A Survey on Resource Scheduling Algorithms of LTE 4G Wireless Communication

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Abstract - Different types of traffic with different Quality of Service requirements are competing for its resources. The 3G LTE accommodates smart selections of users and transmission of data through packets. In this paper, packet scheduler for LTE downlink is described and comparison of four basic packet scheduling algorithm is explained. It unties obscurity of dividing the packet scheduler into a time domain, frequency domain and relaxes the ambiguousness of utilizing different algorithms; the throughput fairness between users can be effectively controlled. This paper explores 4G wireless system, its features and technologies to fulfil its requirement also we compare different packet scheduling algorithms of 3GPP UTRAN Long Term Evolution (LTE) Downlink.

Keywords : Wireless communication, 4G,

I. INTRODUCTION

The mobile and wireless communication is a fast improving technology. Devices persist to shrink in size with concurrent growing of processing power. Consumers demand more advanced, progressive, contemporary and handy applications. Hence, there is need of subsistent improvements in wireless communication. Wireless communication is a dynamic zone for technology development of outrage. Several major cellular wireless communication techniques have been proposed in order to meet user’s expectations. The primary expectation for the future 4G system is that they provide enormously high data rates to an undue number of users all at the same time. The first generation (1G) wireless network was basically an analog cellular system with circuit switched network architecture. The main challenges of these wireless networks were basic voice telephony, low capacity and limited local and regional coverage. The increased demand for high frequency ranges in the telecommunications sector required a progression in analog to digital transmission techniques. Meanwhile in the early 1990s, second generation (2G) paved way to meet capacity demands of burgeoning voice plus telephony, text messaging and limited circuit switched data services. By utilizing digital system, the signal can be compressed much more efficiently than analog system, with an amendment of transmitting more packets into the same bandwidth and propagation with less power [5]. The third generation (3G) systems integrate voice and data applications. Vendors and operators started seeking ways for determining a new next generation wireless technology, namely fourth generation (4G). 4G Technology is basically the extension of 3G technology with more bandwidth and service offers than 3G. The expectation for 4G technology is basically high quality audio/video streaming over end to end Internet Protocol. The applications of 4G technology includes

- 4G Tele-medicine
- 4G Location-based services
- 4G Ultra high speed internet access
- 4G HDTV
- 4G High Definition Video on demand
- 4G Video games on demand

II BACKGROUND OF INVENTION

3GPP: LTE –Long term evolution is baseline to the modern 4th generation communication systems. It is an enhanced version of Universal Mobile Telecommunication System (3G). LTE is introduced by 3GPP. LTE is standardized in the form of REL-8, this is operated at data rate 100 Mbps for downlink and 50 Mbps for uplink with 20 MHz bandwidth. LTE can accommodate up to 200 users through mobile (5 MHz)[2]. Nowadays the increase of mobile data usage and advent of new applications like mobile TV, Web2.0 and other streaming contents force the 3rd Generation Partnership Project (3GPP) to develop this Long-Term Evolution (LTE). The 3GPP LTE with radio network architecture has only one node between the user and the core network known as eNodeB which operates all radio resource management (RRM) functions. This function of RRM is termed as “packet scheduling”. Because of its smart selections of users and transmission
of their packets, the radio resources are utilized efficiently and QoS (quality of service) is also maintained. Scheduling is the key functionality of radio protocol stack. It is performed by the MAC scheduler in the eNodeB. The scheduler is responsible for allocating the radio resources in both directions (DL and UL) considering the QoS requirements for all active radio flows (bearers). This is achieved by allocating the available radio resource blocks (RBs) to specific User Equipment’s (UEs) within the sector or the cell for the transmission and reception of variable-size Transport Blocks (TB). The scheduler runs every sub frame or Time Transmission Interval (TTI) and allocates the RBs to the UEs in the DL and UL. A single TB may be allocated to a UE as per TTI [1]. The scheduling algorithms have a significant impact on the performance of each individual eNodeB and overall LTE network.

