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Downlink Packet Scheduling on LTE Network: A Review

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Abstract- LTE is a revolutionary 4g technology; it provides different type of service such as video telephony, voip, web browsing and video streaming etc. LTE is compatible with previous cellular networks. The recently, demand is increasing day per day of real time services on cellular networks. For that reason, how to distribute resource blocks in number of users. So scheduling play a fundamental role, because it has responsibility how to distribute the available radio resource between among different station. In this paper downlink scheduling over lte networks and classification of scheduling, architecture of lte network, its protocol and working layers are discussed.
Keywords: - LTE, Downlinks Scheduling, LTE Architecture, Physical Layer.

I. INTRODUCTION

In 2008 3GPP introduced a wireless 4G technology LTE (long term evolution) specification. 3GPP stands for third generation partnership project. The rising stipulate (demand) for network services like video streaming, web browsing and VoIP etc. As compare 3GPP release 6 LTE system improved spectral efficiency 2-4 Time [16]. In LTE system HARQ play a fundamental role in accomplishing the required performance [15].The purpose behind to design of LTE networks is to full fill different requirements. It is accepted that LTE provide an addition in capacity and a performance enhancement to current HSPA (high speed packet access) networks. The intention of LTE is to build up environment, which provide benefits such as high data rates for appropriate communication, minimum delay known as latency and high range of spectral efficiency over a wide range of bandwidth [5].

In LTE networks the radio resources are divided in time and frequency domain and sheared efficiently among different active users at the same time a satisfied level of Qos is maintained. To complete the requirements, the LTE system based on orthogonal frequency division multiple access (OFDMA) technology in downlink.

(FDFS) frequency domain packet scheduling can provide both cell throughput and coverage gain around 40% [11]. Basic transmission scheme of LTE network used (MIMO) multiple input multiple output and OFDMA [13]. Where-as SC-FDMA (single carrier frequency division multiple access) in uplink direction [5] is utilized because it offers power conservation at user equipment (UE) side and multi -antenna technology. The resource block is smallest unit of size 180 KHZ in frequency domain which is divide into two slots in time domain, length of each slot is 0.5 ms. Every slot has a transmission time interval unit (TTI) which is set to just 1 ms[9].

LTE afford different transmission bandwidth for downlink and up-link scheduling the range can be certain between 1.4 MHZ and 20 MHZ [5]. With different requirement that is not satisfied with existing technology in 2010 (LTE-A) was released by 3GPP [4]. LTA-A provide carrier aggregation with this feature up to 100 MHZ transmission could be supported [4].

Rest of paper are organized as follow: section II gives an overview on architecture and layers of LTE, section III describe various resource allocation algorithms. In section V a related work. In section VI a conclusion on basis review paper and references.

II. OVER VIEW ON LTE SYSTEM ARCHITECTURE

The LTE system designed with challenging requirements, it is based on flat architecture with regarding to previous 3G system. The network architecture of LTE system consist mainly three basic components know as core networks called Evolved Packet core network (EPC), access network called Evolved-Universal Terrestrial Radio access network (E-UTRAN) and User equipment (UEs). In earlier system, node requirement is higher because separate radio access network that consists of radio link control (RLC), radio resource control (RRC) and medium access control (MAC) protocol is used that provide interface to user equipment (UE). Where as in LTE system, the over mentioned protocol function are performed by eNB [1].

LTE radio access network consist of eNodeBs. which are accountable for radio resource management function [12]. The E-UTRAN

is a radio component that consist only eNodeB. The EPC is core network component that form a gateway between the LTE networks. LTE architecture comprise two main part such as (EPC) evolved packet core and E-UTRAN [17]. The E-UTRAN and EPC together consist of EPS know as system Architecture Evolution. In LTE system with interface component, non-radio component (core network) is also included with the changing technology. This permit for compatibility with existing standard [4]. The "evolved packet core" which is made of a core network and a radio access network that is evolved universal terrestrial radio access network (E-UTRAN). The mobility management unit (MME), the serving gateway (SGW), and packet data network gateway are component of "Evolved Packet core". The MME is provide connection establishment and in charge for user mobility, tracking, intra-LTE handover and paging method of user equipment (UEs). The SGW Route and forward user data in among LTE node and manage handover in LTE and other 3GPP technology. With rest of the world the PGW provide an interconnection between LTE networks [7]. The packet scheduling is performed at eNB and its reasonability to assign portion [1]. In LTE network there is basically, two broad traffic class real time and non- real time [14].

