QALAAI ZANIST JOURNAL
A Scientific Quarterly Refereed Journal Issued by Lebanese French University – Erbil – Kurdistan – Iraq
Vol. (2), No. (2), April 2017
Speical Issue : The 1st International Conference on Information Technology (ICoIT'17)
ISSN 2518-6566 (Online) - ISSN 2518-6558 (Print)

DSP for Mobile Wireless LTE System: A Review

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ARTICLE INFO

Article History:

Received: 17 March 2017

Accepted: 1 April 2017

Published: 10 April 2017

DOI:

10.25212/lfu.qzj.2.2.23

Keywords: *LTE, MIMO, OFDM, OFDMA, smart antenna technology, wireless network.*

ABSTRACT

Long term evolution (LTE) is the last step towards the 4G of radio technologies designed to increase the capacity and speed of cellular networks. With the appearing of 4G LTE networks, there has been increasing interests and special attention is paid to the performance and power characteristics as compared with 3G networks. This paper provides detailed information about mobile wireless MIMO-LTE system. It is also presents a brief explanation of the characteristics, performance and state of art techniques used within mobile wireless MIMO-LTE system. There are several types of commercial digital signal processing (DSP) chips available in marks which can be used with MIMO- LTE system. Therefore, this work will be focuses on the applications of commercial DSPs in MIMO-LTE system and taking into consideration types and characteristics where can enables efficient baseband processing for 3G,4G and MIMO-LTE wireless system equipment with its scalable, high-performance architecture.

1. INTRODUCTION.

The new advanced networks always depends on many technological and economic factors such as limited frequency resource availability, the cost and operational conditions of developed radio equipment and optimization process. Efficient analytical techniques are required for planning and analyzing the wireless networks[1]. In regards to the third generation (3G),it has several problems such as, technology is unripe, and resulting there is a big problems still exist from the base station (BS) to the mobile station (MS). The speed of transmission is lowand instability. Speed

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theoretically ranging from 384k / s to 480k / s. But the average speed in practicein download from Internet only about 10K. Network coverage is bad due to the equipment of base station (single station about 2m, 500kg-800kg), therefore, the coverage of large areas will bring significant obstacles. The roaming is not international. For example,the mobile brought to America or Europe, can't use 3G. The most extensive Global roaming in 3G network is WCDMA, including the more developed regions in Europe and America, Australia, etc. It is due to the many disadvantages of 3G, people have come to expect 4G to solve these problems, which can provide higher data rates, greater capacity and bandwidth [2]. LTE system also depends on many factors and is affected by many factors which we spell out in this view. 4G LTE is the newtechnologyin the mobile communicationsof cellular network that Equip us anexcellent speedin data services. 4G technology is the acronym which refers to fourth generation mobile communication technology. 4G LTEenabled us to transmit HD video and big image in addition to other features[3]. Speed transmission theoretically Up to 100 Mbps. The advantage of the bandwidth in 4G network is much higher than the bandwidth of 3G network systems, Where approximately 100 MHz spectrum, That means roughly equal 20 times the W-CDMA 3G networks [4]. LTE can increase capacity by using standard antenna techniques, widespread deployment and reliance on MIMO (Multiple-Input Multiple-Output) antenna techniques[5]. Due to much increased data rates and reduced latencies, LTE is pushing DSP based architectures to the maximum can be. The use of higher order antenna systems are driving algorithmic demands forward at an exponential rate [6].With the other side, using the kind optimal and appropriateof DSP chip in the system will advance the capabilities of wireless broadband equipment, performance and power savings, and other. There are many kinds of DSP chips can be integratedand programmed with our work in LTE MIMO system to get the best results. This is due to any types we'll use, and any types commensurate with the system. In this paper we'll take some of the details about Texas Instruments DSP chip and Controllers TMS320CS6, Qualcomm Snapdragon So Cs 835 and MSC8156 High-Performance Six-Core DSP

1.1 background of LTE.

