CHANNEL ESTIMATION FOR MASSIVE MIMO: A SURVEY

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Abstract: **The scope of this paper is to compare technologies changes that have decided the evolution and growth of communication technologies. The telecommunication evolution from first to upcoming fifth generation communication network is descried along with the uses cases of fastest growing Device to Device technology and Internet of Things. By using 5G libraries which are freely available and LTE toolbox, we construct end to end simulation model by using MATLAB 2016 b. Here we are planning to check performance of some variables like data rate, delay from one end to another end and ratio of delivery of data. Then study the EPA and EVA models, duplex modes like TDD and FDD.**

Keywords: **5G Technology, TDD, FDD, LTE Toolbox**

I. INTRODUCTION

The voice communication over a long distance started with a simple copper wire. The wired communication required a dedicated connection between two ends. As switching technology and wireless technology evolved the common term used for communication over a long distance was called as telecommunication. The communication technology has grown in various generations and is called First Generation, second Generation, and 2.5th Generation , 2.75th Generation, 3rd Generation, 3.5th Generation, 3.75th Generation, fourth Generation and now the latest 5G wireless technology.

The way people communicated with each other changed rapidly due to the evolutionary changes in mobile communication technology. The wired telephone system was developed in 1877. The communication system based on Amplitude Modulation was introduced in 1934 and was only used in selected organization. As the demand for mobile communication increased the changes also happened in modulation techniques. Another technology called Frequency Modulation technique was developed. Earlier telephones were used only in important offices and it was not available for commercial purpose. The Global System for Mobile communication was introduced and it grew to around 3 billion at the end of 2007 year.

Every cell phone talks to cell site through the separate radio frequency which is temporary allocated to each cell phone. Each channel uses two frequencies for transfer the information. One channel is called uplink which is used for transmitting information and other frequency channel is called downlink which is used for receive the information from client. Basic Mobile structure is having traditional telephone framework as well as providing radio services. Telephone structure is used to inner-connected to telephone network and radio services are used in closed network.

The demand for wireless throughput has grown exponentially in the past few years, with the increase in a number of wireless devices and number of new mobile users. The throughput is the product of Bandwidth (Hz) and Spectral efficiency (bits/s/Hz) [1]. To increase the throughput, either Bandwidth or Spectral efficiency has to be increased. Since increasing the Bandwidth is a costly factor, the spectral efficiency has to be taken into consideration. It can be increased by using multiple antennas at the transmitter and receiver. Multiple-Input Multiple Output (MIMO) antennas enhance both communication reliability as well as the capacity of communication (by transmitting different data in different antennas). Generally MIMO systems are divided into two categories: Point-to-Point MIMO and Multi User - MIMO (MU-MIMO) [2], [3]. In Point-to-Point MIMO, both the transmitter and receiver are equipped with multiple antennas. The performance gain can be achieved by using the techniques such as beamforming and spatial multiplexing of several data streams. On the other hand, in MU-MIMO, the wireless channel is spatially shared among the users. The users in the cell transmit and receive data without joint encoding and joint detection among them. The Base Station (BS) communicates simultaneously with all the users, by exploiting the difference in spatial signatures at the BS antenna array. MIMO systems are incorporated in several new generation wireless standards like LTE - Advanced, Wireless LAN etc. The main challenge in MU-MIMO system is the interference between the co-channel users. Hence, complex receiver technique has to be used, to reduce the co-channel interference. In [4], it is shown that by using an infinite number of antennas at the BS in comparison with the number of users in the cell, the random channel vectors between users and the BS become pair-wise orthogonal. By introducing more antennas at the BS, the effects of uncorrelated noise and intra cell interference disappear and small scale fading is averaged out. Hence, simple matched filter processing at BS is optimal. MU-MIMO system with hundreds of antenna at the BS which serves many single antenna user terminals simultaneously at same frequency and time is known as Massive MIMO system or large antenna array MU-MIMO system [5],[6]. One of the architectures proposed for 5G wireless communication is the massive MIMO system in which BS is equipped with a large number of antennas and serves multiple single antenna user terminals as shown in Fig 1.
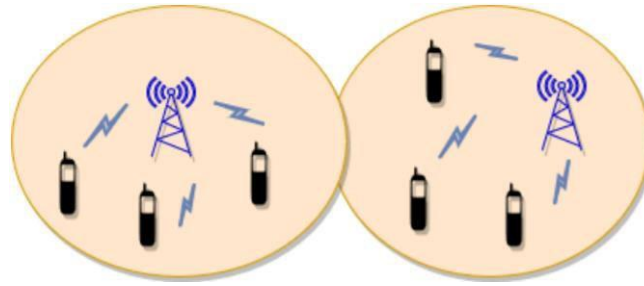
Figure 1: Multi-cell Massive MIMO System

