A Voyage of Long Term Evolution-Advance (LTE-A) : A mainstay of 4G Technology: A literature Review

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Abstract - Future generations has put high demand on use of internet and video services. To fulfill these requirements the prior generations like first, second and third are not up to the mark. To overcome this fourth generation is used which provides much higher peak data rates so that better quality of experience can be given to customers. The objective of this paper is to provide gist to the beginners who are exploring their research carrier in wireless networking at the age when fourth generation technology named as a Long Term Evolution is at peak of its exploration. The paper gives the view of LTE-A, Quality of service (QOS) and how both these terms contribute to design a scheduler for resource allocation. LTE-A architecture, features and its challenges are discussed in the paper. The paper will surely build a sequenced flow in mind of readers to grasp the idea of LTE-A.

Index Terms: EPC, E-UTRAN, GBR, LTE, OFDMA, QOS, UE.

I. Introduction

LTE is a 4G technology specified in 3GPP [1] (3rd Generation Partnership Project) release 8 document series where as LTE-A is given in release 10 and must satisfy the requirements of IMT-A [11]. The world's first publically available LTE service was launched in year 2009. LTE/LTE-A is very fast, intelligent and efficient which delivers data profitably. The customers who want more bandwidth, good service and better quality the LTE/LTE-A is an answer to all their requirements. Use of LTE-A will lower the operating cost of retrieving data. LTE is all IP based technology [2] and never uses circuit switched networks. The various emerging technologies which support applications like video conferencing, video chats, and voice over internet protocol VoIP etc are supported by LTE-A architecture. To provide these services LTE-A uses Radio Resource Management (RRM) procedure which enhance the user throughput, spectrum efficiency and spectrum flexibility. The main objective of the LTE-A network is to provide Quality-of-Service (QOS) to all the active users. In simple terms we can say that LTE-A without QOS will never boom 4G technology. QOS is a mechanism which provides performance assurance and service differentiation and the metrics involved are bandwidth, delay, jitter and packet loss. To fulfill this need, Orthogonal Frequency Division Multiple Access (OFDMA) is the key technology used by LTE-A in the Downlink (DL) and Single Carrier- Frequency Division Multiple Access (SC-FDMA) in the Uplink (UL) with Asymmetric bandwidth. The basic purpose of OFDMA is to divide the given bandwidth into number of multiple sub-carriers. This technique of dividing bandwidth into multiple subcarriers has significance that each user will get resources according to its QOS requirements. This led to the design of an efficient and simple bandwidth and resource allocation algorithm for effectively using of radio/spectrum resources to increase the system performance. The task of assigning resources to user is not so simple rather it involves user's channel conditions if they are good transmission will have high quality otherwise degraded information will be transmitted. 3G networks for voice services [1] are over taken by LTE network which is designed with challenging requirements. In LTE-A there are two types protocols exists i.e. access stratum (AS) and non-access stratum (NAS). AS are type of protocols which are used in three layers of LTE named as PHY (Physical), MAC (Media Access Control) and RRC (Radio Resource Control). NAS deals with protocols defined between User Equipment (UE) and the core network. There is further categorization in LTE according to the channels used. The channels can be control channels or data channels.

II. LTE Vs. QOS

To define relationship between LTE and quality-of-service we need to describe the concepts like parameters of traffic flows and second one is policy management. Traffic flow parameters ensures that bit rates are guaranteed or not and also check the priority of traffic flows, maximum amount of packet delay, and packet loss ratio. Policy management are schemes or protocols to be used by operators to potentially apply QOS to different applications or users. There are various challenges which exists while managing QOS. Following is the list of parameters which are involved:

Area: If rural area is considered then the less obstacles are the on the way of waves and if area is urban then more number of obstacles are involved so to provide QOS for both regions will have different requirements.

Capacity: Capacity depends on many factors, including geography, percentage of subscribers indoors, amount of spectrum available, and backhaul constraints.

User demand: If in one cell user demand is more than the overhead of QOS will increase as compare to less user demand. Demand is affected by the number of users in a cell at any moment in time and the types of applications they are using.

