Technologies for Move towards 5G

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Abstract: - Data traffic is increasing day by day so does the demand of higher speed which makes fifth generation inevitable. In previous generations there were some challenges that couldn't be handled even by 4G, such as the spectrum crisis and high energy consumption. 5G is the technology which will be the solution to the requirements of today. For 5G, very high frequencies with massive bandwidths and extraordinary base stations are required. 5G will operate above 6 GHz. In this paper we are trying to describe some disruptive technologies that will be helpful in the achievement of high data rates in 5G. We will try to describe these technologies by using previous literature. The technologies include Machine to machine communication (M2M), Massive MIMO, Millimeter wave (mm wave) and smarter devices which means device to device communication. Readers will have a comprehensive overview of these technologies and will be able to develop understanding about what 5G will be?

***Keywords*: -** *6GHz, Millimeter Wave, Directional Antennas, Channel Models, 5G, Cellular, Architecture, MIMO, Long Term Evolution.*

I. INTRODUCTION

We are living in the world of modern science. Science has become an essential part of our life. We cannot consider of a single moment without science and its legacy. Science has always been making our life easy and comfortable. During last few spans, science has brought many big changes in telecommunications industry. We have mobile and wireless communication technologies that have already been deployed which comprise Wi-Max, Wi-Fi, LTE, 3G and 4G technologies. These technologies differ from each other and consequently many differences have been noticed in the previous generations. Mobile data traffic has been increased globally and this will continue to rise in coming years. This is the result of cloud computing and high definition video streaming in wireless networks and other higher data rate hungry technologies. It is considered that in 2017 the data traffic of mobile phones is expected to exceed 6 EXA bytes per month. It is defined in fig 1 how to change technology with the passage of time [1][2].

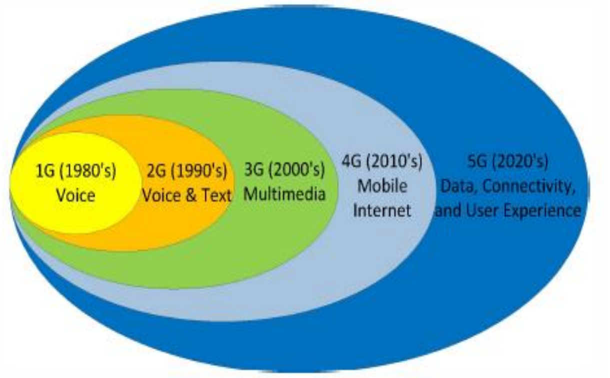

Fig 1:- Wireless Mobile Generation Service Type

Cell phones in 5G will be operated on very high bandwidth. 5G will have a wide area coverage and high throughput. 5G is offering high tenacity for great mobile users. It also offers finest Quality of service (QoS), huge bandwidth, high data rates. As far as latency and reliability requirements are expected, 5G should support applications related to health, security and automotive applications etc. The researchers have already accepted that with respect to 4G, 5G should achieve 10 times the spectral efficiency, 1000 times the system capacity, energy efficiency and data rate [3]. 5G can achieve 10 Gb/s at low mobility and 1 Gb/s at high mobility [3]. Internet is making our daily life more comfortable and efficient. But on the other hand it is said that by 2020 there will be 50 billion connected devices [4].

The question is that, what technologies will define it? How can we achieve huge bandwidths and high data rates in 5G? The answers of these questions are provided through some disruptive technologies which are discussed in this paper. These technologies include

- Millimeter wave (mm wave)
- Massive MIMO
- M2M Communication
- Smarter devices Communication

M2M (Machine to machine) communication addresses base stations architectures of cellular systems. It is the time to change and reconsideration of up and downlinks concepts[28]. Control channels and data channels may change also. These changes will provide a better route for flow of information towards different nodes in a network. These architectures may also define the radio access network and the network core of the system.

Massive MIMO is multiple inputs and multiple outputs. Many antennas are used to multiplex messages for different devices. Base station design may need some architectural changes and it may lead to new type of implementations [19]. In Massive MIMO systems, the receiver and transmitter are equipped with a huge number of antenna rudiments typically tens or few hundreds in number. It can also pointedly improve both spectral effectiveness and energy effectiveness.

