8thInternational Conference on Contemporary Information Technology and Mathematics (ICCITM2022), Mosul University, Mosul-Iraq

2022 8th International Conference on Contemporary Information Technology and Mathematics (ICCITM) | 979-8-3503-3486-9/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICCITM56309.2022.10031632

BER Enhancement of M-ary BPSK Multi-Codes CDMA System based on ACO Optimization Algorithm

Hayder Fadhil Abdulsada
Electrical Engineering Department
University of Babylon
Al-Furat Al-Awsat Technical University,
Babylon, Iraq
inj.had1@atu.edu.iq

Samir J. Mohammed
Electrical Engineering Department
University of Babylon
Babylon, Iraq
dr.samiralmuraab@uobabylon.edu.iq

***Abstract*— Wireless communications have achieved wide development in recent years. There is a great need for wireless communication services that reduce the effects of the transmission channel and transmit data with high data rates. There are many services that increase data transmission rate, such as M-ary BPSK Multi-Code CDMA system. The M-ary BPSK CDMA system has been designed and simulated using Walsh-Hadamard spreading code with lengths of 256, 128, 64, and 32 in the AWGN channel. An Ant Colony Optimization (ACO) algorithm is proposed to find the best constellation points for the M-ary BPSK system that improves the bit error rate performance of the system. The results demonstrate that the M-ary BPSK CDMA system based on the ACO algorithm to find the best constellation points outperforms the system that doesn't depend on the best constellation points. The results proved that the bit error rate performance was improved by relying on the best set of constellation points in which about 2dB was gained, and this means that more users can be accessed at the same bit error rates. Also, the bit error rate performances for M=8 and M=16 are very close because the 16-ary used best constellation points, and three spreading codes were allocated for each user, while for the 8-ary system, two spreading codes were allocated for each user.**

Keywords—Multicode CDMA, M-ary BPSK CDMA system, ACO optimization algorithm.

I. INTRODUCTION

The need for wireless communications has increased for high data rates in the field of multimedia and data transmission. The Code Division Multiple Access (CDMA) technique can be classified as one of best multiple access systems. The CDMA communication system is based on the spread spectrum technique where all users share the same channel [1][2].

Multi-code CDMA is a technique derived from the classical CDMA system. The classical CDMA system works on a unique spreading code for each user, and this code represents the signature of that user to recognize it from other users. Orthogonal or quasi-orthogonal codes are used as signature codes to identify each user. In the classical CDMA system, the spreading process performs two essential functions. The first is spreading of the signal bandwidth to attain specific processing gain, while the second is the assignment of a unique signature to each user to distinguish it from other users [1][3][4]. In the multicode CDMA system, multiple spreading codes could be assigned for a user to encode the data symbols as required. As a result, a significant degree of freedom is available to get different data transmission rates. Different schemes of multicode CDMA could be used to encode the information data, such as multicode CDMA system, orthogonal code CDMA system, parallel combinatorial CDMA system, and M-ary BPSK CDMA system [5][6].

A. M-ary BPSK CDMA system

Figure 1 and Fig. 2 below illustrate the transmitting and receiving parts of the M-ary BPSK CDMA system. At first, the incoming data serial bits will pass via serial to parallel converter before the mapping process of the data symbol [7].

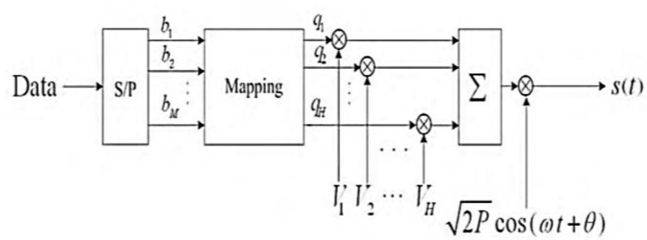

Fig. 1. Transmitting unit of M-ary BPSK CDMA System [7].

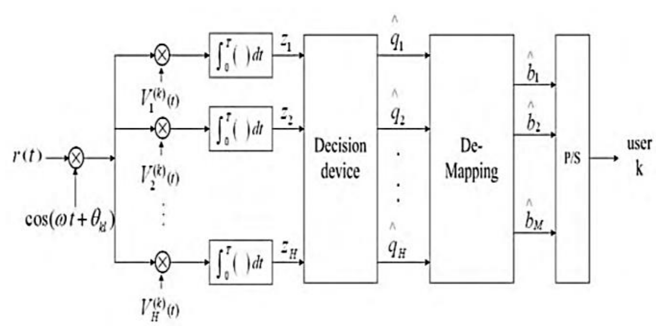

Fig. 2. Receiving unit of M-ary BPSK CDMA System [7].

