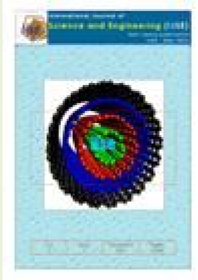
International Journal of Science and Engineering (IJSE)

Home page: http://ejournal.undip.ac.id/index.php/ijse



An Enhanced Feedback-Base Downlink Packet Scheduling Algorithm for Mobile TV in WIMAX Networks

Joseph Oyewale#1, Liu Xiao Juan*2

#Department of Information and Electronic Engineering, Lanzhou Jiaotong University, Lanzhou, Gansu Prov. China

e-mail: [1]joseph4real4u@yahoo.com; [2]liuxiaojuan@mail.lzjtu.cn

***Abstract* -** With high speed access network technology like WIMAX, there is the need for efficient management of radio resources where the throughput and Qos requirements for Multicasting Broadcasting Services (MBS) for example TV are to be met. An enhanced feedback-base downlink Packet scheduling algorithm that can be used in IEEE 802.16d/e networks for mobile TV "one way traffic"(MBS) is needed to support many users utilizing multiuser diversity of the broadband of WIMAX systems where a group of users(good/worst channels) share allocated resources (bandwidth). This paper presents such enhanced downlink packet scheduler for mobile TV traffics in IEEE 806.16, whereby network Physical Timing Slots (PSs) resource blocks are allocated in a dynamic way to mobile TV subscribers considering the Channel State information CSI (CQI) feedback. It also considers users with worst/weak channels with the aim of improving system throughput while system coverage is being guaranteed. Change in the PSs bandwidth allocation to users and different number of users per cell sector are use to check the algorithm. Simulation results show our proposed algorithm performed better than other algorithms (blind algorithms) in terms of improvement in system throughput performance. Further work like above can be done for another traffic e.g. gaming traffics utilizing broadband technology of WIMAX.

***Keywords* —** *Channel Quality Indicator (CQI); Multicast Broadcasting Services (MBS); Physical Time Slots (PSs); Packet Scheduler (PS); Signal-to-Noise plus Distortion Ratio (SNDR)*

Submission: Juny 4, 2013 Corrected : Junly 5, 2013 Accepted: July 10, 2013

Doi: 10.12777/ijse.5.1.55-62

[**How to cite this article**: Oyewale, J. and , Juan, L.X.. (2013). An Enhanced Feedback-Base Downlink Packet Scheduling Algorithm for Mobile TV in WIMAX Networks. *International Journal of Science and Engineering*, 5(1),55-62. Doi: 10.12777/ijse.5.1.55-62]

I. INTRODUCTION

With the increase in demand of multimedia services especially Multicasting Broadcasting Services (MBS) e.g Mobile TV, there is a need for a rapid to market technology that provide all IP flat network solution that can complement existing 2G/3G and DSL networks so as to deliver mobile TV and video services with a guaranteed system throughput. Such leading choice technology is 4G WIMAX based upon a 2-layer all IP network architecture and which is widely regarded as a cost-effective means to provide MBS mobile TV, given that 3G networks are currently under utilized, some mobile operators are offering streamed TV and video content at highly attractive prices, so to encourage consumers to adopt and use these services there should be a better cheap and rich MBS (TV) utilizing WIMAX broadband technology. Additionally, with this cost effective means of using 4G WIMAX in providing streaming of Mobile TV services, there is a need to design an efficient downlink scheduling of resources blocks to various Mobile TV users which is the main focus of this paper.

MBS or MCBCS (Multicasting Broadcasting Services) is a point to multipoint interface specification for existing and upcoming 3GPP cellular networks which is designed to provide efficient delivery of broadcast and multicast services both within a cell as well as within the core network in a more cheaper way whereby multiple users receive the same information using the same radio resources. Target applications include mobile TV and radio broadcasting, as well as file delivery and emergency alerts. Broadcast services are services in which all users within the broadcasting area can receive the same information and multicast services are services in which only subscribed users can receive the information.

The two ways to provide mobile TV are through unicast (PtP) and broadcast (PtM), and they differ in three basic aspects: channels (dedicated channel for PtP or common channel for PtM), requirements (individual or general), and tariffs (high or low). By specification suggestions were made by using broadcast for basic services(real time) and unicast for targeted services (Non-real time). But the unicast for PtP can be made multicast for PtM when it comes to providing services to a group of subscribed users, since broadcast can support large numbers of people viewing video at once. The WIMAX networks are usually in PtM or MESH mode, and multicasting broadcasting are in a form of PtM mode.

