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**Threshold Optimization Using Metaheuristics In  
Distributed TM-CFAR Detection For DS/SS Acquisition:  
Application On Double-Dwell Serial Search System.**

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



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**Djamal end said**



## **Dedication 01**

*This thesis is dedicated to those whose unwavering support and encouragement have been my guiding light throughout this academic journey.*

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***MOHAMED SAID***

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### Glossary

**AWGN** :Additive White Gaussian Noise

**CA- CFAR**: Cell Averaging-CFAR

**CDMA**: Code Division Multiple Access.

**CFAR**: Constant False Alarm Rate

**CMA-ES** : Covariance Matrix Adaptation Evolution Strategy

**CMLD - CFAR**: Censored Mean Level Detector-CFAR

**CUT**: Cell Under Test

**DLL**: Delay Lock-Loop

**DS-SS**: Direct Sequence-CDMA

**FDMA**: Frequency Division Multiple Access

**FH-SS**: Frequency Hoping Spread Spectrum

**GO-CFAR**: Greatest-Of-CFAR

**ICA**: Imperialist Competitive Algorithm

**MAI** :Multiple Access Interference

**OS-CFAR**: Order Statistic-CFAR

**Pd**: Probability of Detection.

**Pfa**: Probability of False Alarm.

**PN**: Pseudo-Noise

**PSO-GSA** : Particle Swarm Optimization - Gravitational Search Algorithm

**SNR**: Signal-to-Noise Ratio

**SO-CFAR**: Smallest-Of-CFAR

**TDMA**: Time Division Multiple Access

**TM-CFAR**: Trimmed Mean CFAR

**WOA** :WhaleOptimizationAlgorithm

*General*

*Introduction*

### **1. Introduction:**

In a digital transmission system, a finite sequence of symbols represents the information. The signal can assume an infinite number of different values, making it susceptible to various forms of disturbances and interference. These factors can result in errors in the interpretation of the received signal by the receiver. Over recent decades, spread spectrum systems have transitioned from primarily military applications to commercial use due to their low probability of interception and their effectiveness in combating jamming and interference.

One fundamental limitation of spread spectrum systems, particularly DS-CDMA systems (Direct Sequence-Code Division Multiple Access), is the synchronization time required to align the PN code (Pseudo-Noise) sequence locally with the incoming spreading sequence. The synchronization process generally involves two main stages: coarse synchronization (or acquisition) followed by fine synchronization (or tracking).

Acquiring the code poses the most challenging step in a spread spectrum receiver[1]. Depending on the search mode, methods for acquiring the PN code can be categorized into three schemes: serial, parallel, and hybrid search strategy systems. All of these systems necessitate a threshold detector, which can either be fixed or adaptive, in the acquisition process. Many researchers prefer adaptive thresholding systems for stable and fast acquisition, where the threshold values are determined based on the environment. However, these systems still cannot guarantee stable acquisition because they lack a mechanism for maintaining a constant false alarm rate. Various Constant False Alarm Rate (CFAR) processors, commonly used in radar systems, have also been employed to address the acquisition challenges of PN sequences in DS-CDMA systems, aiming to mitigate variability and instability in detection and false alarm probabilities[2-3].

To enhance the performance of detection and monitoring systems, distributed detection systems are introduced. One of the primary objectives of employing these systems is to improve system performance in terms of reliability, speed, and constraints on communication bandwidth[4]. In the distributed detection technique, each detector transmits either a binary decision or a condensed form of statistical information regarding observations available at each detector to the data fusion center, where a final decision about the presence of a signal is made. This technique can be applied to several types of

CFAR detectors. Obtaining the optimal parameters of the latter requires the use of optimization techniques, given the large number of unknowns compared to the available equations[5].

Consequently, this study proposes an adaptive thresholding acquisition system based on distributed CFAR detection with optimization techniques. These techniques are applied to a double-dwell serial search acquisition scheme. The proposed system utilizes the TM-CFAR (Trimmed Mean CFAR) constant false alarm rate detector to maintain a constant false alarm rate and enhance the robustness of the system. The objective of this study is to conduct a comparative analysis of various metaheuristic optimization methods used to solve the problem of obtaining optimized parameters of the two TM-CFAR detectors. Four metaheuristic techniques are used and compared to determine the one that offers the best performance in terms of detection probability and acquisition time.

## **2. Organization Of The Memory:**

This thesis is organized into three main chapters, followed by a general conclusion.

