IMAGE TRANSMISSSION OVER LTE

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CERTIFICATE

This is to certify that Showkat Ahmad Bhat bearing Registration no. 11612892 have completed objective formulation/Base Paper implementation of the thesis titled, **“**Review on Effective Image Communication Models**”** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of thesis has ever been submitted for any other degree at any university.

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DECLARATION

I, Showkat Ahmad Bhat, student of M. Tech under Department of Electronics and Communication of Lovely Professional University, Punjab, hereby declare that all the information furnished in this Dissertation-I report is based on my own intensive research and is genuine.

This report does not, to the best of our knowledge, contain part of my work which has been submitted for the award of my degree either of this University or any other University without proper citation.

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ABSTRACT

The continuous plan and institutionalization of the fifth generation (5G) new radio (NR) will empower new utilize cases and applications, forcing all the more difficult necessities as far as portability execution. For instance, 5G portable systems should bolster consistent portability with zero information interference at every handover, even at high speeds. This thesis studies about the different techniques used for efficient image transmission over LTE network under different fading channels. By studying different techniques at each stage of image transmission, the intention is to find the optimum techniques which can enhance the implementation of image transmission over LTE system. Image segmentation is first stage in image transmission, in which the image is broken into segments. The second stage is encoding where different codes can be used. Interleaving is the third step where block inter-leaver, chaotic inter-leaver are used. The fourth step is modulation where the interleaved data blocks are modulated with the carrier signal. The modulation schemes like QPSK, BPSK and QAM can be used.

Digital imaging is broadly employed in different field like medical, multimedia, biometric, weather forecasting …etc. in several cases images are to be transmitted to receiver station through wireless communication to perform desired processing of the image. While image acquisition and transmission, there are several factors which degrades the image quality like channel interference, additive noise. Image de-noising method makes an attempt to cut back or eliminate the noise. De-noising could be a difficult process from an image corrupted with additive white Gaussian noise (AWGN). Certain parameters like noise variance and mean are useful to eliminate the noise efficiently from the received image or data. MIMO channels employ multipath propagation offers critical increment in data throughput and range of the communication is increased without any increase in bandwidth requirement and transmit power of signals. MIMO channels provide high data rates which make image transmission possible over LTE network with high unwavering quality. Several image processing and channel coding techniques are used to maintain the quality of the transmitted image from transmitter to receiver. In this paper we analyse the transmission of different kind of digital images over LTE-MIMO channel by using different image and data processing techniques at both transmitter and the receiver side to reconstruct the original image transmitted from transmitter.

LIST OF ABBREVIATIONS

Abbreviation	Full Form
1G	First generation of mobile networks
2G	Second generation of mobile networks
3GPP	Third generation partnership project
4G	Fourth generation of mobile networks
5G	Fifth generation of mobile networks
ACK	Acknowledgment
C-RAN	Cloud-RAN
CA	Carrier aggregation
CN	Core network
CPICH	Common pilot channel
CQI	Channel quality indicator
DL	Downlink
E-RAB	E-UTRAN radio access bearer
E-UTRAN	Evolved UTRAN
eNB / eNodeB	Evolved Node-B
EPC	Evolved packet system core network
GPRS	General Packet radio system
HSPA	High-speed packet access
ID	Identity
ITU	International telecommunication union
KPI	Key performance indicator
LTE	Long term evolution
LTE-A	LTE-Advance
MAC	Medium access control
MIMO	Multiple-input and multiple-output
PDSCH	Physical downlink shared channel
PRACH	Physical random access channel
PS	Packet switched
QoS	Quality of service
RA	Random access
RACH	RA channel
RAN	Radio access network
RX	Receiver
S-GW / SGW	serving gateway
S-Synch	Secondary synchronization signal
UE	User equipment
UL	Uplink
UMTS	Universal mobile telecommunications system
UTRAN	UMTS terrestrial RAN
WCN	Wireless Communication Networks
WLAN	Wireless local area network

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CHAPTER 1
INTRODUCTION

1.1 Motivation

With the late development in the utilization of mobile innovation applications, the popularity in the utilization of voice and information exchange has made an exceptional increment for different solutions for portable broadband administrations. There has been factual increment in the utilization of cell phones for perusing the (web inclining applications and sites, for illustrations, Facebook, and Twitter), video gushing (Russia Today, Al-Jazeera and Cable News Network (CNN) live communicates), Voice-over-Internet Protocol (VoIP) applications for web calls (Mobile VoIP and Skype), therapeutic applications that keep running on constant information logging, video and voice calls and various new applications that has more noteworthy demands for high information activity. The most critical figure included this is the specialist organizations have been attempting to give the requested rates their clients need. Accomplishing a higher information rate with least BER and security represented the greater dialog in taking care of the endorsers' requests.

1.2 Overview

TE remains for LTE and it was begun as a task in 2004 by media transmission by 3GPP. SAE is the relating development of the GPRS/3G bundle center system advancement. The term LTE is normally used to speak to both LTE and SAE. LTE advanced from a before 3GPP framework known as the UMTS, which thus developed from the Global System for Mobile Communications. Indeed, even related determinations were formally known as the advanced UMTS earthbound radio access (E-UTRA) and developed UMTS earthly radio access organize (E-UTRAN). To start with rendition of LTE was archived in Release 8 of the third generation partnership project details [16].

Abrupt increment of mobile information use and development of latest applications, for example, MMOG, versatile TV, Web 2.0, spilling substance have spurred the third Generation Partnership Project (3GPP) to take a shot at the Long-Term Evolution (LTE) in transit towards fourth-age portable. The fundamental objective of LTE is to give a high information rate, low idleness and bundle improved radio-get to innovation supporting adaptable transmission capacity organizations. Same time its system engineering has been composed with the objective to help packet-switching traffic with consistent versatility and extraordinary nature of service. LTE is a high speed wireless communication system for mobile phones and data terminals. Currently LTE networks have raised themselves to HSDPA technology in order to have high data rates and high capacity for downlink packet data. LTE has attained a data rate of about 100Mbps and about 75 Mbps uplink speed by using HSUPA. LTE uses new modulation schemes for downlink and uplink OFDMA and SC-FDMA respectively. MIMO technology is used for transmitter and receiver antennas which has improved the data rate and efficiency of the LTE. The main requirements of the LTE are high data rate, reduced cost, and more services at low cost, spectrum efficiency, throughput latency, flexible bandwidth, mobility and quality of service. OFDMA is not optimum in the uplink transmission. This is due to the lesser PAPR ratio of the OFDMA in uplink. Thus, both FDD and TDD transmission techniques are supported by SC-FDMA scheme. SC-FDMA has good PAPR ratio in uplink. PAPR ratio is very important in the cost effective design UE power amplifiers. There are certain features of OFDMA similar to SC-FDMA signal operations, so different variables of reverse channel and forward channel can be harmonized. Unlike 3G which is based on circuit switching parallel with the packet switching the LTE (4G) is based on the packet switching only. Packet switching is more desirable than the circuit switching [3]. With the introduction of IPv6 LTE provides higher communication speeds, higher capacity and other diverse usage formats that are compatible with other communication systems. IPv6 is important to support number of wireless user equipment's. By using IPv6 the large number of addresses is available which overrules the use of Network Address Translation (NAT), a technique of sharing limited number of IP addresses among large group of UE's.

Performance of network can be improved by using different modulation techniques like QPSK, QAM and BPSK for improving Bit Error Rate (BER) and PAPR (peak amplitude power ratio) and Signal to Noise ratio (SNR). Different channel coding, scheduling algorithms, communication channels and channel access schemes are to be used to provide better resource (bandwidth) utilization, Quality of Services (QOS) and to support multiply services, which can be achieved by using techniques for data transmission at both the transmitter and receiver ends [4]. Those techniques are selected based on the requirements of the system. There are different types of noises which get added with the information signal and produce errors in the data signal. To enhance the reliability of the LTE network, these errors need to be detected and corrected by the network in adverse conditions.

This paper studies about different techniques to determine the various challenges which occur at every step and which techniques can be used to improve the image transmission through LTE communication system. The complete process of image transmission is described step by step. Part 2, proposed image transmission over LTE, section 3, image segmentation techniques, section 4, channel encoding techniques, section 5, the interleaving schemes, section 6, the modulation schemes and section 7, the fading channels [2].

The virtual MIMO (V-MIMO) and facilitated multipoint transmission (CoMP) are embraced by the LTE framework to broaden the uplink ghostly productivity. V-MIMO makes utilization of spatial multiplexing to expand framework throughput while CoMP by methods for moderating entomb cell impedance (ICI) altogether accomplish a similar impact. In this paper, we introduce an orthogonality based corresponding reasonable planning (OPF) plot for virtual MIMO and CoMP in TD-LTE uplink. To assess the viability of the OPF calculation, three plans are broke down and looked at customary single info different yield (SIMO), V-MIMO and CoMP. At long last, we assess and look at the potential pick up in ghostly proficiency for the SIMO, V-MIMO, and CoMP utilizing LTE semi-dynamic framework level test system.

1.2LTE Basic Parameters

Table 1.1 LTE Basic Parameters [5]

Parameters	Description
Frequency range	UMTS FDD bands and TDD bands defined in 36.101(v860) Table 5.5.1, given below
Duplexing	FDD, TDD, half-duplex FDD
Channel coding	Turbo code
Mobility	350 km/h
Channel Bandwidth (MHz)	• 1.4 • 3 • 5 • 10 • 15 • 20
Transmission Bandwidth Configuration NRB :	• 6 • 15 • 25 • 50 • 75 • 100
Modulation Schemes	UL: QPSK, 16QAM, 64QAM(optional) DL: QPSK, 16QAM, 64QAM
Multiple Access Schemes	UL: SC-FDMA (Single Carrier Frequency Division Multiple Access) supports 50Mbps+ (20MHz spectrum) DL: OFDM (Orthogonal Frequency Division Multiple Access) supports 100Mbps+ (20MHz spectrum)
Multi-Antenna Technology	UL: Multi-user collaborative MIMO DL: TxAA, spatial multiplexing, CDD ,max 4x4 array
Peak data rate in LTE	UL: 75Mbps(20MHz bandwidth) DL: 150Mbps(UE Category 4, 2x2 MIMO, 20MHz bandwidth)

	DL: 300Mbps(UE category 5, 4x4 MIMO, 20MHz bandwidth)
MIMO (Multiple Input Multiple Output)	UL: 1 x 2, 1 x 4 DL: 2 x 2, 4 x 2, 4 x 4
Coverage	5 - 100km with slight degradation after 30km
QoS	E2E QOS allowing prioritization of different class of service
Latency	10Ms

1.4 LTE Network Architecture

The architecture of LTE includes three principle segments:

- The User Equipment
- The Evolved UMTS Terrestrial Radio Access Network
- The Evolved Packet Core

The EPC speaks with PDN in the outside world, for instance, the web, private corporate frameworks or the IP sight and sound subsystem. The interfaces between the assorted components of the structure are demonstrated Uu, S1 and SGi as showed up underneath in Fig.1.1

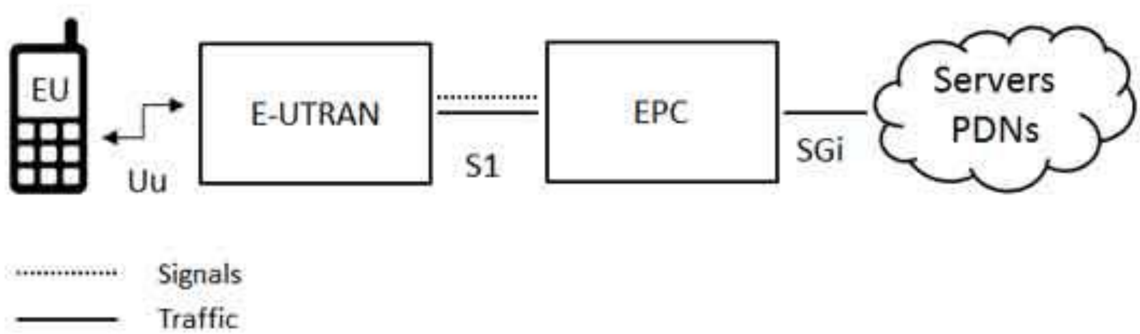


Fig. 1.1 LTE high levels Network architecture [6]

1.4.1 The User Equipment

The inward engineering of the client gear for LTE is indistinguishable to the one utilized by UMTS and GSM which is really a Mobile Equipment. The versatile hardware involved the accompanying critical modules:

- **Mobile Termination:** Controls all the correspondence capacities.
- **Terminal Equipment:** This controls information streams.

- **Universal Integrated Circuit Card:** This is generally called the SIM card for LTE hardware. It runs an application known as the Universal Subscriber Identity Module (USIM).A USIM stores client particular information fundamentally the same as 3G SIM card. This keeps data about the client's telephone number, home system personality and security keys and so on.

1.4.2 The E-UTRAN

The architecture of developed E-UTRAN has been represented beneath in Fig. 1.2:

The E-UTRAN controls the wireless interchanges among the versatile and the developed parcel center and simply consists of segment, the advanced base stations, called eNodeB or eNB. Each eNB is a base station that controls the mobiles in at least one cell. The base station that is speaking with a versatile is called its serving eNB.

LTE Mobile speaks with single eNB and single cell at any given moment and there are two primary capacities bolstered by base station:

- The eBN transmits and gets radio transmissions to every one of the mobiles utilizing the simple and advanced flag preparing elements of the LTE air interface.

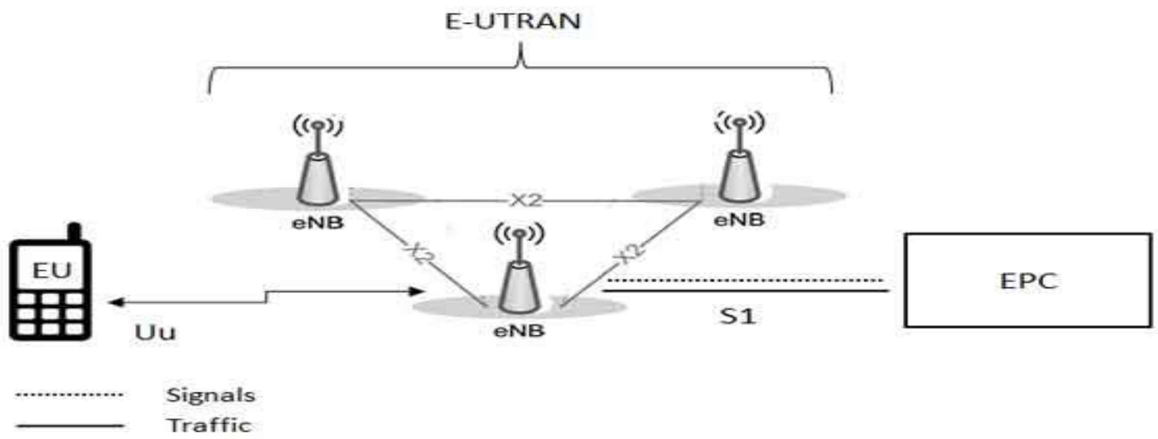


Fig. 1.2 evolved UMTS Terrestrial Radio Access Network [14]

- Every eBN associates with the EPC by methods for the S1 interface and likewise be associated with adjacent base stations by the X2 interface, which is for the most part utilized for flagging and bundle sending amid handover.
- A HeNB is a BTS that a client brings to give femtocell scope inside the home. A home eNB has a place with a shut supporter gathering (CSG) and must be gotten to by mobiles with a USIM that additionally has a place with the shut endorser gathering.

1.3.3 The Evolved Packet Core

The design of Evolved Packet Core has been delineated beneath in Fig. 1.3. There are couples of more parts which have not been appeared in the chart to keep it straightforward. These parts look like the Earthquake and Tsunami Warning System (ETWS), the Equipment Identity Register (EIR) and Policy

Control and Charging Rules Function (PCRF).

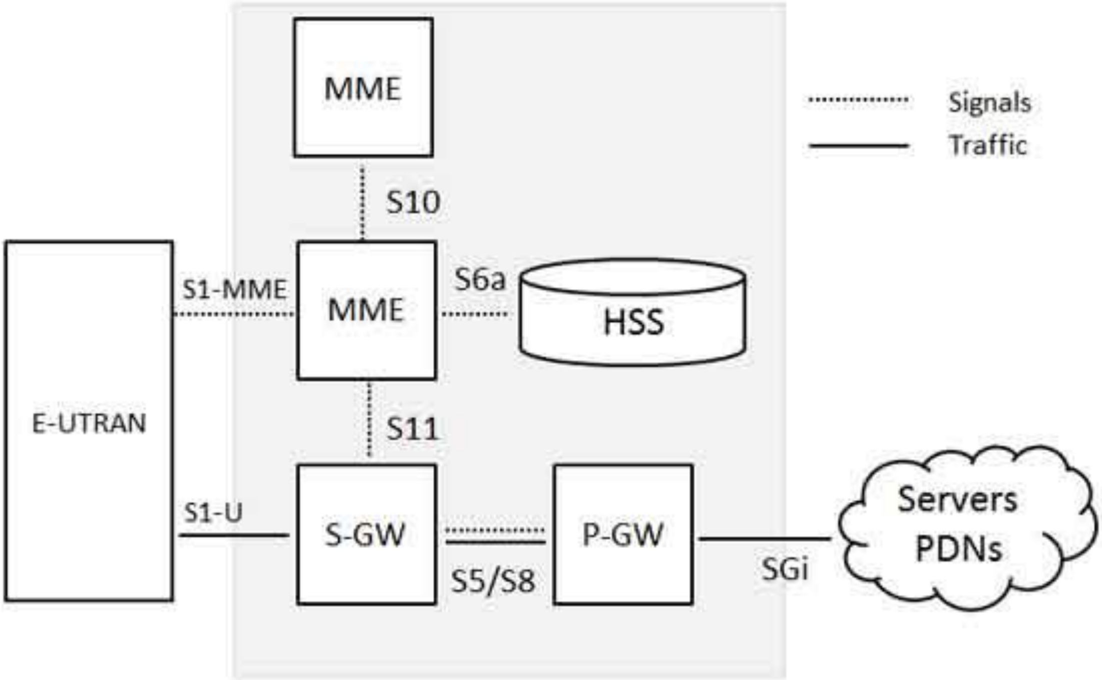


Fig. 1.3 Evolved Packet Core (EPC) [18]

Brief description of each component used in above architecture:

- The HSS segment has been conveyed directed from UMTS and GSM and is a focal database consists of data about every system administrator's endorsers.

