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An Optimized User Prioritized Service Provisioning in LTE Network

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Abstract*: An exponential increase in the number of multimedia users over LTE network necessitates user prioritization and differentiated services support. LTE standard has defined Quality of Service (QoS) class-based user priority rather than priority among users within a QoS class. However, when the cell load exceeds the system capacity, Quality of Experience (QoE) of all the users may deteriorate due to lack of radio resources allocated to them. Under these circumstances, some users of interest may be prioritized over other users in the cell during resource allocation to enhance their QoE. In this paper, Proportional Fair (PF) scheduling algorithm Based User Priority (PFBUP) mechanism is proposed to prioritize organizational users over other users. Performance evaluation of the proposed mechanism is carried out using QualNet 7.1 network simulator by varying priority coefficient for the organizational users.

***Keywords*: LTE, Proportional Fair, Scheduling, Simulation, User priority.**

I. INTRODUCTION

Recent era has witnessed an explosive growth of multimedia users with varied interests over Long Term Evolution (LTE) mobile broadband access network. In order to accommodate varied interests of users and to enhance their Quality of Experience (QoE), user categorization and differentiated service provision over LTE network is necessary. LTE has defined user prioritization based on services through Quality of Service (QoS) classes. These QoS classes provide different priorities to users, for example, conversational class users are prioritized over the best effort users [1]. Further, prioritization among users with services belonging to same QoS class i.e., making decision about selection of users which needed to be serviced first among the users in the cell may be necessary to maximize user satisfaction which is not defined in the LTE standard. Especially in heavily loaded LTE cells, when all users are treated equally for the resource allocation, the priority users may suffer from degraded QoE. Hence, user categorization and prioritization mechanisms need to be provided for LTE network when the cell load exceeds the available system capacity. In user prioritization, users of interest can be assigned with higher priority over other users in the cell so that the users of interest get the higher resource allocation which enhances their QoE.

User prioritization may be accomplished by categorizing the users based on different policies such as the account balance of the users, taking QoS parameters, physical resource blocks utilization, user valuation and Packet Charging and Rate Function (PCRF) policies (premium/ high rate pack subscribers). Hence in this paper, a novel user prioritization algorithm for organizational users over roaming users has been proposed for allocating radio resources by eNodeBs (eNBs) deployed inside the campus. Further, the proposed prioritization algorithm is a variant of existing Proportional Fair (PF) scheduling algorithm which increases scheduling chance for the organizational users over non-prioritized roaming users. The proposed prioritization policy enhances the QoE for the priority users without degrading the total unicast throughput of the network achieved by the existing PF scheduling algorithm.

The rest of this paper is organized as follows. Section II gives the related work and section III describes the PF scheduling algorithm Based User Priority (PFBUP) mechanism for LTE Network. Section IV gives the simulation results and discussion followed by conclusion in Section V.

II. RELATED WORK

User prioritization may be accomplished by categorizing the users based on different policies. Authors in [2] have introduced user priority based on the account balance of the users during Call Admission Control (CAC) wherein user with higher account balance is given higher priority. Author in [3] propose a novel Utility-based Priority Scheduling (UPS) algorithm to support multimedia services over LTE networks by considering device differentiation based on device classification, mobile device energy consumption and multimedia stream tolerance to packet loss ratio. A priority-based congestion control algorithm for cross-traffic assistance on LTE networks is proposed in [4] wherein the UEs are prioritized based on certain criteria and when cell load exceeds the network capacity then low priority users are disconnected in order to serve high priority users.

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In [5] authors propose a class based dynamic priority scheduling algorithm for uplink transmission of Machine-to-Machine (M2M) and Human-to-Human (H2H) traffic in LTE. Using simulation studies, the authors in [5] evaluate and compare the performance of the proposed with existing schedulers.

Salman Ali AlQahtani in [6] propose an efficient CAC scheme by dynamically adjusting the user priority based on current network conditions, users' categorizations and traffic delay tolerances etc., to maximize resource utilization and operators' revenue. Using simulation studies, the author in [6] show that the proposed scheme achieves better balance between system resource utilization and users' privileges provided by network operators. Authors in [7], demonstrate the behavior of LTE base stations employing user prioritization schemes using real-world network test experiments.

