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Massive MIMO a Candidate Technology for Future Generation Wireless Communication System

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Abstract: The demands of wireless communication systems are continuously growing as users are increasing day-by-day. In our modern society, high data-rate, very low power consumption transmitter, simple transmitter and receiver, and very high quality of services are mostly needed. To meet above-mentioned demands massive multiple input multiple output (MIMO) is the only technology which may cater this demand as this technology is equipped with a large amount of base station (BS) antennas at the transmitter. It is only promising technology to offer higher data-rate in large coverage. It recently drew more researcher attention as of its huge system performance. In it, the large number of BS antennas all together work at the same spectrum resource. With a very large amount of BS antennas, MIMO is serving fully adaptively and coherently. In massive MIMO, the extra antennas help the system to cover the signal energy into ever smaller coverage area. When using joint antenna and user selection and scheduling in massive MIMO which improve system performance and energy efficiency. In this system, when BS antennas reach an infinite number, the additive noise and user interference tends to zero. In a massive MIMO system, it is very hard to achieve channel state information (CSI) to fulfill the demands of the user. In this paper the potential and how this technology is serving the 5G and future wireless communication system are presented in detail.

Keyword: Massive MIMO; base station; channel state information (CSI); 5G; frequency division duplex (FDD), Time division duplex (TDD), Favorable propagation.

I. Introduction of Massive MIMO

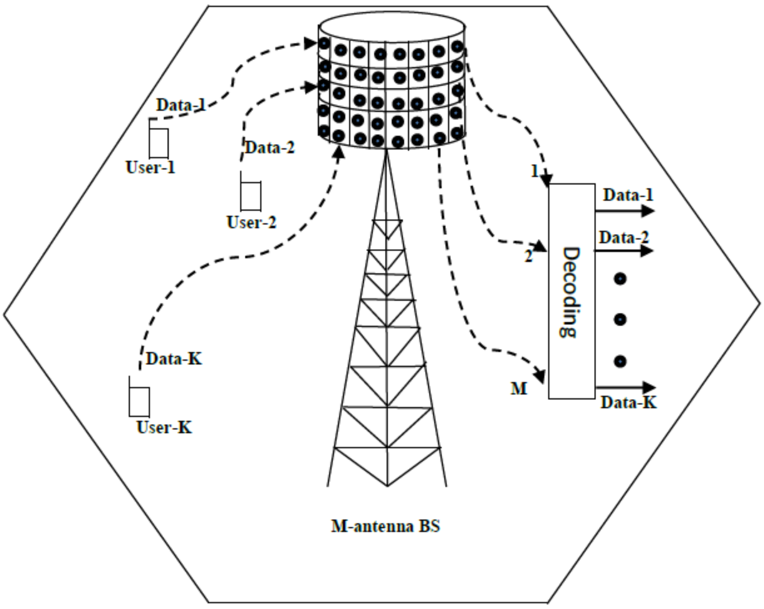
The demands of wireless communication system continuously growing as users are increasing day-by-day. In our modern society high data-rate, very low power consumption transmitter, simple transmitter and receiver, and very high quality of services mostly needed. To meet above-mentioned demands massive multiple input multiple output (MIMO) is the only technology which may cater this demand as this technology equipped with a large amount of base station (BS) antennas at transmitter. It is only promising technology to offers higher data-rate in large coverage. It recently draws more researcher attention as of its huge system performance. In it, the large number of BS antennas all together works at same spectrum resource. With a very large amount of BS antennas massive MIMO is serving fully adoptively and coherently. In massive MIMO, the extra antennas help the system to cover the signal energy into ever smaller coverage area. When use joint antenna and user selection and scheduling in massive MIMO which improve system performance and energy efficiency. In this system, when BS antennas reach to infinite number, the additive noise and user interference tends to zero. In massive MIMO system, it is very hard to achieve channel state information (CSI) to fulfill the demands of users [1-2].

Major merits of massive MIMO are-

A. *Estimation of Channel using Time Division Duplex(TDD) :*

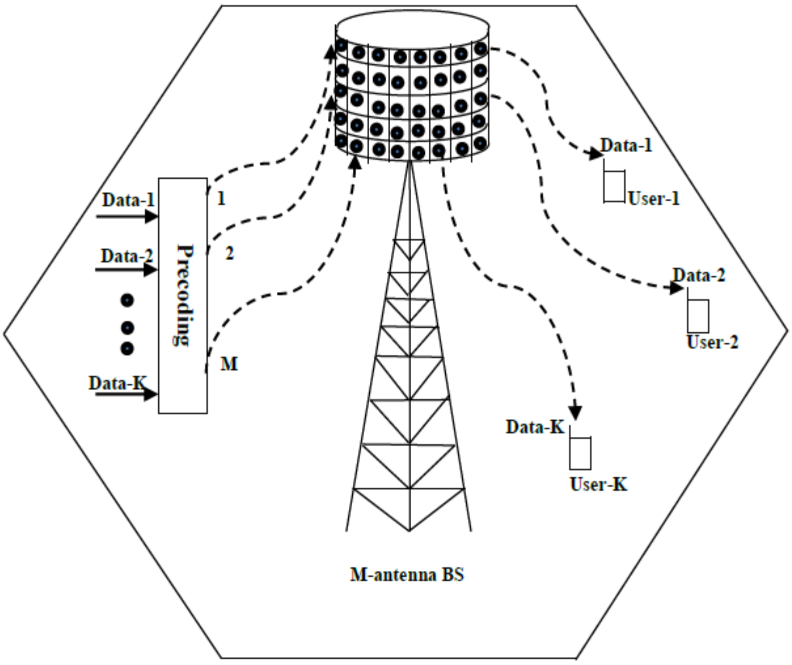
In time division duplex (TDD) based massive MIMO system for transmission, uplink and downlink same spectrum is use that is shown in Fig.2, but the time slot is different and the channel estimation is achieve as below-

- *Uplink:* The uplink transmission is shown in Fig.1 (a). In uplink transmission, channel state information (CSI) requires at BS to detect K-user transmit signals. Based on K-user transmit orthogonal pilot signals to BS, channels are estimate at BS terminal. Once receive pilot signal send by users' channel is estimated. For this complete process, at least K-number of channels is required.



