Impact of Convolutional Coding on Downlink Performance of WCDMA Network

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ABSTRACT

Third generation of mobile communications systems (3G) integrate a wide variety of wireless services as multimedia services. Universal Mobile Telecommunications System (UMTS) is the main standard of 3G with WCDMA air interface. The CDMA provides both error detection and error correction as channel coding scheme. The first one is provided by Cyclic Redundancy Check (CRC) coding and the latter by a combination convolution code with turbo decoding. For convolution coding, both soft and hard decision is considered This paper gives simulation observations of convolution coding effect on forward link (downlink) for voice and video service. The results are compared with and without utility based CAC scheme of WCDMA technology and its channel convolution coding soft and hard decision scheme.

Keywords

Bit error rate, channel coding, WCDMA, Voice activity factor. .

1. INTRODUCTION

Third generation wireless systems are expected to provide high bit rate data services suitable for transmitting multimedia information in different types of environments. The potential capabilities of 3G systems include global roaming, high speed data transmission, high quality wireless video and image, internet and intranet access and the convergence of value added data and voice services onto the same mobile device. Third generation has a variable date rate even more than 2Mbps for a user in indoor environment that will tell how this is possible by multicode method. The name WCDMA is used to cover both FDD (Frequency Division Duplex) and TDD (Time Division Duplex) operations. The capability for operating in either FDD or TDD mode allows for efficient utilization of the available spectrum. Here all information and details are about FDD mode.

Using code division multiple access (CDMA) in spread spectrum form is emphatic for personal and cellular communication systems. In general, a CDMA transmitter is integrated of three parts, data modulation, spreading circuit and spreading modulation and the receiver performs vise versa operations.

In WCDMA, the spreading code that is called here scrambling code, is a complex code and therefore, spreading circuit is a complex one and data is inserted to the circuit in two orthogonal branches. Complex spreading is capable for minimizing the signal peak to average ratio and therefore reducing of variations in signal envelope and access to better efficiency in output amplifiers. Utilization of multimedia communications is one target of 3G and WCDMA. WCDMA is designed for supporting different data services, from low to high bit rate. The WCDMA nominal bandwidth is 5 MHz. Since the bandwidth of spread signal is common for all users, multiple rate transmission is required and variable spreading factors are necessary in physical channels. An example is using orthogonal variable length code for spreading. This code is usable for synchronous case between transmitter and receiver [1].

WCDMA system is discussed as the network access of the UMTS. Error detection on transport channel and announcing it to higher layers and error correction are other functions of WCDMA physical layer. This layer executes the commands that come from higher layer only and has no decision about data transmission quality.

Many researchers have been done on the capacity of WCDMA system. In [6] Alma Skopljak Ramovic determined the WCDMA capacity by processing gain, bit energy to noise density ratio, voice activity factor and the total interference. The interference is already included in noise power density and it comprises the Multiple Access Interference (MAI), self interference and co-channel interference.

In [7] B Christer V Johansson explained the optimum value of target Eb/No with respect to bit error rate (BER) to improve the system capacity. In a WCDMA packet data system if the target Eb/No is set too low then the system will suffer from many retransmissions. This will reduce the capacity of the network. However, the number of mobiles that a system can serve simultaneously is inversely proportional to the Eb/No target, so also a too high Eb/No target will result in a capacity decrease.

The parameters which impact on WCDMA capacity are based on type of services such as real-time and non-real-time services. Real-time applications need some guaranteed minimum transmission rate which requires reservation of system capacity.

In [8] Hedge and E. Altman determined the capacity of multi-service WCDMA networks with variable Grade of Service (GoS). The inputs of multi-service cell dimensioning are the offered load, the required resource (effective bandwidth), the requirements on blocking for each service and the total resource available in the cell. For a given number of subscribers the blocking probabilities are different for different services because they share the same pool of resources. The more resources a service needs for one user the [9, 10] higher is the blocking probability.

