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Capacity Behaviour using WSDV Scheme over WiMAX

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Abstract
The objective of this project is to create Mobile Worldwide Interoperability for Microwave Access (WiMAX) for 4th generation mobile wireless networks in which it is foreseen that mobile Television (TV) services will reproduce rapidly. In television applications are bandwidth hogs that cause a challenging capacity problem in wireless networks. To address this challenge, a novel scheme for mobile Television services over WiMAX network, called the Wireless Switched Digital Video (WSDV) scheme, is proposed. Compared with the conventional broadcast or unicast schemes, the hybrid approach introduced in the proposed WSDV approach exploits the merits of two conventional schemes and mitigates their demerits, which enables it to increase wireless capacity for mobile Television services. The analytical model can capture the details of WiMAX resource allocation and take into consideration the popularity of the mobile Television contents being viewed by users enabling it to provide an accurate estimate of the amount of bandwidth required for WiMAX TV services and also enabling a designer to optimally select the number of channels via the WSDV service while meeting a desired level of blocking probability. The proposed optimized scheme outperforms the conventional schemes with respect to blocking probability. Finally, an end-to-end solution to the WSDV scheme is also presented.

Keywords*: WiMAX, WSDV, MBS, MCS, QPSK, OFDM, DCT.*

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1. Introduction

WiMAX is a technology standard for long-range wireless networking. WiMAX equipment exists in two basic forms - base stations, installed by service providers to deploy the technology in a coverage area, and receivers, installed in clients. WiMAX supports several networking usage models

- A means to transfer data across an Internet service provider network, commonly called backhaul.
- A form of fixed wireless broadband Internet access, replacing satellite Internet service
- A form of mobile Internet access that at one time competed directly with LTE technology

While at one time WiMAX was envisioned to be a leading form of Internet communications across all three of the areas above, it's adoption has been limited. The network reference model envisions unified network architecture for supporting fixed, nomadic, and mobile deployments and is based on an IP service model. The overall network may be logically divided into three parts, there are

- Mobile Stations (MS) used by the end user to access the network.
- The Access Service Network (ASN), which comprises one or more base stations.
- Connectivity Service Network (CSN), which provides IP connectivity and all the IP core network functions.

A. Spectrum Allocation

There is no uniform global licensed spectrum for WiMAX, however the WiMAX Forum has published three licensed spectrum profiles 2.3 GHz, 2.5 GHz and 3.5 GHz, in an effort to drive standardization and decrease cost. WiMAX profiles define channel size, TDD/FDD and other necessary attributes in order to have inter-operating products. The current fixed profiles are defined for both TDD and FDD profiles. At this point, all of the mobile profiles are TDD only. The fixed profiles have channel sizes of 3.5 MHz, 5 MHz, 7 MHz and 10 MHz. The mobile profiles are 5 MHz, 8.75 MHz and 10 MHz.

B. Mobile Wimax

Mobile WiMAX has been defining the MBS architecture and its related component protocols. Mobile TV service has made steady progress over the past year and is widely predicted to be a major driver of future growth in 4^{th} generation (4G) mobile wireless networks that offer enough flexibility and network robustness to economically deliver a truly multimedia experience. Mobile WiMAX is able to achieve high spectral efficiency which translates to lower cost per subscriber for the operator, by utilizing orthogonal frequency division multiple access (OFDMA) radio design, advanced multi-antenna technology with multiple-input multiple-output (MIMO) and beam forming, adaptive modulation and coding (AMC) schemes, and smart packet scheduling methods. Recently, in order to extend the benefits of WiMAX to mobile TV services and meets the increasing demands for ubiquitous, widely available TV services.

C. Multicast And Broadcast Service (MBS)

Multicast Broadcast Services (MBS) 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. For broadcast transmission across multiple cells, it defines transmission via single-frequency network configurations. Target applications include mobile TV and radio broadcasting, as well as file delivery and emergency alerts.

2. Proposed Method

A. Introduction

In this project, the new WSDV scheme was introduced. Using this scheme, WiMAX server is created and then calculated the popularity of the TV programs using Zipfian distribution. The video is transmitted to the mobile TV users. The various modulation schemes are used to assign the values to the spectral efficiency. So the various users can able to watch the TV programs in mobile TV with different speed.

