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Network Topology Variation of Convolutional Coders on Performance of O-IDMA with Random Interleaver

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Abstract *Optical IDMA is a prominent technology used in recent mobile communication. Different kind of interleaver are used in this technique to improve the quality communication. Convolutional coders are used in any communication system is basically to enhance the error correcting capability of communication. A large number of network connections are possible for a fixed hardware component convolutional encoder. By varying the network topology of convolutional encoder that is the feedback path, and hence the hamming distance of generated code-words are changed which effect the bit error rate. In the present work we have used the different possible combinations of network topologies for fixed constraint length convolutional encoders and observed their effect on performance of OIDMA system. In present case we have used random inter-leavers for analysis purpose.*

Keywords- *O-IDMA, Network topology, Hamming distance, Random Interleaver, Constraint Length*

1. INTRODUCTION

The multiple access methods are an essential communicational requirements in a multi-user environment. Multiple access techniques are required to meet the demand for high speed and large user handling capability of communication optical networks, which permit multiple user to share the fiber bandwidth. O-IDMA (optical interleave division multiple access) made its attention due to its probable applications for LAN optical networks.

Interleaver is usually working a key component in turbo codes, due to the fact that iterative method of the turbo coding will use interleaved version of information iteratively to produce high coding gain.

A very powerful and widely used a variety of codes, called convolutional codes, which are used in a variety of system including todays standard wireless, optical and in satellite communication. Convolutional error correcting or channel coding is used to improve the efficiency and accuracy of information transmitted. Convolutional codes are beautiful because they are intuitive, one can know them in many different ways, and there is a way to decode them so as to recover the mathematically most possible message from among the set of all possible transmitted message [4-5]. Other major reason for this is the possibility of achieving real time decoding without visible information losses thanks to the well known soft input Viterbi Algorithm.

In present paper, the convolutional coder of fixed constraint lengths with varying network topology is designed and connected in the IDMA system [6]. Varying the network topology specifies that different possible combinations of shift registers and adders are used in encoder generates more number of uncorrelated code words and produces larger hamming distance means increasing the error detection and correction ability of codes. Constraint length and network topology are the important parameter of the convolutional encoder. The longer the constraint length, the larger the number of parity bits that are subjective by any given message bit. Because the parity bits are the only bits sent over the channel, a larger constraint length generally implies a greater flexibility to bit errors [7]. The trade – off, though, is that it will take significantly larger to decode codes of long constraint length. So one can not increase the constraint length at random and expect fast decoding.

In this article, varying the network topology and fixed the constraint length makes system more efficient agains the larger number of users and we get reduction in bit error rate (BER).

2. OPTICAL IDMA SYSTEM

The block diagram of optical IDMA system shown in figure-1, having k different users, proposing single path of optical window 1550 nm. It all users having converted in fixed code length, which is assumed to be low rate [8-9]. The chip is interleaved by a chip level interleaver. After transmitting through the channel, the bits are seen at the receiver side.

In receiver section, after chip matched filtering, the received signal from the k users. In the receiver side for multiuser detection we have used elementary signal estimator, APP and SDECs having variable iterative mechanisms. The produced LLR are further classified in two ways, one which is produced by PSE and another which is generated by DEC. The concept and ethics involved in CBC has shown in, the function of ESEB and APP decoders are based on users.

3. RANDOM INTER-LEAVER

Some time for security purpose the bits which are filled in interleaver are changed randomly with some pseudorandom manner [10]. There are many alternative mechanism of putting

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the bits in the interleaver depending upon size cost, power back up ete. Some commonly known interleavers which are frequently used are random, tree and prime. Prime interleavers are generated with specific seed length which is always prime number and produces quality interleaved bits.

It provides very goods results in terms of bit error rate. The only disadvantage of random interleaver is that it suffers from the problem of large storage crisis. In random interleavers the input bits are arranged by randomly selected combinations. It is simple in terms of design as only few flip flops and combinational circuits are used for designing random interleavers.

