Estimating the consuming resources of IEEE 802.16e cell in case of video conference application

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Abstract. IEEE 802.16e is a WiMAX standard which mixes between broadband and wireless. It is based on OFDMA and provides large capacity as compared with other standards that support previous technologies. One of IEEE 802.16e features is to provide quality of service (QoS) as service classes. However, real time applications are a real challenge for systems capacity due to consume heavy data rate such as video conference application. The service classes of 802.16e standard are depended on minimum reserved traffic rate to submit the service. This paper estimates the consuming resources of 802.16e cell during providing video conference service taking into account the minimum reserved traffic rate of service classes related to real time applications and other factors.

1. Introduction
The operation of resources consumption in systems is a hot key for sustainability of systems success. The consuming of resources depends on three factors, first of them is the free resources which is submitted by the system before request the service by users. The second factor is the type of application where the quantity of data rate which required to delivering a specific service varies from one application to another. There are many kinds of applications ranging from light to heavy applications in terms of data rate such as text, email, voice, file transfer or video applications. The last factor is the strength of the signal to noise ratio (S/N) of the user station that qualified the user to employ the nominal scheme of modulation and coding rate. Hence, the weak S/N lead to use robust scheme of modulation and coding rate while the higher scheme of modulation and coding rate allows subscriber to drain less resources than robust scheme [1].

Generally, the systems of computer and communication networks are divided into centralized and decentralized systems. In the decentralized systems, the process of system management is distributed among the participants. On the other hand, the process of system management in centralized systems is controlled by the base station (BS) of the cell. Therefore, the resources consumption for these systems could be calculated from BS.

WiMAX is a centralized system when works at point to multipoint mode (PMP)[2]. The BS of WiMAX cell offers on users submitting requests for upload and download. The decision to allocate the resources for upload and download data related to the criterion which is adopted by BS. Furthermore, the standard of 802.16e of WiMAX submits many service classes to relevance the application kind [3]. On the other side, the resources of BS are slots of time where it depends on the principals of orthogonal frequency division multiple access (OFDMA)[4]. These slots form the symbols in the time domain, the resources of WiMAX system is measured by symbols per second (SPS).

The idea behind this research aims to estimate the resources consuming of the cell of 802.16e standard for each scheme of modulation and coding rate at heavy application (video conference) in
order to study the effect of increasing quality of service on system capability in case of video conference service to avoid the failure in the cell capacity.

2. Theoretical Background

2.1. IEEE802.16e standard subframe

The standard of IEEE 802.16e supports two types of duplexing time division duplexing (TDD) and frequency division duplexing (FDD) and the size of OFDMA frame is variable from 2msec up to 20msec[3]. The OFDMA subframe of TDD is shown in Figure 1, it contains on three sections, the first one is mandatory to decode by all users. This part of subframe concerns with two issues (preamble and FCH with maps). The preamble is favor to synchronization issue while FCH and DL-map as well as UL-map locate which modulation and coding rate schemes are used by users depending on the strength of received signal to noise ratio that sent form user to base station (BS). Moreover, the process of request and grant in the system is executed by this period. The second section is dedicated for downlink from BS to users where carry different permutations (full usage of the sub channels (FUCH), partial usage of the sub channels (PUCH), adaptive modulation and coding (AMC), and/or tile usage of sub channels TUSC)[5]. It is worth to mention that the main difference among the permutations is the distribution of subcarriers on the sub channels. The last section of subframe is reserved to uplink with respect to users. The uplink section of the subframe supports two kinds of zone PUCH and/or AMC.

![Figure 1. It explains the subframe of 802.16e.](image)

On the other hand, the resources of OFDMA cell which depends on 802.16e standard are in the form of symbol (time period) and the consuming of these symbols depends on which schemes of modulation and coding using at users [6].

2.2. Resources allocation and QoS in 802.16e

In order to control any data connection (uplink or downlink) in 802.16e standard in oriented connection manner, a sixteen bits connection is identified. Whilst management messages are separated on data connections and sent over management connections. Each connection is unidirectional and associated to service flows which describes the properties of related QoS[7]. The base station is in control with the whole connections in centralized fashion. Firstly, the base station establishes the primary connections with the users, and then it checks the requests of the users to meet their requirements depending on the available resources [8]. The standard of 802.16e submits multiple kinds of service flow: Unsolicited data grants (UGS), Real-time polling service (rtPS), Non real-time polling service (nrtPS), extended real-time polling service (ertPS), and Best effort (BE). This research deals with rtPS service class [9].

2.3. Video conference service

Video conferencing is the communication between two or more people which have both audio and a moving video image using a computer or dedicated video telephone. Video conferencing application consumes large bandwidth and affected with latency and loss packet [10].
A network must be had the sufficient bandwidth to support the demands of this application as well as, a video compression process must be applying on the live video stream in such a way that it making the video consumes less bitrate than the original one to be easier to transmit over the network/Internet.