(a): Uplink

• *Downlink:* Fig. 1(b) shown the downlink transmission. In downlink transmission, to receive suitable signals need sufficient gain in the channel and BS has to precode the transmitted signals. The user estimated the desired gain of the channel from the BS beamform pilot signals. At least *K*-channel required for this complete process.



(b) Downlink
Figure 1: Massive MIMO network

In TDD uplink and downlink system need $2T$ channel, where T is the total number of symbols. We also consider that for symbol T and $T > 2K$ the channel is constant and K is the number of active users in the channel. The block diagram of TDD system channel estimation is presented in Fig-2. In Fig-2 first slot is used for uplink pilots, second slot are for uplink transmission. Again, the out of T symbols K symbols are allow for downlink beamformed pilots and the last slot is allocate for downlink data transmission.

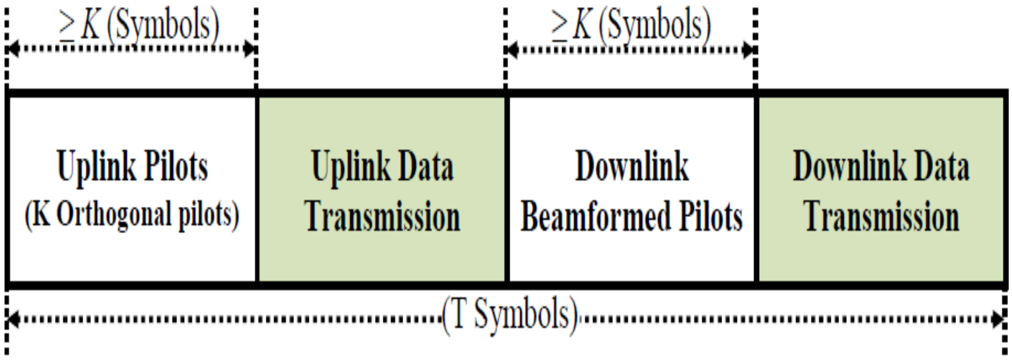


Figure 2: Channel Estimation in TDD system and Slot structure

The estimation of channel overhead at uplink is totally dependent on users and independent on BS antennas in TDD system. Hence, TDD system may consider a favorable technology, as massive MIMO consist huge number of BS antenna. If the antenna arrays and channel response is predefining in massive MIMO than from the estimation theory it can say that the channel estimation quality cannot decrease with the growing of BS antennas, perhaps it enhances the estimation quality. By taking the channel reciprocity of the receiver, BS estimated the CSI in massive MIMO system [3-4].

B. *Channel Estimation using Frequency Division Duplex (FDD):*

In the frequency division duplex (FDD) system typically, channels do not reciprocal because it requires different frequency spectrum for the transmission of downlink and uplink. The information of the channels is obtained that is described in bellow.

- *Downlink*-In FDD downlink system, the BS requires desired CSI to precode the signal that is going to transmit to the user. An M orthogonal pilot signal is transmitted by the M BS antenna to K users. As soon as receive pilot signals, CSI will estimate by the user. By the uplink training method, the users send its feedback to BS. For this complete process, it required at least M-channel used for uplink and downlink.
- *Uplink*- The BS need a desire CSI to decode the signal that has transmitted by the user. BS will estimate the channels after receiving K orthogonal pilot signals, transmitted by users to BS. At least K channel required for this complete process.

Therefore, in FDD system required minimum $K+M$ channels for estimation of channel, and in uplink needed K channel and downlink required M-channel. We consider that for symbol T i.e., $T > K+M$ the channel is constant. The Fig-3 represented the FDD based channel estimation [3-4] in massive MIMO. In Fig-3 for the uplink a small slot is used for downlink pilots and remaining are unused.

For downlink first slot is unused and second slot is used for uplink pilots and third slot is allocate for feedback MK channel estimation. The last slot is unused.

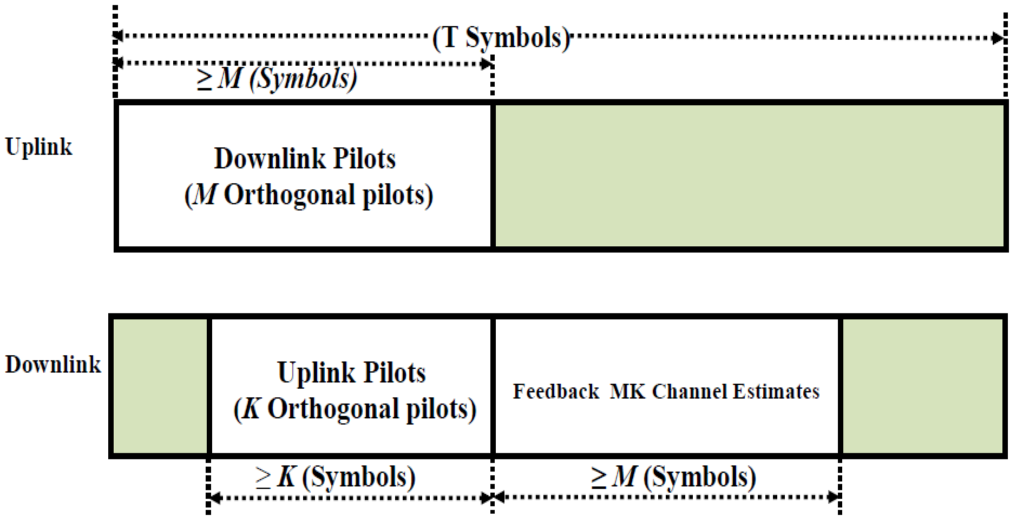


Figure 3: Channel estimation in FDD system and Slot structure.

