

Research Article

## Understanding LTE communication with MIMO Diversity

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### Abstract

*In this Modern age from small to large applications are directly or indirectly depends on communication and its infrastructure. This paper is dedicated to study about the wireless communication and the new technologies which helps to advance the communication performance. Therefore first the wireless communication is reported and then the MIMO communication technique is investigated. Meanwhile it is observed the communication is taken place in two different flavour namely uplink and downlink. Thus both the techniques are explored and then decided to work for uplink communication. Therefore the paper also includes the study about Uplink communication is based on OFDMA and SC-FDMA. Finally the frequently used technique namely MU-MIMO has also been discussed in this paper. In addition of that for further work the key conclusion of the conducted study is also provided in the paper.*

**Keywords:** LTE communication, uplink and downlink, OFDMA, SC-FDMA, MU-MIMO

### Introduction

Wireless technology gained attention in modern years because of less maintenance cost, effort and freedom of mobility as compared to wired network technologies. In wireless communication, the two sides are communicating most of the time. Among first party is termed as transmitter and who receive communicated data is termed as receiver. For frequent communication the transmitter is termed as Tx and receiver is denoted as Rx. That is come on the existence by the radio communication term transceiver which is used for dual functional devices transmission and receiver [Andrea Goldsmith, 2005].

In wireless communication the device needs to send and receive data using the radio frequencies. These radio frequencies are fixed for the devices. In other words the radio devices have the limited range of communication, therefore the radio devices need to use the relay communication technique for forwarding data to the destination. In this background, the source and destination are interconnected through the intermediate devices. In this way, source and destination cannot converse to each other directly because of transmission range thus need to intermediate nodes to relay information [Ralf Pabst, 2004].

Antennas are important element of all devices that uses radio frequencies for communication. Classically, an antenna includes an arrangement of metallic

conductors. Additionally these conductors are electrically connected through a dedicated line with receiver or transmitter. Antennas are basically designed to transmit and receive radio waves from entire directions equally. Such kind of antenna is termed as omnidirectional antennas [Antenna Basics]. In addition, for a particular direction the directional or high gain antennas are used. According to the configuration of the radio propagation the antenna can be one of the following types Dipole, Monopole, Array, Loop, Aperture and Traveling wave. This section provides the basics of the wireless communication and the next section provides the discussion about the MIMO communication.

### MIMO Communication

In radio communication networks MIMO or multiple-input and multiple-output is a technique which is used to progress the capability of radio connectivity. This technology uses multiple transmitters and receiver antennas to achieve multipath propagation. The term "MIMO" indicates the use of multiple antennas at the transmitter side and similarly at the receiver side. The "MIMO" technique is used for transmitting and receiving in excess of one data signal concurrently over the same radio channel. MIMO is basically dissimilar from smart antenna techniques that are developed to improve the performance of a single data signal such as beam-forming and diversity.

In communications, diversity is a technique to improving the trustworthiness of message signals or information. In this context, two or more than two

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communication channels with different features are used. Diversity plays a vital role to reduce fading and co-channel interference to avoiding errors. It is based on the reality that an individual channels experience in different levels of interference and fading. A number of instances of the same signal may be transmitted or received. Additionally that is combined in the receiver. The following classes of diversity schemes can be identified [Yi wang, 2013]:

- **Time diversity:** Multiple versions of the information signal are transmitted in different time frames. That helps to simplify the error correction.
- **Frequency diversity:** The signal is transmitted using some frequency channels or spread over a wide spectrum. The frequencies are sometimes affected by frequency-selective fading for example:
  - OFDM modulation in different combination are used with subcarriers to involve and forward error correction details
  - Spread spectrum is used such as frequency leaping.
- **Space diversity:** to achieve the reliability on received singles, the information signals are transmitted through different paths. During the wired communication it is achieved by via multiple wired paths. Additionally, in case of wireless communication that is achieved through antenna diversity. And by using multiple transmitter and receiving antennas. In case antennas are far away than it is termed as site diversity or macro diversity. In the similar manner when antennas are at a distance of wavelength this phenomena is called micro diversity. Sometimes phase antenna arrays are also used for MIMO channels, space-time coding (STC) and beam-forming.
- **Polarization diversity:** A signal in different manners are transmitted and received via antennas using different polarization technique. Additionally, to recover the information, diversity merging methods are employed on receiver devices.
- **Multiuser diversity:** the user scheduling at the end of transmitter or receiver is performed for achieving Multiuser diversity. For example transmitter selects the user among available receivers according to channel qualities between transmitter and receiver. A receiver pushes a feedback about channel quality to transmitter that helps to implement Multiuser diversity.
- **Cooperative diversity:** Achieves antenna diversity gain by using the cooperation of distributed antennas belonging to each node.

## LTE communication

LTE is also called Long Term Evolution. That is developed for wireless communications and development of GSM/UMTS standards [Subharthi

Paul]. The goal of LTE was to increase the competence and speed of wireless networks using digital signal processing techniques and modulations. Additionally redesign and simplification of network architecture towards an IP-based system to reduced transfer latency as compared to the 3G architecture. The LTE wireless interface is incompatible with 2G and 3G networks. Therefore it is operated on a separate radio spectrum [L-F Pau].

The current and future mobile generations is aimed to develop the techniques that are able to provide higher data rates. Therefore need to enhance the uplink transmission merits such as higher network capacity, throughput and lower Mean File Transfer Time [Federico Boccardi, 2016]. Basically the LTE systems functions in two different manners of radio links or connections. First one is termed as downlink means tower or base station to device and second is uplink that is defined as device to tower or base station. By using different types of interfaces LTE offers optimal manner wireless connections for both downlink and uplink. These techniques create a superior optimized network and improved battery existence for LTE devices.

An OFDMA or orthogonal frequency division multiple access connection technique as respect to CDMA and TDMA connection is used for downlink. OFDMA is regulated using MIMO (multiple in, multiple out) and it is always preferred to use. In this context MIMO means devices are enabled to work with multiple connections for a single cell. That helps to increase the constancy of the connection and also reduces latency. Due to this the throughput of a connection is also increases significantly. MIMO technology works well where carrier antennas are further apart.

On the other hand when LTE uses the DFTS-OFDMA or discrete Fourier transform spread orthogonal frequency division multiple access system to create a SC-FDMA signal the technology becomes uplink. Basically according to the literature the SC-FDMA is good for uplink because that simulate better peak-to-average power ratio over OFDMA for uplink enhancements for LTE-enabled devices. For energy preservation characteristically don't have a well-built and controlling signal departing rear to base station. Therefore a lot of the remuneration of standard OFDMA would be mislaid with a poor signal. The SC-FDMA is a kind of MIMO system. That supports 1x2 configuration for every antenna on the transmitting device [UEET 4563 Mobile and satellite communications].

In order to differentiate both the techniques uplink and downlink the difference between the OFDMA signal and the SC-FDMA signal are need to be established. In uplink communication the system uses a discrete Fourier transform function to convert data into a different form to transmit. The DFT functions are used to translate digital data into analog signals for decoding and that is also used to produce output proper radio frequencies.

The LTE technology comes in two main streams FDD (frequency division duplex) and TDD (time division duplex). Among both of them the most frequently used variant is FDD. The FDD uses detach frequencies for uplink and downlink in terms of a band pair. Means for every band it actually uses two radio frequency ranges. That is known as paired frequency bands. The TDD uses a single range of frequencies band but it is segmented to support transition and receiving of signals in a single frequency range.

The main aim of the work is to provide understanding about the LTE communication and to find the methods on which the uplink technique becomes improvable. This section provides the study about the LTE communication and the next section involves the detailed discussion about the uplink communication technology and their some popular enhancement techniques.

