Presenting a New Model of Optimal Coordinated Beamformer Vector Selection in DRFM for Radar Jamming

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ABSTRACT:
Digital Radio Frequency Memory (DRFM) is a technique that uses high-speed sampling and digital memory to store radio frequency and microwave signals. DRFM is a popular technique for implementing false-target ECM systems. DRFM is a technique that stores and reproduces radio frequency (RF) and microwave signals. Input an RF signal that has been converted to a frequency sufficient for sampling by a high-speed A/D converter (ADC). The sampled signal is stored in a high-speed memory and can be retrieved and converted to the original signal using a D/A converter (DAC). In this article, the principles and architecture of DRFM have been reviewed and to improve the performance of this system, the method of interference matching has been proposed using a coordinated beam shaper to improve the performance of this system in creating interference. This article, it is presented to evaluate the proposed method in improving the interference values and BER in the method based on the improvement of the coordinated beamformer. For this purpose, a DRFM was considered for disruption. Then the proposed method was implemented with the help of signal processing and in MATLAB software on this DRFM. In the proposed method, an objective function is considered by considering the increase in the number of objectives in proportion to the fulfillment of the acceptable rate. Based on this objective function, the amount of interference and BER has been reduced. The effect of increasing targets on interference and BER has been investigated in evaluating the proposed method. For this purpose, the SINR value was changed, and based on the change of the SINR value and the change in the number of targets, the evaluation was done. The obtained results show that with the increase in the number of targets, the amount of interference and also the amount of BER have increased. The increase in the number of targets in the proposed optimal and quasi-optimal coordinated beamformer method with the increase in the number of targets is much less than that of the coordinated beamformer. It is also the reason for this superiority. Also, the desired optimization function in the stated situations has caused this importance to be taken into account. The proposed method has been evaluated in terms of bit error rate and interference. The evaluation results show a reduction in bit error rate up to 6%, and interference up to 5% compared to the coordinated beamformer as the number of targets increases.

KEYWORDS: DRFM, Digital Signal Processing, Frequency Domain, Coherent Beamformer.

1. INTRODUCTION

DRFM systems are a transmitter and receivers capable of digitizing, storing, modifying, and retransmitting the recorded waveform. Doing this requires different types of sub-systems as follows: receiver, analog-to-digital converters (ADC), digital signal processing (DSP), electronic control system (EA), digital-to-analog converters (DAC), and transmitters. Although the working principle of DRFM is very simple, however, the existing problems come back to the understanding of its technology.

DRFM enables the realization of the following:

- Harmonious storage and reproduction of received signals

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- Delay the output signal until it is desired
- Noise generation around the frequency of the received signal
- Production of each frequency in the frequency band
- Production of coherent disturbances

2. AVOIDANCE

Interference avoidance is a fundamental idea in wireless telecommunication networks. Interference equalization has recently emerged in the discussion of the capacity analysis of networks with interference. In a relatively short time, this topic has challenged a lot of knowledge about the limits of the performance of wired and wireless networks. As a practical example, a wireless interference channel with K transmitter-receiver pairs where, due to interference uniformity, each user can simultaneously achieve half the capacity of the interference-free channel, even if the number of targets is arbitrarily K. be a lot As a result of a wireless communication channel, the existence of interference is not an annoying limitation and it can be reduced to a minimum value by using different methods. While the significant advantages of interference matching have been shown, mostly under idealistic assumptions, such as: knowing the global channel, expanding the bandwidth, infinite resolution, high signal strength, and significant delays, this idea attracted a growing number of enthusiasts in the telecommunications, signal processing, network, and information theory communities and provided fundamental insight into the number of signaling dimensions available in wired and wireless communications networks.

steganography is the art and science of covert communication, the purpose of which is to hide the communication by placing the message in a mask (a medium that has the ability to hide information in it such as image, sound, or any possible data) in such a way that the least detectable change is made. Create in it and the existence of the hidden message in the media cannot be revealed even in a possible way [1].

