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Performance Study of LTE Scheduling Algorithms in Vehicular and Pedestrian Mobility

Mahesha .S.N[1], C.Y. Gopinath[2], Hemanth Kumar .A.R[3], Eshwar.N.Kumar[4]

PG Student [DEC], Dept. of ECE, Bangalore Institute of Technology, Bengaluru, Karnataka, India[1]

Associate Professor, Dept. of ECE, Bangalore Institute of Technology, Bengaluru, Karnataka, India[2]

Professor, Dept. of ECE, Bangalore Institute of Technology, Bengaluru, Karnataka, India[3]

Student [EC], Dept. of ECE, Bangalore Institute of Technology, Bengaluru, Karnataka, India[4]

ABSTRACT: Future generation cellular networks are expected to provide ubiquitous broadband access to a continuously growing number of mobile users. LTE (Long Term Evolution commonly marketed as 4G LTE) represents an emerging and promising technology for providing mobile internet access to next generation multimedia services. The scope of LTE network is to improve the system performance in terms of data rate, latency, throughput, coverage and cost. Even with the increased data rate in the current LTE system, it is necessary to improve Quality-of–Service (QoS) to the users under various mobility scenarios especially during handover. The performance of network varies with the scheduling algorithm used by scheduler. Performance of scheduling algorithms is also affected by the handover. Hence, the performance of the scheduling algorithms (RR, PF, MT,BET) in a multi cell network is evaluated to study the impact of handover on performance of scheduling algorithms.

KEYWORDS: LTE, Round Robin, Proportional Fair, Maximum Throughput, Blind Equal Throughput, UDP.

I.INTRODUCTION

LTE as standardized by Third Generation Partnership Project (3GPP) is a cellular standard based packet switching network architecture, that supports a high data rate of 100 Mbps in Downlink and 50 Mbps in Uplink direction[12]. LTE is Internet Protocol (IP) based architecture with all IP based communication including Voice-over-IP (VoIP), video streaming, online gaming and Transport Control Protocol (TCP) based services. LTE radio access network, based on Orthogonal Frequency Division Multiple Access (OFDMA), is expected to support wide range of multimedia and internet services, even at high mobility of users. The OFDMA technology divides the available bandwidth into multiple subcarriers and the downlink scheduler allocates a group of subcarriers (Resource Block) to a user based on its QoS requirements. Hence, the design of efficient resource allocator is important for effective use of radio resources to meet the system performance targets.

A defining feature of cellular networks is the ability of users to roam in the coverage area of the network without losing their end-to-end connectivity. LTE is capable of providing satisfactory services to mobile users with high mobility. When a user is moving from coverage area of one cell to coverage area of another cell, user switches from serving eNB to target eNB and this procedure is called as "Handover" [12]. Even though the handover procedure in LTE is designed to have low latency, still certain users may have high handover latency. During handover, the source eNB forwards the user data in its buffer to destination eNB over the X-2 interface. However this forwarding of user data may cause out of order delivery of packets and might also result in discarding of packets due to increased delay. In this work we use ns-3 and different mobility scenarios in multi cell network to simulate realistic LTE network across a wide range of network conditions in terms of throughput and delay.

The rest of the paper is organized as follows. Section II describes the architecture of LTE network. Radio Resource allocation techniques are discussed in section III. Section IV describes the Handover procedure and section V provides a brief overview of the scheduling algorithms used in LTE. Simulation studies and results are discussed in section VI and paper is concluded in Section VII.

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II. LTE ARCHITECTURE

In order to support wide variety of applications, LTE network is designed with challenging requirements that overtakes the features of 3G networks [7]. The main goal in the design of LTE network is to provide high data rate, spectrum efficiency, and QoS support without any disruption to end users applications during mobility. The high level architecture of LTE is comprised of the following three components- The User Equipment (UE), Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) and Evolved Packet Core (EPC) as depicted in Fig-1.

