International Journal of Recent Trends in Engineering & Research
ISSN(ONLINE) : 2455-1457
IMPACT FACTOR : 3.344

REVIEW PAPER ON OPERATIONAL ASSAY OF LTE SYSTEM IN STINT OF OFDMA & SC-FDMA

Rahul Ohlan[1], Kusum Dalal[2]
[1]M.Tech Scholar ECE Department D.C.R.U.S.T Murthal
[2]Assistant Professor, ECE Department D.C.R.U.S.T Murthal

Abstract- This paper presents a vivid view of recent trends and developments in Long Term evolution (LTE) systems. A complete analytic discussion is made on LTE systems based on Orthogonal Frequency Division Multiple Access (OFDMA) with cyclic Prefix (CP) in the downlink and on Single –Carrier Frequency Division Multiple Access (SC-FDMA) in the uplink.
SC-FDMA has the advantage of lower PAPR (Peak to Average power ratio) in comparison of OFDMA. In this paper, we will review historic developments and give some recent survey results on LTE in stint of OFDMA and Single-Carrier FDMA.
Keywords - LTE, SC-FDMA, OFDMA, PAPR.

I. INTRODUCTION

Long Term evolution (LTE) commonly marketed as **4G LTE** is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements [1] [2]. The standard is developed by the 3GPP (3rd Generation Partnership Project) and is specified in its Release 8 document series, with minor enhancements described in Release 9.

LTE is the natural upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks. The different LTE frequencies and bands used in different countries will mean that only multi-band phones will be able to use LTE in all countries where it is supported. Long Term Evolution (LTE) will ensure the competitiveness of UMTS for the next ten years and beyond by providing a high-data rate, low-latency and packet-optimized system. Also known as E-UTRA (Evolved Universal Terrestrial Radio Access), LTE is part of 3GPP Release 8 specifications. LTE can be operated in either frequency division duplex (FDD) or time division duplex (TDD) mode, also referred to as LTE FDD and TD-LTE. The main key technology aspects of LTE are:

1. New, Orthogonal Frequency Division Multiple Access (OFDMA) based multiple access schemes for both LTE FDD and TD-LTE.
2. Scalable bandwidth up to 20 MHz
3. Support for Multiple Input Multiple Output (MIMO) antenna technology.
4. New data and control channels.
5. New network and protocol architecture (two node, IP based)

LTE (3GPP Release 8) supports theoretical peak data rates of 300Mbps in downlink and 75Mbps in uplink direction.

The first commercial network was launched in Sweden in December 2009 whereas meanwhile LTE has become the fastest growing mobile communication technology ever. Commercially available end user devices support max. 100 Mbps(DL)/50Mbps (UL)[3]. Achievable data rates in real life networks varies depending on e.g. network load and propagation conditions and is generally significantly lower than the maximum rates achieved in test lab environment.

Although marketed as a 4G wireless service, LTE (as specified in the 3GPP Release 8 and 9 document series) does not satisfy the technical requirements the 3GPP consortium has adopted for its new LTE Advanced standard. The requirements were originally set forth by the ITU-R organization in its IMT Advanced specification. However, due to marketing pressures and the significant advancements that WiMAX, Evolved HSPA and LTE bring to the original 3G technologies, ITU later decided that LTE together with the aforementioned technologies can be called 4G technologies [4]. The LTE Advanced standard formally satisfies the ITU-R requirements to be considered IMT-Advanced [5]. To differentiate LTE Advanced and WiMAX-Advanced from current 4G technologies, ITU has defined them as "True 4G"[6] [7].

In March 2008, the International Telecommunications Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards, named the International Mobile Telecommunications Advanced (IMT-Advanced) specification, setting peak speed requirements for 4G service at 100 megabits per second (Mbit/s) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbit/s) for low mobility communication (such as pedestrians and stationary users).

Since the first-release versions of Mobile WiMAX and LTE support much less than 1 Gbit/s peak bit rate, they are not fully IMT-Advanced compliant, but are often branded 4G by service providers. According to operators, a generation of the network refers to the deployment of a new non-backward-compatible technology. On December 6, 2010, ITU-R recognized that these two technologies, as well as other beyond-3G technologies that do not fulfill the IMT-Advanced requirements, could nevertheless be considered "4G", provided they represent forerunners to IMT-Advanced compliant versions and "a substantial level of improvement in performance and capabilities with respect to the initial third generation systems now deployed"[8].
Mobile WiMAX Release 2 (also known as Wireless MAN-Advanced or IEEE 802.16m') and LTE Advanced (LTE-A) are IMT-Advanced compliant backwards compatible versions of the above two systems, standardized during the spring 2011, and promising speeds in the order of 1 Gbit/s. Services were expected in 2013.

