# AN EFFICIENT LICENSE ASSISTED CLUSTER BASED HETEROGENEOUS LTE NETWORK

## A MAJOR PROJECT REPORT

A DISSERTATION/REPORT submitted in partial fulfilment

submitted by


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for the award of the degree of

**BACHELORS IN TECHNOLOGY IN ELECTRONIC AND COMMUNICATION ENGINEERING**


**V R SIDDHARTHA ENGINEERING COLLEGE**

**(AUTONOMOUS - AFFILIATED TO JNTU, KAKINADA)**

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## CERTIFICATE

This is to certify that the major project titled **"AN FFICIENT LICENSE ASSISTED CLUSTER BASED HETEROGENEOUS LTE NETWORK"** was prepared and presented by **G.HEMA(168W1A015),N.HAVEELA(168W1A35),G.SRAVANI(168W1A016)** of B. Tech., VIII-Semester, Electronics and Communication Engineering in partial fulfilment of requirements for the award of the Degree of Bachelor of Technology in Electronics and Communication Engineering under the Jawaharlal Nehru Technological University Kakinada, Kakinada during the year 2019-20.

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# DECLARATION

We hereby declare that the work is being presented in this Major Project **”An efficient license assisted cluster based heterogeneous LTE network”** submitted towards the partial fulfilment of requirements for the award of the degree of **Bachelor of Technology in Electronics and Communication Engineering** in V.R.Siddhartha Engineering College, Vijayawada is an authentic record of our work carried out under the supervision of **Khalim Amjad Meerja(Professor)** in ECE Department, in V.R.Siddhartha Engineering College, Vijayawada. The matter embodied in this dissertation report has not been submitted by us for the award of any other degree. Furthermore, the technical details furnished in various chapters of this report are purely relevant to the above Major Project.

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# ABSTRACT

In face of the explosive surge of mobile data services, spectrum aggregation or carrier aggregation technology has been proposed to improve system throughput and spectrum efficiency (SE) by aggregating licensed and unlicensed spectrum bands. However, the system performances would be severely deteriorated by the channel access collision if the channel access and resource scheduling approaches are not coordinated among different networks in the same spectrum band. Therefore, in order to improve the system throughput and the SE, a fairness-based license-assisted access and resource scheduling scheme are designed for the coexisting systems, incorporating long term evolution-advanced and Wi-Fi systems in the unlicensed band. The optimal sizes of the contention window in the proposed fairness-based channel access approach are obtained in terms of various density ratios between these two systems. Furthermore, a novel resource scheduling approach employing linear programming is proposed to maximize the utility function with the goal of improving the service experience of users and the SE with various spectrum qualities. The theoretical proofs and simulation results verify the enhanced performances of the proposed approaches in terms of key metrics, such as throughput, SE, delay, and packet loss ratio.

# CHAPTER 1

# INTRODUCTION

The Wireless Sensor Networks (WSN) consists of enormous amount of sensor nodes. These nodes sense the physical parameters from the environment and forward the information to the destination (or) sink node. The sensor nodes have limited sensing, computation and communication capabilities. Those sensor nodes are mostly battery operated devices. This restriction makes the sensor nodes may prone to failure because of the more energy is wasted for data transmission to longer distance. This is a main challenging task in WSN to increase the network lifetime by increasing the number of alive nodes and to decrease the end to end delay and increase the average energy consumption. To aggregate the collected data before transmission is an intelligent technique in WSN. This technique will reduce the number of packets sent across the networks. The existing cluster chain mobile agent routing (CBRP) having high end to end delay and very high energy wasted for unnecessary transmission of data packets. To avoid this, the modified cluster chain based routing protocol are designed. It makes the advantage of very low energy consumption by using clustering hierarchy, improved network lifetime and very low end to end delay by using chain hierarchy.

**5G NETWORKS**:

Like the earlier generation 2G,3G,and 4G mobile networks, 5G networks are digital cellular networks, in which the service area covered by providers is divided into a mosaic of small geographical areas called cells. Analog signals representing sounds and images are digitized in the phone, converted by an Analog to digital converter and transmitted as a stream of bits. All the 5G wireless devices in a cell communicate by radio waves with a local antenna array and low power automated transceiver (transmitter and receiver) in the cell, over frequency channels assigned by the transceiver from a common pool of frequencies, which are reused in geographically separated cells. The local antennas are connected with the telephone network and the Internet by a high bandwidth optical fibre or wireless backhaul connection. Like existing cell phones, when a user crosses from one cell to another, their mobile device is automatically "handed off" seamlessly to the antenna in the new cell.

The exchange of information or communication with the friends, relatives, and dear ones has become very easy and simple that just with a mobile phone we can be in touch with all of them.5G technology is the abbreviation of the fifth generation mobile technology. Wireless communication has commenced in early 1970's and after four decades of it, the technology From 1G to 5G the world of telecommunication is totally changed and now the aim of such industries is to furnish the best of the best services to the customers. The technical people worked very hard to furnish a smooth, undisturbed network and at last they released 5G technology which aims for such wireless telecommunication network. This 5G network offers the data bandwidth of greater than 1Gbps, furnishes CDMA multiplex and has the internet as the core network. Well, the 5G is not completely released but there are few countries which are using the 5G technology has evolved from 1G to 5G.

To all the wireless and mobile networks, the data and the signalling are transferred through the IP i.e. internet protocol or the network layer. Now, coming to the fifth generation technology it furnishes all the necessary and required facilities like mp3 recording, camera, video and audio player, large phone memory and with many more applications which the user have never imagined before. This new period of telecommunication is going to begin and surely changes everything related to the cellular industries. In the coming years, the 5G technology will be in use because of its advancement, affordable cost, and possess a bright future that will keep it safe for years. The mobile multimedia internet networks can be totally the wireless without any limitations and make the networks as worldwide wireless web (WWWW).

This fifth generation is based on 4G technology as it is an advanced form of 4G and the internet networks are truly wireless which are supported by LAS-CDMA which stands for Large Area Synchronized-Code- Division Multiple Access, OFDM which stands for Orthogonal Frequency Division Multiplexing, MC-CDMA which stands for Multi-Carrier Code Division Multiple Access, UMB which stands for Ultra-wideband, Network-LMDS which stands for Local Multipoint Distribution Service and Ipv6. At the same time, 5G technology offers very large data capabilities, unlimited data broadcast with the mobile operating system. It makes the vital difference, give more services and advantages to the world when compared to 4G. The people are not availing it as these are just theories but before the innovation of 4G it was also a theory and now it is in existence which proves that theories are the base of every innovation.

**ADVANTAGES:**

- 5G promises superior speeds in most conditions to the 4G network. Qualcomm presented a simulation at Mobile World Congress that predicts 490 Mbit/s median speeds for 3.5 GHz 5G Massive MIMO and 1.4 Gbit/s median speed for 28 GHz mm Wave. 5G NR speed in sub-6 GHz bands can be slightly higher than the 4G with a similar amount of spectrum and antennas, though some 3GPP 5G networks will be slower than some advanced 4G networks, such as T-Mobile's LTE/LAA network, which achieves 500+ Mbit/s in Manhattan.

The 5G specification allows LAA (License Assisted Access) as well but it has not yet been demonstrated. Adding LAA to an existing 4G configuration can add hundreds of megabits per second to the speed, but this is an extension of 4G, not a new part of the 5G standard.[19]

- The major advantage is that 5G networks achieve much higher data rates than previous cellular networks, up to 10 Gbit/s; which is faster than current cable internet, and 100 times faster than the previous cellular technology, 4G LTE.
- Another advantage is lower network latency (faster response time),below 1msec (millisecond), compared with 30-70ms for 4G. Because of the higher data rates,5G networks will serve not just cell phones but are also envisioned as a general home and office networking provider, competing with wired internet providers like cable.
- Previous cellular networks provided low data rate internet access suitable for cell phones, but a cell tower could not economically provide enough bandwidth to serve as a general internet provider for home computers.
- Speed in the transmissions can approach 15 or 20 Gbps. By being able to enjoy a higher speed we can access files, programs and remote applications in a totally direct and without waiting.

For example, being able to activate software remotely as if it were executed in personal devices, will allow not having installed the mobile applications (APPs) in the terminal and executing them directly from the cloud.

- Because of the increased bandwidth, people will be able to use more of it without crowding out other users. With more of the network dedicated to each individual smart device, smart devices will be able to run faster than ever before.

- ❖ In 5G the latency will be ten times less than in 4G, being able to perform remote actions in real time.
- ❖ With 5G the number of devices that can be connected to the network increase greatly. It will go to millionaire scale per square kilometre.
- ❖ For the low latency and the increase of the sensors, it is possible to control the machinery of an industrial plant, control logistics or remote transport, surgical operations in which the doctor can intervene a patient who is at another side of the world with the help of precision instrumentation managed remotely or the complete control of remote transport systems, automated and without driver.

5G networks achieve these higher data rates by using higher frequency radio waves, in or near the milli meter wave band from 30 to 300 GHz, whereas previous cellular networks used frequencies in the microwave band between 700 MHz and 3 GHz. A second lower frequency range in the microwave band, below 6 GHz, will be used by some 5G providers, but this will not have the high speeds of the new frequencies. Because of the more plentiful bandwidth at milli meter wave frequencies, 5G networks will use wider frequency channels to communicate with the wireless device, up to 400 MHz compared with 20 MHz in 4G LTE, which can transmit more data (bits) per second. OFDM (orthogonal frequency division multiplexing) modulation is used, in which multiple carrier waves are transmitted in the frequency channel, so multiple bits of information are being transferred simultaneously, in parallel.

**HARDWARE OF 5G**

- It uses UWB (Ultra Wide Band) networks with higher BW at low energy levels.
- This BW is of 4000 Mbps, which is 400 times faster than today's wireless networks.
- It uses smart antenna either Switched Beam Antennas or Adaptive Array• Antennas.
- It uses CDMA (Code Division Multiple Access).

**SOFTWARE OF 5G**

- 5G will be single unified standard of different wireless networks, including LAN technologies, LAN/WAN, WWWW- World Wide Wireless Web, unified IP & seamless combination of broadband.
- Software defined radio, Packet layer, Implementation of Packets, Encryption, Flexibility, Anti-Virus.

**FEATURES OF 5G**

- 5G technology offer high resolution for crazy cell phone user and bidirectional large bandwidth shaping.
- The advanced billing interfaces of 5G technology makes it more attractive and effective.
- 5G technology also providing subscriber supervision tools for fast action. ¬ The high quality services of 5G technology based on Policy to avoid error.
- 5G technology is providing large broadcasting of data in Gigabit which supporting almost 65,000 connections.
- 5G technology offer transporter class gateway with unparalleled consistency.
- The traffic statistics by 5G technology makes it more accurate.
- Through remote management offered by 5G technology a user can get better and fast solution.
- The remote diagnostics also a great feature of 5G technology.
- The 5G technology is providing up to 25 Mbps connectivity speed.
- The 5G technology also support virtual private network.
- The new 5G technology will take all delivery service out of business prospect.
- The uploading and downloading speed of 5G technology touching the peak.
- The 5G technology network offering enhanced and available connectivity just about the world.

Low-band 5G uses a similar frequency range as current 4G cell phones, 600 - 700 MHz giving download speeds a little higher than 4G: 30-250 Megabits per second (Mbps). Low-band cell towers will have a similar range and coverage area to current 4G towers. Mid-band 5G uses microwaves of 2.5-3.7 GHz, currently allowing speeds of 100-900 Mbps,with each cell tower providing service up to several miles radius. This level of service is the most widely deployed, and should be available in most metropolitan areas in 2020. Some countries are not implementing low-band, making this the minimum service level. High-band 5G uses frequencies of 25 - 39 GHz, near the bottom of the millimetre wave band, to achieve download speeds of 1 - 3 Gigabits per second (Gbps), comparable to cable internet.