User speed: The Pedestrian user have different QOS requirements as compare to user at speed of 120km/hr in terms cell interference and frequent handoffs.

Cell size: For small cell size better QOS can be provided and for big cell size performance degrades.

Admission Control: The admission control is a complex process by which resources can only be assigned if bandwidth is available. For QOS applications which require guaranteed bit-rate, it is mandatory that if the cell does not have sufficient capacity, then it must deny access to the applications at that moment of time.

III. LTE Architecture

Long Term Evolution network supports spectrum flexibility in which the scalable carrier bandwidth will range in between 1.4 MHz and 20 MHz and it depends upon the size of spectrum. LTE specifications provide downlink (DL) peak data rates of 300 mbps whereas for uplink (UL) peak rates are 75mbps. The peak data rates are important because they provide amount of spectrum used. The basic difference which distinguishes LTE from LTE-A is the presence of carrier aggregation in later one. The architecture of LTE/LTE-A consists of core network in which Evolved-Universal Terrestrial Radio Access Network (E-UTRAN) which is collection of e-Node-B communicates with Evolved Packet Core (EPC) which is collection of user equipment (UE's) as shown in Fig. 1

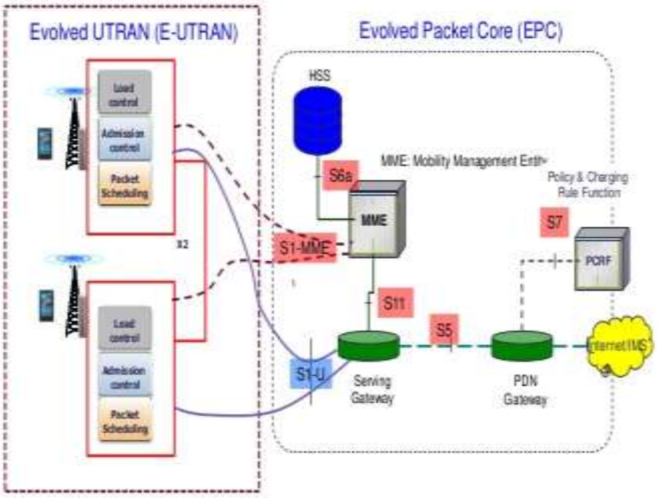

Fig. 1 Long Term Evolution architecture for scheduling data between E-UTRAN and EPC.[27]

In simple terms It is assumed that LTE-A is combinations of small modules of LTE combined to form bigger network. LTE-A is more user friendly and supports heterogeneous networks. There are various tasks which are performed by e-Node-B which includes radio bearer control, radio admission control, dynamic resource allocation etc. for both DL and UL. It also ensures that proper QOS requirements are fulfilled for bearers. Each bearer is assigned with QOS Class Identifier (QCI) [3] and this categorization is based on the priority of bearer ,its PLR(packet loss ratio) , and delay it can handle as shown in Table 1. For transmitting the data LTE-A's physical layer divides the resource allocation in both time domain and then in frequency domain [4]. In other words the distribution of physical resource will take place only in time frequency resource grid. This grid consists of RB (resource block) which is the smallest allocated unit in LTE-A. In frequency domain the RB occupies 12 consecutive subcarriers where as in time domain it consists of .5 ms and it takes two slots for its allocation. The duration of 1 ms is allocated to each TTI (Transmission Time Interval). In order to address this challenge an efficient radio resource management module is needed of which the packet scheduler is an important component. For performing all these activities of various resource allocation and packet scheduling algorithms are designed. Before designing a scheduler we must know the following features possessed by the scheduler.