III. PROPOSED PF SCHEDULING ALGORITHM BASED USER PRIORITY (PFBUP)

The existing PF scheduling algorithm is one of the basic algorithms employed to select different users in time domain and allocate radio resources based on their channel conditions to optimize system throughput and throughput fairness among allocated users. The PF scheduling algorithm calculates PF metric for each user in the cell at every scheduling instant using equation (1)

$$m_{i.k}^{PF} = \frac{d_k^i(t)}{R^i(t)} \quad (1)$$

where $d_k^i(t)$ is expected data rate for the ith User Equipment (UE) at time t on the kth Resource Block (RB) given by equation (2)

$$d_k^i = \log(1 + SINR_k^i(t)) \quad (2)$$

$SINR_k^i(t)$is Signal to Interference plus Noise Ratio for the ith UE on the kth RB at time instant t. The factor $R^i(t)$ represents the past average throughput experienced by the ith user until time t, is calculated as a moving average and it is updated every Transmission Time Interval (TTI) for each user. $R^i(t)$ is given by equation (3)

$$R^i(t) = (\beta)R^i(t-1) + (1-\beta)r^i(t) \quad for\ 0 \leq \beta \leq 1 \quad (3)$$

where $r^i(t)$ is the data rate achieved by the ith user at time t and parameters β determines fairness.

In the proposed priority mechanism, the organizational UEs are identified based on International Mobile Subscriber Identity (IMSI) by the network during attach process and the priority flag for organizational UE is set. During each scheduling instant the priority metric is calculated using equation (4).

$$Priority\_metric_{i.k}^{PF}(t) = K \times \frac{d_k^i(t)}{R^i(t)} \quad (4)$$

where K is the priority coefficient

The priority coefficient K is set to 1 for the non-priority UEs and can be set with value higher than one depending on the priority level of the organizational users (priority users) so that the probabilistic chance of resource allocation to priority users can be enhanced. Hence, QoE for organizational users can be enhanced without degrading the total unicast throughput of the network achieved by the existing PF scheduling algorithm by prioritizing them over non-prioritized roaming users.

After calculating PF metrics for all possible combinations of users (priority and non-priority users) and RBs, PF metric list is prepared and sorted according to the metric values in descending order. The eNB then initiates allocating RB to the UE with highest PF metric value in the PF metric list and remaining entries of the allocated RB are deleted from the sorted list. This procedure of RB allocation and deletion of corresponding entries from the PF metric list is repeated till all the RBs are allocated to UEs or sorted PF metric list becomes empty. Fig.1 shows flowchart of the proposed PF scheduling algorithm Based User Priority (PFBUP) mechanism for enhancing QoE of organizational users over roaming users.

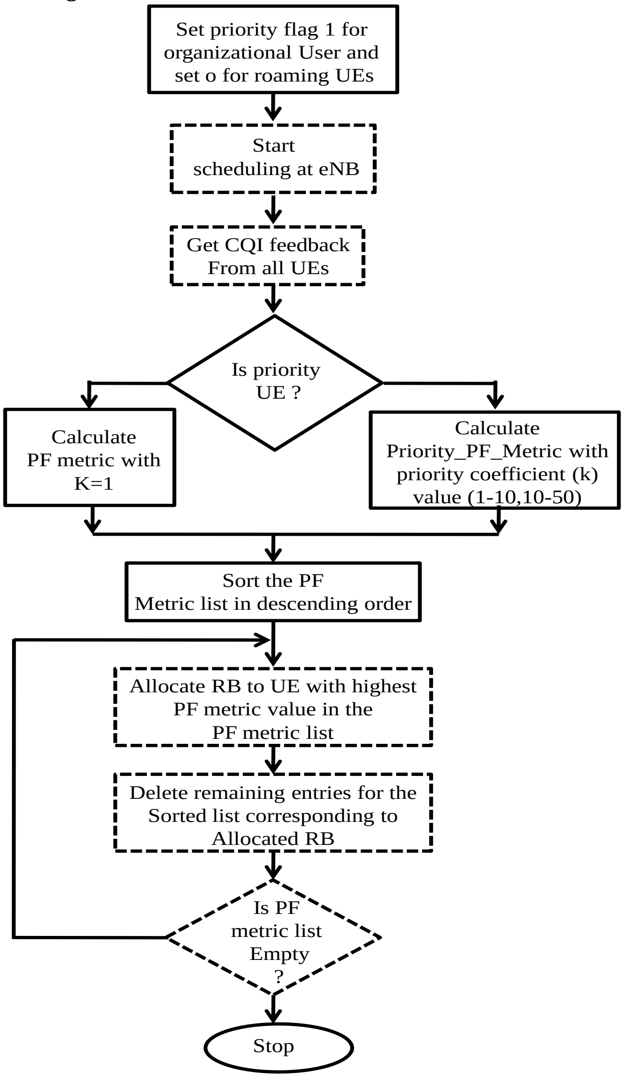

Fig.1. Flowchart of Proposed PF scheduling algorithm Based User Priority (PFBUP) algorithm

