



## Cross Layer Optimization for Video Broadcast in Mobile WI-MAX

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**Abstract—** IEEE 802.16e mobile WiMAX standard provides a promising technology for broadband wireless access. Owing to the limited bandwidth resource and increased data-rate requirement, some sort of mechanism is essential to achieve good spectral efficiency and to better manage the limited resources of bandwidth. Link adaptation technique helps in meeting out these demands and has now emerged as one of the powerful tools for future wireless broadband networks. Here, we propose a modified layer design architecture that utilizes adaptive modulation and coding to provide link adaptation in mobile WiMAX network and also determine the number of supportable users with the consideration of a variety of real-time and non-real-time services for a mixed type of subscribers.

**Keywords—** WiMAX, broadband, link adaptation, adaptive modulation and coding, layer design

### I. INTRODUCTION

Multicast and broadcast service (MBS) such as mobile IPTV is emerging recently as one of killing applications in IEEE802.16e standard based mobile WiMAX networks. [1] As a wireless technology, the inherent ability to simultaneously transmit the same video Multicast and broadcast service (MBS) such as mobile IPTV is emerging recently as one of killing applications in IEEE802.16e standard based mobile WiMAX networks. [1] As a wireless technology, the inherent ability to simultaneously transmit the same video content to a group of users will reduce bandwidth consuming. Even under the connection-oriented network like WiMAX, how to provide link adaptation for video delivery among receivers under various channel condition is a great challenge.

There is no direct feedback channel designed for MBS, to acquire comprehensive information of receiver's distribution, some periodic polling method initiated from BS should be deployed, suffering from the overhead and scalability problem. Therefore the conventional method is either to skip the link adaption and rely on fixed robust modulation and coding scheme, or to select a representative. The shortcomings are the poor performance because the spectrum efficiency is much lower for more robust modulation scheme and it may not accurately represents other group members' status.

Some literatures proposed video multicast optimization mechanism in mobile WiMAX network [2]-[7], but few of them consider the overhead for feedback signal. The receiver can perfectly estimate the channel state and reliably feed it back to the sender without delay. Whereas, the channel condition is not predictable, the periodic polling message exchange for multicast group member may be a waste because of the following two reasons.

(a) The channel condition for some receiver is stable during a long period of time, BS receives the same report each time in the polling mechanism.

(b) The upgrade/downgrade of modulation and coding scheme happens under discrete level.

The variation of MS's channel condition reaches the given threshold value. Some literatures proposed video multicast optimization mechanism in mobile WiMAX network [2]-[7], but few of them consider the overhead for feedback signal. The receiver can perfectly estimate the channel state and reliably feed it back to the sender without delay. Whereas, the channel condition is not predictable, the periodic polling message exchange for multicast group member may be a waste because of the following two reasons.

So we propose a MS-triggered feedback report mechanism to release the fixed polling cycle, each MS belonging to a multicast group is allowed to send feedback report only when the variation of channel condition, represented by CINR(Carrier to Interference and Noise Ratio), reaches some threshold value. Each time when MS sends back the report, it is qualified to do link adaptation. On the other hand, advanced scalable video coding technology [11] such as layered video coding provides an efficient approach to support multiple receivers with varying bandwidth requirements and decoding capability.

A video program is separated into several layers of different visual importance. The base layer, contains the most important data features and the bottom line includes the visual quality, while additional layers(i.e) enhancement layer includes the reconstructed video quality. A cross layer optimization can be fulfilled with the combination of layered coding in multicast program session and link adaptation in the wireless network transmission. In order to accomplish the cross layer optimization, two problems should be solved: Firstly, how to provide good quality video to users experiencing good channels, while guaranteeing a minimal quality to other uses. Secondly, how many layers can be generated for one video program and how much bandwidth should be assigned for each layer.

The mobile WiMAX multicast optimization literatures, [2] and [3] focus on the architecture design and general issues for MBS in WIMAX network; the work in [4] maps the base layer and enhanced layer into different service flows. [6] takes adaptive modulation and coding into consideration for layer-encoded streams and channel fading during the multicast transmission. [5] proposes a utility-based multicast scheme by the time slot adjustment of each layer. [7] uses the utility function to maximize the sum of the logarithm of the rates of each receiver, missing the consideration for the expected bandwidth / rate requirement of receiver based on its status and decoding capability. The aim of the scheduling algorithm is to provide differentiated video quality for the receivers located in the places with different channel conditions and decoding capabilities.

The subscribers under good channel condition can watch the higher quality video stream, while others in bad condition or with basic decoding capability may receive the basic service, the BS will dynamically adjust the bandwidth resource, as well as modulation and coding scheme (MCS) allocation for each video program to achieve the optimized overall utility.

