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D2D COMMUNICATION ON LTE FOR DISASTER MANAGEMENT AND EMERGENCY RESCUE OPERATIONS

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Abstract
Many people around the world are adversely affected by various unforeseen disasters such as earthquakes, floods, tsunami, volcanic eruptions etc. Disasters and emergency crisis are usually unpredicted events that cause panic condition in the civilian and affect existing resources. Further to minimize damage caused to civilians and property, efficient rescue operations need to be carried out which needs establishment of reliable communication link. However, during disaster, the existing communication infrastructure may be damaged due to which services may not be available or may be heavily congested. Hence in this paper, novel algorithms have been proposed to extend coverage for partial coverage areas and out of coverage areas (coverage holes) through interworking Long Term Evolution (LTE) system with ad-hoc networks, to enhance Quality of Service (QoS) requirements of disaster area User Equipments (UEs) within cell by deploying micro eNodeB (eNB) near the disaster site which is enabled with Geo-Tagging (GT)-based Connection Admission Control (CAC) mechanism for serving disaster area UEs.

Keywords:
Device-to-Device (D2D) Communication, LTE, QoS, Connection Admission Control, Scheduling, Proportional Fair

1. INTRODUCTION

Effective disaster management and emergency rescue operations depend on the establishment of reliable communication link between first responders and victims. Recently Long Term Evolution (LTE) broadband communication technology has been deployed to provide ubiquitous and mission-critical voice and data support during disaster recovery and rescue operations [1]. In addition, Device-to-Device (D2D) communication technology makes LTE systems more suitable for emergency rescue operations. D2D communication enables direct communication between first responders and victims even if they are in partial-coverage or out of coverage of the LTE system.

Partial coverage and out of coverage scenarios may include coverage hole created due to fading and path loss created by physical obstacles like buildings or indoor areas which may lose radio coverage that would limit communication during rescue operations. Integration of LTE and D2D communication is considered in this work for extending the coverage to partial coverage and out of coverage scenarios. D2D communication is a technology that permits User Equipments (UEs) to relay information to each other without accessing the cellular network [2]. Also, an algorithm is proposed to prioritize relay UE over other non-disaster area UEs in the cell during resource allocation.

Further, to enhance Quality of Service (QoS) requirements of disaster area UEs within coverage area of LTE network an additional micro eNodeB (eNB) is deployed near the disaster site. In addition, the micro eNB is enabled with Geo-Tagging (GT)-based Connection Admission Control (CAC) to prioritize disaster area UEs over other UEs within microcell.

The rest of this paper is organized as follows. Section 2 presents the related work carried out by various researchers. Section 3 discusses proposed algorithms to extend coverage to UEs in partial coverage area. Section 4 depicts the proposed Geo-tagging-based Resource Allocation Algorithm (GTRAA) and Geo-Tagging-based Connection Admission Control (GTCAC) mechanism to enhance the QoS requirements of disaster area UEs. Simulation results and discussions of the proposed work are presented in section 5. Section 6 concludes the paper.

2. RELATED WORK

The existing fundamental works on disaster communication and basic concepts of D2D communications are discussed in [3]. Authors in [3] have evaluated performance of the network architecture by utilizing the relay assisted transmission which effectively enhances the capacity and power saving of the network. The feasibility of capacity enhancement for high traffic situations through the introduction of D2D communication is presented in [4]. Using system level simulation results, authors show that resource sharing among D2D users is essential to achieve higher-capacity communication. In [5], spatial reuse in Round Robin (RR) and Proportional Fair (PF) scheduling algorithms for allocating radio resources to D2D communicating User Equipment (DUE) that satisfy certain sharing conditions is proposed to efficiently enhance system capacity of the Public Safety (PS) LTE. The use of mobile devices and applications in disaster situations is described in [6].

A standalone eNB architecture which deploys its own integrated virtual Evolved Packet Core (EPC) to ensure service without backhaul connection is proposed in [7]. The proposed standalone eNB establishes backhaul connection with each other to extend the coverage without the need for a central EPC structure. Authors have also discussed about basic LTE functions and design challenges related to connected or non-connected standalone eNBs. In [8], authors propose a system architecture solution for Public Protection and Disaster Relief (PPDR) service provisioning that enables PPDR service access through dedicated and commercial networks in a secure and interoperable manner. The spectrum related issues to the proposed PPDR service provisioning are addressed and a solution-based on the joint exploitation of dedicated and shared spectra is proposed in [8]. In [9], authors present a Smartphone-Assisted Victim Localization (SmartVL) method wherein the victims' smartphone detects the occurrence of disaster by monitoring the radio environment and self-switches to disaster mode and transmits emergency help messages to nearby smartphones. Using simulation studies, authors show that SmartVL method increases the possibility of saving lives by providing guidance during search and rescue operations.

Using WiFi tethering, a smartphone-based post-disaster management mechanism in natural-disaster affected areas is proposed in [10]. In the proposed scheme in [10], smartphones belonging to users stuck within the coverage areas of disaster-affected eNBs act as temporary mobile hotspots and provide internet connectivity to other WiFi-enabled clients. The scheme aims to relieve eNBs from getting more congested with the addition of new traffic and to retrain their battery backup. In [11], authors propose a navigation scheme to locate a victim during rescue operation by establishing a network initiated by either victim or rescuer. Using simulation studies, authors show that minimal time is required in locating victim during rescue operation with or without the service of mobile operator. A Time and Energy-Efficient Contention-Resolving Device Discovery Resource Allocation (TEECR-DDRA) scheme is proposed in [12] to enhance the success ratio for discovery of D2D users by reducing collisions among users. The proposed TEECR-DDRA scheme prioritizes public safety users to meet their QoS and latency requirements.

3. PROPOSED ALGORITHMS TO EXTEND COVERAGE TO UE IN COVERAGE HOLE

Establishing a reliable communication link is vital in disaster management and rescue operations. However, disaster area UEs may be present in a coverage hole, created due to fading and path loss of the wireless channel caused by physical obstacles like buildings, indoor scenario, out of coverage area of the eNB etc. A coverage hole is a region where the received signal strength of the serving cell and any other neighbour is below the signal level required to maintain QoS [13, 14]. In this work, a mechanism has been proposed to extend connectivity to the users (disaster area UEs) within coverage holes by adapting D2D communication system. D2D communication allows UEs in close proximity to communicate using 802.11b radio link rather than communicating through the eNB. Using D2D communication mechanism, the connectivity to UEs within coverage hole may be extended through a proximity UE having better connectivity to the eNB and which serve as a relay UE. Relay concept not only extend the system coverage but also increase the system capacity [15].