IV. SIMULATION AND RESULTS

The performance of proposed PF scheduling algorithm Based User Priority (PFBUP) mechanism is evaluated using QualNet 7.1 network simulator by considering single cell scenario in a simulation area of 5Km x 5Km. In the QualNet Network simulator, User Equipment (UEs) are identified by node Ids (equivalent to IMSI of the device) and a flag (priority flag) is defined for each UE.

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Further, priority flag is set to 1 for the UEs which are considered as priority users (organizational users) and set to zero for remaining UEs which are considered as non-priority users (roaming users). Two ray path loss model with lognormal shadowing is considered for the simulation studies. The remaining simulation parameters are listed in table 1.

Table-I: Simulation Parameters

Property		Value
Simulation-Time		30sec
Simulation-Area		5Km X 5Km
Downlink-Channel-Frequency		1.85GHz
Uplink-Channel-Frequency		1.75GHz
Pathloss model		Two-ray
Propagation-Model		Statistical
Fading Fodel		Ricean
Ricean K factor		4.0
Shadowing mean		4dB
Channel-Bandwidth		10MHz
Antenna-Model		Omnidirectional
eNB	Scheduling Algorithm	Proportional Fair
	PHY- Tx-Power	46dBm
	PHY- Num-Tx-Antennas	1
	PHY- Num-Rx-Antennas	1
	Antenna-Height	15m
UE	MAC- Scheduler-Type	Simple-Scheduler
	PHY- Tx-Power	23dBm
	PHY- Tx-Antennas	1
	PHY- Rx-Antennas	1
	Antenna-Height	1.5m
Traffic type		CBR
Connection type		Downlink

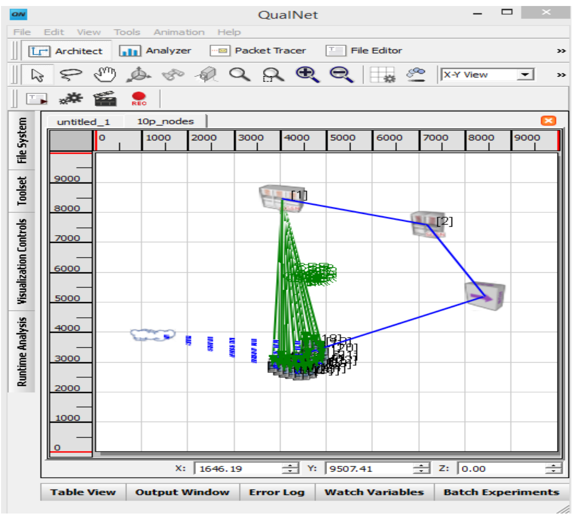

Fig. 2. Snapshot of the scenario designed for performance evaluation of PFBUP mechanism for 10 priority users and 10 non-priority users with K=1

The snapshot of the scenario designed for simulation study of the proposed PFBUP mechanism for 10 priority users and 10 non-priority users with K=1 using QualNet 7.1 network simulator is shown in fig. 2. In this scenario, single Core Network (CN), one Serving Gate-Way/Mobility Management Entity (S-GW/MME) and an eNB with 10 priority UEs & 10 non priority UEs are considered for the performance evaluation. A downlink Constant Bit Rate (CBR) connection of 3.0768 Mbps is established between CN and each UE. Initially simulation is carried out by considering priority coefficient K=1 for both priority and non-priority users. The performance metrics such as total unicast messages received, average throughput, average delay, average jitter are recorded for priority users, non-priority users and all users. The simulation studies are repeated by varying K value from 2 to 10 in steps of 1 for priority users and retaining K=1 for non-priority users.