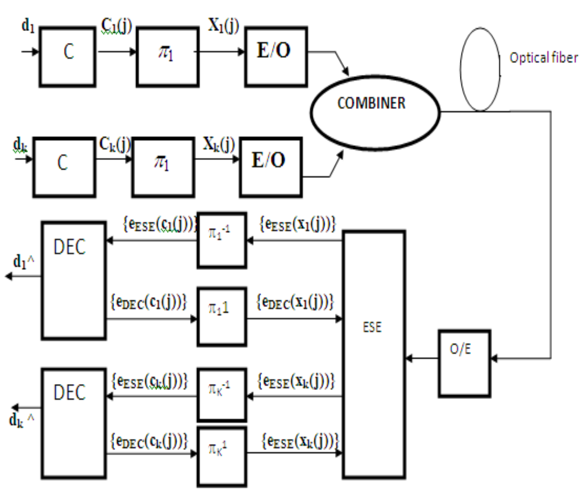

Figure -1: Optical IDMA Transmitter and Receiver Structure.

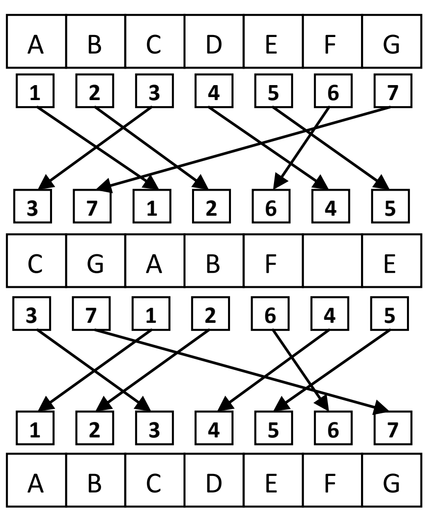

Figure 2: Random Inter-leaver

4. CONVOLUTIONAL CODING

Convolutional codes cares for information by adding redundant bits to any binary data. The convolutional encoder calculates each *n*-bit symbol (n > k) of the output sequence from linear operations on the current input k-bit symbol and the contents of the shift register(s) [11-12]. Thus, a rate *k/n* convolutional encoder processes a k-bit input symbol and computes an *n*-bit output symbol with every shift register update. Convolutional codes are commonly specified by three parameters; (n, k, m).

n = number of output bits

k = number of input bits

m = number of memory registers

The amount k/n is called as code rate. It is a measure of the efficiency of the code. Generally k and n parameters range from 1 to 8, m from 2 to 10 and the code rate from 1/8 to 7/8 except for deep space applications where code rates as low as 1/100 or even longer have been in employment. Here The quantity L is called the constraint length of the coder.

The constraint length L denotes the number of bits in the encoder memory that affect the generation of the n output bits. The constraint length L is also referred to by the capital letter K, which can be confusing with the lower case k, which represents the number of input bits.

4.1 Design of Convolutional Encoder

In designing of convolutional encoder there are two prime constraints. First one is number of shift register and another one is number of Ex-OR gates used in encoder circuit. The constraint length L of a encoder is well-defined as number of shift registers where only one message bit can effect the encoder output, designed as L = m+1, where m represents number of memory elements or shift registers used. As more numbers of shift registers are used in encoder more number of output bits are influenced by single bit, which reduces the chance of error in deciding input bits at receiving side. If we increase the number of adders at output then more number of uncorrelated bits as well as code words produces at output, which increases the d_{min} (minimum hamming distance) between code wards and increases the error correcting capability of encoder.

4.2 Network Topology Variation of Coders

Network topology is the schematic description of a network arrangement connecting various nodes (Sender & Receiver) through lines of connection. In other words, network topology is the arrangement of various network elements used in data transmission and formations of interconnection like node and link with each other.

