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Design and Performance Evaluation of DL MAC Scheduling Model in LTE

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Abstract- In case of Long Term Evolution (LTE), the scheduler in the MAC layer of the eNodeB allocates the available radio resources among different UEs in a cell through proper handling of priority. The scheduling method used largely impacts the throughput of individual users as well as throughput of the cell. It is worthwhile to check on the throughput conditions for different scheduling scenarios before the actual deployment of LTE. This would help design the algorithm of the scheduler at the eNodeB appropriately. In this dissertation, the throughput conditions require to investigate for different scheduling methods in LTE.

Keyword- *Scheduling, MAC, CQI , Throughput. UE, eNodeB.*

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I.INTRODUCTION

In the recent years, the world was introduced to mobile broadband. Multimedia applications through the Internet have gathered more attention. Applications such as live streaming, online gaming, mobile TV require higher data rate. The Third-generation Partnership Project (3GPP) started to work on solutions to these challenges and came up with the HSPA. The HSPA is currently used in 3G phones for such applications. Later, the 3GPP[2] has worked on the Long Term Evolution (LTE)[1] and intends to surpass the performance of HSPA. The Long Term Evolution supports high peak data rates (100 Mb/s in the downlink and 50 Mb/s in the uplink), low latency (10ms round-trip delay) in different bandwidths ranging from 1.4MHz up to 20MHz. In mobile broadband networks like LTE, the high performance and throughput[3] of the radio network can be realized with proper scheduling of resources for different types of services. The scheduling of resources in the transport network is an area which needs proper attention especially. In December 2008, the LTE specification was published as part of Release 8. The initial deployment of LTE was expected in 2009. The first release of LTE namely release-8 supports peak rates of 300Mb/s, a radio-network delay of less than 5ms. Multiple Input Multiple Output(MIMO) have gathered a lot of attention recently. It allows the achievement of high peak data rates. Furthermore LTE operates both Frequency Division Duplexing(FDD) and Time Division Duplexing (TDD) and can be deployed in different bandwidths. With TDD the uplink and downlink operate in same frequency band whereas with TDD the uplink and downlink operate in different frequency bands.LTE uses a simplified flat network infrastructure that consists of only two nodes: the enhanced eNodeB (eNB) and the mobile management entity/serving gateway (MME/S-GW). This is also one of the main factors that LTE can achieve a reduced latency compared to UMTS/HSPA. Another design goal was to increase spectrum efficiency. LTE uses a combination of multi-antenna techniques and Orthogonal Frequency Division Multiplexing (OFDM) to achieve higher data rates and offer the required spectrum deployment and flexibility.

II. LTE SYSTEM ARCHITECTURE

Research of the 3GPP has resulted in the development of the Evolved Packet System (EPS). The EPS consists of: Core Network (CN), Evolved Packet Core (EPC), and Evolved UTRAN (E-UTRAN)[9], it is also referred to as LTE.

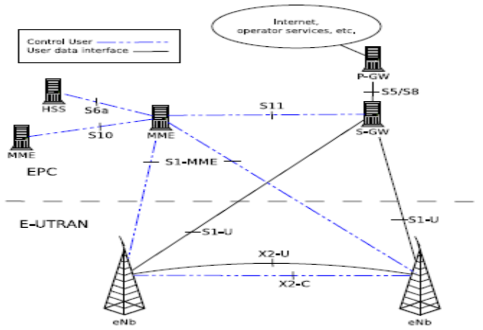

Figure.1 Overview of the EPC/LTE architecture.

The EPC has the components of the mobility management entity (MME), serving gateway (S-GW) and the packet data network gateway (P-GW). The EPC components can be grouped into two main planes: the user plane and the control plane. While MME forms the core of the control plane, S-GW forms the core of the user plane. MME is an entity that manages signalling and connections with RAN.S-GW is the system that forwards and receives packets from RAN. The P-GW is the termination point of the packet data interface and it interfaces with the packet data network[5][6]. The S1 interface connects the eNodeB to the MME and S-GW. It supports the user and control plane traffic between the E-UTRAN and EPC.

