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NYUSIM-based Millimeter Wave Propagation Channel Model in 5G

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Abstract:- This paper represents experimentally determined large-scale and small-scale channel model parameters for 28 GHz and 73 GHz that describe the typical temporal and angular characteristics of multipath components for 5G communication. New York University researchers created a statistical spatial channel model for broadband millimeter-wave (mmWave) wireless communication systems, which served as the foundation for NYUSIM (NYU). The simulator works with a variety of carrier frequencies (500 MHz to 100 GHz). We display the 32x32 graphs between the transceivers using the NYUSIM. Performance demonstrates that the directed PDP (Path Delay Profile) has the best performance and that the PLE (Path Loss Exponential) is greater than the Line Of Sight (LOS).

Keywords:- *mmWave, MIMO (Multiple Input Multiple Output), 5G, NYUSIM.*

I. INTRODUCTION

Millimeter wave MIMO is viewed as one of the main 5G wireless network enablers. The Millimeter-wave (mmWave) with bandwidth of 30-300 GHz has been proposed for the 5G mobile network (1). Highly directional, steerable narrow beams may be generated in mmWave antenna arrays to accurately guide the broadcast power to the intended consumers along chosen direction. Compared to currently utilised microwave bands, mmWave bands have a relatively tiny wavelength. This allows for the combination of multiple antennas into a small-sized device, allowing for the physical miniaturisation of smaller circuits, modules, and equipment for 5G millimetre Wave applications. (2-6). Nowadays cellular systems use UHF (ultrahigh frequency) and Microwave bands exploiting multi-user multiple-input multiple-output (MU-MIMO). A 3D mm wave SSCM (Spatial Channel Model) for channel impulse response (CIR) is for omnidirectional and directional channel for transmitter and receiver. This article introduces an open-source channel simulator called NYUSIM (10). It is a developed based on extensive real-world broadband propagation channel measurements at several millimeter wave (mmWave) frequencies from 28 to 73 GHz. NYUSIM is accurate Rendering of the channel's actual impulse response in both time and time as well as the measured actual signal level Applicable to a wide range of carrier frequencies from 500 MHz to 100 GHz and RF bandwidth 0 to 800 MHz, there are 28 input parameter for this channel simulator. It can be grouped into two types channel parameter and antenna properties. NYUSIM searches the best pointing angles out of all possible pointing angles using the specified antenna details. The omnidirectional CIR and associated joint angle of departure (AOD)/angle of arrival (AOA) power spectrum are modelled using the statistical spatial channel model (SSCM) (8) in NYUSIM, which makes use of temporal clusters (TC) and spatial lobes (SL). The principal routes of arrival or departure of energy over several hundreds of nanoseconds are represented by spatial lobes.

II. LITERATURE REVIEW

Yichuan Lin et al. (3) focus on beam tracking in the millimetre wave range and are based on phase array antennas. This document also provides the sensor's attitude information and angle of arrival for mobile terminals. Angle of arrival mismatches caused by the mobile station in the beam tracking approach is the paper's restriction or research gap. The author of this study put up a predictive beam tracking system to avoid self blockage loss.

Sarvjit Singh et al (2, 4, 6, 9) show the simulation of different type of data over the LTE packet wavelets. This paper also included a performance analysis of wireless VOIP (Voice over Internet Protocol) for listed audio signal by applying other wavelets families. "The pro's of time frequency resolution and localization in wavelets makes it favourable too for audio signals transmitted via VOIP applications". ANOVA (Analysis of Variance) is used for the accuracy level of the recorded data.

Ahmed Alkhateeb et al (5) employ a hybrid precoding approach for a millimetre wave system with many users. A combination of digital and analogue processing based on signal hardware is needed for hybrid precoding. The asymptotic optimality technique and beam steering solution are provided in this study after analysis of the effects of single-path channels on the size of the system. The outcome demonstrates that the hybrid precoding gain is quite sensitive to the RF angles quantization.