B. Orthogonal Frequency-Division Multiple Access

Orthogonal Frequency-Division Multiple Access (OFDMA) is a multi-user version of the popular Orthogonal Frequency-Division Multiplexing (OFDM) digital modulation scheme. Multiple accesses are achieved in OFDMA by assigning subsets of sub-carriers to individual users as shown in the figure 1. This allows simultaneous low data rate transmission from several users. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

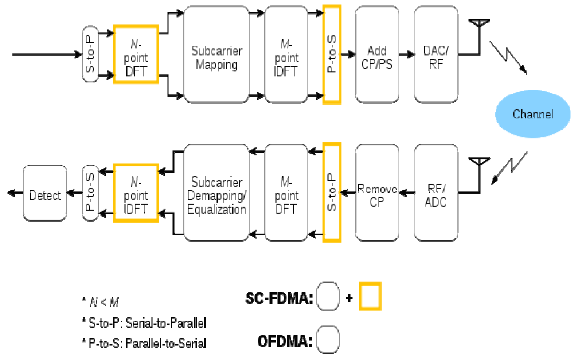

Fig.1: Block diagram of OFDMA

C. Characteristic Principles

Based on feedback information about the channel conditions, adaptive user-to-sub-carrier assignment can be achieved. If the assignment is done sufficiently fast, this further improves the OFDM robustness to fast fading and narrow-band co-channel interference, and makes it possible to achieve even better system spectral efficiency. Different numbers of sub-carriers can be assigned to different users, in view to support differentiated Quality of Service (QoS), i.e. to control the data rate and error probability individually for each user.

D. Modulation And Coding Scheme

Modulation and Coding Scheme (MCS) index values can be used to determine the likely data rate of the WiMAX connection. The MCS value essentially summarizes the number of spatial streams, the modulation type and the coding rate that is possible when connecting the wireless access point. In reality, the actual MCS will depend on the variables such as hardware design and local interference. If a wireless or WiMAX connection cannot be maintained, i.e. there are too many CRC errors being experienced on the link, the MCS value can be lowered which will reduce the error rate (by selecting a more forgiving modulation type/coding rate) but will come at the price of a slower data rate. The MCS will indicate the data rate of the wireless or WiMAX connection, it will not determine the actual usable network throughput.

E. QPSK (Quadrature Phase Shift Keying)

QPSK (Quadrature Phase Shift Keying) is type of phase shift keying. Unlike BPSK which is a DSBCS modulation scheme with digital information for the message, QPSK is also a DSBCS modulation scheme but it sends two bits of digital information a time. The amount of radio frequency spectrum required to transmit QPSK reliably is half that required for the BPSK signals. Several review of the literature on mobile TV WiMAX have been published, from a variety of different view point.

In Liao, Y. Shi, J. Chen, and J. Li, proposed scheme a cross-layer multicast service management scheme that can not only avoid the service interruption and power-saving mode disruption. But also reduce the bandwidth consumption for IP-layer multicast signaling. WiMAX technology is a good candidate to provide broadcast TV services for mobile users because it supports QoS based multicasting functionality. Simulation results demonstrate that the scheme can eliminate the unnecessary power consumption caused by IP-layer multicast signaling, and improve the wireless uplink throughput as well. The simulation and the influence of the multicast management signaling procedures on channel switching time that is a major performance indication for mobile TV services. Future work will investigate about the multicast TV service delivery during handover.

3. Module Description

A. Channel Model

OFDM Time Division Duplex (TDD) frame structure and gives an example of the logical layout of a frame. Each frame is divided into Down-Link (DL) and Up-Link (UL) sub frame separated by Transmit receives and Receive-transmit Transition Gaps (TTGs and RTGs, respectively) to ensure that the transceiver at the BS has the time required to switch between receive and transmit. Each DL sub frame starts with a preamble, followed by the Frame Control Header (FCH), the DL-MAP, and a UL-MAP respectively. The FCH has a fixed location and duration in the frame and contains only the DL Frame Prefix (DLFP), which specifies the sub channel groups that make up the segment, the length of the DL-MAP, specifies the amount of repetition coding is used on the DL-MAP, and whether there is any change to the ranging allocation from the previous frame. The DL-MAP and UL-MAP signal the sub channel and slot allocation and other control information for the DL and UL sub-frames, respectively.