### Uplink communication

From the LTE standards it is expected to deliver high data transfer rate. Therefore not only wider bandwidth required it is also need to consider an advanced modulation technique. Orthogonal Frequency Division Multiplexing (OFDM) is measured to be the best possible modulation method for the downlink transmission. Additionally high Peak-to-Average Power Ratio (PAPR) of OFDM makes it less compatible to use for the uplink communication. Therefore Single-Carrier FDMA is used. FDMA technique is also termed as DFT-Spread OFDM (DFTS-OFDM) [Rafal Surgiewicz].

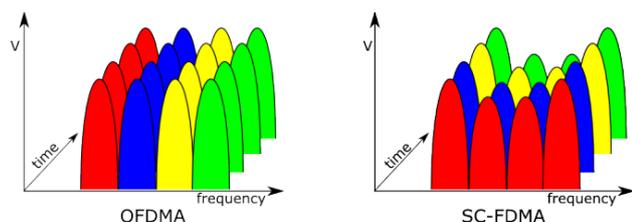


Figure 1 comparison between OFDMA and SC-FDMA

The OFDM policy is much similar to SC-FDM. Except that the Inverse DFT (IDFT) is additionally used in transmission side. Due to this additional processing of signals using DFT it is also termed as DFTS-OFDM. The DFT transformations make information bit spread over all subcarriers. That results a little variations in instantaneous power of transmitted signal. That is basically used with 'single carrier' transmission schemes.

Figure 1 shows the comparative aspect between OFDM and SC-FDMA. Additionally that demonstrates how information is added to multiple subcarriers instead of transmitted over single subcarrier. SC-FDMA enables the opportunity for low-complexity. On the other hand high-quality equalization in the frequency domain and it is also promising to have supple bandwidth assignments with SC-FDMA [J. Skold P. Beming E. Dahlman, S. Parkvall, 2008]. SC-FDMA is also

support the frequency diversity because SC-FDMA multiplies the information of one representation all the way through all the subcarriers. Due to this the losses are too few in quantity. [Hikmei Sari Cristina Ciochina, 2010].

### Uplink MU-MIMO Technology

The key concern of the proposed work is to enhance the Uplink communication performance. Therefore the detailed study on LTE communication is proposed as survey of the existing technology. As we discussed in previous sections the uplink communication is also support the MIMO technology thus in this section MU-MIMO technology that helps to enhance the performance of LTE communication is described.

Multiple-Input Multiple-Output (MIMO) technology is a wireless technology. In MIMO multiple transmitters and receivers are used to transfer data in a high order simultaneously. MIMO technology takes advantage of a radio-wave occurrence this technique is termed as multipath. In this context transmitted information degraded through walls, trees ceilings, and other reasons because the reaching singles at receiving antenna using multiple times through different angles and different times. MIMO technology demonstrates the different behaviour by using multipath and multiple smart transmitters and receivers. That also includes spatial dimensions to increase or scale up the performance and radio range. Therefore we can say MIMO technology usages multiple antennas for sending and receiving manifold spatial streams simultaneously.

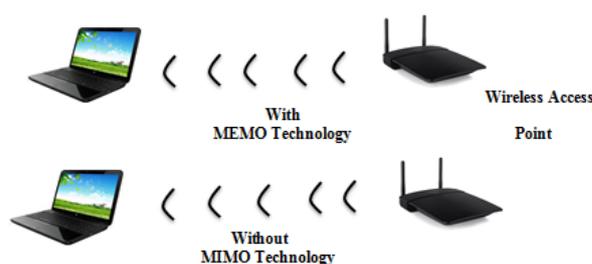


Figure 2 MIMO Technology uses multiple radios to transfer more data at the same time [Study Paper on Multiple-Input Multiple-Output (MIMO) Technology]

MIMO technology is able to create antennas smarter by including the data streams reaching from dissimilar paths and at diverse times. That also enhances the receiver's signal-capturing ability. In most of the literature Smart antennas are always used with spatial diversity technology. That helps to better utilization of antennas. In the cases when more antennas are used with the fewer amounts of spatial streams the additional antennas helps to enhance the receiver diversity and also improves the radio range.

