5G Network Advanced techniques: A Literature Review

Krishna Avatar Garg, Dr. Agya Mishra

Abstract— **Mobile technology plays a vital role that is developing extremely fast in present time. With the increase in higher demand for higher date rate and large user experience. Larger data rates, larger coverage and throughputs, and lower time for transmission and reception, which results with the better user experience is being supported by LTE-Advanced. After reviewing various papers a performance based discussion and comparison of existing 5G Network Advanced technology is being discussed. Comparison in technique, measuring parameters, advantages and limitation are presented. The review concluded with future opportunities in 5G Network.**

Index Terms—**5G Network, BER, Outage probability, Path loss, SINR, Throughput.**

I. INTRODUCTION

In the simplest possible definition, 5G LTE-A is the fifth generation of cellular networking. It's the next step in mobile technology, what the phones and tablets of the future will use for data, and it should make our current LTE networks as slow and irrelevant as 3G data seems now. There are so many different technology for 5G LTE-A communication. The wireless research community aspires to conceive full duplex operation by supporting concurrent transmission and reception in a single time/frequency channel for the sake of improving the attainable spectral efficiency by a factor of two, Potential FD Technologies, Including Passive suppression, active Analog and Digital Cancellation [1]. As we are on the verge of new era, where everyone and everything will be connected, with more demanding and varied requirements that cannot be satisfied by current networks [4]. Efficient coordination among network elements and optimal resource utilization in heterogeneous mobile networks (HMNs) is a key factor for the success of future 5G systems. The COHERENT project focuses on developing an innovative programmable control and coordination framework which is aware of the underlying network topology, radio environment and traffic conditions, and can efficiently coordinate available spectrum resources [5]. Modeling and computation of the capacity of the LTE-A Random Access Channel (RACH) in terms of simultaneous successful access. In particular investigate the hypothesis of piggybacking the payload of Machine Type Communications from M2M devices within the RACH, and show that M2M densities considered realistic for smart cities applications are difficult to sustain by the current LTE-A architecture [6]. Relay-assisted D2D communication was proposed as a supplement to direct D2D communications for enhancing traffic offloading capacity in LTEA systems. This work aims to design a relay UE selection strategy for D2D communications, which improves D2D communication performance significantly [7]. Backhaul link is one of the links in the relay networks that is responsible for data communication between base station and relay stations. To ensure efficient communication in the backhaul link, good radio propagation environment, such as path loss, is required Path loss Model [8]. The introduction of relay will not only bring a wider coverage and higher capacity to the system but also lower the cost of network building. Multi-hop wireless relay technology plays an important role in next-generation mobile and wireless communication systems. Nowadays, we are witnessing the formation of a new technological marvel: Internet of Things (IoT) [10]. Relay are expected to extended coverage in efficient manner in various locations such as place where backhaul link are difficult to deploy [11]. Approach of comparison in different technique, measuring parameters and their values, advantages and limitation is viewed and the Conclude for best method.

This paper is ordered as: section II covers the concept of LTE –A system, section III deals with performance analysis, section IV deals the comparison table of existing technology, and finally section V concludes the review.

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II. CONCEPT OF 5G NETWORK

5G is the newest, but yet-to-be-released, mobile network that will ultimately replace the current 4G technology by providing a number of improvements in speed, coverage, and reliability. The primary focus and reason for needing an upgraded network is to support the growing number of devices that demand internet access, many of them requiring so much bandwidth in order to function normally that 4G simply doesn't cut it anymore. The radio spectrum is broken up into bands, each with unique features as you move up into higher frequencies. 4G networks use frequencies below 6 GHz, but 5G will likely use extremely high frequencies in the 30 GHz to 300 GHz range. These high frequencies are great for a number of reasons, one of the most important being that they support a huge capacity for fast data. Not only are they less cluttered with existing cellular data, and so can be used in the future for increasing bandwidth demands, they're also highly directional and can be used right next to other wireless signals without causing interference. In future every one want to connect with higher data rate, and 5G will give us to peak data rate up to 20Gbps for downlink and 10Gbps for upload. Latency refers to the time lapse between when the cell tower sends data and when the destination device receives the data. 5G requires a minimum latency of just 4 ms assuming that ideal conditions are met, but could drop as low as 1ms for some forms of communication, particularly ultra-reliable and low-latency communications. For comparison, the latency on a 4G network might be around 50-100 ms. Mobility refers to the maximum speed at which a user can be traveling and still receive 5G service. The 5G will support, anywhere from a stationary person who isn't moving to someone in a high-speed vehicle like a train, who's traveling up to 500 kmh. It's possible that different areas will require a different mobile base station to accommodate for varying speeds.