A. *Lte Network Protocols*

1) The Radio Resource Control, which is in charge of organization and management of connection, the broadcast of system information, the paging procedure, the mobility and establishment, reconfiguration and management bearers.
2) Packet Data Control Protocol, which perform compression of upper layers before MAC queuing.
3) Radio Link Control, it provides interface between the radio bearer and MAC unit. This protocol provide most important process for the LTE radio inter face such as scheduling request, multiplexing/demultiplexing, radio resource allocation and random access[7].

B. *Lte Physical Layers*

Both type of modulation FDD and TDD is perfumed at physical layer. At downlink OFDMA technique is used and SC-FDMA is chosen for uplink .the available bandwidth divide into multiple resource blocks, each resource block can be independently modulated. RB's are dividing into time and frequency domain it is a smallest unit that is sheared by among users in a single cell at uplink side. MAC layer play important role in LTE system it's responsibility for radio inter face like multiplexing/demultiplexing , random access procedure and scheduling request. The packet scheduling (PS) is unit of RRM in LTE, Which is present in MAC layer [1].

In LTE system physical and Mac layer are strongly connected for efficient utilization of sheared-channel among user equipment (UEs). To achieve this goal the radio resource management (RRM) block utilize a mix of advanced MAC and Physical function.

III. SCHDULING STRATGIES FOR LTE DOWNLINK

In LTE network basically two type of scheduling is performed that is uplink and downlink which is called by different researcher with different name, like wired scheduling named as channel un- aware/channel independent scheduling. The channel independent scheduling based on some assumption that is channel is Error free and time invariant. Channel independent scheduling has two type of scheduling algorithm named as channel aware which gives preference to quality of services, where as channel un-aware scheduling they simply schedule. Example of channel independent scheduling are fist-in-first-out (FIFO),round robin (RR), weighted fair queuing (WFO), earliest Deadline first (EDF), largest weighted delay first (LWDF) etc.

In wireless scheduling, only channel sensitive scheduling is performed based on channel Quality indicator (CQI) reports which is at regular intervals sent by UEs to eNB. Wireless scheduling is named as channel sensitive/channel aware scheduling. In such kind scheduling the scheduler may maximize the QoS requirement of each UEs (QoS aware scheduling), if it tries to provide fairness among users (QoS un-aware scheduling). Example of channel sensitive scheduling are Maximum Throughput (MT), Proportional Fair (PF), Throughput to Average (TTA), Modified-Largest Weight delay first (M-LWDF), Exponential Proportional Fairness (EXP/PF), Exponential rule (EXP rule), Logarithmic rule (LOG rule) etc. some of them scheduling discuss here[1].

Channel sensitive scheduling: many scheduling algorithm are aim to maximize the throughput like (MT, M-LWDF, EXP/PF, EXP rule, LOG rule) while some are designed to provide fairness among UEs (PF, TTA). Some of them discuss here [1].

1) *Proportional fairness:* it provides a balance between spectral efficiency and fairness among UEs.
2) *Maximum Throughput:* In this algorithm priority metrics is used, the RB is allocated to UEs which experience good channel condition will always be scheduled It provide maximum overall throughput.
3) *Modified-Largest Delay First:* It is modified version of LWDF used in wireless networks. It also working with priority metrics,

this algorithm treats real and non-real traffic differently.