C. Linear Processing:

The linear processing may provide optimum performance with the help of favorable propagation. Noise and interference have been mitigated on the uplink with simple linear detector such as a matched filter (MF). Moreover, BS is simultaneously beam-form multiple data stream to the multiple users without sensing the mutual interference on the downlink with linear beamforming method [5]. The huge number of users and BS antennas are equipped in massive MIMO system; hence the signal-processing vector at user is very large dimensional metrics. Therefore, a simple and almost ideal signal processing technique is generally adaptable in this technology.

To obtain the good signal, a complicated signal processing method must have to be employed. Maximum likelihood (ML) method and multiuser detection schemes are usually use in uplink for detect good quality of the signal. All good quality of signal $\hat{\mathbf{x}}$ can search by the BS through the below equation.

$$\hat{\mathbf{x}} = \arg\min_{\mathbf{x}\in X^K} \left\| r_{ul} - \sqrt{\rho_u} H\mathbf{x} \right\| \cdots\cdots\cdots (1)$$

The finite data symbol of x is X, where $k=1,\dots, K$, and r_{ul} is K users to M antennas received signal vector at BS. $H \in \mathbb{C}^{M\times K}$ is the channel matrix and ρ_u is the uplink average SNR.

$$r_{ul} = \sqrt{\rho_u}\sum_{k=1}^{K} h_k \mathbf{x}_k + n..........(2)$$
$$= \sqrt{\rho_u} H\mathbf{x} + n$$

where, $n \in C^{M\times 1}$ is noise vector with independent and identically distributed (i.i.d), and finite data symbol is $\mathbf{x} = [\mathbf{x}_1, \ldots \mathbf{x}_k]^T$ and h_k denoted as a column matrix of H. The only difficulty of Eq.1 is the least square (LS) to find the finite value of X. The ML find optimal signal from $|X|_k$, searching by the BS and $|X|$ is represents the sets of cardinalities. As BS search all $|X|_k$ therefore there exits an exponential complexity in ML. So, to reduce the complexity in massive MIMO, BS uses linear signal processing technique in uplink and downlink. In massive MIMO the linear signal processing techniques reaches towards the optimal value, hence it not only an ideal technique but also increase the number of BS antenna in massive MIMO as reported in [6-7]. Therefore, it chooses the linear signal processing method. The working procedure of linear signal processing scheme is shown below.

- *Linear Detector*: At the BS, the K users to M BS antenna of the receive signal vector r_{ul} can be written as Eq.3

$$\tilde{r}_{ul} = A^H r_{ul} = \sqrt{\rho_u} A^H H\mathbf{x} + A^H n \text{..........(3)}$$

where $A \in C^{M\times K}$ the linear detection matrix and A^H Hermitian of matrix A and each of the channel is decode independently. The complexity is approximate $K|X|$ as shown in the fig-3 from the Eq.3, the k^{th} streams of r_{ul} are decode into x_k is given by-

$$\tilde{r}_{ul,k} = \sqrt{\rho_u} a_k{}^H h_k \mathbf{x}_k + \sqrt{\rho_u} \sum_{j\neq k}^{K} a_k^H h_j \mathbf{x}_j + a_k^H n \text{..........(4)}$$

where a_k and h_k denoted as a column matrix of A and H respectively. In Eq.4, the first part is the desired signal, second part is interference and last part is noise. The signal to noise plus interference ratio (SINR) of k^{th} the receive signal is given by Eq.5

$$SINR_k = \frac{\rho_u \left| a_k^H h_k \right|^2}{\sqrt{\rho_u} \sum_{j\neq k}^{K} \left| a_k^H h_j \right|^2 + \left\| a_k^H \right\|^2} \text{..........(5)}$$

The sum capacity C_{sum} of the system can calculate as-

$$C_{sum} = \max \log_2 \det(I_M + SINR_k) \text{.........(8)}$$

In massive MIMO commonly use three multiuser detector techniques at the BS, such as minimum mean square error (MMSE), zero forcing beam-forming (ZFBF) and maximum ratio combining (MRC). The linear detector of massive MIMO is shown in Fig.4 below.

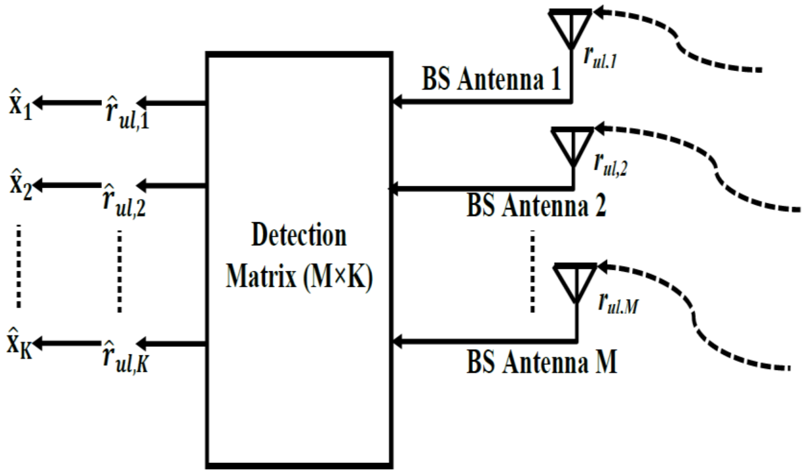


Figure.4: Detection process in massive MIMO

- *Linear Precoder*: The linear precoder of massive MIMO is shown in Fig.5 below. We consider the signal transmitted by the BS antenna has signal vector $\mathbf{x} \in C^{M\times 1}$ and $E\left\{\|\mathbf{x}\|^2\right\}=1$, the k^{th} receive signal is given by Eq.6.