As opposed to earlier generations, a 4G system does not support traditional circuit-switched telephony service, but all-Internet Protocol (IP) based communication such as IP telephony. The spread spectrum radio technology used in 3G systems is abandoned in all 4G candidate systems and replaced by OFDMA multi-carrier transmission and other frequency-domain equalization (FDE) schemes, making it possible to transfer very high bit rates despite extensive multi-path radio propagation (echoes). The peak bit rate is further improved by smart antenna arrays for multiple-input multiple-output (MIMO) communications.

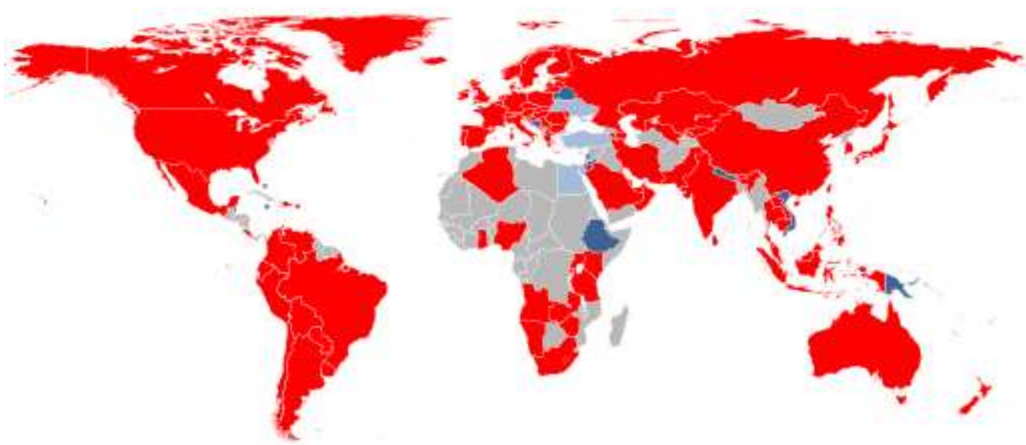


***Figure1.** Adoption of LTE technology as of December 7, 2014*

Adoption of LTE technology as of December 7, 2014 Countries and regions with commercial LTE service Countries and regions with commercial LTE network deployment on-going or planned Countries and regions with LTE trial systems (pre-commitment)

II. PREVIOUS WORK DONE ON LTE

2.1. Muhammad Mokhlesur Rahman, Shalima Binta Manir "Performance Analysis of Sc-FDMA and OFDMA in LTE Frame Structure" - This paper conclude that PAPR characteristics of LTE Frame Structure Type (LTE FDD & LTE TDD) of SC-FDMA and OFDMA. From the result we conclude that, LTE FDD has better performance than LTE TDD. PAPR of SC-FDMA and OFDMA in LTE FDD achieve lower values on average. We see that FDD has a continuous reduction of BER (Bit Error Rate) and it minimizes the BER up to a certain values of SNRs. Comparing the Performance analysis, we can conclude that LTE FDD is the better option than in LTE TDD in uplink Transmission-SC-FDMA and downlink Transmission-OFDMA, because of its higher efficiency due to low PAPR [9].

2.2 Moray Rumney "3GPP LTE: Introducing Single-Carrier FDMA" - This paper concludes that SC-FDMA means "create a single-carrier waveform and shift it to the desired part of the frequency domain." After a careful consideration of the characteristics of OFDMA and the new SC-FDMA, we can conclude that SC-FDMA provides the advantages of OFDMA — especially robust resistance to multipath — without the problem of high PAR. The use of SC-FDMA in LTE, however, is restricted to the uplink because the increased time-domain processing would be a considerable burden on the base station, which has to manage the dynamics of multi-user transmission.

It will be interesting to see if LTE — the latest of the three new OFDMA cellular standards — has indeed identified a superior solution for the uplink or whether the pure OFDMA used in WiMAX or the OFDMA/CDMA combination used in UMB prove to be just as successful when all the factors are taken into account. Today, the experts disagree so we will have to wait on the ultimate arbiter, time, before we find out for sure [10].