- The Packet Data Network Gateway speaks with the external networks i.e., parcel information systems PDN, utilizing SGi interface. Every bundle information organize is distinguished by an entrance APN. The PDN portal has an indistinguishable part from the GGSN and SGSN with UMTS and GSM.

- The serving gateway goes about as a switch and advances information between the base station and the PDN passage.

- The MME controls the abnormal state operation of the versatile by methods for flagging messages and Home Subscriber Server.

- The Policy Control and Charging Rules Function is a part which hasn't appeared in the above chart however it is in charge of arrangement control basic leadership, and also to control the stream based charging functionalities in the Policy Control Enforcement Function (PCEF), which lives in the P-GW.

The interface between the serving and PDN passages is known as S5/S8. This has two marginally unique executions, to be specific S5 if the two gadgets are in a similar system and S8 on the off chance that they are on various systems.

1.3.4 Functional split between the E-UTRAN and the EPC

Following Fig. 1.4 demonstrates the practical split between the E-UTRAN and the EPC for a LTE organize:

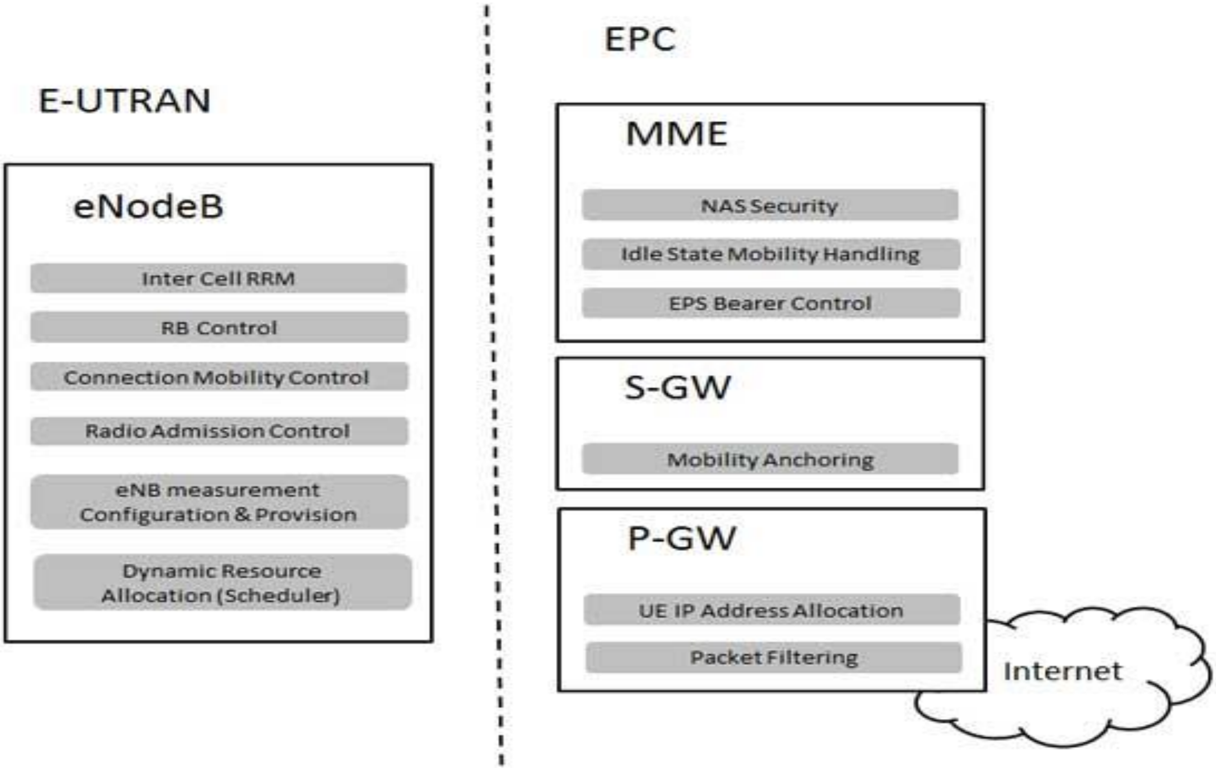


Fig. 1.4 Functional split between the E-UTRAN and the EPC [20]

CHAPTER 2

Review of Literature

2.1 Technology

Clearly, this outweighs all others. The better should win, or would it be a good idea for it too? Shouldn't cost viability matter? In any case, first how about we focus absolutely on innovation. BWA can sensibly be a blend of pre-4G advances, for example, portable WiMax and the primary discharge LTE which have been in discussion after 2006 and 2009 separately and frequently marked as 4G in showcasing material, and 4G advances. Both LTE-Advanced innovation and the IEEE Wireless MAN-Advanced innovation make utilization of same key advances viz. OFDMA, MIMO and SAE. WiMAX and LTE group of advances are talked about in the accompanying sections [Dahlman, E. et al.[17]; Nuaymi, L.,].

LTE has been created to offer both FDD and TDD modes, empowering TD-SCDMA systems to likewise make a smooth change to TDD LTE. In reality, a joined FDD and TDD LTE sending is relied upon to pick up a wide a dependable balance in many markets [Dahlman, E [17].; C Lim T. Yoo et. Al.[19]].

This paper considers the transmission of picture transmission over WiMAX systems under various blurring channels. The goal is deciding the ideal procedure in each transmission organize that can be utilized for getting the ideal execution of the picture transmission process. The outcomes are assessed as far as Bit Error Rate, and Peak Signal to Noise Ratio for different estimations of Signal to Noise Ratio Kasban, H., [2].

In this paper, they have assessed the noteworthy research commitment distributed in most recent 5 years related with remote picture transmission, channel coding system, and examined the size of adequacy in the strategies in light of points of interest and impediments Gururaj, Bharathi.et. al.[3].

This paper presents information uprightness assurance and created committed apparatuses of substance insurance and secure piece stream transmission for therapeutic encoded picture purposes. Specifically, the LAR picture coding strategy is characterized together with cutting edge security administrations Babel, Marie, et al. [4].

This paper researches the execution of picture transmission with unequal mistake assurance (UEP) plans in view of sporadic Low-Density Parity-Check (LDPC) codes. Right off the bat, the UEP is accomplished by mapping diverse bits of the picture bytes to various places of LDPC codes Zhang, Yuling, Xia Li, et. Al.[5].

LTE was proposed in 2004 Toronto gathering to satisfy the prerequisite of accomplishing higher speed and lower parcels idleness in UMTS 3G frameworks. LTE which is condensed as long-haul development is an essentially a transmission method of giving the correspondence channel/correspondence interface between the versatile compact gadget's associated with each other to build up the association between the two. LTE is made out of numerous new advancements thought about with the past age of cell frameworks. These new innovations are utilized to create more effective with respect to range and higher information rates not surprisingly by originators Feng, Daquan, et al. [6].

Table 2.1 LTE Evolution [26]

Year	Event
Mar 2000	Release 99 - UMTS/WCDMA
Mar 2002	Release 5 – HSDPA
March 2005	Release 6 – HSUPA
March 2006	Release 7 - DL MIMO, IMS (IPMS)
November 2004	Work started on LTE specification
January 2008	Spec finalized and approved with Release 8
2010	Targeted first deployment

CHAPTER 3

OBJECTIVES OF RESEARCH

1. To analyse and compare about the different techniques used for efficient image transmission over LTE network under different fading channels.
2. Implementation of effective Image transmission over LTE for Noise effect analysis on diverse Image data set.
3. Implementation and comparison of efficient channel model and security with previous results for performance improvement of digital image transmission over LTE.

CHAPTER 4

LTE-Enabling Technologies

The empowering advancements of LTE and the recent development incorporate the OFDM, MIMO, turbo coding, and dynamic connection adjustment strategies. As examined in the last segment, these advances follow their birthplaces to entrenched territories of research in interchanges and together help add to the capacity of the LTE standard to meet its necessities.

4.1 OFDM

As carefully depicted in Reference [27], the primary case LTE chooses OFDM and its single-bearer partner SC-FDM as the basic communication plans incorporate the accompanying: heartiness to the multipath blurring channel, high otherworldly productivity, low-multifaceted nature usage, and the capacity to give adaptable transmission transfer speeds and bolster propelled highlights, for example, recurrence particular planning, MIMO transmission, and impedance coordination. OFDM is a multicarrier transmission conspires. The primary thought behind it is to subdivide the data transmitted on a wideband divert in the recurrence area and to adjust information images to various narrowband orthogonal sub-channels known as subcarriers. At the point when the recurrence separating between subcarriers is adequately little, an OFDM transmission plan can speak to a recurrence specific blurring channel as an accumulation of narrowband level blurring sub-channels [29]. This thusly empowers OFDM to give an instinctive and basic method for assessing the channel recurrence reaction in view of transmitting known information or reference signals. With a decent gauge of the channel reaction at the beneficiary, we would then be able to recoup the best gauge of the transmitted flag utilizing a low-many-sided quality recurrence space equalizer. The equalizer it could be said rearranges the channel recurrence reaction at each subcarrier.

4.2 *SC-FDM*

Multicarrier is the extensive varieties in the immediate transmit control among the downsides of OFDM. That suggests a diminished productivity in control enhancers and causes increase in versatile terminal power utilization. In uplink transmission, the outline of complex power amplifiers is particularly testing. Thus, enhanced version of the OFDM transmission i.e. SC-FDM is used in the LTE standard for UL. SC-FDM is actualized by consolidating a consistent OFDM framework with a pre-coding in light of DFT [27]. By employing a DFT-based pre-coding, SC-FDM considerably lessens vacillations of the transmit control. The subsequent uplink transmission plan can, in any case, include the vast majority of the advantages related with OFDM, for example, low-intricacy recurrence space evening out and recurrence area planning, with less stringent necessities on the power enhancer outline [29].

4.3 MIMO

MIMO is one of the important advancements conveyed in the Long Term Evolution norms. With profound base in portable correspondences look into, MIMO methods convey to hold up under the benefits of utilizing various radio wires keeping in mind the end goal to provide the driven necessities of the Long Term Evolution standard as far as pinnacle information rates and throughput. MIMO strategies can enhance versatile correspondence in two diverse routes: by increasing the general information rates and expanding the unwavering quality of correspondence interface [12]. MIMO calculations utilized as a part of the LTE standard can be separated into four general classifications: get decent variety, transmit assorted variety, shaft framing, and the spatial multiplexing. In transmit assorted variety and shaft framing; we send excess data on various radio wires. In that capacity, these strategies don't add to any lift in the achievable information rates yet rather influence the correspondences to interface more powerful. In spatial multiplexing, in any case, the framework transmits free (non-repetitive) data on various reception apparatuses. This sort of MIMO plan can significantly help the information rate of a given connection. The degree to which information rates can be enhanced might be straightly corresponding to the quantity of transmitting reception apparatuses. With a specific end goal to oblige that, LTE technology gives numerous transmit designs of up to four antennas at transmitter in its downlink. The LTE-A allows the utilization of up to eight transmit-receiving antennas for DL [25].

4.4 Turbo Channel Coding

Turbo encoding is a development of the convolutional encoding innovation utilized as a part of every single past standard with great close channel limit execution [28]. Turbo coding was very first time presented in 1993 and has been mentioned in 3G UMTS and HSPA frameworks. Be that as it may, in these norms it was utilized as a discretionary method for increasing the execution of the framework. In the LTE standard also, turbo coding forms the main channel coding component employed to compute the client information. The close ideal execution of turbo coders is all around archived, similar to the computational multifaceted nature related to their usage. The LTE turbo coders accompany numerous enhancements, went for making them more proficient in their execution. For instance, by affixing a CRC detecting disorder to the contribution of the turbo encoder, LTE turbo decoders can exploit an early end component if the nature of the code is considered satisfactory. Rather than finishing a settled number of disentangling emphases, the unraveling can be ceased early when the CRC check detects that no mistakes are recognized. This extremely straightforward arrangement permits the computational multifaceted nature of the LTE turbo decoders to be diminished without seriously punishing their execution.

4.5 Link Adaptation

Link adaptation is characterized as an accumulation of methods for varying and adjusting the transmission parameters of a portable correspondence framework to effective react to the robust idea of the correspondence channel. Contingent upon the channel health quality, we can utilize diverse balance and coding systems (versatile tweak and coding), change the quantity of transmitting or get reception apparatuses (versatile MIMO) and even change the transmission transfer speed (versatile data transfer capacity). Firmly identified with connecting adjustment is direct reliant planning for a versatile correspondence framework. Planning manages the topic of how to share the radio assets between various clients keeping in mind the end goal to accomplish more effective asset usages. Commonly, we have to either limit the measure of assets designated to every client or match the assets to the sort and need of the client information. Channel-subordinate planning intends to suit however many clients as could be expected under the circumstances while fulfilling the best nature of-benefit prerequisites that may exist in view of the quick channel condition [29].

CHAPTER 5

LTE Physical Layer Modeling

In this thesis, discussion is only concentrated on computerized flag preparing in the physical layer of the Radio Access systems. No talk of the LTE center systems is available here, and we will leave the discourse of higher-layer handling, for example, Radio Resource Control (RRC), Radio Link Control (RLC), and Medium Access Control (MAC) to another event. Physical layer demonstrating includes all the handling performed on bits of information that are passed on from the higher layers to the PHY. It depicts how different transport channels are mapped to physical channels, how flag preparing is performed on each of these channels, and how information is eventually transported to the receiving wire for transmission. For instance, Figure 1.2 [29] shows the PHY demonstrate for the LTE downlink transmission. In the first place, the information is multiplexed and encoded in a stage known as Downlink Shared Channel preparing (DLSCH). The DLSCH handling chain includes appending a CRC code for blunder discovery, sectioning the information into little lumps known as sub-pieces, undertaking station coding operations in view of turbo coding for the client information, completing a rate-coordinating operation that chooses the quantity of yield bits to mirror a coveted coding rate, lastly remaking the code-hinders into code words. The following period of preparing is known as physical downlink shared channel handling. In this stage, the code words initially wind up plainly subject to a scrambling operation and after that experience a regulation mapping those outcomes in a balanced image stream.

The following stage contains the LTE MIMO or multi-receiving wire handling, in which a solitary stream of tweaked images is subdivided into different sub-streams bound for transmission by means of various radio wires. The MIMO operations can be viewed as a blend of two stages: precoding and layer mapping. Precoding scales and sorts of images assigned to each substream and layer mapping chooses and courses information into each substream to execute one of the nine distinctive MIMO modes determined for downlink transmission. Among the accessible MIMO strategies actualized in downlink transmission are transmit decent variety, spatial multiplexing, and beamforming. The last advance in the handling bind identifies with the multicarrier transmission. In downlink, the multicarrier operations depend on the OFDM transmission conspire [26]. The OFDM transmission includes two stages. To start with, the asset component mapping composes the balanced images of each layer inside a time–recurrence asset matrix. On the recurrence hub of the network, the information is lined up with subcarriers in the recurrence area. In the OFDM flag age step, a progression of OFDM images is produced by applying reverse Fourier change to process the transmitted information in time and is transported to every radio wire for transmission. As I would see it, it is exceptional that such a clear and natural transmission structure can consolidate all the empowering innovations so successfully that they meet the various and stringent IMT-Advanced necessities set out for the LTE institutionalization. By concentrating on PHY demonstrating, we mean to address challenges in understanding the advancement of the computerized flag preparing related with the LTE standard.