$$r_{dl,k} = \sqrt{\rho_d}\, h_k^T \mathbf{x} + n_k \quad ....(6)$$

In Eq.6 ρ_d is average downlink SNR of k^{th} user and Eq.6 rewritten as below-

$$r_{dl,k} = \sqrt{\rho_d}\, H^T \mathbf{x} + n_k ....(7)$$

where $H^T \in \mathbb{C}^{M\times K}$ is the transpose of H, $n = [n_1, \ldots, n_K]^T$ an $r_{dl,k} = \left[r_{dl,1}, \ldots, r_{dl,k}\right]^T$. Due to broadcast nature in channel the system sum capacity can calculate as-

$$C_{sum} = \max_{\substack{\{q_k\} \\ q_k \geq 0, \sum_{k=1}^{K} q_k \leq 1}} \log_2 \det(I_M + \rho_d H^* D_q H^T) ....(8)$$

where D_q is the matrix, whose k^{th} diagonal element is q_k. In the downlink section with the help of linear precoding method, the linear combinational signals x, is transmit from M number of antennas to K number of users. Here assume that q_k, and $E\left\{\|\mathbf{x}\|^2\right\}=1$, which are intended for the k^{th} user. Therefore, precoding signal is-

$$\mathbf{x} = \sqrt{\alpha} W q \cdots\cdots\cdots(9)$$

where, precoding vector is $W \in C^{M\times K}$ and $q = [q_1, \ldots, q_k]^T$, the normalization factor α measure as-

$$\alpha = \frac{1}{\left\{tr\left(WW^H\right)\right\}} \cdots\cdots\cdots(10)$$

By substituting Eq.9 into Eq.6, we obtain,

$$r_{dl,k} = \sqrt{\alpha\rho_d}\, h_k^T W q + n_k \text{..........(11)}$$

$$r_{dl,k} = \sqrt{\alpha\rho_d}\, h_k^T w_k q_k + \sqrt{\alpha\rho_d} \sum_{j \neq k}^{K} h_j^T w_k q_k + n_k \text{..........(12)}$$

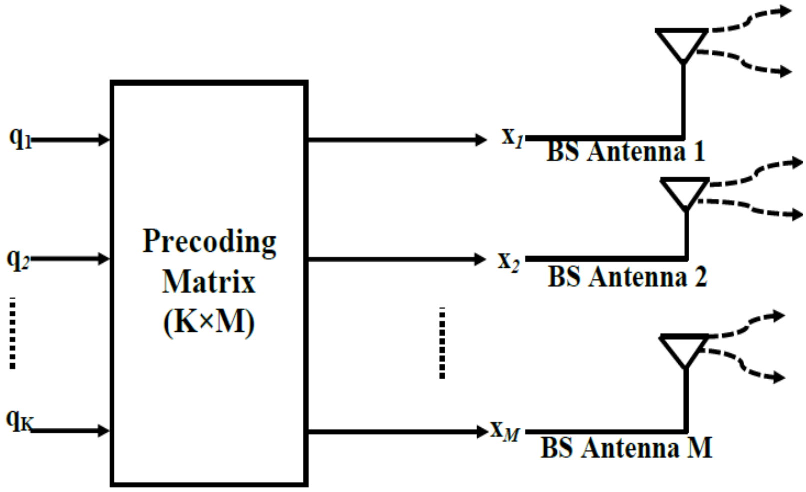


Figure.5: Precoder Process in Massive MIMO

Thus, SINR for the k^{th} user in BS is given as–

$$SINR_k = \frac{\alpha\rho_d \left| h_k^T w_k \right|^2}{\alpha\rho_d \sum_{j \neq k}^{K} \left| h_j^T w_k \right|^2 + 1} \text{..........(13)}$$

The three conventional linear precoders are maximum ratio transmission (MRT), MMSE, and ZFBF which use in downlink presented in Eq.14.

$$W = \begin{cases} H^H; & \text{for MRT} \\ H^H (HH^H + \frac{K}{\rho_d} I_K)^{-1}; & \text{for MMSE} \\ H^H (HH^H)^{-1}; & \text{for ZFBF} \end{cases} \text{..........(14)}$$

D. Favorable propagation:

Massive MIMO works under the favorable propagation environment where numbers of scattering channels are more compared to number of users and its channel. On the other hand, favorable propagation is the mutual orthogonality among the channels and users. Since, in massive MIMO huge number BS antenna and users are consisting in a single system. As of the favorable propagation in massive MIMO, the linear processing can achieve the optimum data-rate. Additionally, on the uplink, noise and inference can cancel out with a simple linear detector of match filter (MF). On downlink, with linear beamforming techniques, BS concurrently beamforming multiple data stream to multiple active users without causing mutual interference. It offers maximum sum-rate in massive MIMO system under constant power [5].

$$h_i^H h_j = \begin{cases} 0, & for\, i \neq j, \quad i, j = 1, \ldots, K \\ \|h_k\|^2 \neq 0, & for\, i = j, \quad k = 1, \ldots, K \end{cases} \text{..........(15)}$$

where h is channel vector of M BS antenna and K user, $\|.\|^2$ indicate Frobenius norm of channel vector. The conditions in Eq.15 never satisfy exactly, but it can be achieved approximately. From Eq.15, we can conclude that the channel may offer favorable propagation. In massive MIMO at BS as huge number of antennas are equipped and if it holds $k \neq j$, with the help of law of large number we may written as -

$$\frac{1}{M} h_k^H h_j \to 0, \quad M \to \infty \quad \text{..........(16)}$$

Eq.15 not only provides optimal performance utilizing linear processing but also maximizes the information rate.