III. PERFORMANCE ANALYSIS

A. Full Duplex Techniques for 5G Networks: self-interference cancellation, protocol design, and relay section [1]

The spectral efficiency (SE) of networks has to be further improved in order to deliver ever increasing data rates. However, the operational wireless communication systems usually rely on half duplex (HD) operations, leading to erosion of resource exploitation. The promise of radical full duplex (FD) operation, on the other hand, improves the achievable SE of wireless communication systems by always transmitting and receiving in the entire bandwidth .The main driving force behind the advances in FD communications is the promise of nearly doubled channel capacity compared to conventional HD communications, thus offering the potential to complement and sustain the evolution of the fifth generation (5G) technologies toward denser heterogeneous networks with flexible relaying modes. Figure 1 shows the Practical implementable SI suppression.

Directional SI Cancellation

In this technique, the main radiation lobe of the transmit/receive antennas of an FD device have minimal intersection, enabling the SI to be partially suppressed prior to the receiver's RF front-end.

Analog Cancellation

In analog cancellation, the family of time-domain (TD) cancellation algorithms such as training-based methods can be employed by both single-input single-output (SISO) and multiple-input multiple-output (MIMO) based techniques, where the latter may perform SI suppression by exploiting the spatial diversity achieved by the associated multiple transmit and/or receive antennas.

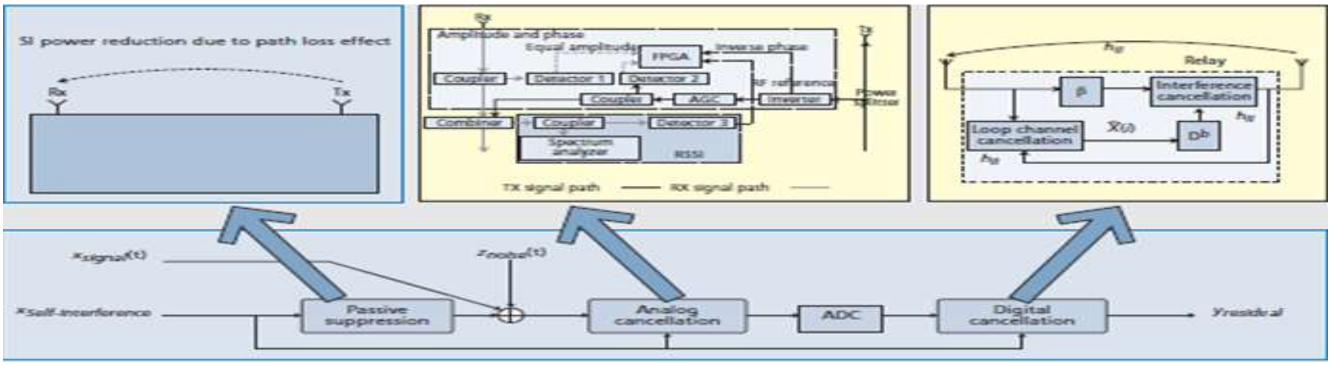

Fig.-1: Practical implementable SI suppression [1]

B. Basic of 5G Technology and Evaluation [2]

The 5G mobile system is based on all-IP model which is a common platform for radio access technologies. The network architecture of
5G consists of a user terminal and a number of autonomous radio access technologies.

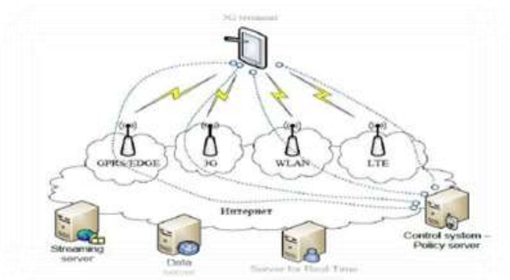

Fig. -2: 5G Architecture [2]

C. Joint Network Channel Fountain Schemes for Machine Type Communication over LTE-A [3]

The optimal distribution of degree for constructing LT codes is the robust soliton distribution (RSD) proposed by LUBY is given below:

$$\rho(i) = \left\{\frac{\mu(i)+\nu(i)}{\beta}, \quad \text{for } 1 \le i \le k \qquad (1)\right.$$

