Channel Estimate In MIMO Using DFT In Leakage Estimation

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Abstract

In the wireless industry full dimension MIMO has attracted significant attention and for the next generation evolution toward beyond fourth generation and fifth generation cellular systems developed as a candidate technology. For realizing spatially separated transmission links to a large number of mobile stations FD-MIMO utilizes a large number of antennas placed in a 2D antenna array panel. The extension of spatial separation to the elevation domain as well as the traditional azimuth domain is due to the arrangement of these antennas on a 2D panel. We are going to discusses ongoing standardization efforts in 3GPP to incorporate FD-MIMO features in the next evolution of LTE along with the features and performance benefits of FD-MIMO. Also a 2D antenna array design and its role in the implementation of FD-MIMO, is discussed. Performance benefits of FD-MIMO are demonstrated, system-level evaluation results are given.

Introduction

On a global scale [1], in recent years the wireless industry has seen a drastic increase of wireless data traffic. Compared to traditional voice calls it increase fueled by the development of new mobile smart devices and applications that consume significantly larger volumes of data compared to traditional voice calls. The Third Generation Partnership Project (3GPP) has focused much of its standardization efforts in providing cutting edge techniques to improve spectral efficiency and user experience, in response to the increase in wireless data traffic.

Multiple-input multiple-output (MIMO), coordinated multipoint (CoMP) transmission/reception, and carrier aggregation (CA) are among such techniques. To enhance user equipment (UE) performance at cell edges, CoMP relies on coordination between multiple transmission and reception points but requires a very capable backhaul connection for inter-site coordination. Multiple frequency bands to enhance peak data rate and a network’s load balancing capability are utilized by Carrier aggregation simultaneously but requires the use of large frequency resources. For wireless data traffic developments of new technologies are required to meet the exponentially growing demand although each of these techniques represents a major step forward in improving system performance. One of the key technologies currently studied in the 3GPP for the next generation Long-Term Evolution (LTE) systems is Full dimension MIMO (FD-MIMO) [2]. A study item [3] has been initiated to study a new channel model under which future evaluation of the antenna technologies will be performed as a first step. As early as this year 3GPP study and work items on FD-MIMO are expected.

Our aim is to identify key areas in the LTE standards that need to be enhanced to support up to 64 antenna ports placed in a 2D array. It is expected that system throughput will be drastically improved beyond what is possible in conventional LTE systems by incorporating FD-MIMO into LTE systems. FD-MIMO is capable of enhancing system performance without requiring a very capable backhaul or large frequency resources, compared to CoMP and CA. Details of FD-MIMO in terms of deployment
scenarios, 2D antenna array implementation, possible enhancements to the current LTE standards, and system-level evaluation results is provided on the discussions in [2]. High order multiuser MIMO (MU-MIMO) transmissions is realized by multiple antennas placed in a 2D antenna array panel, which is utilized by FD-MIMO. To transmit or receive spatially multiplexed signals to or from a large number of terminals high-order MU-MIMO refers to the use of a large number of antennas at the base station. Figure 1 depicts an enhanced Node Bs with FD- MIMO capability transmitting simultaneously to multiple UEs. 2D antenna array panel on which the antennas at the eNB are placed where every antenna is an active element. These active antenna elements allow dynamic and adaptive precoding to be performed jointly across all antennas. As a result of such precoding, eNBs can realize.

FD-MIMO has two important differentiating factors, as compared to MIMO transmissions of conventional LTE systems. Initially, the number of antennas has been increased up to eight antennas that is beyond the number supported in conventional LTE systems. Therefore there is improvement in, beamforming and spatial user multiplexing capability. Second, antennas are placed in a 2D planar array, but they are no longer placed in a 1D linear array. Reduction in the form factor of the antennas to be more practical is the main motivation for the planar placement. For example, a form factor of 50 cm × 50 cm is result of 64 antennas supported at 2.5 GHz in an 8 × 8 planar array with 0.5 λ spacing.

The array would be 4 m wide, making it unpractical, if the antennas are placed in a linear array. As compared to a linear array, a planar array does reduce the effective spacing between different antenna elements, it provides the benefit of being able to extend spatial separation to the elevation domain as well as the traditional azimuth domain. Following sections presents more details on the design of the 2D antenna array and its impact on system performance technical aspects of FD-MIMO are introduced in this article. We have presented discussions on system deployment, implementation of a 2D antenna array, modeling of a 3D channel, and possible enhancements to the current LTE standards.