Packet scheduling for wireless communications has been an active research area in recent years, because there has been rapid increasing demands on data services with a probable explode progress of traffic such as Internet, Email, multimedia. To support these packet data services, the scare and limited wireless resource must be used in best way by increase in capacity and QoS security. Providing priority or fairness is also an open issue in wireless system. However, it is not simple to meet all of these requirements. The throughput of a UE depends on the different factors like scheduling algorithms, distance from eNodeB, multipath environment, multiple antenna techniques and UE speed. In this paper, we consider the effect of scheduling algorithm with throughput performance. We apply proportional fair (PF) scheduler, round robin, best CQI and MaxMin Scheduler for LTE in order to find best scheduler which provides high-quality cell throughput and improved fairness. The scheduler has to serve multiple users and try to meet an individual’s requirements on bit rates and delays. The fairness of the scheduler is a way to couple the scheduler and it’s weakest users. To achieve the objective of LTE, advanced Radio Resource Management functions have been defined. LTE contains some algorithms such as Hybrid ARQ (HARQ), Link Adaptation (LA) and Channel Quality Indication (CQI). HARQ is utilized for fast retransmissions of the correct packets. HARQ is use to keep the radio interface delay minimum. User Equipment (UE) is used to measure the received channel quality, e.g. SINR, and update the channel dependent CQI reports by uplink. They give information to the Radio Resource Management (RRM) about time and frequency variant channel quality like PS and LA. Based on CQI reports, LA selects different modulation and coding schemes (MCS) to maximize the spectral efficiency. [5]. Both time (TDD) and frequency division duplex (FDD) modes can be used in LTE. In downlink the time is fragmented into 1 ms Transmission Time Intervals (TTI) and 180 kHz Physical Resource Blocks (PRB) in frequency. LTE is optimized for packet data transfer and the core network is purely packet switched. In [8] the authors study the spectral efficiency of LTE DL with different UE receiver structures and with advanced SIMO receivers they have achieved about 1.25 bits/s/Hz. In [9] the authors show 1.56 bits/s/Hz spectral efficiency. The time domain (TD) packet scheduler chooses a subset of all users linked to the base station (called evolved Node-B (eNB) in LTE ) and the FD scheduler does the real frequency allocation for the users. The scheduling in both the TD and FD is through algorithm-specific scheduling priority metrics. A priority metric generally provides the function for obtaining a certain general characteristic of the scheduling algorithm. The purpose of time domain packet scheduling is sharing out of all users requesting frequency resources. The purpose of the frequency domain packet scheduler is to allocate PRBs for the users in the SCS provided by TD-PS. However, it should be distinguished that users in the SCS are considered candidates, since FD-PS does not necessarily guarantee that all users are being allocated frequency resources. A user may be given any number of PRBs, and the PRBs do not need to be consecutive. The algorithm’s particular priority metrics are taken into account in PRB selection.
III DOWNLINK RESOURCE ALLOCATION

OFDMA is used for downlink transmission in LTE. Data is allocated to the UEs in terms of Resource Blocks (RB). In time, the length of RB is 0.5ms in one slot of frame. The eNodeB allocates different RBs to an exacting UE in either localized or distributed way. The eNodeB uses DCI format 1, 1A, 1B, 1C, 1D, 2, 2A or 2B on PDCCH to transmit the resource allocations on PDSCH for downlink transmission. The scheduler at eNodeB attempts for appropriate allotment of the resources among UEs. The UE reports CQI (Channel Quality Indicator) which helps eNodeB to approximate the downlink channel quality. The channel dependent scheduling requires maintaining some fairness among the users and on the other hand it would correspond to provide higher cell throughput in their resource allocations. There is a connection between fairness and cell throughput.

Figure. 2 LTE Frame Format

Different scheduling methods are shown below in order to address this trade off.

