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Wimax: Combining Adaptive and Modulation Coding& Hybrid Automatic Repeat Request to Improve Performance and Capacity

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ABSTRACT-
The aim of this paper is to tune the WIMAX network such that to improve application throughput and delay as well as network capacity. The paper presents the simulation results to be obtained on a static QPSK½ Modulation and Coding Scheme (MCS) is adopted. The study is focused at evaluating the improvements introduced by the adoption of AMC(Adaptive and Modulation Coding) and AMC combined with Hybrid Automatic Repeat request (HARQ). Results enable it to indicate that the best strategy is to use an aggressive AMC table with HARQ. WIMAX (IEEE 802.16)is a promising technology for providing connectivity by low cost of distribution of work, radio link due to its large coverage area, and high speed data rates. However, the maximum number of channels defined in the system may slow and limit the overall system capacity. So to use the best strategy it being stated out.

Keywords: Bs: Base Station **Ss:** Subscriber Station **Fec:** Forward Error Correction **Amc:** Adaptive and Modulation Coding **Harq:** Hybrid Automatic Repeat Request **Ber:** Block Error Rate

I. INTRODUCTION

WIMAX**(IEEE 802.16)** is an alternative wireless LAN for providing last-mile connectivity by radio link due to its large coverage area , high speed data rates and low cost of deployment. The standard specifies the air-interface between a Base Station (BS) and a Subscriber Station (SS) .For improved multipath performance in non line of sight (NLOS) environments; the mobile WIMAX air interface adopts Scalable Orthogonal Frequency Division Multiple Access (SOFDMA).

AMC is an effective mechanism to maximize throughput in a time varying channel. It supports forward error correction (FEC) coding schemes anda number of modulation and allows the scheme to be changed on a per user, per frame basis, based on conditions of a channel. The adaptation algorithm typically calls for the use of the highest modulation and coding scheme that can be supported by the signal-to-noise and interference ratio at the receiver such that each user is provided with the highest possible data rate that can be supported on their respective links. Data transmitted through the air are more likely to be corrupted reason of this interrupt is background noises, channel interferences and many others .Hybrid Automatic Repeat request (HARQ) provides a reliable way to ensure that packets are received successfully are in sequence. HARQ must play a key role to reduce system bit error rate (BER)in system design. By combining flexible channelization with AMC, it enables mobile WiMAX technology to improve both system capacity and coverage.
Some studies examining on the performance of WiMAX Networks using AMC and HARQ.

(i) Its evaluated the performance of asymmetric (TDD) Time Division Duplex system that employs AMC and HARQ, with consideration of the effect of control delays in TDD.

(ii) It states an enhanced HARQ that determine the number of multiple copies needed based on the channel feedback.

(iii)More on Dynamic HARQ (DHARQ) for WiMAX, a power control scheme for WiMAX multi-hop relay system.

(iv)More studies need to be conducted to ascertain the effects of AMC and HARQ in optimizing network capacity and application delays.

This paper is organized as : second Section explains an overview of the AMC and the HARQ. 3rd section provides the design of system models, results are presented in 4th section. Final Section concludes the paper. The purpose of this study was to design a WiMAX system configuration to optimize both network capacity and application delays since the capacity and the application delays usually have a trade-off. We used AMC and HARQ to tune the WiMAX network such that its adaptations improve both performance capacity and delay. First , we examined the performance of the WiMAX network with respect to capacity usage and application delays using static Quadrature Phase Shift Keying (QPSK) ½ Modulation and Coding Scheme (MCS). In second, we used AMC to compare performance with that of QPSK ½ setting. Then, we used an aggressive AMC table to study its impact on capacity usage and application delays. Finally, we used AMC table in conjunction with HARQ.