In the proposed D2D Communication-based Coverage Extension Algorithm (D2DCCEA), the Radio Resource Control (RRC) layer of UEs in the coverage hole activates the route search (through D2D communication) using 802.11b radio after it fails to establish direct connection with the eNB. One of the proximity UE from coverage area of eNB which is configured as relay UE receives and forwards these 802.11b connectivity requests to eNB, there by establishing connection between coverage hole UE and eNB through relay UE. Further, relay UE aggregates the uplink data received from all connected coverage hole UEs and sends the Buffer Status Report (BSR) indicating different Logical Channel IDs (LC ID) corresponding to each coverage hole UEs. While downlink data transfer from eNB, the relay UE decodes and forwards the data to the corresponding UEs within the coverage hole through 802.11b standard. Further, allocation of Resource Blocks (RBs) to relay UE and non-disaster UEs within the cell is carried out as per the existing PF scheduling algorithm. The Fig.1 shows representative scenario showing the extension of coverage to UEs in coverage hole using D2D communication.

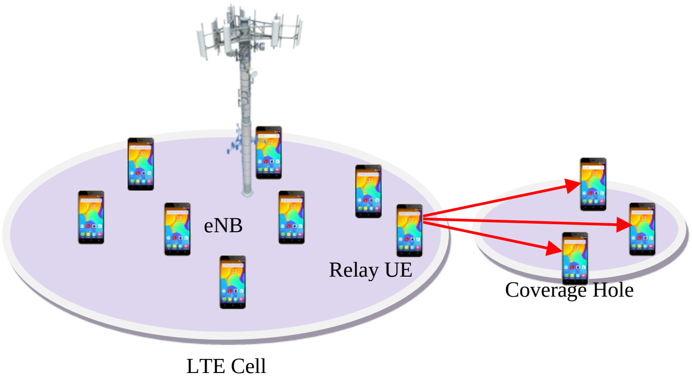

Fig.1. Representative scenario showing the extension of coverage to UEs in coverage hole using D2D communication

However, if the relay UE is treated with same priority as other UEs in the cell then the number of RBs allocated may not be sufficient to suffice the requirement of relay UE and connected coverage hole UEs. Hence, D2D Communication-based Relay UE Priority Algorithm (D2DCRUPA), which is an extension to D2DCCEA, is proposed by considering number of connected coverage hole UEs to prioritize relay UE over other UEs. In the proposed D2DCRUPA, the number of coverage hole UEs connected to the relay UE is sent to the eNB along with the BSR. In the proposed D2DCRUPA, the scheduling metric values are calculated for all possible UE-RB pairs and list is prepared as per the existing PF scheduling algorithm. Further, number of connected coverage hole UEs is multiplied to scheduling metric values corresponding to relay UE-RB pairs and metric list is sorted in descending order and the process of RB allocation to UEs is carried out as per existing PF scheduling algorithm. This modification of scheduling metric value corresponding to relay UE increases the chance of RB allocation to relay UE by the number of coverage hole UEs connected to it.

4. PROPOSED ALGORITHMS TO ENHANCE QOS REQUIREMENTS OF DISASTER AREA UES

The establishment of communication infrastructure is utmost priority for efficient search and rescue operation of disaster victims. The efficiency of critical disaster management and rescue operations are hindered as the number of disaster area UEs and other UEs in cell accessing eNB increases thereby degrading Quality of Experience (QoE) due to insufficient RBs allocated to each UEs. Hence in this work, Geo-tagging-based priority mechanism has been proposed wherein the disaster area UEs within the coverage area of eNB are prioritized over other UEs in the cell. In this mechanism, eNB identifies the area where the disaster has occurred and request’s location information of the UEs trying to establish connection-based on UEs feedback, eNB identifies the UEs as disaster area UEs if it is within radius R from epicentre of disaster area (Fig.2). These disaster area UEs are prioritized for resource allocation by multiplying their metric value by the priority coefficient K in the PF metric list prepared and the process of RB allocation to UEs is carried out as in existing PF algorithm.

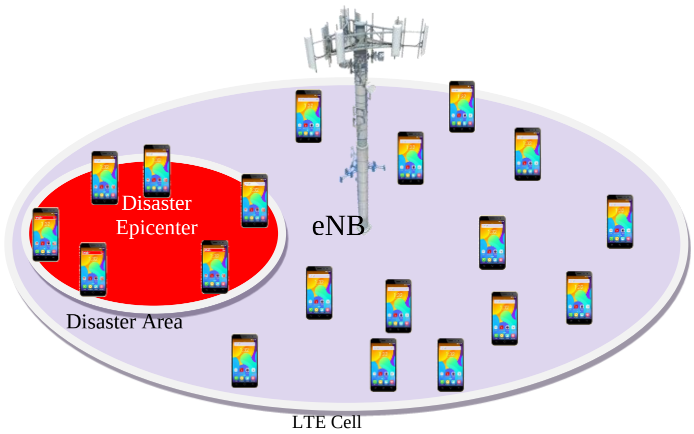

Fig.2. Representative scenario showing the disaster area within a macrocell

As the number of UEs (disaster and non-disaster area UEs) in the cell increases there may be considerable degradation in the performance of the disaster/non-disaster area UEs due to cell overload. In order to enhance performance of disaster area UEs and avoid degradation in the performance of non-disaster area UEs due to increase in number of disaster/non-disaster area UEs, it is proposed to introduce an additional micro eNB called Disaster Management micro eNB (DMmeNB) near to epicentre of the identified disaster area (Fig.3).

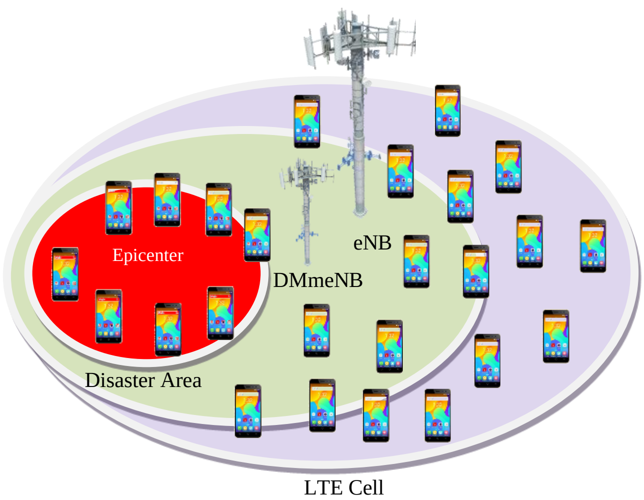

Fig.3. Representative scenario showing the deployment of micro eNB within macrocell

Further, if the number of non-disaster area UEs within the microcell connecting to the micro eNB increases, it may deteriorate the performance of the disaster area UEs. Hence it is also proposed to identify the disaster area UEs using Geo-Tagging-based Connection Admission Control (GTCAC) mechanism implemented in the micro eNB. In the proposed GTCAC algorithm, micro eNB requests location information of the UEs during connection establishment-based on UEs response, eNB accepts connection request of UEs within disaster area and rejects connection request of UEs outside the disaster area.

