Performance Analysis of WCDMA Using Different Spreading Codes

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***Abstract* - This paper analyzes the performance of various spreading codes in wireless code division multiple access. The work contributed a little towards the evolution of next generation CDMA technology because the generated PN sequence based on Residue arithmetic.**

I. INTRODUCTION

Code Division Multiple Access (CDMA) based on Spread Signal (SS) has emerged as one of the most important multiple access technologies for Second Generation (2G) Third Generation (3G) wireless communication systems by its wide applications in many important mobile cellular standards. CDMA technique relies on spreading codes to separate different users or channels and its properties will govern the performance of the system. So many of the problems of communication systems based on CDMA technology stem from the spreading codes/sequences, which includes two sub-categories, one being the orthogonal codes, such as Walsh Hadamard (WH) codes and Orthogonal Variable Spreading Factor (OVSF) codes, and the other being pseudo-noise or Pseudo Random (PN) sequences, such as Gold sequences, Kasami sequences, m-sequences, etc

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In this work a PN sequence generation based on Residue Arithmetic is investigated with an effort to improve the performance of existing interference-limited CDMA technology for mobile cellular systems. This interference-limited performance is due to the fact that all the existing CDMA codes used in mobile cellular standards does not consider external interferences, multipath propagation, Doppler Effect etc. So the non-ideal correlation properties of the pseudo-random CDMA codes results in MAI when used in a multi-user system. The PN codes appear random yet they are completely deterministic in nature with a small set of initial conditions. Consequently this work focuses on CDMA code design approach based on Residue Number System (RNS) which should take into account as many real operational conditions as possible and to maintain a sufficiently large code set size.
First, the work will review RNS, DS-CDMA and CDMA codes that are already implemented in various mobile cellular standards. Then the new PN Sequence generator design based on RNS is discussed. Comparison of the generated PN sequence with respect to other standard sequence is done in terms of number of codes and correlation properties. Monte-Carlo simulations with the generated sequence are carried out for performance analysis under multi-path environment. The system has been evaluated in AWGN, Rayleigh Fading channel and different Stationary Multipath Channels for different cross-correlation threshold.

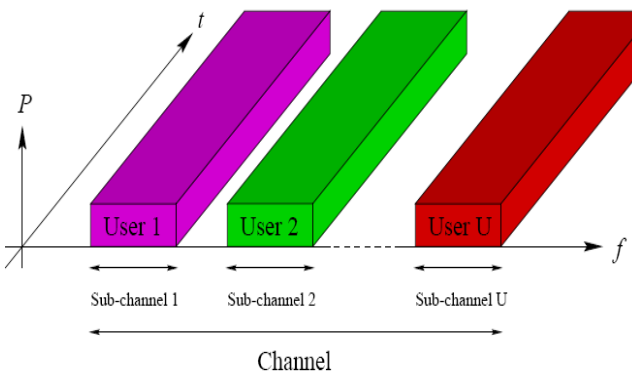

Figure 1.1 Multiple Access Frequency Division Multiple Access Technique [2]

Within few years of launching, the network began to hit a capacity ceiling as millions of new subscribers signed up for mobile voice services. To accommodate more users within a limited amount of spectrum, a new set of wireless technology called Time Division Multiple Access (TDMA) has been developed. Figure 1.2 shows how a TDMA system works. Several users share a common channel but they are separated by time. DAMPS (Digital AMPS) and Global System for Mobile (GSM) then came onto the stage [3].

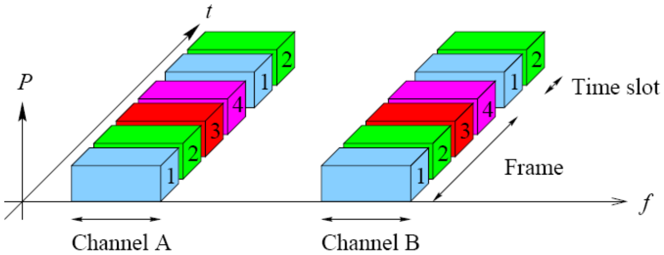

Figure 1.2 Multiple Access Time Division Multiple Access Technique [2]

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II. Background and Literature survey

RNS were introduced in field of DS-CDMA by many researchers as early as late 90s by Lie Liang Yang and Lajos Hanzo. In conventional systems, due to the carry forward required by the weighted number system, a bit error may affect all the bits of the result. In they proposed a parallel communication scheme based on RNS, which is a non-weighted carry-free number system. The symbol to be transmitted is transformed to RNS representation, mapped into a set of orthogonal sequences and are transmitted in parallel. Error control was also incorporated in this paper using redundant RNS (RRNS) code. Performance of the same system over bursty communication channels is done by Madhukumar and Chin [8]. They have also proposed a modulation technique by combining RNS representation, PSK/QAM modulation and orthogonal modulation for bandwidth efficiency in [9].