2.3. Ixia "SC-FDMA Single Carrier FDMA in LTE" -SC-FDMA offers similar performance and complexity as OFDM. However, the main advantage of SC-FDMA is the low PAPR (peak-average-power ratio) of the transmit signal. PAPR is defined as the ratio of the peak power to average power of the transmit signal. As PAPR is a major concern at the user terminals, low PAPR makes the SC-FDMA the preferred technology for the uplink transmission. PAPR relates to the power amplifier efficiency at the transmitter, and the maximum power efficiency is achieved when the amplifier operates at the saturation point. Lower PAPR allows operation of the power amplifier close to saturation resulting in higher efficiency. With higher PAPR signal, the power amplifier operating point has to be backed off to lower the signal distortion, and thereby lowering amplifier efficiency. As SC-FDMA modulated signal can be improve PAPR [11].

2.4. Monika Sehrawat "*Performance comparison between OFDMA and SC-FDMA*" - This paper conclude that BER is the key parameter for indicating the system performance of any data link. In this paper we analyzed that for different values of SNR, the BER increases for high order modulation in both the multiple access techniques (OFDMA and SC-FDMA) used in next generation system and hence it is easily affected by the noise. BER Performance of SC-FDMA and OFDMA are very similar but a part of them SCFDMA have good performance as compare to the OFDMA [12].

2.5. Murtadha Ali Nsaif Sukar and Maninder Pal"SC-FDMA & OFDMA in LTE physical layer"- This paper provides the introduction to LTE and the key components of its physical layer. These descriptions are simplified version of the detailed descriptions provided by 3gpp. From the discussion, it is observed that OFDMA is used as downlink and SCFDMA as uplink modulation schemes; with OFDM as the basic building block. It presents the description of OFDMA and SCFDMA; along with their Mat lab based simulation results. From the results, it is observed that for a fix value of SNR, the BER increases for high order modulation (16-QAM and 64-QAM) in both the multiple access techniques (OFDMA and SC-FDMA) used in LTE system. On the other hand, the lower order modulation schemes (BPSK and QPSK) experience less BER at receiver; thus lower order modulations improve the system performance in terms of BER and SNR. If the bandwidth efficiency of these modulation schemes is considered, the higher order modulation accommodates more data within a given bandwidth and is more bandwidth efficient as compared to lower order modulation. Thus, there exists a tradeoff between BER and bandwidth efficiency among these modulation schemes used in LTE. It is also concluded from the results that, the error probability increases as order of modulation scheme increases. Therefore, the selection of modulation schemes in adaptive modulation is quite crucial based on these results.

From the simulation results, it can also be noticed that the higher order modulation schemes have an impact on the PAPR of both OFDMA and SC-FDMA. The PAPR increases in SC-FDMA and slightly decreases in OFDMA for higher order modulation schemes. The overall value of PAPR in SC-FDMA is less than that of OFDMA in all modulation schemes, and that is why it has been adopted for uplink transmission in LTE system. Based on the results obtained, it can be concluded to adopt low order modulation scheme i.e. BPSK, QPSK and 16-QAM for uplink in order to have less PAPR at user end. In nutshell, SC-FDMA is more power efficient [13].

2.6. Ghassan A. Abed , Mahamod Ismail and Kasmiran Jumari “A Realistic Model and Simulation Parameters of LTE-Advanced Networks”- This paper provides the full details of the layering, architecture, and the configurations of the traffic model for LTE-Advanced networks. After explaining the development from LTE to LTE-Advanced, the paper focused on the benefits and the key features of it and illustrated how LTE Advanced will become the major cellular system for the users in next decade. The architecture of E-UTRAN and EPC are specified in details with the links interfacing between the different elements of the network. The main contribution of this article is to present and configure the traffic model of LTE-Advanced using NS-2 simulator. One of the new concepts add to LTE-Advanced was the relaying node, where this technique add to the proposed model to support the model and to give it more credibility. Then, the simulation parameters also identified with all links parameters in sides of bandwidth and propagation delay. Lastly, the proposed topology implemented with an animation demonstration using SCTP/TCP protocols to monitor the traffics and the expected loss in packets during simulation scenario. In fact, this paper tried to provide an efficient model of LTE-Advanced to assist the researchers to experiment the developed items of this network over different conditions and situation such as improve the congestion control algorithm for the protocol used or to derive new technique to minimize the handover among base stations[14].

