call the script from the command line.

In summary, scripts and functions in MATLAB serve different purposes: scripts work as command-line statements without input or output arguments, while functions have their own workspace and can be called with input arguments and return output arguments.

5. Performance Characteristics

The special performance characteristics are Spectral Efficiency, Signal to Noise Ratio, Bandwidth, Subcarriers and Orthogonality.

A) Spectral Efficiency

Spectral Efficiency is a measure of how efficiently the available frequency spectrum is utilized to transmit data in wireless communication systems. It quantifies the amount of information that can be reliably transmitted per unit of bandwidth in the communication channel.

B) Signal to Noise Ratio

SNR is defined as the ratio of the power or amplitude of the signal to the power or amplitude of the noise in a given channel. It quantifies the quality and reliability of the received signal. A higher SNR indicates a stronger signal relative to the noise, resulting in better communication performance.

C) Bandwidth

Bandwidth refers to the range of frequencies or the frequency range that is allocated for a wireless communication signal to be transmitted or received. It represents the capacity of the communication channel to carry information.

D) Subcarriers

Subcarriers refer to individual frequency components that are used to transmit data within a broader bandwidth. They are commonly employed in techniques such as Orthogonal Frequency Division Multiplexing (OFDM) and its variants.

E) Orthogonality

Orthogonality in wireless communication refers to a mathematical property of signals or waveforms that are completely independent and do not interfere with each other, even when they are transmitted or received simultaneously in the same frequency band.

V. RESULTS

The result of the project includes:

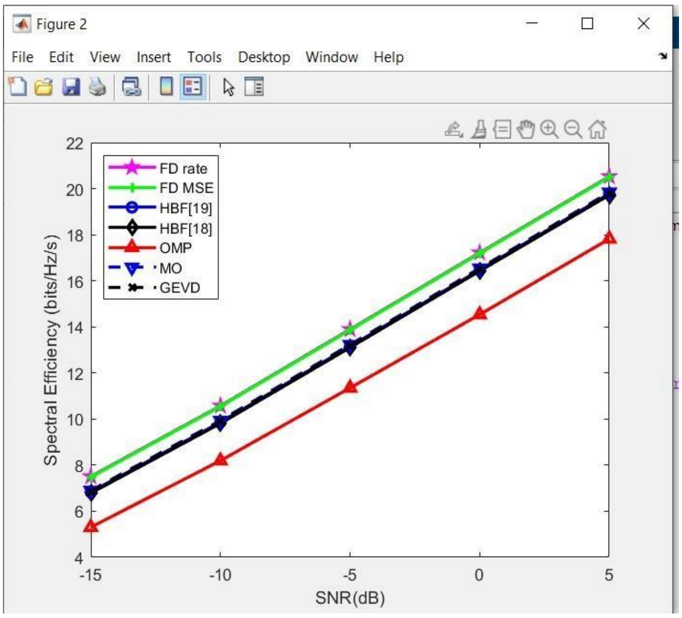

Fig 3. SNR vs Spectral Efficiency

Fig describes the changes in spectral efficiency under different SNRs. It can be seen that when the SNR is lower than -10 dB, the spectral efficiency is very close to the upper bound. This is because the interference has limited effects on the spectral efficiency when the SNR is low. It can also be seen that the spectral efficiency is close to the approximation when the SNR is lower than -10 db.