The ITU-R has defined three main application areas for the enhanced capabilities of 5G. They are Enhanced Mobile Broadband (eMBB), Ultra Reliable Low Latency Communications (URLLC), and Massive Machine Type Communications (mMTC). Only eMBB is deployed in 2020; URLLC and mMTC are several years away in most locations.

Enhanced Mobile Broadband (eMBB) uses 5G as a progression from 4G LTE mobile broadband services, with faster connections, higher throughput, and more capacity. Ultra-Reliable Low-Latency Communications (URLLC) refer to using the network for mission critical applications that require uninterrupted and robust data exchange. Massive Machine-Type Communications (mMTC) would be used to connect to a large number of devices, 5G technology will connect some of the 50 billion connected IOT devices. Most will use the less expensive Wi-Fi. Drones, transmitting via 4G or 5G, will aid in disaster recovery efforts, providing real-time data for emergency responders. Most cars will have a 4G or 5G cellular connection for many services. Autonomous cars do not require 5G, as they have to be able to operate where they do not have a network connection. While remote surgeries have been performed over 5G, most remote surgery will be performed in facilities with a fibre connection, usually faster and more reliable than any wireless connection.

**DESIGN TECHNIQUES:**

Milli meter waves are absorbed by gases in the atmosphere and have shorter range than microwaves, therefore the cells are limited to smaller size; 5G cells will be the size of a city block, as opposed to the cells in previous cellular networks which could be many kilo meters across. The waves also have trouble passing through building walls, requiring multiple antennas to cover a cell.

Milli meter wave antennas are smaller than the large antennas used in previous cellular networks, only a few inches (several cm) long, so instead of a cell tower 5G cells will be covered by many antennas mounted on telephone poles and buildings.

In a technique called beam forming the base station computer will continuously calculate the best route for radio waves to reach each wireless device, and will organise multiple antennas to work together as phased arrays to create beams of milli meter waves to reach the device. The smaller,more numerous cells makes 5G network infrastructure more expensive to build per square kilometer of coverage than previous cellular networks. Deployment is currently limited to cities, where there will be enough users per cell to provide an adequate investment return, and there are doubts about whether this technology will ever reach rural areas. The existing systems the routing protocol is have a mobile Agents are very much useful to perform the aggregation of the data. Here, the Mobile agent is used to monitor the node mobility and data aggregation. The most important focus of the system is to design an energy efficient and improve the network lifetime for the routing protocols.

**APPLICATIONS:**

- Virtual reality and Augmented reality
- Fast machine to machine interaction in the IOT
- Enhanced mobile broadband (EMBB)
- Ultra reliable low latency communication (URLLC)
- Massive machine type communication (MMTC

The nodes sense the physical parameters from the environment and forward the information to the destination (or) sink node. The sensor nodes have limited sensing, computation and communication capabilities. Those sensor nodes are mostly battery - operated devices. This restriction makes the sensor nodes may prone to failure because of the more energy is wasted for data transmission to longer distance. This is a main challenging task in WSN to increase the network lifetime by increasing the number of alive nodes and to decrease the end to end delay and increase the average energy consumption. To aggregate the collected data before transmission is an intelligent technique in WSN. This technique will reduce the number of packets sent across the networks. The existing cluster chain mobile agent routing (CBRP) having high end to end delay and very high energy wasted for unnecessary transmission of data packets. To avoid this, the modified cluster chain-based routing protocol are designed. It makes the advantage of very low energy consumption by using clustering hierarchy, improved network lifetime and very low end to end delay by using chain hierarchy.

**BPSK MODULATION**

Consider a sinusoidal carrier. If it is modulated by a bi-polar bit stream according to the scheme illustrated in Figure 1 below, its polarity will be reversed every time the bit stream changes polarity. This for a sine wave, equivalent to a phase reversal (shift). The multiplier output is a BPSK 1signal.The information about the bit stream is contained in the changes of phase of the transmitted signal. A synchronous demodulator would be sensitive to these phase reversals. The appearance of a BPSK signal in the time domain is shown in Figure (lower trace). The upper trace is the binary message sequence.

There is something special about the waveform of figure 2.The wave shape is "symmetrical" at each phase transition. This is because the bit rate is a submultiples of the carrier frequency $\omega/(2\pi)$. In addition, the message transitions have been timed to occur at a zero-crossing of the carrier. Whilst this is referred to as 'special', it is not uncommon in practice. It offers the advantage of simplifying the bit clock recovery from a received signal. Once the carrier has been acquired then the bit clock can be derived by division.

Demodulation of a BPSK signal can be considered a two-stage process.

1. Translation back to baseband, with recovery of the band limited message waveform

2. Regeneration from the band limited waveform back to the binary message bit stream. Translation back to baseband requires a local, synchronized carrier.

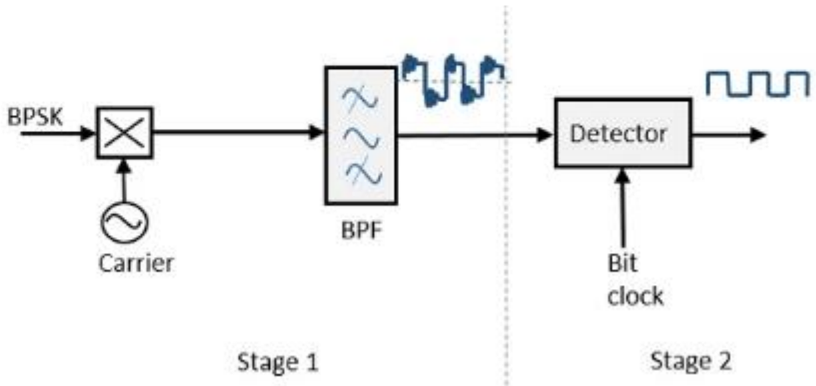


Fig:1.1 demodulation of Bpsk in 2 stages

# CHAPTER 2

# LITERATURE SURVEY

Q. Zhang, T. Yang, Yue Zhang and Z. Feng **[1]** proposed solutions for capacity enhancement, densely deployed small cells are proposed to provide a huge capacity gain and improve the user experience with high data rate services. However, the inter-cell interference among densely deployed cells is a big challenge that constraints the performance of capacity improvements in hierarchical multi-tier heterogeneous cellular networks. To minimize the inter-cell interference and achieve a fairness guaranteed solution among different users, a novel enhanced inter-cell interference coordination (e ICIC) technology is proposed by jointly considering about the cell range expansion (CRE) scheme to minimize interferences among multi-tier cellular networks, improving the network throughput and quality of service (QoS). Optimal CRE bias and almost blank subframe (ABS) ratio solutions are achieved in this paper by considering the fairness among users at the centre and cell edge. Moreover, the multi-objective decision-making problem is solved by maximizing the proportional fairness (PF) utility and area capacity in multi-tier heterogeneous cellular networks. Simulation results denote that a trade-off between fairness and network throughput is achieved when CRE bias is from 8 to 12 dB and ABS ratio is from 4/8 to 6/8.

M. Agiwal, Abhishek Roy, and N. Saxena [2] stated that Ever increasing proliferation of smart devices, introduction of new emerging multimedia applications, together with an exponential rise in wireless data (multimedia) demand and usage is already creating a significant burden on existing cellular networks. 5G wireless systems, with improved data rates, capacity, latency, and QoS are expected to be the panacea of most of the current cellular networks' problems. The new architectural changes associated with the radio access network (RAN) design, including air interfaces, smart antennas, cloud and heterogeneous RAN are discussed. Subsequently, they make an in-depth survey of underlying novel mm-wave physical layer technologies, encompassing new channel model estimation, directional antenna design, beam form algorithms, and massive MIMO technologies. Next, the details of MAC layer protocols and multiplexing schemes needed to efficiently support this new physical layer are discussed.

F. M. Abinader, Jr., Erika P. L. Almeida, Fabiano S. Chaves, André M. Cavalcante, Robson D. Vieira, Rafael C. D. Paiva, Angilberto M. Sobrinho, Sayantan Choudhury, Esa Tuomaala, Klaus Doppler, and Vicente A. Sousa, Jr, [3] In this article, they discuss the issues that arise from the concurrent operation of LTE and Wi-Fi in the same unlicensed bands from the point of view of radio resource management. They show that Wi-Fi is severely impacted by LTE transmissions; hence, the coexistence of LTE and Wi-Fi needs to be carefully investigated. They discuss some possible coexistence mechanisms and future research directions that may lead to successful joint deployment of LTE and Wi-Fi in the same unlicensed band.

A.Bhorkar, C. Ibars, and P. Zong [4] proposed that, the multi-channel performance of largescale deployment of Long-Term Evolution (LTE) in Unlicensed (LTE-U) band and Wi-Fi using stochastic geometry is studied. This stochastic geometry-based framework is used to analyse the co-existence of LTE- U and Wi-Fi systems operating in the same set of available channels in unlicensed band. Several interesting results are derived. First, it is shown that fair coexistence can be achieved by LTE-U implementing a Listen-Before-Talk (LBT) protocol. Different variations of LBT are explored to improve the co-existence. Secondly, it is shown that the classical hidden node problem can severely affect performance, and that channel selection mechanisms can significantly alleviate the problem.

H. Zhang, X. Chu, W. Guo and S. Wang [5] proposed that, due to the limited licensed spectrum for cellular networks, any effort to achieve capacity growth through network densification will face the challenge of severe inter-cell interference. In view of this, recent standardization developments have started to consider the opportunities for cellular networks to use the unlicensed spectrum bands, including the 2.4 GHz and 5 GHz bands that are currently used by Wi-Fi, Zigbee and some other communication systems. In this article, they mainly look into the coexistence of Wi-Fi and 4G cellular networks sharing the unlicensed spectrum. They introduce a network architecture where small cells use the same unlicensed spectrum that Wi-Fi systems operat in without affecting the performance of Wi-Fi systems. They present an almost blank subframe (ABS) scheme without priority to mitigate the co-channel interference from small cells to Wi-Fi systems, and propose an interference avoidance scheme based on small cells estimating the density of nearby Wi-Fi access points to facilitate their coexistence while sharing the same unlicensed spectrum.

R. Zhang, Z. Zheng, M. Wang, X. Shen, and L.-L. Xie, [6] In this paper, the (equivalent capacity) EC performance of LTE-A systems with CA for LTE and LTE-A users under two bandwidth allocation strategies are studied. The concept of effective bandwidth has been introduced to map the user throughput requirement into the bandwidth requirement considering the wireless channel statistics. Then, closed-form expressions of EC have been derived with the binomial-normal approximation for both kinds of users under both strategies. We have further formulated a net profit-maximization problem to investigate the trade- off among the bandwidth weights for heterogeneous user classes.

R. Zhang, M. Wang, L. X. Cai, Z. Zheng, X. Shen, and L.-L. Xie, [7] proposed that a comprehensive overview of the LTE-U technology from both operator and user perspectives, and examine its impact on the incumbent unlicensed systems. Specifically, they first introduce the implementation regulations, principles, and typical deployment scenarios of LTE-U. Potential benefits for both operators and users are then discussed. They further identify three key challenges in bringing LTE-U into reality together with related research directions. In particular, the most critical issue of LTE-U is coexistence with other unlicensed systems, such as widely deployed Wi-Fi. The LTE/Wi-Fi coexistence mechanisms are elaborated in time, frequency, and power aspects, respectively. Simulation results demonstrate that LTE-U can provide better user experience to LTE users while well protecting the incumbent Wi-Fi users' performance compared to two existing advanced technologies: cellular/Wi-Fi interworking and licensed-only heterogeneous networks.

R. Ratasuk et al., [8] proposed that, this paper investigates deploying LTE in a license-exempt band as part of the pico-cell underlay. Coexistence mechanism and other modifications to LTE are discussed. Performance analysis shows that LTE can deliver significant capacity even while sharing the spectrum with Wi-Fi systems.

F. M. Abinader et al., [9] show that Wi-Fi is severely affected by concurrent operation of LTE in the same band. This indicates a serious need for coexistence mechanisms to improve the performance of both systems. The applicability of some coexistence enabling features for both LTE and Wi-Fi are discussed, and research directions for further development of inter-technology coexistence are presented. They also propose coexistence mechanisms by reusing the blank subframe approach and the UL transmit power used in LTE, and show that it can significantly improve Wi-Fi performance when coexisting with LTE in the same unlicensed bands.