III. TECHNOLOGY USED IN LTE SYSTEM

3.1. Frequency Division Multiple Access (OFDMA) Orthogonal

OFDMA is a multiple access technique which uses Orthogonal Frequency Division multiplexing (OFDM) for each user. In this technique each user is allotted separate channel and available frequency band of that channel is divided into number of orthogonal frequency subcarriers. The high speed serial data from each user is first converted into low speed parallel bit streams with increased symbol duration then it is modulated on each subcarrier using conventional modulation schemes. OFDMA allows achieving high data rate for each user. With little modification to air interface it can be deployed across different frequency bands. OFDMA reduce the effect of multipath fading because data from each user is modulated over several orthogonal frequencies rather than a fixed frequency for entire connection period. In addition, the OFDMA is bandwidth efficient as orthogonal frequency carriers with small spacing is used. All these advantage make it to be used in the downlink transmission of LTE.

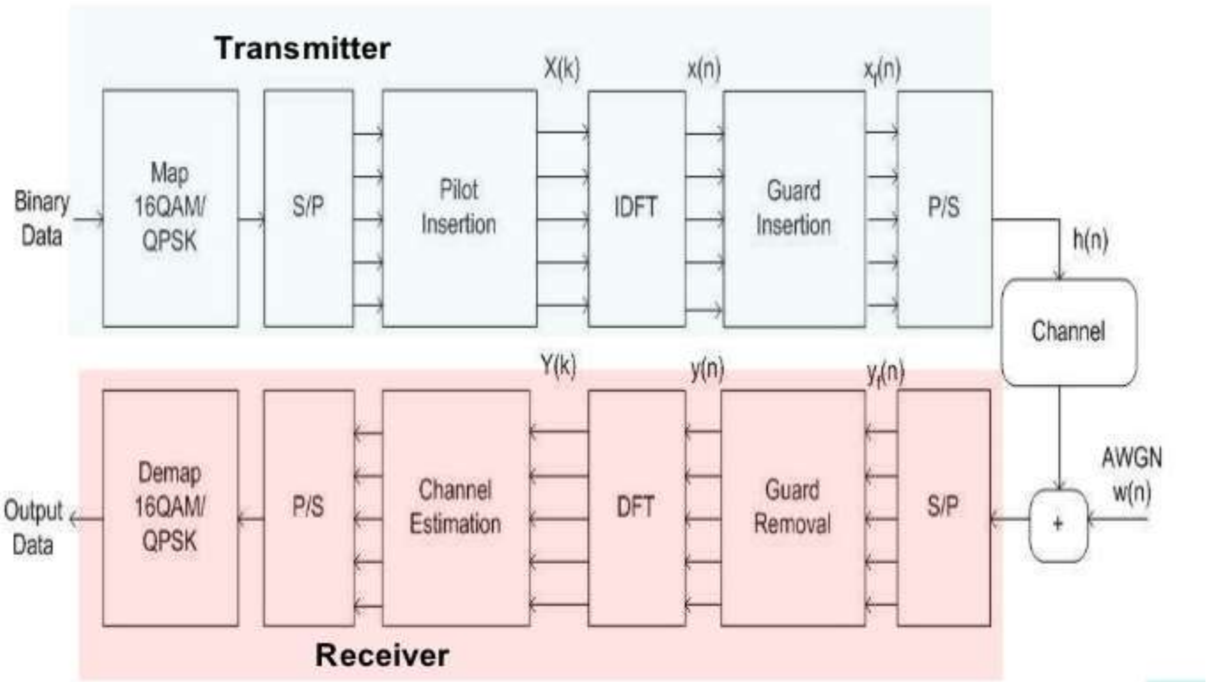
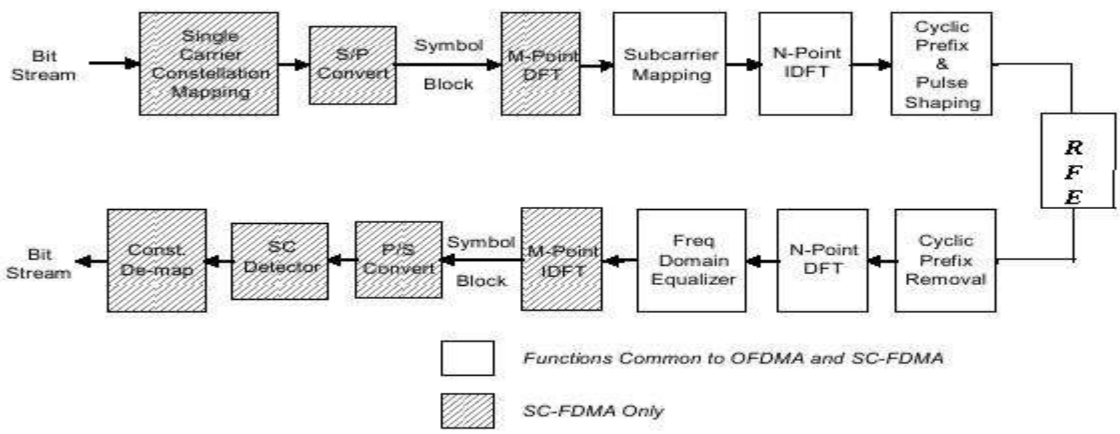