Spectrum has become insufficient at microwave frequencies. While on the other hand we see a sufficient spectrum in mm wave frequencies (57–66, 71–76, and 81–86 GHz) [2]. "Millimeter Wave technologies have already been adopted (IEEE 802.11ad) and already been used for hollow applications such as small-cell backhaul". We will discuss applications of mm wave in 5G. In smarter devices D2D communication is faster technique move towards 5G because it is interconnected device to device which may attain their efficiency in linear manners. In which discuss the macro-dominated evolution of 5G and D2D communication scenario.

The objective of this paper is to discuss some disruptive technologies for 5G by using previous literature. The study shows that these disruptive technologies may become key technologies for 5G. These technologies will increase data rate and the problem of increased data traffic can be solved through these technologies. The other objective is to give an overview to the readers about disruptive technologies that are currently used in 5G. The remaining part of this review is organized as follows. We discussed key technologies that can be a part of 5G system. Importance of these technologies is described in the context of 5G and then impacts of these technologies are also outlined and lastly conclusions are drawn.

II. LITERATURE REVIEW

Initial start of our communication system was called Mobile Radio Telephone System. It was known as Zero generation. It was an analog cellular system. In 0 G some technologies that were used Mobile Telephone System (MTS), Advance Mobile Telephone System (AMTS), Improve Mobile Telephone Service (IMTS) and Push TO Talk (PTT) and [5]. There were only twenty five channels and no roaming facility [9]. Its range was 20 Km, in this range local telephones were connected [5]. Next generation was called 0.5G.In this generation there were used Auto radio puhelin (ARP) technique [5]. This was the first public mobile phone network. It was launched in Finland in 1971 [9]. Its 8 channels were operated on 150 MHz in the range of (147.9- 154.8 MHz). Power transmission was in 1 to 5 watt range [9]. First generation was also analog communication system. There was no data achievement in this Generation. Some techniques Nordic Mobile Telephone (NMT), Advance Mobile Phone service (AMPS), Japanese Total Access Communication system (JTACS). 1G was typically modulated to 150 MHz and up [10]. 2nd generation was divided into (TDMA) Time Division Multiplexing Access and (CDMA) Code Division Multiplexing Access [11]. It was operational frequency band is 900 to 1800 MHz covers Europe and Asia [11]. 850 to 1900 MHz covers US. In CDMA operational frequency band is 800 MHz and 1900 MHz [7]. Third generation was first used in 2001 [12]. There were two families of 3G that were 3GPP1 and 3GPP2[12]. The technologies that were used in 3GPP were GPRS offers 114 Kbps, EDGE offers 384 Kbps, WCDMA offers 1.9 Mbps speed [8]. The present generation is 4G and it was first used by South Korea in 2007.The technologies that are used is mobile WI- MAX, LTE, OFDMA. It achieved the data rate is about 36 Mbps [13].

III. MILLIMETER WAVE

Now a day's terrestrial wireless systems have limited their operations to small range of microwave frequencies. Their range is from several hundred MHz to few GHz. This spectral band has nearly fully occupied, so more bandwidth is needed. Fortunately large amount of idle spectrum exists in mm wave range 30-300 GHz and wavelengths are 1-10mm [14]. Several GHz are also feasible in range of 20-30 GHz [14]. Idle spectrum of mm wave is unsuitable for the mobile communications and the reason is hostile propagation qualities, low diffractions and penetration through subjects etc. Many bands are also feasible including the license free In mm wave antenna arrays are key features. In utilization of one side link or both side link, we can maintain antenna apertures constant keeping arrays large[5]. The impact of interference can be reduced by using adaptive arrays of narrow beams. If we have sufficient array gain then meaningful communication can be made possible, for this we need some new access protocols that work when transmitter emits in definite directions and receivers receive form definite directions. Some operational algorithms are also needed that adjust quickly when beams are stopped by something.

