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A THEORETICAL PREDICTION OF USERS IN WCDMA INTERFERENCE

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ABSTRACT

The major problem that we are faced too in wireless systems is the interference. This problem contributes in limiting the performance of cellular networks. In 3G, Wide Code Division Multiple Access (WCDMA) techniques play an important role. WCDMA is defined as a digital cellular wireless technique that uses the method of spread spectrum to convert a digital narrow radio signal to a wide radio signal. Among the popular civilian techniques that use spread spectrum communications, we find Code Division Multiple Access (CDMA). In this paper, we study the cochannel interference that affects the system performance. Also,the different causes of interference are identified. By adopting microzoning architecture, we have developed an analytical expression of the ratio Signal to Noise (SNR). Then, we used this result to predict some parameters. By fixing the SNR variable to a specific value, we extract easily information on the optimal numbers of users.

Keywords: *Wcdma, Interference, Wireless Systems, Cellular System, 3g.*

1. INTRODUCTION

Actually, there have been three different types of wireless networks. The first three types are defined by air interfaces and transport techniques. The basic mobile technology called 1G [1] is based on analog modulation technique, such as the American Mobile Phone Service (AMPS) and the NTT technologie used in Japan. The second generation
(2G) [2] is based on digital modulation technique. Among the 2G systems, we distinct the europeen Global System for Mobile Communications (GSM), the North American Standard (IS-95) and the Personal Digital Cellular (PDC) used in Japan. To meet a need of users in terms of data transfer, we find the 2.5G [3] wireless networks . This technology offers a lot of range of services which are articulated around the following points : telephone banking, airline reservations, transactions, E-mails, games The third generation (3G) mobile networks [4],[5] are characterized by their ability to carry data
at rates greater than 9.6 Kbps (Kilobits per second) supported by 2G mobile networks, and several tens of Kbps (around 164 Kbps) offered by 2.5G mobile networks. The 3G mobile technologies offers significantly much bandwidth and can offer new mobile services, as enhanced multimedia applications that cannot be supported by 2G and 2.5G mobile networks. With dereglementation of telecommunication sector, many operators are developing systems for new generation of cellular networks such as 3G, 4G and beyond. The evolution of flow and looking for a greater capacity for these new generations will be accompagned by an improvement of transmission constraints in relation to the growing number of users for mobility and diversity of services. The determination of number of users for an operator is of great interest because it permit to improve their revenue.

2. WCDMA OVERVIEW

Wideband Code Division Multiple Access (WCDMA) [6] is the access technique used in a 3G mobile communication system. It gives higher speeds which permit greater transfer of data because of a convergence of three perspectives : user services convergence, device convergence and network convergence. a) User service convergence It implies that there are common user service delivery capabilities with access and device awareness. It means that a

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multitude of services (person to person, person to content and content to person) can be provided to the same user over different access networks and to different devices. b) Device convergence Implies common devices supporting several access types. This convergence allows multiple applications to ber un, reusing the same function for identification and authentification. The mobile device supports more and more function in addition to telephony, e.g. Camera, TV, Video and E-mail. c) Network convergence Implies the consolidation of the network to provide different user services, with telecom-grade quality of service to several access types with an emphasis on operator cost efficiency. To realize the convergence, a layered architecture is implemented.

2.1 WCDMA General principles

WCDMA is a digital method for sharing the frequency spectrum. It is a spread-spectrum technology that uses codes to separate users in the same frequency spectrum. The main parameters of WCDMA is given as follow:

- WCDMA is a wideband Direct Sequence Code Division Multiple Access (DS-CDMA) system, ie., user information bits are spread over a wide bandwidth by multiplying the user data with bits (called chips)derived from CDMA spreading codes. In order to support very high bit rates, the use of a variable spreading factor and multicode is supported.

- The chip rate of 3.84 Mcps leads to a carrier bandwidth of 5 MHz. The wide carrier bandwidth of WCDMA supports high user data rates and have certain benefits, such as multipath diversity.
- WCDMA supports high variable user data rates, in other meanings the concept of obtaining Bandwidth on Demand (BoD) is supported. The user data rate is kept constant during each 10 ms frame.

- WCDMA supports two basic modes of operation:Frequency Division Duplex (FDD) and Time Division Duplex (TDD). In FDD mode, separate 5 MHz carrier frequencies are used for the uplink (from user equipment to Node B) and downlink respectively, whereas in TDD only one 5 MHz is timeshared between the uplink and downlink.