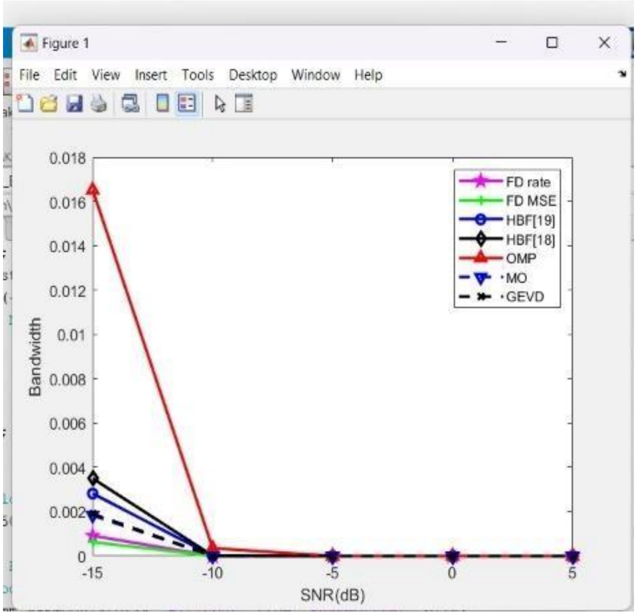

Fig 4.SNR vs Bandwidth

This is verifying that the approximation for the narrow bandwidth case is of little error for the low SNR case. When the SNR is higher than -10 dB, the spectral efficiency begins to saturate, while the approximation still increases. Bandwidth vs SNR shows that when the bandwidth increases SNR decreases.

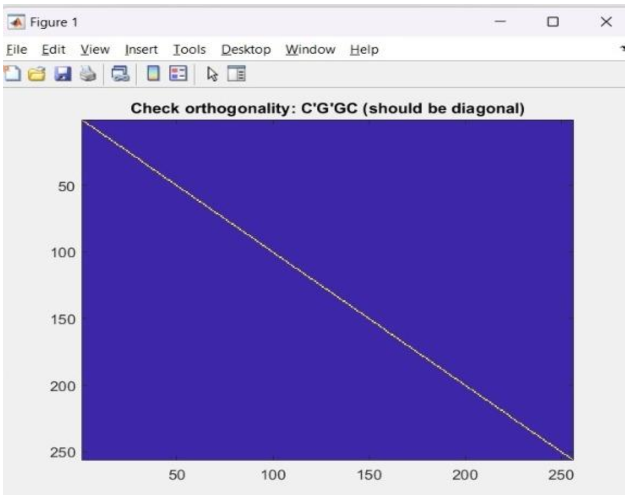

Fig 5. Orthogonality

Analyses the autocorrelation properties of individual subcarriers. Each subcarrier should have a low autocorrelation value at all lags except at zero lag, where it should have a high autocorrelation value. This indicates that the subcarriers are orthogonal to one another and do not interfere with each other. As a reason we will get diagonal graph.

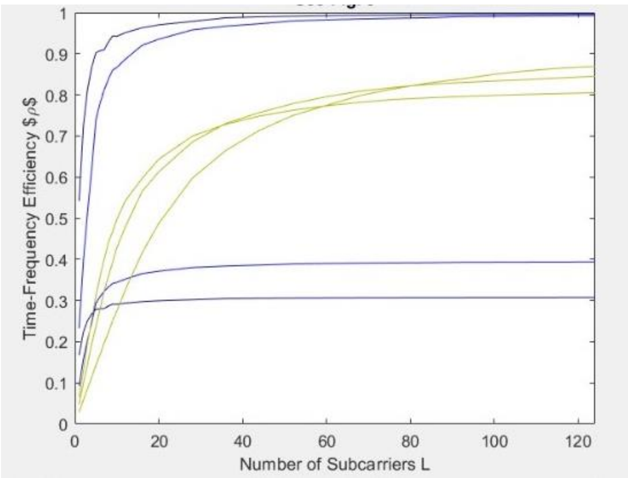

Fig 6. Number of Subcarriers vs time-frequency Efficiency

The time-frequency efficiency in a communication system involves optimizing the utilization of both the spectral and temporal resources. The number of subcarriers in techniques like OFDM plays a significant role in achieving this efficiency, as it affects the spectral efficiency and the trade-off between the data rate per unit bandwidth and the overhead associated with guard bands and synchronization. Time-Frequency efficiency increase with number of subcarriers shows that the strength of signal is high.

VI. FUTURE SCOPE

Satellite communication has been important for broadcasting and multimedia services for a long time. Satellites help transmit TV, radio, and multimedia content to a large audience over bigareas. To deliver high-quality audio and video, a technique called FDMCM is used. It divides the available spectrum into smaller parts and uses them to transmit content. This method ensures reliable and strong transmission, even when there are obstacles or interference, so we can enjoy good-quality multimedia services.