Table 1 List of Guaranteed Bit Rate and non- GBR resource type [28]

QCI	Resource type	Priority	Packet delay budget	Packet error loss rate	Example services
1	GBR	2	100 ms	10^{-2}	Conversational voice
2		4	150 ms	10^{-3}	Conversational video (live streaming)
3		3	50 ms	10^{-3}	Real time gaming
4		5	300 ms	10^{-6}	Non-conversational video (buffered streaming)
5	Non-GBR	1	100 ms	10^{-3}	IMS signaling
6		6	300 ms	10^{-6}	Video (buffered streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.)
7		7	100 ms	10^{-6}	Voice, Video (live streaming), Interactive gaming
8		8	300ms	10^{-3}	Video (buffered streaming) TCP-based (e.g., www, e-mail, chat, ftp, p2p file sharing, progressive video, etc.)
9		9		10^{-6}	

Medium Access Control (MAC) consists of scheduler and controls the way in which assignment of resources will be done in uplink (UL) and downlink (DL). Scheduler works on the principle of dynamic scheduling where e-Node-B makes decision that which information should be transmitted to which UE. There are list of functions performed by downlink scheduler which includes dynamic control over terminals to transmit the data.

Deciding the number of resource blocks for DL Shared Channel (DL-SCH)Deciding user data rate for Physical Downlink Shared Channel (PDSCH)

Deciding which resources blocks should be allocated to Physical Downlink Control Channel (PDCCH) with 1 ms granularity [12].

Basically there are two types of scheduling with respect to channel conditions. The first one is channel independent and other is channel dependent. In channel dependent scheduling, the channel status report is transmitted by which reflects the channel quality.

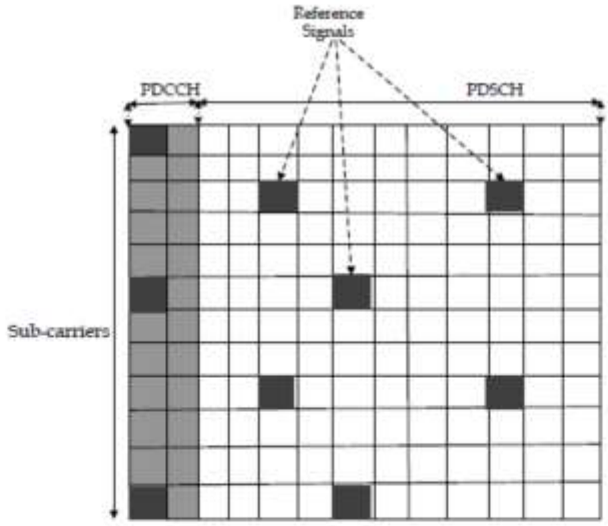

Fig. 2 Sub-carriers PDSCH and PDCCH Reference Signals [29]

In accordance with 3GPP standards, the reference signals are embedded in the Physical resource block (PRB) as shown in Fig 2.

On getting the channel status report during downlink transmission, the DL scheduler assigns resources to different UE's. During each transmission time interval (TTI) the scheduler will perform the following functions as described below [13]:

Considering physical radio environment (PRE) conditions for each (UE): On getting resources all UE's send acknowledgement about the radio quality to the scheduler to make Modulation and coding (MCS) decisions using Hybrid Automatic Repeat Request (HARQ)

QOS service Prioritization among UE's: LTE-A provides two types of services: real-time services and data services. Where real time services are delay sensitive and data services need high peak data rates. To provide QOS to each UE the prioritization is done according to UE's service requirements.

Intimation to UE's about allocation: Scheduling in e-Node-B schedules the UEs both on the DL and on the UL. For each UE scheduled in a TTI, a Transport Block (TB) is generated carrying user data, which is delivered on the transport channel. This control channel carries scheduling control information [13].

IV. Features Of Scheduling Algorithms

Proper link utilization: Channel utilization must be done properly and there is need of an efficient algorithm for it. The scheduler must be intelligent enough for not to allocate a transmission slot to a session which are currently in bad condition link as it will lead to the wastage of transmission.

Requirement of Delay bound algorithm: To support delay-sensitive applications user must have an algorithm that is able to assures that for individual sessions, delay bound guarantees will be given.

Provide Fairness: The design algorithm should be such that it will distribute all the available resources fairly among all the users across the sessions. It muet be able to give fairness to error-prone sessions (long-term fairness) and error-free sessions (short-term fairness).