Tyagi et al (7) used two AB structures that are presented the main emphasis of this article. The antenna is linked to a different RF chain using a switch-based network that changes the phase shifter. There is a 50% gain in energy efficiency. The ZF methodologies for both perfect and imperfect CSI were employed for the estimate of the transmitted symbol.

Morsali et al() The basic HB design was initially constructed by Morsali who then presented a method to verify the bare minimum of RF chains required to find any FD in HB. A common unit is thought to exist amongst all AB components. There is a minimal amount of RF required on its own if the output of the DB is the same throughout the

RF chain, and if it is not different, the minimum value of the RF chain is two, which is why the degree of freedom in design is discovered as a full solution.

Tyagi (2019) focusing on the two AB (Analog Beamforming) structures is proposed. The two different RF (Radio Frequency) chain is connected to the antenna where phase shifter can be changed into the switch based network. 50% of the energy efficiency can be increased. For the estimation of transmitting symbol used the ZF techniques for perfect and imperfect CSI.

Om Prakash Roy et al (9) focused on voice over the internet protocol technology. It deals with real time data transfer to make the use of internet for phone calls and video. This paper also includes the reliability techniques for obtaining the high quality of voice in voice over the internet protocol network.

Mustafa Sabah Noori et al (10) focused on the wireless network voice over the internet protocol (IP) protocol performance evaluation. This paper also include that the two signalling protocol are simulated using QualNet network to analyzed the performance of wireless network.

III. METHODOLOGY

- Uses millimeter-wave MIMO radio channels.
- Channel model with a frequency of 28GHz to 73GHz. UMi (Urban Microcell) scenario with 800 MHz bandwidth using the antenna of 32 x 32 ULA array antennas.
- NYUSIM application affects millimeter wave parameters such as in line of sight.

A. NYUSIM

New York University researchers created a statistical spatial channel model for broadband mmWave wireless communication systems on which NYUSIM is based. From 2 to 73 GHz, a 5G mmWave channel model was constructed. In order to support his 5G communication designs and realistic physical and data link layer simulations, NYUSIM may be utilised to provide realistic temporal and spatial channel responses. A large carrier frequency range, from 500 MHz to 100 GHz, may be covered by this simulator.

B. INPUT PARAMETER

The simulator's 28 entry parameters may be divided into two major categories: channel parameters and antenna attributes**.** Now the input channel parameters in NYUSIM can be defined as:

- Frequency: 28 GHz
- RF bandwidth: 800 MHz
- Scenario: UMi
- Environment: LOS
- Lower Bound of T-R
- Separation Distance: 10 m
- Upper Bound of T-R
- Separation Distance: 50 m
- TX Power: 30 dBm
- Base station height :3m
- user terminal height : 1.5m
- number of RX location:1
- Barometric Pressure:
- Humidity: 50%
- Temperature: 20?
- Rain Rate: 0 mm/hr
- Polarization: Co-Pol
- Foliage Loss: No
- TX Array Type: ULA
- RX Array Type: ULA
- Number of TX Antenna
- Elements Nt: 32
- Number of RX Antenna
- Elements Nr: 32
- TX Antenna Spacing: 0.5 wavelength
- RX Antenna Spacing: 0.5 wavelength
- Number of TX Antenna
- Elements Per Row Wt: 1
- Number of RX Antenna
- Elements Per Row Wr: 1
- TX Antenna Azimuth HPBW
- TX Antenna Elevation HPBW
- RX Antenna Azimuth HPBW
- RX Antenna Elevation HPBW

IV. RESULT

Through NYUSIM v3, results are collected and New York University produced it (NYU). With NYUSIM's drop-based mode, it is simple to create an ensemble of random, independent channel responses for either a set T-R separation distance or a range of T-R separation distances. For various T-R separation lengths, a simulation run may generate hundreds or thousands of channel impulse responses. In the simulations the Urban Microcell (UMi) is used in high density areas with distances up to 200 m, and the distance between the transmitter and receiver is also 10 m. Figure 1 shows 3D AOD power spectrum with a frequency of 28 GHz. The selected scenario is shown in UMi (Urban Microcell). The number of transmit / receive antenna elements is 32.