5. SIMULATION AND RESULTS

The performance of the proposed algorithms is evaluated using QualNet 7.1 network simulator. A single cell scenario with two ray path loss model and constant shadowing of mean 4dB are considered. Remaining simulation parameters considered are listed in table 1.

Table.1. Simulation Parameters

Property		Value
Simulation-Time		10 seconds
Simulation-Area		10km×10km
Downlink/Uplink-Channel-Frequency		2.4GHz/2.5GHz
Propagation-Model		Statistical
Channel-Fading-Model		Rayleigh
Channel-Bandwidth		10MHz
Antenna-Model		Omnidirectional
eNB	MAC-LTE-Scheduler-Type	Proportional-Fairness
	PHY- Tx-Power	23dBm
	Antenna-Height	12m
	MAC-Tx-Mode	1(SISO)
UE	MAC- Scheduler-Type	Simple-Scheduler
	PHY- Tx-Power	12dBm
	PHY- Rx-Antennas	1
	Antenna-Height	1.5m

5.1 PROPOSED D2DCCEA AND D2DCRUPA

The snapshot of scenario designed for performance evaluation of proposed D2DCCEA algorithm is shown in Fig.4. In this scenario, 10 UEs are placed within the coverage area and 4 UEs are placed outside the coverage area (coverage hole) of an eNB. An uplink Constant Bit Rate (CBR) connection of 100Kbps is established between eNB and each UE.

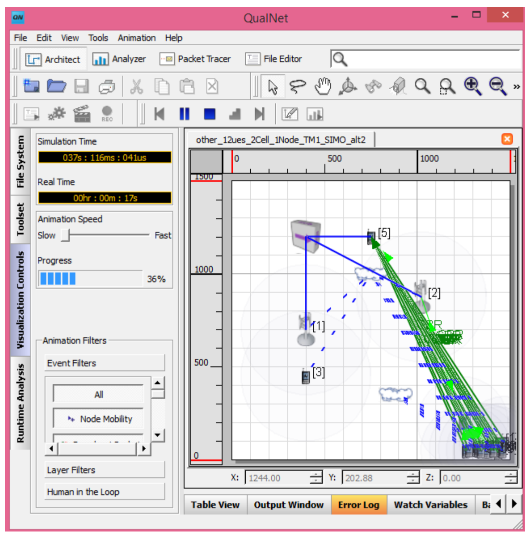

Fig.4. Snapshot of scenario designed for simulation studies of proposed D2DCCEA algorithm using QualNet 7.1 network simulator

Initially simulation is carried out by enabling only LTE interface for all UEs and performance metrics such as total messages received, average delay and average jitter are recorded. Simulation studies are repeated by increasing the number of coverage hole UEs from 4 to 20 in steps of 4 UEs. Further, simulation studies are repeated by increasing the data rate of uplink CBR connections to 200Kbps. Also, simulation studies are repeated for the proposed D2DCCEA by enabling both 802.11b and LTE interface for all UEs.

Similar set of simulation experiments are carried out to evaluate the performance of proposed D2DCRUPA, in which relay UE 4 is prioritized over other coverage area UEs during resource allocation.

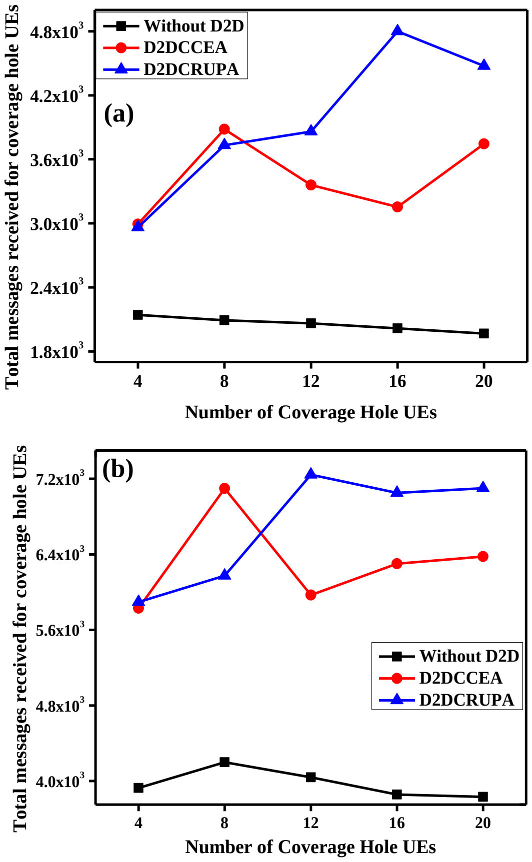

Fig.5. Total messages received performances of coverage hole UEs for D2DCCEA, D2DCRUPA and PF scheduling algorithm with increasing number of coverage hole UEs at different uplink data rates of (a) 100Kbps and (b) 200Kbps

The Fig.5(a)-Fig.5(b) shows the total messages received performance of coverage hole UEs with 100kbps and 200kbps data rates respectively for D2DCCEA, D2DCRUPA and PF scheduling algorithm with increasing number of coverage hole UEs. From Fig.5(a)-Fig.5(b), it is observed that the proposed D2DCCEA achieves higher total messages received performance compared to existing PF scheduling algorithm, since the proposed algorithm extends coverage to UEs in the coverage holes by establishing D2D connectivity using 802.11b radio. From the Fig.5(a-b), it is also evident that the proposed D2DCRUPA further enhances the total messages received performance. The proposed D2DCRUPA prioritize relay UE over other users in the cell for resource allocation, thereby allocating more number of RBs to relay UE leading to increase in total messages received performance. From Fig.5(a)-Fig.5(b) it is also observed that the total messages received performances of coverage hole UEs in the existing PF scheduling algorithm is decreasing with the increase in the number of coverage hole UEs. Since coverage hole UEs are enabled with only LTE interface in the existing PF scheduling algorithm, the possibility of serving them is scarce thereby degrading the total messages received performance.