Maximum Throughput: Throughput is a metric for measuring how many units or bits of information a system can process in a given amount of time or in other words bits per second. The algorithm should give guarantee to long-term throughputs for all existing sessions and also provide guaranteed short-term throughputs for error free sessions.

Implementation complexity: For getting maximum throughput it becomes mandatory to have low-complexity algorithm as it is required in high-speed networks because there scheduling decisions are made very rapidly.

Isolation: There must be an independence among algorithms so that ill effects of misbehaving sessions should not affect each other. It is the responsibility of the scheduler to guarantees QOS requirements for a session and maintain proper balance among the sessions whose demands are exceeding their reserved values.

Energy consumption requirements: The algorithm must be designed keeping in view the need for prolong UE battery life.

Decoupled Delay/bandwidth: There are different types of delays in the network like processing delay, queuing delay, serialization delay and propagation delay. For maximum schedulers, the delay is always tightly coupled with their reserved rates; it is assumed that, a lower reserved rate gives a higher delay and vice versa. The applications, like Web browsing which are having high-bandwidth but they can tolerate relatively very high delays.

Scalability issue: There must be a zero effect of channel extension on the sessions and each session should work properly and efficiently without considering this change.

V. Challenges In Designing Scheduler

While designing a scheduler it mandatory to keep in mind the following factors so as to proceed in right direction. There are various factors on which Wireless channels depend it includes time- and location-dependent signal attenuation, signal fading, signal to noise ratio, signal interference. There may be possibility of getting bur sty errors due to it. A major challenge in designing an efficient scheduler for LTE is to make efficient utilization of spectrum bandwidth.

For making scheduling decisions we must keep in mind the following parameters, the number of sessions created , the reserved rates required for the session , its link states, and also the status of session queues as required by the scheduler. For downlink such type information is easily available as scheduler lies in EnodeB but for uplink queue status information is required by user equipment (UE).
Another challenge arises due to the need of maximizing UE battery life. For saving battery energy UE can transmit and receive signals in specific time slot in that session, for rest of the time it must be in sleeping mode so that very low energy consumption can take place. If switching will frequently occur in these three modes transmit/receive/sleep then it will drain maximum energy. So it needs QOS to maintain balance in between them these modes.

The size of multi hopping network must be small because rapidly changing topology will limit the UE communications. The major challenge for scheduler is a Handoff. Handoffs are essentially exist in wireless cellular systems when an UE, **X**, changes its position from current cell named as **C**1 to a its neighboring cell named as **C**2. In case of a handoff, any packets destined for **X** queued at cell **C**1's E-node B will be forwarded to cell **C**2's e-node B. If we opt for time-stamp based scheduling then there is problem of how to the change timestamp values for these packets in neighboring cells. Another problem which handoff situation may generate is that the timestamps of packets allotted in a new session may be artificially low and which causes requirement of extra service for the new sessions and hence a fairness gap will be introduced in among various users.

Signal-to interference ratio (SIR) is required for handling bit error rate (BER). So for UE the total interference must be small. It is the duty of scheduler to keep the track of simultaneous transmissions in the network and check that number of simultaneous transmissions will not be so high as to result in excessive interferenceSecurity is of prime concern in LTE, especially in m-commerce and e-commerce applications [5]. Mobility of users has great impact on the security of wireless network. Currently available wireless networks use authentication, authorization, data encryption and cryptography techniques on the wireless interface to provide security to its vendors and users.

VI. List Of Various Scheduling Techniques

Packet scheduling is an RRM (Radio Resource Management) scheme used for intelligently selecting users & transmitting them with efficient radio resources so that good QOS is provided to user. Radio resource management is done by MAC scheduler in MAC layer. In LTE-A base station the E-node-B allocates the resources. SC-FDMA scheme is used in uplink of LTE-A.

