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Performance Analysis of Massive MIMO System over FDD based Channel Estimation Technique

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Abstract— The most recent ten years have seen an enormous development in the quantity of associated remote gadgets. In the meantime, every gadget needs a high throughput to help applications, for example, voice, constant video, motion pictures, and diversions. What's more, there is a developing worry about vitality utilization of remote correspondence frameworks. In this manner, future remote frameworks need to fulfill three principle prerequisites: I) having a high throughput; ii) at the same time serving numerous clients; and iii) having less vitality utilization. Enormous different info various yield (MIMO) innovation, where a base station (BS) outfitted with huge number of reception apparatuses (gathered or disseminated) serves numerous clients in a similar time-recurrence asset, can meet the above prerequisites, and subsequently, it is a promising applicant innovation for next ages of remote frameworks. This paper is concentrated of Spread range framework used to defeat multipath engendering issues, to know its impact against blurring condition the presentation of spread range correspondence framework is tried under blurring channel condition.

***Keywords:* -** Massive MIMO, TDD, FDD

I. INTRODUCTION

Amid the most recent years, information traffic (both versatile and fixed) has become exponentially because of the sensational development of cell phones, tablets, workstations, and numerous different remote information expending gadgets. The interest for remote information traffic will be significantly more in future [1]. Figures 1 demonstrates the interest for portable information traffic and the quantity of associated gadgets. Worldwide versatile information traffic is relied upon to increment to 15.9 exa-bytes every month by 2018, which is around a 6-overlay increment more than 2014. Moreover, the quantity of cell phones and associations are required to develop to 10.2 billion by 2018. New advancements are required to satisfy this need. Identified with remote information traffic, the key parameter to think about is remote throughput (bits/s) which is characterized as:

Throughput = Bandwidth (Hz) × Spectral productivity (bits/s/Hz).

Obviously, to improve the throughput, some new advances which can expand the data transfer capacity or the ghostly effectiveness or both ought to be misused. In this proposition, we center on systems which improve the unearthly effectiveness. A notable method to expand the ghastly proficiency is utilizing different radio wires at the handsets [2, 3].

In remote correspondence, the transmitted sign are being weakened by blurring due to multipath spread and by shadowing because of enormous snags between the transmitter and the collector, yielding a major test for solid correspondence. Transmission with various information different yield (MIMO) reception apparatuses is a notable assorted variety system to improve the unwavering quality of the correspondence. Moreover, with various receiving wires, numerous streams can be conveyed and henceforth, we can get a multiplexing gain which essentially improves the correspondence limit. MIMO frameworks have increased noteworthy consideration for as far back as decades, and are currently being consolidated into a few new age remote gauges (e.g., LTE-Advanced, 802.16m).

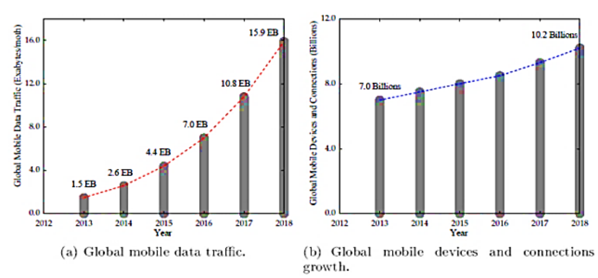

Figure 1: Demand for mobile data traffic and number of connected devices

The push to misuse the spatial multiplexing increase has been moved from MIMO to multiuser MIMO (MU-MIMO), where a few clients are at the same time served by a numerous receiving wire base station (BS). With MU-MIMO setups, a spatial multiplexing increase can be accomplished regardless of whether every client has a solitary radio wire [4]. This is significant since clients can't bolster numerous receiving wires because of the little physical size and minimal effort prerequisites of the terminals, while the BS can bolster numerous radio wires. MU-MIMO does receive all rewards of MIMO frameworks, yet in addition defeats the majority of engendering constraints in MIMO, for example, badly carried on channels. In particular, by utilizing planning plans, we can decrease the impediments of poorly acted channels.

II. MASSIVE MIMO

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 [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. MIMO antennas enhance both communication reliability as well as the capacity of communication (by transmitting different data in different antennas. 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. 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. By introducing more antennas at the BS, the effects of uncorrelated noise and intra cell interference disappear and small scale fading is averaged out. 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].