Traditional definition of capacity of networks is either related to the number of calls they can handle (pole capacity) or to the arrival rate that guarantees that the rejection rate (or outage) is below a given fraction. In this paper a Quality of Service based capacity enhancement for WCDMA networks is designed for different services by fixing thresholds to each service according to their utilization with convolutional coding scheme by selecting suitable Eb/No value with respect BER to maintain the quality of service.

This paper is organized as follows; Section 2 discusses the downlink modulation for WCDMA wireless network Section3 brings out the call admission control scheme and Section4 explain about the simulation results for downlink capacity calculation for different services with and without utility based CAC scheme along with convolution coding soft and hard decision schemes. Section 4 concludes the paper.

2. DOWNLINK MODULATION

Whereas data modulation or symbol mapping of all channels of the uplink is BPSK, in downlink the modulation scheme is QPSK and since the modulation has direct effect on hit rate, there is a difference between bit rates of these two links.

After data modulation, spreading modulation is performed. In WCDMA, spreading is performed in two steps.In the first step, a real code with a chip rate equal to transmission chip rate (3.84 Mcps) is multiplied by data modulated sequence. In the second step a complex sequence with the same chip rate is multiplied by complex spread spectrum signal. The first step is called real or channelization spreading and the second is called complex or scrambling spreading. Figure 3 shows uplink dedicated physical channel spreading and modulation [6].

By data modulation, modulated DPDCHs are split alternatively to I and Q branches with independent BPSK modulated signals. Also, DPCCH is mapped to the Q branch. As mentioned in the previous section, every user has only one DPCCH but several DPDCH. These channels are spread by the same channelization code, Cch and then with scrambling code Channelization codes used in WCDMA are orthogonal variable spreading factor (OVSF) codes. In these codes, even with different spreading factors in their uplink physical channels, the orthogonality is conserved. Orthogonal codes provide variable rate from their variable spreading factors that is used in both links. Using OVSF is one of the suitable factor for flexibility of service access. Spreading modulation scheme in both links is QPSK.

In uplink, users are separated by scrambling code and then can use the same channelization codes. On the other side, channelization codes separate the dedicated channels of a user. Therefore, different users can have the .same channelization codes. But in downlink the conditions is different, both channelization and scrambling codes are used for user separation. It is notable that in this link, scrambling code only separates neighboring cells. Scrambling code has no effect on signal bandwidth extension.

3. CALL ADMISSION CONTROL SCHEME

Call admission control is one of the major tasks of radio resource management (RRM); when a new connection is set up, the admission control will be used to guarantee that there are free radio resources. In addition, CAC determines which base station will have power control and must have sufficient bandwidth to support the new connection without dropping any of the existing ones. If this condition is not met, the new connection request will be rejected. This check is done whenever a user enters a new cell, either through a new call or handover call [10].This section explains about the CAC for WCDMA system with adaptive multi rate technique to enhance the voice user capacity.

3.1 CAC for WCDMA

The two most commonly used call admission control schemes are Wideband Power Based (WPB) scheme and Throughput Based (TB) scheme [11, 12]. The principle of this scheme is a new user is admitted when the new load factor after the new user's admission does not exceed the predefined threshold. The uplink and downlink directions are considered and only if the condition is met, the new connection request can be admitted.

The new load factor for the network uplink or downlink is the sum of the existing uplink or downlink load factor and the increase in load factor. ΔL.

$$\eta_{New} = \eta_{Old} + \Delta L \qquad (1)$$

The computation of the uplink existing load factor and the downlink existing load factor is shown in (2) and (3) respectively.

