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A Packet Based Scheduling Mechanism in Real Time Traffic for LTE Downlink Networks

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***Abstract*—The increasing demand for cellular communications leads to the development of a 4G technology known as Long Term Evolution (LTE). LTE is the evolution for existing 3G mobile networks which offers higher capacity, higher spectral efficiency efficient utilization of radio resources and bandwidth, lower latency.3GPP LTE is an emerging and promising technology for improving the performance which is achieved through streamlining the system for packet services as long term evolution is an all Internet protocol based network. Traffic scheduling plays an important role in LTE technology by assigning the shared resources among users in the most efficient manner. This paper presents the a scheduling mechanism for the different traffic flows by comparing and analyzing the effect of varying the number of packets in the queue in terms of the Average Goodput, Average Delay time, Invalid Packet rate, Packet loss ratio and Spectral efficiency.**

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

1. INTRODUCTION

In the growing complexity of today's wireless communication systems; the cellular data networks are experiencing an increasing demand for its high data rate and wide mobility. In 2008, the Long Term Evolution (LTE) was introduced by the 3rd Generation Partnership Project (3GPP) and in order to increase the capacity and speed of wireless data networks [1]. LTE is a global standard for fourth generation of mobile broadband (4G) supported by all major players in the industry. LTE is expected to provide an extended capacity and an improved performance compared to the current HSPA (High Speed Packet Access) networks. The objective of LTE was to develop a framework for the evolution of the 3GPP radio-access technology towards a high-data-rate, high spectral efficiency, low-latency and packet optimized radio-access technology. The requirements specified are high speed data rates, low latency, increased spectral efficiency, scalable bandwidths, flat all-IP network architecture, optimized performance for mobile speed etc [2]. One of the primary objective of the LTE network is to increase the data-rate to fulfill the highly demanded services. 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 Key characteristics of LTE are Resource allocation in the frequency domain takes place with the resolution of 180MHz resource blocks both in uplink and in downlink [2].The frequency dimensioning in the packet scheduling is one of the important reasons for the high LTE capacity. Uplink single carrier solution is designed to allow efficient user terminal power amplifier design, to protect user terminal battery life. The LTE solution enables spectrum flexibility. 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. The aim is to improve the network scalability for increased traffic and to minimize the end-to-end latency by reducing the number of network elements. The LTE may operate as a pure packet switching system and all traffic including delay sensitive services need to be scheduled[4].So, the scheduling mechanism, implemented in the evolved base station (BS) and distributing radio resources among users considered as a significant part of the system design. To support downlink data services with high transmission rates, a BS transmit data using shared channels where the data and information that comes from many users is multiplexed in time and frequency domains. So, these scheduling policies are in demand to achieve desired performance and QoS level by the BS users.

2. RELATED RESEARCHES

Extensive scheduling strategies have been studied and analyzed in terms of different parameters in [1, 3, 4]. M.H Habaebi et.al compared the different scheduling algorithm like Round Robin, Proportional Fair and Best CQI in terms of fairness [5].

Gbolahan Aiyetoro et.al has done the performance analysis of the two real time scheduler i.e. MLWDF and EXP/PF for the Satellite LTE networks in terms of average throughput, delay time, packet loss ratio [6]. Deng Keke et.al proposed an energy saving strategy for LTE services known as Energy saving based Inter group Proportional fair (EIRP) algorithm [8]. Prio et al. propose a two-level downlink scheduling for real-time flows in LTE networks [10]. The upper-level is based on discrete control theory and the lower level is a proportional fair scheduler. The evaluation of quality-of experience (QoE) to end users is provided. The scheduling strategy is compared to EXP and Logarithmic (LOG) rule.

Huang et al. consider the power and subcarriers for OFDM systems [7].Several practical factors such as sub channelization schemes, maximum SNR and phase noise are taken into account. A gradient-based scheme is introduced and the problem is reduced to an optimization problem for each time slot. Then by using a dual formulation for the optimization problem, the optimal algorithm and suboptimal algorithms can be developed. Wei Kuang Lai et.al proposed a scheduling mechanism with the different phases with fixed number of packets in a queue and analyzed the performance in terms of average goodput, average delay time, invalid packet rate [9].

3. PACKET SCHEDULING

The purpose of Packet Scheduling is to distribute the resources among users in a fair and efficient way to maximize the system throughput along with fairness.

