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Comparison of Priority-based two-level Schedulers in LTE-Advanced

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Abstract- Scheduler is part of executing throughput in MAC Layer. A good scheduler provides high Quality of Service (QoS) and work towards getting more and more throughput. There are varieties of Scheduler based on different factors such as fairness and maximum feedback etc. Priority Scheduler is based on the need of the service to be catered. We have designed a priority based schedulers on the top of ZF-MUMIMO, MaxThroughput and Optimum throughput schedulers. Our Proposed schedulers are two-level schedulers. In this paper, we present the performance of designed Priority schedulers with different Base schedulers.

Index Terms- ZF-MUMIMO Scheduler, Frame Error Rate (FER), Cell-Specific, UE Specific, Maximum Throughput scheduler, and Optimum Throughput Scheduler.

I. Introduction

As the technology advances we come across several new inventions as per the need of Human being. There is also a competition to discover the way to satisfy the quench of throughput by various Scientists and Researchers. We require the throughput at the required level as desired by us but if we badly need some of our application to have executed in short span of time, we may fail some time. Depending on the need we want our work to be done. So we have developed the priority scheduler so that our need get catered according to the priority. The rest of the paper is organized in to four sections. The parameter for the setup of testing the scenario is explained in section II. In section III, we have presented the proposed Scheduler Models. The performance of priority schedulers with different Base schedulers is discussed in section IV. The section V presents conclusions.

II. Parameters for Scenario Conducted

In order to carry out the simulation and get results we need to setup certain parameters in Simulation tool. These parameters are set according to the compatibility of LTE Advanced technology. The Parameters are mentioned as below

Channel Model	Binary Symmetric Channel
NSNR (Normalized Signal-to-Noise Ratio)	100
Number of transmitting Antennas (nTX)	4
User count (nUE)	5
Simulation Type	LTE-A-MUMIMO
Carrier frequency	2.1e+09
No of Base stations (nBS)	1
Bandwidth	1.4e+6
Subcarrier Spacing	15000
Cyclic Prefix	normal
Simulation type	Parallel
Pathloss Model	Activated
Sampling Time	5.2083e-07
OFDMN Symbol	140
Number of Sub frames	1000
Scheduled TTIs	132
HARQ process count	8
Maximum HARQ retransmission	0
Base scheduler	• Priority based on ZF MUMIMO • Priority based on Maximum Throughput • Priority based on Optimum Throughput
Filtering	’Block Fading’
Channel model Type	’flat Rayleigh’
Time Correlation	’independent’
Interpolation Method	’shift to nearest neighbor’
Propagation Condition	’NLOS’
Sample Density	2
Uniform Time Sampling	Applied
Traffic model	Data packet traffic + FTP traffic + Full Buffer traffic + Gaming traffic+ HTTP traffic + Video traffic + VoIP traffic

III. Priority Scheduler Model

The priority scheduler is a two-level Scheduler. The base scheduler is ZF-MUMIMO on which priority factor governs. QoS depends on:

- Response Time Expected by Users
- Delay
- Data Rate
- Required Bandwidth
- Loss Rate
- Error Rate

Since we are developing the scheduler for 4G, LTE-Advanced, we are supplied with data rate, bandwidth etc. We have proposed a scheduling model which will cater the application need depending upon priority factor. This Priority factor depends upon following

Response Time Expected by Users: The users.' expected response time is the time elapsed between sending a request and the reception of the first response by the user. Higher the response time expected by the users, lower the Priority factor.

Delay: The network transmits delay is the time elapsed between the emission of the first bit of a data block by the transmitting end-system, and its reception by the receiving end-system. More the delay, there is a corresponding increase in Priority factor.

Jitter: In transmission technology, jitter refers to the variation of delay generated by the transmission equipment. This parameter doesn't come into picture because this is user specific.

Buffer length: Larger Buffer length results in lesser data overflow and increase in the throughput. As buffer length increases the Priority factor increases. This is because the traffics which are non real time have a high buffer length and those who are Real time traffic are having very less buffer length.

Priority factor=PF
Response Time Expected by Users=X
Delay=D, Buffer length=B

PF=B/(X×D);
Response Time Expected by Users (X) for various traffic models is as below:
Full Buffer Model=20 msec
VoIP traffic model=50 msec
HTTP traffic model=400 msec
Data packet traffic model=150 msec
Video traffic model=200 msec
Gaming traffic model=250 mSec
FTP traffic model=5 Sec.

The need and the necessity of a person to get the data at required time is noticed and well addressed in Priority Scheduler. We have seen the normal priority scheduler also but it has a great disadvantage, it will not consider the delay and remaining Buffer size. In our Priority Scheduling we are using delay, Buffer Length as a factor to calculate the Priority factor for the traffic. The delay consists of Tap delay, HARQ delay and Uplink delay altogether.

Delay =Tap delays +HARQ delay + uplink delay;
Tap delay=Interpolator delay;

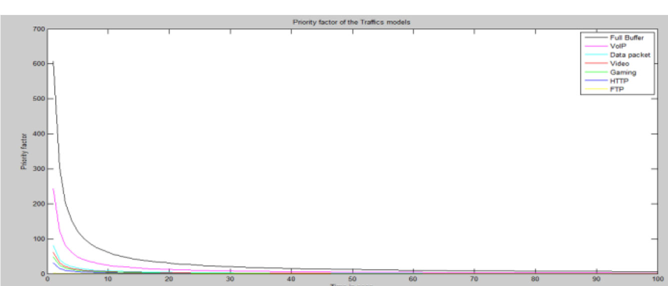

Fig.1 Dimensionless priority factor based on buffer length and delay

The maximum Priority factor generated from whichever traffic will be selected for the scheduler under ZF-MUMIMO which is base scheduler. This is how we are able to send only those traffics which have highest priority at a particular instant among all the traffics needed to be sending across.

The maximum Priority factor generated from whichever traffic will be selected for the scheduler under MaxThroughput scheduler who is base scheduler. This is how we are able to send only those traffics which have highest priority at a particular instant among all the traffics needed to be sending across.

The maximum Priority factor generated from whichever traffic will be selected for the scheduler under OptimumThroughput scheduler who is base scheduler. This is how we are able to send only those traffics which have highest priority at a particular instant among all the traffics needed to be sending across.

ZF-MUMIMO Scheduler: In ZF-MUMIMO scheduler given a set of users, the scheduler selects more than one user and transmits independent data to them simultaneously by using zero-forcing beam forming [1].

MaxThroughput Scheduler: It is used for best effort packet switched network like wireless to maximize the total throughput of the network. This is done by giving scheduling priority to the least "expensive" data flows in terms of consumed network resources per transferred amount of information.