Round Robin (RR): The scheduler provides resources cyclically to the users without considering channel conditions into account. It’s a simple procedure giving the best fairness. RR meets the fairness by providing an equal share of packet transmission time to each user. But it witnesses poor performance in terms of cell throughput. In Round Robin (RR) scheduling the terminals are assigned the resource blocks in turn (one after another) without considering the CQI. Thus the terminals are equally scheduled [4]. However, throughput performance degrades significantly as the algorithm does not rely on the reported instantaneous downlink SNR values when determining the number of bits to be transmitted.

Proportional fair (PF): Proportional fair is a Downlink algorithm best suited for best traffic effort. Main purpose of Proportional Fair algorithm is to balance between throughput and fairness [8] among all the UEs. It tries to maximize total [wired/wireless network] throughput while at the same time it provides all users a least minimal level of service. PF was originally developed to maintain NRT service in Code Division Multiple Access High Data Rate (CDMA-HDR) systems. The scheduler can affect Proportional Fair (PF) scheduling by allocating more resources to a user, and a comparatively better channel quality. This is done by giving each data flow a scheduling priority that is inversely proportional to its anticipated resource consumption. This gives high cell throughput as well as fairness satisfactorily. Thus, Proportional Fair (PF) scheduling could possibly be the best option.

Best CQI: This scheduling algorithm is used as a strategy to assign resource blocks to the user with the best radio link conditions. The resource blocks assigned by the Best CQI to the user will have the highest CQI on that RB. The MS must feedback the Channel Quality Indication (CQI) to the BS to perform the Best CQI[4]. In order to perform scheduling, terminals send Channel Quality Indicator (CQI) to the base station (BS). Basically in the downlink, the BS transmits reference signal (downlink pilot) to terminals. These reference signals are used by UEs for the calculation of the CQI. A higher CQI value means better channel condition.

MaxMin Scheduler: The task of a MaxMin scheduler is to maximize the minimum of the UE throughputs. MaxMin is a type of scheduler that maximizes the minimum data rate of the resources[4]. MaxMin fairness provides lower average throughputs where least expensive data flow (UE located far from base station) is assigned all capacity they can use.
on Pareto optimal, the rate of one UE cannot be increased without decreasing the rate of another UE that has a lower rate than the one considered.

Table 1 Simulation Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Assumptions</th>
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<tbody>
<tr>
<td>Transmission bandwidth</td>
<td>2.0GHz</td>
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<tr>
<td>Inter-site distance</td>
<td>5MHz</td>
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<tr>
<td>Receiver noise figure</td>
<td>9dB</td>
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<tr>
<td>Simulation length</td>
<td>100 TTI</td>
</tr>
<tr>
<td>UE speeds of interest</td>
<td>5km/hr</td>
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<tr>
<td>Fair</td>
<td>Thermal noise density</td>
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<tr>
<td>Uplink delay</td>
<td>3 TTIs</td>
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<tr>
<td>Scheduler</td>
<td>Round Robin, Proportional fair,</td>
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<td></td>
<td>Best CQI, MaxMin</td>
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<tr>
<td>eNodeB TX power</td>
<td>43dB</td>
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</table>

CONCLUSION

The standardization of LTE became one of the most important technology shifts in cellular networks since the introduction of WCDMA. However, it was not until the introduction of LTE-Advanced in Rel-10 that the requirements established by the ITU for 4G technologies were finally achieved. Nevertheless, both industry and academia have continued improving LTE-Advanced through enhancements in the core technologies of carrier aggregation, MIMO, relaying, and cooperative multipoint communications. This paper sketches the drawbacks of earlier generation wireless networks and the invention of 3GPP 4G wireless communication systems, furthermore, comparison of different scheduling algorithms for LTE-Advanced. Component Carriers with the user radio conditions by QoS requirements, and targets of maximization of user throughput. This evolution will continue, not only by improving these technologies, but also by introducing new ones, especially at higher frequency bands capable of satisfying the demand for even faster data access than the ones seen today.

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