PERFORMANCE OF SYSTEME

By utilizing FD-MIMO, ability to handle high order MU-MIMO is the, key source of performance enhancement. FD-MIMO is capable of supporting a significantly larger number of MU-MIMO UEs with a larger number of antennas. Compared to conventional LTE systems where the maximum number of MU-MIMO co-scheduled UEs is limited to four. Consider an FD- MIMO system with $N_T$ transmit antennas at eNB, $K$ co-scheduled UEs and downlink transmission power of $P$. With channel conjugate precoding, the received signal for the $k$th UE can be derived as

$$\mathbf{y}_k = \sqrt{\frac{P}{N_T K}} \mathbf{h}_k \mathbf{x}_k + \left( \sqrt{\frac{P}{N_T K}} \sum_{j \neq k} \mathbf{h}_j \mathbf{x}_j + \mathbf{n}_k \right)$$

Figure 1. Conceptual diagram of an FD-MIMO system realizing high-order MU-MIMO by utilizing a 2D antenna array.
For the $k^{th}$ UE, $x_k$ is the transmitted signals and $h_k$ is the downlink channel. $n_k$ is the Gaussian noise at the $k^{th}$ UE’s receiver. As the number of antennas increases, theoretically, the two random channel cross-correlation realizations converges to zero as shown in [4],

$$\lim_{N_T \to \infty} \frac{h_k h_k^*}{N_T} = \delta_{kl},$$

(2)

where $d_{kl} = 1$ if $k = l$ and otherwise $d_{kl} = 0$. Assuming a large $N_T$ and $K$ ($K < N_T$), the average signal-to-interference-plus-noise ratio (SINR) for each UE is given as

$$\gamma_k = \frac{P}{N_T K} \sum_{k} \left| h_k h_k^* \right|^2 \sigma_n^2,$$

(3)

For the case where inter-user interference is significantly larger than the noise variance. This is downlink analysis, but a similar analysis can be applied for the uplink multiple access channel [4]. Although the above analysis is based on an ideal signal model, important insights can be obtained. From Eq. 3, it is cleared that the SINR at each UE linearly increases as number of antennas. The same SINR can be maintained, if the number of antennas increases at the same rate as the number of co-scheduled UEs. If we increase the number of transmit antennas by a factor of $G$, then without any sacrifice in SINR, the number of UEs that can be co-scheduled using the same wireless resource can also increase by a factor of $G$. For example, a 10-fold system capacity increase can be achieved, if the number of antennas increases from 10 to 100 while the number of UE’s increases from 2 to 20. Note that the above analysis assumes

**DEVELOPMENT METHOD**

With FD-MIMO capability should be deployed in scenarios, in order to fully exploit the enhanced beam-forming and spatial user multiplexing of FD-MIMO, eNBs where such characteristics can enhance system performance. Examples of such FD-MIMO deployment in urban micro, urban macro, high rise, and high population density scenarios are shown in Figure 2. Most UEs in urban locations are indoors on different floors, in practical situations. In the elevation domain as well as the azimuth domain having the capability to control the beam direction, presents new opportunities to enhance system performance for FD-MIMO in such scenarios. The urban out-door to indoor scenario between an outdoor eNB and indoor UEs on different floors. Using beam forming in the elevation direction transmissions originating from the outside of the building to UEs located on different floors can be better separated. The high population density scenario in a hot zone, where a large number of UEs are...
closely located with one another. Examples of high population density scenarios are Shopping malls Stadiums or concert halls Transportation hubs such as major airports.

A large number of people are located in a limited area, generating high traffic demand simultaneously is a key characteristic of the high population area scenario. Hundreds or even thousands of UEs in a hot zone can simultaneously try to access the cellular system, leading to severe quality of service (QoS) instability, typically in such scenarios. Taking advantage of the additional beam directivity, MU-MIMO transmission from the 2D antenna array can be made simultaneously for multiple UEs in such scenarios. For example, in a shopping mall with a high ceiling, the 2D antenna array can be positioned on the ceiling facing downward to provide high order MU-MIMO transmission.

3D CHANEL MODEL

By a number of research groups such as 3GPP, geometry based stochastic channel models have been developed and refined over time, 3GPP2, the International Telecommunication Union (ITU), and the WINNER initiative [5, 6]. To evaluate performance of different wireless technologies, the spatial channel model (SCM) [6], an example of a geometry based stochastic channel model [7], is widely used in the 3GPP community. In the 3GPP community, traditional SCM used is a 2D channel model, where an elevation angle of each signal path is always assumed to be zero. For evaluating performance of systems for such an approach is acceptable, with horizontally placed linear antenna arrays, modeling of elevation angles is necessary when evaluating an FD-MIMO technology utilizing a 2D antenna array.