The paper propose an efficient downlink scheduling of resource blocks as a packet downlink scheduling algorithm to feedback channel state condition (in form of CQI which includes: SNR, SINR SNDR, Transmission power,) by using optimum CQI reporting metric to the base station in order to allocate set aside dedicated bandwidth with a required adaptive Modulation and Coding Schemes (MCS) channel diversity to a number of megabits per second per channel users according to connection requirement in order to guarantee system throughput and Qos of video and audio (Mobile TV) considering statistical multiplexing, Statistical multiplexing makes it possible to allocate required bandwidth to run different types of programming in real time. Statistical multiplexing is when more bandwidth is dynamically allocated to a bandwidth-intensive stream of programs. We used Max-Min Principle to tackle Physical Time Slots allocation based on CSI reported. Performance of algorithm proposed was evaluated with other algorithms (blind algorithms) in terms of both system throughput gain, probability of packet dropped and BLER coverage; here coverage is defined as the fraction of users with BLER (*Block-Error Rate*) less than the target BLER. With OPNET simulation results, our algorithm was able to show improvement in system throughput performance.

The organization of the paper is as follows: Section II presents related work; III explains the scheduler main components, IV gives the overview of the system model of the packet scheduler, V discusses the simulation, and results obtained and finally VI gives the conclusion.

II. RELATED WORKS

A lot of researches have been done in the areas of scheduling algorithms for WIMAX networks based on throughput and Qos of other traffic applications using concept of scheduling in LTE and similar OFDMA systems to support real time and non real time applications. TV traffic is a highly asymmetric traffic workload whereby all the traffics are meant to be downlink, it is a mixture of synchronized real and non real time one way traffic, they are light video and audio clips or other data to a large group of mobile subscribers (Multicast) in an efficient manner. The traffic application are characterized into duration and size of Intra Coded Pictures (I-frame), Predicted Pictures (P-frame) frames for MPEG video and Bi-directionally predicted pictures (B-frame) and I-frames basically very large and occur periodically.

The scheduling algorithm discussed below: uplink and downlink scheduling for voice, data, video traffics respectively are of great advantages in WIMAX networks but none was developed or proposed for TV traffics, as it was known that WIMAX developers left the scheduling aspect in the hand of researchers and vendors, however Vendors have their choice among many existing scheduling techniques or they can develop their own. Our algorithm is a feedback base Opportunistic (i.e. channel-aware) downlink scheduling meant for scheduling bandwidth for Mobile TV users, existing related opportunistic scheduling are [2], [8], [4], [5], [10] and [7].

[2], [7] are more related to our downlink scheduling algorithm for video traffic, [2] In term of better throughput performs well, packet dropping is less and it is fair in delay distribution. it does it scheduling in subcarrier allocation and assignment, for fairness and priority tie purpose, users with more packet dropped are favoured and does not give precedence to user with poor Channel Quality, [7] designs a queue and channel aware downlink scheduler (a scheduler priority-based) algorithm for WiMAX, where all of the QoS metrics, such as channel, queue, non-urgent and urgent data status are translated to priority metric by a black-box formula in the study, but it is not fair to all users, there is no CQI reporting metrics. [10] works on a cross-layer scheduler that does assignment priority for each flow base on its service and channel status, then the flow with highest priority is scheduled, it only but gives precedence to good channel flow and bad channel flow suffers. Other downlink scheduling of real time traffic that can be use in WIMAX are WRR and DRR [9], but they are not suitable for non-real time application since traffic of focus is made of both real and non real traffics, they are also channel unaware scheduler i.e. unaware of channel condition. Application based scheduler in [1] provides a model that uses time series for forecasting future video frames generation, it is only a real time scheduler and does not consider the channel state behaviour that is much need in TV traffics. [8], [5], and [10] are uplink schedulers and they not much regard to downlink scheduling of traffics e.g. mobile TV, O-DRR didn't consider the different service classes and made its scheduling decision based on the channel quality only without reporting metrics. [8] is an uplink scheduler joint sub-carrier allocation and symbol duration which supports multiple traffic classes with trade-off between system throughput and QoS (delay guarantee) but it is difficult to choose the optimal constant for each type of traffic so not suitable for downlink TV traffic.

Additionally, related works above based on channel condition do not use any CQI reporting metrics like in ours, the benefits of reporting metrics is to know the channel status of users and therefore use multiuser diversity to improve good channel and adjust the poor channel base on fairness, they do not possess the complete objectives of scheduling resource allocation (e.g. Qos, throughput, fairness and priority) like ours, it take cares of users with bad/worst channel condition. In this paper we referred to related Opportunity Scheduling and others scheduling as *blind algorithms* especially [2]. The blind algorithms do not offer pragmatic solution for scheduling a synchronized real time (basic service in the form of programs with mass appeal examples, live sporting events and real-time news and non real time or live programs example pay-to-view prime time programs targeting a given user group with specific interests), multi traffic applications for mobile TV. The work utilizes the better, cheap and richness of WIMAX broadband technology and fulfils the objectives of scheduling resource blocks.

III. THE SCHEDULER MAIN COMPONENTS

Figure 1 shows the structure of the packet scheduler scheduling processes adopted in our model, which include scheduling units 1, 2 and 3, the BS downlink link scheduling unit 1 which schedules the TV content (SDUs), and BS uplink scheduling unit 2 which schedules the Physical Time Slots (PSs) resource blocks (bandwidth) requested by the MS subscribers.