Mobile communications have a major development over the past years. Theintegration in performance of technologies are rapidly moving toward. Reality ofMobile broadband leads us togrow quicklyin internet generation to having broadband access in everywhere. Estimates show1.8 billion people have broadband since 2012, some two-thirds will be mobile broadband consumers and most of these services offered by HSPA (High Speed Packet Access) and LTE (Long Term Evolution)[7]. The main sign of this project is to improve the Universal Mobile Telecommunications System (UMTS). Scientists are busy in establishing a mobile broadband highwaywith more features that will be that suits and supports the growing demand in the future, like efficiency improvement,enhancement ofall service, reduce costs significantly and better integrationin (technical and performance). In December 1998(Third Generation partnership project) established. The members of 3GPP project are

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ARIB/TTC (Japan), China communication standard association, Telecommunications industry association (North America) and telecommunication technology associate (South Korea). Because of the failure to meet the requirements fully by 3G, The need necessary to build up the fourth generation 4G [8]. It is worth mentioning that MIMO technology as shown in figure 1is the important basics to building LTE technology, where it is characterized by:

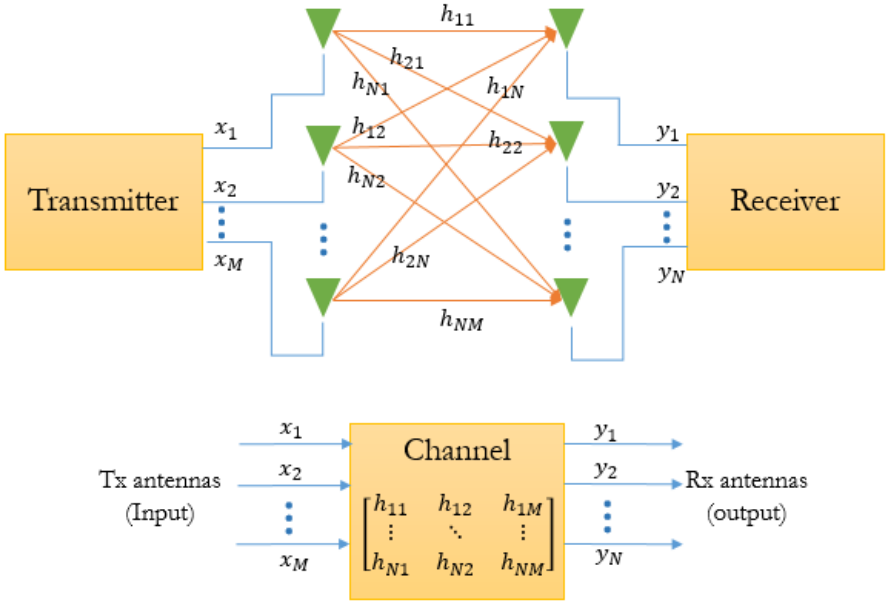

Figure 1: MIMO - Multiple Input Multiple Output [9]

1. Multiple antenna can be used to get rid of the detrimental effects of multi-path.
2. Superior Data Rates.
3. Increases throughput and range [10].

1.2LTE System Upgrade Path.

From the theoretical side, 4G is much faster than 3G. But before we start study the difference between 4G speed and 3G speed, we must know first versions of 4G. When talking about 4G, We will face some confusing things. Basically, there is 4G and 4G LTE. A lot of people seem to think LTE is true 4G technology. Generally, if the 4G network described without mentioning LTE, It most likely talking about a High Speed Packet Access (HSPA) network. A faster version of the 3G GSM network is the HSPA network. But it's not faster than LTE network [4]. LTE offers a major growth in cellular technology and it provides high speed data and media transport as well as high capacity voice support well currently. Actually LTE provides way to develop UMTS network towards fourth generation (4G) mobile networks with today's 2G and 3G networks [11]. Transitional from 3G to 4G it will take a long time, as is the case with 2G to 3G. Whereas, the mobile operators must look for the best and fastest solutionsthat raise the performance and efficiency 3G networks while meeting the requirements of the fourth generation development without upgrading all equipment [12].