6.1 Modified Largest Weighted Delay First

This scheme is both channel aware & QOS aware. It is throughput optional scheme. MLWDF can make clear distinction between real time traffic and non real time traffic [19]. It provides good throughput with acceptable level of fairness. The metric for MLWDF consist of following equation:
Metrics (MLWDF) = Data rate * Packet delay at HOL * Weighting factor.
In this weighting factor is used so that user's with bad channel conditions can be served within time. It provides good performance by giving high spectral efficiency, good fairness & less PLR. This scheme prioritizes the packet based on their head of time (HOL) delay. In case of MAC queue the packets with expiry date are removed to avoid consumption of bandwidth.

6.2 EXP rule

EXP rule is assumed to be more robust than LOG rule. EXP rule is channel aware scheme & it can be expressed as:
Metrics (EXP) = Delay single user/Average delay of all users [19].

6.3 LOG Rule

LOG rule also controls delay. QOS support is given to network by maintaining an average amount of delay. It is channel aware scheme which keep the track of traffic arrival time. LOG rule is [20] able to implement inverse performance of EXP function.

6.4 Proportional Fairness

PF alone can provide three QOS parameters. They are fairness, Throughput and spectral efficiency. It simultaneously allocates radio resources, check channel quality & check previous user throughput [19]. It provides balance between spectral efficiency & fairness. The metric for PF can be expressed as.
Metrics (PF) = Expected data rate of user at given time on specific resource block/ Past average throughput of all users.
If users experience bad channel conditions than average throughput will decrease. If past average throughput will decrease then it will automatically maximizes the priority metric of PF. So the poor channel users will also be allocated resources [21]. PF scheme can be used in both time domain & frequency domain. Per flow queuing is the basic feature of PF. Per flow queue cause lot of burden on core network. In order to get channel condition of each user in network, PF scheduling is used. PF scheduler gets this information through E-node-B. As the number of user increases it leads to the increase of cost also [22]. PF scheduler provides fairness as well as an efficient amount of bandwidth to its network. PF channel check the previous user throughput & channel condition to complete this task. The best effort traffic is easily scheduled by PF.

PF = Attainable amount of data**/ F**orecasts attainable throughput rate

This scheme is not capable to prioritize the traffic with critical or bad channel conditions. This may lead to delay & packet Loss [26]. This scheme is channel aware but QOS unaware.

6.5 Round Robin

It assign time interval to its user's. It gives fairness to every connection. It is channel unaware scheme [19]. It is simple procedure which provides high fairness. But cell throughput is not good in this case. Here UE's are allocated resources without knowing the value of CQI. The throughput will decrease because SNR is not considered when number of bits is transmitted [23].

6.6 Best CQI

This algorithm is used for assigning resource blocks to user with channel conditions. It is channel aware strategy where high CQI value states that better channel condition. The user with high value of CQI will be given resource block first [23].

6.7 Maximum Throughput

This scheme will allocate resource blocks (RB) to every user equipment (UE) which has good channel conditions. It is channel aware scheme. This algorithm is efficient in providing minimum cell throughput to all its UE's. The only disadvantage of the scheme is that it provides unfairness among UE's. It can be expressed [21].

Metrics (MT) = Expected data rate of user at given time on specific resources block.

Throughput is equal to minimum number of packets transmitted through a channel in fixed interval of time. It uses signal to noise ratio in calculating the throughput value. It does not provide fairness. Low priority packets may suffer starvation. To attain maximum data rate in current TTI, the MT algorithm assign Resource Block Guarantee (RBG's) to each individual user equipment (UE). MT is also equal to achievable data rate. If all the UE's have same achievable data rate then the UE which is created first is selected. It is not good for providing fairness to UE's with poor channel conditions.

6.8 Throughput to Average

This approach is intermediate between MT & PF. The Metric for it can be expressed as: [21]

Metrics (TA) = Data rate of user on single resource block/ Average data rate of user on all resources blocks

Metrics (TA) = Throughput on single resources block/Overall expected throughput of UE

6.9 Frame Level Scheduler (FLS)

It is QOS aware scheduler. The algorithm work best for real time flow. FLS is considered as two level scheduling algorithms which includes upper level & lower level scheduling. The interaction between upper & lower level allocate resources blocks to UE's. In its upper level FLS uses discrete–time (D-T) linear control loop. FLS in equal to amount of data packets transmitted in real time flow. The packets should be transmitted frame by frame to satisfy its delay constraints. In low level PF scheme is used to allocate resources blocks to UE's. In lower level FLS is calculated by the given formula.