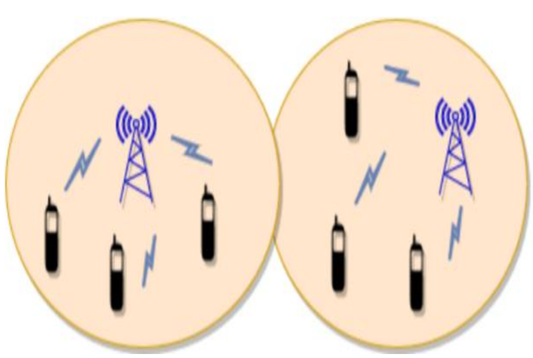

Figure 2: Multi-cell Massive MIMO System

Advantages of Massive MIMO System:-

High energy efficiency: If the channel is estimated from the uplink pilots, then power decrease 1/ √ M for each user's transmitted power to considering M is very large. If perfect Channel State Information (CSI) is available at the BS, then the transmitted power is reduced. In the downlink case, the BS can send signals only in the bearings where the client terminals are found. 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.
- **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 be almost eliminated and the latency will be reduced significantly.

III. CHALLENGES

Propagation Model: In most of the Massive MIMO related works, the assumption that made was: as the BS antennas grow pair wise. But in real time propagation environment, antenna correlation comes into the picture. If the antennas are highly correlated, then the channel vectors cannot become pair-wise orthogonal than number of antenna is increase.

Channel Estimation: To perform detection at the receiver side, we need perfect CSI at the receiver side. Due to the mobility of users in MU case, channel matrix changes with time. In high mobility case, accurate and time acquisition of CSI is very difficult. FDD Massive MIMO induces training overhead and TDD Massive MIMO relies on channel reciprocity and training may occupy a large fraction of the coherence interval.

Coupling between antenna arrays: At the BS side, several antennas are packed in a small space. This causes mutual coupling in between the antenna arrays. Mutual coupling degrades the performance of Massive MIMO due to power loss and results in lower capacity and less number of degrees of freedom. When designing a Massive MIMO system.

Mobility: If the mobility of the terminal is very high, then the coherence interval between the channel becomes very less. Therefore, it accommodates very less number of pilots.

IV. CHANNEL ESTIMATION

In order to achieve the benefits of a large antenna array, accurate and timely acquisition of 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 uplink and downlink transmissions are same frequency band 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 3. 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 4.

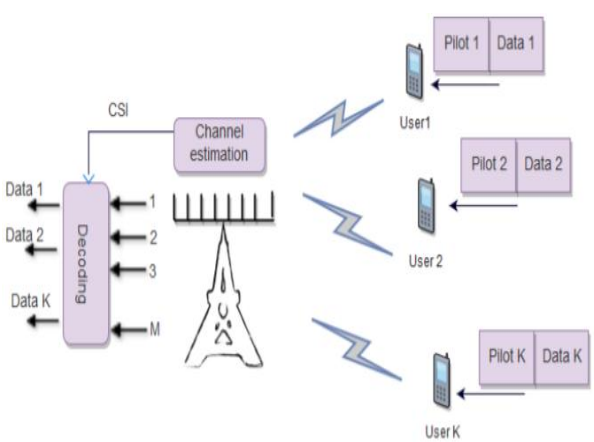

Figure 3: TDD based Uplink Transmission

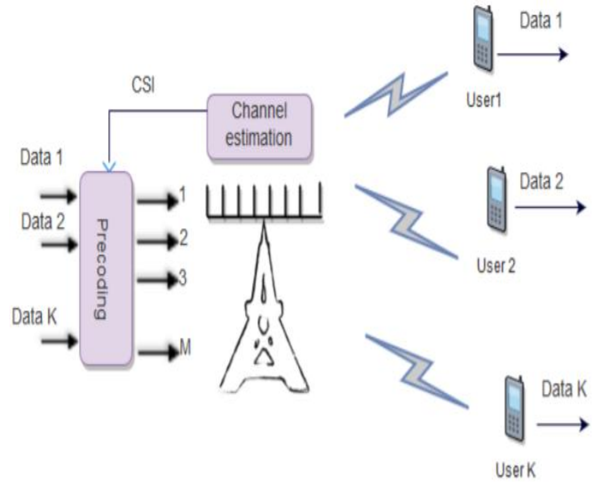

Figure 4: TDD based Downlink Transmission

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. 5. 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.

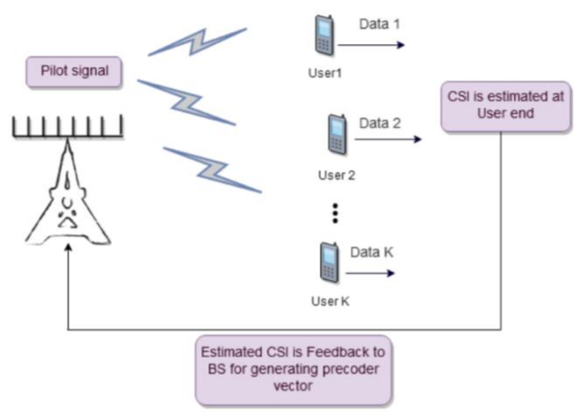

Figure 5: Downlink transmission in an FDD Massive MIMO system

V. PROPOSED METHODOLOGY

In this paper we have assumed, instead of estimating the channel vector at the user side, the observed pilot signal by each user is fed back to the BS. The joint MIMO channel estimation of all users is done at the BS. The pilot observation of all users is expressed as

$$Y = H\phi + N \quad (1)$$

Where $Y \in C^{K\times L}$ is the received signal, K denote for number of resolvable physical path, L denote for channel $H = [h_1^T, h_2^T, \ldots h_k^T]^T \in C^{K\times M}$ is the downlink channel to be recovered. M is denote by Massive MIMO system.