III.SCHEDULING ALGORITHM

Scheduling is simply allocating or reserving resources to users in a communication system to maximize throughput and system efficiency. Scheduling in LTE downlink takes advantage of various factors including channel variations by allocating frequency and time resources to a user with transiently better channel conditions. The quality of service requirement in a multi-user communication system varies therefore the choice of a scheduling algorithm critically impacts the system performance.The scheduler[4] determines to which user the shared resources (time and frequencies) for each TTI (1 ms) should be allocated for reception of DL-SCH transmission.The MAC scheduler is responsible for scheduling the air interface resources among the users in both the downlink and the uplink. Since OFDM technology is used in LTE, the scheduler effectively distributes the radio resources in both time and frequency domain.The smallest scheduling resources is called Physical Resource Block (PRB). In order to simplify the LTE MAC scheduling, two stages have been defined: Time Domain (TD) and Frequency Domain (FD) scheduler.There are different MAC Scheduler available.

1. Round Robin (RR) Scheduler
2. Proportional Fair (PF) Scheduler
3. Maximum Throughput (MT) Scheduler
4. Throughput to Average (TTA) Scheduler
5. Blind Average Throughput Scheduler
6. Token Bank Fair Queue Scheduler
7. **Priority Set Scheduler**

1. *Round Robin (RR) Scheduler*:
   - Time slices are assigned to each process in equal portions and in circular order, handling all processes without priority.
2. *Proportional Fair (PF) Scheduler:*
   - It's based upon maintaining a balance between two competing interests: Trying to maximize total [wired/wireless network] throughput while at the same time allowing all users at least a minimal level of service.
3. *Maximum Throughput (MT)Scheduler:*
   - Aims to maximize the overall throughput of eNB. It allocates each RB to the user that can achieve the maximum achievable rate in the current TTI.
4. *Throughput to Average (TTA) Scheduler:*
   - It can be considered as an intermediate between MT and PF.
5. *Blind Average Throughput Scheduler:*
   - IT aims to provide equal throughput to all UEs under eNB..
6. *Token Bank Fair Queue Scheduler:*
   - The bandwidth allocation mechanism integrates the leaky bucket structure with priority handling to address the problem of providing quality-of-service (QoS) guarantees to heterogeneous applications in the next generation packet-switched wireless networks.
7. *Priority Set Scheduler:*
   - Is a QoS aware scheduler which combines time domain (TD) and frequency domain (FD) packet scheduling operations into one scheduler.

IV. CHANNEL QUALITY INDICATOR

The Channel Quality Indicator (CQI) contains information sent from a UE to the eNode-B to indicate a suitable downlink transmission data rate, i.e., a Modulation and Coding Scheme (MCS) value. CQI is a 4-bit integer and is based on the observed signal-to-interference-plus-noise ratio (SINR) at the UE. The CQI estimation process takes into account the UE capability such as the number of antennas and the type of receiver used for detection. This is important since for the same SINR value the MCS level that can be supported by a UE depends on these various UE capabilities, which needs to be taken into account in order for the eNode-B to select an optimum MCS level for the transmission. The CQI reported values are used by the eNode-B for downlink scheduling and link adaptation, which are important features of LTE.LTE supports wideband and subband CQI reporting. A wideband CQI value is a single 4-bit integer that represents an effective SINR as observed by the UE over the entire channel bandwidth. With wideband CQI, the variation in the SINR across the channel due to frequency selective nature of the channel is masked out. Therefore, frequency selective scheduling where a UE is placed only in resource blocks with high SINR is not possible with wideband CQI reporting. To support frequency selective scheduling, each UE needs to report the CQI with a fine frequency granularity, which is possible with sub-band CQI reporting. A sub-band CQI report consists of a vector of CQI values

ISSN: 2321-8169
17 – 19

where each CQI value is representative of the SINR observed by the UE over a sub-band. A sub-band is a collection of n adjacent Physical Resource Blocks (PRBs) where the value of n can be 2, 3, 4, 6, or 8 depending on the channel bandwidth and the CQI feedback mode[8].