Variation of network topology means changing the different connections from the input to output and changing the feedback path from fixed hardware component of a convolution encoder by altering the different possible connection from the shift register and adders used in convolutional encoder. The number of loops in network topologies are changed, by using different connections and feedbacks in all possible combinations of network topologies the node and loops and possible signal flow graph is changed. In present example of (1,2) convolutional encoder with two shift register and two adder (fixed) ,one can draw all possible network topology combinations like(7,1) (7,2) up to (7,7)

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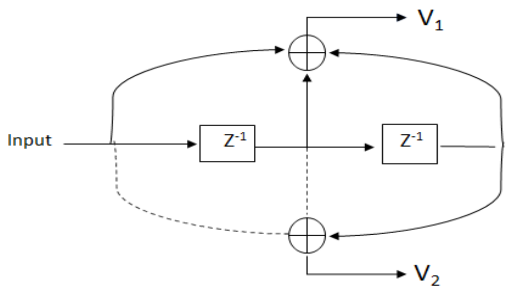
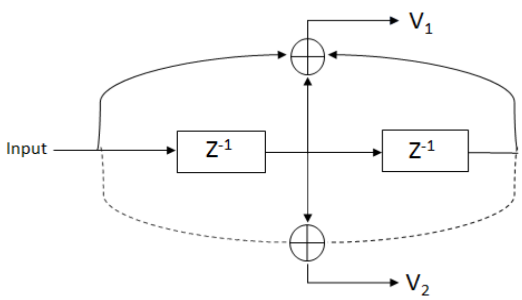
shown in fig. By adding or deleting various paths from input to output these possible topologies are deduced. We have used all these different network topologies in OIDMA system and calculated BER for each case. By finding the result of BER in each cases., we have derived the optimum network topologies which will give the best result i.e. minimum value of BER obtained.

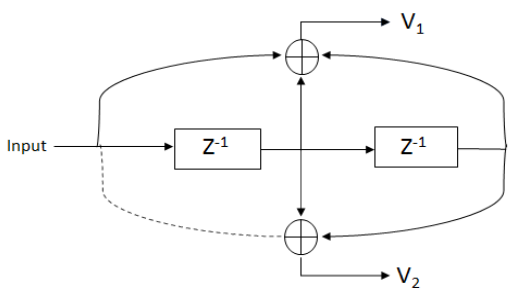
Network topology -1. Convolutional Encoder- (7, 1).



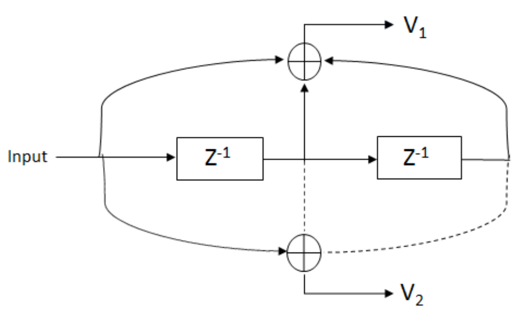
Network topology -2. Convolutional Encoder- (7,2).



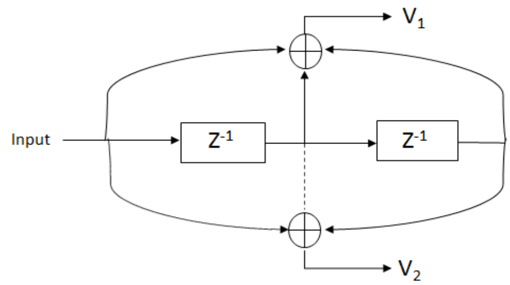
Network topology -3. Convolutional Encoder- (7,3).



