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A NOVEL MAC SCHEDULING ALGORITHM FOR TCP THROUGHPUT IMPROVEMENT IN LTE SYSTEM

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Abstract— Different Quality of Service (QoS) choices are provided by the LTE standard, allowing the User Equipment (UE) to receive numerous services. In wireless networks, designing a scheduling method for traffic based on Transmission Control Protocol (TCP) is difficult. Several articles have been written to increase TCP traffic throughput. To increase the total LTE cell and UE performance, a unique and realistically practicable scheduling approach is suggested in this study to manage the TCP traffic. When scheduling Downlink (DL) TCP traffic for acknowledgment transmission, an uplink grant is given. This reduces TCP throughput fluctuations, enhancing cell and per UE performance. The Kalman filter technique may be used to calculate the advanced uplink grant amount by taking into account real-time reported parameters in accordance with the LTE standard. Results are produced in real time when the suggested method is put into practice on a tiny cell platform. The data indicates that under certain traffic circumstances, a significant increase in throughput may be attained.

Keywords— MAC Scheduling, TCP transmission, Throughput Improvement, Advanced Grant.

I. INTRODUCTION

For mobile wireless applications, achieving a high data throughput while maintaining a low latency is the primary objective of the LTE technology. LTE is a standard that offers variable bandwidth choices for operations ranging from 1.25 MHz to 20 MHz. These possibilities are determined by taking into consideration various sampling frequencies. Backward compatibility is supported by the standard, which aspires to achieve spectral efficiency of up to 10 bps/Hz with an overall network latency of less than 1 millisecond. This provides cellular operators with more incentive to construct LTE networks so that they can accommodate a wider range of apps.

Orthogonal Frequency Division Multiplexing, or OFDM, is the physical layer technology that is used by the LTE standard. Within this technology, symbols are modulated for each Transmit Time Interval, or TTI, of 1 millisecond. [6][7][8][9]. As a result, the scheduling mechanism in LTE systems is two-dimensional. This indicates that the UEs share resources with one another in terms of both time and frequency. When opposed to transmission methods used by prior generations, the LTE system has a finer granularity for distributing resources to the user equipment that is linked to the system. As a result, the complexity of the scheduler is increased in comparison to older transmission techniques. At the same time, spectral efficiency may be adjusted at each sub-band level depending on the input received from the UE. This feedback is sent back and forth between the UE and the base station.

There are various scheduling methods for OFDM-based transmission that have been explored in the literature. These algorithms take into account factors such as fairness among linked UEs, cell throughput maximization, priority, and other similar factors.[1].

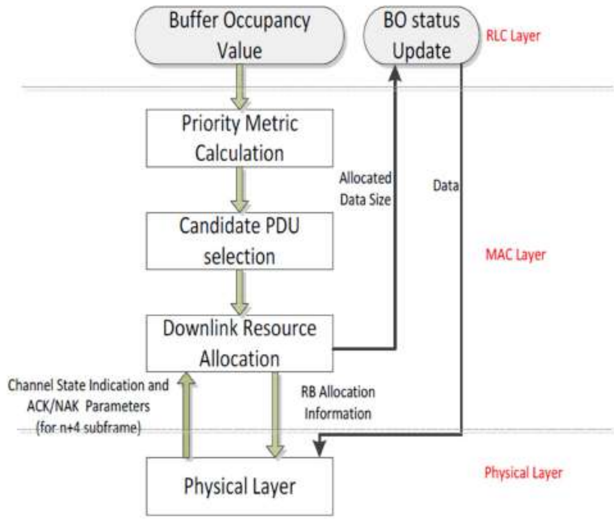

Fig. 1 Downlink

The LTE downlink scheduling and resource allocation function is broken out in further detail in Figure 1. The Medium Access Control (MAC) layer is very important to the processes of resource allocation and time and frequency scheduling. Within each TTI, the Radio Link Control (RLC) layer provides the MAC layer with information on the Buffer Occupancy (BO) value for each bearer. The value of the BO provides information about the quantity of data that will be sent for each bearer. Priority Metric (PM) value is computed for connected UEs at the MAC layer based on characteristics such as the reported Channel Quality Indicator (CQI) value, the average throughput of the UE, the BO value, the type of bearer, the QCI value, and the QoS class, among other things.

The complexity of the implementation determines the number of candidates that are taken into consideration for data transmission in a TTI. The Priority Metric value that was produced is used to determine the order in which resources are allocated.

MAC layer to execute resource allocation and priority computation among linked UEs; also responsible for computing priority. It is informed to the RLC layer once the Transport Block (TB) size has been determined for each UE based on the number of Physical Resource Blocks (PRBs) that have been assigned and the MCS level. The RLC de-queues the data and then transfers it on to the Physical layer based on the TB size that has been allotted to each bearer. Concurrently, the RB allocation information for each bearer will be sent from the MAC layer to the Physical layer.