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And we can follow the evolution of LTE by embracing GSM (Global System for Mobile Communication), GPRS (General Packet Radio Service) and EDGE (Enhanced Data rates for GSM Environment) as well as WCDMA (Wide Band Code Division Multiple Access) and now HSPA [9]. LTE It is an excellent design to providea very high bandwidth up to several megabits, wherever it is more efficient use of the radio spectrum, reduce latency, and enhancement mobility. The aim of this development that subscriber's interaction significantly with the network with the (increase in demand and the speed of response) for mobile multimedia services. In this,it became possible for subscribers accessreadily to their Internet services, such as online television, video streaming, and interactive gaming, etc. [13]. Figure 2 describes the 3GPP group technical specifications.

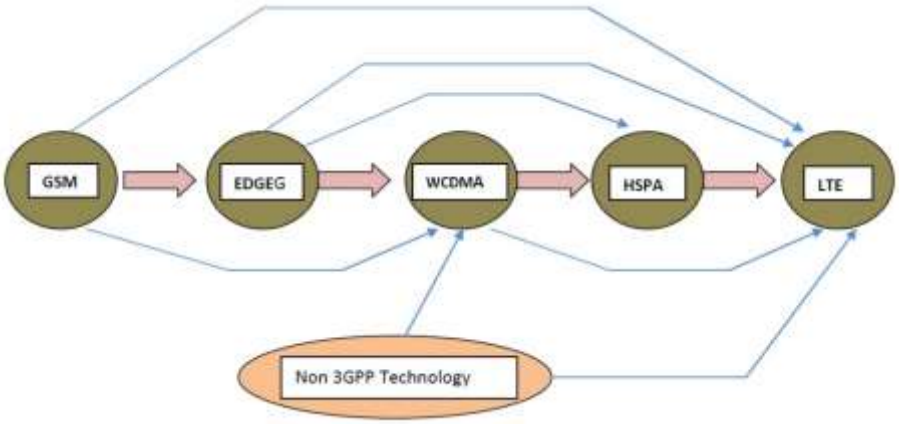

Figure 2: LTE upgrade path. [10]

Table 1: Comparison of 2G, 3G, 3.5G and 4G [11]

G	*Technology*	*Speed*	*Features*
1G	AMPS,NMT, TACS	14.4 Kbps (peak)	This generation is used to transmit voice only
2G	TDMA, CDMA	9.6/14.4 Kbps	In one single channel, allowing multiple users by using multiplexing. also during 2G, the send data are used in phones side by side voice
3G	CDMA 2000 (1xRTT, EVDO) UMTS, EDGE	3.1 Mbps (peak) 500-700 Kbps	In this generation appeared services of multimedia in addition to previous service. Also 3G supports different types of device such as (Telephones, PDA's, etc.)

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3.5G	HSPA	14.4 Mbps (peak) 1-3 Mbps	This generation supports increased throughput, larger than the previous. In order to support the growing needs of subscribers to data.
4G	WiMax LTE	100-300 Mbps (peak)	With fourth generation find high Speed, high definition streaming, higher capacities and higher performance, In addition to the increase of cover spaces.

1.4 LTE System Key Features.

What is the reason for the need to 4G LTE? To answer this question we must be understand several limitations of 3G [4], such as below:

- It is difficult in 3G provide higher data rates due to CDMA technology.
- Multimedia need increase data rate and high bandwidth to meet its requirements.
- Allocation of spectrum is limited.
- Limited coverage due to access methods in 3G.