- Efficient power control. It reduces the interference in the whole network and automatically increases capacity. Also, the battery lifetime of the mobile is increased. - Fast and efficient packet-access. - Built-in support for capacity/coverage-enhancing technologies such as adaptive antennas, advanced receiver structurs and transmitter diversity. – Support of inter-frequency handover and handover to other systems, including handover to GSM.

- HSDPA (High Speed Downlink Packet Access) [7] provides peak data rates up to 14.4 Mbps. The new transport channel is called HS-DSCH (High Speed Downlink Shared Channel) and it supports for interactive, background, and to some extent, streaming services.

- HSUPA for uplink packet access and is specified for FDD mode. It provides up to 1.92 Mbps in the uplink.

3. CAUSES OF INTERFERENCE

The causes of interference are diverse. Radio Frequency (RF) interference to mobile communication network may be caused by such parameters as an original dedicated radio system ocuupying an existing frequency ressource, improper network configuration by different operators (value of power), cell overlapping, the radio channel, electromagnetic compatibility (EMC), external interference sources. Reffering to [8], it comes out that the primary forms of interference to mobile communication systems mainly include : common-frequency interference, adjacent-frequency interference, out of band spurious emission, inter-modulation emission, and blocking interference. The problem of interference between systems working in different frequencies is caused by hardware problem in the transmitter (Tx) and the receiver (Rx). The Tx in sending useful signal, in some situations generate out-of-band spurious emission signal, which include adjacent-frequency emission and out-of-band spurious emission. While the Rx receives the useful signals, interfering signals falling into the channel is the cause of losing the receiver sensitivity, and the interfering signals falling into the receiving bandwidth may cause in-band blocking ; meanwhile, the Rx also has imperfections due to non-linearity, and out-of-band signals (Tx useful signals) will cause out-of-band blocking of the Rx. Recall also that the

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interference between the Tx and the Rx depends on some parameters such as the interval between the working frequency ranges of the two systems and the spatial distance which separate the Tx and Rx. For a WCDMA system, the interference can be generated by different source, namely, thermal noise, traffic intra-cell, traffic in adjacent cells and external traffic [9],[13],[11] (other operators using adjacent frequencies). One method of measuring the interference leakage between channels operating on different frequencies, we find the ACLR (Adjacent Channel Leakage Ratio) [12] which measures the imperfections of filter when transmitting in its own channel and one carrier will send part of its power into adjacent channels. In case of considering the existence of interference caused by two adjacent carriers, the parameter measuring the total interference is given by ACIR (Adjacent Channel Interference Ratio) [12] and expressed as:

$$ACIR = \frac{1}{\frac{1}{ACLR} + \frac{1}{ACS}} \qquad (3.1)$$

Where
ACLR: Adjacent Channel Leakage Ratio is a measure of transmitter performance for WCDMA. It is defined as the ratio of the transmitted power to the power measured after a receiver filter in the adjacent RF channel. This is what was formerly called Adjacent
Channel Power Ratio. ACLR is specified in the 3GPP WCDMA standard and ACS:
Adjacent Channel Selectivity (ACS) is a measurement of a receiver's ability to process a desired signal while rejecting a strong signal in an adjacent frequency channel. ACS is defined as the ratio of the receiver filter attenuation on the assigned channel frequency to the receiver filter attenuation on the adjacent channel frequency.In Wireless access technologies, besides environmental natural phenomena which cannot be eliminated we distinguish other kinds of interference scenarios [7] :
(a) CDMA-800 DL in 869-894MHz and the GSM or WCDMA UP in 880-915 MHz,
(b) Coexistence of TD-SCDMA and PHS systems,
(c) Coexistence of CDMA-2000 networks operating in the 450 470MHz and other services,
(d) CDMA-2000 downlink (DL) in the band frequency 1930-1990MHz and theWCDMA uplink (UP) in 1920-1980 MHz. A detailed study of the mutual interference between CDMA-800 operating at DL 869-894MHz and GSM 900 at UP 890-915 MHz is recently given in (ref-my paper).system