Video compression is performed through a video codec that works on one or more compression algorithms. An H.264 video encoder carries out prediction, transform and encoding processes to produce a compressed H.264 bit stream [11]. An H.264 video decoder carries out the complementary processes of decoding, inverse transform and reconstruction to produce a decoded video sequence see Figure 2.

![Figure 2](image)

Figure 2. It illustrates the stages of video conference service.

3. Model Description
The simulation model of the cell is shown in Figure 3. It includes BS, Server, and six types of users. The difference among users related to scheme of modulation and coding rate only (QPSK1/2, QPSK3/4, 16QAM1/2, 16QAM3/4, 64QAM2/3, and 64QAM3/4). It is worth to mention that, OPNET modeler version14.5 is adopted to be the simulator.

![Figure 3](image)

Figure 3. It shows the content of cell model.

3.1. Model Assumptions
- The cell of this model includes one base station (BS) with one sector.
- The BS of the cell is connected to a server using 10 Gbps Ethernet cable.
- The server submits the service of video conference application.
• The simulation is implemented for each user alone to calculate the resources consuming.
• The rest of assumptions are illustrated in table (1).

| Issue                        | Description |
|------------------------------|-------------|
| Standard                     | 802.16e     |
| Stations type                | fixed       |
| The resources of the cell (Mps) | 11.654     |
| Service class type           | rtPS        |
| Duplexing technique          | TDD         |
| Bandwidth                    | 20 MHz      |
| Length of frame (msec)       | 5           |
| Symbol duration              | 102.86 µsec |
| No. of subcarriers           | 2048        |
| UL / DL size                 | 50% / 50%   |
| Simulation time (sec)        | 600         |
| Radius of the cell (Km)      | 1           |

Table 1. shows the model assumptions.

4. The Results
Figure 4 declares the ratio of resources consuming (symbols) for each scheme of modulation and coding rate in 802.16e standard at minimum guaranteed bandwidth equal to 384kpbs in case of video conference application. The amount of consumed symbols for one user at QPSK1/2 scheme with respect to free symbols is the largest (about 2.2%) compared to other types of schemes. It is noted that the scheme of QPSK1/2 expends abundant symbols to compensate the effect of weak S/N ratio while the scheme of 64QAM3/4 consumes 0.5% from the total symbols of the cell. The QPSK3/4, 16QAM1/2, 16QAM3/4, and 64QAM2/3 schemes consume 1.5%, 1.1%, 0.7%, and 0.6% with respect to overall free symbols of the cell. Addendum to the foregoing the quantity of depleted resources gets to close at 64QAM modulation where there are two types of coding (2/3 and 3/4). This is related to the number of information bits with respect to the overall bits block which are sent together in each transmission burst.

![Resources Consuming at 384Kbps](image)

Figure 4. The ratio of symbols consumption at 384kpbs reserved traffic.

Figure 5 shows the ratio of consuming resources for each scheme of modulation and coding rate in case of upgrading the video conference quality of service from 384kpbs to 0.5Mbps. It is expected that the ratio of resources consuming will increase in relation to the first scenario. The scheme of QPSK1/2 records 2.9% while 64QAM3/4 scheme consumes 0.6% from the total symbols of the cell. Figures 6
Figure 5. The ratio of symbols consumption at 512kbps reserved traffic.

Figure 6. The ratio of symbols consumption at 1024kbps reserved traffic.
Figure 7. The ratio of symbols consumption at 3072kbps reserved traffic.

It is obvious that the ratio of consuming the symbols is increased with the increment of minimum guaranteed bandwidth for each user, for example about 5 user utilize QPSK1/2 scheme could be led the system to fall at reserved bandwidth equal to 3Mbps. It is also noteworthy that, the schemes of 16QAM modulation are submitted equilibrium between the quality of video and the amount of consuming resources while QPSK and 64QAM modulation schemes are behaved as extremist behaviour as to QAM modulation performance.

5. Conclusion
This research estimated the consuming symbols for each modulation and coding rate scheme of 802.16e standard at the service of video conference, it dealt with four values of minimum reserved guaranteed bandwidth (384kbps, 512kbps, 1024kbps, and 3072kbps) to represent four different cases for service quality of video conference application. The results shown that the upgrade of service quality is not appropriate for the case of QPSK1/2 scheme related to huge resources consuming hence five users utilize this scheme could push the system to collapse at guaranteed bandwidth for each user equal to 3Mbps. Moreover, the ratio of consuming the symbols is not uniform among the different schemes where the first three schemes (QPSK1/2, QPSK3/4, and 16QAM1/2) consume about three times as much as the second three schemes (16QAM3/4, 64QAM2/3, and 64QAM3/4). The 16QAM3/4 scheme offered the relevance performance for video conference application from symbols consuming and the strength of S/N of the user points of view.

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