Advantages of Massive MIMO System:-
High energy efficiency: If the channel is estimated from the uplink pilots, then each user's transmitted power can be reduced proportionally to $1/\sqrt{M}$ considering M is very large. If perfect Channel State Information (CSI) is available at the BS, then the transmitted power is reduced proportionally to 1/M [7]. In the downlink case, the BS can send signals only in the directions where the user terminals are located. By using the Massive MIMO, the radiated power can be reduced achieving high energy efficiency.

• **Simple signal processing:** Using an excessive number of BS antennas compared to users lead to the pair-wise orthogonality of channel vectors. Hence, with simple linear processing techniques both the effects of inter user interference and noise can be eliminated.

• **Sharp digital beamforming:** With an antenna array, generally analog beamforming is used for steering by adjusting the phases of RF signals. But in the case of Massive MIMO, beamforming is digital because of linear precoding. Digital beamforming is performed by tuning the phases and amplitudes of the transmitted signals in baseband. Without steering actual beams into the channels, signals add up in phase at the intended users and out of phase at other users. With the increase in a number of antennas, the signal strength at the intended users gets higherand provides low interference from other users. Digital beamforming in massive MIMO provides a more flexible and aggressive way of spatial multiplexing. Another advantage of digital beamforming is that it does not require array calibration since reciprocity is used.

• **Channel hardening:** The channel entries become almost deterministic in case of Massive MIMO, thereby almost eliminating the effects of small scale fading. This will significantly reduce the channel estimation errors.

• **Reduction of Latency:** Fading is the most important factor which impacts the latency. More fading will leads to more latency. Because of the presence of Channel hardening in Massive MIMO, the effects of fading will bealmost eliminated and the latency will be reduced significantly.

• **Robustness:** Robustness of wireless communications can be increased by using multiple antennas. Massive MIMOhave excess degrees of freedom which can be used to cancel the signal from intentional jammers.

• **Array gain:** Array gain results in a closed loop link budget enhancement proportional to the number of BS antennas.

• **Good Quality of Service (QoS):** Massive MIMO gives the provision of uniformly good QoS to all terminals in a cell because of the interference suppression capability offered by the spatial resolution of the array. Typical baseline power control algorithms achieve max-min fairness among the terminals.

• **Autonomous operation of BS's:** The operation of BS's is improved because there is no requirement of sharing Channel State Information (CSI) with other cells and no requirement of accurate time synchronization.

II.   CHANNEL ESTIMATION
In order to achieve the benefits of a large antenna array, accurate and timely acquisition of Channel State Information (CSI) is needed at the BS. The need for CSI is to process the received signal at BS as well as to design a precoder for optimal selection of a group of users who are served on the same time-frequency resources. The acquisition of CSI at the BS can be done either through feedback or channel reciprocity schemes based on Time Division Duplex (TDD) or Frequency Division Duplex (FDD) system. The procedure for acquiring CSI and data transmission for both systems is explained in the subsequent sections.