If we talk about the hardware of mm wave systems, chiefly ADC and DAC are used. One of the alternatives is a mixture construction in which beam establishing is performed in analog at RF. Another alternative can be performed by connecting RF chain to 1 bit ADC/DAC and power consumption requirements should be used low. In this scenario beam forming would be performed digitally but data will be noisy. The optimization of different transceiver techniques is one of the research challenges. When we talk about mm wave then backhauling concept is also considerable. In fig.2 at mm waves backhauling the data is now accepted commonly among the equipment providers. Siemens networks in New York at 72 GHz, Nokia, Austin and Korea at 28 and 38 GHz, Samsung in New York have already arranged prototypes for measurement drives [2,32]. The figure1 illustrates dense urban environment in which Macro cell BSc (M-BSs) are located on the roof top and small cell base stations (BSs) are in street corners [4]. Networks are 3 dimensional in big cities and minor cells are situated at diverse heights, altitudes for different user categories. BSs and mm wave backhaul systems will be installed together on band at 60 GHz multipoint distribution service at 28-30 GHz the E band at 71-76 GHz, 81-86 GHz and 92-95 GHz [6,8]. From this we can conclude that several tens of GHz could be utilized for 5G. The basic difference between microwave and mm wave is responsive to obstructions. Research study on mm wave cellular system tells us about the outcomes such as infrastructure and relays about complex channel model analysis.

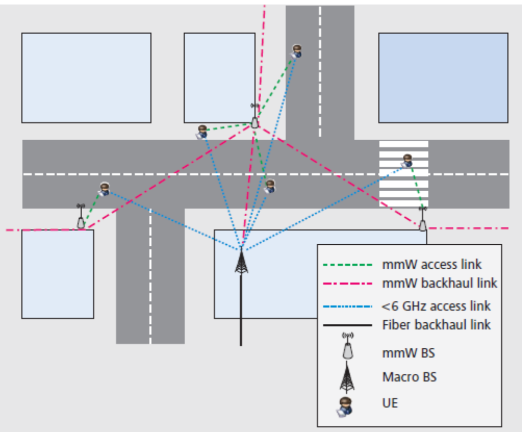

Fig 2:- Mm Wave Urban Environment and Back Hauling Scenario [32]

Street lamps, utility poles etc. Whenever mobile device is connected to such networks and massive data exchange occurs in the coverage area of mm wave small cell, M-BSs will assist the UE to perform mm wave cell discovery. In this scenario transceiver of mobile device has to be activated and M-BSs cooperate with mm wave BS to enable seamless handover [5,7]. A data rate comparison is made in Fig.3 between technologies in terms of 5% outage rates and mean [31]. Microwave systems have shown low rates as compare to mm wave.

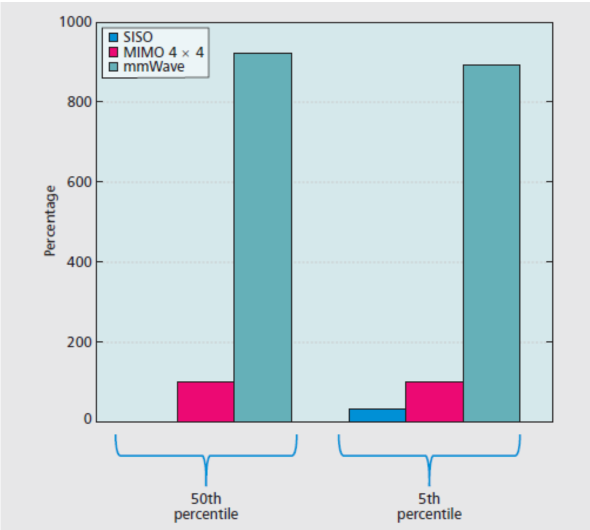

Fig 3:- Comparison of Data Rate between 50 MHz and 500 MHz Microwave System Bandwidth with Use of Single MIMO [31]

Due to increase the signal power and low intrusion, the gain exceeds to 10x spectrum increase. This is achieved through directional beam forming at both transmitter and receiver. Studying different papers we can conclude that Millimeter wave requires comprehensive fluctuations in the system. Millimeter wave has a strong influence in both component and structural designs. It is a disruptive technology for 5G.

IV. MASSIVE MIMO

In 2010 Thomas L. Marzetta proposed massive MIMO system which incorporates multiple input and multiple output (MIMO) concepts. Massive MIMO terminology also called as large scale antenna system or as a large scale MIMO is a form of lot of user MIMO in which the base station antennas are more than the number of devices each signaling resource. Energy efficiency ha huge data rate are important for 5G system. By massive MIMO we can achieve the both with the increasing number of antennas at base stations and operating in time division duplex (TDM) mode. There is also effect of user location distribution (ULD) distinction on the energy efficiency of a load-adaptive massive MIMO system. [45].