A. Packet Schedule

It is the main central processing Radio Resource Management (RRM) functions of the core network. It determines which users shared channel transmission and assigns a given time slot. It uses Physical Downlink Shared Channel (PDSCH) to transmit data and schedules in a physical time slots at all frequency, in time domain TD MBS for TV is usually scheduled in every frame duration (WIMAX fixed 5ms) sub-bands feedback so we define the resource block allocation as the number of Physical Time Slots PSs and the slots are mapped into number of sub-channels and time duration according to throughput and Qos requirements, it's made of link adaptation (modulation coding system MCS and error correcting mechanism for channel estimation) for configuring channel for fair performance for different application and a good optimization of using radio service, it does CQI handlings, HARQ handling of decision of retransmission by using various variants, it makes sure the objectives of scheduling are met.

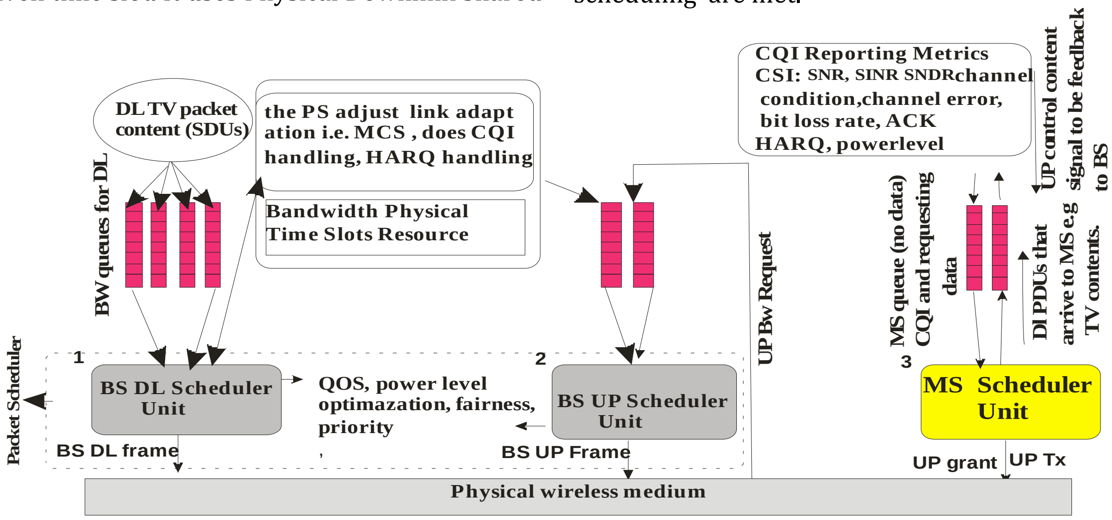


Figure 1. Downlink Packet Scheduler Components

B. Channel Quality Indicator

It is a carrier information indicator on how good/bad the communication channel quality is? It's a feedback reporting metrics or measurements in term of CINR and SINR by which users CSI (channel error, power level, and loss rates, multipath fading, and doppler effect) are feedback to BS based on the scheduling resources dispatch to the user for the right allocation of Qos and maximizing throughput. Some overhead maybe involve so algorithm that consider reducing feedback information (WIMAX standard) in DL sub-frame overhead burst is found in [13], This paper adopt optimum CQI formatting metric framework like in [12] but different. It is an hybrid reporting metrics made up of periodic and aperiodic CQI i.e. MS reports at a periodic i.e all time and aperiodic i.e. at specific time intervals and FL and FLI (Frame Latency Indicator) [11] fields can be added to provide information to BS on synchronizing of user's traffic to detect frame latency that service flow experienced.

On MS terminal side *Qi* (i = *1, ..., n*) correspond to the CQI measurement value for sub-channel and sub-channel size of 1 physical slot (PSs). In this concept one CQI value measured in the whole system is sent to the BS by MS. Let total number of BW sub-channel = N for MS selected sub-channel feedback in the whole system be divided into j fractions called bandwidth unit, in each bandwidth unit a particular sub-channel is selected and the measured channel quality in the sub-channel with its position in the bandwidth unit is sent to BS. We used aperiodic CQI for aperiodic transmission of CQIs by the MS so that loss of synchronous traffic between (audio and video) can be maintained for optimum performance. Base on the CQI reporting value (report of good channel), higher order modulation schemes and coding (MCS) rate are employed for high data rate, and (for report of bad channel i.e. worst users) moderate MCS and compensation mechanism we introduced can be selected to maintain minimum reserved threshold rate for Qos and fairness purposes, table 1 is a format example of the CQI reported values used for BS downlink scheduling and link adaptation, this concept was model in our simulation.