OFDMA system is the concept of sub-channelization. It distributes the allocated OFDMA sub-carriers to sub channels using a permutation mechanism. Bandwidth allocations by MAP signaling are done in sub channels. The OFDM Time Division Duplex (TDD) frame structure and gives an example of the logical layout of a frame. Each frame is divided into Down-Link (DL) and Up-Link (UL) sub frames separated by Transmit receive and Receive-transmit Transition Gaps (TTGs and RTGs, respectively) to ensure that the transceiver at the BS has the time required to switch between receive and transmit. MBS is supported in mobile WiMAX systems to provide an efficient way to transmit a diversity of multimedia data to multiple users through a shared radio resource. MBS zone is defined as a specific region allocated by a BS or a group of BSs in the DL frame, along with MBS services. A BS can send multicast/broadcast data synchronously through the same Multicast Connection Identifier (MCID) and Security Association (SA) carrying MBS data in the same MBS zone.

B. Mobile TV Model

The Video Source Rate (VSR) for a mobile TV program channel is calculated depends upon the data rate using a Zipfian distribution to estimate the popularity of the available TV programs. A WiMAX MBS controller (called a WSDV server) that receives requests from users and classifies requests according to their BSs. Compression Ratio (CR) which varies with compression technique and picture type. Data Bits per Pixel (BPP), which consists of three components, R/G/B or Y/Cb/Cr (the usual data bits per pixel are 24 bits). The video source rate for a mobile TV program channel is calculated using the following equation

$$VSR=W*H*RR*BRP*1/CR \qquad (1)$$

Thus, transferring QCIF screen resolution at 30 fps with the assumption of 24-bit coloring per pixel and a compression ratio of 48 should be required.

VSR=176*144*30*24*1/48=380 kbps. The conditional probability that gives the arrival of a particular user request is using the Zipf's distribution. Consider a WiMAX MBS controller that receives requests from users and classifies requests according to their BSs and TV programs in which the users are interested. For simplicity, consider the requests from users served by a BS. Let N be the total number of available TV programs and let all TV programs be ranked in order of the user popularity, where the i^{th} most popular program is program i. Let qN(i) be the conditional probability that, given the arrival of a particular user request, the particular request is made for program i ($1 \leq i \leq N$).Then, qN(i) is derived from a cut-off Zipf-like distribution given by

$$q_N(i) = \left(\sum_{i=1}^{N} i^{-\beta} \right)^{-1} \cdot i^{-\beta} \tag{2}$$

Where β is the Zipf parameter. Assigning a Zipf parameter in the range $0 < \beta \leq 2$.

C. Bandwidth Requirement Model

It calculates the amount of WiMAX resources required for video channel delivery according to each of four delivery approaches in the WSDV scheme. The probability of Convolution Turbo Code (CTC) block error for each of various Modulations and Coding Schemes (MCSs) in OFDMA WiMAX and addresses the SNR levels required in the corresponding MCSs with CTC block error rate of 0.01.The coverage is calculated through the relation with SNR. Create the WSDV delivery schemes and assigning spectral efficiency for each user channel. The delivery schemes are Conventional Broadcast Scheme (CBS), Conventional Unicast Scheme (CUS), Switched Broadcast Scheme (SBS), and Switched Multicast Scheme (SMS). Calculate the resource requirement to transmit a video packet of size. This table shows Modulation and Coding Schemes in Mobile WiMAX.

Index	**MCS**	**Bits per PUSC Slot**	**SNR Required (db)**	**Distance (m)**
0	QPSK (CTC)1/2 Rep6	48	SNR_0=-2.56	D_0=1815
4	16QAM (CTC)1/2	96	SNR_4=10.13	D_4=834
5	64QAM (CTC)1/2	144	SNR_5=15.15	D_5=614

Table 1: Comparison of SNR for different MC's

The table summarizes typical spectral efficiency, required SNR, and the coverage of available MCSs in OFDMA WiMAX. The coverage is calculated through the relation with SNR represented by two equations as follow,

$$SNR=P_{BS}+AG_{BS}+AG_{MS}-PL_{ITU-V}-N_{MS}-CL \tag{3}$$

$$PL_{ITU-V}(f,d)=80-18 \log_{10}(\Delta H_{BS})+21 \log_{10}f+ 40 (1-4 \Delta H_{BS}/1000) \log_{10}d \tag{4}$$

Where PBS and NMS are BS transmit power and MS noise power in dBm, respectively. AGBS/MS is the BS/MS antenna gain. CL is the cable loss and PLITU−V is the path loss model for non-line-of-sight propagation. In addition, HBS is the BS antenna height in meters, d is the distance between BS and MS in km, and f is the carrier frequency in MHz. To simplify the presentation, assume that an MCS is determined primarily from the path loss and the MSs are uniformly distributed in the cell, where the maximum radius is d_0.