H. Ko, J. Lee, and S. Pack [10] proposed a fair listen-before-talk (F-LBT) algorithm to allocate the appropriate number of idle subframes by considering the fairness between LTE-U and WLAN and the total system throughput. To this end, F-LBT estimates the number of WLAN nodes and then determines the number of idle subframes. Evaluation results demonstrate that F- LBT provides higher fairness between LTE-U and WLAN while maintaining high total system throughput. In our future work, we will extend the proposed algorithm to reflect different channel qualities of each nodes and investigate time division duplexing (TDD) based LTE-U system where both uplink and downlink transmissions are conducted in the same bands.

Shao-Yu Lien, Shin-Lin Shieh, Yenming Huang, Borching Su, Yung-Lin Hsu, and Hung-Yu WeiIn provided in this article, foundations of radio access including deployment scenarios sustaining LTE/NR interworking, frame structure multiplexing multiple numerologies, DFT-S-OFDM- and CP-OFDM based new waveforms, NOM-based multiple access, RA with beam steering, and enhanced CA for RA latency improvement are revealed. The insights provided thus boost knowledge not only for engineering practice but also for further technological designs. Nevertheless, NR is just at the beginning stage of development, and a number of issues and optimizations still remain open for further study Qingyue Long provided a comprehensive review of cellular system evolution towards software defined 5G/6G networks. And the first part was about the 5G/6G application scenarios, key technologies and the SDN. On this basis, he made a systematic introduction to SDN. The SDN architecture provided open control of the network through changing differences among network devices.Routing mechanism in network, which solved the problem of complex network configuration, can be defined conveniently under the traditional IT network architecture. Then on the basis of 5G/6G network design principles, he gave the future network structure based on SDN. And next, he discussed the recent resource allocation and management methods. Due to the existence of advanced spectrum sensing and monitoring technologies, REMs could play a significant Mobile Network Apply role in future network research. Meanwhile, he also looked into the recent 5G/6G networks mobility management technology and discussed how to solve the mobility problem of connected-state reasonably in ultra-dense networks with SDN. He did a brief survey on the interference management based on SDN in 5G/6G wireless networks. Moreover, he gave a detailed description of the IG abstraction that can be used by the SDN controller to optimize network segments with several practical constraints. Finally, we pointed out the research challenges and open issues on SDN based 5G/6G networks and identified the possible directions of next work

Wi-Fi is already widely deployed and continue to be with the next generation of 802.11 in the unlicensed 60GHz bands. LTE-A/Wi-Fi and 5G New Radio/Wi-Fi coexistence will be a critical challenge for IoT networks and beyond 5G. In this paper, we investigate the eLAA/Wi-Fi coexistence in the same spectrum for uplink scheduled and random access witha combined spatial and time domain model based on Markov chain and stochastic. geometry tools. The analytical model and numerical results show that eLAA uplink transmission would impact more Wi-Fi performance in SA than RA. Maintaining RA like Wi-Fi would be the best choice for eLAA fair coexistence with other RATs including eLAA itself. In RA with LBT-category 4, the synchronization procedure is not needed, UEs can start transmission immediately when they sense the channel to be free. This procedure will avoid the double LBT mechanism and design complexity observed in the SA. However, the drawback of implementing RA for eLAA uplink transmission is that LTE-A will lose its high effeciency for uplink multiplexing since only one user will occupy the channel for a given transmission opportunity.

Weiwei Zhou, Gordon J. Sutton, J. Andrew Zhang, proposed an admission control scheme for LAA eNBs based on quantitative delay analysis for LAA and WiFi coexisting systems in the unlicensed band. Our scheme can guarantee the desired MAC delay for the LAA eNBs via controlling the number of admitted LAA eNBs, based on the number of existing WiFi stations. Our algorithm also works for other systems, such as MulteFire, that operate in the unlicensed band and support the LBT mechanism. Our investigation on channel occupation ratio (COR) discloses that LAA eNBs benefit from designated longer frame and that admitting more eNBs can degrade the overall system performance. Our study on the fairness index of COR further highlights the importance of the frame length and the number of admitted stations on the overall system fairness of access. Our work hence provides an accurate method for admission control, guaranteeing the MAC delay of the LAA eNBs.Mohammed Hirzallah, Marwan Krunz, Yong Xiao, developed simple yet accurate approximate closed-form solutions that allow MNOs to evaluate their operation over unlicensed bands with heterogeneous channel access priority classes. These approximate closed-form solutions can be used in practical scenarios to decide on resource allocation for LTE and Wi-Fi systems. Extensive simulation results reveal that some of the channel access parameters adopted by 3GPP to operate over unlicensed channels are not fair to Wi-Fi systems. We find that changing the values of AIFSN and CWmin of LTE priority classes P1 and P2 improves fairness between LTE and Wi-Fi systems. They also find that changing the AIFS values for LTE/Wi-Fi priority classes impact their coexistence more than changing their contention window.

Atoosa Dalili Shoaei_, Mahsa Derakhshaniy, Tho Le-Ngoc_provided in order to satisfy the increasing demand for mobile traffic, LTE operation over unlicensed bands has been proposed. In this paper, they consider the scenario that both LTE and WiFi systems share the same unlicensed band. In such a setting, the main challenge for U-LTE deployment is that the performance of WiFi system should not degrade significantly. In order to address this issue, they consider a coordinated approach in which both systems are connected to a central network entity. This entity manages the channel access between these two systems such that the overall spectrum efficiency is improved, while the WiFi performance does not fall below a certain level. In order to reach this goal, a duty-cycle-based approach is used, in which the time is divided into duty cycles and the exclusive share of each system is dynamically optimized by the network entity. It is shown that the developed algorithm can ensure a minimum throughput requirement for WiFi while maximizing the total throughput. Furthermore, they obtain an upper-bound for average delay of LTE users. Using this analysis, we can derive minimum number of LTE users that can be admitted by the network while their delay requirements are met.

Xinyi Liu, Zhiqing Wei, Zhiyong Feng, Fan Nin said a MAC protocol named UD-MAC has been proposed to exploit returning UAVs to construct delay tolerant transmission. CNPC links have been used to support security functions and inform GU with information about the states of UAVs. We designed an adaptive access time slots assignment scheme. GU changes the number of time slots assigned to each type of nodes according to the number of UAVs in different states. We also set different access priorities in UD-MAC to achieve superior access efficiency. Simulation results proved that UD-MAC has higher access efficiency than VeMAC. Harim Lee and Hyun Jong Yang, they have proposed the downlink interference control scheme based on power allocation for the eNB, which protects its transmission from the interference of asymmetric hidden terminals. Through extensive simulation results, they conclude that our proposal allows the eNB to effectively prevent the exposure boundary APs from becoming asymmetric hidden terminals. As a result, the proposed scheme increases throughput and reduces long delay of the eNB while preserving or even improving the performance of WLAN in various deployment scenarios.

Kangjin Yoon, Weiping Sun, and Sunghyun Choi ,they have proposed COALA to mitigate the impact of collisions to MCS selection. They first show that AMC, the conventional link adaptation of LAA, does not operate well in unlicensed band due to collisions. To solve this problem, COALA detects collision based on unsupervised clustering and takes different MCS selection strategies depending on whether a received CQI report is affected by collision or not. By doing so, COALA can avoid the usage of unnecessarily low MCS. Our implementation and simulation verify the feasibility and the performance of COALA in various scenarios. COALA improves the LAA throughput by up to 10.6% and the LAA UPT by up to 74.7% when four LAA eNBs coexist. COALA also yields the LAA throughput improvement of up to 38.6% when there are hidden collisions. As future work, they plan to extend our algorithm for uplink transmission of LAA.

Michal Cierny, Timo Nihtilä, Toni Huovinen, Markku Kuusela, Fedor Chernogorov, Kari Hooli, and Antti Toskala says this work represents a deep dive into the channel access of Rel-13 LAA, the first major venture of a cellular system into the unlicensed spectrum. They discussed the effect of this channel access mechanism on coexistence with the incumbent WiFi counterpart and subsequently augment the discussion with insightful system simulation results. In a realistic scenario LAA coexists well with WiFi as is, whereas in an artificial DL-only scenario small adjustments to the channel access mechanism suffice to achieve the same. The downlink channel access of LAA is also used in Rel-14 eLAA and in MulteFire; therefore, some of our insights are applicable for these technologies. Uplink channel access and standalone functionality deserve their own investigations. Furthermore, we believe that 3GPP will attempt to reuse the downlink channel access mechanism in 5G, simply to avoid lengthy coexistence discussions. But 5G may also open interesting new frontiers. For example, could a 5G node avoid transmission in the direction of a victim WiFi node, but stay active in the other directions? Or can we define spectrum sharing principles that are a compromise between licensed spectrum that is expensive and unlicensed spectrum where nothing is guaranteed? Such discussions may have already started.

Yifei Cai, Qixun Zhang, Zhiyong Feng says a QoS-guaranteed resource scheduling framework was proposed for the 5G V2X heterogeneous systems and three types of services with different QoS requirements were considered. A novel resource scheduling scheme considering the traffic load, buffer queue length and the users' fairness was proposed and a dynamic programming based RB allocation algorithm was applied to maximize the system utility by ensuring the QoS requirements of different services. System level simulations demonstrated that the proposed scheme can utilize radio resources in a more efficient way and satisfy different users' QoS requirement in 5G NR-V2X system.

Harim Lee and Hyun Jong Yang have proposed the downlink interference control scheme based on power allocation for the eNB, which protects its transmission from the interference of asymmetric hidden terminals. Through extensive simulation results, we conclude that our proposal allows the eNB to effectively prevent the exposure boundary APs from becoming asymmetric hidden terminals. As a result, the proposed scheme increases throughput and reduces long delay of the eNB while preserving or even improving the performance of WLAN in various deployment scenarios.

Xuan Chen, Yubin Xu, Lin Ma have proposed a queuing model to analyze the performance of IEEE 802.11 DCF. Based on the classic Markov model for the binary exponential backoff procedure in DCF in the saturated case, the proposed model analyzes the performance in the unsaturated case. Compared with existing models which only focus on the saturated case, the proposed model can analyze the unsaturated case for specific traffic types, and get the key QoS parameters of the traffic. Besides, the effects caused by the shadow channel were taken into account to make the model more close to actual systems. Hence, the proposed model could be applied in many fields such as access control, congestion control, VoWLAN and etc.

Jinming Wen, Baojian Zhou, Wai Ho Mow and Xiao-Wen Chang proposed based on the idea of sphere decoding, a new low-complexity algorithm, which gives the optimal coefficient vector that maximizes the computation rate for a relay in the compute-and-forward scheme is proposed. They derived an efficient algorithm to compute the Cholesky factorization by using the special structure of the Gram matrix. It transformed the problem into a SVP in O(n) flops without explicitly forming the whole Cholesky factor matrix. Some conditions, under which e1 is an optimal coefficient vector, have also been given, and can be checked in O(n) flops. They then modified the Schnorr-Euchner search algorithm to solve the SVP by taking advantage of the properties of the optimal coefficient vector. They showed that the expected complexity of our new method is O(n1:5) for i.i.d. Gaussian channel entries based on the Gaussian heuristic. Simulations showed that our optimal method is not only much more efficient than the existing ones that give the optimal computation rate, but is also more efficient than some best previously known methods that give the close-to-optimal rate. In addition, they demonstrated how to adapt our algorithm so that it can be applied in compute-and forward design.