We can enumerate key features of LTE as follows:

1. Improvement the air interface allows increased data rates: LTE provides greater Enhancement in performance of the system by using (OFDM) and (OFDMA) technology rather than (WCDMA).
2. High Spectral Efficiency: LTE it gives a significant improvement in spectral efficiency and it gives a field to mobile operators to increase number of subscribers within existing spectrum with a detraction cost of delivery [14].
3. Reduced Latency: LTE technology has succeeded in reduces round trip times to 10ms or less, which makes LTE provide more interactive and real time to services[15].
4. Flexible Radio planning: LTE can achieve optimal performance in a cell size of up to 5 km as an effective and successful than performance in cell size of up to 30 km radius but performance is limited in cell sizes up to 100 km radius [16].
5. Scope of Services: smooth seamless service Available in LTE and users can access basic data services Even if they are outside the coverage areas[12].

2. MIMO LTE DSP System Model.

The basic idea of the research is writing LTE system as program and apply it to an efficiently DSP chip, later added noise and work to improve the system to adapts and raise his performance. There are many kinds of DSP chip can be used it in practical model construction, we will take idea to some of it:

A. Texas Instruments DSP chip and Controllers TMS320CS6, as shown in figure 3 :

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Figure 3:Texas Instruments DSP chip and Controllers TMS320CS6 [17]

DSP, DSC Multicore Fixed and Floating.
(Clock Frequency) as Maximum: 1000 MHz, 1200 MHz.
(Memory Size) of Program: 256 kB.
Size of (Data RAM): 6 MB.
(Supply Voltage) in Operating: 900 mV to 1.1 V.
Number of I/O: 16 I/O.

B. Qualcomm Snapdragon SoCs 835, as shown in figure 4 :

Figure 4: Qualcomm Snapdragon SoCs 835 [17]

CPU 4* Kryo 280 performance 2.45GHz.
Memory 2x 32-bit @ 1866MHz 29.9GB/s.
Integrated Modem Snapdragon X16 LTE (Category 16/13) DL = 1000Mbp.

C. MSC8156 High-Performance Six-Core DSP, as shown in figure 5 :

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Figure 5: MSC8156 High-Performance Six-Core DSP [17]

Six Star Core® subsystemswith (DSP) core, each onereach to 1 GHz and 512 KB.cache is unified (L2 /M2) memory.
Two DDR 64-bit,reach to (800 MHz data rate).
Voltage: (1-volt core, 2.5, 1.8/1.5-volt I/O).

D. Texas Instruments (TI) - multi-core DSP architecture, as shown in figure 6:

Figure 6: TMS320C66x (C66x) [17]

TMS320C66x (C66x).
(Clock speeds) is available from (1.0) to (1.25 GHz).
There are additional accelerators for (3G chip-rate) and (4G bit-rate) processing.

2.1 Comparison between DSP Chips

We can clarification some differences between the DSP chips based on CPU core, Clock Frequency, Memory Size, and Supply Voltage as shown in table 1:

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Table 1: Comparison between DSP Chips

	Texas Instruments DSP chip and Controllers TMS320CS6	**Qualcomm Snapdragon SoCs 835**	**MSC8156 High-Performance Six-Core DSP**	**Texas Instruments - multi-core DSP architecture**
CPU Core	Multicore Fixed and Floating	CPU 4* Kryo	Six-Core	up to 8 *cores*
Clock Frequency	1000 - 1200 MHz	1900 – 2400 MHz	800 MHz	1000 – 1250 MHz
Memory Size	256 kB	supports 2 channel LPDDR4X-1866 memory	unified 512 KB L2 cache memory	shared with all cores,memory size 4MB
Supply Voltage	900 mV to 1.1 V	voltage and frequency Varying to reduce power of CPU	1-volt core, 2.5, 1.8/1.5-volt I/O	85 mV - 1.8 V

3Mobile WirelessLTE System over DSP.
DSP Code optimized for memory or speed,or both.We will discuss ways and benefits for optimization for speed. This can be done in many methods and different levels as shown in figure 7:

1-Design level: In highest level, the most appropriate design may be best to benefit the most as possible of the available resources. Selection the efficient algorithms will benefit in the implementation of this design. The architectural design effects on the performance of a system. The choice of algorithm it is the largest impact on the design. So, the first thing that must be done choice the appropriate and most efficient algorithm. A "fully optimized" program it is the most difficult in terms of understanding,thereforemay contain faults larger than small programs [18].