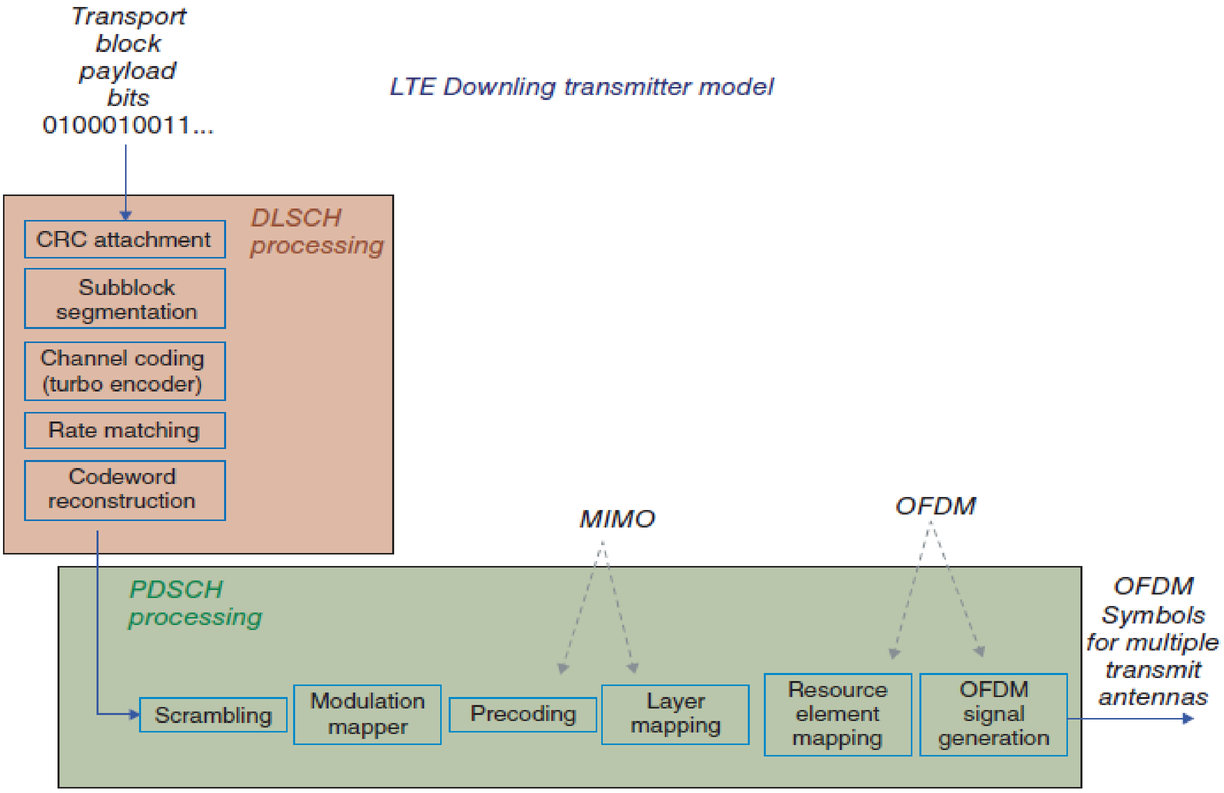


Fig. 3.1 Physical layer specifications in LTE [27]

5.1 Air Interface

The LTE air interface depends on OFDM (Orthogonal Frequency Division Multiplexing) numerous entrance innovations in the downlink and a firmly related innovation known as Single-Carrier Frequency Division Multiplexing (SC-FDM) in the uplink. The utilization of OFDM gives critical focal points over option different access advances and flags a sharp takeoff from the past. Among the points of interest are high unearthly effectiveness and flexibility for broadband information transmission, protection from intersymbol obstruction caused by multipath blurring, a characteristic help for MIMO (Multiple Input Multiple Output) plans, and support for recurrence space strategies, for example, recurrence specific booking [1]. The time– recurrence portrayal of OFDM is intended to give abnormal amounts of adaptability in apportioning both spectra and the time allotments for transmission. The range adaptability in LTE gives an assortment of recurrence groups as well as a versatile arrangement of data transmissions. LTE likewise gives a short casing size of 10ms to limit dormancy. By indicating short edge sizes, LTE permits better channel estimation to be performed in the versatile, permitting auspicious inputs vital for connecting adjustments to be given to the base station. Some propelled types of transmission multiplexing join recurrence and time division approaches like OFDM or CDMA. It is typically utilized with a radio transmitter or radio recipient.

5.2 Frequency Bands

The LTE gauges indicate the accessible radio spectra in various recurrence groups. One of the objectives of the LTE benchmarks is consistent joining with past portable frameworks. In that capacity, the recurrence groups effectively characterized for past 3GPP gauges are accessible for LTE sending. Notwithstanding these normal groups, a couple of new recurrence groups are likewise presented without precedent for the LTE detail. The controls overseeing these recurrence groups change between various nations. Thusly, it is possible that not only one but rather a significant number of the recurrence groups could be sent by any given specialist organization to make the worldwide meandering instrument substantially simpler to oversee. Discharge 11 of the 3GPP details for LTE demonstrates the far-reaching rundown of ITU IMT Advanced (International Telecommunications Union International Mobile Telecommunication) recurrence groups [28]. It incorporates 25 recurrence groups for FDD and 11 for TDD. As appeared in Table 4.1, the combined groups utilized as a part of FDD duplex mode are numbered from 1 to 25; the unpaired groups utilized as a part of TDD mode are numbered from 33 to 43, as represented in Table 4.2 The band number 6 isn't pertinent to LTE and groups 15 and 16 are devoted to ITU Region 1 [15].

Table 4.1 Paired frequency bands defined for E-UTRA [14]

Operating Band Index	Uplink (UL) operating band frequency range(MHz)	Downlink (DL) Operating band frequency range(MHz)	Duplex Mode
1	1920–1980	2110–2170	FDD
2	1850-1910	1930-1990	FDD
3	1710-1785	1805-1880	FDD
4	1710-1755	2110-2155	FDD
5	824-849	869-894	FDD
6	830-840	875-885	FDD
7	2500-2570	2620-2690	FDD
8	880-915	925-960	FDD
9	1749.9–1784.9	1844.9–1879.9	FDD
10	1710–1770	2110–2170	FDD
11	1427.9–1447.9	1475.9–1495.9	FDD
12	699–716	729–746	FDD
13	777–787	746–756	FDD
14	788–798	758–768	FDD
15	Reserved	Reserved	FDD
16	Reserved	Reserved	FDD
17	704–716	734–746	FDD

18	815–830	860–875	FDD
19	830–845	875–890	FDD
20	832–862	791–821	FDD
21	1447.9–1462.9	1495.9–1510.9	FDD
22	3410–3490	3510–3590	FDD
23	2000–2020	2180–2200	FDD
24	1626.5–1660.5	1525–1559	FDD
25	1850–1915	1930–1995	FDD

Table 4.2 Unpaired frequency bands [14]

Operating band index	UL and DL operating band freq. range (MHZ)	Duplex Mode
33	1900-2000	TDD
34	2010–2025	TDD
35	1850–1910	TDD
36	1930–1990	TDD
37	1910–1930	TDD
38	2570–2620	TDD
39	1880–1920	TDD
40	2300–2400	TDD
41	2496–2690	TDD
42	3400–3600	TDD
43	3600–3800	TDD

5.3 Bandwidth Allocation

The IMT-Advanced rules needs range adaptability in LTE standard. That prompts versatility in the recurrence space, which is showed by a rundown of range portions running from 1.4 to 20MHz. The recurrence spectra in LTE are framed as links of asset squares comprising of 12 subcarriers. Since subcarriers are isolated by 15 kHz, the aggregate transfer speed of an asset square is 180 kHz. This empowers transmission transfer speed arrangements of from 6 to 110 asset obstructs over a solitary recurrence transporter, that clarifies how the multicarrier transmission character of the LTE standard takes into account channel data transmissions going from 1.4 to 20.0MHz in ventures of 180 kHz, enabling the required range adaptability to be accomplished. Table 4.3 shows the connection between the channel data transmission and the power transmitted over an LTE RF bearer. For transfer speeds of 3– 20 MHz, the totality of asset hinders in the transmission data transfer capacity involves around 90% of the channel transmission capacity. On account of 1.4 kHz, the rate drops to around 77%. This diminishes undesirable emanations outside the data transfer capacity, as delineated in Figure 2.1. A formal meaning of the time– recurrence portrayal of the range, the asset network, and the pieces will be displayed in a matter of seconds.

Table 4.3 Channel bandwidths specified in LTE [9]

Channel Bandwidth (MHz)	Number of Resource Blocks
1.4	6
3	15
5	25
10	50
15	75
20	100

5.4 OFDM Multicarrier Transmission

Orthogonal Frequency Division Multiplexing (OFDM) is a computerized multi-bearer balance plot that broadens the idea of single subcarrier balance by utilizing various subcarriers inside a similar single channel. As opposed to transmitting a high-rate stream of information with a solitary subcarrier, OFDM makes utilization of an expansive number of firmly dispersed orthogonal subcarriers that are transmitted in parallel. Each subcarrier is tweaked with a regular computerized balance plot, (for example, QPSK, 16QAM, and so on.) at low image rate. Nonetheless, the blend of numerous subcarriers empowers information rates like customary single-transporter balance plots inside equal transmission capacities.

OFDM depends on the outstanding procedure of Frequency Division Multiplexing (FDM). In FDM diverse surges of data are mapped onto isolate parallel recurrence channels. Each FDM channel is isolated from the others by a recurrence watch band to decrease impedance between neighboring channels.

The OFDM conspire varies from conventional FDM in the accompanying interrelated ways:

1. Multiple transporters (called subcarriers) convey the data stream,

2. The subcarriers are orthogonal to each other, and

3. A watch interim is added to every image to limit the channel postpone spread and intersymbol impedance.

Under the LTE standard, the DL transmission depends on OFDM plot and the UL transmission depends on a firmly related philosophy called SC-FDM. OFDM is a multicarrier transmission approach which speaks to the broadband transmission transfer speed as an accumulation of numerous narrowband sub-channels [12]. There are numerous means engaged with OFDM flag age. To begin with, regulated information is mapped on to the asset framework, where they are sorted out and adjusted in the recurrence space. Each balanced image ak is doled out to a solitary subcarrier on the recurrence hub. Having N subcarriers possessing the data transfer capacity with a subcarrier dispersing of Δf, the connection between the transmission capacity and subcarrier dividing is given by:

$$BW = N_{rt}\Delta f \quad (1)$$

Every f_k subcarrier is viewed as a whole number numerous of subcarrier dividing:

$$fk = k\Delta f \quad (2)$$

The OFDM modulator includes a bank of N complex modulators, where each modulator identifies with a singular subcarrier. The OFDM adjusted yield x(t) is in this way conveyed

as: $x(t) = \sum_{k=1}^{N} a_k \, e^{j2\pi f_k t} = \sum_{k=1}^{N} a_k \, e^{j2\pi k \Delta f t}$ (3)

Expecting that the channel test rate is Fs and the channel test time is Ts=1/Fs, the discrete-time depiction of the OFDM modulator can be conveyed as:

$$x(n) = \sum_{k=1}^{N} a_k \, e^{j2\pi k \Delta f n / N} \quad (4)$$

The OFDM take weak itself normally to an effective usage in light of Inverse Fast Fourier Transform. After the OFDM modulation, an OFDM image is created and a cyclic prefix is attached to the tweaked flag. Addition of a cyclic prefix is basically replicating of the last piece of the OFDM image to its start.

CHAPTER 6

Review on Effective Image Communication Models

Abstract: This paper studies about the different techniques used for efficient image transmission over LTE network under different fading channels. By studying different techniques at each stage of image transmission, the intention is to find the optimum techniques which can enhance the implementation of image transmission over LTE system. Image segmentation is first stage in image transmission, in which the image is broken into segments. The second stage is encoding where different codes can be used. Interleaving is the third step where block inter-leaver, chaotic inter-leaver are used. The fourth step is modulation where the interleaved data blocks are modulated with the carrier signal. The modulation schemes like QPSK, BPSK and QAM can be used.

Keywords: Image Segmentation, Encoding, Interleaving, Modulation, Fading channels.

6.1 Introduction

LTE is a high speed wireless communication system for mobile phones and data terminals. Currently LTE networks have raised themselves to HSDPA technology in order to have high data rates and high capacity for downlink packet data. LTE has attained a data rate of about 100Mbps and about 75 Mbps uplink speed by using HSUPA. LTE uses new modulation schemes for downlink and uplink OFDMA and SC-FDMA respectively. MIMO technology is used for transmitter and receiver antennas which has improved the data rate and efficiency of the LTE. The main requirements of the LTE are high data rate, reduced cost, and more services at low cost, spectrum efficiency, throughput latency, flexible bandwidth, mobility and quality of service. OFDMA is not optimum in the uplink transmission. This is due to the lesser PAPR ratio of the OFDMA in uplink. Thus, both FDD and TDD transmission techniques are supported by SC-FDMA scheme. SC-FDMA has good PAPR ratio in uplink. PAPR ratio is very important in the cost effective design UE power amplifiers. There are certain features of OFDMA similar to SC-FDMA signal operations, so different variables of reverse channel and forward channel can be harmonized. Unlike 3G which is based on circuit switching parallel with the packet switching the LTE (4G) is based on the packet switching only. Packet switching is more desirable than the circuit switching. With the introduction of IPv6 LTE provides higher communication speeds, higher capacity and other diverse usage formats that are compatible with other communication systems. IPv6 is important to support number of wireless user equipment's. By using IPv6 the large number of addresses is available which overrules the use of Network Address Translation (NAT), a technique of sharing limited number of IP addresses among large group of UE's.

Performance of network can be improved by using different modulation techniques like QPSK, QAM and BPSK for improving Bit Error Rate (BER) and PAPR (peak amplitude power ratio) and Signal to

Noise ratio (SNR). Different channel coding, scheduling algorithms, communication channels and channel access schemes are to be used to provide better resource (bandwidth) utilization, Quality of Services (QOS) and to support multiply services, which can be achieved by using techniques for data transmission at both the transmitter and receiver ends. Those techniques are selected based on the requirements of the system. There are different types of noises which get added with the information signal and produce errors in the data signal. To enhance the reliability of the LTE network, these errors need to be detected and corrected by the network in adverse conditions.

This paper studies about different techniques to determine the various challenges which occur at every step and which techniques can be used to improve the image transmission through LTE communication system. The complete process of image transmission is described step by step. Part 2, proposed image transmission over LTE, section 3, image segmentation techniques, section 4, channel encoding techniques, section 5, the interleaving schemes, section 6, the modulation schemes and section 7, the fading channels [2].

6.2 Image Transmission over LTE

The processing of image transmission over LTE network is explained by the different stages of the block diagram shown in fig. 5.1 In first step the image is broken into the small data packets by various schemes and then various encoding scheme is applied. Encoding is followed by interleaving process and then different modulation techniques are applied to the encoded data. To transmit data IFFT (Inverse Fast Fourier Transform) is carried out to convert data signal from data domain into frequency domain. And finally is transmitted from the communication channel. At the receiver inverse process as that of transmitter are carried out to receive the original transmitted data. Quality of image is evaluated by measuring the SNR and PSNR. The different transmission stages are studied with details in following section [1].

6.3 Image Segmentation

For converting the image into digital form, image is broken into number of small data packets called pixel sets. Image segmentation change the representation of image to some different form which is easier to analyses and do some processing. In this process, the curves, lines and boundaries of the images are determined. The pixel sets taken from the original image is able to represent the whole image. Every pixel of image is assigned a label where pixels with same label have some common peculiarities. There are different types of image segmentation schemes which are discussed in following section are edge-based, region-based, Thresh-holding based and clustering based segmentation algorithm [9][8].

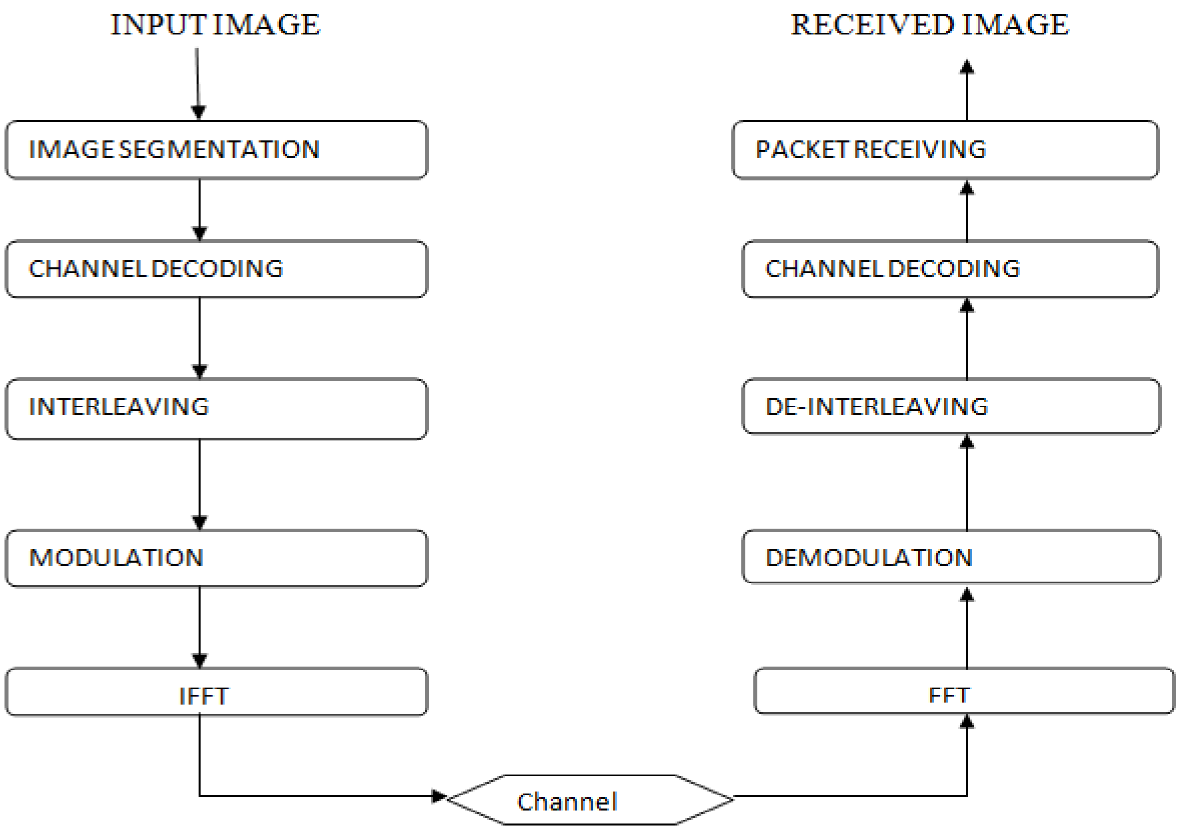


Fig. 5.1 Block diagram of image transmission

6.3.1 Edge-Based Segments

In edge based segmentation the abrupt change in intensity at the boundaries and edges of the image are detected. There are different edge detector operators like Prewitt operator, Sobel operator and canny operator.