GORDON J. SUTTON1 , REN PING LIU1  AND Y. JAY GUO1 has developed a model for Wi-Fi and LTE-frame MAC-delay distributions, for an eNB operating under a load-based listenbefore-talk (LB-LBT) channel-access scheme and coexisting with Wi-Fi in the unlicensed spectrum. The LB-LBT scheme belongs to LBT Category 4, as recommended by 3GPP, and employs a slot-based backoff process, similar to that used by Wi-Fi stations, with slot transitions synchronised with Wi-Fi MAC slots. The model was validated by simulations, with agreement between the model and simulations in the upper tails of the MAC-delay distributions. Wi-Fi and LTE throughput and reliability were explored. As expected, the LTE throughput increased with LTE frame Delay and Reliability of Load-Based Listen-Before-Talk in LAA duration, decreased with Wi-Fi load and decreased with average initial LTE backoff window length, while Wi-Fi throughput had the opposite interactions. LB-LBT was more reliable than Wi-Fi, with LTE backoff window set to [0, 100]. For example, the LTE-frame reliability was almost 100% at MAC-delay 25 ms, with 20 competing Wi-Fi STAs, whereas the Wi-Fi reliability had dropped to 92% at MAC-delay 25 ms with 10 competing Wi-Fi STAs The scheme proposed to control of the LTE/Wi-Fi channel time share by adjusting the initial LTE backoff window based on the channel activity, which is monitored while implementing the LB-LBT backoff procedure. With the LTE/WiFi channel-time share maintained at 50%, the upper tail of the Wi-Fi MAC-delay CDF was found to be sensitive to the Wi-Fi load, but insensitive to the LTE parameters. Instead, the LTE-frame MAC-delay CDF was insensitive to the Wi-Fi load, but sensitive to the LTE frame duration and the spread of the initial LTE backoff-window around an average length. In particular, for the same LTE channel-time share, reducing the LTE frame duration and the initial LTE backoff-window spread produces lower LTE delays, while having little impact on the Wi-Fi delay. The model was used to explore the trade-off between LTE throughput, LTE frame-duration, and LTE-frame MAC delay under LB-LBT for a given channel-time share constraint. An 'example feasible region' was identified that achieved 30 Mbps LTE throughput with 99% reliability at 30 ms LTE frame MAC-delay, while the process was controlled to meet a 50% channel-share constraint; thereby demonstrating the plausibility of using the unlicensed spectrum for reliable LTE communications.

# CHAPTER 3

# LTE NETWORKS

## AMPLIFY FORWARD METHOD FOR CO-OPERATIVE MIMO COMMUNICATION:

In general, it can be proved that there must be an optimal subcarrier and power allocation scheme that satisfies the proportional fairness constraints and the total power constraint. Furthermore, the optimal scheme must utilize all available power. Several facts lead to the above conclusion. First, to a certain user, that capacity of the user is maximized if water filling algorithm is adopted. Furthermore, the capacity function is continuous with respect to the total available power to that user. In other words, Rk(Pk,tot) is continuous with Pk,tot. Second, if the optimal allocation scheme does not use all the available power, there is always a way to redistribute the unused power among users while maintaining the capacity ratio constraints, since Rk(Pk,tot) is continuous with Pk tot for all *k*. Thus, the overall capacity is further increased.

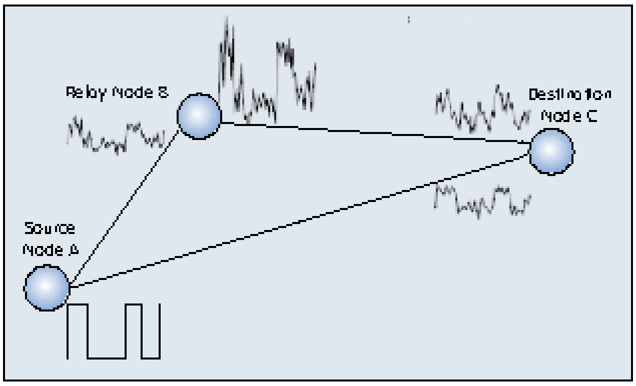


**Fig:3.1 signal processing in AF scheme**

As shown in Figure, signal processing in AF scheme can be simplified into three phases: In Phase 1, the source node transmits the signals by way of broadcasting, while the destination node and the relay node receive the signals. In Phase 2, the relay node amplifies the powers of the signals received from the source node and forwards them to the destination node. In Phase 3, the destination node combines and decodes the signals received from the source Code in Phase 1 and the relay node in Phase 2 so as to restore the original information. AF is also called non-regenerative relaying scheme and it is basically a processing method for analog signals. Compared with other schemes, AF is the simplest. Besides, as the destination node can receive independent fading signals from the source and relay nodes, full diversity gain and good performance can be achieved with this scheme. However, AF scheme is proneto noise propagation effect because the relay node amplifies the noise on the source-relay channel when the retransmitted signals are amplified.

In AF, the source-relay channel and the relay-destination channel are of the same importance because the relay node only amplifies, not decodes, the information received from the source node; the incremental mode focuses on the source-destination channel, but in DF scheme, errors will accumulate and broadcast with information forwarding if serious fading takes place on the source-relay channel and lots of errors are resulted from decoding. Therefore, selection mode is more suitable for DF scheme, while incremental mode is more suitable for AF scheme.

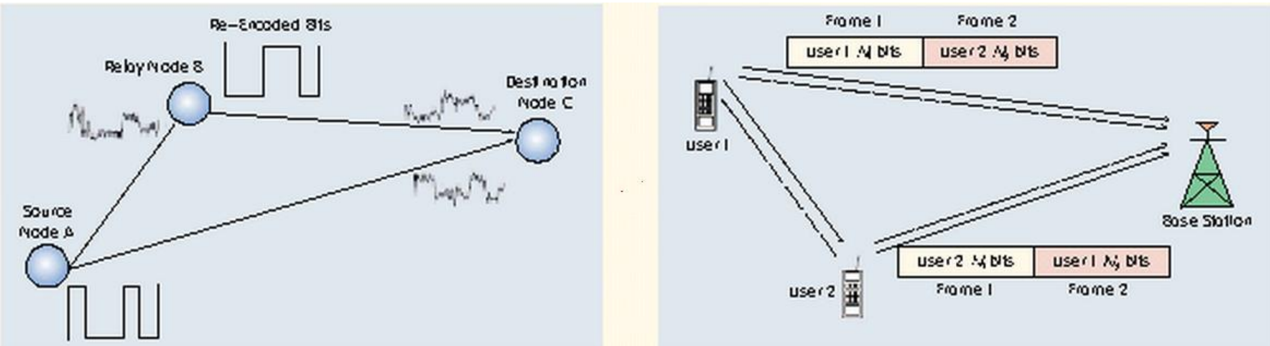


**Fig: 3.2 data transmission AF scheme**

In CC scheme, different segments of each user’s code words can be sent via two different fading paths. Each user correctly decodes the information received from cooperative partners and then re-encodes them before forwarding them. With redundant information bits being repeatedly transmitted through different spaces, the system performance is improved. In CC scheme, each mobile terminal achieves diversity and coding gains by re-encoding and transmitting different redundant bits, thus the system performance is greatly enhanced. Moreover, this scheme does not require information feedback between cooperative nodes. When a relay node cannot correctly decode the information bits, it automatically reverts back to non-cooperative mode, ensuring the system efficiency.

Network coding is a multi-cast technology. The core idea of network coding is that an intermediate node no longer performs simple store-and-forward function but encodes and forwards the received information, thus improving the capacity and robustness of the whole network. The network coding concept was originally used for wired networks, so is most of current related work. But the broadcast characteristics of radio channels are suitable for application of network coding in wireless networks, and the information interaction between wireless nodes can be fully achieved via network coding. As a result, the combination of network coding and cooperative communication can effectively improve the performance of wireless communication systems.

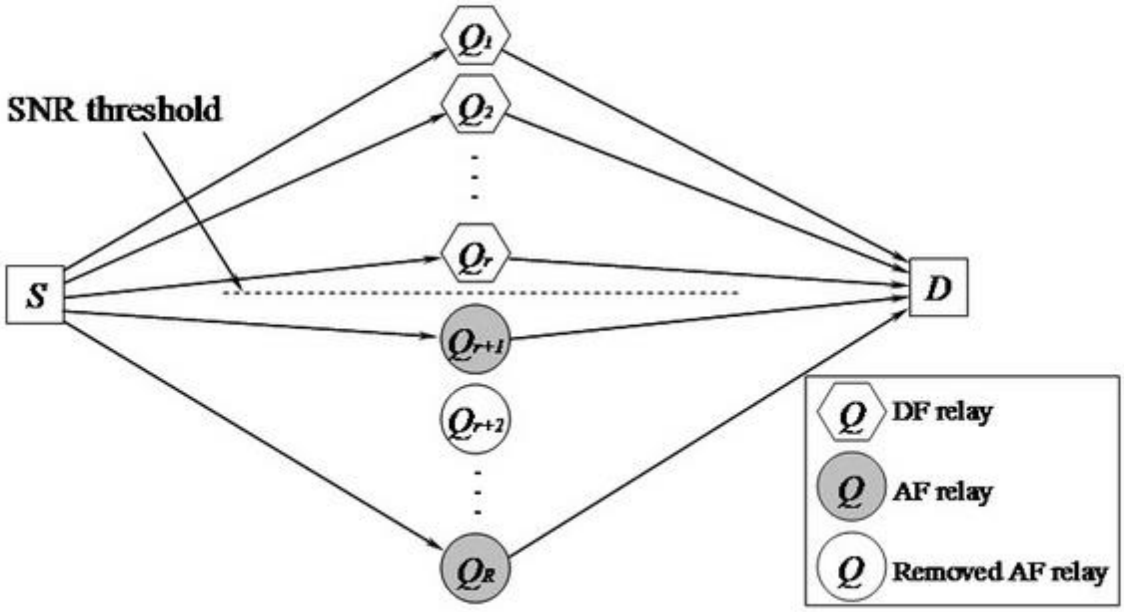


**Fig :3.3 Relay scheme**

Current NCC research focuses on the relay node's network coding schemes and basic communication methods. By the network coding schemes used by the relay node, NCC can be divided into two categories: linear and non-linear; by basic communication methods adopted, NCC can be divided into fixed relaying, opportunistic relaying, reciprocal relaying, and bi-directional relaying

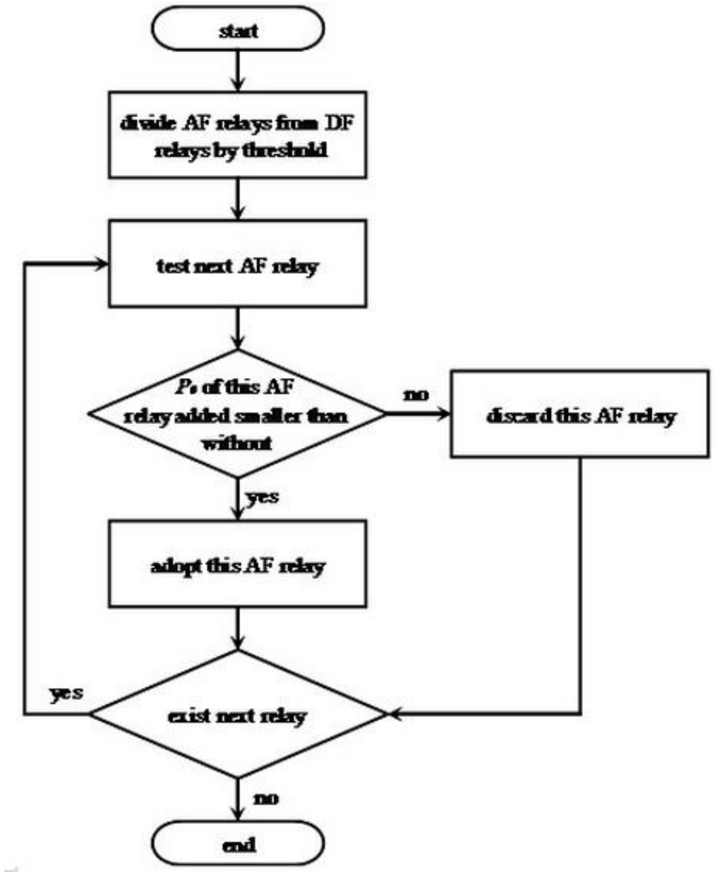


**Fig: 3.4 Amplify and forward strategy flow**

The channel fading for different links are assumed to be identical and statistically independent, quasi-statistic, i.e., channels are constant within several symbol durations. This is a reasonable assumption as the relays are usually spatially well separated and in a slow changing environment. We assume that the channels are well known at the corresponding receiver sides, and a one bit feedback channel from destination to relay is used for removing the unsuitable AF relays. All the Additive White Gaussian Noise (AWGN) terms have equal variance *N0*. Relays are re-ordered according to the descending order of the Signal-to-Noise Ratio (SNR) between *S* and *Q*, i.e., SNRS Q1 >>SNRSQR, where SNRS Or denotes the *r*-th largest SNR between *S* and *Q*.