3. PROPOSED SCHEMES FOR SELECTING THE COORDINATED BEAM-FORMING VECTOR

Special coordinated beam-forming interference alignment method KS((K-I)M-N) provides a selectable vector for interference alignment, among which p can be selected vector and matrix. Get the transmit V and receive filter W for all purposes. Here, using this method, we examine the first and third strategies. If $\boldsymbol{C_T}$ is the set of valid coordinated beam-forming vectors and $\tilde{V}^{(i)}$ is the coordinated beamforming vector and the number of these vectors is equal to L_v, we will have:

$$\mathbf{C_T} = \left\{\square^{(\mathbf{1})}, \square^{(\mathbf{2})}, \dots\ , \square^{(\boldsymbol{L_v})}\right\} \tag{1}$$

Now, if $\mathbf{C}_{\boldsymbol{i}}$ is a combination including p vector $\tilde{V}$ that can be selected for use in the network, then the number of these sets, i.e. n($\mathbf{C}_{\boldsymbol{i}}$) in each algorithm can be considered as a criterion for the number of calculations. Here, the problem is to find a C (from which the precoder matrices and the received filter are obtained) that increases the rate according to the first or third strategy. That is, in the first strategy, it increases the rate of interference and disruption, and in the third strategy, it increases the rate of the whole system.

4. OPTIMUM COORDINATE BEAMFORMING VECTOR SELECTION SCHEME

The most optimal way to choose the set of coordinated beam-forming vectors is to search and calculate the rate and then choose the best set (which here is the set that gets the highest rate). In this method, the rate of all combinations of $\tilde{V}$ vectors, i.e. all possible ($\mathbf{C}_{\boldsymbol{i}}$) sets, must be calculated. Calculating the rate means building the precoder matrix of the transmitter and the received filter in the receiver for all purposes. Therefore, the optimal coordinated beam-forming vector selection method seems appropriate in places where the number of targets and also the number of antennas are small, but in crowded places or in systems where the channel varies with time and the calculation time plays a major role. This method is not practical and a pseudo-optimal method should be used, which is more efficient in terms of the speed of performing calculations.

5. PSEUDO-OPTIMAL BEAM-FORMING VECTOR

As mentioned above, due to the many calculations, the optimal design is rarely used, and most networks require a design with high speed, few calculations, and close to optimal performance. In this quasi-optimal design, the selection of coordinated beam-forming vectors for the formation of $\mathbf{C}_{\boldsymbol{i}}$ is based on adjacent vectors with steps of μ. That is, if according to the definition:

$$\mathbf{C_T} = \left\{\square^{(\mathbf{1})}, \square^{(\mathbf{2})}, \dots\ , \square^{(\boldsymbol{L_v})}\right\} \tag{2}$$

$\tilde{V}^{(i)}$ Vectors are arranged, the set of coordinated beam-forming vectors is formed as follows:

$$\mathbf{C_1} = \left\{\tilde{V}^{(\mathbf{1})}, \tilde{V}^{(\mathbf{2})}, \dots, \tilde{V}^{(\boldsymbol{p})}\right\} \tag{3}$$
$$\mathbf{C_2} =$$

$\left\{ \tilde{\mathrm{V}}^{(\mu+\mathbf{1})}, \tilde{\mathrm{V}}^{(\mu+\mathbf{2})}, \dots, \tilde{\mathrm{V}}^{(\boldsymbol{u}+\boldsymbol{p})} \right\},$

$\mathbf{C_3} \ =$
$\left\{ \tilde{\mathrm{V}}^{(\boldsymbol{p}+\mu+\mathbf{1})}, \tilde{\mathrm{V}}^{(\boldsymbol{p}+\mu+\mathbf{2})}, \dots, \tilde{\mathrm{V}}^{(\boldsymbol{u}+\mathbf{2}\boldsymbol{p})} \right\}$