Massive MIMO is a possible authorized technology for concurrently increasing the reliability and highest data rates to reducing the energy loss. The capacity and solidity of wireless communication systems is increased with the use of multiple input antennas and multiple output antennas. Multiple-input multiple- output wireless systems are now part of present standards and will deploy throughout the world in 5G. Typical MIMO installations for the use of access points or base stations with relatively few(less than 10) antennas [21], and the corresponding improvements in spectral efficiency has been relatively increased. To achieve the higher data rates and multiple users access in MIMO concept uses more antennas (100 or more) at each base station, this phenomena is often referred to as massive MIMO [15].

With accordance to Henderson Clark model, we can say that Massive MIMO is a key technology for 5G. "There is an inventible angle faded of the propagation in turn of single user Massive MIMO that can be constructed by a lot of antennas and that can be varied in different devices [23]. To enable the channel estimation through uplink model, time division multiplexing and lot of antennas are used at base station with no limit in massive MIMO. It enables the new deployments, structure and architectures. Low gain resonant antennas with arrays have been direct replacement in macro base stations that can be the source of other deployments. Moreover the control principles of collected arrays of the antennas will also be needed"[3].

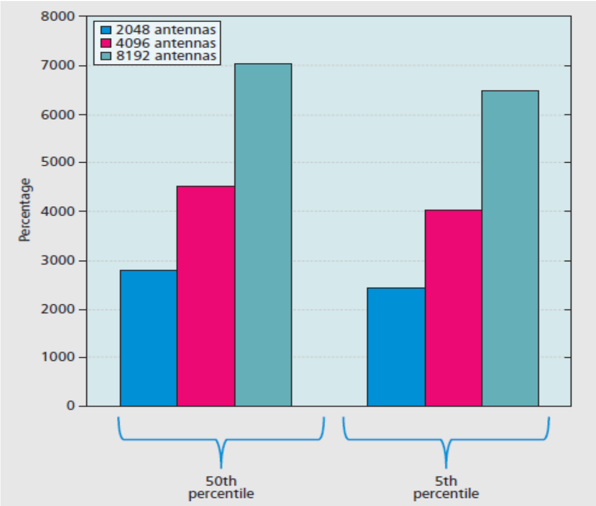

Fig 4:- Cell Data Range Comparison [33]

A comparison of antenna range of 2048, 4096 and 8192 is shown in Fig.4 [33]. These antennas are using 50 MHz and radiating 12 watts. These antennas are serving 1000 users in a distance range of 6 KM. A key advantage of the massive MIMO concept lies in its possible energy gain in energy efficiency. In an ideal channel state information of massive MIMO system, a user can access the same uplink throughput with a single antenna base station with the required transmit power of 1⁄Nt [16]. For each end user, power to the same throughput on scales of 1⁄Nt in channel state information, represents that specific power savage at the end user. In overall same transmit power and the dissipation of received signal to noise ratio in scaling law for downlink principles. For particular power amplifier is required to generate 1⁄Nt of the whole power in massive MIMO. The specific implications in terms of design, cost, heat dissipation, simplicity and efficiency of power amplifiers can be drawn. These terminologies for the increase of power efficiency can be helpful to reduce the large scale path losses in multi-meter wave frequencies and it can increase the operational range of the overall system [15]. There is some algorithm that's inhance the efficiency of the high complexity of channel estimation. In which sparse channel estimation algorithm that's has low complexity it distinct the channel taps from the noise space with the help of discrete Fourier transform (DFT) channel estimation and it can achieve the minimum time square error performance[46].

In wireless transmission, the channels are influenced by the factors in which shadow effect, the free-space propagation loss, the multipath effects and the Doppler effects are included [17,22 ,25,26].