OptimumThroughput Scheduler: Future wireless networks are likely to provide each user access to multiple channels. The dynamic scheduling problem at any given time in such networks is to determine (i) the set of users that can transmit/receive, and (ii) the set of channels that a user can use. Our goal is to optimally determine the above so as to maximize the system throughput using on-line adaptive policies. The availability of multiple channels gives rise to several unique challenges in attaining the above goal. Channel characteristics at any given time will typically be different for different channels, and these characteristics will also vary with time. In a system with a large number of users and channels, an individual user could use only a small number of channels at any time. Therefore, measuring the channel quality perceived by each user for each channel would require additional probe packets, which introduces a significant measurement overhead.

Thus unlike single-channel networks, scheduling in multichannel networks must be done under inaccurate channel state information, resulting from infrequent channel measurements. Moreover, in a multichannel wireless system, the scheduling questions depend strongly on the transmission mechanisms. Specifically, the scheduling constraints differ significantly based on whether simple (pure) or orthogonal frequency division multiplexing (FDM) is used, and the manner in which power is allocated across channels [2].

IV. PERFORMANCE OF PRIORITY SCHEDULER

We will analyze the performance of Priority Scheduler with the normal ZF-MUMIMO scheduler. We want this performance because in Priority scheduler the root scheduler is ZF-MUMIMO. Hence we are comparing them. There are two divisions for comparison of each of the parameters i.e. Cell Specific and UE specific. Cell specific is more important than

UE Specific. Under UE Specific we are evaluating the first UE parameter out of 5 UEs.

- Throughput Measurement

In communication networks, such as VoIP, Ethernet or packet radio, throughput is the average rate of successful message delivery over a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node. The system throughput is the sum of the data rates that are delivered to all terminals in a network.

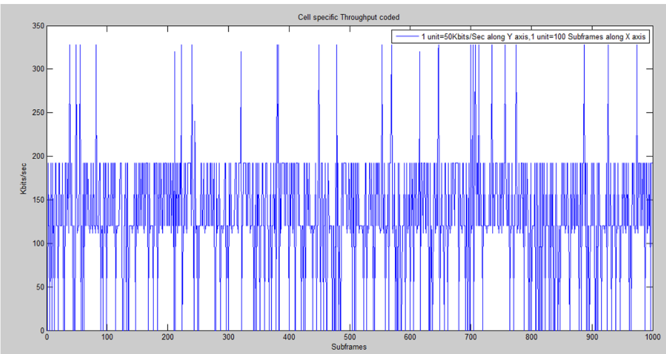

Fig.2 Cell specific throughput coded in priority scheduler based on ZF-MUMIMO

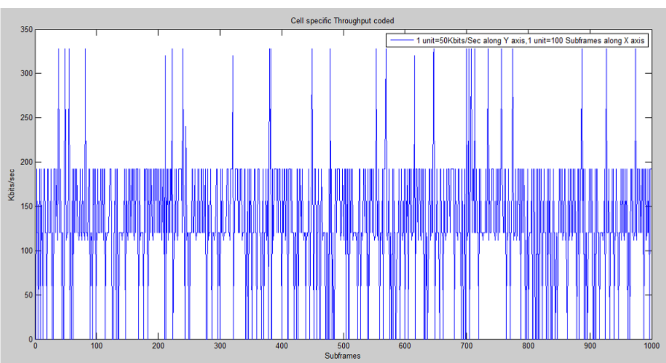

Fig.3 Cell specific throughput coded in priority scheduler based on Max Throughput

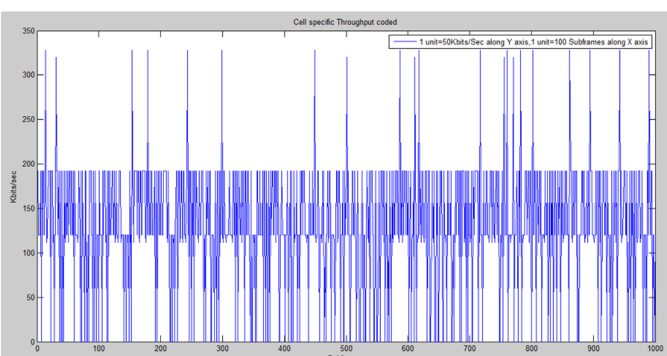

Fig.4 Cell specific throughput coded in priority scheduler based on Optimum Throughput

The Cell specific throughput coded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput and Optimum throughput is almost same in each of the cases.

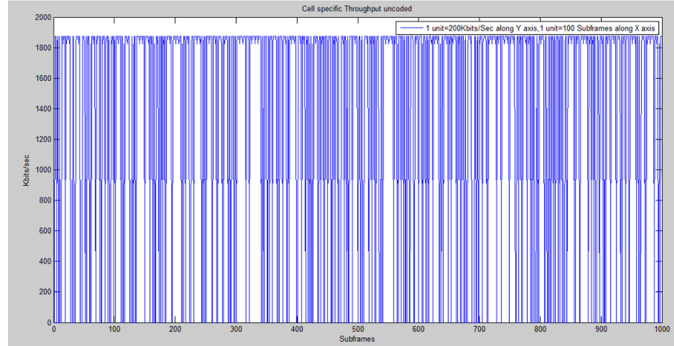

Fig.5 Cell specific throughput uncoded in priority scheduler based on ZF-MUMIMO

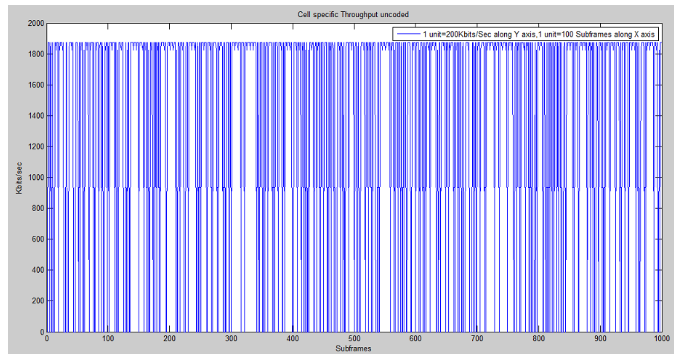

Fig.6 Cell specific throughput uncoded in priority scheduler based on Max Throughput

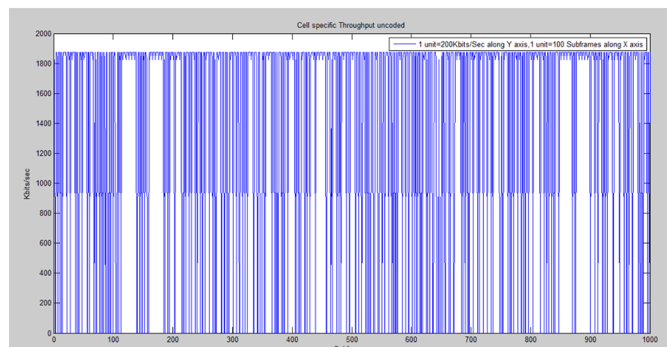

Fig.7 Cell specific throughput uncoded in priority scheduler based on OptimumThroughput

The Cell specific throughput uncoded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput and Optimum throughput is almost same in each of the cases.