$\mathbf{C}_{\boldsymbol{i}} \ =$
$\left\{ \tilde{\mathrm{V}}^{(\boldsymbol{pi}+\mu+\mathbf{1})}, \tilde{\mathrm{V}}^{(\boldsymbol{pi}+\mu+\mathbf{2})}, \dots, \tilde{\mathrm{V}}^{(\boldsymbol{u}+\mathbf{2}\boldsymbol{pi})} \right\}$

Where $\mathbf{C}_{\boldsymbol{i}} \subset \mathbf{C}_{\boldsymbol{T}}$_T. Keep in mind that the condition $1 \le \mu \le p$ should be established in order for all the vectors of the coordinated beam to be selected at least once in this scheme. As it can be seen, each set differs from the next set in μ members, as a result μ=1 means the maximum number of groups in this method and μ=p means no overlap between groups and in The result contains the smallest number of groups. μ can be called the step size because to form the next group, it is necessary to move forward by the size of μ. From a computational point of view, this method with step size one (μ=1) which has the largest number of groups, using the criterion of the number of sets is equal to:

$$\mathrm{n}(\mathrm{C}_i{}^{\mu=1}) = L_v - 1 \qquad (4)$$

Which has significantly reduced the amount of calculations compared to the optimal method.

6. EVALUATION OF THE PROPOSED METHOD IN DRFM

The main objective is to implement the frequency jammer in DRFM. Therefore, the coordinated beam-forming method based on the selection of the optimal coordinated beam-forming vector was presented. For this purpose, a DRFM is considered for simulation. This DRFM is simulated in MATLAB environment and the necessary processing will be done on it. In this chapter, the results of the research will be presented.

7. SIMULATION

In all simulations, the number of targets is 100. All target devices are external and the simulation environment is a common environment. Each user's device has its own traffic generation and is capable of generating all kinds of traffic. In all the experiments, the number of power levels considered is J=10, while the maximum allowed power level is P_max, P_max=23dB_m.

Also, the main simulation parameters are shown in Tables 1 and 2.

Table 1. Interfering frequency bands

$\boldsymbol{k} \in$ Chanels $\boldsymbol{C_k}$ $\boldsymbol{K_n}$	Bandwidth $\lvert \boldsymbol{K_n^c} \cup \boldsymbol{K_n} \rvert$	BS
$K_1 = \{1, \dots, 10\}$	$25RB_s(5\ MHz)$	BS_1
$K_2 = \{1, \dots, 10, 26, \dots, 40\}$	$50RB_s(10\ MHz)$	BS_2
$K_3 = \{26, \dots, 40\}$	$25RB_s(5\ MHz)$	BS_3

Table 2. Simulation Parameters.

Value	**Parameter**
TDD	Frame structure
1 msec	Time slots T_s
46dBm	Transmission power of each eNodeB
23 dBm	Maximum transmission power
-174 dBm	noise power
, d[34] 128.1 + 37.6log(d)	Link path losses
$40\log(d) + 30\log(f) + 49$ d[34], f[Hz]	indirect path loss (NLOS)
$16.9\log(d) + 20\log(f/5) + 46.8$ d[34], f[GHz]	direct path loss (LOS)

8. COMPARISON OF THE AMOUNT OF INTERFERENCE

The evaluation is based on the change of SINR value. In other words, for the evaluations, the SINR value has been increased in the desired network, then the throughput value has been calculated based on the proposed improvement type in the coordinated beam shaper. Increasing SINR means increasing the user's transmission power in sending data in the proposed method. What is expected is that with the increase of SINR in a DRFM, the throughput value will increase. In other words, the amount of interference improves with increasing power. Three coordinated beam-former schemes, optimal and quasi-optimal coordinated beam-former will be compared with each other by increasing the number of targets in the discussed DRFM. Figure 1 shows the throughput rate with 4 targets. As expected, this throughput has improved. In the proposed optimal and quasi-optimal method, by increasing the SINR value, the interference has decreased, in other words, the throughput has increased.