(a) Prewitt operator

Prewitt operator is a discrete separation operator, registering a close estimation of the gradient of the image strength per unit. The Prewitt operator provides direction of the most elevated time permits build or diminishing from light with darker. What is the rate of change happening in that specific course by figuring the gradients of the image intensity at each points? The result following applying operator reveals to how "abruptly" alternately "smoothly" those image progress during that side of the point and more in that direction. Also demonstrates how probable it will be that and only the image represents to an edge. [21].

Mathematically, for ascertaining the close estimation of the derivate the driver convolves the unique image for the 3x3 kernels one to level changes and another for vertical. Though the original image may be characterized Toward A, and Gx and Gy would two images which toward each perspective hold numerous those level and vertical subordinate approximations, the convolutions would be calculated as:

$$G_x = \begin{bmatrix} -1 & 0 & +1 \\ -1 & 0 & +1 \\ +1 & 0 & +1 \end{bmatrix} * A \text{ And } G_y = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ +1 & 0 & +1 \end{bmatrix} * A \quad (5.1)$$

Where * is a convolution operator.

The x-coordinate here is indicating the expansion in the up-direction and the y-coordinate in down-direction. At every point, the resultant gradients can be merged together to give the resultant gradient magnitude using:

$$G = |Gx + Gy| \quad (5.2)$$

By utilizing this information, gradient direction can be calculated.

$$\theta = \tan 2(Gx\ Gy) \quad (5.3)$$

For example, Θ is 0 for a horizontal edge which is darker on the right side.

(b) Sobel Operator

Sobel operator is a technique for edge detection. It is a discrete differentiation operator, which calculates the approximation of the gradient of the image intensity function. The outcome of this operation is either the standard of the vector alternately the gradient of this vector at each single point. The Sobel–Feldman operator will be in view of convolving those images with a small, separable, and integer-valued channel in both directions [21].

$$Gx = \begin{pmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{pmatrix} * A \text{ and } Gy = \begin{pmatrix} +1 & +2 & +1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix} \quad (5.4)$$

Where * denotes the 2-dimensional convolution operator.

Canny Edge Detection

Canny edge detection is a process of extracting suitable structural information to reduce the data to be processed from different images. It has been used in different computer vision applications. Thus, an edge identification solution these necessities might make executed for an extensive variety of particular circumstances [5] [21]. The all criteria for edge identification include:

1. Edges are distinguished for low error rate that is edge identification should faultlessly detect large portions edge in those images as possible.
2. From the edge points detected by canny operator should precisely find the position of middle point of edge.

3. The edge detected by canny operator should not be marked more than once, which could create false edges.

Canny operator is having five well defined steps:

1. Apply Gaussian channel filter should smooth birch in the image in place will uproot the commotion (noise).
2. Determine the power gradients of the image.
3. Apply non-maximum concealment on dispose of spurious light of edge identification
4. Apply twofold edge with determine possibility edges.
5. Track edge by hysteresis. Conclude the identification of edges by suppressing every last one of other edges that are feeble which are not associated with solid edges.

6.3.2 Thresholding Based Segmentation

Thresholding is the simplest technique of breaking image into pixel sets by which binary picture is created from grey-level with a black pixel, assuming that the intensity Ii, j under a threshold value T and with white pixel if the intensity Ii, j is higher than T. The pixels below certain value is treated as zero and above certain value as one. If f(x, y) is the threshold form of the grey level image h(x, y) towards global threshold value T is shown below.

$$f(x,y) = 1, if\ h(x,y) > T$$

$$= 0\ otherwise \qquad (5.5)$$

Thresholding operation is represented by $T = M[x, y, p(x,y), h(x,y)]$ assuming$p(x,y)$ p(x,y) any point and $h(x,y)$ the grey value of that point on the particular image. Based on this there are two methods of threshold based segmentation [20] [3].

(a) Global Threshold

In global threshold, the value of T solely depend only on the $h(x,y)$ and T is belong to the characteristics of pixels. The technique is called global threshold.

(b) Local Threshold

In local threshold, the image is divided into different segments and for each segment different threshold values are chosen. The value of T depends on $h(x,y)$ and $p(x,y)$. This technique of thresholding is called local threshold.

(c) Utsu Segmentation

Utsu calculation is generally utilized in light of its effortlessness, furthermore not difficult to utilize. Yet the calculation is main utilized for 1D image. Utsu algorithm main recognized grey-level majority of the data without acknowledging those pixels' spatial neighborhood majority of the data best thereabouts it will be challenging on get efficient segmentation. This algorithm doesn't work for the points which are widely distributed about center and background change broadly. Utsu segmentation provides for beneficial segmentation impact for two equivalent classes [3].

6.3.3 Clustering based segmentation

Clustering is a process of grouping different image segments having similar characteristics with each other. In this technique different cluster centers are taken with other neighbor pixels having similar properties one way or the other [20] [3].

(a) K-means Clustering

The K-means clustering algorithm determines the data sets (groups) clinched alongside. The information about the dissimilarity between data sets can depend on determining data sets clinched alongside by which cost function of dissimilarities measure is reduced, which is known as the Euclidean distance.

Assume set of n vectors, j =1...., n, which are divided into c groups G, i = 1.... c. The object function on the Euclidean distance among a vector Xk in group j and related cluster center Ci can be given by:

$$J = \sum_{i=1}^{c} J_i = \sum_{i=1}^{c}\left(\sum_{k, X_k \in G_i} \|X_k - C_i\|^2\right) \quad (5.6)$$

Where, Ji denotes the object function in group i. These different groups are denoted by a Cn binary membership matrix U, here the element Uij is 1 if the jth data point xj is of group i, and 0 otherwise. After selecting and fix the cluster center's Ci, the minimizing Uij for Equation (1) can be derived as follows:

$$u_{ij} = f(x) = \begin{cases} 1 \; if \; \left\|X_j - C_i\right\|^2 \leq \left\|X_j - C_i\right\|^2, for \; each \; k \neq 1 \\ 0 \qquad\qquad\qquad\qquad\qquad\qquad otherwise \end{cases} \quad (5.7)$$

Thus Ci is the center of all centers when Xi belongs to group 'i'.

$$Ci = \frac{1}{|Gi|}\sum_{Xk \in Gi} Xk \quad (5.8)$$

(b) Fuzzy C-Means Clustering

Fuzzy C-means clustering (FCM), relies on concept of k-means clustering, but every data point in Fuzzy is given a membership degree. Fuzzy partitioning is used in FCM, the data points having value between 1 and 0 of membership function shows the close relationship with several groups. However, FCM still utilize a cost function, to divide the data sets the cost function has to be decreased. In fuzzy sets membership function (matrix U) can have values between 0 and 1. However, the summation degree of closeness of a data point with all other clusters is always equal to unity [3] [23].

$\sum_{i=1}^{c} U_{ij}$ =1,∀ $j = 1$, ...n. (5.9)

The cost function for FCM is a generalized form of Equation (1):

$$J(U, c_1, \ldots, c_c) = \sum_{i=1}^{c} \sum_{j=1}^{n} u_{ij}^{m} \ d_{ij}^{2} \quad (5.10)$$

Where value of uij is in between 0 and 1; Ci is the centre of cluster of fuzzy group i; Euclidean distance in between cluster centre and jth data point is dij = ||c - x||.

The FCM algorithm moves around two states repeatedly until no more change in the result occurs. In a clump mode operation, FCM finds the centre of the data groups Ci and the membership matrix U, utilizing those emulating steps:

Step 1: A random variable is used to initialize the membership matrix U between 0 and 1, such that the conditions in equations (1) are fulfilled.

Step 2: Using equation compute the fuzzy cluster center's Ci, i =1...c.

Step 3: Calculate the cost function by using equation (1). Abort if the value of cost function is below a certain threshold value or its improvement is less than in previous step. Step 4:

Calculate new value of U and go to step 2.

6.3.4 Region-based segmentation

Region based segmentation methods are dependent on continuity of certain properties in a particular region of image. In this technique the image is divided into different divisions having different characteristics like grey level. Region based techniques depend upon the intensity values of different pixels within a cluster of neighboring pixels. These clusters are called regions, and the objective of this algorithm is to form different groups of these divisions depending upon their functional roles. Region based algorithm is simple compared to edge based segmentation methods which is more immune to noise. Region based segmentation consist of following methods [24] [19]. Where an edge based system may attempt to investigate the question limits and afterward find the question itself by pressing them in, a district-based technique adopts the inverse strategy, by (e.g.) starting in within a protest and after that "developing" outward until the point that it experience the protest limits.

(a) Region Growing

Region growing is an operation performed to distinguish the pixels of image into sub-regions or larger regions according to certain predefined rules. There are four steps in region growing operation:

(i) First choose a seed pixel set in original image.

(ii) Define a set of parameters such as grey intensity level or color and define the stopping condition.

(iii) Start growing regions by determining the parameters of each neighboring seed with the predefined pixel sets for similarity check.

(iv) Abort the process when no pixel seems to have similar characteristics based on predefined rule.

(b) Region Splitting and Merging

Instead of selecting a seed pixel sets, we can divide an image into various sub-regions and then merging them in order to meet the certain conditions of moderately good image segmentation. Quad tree data is normally used for the implementation of the region splitting and merging image segmentation.

6.4 Encoding

In digital communication system data rate is increasing to a significant degree but the bandwidth requirement is high for increased data rate. It is not wise to use more bandwidth that will decrease the capacity of the digital communication system. Bit error rate is increased by transmitting high data rate over limited bandwidth. Data is lost as a result of high traffic over communication channel, data corruption or other traffic channel problems can cause large distortions. The efficiency of various channel coding scheme is explained in order to improve the quality of data transmission over the channel [7] [13].

6.4.1 BCH Codes

BCH is one of the highly effective channel coding scheme among Linear Block Coding schemes. Block size in BCH is given as n=2m-1 and number of check bits in BCH codes are

(n-k) <=mt. For any basic integers m and t, there may be a binary (n, k) BCH codes. In BCH coding we can select different parameters according to our requirement. BCH code is able to correct at maximum of ‘t’ number of errors. For correcting a single bit error BCH code will work same as Hamming code. BCH codes are most widely used in wireless communication applications. When Signal to Noise ratio (SNR) ids increased in BCH coding BER is minimized almost to zero.

There would three choices provided for of the BCH Encoder block:

(1) **Specific Primitive Polynomial**: it changes over nonnegative decimal basic d on a binary row vector. The output d vector comes out in matrix form, who’s each row is in the binary value to the corresponding element value in vector d.

(2) **Specific Generator Polynomial**: a generator polynomial utilizing Galois column vector that schedules those polynomial's coefficients in decreasing order of the variable.

(3) **Puncture Code**: when there are different code words per frame and are given to encoder, all code words are operated with some puncture pattern. The function of Puncture code word is to discard the parity symbol from code words.

There would be two steps in BCH decoder:

1) If receiver at the input port generates erasures, performance of the BCH decoder is enhanced especially in fading channel.

2) Output number of error corrected: it indicates how many detected errors are corrected at the output.

6.4.2 Convolution Encoder

Convolution codes generate the parity bits by sliding application of Boolean polynomial to detect and correct the error in a data stream. Convolution of encoder over data is done by the application of sliding window. Three parameters are used for the representation of convolution codes n K, h where k denotes how many shift registers used in the encoding block. In convolution codes the continuous stream of data is used at the encoders input. The codes obtained after encoding also depend on the previous information bits transmitted and the k bit information message. Convolution codes are used in random errors. Convolution codes with block codes are used to increase their performance. In Fig. 5.2 below, convolutional encoder is shown having the constraint length 3 and has ½ data rate due to two adders used in it. At LSB the bit is shifted towards left and bits at MSB are shifted towards right. Then afterward applying the modulo-2 operation relating outputs requirement. This process is continued until the data reaches at the input port of encoder. The characteristics of code depend on how the shift registers are connected with each other [13].

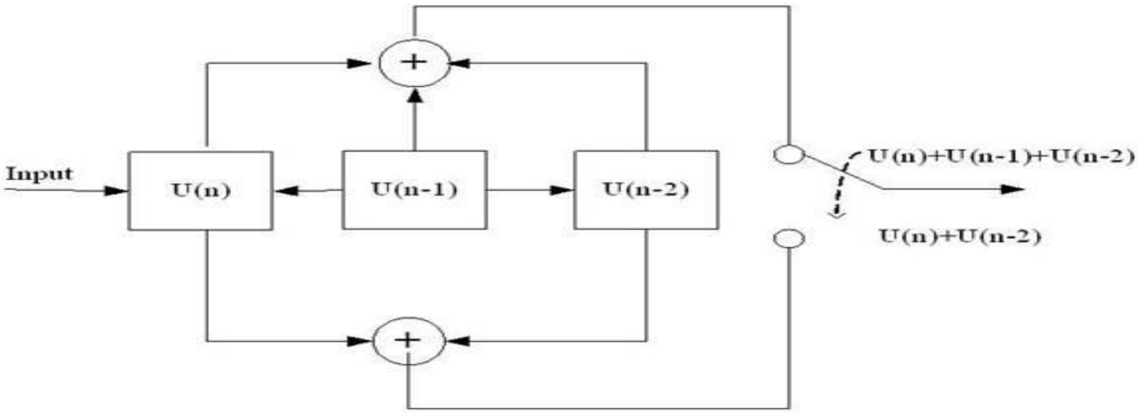


Fig. 5.2 Convolutional Encoder (Code Rate ½, Constraint length 3)

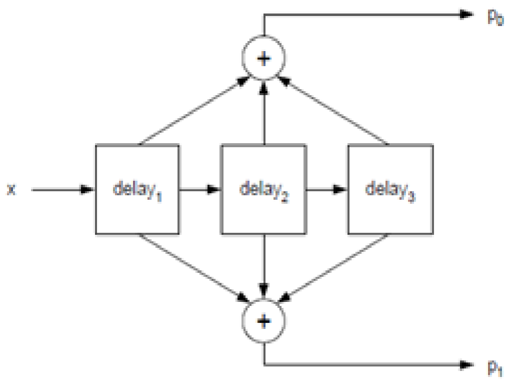
6.4.3 Turbo coding

Turbo coding is iterated soft computing method of producing block codes deduced by combining more than one convolution codes with an inter-leaver that can operate in a fraction of decibel of Shannon limit. Shannon coding can be achieved by using large block lengths codes, but due to large requirement of processing power makes it impossible. Turbo codes remove these drawbacks by using recursive coders. Recursive coders make the short length codes to appear block codes and soft decoder improves the reception of messages.

A simple type of convolutional coder can generate turbo codes. The coder shown in fig.5.3 (a) having certain inputs and a constraint length K=3. Multiplexing the outputs produces a code of rate R=1/2.

The convolutional coder shown in fig.5.3 (b) is called recursive convolutional coder in which one of the outputs p0 has been given feedback at the input port make it recursive. A turbo code is framed from the parallel connection of two codes isolated by an inter-leaver. The two encoders utilized are typically indistinguishable. The code is in a methodical frame, i.e. the input bits additionally happen in the yield.

Encoders are recursive orderly convolutional codes (RSC).The inter-leaver peruses the bits in a pseudo-irregular request. The central turbo code encoder is fabricated utilizing two indistinguishable recursive orderly convolutional (RSC) codes paralleling.



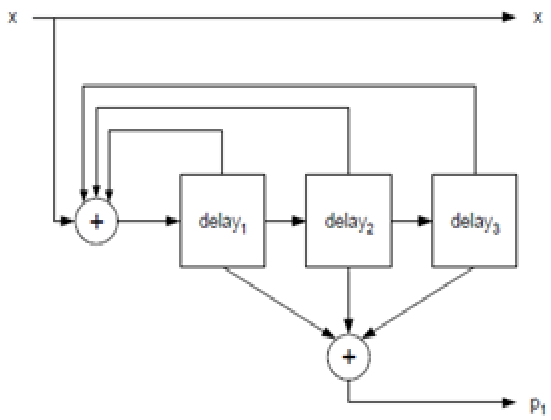


Fig. 5.3(a) Convolutional coder Fig. 5.4(b) Convolutional decoder

6.4.4 Low-density parity-check (LDPC) codes

LDPC code corrects the linear block errors code and is used for transmitting data over a very high noisy channel. Sparse bipartite graph is used for the generation of low density parity codes. LDPC codes are capacity dependent codes and can be constructed practically by keeping the noise threshold value near to the theoretical maximum for symmetrical memory less channel. By setting the noise threshold, we select the upper bound for the channel noise, where probability of data lost can be made possible. Using iterative belief propagation techniques, LDPC codes are represented by matrices and graphical representation. Let’s look at the examples of matrices and graphical representation is shown below in fig.5.4 [10]:

Matrices representation:

$$H = \begin{pmatrix} 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 & 0 & 1 & 0 \end{pmatrix} \tag{5.11}$$

LDPC code algorithm:

The steps of algorithm are given below:

1. The V node is given a received code word value.
2. The value from V node is transported to each of the connected C nodes.