The Fig.6(a)-Fig.6(b) and Fig.7(a)-Fig.7(b) shows the average delay and average jitter performances of coverage hole UEs with 100kbps and 200kbps data rates respectively for D2DCCEA, D2DCRUPA and PF scheduling algorithms with increasing number of coverage hole UEs. It is evident from Fig.6(a)- Fig.6(b) and Fig.7(a)-Fig.(b) that average delay and average jitter performances increase as the number of coverage hole UEs increases. Since in proposed algorithms coverage hole UEs get connectivity to eNB through relay UE wherein the total delay increases linearly with increase in number of UEs in coverage hole due to higher delay incurred in D2D communication with 802.11b standard. Whereas in existing PF scheduling algorithm only LTE interface is enabled for all UEs hence UEs in coverage hole may not be served.

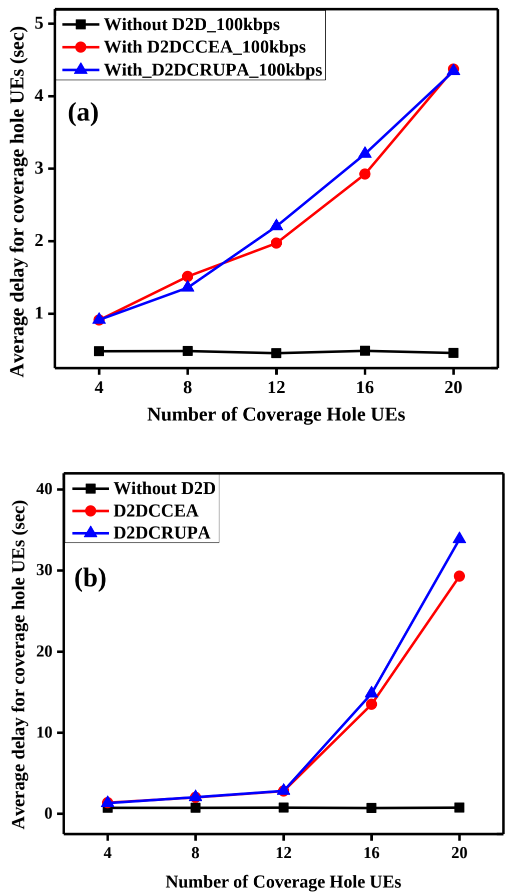

Fig.6. Average delay performances of coverage hole Ues for D2DCCEA, D2DCRUPA and PF scheduling algorithm with increasing number of coverage hole Ues at different uplink data rates of (a) 100Kbps and (b) 200Kbps

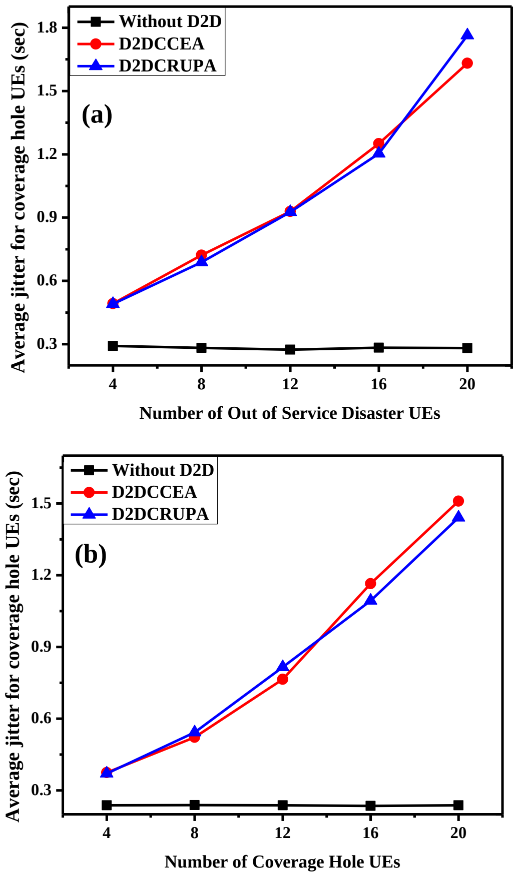

Fig.7.Average jitter performances of coverage hole UEs for D2DCCEA, D2DCRUPA and PF scheduling algorithm with increasing number of coverage hole UEs at different uplink data rates of (a) 100Kbps and (b) 200Kbps

5.2 PROPOSED GTRAA AND GTCAC ALGORITHM

The performance of proposed GTRAA and GTCAC algorithm for different scenarios considered are as follows:

5.2.1 Scenario 1:

The snapshot of scenario designed for simulation studies of the proposed GTRAA (for disaster and non-disaster area UEs) with single macro eNB is shown in Fig.8. In this scenario, a macro eNB with four groups of 10 UEs each is placed inside a terrain area of 10Km x 10Km where each group covers an area of radius 1Km within the cell. Further, group 3 (GP3 shown in Fig.8) UEs are considered as disaster area UEs and other group (GP1, GP2 and GP4) UEs are considered as non-disaster area UEs. A downlink CBR connection of data rate 512Kbps is established between Core Network (CN) and each of the 40 UEs. Simulation is carried out for PF scheduling algorithm which considers disaster and non-disaster area UEs with same priority in resource allocation. Performance metrics such as total messages received and average throughput are recorded for disaster area UEs (D_UEs) and Non-Disaster area UEs (ND_UEs). Simulation studies are repeated by increasing number of disaster area UEs (GP3 UEs) up to 50 in steps of 10 UEs.

The area of radius 1Km covered by group 3 (GP3) UEs is identified as disaster area and center of this area is assumed as an epicenter of the disaster area. Simulation studies are repeated for GTRAA with priority coefficient K=1.5. Later, simulation studies are repeated for GTRAA with K=2 and K=5.

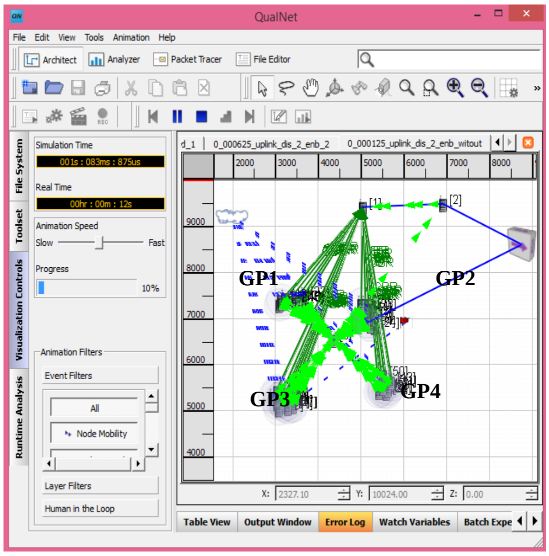

Fig.8. Snapshot of QualNet 7.1 network simulator scenario for macro eNB in single cell environment for performance evaluation of GTRAA

The Fig.9 and Fig.10 shows the total messages received and average throughput performance respectively for the disaster and non-disaster area UEs with increasing number of disaster area UEs for proposed GTRAA and existing PF scheduling algorithm in single macrocell scenario. From Fig.9 it is evident that the total messages received performance for disaster area UEs increases and for non-disaster area UEs decreases with the increase in number of disaster area UEs. The number of UEs served in the cell depends on the total number of RBs available for allocation, which is limited for a given bandwidth and shared among all UEs in the cell [13]. As the number of disasters UEs increases by keeping number of non-disaster area UEs constant (30), this may increase the possibility of serving disaster area UEs and reduces the possibility of serving non-disaster area UEs.