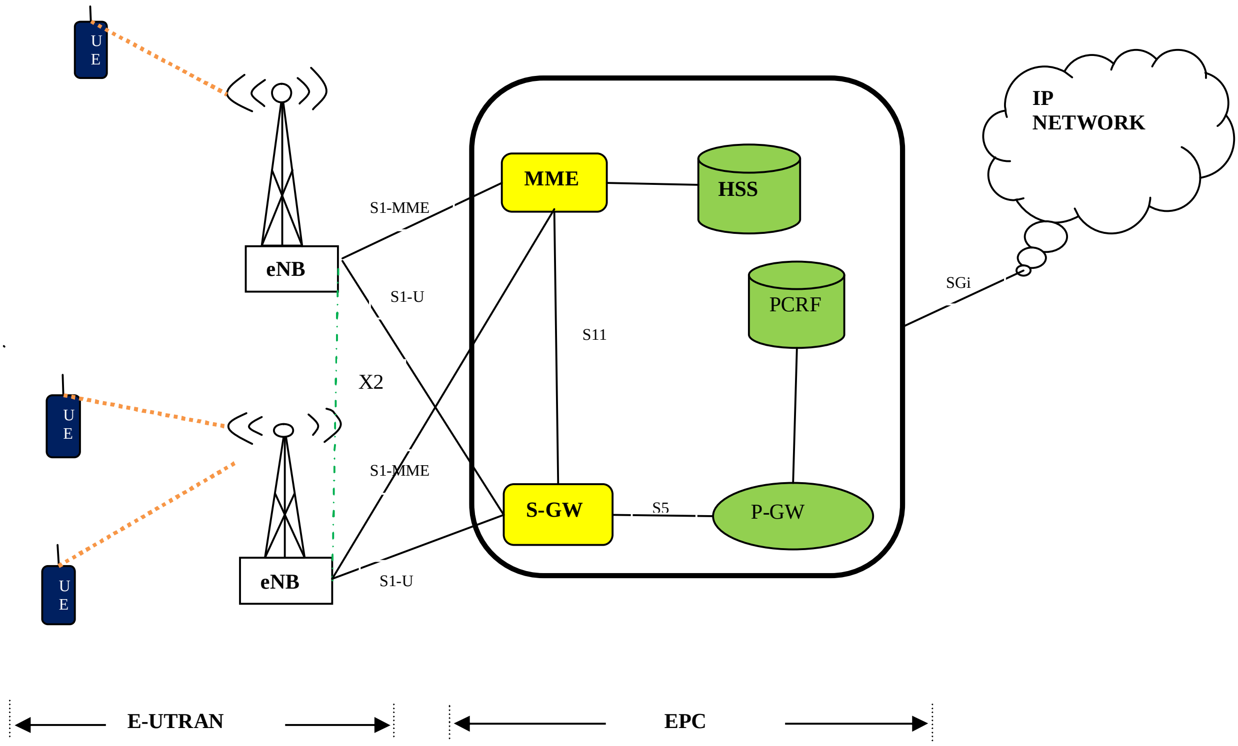

Fig.1 High Level LTE network architecture.

- User Equipment (UE): As the name suggest the User Equipment is the hand held device that allows user access to the voice and data services. UE is identical to the one used by UMTS and GSM.
- E-UTRAN (Evolved Universal Mobile Telecommunications systems Terrestrial Radio Access Network): The LTE Radio Access Network, E- UTRAN simply consists of a network of eNodeB's, which is used to provide transmission and reception of signals (S1-MME) and user data (S1-U) over the radio interface. The E-UTRAN provides connection between UEs and the Evolved Packet Core.
- Evolved Packet Core (EPC):The EPC acts as the inter-mediate gateway between the eNB and external data network. Functionalities of EPC include, charging and rate policing, end-to-end connection setup, mobility management and authentication etc.

III.RADIO RESOURCEALLOCATION IN LTE

OFDM is well known technique which is used by LTE system for transmission of data from eNB to the user equipment. The necessities of the LTE network such as increasing the peak data rate and improving the spectral efficiency is enhanced by OFDM technology. With OFDMA, each scheduled user occupies a number of resource blocks while each resource block is assigned exclusively to one user at any time. Resource block is the smallest radio resource unit that can be allocated to a UE. Each resource block correspond to12 consecutive subcarriers in frequency domain and one time slot of 0.5ms in time domain. A resource block consists of either 6 or 7 ODFM symbols, depending on whether the normal or extended cyclic prefix is employed. Two time slots of 0.5ms forms a Transmission

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Time Interval of 1ms. During every TTI scheduling decision is made depending on the Channel Quality Indicator (CQI) value reported by UE. Ten consecutive TTIs of 1ms form a LTE frame.

IV. HANDOVER IN LTE

LTE is capable of providing the satisfactory services to users with high mobility. In LTE, the handover (HO) procedure is controlled by the network but it is assisted by the User Equipment (UE). In LTE network, only Hard Handover is considered (i.e., break before connect).

Typical handover process involves four stages measurement control, HO preparation, HO execution and HO completion. fig-2 shows the complete handover process and the steps involved in handover[5].