II.BACKGROUND

WiMAX systems use AMC in order to take advantage of fluctuations in the channel. The basic idea is quite simple: Transmit as high a data rate as possible when the channel is good, and transmit at a lower rate when the channel is poor, in order to avoid excessive dropped packets. Lower data rates are achieved by using a small constellation, such as QPSK, and low-rate error-correcting codes, such as rate convolutional or turbo codes. The higher data rates are achieved with large constellations, such as 64 QAM, and less robust error correcting codes; for example, rate turbo, convolutional or low-density parity check (LDPC) codes. In all, 52 configurations of modulation order and coding types are possible, although most implementations of WiMAX offer only a fraction.

Block Diagram Of AMC: For simplicity, we 1st consider a single-user system attempting to transmit as quickly as possible through a channel with a variable signal-to-interference-plus-noise ratio (SINR), for eg. due to fading. Main objective of the transmitter is to transmit data from its queue as rapid as possible, which subject data being decoded reliably on receiver side and demodulated. The feedback is critical for AMC: Transmitter needs to know the “channel SINR” γ, which is defined as the received SINR γ_r divided by the transmit power P_t, which itself is usually a function of γ. The received SINR is thus $\boldsymbol{\gamma_r = P_t\gamma}$ **.**

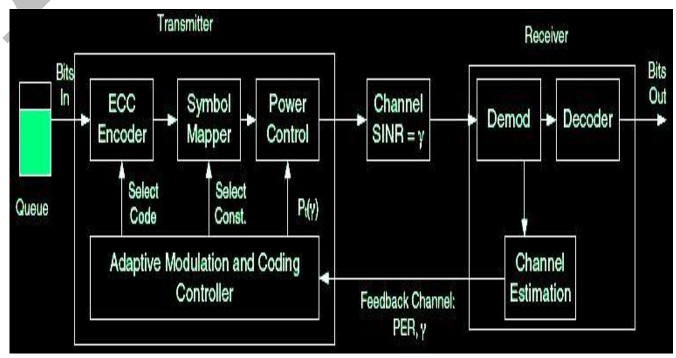


Figure 1-Block Diagram Of AMC

A key challenge in AMC is to efficiently control three quantities at once : transmit rate,transmit power and the coding rate. Reasonable guidelines be developed from a theoretical study of adaptive modulation, in practice, the system engineer needs to fine-tune and develop the algorithm which is based on extensive simulations, basically performance depends on many factors. Some of these considerations are block error rate (BLER) and received SINR, Adaptive modulation in OFDMA ,Automatic repeat request (ARQ), Power control versus water filling.

Hybrid-ARQ generally increases the ideal BLER operating point by about a factor of 10: for example, from 1 percent to 10 percent. ARQ allows rapid retransmissions .For delay tolerant applications; it may be possible to accept a BLER approaching even 70 percent.

III.SYSTEM MODELS

Software required is OPNET Modeler version 14.5 enabling WIMAX module capability. Four scenarios to be made out , **Baseline scenario, Aggressive AMC Conservative AMC ,AMC with HARQ .**The network topology having cell with a single Base Station(BS) and 20 Mobile Station or Subscriber Station (SS) as shown in figure 2. The parameters of Subscriber Station and Base Stations per illustrated in table. In the wired part of the network in scenario each Subscriber Station represents a TCP client executing an upload towards a TCP server located. The channel had been config. to vary according to ITU Pedestrian A multipath fading model .Traffic config. all Subscriber Station nodes an uplink application load of **20 Kbps** for a total of 0.4 Mbps. All SS nodes, configured to use QPSK ½ for the uplink application. The cell used an a frame duration of **five** milli seconds and SOFDMA frame with **512** subcarriers.QPSK½, capacity of uplink was around **0.59 Mbps**.