IV. SYSTEM MODEL: PACKET SCHEDULER

This section shows how the packet scheduler is going to work in scheduling Physical Time Slots (PSs) resource block allocation and assignment considering the objectives of scheduling. The MBMS in LTE scheduling model adopted is the one described in [12]. Our algorithm takes care of downlink (one way traffic) scheduling in TDD. According to standard, MBS mobile TV traffic are one way traffic i.e. usually from BS to MS, the scheduling resource blocks are in number of slots in time domain at all frequency (256 slots of subcarriers), according to figure 1, downlink packet PDUs (resource blocks and SDUs TV contents) are much more than uplink PDUs (requesting information and CSI), in the uplink scheduling the MS uses its resource allocation for conveying "request" of services and CQI reporting messages to the BS base on awareness knowledge of the instantaneous channel condition, location and speed of MS through Physical Uplink Control and Shared Channel (PUCCH and PUSCH). The algorithm uses a BWR grant request called Incremental Bandwidth Request (by an MS) in multicast and broadcast polling, since we consider MBS to request for BW, but since the polling can utilize bandwidth but not guarantee delay which is more needed in TV video frames, we decide to adopt "polling in every frame to ensure the delay bound in order to prevent new connection I- Frame from overlapping with existing connection I-Frame [3]. Multicast and broadcast polling support ertPS and rtPS and nrtPS Qos classes, so the algorithm supports these three Qos classes.

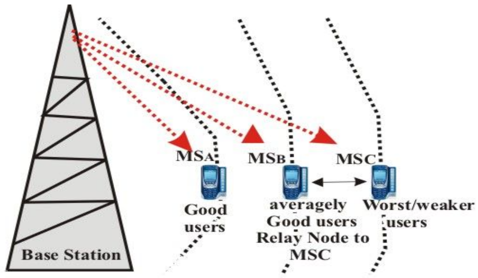
Table 1. Parameters of the CQI Report for MS-selected

System Downlink Bandwidth (N)	Size of sub-channel (k)	Bandwidth Units (j)	CQI Value	Modu-lation	Coding rate X 1024
10-20	3	1	4	QPSK	72
21-40	4	2	5	QPSK	110
41-60	6	3	14	64QAM	773
61-80	8	4	15	64QAM	928

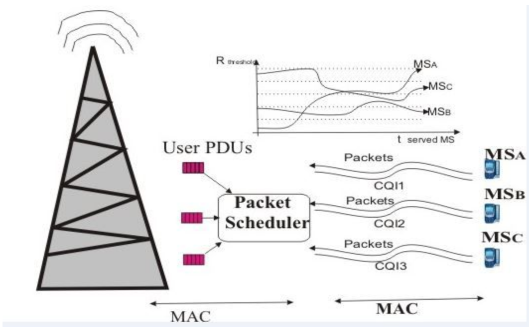
Figure 2 shows the system model which is based on MS users location and CQI metrics of good and worst or weakest users in sector of a cell or group(MSc users) and CQI information report to the BS, the BS uses all these CQI metrics reporting to adjust and improve the channel and counter the poor CQI of worst users by providing more PSs resource block from the reserved dedicated bandwidth, higher MCS, Bit error Correcting mechanism (e.g. Forward Error Control) for good channels and compensation mechanism to maintain minimum reserved threshold rate for worst user, it also employs statistical multiplexing to handle bandwidth real intensive stream of videos that may drop packets or by worst or weakest (users usually at edge of cell) , this concept makes the algorithm to be more fair to users no matter their channel constraints for improved system throughput when scheduling PSs resource block. The figure in 3 gives an explanatory diagram for the scheduler and the CQI reporting metrics.

We adopted PtM mode for WIMAX Multicasting Broadcasting Services MBS [3] (Mobile TV), whereby one BS or group of BSs in the same area such that all sends the same multicast or broadcast message at the same rate at the same frequency/time slot channel to group of MSs with less bandwidth cost. The important fact for the Scheduler design is that it conformed to WIMAX standard: frame duration of 5ms and 10ms based on bandwidth either 3.5MHz or 7MHz, and numbers of symbols vary in each frame of sub channel along with OFDMA symbols, and 2-dimentional resource allocation is used. For downlink PUSC it is 1 sub channel across 2 OFDMA symbols and for uplink PUSC it is 1 sub channel across 3 OFDMA symbols. For Downlink FUSC it is 1 sub channel across 1 OFDMA symbol, in MCS zone it uses 2 sub channels versus 3 OFDMA symbols.

Note: Physical slot (PS): It is the minimum unit of bandwidth allocation used by BS in giving resources to the MSs. PS duration =4/Fs.



(a)



(b)

Figure 2. (a) System model; (b) Resource Block scheduler base on CQI feedback

A. *Network Resource Block Allocation and Assignment Scheme*

Referring to the algorithm, MSs measure, report and feedback the CSI (CQI) to a selected base station, whereby channel subcarriers, and power allocation are decided based on users' CQI value (given in table 1). Once the decisions of sub-channel allocation for each user have been made, each user must be informed on which allocated subcarrier by the base station, so whenever the resource allocation changes, this mapping of the subcarrier must be broadcasted to all users involved, and because the CSI is needed by the base station to assign sub-channel needed by the users. For BLER Coverage gain and improving system throughput a more modified principle called "Max-Min" principle is used in scheduling in TDD, for the good *(MS_A, MS_B)* and poor *(MS_C)* users channel quality parameters for different users, different Physical slots resource blocks of good and worst user may not be same, so the algorithm proposed uses the available Physical Time Slot instead of users. Figure 3 describes how we design our model base on position of MS_A, MS_B and MS_B, with different CQI 1, CQI2, and CQI3, a graph display by the right shows CQI reporting metrics, we have

MS_A and MS^B as best and good users (i.e. good channel), while MS_C as worst users (i.e. bad channel), according to our concept CQI maybe good since (downlink interference) i.e. CINR is minimal and SINR is good because they are positioned as "best and good" position, therefore the scheduler configure higher MCS to increase data rate, but for the worst MS_C user incase higher MCS cannot be possible since the channel is bad then it has to be given some compensation in order to meet the Qos in term of reserved min threshold rate, below describe our resource allocation concept, the below expression model fairness, priority, statistical multiplexing into our algorithm.