Each customer is assigned H codes (V_1, V_2, …, V_H) in the M-ary BPSK CDMA system. It can be noticed from Fig 1 that the mapping unit in the transmitting part selects a code combination (one constellation point) for each specific m bits data symbol. This point represents the weight of spreading codes. Therefore, the transmitter sent combinations of codes that representing each symbol. Suppose that each m bits data symbol is represented by the vector (b_1, b_2, …., b_m) and can be mapped into another vector denoted as (q_1, q_2, . . . , q_H) where H (>1) is the number of codes given to each user.

For H = 3 (Three codes are available q_1, q_2, and q_3), the transmitter has the following available cases to transmit different spreading codes. The transmitter can transmit single code with six possibilities which are $+q_1$, $-q_1$, $+q_2$, $-q_2$, $+q_3$, $-q_3$. It can transmit two codes with twelve possibilities which are $+q_1 +q_2$, $+q_1 +q_3$, $+q_2 +q_3$, $-q_1 +q_2$, $-q_1 +q_3$, $-q_2 +q_3$, $+q_1 -q_2$, $+q_1 -q_3$, $+q_2 -q_3$, $-q_1 -q_2$, $-q_1 -q_3$, $-q_2 -q_3$. Also, it can transmit three codes with eight possibilities which are $+q_1 +q_2 +q_3$, $-q_1 +q_2 +q_3$, $+q_1 -q_2 +q_3$, $+q_1 +q_2 -q_3$, $-q_1 -q_2 +q_3$, $-q_1 +q_2 -q_3$, $+q_1 -q_2 -q_3$, $-q_1 -q_2 -q_3$. As a result, there are 6 + 12 + 8 = 26 possible states, which is exactly $3^H - 1 = 26$. Table I explains the relation between the available spreading codes for each user (H), the number of states, the number of bits per symbol, and the unused states. In this manner, it is clear that the 16-ary BPSK CDMA system can have 26 different code states. Only 16 states or combination codes of the 26 states should be utilized to encode different four bits data symbols [4][7][8].

TABLE I. RELATIONSHIP BETWEEN THE IMPORTANT PARAMETERS FOR M-ARY BPSK CDMA SYSTEM

H	States	Bit/symbols(m)	Unused states
2	8	3	-
3	26	4	26-16=10
4	80	6	80-64=16
5	242	7	242-128=114
6	728	9	728-512=216

II. ACO OPTIMIZATION ALGORITHM

ACO optimization algorithm is a robust algorithm that employs a distributed parallel processing approach. It was introduced by Dorigo M and others researchers in 1992. The algorithm is started by making a number of ants take a tour and depending on positive feedback (storing pheromone) that made by ants. The algorithm can reach the source of food with optimal path [9][10].

The ACO algorithm model has been come from the capability of ants to make a pheromone at paths during the searching for food. At the searching process, ants use the strength of the remaining pheromone to determine their direction, and they generally travel in the orientation of the highest pheromone intensity. Based on positive feedback of pheromone. The shorter path is gradually obtained with high concentration of pheromones [10].

III. RELATED WORKS

M. G. Zia (2013) presented the multicode-MC-CDMA based on the chaotic code sequence and how this sequence affects the system performance in wireless communication. The chaotic sequence has been used as a code sequence set to spread the data at the multicode stage. One chaotic generator which depends on multiple initial conditions is used to generate the sequence code sets. The system outcomes show that the multicode-MC-CDMA system based on chaotic code sets outperforms the system based on Walsh-Hadamard spreading codes [11].

T.D.V.A Naidu et al. (2014) introduced a multicode-MC-CDMA system that gets the MC-CDMA benefits to eliminate the multipath and prevent interferences. It also exploited the benefits of multicode to obtain different data transmission rates. The researchers use multiple code sets in the multicode part in AWGN and multipath fading channels. The MTC-MC-CDMA system utilizes the advantage of MTC-CDMA to get different data transmission rates and the advantages of MC-CDMA to resist multipath fading. The proposed system offers better BER performance than the MTC-CDMA [12].

In 2016 Z. Abdelhak used an M-ary BPSk CDMA system as a multicode technique for the multicode Multicarrier CDMA system. The researcher chooses a random set of constellation points to form the combination codes used for data spreading, where the system's design is based on selecting any set of constellation points. The researcher also used an interleaver with the MC-MC-CDMA to make the spreading of data in time and frequency domains [7].