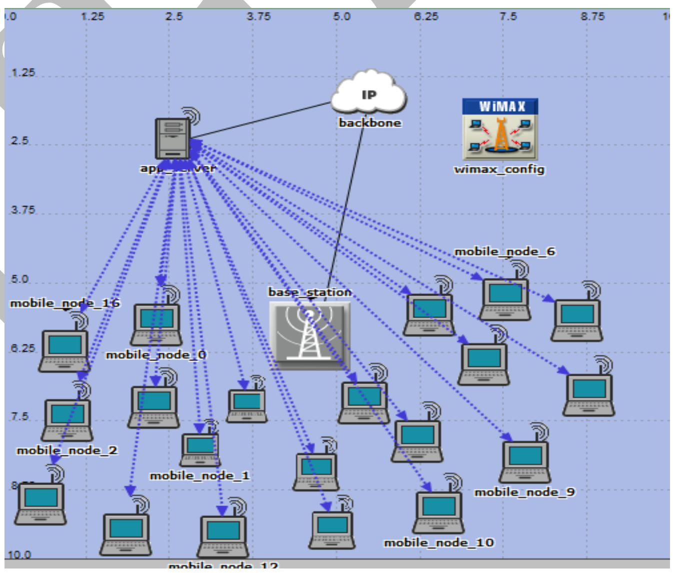


Figure 2- Topology Of Network Model

TABLE I SS PARAMETERS

(Mobile_1_1) Attributes

Type: workstation

Attribute	Value
name	Mobile_1_1
trajectory	NONE
WiMAX Parameters	
Antenna Gain (dBi)	-1 dBi
Classifier Definitions	(...)
MAC Address	Auto Assigned
Maximum Transmission Power (W)	0.05
PHY Profile	WirelessOFDMA 20 MHz
PHY Profile Type	OFDM
SS Parameters	(...)
BS MAC Address	Distance Based
Downlink Service Flows	(...)
Uplink Service Flows	(...)
Multipath Channel Model	ITU Pedestrian A
Pathloss Parameters	(...)
Pathloss Model	Free Space
Terrain Type (Suburban Fixed)	Terrain Type A
Shadow Fading Standard Deviati...	Disable Shadow Fading
Ranging Power Step (mW)	0.25
Timers	(...)
Contention Ranging Retries	16
Mobility Parameters	(...)
HARQ Parameters	(...)
Piggyback BW Request	Enabled
CQICH Period	3
Contention-Based Reservation Tim...	16
Request Retries	16

Filter | Exact match | Advanced | Apply to selected objects | OK | Cancel

TABLE-II BASE STATION PARAMETER

(Base_Station) Attributes

Type: router

Attribute	Value
name	Base_Station
WiMAX Parameters	
Antenna Gain (dBi)	15 dBi
BS Parameters	(...)
Maximum Number of SS Nodes	100
Received Power Tolerance	(...)
CDMA Codes	(...)
Backoff Parameters	(...)
Ranging Backoff Start	2
Ranging Backoff End	4
Bandwidth Request Backoff Start	2
Bandwidth Request Backoff End	4
Mobility Parameters	Default
Channel Quality Averaging Parameter	4/16
Number of Transmitters	SISO
ASN Gateway IP Address	Disabled
DL AMC Profile Set	Default DL Burst Profile Set
UL AMC Profile Set	Default UL Burst Profile Set
CQICH Period	Accept SS Configured Value
Reserved DL Subframe Capacity (%)	No Reservation
Reserved UL Subframe Capacity (%)	No Reservation
Classifier Definitions	(...)
MAC Address	Auto Assigned
Maximum Transmission Power (W)	0.5
PHY Profile	WirelessOFDMA 20 MHz
PHY Profile Type	OFDM

Filter | Exact match | Advanced | Apply to selected objects | OK | Cancel

TABLEIII AMCA

	Mandatory Exit Threshold (dB)	Minimum Entry Threshold (dB)	Modulation and Coding
0	-20	3.0	QPSK 1/2
1	6.6	7.5	QPSK 3/4
2	9.6	10.5	16-QAM 1/2
3	12.6	13.5	16-QAM 3/4
4	15.6	16.5	64-QAM 1/2
5	18.6	19.5	64-QAM 2/3
6	21.6	22.5	64-QAM 3/4
7	24.6	25.5	64-QAM 3/4

