A Survey of Millimeter Wave communications (mmWave) for 5G:Future Promising Technology

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Abstract— **The drastic increase in the number of users in wireless technology created traffic handling problem. In future to provide faster data rate, reduced latency, better quality of service and more capacity 5G technology has emerged. Different frequencies are used to transmit and receive data over radio waves. In this paper, a survey on characteristics wave communication for 5G and challenges and of milli meter existing solutions.**

Keywords— Millimetre wave, Data rate, Directivity, Sensitivity to blockage, Energy and Cost, Interference management

I. INTRODUCTION

The millimeter wave (mmWave) technology is signals which has wavelength in millimeters level, usually mmwave frequency between 30 GHz and 300 GHz. The FCC has already assigned spectrum in milli meter wave range for both licensed and unlicensed use.several challenges like integrated circuits,interference management, system design, spatial reuse, anti-blockage, and dynamics control are exist in 5G technology. There are some key factors which has to be stressed out are discussed below, but it is necessarily to be satisfied simultaneously.

1) 5G technology should be able to handle better traffic explosion than existing system. In order to handle traffic caused by the user effectively, parameters like area capacity, edge rate and peak rate has to be taken care.

2) Latency varies from one system to other that is it is different for different system. The 4Ghas overall latencies about 15 ms, so latency should be less in 5G for faster communications.

5G aims to support round trip latency of about 1ms and also shrinking down the sub frame structure. Latency is the delay from input into a system to desired outcome.

3) The next generation communication requires more cost and energy on per-link basis. So the foremost objective of 5G network is to provide faster data rate and more bandwidth with less cost.

II. LITERATURE SURVEY

The characteristics of mmWave are considered in doing literature survey of 5G technology using mmwave. The literature survey has three main categories; they are measurement of wireless channel, directivity, and sensitivity to blockage. This has been summarized and showed below.

There is lot of propagation loss in the mmWave in compared to the other types of waves frequencies. The mmWave losses its energy by molecular absorption and rain attenuation because it limit the propagation of the waves [1]. The figure 1 and figure 2 shows the characteristic of mmWave in rain attenuation and molecular absorption against various frequencies. Smaller cell sizes are used to lower the propagation loss and to improve efficiency. Since rain attenuation and atmospheric loss do not affect the spectral efficiency of wave till 200m [2]. Due to this characteristic of the signal, it is mainly used in indoor applications and for small distance communication. In these communications small cell access and backhaul are used to implement to carry out the communication. Using this there has been an experiment has been conducted at 60GHz band in mmWave [3]. But the propagation loss in free space directly proportional to square of carrier frequency used. Therefore propagation loss in free space at 60 GHz is 28dB at wavelength of 5mm [4]. Also the oxygen absorption at 60GHz has been reported [5] and it has peak value between 15 dB/km to 30 dB/km. Non-line-of-sight (NLOS) and line-of-sight (LOS) has mentioned and he large-scale fading F(d) is given as

$$F(d) = PL(d_0) + 10n\log_{10} (d/d_0) - S_\sigma$$

Where the path loss and path loss exponent is represented by $PL(d_0)$ and n respectively. In below table the parameters of path loss are tabulated. Directional antennas are better in removing different propagation losses; hence it is used at both side of communication system to get very good antenna gain.

	$PL(d_0)$[db]	N	σ[db]
Corridor	68	1.65	2.52
LOS hall	68	2.17	0.88
NLOS hall	68	3.02	1.56

Table 1: Path exponent loss and path loss

In the LOS channel model, channel is called as Additive White Gaussian Noise (AWGN) channel if there is no multipath component and the direct path has all the energy. It is observed that there is no direct path in NLOS channel and there exist less energy. Therefore milli meter wave communication makes use of LOS transmission to attain high data rate and to increase power. Different frequencies like 28 GHz, 73 GHz, and38 GHz band channel measurements for mmWave has been executed[6].

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

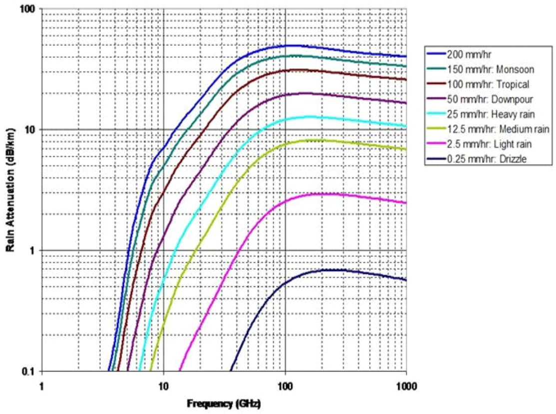

Fig. 1: Rain attenuation v/s frequencies [4]

