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Public Safety Communication using Relay Node in LTE-Advanced Technology

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Abstract -- *Relaying* is one of the best technologies used in LTE Advanced networks. It improves the quality of service over conventional one with respect to emergency services. The existed broadband services show poor quality for indoor services due to lack of coverage of macro cell network. To be effective in indoor communication, this paper proposes relaying concept in telecommunication services. This paper aims to promote best indoor coverage using relaying concept when compared to traditional macro cell network configuration. To do this, resource sharing algorithm was introduced in relay link to provide the information about maximum-minimum fairness of signal.

Key words -- Relay node, Telemedicine, Indoor coverage and Relay Enhanced Cell.

I. INTRODUCTION

Improved spectral efficiency and high data rates are achievable by 4th generation wireless technologies. To provide high quality of service and to easy deployment, the research is going on Long Term Evaluation – Advance (LTE-A) [5][2]. Interference is the common phenomenon between user terminal and base station. Some of the factors which cause interference are fading, shadowing and path loss. To decrease this factor, the engineer has to increase the transmitting power or to decrease the area covered by base station. The instructor is always reluctant to increase the base station due to several reasons. Relaying is one of the best radio access techniques to solve this problem [1][9]. This technique uses the Relay Node (RN), which acts as low power base stations. It is also possible to create dynamic relay node according to the situation.

With this rapid development of relay concept in telecommunications, so many applications were designed. This technique is also suitable for the Public Safety Communication (PSC) purpose [4]. In current scenario, the developed countries are showing interest to deploy this concept in emergency applications like hospitals. The main theme of this paper is the analysis of RN in macro network. This paper will show the relaying benefits of Relay Enhanced Cellular (REC) network with respect to the emergency telemedicine case.

II. LTE SYSTEM REQUIREMENTS

There are different specifications to operate the 4th generation wireless networks. The system requirements for this were explained below.

- System capability:
    1. Data rate = 5 Mbps with Spectral efficiency = 3 bps/Hz
    2. Data rate = 100 Mbps with Spectral efficiency = 5 bps/Hz
    3. Bandwidth = 20MHz
- Latency:
  System latency was reduced in LTE. Here, user plane latency is used. It can be defined as one way transition time between user equipment and RAN.
- Throughput:
  LTE aims to improve the performance of the cell edge. If this is achieved, it is possible to make the same quality of the signal through out the area of cell. Practically it achieved 3 times to the high speed packet access in both uplink and downlink [7].
- Spectrum efficiency:
  In both uplink and downlink case, LTE was achieved 2 to 3 times to the high speed public access technologies. LTE is also compatible with third generation partnership project (3GPP)

III. LTE ADVANCED TECHNOLOGY PROPOSALS

In order to compatible with existed equipment, technology specifications and usage is critical. The following are the some of the proposals regarding LTE.

- Carrier Aggregation (CA):
  LTE supports wide bandwidth for both uplink and downlink. To provide this feature, it is recommended to aggregate multiple carrier components.
- Extended MIMO:
  To support the feature of multiple input and output, LTE is following the eight layers in down link [10]. In uplink it supports half of the number of layers to the downlink i.e. four.

- Coordinated multi point:

  Instead of using one base station, LTE is using the multiple base stations to guide the transmission and reception activity. This coordination between several base stations will increase the system performance as shown in below figure 1.

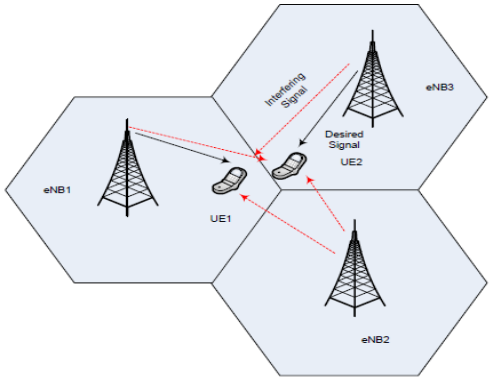

Fig 1: multi point transmission and reception

All geographically placed base station should maintain the common base band processing unit. To achieve this, the one common technique was Centralized RAN (CRAN).

Heterogeneous network

It is one of the popular deployment schemes which use low power nodes. This network uses multiple layers in transmission process. There are several systems which operated based on the property of heterogeneity [2]. One among them was Pico base stations. Relaying for the heterogeneity is shown in the following figure 3.