TABLE IV

AMC B

	Mandatory Exit Threshold (dB)	Minimum Entry Threshold (dB)	Modulation and Coding
0	-20	0.0	QPSK 1/2
1	9.6	10.5	QPSK 3/4
2	12.6	13.5	16-QAM 1/2
3	15.6	16.5	16-QAM 3/4
4	16.6	19.5	64-QAM 1/2
5	20.6	21.5	64-QAM 2/3
6	23.6	24.5	64-QAM 3/4
7	26.6	27.5	64-QAM 3/4

A.Scenario I: Baseline setting

In this scenario, we examine the performance of the WiMAX network with respect to capacity usage and application delay for static QPSK½ modulation implemented QPSK½ modulation .QPSK½ is a conservative MCS, bits to symbol ratio of **one**. Using QPSK½ may reduce **the block error rate**, and itbe estimated that TCP retransmissions are lower as well of improving application performance.

B.Scenario II: Aggressive AMC

In this scenario, the impact of an aggressive AMC configuration on system performance (capacity usage and application delay) with respect to the baseline. It turned on AMC functionality on the service flows of the mobile station nodes and select an AMC table for the Base Station to use on the uplink (Table III). AMC automatically adjusts to an appropriate MCS give SNR value. If the SNR is good , a node uses MCS more efficiently than the basic QPSK ½. We determined if using AMC had any disadvantages at all against static MCS of QPSK ½.

C.Scenario III : Conservative AMC

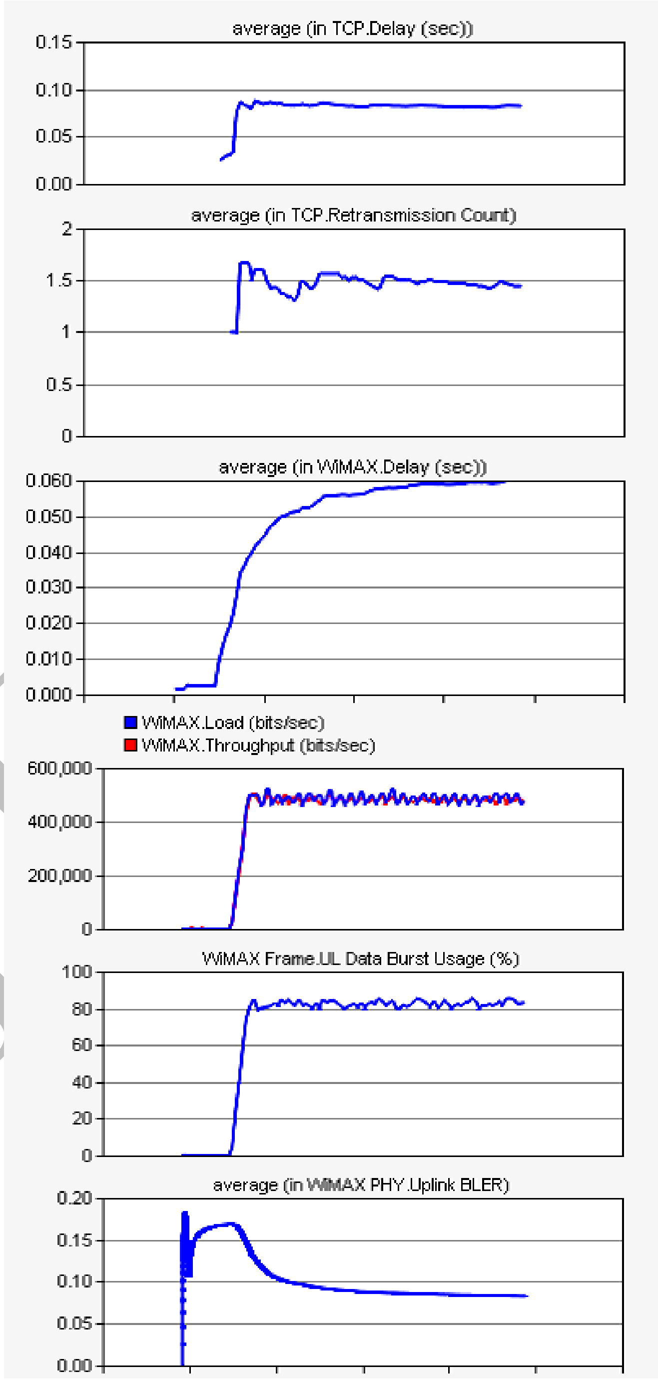
In this scenario, the effects of a conservative AMC configuration on system performance. MCS at higher SNR values (Table IV). The aim to reduce BLER, but it might use more system capacity. Examining the physical layer BER which compared with QPSK ½ scenario.