Channel Estimation and Data Transmission in TDD System
In TDD system, the signals are transmitted in the same frequency band for both uplink and downlink transmissions but at different time slots. Hence, uplink and downlink channels are reciprocal. During uplink transmission, all the users in the cell synchronously send the pilot signal to the BS. The antenna array receives the modified pilot signal by the propagation channel. Based on the received pilot signal, BS estimate the CSI and further, this information is used to separate the signal and detect the signal transmitted by the users as shown in Fig 2. In downlink transmission, due to channel reciprocity, BS uses the estimated CSI to generate precoding/beamforming vector. The data for each user is beam formed by the precoded vector at the BS and transmitted to the user through propagation channel as shown in Fig 3.
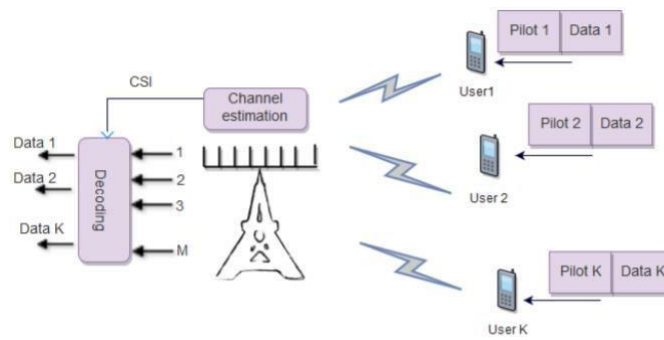
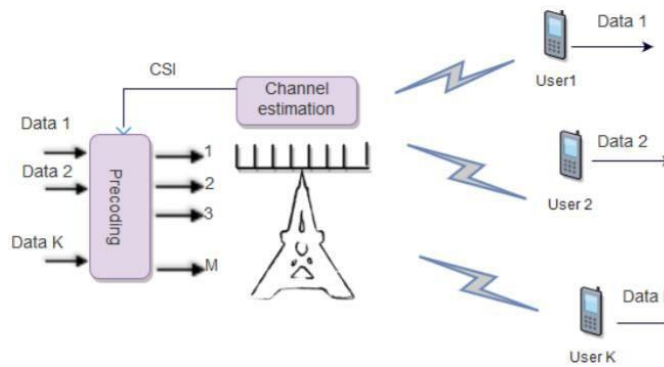Figure 2: Uplink transmission in a TDD Massive MIMO system

Figure 3: Downlink transmission in a TDD Massive MIMO system

Channel Estimation and Data Transmission in FDD System
In FDD system, the signals are transmitted at different frequency band for uplink and downlink transmission. Therefore, CSI for the uplink and downlink channels are not reciprocal. Hence, to generate precoding/beamforming vector for each user, BS transmits a pilot signal to all users in the cell and then all users' feedback estimated CSI of the downlink channels to the BS as shown in Fig. 4. During uplink transmission, BS needs CSI to decode the signal transmitted by the users. To detect the signal transmitted by the user, CSI is acquired by sending pilot signal in the uplink transmission.
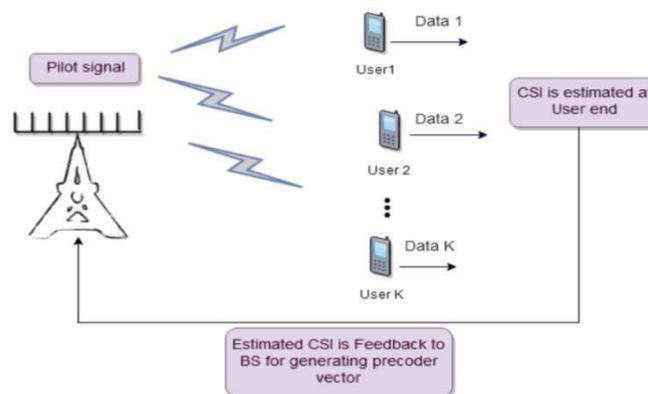