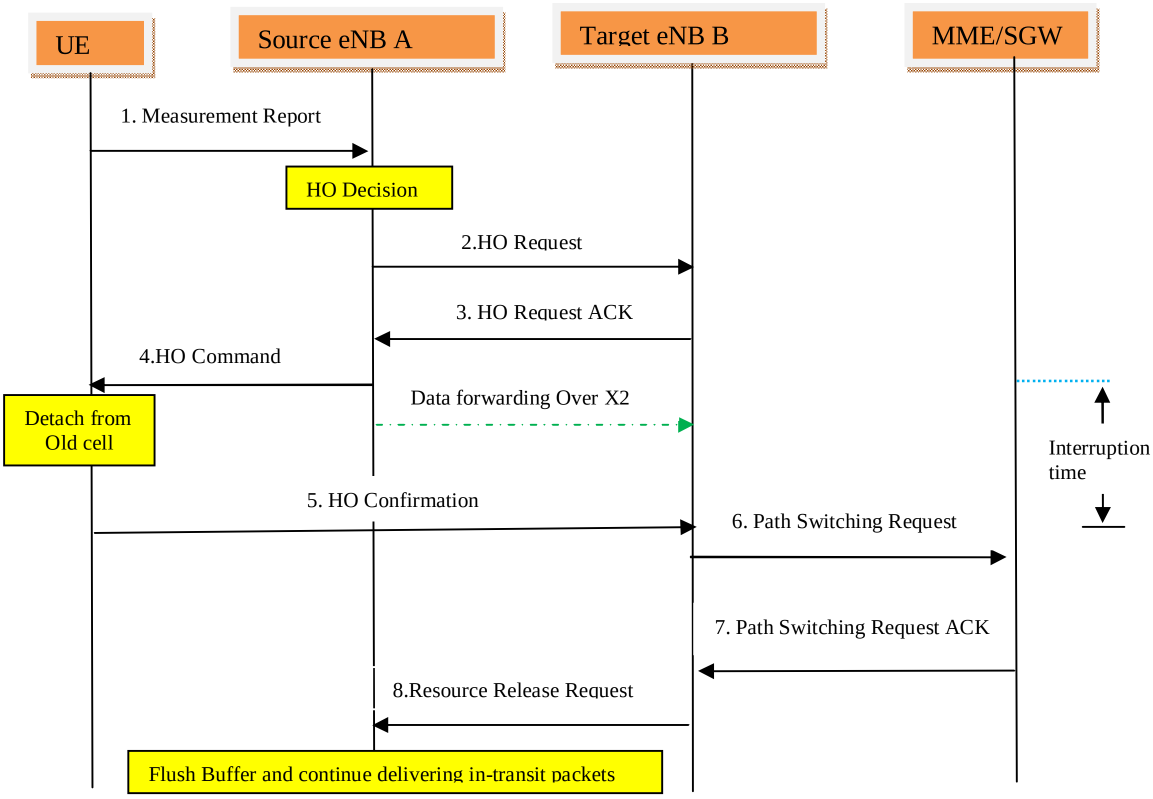

Fig.2. A typical Hard HO procedure in LTE.

Currently user is served by source eNB A, and moving towards target eNB B (UE sends the RSS measurements to both eNBs). Whenever the RSS of source eNB A becomes less than the RSS of target eNB B, then the source eNB A initiates the handover process [6].

The service quality experienced by the end user during handover is affected by: the Interruption time (Detach time) during which UE is not connected to the system and the delay of forwarded packets. In this paper we evaluate the effect of handover on performance of downlink scheduling algorithms.

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V. PACKET SCHEDULING ALGORITHMS IN LTE

Scheduling algorithms are mainly concerned with allocating the available radio resource among the active users based on the metrics like channel condition, Quality of Service requirement of users etc. The LTE standard does not impose any restriction on the type of scheduler to be used at the MAC layer of eNB. Hence, the choice of different scheduling algorithms such as Round Robin (RR), Proportional Fair (PF), Maximum Throughput(MT) and Blind Equal Throughput (BET) scheduler leads to different level of system performance.

1. Round Robin(RR)

Round Robin scheduling algorithm can be considered as the simplest scheduler. In RR scheduling algorithm, the available resources are shared among various users one after the other without any priority. The scheduling only based on the available resource blocks (RBS) during scheduling process [9].