In a 3D SCM, every signal path has to be modeled with an elevation angle as well as an azimuth angle. The wireless channel propagation in the elevation direction as well as the azimuth directions has taken into account by 3D spatial channel model. One of the main challenge is to model the correlation of large-scale parameters along with the statistical distribution of elevation angles. Azimuth spread at departure (ASD), azimuth spread at arrival (ASA), elevation spread at departure ,elevation spread at arrival (ESA), shadow fading, Rician $K$-factor, and delay spread, these large-scale channel parameters have been shown to be correlated.
a) photo of a fabricated antenna array panel comprising eight 0.5 spaced sub-arrays, taken during measurements in an anechoic chamber;

b) magnitude of reflection coefficients (self $S$-parameters) of eight sub-arrays within FD-MIMO antenna panel;

c) magnitude of mutual coupling coefficients ($S_{i+1,i}$ parameters) between adjacent sub-arrays;

d) co-pol and cross-pol radiation patterns of one sub-array on azimuth (0°) and elevation (90°) planes at 2.6 GHz.

At the terminal side, the cross-correlations of these parameters must be measured and modeled. The large scale parameters are correlated for different terminals as well, if the terminals are closely located. In the literature these cross-correlations have not been
extensively measured and reported. The elevation spread is assumed to have the same spatial correlation as the azimuth spread, in some references, since the azimuth and elevation spreads originate from the same clusters and their autocorrelations may behave in a similar manner, such approximation is considered reasonable. For the other elevation parameters, further study and measurements are needed to confirm this assumption and determine whether or not the same approach could be taken.

The distribution of the elevation spread is assumed to be wrapped Gaussian, which is symmetric around the mean, in some references. However, it is observed that the distribution of elevation angles is asymmetric, in other measurements, so the distributions that reflect the asymmetric nature of elevation angles are considered. In WINNER+ this aspect is reflected. By using two standard deviations (left and right), a double exponential (or Laplace) distribution is proposed in WINNER+, which models such skewness. Extending a 2D channel model to a 3D channel model is done by a proper modeling of the mean and variance. On a global scale, in recent years the wireless industry has seen a drastic increase of wireless data traffic. Compared to traditional voice calls it increase fueled by the development of new mobile smart devices and applications that consume significantly larger volumes of data compared to traditional voice calls. The Third Generation Partnership Project (3GPP) has focused much of its standardization efforts in providing cutting edge techniques to improve spectral efficiency and user experience, in response to the increase in wireless data traffic. Multiple-input multiple-output (MIMO), coordinated multipoint (CoMP) transmission/reception, and carrier aggregation (CA) are among such techniques. To enhance user equipment (UE) performance at cell edges, CoMP relies on coordination between multiple transmission and reception points but requires a very capable backhaul connection for inter-site coordination. Multiple frequency bands to enhance peak data rate and a network's load balancing capability are utilized by Carrier aggregation simultaneously but requires the use of large frequency resources. For wireless data traffic developments of new technologies are required to meet the exponentially growing demand although each of these techniques represents a major step forward in improving system performance. One of the key technologies currently studied in the 3GPP for the next generation Long-Term Evolution (LTE) systems is Full dimension MIMO (FD-MIMO) [2]. A study item [3] has been initiated to study a new channel model under which future evaluation of the antenna technologies will be performed as a first step. As early as this year 3GPP study and work items on FD-MIMO are expected. Our aim is to identify key areas in the LTE standards that need to be enhanced to support up to 64 antenna ports placed in a 2D array. It is expected that system throughput will be drastically improved beyond what is possible in conventional LTE systems by incorporating FD-MIMO into LTE systems. FD-MIMO is capable of enhancing system performance without requiring a very capable backhaul or large frequency resources, compared to CoMP and CA. Details of FD-MIMO in terms of deployment scenarios, 2D antenna array implementation, possible enhancements to the current LTE standards, and system-level evaluation results is provided on on the discussions in [2]. High order multiuser MIMO (MU-MIMO) transmissions is realized by multiple antennas placed in a 2D antenna array panel, which is utilized by FD-MIMO. To transmit or receive spatially multiplexed signals to or from a large number of terminals high-order MU-MIMO refers to the use of a large number of antennas at the base station. Figure 1 depicts an enhanced Node Bs with FD-MIMO capability transmitting simultaneously to multiple UEs. 2D antenna array panel on which the antennas at the eNB are placed where every antenna is an active element. These active antenna elements allow dynamic and adaptive precoding to be performed jointly across all antennas. As a result of such precoding, eNBs can realize.
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**Conclusion**

In this article, for evolution towards B4G and 5G cellular systems, the characteristics and performance of FD-MIMO technology were discussed. In terms of performance, future deployment scenarios, and potential enhancements to the LTE standards fundamental characteristics of FD-MIMO were presented. Further for the support of FD-MIMO, details on the design of a 2D antenna array were discussed. A 3D channel model that captures the wireless channel characteristics of the azimuth and elevation directions was introduced in order to evaluate the performance of FD-MIMO. FD-MIMO systems can potentially provide substantial system performance enhancement over legacy MIMO systems from the system level evaluation results shown.

**REFERENCE**


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