[3] makes a suggestion for a scheduling system that may be used with TCP transmissions. The purpose of this work is to examine the process of allocating priority to TCP users during scheduler implementation, which may involve sophisticated communication in order to be successful. There is a proposal for a window regulator technique to be used in TCP applications for third generation wireless networks [4]. However, a few adjustments are necessary before it can be used in 4G networks.

II. PROPOSED METHOD

This novel scheduling technique is suggested in this study as a potential solution to the issue that was discussed in the preceding section. According to this approach, the grant for TCP ACK/NACK is delivered at the same

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time that TCP Downlink (DL) data is being transmitted. At the time of scheduling DL TCP traffic for each TTI, a grant is supplied that allows for the transmission of TCP ACK/NACK messages. The time it takes to send TCP ACK/NACK is cut down by 17 TTIs as a result of the suggested solution, as can be seen in Figure 3. The technique that has been suggested provides the grant for sending TCP ACK at the same time as RBs are being allocated for TCP DL transmission.

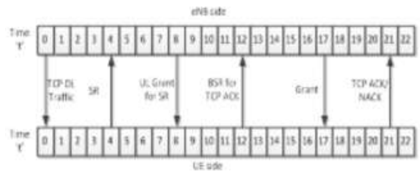

Fig. 2. Conventional TCP transmission mechanism

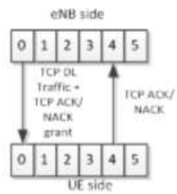

Fig. 3. Proposed TCP transmission mechanism

The Kalman Filter technique that is applied at the MAC layer provides an estimate of the number of RBs that will be used for sending TCP ACK/NACK in the uplink. This technique takes into consideration a number of factors in order to determine the necessary number of RBs for TCP ACK/NACK in the Uplink (UL). These parameters include of things like the User priority setting, QCI information, BO requests from RLC layers, UE channel condition information, and past ACK/NACK transmission statuses among other things. The quantity of TCP packets that are sent in DL and for which an ACK or NACK is anticipated is the primary factor that determines RB allocation. TCP status grant for ith UE at time instant 't' using suggested technique may be mathematically represented as, The purpose of this study is to determine the best RB allocation for broadcasting TCP status, which is shown as a system model in the image below.

III. KALMAN FILTER ALGORITHM

The Kalman filter method has been suggested in the literature for a range of applications, such as interference estimates and channel gain prediction. This study investigates the use of the Kalman filter in order to calculate resource block allocation in the Long-Term Evolution (LTE) scheduler for every Transmission Time Interval (TTI). The parameters of the Kalman filter are adjusted at each Transmission Time Interval (TTI) to optimize the desired data rate and minimize the Bit Error Rate (BER). The Kalman filter algorithm is used to calculate the resource blocks (RBs) for individual users, taking into account the channel conditions and round trip latency, with the objective of achieving the desired Quality of Service (QoS). This work considers the transmission of both uplink and downlink data with reference signals in a multi-user equipment (UE) situation, without any loss of generality. The first step in deriving the Kalman filter equation is to describe the TCP resource allocation issue in a state space formulation.

IV. RESULTS AND DISCUSSIONS

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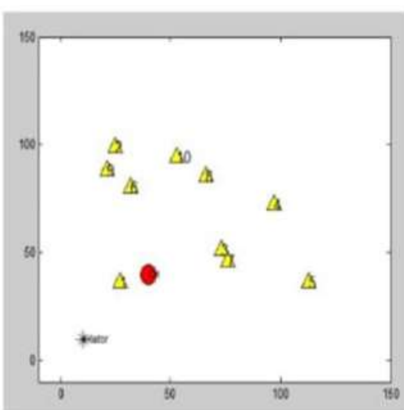
The factors that were taken into consideration for the simulation are shown in Table 1. The algorithm under consideration has been successfully implemented on the Samsung tiny cell platform, and its performance has been thoroughly verified. The User Equipment (UE) is connected in real-time and its monitoring is conducted via the use of the QXDM analyzer. Additionally, TCP data is sent from the traffic server.