2-Source code level: To improve performance, poor quality coding should be avoiding. After that, some improvement in encoding can be actually reduce maintenance times. Some, but

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not all.Taking into consideration, nowadays improvement compilers can improve the system [19].

3-Build level: Between the compile and source level, directives can affect performance options in a positive way in thecompiler and the sources of codes, such as disables the unneeded codes (software features) by using preprocessor, or improvement for processor models or increasecapabilities of hardware [19].

4-Compile level: Use the best and most efficient compiler leads to ensure that the executable program Instead of the loss of time in the proceedings unnecessary [18].

5-Assembly level: At lowest level, assembly language using in writing codes, designed for a particular hardware platform can be the best and most efficient in several ways. Many operating systems used on embedded systems better to write in the assembler language due to this reason. Programs (What is meant here is not programs that characterized it small) are very rare written from the beginning to end in assembly due to it takes time and increase the cost [18].

6-Run time: Run time optimization can be done by compilers and assembler, In addition to modifying of code by itself as response to increase the efficiency of the system. Some designs of CPU can perform many optimizations at runtime [19].

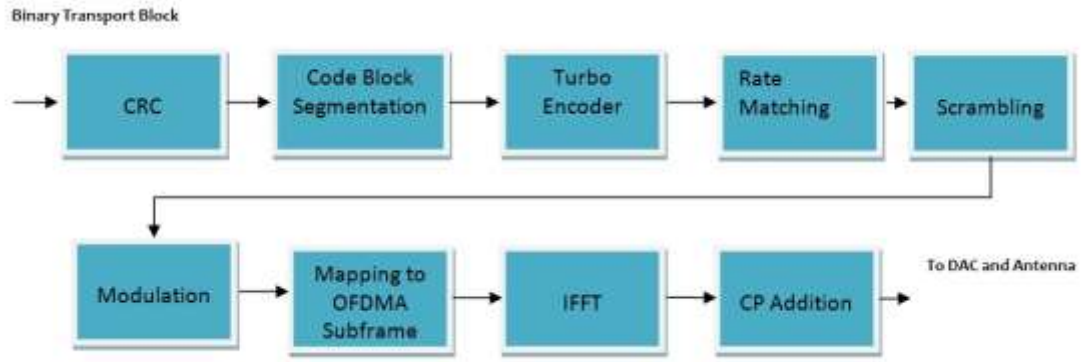

Figure 7: PUSCH (Physical Uplink Shared Channel) [18]

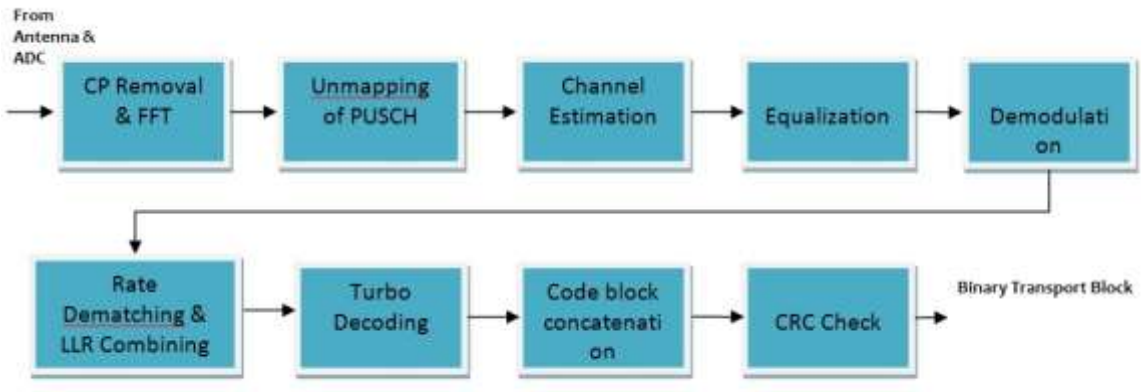

Figure 8: Processing blocks at PUSCH receive[18]

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4 LTE – DSP System Model.