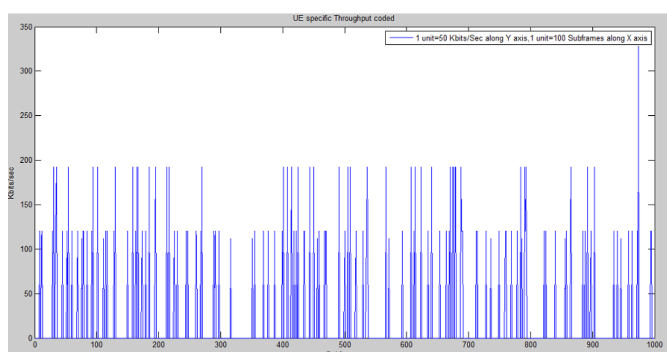

Fig.8 UE specific throughput coded in priority scheduler based on ZF-MUMIMO

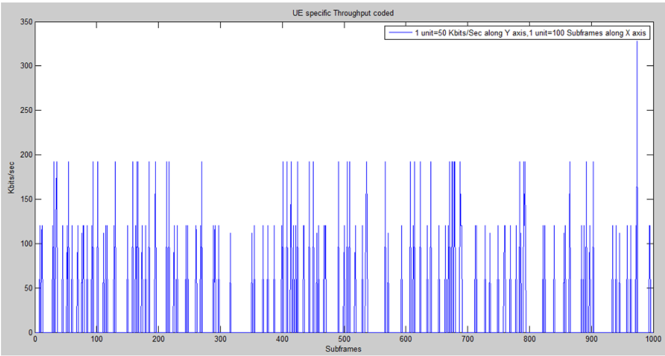

Fig.9 UE specific throughput coded in priority scheduler based on Max Throughput

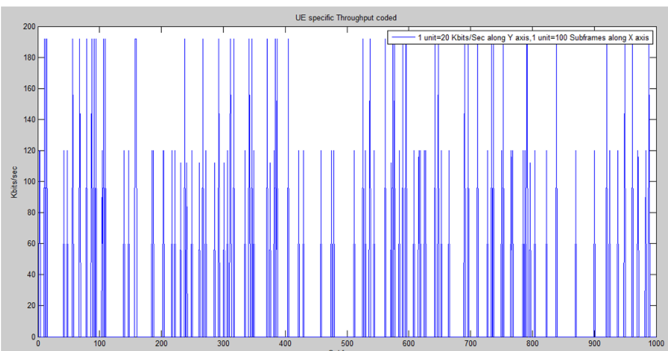

Fig.10 UE specific throughput coded in priority scheduler based on OptimumThroughput

The UE specific throughput coded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput and Optimum throughput is almost same in each of the cases.

- Frame Error Rate Measurement

Frame error rate (FER) has almost the same meaning as BER (Bit error rate), but the error rate calculation is between frame and not bit. In other words, let say, we transmit 100 frames and out of them only 3 frames having errors so the FER is 3/100. While BER has its theoretical importance, we can in no way measure this value in real world (if we know the transmit bits at the receiver, we in fact do not need to transmit at all). When designing a code, the exact BER criteria might not be tractable. Therefore, PER (Packet error rate) is used instead. In real system, we do not have access to BER or PER, but only FER through CRC.

Frame Error Rate (FER) measurement is used to test the performance of a mobile station's receiver. During an FER measurement, the test set sends a sequence of frames to the mobile station. Each frame contains CRC (Cyclic Redundancy Code) bits, which provide frame quality indicator and allow the mobile station to verify that it has correctly decoded a frame. The mobile station is put into a loopback service option and makes its best attempt to decode each received frame sent from the test set. Once the mobile station determines the Category Type that specifies whether the frame received is a good frame, bad frame, frame erasure, or a frame blanked by signaling, the mobile station encodes and re-transmits the frame, with the first two bits replaced with the Category Type information, back to the test set. The test set compares each received frame to the corresponding frame that was sent and validates the Category Type information, then determines the measurement results. The test set keeps a running count of the measured frames and the number of frames that contain bit errors. Confidence level testing is a feature of FER measurements that applies statistical analysis to FER measurements so that pass/fail test results can be obtained in the shortest possible time.

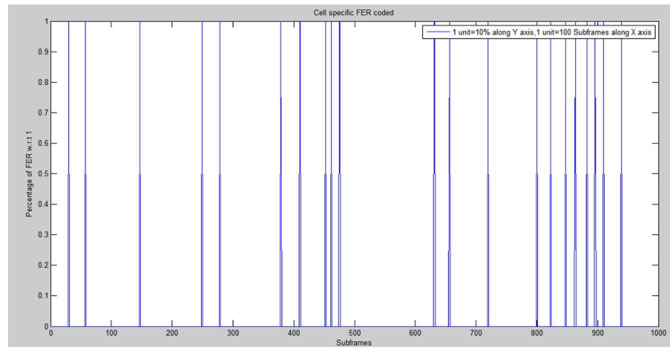

Fig.11 Cell specific FER coded in priority scheduler based on ZF-MUMIMO

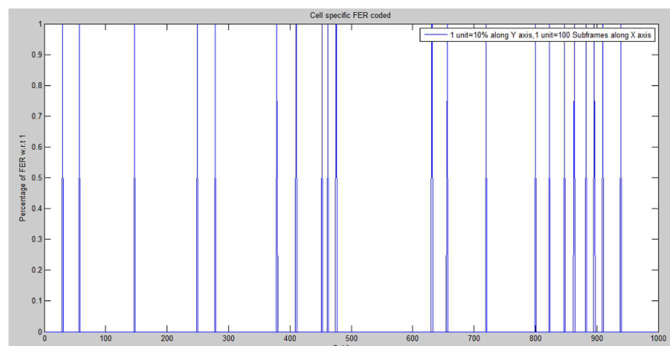

Fig.12 Cell specific FER coded in priority scheduler based on Max Throughput

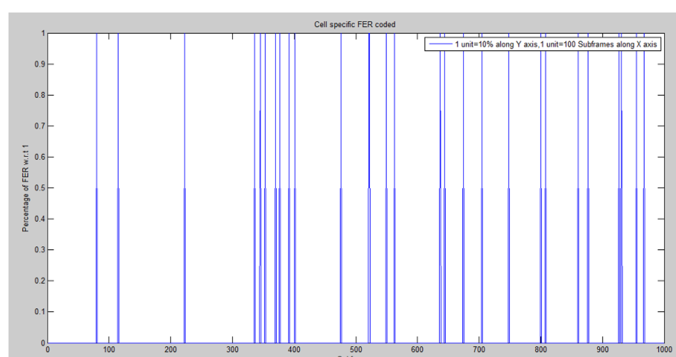

Fig.13 Cell specific FER coded in priority scheduler based on Optimum Throughput

The Cell specific FER coded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput is less and the priority scheduler who has base scheduler as Optimum throughput is more.