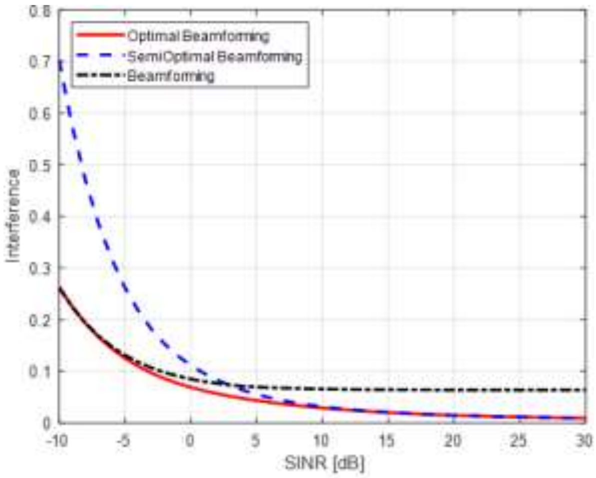

Fig. 1. The change in the amount of disruption in the network for 4 targets

By increasing the number of targets in the network and by incrementally changing the SINR value, it is expected that the amount of interference will decrease. In other words, with the increase in the number of targets, the amount of disruption will also increase. But the increase in interference can be compensated by increasing the SINR value. In the proposed method, in order to investigate this claim, the number of targets has been increased, and a comparison has been made with a larger number of targets. Figure 2 shows these changes for 8 targets. Figure 3 shows the amount of interference for 12 users. Finally, Figure 4 examines the interference for 20 targets.

