Abstract— With the exponential growth in wireless mobile communication in present days we need huge bandwidth. Now-a-days researchers are focusing on so called 5th Generation mobile networks. To increase the communication capacity the future Fifth generation mobile wireless network is expected use a large bandwidth of frequency spectrum in the millimeter wave bands. Device to device (D2D) Millimeter wave communication technology will be one of the most attractive technologies which are going to be implemented in future 5G wireless cellular networks to provide a very high speed data rate more than recent 4G networks. In this review article we have described briefly the propagation and some of the technical challenges in D2D. Basically in the traditional wireless cellular networks devices were communicating with each other through base stations. Here in the fundamental network architecture part we have surveyed the hybrid combination of 4G and mm wave communication. Apart from this we also discussed some of the potential application of mm wave communication technology in 5G.

Keywords— 5G; D2D; mm wave; high speed data; propagation; technical challenges; 4G.

I. INTRODUCTION

Now a day’s the use of mobile telephones and other wireless smart devices are increasing day by day. The demands of today’s consumers have shown significant change in bandwidth hungry applications like video streaming and multimedia file sharing have already exceeded the limits of current wireless systems. The increasing requirement for higher data rates and capacity has forced researchers towards critical thinking for the next generation (5G) cellular systems. The Next generation 5G cellular network is being developed to avoid the high data traffic between two mobile devices [1] and also it is being developed to increase the data rates between two smart devices. Table presented below summarizes the evolution of 1G to LTE/ 4G in brief. This new transmission method assures notable interpretation gains in context to link reliability, spectral efficiency, system capacity, and transmission range [14].

As per current observation it has been predicted that, in every 10 years a new generation is available with the users to fulfil their demand on data speediness and also it has been assumed that the future fifth generation mobile wireless cellular network will do an exceptional transform in the capacity of wireless cellular networks and also Multi giga bits per second data rate would also be provided to access various applications [1]. Also it has been predicted that 5G would provide data speed up to 4000 to 5000 times more than that of current cellular network usage.

The usage of D2D technology has not been taken in to consideration in first 4 generation of mobile wireless cellular networks. Because of several trends in the wireless market, the operators’ attitude towards D2D functionality has been changing day by day. Recent scenarios indicate a growth in the number of context-aware applications. These applications require location finding and telecommunication with adjacent
devices, and the availability of such functionality would reduce the cost of communication among devices.

Device-to-Device communication is one of the most important solutions for the coming next generation i.e. fifth generation cellular networks. Multi-gigabits-per-second transmission at mm Wave band has been realized in both indoor and outdoor systems. It has been predicted that there will be a definite implementation of very high gain directional antenna at both the transmitting and receiving end in future Millimeter Wave fifth generation wireless cellular networks and wireless smart devices would provide exceptionally high data rate. The need for a wireless backbone for 5G can be done by configuring Mm Wave mesh networks to provide mesh-like connectivity.

Device to device communication technology can perform a crucial role in mobile cloud computing and facilitate effective sharing of resources such as: spectrum, computational power, applications, social contents, etc. for users who are spatially close to each other. An advantage of Device-2-Device communication technology can be taken by network providers by sharing some load of the network in a local area by allowing direct transmission among mobile phones and other devices. Device to Device technology can be further used in case of any natural calamities and disasters by enabling the connection between two smart devices like mobile phones in a short time period, replacing the physically damaged traditional network infrastructure.

### TABLE 1. EVALUATION OF 1G TO 4G CELLULAR SYSTEMS

<table>
<thead>
<tr>
<th>Generation</th>
<th>Features</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1G</td>
<td>Launched in 1980s. Analog Technology is used.</td>
<td>Voice Communication</td>
</tr>
<tr>
<td>2G</td>
<td>Launched in 1990s. Digital Modulation scheme is used.</td>
<td>Voice SMS and low rate data.</td>
</tr>
<tr>
<td>2.5G</td>
<td>Data speed is up to 115kb/s.</td>
<td>Hardly a web page can be browsed</td>
</tr>
<tr>
<td>2.75G</td>
<td>Data speed is up to 384kb/s. 8PSK encoding scheme is used.</td>
<td>Audio streaming is possible.</td>
</tr>
<tr>
<td>3G</td>
<td>2 Mb/s for indoor.</td>
<td>New applications, video conference, location based service</td>
</tr>
<tr>
<td>4G</td>
<td>Offers data speed up to 100 Mb/s. LTE, LTE- A.</td>
<td>Movie can be downloaded easily.</td>
</tr>
</tbody>
</table>

Two methodologies such as: Direct connection or Frequency hopping can be provided by the future D2D technology to establish connection between two smart wireless devices like mobile phones and the most important fact is Device to Device connection can be established through base transceiver stations [1]. The foremost requirement is one wireless smart device needs to communicate with the base station and secondly base transceiver station needs to send the data to another wireless device directly or via backbone networks. In mm Wave 5G cellular networks, we can establish local Device 2 Device communications to unload wireless cellular communications. Meanwhile, we can establish the global Device-to-Device communications between two wireless devices through base stations with multi-hop. In current scenario, some of the technologies like Wi-Fi and Bluetooth, they use D2D communication technology but here the interference is uncontrollable. However they cannot provide Quality of Services.

