

*Study of Power Control in CDMA System on the basis of
optimization Technique: A Survey*

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Abstract: The power control in CDMA systems, grant numerous users to share resources of the system uniformly between each other, leading to expand capacity. With convenient power control, capacity of CDMA system is immense in contrast of frequency division multiple access (FDMA) and time division multiple access (TDMA). If power control is not achieved numerous problems such as the near-far effect will start to monopolize and consequently will reduce the capacity of the CDMA system. However, when the power control in CDMA systems is implemented, it allows numerous users to share resources of the system uniformly between themselves, leading to increased capacity For power control in CDMA system optimization algorithms i.e. genetic algorithm & particle swarm algorithm can be used which regulate a convenient power vector. These power vector or power levels are dogged at the base station and announce to mobile units to alter their transmitting power in accordance to these levels. The performances of the algorithms are inspected through both analysis and computer simulations, and compared with well-known algorithms from the literature.

Keywords: Power Control, CDMA, Algorithms, Optimization, performance.

I. INTRODUCTION

Code in frequency so that the transmitted signal bandwidth is much larger than the original signal's bandwidth. CDMA offers many benefits that make it more bandwidth efficient than plain FDMA or TDMA. These benefits are obtained by incorporating certain features that are possible due to the noise-like characteristics of the signal waveform. One of the most important of these is universal frequency reuse, that Division multiple access (CDMA) is a spread spectrum technology, in which each user is assigned a pseudo-random spreading code. Using this code, the narrowband data signal of the user is spread is, all users occupy a common frequency spectrum allocation. This increases the spectrum usage, and eliminates the need for planning for different frequency allocation for neighbouring users or cells. Another benefit is the use of the RAKE receive, which can constructively combine multi path components, thus mitigating channel fading-CDMA also enables soft handoffs among base station which improves cell boundary performance and prevents dropped cells. Yet another benefit is the use of voice activity (reducing the transmission rate during silent periods in a conversation), which reduces interference and thus has a direct impact on capacity.

There is no single well-defined definition for wideband CDMA (WCDMA). One proposed definition is based on the coherence bandwidth of the channel, i.e., the minimum distance between two frequencies such that the channel fading at those frequencies is essentially uncorrelated. The CDMA system is called wideband CDMA if the transmission bandwidth exceeds the coherence bandwidth. Some definitions are based on the chip rate or bandwidth as a fraction of centre frequency. Anyway, there is no distinct threshold separating narrowband CDMA from WCDMA.

II. POWER CONTROL

With convenient power control, CDMA offers great capacity in contrast to FDMA and TDMA. Since in CDMA systems there is no need of secluding of time or frequency slots among users, the fundamental mechanism for resource allotment and interference management is power control. So power control is a powerful design problem in CDMA systems. Every user adjusts its approach to the resources by acclimate its transmitting power to the dynamic channel and interference circumstances. Therefore power control also known, as Transmit Power Control (TPC) is a powerful design problem in CDMA systems. Power control encloses the techniques and algorithms used to govern the transmitted power of base stations and mobiles. Power control helps in to overcome co-channel interference, raising the cell capacity by diminish interference and increase the battery life by using a minimal transmitter power. In CDMA systems power control guarantee disposal of resources among users. If power control is not enforce, all mobiles will transmit signal with the same power without taking into attention the fading and the distance from the base station, so mobiles near to the base station will cause a high level of interference to the mobiles that are at the distance from the base station.

III. CODE DIVISION MULTIPLE ACCESS (CDMA) DIGITAL SYSTEM

A. A critique of CDMA System in Wireless Communication

The development of the code division multiple access (CDMA) scheme is mainly for capacity reasons. CDMA is one of the techniques used in spread spectrum systems. Spread spectrum is a means of transmission in which the signal occupies a bandwidth in excess of the minimum necessary to send the information: the band spread is accomplished by factor of a code which is autonomous of the data, and a harmonized reception with the code at the receiver is used for de-spreading and consequent data recovery. In CDMA users are allowed to transmit simultaneously in time and occupy the same RF bandwidth as well, every user is given its own code, which is almost orthogonal (i.e, has low cross correlation) with the codes of the other users [1]

The essence of CDMA is the use of an additional dimension in signal space which enables transceivers which occupy the same bandwidth (in contrast to FDMA systems) and exist at the same time (in contrast to TDMA systems) still to be separate. This is done by spreading the wanted transmission bandwidth, multiplying the wanted digital signal by a spreading code at a substantially higher bit rate. (The resulting bits are usually referred to as “chips” to distinguish them from message bits.) if the spreading code has the spectral properties of a pseudo-random binary sequence, then the result the multiplication is a noise-like signal, but when the spread spectrum signal is processed through a correlation, which has knowledge of the sequence used to perform the spreading in the transmitter, then the wanted signal is recovered. If many sequences can be identified which have low cross-correlation characteristics then an equivalent number of spread spectrum transmission can co exists but remain orthogonal or quasi-orthogonal.