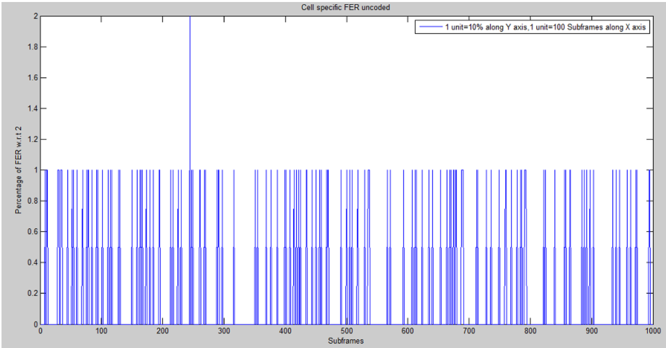

Fig.14 Cell specific FER uncoded in priority scheduler based on ZF-MUMIMO

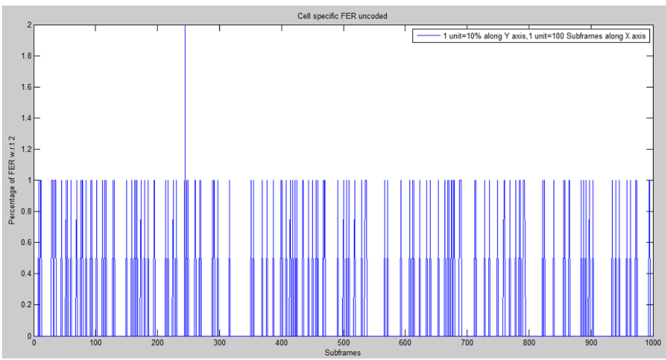

Fig.15 Cell specific FER uncoded in priority scheduler based on Max Throughput

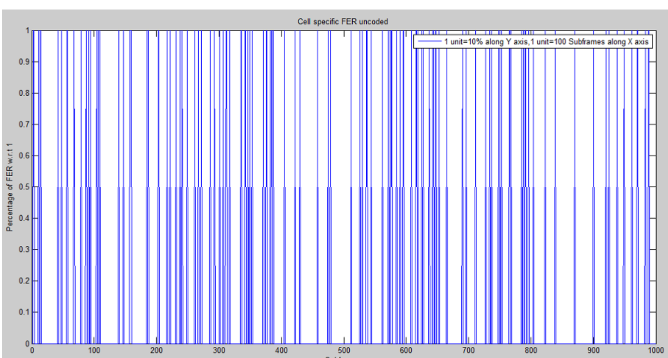

Fig.16 Cell specific FER uncoded in priority scheduler based on Optimum Throughput

The Cell specific FER uncoded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput is almost half of the FER uncoded when compared with the priority scheduler which has base scheduler as Optimum throughput.

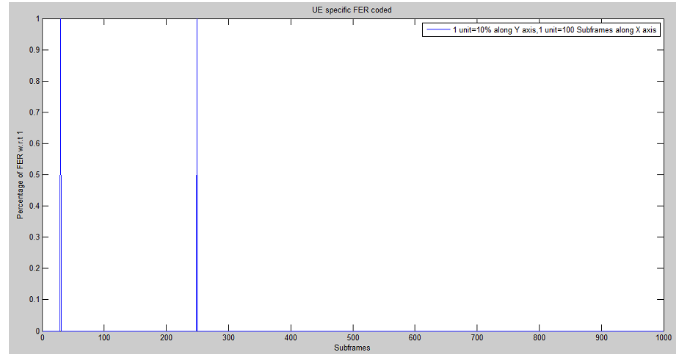

Fig.17 UE specific FER coded in priority scheduler based on ZF-MUMIMO

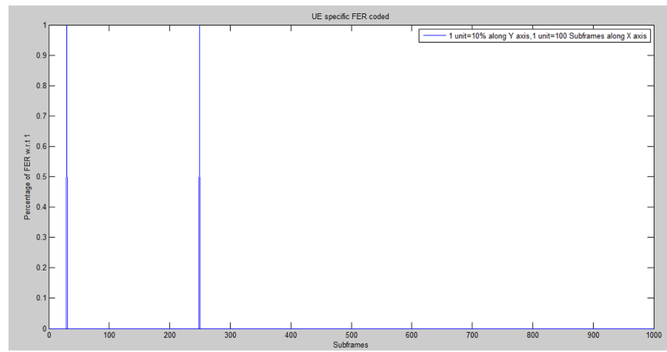

Fig.18 UE specific FER coded in priority scheduler based on Max Throughput

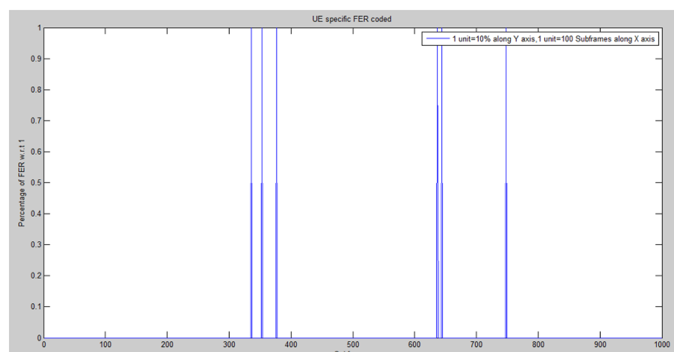

Fig.19 UE specific FER coded in priority scheduler based on Optimum Throughput

The UE specific FER coded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput is very less and the priority scheduler who has base scheduler as Optimum throughput is more.