The probability that an MS is served using the i^{th} MCS level (M_i) as $P_r(M_i)$, and the maximum distance of the corresponding MCS level at which the probability is achieved as d_i,

$$P_r(M_i)=d_i^2-d_{i+1}^2/d_0^2, d_9=0 \text{ and } 0 \le i \le 8 \qquad (5)$$

The number of video channels accommodated is a good indicator of the spectral efficiency for wireless video transmission with the understanding of dynamics of the required bandwidth for a ranked video channel.

$$\begin{gathered} \text{Maximize } N \\ \text{subject to} \\ \sum_{i=0}^{n_{cb}} \varphi_i^{cbs} + \sum_{n_{cb}+1}^{n_{cb}+n_{sb}} \varphi_i^{sbs} + \sum_{n_{cb}+n_{sb}+1}^{N} \varphi_i^{sms} \le C \end{gathered} \qquad (6)$$

Where n_{cb} and n_{sb} are the number of video channels put on CBS and SBS respectively, and C is the system capacity in terms of OFDMA slot rate. The system capacity is $\zeta \times 84$ Ksps where ζ is the MBS capacity fraction and is set to a value less than 1. Figure 2 and figure 3 shows the required bandwidth for a ranked channel in terms of OFDMA PUSC slot rate with respect to the WSDV delivery schemes. The total number of users U is 200 and two values (1.5 and 1.9) were used for the Zipf parameter.

D. Video Compression

In this project, implement the system with compressed video using video compression techniques. It is reduced the video size. So transmission is needed some limited amount of bandwidth only. And also it improved the spectral efficiency. So it transmit large amount of video simultaneously. It calculates motion vectors between successive frames and uses them to reduce redundant information. It divides each frame into sub matrices and applies the discrete cosine transform to each sub matrix. In DCT the encoder performs the compression and it produce the compressed image. The compressed image pixel values are stored. After decompression the pixel values are stored in I_n (1<n<8) as shown in figure 2. The decoder subsystem performs the inverse process to recover the original video.

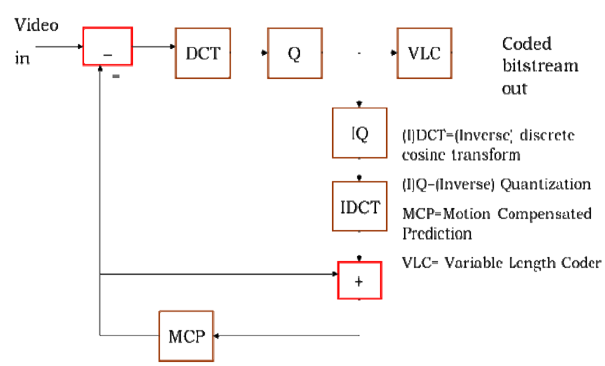

Fig. 2: Block diagram of DCT coder

E. Original video without Compression

- 176 × 144 pixels per frame
- 30 frames per second
- Total 90 minutes
- 24-bit coloring

F. Block Diagram

G. The Discrete Cosine Transform (DCT)

The discrete cosine transform (DCT) helps separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). The DCT is similar to the discrete Fourier transform. It transforms a signal or image from the spatial domain to the frequency domain. The general equation for a 1D (*N* data items) DCT is defined by the following equation,

$$F(u) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \Lambda(i).cos\left[\frac{\pi.u}{2.N}(2i+1)\right] f(i) \qquad (7)$$

$$\Lambda(i) = \begin{cases} \frac{1}{\sqrt{2}} & \text{for} \xi = 0 \\ 1 & \text{otherwise} \end{cases} \qquad (8)$$

The general equation for a 2D (N by M image) DCT is defined by the following equation

$$F(u,v) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \left(\frac{2}{M}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \Lambda(i).\Lambda(j).cos\left[\frac{\pi.u}{2.N}(2i+1)\right] cos\left[\frac{\pi.v}{2.M}(2j+1)\right] .f(i,j) \qquad (9)$$

and the corresponding inverse 2D DCT transform is simple $F^{-1}(u,v)$.

The basic operation of the DCT is described as the input image is N by M. f (i, j) is the intensity of the pixel in row i and column j. F(u,v) is the DCT coefficient in row k1 and column k2 of the DCT matrix. For most images, much of the signal energy lies at low frequencies appear in the upper left corner of the DCT. Compression is achieved since the lower right values represent higher frequencies, and are often small enough to be neglected with little visible distortion. The DCT input is an 8 by 8 array of integers. This array contains each pixel's gray scale level. The 8 bit pixels have levels from 0 to 255.