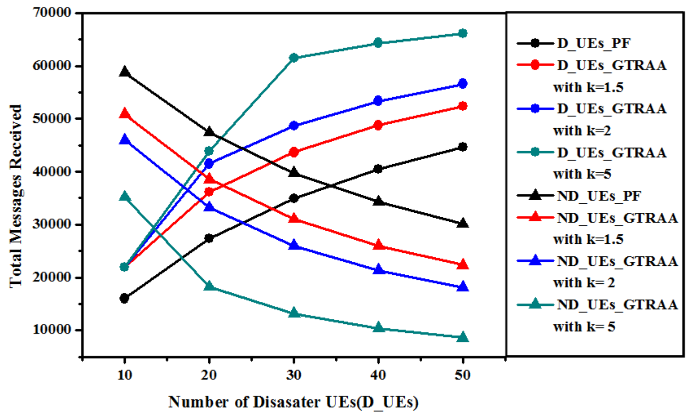

Fig.9. Total messages received performance of disaster and non-disaster area UEs with increasing priority coefficient (K) for proposed GTRAA and existing PF scheduling algorithm with increasing number of disaster area UEs

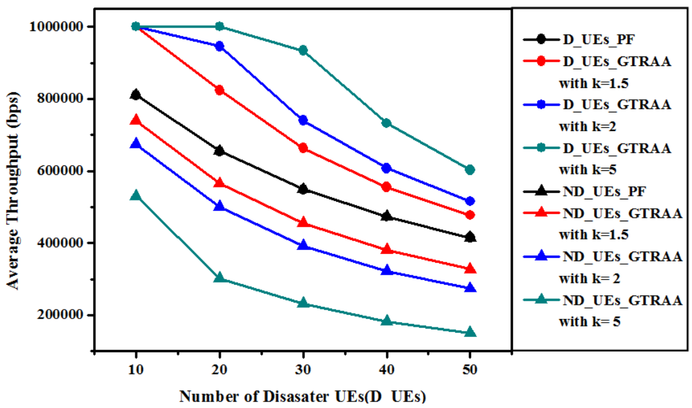

Fig.10. Average throughput performance of disaster and non-disaster area UEs with increasing priority coefficient (K) for proposed GTRAA and existing PF scheduling algorithm with increasing number of disaster area UEs

From Fig.10 it is evident that the average throughput performance for disaster area UEs and non-disaster area UEs for GTRAA and PF scheduling algorithm decreases as the number of disaster area UEs increases. The number of RBs allocated to individual UE decreases as the number of UEs in the cell increases since the total number of RBs available for allocation is limited for a given bandwidth.

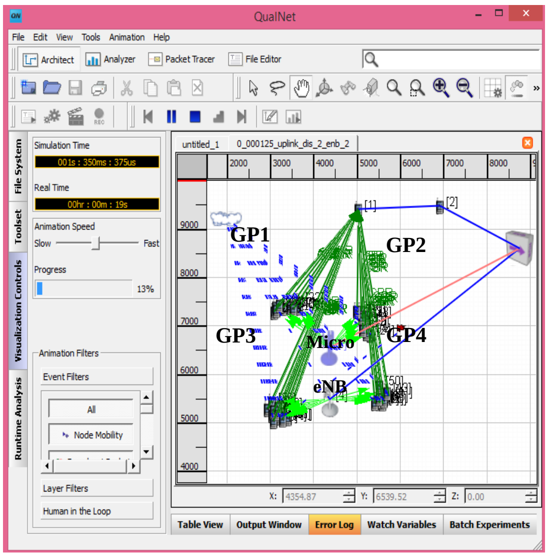

Fig.11. Snapshot of QualNet 7.1 network simulator macrocell scenario with micro eNB serving disaster area UEs

It is also observed from the Fig.9 and Fig.10 that the total messages received and average throughput performances increases for disaster area UEs and decreases for non-disaster area UEs with GTRAA as the value of priority coefficient (*K*=1.5, 2, 5) increases. Since GTRAA increases scheduling chance for disaster area UEs by a factor K, which increases possibility of allocating more RBs to the disaster area UEs and reduces the possibility of RB allocation to the non-disaster area UEs by a factor K.

5.2.2 Scenario 2:

The Fig.11 shows the snapshot of scenario designed for evaluating performance of PF scheduling algorithm with single macrocell (Fig.8), microcell without GTCAC and microcell with GTCAC algorithm. In this scenario, design parameters are retained as in Scenario 1. Initially simulation is carried out for single macrocell scenario and PF scheduling algorithm with CBR connection of 512Kbps established between the Core Network (CN) and 40 UEs. The total messages received, average delay, average jitter and average throughput metrics for GP3 disaster area UEs are recorded. The simulation studies are repeated by increasing data rate for all UEs from 1Mbps to 6Mbps in steps of 1Mbps.

For further simulations a dedicated Disaster Management micro eNB (DMmeNB) is placed inside the macrocell in such a way that it provides radio coverage to serve the GP3 and GP4 UEs whereas remaining UEs (GP1 and GP2 UEs) are still served by macro eNB. Simulation studies are repeated for PF scheduling algorithm with DMmeNB without GTCAC. Further, similar set of simulation studies are repeated with DMmeNB with GTCAC.