Table 1. Simulation Parameters

Standard	LTE, 3GPP R8
Bandwidth	10 MHz
No. of RBs	50
No. of UEs	1
Scheduling algorithm	Proportional Fairness
Channel	Wireless
Transmission mode	FDD
Subcarrier Spacing	15 KHz

Fig.5 provides specific information on the TCP DL throughput that was measured in the small cell LTE platform for a variety of TCP Window size values while taking into account a variety of grant procedures. The received signal reference power (RSRP) that was used for these calculations was -70 dBm. When using the maximum TCP window size, it is possible to reach a peak throughput of 71 Mbps, as can be seen in the following observation. On the other hand, throughput approaches 0 with smaller window sizes. In a real-time situation, the size of the Window is dynamically modified dependent on the status of the TCP ACK. Figure 5 further reveals that the suggested strategy achieves a large boost in throughput, as can be seen by looking at the graph. Because of the latency in the ACK status transfer in the uplink, the throughput increase for the advanced adaptive BSR grant is around 10 Mbps, whereas it is only 5 Mbps for the SR grant.



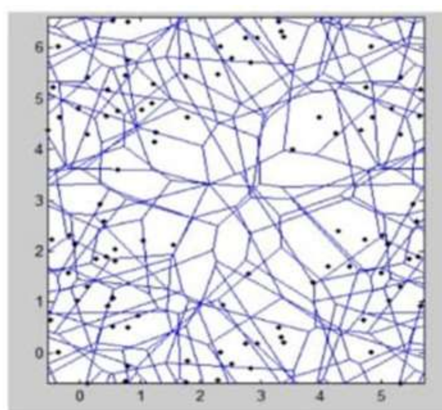


Fig 4 Result 1

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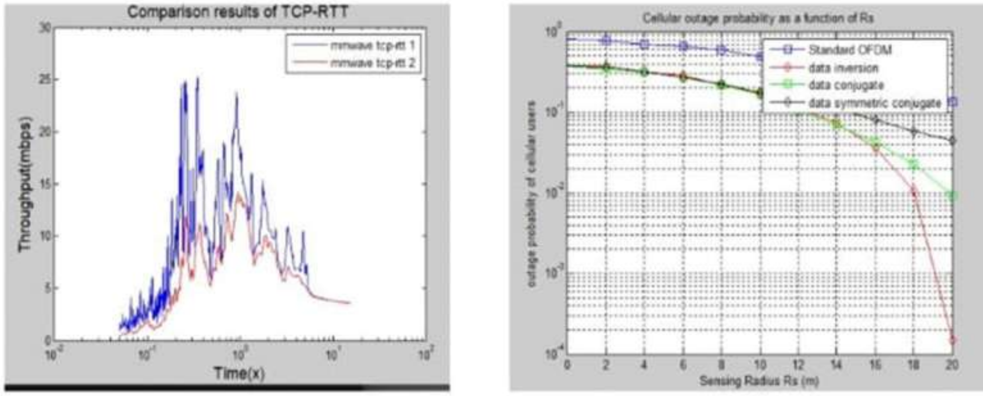

Fig 5 Result 2

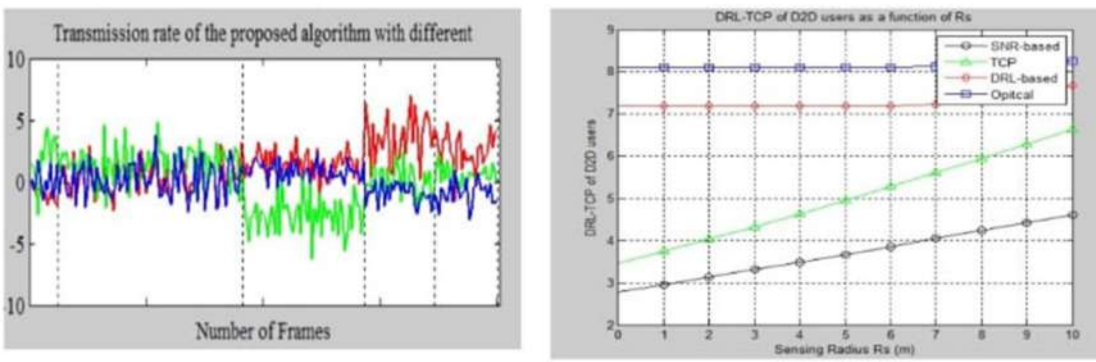

Fig 6 Result 3

The suggested method has been tested and shown to work in conditions with a low RSRP, and the results have yielded comparable benefits, as shown in Figure 6. A comparison was made between the total peak throughput for the BSR grant operating at low and high RSRP levels. It has been noticed that the peak through has a little decrease as a result of the low received power.

V. CONCLUSION

In this research, we present a unique MAC scheduling technique with the goal of increasing the throughput that TCP users in LTE systems experience. This MAC scheduling approach that has been developed has been verified using real time findings. It is clear from the findings that it is feasible to attain peak throughput using the suggested strategy, even when the window size is rather small. When compared to the processing power of LTE eNBs, the extra overhead involved in implementing the suggested solution is much lower. The scope of this study may be expanded by taking into consideration other data traffic models for numerous UEs.

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