In theory, it does not matter whether the spectrum is divide into frequencies, time slots, or codes, the capacity provided from these three multiple access schemes is the same. The difference between the three multi accessing techniques becomes apparent when various real-world constraints are imposed upon the ideal situation. For example, one attractive feature of CDMA is that it does not require the network synchronization TDMA requires. However, in cellular system where multi path is one of the major concerns, CDMA exhibits the unique feature of anti-multi path [6]. In CDMA, the frequency selectivity of the radio channel, which severally impairs the system performance, can be averaged out. Hybrid combinations of these techniques are frequently used (as in frequency –hopping GSM systems)

Spread-spectrum conversation with its implicit inference attenuation capability has over the years become a progressively popular technique for use in various systems. Applications field from anti-jam system as in military use [8] to code divisions multiple access system, to systems designed to encounter multi path in wireless communication.

B. A Basic summary of a CDMA System

The ways in which the spectrum is spread include “direct-sequence”, “frequency hopping” and “time hopping”. By “direct sequence” it means that a fast generated pseudorandom sequence causes phase transitions in the carrier containing data, and “frequency hopping” in which the carrier is caused to shift frequency in a pseudorandom way. While in ‘time hopping’ a message transmitted with a data rate of R requiring a transmit time interval is now allocated at a longer transmission time interval which the data are sent in bursts dictated by a hopping pattern. The time interval between bursts also can be varied. Among the three methods the first two spreading techniques are commonly used. Figure 1 shows a basic system used in spread spectrum technology. Spread spectrum technology can be thought of as second modulation techniques [2].

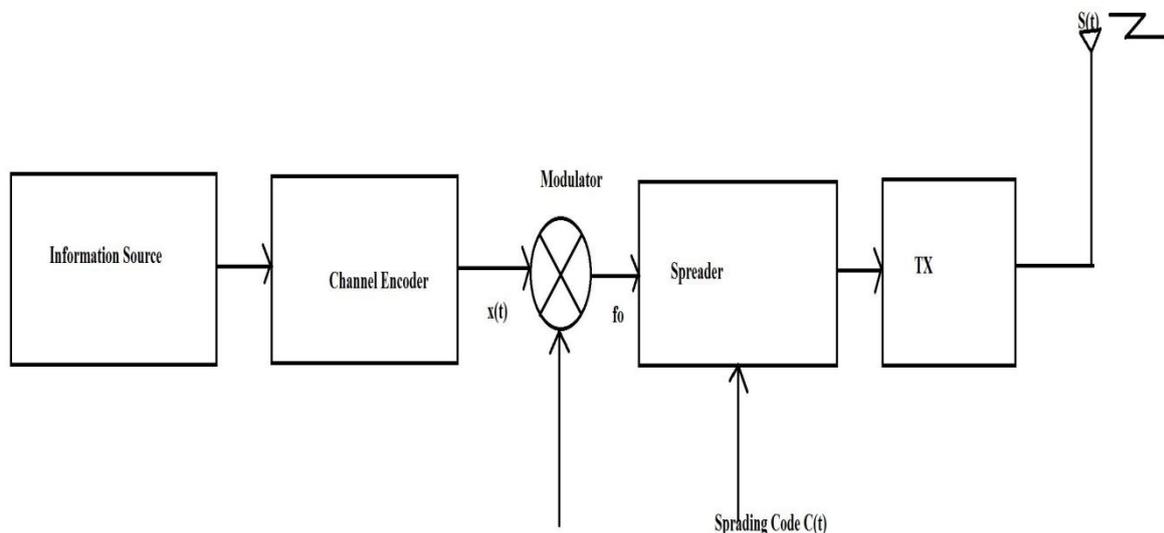


Fig.I : A basic spread spectrum system

IV. UNIQUENESS OF CDMA SYSTEM

CDMA permits all users to transmit using the same band of frequencies all the time. Each use a code which is as orthogonal to the codes of other users as possible. Thus CDMA techniques provide great immunity to interference. In wireless digital communications, multi path is the main cause of fast Rayleigh fading, interference arise both from others and self-interference because of multi path. Transmitting signals over multi path fading channels causes distortions and variations at the receiver. For wide band signals, the effect of Rayleigh fading is mitigated [3].

In cellular CDMA system the same channel centre frequency is used in all cells. The CDMA waveform properties that provide processing gain are used to discriminate between signals that occupy the same channel. When the mobile is handed-off from one cell to another, it does not switch frequencies. The new cell site assigns a modem. While the old cell site still continues to handle the call. While the mobile is located in the transition region between two cells, the call can be switched back and forth between them as signal strength dictates; at this time cell site diversity mode can be given to the mobile. Only when the mobile is well established in the new cell with the original cell site discontinue handling the call.

Any user can access the system any time without waiting for a free channel. Thus there are no blocked calls in the usual sense. There is no hard limit on the number of active users that can be handled simultaneously by the system. When the number of active users exceeds the design value, the result is a degradation of performance for all users rather than denial of access. This is usually referred to as “graceful degradation”.