D.Scenario IV : AMC with HARQ

In this scenario, the effects of the combination of HARQ and aggressive AMC on system performance. We used a conservative AMC table to improve and maintain application performance significantly at the expense of system capacity. Since we do not want to lose the advantages of AMC_A (less system capacity usage), but at the same time, we do not want to cause TCP retransmissions that significantly degrades the application performance, so that we keep AMC_A table, but used HARQ on service flows. HARQ give advantages of SNR gain and fast retransmissions. We configured HARQ on the Subscribe nodes.

IV.RESULTS

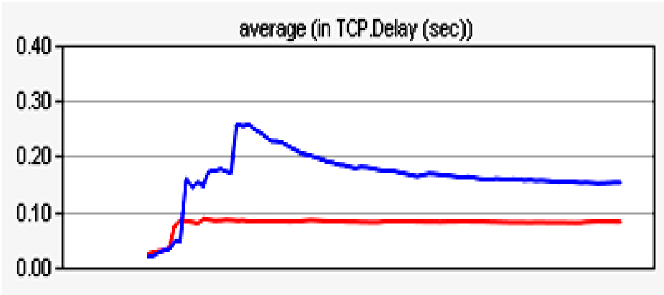
In **scenario 1**, Both the load and the throughput were around 480 kbps. This equal to the application load plus IP headers and the TCP header. We saw that UL frame usage was around 81% showing that QPSK ½ MCS was consuming large system resources and WiMAX delay was high.Thus application delay have a trade off with system capacity.

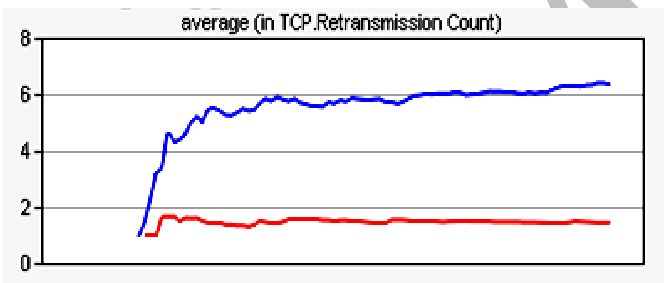


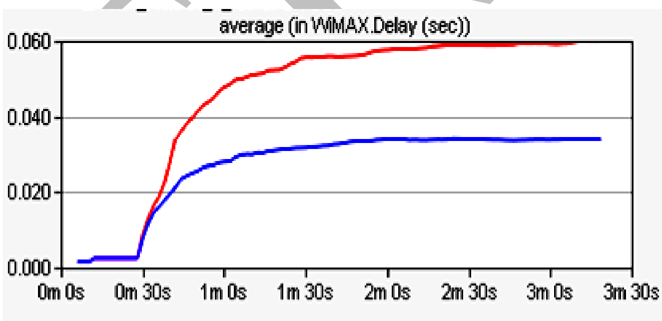
In **scenario 2**, We noticed that WIMAX delays were less .We saw that UL frame usage was around 40% only compared to 81% with QPSK ½ . Thus AMC did gain in system capacity. However, we examine that AMC_A table was too aggressive for both the load andthe throughput .To solve this, the strategy was to use a conservative AMC table which can reduces BLER, but it might use more system resources.