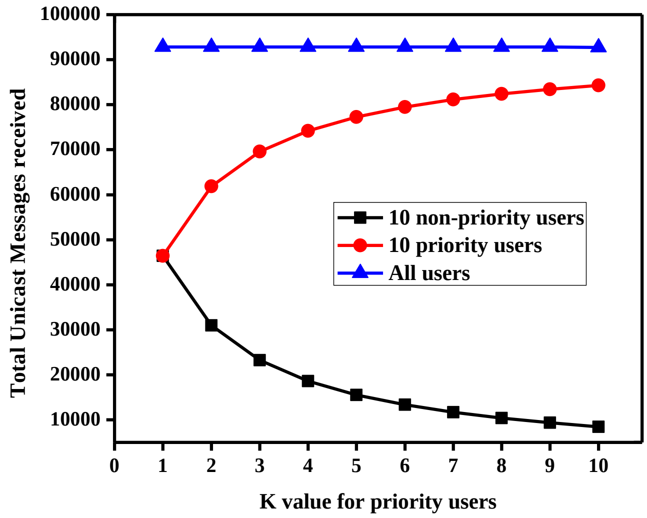

Fig. 3. Total unicast messages received performance for increasing priority coefficient (K) for priority users

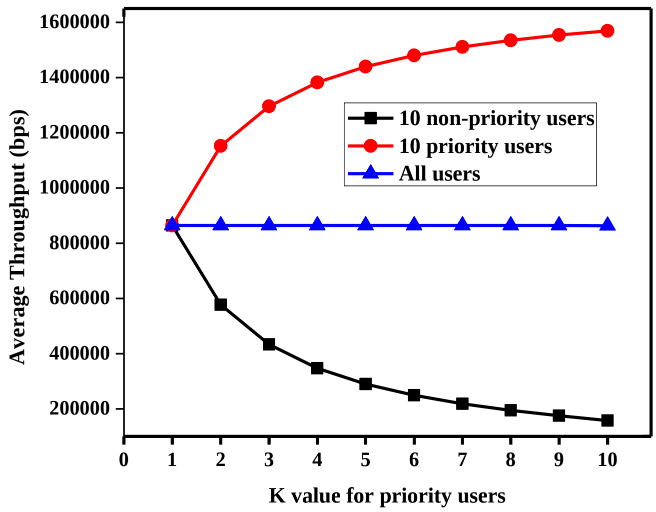

Fig. 4. Average throughput performance with increasing priority coefficient (K) for priority users

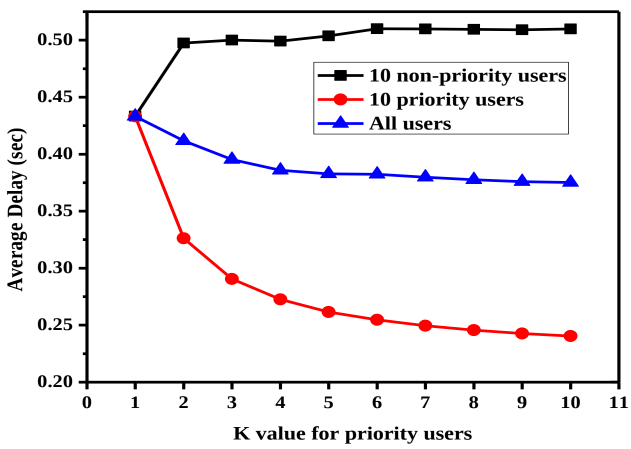

Fig. 5. Average delay performance with increasing priority coefficient (K) for priority users

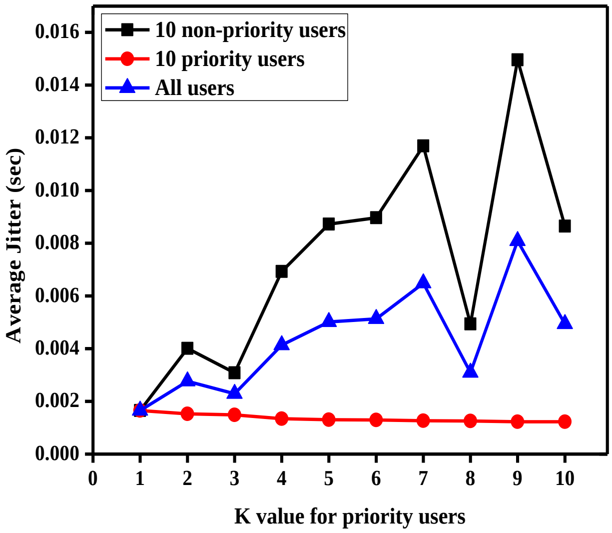

Fig. 6. Average Jitter performance with increasing priority coefficient (K) for priority users

Figures 3, 4, 5 and 6 show the total unicast messages received, average throughput, average delay and average jitter performances respectively with increasing priority co-efficient (K) values for priority users and retaining K=1 for the non-priority users. It is evident from figures 3, 4, 5 and 6 that when priority coefficient K=1 for both priority and non-priority users, total unicast messages received, average throughput, average delay and average jitter performances are almost same. This is because, when K=1, both priority & non-priority users are considered equally for resource allocation and the number of priority & non-priority users are equal in number (10 users).