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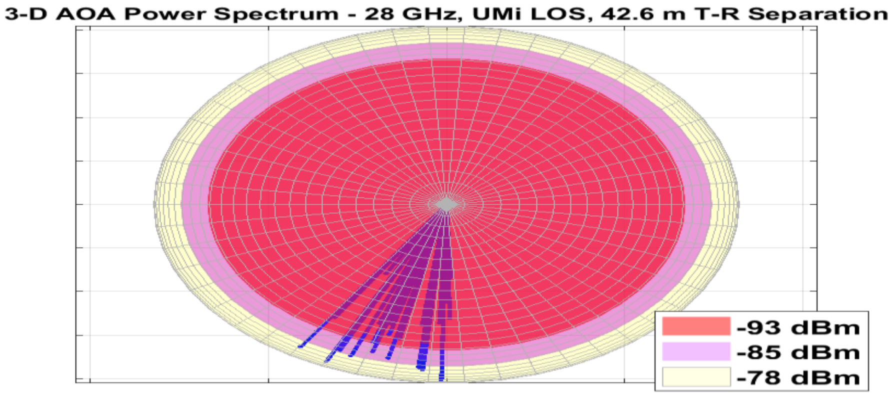

Fig. 1: 3D Angle of Arrival power spectrum

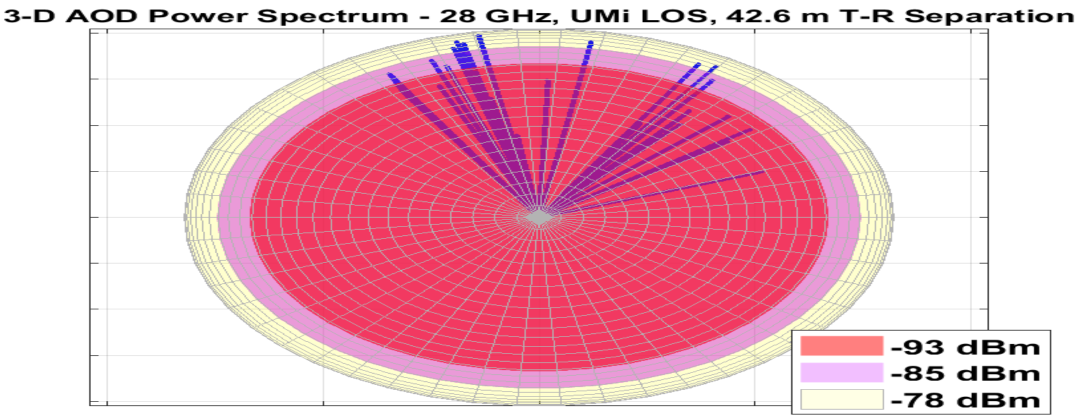

Fig. 2: 3D Angle of Departure power spectrum

In the NYUSIM simulator, the distance between the transmitter and receiver is in the range of 20-200m for UMi scenarios, LOS (Line of Sight) and Urban Microcell. In Figure 3 shows the omnidirectional Power Delay Profile (PDP). The PDP plot shows a few key pieces of data, including the frequency, environment, T-R separation distance, RMS delay spread, omnidirectional received power, omnidirectional path loss, and PLE. The transmit power, dynamic range of our measuring equipment, and a 10 dB SNR are used to calculate the lower limit of the y-axis, which represents the noise threshold. There are two main components to this figure: received power and time delay. The received power is 71.3 dBm and the propagation delay is 17.9 ns. The exponential path loss is 2.5.