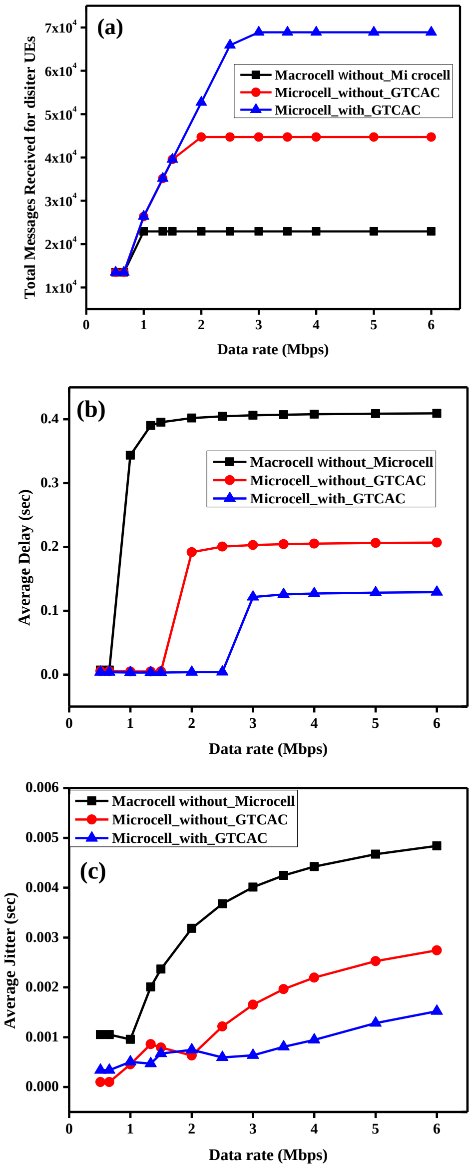

Fig.12. (a) Total messages received, (b) Average delay and (c) Average jitter performances of PF scheduling algorithm with single macrocell, microcell without GTCAC and microcell with GTCAC algorithm at different data rates

The Fig.12(a)-Fig.12(c) shows the total messages received, average delay and average jitter performance for disaster area UEs within macrocell, microcell with and without GTCAC for increasing data rates. From the Fig.12(a)-Fig.12(c), it is evident that the total messages received, average delay and average jitter performance of disaster area UEs are better with microcell considering GTCAC algorithm than microcell without considering GTCAC algorithm and without microcell. Since the connection requests of only disaster area UEs are accepted and these disaster area UEs are exclusively served by micro eNB with bandwidth 10MHz by sharing the available RBs in the microcell. Further, the performance of disaster area UEs in microcell without considering GTCAC algorithm is lower compared to performance with considering GTCAC algorithm, since the DMmeNB also serves non-disaster area UEs along with disaster area UEs within its coverage area sharing the available RBs which may reduce the resources (RBs) available to the disaster area UEs.

It is also evident from the Fig.12(a)-Fig.12(c) the performance of the disaster area UEs in microcell without considering GTCAC algorithm is better compared to performance of disaster area UEs within macrocell. This is because, without microcell eNB all the UEs including disaster area UEs (40UEs) are served by macrocell eNB which may lead to scarcity in the availability of RBs for disaster area UEs. Whereas with the introduction of DMmeNB near to the disaster area with a bandwidth of 10MHz, the resource availability is almost doubled and serves all disaster and non-disaster area UEs within its radio range thereby reducing the load on macro eNB.

5.2.3 Scenario 3:

Scenario parameters are retained as in Scenario 2 and simulation studies are carried out for PF scheduling algorithm in single macrocell scenario with CBR connection of 512Kbps established between the CN and 10 UEs in each group (total 40 UEs). Performance metrics such as total messages received, average delay, average jitter and average throughput are recorded for GP3 disaster area UEs (D_UEs) and other non-disaster area UEs (ND_UEs) in GP1, GP2, GP4. Simulation studies are repeated by increasing number of non-disaster area UEs in GP1 upto 50 in steps of 10 UEs.

Simulation studies are repeated for PF scheduling algorithm with DMmeNB without GTCAC and with GTCAC.

The Fig.13(a)-Fig.13(d) shows total messages received, average delay, average jitter and average throughput performances respectively of disaster area UEs with increasing number of non-disaster area UEs in macrocell for PF scheduling algorithm with single macrocell, microcell without GTCAC and microcell with GTCAC algorithm. It is evident from the Fig.13(a)-Fig.13(d) that total messages received, average delay, average jitter and average throughput performances for disaster area UEs remains unaltered with increase in number of non-disaster area UEs in macrocell. Since the disaster area UEs in microcell with and without GTCAC algorithm are served by microcell eNB, increasing number of non-disaster area UEs in the macrocell does not have any effect on the performances of disaster area UEs connected to micro eNB. However, when the disaster area UEs are served by macrocell without microcell, the performances of disaster area UEs decreases as the number of non-disaster area UEs in macrocell increases.

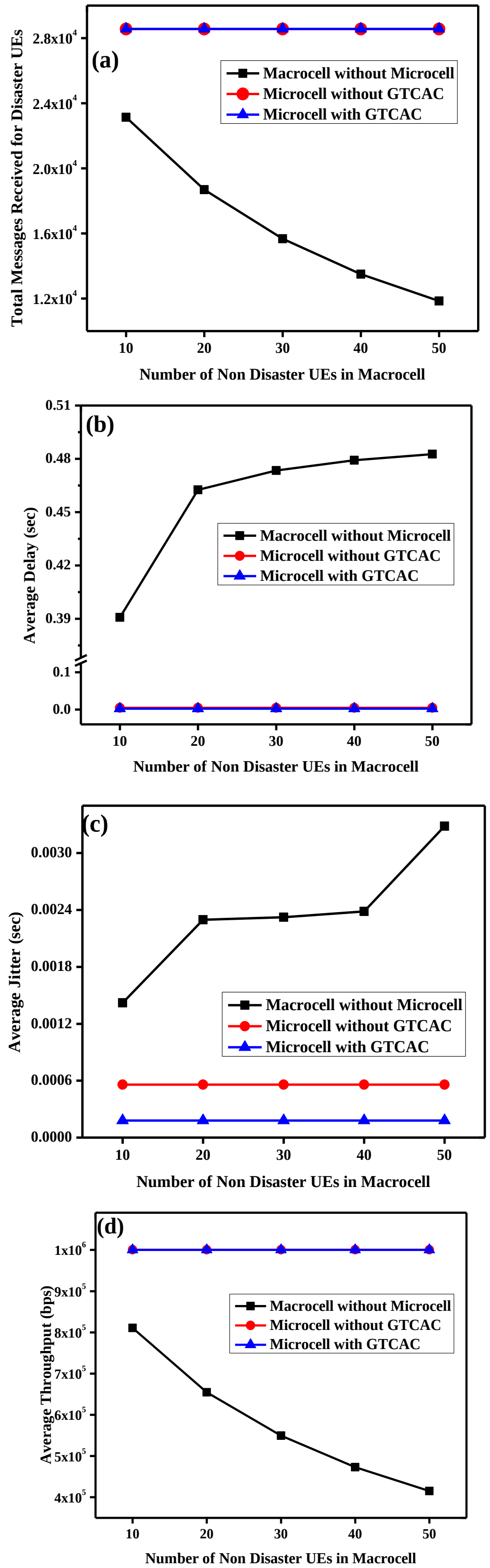

Fig.13.(a) Total messages received,(b) Average delay, (c) Average jitter and d) Average throughput performances for disaster area UEs with respect to increasing number of non-disaster area UEs in macrocell with single macrocell, microcell without GTCAC, microcell with GTCAC algorithm