3. The value of edge is computed in C nodes and transmitted back to V node.

4. The value received from C node is added with original code word value and the values are updated.

5. Steps 2 – 4 are repeated for predefined number of iterations.

6. The final values are calculated at V nodes and the values are corrected results.

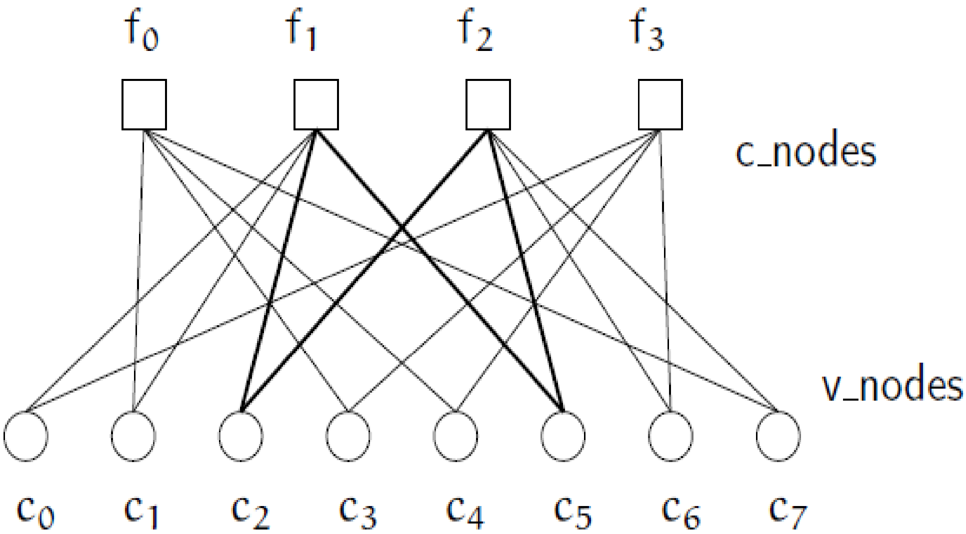


Fig. 5.4 LDPC code

6.4.5 Hamming codes

Hamming codes are linear error correcting code and are used for detection of single bit and two bits' errors. Hamming codes are suited for random errors, not for errors that come in bursts. With contrast to the parity codes cannot correct errors, and are able to detect only odd error bits in errors. Hamming codes are very accurate codes and having high rate of codes with block length and minimum distance. Our advanced Hamming approach relies upon the nonzero bits in a code. It speaks to another method for registering the Hamming equality. Best case scenario, no calculation is essential and best case scenario, the quantity of operations is equivalent to that of the consistent Hamming approach. Then again, on the off chance that every one of the bits of a message is equivalent to one, at that point the number of operations expected to figure the equality is equivalent to the number of operations expected to figure the Hamming code. An illustration is offered alongside clear up these ideas.

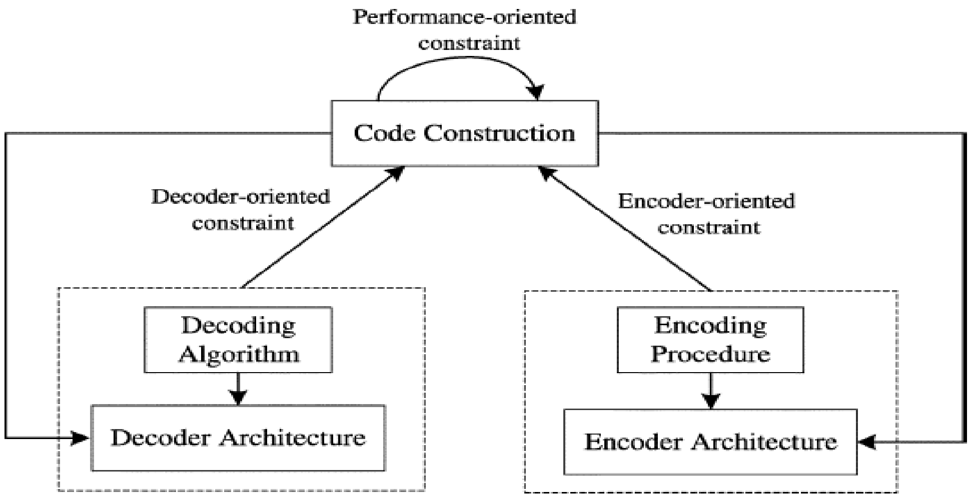
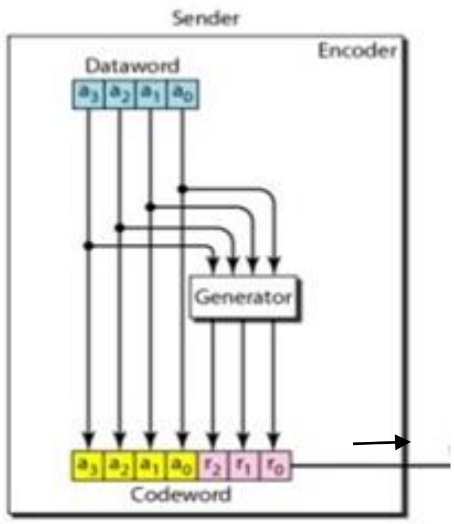


Fig. 5.5 Block diagram of LDPC encoder and decoder



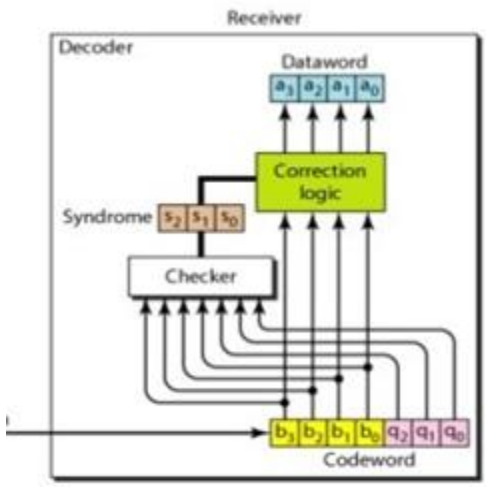


Fig. 5.6(a) Hamming coder

Fig.5.6 (b) Hamming decoder

Mathematically, hamming codes are class of binary linear codes. Hamming codes are shortened Hadamard codes. To each integer $r \geq 2$ there may be a code for square length $n = 2r - 1$ What's more message length $k = 2r - r - 1$. Consequently, those rate from claiming hamming codes is $r = k / n = 1 - r / (2r - 1)$, which is the minimum achievable for codes with least separation of three and block length $2^r - 1$. Block diagram of Hamming code encoder and decoder is given in fig. 5.6(a) and fig.5.6 (b):

6.5 Interleaving

Interleaving is a process or methodology of rearranging the data in non-contiguous manner to make system more reliable, efficient and fast based on predefined rules. To receive the data at receiver side the reverse rule is followed to retrieve the original data symbols. Interleaving of the binary data is important before modulation because it allows long distance propagations in different difficult propagation conditions. There are different interleaving techniques [9] [15].

6.5.1 Block Inter-leaver

Without repeating or omitting any elements the block Inter-leaver rearranges the elements of input. The input to the block Inter-leaver can be any number (real or imaginary). If there are N elements at input, the element parameters are given by a vector of length N. Square Inter-leaver rearranges those components for its information without rehashing decimal alternately omitting at whatever components. That information might a chance to be genuine or mind boggling. If those information holds n elements, that point the components parameter will be a vector from claiming period n that demonstrates those indices, to order, of the enter components that manifestation the Length-N yield vector. Block Inter-leaver may be basic and simple should execute over different systems. A block inter-leaver will be in the structure of a row-column grid from claiming size RxC; the place R may be aggregate number about rows C's may be those downright number from claiming columns. To perform interleaving, the majority of the data may be composed of the RxC row-column grid can be read back in column wise as shown in fig.5.7. There would no inter-row or inter-column permutations utilized within this illustration, consequently those interleaved arrangement holds a percentage precise request. The piece de-interleaver performs the opposite operation of the interleaver over which the data is composed of the RxC row-column grid section insightful Also perused over to column insightful.

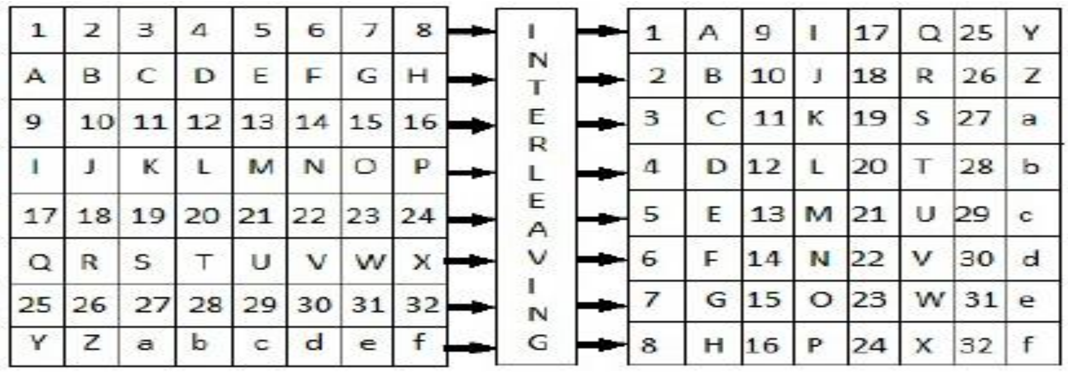


Fig. 5.7: Block Interleaving

6.5.2 Convolution Interleaver

Convolutional interleaver consists of shift registers, each register having a fixed delay. The delays in a conventional convolutional interleaver are non-negative integer multiple of a fixed integer. The new symbols are added into the next register from input and the previous data symbols from that register goes in the output vector. The functioning of interleaver depends upon the past symbols along with current symbols feed from input, that is a convolutional interleaver requires memory for its operation. A schematic fig.5.8 and below explains the structural block diagram of the convolutional interleaver having some shift registers with delay values D (1), D (2) ..., D(N). The blocks in this library have hidden parameters that show the delay of every shift register. The convolutional encoder and decoder is shown in fig.5.9.

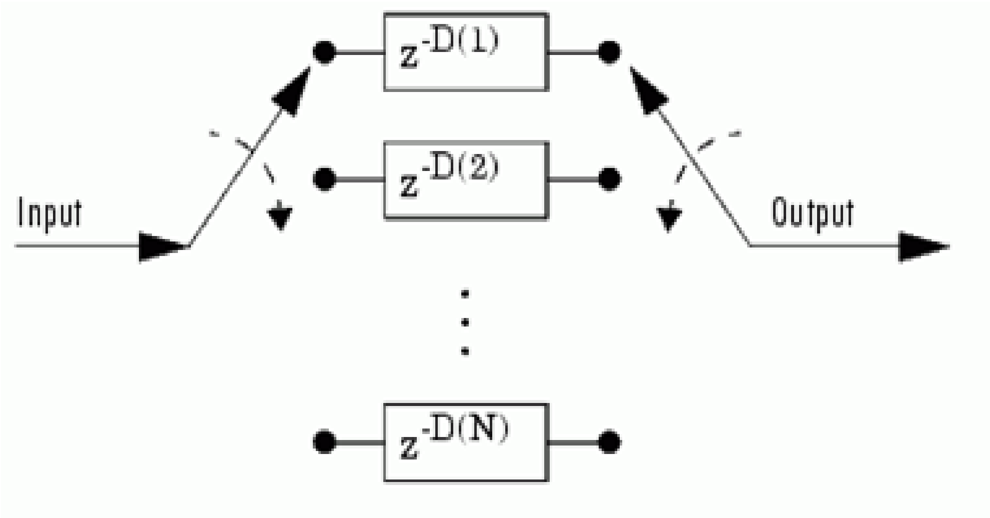


Fig. 5.8. Convolution interleaver

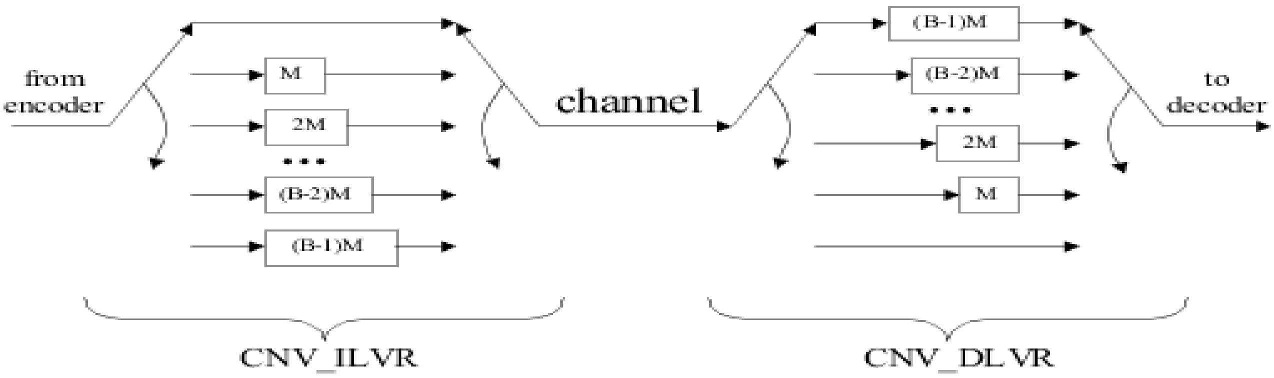


Fig.5.9 Convolutional interleaver and deinterleaver

When an arranged data is passed through an convolutional interleaver and an comparing deinterleaver, the detected data lags behind those first succession data. The dalay between the original and restored sequence is (Number of shift registers)*(Maximum dealy among all shift registers) for the most general multiplexed interleaver. If there incurs an extra delay between interleaver outputs and deinterleaver input, that point those restored data arrangement lags behind first grouping. Eventually this aggregates the extra delay and the add up in the first equation.

6.5.3 Matrix interleaver

Matrix interleaver is also a block interleaver. This process is done by feeding the data into matrix rows by row and output is given by matrix interleaver at output column by column. The dimensions of the matrix are determined by the number of rows and columns which is used for block computation. Matrix interleaver shown in fig.5.10 is a block interleaver in which that data is fed into matrix row by row and retrieved at output column by column. The de-interleaver performs de-Interleaving operation by feeding the matrix with the input data sequence column by column and reverse operation at output. The input vector length must be equal to Number of rows times Number of columns.

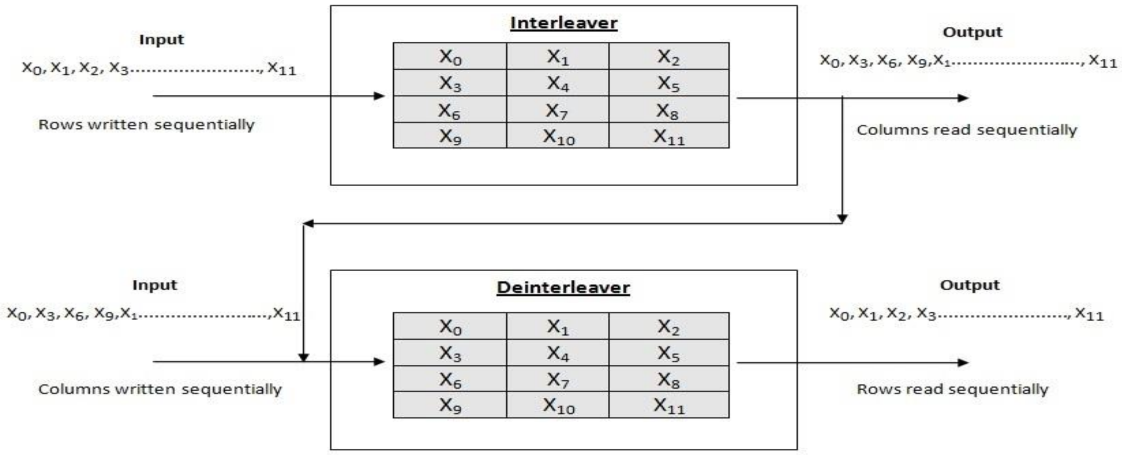


Figure 5.10 Matrix Interleaver and de-interleaver

6.5.4 Random Interleaver

Random interleaver block performs interleaving by using a random permutation to rearrange the components of its input vector. The number of elements present at the input vector denotes how many element parameters are there. Column vector is utilized if the input data is in frames. Random interleaver fig.5.11 rearranges the input data before sending it into channel with various predefined permutation schemes. Because of this random arrangement of data, the error symbols get randomized at receiver side. After the randomization of the error bursts, due to which the whole data blocks gets rearranged and can now be detected and corrected easily.

At interleaver side pseudo-random permutation are generated of available memory addresses. The data symbols are rearranged according to these generated pseudo-random orders of memory addresses. The data can be received and de-interleaved at de-interleaver side only if it knows the exact order of permuter-indices. The de-interleaver should know order of pseudo codes exactly as that in interleaver.

6.6 Modulation

Modulation is a process of mapping the code bits in a format that is effectively send over the communication channel. A modulation scheme converts the digital data signal into the signal which can be transmitted through the communication channel. The main aim of the modulation is to compress the data as much as possible into the spectrum or bandwidth available. There are different techniques of modulation [6] [15]. A message carrying signal has to get transmitted over a distance and for it to establish a reliable communication; it needs to take the help of a high frequency signal which should not affect the original characteristics of the message signal.

A high frequency signal can travel up to a longer distance, without getting affected by external disturbances. We take the help of such high frequency signal which is called as a carrier signal to transmit our message signal. Such a process is simply called as Modulation.