- Shadow effect, also called as slow fading, is a blockage due to the building or the receiving antenna topography that produce electromagnetic shadow. Strength of the antenna due electromagnetic field will be changed also. If we compare slow fading and fast fading then in fast fading that's changes macroscopically and it is normally dignified on a large specific scale. Speed has not effected the frequency because it specifically depends upon the environment in slow fading.
- In case of free space, we refer to as a full vacuum state but in reality an ideal space in common will be denoted as a free space. There are no reflections, refractions and diffractions in a vacuum environment. Therefore, the radiated speed of the radio waves is identical to the speed of light.
- The multipath effect is a main factor that effects on a wireless communication. The signals are not fading at the receiving end over a single path in a wireless mobile environment but are the superposition of many reflected signal in wireless mobile. The phase of different reflected waves and approach time are not equal but super imposed signals may result by signal spreading or failing.
- Doppler shift occurs when the transmitter of a signal is moving in accordance to the receiver end. If we shift the frequency of the signal with the relative movement that makes it different at receiving end then further at transmitting end. Each frequency is received by the receiver is different from the transmitter. This phenomenon is best in the sound waves for observation and understanding.

Massive MIMO is useful for the 5th generation network in many ways as under [19,20,24]:

- It has increased the specific resolution as compared with the conventional MIMO and the resources of specific dimensions without the gain in base stations compression.
- The focus on beam forming with an extreme intensity into micro regions is decreasing the interference.
- Massive MIMO can also help to increase the spectral efficiency and energy efficiency in the case of magnitude related with the particular antenna system.

We can say that the Massive MIMO system has a greater potential and key authorizing technology for the fifth generation (5G) with these benefits.

V. M2M COMMUNICATION

A. M2M Communication in LTE

The enhancements for M2M in LTE have been made by 3GPP [18]. Enhancements are overload control, cost reduction, power saving and signaling overhead etc. which are summarized in Table I.

Release of LTE	*Feature*
Type Rel-11 in 2012	Preference indication of UE power Control of overloading of RAN
Type Rel-12 in 2014	(Cat-0) UE category of low cost For UE Power saving mode For eNB parameter tuning UE assistance information
Type Rel-13 in 2016	UE category of low-cost Increase the coverage Increase the power saving

Table 1: - Enhancements for M2M in LTE [18,30]

Rel-11, Rel-12 and Rel-13 are different releases of LTE. Rel-13 is a new device of category 0 of less lower complexity. Listed features in Table 1 show that LTE can meet M2M requirements. Different techniques are available that can support association of machine and human traffic. The techniques like scheduling prioritization that reduces the overhead are used. By this technique effect of machine traffic to human can be reduced [29].

➢ *Low Cost Devices*

Low cost devices are one of the supporting elements for M2M in LTE. The lowest LTE device is category -1 device; it has two RX antennas and can support 5 Mbps in uplink and 10 Mbps in downlink.

The new introduced device is thrown in (category- 0) that has following features:

- It has only one RX antenna and antenna chain.
- Peak data rates are reduced to 1 Mbps in uplink and downlink [18,28].

Single Rx has reduced 4 dB in downlink channels [18]. Due to reduced power breakdown of efficiency in uplink channels has occurred. Table 2 has shown a comparison of LTE FDD device categories. Comparison is made between different releases or different categories.

Capability of devices	*Type Rel-8 in Cat-4*	*Type Rel-8 in Cat-I*	*Type Rel-12 in Cat-0*	*Type Rel-13 in low-cost*
Peak rate of downlink	0.15 Gbps	0.01 Gbps	0.001 Gbps	0.001 Gbps
Peak rate of uplink	0.5 Gbps	0.05 Gbps	0.001 Gbps	0.001 Gbps
No. of receiver chains RF	2	2	1	1
No. of spatial layer of downlink	2	2	1	1
Bandwidth of device	Full	Full	Half	Half
Mode of Duplex	0.02 GHz	0.02 GHz	0.02 GHz	0.0014 GHz
Modem complexity of Cat-I	1.25 or 125%	1 or 100%	0.5 or 50%	0.25 or 25%
Maximum power of TX	23 dBm	23 dBm	23 dBm	-20 dBm

Table 2: - Comparison of LTE FDD Device Categories [18,28]

➢ *Device Power Saving*

Power saving and Power preference mode are two features that have been presented in LTE to save or reduce power feeding.