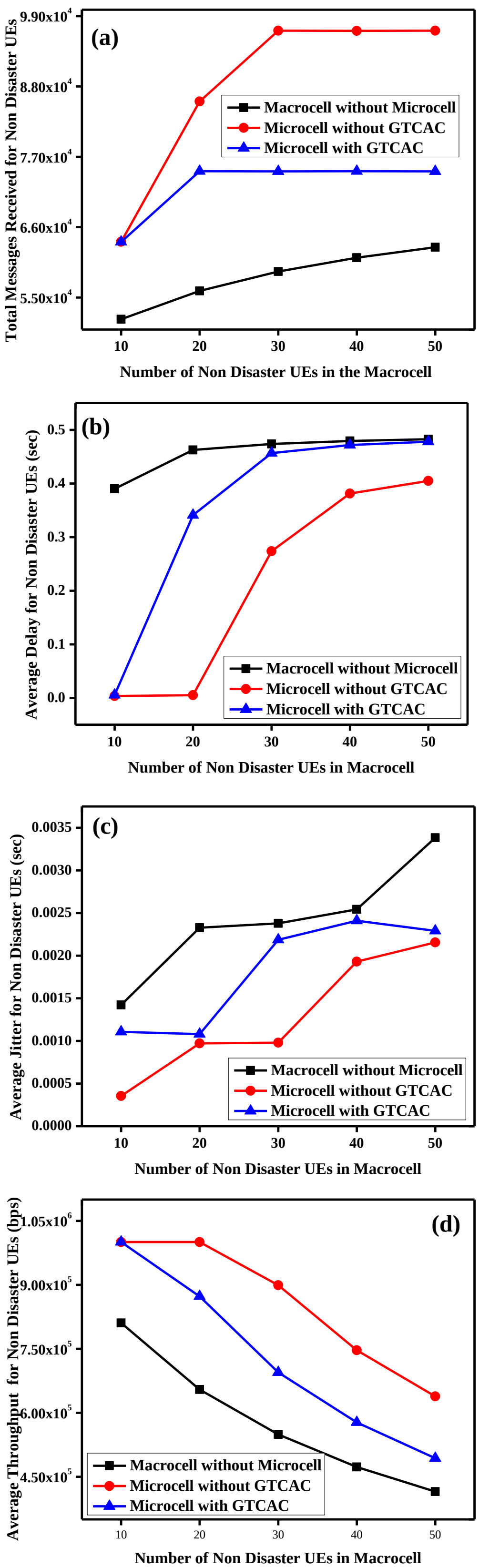

Fig.14.(a) Total messages received, (b) Average delay, (c) Average jitter and d) Average throughput performances for non-disaster area UEs with respect to increasing number of non disaster area UEs in macrocell with single macrocell, microcell without GTCAC and microcell with GTCAC algorithm

Since in macrocell scenario as the number of non-disaster area UEs increases, the number of RBs allocated to individual disaster area UE decreases thereby decreasing total messages received, average delay, average jitter and average throughput performance for disaster area UEs.

The Fig.14(a)-Fig.14(d) shows total messages received, average delay, average jitter and average throughput performance respectively for non-disaster area UEs with increasing number of non-disaster area UEs (GP1) in macrocell. It is evident from the Fig.14(a)-Fig.14(d) that total messages received, average delay, average jitter and average throughput performances for non-disaster area UEs are better with microcell without GTCAC than the microcell with GTCAC and served with macrocell without microcell. This is because for microcell without GTCAC, microcell eNB serves non-disaster area UEs belonging to GP4 along with the disaster area UEs reducing load on the macrocell which serves only UEs belonging to GP1 and GP2, which increases the RBs availability to non-disaster area UEs. Also, it is evident from the Fig.14(a-d) that the performance of microcell with GTCAC is lower than without GTCAC, since only the disaster area UEs (GP3) are served by microcell eNB with GTCAC algorithm, which makes macrocell to serve GP4 non-disaster area UEs along with GP1 and GP2.

However, the performance of the non-disaster area UEs without microcell is poor since macrocell eNB has to serve both disaster area UEs (GP3) and non-disaster area UEs (GP1, GP2 and GP4) by sharing limited available resource among all users.

5.2.4 Scenario 4:

Scenario parameters are retained as in Scenario 2 and initially simulation is carried out for PF scheduling algorithm in microcell without GTCAC scenario with CBR connection of 512Kbps established between the CN and 20 UEs including 10 GP3 disaster area UEs and 10 GP4 non-disaster area UEs. Performance metrics such as total messages received, average delay, average jitter and average throughput are recorded for GP3 disaster area UEs and GP4 non-disaster area UEs. Simulation studies are repeated by increasing number of GP4 non-disaster area UEs upto 50 in steps of 10 UEs.

The Fig.15(a)-Fig.15(d) shows the total messages received, average delay, average jitter and average throughput performance of disaster area UEs in microcell with and without the GTCAC with increasing number of GP4 non-disaster area UEs. It is observed from Fig.15(a)-Fig.15(d) that the total messages received, average delay, average jitter and average throughput performance for GP3 disaster area UEs in microcell is better with GTCAC than without GTCAC. Since only disaster area UEs are served by microcell with GTCAC algorithm, increasing number of GP4 non-disaster area UEs does not affect the performance of disaster area UEs. Whereas without GTCAC algorithm in microcell, performance of disaster area UEs decreases with increase in GP4 non-disaster area UEs. Since microcell eNB serves non-disaster area UEs along with the disaster area UEs which are in radio range of microcell which decreases the number of RBs allocated to disaster area UEs degrading the performance.