# CHAPTER 4

# ROUTING ALGORITHMS AND PROTOCOLS

**Routing** is process of establishing the routes that data packets must follow to reach the destination. In this process, a routing table is created which contains information regarding routes which data packets follow. Various routing algorithm are used for the purpose of deciding which route an incoming data packet needs to be transmitted on to reach destination efficiently.

**Classification of Routing Algorithms:**

The routing algorithms can be classified as follows:

**1. Adaptive Algorithms**

These are the algorithms which change their routing decisions whenever network topology or traffic load changes. The changes in routing decisions are reflected in the topology as well as traffic of the network. Also known as dynamic routing, these make use of dynamic information such as current topology, load, delay, etc. to select routes. Optimization parameters are distance, number of hops and estimated transit time.

Further these are classified as follows**:**

**(a) Isolated**

In this method each, node makes its routing decisions using the information it has without seeking information from other nodes. The sending nodes doesn’t have information about status of particular link. Disadvantage is that packet may be sent through a congested network which may result in delay. Examples: Hot potato routing, backward learning.

**(b) Centralized**

In this method, a centralized node has entire information about the network and makes all the routing decisions. Advantage of this is only one node is required to keep the information of entire network and disadvantage is that if central node goes down the entire network is done.

**(c) Distributed**

In this method, the node receives information from its neighbours and then takes the decision about routing the packets. Disadvantage is that the packet may be delayed if there is change in between interval in which it receives information and sends packet.

**2. Non-Adaptive Algorithms**

These are the algorithms which do not change their routing decisions once they have been selected. This is also known as static routing as route to be taken is computed in advance and downloaded to routers when router is booted.

Further these are classified as follows:

**(a) Flooding**

This adapts the technique in which every incoming packet is sent on every outgoing line except from which it arrived. One problem with this is that packets may go in loop and as a result of which a node may receive duplicate packets. These problems can be overcome with the help of sequence numbers, hop count and spanning tree.

**(b) Random walk**

In this method, packets are sent host by host or node by node to one of its neighbours randomly. This is highly robust method which is usually implemented by sending packets onto the link which is least queued.

**ROUTING PROTOCOLS**

The routing protocol is a process to select suitable path for the data to travel from source to destination. The process encounters several difficulties while selecting the route, which depends upon, type of network, channel characteristics and the performance metrics. The data sensed by the sensor nodes in a wireless sensor network (WSN) is typically forwarded to the base station that connects the sensor network with the other networks (may be internet) where the data is collected, analyzed and some action is taken accordingly.

In very small sensor networks where the base station and motes (sensor nodes) so close that they can communicate directly with each other than this is single-hop communication but in most WSN application the coverage area is so large that requires thousands of nodes to be placed and this scenario requires multi-hop communication because most of the sensor nodes are so far from the sink node (gateway) so that they cannot communicate directly with the base station.

**Routing challenges in WSNs**

The design task of routing protocols for WSN is quite challenging because of multiple characteristics, which differentiate them, from wireless infrastructure-less networks. Several types of routing challenges involved in wireless sensor networks. Some of important challenges are mentioned below:

- It is almost difficult to allocate a universal identifiers scheme for a big quantity of sensor nodes. So, wireless sensor motes are not proficient of using classical IP-based protocols.
- The flow of detected data is compulsory from a number of sources to a specific base station. But this is not occurred in typical communication networks.
- The created data traffic has significant redundancy in most of cases. Because many sensing nodes can generate same data while sensing. So, it is essential to exploit such redundancy by the routing protocols and utilize the available bandwidth and energy as efficiently as possible.
- Moreover wireless motes are firmly restricted in relations of transmission energy, bandwidth, capacity and storage and on-board energy. Due to such dissimilarities, a number of new routing protocols have been projected in order to cope up with these routing challenges in wireless sensor networks.

**Design challenges in WSNs**

There are some major design challenges in wireless sensor networks due to lack of resources such as energy, bandwidth and storage of processing. While designing new routing protocols, the following essentials should be fulfilled by a network engineer.

**Energy efficiency:** Sensor networks are mostly battery powered. Energy shortage is a major issue in these sensor networks especially in aggressive environments such as battlefield etc. The performance of sensor nodes is adversely affected when battery is fallen below a pre-defined battery threshold level. Energy presents a main challenge for designers while designing sensor networks.

**Complexity:** The complexity of a routing protocol may affect the performance of the entire wireless network. The reason behind is that we have inadequate hardware competences and we also face extreme energy limitations in wireless sensor networks.

**Scalability:** As sensors are becoming cheaper day by day, hundreds or even thousands of sensors can be installed in wireless sensor network easily. So, the routing protocol must support scalability of network. If further nodes are to be added in the network any time then routing protocol should not interrupt this.

**Delay:** Some applications require instant reaction or response without any substantial delay such as temperature sensor or alarm monitoring etc. So, the routing protocol should offer minimum delay. The time needed to transmit the sensed data is required to be as little as possible in above cited WSN applications.

**Robustness:** Wireless sensor networks are deployed in very crucial and loss environments frequently. Occasionally, a sensor node might be expire or leaving the wireless sensor network. Thus, the routing protocol should be capable to accept all sorts of environments including severe and loss environments.

**Classification of routing protocols**

The routing protocols define how nodes will communicate with each other and how the information will be disseminated through the network. There are many ways to classify the routing protocols of WSN. The basic classification of routing protocols is illustrated in Figure

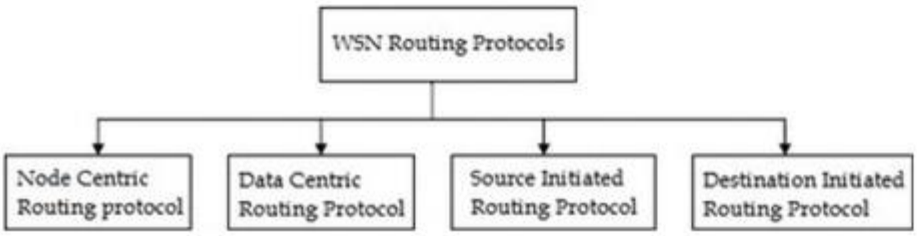


**Fig:4.1 WSN Routing Protocols**

**1.Node centric**

In node centric protocols the destination node is specified with some numeric identifiers and this is not expected type of communication in Wireless sensor networks. E.g. Low energy adaptive clustering hierarchy (LEACH).

**1(a) Low energy adaptive clustering hierarchy (LEACH)**

LEACH is a routing protocol that organizes the cluster such that the energy is equally divided in all the sensor nodes in the network. In LEACH protocol several clusters are produced of sensor nodes and one node defined as cluster head and act as routing node for all the other nodes in the cluster.

As in routing protocols the cluster head is selected before the whole communication starts and the communication fails if there is any problem occurs in the cluster head and there is much chances that the battery dies earlier as compare to the other nodes in cluster as the fix cluster head is working his duties of routing for the whole cluster. LEACH protocol apply randomization and cluster head is selected from the group of nodes so this selection of cluster head from several nodes on temporary basis make this protocol more long lasting as battery of a single node is not burdened for long. Sensor nodes elect themselves as cluster head with some probability criteria defined by the protocol and announce this to other nodes.

**2.Data-centric**

In most of the wireless sensor networks, the sensed data or information is far more valuable than the actual node itself. Therefore data centric routing techniques the prime focus is on the transmission of information specified by certain attributes rather than collecting data from certain nodes. In data centric routing the sink node queries to specific regions to collect data of some specific characteristics so naming scheme based on attributes is necessary to describe the characteristics of data. Examples are as follows:

**2(a).Sensor protocols for information via negotiation (SPIN)**

SPIN is abbreviation of sensor protocol for information via negotiation. This protocol is defined to use to remove the deficiency like flooding and gossiping that occurs in other protocols. The main idea is that the sharing of data, which is sensed by the node, might take more resources as compare to the meta-data, which is just a descriptor about the data sensed, by the node. The resource manager in each node monitors its resources and adapts their functionality accordingly.

**3. Destination-initiated (Dst-initiated)**

Protocols are called destination initiated protocols when the path setup generation originates from the destination node. Examples are directed diffusion (DD) & LEACH.

**3(a) Directed diffusion (DD)**

Directed diffusion is a data centric routing technique. It uses this data centric technique for information gathering and circulating. This routing protocol is also energy efficient and energy saving protocol so that's why life time of the network is increased. All the communication in directed diffusion routing protocol is node to node so there is no need of addressing in this protocol.

**4. Source-initiated (Src-initiated)**

In these types of protocols the source node advertises when it has data to share and then the route is generated from the source side to the destination. Examples is SPIN.

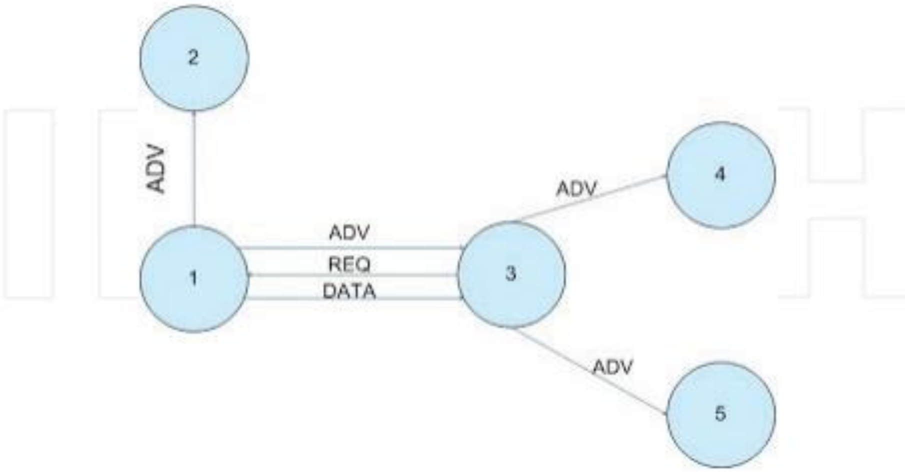


**Fig: 4.2 SPIN routing protocol**

# CHAPTER 5

# PROPOSING IDEA

There are N number of hierarchical based protocols are designed such as cluster based, grid based, chain based, area abased etc. The researchers are proposed the routing agent based routing protocols for WSN. The data packets are forward based on their geographic coordinates. In this routing protocols, routing agents are used to transmit the information packets from the cluster heads to destination/monitoring sink. The contribution of this paper are discussed as follows, 1. Cluster chain based routing may suit for high reliable and guaranteed less delay transmission of data packets. 2. Low time complexity and the effectiveness of the network is increased by routing agent. 3. The proposed method is widely used to manage the mobility agent/sink node by the cluster-chain head re-election.