The computation of η_{UL} is given by

$$\eta_{UL} = (1+i)\sum_{j=1}^{N} \frac{1}{1+\dfrac{W}{(E_b/N_o)_j R_j v_j}} \qquad (2)$$

where

W is the chip rate
v_j is the voice activity factor of j^{th}user
R is the bit rate of j^{th}user
E_b/N_o is the bit energy to noise density ratio of j^{th} user
i is the total interference
N is the number user

The computation of η_{DL} is given by

$$\eta_{DL} = \sum_{j=1}^{N} R_j \frac{v_j (E_b/N_o)}{W} [(1-\alpha_{av}) + i] \qquad (3)$$

α_{av} is the average orthogonality factor of the cell

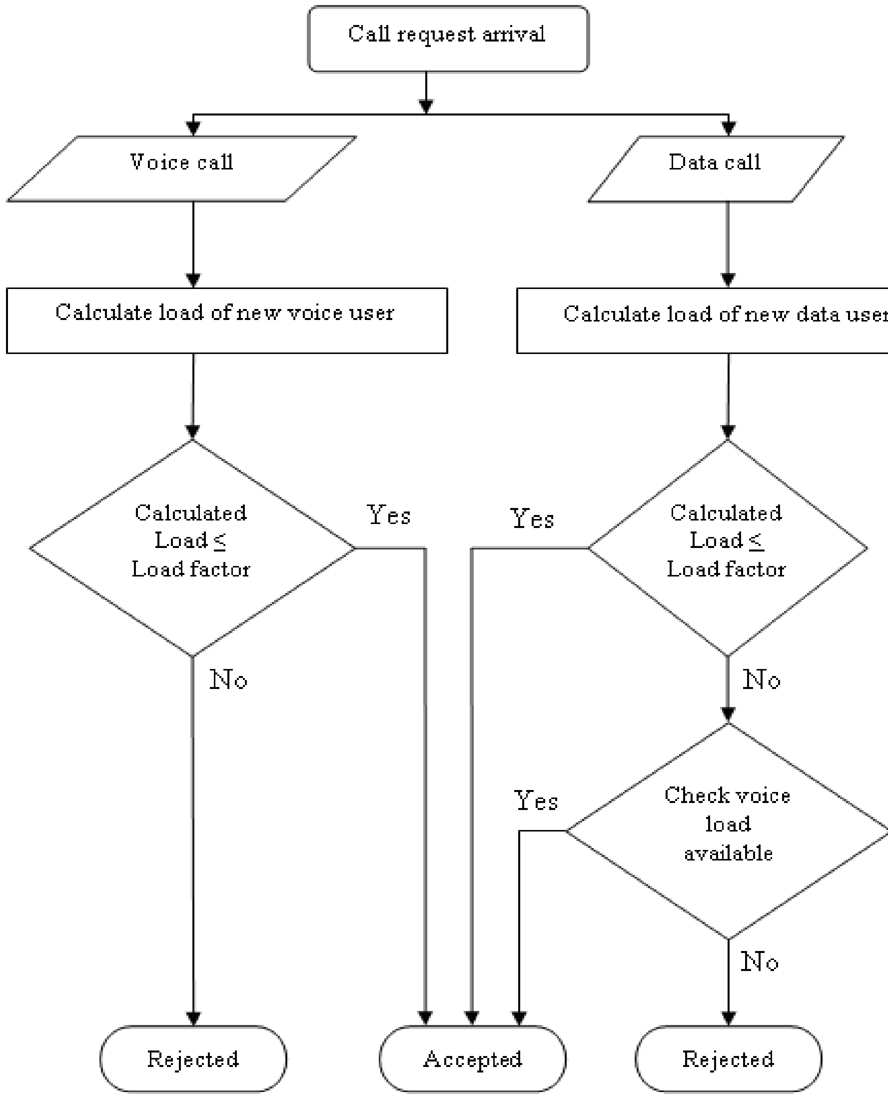

Fig 1: Flow chart of utility based CAC scheme

The performance of utility function based CAC algorithms is analyzed in the downlink channel of WCDMA network. The downlink load factor is set to 0.7 to maintain the channel load without affecting the QoS. Within the load factor limit of the channel the load factor for different services are selected according to the service needs and QoS [14]. The new call request is admitted as per flow chart shown in Fig.1.