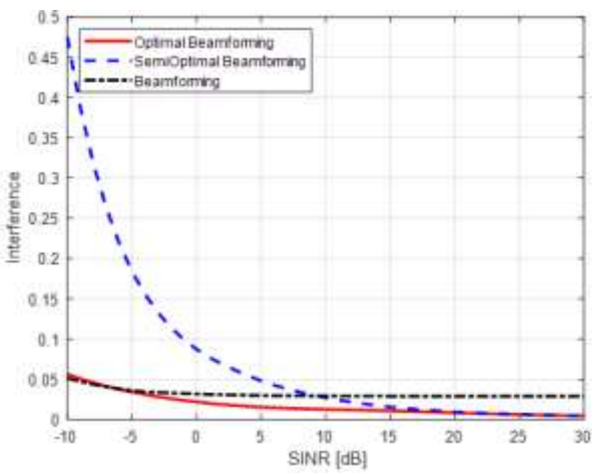

Fig. 2. The change in the amount of disruption in the network for 8 targets

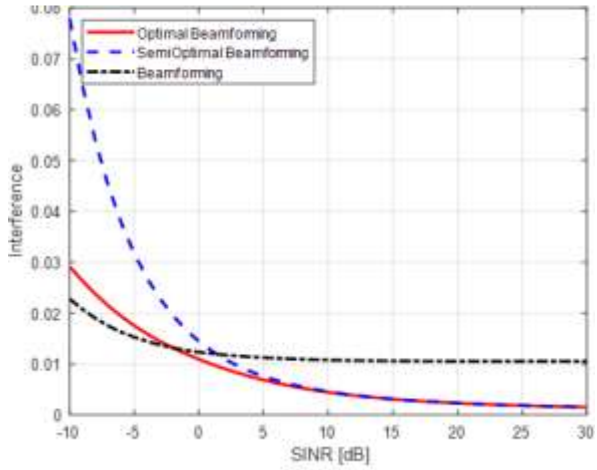

Fig. 3. The change in the amount of disruption in the network for 12 targets

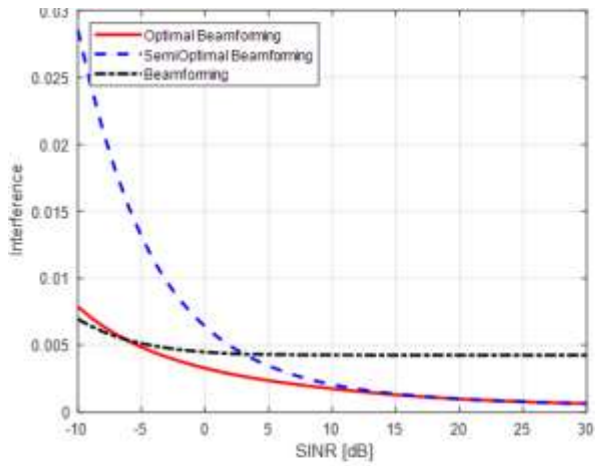

Fig. 4. Variation of network disturbance rate for 20 targets

As expected, with increasing SINR value, the amount of interference has decreased. But with the increase in the number of targets, the amount of interference has also increased. Meanwhile, in the proposed optimal and quasi-optimal method of coordinated beam-forming, the amount of interference increase is much less compared to the coordinated beam-forming method. In all experiments, the number of targets is fixed. Based on the results obtained in the simulations, the results of both the proposed optimal and quasi-optimal methods of coordinated beam-forming are almost the same. But the superiority of the coordinated beam-forming method has been shown to be superior to the basic method.

9. EVALUATION OF BER VALUE

In order to compare the bit error rate (BER), as well as to evaluate the interference rate, the SINR value is increased. At the same time, the BER value is calculated. Figure 5-4 shows the BER value in the network with 4 targets. As it can be seen from the figure, the value of BER has decreased from about 0.95 to 0.74 for the increase of SINR in the proposed optimal method. Although this value has been reduced from 0.95 to 0.74 in the coordinated beam-forming method, the most important part of the superiority of the proposed method is reaching the minimum value in lower SINR. In other words, in the proposed coordinated beam-forming method, it has reached its lowest value at the SINR value of about 10 dbm. But in the optimized method of the coordinated shaper, this event has taken place in dbm20. In other words, by presenting the proposed optimal method, energy consumption will also be reduced in reaching the optimal BER. Which is one of the advantages of the proposed method.

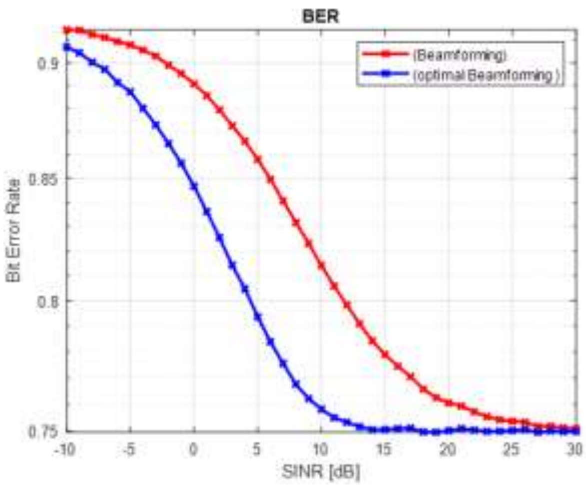

Fig. 5. BER values for 4 targets.

The number of targets has been increased to 8, then 16 and finally 20 targets in figures 6, 7 and 8. As expected, the BER value has increased with the increase in the number of targets, while the BER value in the optimal proposed method is far less than the value of the coordinated beamforming method. Also, based on the graphs, the best SINR value in sending data and communicating in the network in the proposed method has been achieved around 10dB. The reason for the superiority of the proposed method can be seen in the fact that the targets are trying to increase their rate against jamming. In other words, the desired objective function in the optimization of the coordinated beamforming method has caused this relative improvement. It is also considered to increase the efficiency and rate of the whole system in coherent beam shaping. Also, in the proposed method, with less energy consumption, a suitable BER will be achieved in the network.