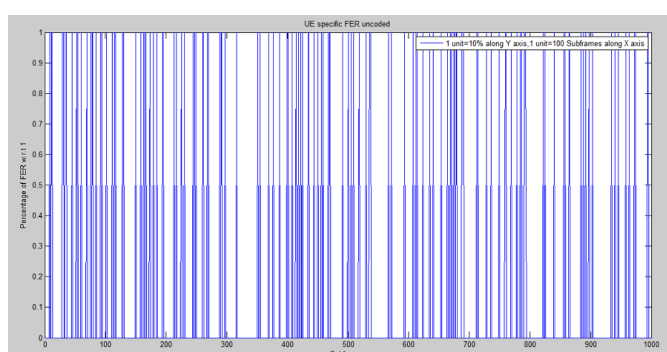

Fig.20 UE specific FER uncoded in priority scheduler based on ZF-MUMIMO

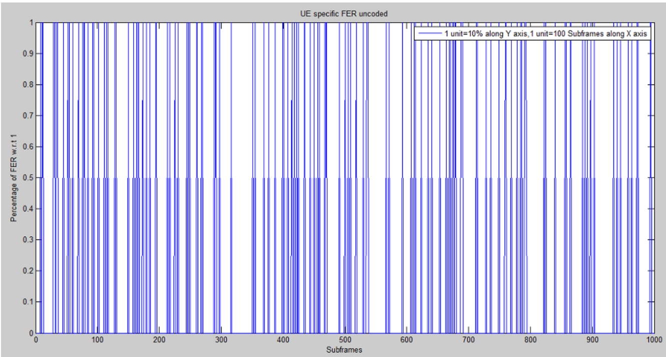

Fig.21 UE specific FER uncoded in priority scheduler based on Max Throughput

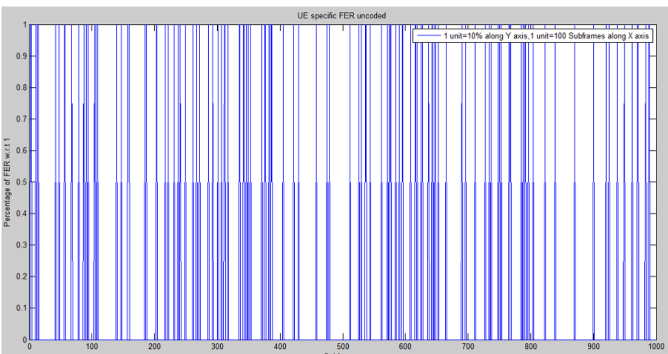

Fig.22 UE specific FER uncoded in priority scheduler based on Optimum Throughput

The UE specific FER uncoded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput and Optimum throughput respectively is almost same.

- Bit Errors Measurement

The main reasons for the degradation of a data channel and the corresponding bit error rate, BER is noise and changes to the propagation path (where radio signal paths are used). Both effects have a random element to them, the noise following a Gaussian probability function while the propagation model follows a Rayleigh model. This means that analysis of the channel characteristics are normally undertaken using statistical analysis technique.

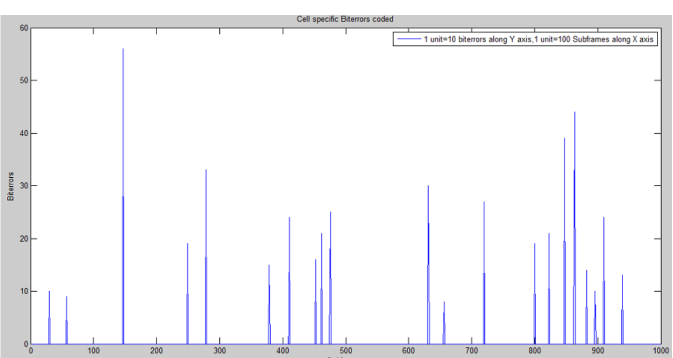

Fig.23 Cell specific bit errors coded in priority scheduler based on ZF-MUMIMO

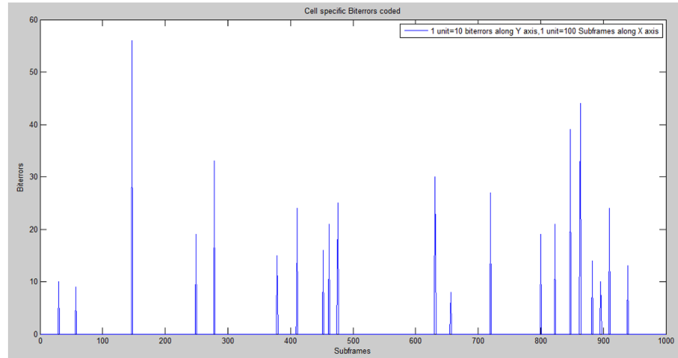

Fig.24 Cell specific bit errors coded in priority scheduler based on Max Throughput

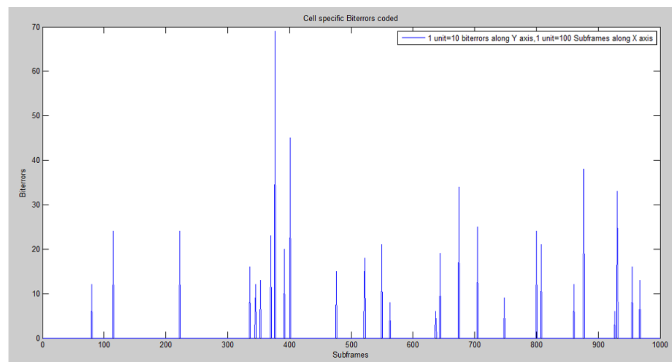

Fig.25 Cell specific bit errors coded in priority scheduler based on Optimum Throughput

The Cell specific bit errors coded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput is less and the priority scheduler who has base scheduler as Optimum throughput is more.

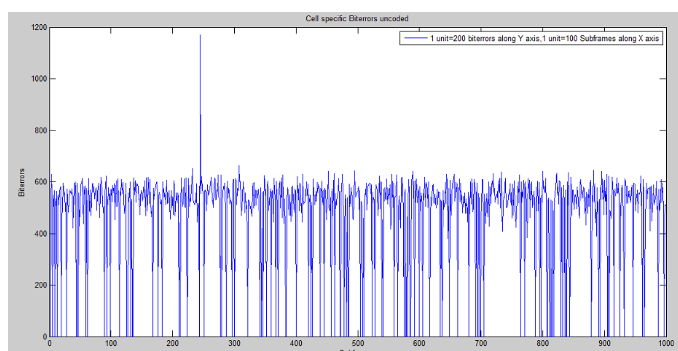

Fig.26 Cell specific bit errors uncoded in priority scheduler based on ZF-MUMIMO

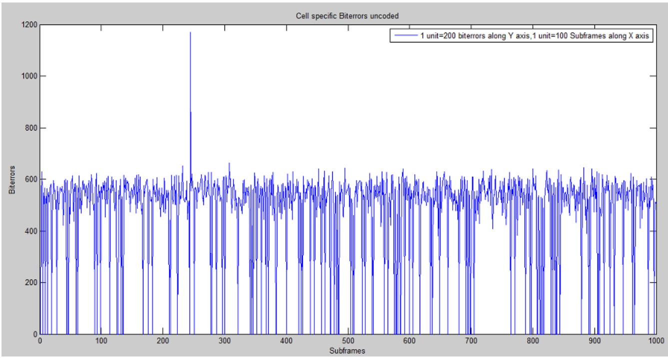

Fig.27 Cell specific bit errors uncoded in priority scheduler based on Max Throughput