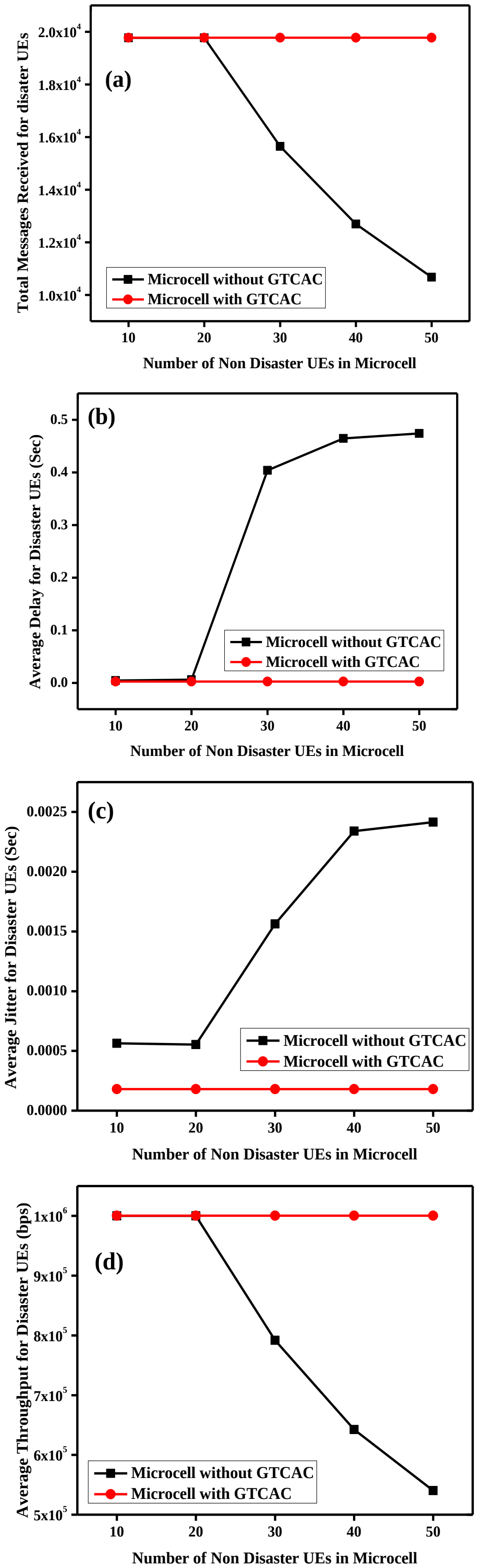

Fig.15.(a) Total messages received,(b) Average delay, (c) Average jitter and (d) Average throughput performances for disaster area UEs with respect to increasing number of non disaster area UEs in microcell

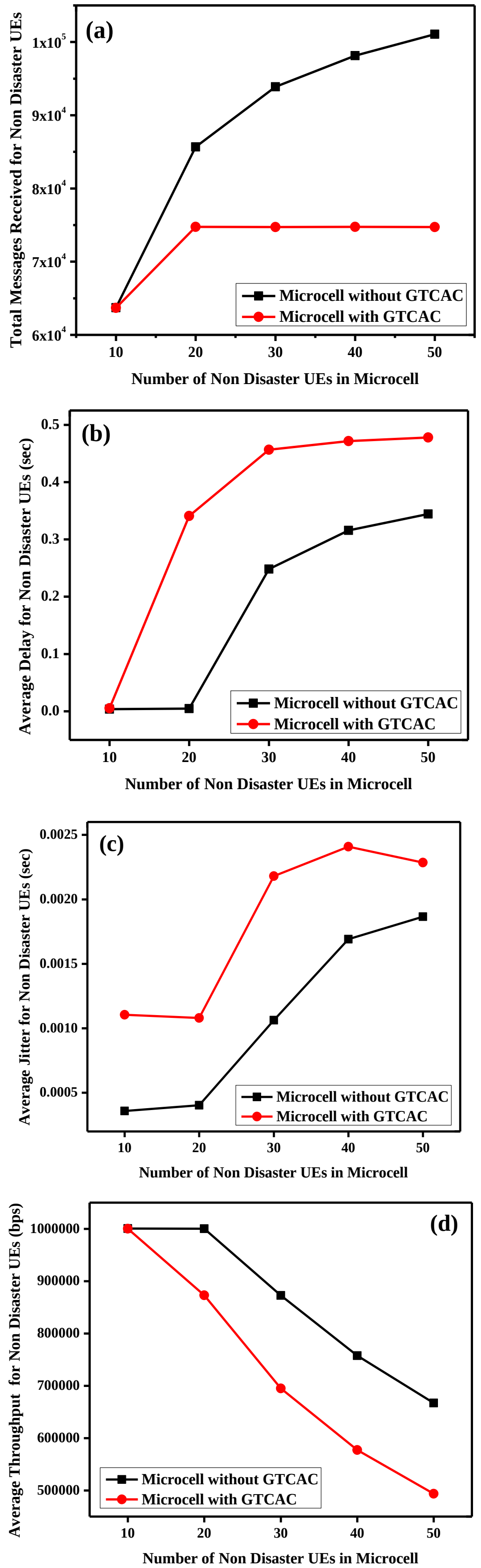

Fig.16. (a) Total messages received, (b) Average delay, (c) Average jitter and (d) Average throughput performances for non-disaster area UEs with respect to increasing number of non-disaster area UEs in microcell

The Fig.16(a)-Fig.16(d) shows the total messages received, average delay, average jitter and average throughput performance for GP4 non-disaster area UEs in microcell with and without the GTCAC with increasing number of GP4 non-disaster area UEs. It is observed from Fig.16(a)-Fig.16(d) that the total messages received, average delay, average jitter and average throughput performance of GP4 non-disaster area UEs is better in microcell without GTCAC than with GTCAC. This is because, when GP4 non-disaster area UEs increases by keeping number of GP3 disaster area UEs constant (10), this may increase the possibility of serving GP4 non-disaster area UEs and reduces the possibility of serving GP3 disaster area UEs.

6. CONCLUSION

The destruction of the communication infrastructure due to occurrence of disasters tends to halt the necessary communications between the rescuers and the people in need. In such scenarios, internetworking LTE system with ad-hoc wireless networks would provide reliable connectivity between rescuers and victims. Hence in this paper, D2D Communication-based Coverage Extension Algorithm (D2DCCEA) has been proposed to extend connectivity to users in coverage hole by making a proximity UE having better connectivity to the eNB as a relay UE. Also, to suffice the resource requirement of relay UE, a D2D communication-based Relay UE Priority algorithm (D2DCRUPA) is proposed. Further, Geo-tagging-based Resource Allocation Algorithm is proposed to prioritize disaster area UEs over other UEs in the cell. In order to serve disaster area UEs better, a micro eNB is placed near to disaster area and prioritization within microcell is provided to disaster area UEs using Geo-Tagging-based Connection Admission Control (GTCAC) mechanism.

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