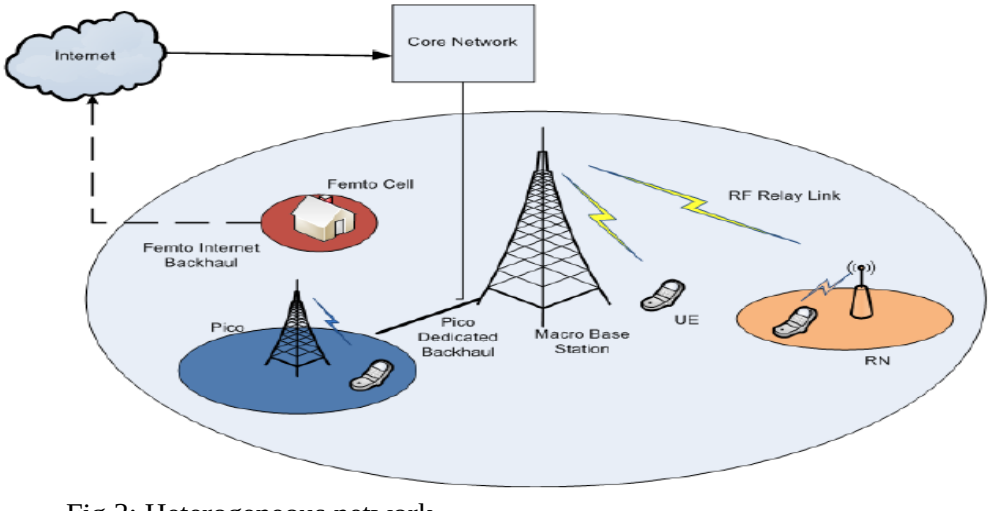

Fig 3: Heterogeneous network

IV. RELAYING IN LTE ADVANCED

In cellular networks the most venerable problems are created by environmental factors such as fading. To improve good Signal to Noise Ratio (SNR), the designer has to increase the base station power. This phenomenon may cause intra interference [1]. The other option to deal this case is to reduce the coverage area, but the number of required base stations and cost will increase.

The solution to this problem was deploying micro over laid network using relay nodes as shown in figure 2. The communication between donor cell and user equipment has both the data and control signal [7]. This relaying has three interfaces. They are evolved node to evolved node, evolved node to gateway and user equipment to evolved node.

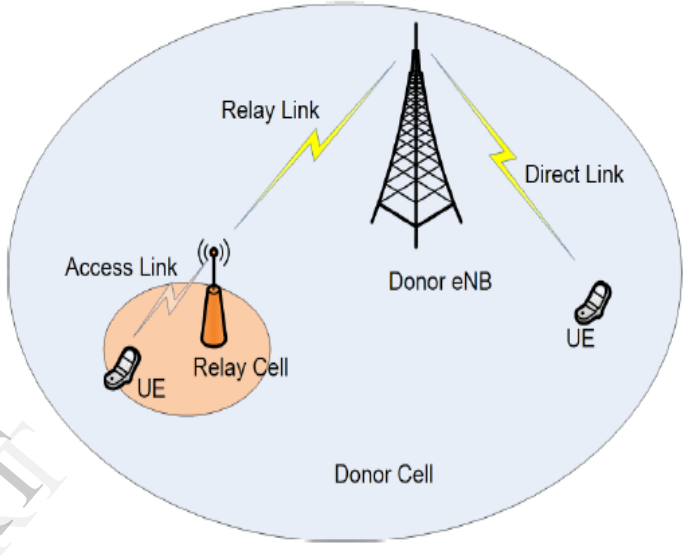

Fig 2: Relaying in LTE

V. IMPORTANT RELAY CLASSIFICATIONS

i. Fixed relay network

This method is best suitable to increase the coverage quality in at cell edges. It is also possible to provide network services for the users who are in out side of the coverage area. It is better to choose the best place to place the relay nodes such as hill stations or top of the buildings as shown in figure4.