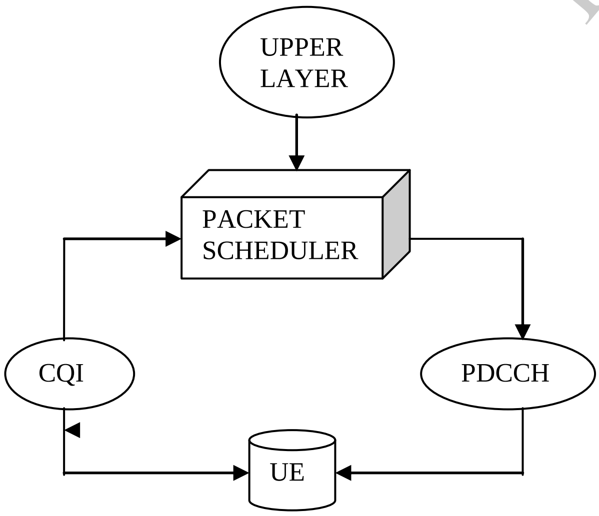

Figure1. Working model of packet scheduler

In packet scheduling, the resources are allocated to the different users by the evolved NodeB depending upon the CQI received from the user equipments to get the information about the channel condition and accordingly it assigns the modulation scheme.

The whole process can be divided in a sequence of operations [1] that are repeated every TTI:
Each User Equipment decodes the reference signals, computes the CQI, and sends it back to the eNB. The eNB uses the channel quality indicator information for the allocation decisions and fills up a Resource block “allocation mask”. The Adaptive modulation and coding module selects the best Modulation and coding scheme that should be used for the data transmission by scheduled users. The information about these users, the allocated Resource blocks, and the selected Modulation and coding scheme are sent to the User equipments on the PDCCH. Each User Equipment reads the PDCCH payload and, in case it has been scheduled, accesses to the proper PDSCH payload. To satisfy the QoS requirements of video users, there is always a trade-off between decision optimality and computational complexity while designing a resource allocation strategy. The study suggests, while defining a resource allocation policy the LTE vendor should take the design factors into account such as: complexity and scalability; spectral efficiency; fairness and QoS provisioning.

4. SCHEDULING MECHANISM

There are many QoS parameters. Time delays, error rates, and goodputs are some of the most important parameters for achieving QoS requirements of LTE networks. In this Scheduling mechanism there are three phases and the first phase is in frequency domain and the other two phases consider the time domain.

1. Initial Scheduling for Physical Resource Blocks (PRBs).
2. Managing queues and predication of packets for delays.
3. Cut in process.

4.1 Initial Scheduling for PRBs

First consider the frequency domain. In this phase, focus is on the system performance. PRBs are allocated to users with best CQI’s. For each TTI, the CQI values of different users are compared. The design goal of the first phase is to have good throughputs.

4.2 Managing Queues and predication of packets for delays

The second phase considers the performance of those users whose CQI values are not as good. They may be located at cell edges relative to base stations. Their packets may not be transmitted to their destinations in time. There will be many out-of-date packets which are discarded at destinations if we only consider throughputs.

4.3 Cut in process

The resource block a is allocated to user b to have maximum throughput if there is no cut-in process. Now, we will find a cut-in user c from all candidate users. Let the user c that will make the least decrease in throughputs among all candidate cut-in users to utilize resource block a. This will make the least decrease to the throughputs. The process is continued until all cut-in users are handled or all resource blacks are allocated.

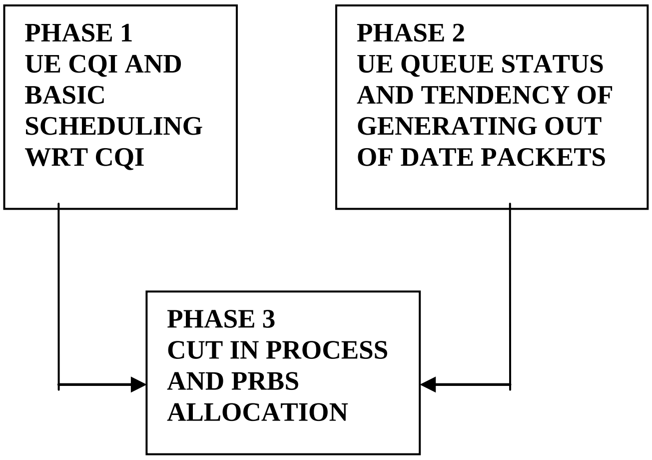

Figure2. Three phases of Downlink Packet Scheduling in LTE networks

5. RESULTS AND DISCUSSION

Figure 3(a) shows the average goodput for video flows for the variable packets in the queue for each User Equipment. As, the number of packets are increasing average goodput shows an improvement. When the packets in the queue are maximum, the average goodput also attains maximum value.

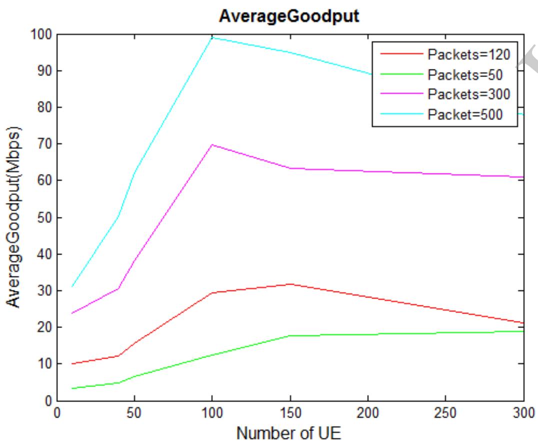

Figure 3(a). Average Goodput for video flow

Figure 3(b) shows the average delay time for video flows and in this for the less number of packets in the queue , the delay time is minimum. As the number of packets increasing the average delay time also increases. Figure 3(c) shows the invalid packet rate for video flows. With the increase in number of packets in the queue, the invalid packet rate also increases. So, it is maximum for queue with maximum number of packets.