In 2018, A. Farzamnia introduced the direct sequence, multi-carrier, and slow frequency hopping CDMA systems in two types of channels: the Rayleigh fading channel and the Rician fading channel. A different number of users have been used to simulate the above systems and measure the BER performances of each system. The result proved that the BER performance of the three systems decreases with the increase in the user's number. Also, the BER performance of the multicarrier-CDMA system outperforms the BER performance of the two other systems [13].

In our proposed system, an ACO optimization algorithm has been suggested to obtain the best combination codes for symbol mapping of the 16-ary BPSK CDMA system, where the researcher at reference (7) used a random selection of codes to represent the data symbols. Our proposed system can enhance the BER performance of the 16-ary BPSK system to be very close to the BER of 8-ary BPSK CDMA system.

IV. SYSTEM MODEL

Figure 3 below displays the block diagram of the M-ary BPSK CDMA System. At first, the serial data is modulated by BPSK modulation and then converted to parallel data symbols; after that, each symbol is mapped into one constellation point of the best set of M-ary constellation points fetched from the ACO optimization algorithm. These mapped points are then multiplied by the spreading codes of the user to form a combination code that will be transmitted to the receiver.

At the receiver, the received information is despreaded by the spreading codes of the user. Later, the receiver should detect the constellation point representing each symbol. It requires determining the Euclidean distances between the despreaded data and all constellation points and selecting the one with a shorter distance.

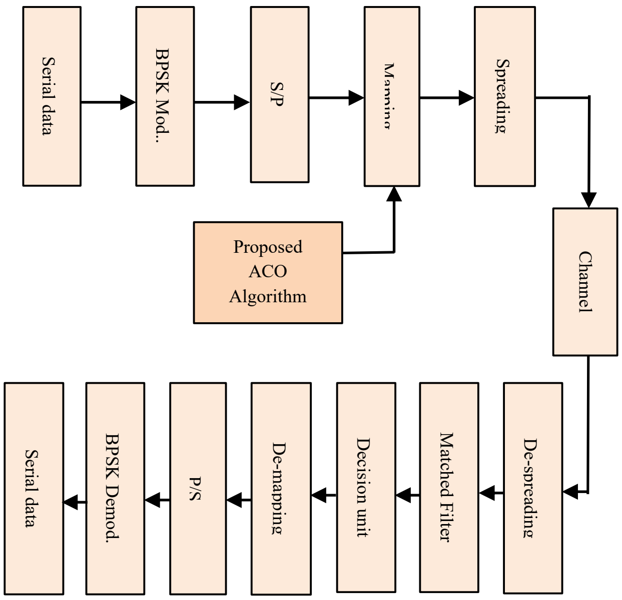

Fig. 3. Block diagram of M-ary BPSK CDMA System

For any value of H, the values of the vector elements (constellation points) are taken depending on the formula

$$\sum_{h=1}^{H} q_h^2 = 1 \quad (1)$$

This ensures that equal average power is utilized for any value of H. Hence, different M-ary systems could be compared correctly with a different number of spreading codes for each user [8][9].

Table II shows all constellation points of an M-ary BPSK CDMA system with H = 3. These points represent the weights of the sent codes for each user. Each data symbol has been mapped to one of these points. It may not be able to use all the points mentioned in table II, whose number equals to $3^H - 1$= 26 points. There are only 16 points required for 16-ary BPSK CDMA system. These 16 constellation points are used to encode 16 symbols with size of m = $\log_2(3^H - 1) = 4$ bits.

For 8-ary BPSK CDMA system, where each data symbol includes three bits, the constellation points for H=2 have been used. For H=2, There are two codes available q_1 and q_2, and eight states. All states should be used (no unused states) to represent the data symbols. Table III below displays the constellation points for H=2 that are used for symbol mapping. For 4-ary BPSK CDMA, H=2 should be used. Four states from the eight states have been chosen, which are (1,0), (-1,0), (0,1), and (0, -1) to represent the symbols in the mapping block.

TABLE II. ALL CONSTELLATION POINTS FOR A M-ARY BPSK CDMA SYSTEM WITH NORMALIZED AVERAGE POWER FOR H=3.