Because each user retains his unique signal set permanently, there is no channel switching or address change as the user moves from cell to cell. Hence, the particularly objectionable characteristic of FM systems known as “forced termination”. Which occurs when mobile crosses a boundary into a cell in which no channel is available –will not occur in this system?

Since all users occupy the same band, all user hardware is identical except for the filters associated with the unique signal set. And each potential user of the system is assigned a unique signal set; message privacy is achieved as a fringe benefit [6].

Priority message can be accommodated in the system, even in the presence of system overload, without assigning dedicated channels or denying other users access to the system. This can be done by increasing the power level, on an emergency bases.

In addition, there are many other attributes of CDMA that are of great benefit to cellular system. Among them are:

- Using voice activity factor and sectorization for capacity.
- No guard time comparing with the case in TDMA.
- Co-existence in the same frequency band as conventional narrowband systems. This makes the transition from existing communication system to digital CDMA system easier.
- Good for micro cell and in-building system. Because of its spreading spectrum feature, CDMA is a nature waveform suitable for micro cell network and in-building environment.
- No frequency management or assignment needed compared with FDMA system.

V. OPTIMIZATION TECHNIQUES

a) Particle Swarm Optimization Approach

Particle Swarm Optimization (PSO) is a method for global optimization and it is different from other well-known Evolutionary Algorithms. As in Evolutionary Algorithms, a population of potential solutions is used to probe the search space, but no operators are applied on the population to generate new solutions. In PSO, each single particle, of the population, called swarm, fix its orbit toward its own previous optimum position, and toward the previous optimum position obtained by any member of its topological neighbourhood. In the global alternative of PSO, the whole swarm is treated as the neighbourhood. [9].

b) PSO-based Algorithm for Power Control Problem

In PSO based approach the uses main binary PSO technique. The PSO algorithm is used to magnify a fitness function that takes into discussion of all the objectives of the power control problem. In PSO-based algorithm, each particle in the swarm should perform a power vector having power values to be transmitted by all mobile units in order to be calculating and increased by the algorithm. The particle portrayal in swarm is akin to the chromosome representation of the power vector in GAME method with $q = 15$ bits which gives a good resolution of tuning the power of the mobile units. If $P_{max} = 1$ watt then the resolution by which user can be tune the power of the unit is $\frac{1}{2^{15}} = 3.051758 \times 10^{-5}$ watts (approx. $30.5 \mu\text{W}$). It may be seen that this method of representation of the power vector inherently satisfies the maximum power constraint as we always assign the value of P_{max} to the string of 15 ones. In this method first the author tried to use the same fitness function of GAME method. That fitness function gave good results in terms of minimization the transmitted power from the mobile units and making the value of $\frac{E_b}{N_0}$ of the received signals from all mobile units exceed [5].

c) GAME Algorithm

GAME is a steady state GA which stops evolution after a timeout period. The inputs are current power level from different users. Additional information like $\left(\frac{E_b}{N_0}\right)$ th maximum power level P_{max} and the link gains G are also required. In GAME approach introductory population of chromosomes is formed by encoding the power levels from mobiles. The chromosome is a string of N bits and it encodes power level of M mobile users. If each mobile power is encoded using q bits then $N=q \times M$. the fitness function is used to evaluate these chromosomes. The cycle of evolution and reproduction works up to a stopping

criterion. The base station transmits the new power vector to the users. In the meantime, the new solution is being used to initialize the input vectors at the next control period. The assumption for GAME method was that the base is situated at the centre of cell. It was only for single cell with radius of unit distance. The users are distributed uniformly over the cell area. The loss model used is distance loss model. The link gain is $G_{ij} = A_{ij} \times D_{ij}$.

A_{ij} is the variation in the received signal due to shadow fading, and assumed to be independent and log normally distributed with a mean of 0 dB and a standard deviation of 8 dB.

VI. CONCLUSION

In a CDMA network, resource allocation is critical in order to provide stable quality of service (QoS) for each user and achieve channel efficiency. An increase in the transmission power of a user increases its E_b/N_0 (bit error rate) but increases the interference to other users, causing a decrease in their E_b/N_0 . On the other hand an increase in the transmission rate of a user deteriorates its own E_b/N_0 . Controlling powers and rates of the user therefore amounts to directly controlling the QoS that usually specified as a pre-specified target E_b/N_0 . Demand for the wireless communication shows the need for technology to further increase the capacity of cellular communication system and improve the system performance. CDMA was developed to increase the capacity of cellular network. Unlike FDMA and TDMA whose capacities are primarily bandwidth limited, the capacity of CDMA is only interference limited, any reduction in interference converts directly and linearly into an increase in capacity. It has been shown that for terrestrial cellular network, the interference suppression feature of CDMA can result in many-fold increase in the capacity of the cellular network. However, the above conclusion is based on the assumption that all signals arriving at the receiver with the same power. So power control is crucial to cellular CDMA system.

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