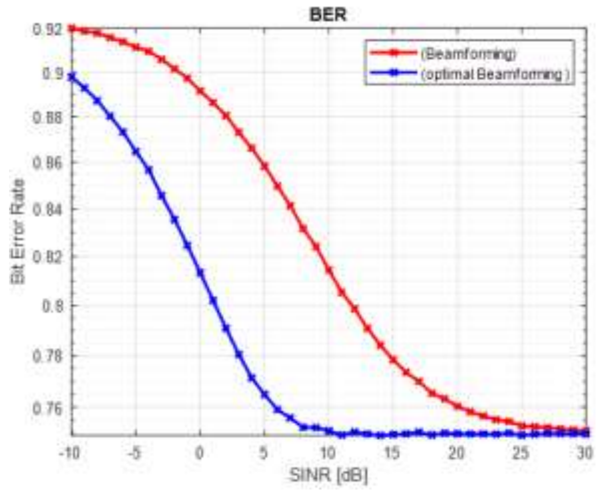

Fig. 6. BER values for 8 targets.

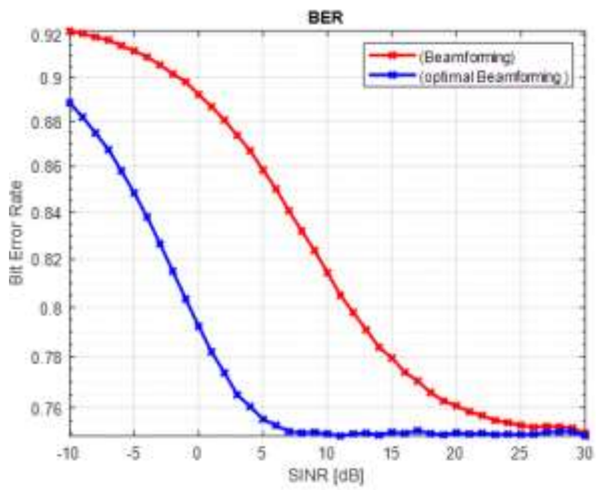

Fig. 7. 7 BER values for 12 targets.

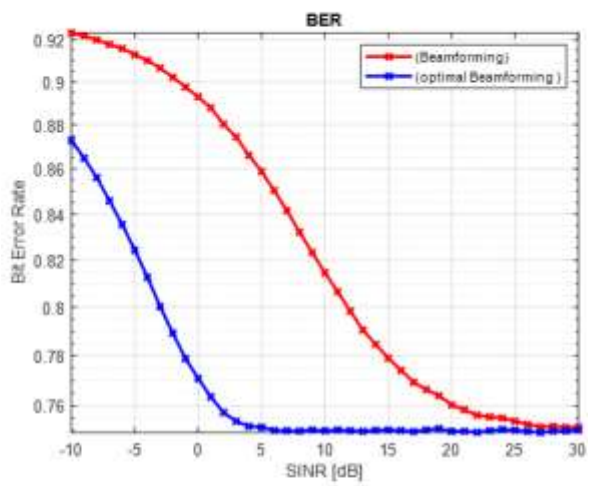

Fig. 8. 8 BER values for 20 targets.

10. CONCLUSION

In this article, in order to evaluate the proposed method, interference and BER values have been measured in different situations. It was tried to increase the number of targets in the network to determine the effect of increasing the number of targets on interference and BER. In these evaluations, the SINR value was changed, and based on the change in the SINR value and the change in the number of targets, the evaluation was done. The results showed that with the increase in the number of targets, the amount of interference and disturbance has increased, and the BER value has also increased. But the noteworthy point here is that the amount of interference in the proposed optimal coordinated beamformer method and the proposed quasi-optimal one is better than the coordinated beamformer with the increase in the number of targets. The reason for this superiority is the increase of the target rate in such a way that the acceptable rate of the primary user is also met. Also, the desired optimization function has been caused in the two stated states.

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