Metrics (FLS) = Number of TTI/Number of RB's

In FLS amount of data transmuted can be calculated as [24]

FLS (ADT) = Pulse response * D-T convolution operator* queue level.

PF scheme in lower level is used to ensure good level of fairness in multimedia flow. It is basically equal to amount of data transmitted in a single frame by real time traffic [25].

6.10 EXP/PF

It is combination of PF & EXP rule. It handles non real time traffic using PF & end delay for real time traffic using EXP rule. It tries to maximize throughput with acceptable level of fairness. EXP/PF proposes QOS over shared wireless connections. The basic EXP was used to improve the priority of real time flow over non real time flow. EXP/PF gives throughput & fairness & also guaranteed bounded delay. For real time traffic EXP/PF provides both high throughput & less PLR.

VII. Recently Proposed LTE Schedulers

Haider Abdul Hassan Hadi Al Kim, et, al.(2017): This paper is based on a comparative analysis of various packet scheduling algorithms in HetNets environment. The comparison is made among PF, MLWDF and EXP/PF and key performance indicators such as packet loss ratio, throughput, fairness and delay are considered to judge the performance of the scheduling algorithms. This paper is based on a comparative analysis of various packet scheduling algorithms in HetNets environment. The comparison is made among PF, MLWDF and EXP/PF and key performance indicators such as packet loss ratio, throughput, fairness and delay are considered to judge the performance of the scheduling algorithms.

Carlos A. Astudillo, et, al.(2017): In this paper, Preamble Priority-Aware (PPA) algorithm for resources Allocation in Packet Downlink Control Channel (PDCCH) is proposed. It prioritizes the control messages of preamble sequences which is being used by the mobile network operator. Simulation results show that the proposed scheduling algorithm is able to decrease random access delays and also achieves high access probability values for users whose preambles sequences are prioritized in the initial phase of the RA procedure. [31]

Samuel O. Aramide, et, al.(2017): Generalized Proportional Fair (GPF) scheduler is proposed to enhance system throughput, and energy efficiency. In this paper GPF is compared to PF, BCQI and RR. Generalized Proportional Fair (GPF) outperforms the PF in the spectral efficiency, sum of the users' throughput and energy per bit as well as in average throughput per user and average energy per bit. On the other hand, the PF scheduler outperforms the GPF, *BCQI* and the RR schedulers in the Jain's fairness index performance.[32]

Nasim, F., et, al. (2016): It Proposed a class-based ranking function, which is a combination of throughput and QOS related parameters. In this method Greedy Knapsack algorithm is presented to evaluate user candidates who are waiting for their scheduling time. [30]

Tzu-Chin, L., et, al. (2016): This paper works on Multi Media traffic report system (MTRS). It proposes QOS aware resource mechanism for MTRS. It improves diversity and completeness and also provides minimum delay and maximum system throughput [15].

Radhakrishnan, S., et, al. (2016): This Paper simulated various Algorithm [16] for packet scheduling like PF, OSA, BET etc. for real time traffic .The conclusion drawn is that every algorithm for real time flow must be QOS aware. It uses carrier Aggregation and Multi Input Multi Output (MIMO) in LTE-A

Ramprasad, S., et, al. (2015): This approach is scenario based. In this bench marking is done of PF algorithms are performed in live network by taking three different user subscriptions. This approach supports relationship between SNR and transmission rate [14].

Nandhini, S., (2015): This paper proposes Low Latency weighted fair queuing (LLWFQ) queue model. It is simulated in real time flow. This algorithm approaches to higher throughput and lower delay. In simulation it is compared to WFQ and provides high QOS for real time service [17].