2. Proportional Fair (PF)

Proportional Fair (PF) scheduler works by scheduling a user when its instantaneous channel quality is high relative to its own average channel condition over time [7]. The PF scheduler uses the scheduling metric as in (1)

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

The factor $d_k^i(t)$ is the average throughput that can be achieved by the ith user using the kth Resource block (RB). $R^i(t)$ represents the past average throughput that was achieved by the i^{th} user up to the time t.

3. Maximum Throughput (MT) Scheduler

Maximum Throughput scheduler aims to maximize the overall throughput of eNB. It allocates each RB to user that can achieve maximum achievable rate in current TTI [7]. The scheduling metric to which RB K is assigned at time t is determined as in (2)

$$m_{i,k}^{MT} = d_k^i(t) \quad (2)$$

4. Blind Equal Throughput (BET) Scheduler

Blind Equal Throughput scheduler aims to provide equal throughput to all UE under eNB. The working of this scheduling method is opposite to the MT scheme. The scheduling metric of BET scheduler expressed as in (3)

$$m_{i,k}^{BET} = \frac{1}{R_i(t)} \quad (3)$$

$R_i(t)$ represents the past average throughput achieved by the users and it can be calculated using the equation (4)

$$R^i(t) = (\beta)R^i(t-1) + (1-\beta)R^i(t) \quad (4)$$

The factor β lies between 0 and 1. $R^i(t-1)$ represents the achievable throughput at time t-1. If $R_i(t)$ is low it implies that the previous average throughput of the UEs are very low and they are in bad channel conditions or edge of the cell. The corresponding metric value $m_{i,k}^{BET}$ is high for these UEs and they will be given service first. In this way this scheduler provides service to the UEs at the edge of the cell whose past throughput is less.

VI. RESULTS AND DISCUSSION

The simulation is performed by considering the seven cell hexagonal cellular network with UEs in all the cells. The UEs are provided with Random way point mobility in which user moves in random direction. We use the channel fading traces for pedestrian and vehicular mobility. The handover algorithm used is “A2-A4-RSRQ” implemented in ns-3, which selects the target eNB based on best Reference Signal Received Power. The remote host is connected to the gateway node of LTE network with a high speed link (100Gbps). There is one UDP flow from the remote host to each UE and each traffic flow is generated by remote host and passes through the gateway to eNB node. A scheduler at eNB

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allocates the radio resources to flow based on the scheduling metric. Various parameters used in the simulation are summarized in table 1.

Table. 1 Simulation parameters

Parameter	Value
Simulation-Time	50 sec
Number of macro cells	7 (Each site has 3 sectors)
Inter eNB distance	1000m
Number of UEs	10,20,30,40,50
Tx power of eNB	46dbm
Bandwidth	5MHz
UE mobility model	Steady state Random waypoint mobility
Fading Model	Pedestrian, Vehicular
Scheduler	RR, PF, BET, MT

Initially simulation is carried out for RR scheduling algorithm with 10 UEs by providing pedestrian and vehicular mobility. The same simulation is repeated for PF, BET and MT scheduling algorithms by varying number of UEs in steps of 10 UEs up to 50 UEs.

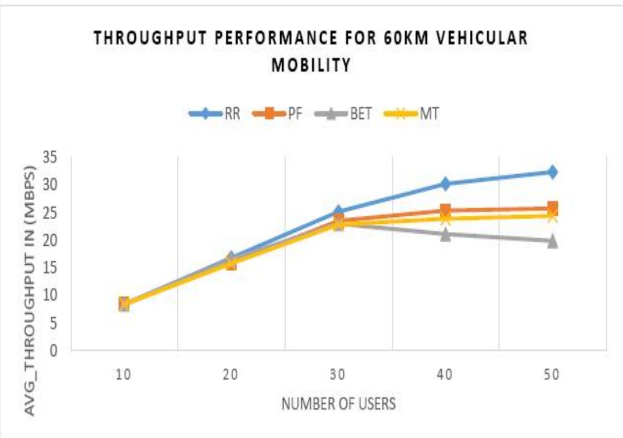

Fig. 3a Average Throughput performance of various Scheduling Algorithms inVehicular mobility.

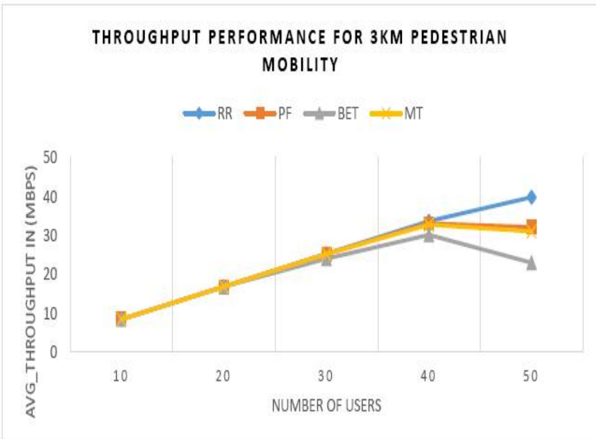

Fig. 3bAverage Throughput performances of various Scheduling Algorithms in pedestrian mobility.