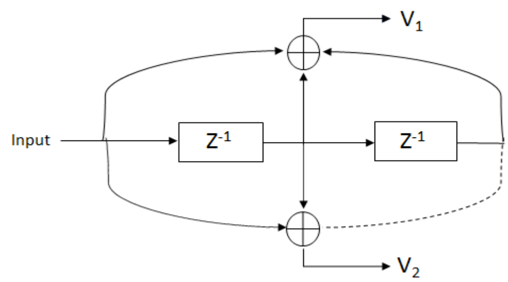
Network topology -4. Convolutional Encoder- (7,4).



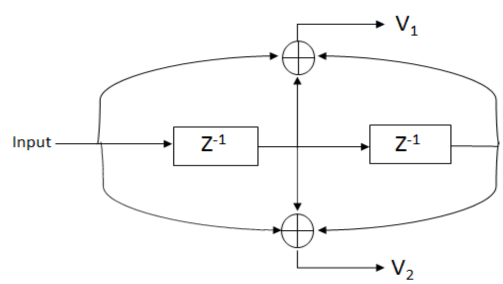
Network topology -5. Convolutional Encoder- (7,5)



Network topology -6. Convolutional Encoder- (7,6).



Network topology -7. Convolutional Encoder- (7,7).



5. SIMULATION RESULT AND DISCUSSION

BER performance of OIDMA system is calculated by varying network topology and fixing constraint length by using Random inter-leaver. Design of convolutional [1, 2] encoder and its network topology has been changed and their effect has been observed in tubular form. The fixed parameters for input is selected as spread length (S.L.=16), data length (m)=512, constraint length (L) = 3 and block =50 for channel parameters are found as optimum merest loss window 1553nm, input optical pulse as Gaussian having input optical power 1mW, efficiency fiber cross section 8×10^{-11}. The APD having internal gain 1000 and efficiency 0.85 is taken as fixed parameters.

Here we have taken seven network topologies of low rate convolutional [1, 2] encoder. In topology 2 and topology 5 having minimum results obtained. Topology 2 has better in comparison to topology 5 that in topology 2 gives bit error rate = 1.1719×10^{-6} in comparison to topology 5 bit error rate = 2.3437×10^{-6}. But in hardware connection topology 2 have only one connection at V_2 that is no requirement of Ex-OR gate at V_2 which is unacceptable condition witch avoids the ethos of hardware

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selection. That's why we have selected [7, 5] trellis diagram for MATLAB expression and topology 5 is optimum topology found suitable for minimum BER.

Another reason for selecting topology 5 as compared to topology 2, that in topology 2 there is no closed loop formed for V_2 so it affects system stability and produces less uncorrelated bits, while in topology 5 there is large closed loop formation among input two shift registers and V_2 makes it more stable and giving larger gain. Other possible topologies results were pessimistic show those are not frequently used in convolutional coder hardware design.

Table 1

Random Interleaver, Convolutional [1,2] Encoding, Spread Length (S.L.=16), Data Length (m)=512, Constraint Length (L) = 3 and block =50				
Network Topology	Generator G_1 G_2	G_1	G_2	B.E.R.
1	(7,1)	111	001	4.4375×10^{-4}
2	(7,2)	111	010	1.1719×10^{-6}
3	(7,3)	111	011	3.8398×10^{-4}
4	(7,4)	111	100	1.1719×10^{-6}
5	(7,5)	111	101	2.3437×10^{-6}
6	(7,6)	111	110	2.7773×10^{-4}
7	(7,7)	111	111	2.668×10^{-4}

6. CONCLUSION

Optical IDMA is important multiple access technique and using convolutional coder various network topologies combinations over it, the optimum network topologies is (7, 5) that is network topology 5 which gives the BER 2.3437×10^{-6}. This hardware connection gives good stability as well as lower BER among all cases. By using another type of interleavers like prime, helical and tree in this technology results may be much improved. We can also use more numbers of adders for fixed constraint length and results of BER be much more reduced. So by changing the adders of upper portion of hardware V_1 which is fixed in our , may also be changed, and results may be observed in future. Overall we can say that convolutional encoders are good and prominent technique to enhance the performance of OIDMA technique.

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