4. CONCEPT OF CELLULAR SYSTEM

The cellular concept play a crucial role in determining the cause of interference and spectral congestion. To satisfy a maximum users, we need more channels and more base stations with a decrease in transmitter power to mitigate problem of interference.
Because of the scares ressources, the cellular network rely on reuse of channels throughout a coverage region [14],[15],[16]. Each base station is composed of a set of a small geographic area called a cell. Among the solution to increase the capacity, we are the frequency reuse which means that the same group of channels may be used to cover different cells that are fare from each other by sufficence distances to maintain interference value within tolerable limits. The following figure illustrates an example of frequency planning, where the cells labeled the same number use the same group of channels. The frequency planning is overlaid upon a map to mention where different frequency channels are used. The hexagonal cell in figure (2) is a theoretical model of the radio coverage for each base station and is considered as a universal model adopted because it allows an easy mathematical analysis.
The hexagonal model given in fig (1) has six equidistant neighbors and the lines joining the centers of any cell and each of its neighbors are separated by multiples of 60 degrees. There are only certain cluster sizes and cell layouts which are possible [17].
In order to make a connection without gaps between adjacent cells, the geometry of hexagons is such that the number of cells per cluster, N, can only satisfy the equation:

$$N = i^2 + j^2 + i * j \qquad (4.1)$$

Where i and j are non negative integers. In order to find the nearest co-channel neighbours of any cell, we must follow by order the following points : 1) Move i cells along any chain of hexagon 2) Turn 60 degrees counter clockwise and move j cells This method is illustrated in the figure 1.

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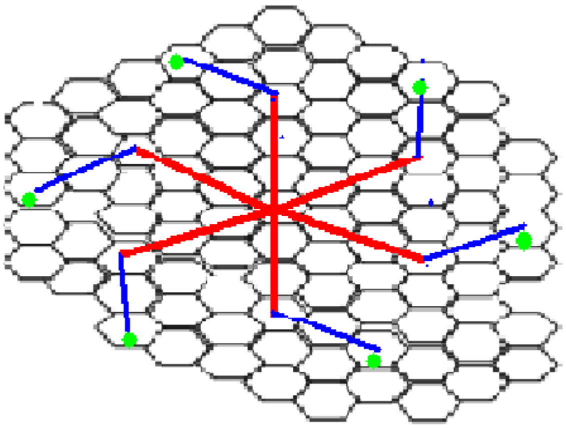

Figure 1: Location of co-channel cells in a cellular network.

In WCDMA system, the problem of the cochannel interferences causing by the neighboring cells is allowed in the objective to improve the capacity. As already seen, there have been a lot of strategies to manage the cochannel interference (ref). In our case we adopt a WCDMA cellular architecture which is used to reduce the CCI. The architecture given in fig (2) consist on 7 circle and each circle included 7 micro hexagonal cells. We suppose that the location of mobile unit is in the center of the hexagonal cellular. In this situation, The CCI is worst.

5. ANALYTICAL EXPRESSION OF S /I

There are many cellular architecture to reduce the cochannel interference. In our situation, we adopt the the architecture given in fig2. Each cell is epresented by a circle and each hexagon represents a microzone [18]),[19],[20]. In the figure2, we have 7 cells and 49 hexagonal microzones. We suppose that the location of mobile unit is at the center and out of 42 outer cells microzones only the cells represented by a red point are causing interference to the mobile unit. Applying the pytagore law, we can easily computed the distance between the mobile unit to the interfering microzones and is given as:

$$\sqrt{19}R$$

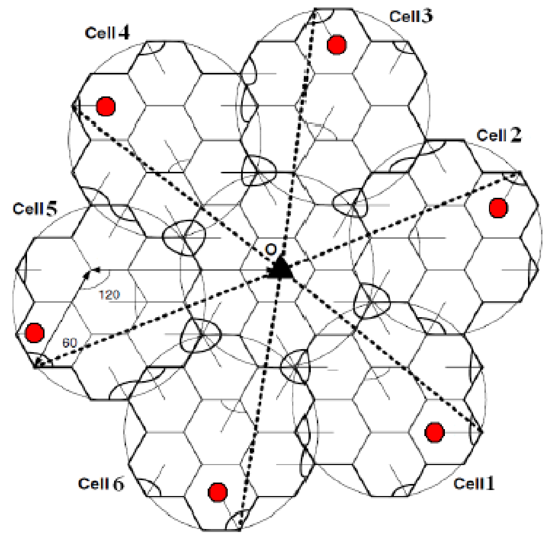

Figure 2: Cellular architecture.