The error control properties of RRNS were exploited in [10] to be used as channel codes for protecting the speech bits. In [11] residue arithmetic is used for representing the symbol to be transmitted. Redundant residue arithmetic system based multi-carrier DS-CDMA (MC/DS - CDMA) dynamic multiple access scheme has been proposed in [12] for dynamically accessing the frequency spectrum available for Cognitive Radio communication. All references basically points to a parallel communication scheme where the symbol to be transmitted by each user is represented in residue arithmetic and an inverse RNS transform block is used at the receiver to get back the symbol. But generation of PN sequences by exploiting the properties of RNS and use of these to spread message signals for multiple user transmission has never been investigated. Wideband Code Division Multiple Access (WCDMA), the air interface technology for third generation (3G) systems specified by 3rd Generation Partnership Project (3GPP) applies DS-CDMA technique with Orthogonal Variable Spreading (OVSF) Code as Channelization code for multiplexing different users [13].

The WCDMA downlink transmission is prone to self interference caused by the loss of orthogonality between spreading codes due to multipath propagation. There are several techniques for interference cancellation and multiuser detection that improves the performance and capacity of the downlink WCDMA system. Most of these techniques are designed at the expense of higher receiver complexity and with OVSF codes derived from Walsh-Hadamard code. Construction methods of OVSF-ZCZ sequences have been proposed in to mitigate interference due to multipath propagation. Since the number of OVSF-ZCZ sequences is limited, various assignment algorithms are required to meet the demand of large number of users. The use of Orthogonal Variable Spreading Code (OVSF) code requires that a dedicated rate matching algorithm to be used in the transceivers [1]. This algorithm consumes a great amount of hardware and software resources and increases computation load and processing latency.

III. Principle of operation

WCDMA networks have recently seen a rapid growth all over the world The reason for this lies in its technological advantages over second generation systems However since the newly rolled out networks have often not yet reached their normal operation conditions the effects of varying traffic load on coverage and capacity still need to be investigated Additionally soft capacity leads to a description of the term coverage that differs from its conventional usage. Unlike conventional systems like FDMA or TDMA where coverage is purely determined by radio frequency RF aspects the cell coverage in WCDMA is extremely sensitive to the customers that are supplied in the cell Due to the soft capacity nature of WCDMA networks the coverage of a cell depends on several factors, the transmission characteristics of the terrain is the dynamics of the power control procedure to the desired quality of service in term of sustainable interference level and the spatial customer distribution and corresponding time dependent customer traffic intensity From previous studies it is known that the coverage part of a CDMA cell is of an elastic nature of both coverage and capacity of a cell need to be planned in such a way that all calls are sufficiently supplied i.e. power controlled according to the quality of service W-CDMA – the radio technology of UMTS - is a part of the ITU IMT-2000 family of 3G Standards. Both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) variants are supported.

W-CDMA is a spread-spectrum modulation technique; one which uses channels whose bandwidth is much greater than that of the data to be transferred. Instead of each connection being granted a dedicated frequency band just wide enough to accommodate its envisaged maximum data rate, W-CDMA channels share a much larger band.

The modulation technique encodes each channel in such a way that a decoder, knowing the code, can pick out the wanted signal from other signals using the same band, which simply appear as so much noise.

UMTS uses a core network derived from that of GSM, ensuring backward compatibility of services and allowing seamless handover between GSM access technology and W CDMA.

The choice of third generation radio technology employed by 3GPP™ in implementing UTRA - Universal Terrestrial Radio Access - was decided upon after a long period of technical discussion in ETSI's SMG Technical Committee during the 1990s. These discussions involved interested parties from the wider cellular community and eventually resulted in the formation of the 3rd Generation Partnership Project (3GPP). The basic technology chosen was Wide-band Code-Division Multiple Access (W-CDMA), with several sub-flavours:

Direct Sequence, Frequency-Division Duplex
Direct Sequence, Time-Division Duplex
Multi-Carrier.
Within the Time-Division Duplex category the initial specifications were augmented shortly afterwards by a low chip-rate version developed largely at the initiative of the Chinese partner. Subsequently, a high chip-rate version has also been specified.

Spread spectrum

W-CDMA is a spread-spectrum modulation technique; that is, one which uses channels whose bandwidth is much greater than that of the data to be transferred. Instead of each connection being granted a dedicated frequency band just wide enough to accommodate its envisaged maximum data rate, W-CDMA channels share a much larger band. The modulation technique encodes each channel in such a way that a decoder, knowing the code, can pick out the wanted signal from other signals using the same band, which simply appear as so much noise.

Using a wide frequency band makes the system inherently resistant to many of the aspects of radio communication which plagues narrow band systems, such as bur sty noise, multipath reflections, and other interfering transmissions. Since all information shares the same band, and channels can only be distinguished with knowledge of the spreading codes used, W-CDMA is also very secure from eavesdropping, even before employing encryption algorithms. Also, unlike systems which use a fixed number of discrete channels in a given frequency band, with W-CDMA there is no fixed number of simultaneous communications links which can be supported. The effect of adding more active links to a given cell will eventually result in the need for data rates for all links to be reduced in order that the wanted signals can be picked out of the ever increasing noise, but this is generally preferable to allowing access of a first-come, first-served basis, with later users simply being denied access.

IV. Result and Conclusion

The core of the next generation CDMA technology lies in CDMA code design approach which should take into account as many real operational conditions as possible and to maintain a sufficiently large code set size. In this context, this paper work contributed a little towards the evolution of next generation CDMA technology because the generated PN sequence based on Residue arithmetic:

- Offers provision to vary correlation threshold based on the channel properties and error tolerance thus providing real operational conditions for spreading code design unlike any existing techniques.
- Inherits high dynamic key range to maintain large code sets such that large number of users can be accommodated.

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