Where,

$$\beta = \sum_{i=1}^{k}\left(\mu(i)+\nu(i)\right) \qquad (2)$$

Here, $\mu(i)$ is the ideal solition distribution and $\nu(i)$ are given by:

$$\mu(i) = \begin{cases} \frac{1}{k}, & for\ i = 1 \\ \frac{1}{i(i-1)}, & for\ 2 \le i \le k \end{cases} \qquad (3)$$

$$\nu(i) = \begin{cases} \frac{R}{k}, & for\ 1 \le i \le \frac{k}{R} - 1 \\ \frac{R}{k}\ln\frac{R}{\delta}, & for\ i = \frac{k}{R} \\ 0, & otherwise \end{cases} \qquad (4)$$

Where δ is the allowable failure probability and the parameter R represents the average number of degree one encode symbol and is defined as

$$R = \lambda \ln(k/\delta)\sqrt{k} \qquad (5)$$

D. 5G –Wireless Communication for 2020 [4]

The architecture of current wireless networks is mostly centered on the base stations (BS) or access points (AP), which are fixed nodes that provide wireless access to user equipment (UE) located inside their coverage areas. Up to now, network evolution has focused mainly on BS deployment densification, which has been to satisfy the coverage and capacity necessities of mobile users. As a consequence of this strategy, radio networks systems are nowadays composed of different types of cells. Depending on the number of users connected to the BS and the extension of the covered area, they can be classified as macro-, micro-, Pico -, or, more recently, femto-cells. The cells can also be classified according to propagation mechanisms. Although this densification approach was sufficient in the past, the demanding 5G requirements, e.g., increased capacity, reliability, reduced latency or different types of IoT users, represents a challenge from the network architecture perspective.

E. LTE-A Random Access Channel Capacity Evaluation for M2M Communication [6]

M2M traffic is essentially heterogeneous and application dependent, which makes it uneasy to classify into a specific category. However, it is common to smart metering and reporting applications to generate and transmit periodically very low amount of data. This means that the M2M UEs have to go through a signaling-heavy RA procedure. The RA procedure consist four steps:

- Preamble Transmission
- Random Access Response
- Connection Request Message
- Contention Resolution

F. On Relay Selection Schemes for Relay-Assisted D2D Communications in LTE-A Systems [7]

Device-to-Device (D2D) communication under laying cellular systems allows two proximity D2D-capable user equipment's (UEs) to transmit data directly with the assistance of evolved Node B (eNB). The scenario is a single cell with its radius equal to 500 meters. All CUEs are uniformly distributed in the cell. There are only two DUEs to perform D2D communications, i.e., the source and destination. To minimize the influence of D2D communications on cellular communications, we presume that the source DUE is located at least half the cell radius away from eNB. Table I shows Major parameter which are used in performance evaluation.

G. Performance Study of Path Loss Models for LTE-A Relay Stations [8]

The original path loss model is given as:

$$PL_{3GPP} = 125.2 + 36.3\log(d) \qquad (6)$$

Where *PL3GPP* is the original 3GPP path loss model and *d*, in km, is the distance between base station and relay.

Modified Version of 3GPP Model is given as:

$$PL_{3GPP} = PL_{3GPP} - \Delta h + 0.38 \qquad (7)$$

$$\Delta h[dB] = 22\log(d/d_0) + \log(h/4) \qquad (8)$$

Where Δh is the Relay Antenna height correction factor

$$PL_{COST231\text{-}HATA} = A + B\log(d) + C_m - a(hm) \qquad (9)$$

$$A = 46.3 + 3.9\log(f) - 13.82\log(hb) \qquad (10)$$

$$B = 44.9 - 6.55\log(hb) \qquad (11)$$

Where $PL_{COST231\text{-}Hata}$ is the original COST231-Hata path loss model, *d*, in [km], is the distance between transmitter and receiver, *Cm* is the environment correction factor *a(hm)* is the receiver antenna height correction factor, *hm* is the receiver antenna height in meter, *f* is the frequency in MHz and *hb* is the transmitter antenna height in meter.