### Uplink MIMO

In LTE communication Uplink MIMO technique may different from downlink MIMO technique. In this

context for uplink MU-MIMO is used. Using this technique multiple user devices are enabled to transmit information simultaneously using the same resource. That phenomenon is also termed as spatial domain multiple accesses (SDMA). In this technique only one transmitter antenna is required at UE (user equipment) side. That is the key advantage with the MU-MIMO. The user devices can share the same resource to implement mutually orthogonal experimental patterns. To achieve advantage of using two or more transmit antennas but still need to control the cost of user devices. Therefore in this technique antenna subset selection method is used. Initially this technique will be used with a user device that has two transmitter antennas but only one transmits. That is performed in chain and amplify manner. In further a switch can be chosen by the transmitter antenna that offers the best channel quality.

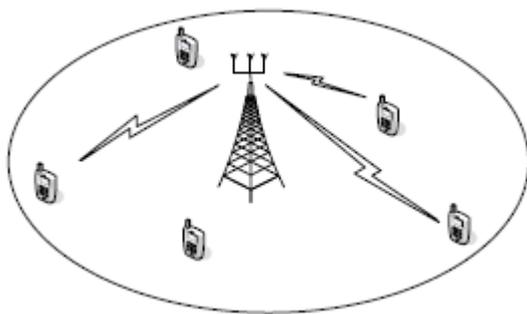


Figure 3 Multiuser MIMO Systems

### Need of MU-MIMO

- a. **More users and more devices per user:** The use of smartphones is leading to increases the quantity Wi-Fi network consumers. A significant amount of smart phone users carry at least two devices. The results are Wi-Fi networks are more crowded and able to deliver limited amount of spectrum.
- b. **Strong appetite for data:** now in these days the use of Wi-Fi is increases for accessing different content oriented applications such as music and video streaming applications on mobile devices. Additionally other professional applications such as video conferencing and others are looking to higher bandwidth and throughput. Therefore it is required to increase Wi-Fi network capacity to meet this demand significantly.
- c. **Need for simple clients:** the end clients are looking to handle low cost devices such as smart phones and laptops. Additionally these devices have limited physical space to involve more components in this case a single antenna is used to offer attractive benefits to end client with low cost and limited physical space.
- d. **Cellular offload:** Global mobile data traffic is growing in rapid rate and it is expected in near future that is increases more rapidly. Due to this demand for data on mobile networks is carried out

using cellular carriers around the world. Additionally to pass on mobile WAN information exchange to Wi-Fi anywhere promising. These trends show that offloading through Wi-Fi will growing exponentially. Additionally the Wi-Fi hotspots and mobile users are also continuously increasing data consumption using mobile devices.

- e. **Demand in enterprise networks:** in most of the enterprises and more specifically in IT industries the employees are allowed to bring their own devices. Due to this more devices and new applications are need to facilitate on employee devices with the support of mobility. That helps to increase flexibility to use different devices on work place and also enhances the employee's productivity. Therefore enterprise networks are dealing with huge Wi-Fi traffic and demands of efficient connectivity [Qualcomm Atheros].

### Conclusions

The main aim of the LTE communication is to achieve efficiency in voice and video based applications which are handled in mobility based scenarios. Therefore two specific scenarios are available downlink for base station to device and uplink device to base station. Among both of them the data transfer speed is higher in downlink technique but the uplink technique is suffers from high energy consumption and low data transfer speed. Therefore the following work is concluded to explore more this domain of technology.

1. Comparative study among OFDMA and SC-FDMA: in further work first the implementation of both schemes are performed and then the possibility on improvements in existing approach is proposed.
2. Study of scheduling techniques in UPLINK communication: in addition of that some of the literature refers to work with the scheduling techniques thus need to explore the available techniques of scheduling and possibility to improve the scheduling.
3. Design and implementation of new technique to enhance the uplink data transfer speed and throughput

In near future the proposed future goals are accomplished and their performance outcomes are reported.

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