E. It has Scalable Capability:

As discussed, previous sections massive MIMO is comfortable in TDD system to obtain CSI at BS with uplink training. In this system, the estimation of CSI directly depends on users and independent of BS antennas. For this great cause, it makes massive MIMO is fully scalable. The estimation theory says that growing of BS antennas does not degrade system performance for known structure among the channel response over the array. So, the adding or removing of the users in system does not hamper on system sum-rate. Therefore, without overhead, channel estimation can increase number of BS antennas as much as require for the efficient model. Moreover, no extra signal processing technique is requiring in this system as in every user's equip a simple linear precoding. We can conclude that massive MIMO is a scalable technology.

II. Working Principle of Massive MIMO

Massive MIMO is comfortable to works in TDD system. In each coherence interval of time slot uplink and downlink data transmission takes place. The transmission protocol of the massive MIMO system using TDD is presented in Fig-6.

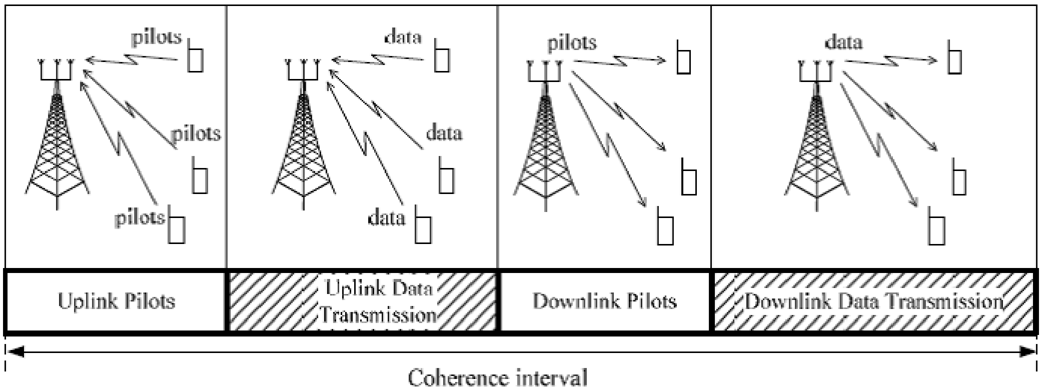


Figure 6: Data transmission with TDD method in massive MIMO

i. *Channel Estimation:*

With the help of uplink training, BS estimate the CSI in massive MIMO system and it needs to precode the signal in downlink that has transmitted from the uplink. In this system, each individual user sent the pilot signal to every BS antenna. After reception of pilot sequences transmitted from all users [8], the BS estimates its channel. The channel estimation using TDD and FDD described in the section-*I*, *A* and *B* respectively. Moreover, to receive signal coherently that is sent from the BS antenna for which every user needs to partially know about the CSI. This CSI obtain through some blind channel estimation theory or downlink training. Hence, for the acquisition of CSI, BSs have to spend a short period for pilot beamforming in downlink [8].

ii. Uplink Data Transmission

In massive MIMO, for uplink data transmission coherence interval generally use where pilots signal transmits all users to all BSs. All users use same spectrum [3] hence the $M \times 1$ receive signal vector could be written as-

$$r_{ul} = \sqrt{\rho_u} \sum_{k=1}^{K} h_k \mathbf{x}_k + n_k \cdots\cdots\cdots (17)$$

$$r_{ul} = \sqrt{\rho_u} H\mathbf{x} + n \cdots\cdots\cdots (18)$$

From proper knowledge of receive signal vectors and CSI, the BS can retrieve the signal which has sent by the k^{th} users. From Eq.18 channel capacity is obtain by [3, 9]-

$$C_{ul,sum} = \log_2 \det (I_k + \rho_u H^H H) \cdots\cdots\cdots (19)$$

Successive interference cancelation (SIC) is use for calculation of system capacity maximization where after detection of the first user, signal remove from the calculation until the next signal will receive.

iii. Transmission of Downlink Data:

In massive MIMO for downlink data transmission, the BS sent data signals to all the users in the system where the BS transmit signal vector $\mathbf{x} \in C^{Mx1}$. The k^{th} received signal vector is compute as-

$$r_{dl,k} = \sqrt{\rho_d} h_k^T \mathbf{x} + n_k \cdots\cdots\cdots (20)$$

The Eq.20 rewritten as-

$$r_{dl} = \sqrt{\rho_d} H^T \mathbf{x} + n \cdots\cdots\cdots (21)$$

The downlink received signal vector and noise is represent as $r_{dl} = \left[r_{dl,1}, \ldots, r_{dl,K} \right]^T$ and $n_k = [n_1, \cdots n_K]^T$. As Eq.21 implies the broadcast channel, so that with the aid of dirty paper coding (DPC) method the system sum-rate is obtain as below-

$$C_{sum,dl} = \max_{\substack{\{q_k\} \\ q_k \geq 0, \sum_{k=1}^{K} q_k \leq}} \log_2 \det(I_M + \rho_d H^* D_q H^T) \cdots\cdots\cdots (22)$$

where D_q is the diagonal matrix of K users and its elements are q_k.

III. Some Potential Elements while Designing Massive MIMO

a. It Increase data-rate and capacity

Massive MIMO can scale-up the data rate up to 10 times or more than the conventional MIMO system. As the huge number of antennas contain at BS in massive MIMO system so very large amount of data stream can simultaneously serve to massive number of users. This is called spatial multiplexing and using this multiplexing technique in massive MIMO results in increase system capacity [10]. Based on TDD as massive MIMO works, so each user can devote the whole bandwidth for each user's data transmission result in improve the system's performance.

In Fig.6.1 we explore the results of applying the three schemes of the M-MIMO system with *N=600*, *SNR=8dB*, *K=12, 18, 24* with variation in the number of BS antennas *M*, using ZF precoding. It is observed from the Fig.6.1 (a), (b), and (c) that the average system sum rate is always highest with *Scheme-2*. It is observed here that the difference between sum rates between schemes increases with higher values of *K* and accordingly more users selected from each group.