The receiver antenna height correction factor, *a(hm)*, for small to medium cities is given as:

$$a(hm) = (1.1\log(f) - .7)hm - (1.56\log(f) - 0.8) \qquad (12)$$

Where *f* is the frequency in MHz and *hm* is the receiver antenna height in meter.

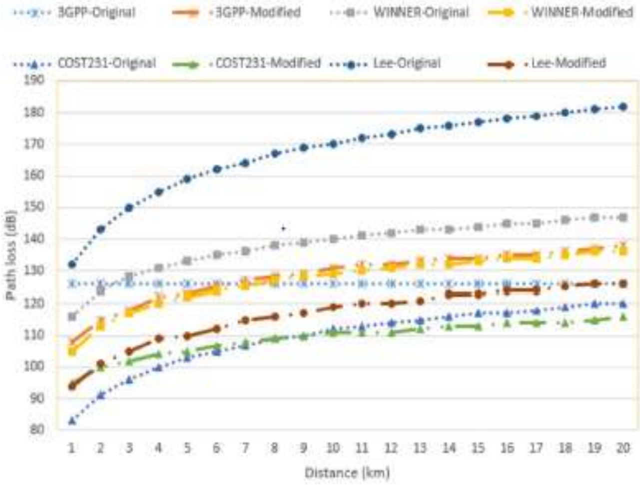

Fig.-3: Path loss versus distance [8]

Table I. MAJOR PARAMETERS USED IN PERFORMANCE EVALUATION [7]

Parameters	Value
Cell radius	500 m
Path loss exponent (α)	4
Path loss constant (K_0)	0.01
Noise power spectral density	-174 dBm/Hz
Transmit power of UEs	24 dBm
Energy conversion loss factor (η)	30%
SNR/SINR requirements for cellular and D2D links (γ_c, γ_d)	10 dB (if fixed)
RUE remaining battery capacity (E_i)	Randomly distributed in [0, 1810] mAh
Slow fading coefficient ($\beta^{(s)}_{a,b}$)	Log-normal distribution with standard deviation of 8 dB
Fast fading coefficient ($\beta^{(f)}_{a,b}$)	Exponential distribution with unit mean
Number of data bits in a packet ($\mathcal{L}$)	1024 bits (if fixed)
Duration of a time slot (ΔT)	1 μs
Maximum retransmission times (φ)	3

H. Scheduling Impact on the Performance of Relay-Enhanced LTE-A Networks [9]

Network infrastructure is composed by a set of network stations, each labeled with an index k. Two types of stations are considered: eNB sectors and RNs. Every eNB sector controls N_{RN} RNs. We focus on the eNB sector with index k = 0 and we denote $S_{RN} \triangleq \{1, \dots, N_{RN}\}$ the set of indices of the corresponding RNs. We define $S \triangleq S_{RN} \cup \{0\}$. Let ε and $\mathcal{R}$ be respectively the set of all eNB sectors and the set of all RNs in the network. There are $N \cup$ UEs in the network, of which N_k are served by station k. Let U be the set of all UEs and U_k the set of UEs served by k, so that

$$U = U_k \in \mathcal{S}^{\mathcal{U}_k} \qquad (13)$$

I. Queueing Analysis of Two-Hop Relay Technology in LTE-A Networks with Unsaturated and Asymmetric Traffic [10]

Mean end-to-end delay of a packet originated from Gi is given by:

$$\mathbb{E}[D_i] = (W_i + W_r)\mathbb{E}[X] = \left(\frac{1}{\tau_i(1-\xi_i)-g_i} + \frac{1}{\tau_r(1-\xi_r)-g_r}\right)\mathbb{E}[X] \quad i = 1, 2. \qquad (14)$$

J. Relay Technology in LTE-Advance [11]

Radio-Relay Station for relaying radio signals come in various types according to the relay technology adopted. There are three types of radio relay technologies.

Layer 1 relay consist of relay technology called a booster or repeater. This is an Amplifier and Forward (AF) type of relay technology by which Radio frequency signal received on downlink from the base station are amplified and transmitted to mobile station.

Layer 2 relay is Decode and forward (DF) type of relay by which Radio frequency signal received on downlink from the base station are demodulated and decoded and then encoded and modulated again before being sent on to the mobile station.

Layer 3 also performs demodulation and decoding of RF signals received on the downlink from the base station, but then goes on to perform processing for retransmitting user data on radio interface and finally perform encoding/modulation and transmission to the mobile station.