Consider a *K*-user system (number of users) each with its CSI (CQI) reporting of periodic and aperiodic reporting (for good channel) and (worst channel), let's say good channel CQI 14, 15 (from table 1) implies traffics are map to higher transmission rate to sub-channels with good CSI, and MS_C users CQI 4, 5 implies worst user with poor channel, low transmission rate i.e. each user's channel gain is of others independent indicated by h_k. The PDF of user *k*'s channel gain $p\ h_k$ ( ) is given by

$$p(h_k) = \begin{cases} 2h_k e^{-h_k^2} & if\ h_k \geq 0 \\ 0 & if\ h_k < 0 \end{cases} \quad \text{(i)}$$

Assumption: That the BS transmits to the highest channel gain users, denoted as $h_{max}=max\{ h1, h2.... hk\}$. It can be verified easily that the PDF h_{max} of

$$p(h_{max}) = A2k\,h_{max}\left(1-e^{-h_{max}^2}\right)^{k-1} e^{-h_{max}^2} \quad \text{(ii)}$$

And transmit to lowest channel gain user denoted as $h_{min} =min \{ h1, h2......\}$

$$p(h_{min}) = 2Bk\,h_{max}\left(1-e^{-h_{min}^2}\right)^{k-1} e^{-h_{min}^2} \quad \text{(iii)}$$

(Where A and B denotes statistical multiplexing and compensation factor we are introducing. The factor A in equation (i) can be resolved by simply allocating more bandwidth since the CQI is high and the channel is good while B in equation (ii) will be resolved using the weighting function below.)

For various values of *k* there is a shift of the PDF of h_{max} to right base on the increment of number of users which means the probability of having an improved large channel gain and shows improvement in system throughput and bit error rate for encoded QPSK increased channel gain. The model concept here makes the lower CQI reporting number of users employ multiuser diversity. Whereby a small constellation (such as QPSK, and low-rate error-correcting codes e.g. rate convolutional or turbo codes) by lower data rates users is used with reserved min threshold rate and compensation mechanism for worst users , and a large constellations (such as 64 QAM, and less robust error correcting codes) by higher data rates users are used.

$$MaxA\{ MinB\ (R_{AB})\} \quad (iv)$$

For priority and fairness purpose we use *max-min principle* for Physical Slots (PSs) resource blocks allocation, A_{PS} and B_{USER} indicate allocated PSs i.e. sub-channels and group of user respectively, and R_{AB} denotes the performance report metric of B_{USER} on allocated PSs. where R_{AB} is the user B throughput on PSs resource block A, estimated based on the user's CQI feedback. As our concern is throughput maximization and minimize packet dropped and also introduce statistical multiplexing, so here the evaluated metric throughput was used, we formulated the algorithm in the following manners:

(a) *Minimum(R_{AB})* – base on performance CQI reporting metric, for each PSs sub-channel allocated and assigned, we determined the least throughput (MS_C users) on it and mark the PSs resource block with this worst-user throughput but maintain the reserved minimum threshold rate and introduce compensation mechanism i.e. fairness.

(b) *Max{ Minimum(R_{AB})}* -Consider the whole available PSs resource block, we find the ones on which the worst-user throughput is the best and allocate it to maintain Qos and throughput i.e. priority.

What we considered here is when there is a relatively large number of users per sector of a cell, PSs are allocated in a fairness way according to user demand for both dedicated and common channels taking statistical multiplexing programs into consideration and there may be a relatively small channel gain group of users i.e worst throughput, maintain the min threshold rate and introducing a compensation mechanism in this case of MS_C worst users:

defining the compensation mechanism: we reformed *Minimum(R_{AB})* to a more scaling form i.e. "*g{Minimum(R_{AB})}*", where *g{}* is call a weighting function meant to resolve the issues of worst users, by making sure they are serve for fairness purpose, we introduce a cooperative multicasting (shown between MS_B and MS_C) to reduce the differences in channel conditions (distance) between MSs in the same multicast group, whereby MS_B serve as a relay to MS_C, this concept with some higher coding improve the channel condition of the MS_C users, for fairness purposes to all users that subscribed.

The Subscriber (MSs) Model from figure 2(a) process the DL MAP burst from the BS for the purpose of reporting the generated CQI to the BS packet scheduler either at every period or at a specific time, there is an effective measurement of SNR over the channel. The mapping equivalent between the measured CQI and effective SNR is match with a target BLER value (given in simulation result). According to table 1 the mapping of the CQI reporting values to the effective SNR is represented below in figure 3, in our model SNR measured is used to generate CQI reporting value.