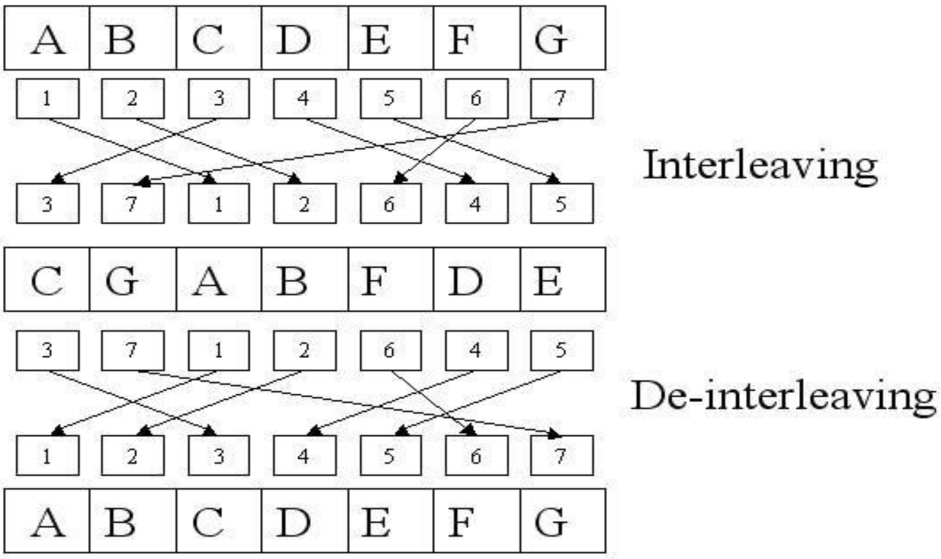


Figure 5.11. Random Interleaver

6.6.1 Quadrature Amplitude Modulation

QAM is used for both analog and digital modulation. It carries only two message signals whether those are analog or two digital bit streams, by modulating (changing) the amplitude of carrier waves by using amplitude shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. The carrier waves are of same frequency but are out of phase by 90 degrees from each other and are called Quadrature components. QAM is most widely used modulation scheme in telecommunication systems. The QAM modulator block diagram is shown in figure 1. By using QAM the high bandwidth utilization can be achieved by selecting suitable constellation size which is limited by noise and linearity of channel. On the transmitter side of QAM modulator, the modulated QAM wave is of the form [6]

$$S(t) = Re\{[I(t) + iQ(t)]e^{i2\pi f_o t}\}$$

$$= \cos(2\pi f_o t) - Q(t)\sin(2\pi f_o t) \qquad (5.12)$$

Where Q (t) is Quadrature components and I(t) is in-phase and components, f0 is the carrier frequency and Re{} denotes real part.

At the demodulation side the I(t) and Q(t) components can be detected separately by multiplying them with cos(t) and sin(t) respectively and the expression is of the form

$$r(t) = \frac{1}{2}I(t)[1 + \cos(4\pi f_o t)] - \frac{1}{2}Q(t)\sin(4\pi f_0 t) \qquad (5.13)$$

6.6.2 Quadrature Phase Shift Keying

In digital modulation schemes a concept of basis functions is used, in which some sinusoidal signals which are orthogonal to each other are used for such specific modulation technique. Gram "Schmitt orthogonalization" procedure is used to generate these basis functions. In the signal space, from the linear combination of these basis functions almost all vectors can be represented.

In QPSK two such sinusoidal signals (sine and cosine) are chosen as basic functions for modulation of the original baseband signal. In QPSK the modulation is done by changing the phase of the sinusoidal basis functions with respect to the message symbols. In QPSK one symbol represents two bits as it is the symbol based modulation scheme. The mathematical equations of QPSK modulation scheme is of the form

Si (t) = 2EsT-√cos (2πfct+ (2n−1) π4), n=1, 2, 3, 4

The phase shift takes different values by changing the values of integer n, phase shifts can be of 45 degrees and is called Pi/4 QPSK. Thus QPSK modulation signal consists of in-phase (I) and Quadrature component (Q).

A QPSK modulator block diagram is shown in fig.5.12 below. A serial to parallel convertor (de-multiplexer) is used to discriminate between the even and odd bits from the data bits produced from generator. Each single odd bits and even bits are converted to NRZ format. I-arm and Q-arm are applied to multipliers and multiplied by cosine and sine components respectively and then adding the resultant signal I-arm and Q-arm to generate QPSK modulated signal. For coherent demodulation of QPSK signal the demodulator must know at what carrier frequency and phase the signal is modulated prior to perform demodulation.

6.6.3 BPSK Modulation

Binary phase shift keying is used for low data rate applications. BPSK can modulate one symbol per symbol then it is unsuitable for high data rate applications. Binary phase shift keying (BPSK) is a low data rate modulation technique which sends only one bit per symbol i.e., 0 and 1. BPSK has same bit rate and symbol rate as we are sending only one bit per symbol. We can have a phase shift of 0 degree or 180 degrees with respect to a reference carrier depending upon the message bit. The BPSK band pass signals are of the form given below.

$$S_1 = \sqrt{\frac{2E}{T}}\cos(2\pi f t) \rightarrow represents\ '1' \qquad (5.14)$$

$$S_2 = \sqrt{\frac{2E}{T}}\cos(2\pi f t + \pi) \rightarrow represents\ '0$$

$$S_2 = -\sqrt{\frac{2E}{T}}\cos(2\pi f t) \rightarrow represents\ '0' \qquad (5.15)$$

Where E is the symbol energy, T denotes time period and f represents the carrier frequency.

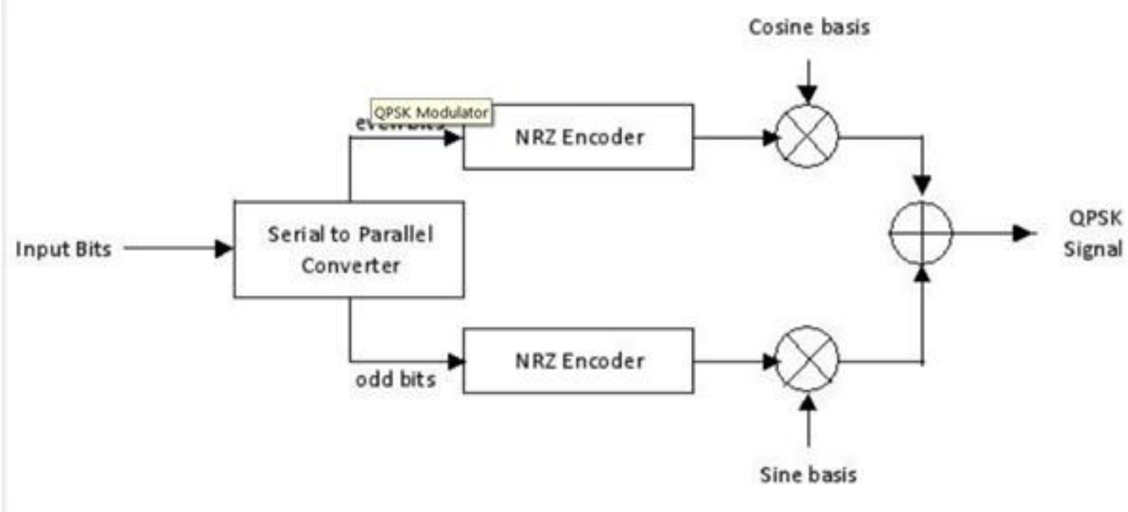


Fig. 5.12 QPSK Modulation

6.7 Fading channel Models

In mobile communication systems, the signals can travel from source to destination through different reflected paths, which introduces the multipath fading; transmitted signal can travel from multiple reflected paths from transmitter to receiver, due to which channel fading, attenuation, amplitude variations, phase and angle variations. Fading can be defined as the variation of the attenuation of a signal with different variables. Fading channel models are used for determining the effects of this fading accurately on the signal in order to decrease its effects. Fading are used for the simulation of the errors in wireless communication. AWGN, Rayleigh and Racian are the most widely used fading models [17].

6.7.1 AWGN Channel

Additive white Gaussian noise forms the important fading channel model which describes the effect of various random processes happening around in nature. There are different natural sources of wideband noise like thermal noise, shot noise, black body radiation and from manmade sources. The Central limit theorem of probability theory shows that AWGN has Gaussian or normal distribution. AWGN channel is used for analyses of modulation techniques when noise is added with signal passing through AWGN channel. AWGN has flat frequency response and linear phase response for all frequencies. AWGN does not introduce any phase distortion and amplitude loss to the signals passing through it. So in such cases, fading is not present but distortion is introduced by the AWGN channel. The signal at the receiver is simplified$r(t) = x(t) + n(t)$. Where n(t) denotes the added noise [14].

6.7.2 Racian Fading Channel

Racian fading is a stochastic model for signal travelling through channel deviations occur by partial cancellation of signal by itself. The radio signal travels to the receiver station through multiple paths and some paths are always changing. Racian fading happens because of high energy signals received through direct path, stronger than other signals. In Racian fading, the amplitude gain is characterized by a Racian probability distribution. Signals' travelling from direct line of sight paths are strongest and faces more fading than multipath components. These types of signals are approximated by Racian distribution [12].

$$p(r) = \frac{r}{\sigma^2}\, e^{-\left(\frac{r^2+A^2}{2\sigma^2}\right)} I\left(\frac{Ar}{\sigma^2}\right) \quad for\ (A \geq 0, r \geq 0) \tag{5.16}$$

Where A is peak amplitude of dominating signal and I () is the zero order modified Bessel functions.

6.7.3 Rayleigh Fading Channel

Rayleigh fading channel is statistical model used for estimating the impact of propagation channel on a radio signal usually used for wireless communication. In this model, we consider that amplitude of signal passing through channel will remain varying randomly of fade. Rayleigh channel model will be viewed as effective to tropospheric What's more ionospheric too to urban surroundings sign proliferation. Rayleigh model is used when there is no direct communication path between transmitter and receiver stations [12]. Rayleigh model is special case of "two wave with diffuse power" (TWDP) fading. Rayleigh is used when there is high density of objects that scatter the radio signals before reaching the receiver. If there will be no predominant part in the scatter, those processes are having zero mean and phase uniformly divided between 0 and 2π radians. The channel will therefore be characterized by Rayleigh distribution. The probability density function of Rayleigh channel is given by Rayleigh channel is given by

$$P\ rayleigh(r) = \frac{r}{\sigma^2}\ exp\left(-\frac{r^2}{2\sigma}\right) \tag{5.17}$$

Where σ standard deviation and r is random variable

The main source of Rayleigh noise is due to the multipath propagation of signals from transmitter to the receiver and when there is no line of sight communication channel available between transmitter and receiver. Successful limit likewise helps in the examination of the asset allotment or booking strategies in different remote frameworks, for example, Relay systems, multi-client frameworks and multi-bearer frameworks subject to measurable QoS necessities. The compelling limit in commotion restricted remote system has just been examined in the current works. Considering the obstruction constrained remote channels, in this paper, we propose a scientific approach in view of Laplace's strategy for the compelling limit of uncorrelated Rayleigh blurring divert within the sight of uncorrelated Rayleigh blurring impedance.

6.8 Flow Chart of Image Transmission

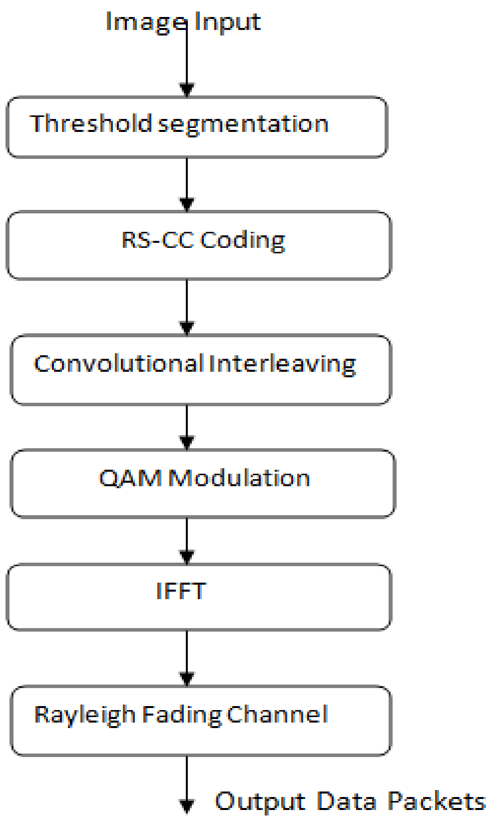


Fig.12. Flow chart of image transmission

6.9 Conclusion

The objective of this paper is to study about the optimum technique at each stage to obtain optimum performance of the image transmission over LTE network under Rayleigh fading channels. Rayleigh fading channel can be used for multipath propagation having no line of sight communication between transmitter and receiver stations and can be used for LTE in heavily built up areas. From all the segmentation techniques, Threshold based segmentation is the best segmentation technique which gives accurate results and is computationally fast. At encoding stage, RS-CC (Reed Soleman-Convolutional codes) codes have good burst error correcting capability and have low BER. AT interleaving stage convolutional interleaving is used because it is more efficient and has less BER rate. For modulating the data signal, QAM modulation is capable to transmit more bits per symbol and large data can be transmitted over small bandwidth and also has low BER. Figure (12) shows the complete image transmission using these efficient techniques at each stage. Using these techniques at each stage, optimum or high performance image transmission can be obtained.

CHAPTER 7

Noise effect analysis on diverse Image data set to procure effective Transmission over LTE

7.1 INTRODUCTION

Multiple input multiple output (MIMO) antenna operations is usually employed technical term to discuss all methods using number of antennas at transmitter and receiver antennas. The LTE uses both MIMO and OFDM multicarrier techniques. The relation between different combination of two corresponding transmitter and receiver antennas in MIMO is best expressed at every independent subcarrier level without analyzing complete bandwidth available. Linear equations are used to relate the received and transmitted resource elements at multicarrier level on various antennas [39].

Channels in wireless communication system are portrayed by multipath propagation because of disseminating by various obstacles. MIMO channels that employ this multipath propagation offers critical increment in data throughput and range of the communication is increased without any increase in bandwidth requirement and transmit power of signals [36].

Hypothetically, the data rate of any wireless communication system can be increased by rising the power of received signal for a given transmit power. A viable method to improve received power is by employing multiple antennas at both transmitter and receiver side, which is known as MIMO technique or multiple-antenna scheme. By using multiple inputs multiple output schemes has brought a tremendous increase in Bit Error Rate (BER) and capacity of the wireless communication system. But has increased the overall computationally complexity, which depends on the antenna configuration employed [40].

Spatial multiplexing is one of the best techniques using in MIMO scheme which gains a linear increase in capacity growth in direct proportion to antenna number. Increasing transmission power just result in logarithmic change, the use of MIMO increases the capacity many times than other ordinary schemes [44].

MIMO channels provide high data rates which make image transmission possible over LTE network with high unwavering quality. Compressive sensing (CS) algorithms are utilized to encode the bit stream generated by image conversion. The encoded bit stream is spatially multiplexed into multiple data streams depending upon the configuration of MIMO channel used and transmitted over the transmit antennas. Channel coding scheme like QPSK, 16QAM or 64QAM is used. Each transmitter antenna gets different power with respect to data it transmits [42].

7.2 LTE DOWNLINK and UPLINK CHANNEL MODEL

The series of information signal processing operations carried out on the downlink channel can be summed up in ordered sequence of transport layer and physical channel operations. The operations are totally given and determined in 3GPP reports depicting the multiplexing techniques and the channel coding and physical channels and regulations. The series of operations carried out on the DLSCH and PDSCH can be represented by the channel model as shown below in Fig.1 and are summed up as follows [36]:

- CRC (Transport block Cyclic Redundancy) code generator
- Code block – Turbo coding with code rate of one-third
- Bit level scrambling of coded bit stream
- Modulation of the scrambled data stream for transmission on the channel ports
- OSTBC Encoder is used for implementing the MIMO for improving the performance of the system

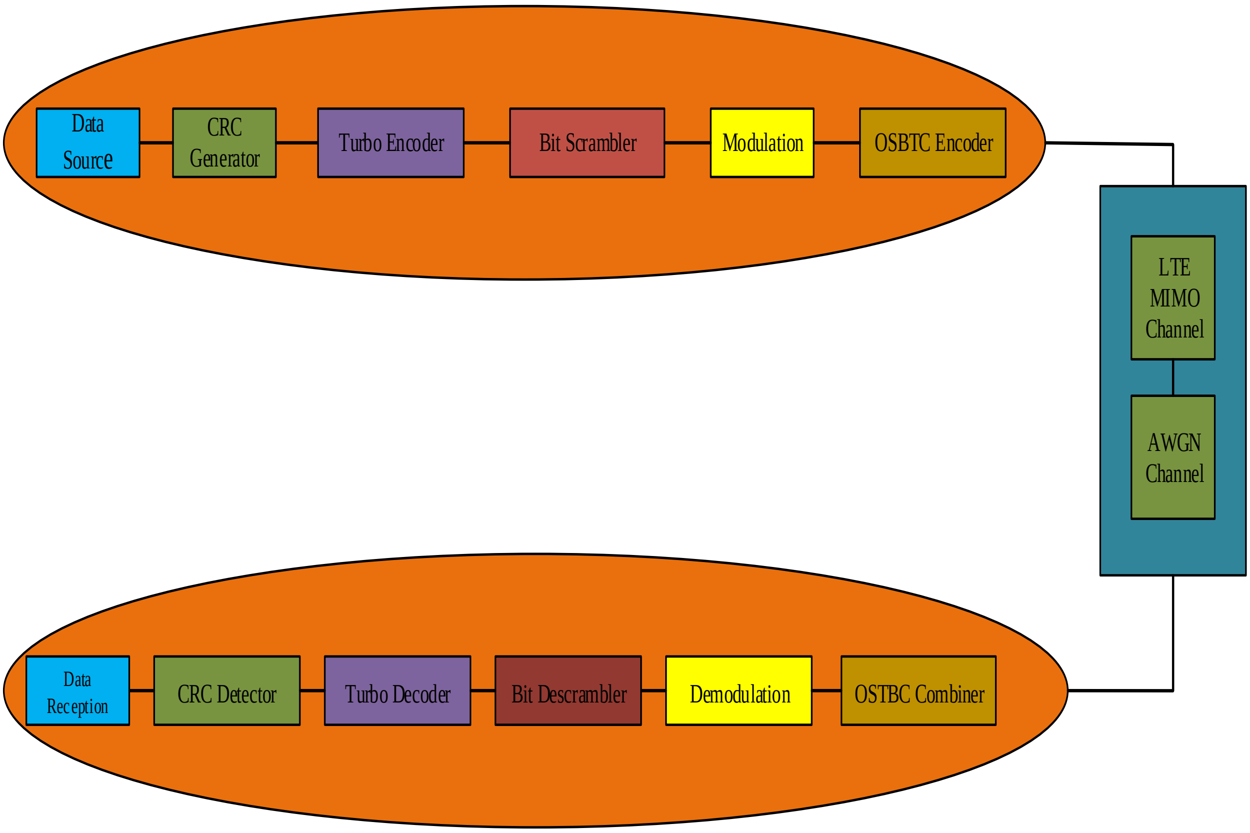


Fig.7.1 DLSCH AND PDSCH Channel Model

7.3 MULTIPLE INPUT MULTIPLE OUTPUT (MIMO)

MIMO wireless channels state explicitly the relation between information signals transmitted through numerous transmit antennas and information signals received at multiple antennas. The number of multiple paths depends upon the number of transmitter (numTx) and receiver (numRx) antennas given by (numTx * numRx). For any given combination of receiver and transmitter antennas, the relation is expressed by scalar gain value called channel path gain. The different values of channel gains form a channel matrix H, with dimensions of (numTx, numRx). Linear equations describe the relationship between transmitted signal, received signal and the channel matrix [38].

