# Analysis of MIMO Transmit Diversity and MIMO spatial multiplexing system in wireless communication

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**Abstract** - *3rd Generation Partnership Project (3GPP) standards fulfil the specification of the Long Term Evolution (LTE) standard towards the 4th generation communication. Most of the operators and vendors are committed to LTE deployments and developments, making LTE as a market leader in the upcoming evolution to 4G wireless communication systems. Key components of LTE to provide higher data rate with better efficiency are the MIMO techniques as spatial multiplexing, transmit diversity and beamforming. "LTE-Advanced" further extends the LTE MIMO techniques under 3GPP which meets the requirement of IMT-Advanced set by International Telecommunication Union Radio communication Sector (ITU-R).*

***Key Words:*** **Multiple-input multiple-output (MIMO) systems, space-time coding, transmit diversity**

## 1.INTRODUCTION

Now a days multimedia communications become more popular, mobile communications has to reliable to support high data rate transmissions. Multiple input multiple output (MIMO) technology is being treated as an emerging technology to fulfil the demand of higher data rate and better coverage using the same average transmit power or frequency bandwidth. It is proved that MIMO structure can successfully constructs the multiple spatial layers where multiple data streams can deliver on a given bandwidth by increasing the channel capacity. MIMO technologies are being supported by many of the recently specified wireless communication standards.

An Orthogonal Frequency Division Multiplexing (OFDM) based technology are recently specified by 3rd Generation Partnership Project (3GPP) by Evolved Universal Terrestrial Radio Access (E-UTRA) to support the wireless broadband data transmission up to 300 Mbps in the downlink and 75Mbps in the uplink. (E-UTRA is also known as LTE in the wireless industry). MIMO technologies in LTE (Long Term Evolution) are widely used to improve downlink peak rate, reliability as well as average cell throughput.

To achieve this set of goals, LTE has been adopted various MIMO technologies as transmit diversity, single input single output (single user (SU)-MIMO), multiuser (MU)-MIMO scheme, closed loop MIMO, and dedicated beamforming. The SU-MIMO scheme is specified for the 2*2 or 4*4 transmission configurations in the downlink. It is used to supports the transmission of multiple spatial layers up to four layers to the allocated User Equipment (UE). The transmit diversity scheme is mainly specified for the configuration of two or four downlink transmission antennas, and two uplink transmission antennas.

The multi user (MU-MIMO) scheme is designed to allocate the different spatial layers for different users in the same time and frequency resource. The allocation of different layers is supported in both uplink and downlink transmission. Single user SU-MIMO technologies has been extended in LTE-Advanced to support the configuration of maximum eight transmit antennas in the downlink transmission, and is for four transmit antennas configuration in the uplink transmission. In this paper we discuss the various MIMO technologies evolved in LTE advanced.

### 1.1 Downlink SU-MIMO in LTE

The single user (SU-MIMO) scheme has been applied to the physical layer through Physical Downlink Shared Channel (PDSCH) which carries the information data from the network host to the user equipment (UE). LTE system can provides a peak rate of 150 Mbps for two transmit antennas and 300 Mbps for four transmit antennas with single user MIMO. There are two operation modes in SU-MIMO spatial multiplexing has two modes of operation: the closed-loop spatial multiplexing mode and the open-loop spatial multiplexing mode.

The base station called eNodeB in the closed-loop spatial multiplexing, applies the precoding in spatial domain on the transmission signal (also known as eNodeB) applies the spatial domain precoding on the transmitted signal which take the precoding matrix indicator (PMI) into account reported by UE. PMI helps to match the transmitted signal with the spatial channel experienced by the UE. The illustration of closed-loop spatial multiplexing with M layers and N transmit antennas ($N \geq M$) is shown in Figure 1.

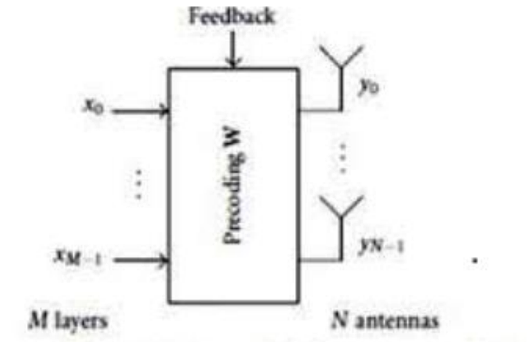


**Figure 1**: Closed-loop spatial multiplexing with *N* antennas and *M* layers

The UE needs to feedback the rank indicator (RI) in the downlink to support the closed-loop SM, while for uplink it needs the PMI, and the channel quality indicator (CQI) as feedback. The RI is the number of spatial layers which can be supported by the current channel experienced at the UE. Transmission rank, M, may be decided by the eNodeB by taking into account the RI reported by the UE.

The open-loop spatial multiplexing may be operated when reliable PMI feedback is not available at the eNodeB, then the open-loop spatial multiplexing come into frame, for example, when the UE speed is faster than enough or when the feedback overhead on the uplink is too high. The open-loop spatial multiplexing with *M* layers and *N* transmit antennas ($N \geq M$) is illustrated in Figure 2.