Figure2. OFDM System architecture

3.2. Single carrier Frequency Division Multiple Access (SC-FDMA)

SC-FDMA is a multiple access method. Its structure is same as OFDMA with an addition of Fast Fourier Transform (FFT) block. The parallel data streams are first passed through FFT block then are modulated on subcarriers because of this the SC-FDMA is also called DFT pre-coded OFDM.

The main difference between OFDMA and SC-FDMA is, in OFDMA, each data symbol is carried on a separate subcarrier while, in SC-FDMA, multiple subcarriers carry each data symbol due to mapping of the symbols frequency domain samples to subcarriers. As SC-FDMA is derived from OFDMA it has same basic advantages as OFDMA but the spreading of each data symbol over multiple subcarriers gives it the profound advantage of lower PAPR value as compare to that of OFDMA. Hence PAPR is a useful parameter for uplink it is used in uplink transmission of LTE system [15].



.

Figure3. Block representation of SC-OFDM & OFDMA

IV. PARAMETERS FOR LTE TESTING

4.1. Bit Error Rate (BER)

The BER is ratio of number of error bits and total number of bits transmitted. It is given by the following formula [2].

BER = Number of Error Bits / Total Number of Transmitted Bits

To plot BER performance first we simulated the developed model, calculated BER for different Signal to Noise Ratio (SNR) values using the above formulae and then we plotted these values against corresponding SNR values. The procedure was repeated for different modulation techniques.

4.2. Peak to Average Power Ratio

We calculated PAPR for both OFDMA and SC-FDMA system using the following formula [2].

PAPR = Peak power of transmitted signal / Average power of transmitted signal

Where peak and average power of transmitted signal was calculated by
Peak power of transmitted signal = Maximum (xt * conjugate of xt)
Average power of transmitted signal = Mean (xt * conjugate of xt)
Where x_t represent transmitted signal.
We calculated PAPR only for BPSK modulation scheme.
To plot PAPR we used Complementary Cumulative Distribution Function (CCDF) of calculated PAPR values. The CCDF of PAPR is the probability that the PAPR is higher than a certain PAPR value PAPR0 (Pr {PAPR>PAPR0}).

V. MAJOR CHALLENGES FOR LTE

Spectrum Harmonization- One of the key benefits of GSM networks has been seamless roaming across countries and continents, largely because of harmonized spectrum spanning large parts of the world. LTE infrastructure is being designed to operate in different spectrum bands of different sizes,[16] however, ranging from 1.25MHz to 20MHz. [For LTE max potential data rates, 20MHz FDD contiguous spectrum is required.] To truly support seamless global roaming, harmonized spectrum will be needed—otherwise the burden is shifted to terminals (e.g., handsets or mobile devices) to support multiple frequency bands, which adds time, expense, complexity and inefficiency to the equation [17].

Secure delivery of traffic over LTE networks- Requires dealing with a range of issues:
• Securing the air interface to avoid eavesdropping, sniffing, theft
• Securing the all-IP core network (i.e., the EPC) [18]
• Securing the all-IP devices

Interoperability - A vibrant and robust ecosystem is essential for wide deployment and adoption of LTE. To achieve deployment flexibility and lower operation costs, network operators need a strong infrastructure and device supplier base. At the heart of this lies the interoperability issue: ensuring operators can mix and match equipment from different suppliers in their networks [19].