C1 ($q_1 q_2 q_3$)	**C2** ($q_1 q_2 q_3$)	**C3** ($q_1 q_2 q_3$)	**C4** ($q_1 q_2 q_3$)	**C5** ($q_1 q_2 q_3$)
(1,0,0)	(-1,0,0)	(0,1,0)	(0,-1,0)	(0,0,1)
C6	**C7**	**C8**	**C9**	**C10**
(0,0,-1)	$(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0)$	$(\frac{1}{\sqrt{2}}, \frac{-1}{\sqrt{2}}, 0)$	$(\frac{-1}{\sqrt{2}}, \frac{-1}{\sqrt{2}}, 0)$	$(\frac{-1}{\sqrt{2}}, \frac{1}{\sqrt{2}}, 0)$
C11	**C12**	**C13**	**C14**	**C15**
$(\frac{1}{\sqrt{2}}, 0, \frac{1}{\sqrt{2}})$	$(\frac{1}{\sqrt{2}}, 0, \frac{-1}{\sqrt{2}})$	$(\frac{-1}{\sqrt{2}}, 0, \frac{1}{\sqrt{2}})$	$(\frac{-1}{\sqrt{2}}, 0, \frac{-1}{\sqrt{2}})$	$(0, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}})$
C16	**C17**	**C18**	**C19**	**C20**
$(0, \frac{1}{\sqrt{2}}, \frac{-1}{\sqrt{2}})$	$(0, \frac{-1}{\sqrt{2}}, \frac{-1}{\sqrt{2}})$	$(0, \frac{-1}{\sqrt{2}}, \frac{1}{\sqrt{2}})$	$(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}})$	$(\frac{-1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}})$
C21	**C22**	**C23**	**C24**	**C25**
$(\frac{1}{\sqrt{3}}, \frac{-1}{\sqrt{3}}, \frac{1}{\sqrt{3}})$	$(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{-1}{\sqrt{3}})$	$(\frac{-1}{\sqrt{3}}, \frac{-1}{\sqrt{3}}, \frac{1}{\sqrt{3}})$	$(\frac{-1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{-1}{\sqrt{3}})$	$(\frac{1}{\sqrt{3}}, \frac{-1}{\sqrt{3}}, \frac{-1}{\sqrt{3}})$
C26				
$(\frac{-1}{\sqrt{3}}, \frac{-1}{\sqrt{3}}, \frac{-1}{\sqrt{3}})$				

TABLE III. ALL CONSTELLATION POINTS FOR A M-ARY BPSK CDMA SYSTEM WITH NORMALIZED AVERAGE POWER FOR H=2.

C1 ($q_1 q_2$)	**C2** ($q_1 q_2$)	**C3** ($q_1 q_2$)	**C4** ($q_1 q_2$)
(1,0)	(-1,0)	(0,1)	(0,-1)
C5	**C6**	**C7**	**C8**
$(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}})$	$(\frac{1}{\sqrt{2}}, \frac{-1}{\sqrt{2}})$	$(\frac{-1}{\sqrt{2}}, \frac{1}{\sqrt{2}})$	$(\frac{-1}{\sqrt{2}}, \frac{-1}{\sqrt{2}})$

V. THE PROPOSED ACO OPTIMIZATION ALGORITHM FOR M-ARY BPSK CDMA SYSTEM

For H greater or equal to 3, There will remain a large number of constellation points that have not been used, and this is a great opportunity to find the best constellation points that the Euclidean distances between them are maximum; therefore, this will give the lowest bit error rate at the receiver.

For H=3, there will be 3^H-1= 26 available constellation points, but we need to select the best 16 points from them to achieve the 16-ary BPSK CDMA. Therefore, there will be $C_{26}^{16} = \frac{26!}{(26-16)!\,16!} = 5311735$ different choices, which is a huge number!

The objective is to select the best constellation set from 5311735 sets for H=3. It is necessary to use a useful optimization algorithm to do this objective. Different algorithms can be utilized for this problem. The ACO

optimization algorithm has been suggested to get the best constellation set where the selected set must satisfy the following terms

1. The best-selected set must be with a maximum average sum of Euclidean distances between any two constellation points.

2. When two sets or more have the same maximum average sum of distances between any two constellation

points, then the best set is that with the least variance of the distances between any two constellation points.

The first term guarantees that the least errors occur in the detection process where the maximum distance between the constellation points gives less interferences and errors, The second term aids in selecting a constellation point set with the most evenly distributed points in the constellation field, resulting in the most evenly distributed detection performance for various states points.

For the worst constellation points, the opposite of the above conditions has been adopted where the worst set must have the minimum average sum of Euclidean distances between any two constellation points and the highest variance of the distances between any two constellation points.