## II. BACKGROUND

The typical single cell scenario with one BS deployment for WiMAX network is used. BS is in charge of the wireless resources allocation to multiple MSs which are uniformly distributed inside the cell. Before receiving the video program, MS should send dynamic service addition (DSA) request to BS and wait for its response, QoS parameters for this service flow and layer coding information. To simplify the explanation and evaluation, the resources are fully used in video multicasting and the overhead for other control message is neglected. Since time division duplex (TDD) is defined in the IEEE802.16e standard, bandwidth resources can also be represented by available time slots in each frame.

### A. MCS in WiMAX network

Adaptive MCS is a key feature for WiMAX technology, BS can deploy high level modulation scheme in the area with higher SNR value. On the contrary, in area near to the cell boundary with poor SNR, the system would step down to a low level modulation scheme to maintain the connection quality and link stability. There is great variation of spectrum efficiency among different MCS: Three categories of modulation are supported in WiMAX: QPSK, 16QAM and 64QAM. It is clear to understand the higher level modulation can improve the sustained data rate significantly over the same amount of bandwidth resource. Based on the performance evaluation from WiMAX forum[9], the 64QAM(5/6) can achieve maximum 31.68Mbps data rate at 10MHz channel with 5-ms frame duration while the QPSK(1/2) can only reach 6.34 Mbps under the same condition.. So we explore the existing report methods defined in the standard in the following sub-section

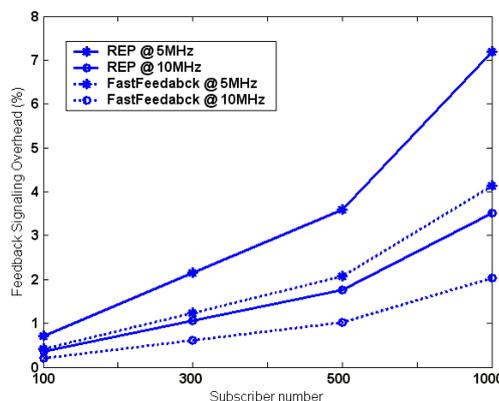


Fig.1. Periodic Feedback Signaling Overhead Analysis

### B. CINR(Carrier to Interference and Noise Ratio) report operation

There are two kinds of operation defined in the standard for MS to report the CINR value to BS. The first one is REP-RSP (Channel measurement Report-Response) MAC message. The second one is periodic CINR report with fast-feedback (CQICH) channel. These two methods are the polling mechanism initiated by BS, thus the amount of signalling overhead depends on the frequency of polling and the total number of subscriber. For example, assuming the report from each subscriber is updated every 1 second and the frequency bandwidth is 5MHz or 10MHz.

The average channel frequency consumption with the augment of subscriber number is shown in Fig.1. It is illustrated that REP message exchange requires higher bandwidth consumption than fast feedback report mechanism. Since the control message should be transmitted by the robust QPSK modulation, and the frequency bandwidth is very limited in WiMAX network (varies from 1.25 to 20MHz), it is not avoided with the signalling overhead in the cell with high subscriber density.

## III. LINK ADAPTATION TECHNIQUE AND AMC CODING

Link adaptation techniques, often referred to as adaptive modulation and coding (AMC), are a good way for reaching the cited requirements. They are premeditated to track the channel variations, thus altering the modulation and coding structure to yield a higher throughput by transmitting with high information rates under flattering channel conditions and tumbling the information rate in reply to channel degradation.

### 3.1 AMC Architecture

The function of AMC is based on SDR-CR combination. The receiver evaluate received packets (i.e. SNR or BER) to estimate the Channel Quality Indicator (CQI) module, then feedback the transmitter to reconfigure itself for the next packet send.

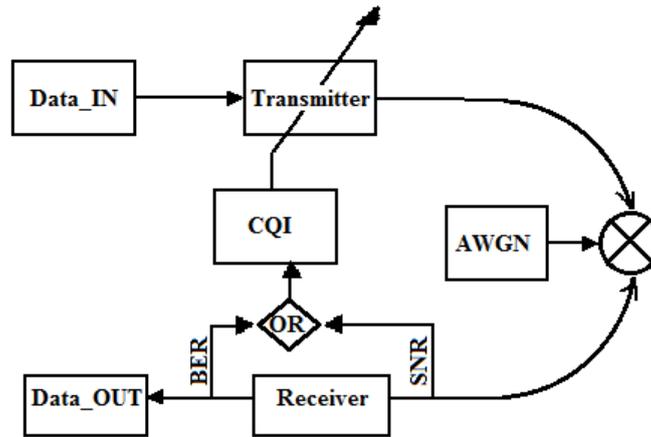


Fig.2. Adapative System

### 3.2 AMC System Performance

The performance of AMC highly depends on the accurate channel estimation at the receiver and the reliable feedback path between that estimator and the transmitter on which the receiver reports channel state information (CSI). In order to assure a high-quality implementation the next steps must be followed:

#### 3.2.1 Channel Quality Estimation

The predictions from the past channel quality estimation, the adaptive system can operate efficiently in a slowly-varying channel conditions only. Therefore, the delay between the quality estimation and the actual transmission in relation to the maximal Doppler frequency of the channel is crucial for the system implementation since poor system performance will result if the channel estimate is obsolete at the time of transmission.