Figure 4: Downlink transmission in an FDD Massive MIMO system

III.   **LITERATURE REVIEW**

The framework gives an assortment of cutting edge interactive media administrations for example, video interchanges and fast web get to. It is normal that this will prompt the cellular communication more vital to our everyday lives and will grow the part as a way of life premise in the following 10 years. It is likewise expected that such a period requires a further developed remote interchanges framework, for example, the Fourth-Generation (4G) portable correspondence framework, which far outperforms the capacity of the current IMT-2000.The improvement procedure of the new mobile frameworks comprises of building up the prerequisites, giving arrangements fulfils the necessities, demonstrating confirmations for every innovation to fulfil the necessities, and in addition building universal accord through the institutionalization exercises [1, 2]. In this article, we portray a fundamental way to deal with the specialized issues and framework setup engaged with accomplishing the capacity and execution required of the 4G framework

and additionally depicts the drifts in institutionalization concerning mobile communication [3]. This paper revealed the 4G framework targets including potential applications and framework necessities, specialized challenges, and related institutionalization exercises. Through the talk, it has been uncovered that the real component of the 4G framework ability ought to be its very fast IP parcel transmission with lessened deferral to meet an assortment of prerequisites got from the two-way upgraded reality interchanges [4, 5].

In this manner, 3G systems will fill an indistinguishable need from LAN and WLAN systems. As far as business open doors, telecommunication organizations' fundamental wellspring of pay is as yet originating from voice- drivenadministrations [6]. For instance, the mobile administrator Hutchinson, offering administrations simply in 3G systems, reported this fall 2004 that its principle wellspring of pay originates from markdown parcels that offer free discourse time in 3G systems [7]. In addition, as long as the cost of the system time is high in 3G, administrators can't hold up quick dispersion of information driven mobile administrations. As indicated by mobile administrators, Industry gauges
- arrange improvement - handset accessibility Consumer acknowledgment - understanding buyer needs and needs - understanding utilization circumstances (at work, at home, in a hurry) Pricing of administrations - business versus private utilize - settled versus variable evaluating Internet on mobile - online administrations (e.g. data and excitement) E-mail administrations - particularly for business clients Messaging administrations - interactive media informing - video applications Willingness to utilize 3G administrations Underlying variables 3G administrations Contemporary Management Research 100 3G is required in congested spots where the request on ebb and flow mobile systems surpasses the limit [8].

We will toss light on the advancement and improvement of different ages of portable remote innovation alongside their importance and preferences of one over the other. In the previous couple of decades, the versatile remote innovationhas understanding of different of innovation insurgency and development, to be specific from 0G to 4G. A propel usages of 5G innovation which are being made on the advancement of World Wide Wireless Wed (wwww) [9, 10].

These problems can be handled with the help of guard period or cyclic prefix. In the case of BER vs. SNR when we are increasing signal to noise ratio (SNR), bit error rate (BER) is decreasing in the same way. At that time bit error rate is zero. We use three modulation techniques such as BPSK, QPSK and 16QAM. BER depends on sub-carriers and symbol time [11, 12]. The minimum signal to noise ratio (SNR) required for BPSK is 7dB, 12dB for QPSK and 26dB for 16QAM. In case of Guard length on the BER performance when we are increasing guard length, bit error rate is reducing in the same way [13]. At that time bit error rate is 0. Finally, from the analysis of the system simulations, it is concluded that a cyclic prefix at least as long as the maximum multipath delay spread is required for complete protection against ISI effects. Also during low velocity and hence Doppler spread conditions it is possible to have lowerchannel estimation rate for improved data throughput efficiency [14, 15].

IV.   5G TECHNOLOGY
Radio technology has rapid evolution in analogue cellular system in 1980s. After analogue system digital wireless communication system comes to fulfil the increasing need of humans being. Voice and message services introduce in 1990s and mobile broadband and long term Evolution introduced in 2010.After that in telecom industries demanding for mobile data and high speed services so they required to develop new generation of telecommunication system. Thatnew generation is called Fifth generation technology. Here we discuss about the features, architecture, advantages, challenges and future scope of 5G technologies.
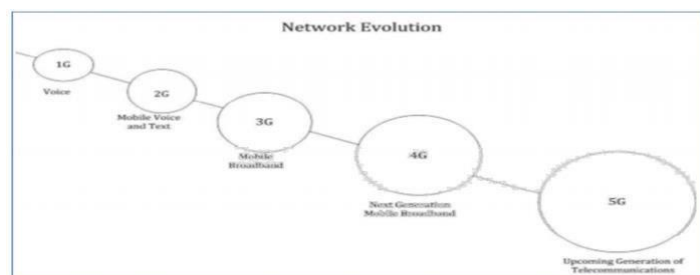