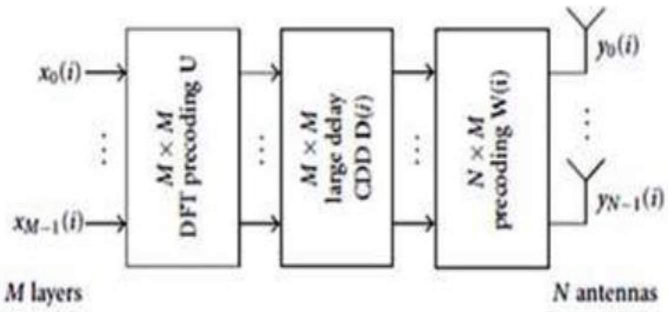


**Figure 2**: Open-loop spatial multiplexing with *N* antennas and *M* layers.

## 1.2 Transmit Diversity in LTE

On the all physical channels such as PDSCH, Physical Broadcast Channel (PBCH), Physical Downlink Control Channel (PDCCH), Physical Hybrid ARQ Indicator Channel (PHICH), Physical Control Format Indicator Channel (PCFICH), the transmit diversity schemes can be applied, in LTE downlink system, while the other MIMO schemes are only applicable to PDSCH. A UE at eNodeB can recognize the number of transmit antennas through *{*1, 2, 4*}* by decoding PBCH. It can be noted that no transmit diversity scheme is specified in LTE apply to the primary and secondary synchronization signals. If the number of transmit antennas at eNodeB is detected, then applicable specific transmit diversity scheme to the other physical downlink channels can be determined.

In uplink system, for the user equipment (UE) with two transmission antennas, the transmit antenna selection diversity specified. For the selection of closed-loop transmit antenna, the eNodeB selects the antenna which is used for uplink transmission and try to communicate this selection with UE using the downlink control message. In case of the open-loop transmit antenna selection; the UE randomly selects the antenna to be used for transmission without eNodeB's interruption.

## 2. MU-MIMO in LTE

The LTE standards are designed to support the MU-MIMO in both uplink and downlink system. For the uplink system, the eNodeB can always select more than one UE for the signal transmission in the same time-frequency resource, which forms a MU-MIMO transmission configuration. However, in order to able to differentiate and demodulate these UEs' signals, eNodeB has been needs to define the orthogonal reference signals for these UEs allocated for the MU-MIMO transmission. In the each cell for a given slot and subframe, as the base sequence, a Zadoff-Chu sequence is defined for uplink reference signals. For a given Zadoff-Chu sequence in the cyclically shifted forms an orthogonal set of sequences. Each UE allocated for MUMIMO transmission is assigned by a separate cyclic shift value, and then each UE combines this cyclic shift value with the acknowledgement (ACK) of the base Zadoff-Chu sequence to create a reference signal sequence. This signal is orthogonal to other UEs' reference signal sequences. It should be noted that the control signalling always contains the cyclic shift value, which is received by the UE for data transmission on uplink, regardless of the MU-MIMO is operated or not.

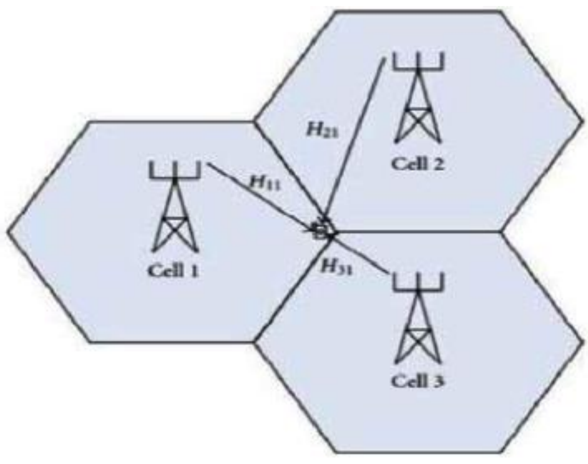


**Figure3:** Coordinated multipoint transmission in the downlink.

## 3 MIMO Schemes in LTE-Advanced

In order to achieve downlink channel peak spectrum efficiency of 30bps/Hz and uplink channel peak spectrum efficiency of 15bps/Hz as mentioned to LTE-Advanced requirement, the spatial multiplexing (SM) with antenna configuration of 8 × 8 for downlink system and 4 × 4 for uplink system is now being investigated. In $N \times N$ configuration, N denotes the number transmit antennas and receive antennas. In addition to achieve the peak spectrum efficiency, the average cell throughput has to improve further as well as the cell edge performance is also an important as the aspect for the LTE-advanced study.

## 4. CONCLUSIONS

In this paper, we introduced the different MIMO technology features of LTE, which are downlink SU-MIMO; transmit diversity, MU-MIMO. Uplink feedback mechanisms are studied for the support of downlink MIMO technologies. We had also described how to provide better understanding about LTE system operation. In addition, the MIMO schemes are briefly studied for LTE Advanced was briefly described.

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