K. LTE Advanced system based on MIMO-OFDM for Rayleigh Channel [13]

Orthogonal Frequency-Division Multiplexing (OFDM) was adopted in LTE-Advanced to counter the Inter-Symbol Interference (ISI). The Cyclic prefix is appended to the OFDM symbol after the IFFT to mitigate the ISI effects. The channel is used as MIMO channel. The rest of the reception process is straight forward, since it is just the reverse of the one having taken place at the transmitter, as described above. Fourier based OFDM is a multicarrier modulation technique which generates orthogonal subcarriers. This implements the rectangular window which creates high side lobes which is one of the cause of ICI. Figure 4 shows the LTE-Advanced model Block diagram.

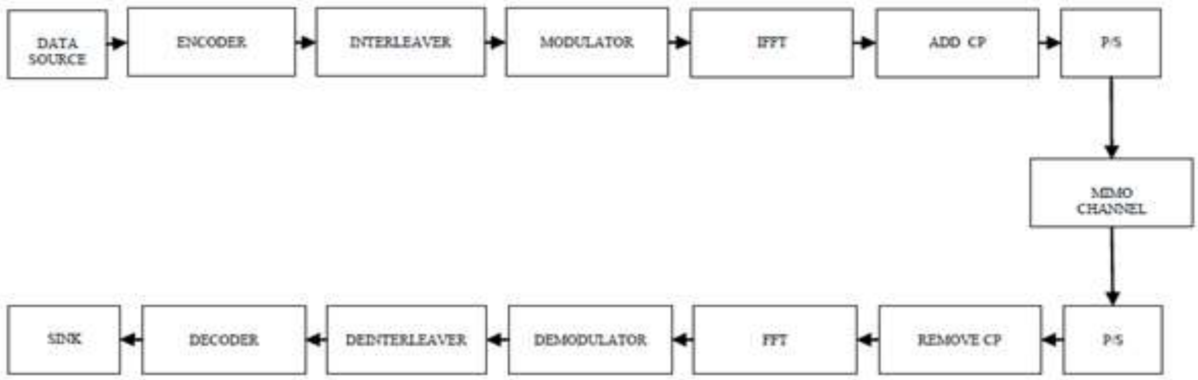

Fig.-4: Block Diagram of LTE-A System [13]

IV. COMPARISION OF EXISTING ALGORITHM

Approach of comparison in different technique, measuring parameters and their values, advantages and limitation is presented in Table II. Potential FD Technologies has advantage it will play a critical role in optimizing the performance gain of multi relay communication system, RAN sharing and RAT sharing increase capacity and reduce cost, Relay selection scheme enhancing traffic offloading capacity in LTE-A system, cost hata model is suitable for implementation of Backhaul link, two hop wireless network increase coverage and capacity and reduce cost/bit, relay technology also increase coverage in urban area and mountainous area.

Table II. Comparison of 5G Network Advancement Techniques

Sr. No.	Title	Technique used	Measuring Parameter	Advantages	Limits
1.	[1]	Potential FD Technologies, Including Passive suppression ,active Analog And Digital Cancellation	Outage Probability (λ=10,$\bar{y}_{LI}$=5dB,And N=4) $\bar{y}_{SR}$=5dB, Probability=0.0316 $\bar{y}_{SR}$=10dB, Probability=6.3×10^{-5}	FDM-based relay selection will play a critical role in optimizing the performance gain of multi relay cooperative communication system	SI Suppression is typically based on Costly hardware or Complex Matrix Computations and Cost Efficient Algorithms
2.	[2], [4]	5G Wireless Technology	Data Bandwidth >500Mbps	High Data Rate, High Capacity, Low Cost /bit	Traffic due to High Data Rate and Large Mobile Network