If the system is using power preference mode, it tells the network to use low power consumption. Then system network takes reduced measurements and keep device for more sleep time to reduce power consumption. There was a power saving mode in Rel-12 which works when UE is available but out of network range. UE can only be seen in power off mode or sleep mode [28].

➢ *Rel-13*

In this release power saving mode is also introduced. Some techniques regarding power saving mode are half duplex operation, reducing control channel overhead, system gaining time etc. To stop system overload in M2M Extended Access Barring (EAB) was introduced in Rel-11[30]. Rel-13 is also capable of sending info to the network about its traffic type.

B. M2M Communication in 5G

Wireless communication has become a valuable important part of our daily life like water and electricity. As the need of communication has been increased, this has given rise to new types of requirements. These requirements are given below:

➢ *Massive connected devices*

Currently system is operating at few hundred devices but M2M system requires more than 104 connected devices [27]. Some examples are sensors, smart grid components etc.

➢ *High link reliability*

We see around the world the things that are dealing with safety or production are connected to wired system instead of wireless system because wireless system gives less security [30]. When we talk about shifting our system from wired to wireless it should be reliable then.

- *Low latency*

This requirement is more important than others because transferring or data in required time is very important. Example is vehicle to X-connectivity in which critical messages are sent in required time interval [29].

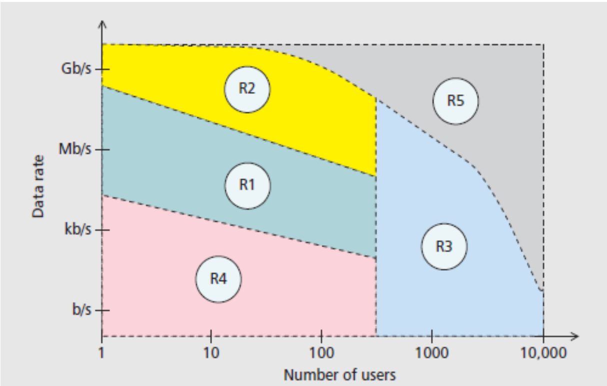

Fig 5:- Population Size and Rate of Data in Operating Regions

Figure 5 is a plot between data rates and population, which shows the requirements of M2M with increase in population. R1 highlights current situation, which describes us that with increase in population data rates decreases. R5 region shows that due to some physical and informational limitations. R3 region indicates the M2M where sensors and machines connected emits data. Current system is not able to deal with large number of data traffic from such devices. Survey says that currently system deals with 5 devices at 2 Mb/s but 10K devices requiring 1 kb/s. R4 refers to the region which shows the low latency and high consistency needs, with small rate per device by average. M2M is measured to be a key technology in future for 5G developments. The probable development in the Mobile Broad Band (MBB) from IMT-2000 and IMT advanced towards 2020.

Machine type communication (MTC) use causes two different scenarios for 5G system future design [18].

- Low cost, low power consumption
- Mission critical

Electricity, gas metering is one of the MTC use case. In critical M2M scenarios, automation industries and controlling of robots are very important areas in terms of latency in quality of service requirements. 2G, 3G, 4G wireless systems that are currently active cannot meet the requirements. It is said 5G is the system that can meet the requirements of future internet industry.

The most important requirement of M2M in 5G are [18]:

- Max permitted end-to-end latency
- Reliability.

VI. SMARTER DEVICES

Cellular designs have factually depends upon them obvious part of "cells" as basic units within the radio access network. Below such a strategy hypothesize, a device attains service by forming an uplink and downlink joining, carrying both mechanism and data circulation [34], with the BS impressive cell where the device is situated. In which base station thickness is growing fast, convey by the increase of varied networks. While various networks were previously consistent in 4G, the architecture does not intend to support them. Network densification will require the most of changes in 5G as compared old terminologies [35]. The need for supplementary spectrum will unavoidably top to the coexistence of frequency bands with very dissimilar broadcast features within the same system. A new thought called centralized base band associated to the idea of cloud radio access networks is developing [36]. Device centric Architecture is mainly linked with device to device communication and remaining technologies.

If we talk about simple daily routine device to device communication so our conclusion is about that everything is connected each other but if there is something disconnected then we have suffer some major flaws so a simple depict fig 6 is to understand the D2D.