The "(2)" displays the average sum of Euclidean distances between any two constellation points, and "(3)" shows the variance of the Euclidean distances between any two points.

$$AvS = E[d_i] = \frac{1}{n}\sum_{i=1}^{n} d_i \quad (2)$$

$$Var(d_i) = E(d_i - AvS)^2] = E\left[{d_i}^2\right] - (E[AvS])^2 \quad (3)$$

$$= \frac{1}{n}\sum_{i=1}^{n} {d_i}^2 - \left(\frac{1}{n}\sum_{i=1}^{n} d_i\right)^2$$

هنا m=log2(26)=4 bits, n=16

يجب الانتباه لهذه المعلومة

Where $n = 2^m$ represents the number of states in each symbol, and d_i is the Euclidean distance between a specific pair of two constellation points.

The proposed ACO algorithm to find the best constellation points is explained in the flowchart in Fig. 4 below.

The fitness function for the best constellation points is expressed by the following formula

$$F_b = \frac{W_1}{AvS} + (W_2 \times Var) \quad (4)$$

And the fitness function for the worst constellation points is explained as follows:

$$F_w = (W_1 \times AvS) + \frac{W_2}{Var} \quad (5)$$

Where the factors w_1 and w_2 were chosen to be 1 and 1×10^{-15} , respectively.

These values have been selected to ensure that the algorithm's decision depends mainly on the average sum of Euclidean distances (AvS) between any two constellation points in choosing the best or the worst set. If two sets or more have the same desired average sum of distances between any two constellation points, then the algorithm uses the variance (Var) to make its decision about the best or worst points.

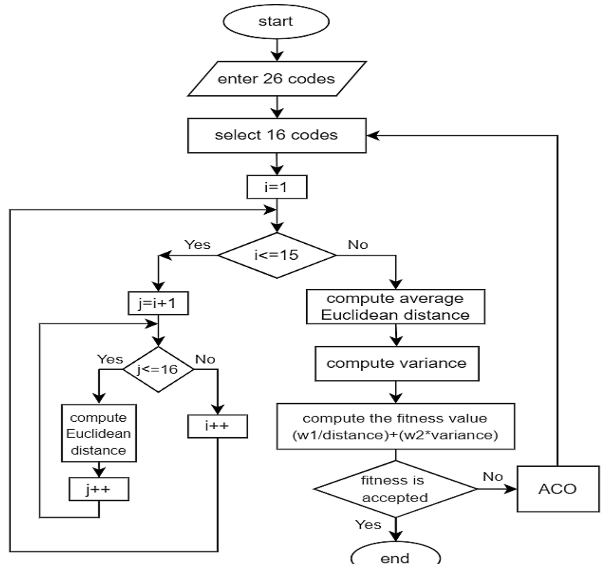

Fig. 4. Flowchart of the proposed system based on ACO algorithm

VI. RESULTS AND DISCUSSION

Depended on the ACO optimization algorithm discussed above, the two best sets of constellation points have been obtained for H = 3 which have the maximum average sum of distances between any two points. These best sets of points are:

(C_1,C_2,C_5,C_6,C_7,C_8,C_9,C_{10},C_{11},C_{12},C_{13},C_{14},C_{15},C_{16},C_{17},C_{18}),

And

(C_1,C_2,C_3,C_4,C_7,C_8,C_9,C_{10},C_{11},C_{12},C_{13},C_{14},C_{15},C_{16},C_{17},C_{18})

Figure 5 below displays the iteration processes of the ACO optimization algorithm to find the best constellation points where the best fitness is obtained at about 1700 iterations.

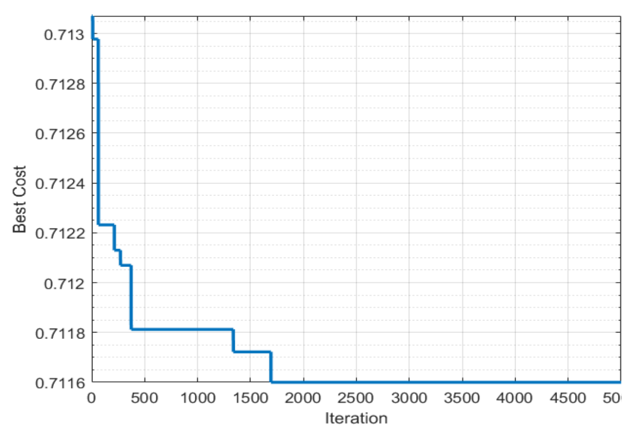

Fig. 5. Iteration process of ACO algorithm to find the best points

The two worst sets of constellation points that have a minimum average sum of distances between any two constellation points for H=3 are