The high performance can be obtained by implement the communication system using DSP chip. This requires several important steps for the new system to be effective and integrated in terms of construction**.** And in order to clarify the new system in a simplified formatas shown in figure 9**.**

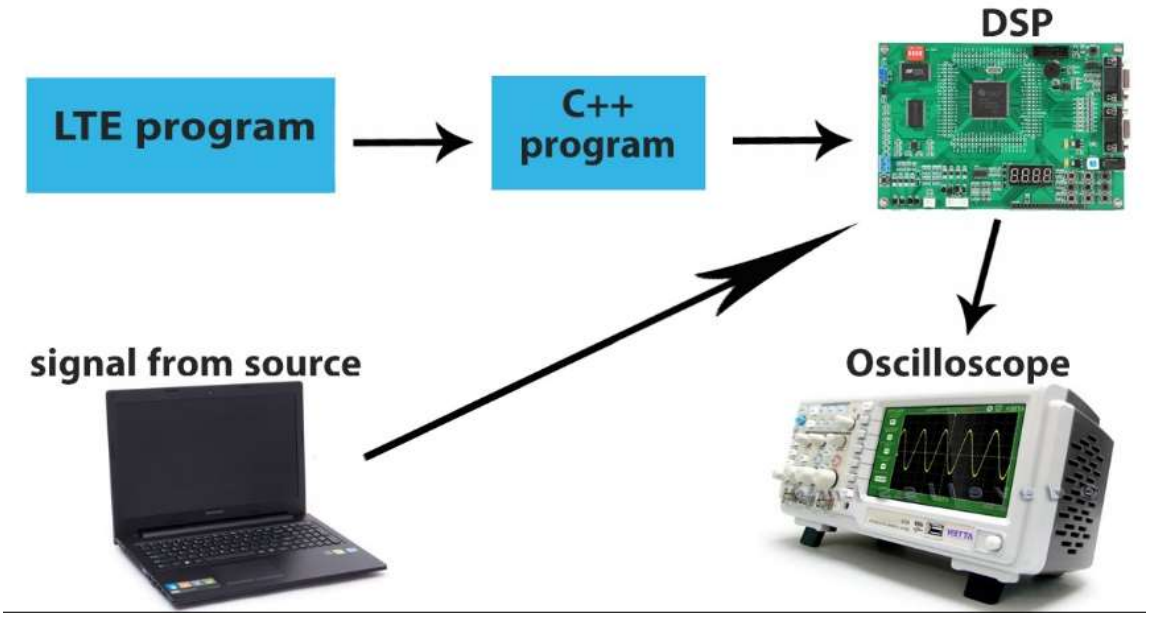

Figure 9: Block Diagram of DSP Model

LTE - DSP System Model consists of several major parts, the most important are: LTE program, it includes a multiple transmitter andreceivers (MIMO), It could be a mathematical as follows:

For MIMO channel model, described by matrix-type equation [20]:

$y(a) = \sum_{a=0}^{A} h(a)x(a - ka)$ (1)

$Y = H*X + n$ (2)

$$H = \begin{Bmatrix} h11 & h12 & h13 \\ h21 & h22 & h23 \\ h31 & h32 & h(d,e) \end{Bmatrix} \quad (3)$$

Where *y* represent the received signal, *H* matrix represent channel, *X*represent transmit signal, *n*represent noise and*h, k* represent the location of the downlink beam from base station (BS) to mobile station (MS), and *a* represent the number of users who connect with the system.And *d*represent subcarrier number, *e*represent transmit antenna number [21].