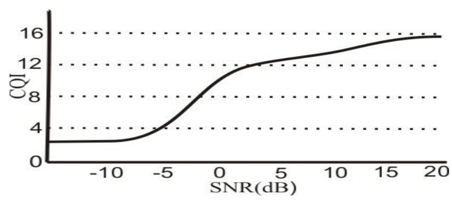


Figure 3. Mapping CQI value to SNR measured

V. SIMULATION, DISCUSSION AND RESULTS

In this section we discuss and consider the performance analysis of our algorithm and compare it with blind algorithms for Downlink Traffic in a WiMAX network. We used Opnet 14.5 DES for simulation, we assume three cell system model shown in figure 7, user's transmission power are set as fixed value and pedestrian users are randomly located at the geographical within the simulation area. Probability of packet dropped (as a result of delay of packets due to queuing), system throughput gain and BLER statistics are collected. Base on WIMAX working group assumptions 6, 15, 25, 50, and 75PSs are available on a fixed bandwidth of 1.4, 3, 5, 10, and 15 MHz respectively. Table 2. Shows (Default) Simulation parameters settings for WIMAX, embedding CQI metrics.

Table 2. Simulation Parameters

Parameter Type	***Configuration***
Base frequency	2.5Gh
System Bandwidth	10MHz (35PS RB)
Frame length	5ms
Duplex Mode	TDD
Reporting interval	6ms
CQI Reporting Mode	Periodic/aperiodic
Traffic Model	Balance load with full buffer
Channel Model profile	ITU Pedestrian
Link Adaptation	Medium/Fast AMC
Used MCS	QPSK (R= ¾, ,5/4, 1/3, 1/5, 2/3. 32QAM (R= 1/3, 2/3, 4/5)
Simulation Duration	1500sec

A. Traffic Source

The traffic parameters for the streaming TV services used in the simulation is given in table 3 and it is based on [6],[12]. where a typical quality live TV show packet size of 600 bytes every 20 ms running at average data rate 394 Kbps and able to deliver TV-quality video at 30 to 40 frames per second.

Table 3. Traffic Parameters

TV Video traffic	**Assumptions**	**Distribution**
No. of packets per frame	40 packets	Deterministic
Frame inter-arrival time	0.02sec	deterministic
packet size	600 bytes	Mean=100 bytes Max= 600bytes
Inter-arrival time between packets	2.8ms,	Mean = 0.667

Table 4. User (TV traffics) Allocation Resource Blocks

Bandwidth allocation	10, 15, 20, 35 (80 PSs)
Number of users in a cell or group	20, 30, 40, 50 users

B. Performance Metrics

We evaluate the throughput gain and the system coverage by the performance of the proposed algorithm over blind algorithms. To fulfil Multicast Broadcasting throughput and Qos for synchronous TV traffic, the required BLER coverage should be 10% and packet drop probability less than 1, so we can say our algorithm fulfil this and therefore the algorithm is robust in term of system throughput.

C. Performance Impact of PSs allocation and number users per area of a cell

Physical Time slot Bandwidth for Mobile TV Users – Our algorithm gain comes from the feedback information from the users to the BS a result of channel constraints thereby adjusting MCS and employing compensation mechanism due to downlink interference. Because Increase of bandwidth for Mobile TV user (in case of a bandwidth-intensive stream of video) will lead to lower channel diversity, and as a result lower gain.

TV users in an area of a cell – as part of our algorithm, in PtM mode worst users channel quality is the major limit to performance of mobile TV users in a network. In a case whereby the number of users are large, and as a result the more of the users will be located at cell edge with low channel gain, in this case it may be impossible to find PSs resource blocks that are better than others but the compensation mechanism called weighting function we included take care of this.

Figure 4 describes the system throughput gain base on number of allocated PSs and number of TV user in a cell, the upper graph denotes number of allocated PSs resource blocks and lower graph denotes number of users.

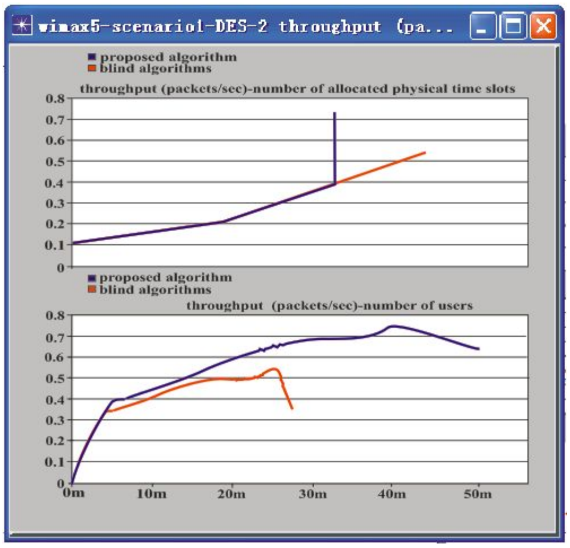


Figure 4. Average system throughput gain base on the numbers of allocated PSs and number of mobile TV users