4) *Exponential PF:* This algorithm regards as both the characteristics of PF for handling non real time flows and exponential function of end to end delay for real time flows. Channel un-aware scheduling: This algorithm has some assumption that is channel is error free and time invariant. Discuss some of this channel independent scheduling here [7].
5) *First in First out:* This is simplest scheduling it serve users according to the order of resource request. Like a queue first in first out.
6) *Round Robin:* it provides an equal size time slot in a fair shearing order to among users. This approach is not fair in-term of user throughput.
7) *Weighted Fair Queuing:* In this strategies avoiding the starvation problem that is create by priority scheduling. In this case resources are sheared according to the proportion among the weight (higher the weights, the higher the allocated resources).

IV. RELATED WORK

S. Fouziya Sultana et al. [1] in this paper author's study the four downlink packet scheduling algorithms are know as PF (proportional fair) this algorithm provide a balance between spectral efficiency and fairness among the UEs. And many algorithms have been proposed in this literature with modification of PF which is tried to balance coverage and cell throughput. MLWDF (modified largest weight delay first) it is channel aware extension algorithm of LWDF. This algorithm flow of real and non real time service treated differently M-LWDF based on token mechanism which provides a better result to real time application. Exponential rule which is extended version of EXP/PF. EXP rule takes overall network status into account. LOG-RULE this algorithm is similar to EXP rule but it uses logarithmic function of delay. The simulation scenario taken into account a single cell with fixed eNB where the users are distributed uniformly among the cell the two users speed (30kmph, 120kmph) are considered for analysis. The buffer at scheduler side considered infinite size. The LTE simulator results showed that PF is suitable for non real time application where as other algorithms show better performance for real time application.

Yuan-Ping-Li et al. [2] a new downlink packet scheduling is proposed in this paper are known as DP-VT-MLWDF. The purpose behind the proposed scheduling is to enhance the Qos performance of real time flows. The VT-MLWDF is modified version of MLWDF. The authors adopt a scenario into accounts to utilize a delay priority function to improve VT-M-LWDF. The next proposed scheme is QUEUE-HOL-MLWDF is a modification of M-LWDF and the VT-MLWDF. The simulation scenario is a single cell and the simulation parameters are bandwidth, number of RBs, frame structure time etc. the simulation result show with different parameter like fairness index for BE is decreasing with rising number of users and a average throughput for BE flows show some degradation especially, when the cell has more than 35 users.

Giuseppe Piro et al. [3] in this paper authors discover an open source frame work for LTE networks is known as LTE-SIM (LTE simulator) is applied to compare many scheduling algorithm and evaluate their performance. In this paper three scheduling algorithms are know as:

(PF, M-LWDF, EXP) the simulation scenario is considered as, there are 19 cells with radius equal to 1 km. The numbers of users are uniformly distributed in the range [10-30] into each cell at speed (3, 120) km/h. the simulation parameter such as packet loss real rate for video and VOIP flows show different behaviour for real time service. The performance result shows PLR increases with number of users. When M-LWDF and EXP scheduling are proposed. Where as PLR decreases as the number of users are increases when proposed scheduling is PF.

Ambreen Ahmed et al. [4] in these paper researchers have proposed many RRA (radio resource allocation) scheduling algorithms and a comparative study is done. Seven scheduling algorithm are proposed and result are categorized into two classes in category 1 results parameters are taken is delay, packet loss ratio and throughput these parameter effected by type of flows.

Category I result showed that the number of video flow increases in system, increases delay. Increase delay when more than 30 users in a single cell, the maximum increases in delay shown by FLS and MT, whereas EXP-PF shows fewer amounts of increases in delay. The similar result showed for packet loss ratio, the maximum packet loss during transmission is shown by FLS and MT. After this observation showed that within a cell with 50 users using EXP-PF least increase in packet loss and delay.

Category II in this class spectral efficiency and fairness of LTE system is observed with comprising of 9 cells with 5 to 50 numbers of users per cell fall in this category. The maximum increases in spectral efficiency shown by M-LWDF and minimum increase shown by LOG-RULE. The fairness index for real time flows it is shown that the fairness index decreases as the delay increases. Hence lower the delay, greater is the fairness. From above observation result showed that the EXP-PF algorithm is well-suited for both real and non-real time flows.