Table1. Channel Quality Indication index versus Modulation

CQI INDEX	MODULATION SCHEME	CODE RATE (X1024)	EFFICIENCY
0	N/A	N/A	N/A
1	QPSK	78	0.1523
2	QPSK	120	0.2344
3	QPSK	193	0.3770
4	QPSK	308	0.6016
5	QPSK	449	0.8770
6	QPSK	602	1.1758
7	16QAM	378	1.4766
8	16QAM	490	1.9141
9	16QAM	616	2.4063
10	64QAM	466	2.7305
11	64QAM	567	3.3223
12	64QAM	666	3.9023
13	64QAM	772	4.5234
14	64QAM	873	5.1152
15	64QAM	948	5.5547

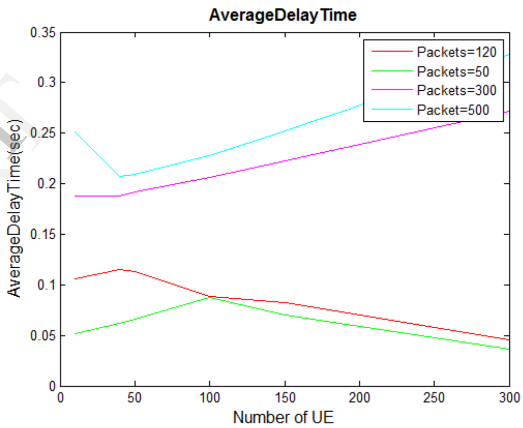

Figure 3(b). Average Delay time for video flow

Figure 3(d) shows the packet loss ratio for the video flow which also increases with increasing number of packets in the queue because then more packets transmitted successfully to the destination but similarly the number of discarded packets also increases. Figure 3(e) shows Spectral efficiency for video flows and the maximum value is attained when the queue is having maximum number of packets.

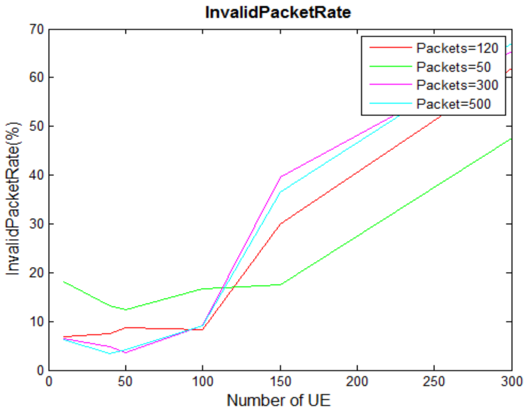

Figure 3(c). Invalid Packet Rate for video flow

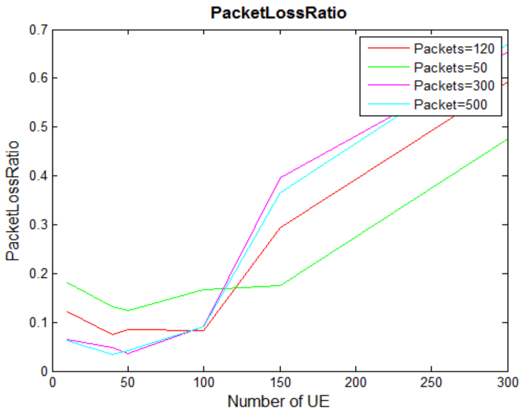

Figure 3(d). Packet Loss Ratio for video flow

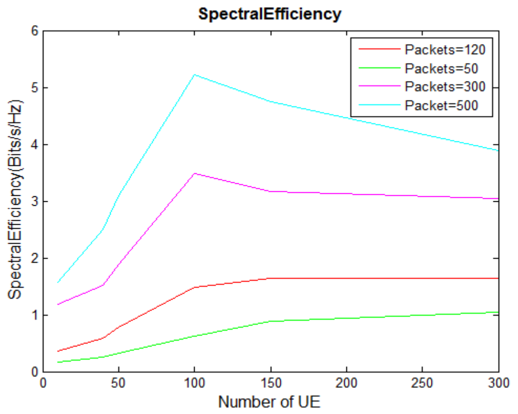

Figure 3(e). Spectral Efficiency for video flow

6. CONCLUSION

In this paper, a scheduling mechanism is studied for downlink video traffic with variable number of packets in the queue for each User Equipment in terms of Average goodput, Average Delay time, Invalid Packet rate, Spectral Efficiency and Packet loss ratio. Future research will focus on more challenging problems of scheduling, considering both the uplink and downlink directions.

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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.