Idris, Z., et. al, (2015): This paper is based on simulation of class based weighted fair queue (CBWFQ) algorithm in IP router . This will provide bandwidth guarantee on different traffic classes. This simulation is based on traffic shaping mechanism [18].

Nasim, F., et, al. (2015): Proposed a new algorithm for LTE downlink scheduling by using technique of "time-domain Knapsack algorithm" for traffic overload patterns[6]. The problem to traffic overload is resolved with the Knapsack algorithm, and it also improves system performance. Paper demonstrates that more efficient performance can be achieved in terms of fairness index and system throughput, which is evaluated using simulation results.

Mattia, C., et, al. (2014): Proposes *Fair Throughput Guarantees Scheduler* (FTGS) in frequency domain and its prior version was implemented in time domain [7]. This scheduler provides equal long term throughput guarantees to all users and also increases cell capacity. But the increased flexibility of this schedulers is paid in terms of complexity and signaling overhead.

IAng, E. M., et, al. (2014): Proposed two level scheduling framework (FLS-M-EXP) [8]. This study worked on real time environment but non real time portion is not covered. This scheduler is compared with Frame Level Scheduler (FLS), Modified-Largest Weighted Delay First (M-LWDF), and Proportional Fair downlink scheduler. The comparisons are carried out in both VOIP and video transmissions and it is observed that FLS-M-EXP always performs better than FLS-PF in terms of end to end delay by an overall average of 2.46%. but when compared to M-LWDF both FLS-M-EXP and FLS-PF gives a better performance in terms of packet loss ratio(PLR), end to end delay, and throughput.

Yashar, F., et, al. (2014): Propose a novel QOS-Aware scheduling algorithm [9] in which a Token Bucket algorithm is used. This gives enhanced spectral efficiency in single cell. The Proposed a QOS-Aware scheduling method works both in time and frequency domains. It uses bearer services for Non-GBR and GBR classes defined in Quality class Indicator (QCI). Classical five tuple method is used to map different flows to different carriers. The VOIP and Video traffic comes under GBR class and FTP and HTTP comes under Non-GBR class. In this method, the Token Bucket algorithm uses GBR class to avoid allocation of all resources to this class. This lead to an efficient design where there is an acceptable amount of fairness exist in between two classes which further increases the total system throughput.

Chao, H. and Richard, D. G., (2014): It provides a new algorithm called rate adaptation and QOS-aware MAC scheduling. It gives high spectrum utilization, spectral efficiency to users as well as operators. It is a good tradeoff QOS and QOE (quality of experience). It provides service satisfaction among the operators by providing the good quality of service for the sessions in which users are involved. It is possible by trading off the spectral resource allocations of connections [10]. The main focus of their research is to provide better voice applications and video applications. They concentrate on Quality of service in 4G and enhancement of system capacity (i.e., the number of supportable users). But they do not concentrate on user satisfaction.

Table 2. Literature survey of various packet scheduling algorithms

Year	Author	Work Proposed	Conclusion
2017	Haider Abdul Hassan Hadi Al Kim, et, al.	This paper is based on a comparative analysis of various packet scheduling algorithms in HetNets environment. The comparison is made among PF, MLWDF and EXP/PF and key performance indicators such as packet loss ratio, throughput, fairness and delay are considered to judge the performance of the scheduling algorithms.	This paper is based on a comparative analysis of various packet scheduling algorithms in HetNets environment. The comparison is made among PF, MLWDF and EXP/PF and key performance indicators such as packet loss ratio, throughput, fairness and delay are considered to judge the performance of the scheduling algorithms..
2017	Carlos A. Astudillo, et, al.	In this paper, Preamble Priority-Aware (PPA) algorithm for resources Allocation in Packet Downlink Control Channel (PDCCH) is proposed.	It prioritizes the control messages of preamble sequences which is being used by the mobile network operator. Simulation results show that the proposed scheduling algorithm is able to decrease random access delays and also achieves high access probability values for users whose preambles sequences are prioritized in the initial phase of the RA procedure.
2017	Samuel O. Aramide, et, al.	Generalized Proportional Fair (GPF) scheduler is proposed to enhance system throughput, and energy efficiency.	In this paper GPF is compared to PF, BCQI and RR. *GPF* outperforms the PF in the spectral efficiency ,sum of the users' throughput and energy per bit as well as in average throughput per user and average energy per bit. On the other hand, the PF scheduler outperforms the GPF, *BCQI* and the RR schedulers in the Jain's fairness index performance
2016	Nasim, F., et, al.	Greedy Knapsack algorithm is presented to evaluate user candidates who are waiting for their scheduling time.	It Proposed a class-based ranking function, which is a combination of throughput and QOS related parameters.
2016	Tzu-Chin, L., et al.,	Multi Media traffic report system(MTRS)	Minimum delay and maximum system throughput are calculated.
2016	Radhakrishnan, S., et al.,	Simulated various algorithms	Carrier Aggregation and Multi Input Multi Output (MIMO) is used.
201	Ramprasad, S.,	Comparative study	Simulator LTE-SIM and NS-3.