The maximum throughput strategies is channel aware scheduling that check channel condition of users but Qos requirement are PF (proportional fair) this algorithm not guarantee fairness when used alone for fairness guarantee used along with MT (maximum throughput) then it guarantee resource allocate under bad channel condition to users. M-LWDF is channel aware extension of LWDF. EXP/PF this algorithm exploit the characteristics of an exponential function of end to end delay that's why exponential rule used with PF algorithm.

vallari Sharma et al. [5] A survey paper on downlink packet scheduling Algorithms in this survey mainly focused on three scheduler (MT, PF and M-LWDF) the proposed scheduling mechanism studied in term of parameter metrics are packet loss, throughput, spectral efficiency are analyzed and results are compared with different scheduling proposed in many paper. The proposed scheduling strategy know as MT (maximum throughput) target to maximize the over all performance each resource blocks assigned to the users in this strategy. PF (proportional fair) the idea in this scheduling the past average throughput can be used as weighting factor of expected data rate. M-LWDF (modified largest weight delay first) is a channel aware extension of LWDF it provided a bounded packet delivery delay.

Ayman Hajjawi et al. [6] Authors investigated and implemented the performance of three scheduling algorithm in smart grid for real and non real time application communication are (VOIP, Video, metering data). Where metering data is non real time application and VOIP and video are real time flows, the proposed scheduling scheme Are (FLS, EXP and LOG).

The system simulation result showed that the FLS performed better for non real application than two other scheduler. Whereas the EXP and LOG performed better for real time flows.

F. Capoozi et al. [7] A survey on downlink packet scheduling and design issues regarding to scheduling are discussed. Many different scheduling strategies are proposed such as channel-unaware, channel-aware/Qos-unaware, channel-aware/Qos-aware, semi-persistent for VOIP and energy-aware. The simulation scenario considered for most relevant channel-aware/Qos-unware scheduling are analyzed proposed scheduler are know as MT, PF, PF-PF and TTA. The parameter are taken into account are the aggregate cell throughput, the average user throughput and fairness index. At final result showed that MT performance better than left scheduler PF and PF-PF performed quite in similar manner. The next simulation scenario based on channel-aware/Qos-aware the proposed scheduler are M-LWDF, EXP/PF, EXP rule, LOG rule and FLS these all proposed scheduling are based on per-RB metrics. Qos-aware scheduling always guarantees packet delivery before deadline. The result showed that Qos-unaware such as PF are not suitable for dealing with constrained traffic. [8] This paper basically, focused on Downlink Scheduling, six scheduling are proposed and their performance checked with different parameters for real and non-real time traffic. The simulation result partition in two levels: first level concern for real time flow and second concern for non real time flow. The result showed that FLS outperform over other scheduler. [9]In this paper a study on three most promising algorithm such as FLS, EXP and LOG rule are proposed for checking video traffic in vehicular environment. The result showed that FLS algorithm is best approach for video traffic. [10] The performance of two downlink schedulers is analysed in term of system throughput, average (RT), and non-real time throughput. Video streaming traffic is real time where as web browsing is NRT. The result showed in term of average throughput or overall throughput for lower no. of users EXP/PF and M-LDWF show similar throughput. Whereas, the increase users M-LWDF provide higher system throughput. For average throughput result showed that M-LWDF provide higher average throughput for NRT users as compare to EXP/PF.

Table 1: Comparison of Different Scheduling Algorithm

Algorithm	Methodology	Pros	Cons
LWDF	LTE Simulator	Provide QOS in term of interruption	Frequency condition not known.
PF	LTE Simulator	Provide equality	Low spectral efficiency
MT	LTE Simulator	Maximize Overall quantity	Partial
M-LWDF	LTE Simulator	Real time and - real time flows are treated differently.	Ineffectivein overloaded condition
EXP/PF	LTE Simulator	Real time and - real time flows are treated differently.	Difficult(complex)
EXP rule	LTE Simulator	Moral scheduling performance	Difficult(complex)
LOG rule	LTE Simulator	Moral scheduling performance	Difficult(complex)

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V. CONCLUSION

After study of many research papers we conclude that there are many scheduling algorithms have been designed for LTE cellular networks. In this paper related work showed that for different type of service scheduler's performance for variable parameter. But 3GPP has not standardized any RRA scheduling algorithms. So there is an open area of research to design an efficient scheduling algorithm that satisfies a majority of user's request.