3.	[3]	Fountain Coding Scheme For Uplink Transmission Between M2M Devices And eNB	At n/n_1=1.4, JNFC-STBC BER <10^{-5}, While DTR BER>10^{-3} JNFC-STBC GER<10^{-3}, While DTR GER>10^{-2} Throughput >41% $BER_{threshold}=10^{-4}$	New communication Paradigm provides Ubiquitous Connectivity between devices without the need of human Intervention	At transmit SNR=10dB JNFC-RSD achieves 14%more efficiency comparing with JNFC-RLNC
4.	[5]	RAN Sharing RAT Sharing	Data capacity	Reduce the cost Increase Capacity	In dense area when traffic is high then more spectrum is required to provide extra capacity
5.	[6]	Modeling And Computation Of The Capacity of (RACH)	Success Ratio =0.00059 For 100 Preamble Success Ratio =0.97 For 500 Preamble	We are able to model in detail the RA procedure, without any supplementary assumptions on collision probability	The capacity of RACH is one order of magnitude smaller than the number of M2M devices
6.	[7]	Relay Selection Scheme For D2D communication	RUE_s Is Identified By $1/2B_0\log_2(1+\min\{\Upsilon_{S,Ri},\Upsilon_{Ri,D}\})\geq B_0 \log_2(1+\Upsilon_{d)}$ SINR=10dB,DUE_s=60m, Probability=0.9 SINR=8dB,DUE_s=60m, Probability=0.93	Enhancing Traffic Offloading Capacity in LTE-A Systems	Reducing Channel Bandwidth will increase the End-to-End delay
7.	[8]	Path loss Model	$PL_0(f)=PL_0(f_0)+20\log(f/f_0)$ PL_0@900MHZ, For Open Area=95dB, m=43.5dB/decade SuburbanPL_0=107.7dB, m=38.4dB/decade	COST231-HATA model has lowest path loss among all the model at all distance	It is not possible to perform real-time measurement of the path loss in the Backhaul link
8.	[9]	Proportional fair (PF) and Round Robin (RR) scheduling	Sector Throughput N_{RN}=2, Throughput = 2.25 (Simulated annealing) Throughput= 2.35 (936configurations Explored)	Optimization of Radio Frame Structure and Sub-Optimal RN Placement Scheme	PF does not bring a consistent Performance improvement w.r.t. RR.
9.	[10]	Queuing Modeling Method For Performance Evaluation Of Two Hop Wireless Relay Network In LTE-A	Expectation of Generic Time slot is:- $E[X]=\{P[\varepsilon_0]\sigma+(P[\varepsilon_1]+P[\varepsilon_2]+P[\varepsilon_r])T_s+(1-P[\varepsilon_0]-P[\varepsilon_1]-P[\varepsilon_2]-P[\varepsilon_r])T_c\}$ Mean End-to-End Delay:- $E[D_i]=\{(1/(\tau_i(1-\varepsilon_i)-g_i))+(1/(\tau_r(1-\varepsilon_r)-g_r))\}E[X]$	Wider coverage, Higher Capacity, Low cost/bit, Performance Analysis of End-to-End Packet Delay network	Network can enter a Steady State if and only if Each Server utilization is less than One
10.	[11]	Relay Technology	Signal to Inter-cell Interference plus Noise Power Ratio (SINR)	Improving Coverage in Mountainous Regions, Sparsely populated areas and Urban Areas and Indoor Environments	Delay Caused by User data Processing is Delay Caused by Modulation/ Demodulation and Encoding/Decoding.
11.	[13]	OFDM	BER Evaluation (BER 0.0065 BPSK @ 9 Eb/No) (BER 0.0092 16QAM @ 5 Eb/No) (BER 0.00 QPSK @ 9 Eb/No) (BER 0.00 64QAM @ 12 Eb/No)	Robust, CP reduces ISI BER is low for BPSK and 16 QAM, BER reduces with iterations	Not guarantee Linear behavior Of system.

V. CONCLUSION

This review focused mainly on the literature survey and analysis of existing 5G Network Advanced technology based application with its algorithm for communication system. A comparison of existing 5G Network Advanced technology is done which discusses 5G Network advanced techniques, measuring parameters, advantage and limitation. Queuing modelling increase the coverage and capacity at low cost and RAT and RAN sharing also increase capacity and reduce cost but in RAN, RAT sharing network need more spectrum in dense area. Modified COST231-HATA model has lowest path loss among all path loss model and in future research it can be implemented in Backhaul link for reduce the path loss in LTE-A system. Relay technology for D2D communication can play an important role to enhancing traffic overload and increase coverage in mountainous region. With introducing Relay in LTE-A system it can reduce interface for LTE-A system and this is a greater advantage for telecommunication sector. Full Duplex communication technique have increased throughput and diversity. In future Relay technology can be used for achieving self-backhauling of the radio signal between base station and mobile It reduce the noise interface and improve SINR and efficient.

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