Figure 3 show the output array of DCT coefficients contains integers; these can range from 1024 to 1023. It is computationally easier to implement and more efficient to regard the DCT as a set of basis functions which given a known input array size (8 x 8) can be pre computed and stored. This involves simply computing values for a convolution mask (8 x8 window) that get applied (sum values x pixel the window overlap with image apply window across all rows/columns of image). The values as simply calculated from the DCT formula. The 64 (8 x 8) DCT basis functions are illustrated.

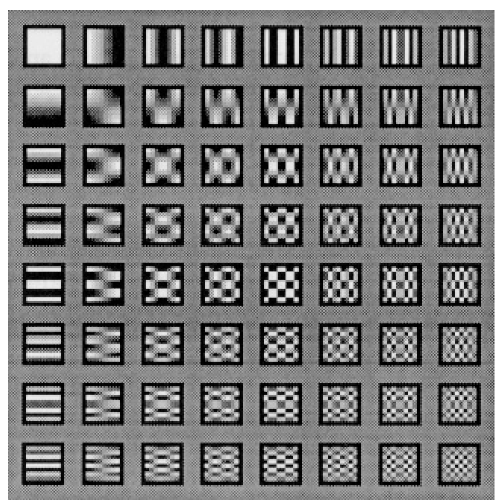

Fig. 3: Visualisation of 64 basis functions cosine frequencies of a DCT

4. Simulation Results

In figure 4, the graph is plotted between the probabilities of user's requesting i^{th} ranked program versus rank of TV programs with various values of beta. Consider the beta values as 1.9, 1.5, 1.0, 0.9, and 0.5. The beta values ranges from 0 to 2. If the rank of TV programs increases the probability of i^{th} request ranked program decreases. The two beta values 1.9, 1.5 are used to calculate the bandwidth requirement in terms of OFDMA PUSC slot rate and delivery scheme allocation.

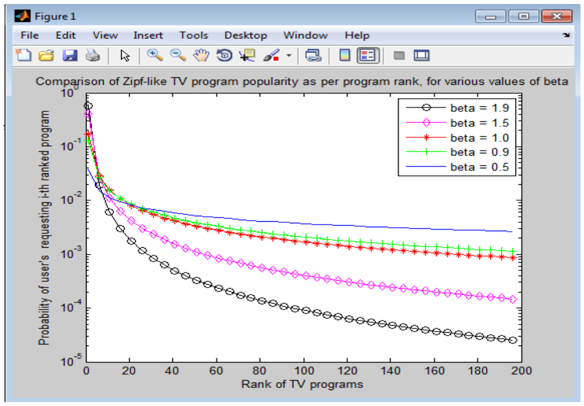

Fig. 4: Rank of TV program versus users requesting i[th] ranked program

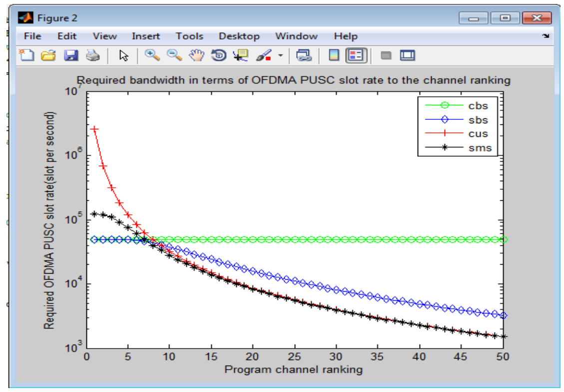

Fig. 5: Required bandwidth in terms of OFDMA PUSC slot rate according to the channel ranking for β = 1.9

Figure 5 shows the required bandwidth for a ranked channel in terms of OFDMA PUSC slot rate with respect to the WSDV delivery schemes. The total number of users U is 200 and two values (1.5 and 1.9) were used for the Zipf parameter. CBS, SBS scheme need limited amount of bandwidth for all number of TV program. But in the case of CUS it requires large amount of bandwidth and also it support unicast only. So it is negligible.