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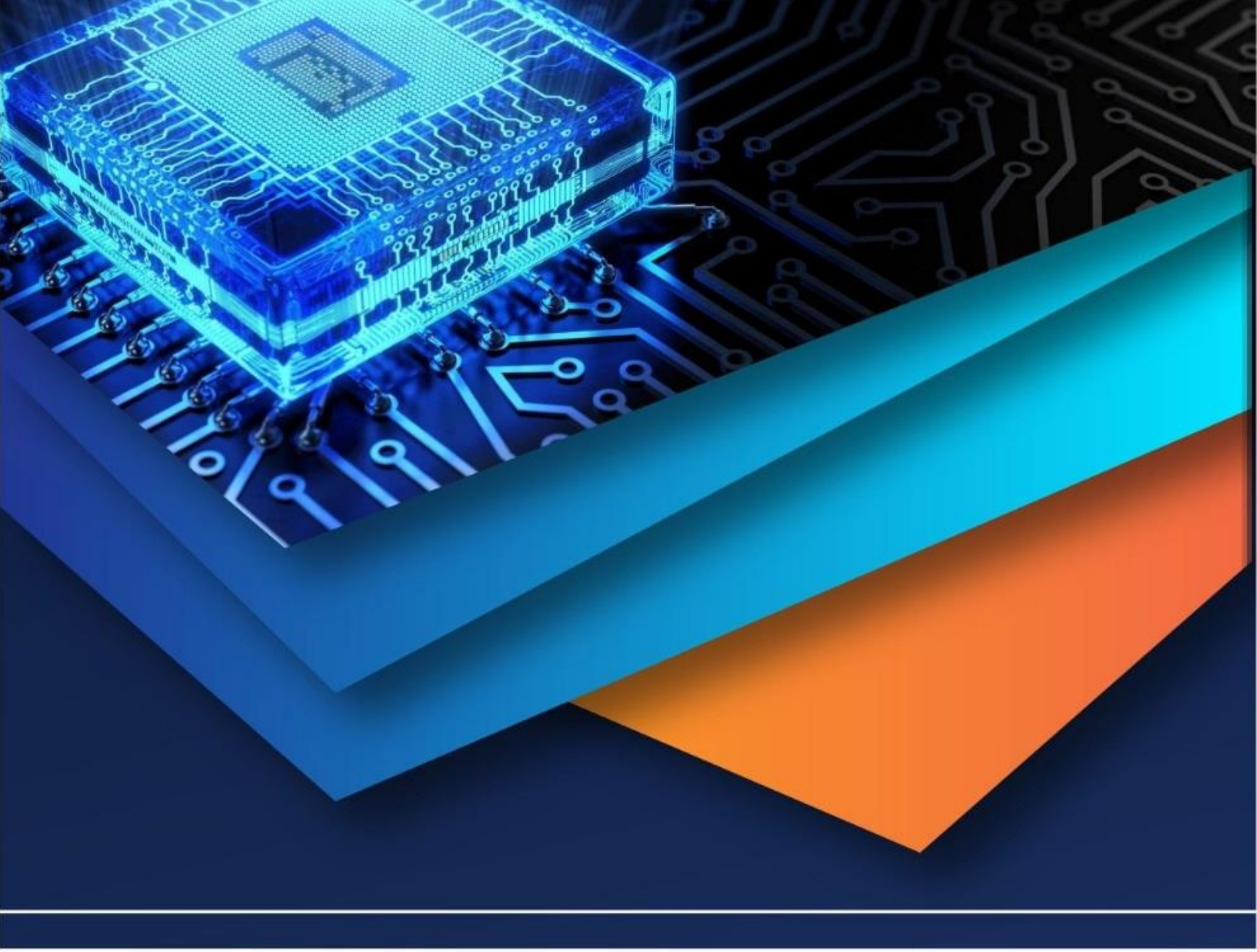

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