In Figure 4 shows the directional PDP with the strongest performance. Since directional antennas/antenna arrays will be used at the TX and/or the RX in a realistic mmWave communication system to provide gains to offset the higher free space path loss at mmWave frequencies, this figure is produced by allowing users to implement arbitrary directional antenna patterns (gains and HPBWs) in an omnidirectional PDP. Using the provided antenna specifications, NYUSIM finds out the optimal pointing angle among all feasible pointing angles in order to achieve the directional PDP with the highest received power. The distance between the transmitter and the receiver is 42.6m. The pass loss index (PLE) is 2.9. This shows that PLE is high for LOS.

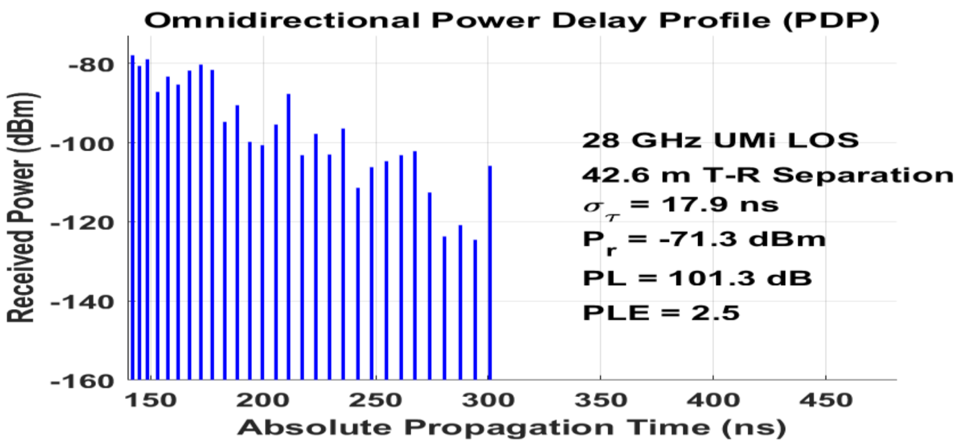

Fig. 3: omnidirectional power delay profile

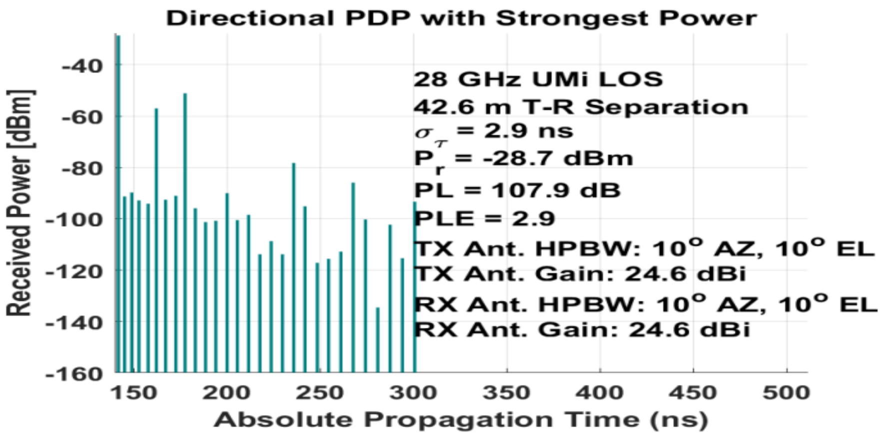

Fig. 4: Directional PDP with strongest power

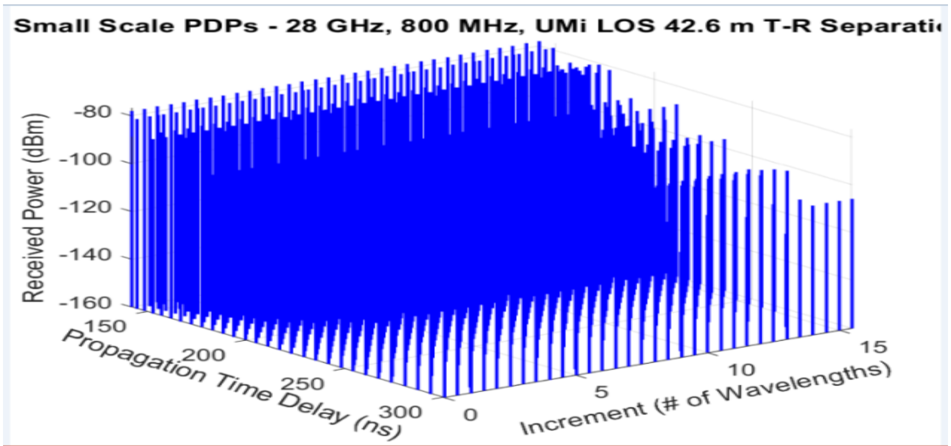

Fig. 5: PDP over different receive antenna elements

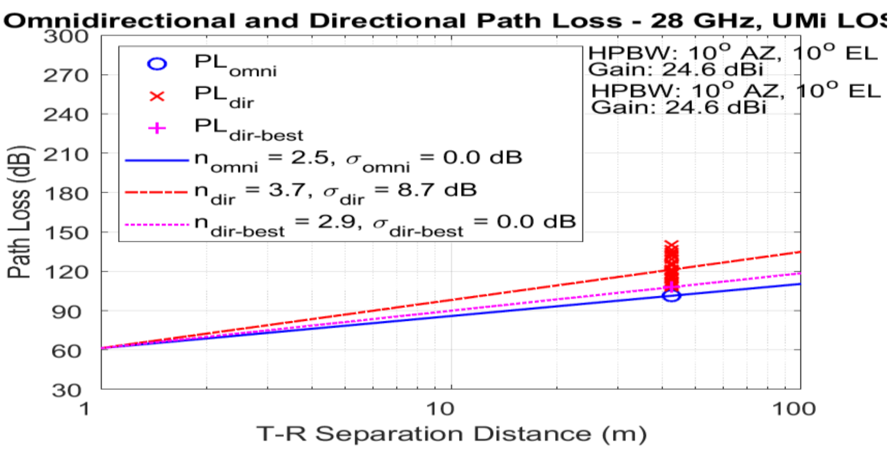

Fig. 6: Omnidirectional and Directional Power Delay Profile with LOS case

In figure 5 shows a sequence of PDPs over each receive antenna element, with the user specifying the GUI for the antenna array type, number of antenna elements, and spacing. In figure 6 shows omnidirectional path loss and directional path loss values throughout the whole distance range, as well as the fitted PLE and shadow fading standard deviation using the minimum-mean-square-error (MMSE) approach, were obtained from the N (N = 1) continuous simulation runs. In the "PathLossPlot," figure "n" stands for the pass loss