The new load factor for the downlink is the sum of the existing downlink load factor η_{DL} and the increase in the load factor ΔL. The new load factor cannot exceed a predefined threshold:

$$\eta_{DL} + \Delta L \leq \eta_{DLthershold} \tag{4}$$

$\eta_{DLthreshold}$ is the downlink load factor threshold value

Initially the call is identified as voice call or data call and then it is checked for the resource availability as per load factor threshold value for individual service. The sum of new call load and existing connection load is less than the threshold value of individual services then the call is admitted otherwise it is rejected.

$$\eta_{DLvoice} + \Delta L \leq \eta_{DLvoicethreshold} \tag{5}$$

$$\eta_{DLdata} + \Delta L \leq \eta_{DLdatathreshold} \tag{6}$$

$\eta_{DLvoicethreshold}$ is the downlink load factor voice threshold value.

$\eta_{DLdatathreshold}$ is the downlink load factor data threshold value.

One major limitation of the fixed threshold schemes is that the reserved capacity for voice traffic classes may remain unutilized while video priority classes are being blocked. In the proposed scheme the unutilized resources are utilized by blocked users of the fixed threshold scheme [15]. This will improve the capacity of the network as well as reduces the call blocking probability of the network.

4. PERFORMANCE ANALYSIS

The objective of this simulation is to analyse the utility based CAC for different services in WCDMA network. The simulation model is based on downlink load factor 0.7 with 70% voice users and 30% video users. The capacity of the network enhanced with utility function based call admission control with convolution code soft decision scheme is compared to the capacity of the network with utility function based call admission control with convolution code hard decision scheme in terms of capacity and number of blocked users. The simulation parameters which are used are shown in Table.1.

Table1. Simulation parameters

S.No	Parameter	Values
1	Chip rate (W)	3.84 Mcps
2	Voice Bit rate (R)	12.2 kbps
3	Video Bit rate (R)	64 kbps
4	Voice Activity factor(υ_j)	0.67
5	Total interference (i)	0.55
6	Orthogonality factor(α)	0.9
7	Voice Bit energy to noise density ratio (Eb/No)	6.7dB,5dB,2.7dB
8	Video Bit energy to noise density ratio (Eb/No)	9.6dB,6.5dB,4.1dB

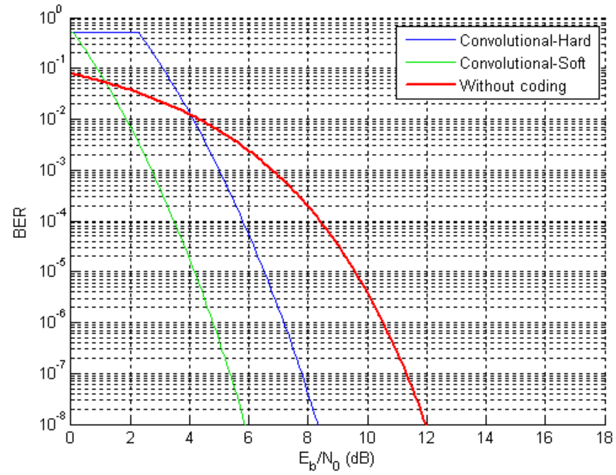

Fig.2. Bit Error Rate vs Bit energy to noise density ratio

The Fig.2 shows the Bit Error Rate to the Bit energy to noise density ratio (Eb/No) of QPSK modulation of WCDMA network for convolution coding with soft and hard decision scheme. To maintain QoS for voice service the BER is 10^{-3} and the corresponding Eb/No values are 6.7 dB for without coding, 2.7 dB and 5 dB for convolution code soft and hard decision scheme respectively. Similarly for video service the BER is 10^{-5} and the corresponding Eb/No values are 9.6 dB for without coding, 4.1 and 6.5 dB for convolution code soft and hard decision scheme respectively.