Consider a corresponding communication system, where from N transmitters we have to send N signals all the while. For instance, in a communication system, at every time slot t, signal $C_{t,n}, n = 1,2\ ,3, \ldots N$ are transmitted at the same time from N transmit antennas. The transmitted data signals travels through different channel to the every of the M receivers. Output from every channel is linear superposition of faded input signals by noise in the channel. Signal path is made by a pair of transmitter and receiver from transmitter to receiver. Path gain from sender n to receiver m is expressed by$\propto_{n,m}$ [39]. Fig. 5 below delineates a baseband discrete-time design for flat fading MIMO channel. In light of this model, the received signal $r_{t,m}$ at time t and at antenna m is expressed as

$$r_{t,m} = \sum_{n=1}^{N} \propto_{n,m} C_{t,n} + \eta_{t,m} \qquad (6.12)$$

Where $\eta_{t,m}$is noise of receiver antenna at time t

To represent the input- output relation in more compact form, we tend to collect the signals that are transmitted from N transmitted antennas throughout T time slots in a T x N matrix, C as given below

$$C = \begin{pmatrix} C_{1,1} & C_{1,2} & \cdots & C_{1,N} \\ C_{2,1} & C_{2,2} & & C_{2,N} \\ \vdots & & \ddots & \vdots \\ C_{T,1} & C_{T,2} & \cdots & C_{T,N} \end{pmatrix} \qquad (6.13)$$

Now, we construct a T x M received matrix during T time slot

$$r = \begin{pmatrix} r_{1,1} & r_{1,2} & \cdots & r_{1,M} \\ r_{2,1} & r_{2,2} & & r_{2,M} \\ \vdots & & \ddots & \vdots \\ r_{T,1} & r_{T,2} & \cdots & r_{T,M} \end{pmatrix} \qquad (6.14)$$

Now, for T<T `, the path gains in N x M channel matrix H is given as

$$H = \begin{pmatrix} \alpha_{1,1} & \alpha_{1,2} & \cdots & \alpha_{1,M} \\ \alpha_{2,1} & \alpha_{2,2} & & \alpha_{2,M} \\ \vdots & & \ddots & \vdots \\ \alpha_{N,1} & \alpha_{N,2} & \cdots & \alpha_{N,M} \end{pmatrix} \qquad (6.15)$$

Therefore the final expression is of the form of

$$r = C.H + \mathbb{N} \qquad (6.16)$$

Where $\mathbb{N}$ is T x M noise matrix is given as

$$\mathbb{N} = \begin{pmatrix} \eta_{1,1} & \eta_{1,2} & \cdots & \eta_{1,M} \\ \eta_{2,1} & \eta_{2,2} & & \eta_{2,M} \\ \vdots & & \ddots & \vdots \\ \eta_{T,1} & \eta_{T,2} & \cdots & \eta_{T,M} \end{pmatrix} \qquad (6.17)$$

Path gains for different paths may be different or independent from each other, that is $\alpha_{n,m}$ is independent from $\alpha_{n`,m`}$ for n≠ n` or m≠ m`. Also, if antennas are close to one another, some correlation might be there between the gains. Two antennas must be at a distance of half of wavelength, then the path gains are independent [41].

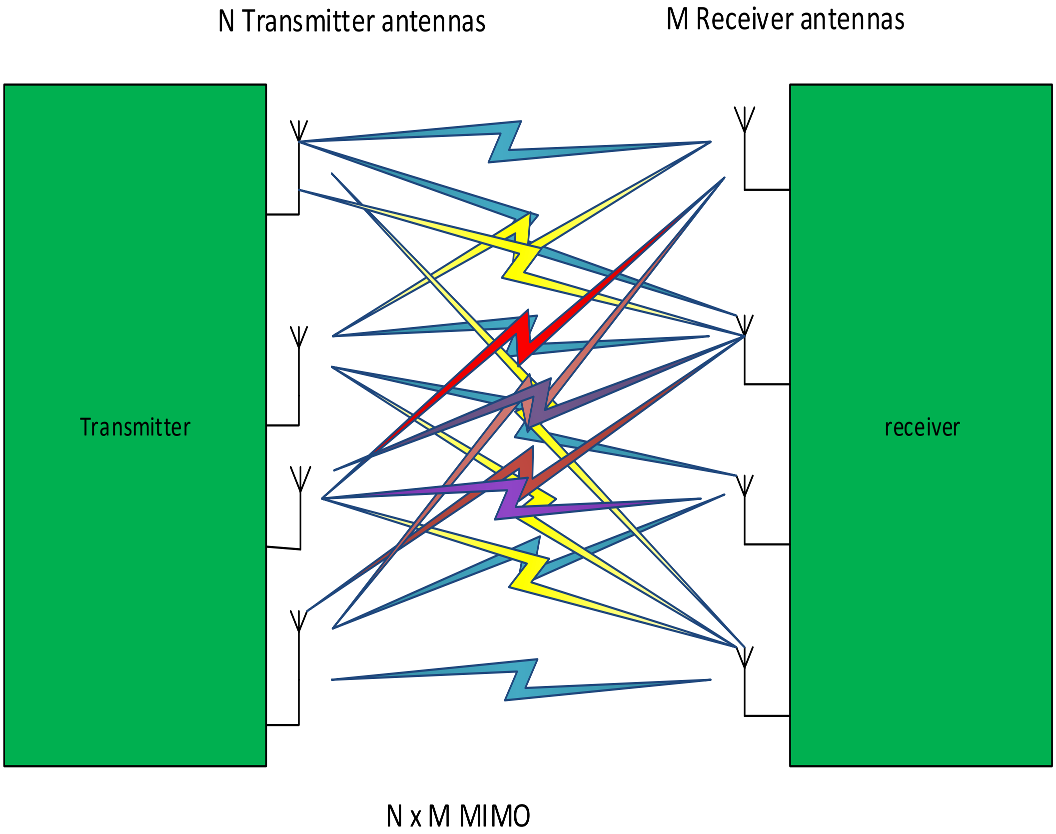


Fig.7.2 MIMO Model

7.4 SPACE-TIME BLOCK CODING (STBC)

Space-time block coding procedure has been actualized in current situation of wireless communication system. STBC joins modulation, coding and uses multiple antennas at both terminals. The fading which occurs in wireless communication channels can be reduced by using MIMO system. MIMO system increases the capacity of the system. Data rates can be improved by utilizing higher order modulation schemes [37] [43].

By expanding the quantity of transmitter and receiver antennas yield more performance improvement and gives diverse advantages to MIMO system with reduced complexity. Therefore, Orthogonal Space-Time Space Time Block Coding (OSTBC) scheme is utilized in that principle of orthogonality has to be used among the signals by every transmitter antenna, which made signal detection linear and also signals are decoded independently and thus makes encoding less complex. OSTBC increases data rates and reduces the complexity of the decoder.

7.5 SIMULATION RESULTS AND DISCUSSION

During simulation, the BER and SNR analysis of LTEMIMO system model is performed for 4QPSK Modulation technique with Turbo coding over AWGN and MIMO fading channels using Orthogonal Space Time Block Coding (OSTBC) structure. Image quality analysis after reconstructed at the receiver is done for image types: Colored images, Biomedical and Binary images by adding noises like Salt and Pepper noise and AWGN noise in increasing amounts at different EbNo values. The plots drawn represent the BER and SNR and energy per (EbNo) bit got from the LTEMIMO channel with the theoretical calculated results of the LTE MIMO channel. This LTE gives equivalent performance for colored, biomedical and binary images.
By analysis all the plots for colored, biomedical and binary images transmission over the LTE it is evident that it gives efficient and quality image transmission type having BER of approximate $8.6e^{-5}$ for EN/BN of 0:20 range for each transmitted image. The simulation results for each images transmitted are represented in tabular form below in tables 3 to 6 and the graphical plot between transmitter BER and the theoretically calculated BER represented Fig.6 and Fig.9.

TABLE 7.1 FOR SIMULATION RESULTS FOR COLORED IMAGES WITH AWGN NOISE

Noise level I	**90%**	**80%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**	**0%**
Image1	0.174	$9.9e^{-2}$	$4.6e^{-2}$	$1.67e^{-2}$	$1.08e^{-3}$	$4.344e^{-4}$	$1.3629e^{-4}$	$9.0862e^{-5}$	$7.78e^{-5}$
Image2	0.169	$4.48e^{-2}$	$1.65e^{-2}$	$5.67e^{-3}$	$1.38e^{-3}$	$4.11e^{-4}$	$1.01e^{-4}$	$6.50e^{-5}$	$7.22e^{-5}$
Image3	0.100	$4.60e^{-2}$	$1.67e^{-2}$	$5.62e^{-3}$	$1.35e^{-3}$	$5.09e^{-4}$	$1.23e^{-4}$	$1.15e^{-4}$	$1.39e^{-4}$
Image4	0.170	$4.56e^{-2}$	$1.56e^{-2}$	$5.05e^{-3}$	$1.49e^{-3}$	$3.10e^{-4}$	$1.58e^{-4}$	$1.17e^{-4}$	$1.17e^{-4}$
Image5	0.171	$4.78e^{-2}$	$1.65e^{-2}$	$5.20e^{-3}$	$1.40e^{-3}$	$3.39e^{-4}$	$9.50e^{-5}$	$8.14e^{-5}$	$8.14e^{-5}$
Image6	0.100	$4.65e^{-2}$	$1.75e^{-2}$	$5.26e^{-3}$	$1.69e^{-3}$	$3.10e^{-4}$	$2.39e^{-4}$	$1.22e^{-4}$	$7.75e^{-5}$

TABLE 7.2 SIMULATION RESULTS FOR COLORED IMAGES WITH AWGN AND SALT AND PEPPER NOISE

Noise level	**90%**	**80%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**	**0%**
Image1	$1.01e^{-1}$	$4.61e^{-2}$	$1.72e^{-2}$	$5.62e^{-3}$	$1.14e^{-3}$	$3.43e^{-4}$	$2.011e^{-4}$	$9.086e^{-5}$	$8.43e^{-5}$
Image 2	$9.93e^{-2}$	$4.57e^{-2}$	$1.69e^{-2}$	$5.76e^{-3}$	$1.35e^{-3}$	$2.60e^{-4}$	$1.30e^{-4}$	$7.22e^{-5}$	$7.01e^{-5}$
Image3	$1.02e^{-1}$	$4.65e^{-2}$	$1.62e^{-2}$	$4.88e^{-3}$	$1.44e^{-3}$	$5.32e^{-4}$	$2.16e^{-4}$	$1.31e^{-4}$	$8.49e^{-5}$
Image4	$1.00e^{-1}$	$4.48e^{-2}$	$1.72e^{-2}$	$4.84e^{-3}$	$1.23e^{-3}$	$3.38e^{-4}$	$2.14e^{-4}$	$1.24e^{-4}$	$1.24e^{-4}$
Image5	$9.85e^{-2}$	$4.55e^{-2}$	$1.63e^{-2}$	$5.26e^{-3}$	$1.65e^{-3}$	$3.52e^{-4}$	$1.76e^{-4}$	$9.503e^{-5}$	$8.14e^{-5}$
Image6	$1.01e^{-1}$	$4.76e^{-2}$	$1.63e^{-2}$	$5.22e^{-3}$	$1.62e^{-3}$	$5.16e^{-4}$	$1.29e^{-4}$	$1.35e^{-4}$	$1.29e^{-4}$

TABLE 7.3 SIMULATION RESULTS FOR BIOMEDICAL IMAGES WITH AWGN AND SALT AND PEPPER NOISE

Noise Level	90%	80%	60%	50%	40%	30%	20%	10%	0%
Image1	$9.96e^{-2}$	$4.46e^{-2}$	$1.70e^{-2}$	$4.57e^{-3}$	$1.87e^{-3}$	$3.89e^{-4}$	$2.34e^{-4}$	$1.22e^{-4}$	$1.01e^{-4}$
Image2	$9.87e^{-2}$	$4.63e^{-2}$	$1.56e^{-2}$	$4.78e^{-3}$	$1.07e^{-3}$	$2.55e^{-4}$	$1.17e^{-4}$	$8.28e^{-5}$	$8.28e^{-5}$
Image3	$1.00e^{-1}$	$4.45e^{-2}$	$1.69e^{-2}$	$5.37e^{-3}$	$1.07e^{-3}$	$4.55e^{-4}$	$1.86e^{-4}$	$1.51e^{-4}$	$1.50e^{-4}$
Image4	$1.00e^{-1}$	$4.59e^{-2}$	$1.66e^{-2}$	$5.49e^{-3}$	$1.35e^{-3}$	$4.07e^{-4}$	$1.93e^{-4}$	$1.03e^{-4}$	$1.03e^{-4}$
Image5	$9.90e^{-2}$	$4.51e^{-2}$	$1.69e^{-2}$	$4.40e^{-3}$	$1.56e^{-3}$	$4.42e^{-4}$	$1.45e^{-4}$	$1.03e^{-4}$	$9.67e^{-5}$

TABLE 7.4 SIMULATION RESULTS FOR BINARY IMAGES WITH AWGN AND SALT AND PEPPER NOISE

Noise Level	90%	80%	60%	50%	40%	30%	20%	10%	0%
Image1	$9.80e^{-2}$	$4.55e^{-2}$	$1.81e^{-2}$	$4.76e^{-3}$	$1.36e^{-3}$	$2.28e^{-4}$	$1.55e^{-4}$	$9.80e^{-5}$	$9.80e^{-5}$
Image2	$1.01e^{-1}$	$4.51e^{-2}$	$1.58e^{-2}$	$4.96e^{-3}$	$1.116e^{-3}$	$3.90e^{-4}$	$2.69e^{-4}$	$1.04e^{-4}$	$1.04e^{-4}$
Image3	$9.89e^{-2}$	$4.61e^{-2}$	$1.77e^{-2}$	$5.19e^{-3}$	$1.59e^{-3}$	$5.68e^{-4}$	$2.57e^{-4}$	$1.61e^{-4}$	$7.18e^{-5}$
Image4	$1.00e^{-1}$	$4.55e^{-2}$	$1.66e^{-2}$	$5.27e^{-3}$	$1.38e^{-3}$	$2.63e^{-4}$	$8.52e^{-5}$	$2.32e^{-5}$	$2.32e^{-5}$
Image5	$9.66e^{-2}$	$4.47e^{-2}$	$1.48e^{-2}$	$5.27e^{-3}$	$1.32e^{-3}$	$4.31e^{-4}$	$1.34e^{-4}$	$1.06e^{-4}$	$1.28e^{-4}$

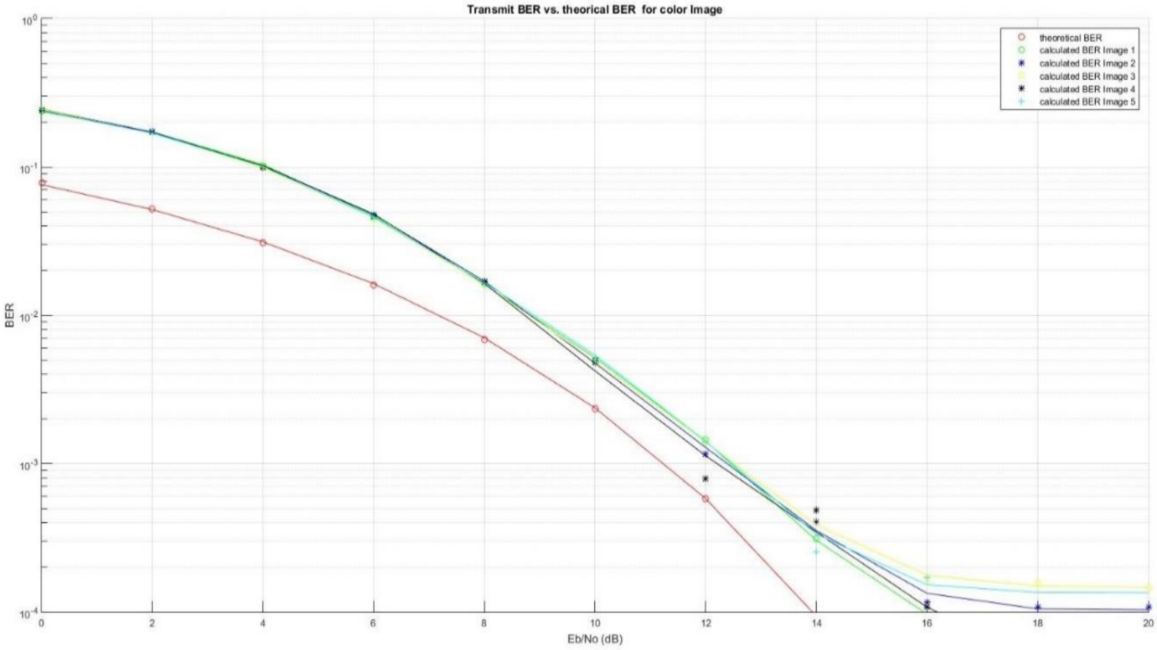


Fig.7.6 BER Vs. EB/NO (dB) plot for colored image with Salt and Pepper Noise and AWGN Noise