exponent (PLE), "s" for the standard deviation of shadow fading, "omni" for omnidirectional, "dir" for directional, and "dir-best" for the direction with the greatest received power. After first creating the omnidirectional PDP, NYUSIM looks for all feasible pointing angles in increments of the azimuth and elevation HPBWs of the TX/RX antenna supplied by the user on the GUI for producing the directional path loss at each RX location. Because of the directional pattern of the directional antenna, which spatially filters out many multipath components, the received power has a higher directional path loss after the antenna gain effect is subtracted. This is because the received power has fewer multipath components, which results in less energy.

V. CONCLUSION

This study introduced the NYUSIM open-source channel software simulator, which was created using in-depth studies of broadband propagation at mmWave frequencies NYUSIM is outfitted with a GUI that makes the simulator more user-friendly. It recreates wideband PDPs/CIRs and channel statistics for a variety of carrier frequencies, RF bandwidths, antenna beam widths, environment situations, and meteorological conditions. In this paper the Genie-aided beamforming for mmWave system is discussed by defining the connection between mmWave MIMO systems and AOAs and AODs. The NYUSIM can be used for the analysis of transmitted and received data and the Angle of Arrival and Angle of Departure can be measured using the NYUSIM. The signal can be transmitted in omnidirectional and directional so there is some path loss which can be measured.

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