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Role of Millimeter Wave for Future 5G Mobile Networks: Its Potential, Prospects and Challenges

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***Abstract*—5G mobile communications targets at having high data bandwidth, endless networking ability for information exchange and huge signal coverage capability to the end users in order to support a well off range of high quality adapted services. Making this 5G vision a reality governs concept of 5G New Radio (NR) defined by 3GPP, a air border design that will bring new levels of elasticity, scalability, and efficiency to meet the increasing connectivity needs in the next era and beyond. It has determined the usability of the beneath-exploited millimeter-wave (mm Wave) radio spectrum for the upcoming 5G broadband wireless communication networks. The mmWaves propagation channel fact is required to its core based for the effective placement of mmWaves mobile communication systems. It exists between series of 3-300GHz bandwidth in mmWaves spectrum ranges. The main trials, keys and benefits linked in perspective with evolving of 5G mobile wireless networks. This paper extant the features the mmWaves propagation channel, and highpoint.**

Keywords—5G, Millimeter wave; 3GPP; new radio; scalability; data bandwidth

I. INTRODUCTION

In communication industry one of the fastest growing sector are mobile phones which is widely used and upgraded in due time. The popularity of smart devices coupled with the concept of IoT has brought about a rapid upsurge in use of mobile data posing a serious challenge for various service providers [1]. The theoretical values show that mobile traffic will observe a spike of 1000 fold increase in near future. A next generation of wireless radio standards should come to play to overcome the current 3G/4G network which should minimize the challenges.

In sub-3GHz spectrum which is severely packed are mainly used in communication system. Radio system designers generally aim for higher frequencies in order to ensure congestion free data rates throughout the network. A wide range of frequencies from 30 GigaHz to 300 GigaHz are assigned for mmWaves service, with roughly a 100 GigaHz in use. Millimeter Waves stand out to be the next big thing for future 5G mobile communication when it is coupled with Massive MIMO and femto cell. In order for such system to be ready to use some issues and questions must be addressed. The millimeter band range can vary in different frequency range which are as follows Q-band(30-40Ghz), U-band(40-60Ghz), V-band(50-75Ghz), E-band(60-90Ghz), W-band(75-100Ghz), F-band(90-140Ghz), D-band(110-170Ghz) and G-band(110-300Ghz).

II. MMWAVES CHARACTERIZATION AND PROPAGATION

It shows the operational range of 30-300 GHz band in mmWaves system, which is a promising result of the 5G cellular system for the future invention for backing up the multiple Gb/s of data rates. But the huddle is the handling of the channel weakening at the high frequency bands and transmission attributes. Due to higher carrier frequency the path loss is high in the propagation of mmWaves, which remains as major disablement and it reduces the existing diversity by decrease in scattering which leads to the obstruction of weak non-line-of -sight path with high outcomes.

As the number increases usage of higher bandwidths the noise power effect is more evident.

Path Loss: - The carrier frequency which is also denoted as 'fc' leads to the path loss in free space. The antenna size is reducing along with the increase of the carrier frequency. The result we obtain by this will be determined by antenna scales by a cause of λ24π, while for the case of free space path loss it grows with fc2. Therefore, the carrier frequency fc is increased from 3 to 30 GHz; irrespective of the distance between transmitter-receiver harmoniously enhance a power loss of 20dB. However for increased frequency, the prevention of the path loss from changing occurs due to a stable antenna opening at one point of the connection by growing frequency. The downfall of free path loss with fc2 will occur by maintaining the constant antenna aperture of each ends [4].

Blockage: - The effect of blockages on Microwave signals is less accountable be-cause of their fading property due to distraction. In addition to it, mm waves have a lesser tendency

to diffract as compared to microwaves and therefore much more vulnerable to blockages. This mainly leads to the formation of a bimodal channel due to absence of line of

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sight. Recent literature survey has revealed that in paper [4] studies has been conducted to study the dependency of path loss on transmitter and receiver distance. It has been found out that the path loss decreases at a rate of 20 dB/decade under standard line of sight transmission. The path loss for the non-line of sight link further decreases to 40 dB/decade with 15-20 dB additional loss. It can be thus concluded that shifting of the connection system from usable to non-usable version according to blockages. Hence small scale remedies cannot evade substantial shortcomings as concluded in [4].