In this review article, basically we explain the implementation of Device-to-Device communications over mm Wave 5G cellular networks. We also throw light on the mm Wave propagation characteristics and the associate difficulties to enable D2D communications [1]. The upcoming architecture of 5G cellular network and MAC structure are also discussed. In the following topic we have presented a brief discussion on Device to Device communication technology.

II. DEVICE TO DEVICE COMMUNICATION TECHNOLOGY

The interest for Device-2-Device communication technology come directly from the user requirements and D2D communications will serve specific future needs. The disclosures of surrounding-aware and multimedia applications have constituted the encouragement of using D2D technology. D2D communications technology will be providing new categories of services like online gaming, video streaming and peer-to-peer (P2P) file sharing respectively [16]. D2D communication refers to technology that enables the communication between multiple D2D devices or users with no base stations on a network. This makes D2D communication as an important technology to solve different problems such as coverage and interference management.

In millimeter wave 5G cellular connections basically two kinds of Device to Device communications can be established. One is local D2D communications and other one is global D2D Communications. Local Device to Device communication is generally established between two smart devices or mobile telephones which are operating in the same base stations. Basically this connection can be established in case of any natural disasters by enabling the connection between two wireless devices by avoiding the damaged network infrastructure. And the second one is Global device to device wireless communication. It can be established between two wireless smart devices which are coming under different base stations. Here in this case first the mobile device will communicate to the base station i.e. D2B communication than
the base station will communicate to the other base station i.e. B2B communication and at last the other base station will communicate with another mobile device associated with same base station i.e. here B2D communication established [1]. Unlike 4G networks where communications media among different base transceiver stations are performed via optic fiber links, mm Wave communication with a highly directional gain antenna can be used in 5G cellular networks [1].

III. PROPAGATION OF MM WAVE

Millimeter wave communication includes Extremely High Frequency Band (EHF band) i.e. 30-300 GHz [6]. It is well known fact that the free space propagation loss is directly proportional to that of square of carrier frequency hence the propagation loss will be much higher in the EHF band. This problem can be addressed by the use of highly directional antennas which also minimizes the loss due to shadowing. Since mm Wave bands have short wavelengths, they suffer from diffraction loss around obstacles. Line of sight (LOS) transmisions can easily be blocked by the obstacles. As we know that non-Line of sight (Non-LOS) transmissions in mm Wave channels agonize from significant attenuation. So the scarcity of multiple paths can be possible if an LOS link is blocked [1]. Another problem with mm wave is difficulties in passing/penetrating through solid materials. This limitation on penetration capability may confine applications of outdoor mm Wave signals to roads and other outdoor structures.

IV. MM WAVE 5G WITH DEVICE TO DEVICE CONCEPT

D2D communication is one of the key technologies to be implemented in coming fifth generation mobile wireless cellular systems to improve the network capacity and establish connection between two wireless smart devices. Mm wave communication has low multi user interference because of high gain directional antennas and high propagation loss. In 5G cellular network systems, Device to Device communication has a chance of facing two types of potential interference. First one is the interference among different local Device 2 Device communications and second one is interference between local D2D or D2B/B2B communications. Previous works have reported on the resource sharing for D2D communications by considering the reciprocal involvement of omnidirectional antennas. It is said that more D2D links can be entertained in each cell in 5G networks using mm Wave, by taking the advantage of high propagation loss and the use of high gain directional antennas, to further amplify the capacity of network and also improvisation of spectrum efficiency [1].

V. TECHNICAL CHALLENGES AND APPROACHING SOLUTIONS

Inspite of the potential of mm Wave communications, there are a number of key challenges to be discussed prior to implementation.

A. Integrated Circuits and System Design

Basically in a new generation or in any new upcoming technologies, one of the most common issue is technical challenges in the design of various complex electronic circuits and antennas for millimeter Wave communications with high carrier frequency and wide bandwidth [3]. The most common fact is the power amplifiers (PA) in the 60 GHz band suffers from severe nonlinear distortion due to high transmit power [3]. Radio frequency (RF) integrated circuits are also facing many challenges/ problems in phase noise and IQ imbalance.

Recent progress in Research on integrated circuits for mm Wave communications in the 60 GHz band has been briefly summarized including on-chip and in-package antennas, radio frequency (RF) power amplifiers (PAs), mixers, and analog-to-digital converters (ADCs) [3].

B. Spatial Reuse and Interference Management

The directivity during transmission allows less interference/ noise between highly directional links. In the outdoor mesh network in the 60 GHz band, the interference between non-adjacent links is almost not considerable. In [20] it is described briefly that, carrier sense cannot be executed by the third party nodes. In this case, for the MAC design the coordination mechanism becomes the key solution, and simultaneous transmission would get utilized efficiently to amplify the capacity of network [3].