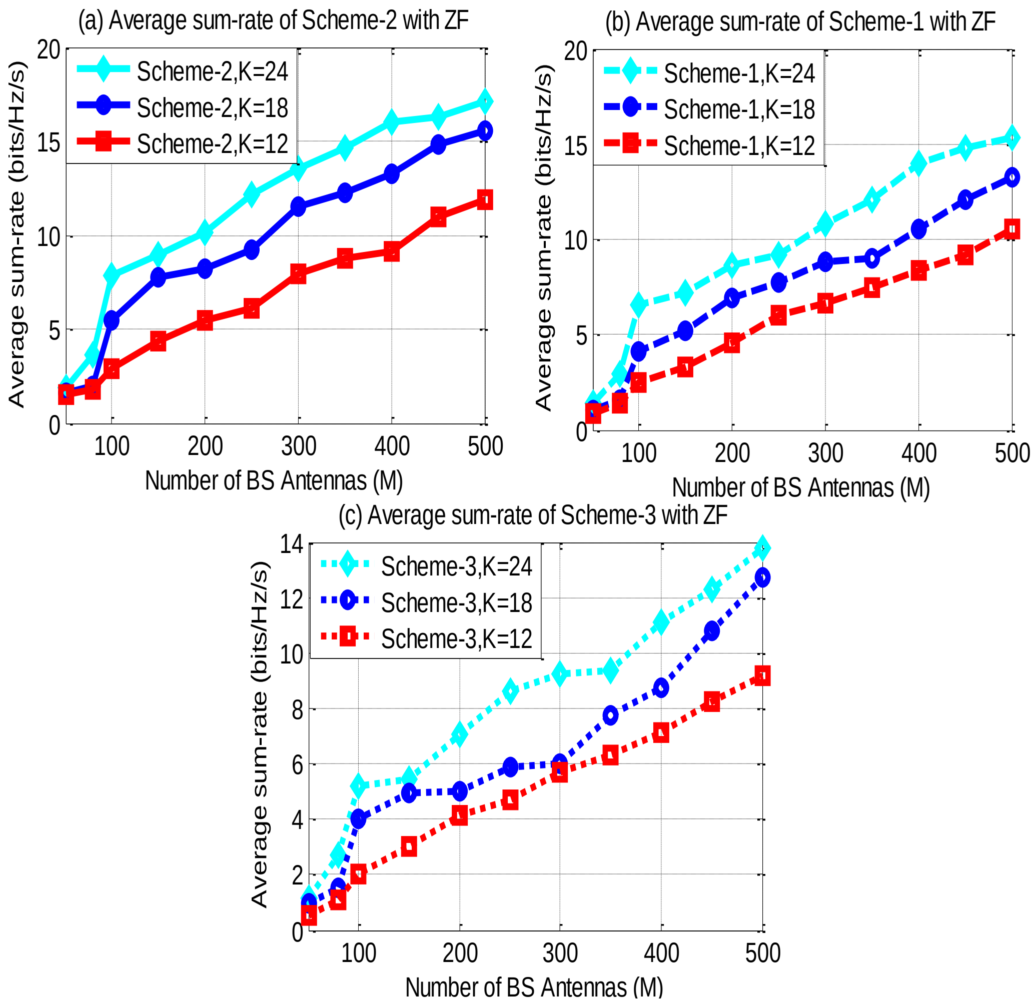


Figure 6.1: Average sum-rate versus number of BS antenna using ZF for various schemes with *Algorithm 3.1* with *N=600, SNR=8dB.*

b. Increase the energy efficiency

The fundamental principle makes dramatic increase of energy efficiency possible in massive MIMO regime as it has huge antenna at BS that is depicted in Fig-7. This leads massive MIMO to enhance energy efficiency. Energy efficiency defines the ratio between the spectral efficiency and transmits energy [8]. The tradeoff for the uplink has been analyzed in [11]. In this system, linearly energy efficiency decreases with the aid of perfect CSI but the spectral efficiency of energy is increase. It is also mentioned in [12] that the efficiency of energy improve at lower transmits power but also spectral efficiency becomes lower and vice versa. At lower energy efficiency and higher spectral efficiency, ZFBF gives better performance than the MF, where conserve holds for higher efficiency of energy and lower the spectral efficiency, and mitigate interference amongst users. When circuit power is taken into account the big problem is how to choose BS antennas to enhance the energy efficiency in the massive MIMO regime, which described in [13-14]. As BS antenna increase in massive MIMO, it is notice that the variance of the mutual information is decrease [14] when mutual information-based antenna selection has been configured.

c. Massive MIMO can design with low cost

The Massive MIMO is only challenging technology in the wireless cellular network in which a large number of low power inexpensive milli-watts ranges antennas should replace expensive ultra linear 50 watts transceiver those have usually used in the conventional MIMO system. In this system tiny type of pico and femto BS antenna are uses which consume very less power. Moreover, it also lowers the constraint on accuracy and linearity of each of the separate antenna and RF chains. Since, massive MIMO works in low of large number so the fading, hardware imperfection and noise can easily average out when the entire transmitted signal is joined at air.