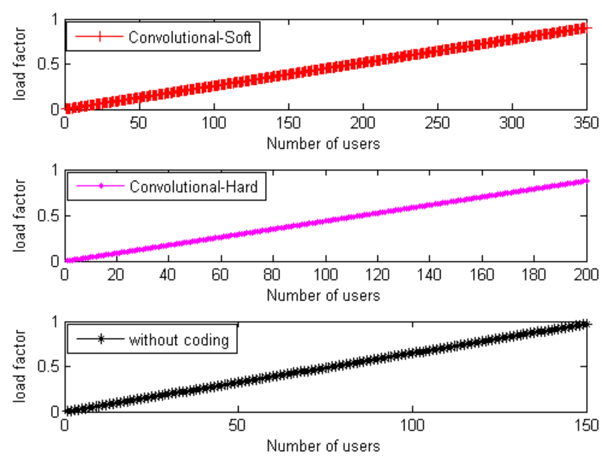

Fig.3. Downlink load factor for voice service with coding

The Fig.3 shows the number users admitted in the forward channel of WCDMA network for voice (12.2 kbps) service without coding scheme and convolution code with soft and hard decision scheme. The number of users connected to the network is 109 voice users for without coding scheme, 160 users and 272 users for convolution code with hard and soft decision scheme respectively for load factor threshold value of 0.7.

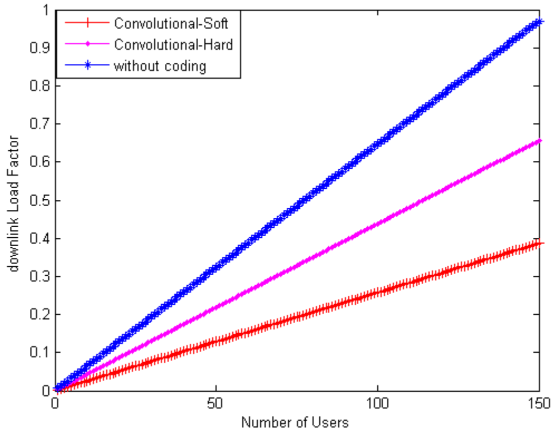

Fig.4. Downlink load factor for voice service with Convolution coding

The Fig.4 shows the capacity enhancement of WCDMA network for voice (12.2 kbps) service for different coding scheme. The number of users at an instant is 150 the corresponding downlink load factor is 0.9708 for without coding scheme, 0.6563 for convolution code with hard decision and 0.3839 for convolution code with soft decision.

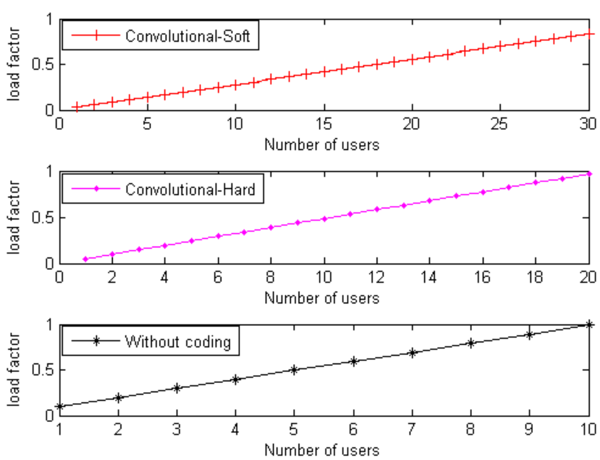

Fig.5. Downlink load factor for video service with Convolution coding

The Fig.5 shows the number users admitted in the forward channel of WCDMA network for video (64 kbps) service without coding scheme and convolution code with soft and hard decision scheme. The number of users connected to the network is 7 video users for without coding scheme and 14 and 25 video users for convolutional hard and soft decision for the load factor threshold value 0.7.