$N = [n_1^T, n_2^T, \ldots n_k^T]^T \in C^{K\times L}$ is the downlink noise matrix

The pilot signal W which is fed back to the BS by all users is given as

$$W = QY + Z \quad (2)$$

Where $Q \in C^{M\times K}$ is the uplink channel matrix

$Z = [z_1^T, z_2^T, \ldots z_k^T]^T \in C^{M\times L}$ is the uplink noise matrix.

To recover the downlink channel matrix at BS, firstly Y has to be estimated. Y matrix is estimated using LS estimation by assuming, uplink channel matrix Q is known. The estimate ˆY is given as

$$\widehat{Y} = (Q^H Q)^{-1} Q^H W \quad (3)$$

Further, the estimation of downlink channel matrix at BS can be formulated as a rank minimization:

$$\min_H rank(H)\ s.t. \widehat{Y} = H\phi \quad (4)$$

The channel matrix is initially assigned as zero matrix. At each iteration, the channel matrix is getting updated using the equation given in equation 2. The weight for each singular values is computed, based on the singular values obtained from the FIWSVD of the matrix in equation 3.

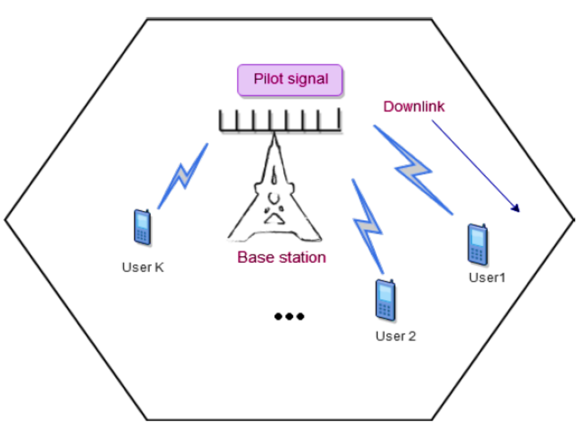

Figure 6: Single cell downlink transmission

In order to get a low rank solution to the estimated channel matrix, in each iteration weighted soft thresholding is done according to the equation in equation 4. These steps executed iteratively until the normalized difference between the previous estimates and current estimates reaches the threshold.

VI. SIMULATION RESULT

In FDD systems, CSI is obtained at every user by sending the pilot signal from BS and estimate the channel information with the help of pilot signal. The obtained CSI is fed back to the BS for precoding the user data.

To estimate the downlink channel, the pilot overhead is in the order of a number of BS antennas which is prohibitively large in Massive MIMO system. Further, the estimated CSI by the user is feedback to the BS over the uplink channel. Hence, the overall overhead for uplink is high. Hence, it is necessary to explore channel estimation method for massive MIMO based on FDD mode with reduced overhead.

Hence, Fast Iterative Weighted Singular Value Thresholding (FIWSVT) algorithm is proposed for channel estimation problem for the non-orthogonal training sequence. Regularization parameter is found in order to have low-rank property for the resultant estimated channel matrix.

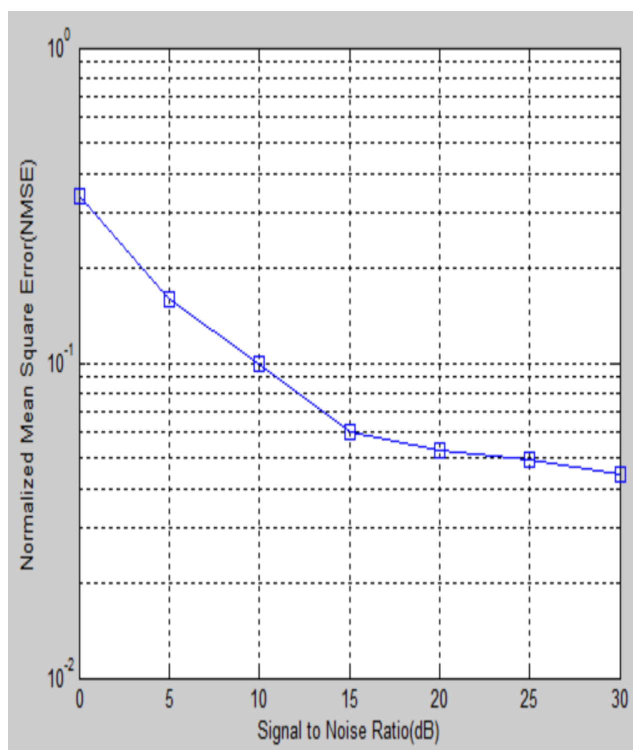

Figure 7: Normalized MSE Vs Uplink SNR (downlink SNR =15 dB)