The graph shows that as more PSs is allocated to users (either bandwidth dependant programs or not) there is increase in throughput and at a certain fixed PSs allocation (33 resource block) the throughput increases more due to CQI feedback to BS which employs multiuser diversity i.e. as the channel is good more higher MCS constellation e.g. 64QAM is employed to increase the throughput more while the blind algorithm throughput only increase as more PSs are being allocated (wasting bandwidth). The lower shows that the algorithm throughput increase as number of users increase but at point (40 users) the throughput begins to decrease which implies the users at the edge of the cell (worst users) channel is degrading, so the compensation mechanism introduced in the model is used to address this for fairness purpose while the blind algorithm as the number of users reached 28 the throughput begin to decrease, and there is no mechanism to address this, therefore, this shows that our algorithm performed better in term of throughput.

Figure 5 shows the probability of packet dropped when scheduling frame packet to the users, it is know that the major factors that determine synchronizing audio/video (mobile TV) quality is as a result of packet lost/dropped during delay and congestion in the network.

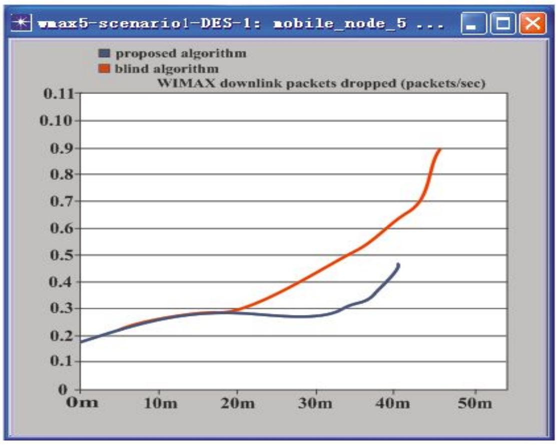


Figure 5. Probability of packets dropped (worst case)

Here we refer to delay as packets dropped because the more delay we experienced the more packet will be dropped. The figure compares our algorithm with blind algorithms and it shows that by adopting our algorithm probability of packet drop is minimized by introducing the system model to counter the issue of packets dropped.

Figure 6 In terms of BLER coverage with variation in number of PSs resource blocks and users per sector of a cell. Block Error Rate (BLER) is used as in 4G technologies to know in-sync or out-of-sync indication during Radio Link Monitoring (RLM), since we are analysing synchronizing traffic e.g. mobile TV, Normal in-sync condition is 2% of BLER and for out-of-sync is 10%, i.e. BLER of coverage should be less or equal to 10. Comparing with a fact: Bad RF environment (downlink interference) = BLER bad coverage = BLER is large, Good RF environment (downlink interference) = BLER good coverage = BLER is small. From the figure result analysis based on the above fact, it shows that the proposed algorithm: as users increase from 10 to 50, BLER changes was from 9% to 11% and that of the blind algorithms are from 10% 16%, it shows that our algorithm difference/changes was minimal (10% range i.e. BLER good coverage) and that of the blind algorithm was large (i.e. BLER bad coverage). Ours algorithm performance gives a low/normal BLER coverage which implies as the number of users increase the algorithm concept is able improve the RF environment (downlink interference) based on our model concept. This shows that our algorithm is robust in terms of system throughput. The BLER shows the meaningfulness of general system throughput because the major Qos requirement in communication is coverage of more users with Qos guarantee.

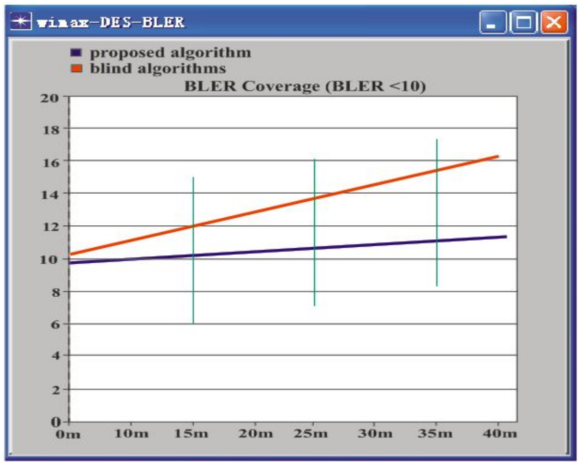


Figure 6: BLER coverage base on number of users in a area of a cell.