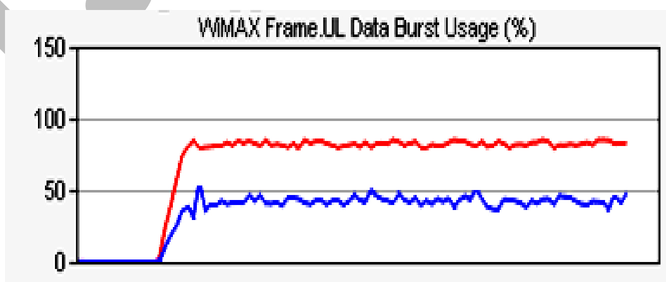
Simulation results for the scenario AMC_A versus the scenario QPSK.

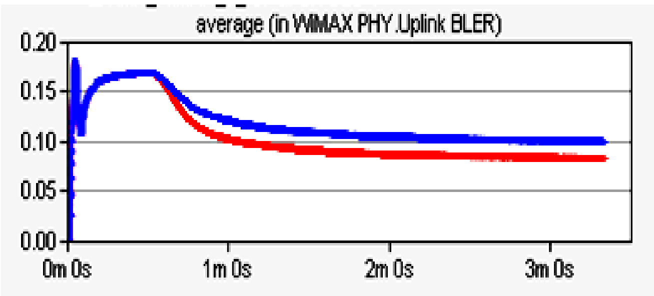
BLUE : AMC_A-DES-1
RED : QPSK-DES_1



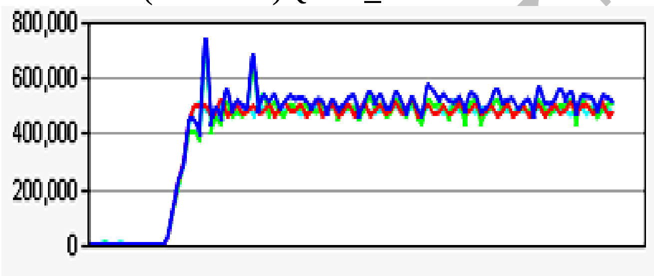






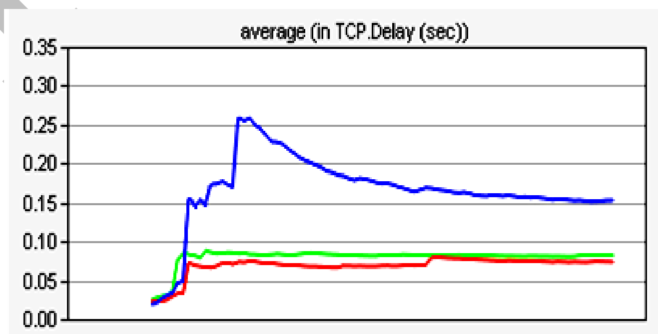


BLUE :WIMAX.LOAD(BIT/SEC)AMC_A-DES-1
RED : WIMAX.LOAD(BIT/SEC)QPSK-DES-1
GREEN:WIMAX.THROUGHPUT(BIT/SEC)AMC_A-DES-1
LIGHTBLUE:WIMAX.THROUGHPUT(BIT/SEC)QPSK_DES-1



In **scenario 3**, we examined the physical layer BER and found that it has been increased as in comparison to scenario 1. Since more packets were dropped at the physical layer, retransmission ensued degrading the application performance. We compared the performance of QPSK, BLERand different AMC table. WIMAX delays for AMC_B were less than that for QPSK ½ but more than that for AMC_A, since average symbols used in AMC_A were lesser It stated that using AMC_B caused more system resources be used .Thus by increasing the system resources usage ,improved the application performance. The BLER for AMC_B has reduced from AMC_A, thats the reason application performance has improved .