VII. CONCLUSION

In this paper, we analysed the spectral efficiency, signal to noise ratio and power spectral density of wideband mm-wave OFDM system with a large antenna array at the BS. The analysis and the simulation show that the wide bandwidth makes the beam points to a direction away from the path, i.e., causes the beam squint effect. We show that by increasing the number of subcarriers the beam squint effect can be alleviated.

VIII. REFERENCES

[1]. Haris Majeed, Rahim Umar, Arslan Ali Basit, “SMART ANTENNAS–MIMO, OFDM & Single Carrier FDMA for LTE”, Master's thesis, Linnaeus University, 2011-06-10

[2]. Saleh Ali Alomari et al. “A Comprehensive Study of Wireless Communication Technology for the Future Mobile Devices,” European Journal of Scientific Research, Vol. 60, pp. 565-573, 2011

[3]. Intel, Broadband Wireless: The New Era in Communications, Technical White Paper, 2004

[4]. Daniel J. Bem, Pawel Kabacik, “Smart Antennas for Mobile Communications Systems”, 13th International Conference on Microwaves, Radar and Wireless Communications, MIKON-2000., Vol. 3, pp.20-30, 22-24 May, 2000

[5]. Rameshwar Kawitkar, “Issues in Deploying Smart Antennas in Mobile Radio Networks,” World Academy of Science, Engineering and Technology, 17, pp. 360- 365, 2008.

[6]. Khurram Sheikh, David Gesbert, Dhananjay Gore, Arogyaswami Paulraj, “Smart Antennas for Broadband Wireless Access Networks”, IEEE Communication Magazine, pp. 1-17, Nov. 1999.

[7]. G. Li, L.L. Yang, W.S. Conner, and B. Sadeghi, Opportunities and Challenges for Mesh Networks Using Directional Antennas., In WiMESH’05, Santa Clara, California, USA. September 2005.

[8]. X. Gao, L. Dai, S. Zhou, A. M. Sayeed, and L. Hanzo, “Wideband beamspace channel estimation for millimeter-wave MIMO systems relying on lens antenna arrays,” IEEE Trans. Signal Process., vol. 67, no. 18, pp. 4809–4824, Sep. 2019.

[9]. B. Wang, F. Gao, S. Jin, H. Lin, and G. Y. Li," Spatial- and frequency wideband effects in millimeter-wave massive MIMO systems", IEEE Trans. Signal Process., vol. 66, no. 13, pp. 3393–3406, Jul. 2018.

[10]. J. H. Brady and A. M. Sayeed, "Wideband communication with highdimensional arrays: New results and transceiver architectures," in Proc. 2015 IEEE Int. Conf. Commun. Workshop (ICCW), London, UK, Jun. 2015, pp. 1042–1047.

[11]. A. Alkhateeb, G. Leus, and R. W. Heath, Jr., "Limited feedback hybrid precoding for multi-user millimeter wave systems," IEEE Trans. Commun., vol. 14, no. 11, pp. 6481–6494, Nov. 2015.

Authors Biography

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B Jyothsna is a Associate Professor in Bhoj Reddy Engineering College For Women, Hyderabad affiliated to JNTUH, where she has been a faculty member since 2001. She completed 20 years of service in this college.

She worked as incharge HoD for a period of eight months. She headed many committees established by the college and conducted various programs for students and faculty. B Jyothsna completed her M. E at Osmania University College Of Engineering, Hyderabad and her undergraduate studies at Osmania University College Of engineering, Hyderabad. Her research interests lie in the area of wireless communications, optical communications, Digital design. Under her guidance many students successfully completed their mini and major projects.

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BTech student currently enrolled at Bhoj Reddy Engineering College. I completed my intermediate education at Narayana Junior College. With a passion for learning and a desire to make a difference, I have been actively pursuing various academic and extracurricular activities. Their dedication to their studies and their curiosity to explore new ideas have helped them develop a strong foundation in their field of study. As a result, they are excited to share their insights and findings in this paper.

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I am a BTech student studying at Bhoj Reddy Engineering College. Before that, I completed my intermediate education at Narayana Junior College. I love learning and want to make a positive impact. I enjoy participating in different academic and extracurricular activities. I am dedicated to my studies and always curious to explore new ideas. Through my hard work, I have developed a strong understanding in my field of study. I am excited to share my knowledge and discoveries in this paper.

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