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A Survey on LTE Downlink Packet Scheduling

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Abstract: Long term evolution (LTE) is a 3GPP (Third Generation Partnership Project) 4G technology which enhances the development in the field of telecommunication and by improving the performance of the network for the different types of traffic flows. As it is an all IP technology so, it is the most emerging technology now a days. The fact that 3G long term evolution is a packet based networks brings some improvements in the form of higher bit rate, lower latencies and a variety of services. This paper presents a survey of the different proposed scheduling algorithms under variable conditions and accordingly, the variation in their results in terms of the performance metrics like throughput, packet loss, delay time, spectral efficiency, fairness etc.

Keywords: Long term evolution (LTE), Channel Quality Indicator (CQI), Physical downlink common control channel (PDCCH), User Equipment (UE), Quality of Service (QoS).

I. INTRODUCTION

LTE is a global standard for fourth generation of mobile broadband (4G) supported by all major players in the industry introduced by 3rd Generation Partnership Project in 2008. It is expected that LTE provide an extension in capacity and a performance improvement compared to the current HSPA (High Speed Packet Access) networks [1]. The basic objective of LTE is to develop a environment which provides benefits such as high data rates for proper

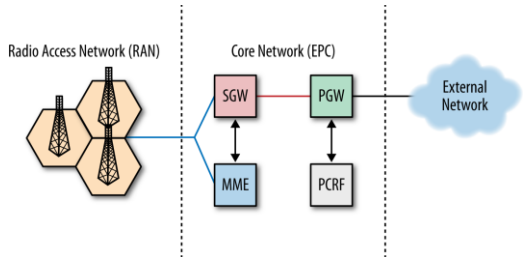

Fig 1 LTE Network

communication, minimum delay known as latency, high range of spectral efficiency over a wide range of bandwidth The main objective behind the evolution of LTE network is to increase the data-rate to fulfill the demands of the user.

The Radio resources are divided and shared efficiently among different active users while maintaining a satisfied level of QoS to all active users. To fulfill the requirements, the LTE system uses orthogonal frequency division multiple access (OFDMA) technology in the downlink. The OFDMA technology divides the available bandwidth into multiple narrow-band sub-carriers and allocates a group of sub-carriers to a user based on its requirements, current system load and system configuration [1] SC-FDMA (Single Carrier Frequency Division Multiple Access) in uplink and multi-antenna technology [3].

The transmission bandwidth can be selected between 1.4MHz and 20MHz [1].The 20MHz bandwidth can provide up to 150Mbps downlink user data rate with 2X2 MIMO and 300 Mbps with 4x4 MIMO. To support downlink data services with high transmission rates, a BS transmits data using shared channels where the data and information that comes from many users is multiplexed in time and frequency domains. So, the different scheduling strategies are proposed keeping in mind the different needs and requirements of the users along with the performance.

II. SCHEDULERS

1. Maximum Throughput Scheduler

The strategy known as Maximum Throughput (MT) aims at maximizing the overall throughput which assigns each Resource block to the user that can achieve the maximum throughput in the current TTI**.**

2. Proportional Fair Scheduler

A typical way to find a trade-off between requirements of fairness and spectral efficiency is the Proportional Fair (PF) scheme. The idea behind this is that the past average throughput can act as a weighting factor of the expected data rate, so that users in bad conditions will be served within a certain amount of time.

3. Modified Largest Weighted Delay First

The Modified LWDF (M-LWDF) is a channel-aware extension of LWDF and bounded packet delivering delay is provided. For, shaping the behavior of PF, MLWDF it uses information about the accumulated delay, assuring a good balance among spectral efficiency, fairness and QoS provisioning. It was developed to support multiple real time data users.

III. LITERATURE SURVEY

In 2013, Biswapratap singh Sahoo et.al [1] studied the downlink packet scheduling algorithms and mainly focuses on the three scheduling algorithms known as:

FLS (Frame level scheduler) in which basically two different algorithms are implemented in two different levels, EXP rule which explains the queue length and waiting time for servicing a queue and LOG rule which gives a balance between delay and robustness. Simulation is done in a vehicular environment by using LTE-Sim for the video traffic and the performance is analyze and the number of users taken for the simulation vary from 10 to 60 and the simulation is done in a region having radius of 1 km and is a bounded region. Simulation results showed that the FLS algorithm performed better than the rest two algorithms in terms of all the parameters.