It is also evident from the figures 3 and 4 that the total unicast messages received and average throughput performance increases for priority users and decreases for non-priority users as the K value for priority users increases. This is due to the fact that as the priority co-efficient K increases for priority users, the possibility of resource allocation also increase by a factor K i.e., priority users are allocated with more number of RBs which in turn reduces number of RBs allocated to non-priority users leading to decrease in total unicast messages received and average throughput for non-priority users. It is also evident from the figure 3 that the total unicast messages received performance of all users is equal to sum of total unicast messages received performance of priority and non-priority users. It is also observed from figure 4 that the average throughput performance of all users is almost equal to average of average throughput performance of priority and non-priority users. Since, the number of priority & non-priority users are equal (10 users each) and total available radio resource is a constant for a deployed eNB. Also, prioritizing organizational users over roaming users does not affect the overall performance of the cell. Further, from figures 5 and 6 it is evident that average delay and average jitter performances for priority users are better with higher K values of priority users (retaining K=1 for non-priority users). Since, allocated radio resource to priority users is higher with higher K value of priority users leading to better delay and jitter performance for priority users.

V. CONCLUSION

In order to enhance QoE for multimedia users with varied interests, user categorization and differentiated service provisioning over LTE network is necessary. In this paper, the users are categorized into organizational and roaming users. A novel PF scheduling algorithm Based User Prioritization (PFBUP) mechanism is proposed which prioritizes the organizational users over the roaming users in resource allocation. Performance evaluation of PFBUP mechanism is carried out using QualNet 7.1 Network simulator by varying priority coefficient for the organizational users. From simulation results, it is evident that total unicast messages received, average throughput, average delay, average jitter and in turn QoE for the organizational users is enhanced without degrading overall system throughput.

REFERENCES

1. Capozzi, G. Piro, L. Grieco, G. Boggia and P. Camarda, "Downlink Packet Scheduling in LTE Cellular Networks: Design Issues and a Survey", IEEE Communications Surveys & Tutorials, p:1-23, DOI: 0.1109/SURV.2012.060912.00100
2. Kalpana Saha (Roy), Iti Saha Misra "Priority Based Call Admission Control Protocol for Videoconference Traffic in Wireless/Cellular Networks", Elsevier Procedia Technology, vol(4), 2012, p:749-753 doi: 10.1016/j.protcy.2012.05.122.
3. Longhao Zou; Ramona Trestian; Gabriel-Miro Muntean, "A utility-based priority scheduling scheme for multimedia delivery over LTE networks", IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB) 2013, Pages: 1 - 7, DOI: 10.1109/BMSB.2013.6621745.
4. Lung-Chih Tung; You Lu; Mario Gerla, 'Priority-Based Congestion Control Algorithm for Cross-Traffic Assistance on LTE Networks", IEEE 78th Vehicular Technology Conference 2013, p: 1-5, DOI: 10.1109/VTCFall.2013.6692378.
5. Mukesh Kumar Giluka; Nitish Rajoria; Ashish C. Kulkarni; Vanlin Sathya; Bheemarjuna Reddy Tamma, "Class based dynamic priority scheduling for uplink to support M2M communications in LTE", IEEE World Forum on Internet of Things (WF-IoT), 2014, Pps: 313 - 317, DOI: 10.1109/WF-IoT.2014.6803179
6. Salman Ali AlQahtani, "Users' classification-based call admission control with adaptive resource reservation for LTE-A networks", Journal of King Saud University Computer and Information Sciences archive, Vol 29(1), 2017, p 103-115
7. Yekta Türk, Engin Zeydan and Cemal Alp Akbulut, "An experimental analysis of differentiated quality of service support for LTE users", 5th International Conference on Electrical and Electronic Engineering (ICEEE), 2018, p 408-412, DOI:10.1109/ICEEE2.2018.8391372

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