For WCDMA system,the cochannel interference at the location of the mobile unit is given as:

$$\left(\frac{S}{I}\right)^{-1}_{CCI} = 2*\frac{(2.59)^{n_0}}{3N}\left[a\left(\sqrt{19}R\right)^{-n_a} + b\left(\sqrt{19}R\right)^{-n_b} + c\left(\sqrt{19}R\right)^{-n_c} + d\left(\sqrt{19}R\right)^{-n_d} + e\left(\sqrt{19}R\right)^{-n_e}\right] \quad (5.1)$$

where a, b, c, d, and e represent the number of users in the interfering microzones of neighboring cells, the n*a;* n*b;* n*c;* n*d;*n*e;* and *nf* represent respectively the path loss exponents for microzones a, b, c, d, e, and f The ratio *S*
I is the signal to co-channel
interference. One method to maximize the *SI* ratio is to increase the the frequency reuse distance, i.e. increase the the distance between the cellules using the some set of frequencies. The *S I* parameter determines the frequency re-use distance of a wireless network.
The signal-to-noise ratio is expressed in terms of the parameters S/I as:

$$\left(\frac{S}{I}\right)^{-1}_{CCI} = \left[\left(\frac{E_b}{N_0}\right)^{-1} + \left(\frac{S}{I}\right)^{-1}_{intra} + \left(\frac{S}{I}\right)^{-1}_{CCI}\right]^{-1} \quad (5.2)$$

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where $\left(\frac{E_b}{N_0}\right)$ is the $\left(\frac{S}{N}\right)$ ratio caused by the additive white Gaussian noise (AWGN), $N0$ is the noise power, $Eb = PbTb$ is the average bit energy, Tb is the bit duration, and Pb the average ransmitted power.

The intra-cell interference is given by,

$$\left(\frac{S}{I}\right)^{-1}_{intra} = \frac{2}{3N}\sum_{K=1}^{K_0}\frac{P_K}{P_0} \quad (5.3)$$

where N is the system processing gain, $k0$ is the number of users in the reference cell,Pk is the average transmitted power from the kth user reference base station

6. SIMULATION & RESULT

The following figure is obtained for the co-channel interference based on eq (5.1).

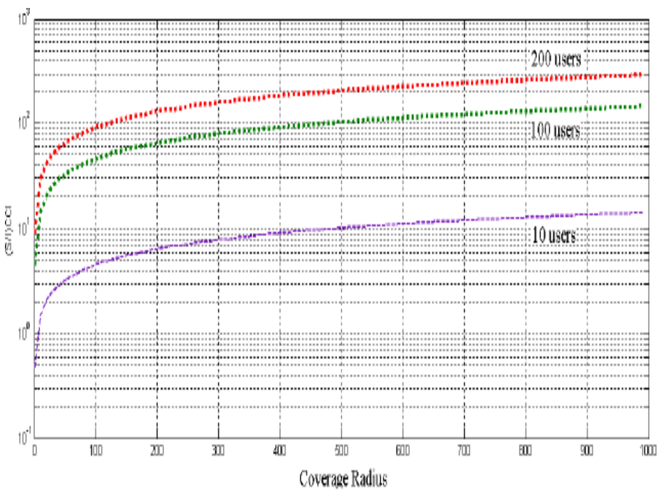

Figure 3: Evolution of cochanel interference.

This simulation is computed for a WCDMA system with some parameters as bellow:
Processsing gain: 128
Path loss exponent : 3/2

The following figure illustrates the variation of ratio (S/I) with respect to the coverage radius of cells. From figure (3), we learn the following:

a) For a given value of coverage radius and for a desired value of (S/I), we can determine the number of users in the interfering microzones. For example, at coverage radius R=400 m and (S/I) < 5dB, we find that required number of users is 10.

b) The same approach may also be used for other architectures for WCDMA cellular systems, the same relation for (S/I) is valid except that we have to compute the distance between the mobile and unit and the cells causing interference to this mobile. This interference in WCDMA affects the quality of service (QoS) negatively. It causes a reduction in revenue for the operators. For this reason, the prediction of number of users plays an important role. Indeed, when we control the number of users in a given area, it is easy to deploy exactly the equipment necessary to ensure a better QoS to users.

Furthermore, if one succeeds to integrate some system parameters into the analytical result, this approach could also be used for other applications.

7. CONCLUSION

In this paper, we have presented the major problem that contributes in limiting the performance of cellular networks. Also, we have developed an analytical method for studying the co-channel interference in WCDMA system. We have adopted a microzoning architecture to compute the (S/I) ratio. This analytical result is used to predict the number of users per microzones. This result is of crucial importance because it contributes positively in improving the quality of services. Furthermore, if one successes to integrate some system parameters into the above theoretical result, this approach could also be used for other applications.

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