(C_2,C_3,C_4,C_6,C_7,C_8,C_9,C_{10},C_{12},C_{14},C_{16},C_{17},C_{22},C_{24},C_{25},C_{26}), And

$(C_1,C_2,C_4,C_5,C_7,C_8,C_9,C_{10},C_{11},C_{13},C_{15},C_{18},C_{19},C_{20},C_{21},C_{23})$

Figure 6 shows the iteration processes of the ACO optimization algorithm to find the worst constellation points where the best fitness has been obtained at about 1900 iterations.

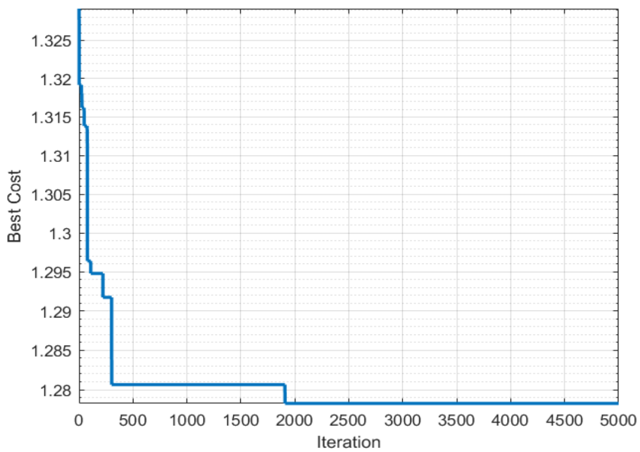

Fig. 6. Iteration process of ACO algorithm to find the worst points

The M-ary BPSK multicode CDMA system has been simulated in the AWGN channel by using Matlab 2021b, where the Walsh-Hadamard code is used for spreading with a length of 256.

In Fig 7 below, the best and worst sets of constellation points were adopted for 10 users 16-ary BPSK multicode CDMA system. The results proved that the bit error rate performance was improved by relying on the best set of constellation points in which about 2dB was gained, and this means that more users can be accessed at the same bit error rates.

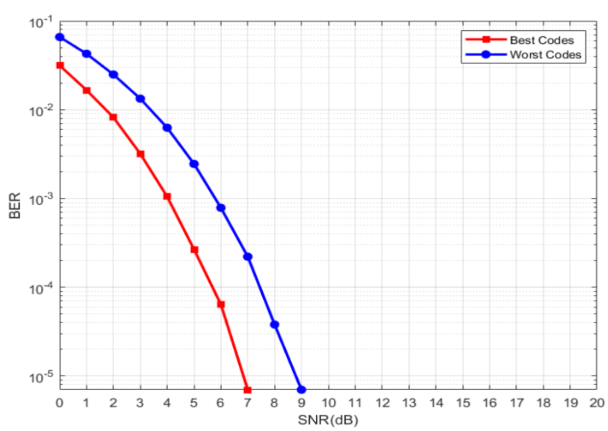

Fig. 7. BER with SNR for 16-ary BPSK multicode CDMA in AWGN channel (K=10 users)

In Fig. 8 below, different numbers of users have been simulated at SNR of 10dB for the 16-ary BPSK multicode CDMA system with both best and worst constellation points. For the 16-ary BPSK multicode CDMA system, The system gives three Walsh-Hadamard codes with a length of 256 for each user; therefore, the system allows up to 85 users to be accessed. It is clear that the 16-ary BPSK multicode CDMA system based on the best set of constellation points outperforms the system based on the worst set of constellation points where it allows more users to communicate at a specified value of BER.

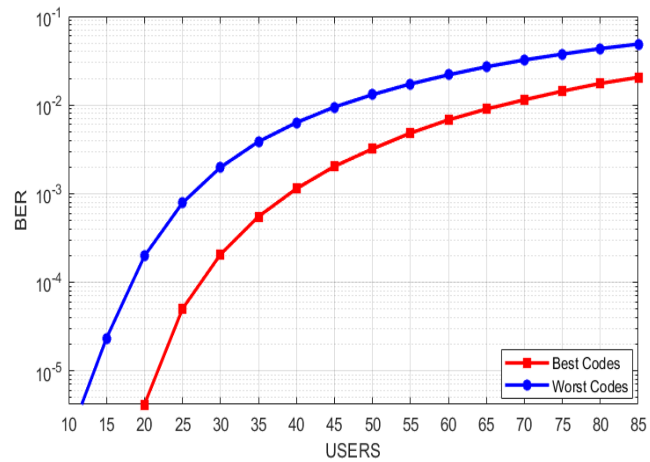

Fig. 8. BER with number of users for 16-ary BPSK multicode CDMA in AWGN channel (SNR=10dB).