VI. CONCLUSION

LTE system is the future of the Wireless broadband network. This technology will allow to create Wireless ecosystem which offers to the users more of what they want, which is untethered mobility. In addition LTE will support more of the products and services in use today, because of its backward compatibility to 3GPP networks. LTE is better suited for global adoption than WiMAX tough competitor of LTE. Although 2.5 GHz, 3.5 GHz, and 5.8 GHz [16] bands are allotted in many regions of the world, many growth markets require new allocations to service their populations.

Given the diverse requirements and regulations of various governments, it will be a challenge for WiMAX to achieve global harmonization as of LTE. We conclude that LTE as the technology to deliver the next generation of mobile services and applications to its customers.

VII. FUTURE SCOPE

The next generation of mobile network has a long way to go before it's a reality, but tests and plans are underway to set the terms for such an upgrade. By achieving Low latency means that not only will download and upload speeds be fast, but the response times for starting those data transfers will be similarly snappy .The other benefit relates to the biggest issue with current mobile network standards - a critical lack of bandwidth. The radio frequencies that our 4G networks operate on are overcrowded to say the least. With more and more people and devices set to be connected over the next five years or so to deliver 5G, carriers will need to boost network capacity between phones and the big antennas, called base stations they need to install every few miles. Radio waves vibrate with a frequency measured in megahertz or even faster gigahertz. Today's phones communicate at less than 3GHz; 5G will require higher frequency bands. But radio waves at higher frequencies are harder to transmit over longer distances or if buildings and walls are in the way. To compensate, carriers will rely on advanced antenna technologies.

REFERENCES

1. "An Introduction to LTE". 3GPP LTE Encyclopedia. Retrieved December 3, 2010.
2. "Long Term Evolution (LTE): A Technical Overview" (PDF). Motorola. Retrieved July 3, 2010.
3. S. Sesia, I. Toufik, and M. Baker, "LTE, the UMTS long term evolution: from theory to practice", John Wiley and Sons, 2009.
4. "Newsroom • Press Release". Itu.int. Retrieved 2012-10-28.
5. "ITU-R Confers IMT-Advanced (4G) Status to 3GPP LTE" (Press release). 3GPP. 20 October 2010 Retrieved 18 May 2012.
6. Press info (2009-10-21). "Release: IMT-Advanced (4G) Mobile wireless broadband on the anvil". Itu.int. Retrieved 2012-10-28.
7. "EC makes official recommendation for 790–862 MHz release". 29 October 2009. Retrieved 11March 2012.
8. PJ.G Proakis and M. Salehi, "Digital Communications", Mc Graw Hill International, 5th edition.
9. Muhammad Mokhlesur Rahman, Shalima Binta Manir "Performance Analysis of Sc-FDMA and OFDMA in LTE Frame Structure" International Journal of Computer Applications (0975 – 8887) Volume 45– No.23, May 2012.
10. Moray Rumney "3GPP LTE: Introducing Single-Carrier FDMA" Agilent Technologies, Inc. 5989-7898EN January 2008.
11. "SC-FDMA Single Carrier FDMA in LTE" Ixia November 2009.
12. Monika Sehrawat "Performance comparison between OFDMA and SC-FDMA" IJRECE VOL.3ISSUE 3JULY-SEPT.2015.
13. Murtadha Ali Nsaif Sukar and Maninder Pal"SC-FDMA & OFDMA in LTE physical layer" International Journal of Engineering Trends and Technology (IJETT) – Volume 12 Number 2- Jun 2014.
14. Ghassan A. Abed, Mahamod Ismail and Kasmiran Jumari "A Realistic Model and Simulation Parameters of LTE-Advanced Networks"- International Journal of Advanced Research in Computer and Communication Engineering Vol. 1, Issue 6, August 2012.
15. Hyung G. Myung, Junsung Lim, and David J. Goodman, "SCFDMA for uplink wireless transmission", Polytechnic University.
16. "Europe plans to reserve 800MHz frequency band for LTE and WiMAX". 16 May 2010. Retrieved 11 March 2012.
17. Manish Singh, CTO "LTE-Top 12 Challenges "White paper Radisys, September 2011.
18. Gsma intelligence "CSL begins dual-band 1800/2600 LTE rollout". 7 October 2010.
19. X. Zhang and B. Ottersten, "Performance analysis of V-BLAST structure with channel estimation errors," 4th IEEEWorkshop on Signal Processing Advances in Wireless Commun. SPAWC 2003, pp. 487–491, June 2003