In this proposed system, the network routing protocol design combine chain and cluster based hierarchical networks. To improve the network lifetime, the networks have less latency and the high energy efficiency. This routing protocol will increase QOS of WSN. The existing systems the routing protocol is have a mobile Agents are very much useful to perform the aggregation of the data. Here, the Mobile agent is used to monitor the node mobility and data aggregation. The most important focus of the system is to design an energy efficient and improve the network lifetime for the routing protocols. This routing protocol is achieving both very less energy consumption and very less propagation and transmission delay over the entire network. This routing protocol divides the entire network into a group of clusters. After forming the clusters heads, the chain is formed among the cluster heads and the nodes for data aggregation. After computation process, the aggregated data is collected by the cluster-chain heads based on the localization [13]. The mobile agent is used to collect the data packets from the cluster-chain head. This will reduce the energy consumption of the nodes in the networks. So, the modified CCBRP protocol is overcome the issues in existing Cluster-Chain based routing protocol. In the existing routing protocol, the cluster-chain head energy drains very faster in collecting, aggregating, and data transmission to destination node. Fig 1.1 Modified Cluster-Chain based routing protocol the assumptions of the Modified CCBRP routing protocol is given as,

1. All the sensors placed in a random manner are homogeneous in nature.

2. The initial energy of all the sensors are always equal (Before Simulation).

3. The energy consumption is based on the energy required by the node for data packets transmission and reception. Here, we assumed that the energy required for transmission and reception are same.

# CHAPTER 6
# SIMULATION TOOL

## INTRODUCTION

MATLAB-Matrix-laboratory

MATLAB is a multi-language inherited high-performance language for technical computing language based system. It integrates computation, visualization, processing and programming in an easy way of use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

- Math and computation
- Algorithm development
- Modelling, simulation, and prototyping
- Data analysis, exploration, visualization, Data processing
- Scientific researching and engineering graphics
- Application development, including graphical user interface building

MATLAB is a matrix values integrated system whose basic data element is an array that does not require dimensioning. MATLAB allows us to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or FORTRAN.

MATLAB features a family of application-specific solutions called toolboxes.

Very important to most users of MATLAB, toolboxes allow us to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

The MATLAB system consists of five main parts:

**Development Environment:** This is the set of tools and facilities that help us use MATLAB functions and files. Many of these tools are graphical user interfaces. It includes the MATLAB desktop and Command Window, a command history, and browsers for viewing help, the workspace, files, and the search path.

**Mathematical Function Library:** This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix Eigen values, Bessel functions, and fast Fourier transforms.

**MATLAB software Language:** This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both & quot: programming in the small & quot; to rapidly create quick and dirty throw-away programs, and & quot; programming in the large & quot; to create complete large and complex application programs. it is also said to be multi inherited language

**Handle Graphics:** This is the MATLAB graphics system. It includes high-level commons for two-dimensional and three-dimensional data visualization, image processing, animation and presentation graphics. It also includes low-level commands that allow us to fully customize the appearance of graphics as well as to build complete graphical user interfaces on user .

**Application Program Interface (API):** This is a library that allows us to write C and FORTRAN programs that interact with MATLAB. It include facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

**DEVELOPMENT ENVIRONMENT**

**Introduction:**

This provides a brief introduction to starting and quitting MATLAB, and the tools and functions that help us to work with MATLAB variables and files. For more information about the topics covered here, see the corresponding topics under Development Environment in the MATLAB documentation, which is available online as well as in print.

**Starting and Quitting MATLAB**

**Starting MATLAB**

On a Microsoft Windows platform, to start MATLAB, double-click the MATLAB shortcut icon on user Windows desktop. After starting MATLAB, the MATLAB desktop opens - see MATLAB Desktop.

## Quitting MATLAB

To end user MATLAB session, select Exit MATLAB from the File menu in the desktop, or type quit in the Command Window. To execute specified functions each time MATLAB quits, such as saving the workspace, us can create and run a finish the m script.

## MATLAB Desktop

When us start MATLAB, the MATLAB desktop appears, containing tools (graphical user interfaces) for managing files, variables, and applications associated with MATLAB.

User can change the way user desktop looks by opening, closing, moving, and re-sizing the tools in it. Us can also move tools outside of the desktop or return them back inside the desktop (docking). All the desktop tools provide common features such as context menus and keyboard shortcuts.

# CHAPTER 7

# PROPOSED DESIGN

Coexist with Wi-Fi friendly, a standalone long-term evolution network over unlicensed spectrum (LTE-U) under listen-before-talk (LBT) mechanism can only access channel in a random and intermittent way, which results in random and time-variant delay in both data and signaling transmissions. In this work, we explore the impact of randomly delayed channel state information (CSI) on the performance of a standalone LTE-U network by analyzing its downlink throughput and users' energy efficiency (EE) under different CSI feedback schemes and frequency-domain schedulers. Further, aiming at maximizing users' EE of a standalone LTE-U network while guaranteeing fair coexistence with Wi-Fi, joint optimization on the medium access control (MAC) protocol and CSI feedback scheme is studied. Due to the non-convex and non-concave characteristic of the formulated optimization problems, decomposition-based low-complexity yet efficient algorithms are proposed.

**Implementation:-**

We consider a standalone LTE-U network and a Wi-Fi network sharing an unlicensed channel with bandwidth B. As shown in Fig. 1, the Wi-Fi network is composed of Nw Wi-Fi stations (STAs) and the standalone LTE-U network consists of a BS and K single-antenna users. All nodes in the network are assumed to have saturated traffic. The standalone LTE-U network divides the channel into S orthogonal subchannels each with bandwidth B/S. Let s (resp. k) and S (resp. K) denote the subchannel (resp. user) index and subchannel (resp. user) set, respectively. Similar to an LTE network, for DL channel-aware transmissions the BS first sends a UL grant signal to inform users of reporting the CSI. The users received the grant signal estimate the channel and report the CSI according to the adopted CSI feedback scheme when they access channel. After receiving the CSI, the scheduler at the BS can allocate resources for data transmissions. The detailed frame structure, channel contention scheme, channel and rate adaption model, frequency-domain scheduler, and CSI feedback scheme are discussed as follows.

## Frame Structure and Channel Contention Scheme

Consider that the standalone LTE-U network works in a time-division duplex (TDD) mode with a frame structure as shown in Fig. 2. So, both the DL and UL transmissions occur in the same unlicensed channel and are time slotted. Here, the slot of duration Tsb is referred to as the subframe used in an LTE system. However, to coexist with Wi-Fi friendly, the LTE-U network cannot always occupy channel but use LBT or on/off-based channel contention schemes . Here, we assume

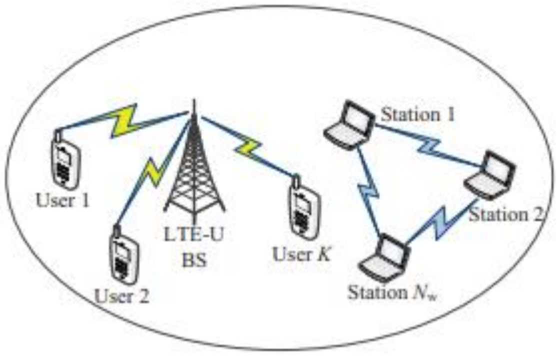


**Fig:7.1 Wifi Networks**

**Channel and Rate Adaption Model**

Let Gk,s denote the channel power gain user k estimates for subchannel s from the BS's one DL transmission. To acquire the latest CSI for rate and subchannel assignment, in the standalone LTE-U network of interest, the users should estimate the channel in the last subframe of the BS's DL transmission. Let Gd k,s,α denote the actual subchannel gain when the BS transmits data for user k according to Gk,s in subframe α (∈ {1, 2, ..., Nsb}) of the next DL transmission, and τα be the involved feedback delay between channel estimation and data transmission. We consider a wide sense stationary Rayleigh fading process.

**Frequency-Domain Schedulers**

Four different frequency-domain schedulers, round robin, greedy scheduler, PF scheduler, and random scheduler, are studied in this work. For each subchannel, the round robin scheduler serves users one by one in order; the greedy scheduler, the PF scheduler, and the random scheduler select the user, among those fed back subchannel gain for this subchannel, with the maximum subchannel gain, the maximum normalized subchannel gain (defined as the ratio of the subchannel gain to its mean ), and an equal probability, respectively. Here, for the random scheduler, as only the users that fed back CSI for the subchannel can be selected, it is different from the round robin scheduler. In addition, we will compare it with the greedy scheduler in terms of the tolerance of feedback delay, which could be long if the standalone LTE-U network needs to coexist (content channel) with a high-load Wi-Fi network.

### Subchannel Gain Feedback Schemes

When the standalone LTE-U network occupies the channel, Wi-Fi might access channel simultaneously, resulting in a collision as shown in Fig. As the duration of a collided Wi-Fi transmission is usually shorter than a subframe used in an LTE system, only the first subframe of the DL or UL effective transmission might occur collisions. Thus, to prevent grant signals and CSI report from colliding with Wi-Fi transmissions, they should not be transmitted in the first subframe of the DL and UL effective transmissions, respectively. Besides, to facilitate analysis, similar to we assume that both channel estimation and CSI feedback are error-free. Two subchannel gain feedback schemes, threshold-based feedback and best-m feedback, are studied. For threshold-based feedback scheme, a user reports the subchannel gain of a subchannel only if the subchannel gain (resp. normalized subchannel gain) exceeds a threshold λ for the greedy, round robin, or random scheduler (resp. PF scheduler). For the best-m feedback scheme, a user feeds back its m highest subchannel gains and indices among all sub channel.

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**Algorithm 1** Threshold Searching Algorithm

Set tolerance $\beta > 0$, maximum threshold $\lambda_{\max} > 0$, $\lambda^* = 0$;
**for** $j = 1$ to $J$ **do**
  Initialize a starting point $\lambda_j \in [0, \lambda_{\max}]$;
  **repeat** ▷ Gradient descent method
    $\Delta\lambda_j \leftarrow d\kappa_{\mathrm{L}}^{\mathrm{G,TH}}(\lambda_j)/d\lambda_j$; ▷ Compute the negative gradient
    Break if $|\Delta\lambda_j| \leq \beta$; ▷ Stopping criterion
    $l \leftarrow \mathrm{argmin}_{\upsilon \geq 0} - \kappa_{\mathrm{L}}^{\mathrm{G,TH}}(\lambda_j + \upsilon\Delta\lambda_j)$; ▷ Choose step size by line search
    Update $\lambda_j \leftarrow \lambda_j + l\Delta\lambda_j$;
  Obtain $\lambda_j^* = \lambda_j$;
  $\lambda^* = \arg\min_{\lambda_j^*} \left\{-\kappa_{\mathrm{L}}^{\mathrm{G,TH}}\left(\lambda_j^*\right), -\kappa_{\mathrm{L}}^{\mathrm{G,TH}}(\lambda^*)\right\}$; ▷ Compare to find an optimized result
**end for**

Algorithm 1: Clustering () 1 set node N, i=0, N(i) for N nodes 2 set Dest nodes 3 sets cluster partition (); 4 i nodes computes the distance di and update routing table 5 nodes update the average energy Eavg(i) 6 if (Eavg > Er(Norm) 7 kind(i) = CCH; 8 end if 9 sends CCH_Selects() 10 if (di < wc) // For each node 11 if N(i) == Er(Norm); 12 kind(i)= CCH; 13 else 14 packets discarded; 15 end if 16 end if 17eachchain-cluster node (CCH)