Always the height of the main base station should be high when compared to the relay

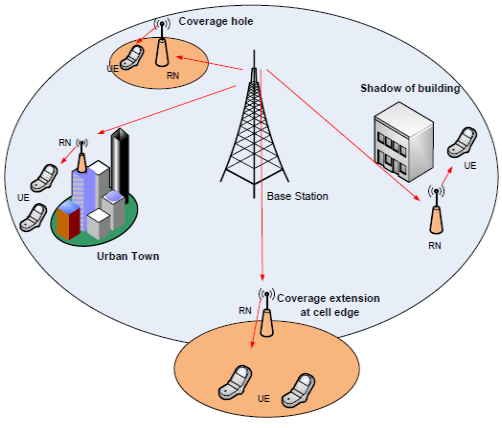

Fig 4: Fixed relay node

node height. It is also possible to provide the Line Of Sight (LOS) to selected location [3].

ii. nomadic RN

As the name indicates, the deployment of Relay Node is temporary as shown in figure5. This is recommended where the main base station faces problems to give proper coverage or if the existed network may face the congestion problems. The situations like emergency services and rescue operations may cause congestion [8]. Then, this type of Nomadic RN's will decrease the congestion. It was operated with both LOS and No LOS. When compared with the height of relay node of Fixed RN, it is comparatively low. This model facing limitations in many aspects like coverage region, power and etc...

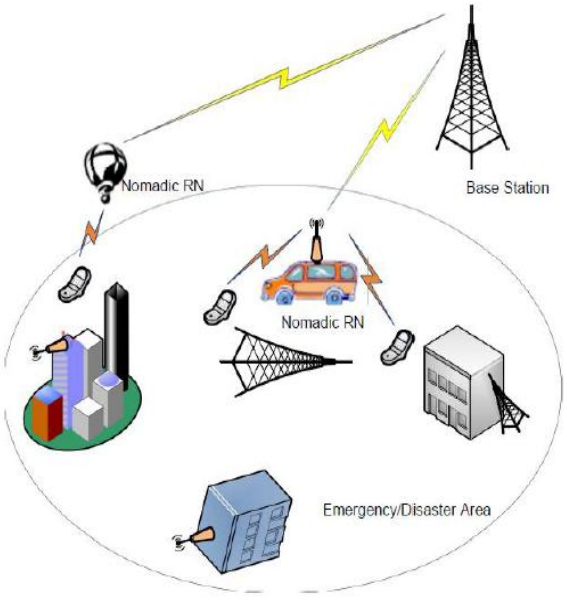

Fig 5: Nomadic Relay Node

VI. PUBLIC SAFETY COMMUNICATION (PSC)

The concept of relay is extended for public safety like public property and life during unpredictable circumstances. In this type of situation, the people need immediate response from concerned authorities. The most common authorities the public will use id police, medical and fire. They approach them with defined telephone numbers or public access points. Some situations like floods in Uttarakhand require fast assistance and help. All authorities who involve in the assistance need excellent coordination among them to deliver effective services.

Emergency telecommunication

This is popular concept to use telecommunication services in emergency case. These events will useful from small scale to wide scale of operations. The following are the some of the important procedures which are used in PSC.

i. *Citizen to authority communication*

In this communication, citizens will initiate call to responders through PSC. To do this communication, Public Safety Access Points (PSAP) is mandatory. But the existed methodologies of emergency call do not provide exact user location to provide immediate or considerable delay action. The expected architecture of citizen to authority communication is shown in figure 6. E-call by vehicle automatically is also introduced in this principle. At the time of accident, by using motion and disaster sensors, the vehicle will dial to the nearest service centre to intimate about the condition. This concept needs the usage of Global Positional System (GPS) to identify the vehicle location and also to provide driving directions [4].

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ii. *Authority to citizen communication*

This communication concentrates on the sending of messages (warnings/instructions) for the citizen. To do this, the authority may use any type of communication. Depending on the situation, they may use point to point, point to multi point etc… To do this, the authority has to identify the effected locations without any user guidance[1]. Figure 7 shows the authority to citizen model. Identification of locations is big challenge task in current scenario within defined threshold time interval [5].