Simulation results for scenario AMC_B versus AMC_A and QPSK.
BLUE : AMC_A-DES-1
RED : AMC_B-DES_1
GREEN : QPSK-DES-1



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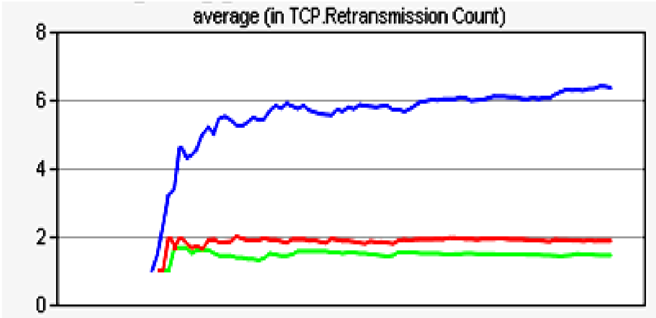
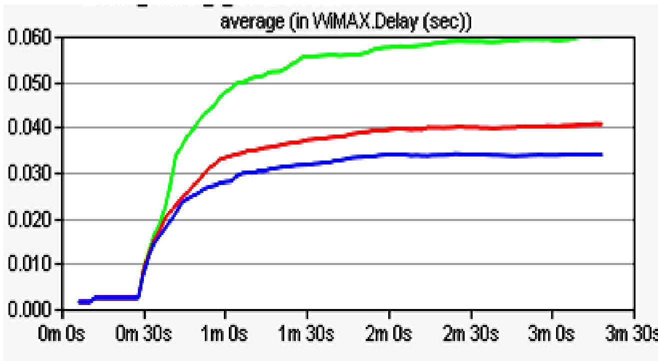
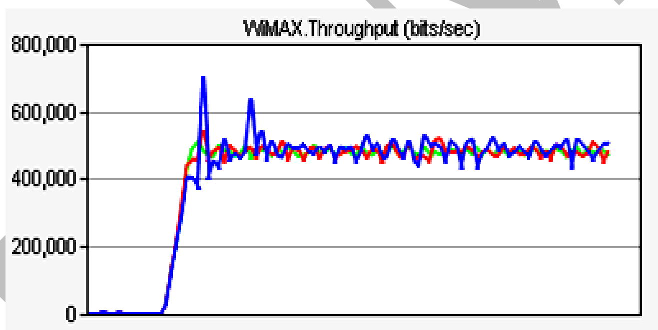
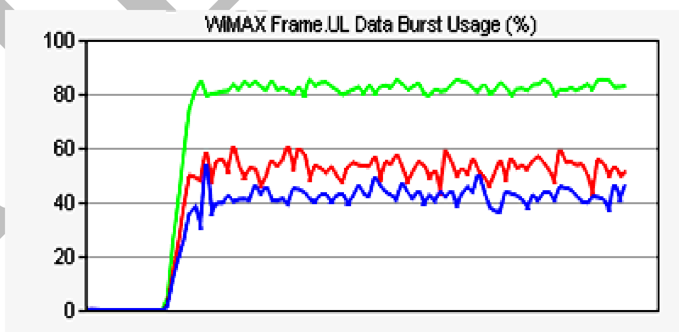
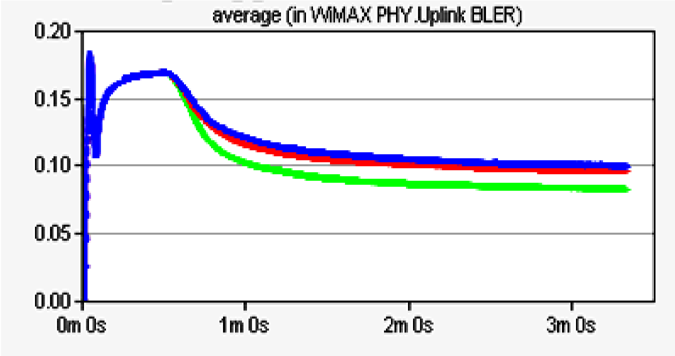