## CHAPTER 8

## SIMULATION RESULTS

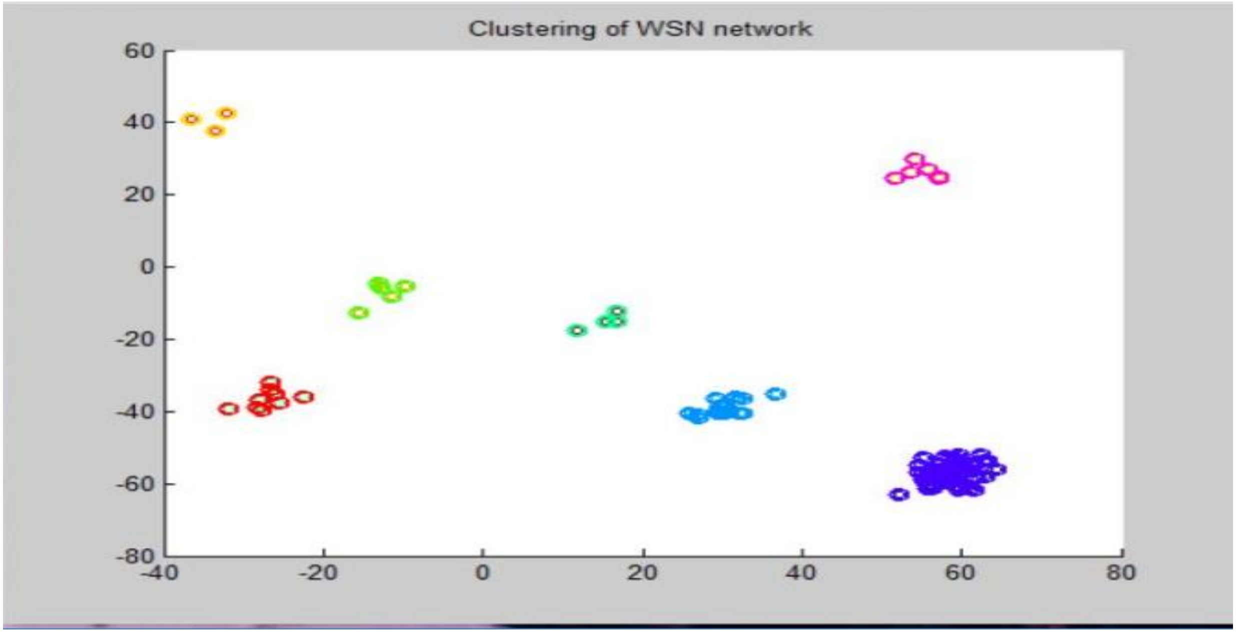


**Fig: 8.1.Clustering of WSN network**

**8.**

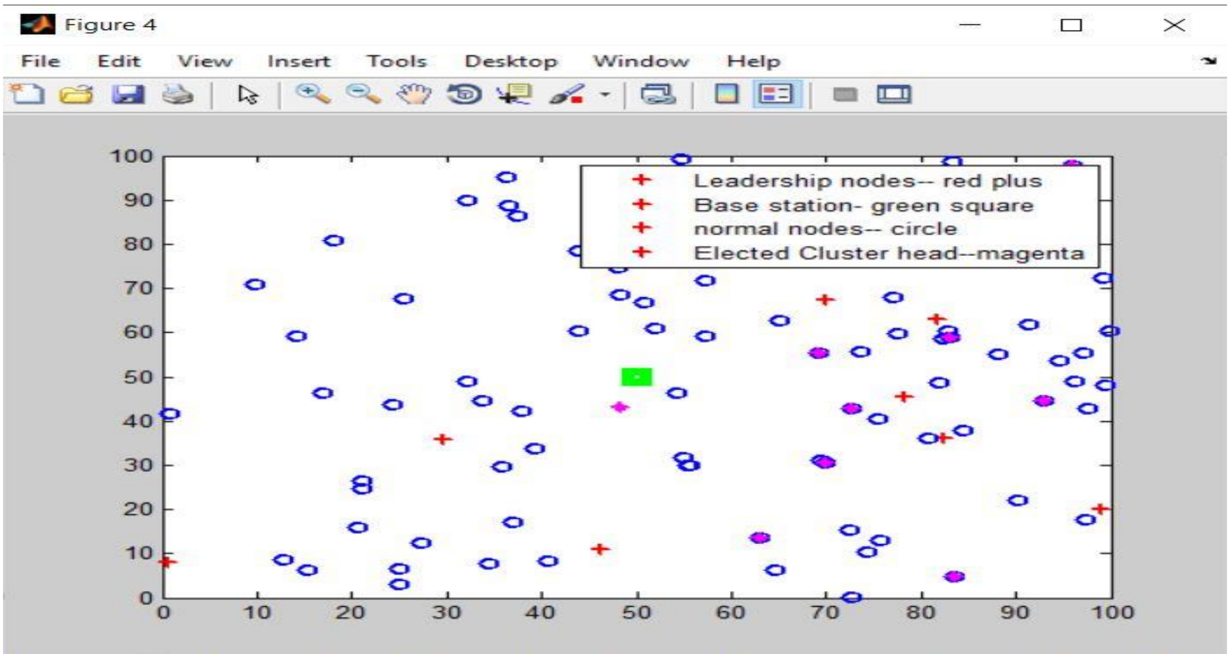


**Fig: 8.2 Network Routing Based of Energy Levels**

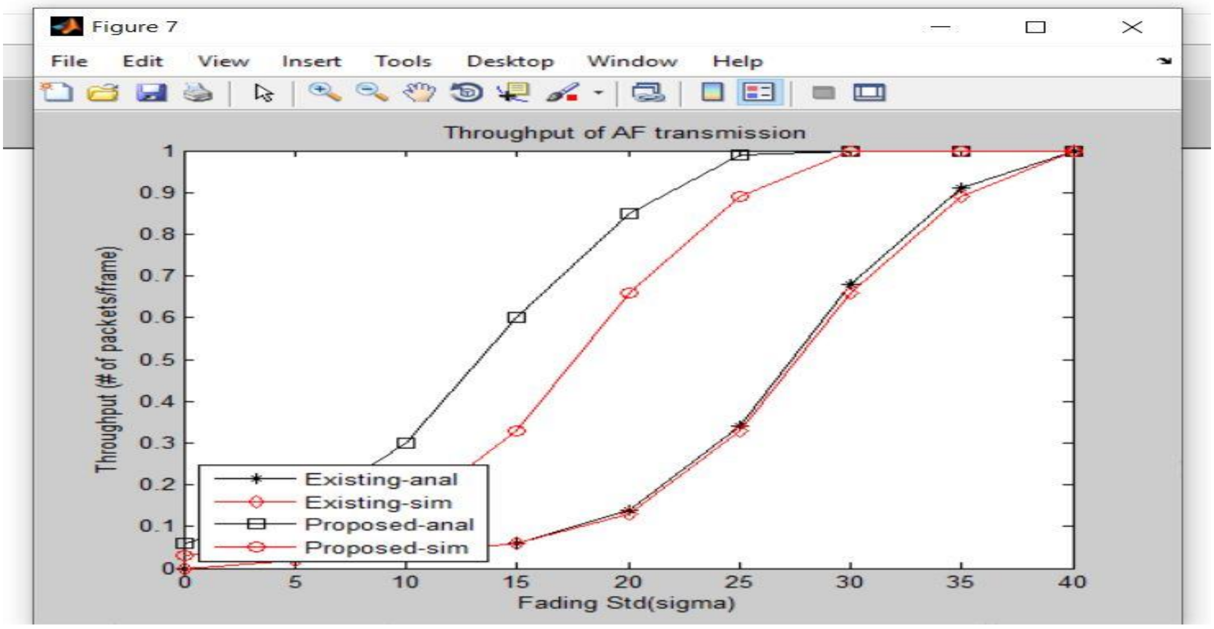


**Fig:8.3 Throughput of AF transmission**

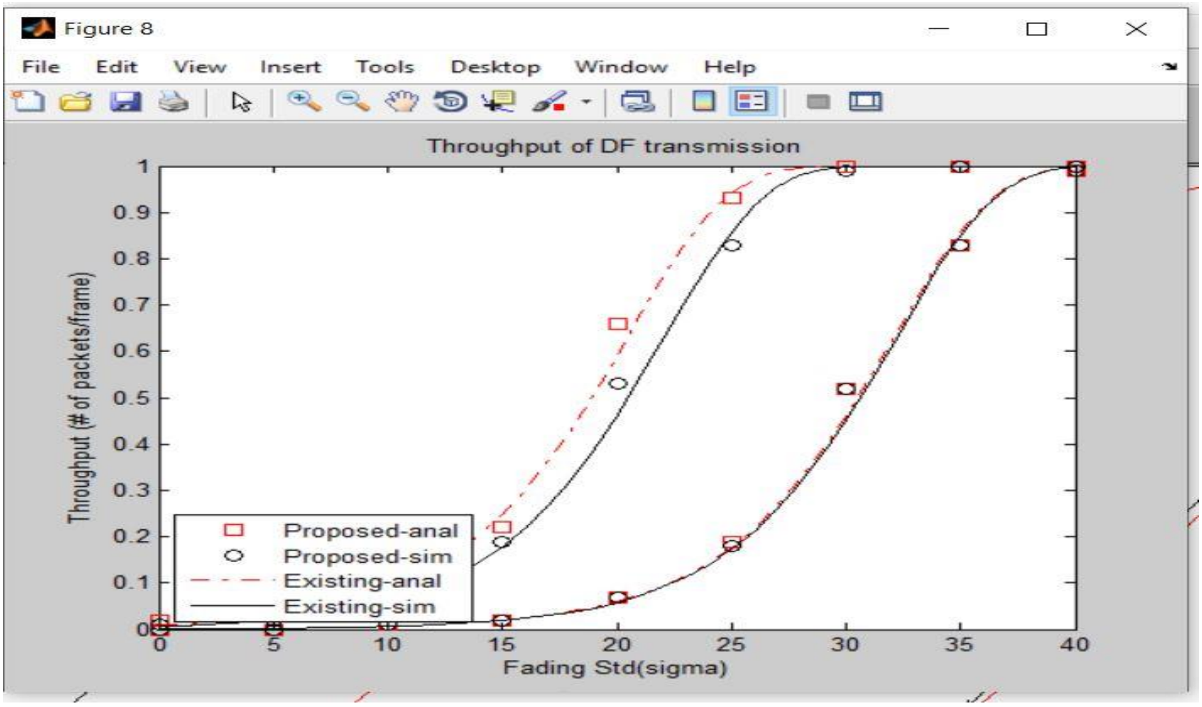


**Fig:8.4 Throughput of DF transmission**

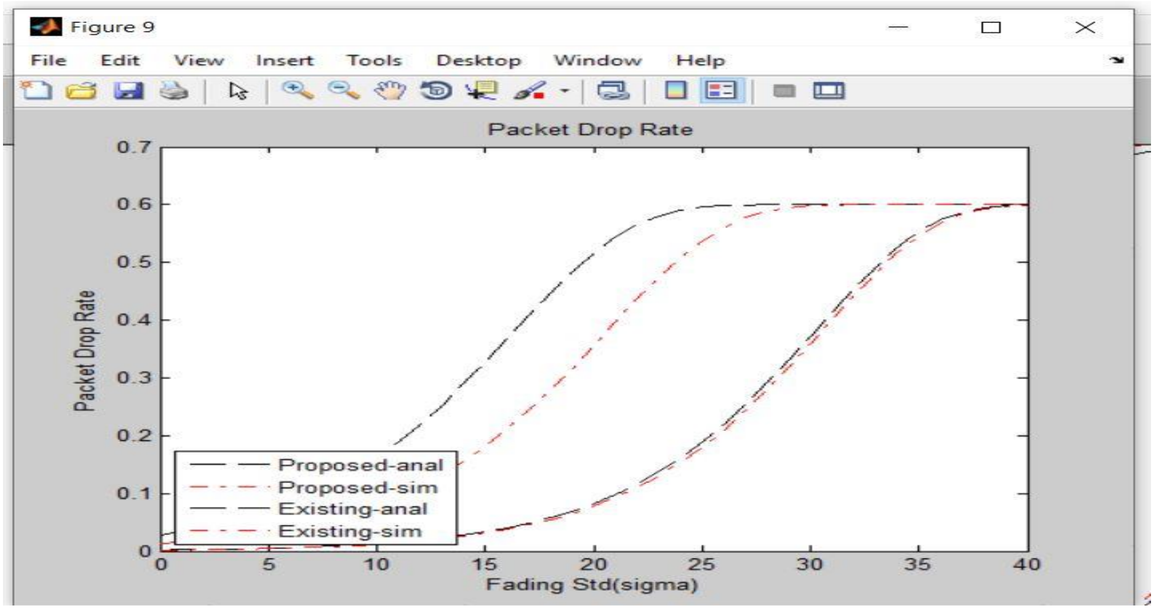


**Fig:8.5 Packet Drop Rate**

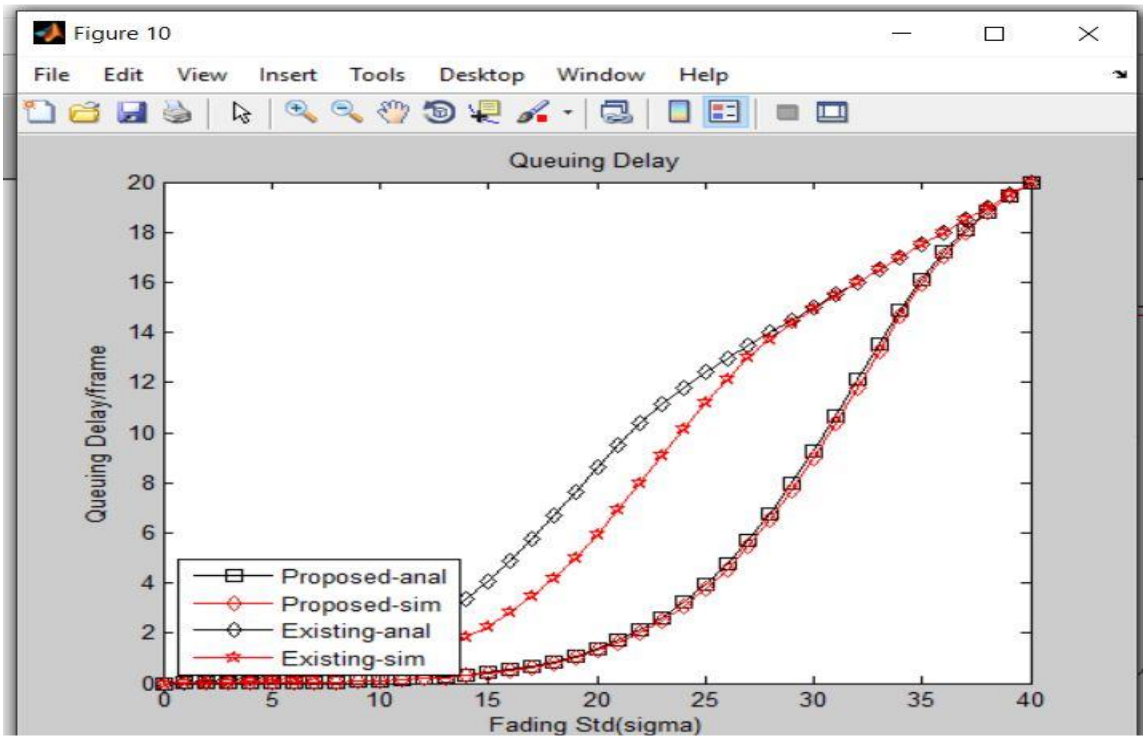


**Fig:8.6 Queuing Delay**

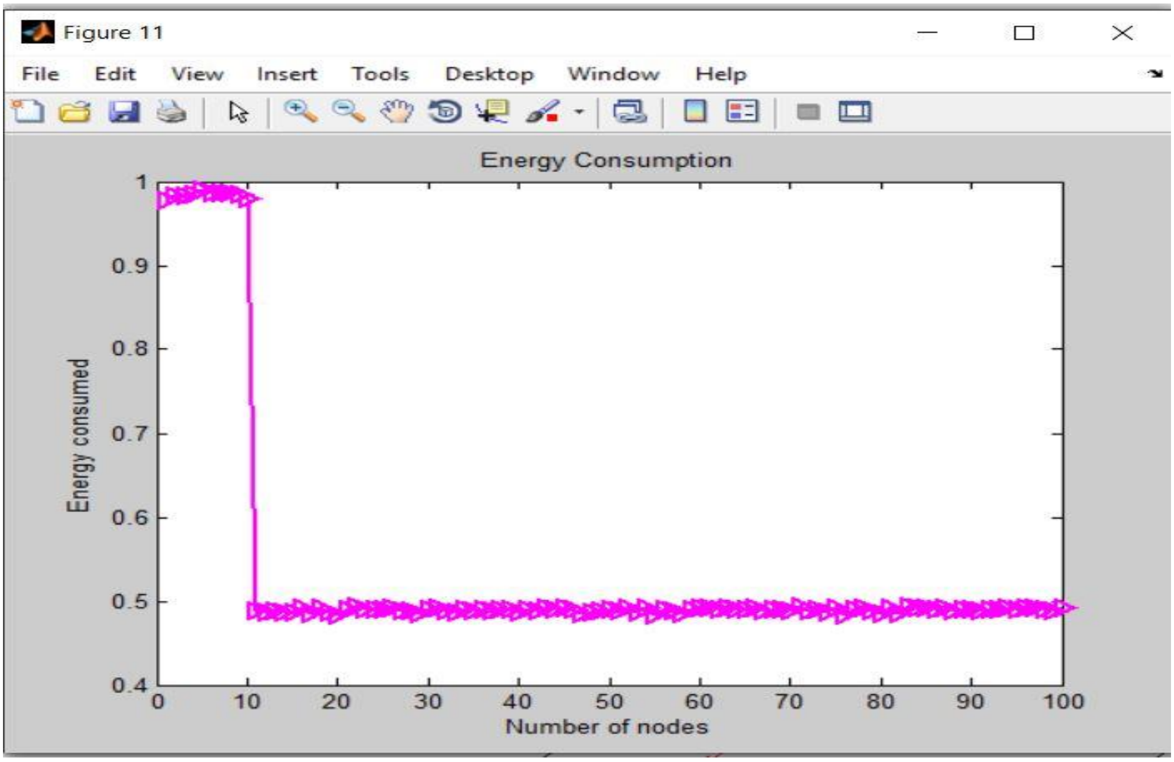


**Fig: 8.7 Energy Consumption**

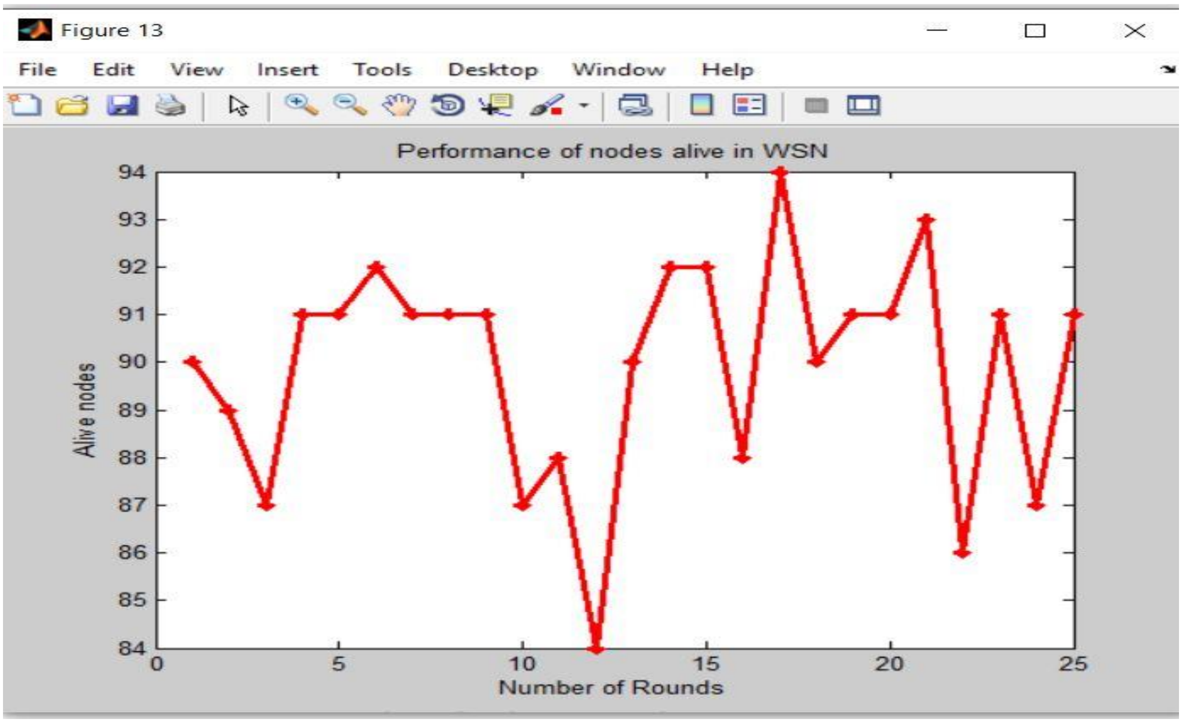


**Fig: 8.8 Performance of nodes alive is WSN**

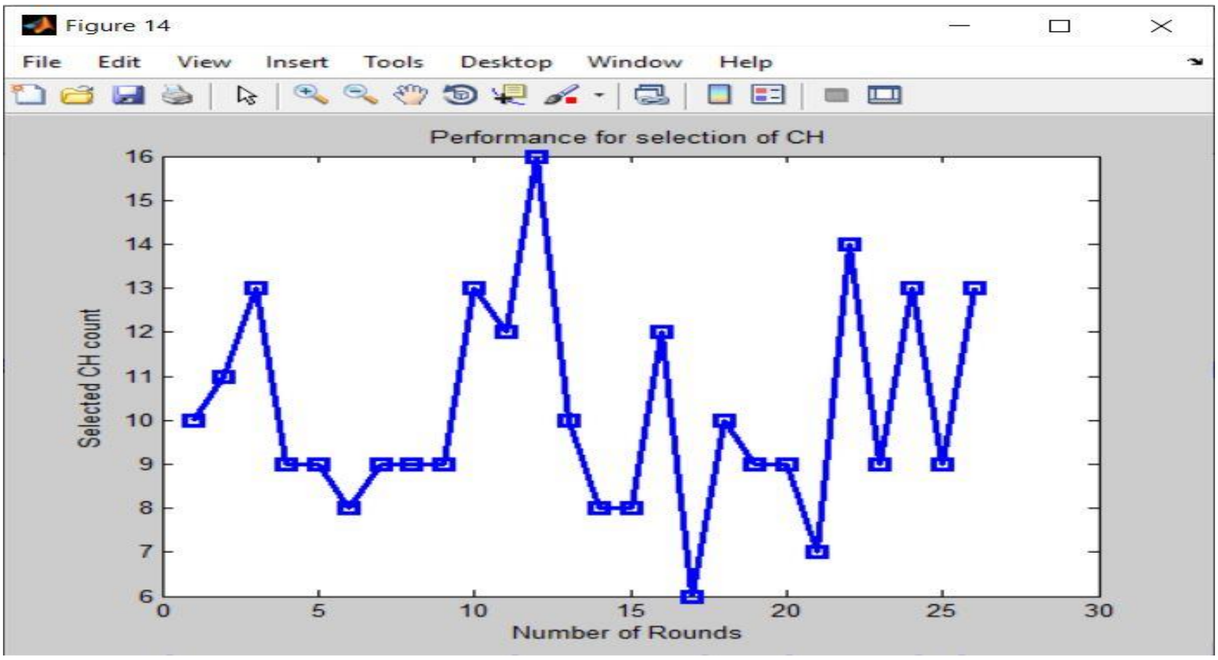


**Fig: 8.9 Performance for selection of CH**

# CHAPTER 9

# CONCLUSION

An approach of increasing efficiency in wireless sensor network, the modified Cluster-Chain based energy efficient routing protocol is used in this project. This routing is highly energy efficient and capable of increasing the network life time of the network, through the energy efficiency and very less propagation delay. The simulated results are compared with existing routing protocols. In this routing protocol, all cluster chain heads of each cluster are used to perform the data aggregation operation by received data packets from all other sensor nodes. In second phase, the Mobile agent collects the data packets from the Cluster-Chain heads. So this, proposed routing protocol has advantages in efficient routing protocol has advantages in efficient data dissemination and gathering. An efficiency of 99% has been achieved by using modified cluster chain-based routing protocol.

## CHAPTER 10

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