The 16-ary BPSK CDMA system for best constellation points is compared with 8-ary BPSK CDMA system. The results show that the 16-ary BPSK CDMA system based on the proposed ACO optimization algorithm to choose the best constellation points slightly outperforms the 8-ary BPSK system in BER performance. The proposed 16-ary system gives a significant data transmission rate where four bits per symbol can be transmitted while the 8-ary BPSK system transmits three-bit per symbol. Fig. 9 below illustrates the BER performance for 8-ary and 16 ary BPSK CDMA systems with a different number of users and SNR of 10 dB in AWGN channel.

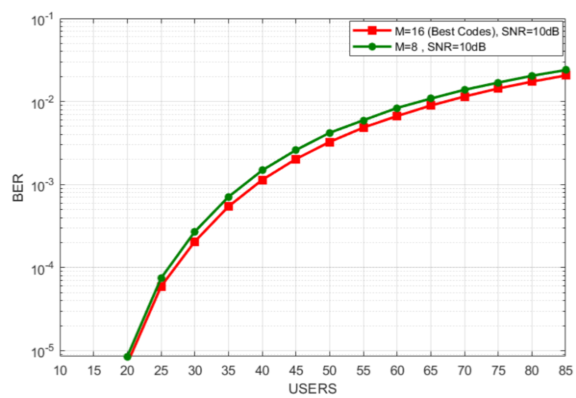

Fig. 9. BER with number of users for 8,16-ary BPSK multicode CDMA systems in AWGN channel (SNR=10dB).

Figure 10 shows the BER performance of the 4, 8-ary BPSK CDMA, and the 16-ary BPSK CDMA system based on the best combination codes or constellation points. The simulation results illustrate that the BER performances for M=8 and M=16 are very close because the 16-ary is based on the best constellation points and has an average sum of

Euclidean distances that approach to the average sum of Euclidean distances of the 8-ary system. The other reason is that three spreading codes were allocated for each user in the 16-ary system; while for the 8-ary system, two spreading codes have been allocated for each user, and the system used all the states for H=2. The simulation is carried out for 85 users with a code length of 256 in the AWGN channel.

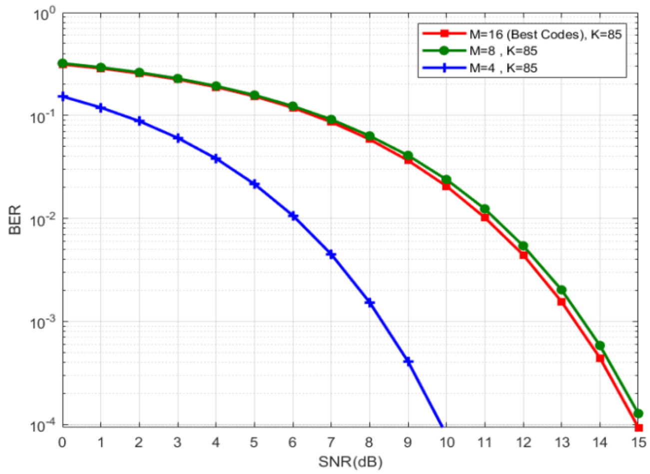

Fig.10. BER with SNR for (4, 8 and 16)-ary BPSK multicode CDMA (K=85 users)

The best-obtained constellation points have been used for 16-ary BPSK CDMA systems with different spreading code lengths such as 256, 128, 64, and 32. The systems have been simulated for 10 users in the AWGN channel. The results show that the BER performance of the system is improved with the increase of spreading code length, as shown in fig. 11 below. The system with longer spreading code is more reliable than the system with shorter spreading code where the correlation process with all transmitted codes at the receiver is more accurate for the longer code.