#### 3.2.2 Parameter Adaptation

The choice of the appropriate modulation and coding mode is based on the prediction of the channel conditions for the next time interval. An SNR threshold guarantees a BER below the target BER ( $BER_0$ ), is defined by the system for each scheme whenever the SNR is above the SNR threshold.

#### 3.2.3 Feedback Mechanism

The mobile channel is time varying and the feedback of the channel information becomes a limiting factor. Therefore, the reliable feedback channel is necessary to achieve an accurate performance of the AMC scheme. In this way, no delay or transmission error can occur in the feedback channel so that no discrepancy between the predicted and the actual SNR of the next frame appears. The receiver must also be informed of which demodulator and decoding parameters to employ for the next received packet.

Table I. Modulation and coding schemes for IEEE 802.16.

Modulation(coding)	Info bits / symbol	Required SNR
BPSK(1/2)	0.5	6.4
QPSK(1/2)	1	9.4
QPSK(3/4)	1.5	11.2
16QAM(1/2)	2	16.4
16QAM(3/4)	3	18.2
64QAM(2/3)	4	22.7
64QAM(3/4)	4.5	24.4

**IV. PROPOSED SYSTEM**

In this 3-Layer design architecture, the first two layers beginning from the base station represented as layers L1 and L2 are maintained the same. As there exists a vast variation in the distance and the SNR in the L3 layer of 3-layer design architecture, a single modulation technique as described in the above figure represented as QPSK 1/2 is not sufficient to meet out the relatively required location based QoS.

Thus in-order to meet out this requirement, an additional modulation technique of the same type but of some higher coding rate can be utilized. With the inclusion of QPSK 3/4 modulation technique for link adaptation, the overall 3-layer design can be increased by one to 4- layer designs.

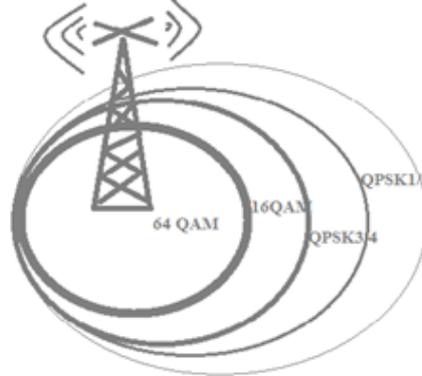


Fig.3.AMC Architecture Cell

**V. SIMULATION RESULTS**

**5.1 Data Rate Vs. Operation Distance**

The Data Rate and the Operation Distance of various modulation schemes, the simulated output is displayed in fig.4 as,

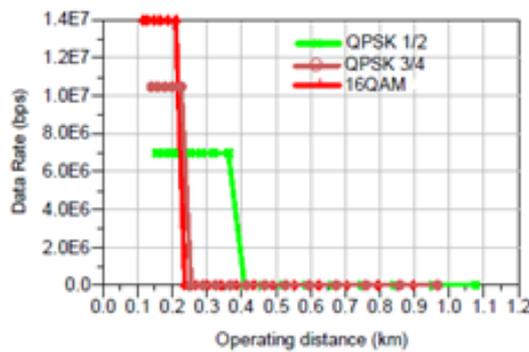


Fig.4 Simulation Data Rate Vs. Operation Distance

**5.2 BER vs. SNR**

BER is the number of error bits occurs within one second in transmitted signal. BER defined mathematically as follow;

$$BER = \text{no of bits with error} / \text{total no. of bits transmitted} .$$

When the transmitter and receiver’s medium are good in a particular time and Signal-to-Noise Ratio is high, and then Bit Error rate is very low. In our thesis simulation we generated random signal when noise occurs after that we got the value of Bit error rate.

$$SNR = \text{signal power} / \text{noise power}$$

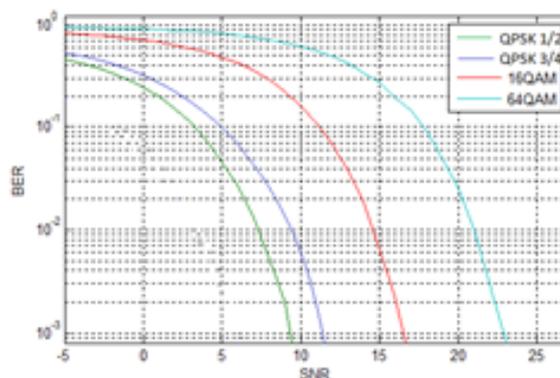


Fig. 5 Simulation BER vs. SNR

The various SNR values , link throughput and operating range for different modulation schemes the simulated output is displayed in table 2.

Table 2. Simulation Result values

Modulation scheme	SNR (dB)	Link throughput (Mbps)	Operating range (km)
QPSK 1/2	9.4	6.99	0.210
QPSK 3/4	11.2	10.49	0.235
16QAM	16.4	13.99	0.400

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