![Fig. 1. Interference among different Base Stations [source arxiv.org]](image)

The assumption of pseudo wired is not applicable for the indoor environments because of limited range. And keeping in view the exponential growth of mobile data demands combined with the limited range of mm Wave communications. To overcome this number of established APs over both public and private areas need to be increased in a practical mm Wave communication system. Basically the interference/ intercession in the network is categorized in to two parts: one is interference within each BSS, and other one is interference among different BSSs. As presented in Fig. 1, when the two radio links in BSS1 and BSS2 communicate in the same time slot t, AP1 will have interference/ intercession to the laptop. So as a result the service of the laptop will be degraded if the distance between them is too short.

C. Dynamics resulting from user Mobility

The high mobility of mobile user several challenges in the mm Wave communication system. First, the channel state will
experience significant changes due to user mobility. This happens because the distance between the transmitter (TX) and the receiver (RX) varies when users are moving and also accordingly the channel state varies. In addition, the channel capacity greatly varies with the distance. Therefore, proper selection of modulation and coding techniques should be performed, according to the channel states to fully utilize the potential of millimeter Wave communications.

Second, due to the small coverage areas of BSSs, quick load fluctuations may occur because of user mobility in each BSS. This needs user association and intelligent handovers between APs to achieve an optimized load balance.

VI. FUNDAMENTAL NETWORK ARCHITECTURE

No Doubt that currently 4G/ LTE system has a huge or large coverage and also it provides seamless, reliable communication because of lower band. Basically 5G system uses the combination of hybrid 4G structure and millimeter wave communication structure which is shown in figure 2. The management information and low-rate applications are transmitted in 4G networks, while the mm Wave bands can be used for high-rate multimedia applications [1].

![Mm Wave 5G Network Architecture](image)

The 5G wireless cellular network comprises of three most important resources such as: mobile telephones, millimeter wave base stations and 4G base transceiver stations. Basically millimeter Wave transmission/reception is based on highly gained directional antennas and the most important fact is because of this reason the mutual interference/ intercession between base transceiver stations will get reduced [1]. In 4G wireless cellular network the complete imaginary geographical area is segregated in to cells and the cells consist of one or more 4G base transceiver stations as shown in figure 2.

The interference in millimeter wave concurrent link is very less i.e. almost negligible in outdoor environment. MmWave technology exempts to install base stations in cells. For mm Wave communication wireless devices and mm Wave base stations need to be equipped with electronically steerable directional antennas [1]. The antennas will be omni-directional antennas for 4G communications.

VII. APPLICATION MMWAVE COMMUNICATION TECHNOLOGY

A. Wireless Backhaul

For a fibre optics based backhaul, it becomes really expensive/ costly to establish a connection between one 5G base transceiver stations (BSs) and other 5G base transceiver stations (BSs) and to the network. On the other hand high speed wireless backhaul will be more cost-effective, flexible, and easier to deploy/ install. Wireless backhaul in mm Wave bands [60 GHz band and E-band] may give several-Gbps data rates and can be a good backhaul solution for small cells with huge bandwidth available. And also a time division multiplexing based scheme has also been proposed to support point- to- multi-point, Non- LOS, and millimeter Wave backhaul [3].

B. Cellular Access

Millimeter Wave cellular networks can provide large coverage area with very large capacity provided and also the infrastructure is densely installed/ established [3]. Depending on the propagation measurement strategies at mm Wave frequencies, the practicality and effectiveness of applying millimeter wave communication technology in the wireless cellular network have been determined at 27 GHz and 37 GHz with each cell sizes in the order of approximately 210 m. D2D communications should be enabled in the mmWave cellular systems to support the applications that involve discovering and provide communication with nearby devices.

C. Small Cell Access

High density of small cells has been discussed in literature to achieve several ten thousand fold increase in the network
capacity by at least 2030 keeping in view mobile traffic demand. Small cells deployed unrevealed the macro-cells as Wireless Local Area Networks or Wireless Personal Area Networks are the key solutions to improve the capacity in the 5G wireless cellular networks. Millimeter Wave small cells are basically illegal to provide multi-gigabit rates, and wide-band multimedia applications like video streaming, online gaming etc with large bandwidth.

VIII. CONCLUSION

Device-to-device (D2D) communications is seen as new paradigm that will be implemented in the next generations of mobile networks to provide high performance in cellular network, improving coverage, provide spectral efficiency, high data rates and offer new peer-to-peer services with QoS guarantees.

This paper briefly summarized the inclusion of mmWave band in the fifth generation wireless cellular networks. For urban areas installations of Millimeter Wave base transceiver stations may be increased to achieve high transmission rate and capacity [1]. Hence hand-offs may become more frequent for mobile users between mmWave base stations. The importance of high gain directional antennas to improve spatial reuse and network capacity is also addressed.

Keeping in view the enormous potential to offer greater capacity over current 4G cellular networks, mm Wave communications become a unique component for the 5G wireless cellular networks. This article basically surveyed and presented millimeter Wave wireless communications for future 5G wireless cellular networks along with some challenges in implementation. The various configuration characteristics of millimetre Wave communications includes the redesign of network architectures and various protocols, set of thumb rules to point out the associated issues, including integrated circuits (ICs) and system design, interference management and spatial reuse, and dynamics due to mobility.

References

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