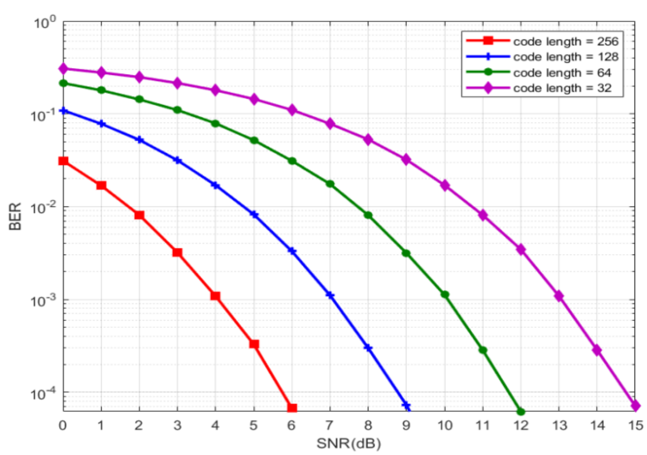

Fig. 11. BER with SNR for 16-ary BPSK multicode CDMA systems with different code lengths in AWGN channel (K=10 users).

VII. Conclusion and Future Works

The M-ary BPSK CDMA system is a multicode code system used to get high and different data transmission rates. An Ant Colony Optimization algorithm was suggested to find the best and worst combination codes for the 16-ary BPSK CDMA system. The results show that the system based on the best combination codes gives better BER performance than the system that depends on a random selection of the 16 codes or that depends on the worst combination codes. Hence, more users can be accessed at the same bit error rates. Also, the 16-ary BPSK system based on the best codes slightly outperforms the 8-ary BPSK system in BER performance. Our future work is to design the MC-MC-CDMA system based on the optimized M-ary BPSK CDMA multicode system and implements it on FPGA.

References

[1] A. A. Patel, A. D. Patel,"MATLAB Implementation of Multiuser Code Division Multiple Access," *Journal Of Telecommunications*, pp40–45, Volume 7, Issue 2, 2011.

[2] R. Ganesh and C. S. Reddy," FPGA Implementation of MC CDMA for High Security Applications", *CVR Journal of Science and Technology*, pp 36-41, Volume 5, 2013.

[3] S. Sadoudi and I. Fennouh," Hyperchaos-Based Spreading Codes Generator for DS-CDMA Communication Systems," *Journal of Circuits, Systems, and Computers,* pp 1-23, Volume 27, Issue 13, 2018.

[4] P. S. Srivastava", Multi Rate -Multi Code - Cdma For Broadband Cellular Communication Network-A Review," *International Journal of Industrial Electronics and Electrical Engineering,* Volume 3, Issue 4, 2015.

[5] M. S. Ali, M. S. Islam, M. A. Hossain, and M. K. H. Jewel, "BER Analysis Of Multi-Code Multi-Carrier Cdma Systems In Multipath Fading Channel", International Journal of Computer Networks & Communications (IJCNC), pp 178-191, Volume.3, Issue3, 2011.

[6] Z. Abdelhak, D. Ali, D. Khalifa, "Interleaving in Time frequency Diversity on Multi-code Multicarrier CDMA System", *Journal of Electrical and Electronics Engineering,* Volume 9, I ssue 1, 2016.

[7] M. Z. Abdelhak, "Effects of Codes and Subcarrier Interleaving on Multi-code Multicarrier CDMA System," PHD theses, Djillali Liabès University of Sidi-Bel-Abbes, 2016.

[8] N. Guo and L. B. Milstein, "On Rate-Variable Multidimensional DS/SSMA with Sequence Sharing," *IEEE Journal On Selected Areas In Communications*, Volume 17, issue 5, 1999.

[9] X. Yu, L.Wen, M. Zheng, J Lu, and L Zhang, "Firefly algorithm and ant colony algorithm to optimize the traveling salesman problem," *Journal of Physics: Conference Series,* pp 1-5, 2022.

[10] H. Fahmi, M. Zarlis, E. Nababan1, and P Sihombing", Ant Colony Optimization (ACO) Algorithm for Determining The Nearest Route Search in Distribution of Light Food Production," *Journal of Physics: Conference Series,* pp 1-5, 2020.

[11] M. G. Zia, "Performance of Chaos-Based MC-MC-CDMA in Frequency Selective Fading Channel", International Journal of Scientific and Engineering Research , pp 1-4, Volume 4, Issue 1, 2013.

[12] T.D.V.A Naidu, K Vamsi, "Multi-Code and Multi-Carrier CDMA Systems for Next Generation Wireless Systems", International Journal of Scientific & Engineering Research, Volume 5, Issue 9, 2014.

[13] A. Farzamnia, M Mariappan, R Thangasalvam, and E G Moung, "Comparison of Bit Error Rate Performance for CDMA Systems in Different Fading and AWGN Channels", IEEE, 2018.