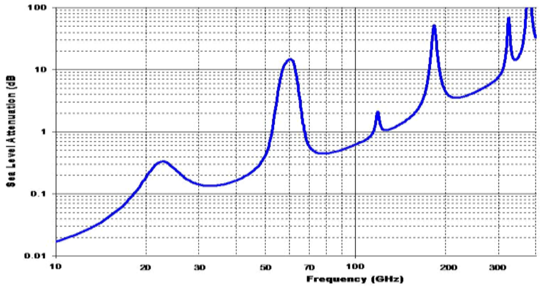

Fig. 2: Atmospheric and molecular v/s frequencies [4]

An experiment conducted at 28GHz and there was 75 to 125m distance kept between two communication systems. They observed increasing antenna gain, reduces the path loss exponent and increase in coverage distance. According to the report, the reflection and penetration measurements in tinted glass and brick pillars have more. But penetration losses and reflection and penetration loss in drywall and clear non-tinted glass are very less. The outdoor materials have more reflection co-coefficients in comparison with indoor materials.

Statistical model which include various losses at 28 and 73 GHz[7] are conducted. It was found strong signals can be received even in highly NLOS environments. The experiment conducted at 38GHz showed base station with lower height has better coverage and base station with higher height has worst coverage [8]. Beam training are used to steer beam towards required direction to get better gain at specific direction and various algorithm are explained to timing of beam training signal[9].

Diffraction of EM wave is weak around obstacles larger than wavelength of wave. Therefore maintaining proper connections using mmWave technology is very difficult process[10].

III. CHALLENGES AND EXISTING SOLUTIONS

Even with the prospective of mmWave communications, there will be number of challenges to be encountered, which are listed.

Distance(m)	1	2	4	6	10
Capacity(Gbps)	16.02	12.51	9.05	7.08	4.75

Table 3: variation of capacitance against distance

1) Integrated circuits and system design:

The high carrier frequency and wide bandwidth, several technical challenges are experienced. At 60GHz band frequency it is observed that there are various nonlinear distortion of power amplifiers caused by enormous bandwidth and high transmit power. There also exist problems like phase noise, IQ imbalance and few other problems in radio frequency integrated circuits.

2) spatial reuse and Interference management :

Interference between the links can be reduced by increasing the directivity of the transmission**.** The interference between nonadjacent links is neglected, and in outdoor mesh network of 60GHz band, the highly directional links are modelled as pseudo wired**.** During the designing the MAC protocols for mmWave mesh network, the antenna beam patterns are ignored. The carrier sense performed as in Wi-Fi cannot recognise in directional transmission which is also called as deafness problem. In this case, the coordination mechanism becomes the key to the MAC design, and concurrent transmission should be exploited fully to greatly enhance the network capacity [11].

3) Dynamics due to user mobility

One more challenge is postulated by user mobility in mmWave communication system is user mobility, due to which the channel state will incur significant changes. The movement of user will lead to results in changing the distance between the transmitter (Tx) and the receiver (Rx), which lead to change of channel state.

Table 3, we list the channel capacities under difference distances between TX and RX [12]. The channel capacity can be calculated using Shannon's channel capacity method by assuming LOS transmission between transmitter and the receiver. The channel capacity varies accordingly with the range between the communication devices remarkably.

III. COMPARISON

In Table 3, in terms of path loss exponent (PLE), the propagation characteristics in different bands of mmWave are summarized. The frequecies bands like 28 and 38 GHz are disturbed from oxygen absorption and rain attenuation. Whereas the frequency bands like 60 and 73 GHz has less effect.While comparing NLOS and LOS transmission, NLOS has more propagation loss.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

Frequency Bands(GHz)	PLE		Rain Attenuation@ 200		Oxygen absorption @
	LOS	NLOS	5mm/h(dB)	25mm/h(dB)	200m(dB)
28	1.8-1.9	4.5-4.6	0.18	0.9	0.04
38	1.9-2.0	2.7-3.8	0.26	1.4	0.03
60	2.23	4.19	0.44	2	3.2
73	2	2.45-2.69	0.6	2.4	0.09

Table 3: Propagation characteristics of mmWave communications in different bands

IV. CONCLUSIONS

Now days, the number of mobile users has been increased dramatically and they want more reliable service and High speed data rate. 5G networks assured to deliver faster data rate. Even though the 5G technology is still under research stage, companies and industry people are working together in overall development of this technology. The main goal of 5G technology is to handle more traffic and to provide faster data rate existing technology. A survey of 5G technology mmWave communications has been discussed. The mmWave communications which are used in operators of satellites, radar systems, and other real-time applications become a promising candidate in implementing 5G technology. In conclusion, it is clear that mmWave communications has potential to provide better performance in cellular communication.

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