In 2012, Ali Alfayly et.al [2] focused on analyzing the performance of the LTE algorithm in a single cell with a set of users at different speeds. As real-time flows like VoIP is considered to measure the impact on Quality of Experience (QoE). The LTE simulation was built based on LTE-Sim with three LTE scheduling algorithms (i.e., PF, EXP-PF, and MLWDF) for a single-cell scenario. Four different scenarios were developed using a single cell: static, pedestrian and vehicular scenarios using different speeds. EXP-PF is only considered for real time flows.PF has best end to end delay which is not suitable for VoIP applications and MLWDF and EXP-PF have less end to end delay.

In 2011, Wei Nie et.al [3] studied the scheduling problem and proposed a two- level scheduling scheme with support for quality of service and fairness guarantees for downlink traffic in a WiMAX network and analyzed the performance of the two- level scheduling scheme and compared it to round robin and weighted round robin algorithms.

In the two level scheduling, in first level strict priority packets are classified by scheduler according to the quality of service then they are arranged into different priority queues and in the second level fairness oriented scheduling schemes for different service flows are used. A simple WiMAX network is simulated by using OPNET simulation and concluded that as compared with round robin algorithm and weighted round robin algorithm, the QoS priority and fairness scheduling scheme for downlink traffic guarantees the delay requirement and maximize the throughput in the downlink.

In 2013, Oana IOSIF et.al [4] evaluated the performance of downlink LTE using System Level Simulator .Sector throughput, user throughput and Block error rate(BLER) are the performance indicators analyzed and in this basically three scheduling strategies are used i.e. Round Robin, Best CQI and Proportional Fair and the results showed for the different scenarios.

For the bandwidth of 20MHz, when the speed of user equipment is 5 Km/hr, the throughput and network BLER are higher as compared to the results for the user equipment speed of 20 Km/hr and for a bandwidth of 10 MHz, the results get halved. For 2x2 MIMO, the performance of Best CQI is better as compared to other two algorithms

In 2013, Arkadiusz Biernacki et.al [5] evaluated the performance of three scheduling algorithms proposed for LTE downlink transmission**.** The three scheduling algorithms i.e.PF, MLWDF and EXP/PF are used for the comparison. A proportional fair (PF) scheduler basically assigns the resources to the users considering the CQI and the past user throughput. The Modified Largest Weighted Delay First (M-LWDF) scheduler supports multiple data users with different QoS requirements. The EXP/PF algorithm supports the streaming services and the best-effort data services. Simulation results showed that the packet delay is maximum but the throughput is minimum in case of proportional fair scheduling algorithm and packet loss ratio performance is quite similar in case of MLWDF and EXP/PF scheduling.

In 2013, Bin Liu et.al [6] proposed a packet scheduling strategy known as Modified-Earliest Deadline First-Proportional Fair (M-EDF-PF) algorithm which is an extension of Earliest Deadline First (EDF) and Proportion Fair (PF) algorithm and having low complexity for real time traffics like video and VoIP in LTE systems. For, verifying the high efficiency of the proposed algorithm, several other well known algorithms are also taken such as EXP/PF, MLWDF etc. for the real time traffic and simulation is done. During the simulation, the proposed algorithm which is designed for the real time traffic services performed better than the other algorithms as it is having low complexity. The proposed algorithm is very efficient and is very suitable to use for the wireless systems.

In 2013, Huthaifa AL-Jaradat et.al [7] explored the performance of three well known packet scheduling algorithms i.e. Proportional Fair (PF) algorithm, Maximum Largest Weighted Delay First (MLWDF) and EXP/PF for the real time traffic. In this paper, LTE-Sim is used to perform the entire simulation.

A single cell of 1 km with inter cell interference is used and out of the total number of users half of them having VoIP flows and remaining half are having video flows. Performance of these scheduling algorithms is tested for five parameters i.e, fairness index, packet loss ratio, total spectral efficiency, packet throughput and packet delay. Simulation results showed that the MLWDF performed better than the PF and the EXP/PF algorithms in terms of all the parameters and for the both the traffics.