V. ALGORITHM AND SIMULATION

Round Robin Scheduler:

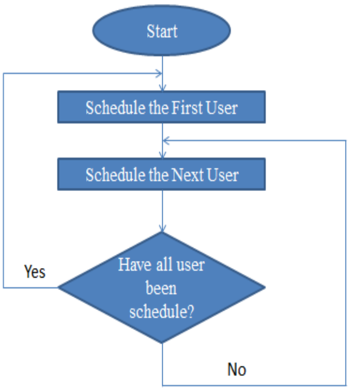

Figure.2.Round Robin scheduling algorithm

Simulation Result:

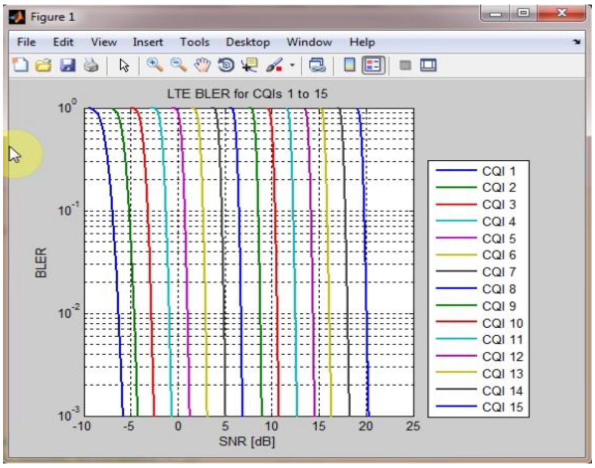

Figure.3.LTE BLER for CQIs

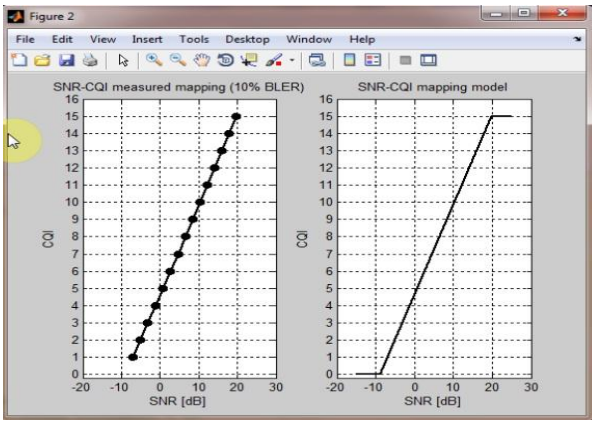

Figure.4.SNR-CQI mapping

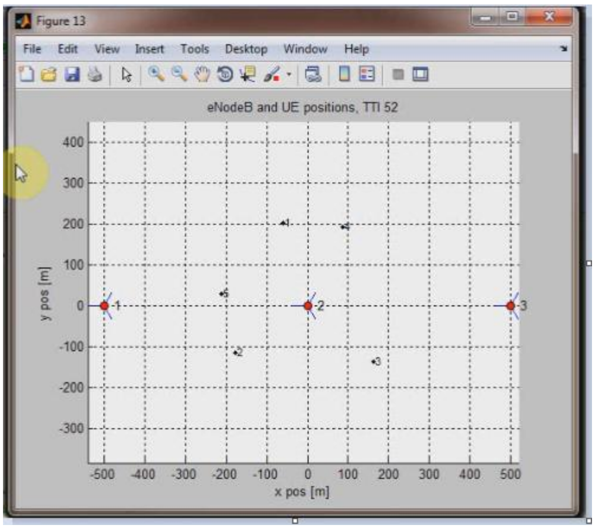

Figure.5.eNodeB and UE positions in different TTI.

VI.CONCLUSION AND FUTURE WORK

From this scheduling algorithm, BLER for different CQIs, their mapping and eNodeB and UE positions in different TTIare also been observed. Furthermore simulator parameter can be obtained using this scheduling algorithm and throughput can be investigated for different types of scheduler.

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