The average throughput performance of the scheduling algorithms under vehicular and pedestrian mobility are shown in Fig.3a and Fig.3b. From the plots it is observed that in both scenarios RR algorithm achieves higher system throughput than the other algorithms considered.

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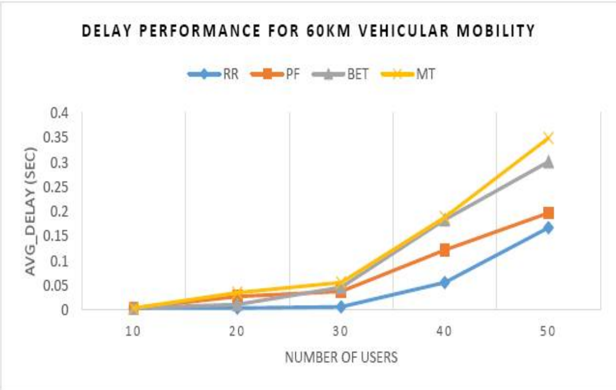

Fig 4 a. Average delay in Vehicular mobility.

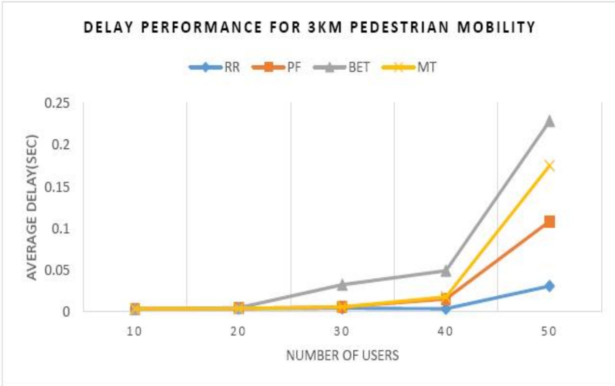

Fig. 4 b. Average delay in Pedestrian mobility.

From the Fig.4a and Fig.4b it is observed that in both scenarios RR algorithm achieves least delay than the other algorithms considered.

VII.CONCLUSION

The simulation is carried out for user mobility in vehicular and pedestrian environment. The throughput of all scheduling algorithms in vehicular mobility is quite less compared to pedestrian mobility. This is because, at higher mobility, the deviation in UE received signal power increases leading to degradation of system performance. Based on the simulation results, we conclude that in a multi cell network with user handover RR scheduling algorithm provides least latency and higher system throughput compared to other scheduling algorithms.

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BIOGRAPHY

Mahesha S.N received his B.E degree in E&C from Visvesvaraya Technological University, Belgaum, India. Currently he is pursuing M.Tech in Digital Electronics and Communication Engineering at BIT, Bangalore. His area of interest includes Wireless Communication, Embedded Systems and Computer Communication Networks.

C.Y. Gopinath received his B.E in E&C from U.V.C.E, Bangalore, in 1985.He specialized in Industrial Electronics from S.J.C.E, Mysore in 1989. He is presently working as Associate Professorin the Department of Electronics and Communication Engineering at BIT, Bangalore. He is currently research Scholar in Visvesvaraya Technological University. His area of interest includes Computer Architecture, Wireless Communication and Coding Techniques. He has published 5 international papers in various indexed journals, and national conference.

Hemanth Kumar A. R is presently working as Professor & Principal Investigator R&D ECE, at BIT, Bangalore. He completed his B.E in E&C from Manipal Institute of Technology in the year 1999. He specialized in Digital Communication from B.M.S College of Engineering in 2003 and received his PhD from Manipal University in 2011. His area of interest includes MANETS, Clustering the network, Path Planning and Routing algorithms. He has published 28 international papers in various indexed journals, and national conference in India, Singapore, and Thailand.

Eshwar.N.Kumar is presently pursuing his B.E degree in E&C at Bangalore Institute of Technology,Visvesvaraya Technological University, Belgaum, India. His areas of interest are Wireless Communication, Digital Signal Processing, Artificial intelligence, VLSI, Embedded Systems.