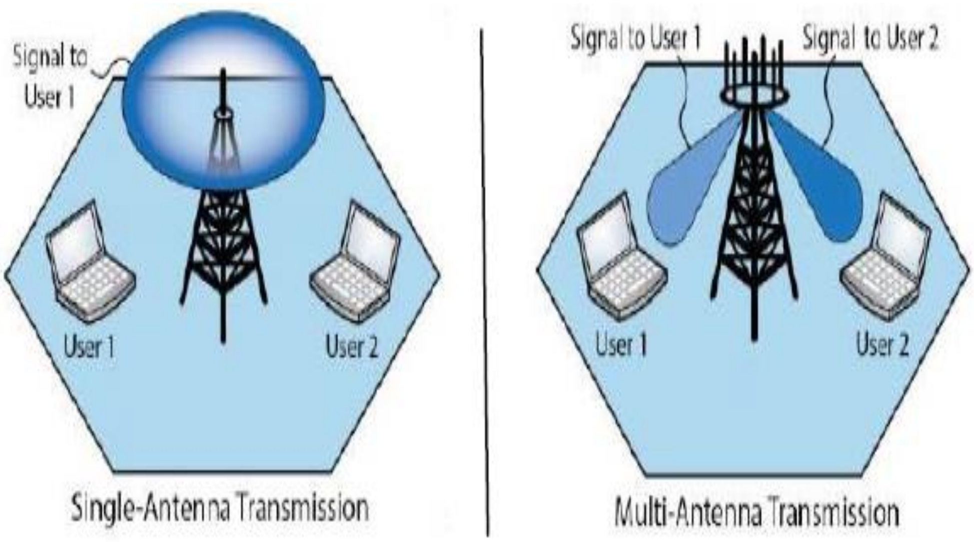


Figure 7: Single antenna transmission and multi-antenna transmission [10,15]

In massive MIMO, BS antennas have one major advantage to improve the total radiated power by transmitting signals with constraint envelop [16-17]. It enables to drastically scale-up the energy efficiency because it can operate with two times less total output power than the current technology. Therefore, this operating power is many times less than the wind and solar power. Hence, this technology may easily adoptable where electricity is not available. Since the total emitted power is very less, therefore BS will generate a small amount of electromagnetic interference compared to the current technology.

d. Reduces the latency on the multipath propagation environment

In wireless communication system, fading plays a pivotal role. Sometimes massive MIMO gives very small signal strength because BS transmits signal travels through the multipath environment before it reaches user terminal. So, these waves are destructed due to multipath interferences [2]. As its operation depends on law of large number, so the fading may easily be shorted out on the multipath propagation environment, resultant reduces the latency.

e. It Simplifies the multiple-access layer

At each cellular generation, the signaling and multiple access formats have been changed significantly to a large extent due to technical features [18]. Based on frequency division multiple access (FDMA) and analog frequency modulation technology the first generation (1G) was developed; later it was transferred to digital format in second generation (2G) and works both in FDMA and time division multiple access (TDMA) for multiple accesses. Because of its novelty of time multiplexing techniques, 2G usually called as TDMA technology. In [19], Qualcomm developed Niche spread spectrum code division multiple access (CDMA) to open the door for all global third generation (3G) standard and to overcome the disadvantage of 2G. As high-speed data is inescapable limitation factor of CDMA, so wireless technology unmistakable retreat back towards the TDMA technology [15]. Due to this cause, the huge crash on high-speed data rate in current orthogonal FDMA (OFDMA) has unanimously adopted in fourth generation (4G) technology with the renewed conjunction of FDMA and TDMA because of its great qualities of orthogonality. In this light history, it is very usual that for transformation to 5G network basically, it needed to change the new waveform designing technology and new techniques of multiple accesses [3]. As massive MIMO operate in the law of large number, therefore the whole bandwidth could be given to each active terminal for conversation. Hence, it may easily remove the complexity of frequency scheduling and reducing redundant of controlling the signals in the physical layer. Therefore, it simplifies the layer of multiple accesses.

f. Increases the robustness

Massive MIMO is robust to intentional jamming. As the bandwidth in wireless communication system limited, thus spreading signal information over a frequency band may not be realizable enough. Massive MIMO technology is a promising one to provide the degree of freedom in cancellation of undesired signals during intentional jamming. It uses the uplink pilot signal for channel estimation, so there is the high possibility of interference with modest transmission power irrespective of smart jammers. However, joint channel estimation and decoding with clever deployment can substantially diminish and could be a good approach to that problem. Without hampering the malfunction of a system, easily swapped failure antennas, this makes massive MIMO technology robust [2].

g. Extra antennas in massive MIMO helps signal to shape

In massive MIMO system, there are remaining the huge number of unused antennas those antennas are called the degrees of freedom. In this system, users are very less compared to antennas consisting at BS. Example, with 1000-service antenna servers 200-terminals used and very few numbers of terminals, stay activated and remaining are unused. So, remaining 800 unused antennas are called the degrees of freedom of a system. These unused antennas can work as hardware friendly and for signal shaping. We call here the signal shaping because in these systems the unused antennas are cover the signal in the ever-smaller region.

IV. Limiting Factor for Designing the Massive MIMO

a. To Obtained Channel Reciprocity

As massive MIMO basically operate based on TDD and in the same frequency spectrum and relies on channel reciprocity theorem in such a way that we can easily reciprocal the uplink and downlink channel [20]. However, as represent in [21], the scenario depicts that the communication channels comprise with physical channels, analog to digital converter, a filter, mixer, and antennas which all are not important. So, a system has to calibrate along with the exploitation of reciprocity of channels. However, uplink and downlink may not be reciprocal in the hardware chain of the BS and in the terminal's transceiver. If hardware chains calibration creates any problem, then [21-22] constitution-based solution techniques have to be devolved. A 64-antenna system channel reciprocity calibration had executed in [22] and claimed that it was successful experiment. In massive MIMO, to obtain full beamforming, does not require the terminal uplink and downlink channel calibration. The antennas array will transmit coherently to the users if the BS equipment is calibrated appropriately and it is not so much important in massive MIMO. As developed in [22], if one antenna is chosen as reference antenna, other antenna's signals dealt among it, and the compensation factor has been developed for each of the antennas. If the maximum phase difference less than 90 degree is achieved between uplink and downlink than reciprocity may vanish and gain of the entire beamforming would appear 3dB less than the actual one.