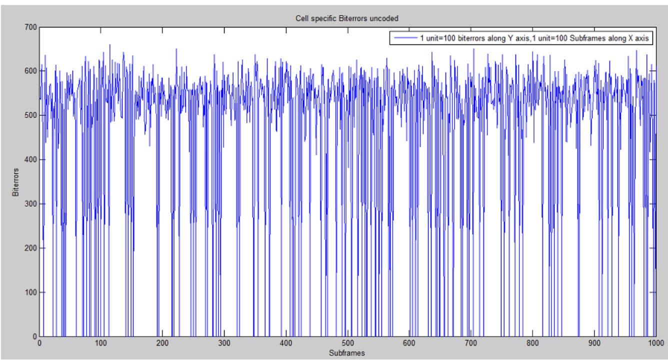

Fig.28 Cell specific bit errors uncoded in priority scheduler based on Optimum Throughput

The Cell specific bit errors uncoded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput and Optimum throughput respectively is almost same. Bits errors are reduced considerable when compared coded and uncoded strategies.

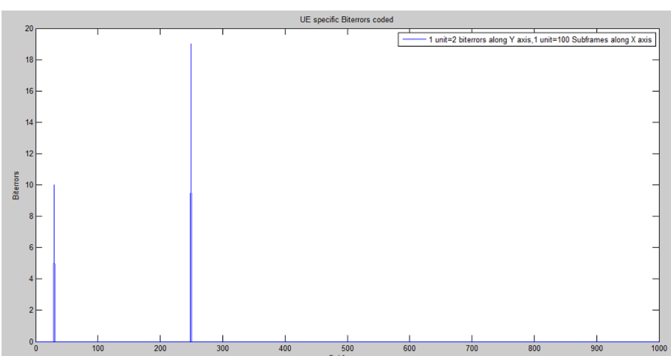

Fig.29 UE specific bit errors coded in priority scheduler based on ZF-MUMIMO

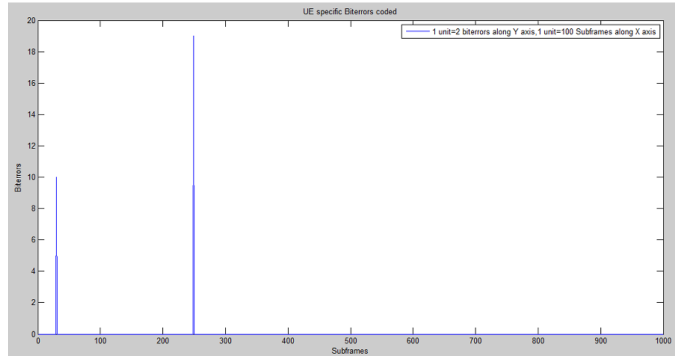

Fig.30 UE specific bit errors coded in priority scheduler based on Max Throughput

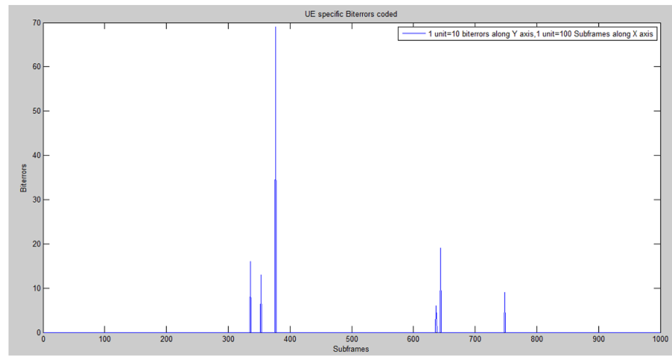

Fig.31 UE specific bit errors coded in priority scheduler based on Optimum Throughput

The UE specific bit errors coded in priority schedulers who have base scheduler as ZF-MUMIMO, Maximum throughput is less and the priority scheduler who has base scheduler as Optimum throughput is more.

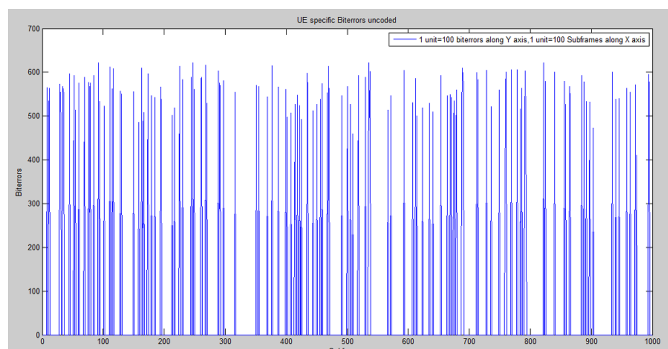

Fig.32 UE specific bit errors uncoded in priority scheduler based on ZF-MUMIMO

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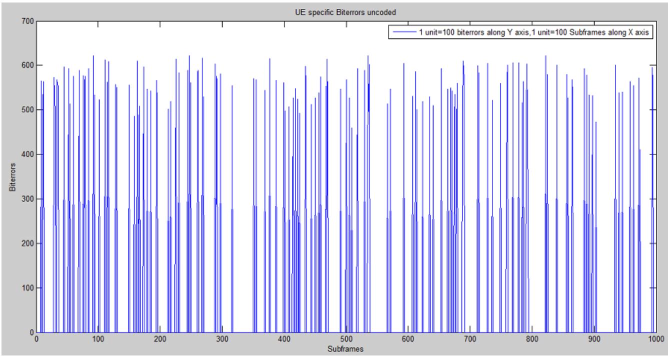

Fig.33 UE specific bit errors uncoded in priority scheduler based on Max Throughput

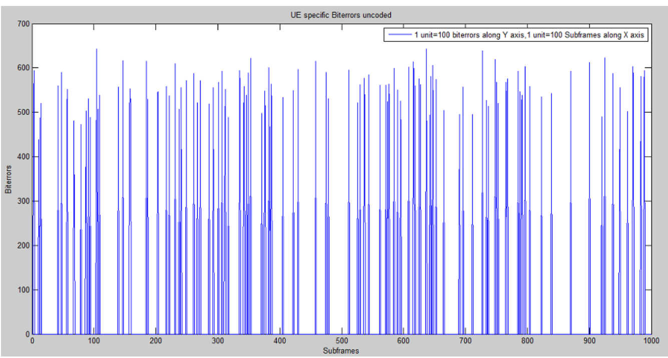

Fig.34 UE specific bit errors uncoded in priority scheduler based on Optimum Throughput

The UE specific bit errors uncoded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput and Optimum throughput respectively is almost same. There is great improvement in the channel quality when it's coded.