Fig.7.3 the transmitted and received colored images over LTE with different dimensions

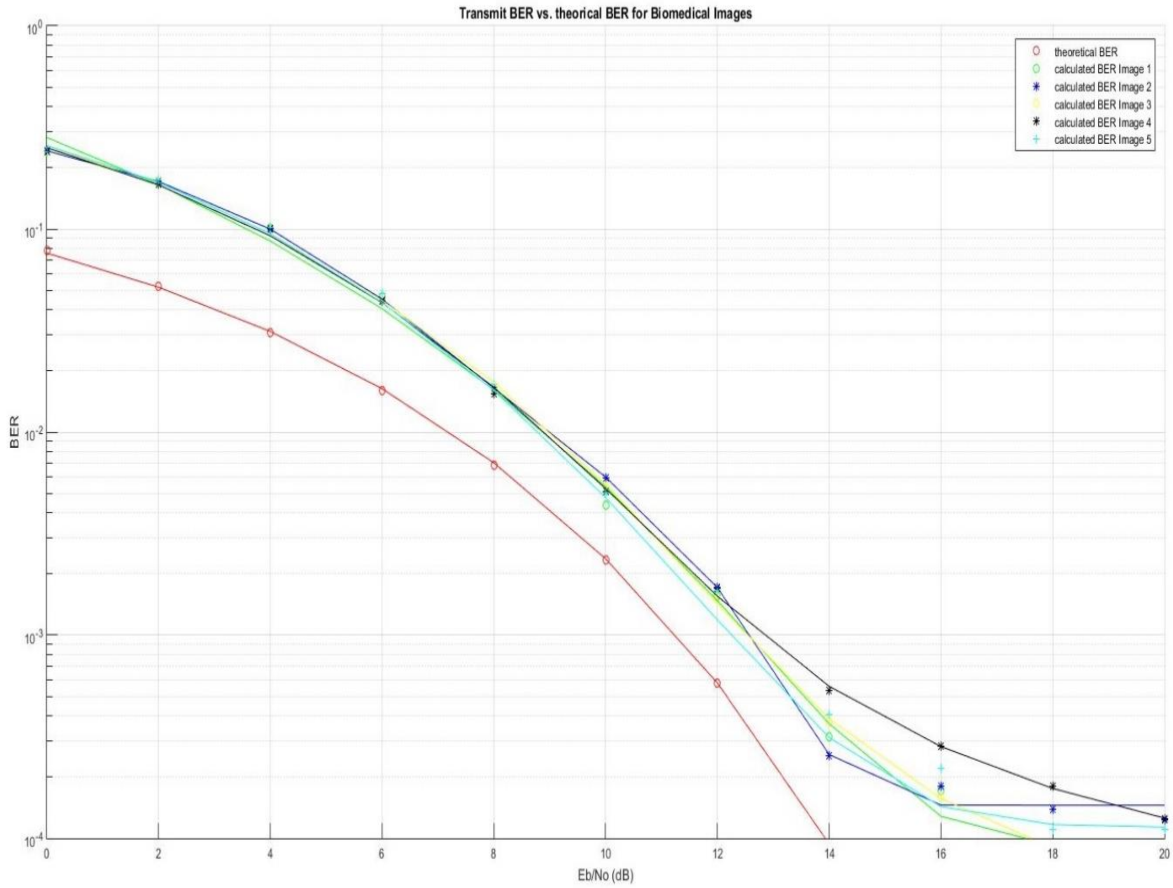


Fig.7.4 BER Vs. EB/NO (dB) plot for Biomedical image with Salt and Pepper Noise and AWGN Noise

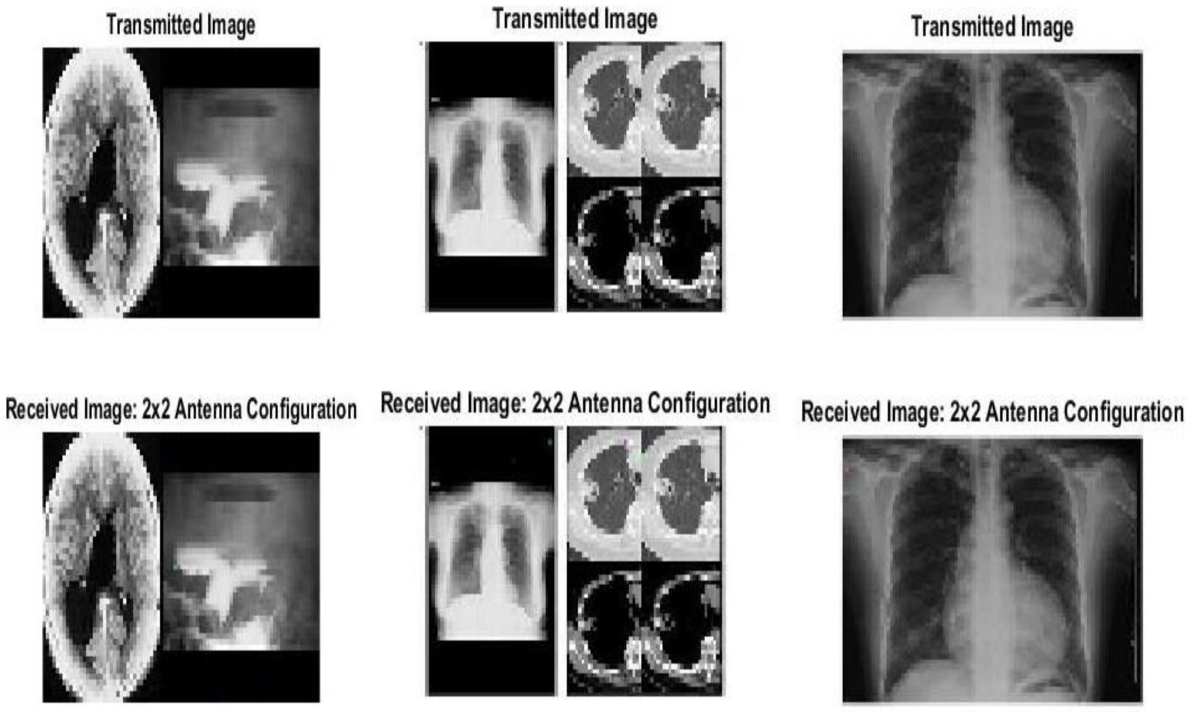


Fig.7.5 the transmitted and received Biomedical images over LTE with different dimensions by adding AWGN and Salt and Pepper Noise

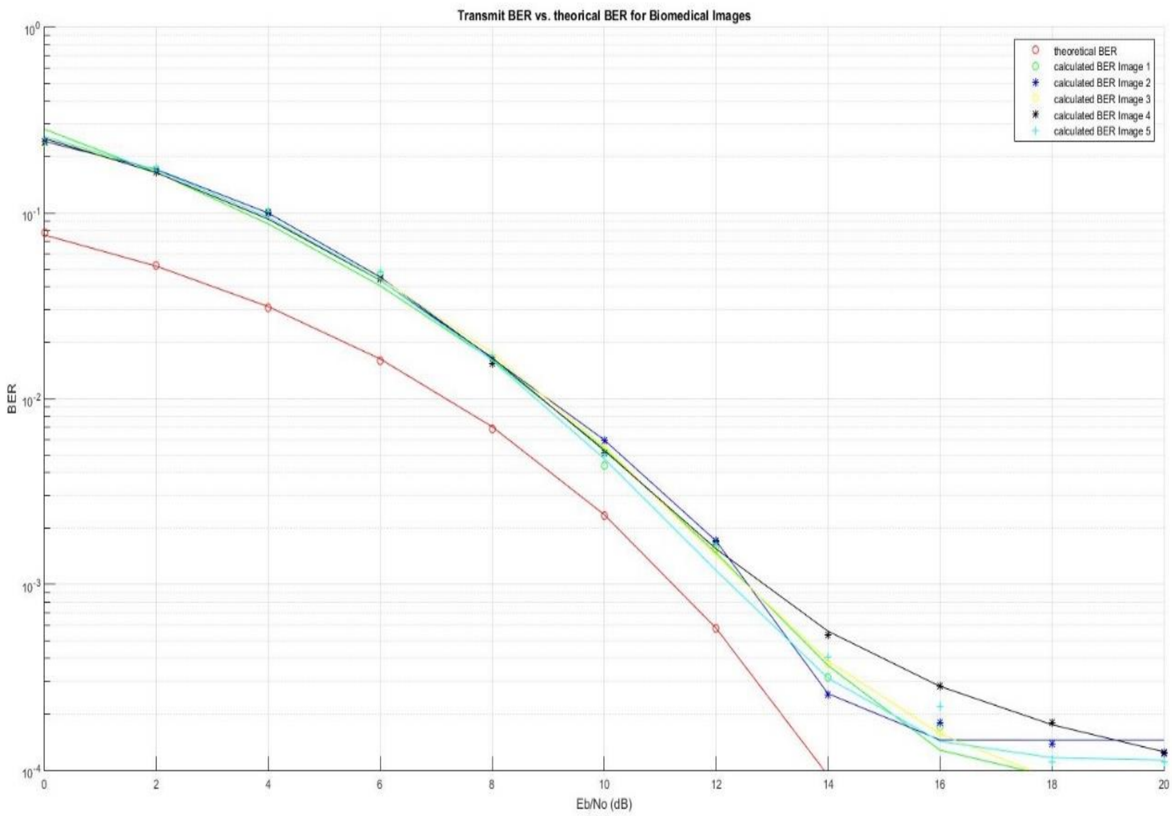


Fig.7.6 BER Vs. EB/NO (dB) plot for Binary image with Salt and Pepper Noise and AWGN Noise

.

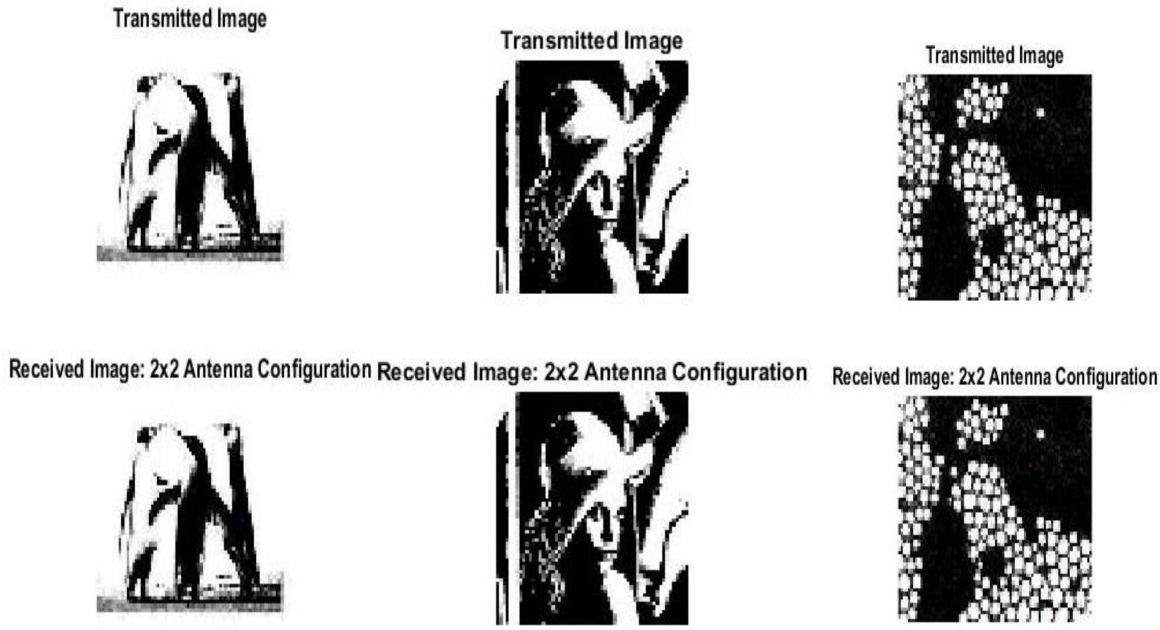


Fig.7.7 the transmitted and received Binary images over LTE with different dimensions by adding AWGN and Salt and Pepper Noise.

TABLE 7.5 FINAL MEANS TABLE FOR SET OF 50 IMAGES FOR EACH OF THREE IMAGE TYPES

Noise Level	90%	80%	60%	40%	20%	10%	0%
Mean of 50 Colored Images	$4.76e^{-1}$	$4.55e^{-2}$	$3.60e^{-2}$	$1.65e^{-3}$	$1.29e^{-4}$	$2.61e^{-4}$	$4.29e^{-5}$
Mean of 50 Biomedical Images	$6.34e^{-1}$	$4.52e^{-2}$	$1.66e^{-2}$	$1.78e^{-3}$	$1.35e^{-4}$	$2.34e^{-4}$	$4.44e^{-5}$
Mean of 50 Binary Images	$6.25e^{-1}$	$4.34e^{-2}$	$1.21e^{-2}$	$1.35e^{-3}$	$3.03e^{-4}$	$3.16e^{-4}$	$4.34e^{-5}$

7.6 CONCLUSION

MIMO channels provide high data rates which make image transmission possible over LTE network with high unwavering quality. Several image processing and channel coding techniques are used to maintain the quality of the transmitted image from transmitter to receiver. In this paper we analyze the transmission of different kind of digital images over LTEMIMO channel by using different image and data processing techniques at both transmitter and the receiver side to reconstruct the original image transmitted from transmitter. An image is imported in the transmitter and Salt and Pepper noise is added to the image and then converted into binary data stream. Then the various signal processing operations are performed on the bit stream like CRC attachment, turbo coding, and 4QPSK modulation and then spatially multiplexed into parallel data streams to be transmitted over LTEMIMO channels. The amount of power transmitted by each antenna depends upon the data to be transmitted by the antenna. Spatial multiplexing is one of the best techniques using in MIMO scheme which gains a linear increase in capacity growth in direct proportion to antenna number. EbNo Vs. BER plots for 4-QPSK over LTEMIMO and AWGN channels for employing MIMO antenna configurations. From the simulation results it can be concluded that in MIMO system, the BER goes on decreasing with increase in SNR. The simulation results indicate that the quality of reconstructed image is excellent than other previous technologies like GPRS irrespective of whether colored, biomedical or binary images are transmitted over the LTE system. Because of unequal power allocation strategy there is noticeable improvement in the PSNR than equal power strategies. The plots drawn represent the BER and SNR and energy per (EbNo) bit got from the LTEMIMO channel with the theoretical calculated results of the LTE MIMO channel. This LTE gives equivalent performance for colored, biomedical and binary images. By analysis all the plots for colored, biomedical and binary images transmission over the LTE it is evident that it gives efficient and quality image transmission type having BER of approximate $4.35e^{-5}$ for EN/BN of 0:20 range for each transmitted image. Table VII contains the mean resultant for 50 set of each type of images Colored, Biometric and Binary.

CHAPTER 7

Conclusion and Future SCOPE

MIMO channels provide high data rates which make image transmission possible over LTE network with high unwavering quality. Several image processing and channel coding techniques can be used to maintain the quality of the transmitted image from transmitter to receiver. In this thesis we will perform the transmission of different kind of digital images over LTEMIMO channel by using different image and data processing techniques at both transmitter and the receiver side to reconstruct the original image transmitted from transmitter. An image can be imported in the transmitter and different types of noises can be added to the image and then converted into binary data stream. Then the various signal processing operations can be performed on the bit stream like CRC attachment, turbo coding, and 4QPSK modulation and then spatially multiplexed into parallel data streams to be transmitted over LTEMIMO channels. The amount of power transmitted by each antenna depends upon the data to be transmitted by the antenna. Spatial multiplexing is one of the best technique using in MIMO scheme which gains a linear increase in capacity growth in direct proportion to antenna number. EbNo Vs. BER plots for 4-QPSK over LTEMIMO and AWGN channels for employing MIMO antenna configurations. WE will also try to enhance the security of the LTE system by improving the Security algorithms.

In this thesis we examines the methodology for assessing the LTE organize limit and execution from the part of enormous capacity, performance and security. There has been statistical increase in the use of mobile devices for browsing the internet (web trending applications and websites, for examples, Facebook, and Twitter), video streaming (Russia Today, Al-Jazeera and Cable News Network (CNN) live broadcasts), Voice-over Internet Protocol (VoIP) applications for internet calls (Mobile VoIP and Skype), medical applications that run on real-time data loggings, video and voice calls and a number of new applications that has greater demands for high data traffic. The most significant factor involved in this is that the service providers have been struggling to provide the demanded rates their customers want. Achieving a higher data rate with minimum BER and security posed the bigger discussion in meeting the subscribers' demands.

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