III. DESIGN OF MMWAVES TRANSCEIVER SYSTEM

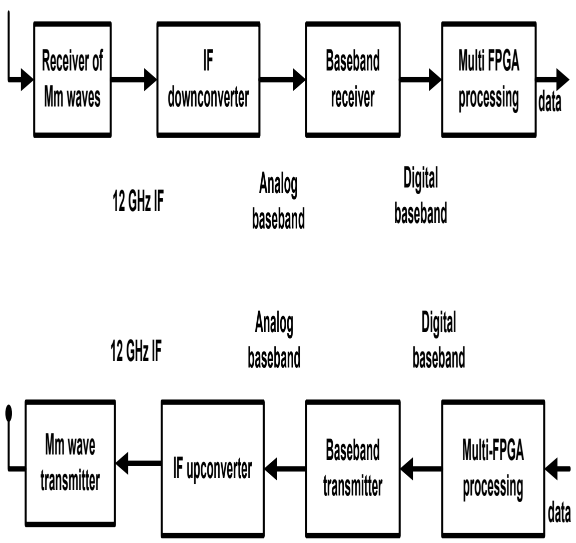

Figure 1: mmWaves transceiver design

I. FUTURE SCOPE

In the past few years, scientists analyzed mmWaves bundled along with couple of symbiotic techniques such as massive MIMO and femto cells are sufficient in attaining an ideal tough system.

Beam forming and Massive MIMO: With an aim of obtain commendable values of signal to noise ratio (SNR), mmWaves ensures that the electronically controlled antennas are given more power and high gain values. This ensures that the antennas will basically undergo pre coding and beam forming operation on arrays of large antenna. The small wavelength therefore ensures that more number of elements of magnitude can be integrated with antennas of real proportions. This thereby delivers sufficient gain to nullify the path loss thereby guaranteeing high SNR [5-6].

II. MIMO AND MMWAVESS: COMPARISON

TABLE 1: COMPARISON BETWEEN MIMO AND MMWAVESS

Parameters	Sub-6 GHz	mmWaves
Deployment scenario	High user mobility by backing of macro cells	Low user mobility by a smaller cell
Number of simultaneous users per cell	For large area coverage it uses up to ten users	As the coverage area is small singular user or less.
Main benefit from having many antennas	In order to attain great spectral efficiency, spatial multiplexing in the range of tens of user ability along with distinct users and array gain.	For improvement of the link budget and extension of coverage a single user Beam forming comes into play.
Channel properties	Best for multipath propagation	Compatible for less propagation paths
Spectral efficiency and bandwidth	Spectral efficiency high but lesser bandwidth	Spectral efficiency low due to limited users, but higher bandwidth.
Transceiver hardware	Completely digitalized with prototype designing complete.	Hybrid hardware comprising both analog and digital needed in the basic products.

Ultra Dense Networks (small cell deployment): Dense arrangement of mm Wave networks for evading blockages are encouraged. They are also unified with flexible arrays to benefit from the current technological scenario and help in transition from a shifting cellular pattern to an infrastructure more heterogeneous in nature that in-clues cells and relays of small dimensions... The absorption property of mmWaves helps in enhancing the isolation between the cells and further reduces the background signal interference arising from base transceiver stations [4-6]. Further research recommends a detailed investigation of MIMO system in which some critical points is to be taken into attention like a detailed insight into Beam forming technology, broader research into design of hardware components and fabrication, different control techniques in both simple and heterogeneous network structure [4].