2015	et al.,		
2015	Fahana, A., et al.,	Comparative analysis of PF, EXP, EXP/PF, M-LWDF, LOG rule, and FLS	FLS scheme is better than other five schemes in terms of throughput, PLR, delay.
2015	Dakuri, C., et al.,	Compare the different algorithms like, FLS, PF, MLWDF, EXP/PF.	FLS will give better results in real time environment as compare to other four
2015	Ramprasad, S., et, al.,	Bench marking is done on PF algorithm	supports relationship between SNR and transmission rate
2015	Nandhini, S.,	Proposed Low Latency weighted fair queuing (LLWFQ) queue model	Approaches to higher throughput and lower delay
2015	Idris, Z., et. al,	Simulation of class based weighted fair queue (CBWFQ) algorithm.	Bandwidth guarantee on different traffic classes.
2015	Nasim, F., et, al.	Time-domain Knapsack algorithm.	More efficient performance can be achieved in terms of fairness index and system throughput.
2015	Aiswariya, M. K., and Shilpa R.,	Algorithm called priority scheduling algorithm (PSA).	But it has highest PLR & response time .
2015	Roshanak, H., et al.,	Comparison between two algorithm MDU & LOG-MLWDF.	LOG-MLWDF algorithm gives best PLR than other algorithms.
2015	Sahoo, B. P. S., et al.,	Comparative study.	The FLS is the best algorithm.
2015	Jonghwan, H., et al.,	Classification method DPI (Deep Packet Inspection)	First step towards classification of packets.
2014	Mattia, C., et al.,	Fair Throughput Guarantees Scheduler (FTGS)	Throughput guarantees to all users and also increases cell capacity
2014	IAng, E. M., et al.,	Two level scheduling framework (FLS-M-EXP).	FLS-M-EXP always performs better than FLS-PF in terms of end to end delay.
2014	Yashar, F., et al.,	Novel QOS-Aware scheduling algorithm in which a Token Bucket algorithm is used.	Fairness exist in between two classes which further increases the total system throughput.
2014	Chao, H. and Richard, D. G.,	A new algorithm called rate adaptation and QOS-aware MAC scheduling.	Provide better voice applications and video applications.
2014	Sulthana, S. F., and Nakkeeran, R.,	General study on key issues of scheduling algorithms.	LOG rule are better choice for real time traffic.

VIII. Conclusion

From the above study it is concluded that during the peak traffic load time, there is no such scheduling algorithm is designed which will meet the requirements of intense traffic. The whole process of implementing down-link algorithm in LTE-A needs to take care of classification techniques as the first step and then retrieving the best queuing strategy. The varieties of algorithms are studied by different researchers but there is no optimum algorithm which is developed to meet the time and frequency domain requirements.

So there is a need of unification of 2 or more methods to generate better results and establish policy which will meet the requirements of heavy Load. As the world is moving ahead towards 5G so it becomes crucial to do more research work to solve the challenges of resource management issues.

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