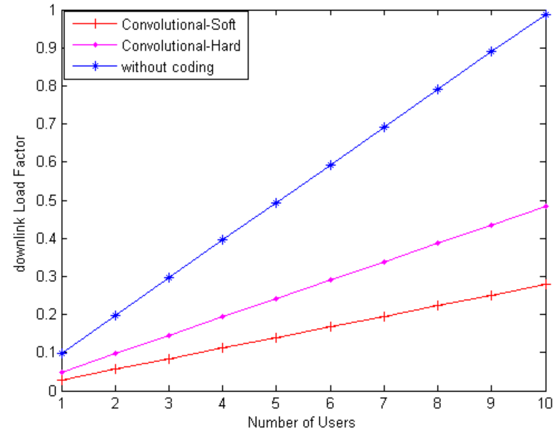

Fig.6. Downlink load factor for video service with Convolution coding

The Fig.6 shows the capacity enhancement of WCDMA network for video (64 kbps) service for Convolution coding scheme with hard and soft decision. When the number of users at an instant is 10 the corresponding downlink load factor is 0.988 for without coding scheme, 0.4839 for convolution hard decision and 0.2785 for convolution soft decision scheme.

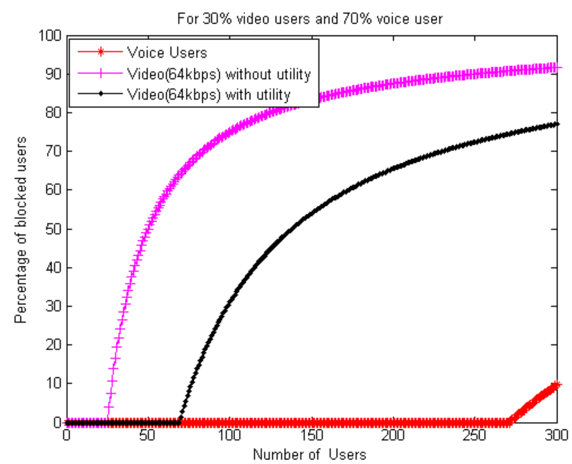

Fig.7. Percentage of blocked video users for Convolutional code –Soft decision

The Fig.7 explains the percentage of blocked users for the service utility combination of 30% video users and 70% voice users. The load factor for video user is 0.21 and for voice user is 0.49. At particular instant if the number user is 100, the percentage of blocked video user is 75% without the utility function and 31% with utility function. The utility based CAC scheme reduces 44% of blocked video users by means providing resources from the unutilized voice service.

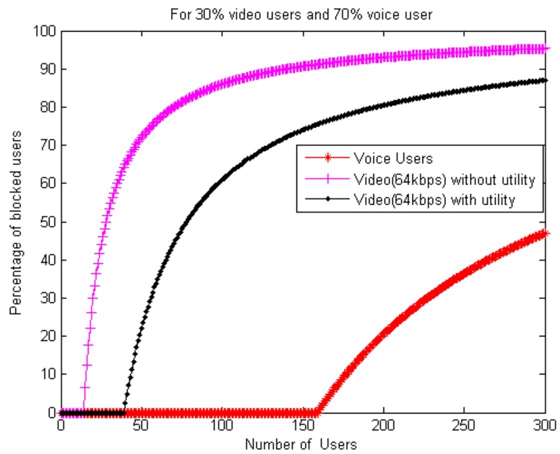

Fig.8. Percentage of blocked video users for Convolutional code –Hard decision

The Fig.8 explains the percentage of blocked users for the service utility combination of 30% video users and 70% voice users. The load factor for video user is 0.21 and for voice user is 0.49. At particular instant if the number user is 100, the percentage of blocked video user is 86% without the utility function and 61% with utility function. The utility based CAC scheme reduces 25% of blocked video users by means providing resources from the unutilized voice service.

5. CONCLUSION

In this paper, the performance of WCDMA network for different services such as voice (12.2 kbps) and Video (64 kbps) are calculated for the downlink load factor value of 0.7. The quality of service for voice and video users are maintain by selecting appropriate value of BER for Convolution code with soft and hard decision scheme and without coding scheme. The number of users admitted is evaluated for convolution coding with soft and hard decision scheme and without coding for the same load factor. The network capacity further enhanced with convolution code with soft decision scheme as well as the utility based CAC scheme.

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