

# FPGA Implementation of Standard Basis CDMA Encoding/Decoding

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**ABSTRACT:** As a high performance on-chip communication method, the code division multiple access (CDMA) technique has recently been applied to networks on chip (NoCs). We propose a new standard-basis based encoding/decoding method to leverage the performance and cost of CDMA NoCs in area, power assumption, and network throughput. In the transmitter module, source data from different senders are separately encoded with an orthogonal code of a standard basis and these coded data are mixed together by an XOR operation. Then, the sums of data can be transmitted to their destinations through the onchip communication infrastructure. In the receiver module, a sequence of chips is retrieved by taking an AND operation between the sums of data and the corresponding orthogonal code. After a simple accumulation of these chips, original data can be reconstructed. We implement our encoding/decoding method and apply it to a CDMA NoC with a star topology. Compared with the state-of-the-art Walsh-code-based (WB) encoding/decoding technique, our method achieves up to 67.46% power saving and 81.24% area saving together with decrease of 30%–50% encoding/decoding latency. Moreover, the CDMA NoC with different sizes applying our encoding/decoding method gains power saving, area saving, and maximal throughput improvement up to 20.25%, 22.91%, and 103.26%, respectively, than the WB CDMA NoC.

**KEYWORDS:** Code division multiple access (CDMA), integrated circuit (IC), network on chip (NoC).

## I. INTRODUCTION

With the rapid growth of the computational complexity, more and more processing elements (PEs) are integrated onto a single chip, and this method has been proposed to address the scalability, throughput, and reliability issues of on-chip communication. However, Conventional packet-switched method suffers from nondeterministic transmission latency and limited opportunities for parallel data transfer, since multiple flows cannot get through a link at the same time [6]. To resolve the problems, the CDMA (Code Division Multiple Access) technique [3] as an effective method for implemented high performance encoding and decoding method.

## II. CDMA

CDMA is a multiple access method. In the last few decades there has been increase in global use of internet and mobile phone services. One of the biggest challenges faced in communication is to clear to large. Number of demands at the same time limited bandwidth of frequency over which transmission lines and devices can actually operate [14]. Traditional solutions of this problem like Time Division Multiple Access or Frequency Division Multiple Access are quite slow and unstable. CDMA on the other hand uses the same frequency channel at the same time to send data to many users without any hindrance. The CDMA is uniquely featured by its spread spectrum process of employing a Pseudo Random noise sequence, thus it is called the Spread Spectrum Multiple Access where several transmitters can send the information simultaneously over a single communication channel.

This allows a several users to share the bandwidth frequency. Few important features of CDMA are wide bandwidth, higher security and Walsh encoding. Wide bandwidth provides immunity against jamming, interference etc.

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The CDMA technique functions at the principle of encoding the original data with a set of orthogonal codes. The encoded data from different users are then added together for transmission without interfering with each other due to the orthogonal property of the spreading codes.

The receiving user can then extract or decode the original data by multiplying the received sum with the corresponding unique spreading code used for encoding.

## SPREADSPECTRUM TECHNIQUE IN CDMA

All of the modulation and demodulation techniques strive to achieve greater power and bandwidth efficiency in a stationary additive white Gaussian noise channel. Since bandwidth is a limited resource, one of the primary design objectives of all modulation schemes is to minimize the required transmission bandwidth. Spread spectrum techniques on the other hand employ a transmission bandwidth that is several orders of magnitude greater than the minimum required signal bandwidth efficient. [14]

There are two types of spread spectrum techniques are used:

- Direct Sequence Spread Spectrum
- Frequency Hopping Spread Spectrum.

### Direct Sequence Spread Spectrum

The baseband data since is multiplied by a PN code which is multiplication of each bit of baseband data with the PN codes, will result into a spread spectrum bandwidth but the spectral power density remains same, because before spreading the energy was concentrated in a small bandwidth, now its spread over large bandwidth.

Now when this spread signal is transmitted its receive data the receiver, with signal from other user of the same spectrum, which became noise for this noise, plus interference from other sources. The receiver in these systems will have a correlate, which use the replica of the PN code to extra the same information.

### Frequency Hopping Spread Spectrum

Signal is broadcast over seemingly random series of radio frequencies

A number of channels allocated for the frequency hopping signal.

Width of each channel corresponds to bandwidth of input signal.

Signal hops from frequency to frequency at fixed intervals

- Transmitter operates in one channel at a time 3.
- Bits are transmitted using some encoding scheme.
- At each successive interval, a new carrier frequency is selected.