III. SIMULATION AND RESULTS

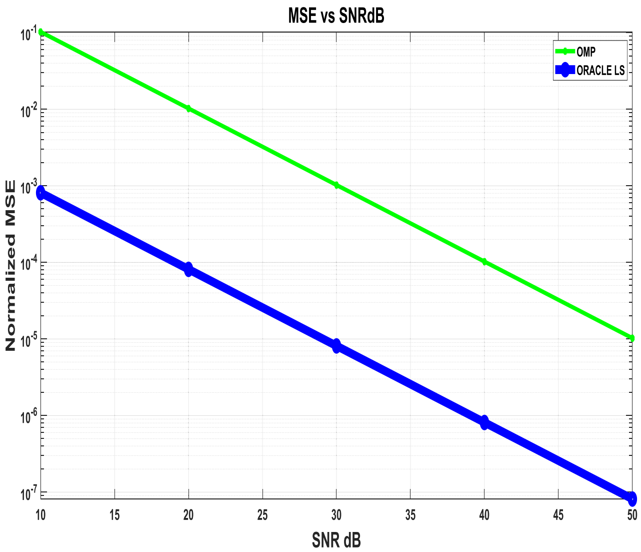

Figure 2: MSE vs. SNR (dB)

The above figure states that OMP (orthogonal matching pursuit) performs better than ORACLES in MSE vs. SNR using mmWaves having transmitter equal to 32 and receiver equal to 32.

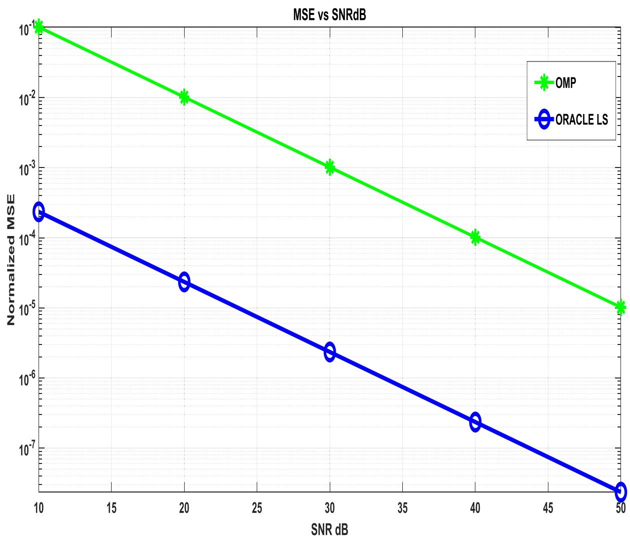

Figure 3: MSE vs. SNR (dB) under different conditions of transmitter and receiver

The above figure states that OMP performs better than ORACLES in MSE vs. SNR using mmWaves having transmitter and receiver equal to 32 and sparsity level to 2.

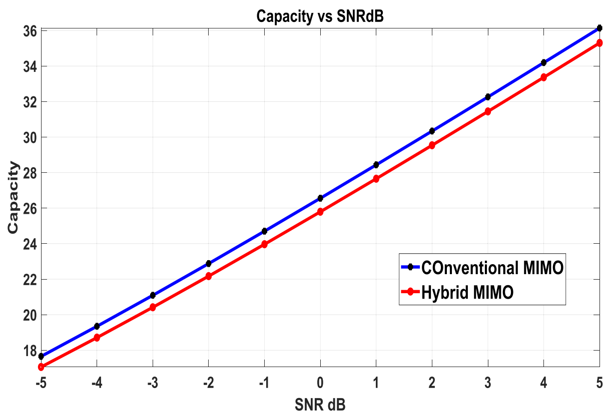

Figure 4: MSE vs. SNR (dB) under varying data streams

In above figure states that the capacity of conventional MIMO and hybrid MIMO increase simultaneously and parallel when the RF chain and data stream is equal to 6 in mmWaves.