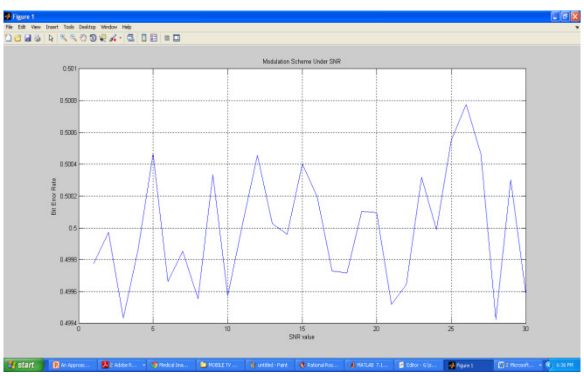

Fig. 6: SNR versus Bit error rate

The eight channels are created and 200 users are watching the program depending upon the delivery schemes. The delivery schemes are CBS, SBS, SMS. These three schemes are used to transmit the video, expect CUS. The transmitting video file size is 176*144, it requires the VSR is in the range of 380 kbps.

Three modulation schemes are providing the various SNR value for 8 channels. The 64QAM provides highest SNR value than the other two modulation schemes (QPSK, 16QAM).

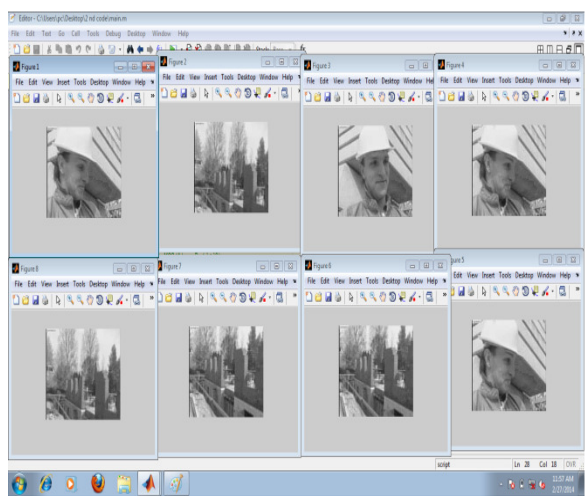

Fig. 7: Creation of 8 Channel using WSDV server

Figure 8 shows the total required bandwidth as a function of the number of users for beta is 1.5 and the spectral efficiency with various combinations of n_{cb} and n_{sb} including the optimal values. Note that the required bandwidth is displayed in terms of the OFDMA PUSC slot rate. For the low Zipf parameter, the combination of n_{cb}=0 and n_{sb}=0 implies CUS. The combination of n_{cb} = 15 and n_{sb} = 15 gets closer to optimality as the number of users increases, the combination of n_{cb} = 5 and n_{sb} = 5 is close to optimality when the number of users is low. However, it diverges increasingly further from optimality as the number of users increases, the combination of n_{cb} = 10 and n_{sb}=10 can maintain the middle road between the above two combinations. Then the result is the optimal selection is able to maintain the minimum of the required bandwidth among all candidate combinations in both beta values.

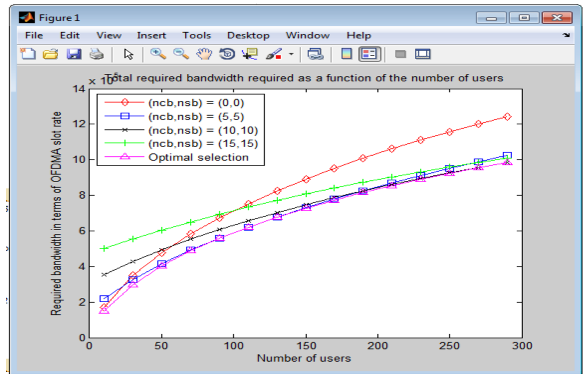

Fig. 8: Total required bandwidth as a function of number of users, β =1.5.

5. Conclusion

This project identified the main hurdle to mobile TV services over WiMAX networks and proposed a hybrid approach, called the WSDV scheme, which is able to expand the limited wireless capacity by exploiting WiMAX AMC gain and by simultaneously accommodating many users watching the same channel. The analytical model can provide an accurate estimate of the amount of bandwidth required for WiMAX TV services, and also enables a designer to optimally select the number of channels via the WSDV schemes while meeting a desired level of blocking probability. Moreover, we proposed an end-to-end framework to efficiently deploy the WSDV solution.

A novel mobile TV services over WiMAX network, called wireless switched digital video (WSDV), is proposed in this project. Unlike with the conventional broadcast or unicast schemes, use a hybrid approach that exploits adaptive modulation and coding (AMC) gain in unicast scheme and at the same time accommodates arbitrary many users watching the same channel like broadcast method, which enables to increase wireless capacity for mobile TV service. And additionally use the AMC based relay and direct communication based mobile TV channels over WiMAX network also design in future.

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