### Advantages of spread spectrum

- As the signal is spread over a large frequency band, the power spectral density is getting very small, so other communication systems do not suffer from this kind of communications. However the Gaussian Noise level is increasing.
- Multiple access can be deal with, as large number of codes can be generated which will permitted large no of user.
- Security: Without knowing the spreading code, it is nearly impossible to recover the transmitted data.
- Fading rejection: As large bandwidth, the system is less susceptible to distortions.



Fig.1.1.CDMA Structure

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## CDMA STRUCTURE

The structure CDMA structure is illustrated in Fig.1.1. The structure having five important units as input, encoder, channel, decoder and output. Generally, the spreading code applied to encoder and decoder section. Based on number of users in the network, the codes are assigned. For example, four users accessed in the network, fourth order standard basis spreading codes are needed to encode and decode the input signal. Input signal defined as terms of user data or codes. The input signal is encoded with help of encoder. This data should be encoded with standardized codes through the channel. The channel combined all encoded signals of each user with some noise signals. The noise signals are correlated with help of decoder. These codes are decoded with standardized codes respect to each receiver. The modified data's are decoded with help of decoder. The original data will show an output unit. Required signals are identified. These structures have the unique units for all methods in CDMA spreading spectrum techniques.

## III. EXISTING SYSTEM

A Gold code, also known as Gold sequence, is a type of binary sequence, used in telecommunication and satellite navigation. Gold codes are named after Robert Gold. Gold codes have bounded small cross correlations within a set, which is useful when multiple devices are broadcasting in the same frequency range. A set of gold code sequences consists of  $2n - 1$  sequences each one with a period of  $2n - 1$ . A set of Gold codes can be generated with the following steps [14]. Pick two maximum length sequences of the same length  $2n - 1$  such that their absolute cross-correlation is less than or equal to  $2(n+2)/2$ , where  $n$  is the size of the LFSR used to generate the maximum length sequence (Gold '67). The set of the  $2n - 1$  exclusive-or of the two sequences in their various phases (i.e. translated into all relative positions) is a set of Gold codes. The highest absolute cross-correlation in this set of codes is  $2(n+2)/2 + 1$  for even  $n$  and  $2(n+1)/2 + 1$  for odd  $n$ . The exclusive or of two Gold codes from the same set is another Gold code in some phase. Within a set of Gold codes about half of the codes are balanced the number of ones and zeros differs by only one.

The structure of encoding unit is given below fig(3.1). The input information can be XOR with gold sequences. The gold sequences are used to create the random sequence by using the two LFSR. The LFSR1 and LFSR2 are paralleled XOR of each bit by bit operation. The XOR of two LFSR is known as gold sequences or M sequences. Again we are going to XOR of input sequences and gold sequences then we going to transmit the data. Depends upon the data with the LFSR width will be changed.

## IV. PROPOSED METHODOLOGY

Standard Basis is defined as something combines the concepts of linear independence and spanning. For example, stated a theorem have vector space that contains a finite number of elements in the basis, then that number will be same across different basis for the same vector space. And by counting the number of elements in the basis, get the notation of dimension that means dimension of a code finally looking some notation.

The basis contains the same number of elements about the dimension of a vector space applied to a code defined means dimension of a linear code and notation. This leads to the concept of dimension in which vector space basis for the single parity check code losses to assign a dimension of the code.

Some subsets of vector space generated the entire subsets. Such subsets called spanning sets. Other subsets did not generate the entire space, but their span was a subspace of the underlying vector space. In some cases, the number of vectors in such a set was redundant in the sense that one or more of the vectors could be removed without changing the span of the set. In other cases, there was not a unique way to generate some vectors in the space. Make this process of generating all the elements of a vector space more reliable and more efficient.

## V. LITERATURE SURVEY

[1] A. Vidapalapati, V. Vijayakumaran, A. Ganguly, and A. Kwasinski (2012) told that "NOC architectures with adaptive Code Division Multiple Access based wireless links"[4]. To implemented multiple