In 2013, A.S Sravani et.al [8] proposed two algorithms known as Max Round Robin and Max Throughput algorithms for high speed packet access giving higher capacity and fairness than other conventional algorithms

Max SNR, Round Robin and Proportional Fair are the three. As the users are not fixed and most probably they are randomly situated so for every instant, the active users are changed Simulation results showed that the two proposed algorithms achieved higher values of efficiency, average cell goodput etc.

Than the conventional algorithms but Max throughput scheduling is used in place of Max SNR because by using this, the performance is improved in terms of capacity of the system and fairness in all the users. So, the proposed scheduling algorithms performed better than the conventional algorithms.

In 2011, T. Ali- Yahiya et.al [9] investigated the performance of PF, M-LWDF and EXP/PF in LTE and in this a single cell with interference scenario is used. There are 40% of users using video flows, 40% of users using VoIP flows and 20% of users using best effort flows and considered that users are constantly moving at speed of 3kmph in random directions.

LTE simulator is used for the simulation because LTE – Sim provides a support for radio resource allocation in a time – frequency domain. This concluded that M-LWDF and EXP performed far better than PF when using real time flows.PF is not considered as a good solution for real time services.EXP/PF scheduling algorithm seems an optimal possible solution for guaranteeing a good QoS level.

In 2013, Deng Keke et.al [10] proposed an algorithm known as Energy-saving based Inter-group Proportional Fair (EIPF) for the LTE downlink multicast services. In this a proper transmission power is calculated first according to the available data rate then IPF principle is followed to allocate the resources among different multicast groups. One typical scheduling algorithm is Inter-group Proportional Fairness (IPF) for multicast services but its disadvantage is that in this data is transmitted at a fixed rate means for each Resource Block the scheduler picks one group to be scheduled on it according to the principle of IPF.

There is a amazing trade-off between throughput and fairness among different groups in IPF. In this paper, a scheduling algorithm is proposed known as Energy-saving based Inter-group Proportional Fair algorithm (EIPF).for utilizing rate of energy of the system. The simulated results showed that the average throughput and energy efficiency are best in EIPF as compared to IPF.

In 2013, Wei Kuang Lai et.al [11] proposed a scheduling algorithm known as Packet Prediction Mechanism (PPM) and compared it with the other schemes. Two typical methods Proportional fair and maximum throughput and other two real time applications MLWDF and EXP/PF were used for the comparison with the proposed algorithm. The results showed that the proposed mechanism performed better than the conventional mechanism in terms of average cell goodput, invalid packet rate, average delay time etc. for both fixed and moving user equipments.

IV. RESULT ANALYSIS

In 2011, T. Ali Yahiya et.al [9] analyzed the results for different parameter metrics. The value of fairness calculated in this is given by,

Scheduling Strategy	Fairness Index
ASA	0.774
RSA	0.830
Max. SNR	0.705
OFDM-TDMA	0.527

Table 1: Result Analysis of [9]

In 2013, Oana IOSIF et.al [4] analyzed the results i.e. the value of throughput for the different schedulers for variable bandwidth,

Schedulers	Throughput (Mbps)
ROUND ROBIN	45.06
PROPORTIONAL FAIR	63.89
BEST CQI	80.72

Table 2: Result Analysis of [4]

V. CONCLUSION

In this paper, different scheduling mechanism are studied for different downlink traffic flows in terms of parameter metrics i.e. throughput, packet loss, delay time, spectral efficiency and fairness index and analysed various results by comparing the parameters and scheduling mechanism proposed in the different papers.

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BIOGRAPHIES

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Prof. Pradeep Kumar Chopra entered the field of education in the year 2004 after 24 years of exemplary service in the technical branch of the Indian Air Force, He earned his Bachelor's degree in Engineering (Electronics) from Delhi college of Engineering in the year 1979 and Masters in Technology from IIT Delhi in the year 1985. He also has a Masters degree in Defense Studies from Madras University. While he was in the Indian Air Force he was part of and headed a number of important technical projects. For his exemplary services he was awarded "Vishist Seva Medal" by the President of India in the year 1993.He took premature retirement from the IAF in the year 2004 and entered the field of education. He is the Head of Dept. (Electronics and Communication) in Ajay Kumar Garg Engineering College in Ghaziabad.