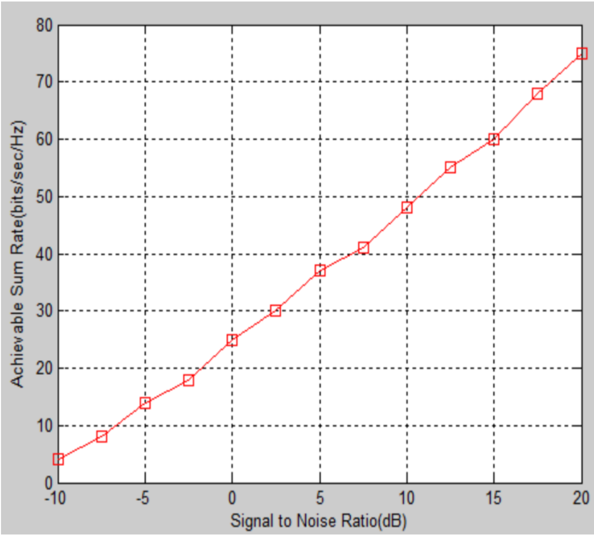

Figure 8: Achievable Sum Rate (bps) Vs Uplink SNR (downlink SNR =15 dB)

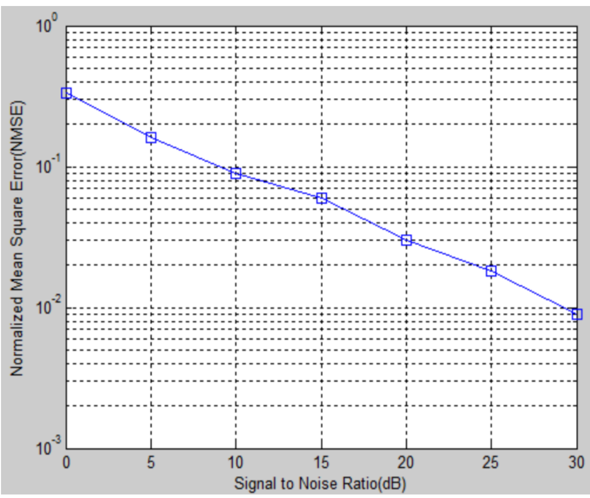

Figure 9: Normalized MSE Vs Uplink SNR (downlink SNR =25 dB)

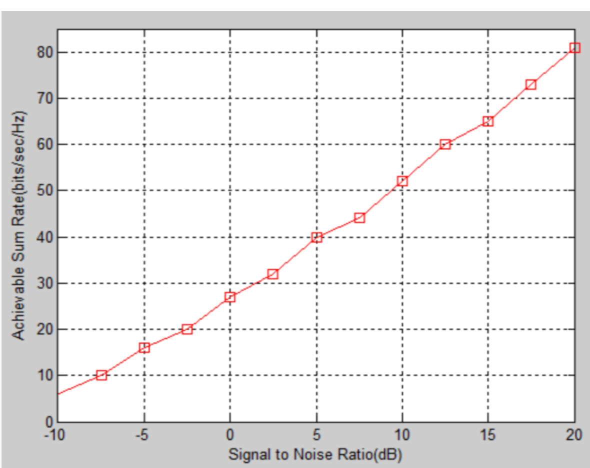

Figure 10: Achievable Sum Rate (bps) Vs Uplink SNR (downlink SNR = 25 dB)

VII. CONCLUSION

The downlink FDD channel is modeled as a low-rank channel by considering most of the clusters are around BS and rich scattering at the user side.

Instead of estimating the downlink channel at the user side, the received pilot signal of the user is sent back to the BS and downlink channel matrix is estimated at BS under the assumption that uplink channel matrix is known. The received pilot signal of the users is estimated using LS method. The downlink channel estimation problem is studied for non-orthogonal training sequence using FIWSVT algorithm when the rank of the matrix is known. The convergence and NMSE of the FIWSVT algorithm are compared with SVP-G, SVP-N, and SVP-H. It is shown through simulation, FIWSVT algorithm has minimum MSE and faster convergence at low SNR compared to other algorithms.

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