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simultaneous access of the shared wireless medium using a traffic-adaptive CDMA scheme the peak performance can be improved significantly while lowering energy dissipation in data transfer compared to the conventional wire line counterparts. Several applications require multicast data transfer such as passing global states, managing the network and implementing cache coherency. Therefore the adopted CDMA protocol must be adaptive to various types of traffic namely unicast, multicast or broadcast in the network on chip. We adopt the collision-free T (transmitter)-protocol in which each transmitter encodes the data according to a unique code. At the receiver, the received signal is correlated with all the code words to decode the transmissions from each transmitter. So the T protocol can operate normally under one-to-one (uniform random) or many-to-one (hotspot) type of traffic scenarios where each receiver can receive data from multiple transmitters at the same time on different code-channels specific to each transmitter. Also, the T-protocol naturally supports one-to-many (multicast or broadcast) traffic conditions as each receiver receives data from all the transmitters at the same time. The receivers check the address information in the data to accept and route it farther if it is intended for the particular wireless switch. The adopted scheme enables concurrent unicast and multicast from different sources as well. Thus the CDMA MAC supports both unicast and multicast traffic patterns. It is completely distributed and does not require centralized control or arbitration circuitry, as any transmitter can encode and transmit data independently of other transmitters. The design of an inherently adaptive CDMA scheme, which can adapt to different traffic patterns in the network on chip. The disadvantages of this method for interconnecting purpose provide each process by antennas.

[2] ManhoKim, Daewook Kim and Gerald E. Sobelman (2005) said that "Adaptive Scheduling for CDMA-Based Networks-on-Chip"[11]. To develop the scheduling algorithm for CDMA based network-on-chip. Here, orthogonal variable spreading factor code is combined with the Dual Round Robin Matching algorithm. High performance scheduling and arbitration for with the CDMA and determine its fairness and performance characteristics through simulation. In the CC-DRRM scheme, when an input and an output are matched only one cell will be transferred from the input to the matched output. After that, both input and output will move their pointers by one position. Therefore, in the next time slot this input-output pair will have the lowest priority of being matched together. Each input port maintains nVOQ (virtual output queuing). An input arbiter at each input selects a nonempty VOQ in a round-robin fashion. After the selection has been made, each input port send sat most one request to an output arbiter. An arbiter at each output port receives up to N requests and chooses one of them on a round-robin basis and sends a grant token to the selected to the input port. The four steps are important for implementation as Request, Grant, Codeword assignment, Packet transmission. The disadvantages of this algorithm implemented only for variable length Codeword not for unique codewords.

[3] N.Gokulakannan, R.L.Sindhu(2014) told that "CDMA based data transmission using Gold Sequences in VERILOG"[14]. To implement encoding and decoding process in CDMA based data transmission. A Code-Division Multiple Access (CDMA) based data transmission using gold sequences is implemented. The principle of encoding process can be identified the original data with a set of gold sequences. The encoded data from different users are then added together for transmission without interfering with each other due to the spreading codes. The receiver can then extract or decode the original data by the received sum with the corresponding unique spreading code used for encoding. The gold sequences have the advantage to create large number of binary random sequences we can't hack or decode the information unless we know the spreading sequence. It is widely used in wireless communication due to its wide bandwidth efficiency and multiple access capability. Wide bandwidth provides immunity against jamming and interference. It provides Multipath, security, and variable rate of speech coding. The gold sequences create large number of Pseudo random binary sequences based on the linear feedback shift register. Gold sequences are a highly secure sequences we can't decode the original unless we know the spreading codes of each user. Here we proved system is likely CDMA networks where a single receiver and several transmitters are used. The multiplexer and demultiplexer play an important role for transmitter and receiver unit. These systems are often used in communications equipment, such as cellular phones, GPS devices, and very small aperture satellite terminals. The disadvantages of this method CDMA based data transmission using gold sequences not to implement the high speed parallel data transmission and Here, using the number of gold sequences in a single user on parallel form it improves the security of each users and then it will increase clock speed and data transmission rate.

[4] X.Wang, AJ.Nurmi(2005) said that "An On-chip CDMA Communication Network"[22]. An on-chip packet-switched communication network which applies Code-Division Multiple Access (CDMA) technique has been

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developed and implemented in Register-Transfer Level (RTL) using VHDL. The principle of CDMA system is to use orthogonal spreading codes to encode the original data. Then the encoded data from different data senders are added together for transmission without messing each other because of the orthogonality of spreading codes. The orthogonality means that the normalized auto-correlation of spreading codes is 1, while the cross-correlation of spreading codes is 0. Therefore, at the receiving end the data can be decoded from the received signals by multiplying the received signals with the corresponding spreading code. Spreading code protocol is a policy used to decide how to assign and use the spreading codes in the CDMA network in order to eliminate or reduce the possible conflicts during the communication processes. The disadvantage of this method here, using six nodes CDMA for data communication and the data transfer latency largely.