- Block Size Measurement

Resource Block size: A frame is 10ms in length. Each frame is divided (in the time domain) into 10 sub frames. A sub frame is 1ms in length. Each sub frame is divided (in the time domain) into 2 slots. A slot is 0.5ms in length. Each slot is divided (in the frequency domain) into a number of resource blocks. The number of resource blocks in a slot depends on the channel bandwidth. A resource block is 0.5ms in length and contains 12 subcarriers from each OFDM symbol. The number of OFDM symbols in a resource block depends on the cyclic prefix being used. The resource block is the main unit used to schedule transmissions over the air interface [3].

Transport Block size: Transmission Bandwidth is the number of active Resource Blocks in a transmission. As the bandwidth increases, the number of Resource Blocks increases. The Transmission Bandwidth Configuration is the maximum number of Resource Blocks for the particular Channel Bandwidth. The maximum occupied bandwidth is the number of Resource Blocks multiplied by 180 kHz [6]. The Transport Block Sizes are calculated based on the MCS (modulation and coding scheme), the number of allocated PRBs(Physical resource Blocks) and the number of available REs(Resource Elements) So the transport block size does not increase linearly with the increase of the index itself. We might have the same number of allocated PRBs but the number of available REs will be smaller because of OFDMA symbols carrying PDCCH or the same number of REs in a PRB but different MCS for the allocation.

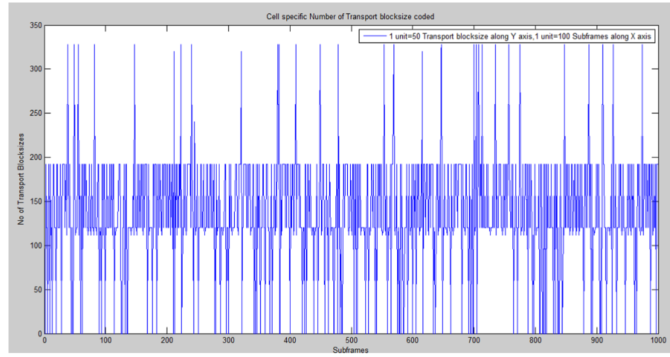

Fig.35 Cell specific block size coded in priority scheduler based on ZF-MUMIMO

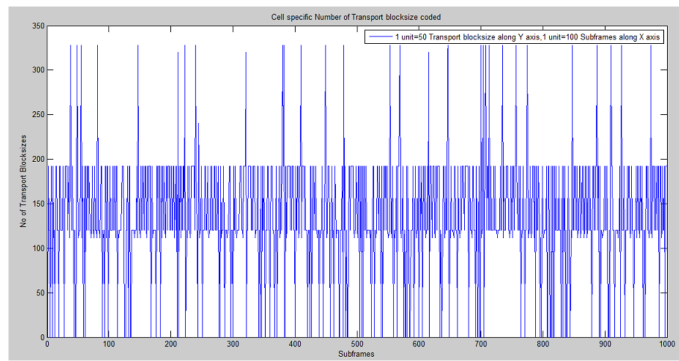

Fig.36 Cell specific block size coded in priority scheduler based on Max Throughput

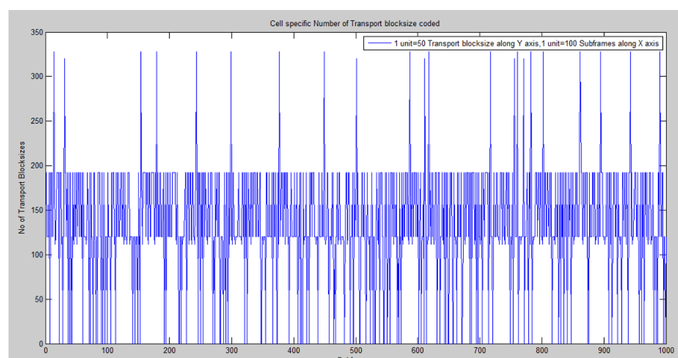

Fig.37 Cell specific block size coded in priority scheduler based on Optimum Throughput

The Cell specific block size coded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput is having more spikes of large size and priority schedulers who have base scheduler as Optimum throughput have less spikes of large size. Rest all of the features for block size is same for all the compared schedulers.

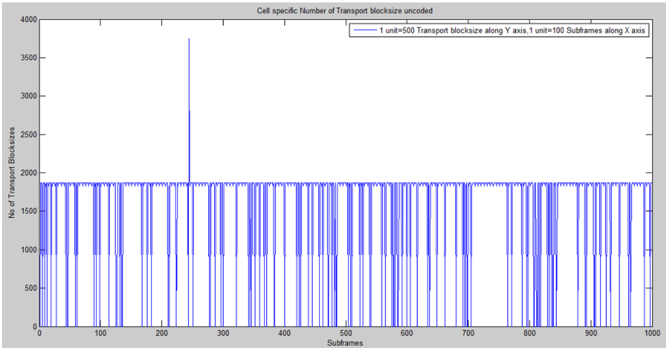

Fig.38 Cell specific block size uncoded in priority scheduler based on ZF-MUMIMO

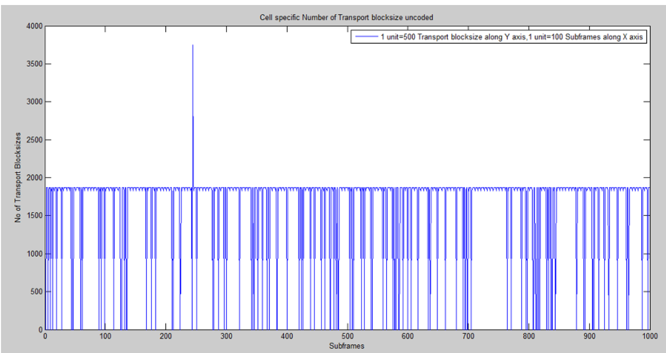

Fig.39 Cell specific block size uncoded in priority scheduler based on Max Throughput

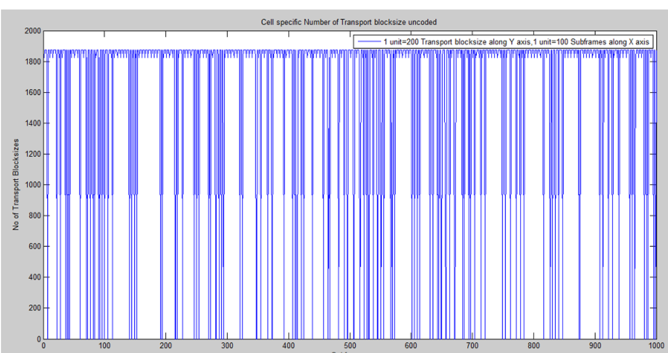

Fig.40 Cell specific block size uncoded in priority scheduler based on Optimum Throughput

The Cell specific block size uncoded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput and Optimum throughput respectively is almost same. However in all the cases Block size Coded is having better performance than that of Block size uncoded.