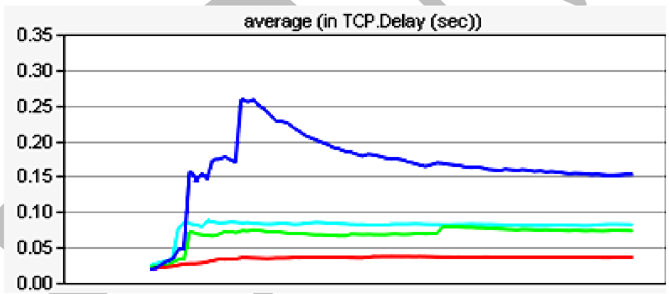


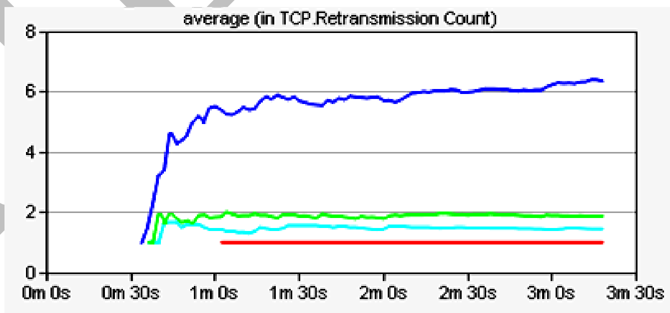


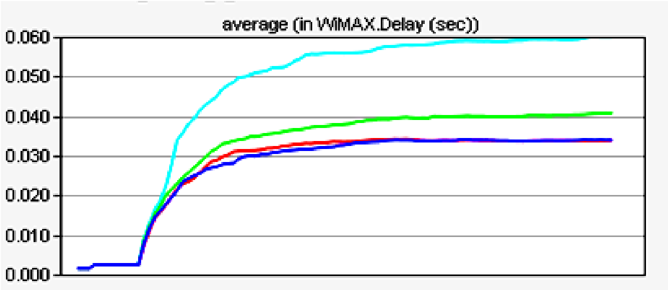
In **scenario 4**, we saw that WIMAX delays for this scenario been reduced, since we switched back to AMC_A and were using the same number of average symbols. Hence we observed that switching back to AMC_A and using HARQ indeed was the optimal strategy. While TCP delays were small and radio resource usage had been reduced back to 40%. Both the capacity and the application delay criteria have now been optimized.

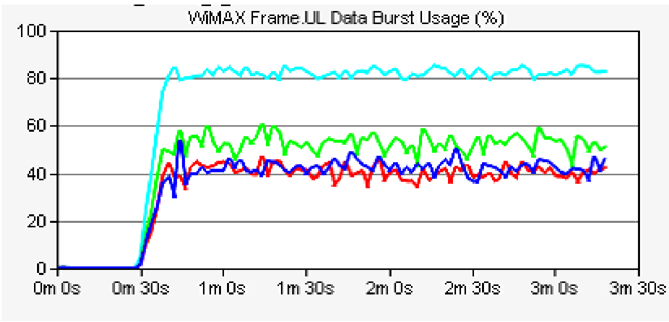
Simulation results for scenariosAMC_A_with_HARQ versus AMC_A , AMC_B , and QPSK.

BLUE : AMC_A-DES-1
RED : AMC_A_WITH_HARQ_DES_1
GREEN : AMC_B-DES-1
LIGHT BLUE : QPSK-DES-1









V.CONCLUSION

This paper represents, conducting a study to find optimal configuration of the WiMAX network with respect to system capacity and application delays.

(i) **Using QPSK½**, delays were very low showing that one of the optimization criterions which delays was satisfied, and QPSK ½ Modulation and Coding Scheme (MCS) was consuming large system resources.

(ii) **Using AMC_A table**, average delays had increased to very high values, and found that the AMC_A table was too aggressive.

(iii) **Using conservative AMC**, the BLER for AMC_B has reduced from AMC_A, that's the reason performance been improved.

(iv) **Using HARQ_with_AMC_A**, average delay were small and radio resources usage be reduced back, so that the capacity and application delay been optimized. This conclude that the best strategy is to use AMC table with HARQ.

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