[5] S.Shimizu,T.Matsuoka,K.Taniguchi(2003) said that “Parallel bus system using CDMA technique”[16]. To implement parallel bus system using code division multiple access technique. For VLSI systems the parallel bus interface using CDMA technique is proposed, which has low power consumption and high noise tolerance. The proposed interface can transfer data between a transmitter and a receiver in one clock. It has tolerance to the timing variation in the signal transfer among every buses which is an advantage compared with conventional parallel bus. The 15bit Parallel CDMA bus interface with the access speed of 2.5 GB/s had been successfully implemented with 0.35µm CMOS technology. Code-Division Multiple Access technique is popular in wireless communication systems for its noise rejection features. The CDMA technique into bus architecture can reduce the signal swing on the bus to several ten milli-volts in order to cut down power consumption. However, there is a problem of interference between neighboring shifted sequence of Pseudo-Noise codes in conventional CDMA interface shown in Moreover, in conventional CDMA a transmitting data signal is spread by a PN code intime span. This means that it requires a lot of clock times (the number of PN code). In addition, the problem of latency is also serious. In this paper, parallel CDMA bus interface used. This interface can transmit I-bit data in one clock with the high noise tolerance. The disadvantage of this method the transmitter and receiver coupled with capacitive method not for through the channel transmission and limited access for users.

## VI. EXPERIMENTAL RESULT

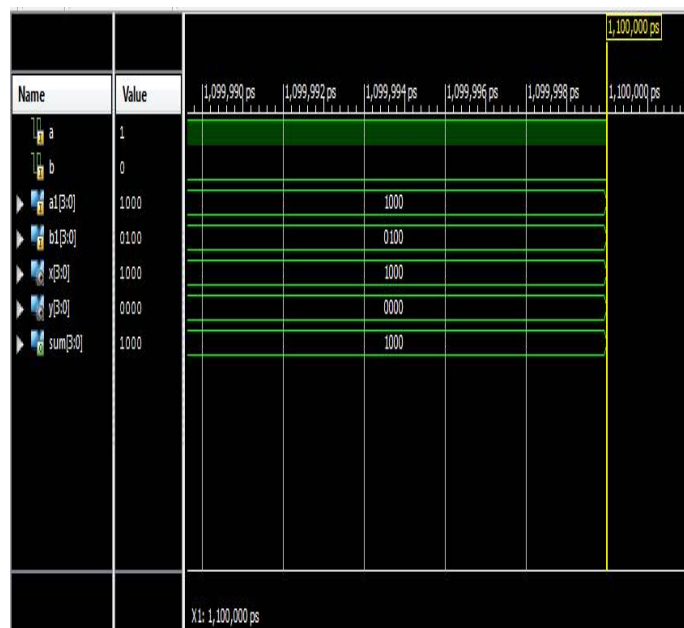


Fig.2. Standard basis CDMA encoder

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sbdecoder Project Status (11/16/2016 - 18:01:10)				
Project File:	vispro.xise	Parser Errors:	No Errors	
Module Name:	sbdecoder	Implementation State:	Programming File Generated	
Target Device:	xc3e400-spg208	•Errors:		
Product Version:	ISE 12.1	•Warnings:		
Design Goal:	Balanced	•Routing Results:	<a href="#">All Signals Completely Routed</a>	
Design Strategy:	<a href="#">Xilinx Default (unlocked)</a>	•Timing Constraints:		
Environment:	<a href="#">System Settings</a>	•Final Timing Score:	0 <a href="#">(Timing Report)</a>	

Device Utilization Summary				
Logic Utilization	Used	Available	Utilization	Note(s)
Number of 4 input LUTs	4	7,168	1%	
Number of occupied Slices	2	3,584	1%	
Number of Slices containing only related logic	2	2	100%	
Number of Slices containing unrelated logic	0	2	0%	
Total Number of 4 input LUTs	4	7,168	1%	
Number of bonded IOBs	14	141	9%	
Average Fanout of Non-Clock Nets	1.43			

Performance Summary	

Fig.3. Design summary reports of standard basis encoder



Fig.4. Standard basis CDMA decoder

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## VII. CONCLUSION AND FUTURE SCOPE

A new standard basis CDMA encoding/decoding method provides high code utilization. This method is used to n-bit of users accessed in the network. So, multiple number of users access at a time over the network. It can be realized by using simple logic and costs less power and area. The standard basis other than the methods is used as the spreading code in our method. It thus decreases the encoding/decoding latency and increases the maximum throughput.

For future implementation, CDMA based bus provides how a multiprocessor system can benefit from use of concurrent data transfers. CDMA has been proposed as an alternative way for interconnecting modules within a system realized in several PCB's.

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