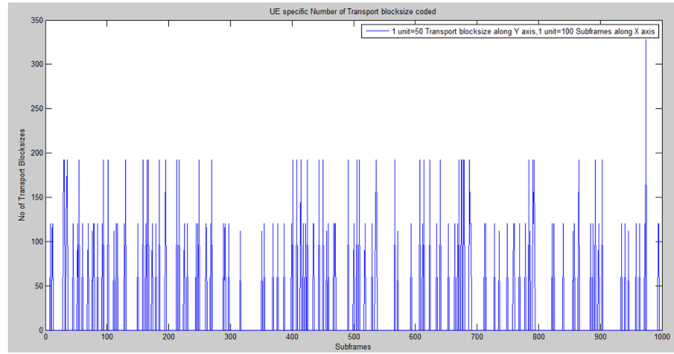

Fig.41 UE specific block size coded in priority scheduler based on ZF-MUMIMO

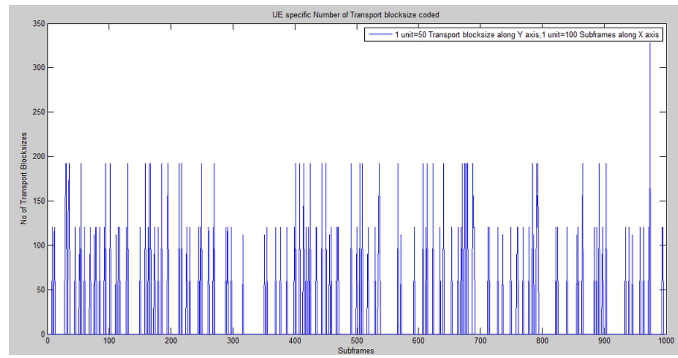

Fig.42 UE specific block size coded in priority scheduler based on Max Throughput

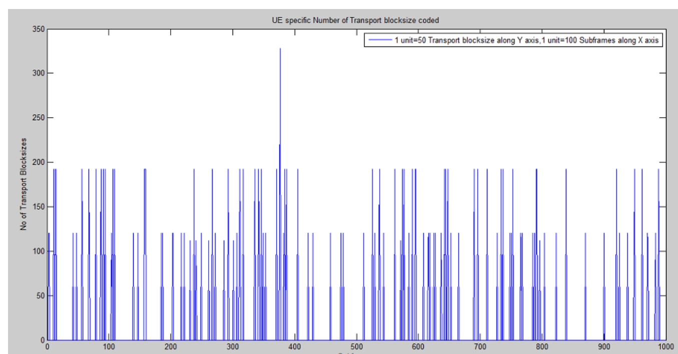

Fig.43 UE specific block size coded in priority scheduler based on Optimum Throughput

The UE specific block size coded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput and Optimum throughput respectively is almost same.

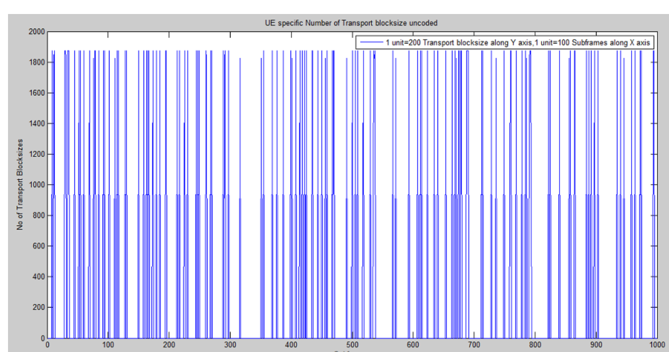

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Fig.44 UE specific block size uncoded in priority scheduler based on ZF-MUMIMO

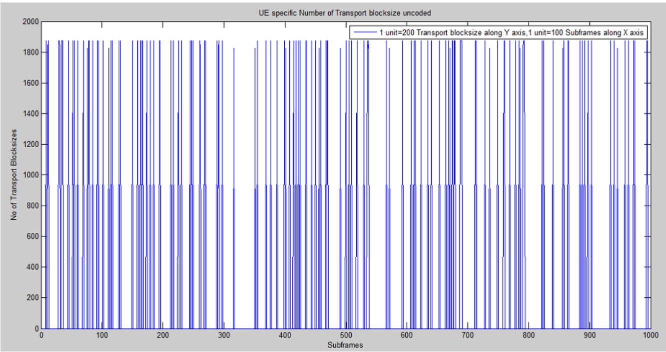

Fig.45 UE specific block size uncoded in priority scheduler based on Max Throughput

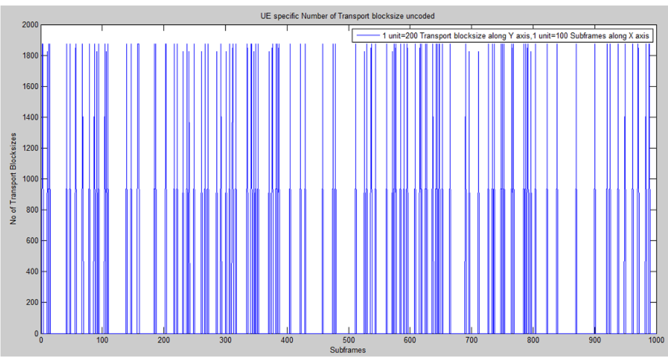

Fig.46 UE specific block size uncoded in priority scheduler based on Optimum Throughput

The UE specific block size uncoded in priority schedulers having base scheduler as ZF-MUMIMO, Maximum throughput and Optimum throughput respectively is almost same.

V. CONCLUSION

There are many schedulers, each having its own specific and unique characteristics. Each of the scheduler has certain advantages and disadvantages. Some of schedulers are specific to applications. We have presented results for priority scheduler having base schedulers as ZF-MUMIMO, Maximum throughput and Optimum throughput scheduler. We have used the cell specific criteria and also the user specific to measure the performance of our proposed Priority Schedulers based on ZF-MUMIMO, Maximum throughput and Optimum throughput scheduler. In all the cases, we used the coded and uncoded parameters like throughput, block size, FER and bit errors to evaluate the performance of the schedulers. The Priority scheduler with base scheduler as ZF-MUMIMO is having the advantage of zero forcing while beam forming and also high Throughput. The Priority scheduler with Maximum throughput has the advantage of high throughput same as earlier mentioned but can't be used for Zero forcing while beam forming. The priority scheduler based on Optimum throughput scheduler is having less number of spikes in Transport block sizes which are advantageous when compared with the other two schedulers. The Priority scheduler having ZF-MUMIMO scheduler at its base is the best in term of reducing the backhaul load and increased throughput which we have come across in the discussion in the paper.

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