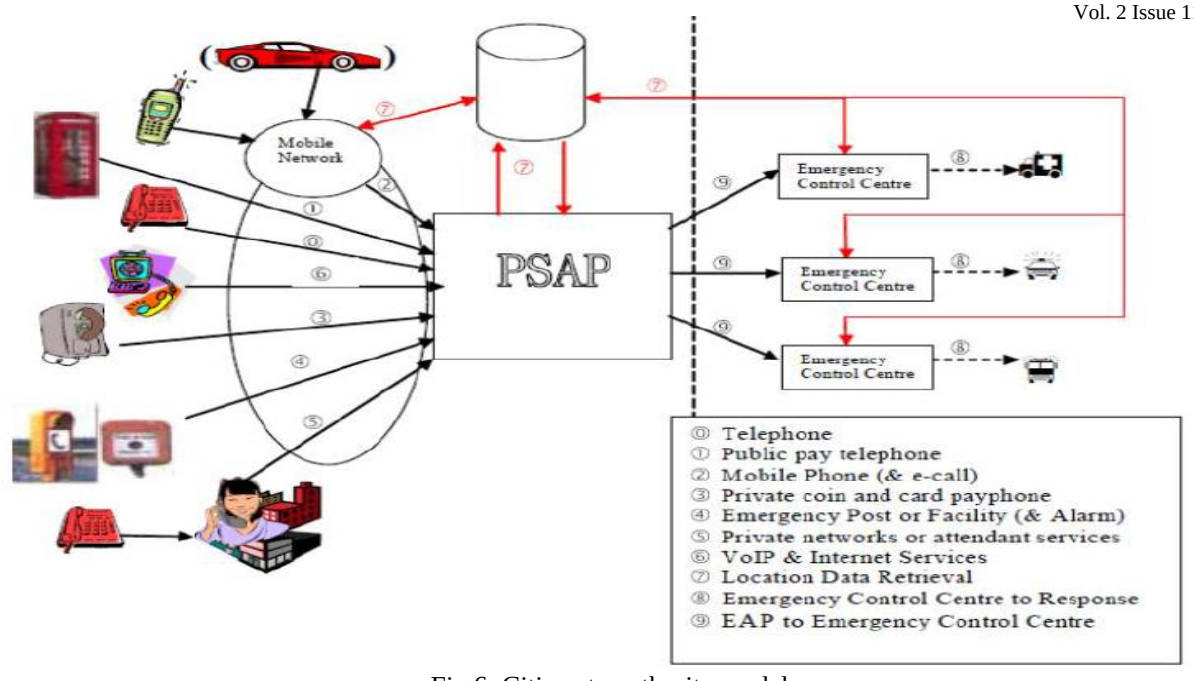


Fig 6: Citizen to authority model

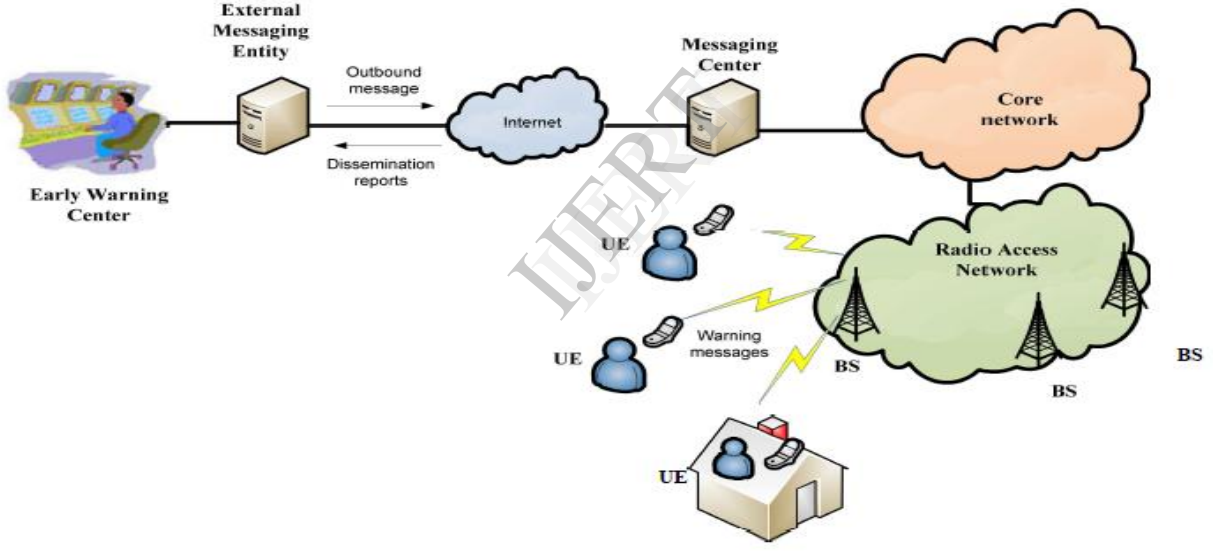


Fig 7: Authority to citizen model

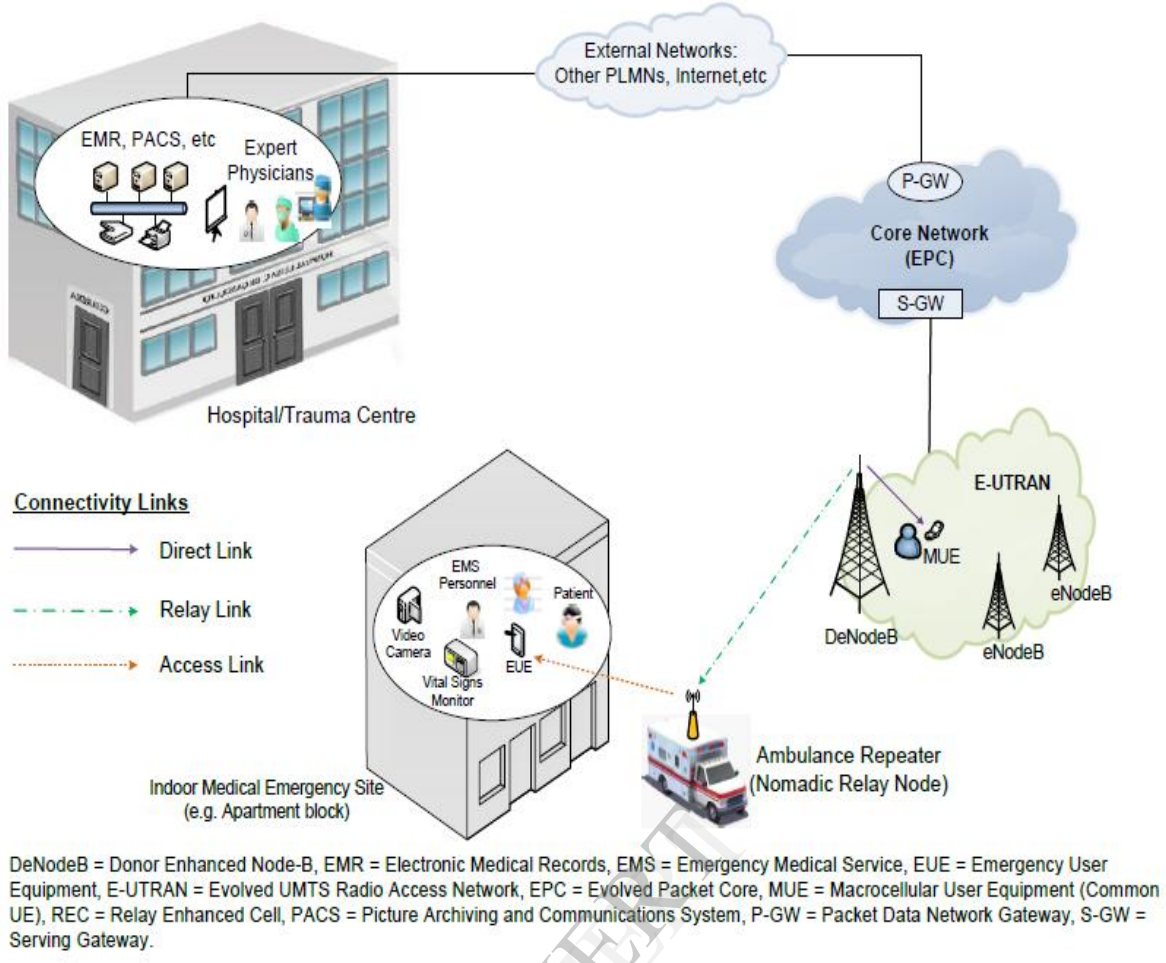
VII. RELAYING IN PSC

Medical services are of the vital services needed without delay. In this concept, we are using authority to authority communications to deliver effective indoor telemedicine services. The existed broadband services like WLAN's doesn't give any guarantee about accessibility due to weal access points. The existed Professional Mobile Radio (PMR) and satellite communications were facing several problems to support indoor communication. In this scenario, relaying is the best option. RN acts as an interface point between base station and user terminal. Nomadic relaying is best suitable in disaster services that allow installation of nodes with semi static in nature as shown in figure 8. Compared to macro cell networks, RN is well suited. Macro cell network may produce delay due to network and data congestion.

VIII. SIMULATION METHODOLOGY

In downlink, on access link relay nodes stops conversation with user equipment. By considering cell specific reference, RN makes compatibility towards user equipment. Each relay node serves for 8 user interfaces and Multi media Broadcast over Single Frequency Network (MBSFN) was achieved. RN sends OFDM symbols in first frame to these 8 UE have to convey information that the UE should not expect transmission in all intervals. Max-Min fairness scheduling was used to distribute RN and evolved nodes.