And the noise can be as:

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n= $\beta_{\eta}^{2} I_{r1}$ (4)

Whereβ_{η}^{2} the variance of additive, and *Ir1* is an identity matrix of the size *r1*.MIMO channel capacity using Shannon's mutualinformation modifying of all input contrast matrices where *BA* isthe bandwidth of the system.And capacity expression becomes:

C= BA log2 det[Iz + $\frac{SNR}{r_2}$ HH^H] (5)

Channel transfer matrixH can be diagonal as:
H = UDV^H (6)
Where*D*= diag($\sqrt{\lambda 1}, \sqrt{\lambda 2}, \sqrt{\lambda 3}, \sqrt{\lambda m}$, ... 0,0)
and*U* and *V* are unitary matrices [4].

The received signal at the downlink for each user a can be represented as the following equation:

Ri,a = $\sqrt{pi}$Fi,aXi,a + $\sum_{j=0}^{C} \sqrt{pj}$Fj, a Xj, a + Na(7)

Where the *j*=0 … *C* , *C* = number of neighboring cell and $j \neq i$, the *pi* , *pj* is the transmit power ofdonor BS and neighboring BSs, also, the *Fi,aFj,a* is the fading channel gain for donor and neighboring cellrespectively and *Na* isAdditive white Gaussian noise(AWGN) for each a- user.

When the massages are sent over channel:

Tm+1= Tm–arrival_time(Tm)(8)
packet_no(Tm+1) = 1 (9)

Where*Tm+1*is the process time of sending massage over channel [22].

The second important part is conversion LTE program to a C++ language with everything contained in the program from equations and algorithms etc. Then insert the converter program to DSP chip after choosing the appropriate type, and this is the third part. Fourth part is the source of signal and noise,which is provided system by Signal, and at the same timeprovides the system by noise for the purposes of the experiment and development. Let it be, for example, a laptop. So we will need to useoscilloscope in final stage to measure the impact ofnoise on the system. And then try to reduce noise effect, which mean that decreasingbit error rate (BER) and increasesignal-to-noise ratio (SNR)tomake the system more receptive and less affected. Where SNR can be a form mathematical as:

SNi,j= $\frac{pi\,|Fi,j|^2}{Na + \sum_{j=0}^{C} pj|Fi,j|^2}$(10)

Where the *SNi,j*is signal to noise ratio [23].

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5Mobile Wireless LTE- MIMO system Applications.

There are a lot of applications and features of LTE MIMO, we can see some of them below:

a.In (Smart Home): LTE MIMO system it will be of high speed network, a send information which does not need for cables, 4G communication allows more Seamless connectivity between people. Based on 4G mobile technology. All things are going to be joined on the Internet, and this is called internet of thinks.[24]

b. In (live TV): 4G way has many advantages, like long distance transmission, easy to use, low in cost of equipment. So television media news that require a direct transfer.Alsousing 4G way will facilitate (power supply conditions) in harsh terrain.

c. In (field of Security): The (network monitoring) has become one of the main things in environment of security. The Monitoring Currently becoming very obvious than the previous, it trending HD. Who is looking for security want to develop cloud storage due to large amount of data generated by security products program, supported large bandwidth and stability of wireless speed are the first important,such as LTE MIMO system. [25]

d. Other Applications: Health care and emergency services has become easier, cheaper and faster with LTE MIMO network, and other important services such as fight against floods, earthquakes, flight and Airports [26].

Conclusion

some new technologies has been added to 4G wireless networks , Thistechnologies makes 4G more efficiency and speed than the 3G network. Covering the world and seamless service are the basic goals of 4G,and it will achieve its goals through the optimal use of spectrum, dynamic and capacity of broadband, etc. Where we can say that a full update for 3G. 4G can use broadband more efficient to improve the(speed of transmission) and the (flow of information) within the time unit, and the (e-commerce). Taking into consideration Concurrent application of digital signal processors (DSP) in wireless base station designs to continue as an effective design approach. This will ensure final products that are not only scalable and cost-effective, but flexible and reconfigurable across multiple evolving standards.

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