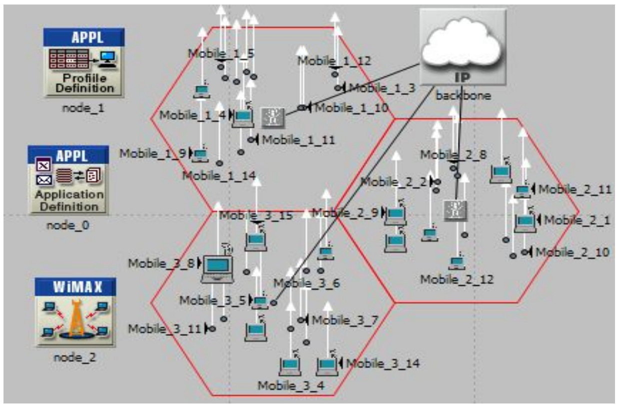


Figure 7: Network Topology

VI. CONCLUSIONS

This paper proposed a feedback base enhanced Packet downlink scheduling algorithm which is based on instantaneous feedback of CSI for mobile TV subscribers in a PtM mode WIMAX System. The work is aimed at using the cost effectiveness of WIMAX to offer improved system throughput by configuring PSs allocation to mobile TV user's especially worst users in a MBS (Mobile TV) group whose system performance is largely impacted by channel constraints. It exploits multiuser diversity (MCS) with moderate PSs allocation to subscribed users, it is achieved by minimizing probability of packet loss (due to delay and congestion) improved throughput gain and BLER experienced by bandwidth-intensive stream of programs, fairness and priority to all subscribed users. Base on a clarified CQI reporting by the optimum CQI metric, the algorithm proposed works well to maximize system performance in terms of system throughput, reduced packet loss and maintained good BLER coverage. The concrete benefits of this work are improved throughput, fairness, priority to all users (especially users with worst or weak channel gain). With our concept, probability of packet dropped was minimized (less than 1), a good a robust average system throughput gain was attained i.e. at a fixed 33 PSs allocation the throughput increase steadily due to multiuser diversity employed and system BLER coverage maintains normal in-sync conditions is 2% of BLER and for out-of-sync is 10% for synchronized TV traffic in all cases with proposed algorithm. Further work like above can be done for another traffic e.g. gaming traffics, TV traffics in WIMAX Multi-hop Relay network utilizing broadband technology of WIMAX and a more explicit standard for description mechanism to calculate CQI.

REFERENCES

[1] Abdel Karim Al Tamimi et al., (2010). "Modeling and Resource Allocation for Mobile Video over WiMAX Broadband Wireless", *IEEE JOURNAL* on Selected Areas in Communications, Vol. 28, pp. 354 – 365,.

[2]Ahmed K.F. Khattab and K.M.F, Elsayed, (2006). Opportunistic Scheduling of Delay Sensitive Traffic in OFDMA Based Wireless. In *WOWMOM: IEEE Proceedings of the INTERNATIONAL SYMPOSIUM ON WORLD OF WIRELESS, MOBILE AND MULTIMEDIA NETWORKS*, pp. 279–88.

[3] hakchai So-In et al, (2010). " Resource Allocation in IEEE 802.16 Mobile WiMAX" Published in "*Orthogonal Frequency Division Multiple Access (OFDMA)*," Edited by Tao Jiang, Lingyang Song, Yan Zhang, *AUERBACH PUBLICATIONS, CRC Press*, ISBN: 1420088246.

[4] Hemant Kumar Rath et al., (2006). An Opportunistic Uplink Scheduling Scheme to Achieve Bandwidth Fairness and Delay for Multiclass Traffic in WiMAX (IEEE 802.16) Broadband Wireless Networks. In *Proceedings of IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE (GLOBECOM)*, pp. 1–5.

[5] Hemant Kumar Rath et al., *(2006)*. "An Opportunistic DRR (O-DRR) Uplink Scheduling Scheme for IEEE 802.16-based Broadband Wireless Networks", *IETE, INTERNATIONAL CONFERENCE ON NEXT GENERATION NETWORKS (ICNGN), Mumbai, Chania, Greece, 18 - 21.*

[6] Hua Wang Iversen et al, (2008) "Hierarchical downlink resource management framework for OFDMA based WiMAX systems," in *WIRELESS COMMUNICATIONS AND NETWORKING CONFERENCE, WCNC. IEEE, pp. 1709-1715.*

[7] J. M. Liang, J. J. Chen, Y. C. Wang, Y.C. Tseng, B.S. Lin, (2009). "Priority-Based Scheduling Algorithm for Downlink Traffics in IEEE 802.16 Networks", *IEEE ASIA-PACIFIC WIRELESS COM. SYMPOSIUM,*

[8] Lihua Wan et al., (2007). "A Cross-layer Packet Scheduling and Sub-channel Allocation Scheme in 802.16e OFDMA System," *IEEE WIRELESS COMMUNICATIONS AND NETWORKING CONFERENCE, WCNC, pp. 1865-1870, Hong Kong*

[9] Maode Ma. (2009). Current Technology developments of WiMax Systems. Nanyang technological University, school of Electronic and Electrical Engineering, Singapore.

[10] Qingwen Liu et al., (2006). "A Cross-Layer Scheduling Algorithm With QoS Support in Wireless Networks", *IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, Vol. 55 pp. 839 – 847.*

[11] Seok Yee Tang et al., (2010). Wimax Security and Quality of Service: An End to End Perspective.

[12] Shan Lu et al., (2009). "Channel-Aware Frequency Domain Packet Scheduling for MBMS in LTE", *VTC Spring IEEE 69th VEHICULAR TECHNOLOGY CONFERENCE*.

[13] WiMAX Forum, "WiMAX System Evaluation Methodology V2.1," 230 pp, July 2008, available at www.wimaxforum.org/technology/documents/