Figure 5: Development in 5G System

Each generation comes up with new ideas and introduces new services. First generation introduces voice; second generation comes up with mobile voice and text. In third generation use mobile broadband and a fourth generation is called Long Term Evolution. In 4G, all advanced features are introduced. Fifth generation, future of technology brings tremendous changes in technology. In the future, data transmission rate gets speedier as compare to previous technology similar improvement done in quality of services. 5G is based on IEEE802.11ac broadband standard. Some technological innovative done in this generation, such as Internet of Things (INTERNET OF THINGS) which is expected in 2020.Number of devices are connected to each other through the network. User equipment like smart phones or tablet can be replaced by smart devices.

Figure 6: Various Hand-set used in all Generation

This thesis tells about evolution of communication technology in each generation, detailed study of LTE, detailed 5G frame work and explanation of various applications of 5G. With examples and detailed analysis it is proved that the data transmission in 5G is much better than 4G in terms of connectivity, there is relatively less end to end delay and it has enhanced packet delivery ratio. Various applications that will become popular in 5G technology are also discussed in detail. Many research laboratories and many mobile companies are examining new possible standards for new upcoming technology which nothing but 5G network to overcome disadvantages of 4G or LTE.

FEATURE OF 5G TECHNOLOGIES

Feature of 5G technology is much more than other cellular technology. It has ultra-high speed. Because of ultra-high speed, it changes the scenario in cellular world. With these innovative features your smart phone is similar to your laptop. Broadband connection can used in smart phone, available variety gaming options, broad multimedia option, you can connect every ever. Other most important feature is low latency, faster response time and high quality picture can be transferred from one cell phone to another cell phone without disturbing and with quality of video and audio.
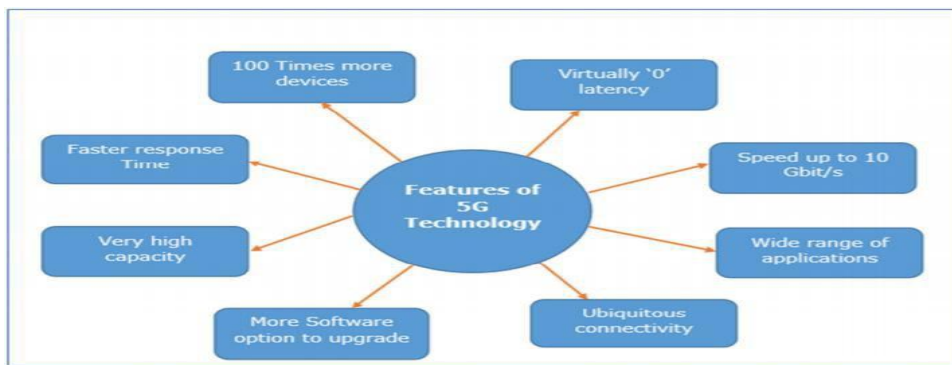

Figure 7: Feature of 5G technology

IV. CONCLUSION

The 4G / LTE technology is being adopted majorly across the Europe, US and India. The technology is still evolving and research and development is going on for small cell technology, signalling interfaces between device to device communications and carrier aggregation. The earlier wireless systems depended heavily on new technologies in one way or the other. Each technology evolved in areas like faster core switching, carrier waves, control and signalling interfaces or antenna towers. The international body for telecom and wireless standards has started writing standards, requirements for 5G. The big Telco vendors, major operators, including IT majors and national laboratories are doing great research to define the 5G requirements, networks, end user applications. As the expectations for the newest 5G technology are very high the 5G technology is expected to have an end to end architecture that covers radio network, switching or core networks, packet data interfaces and even the IP backhaul networks. Also a major deciding factor willbe to have a common interface for the end devices and the end user applications that are going to demand and consume the huge data requirements. This paper explains the end applications, use cases, requirements, market forces, government and regulatory expectations and the network factors for 5G.

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