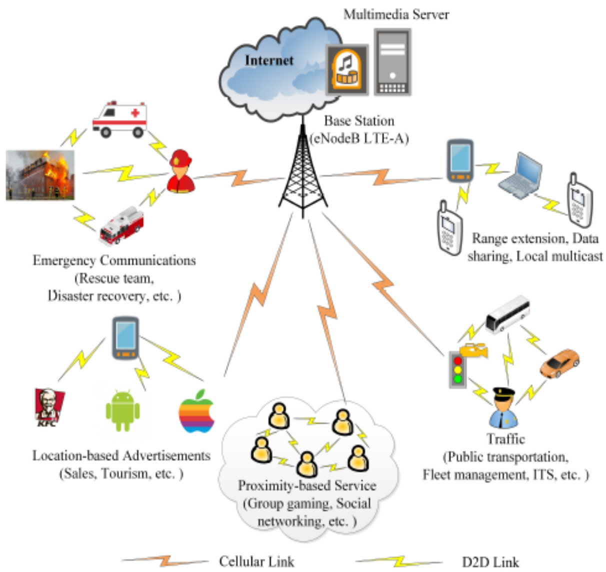

Fig 6:- A Depict Scenario of D2D Communication

Cellular link communication and D2D communication as shown above. Move towards D2D communication because there is a large energy gap may cause the losses so D2D is better solution for this. Therefore different scenario move towards D2D so in which efficient of energy control, jointing strength approach and efficient energy resource allocation [39][40]. For 2G/3G and even 4G, most assigned spectrums are mostly below 3 GHz. So that uses of spectrum up-to the lot of efficiency. Therefore a new possible spectrum for the future establishment mobile communication. It seems that the new obtainable future generation spectrum. Then its range above the 3GHZ and its improve the efficiency and coverage [37][38][43].

If we consider the download sharing resources between the cellular users and D2D links; there is each D2D link uses multiple cellular users channel and each cellular user uses multiple D2D links so there is a quality of Service (QOS) will reliable for each cellular user and improve the cellular utilization spectrum [41][42].

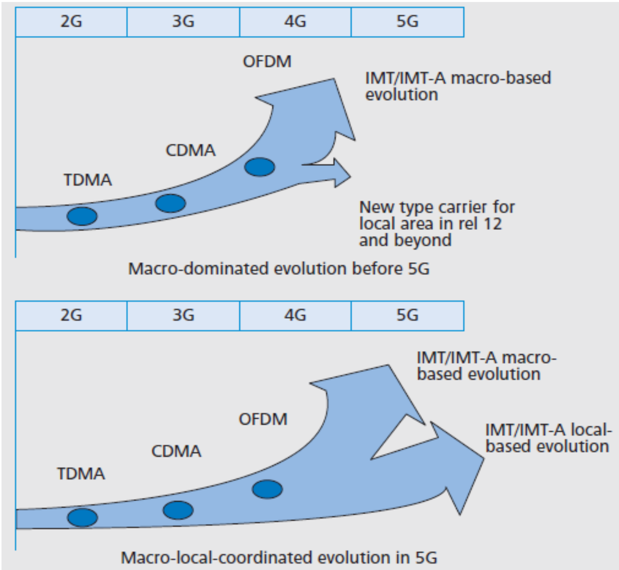

Fig 7:- Move Towards 5G

In figure 7 shows the illustration towards 5g and device to device communication is to involve moving manufacturing machines as a D2D caching helper in manufacturing automation, where massive contents shaped by touching Internet of Things (IoT) tackles should be distributed to the advantage network setup and then forwarded to remote human operators by dependable and high-rate radio links [39][41]. For upholding the dependability of data connections, unusual contents diffusion modes coupled with analytical mode selection strategies based on the expected radio link situations are presented, and then their efficiency is established by assessment [44].

VII. CONCLUSIONS

This paper has discussed some disruptive technologies for 5G. We can say that these technologies can lead to some fundamental changes in cellular networks at node and design level to accomplish the 5G goals. This paper has shown a survey on these technologies. What are the changes made in these technologies in order to attain the high data rates, are also discussed in this article. Importance of these technologies is also highlighted. Hence, from our survey we can say that Massive MIMO, mm Wave and M2M techniques and smarter devices could be the basics of 5G communication technology.

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