With seven hexagonal networks and follows 3 sector antennas, the following figure 9 shows simulated network.



DeNodeB = Donor Enhanced Node-B, EMR = Electronic Medical Records, EMS = Emergency Medical Service, EUE = Emergency User Equipment, E-UTRAN = Evolved UMTS Radio Access Network, EPC = Evolved Packet Core, MUE = Macrocellular User Equipment (Common UE), REC = Relay Enhanced Cell, PACS = Picture Archiving and Communications System, P-GW = Packet Data Network Gateway, S-GW = Serving Gateway.

Fig 8: Nomadic RN in indoor services

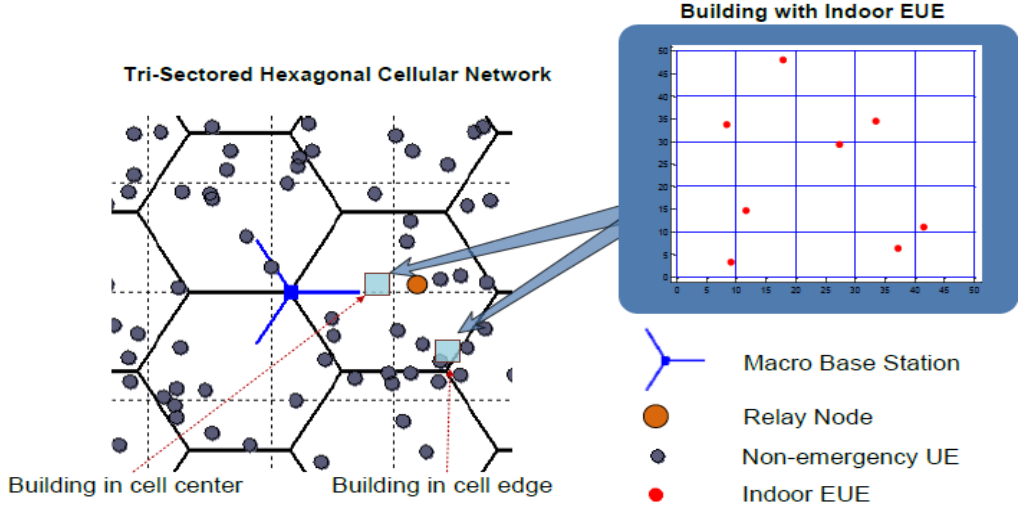


Fig 9: Relay enhanced cellular network

Simulation parameters:

The Table 1 shows required simulation parameters of RN

Table1: RN parameters

RN PARAMETERS	
Antenna configuration	2 transmitters and 2 receivers
RN- user equipment elevated gain	5dBi
Transmitted power	30 dBm
Pattern of antenna	Omni directional

Simulation result

The following figure 10 shows the Cumulative Distribution Function of user equipment throughput

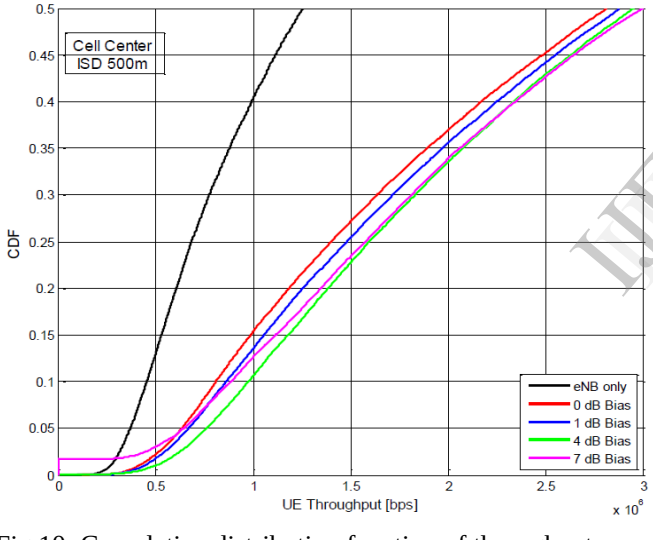


Fig 10: Cumulative distribution function of throughput

CONCLUSION

This paper explained the benefits of Relay Enhanced Network in downlink over ordinary communication in PSC. It also proved that the indoor coverage portions were much better than the conventional one

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