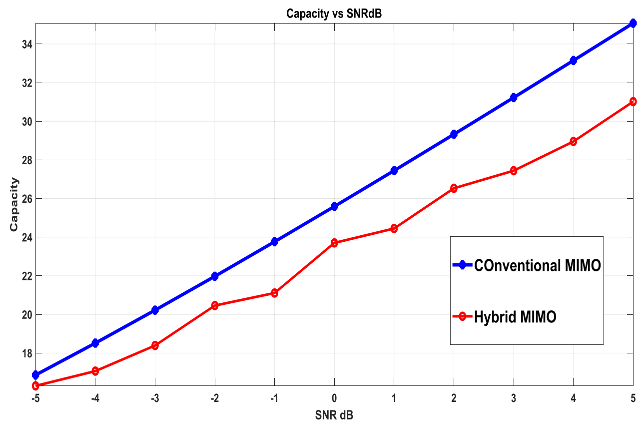

Figure 5: MSE vs. SNR (dB) under the condition of 6 data streams and 5 RF chains

The above figure states that the capacity of conventional MIMO forms in a liner way where as in hybrid MIMO it varies when we change the RF chain to 5 and data stream to 6 in mmWaves.

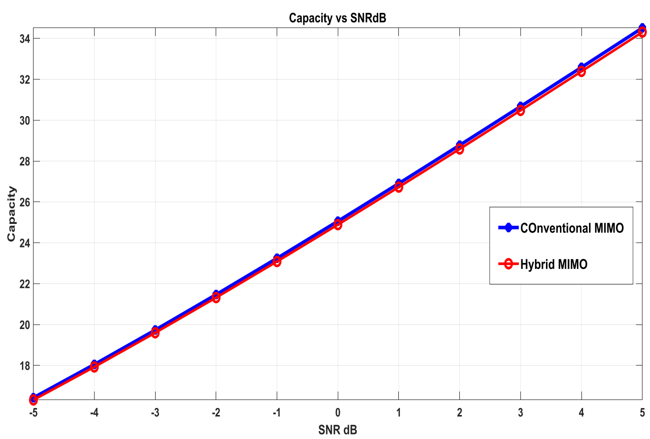

Figure 6: MSE vs. SNR (dB) under the condition of 6 data streams and 7 RF chains

The above figure states that the capacity of conventional MIMO and hybrid MIMO coincide with each other when the RF chain is 7 and data stream is 6 in mmWaves.

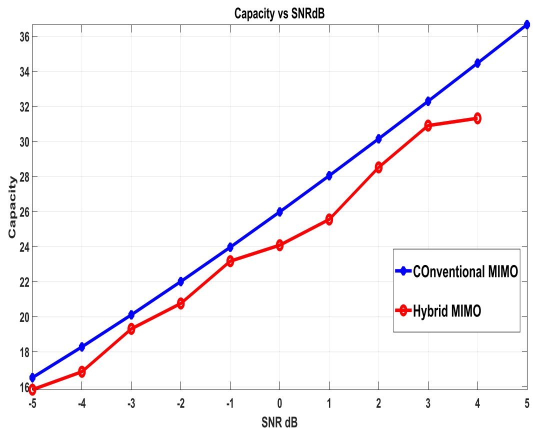

Figure 7: MSE vs. SNR (dB) under the condition of 5 data streams and 6 RF chains

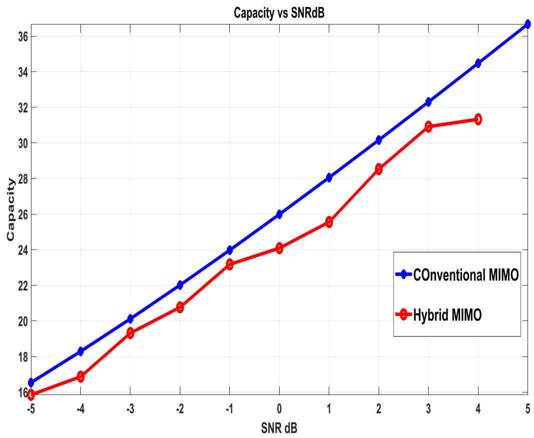

Figure 8: MSE vs. SNR (dB) under the condition of 7 data streams and 6 RF chains

IV. CONCLUSION

This paper shows assumption of mm Wave's development in the expertise field used in 5G cellular system. Addressed and potential solutions were presented to show the propagation challenges of the mmWaves. The major challenges remain on the path loss factor and blockage but the huge contribution of mm Waves with respect to 5G NR will be extremely high speed data transmission with supported enhanced capacity.

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