b. Pilot Contamination Problem

For acquisition of CSI at BS must use pilot signals which are crucial for every wireless network that play the key role in massive MIMO system [23]. In massive MIMO system usually, all users use same set of frequency as it is a limiting resource in wireless communication system. The allocation of pilot orthogonal signals to each user in each cell is not possible as it is a limited resource in massive MIMO system [24]. Therefore, it is reuse in massive MIMO from one cell to other cells. For this cause channel estimation obtain by one cell is contaminate by another user's transmitted pilot signal [25]. The pilot signal must be orthogonal among the same cell users to acquire clean channel estimation between user terminals and BS. Otherwise, it creates the interference among the same cell users. Because of such unavoidable interference generate due to pilot transmission which reduces system capacity of massive MIMO [26-32]. The generation of interference in this way is called pilot contamination and that cannot mitigate, and it increases with growing BS antennas in massive MIMO networks. The uplink and downlink pilot contamination is shown in Fig.8 (a) and Fig.8 (b) in below. It is one of the unavoidable disadvantages in massive MIMO system which is asymptotically held [33-34] and this is the open problem for the wireless communication researchers.

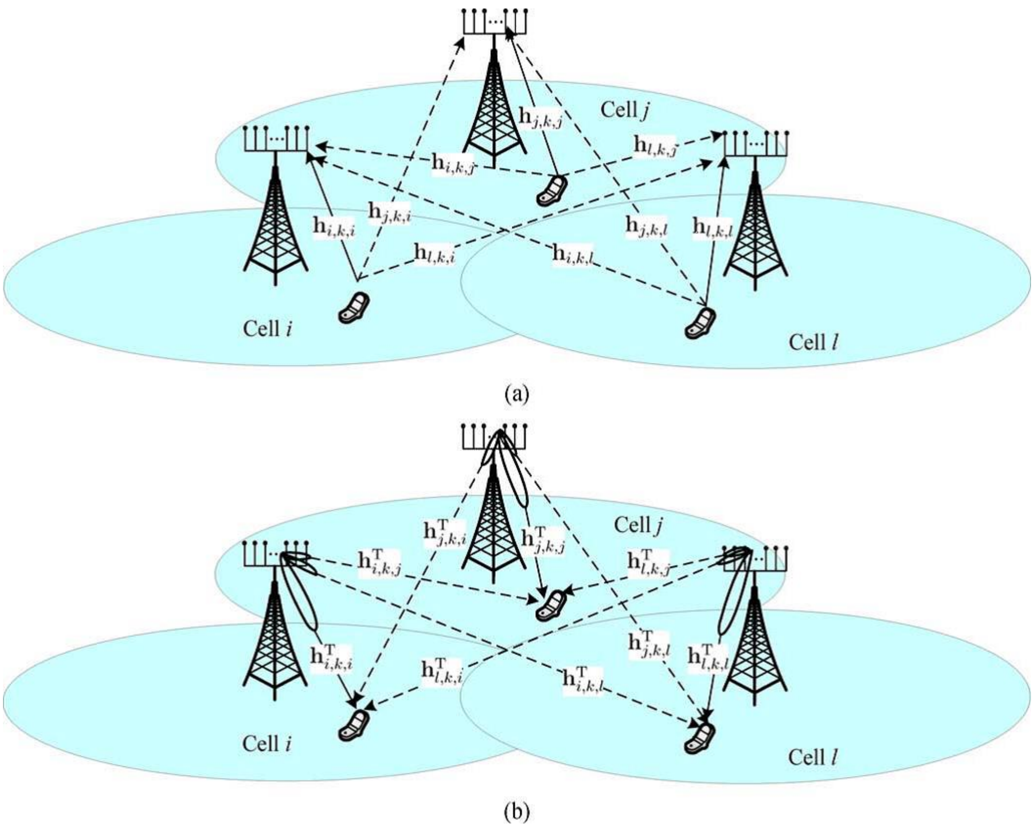


Figure 8: pilot Contamination: (a) Uplink, (b) Downlink [8]

c. Unfavorable Propagation

Massive MIMO can only operate in the environment of favorable propagation. But in a particular situation where atmosphere may be suitable for propagation but channel may not be favorable in that environment when scatter is less comp

ared to active users or BS antenna and the channel from the different active terminals share some common path. This situation is called unfavorable propagation model [35]. To overcome this problem one possible technique is to spread BS antenna in the geographic area.

d. Modern Architecture is Needed

One serious issue of massive MIMO is to design a new architecture. Some fundamental and emerging ideas are required in massive MIMO, such as different BS architectures, where some high-power amplifiers that usually feed a handful of sector antennas should be replaced or embedded with numerous of tiny antennas with a very low power consumption amplifier. The amplifier designed in such a way to integrate each antenna with it. Other vital issue must take into consideration while designing the massive MIMO such as scalability and cost, antenna correlations and mutual couplings [33]. In [36] the author presented an alternate new antenna design methodology that has the electromagnetic lens-focusing capability.

Conclusion: Due to continuously growing of users the demands of wireless communication systems are increasing. In our smart society, high data-rate, very low power consumption transmitter, simple transmitter and receiver, and very high quality of services are mostly needed. To meet above-mentioned demands massive multiple input multiple output (MIMO) is the only technology which may cater this demand as this technology is equipped with a large amount of base station (BS) antennas at the transmitter. It is only promising technology to offer higher data-rate in large coverage. It recently drew more researcher attention as of its huge system performance. In it, the large number of BS antennas all together work at the same spectrum resource. With a very large amount of BS antennas, MIMO is serving fully adaptively and coherently. In massive MIMO, the extra antennas help the system to cover the signal energy into ever smaller coverage area. When using joint antenna and user selection and scheduling in massive MIMO which improve system performance and energy efficiency. In this system, when BS antennas reach an infinite number, the additive noise and user interference tends to zero. In a massive MIMO system, it is very hard to achieve channel state information (CSI) to fulfill the demands of the user. In this paper the potential and how this technology is serving the 5G and future wireless communication system are presented in detail.

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