In the first chapter, we will initially introduce the three primary multiplexing techniques employed in mobile radio systems: FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access), and CDMA (Code Division Multiple Access). Additionally, we will discuss spectral spreading techniques, acquisition, synchronization, and CFAR (Constant False Alarm Rate) detection. Finally, we will introduce distributed CFAR detection.

The second chapter will delve into the operational principle of the TM-CFAR algorithm. We will provide a description of the studied system along with detailed mathematical developments of the expressions for false alarm and detection probabilities. This chapter will also present the expression for the mean acquisition time and descriptions of the Four optimization methods considered in this study.

Moving on to the third chapter, we will develop and test the probability of detection and the mean acquisition time of the studied system for various parameters using metaheuristic optimization methods. The chapter will present and discuss the obtained results from these tests.

*Chapitre I*

*Spread spectrum*

*communication*

*systems.*

## I-1 Introduction:

In this chapter, we will begin by introducing various multiple access techniques employed in communication systems, including FDMA, TDMA, and CDMA. We will delve specifically into spread spectrum techniques, with a focus on Direct Sequence Spread Spectrum (DS/SS). After that, we will outline the fundamental principles of CFAR detection and the architectures of various CFAR detectors.

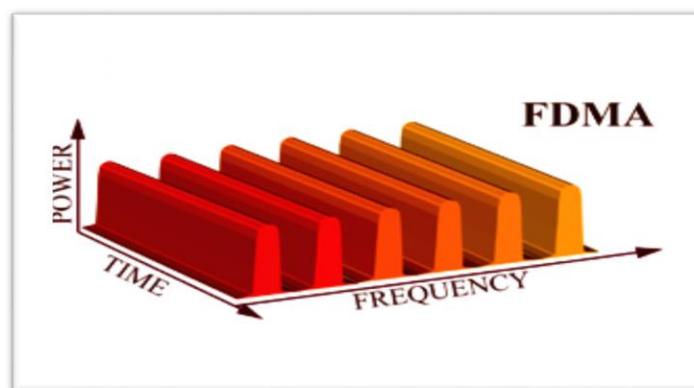
## I-2 Multiple Access Methods:

A cellular system must support multiple-access communication in order to be financially viable. This means that, multiple users can share the same cellular system at the same time. There are three main categories for enabling this sharing in wireless systems [6]:

- Frequency Division Multiple Access (FDMA)
- Time Division Multiple Access (TDMA)
- Code Division Multiple Access (CDMA)

### I-2-1 Frequency Division Multiple Access:

FDMA enables multiple users to share a single channel by dividing the total bandwidth into smaller, non-overlapping frequency bands called channels Figure I.1. Each user is assigned a unique channel to transmit their signal, preventing interference with other users. Imagine a highway with multiple lanes. FDMA allocates each user their own lane to transmit on, ensuring a smooth flow of information[7].



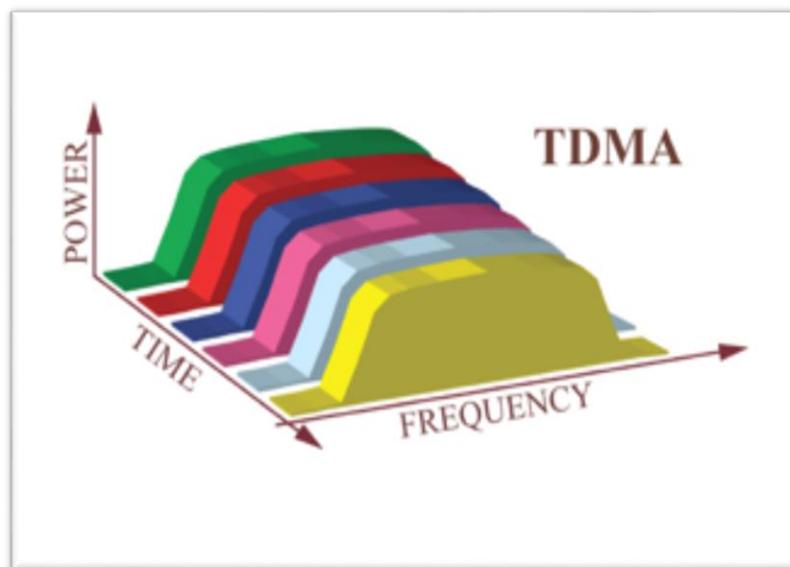
**Figure I.1** : FDMA multiple access technique.

### I-2-2 Time Division Multiple Access:

TDMA (Time Division Multiple Access) is a multiple-access technique that shares a single carrier frequency among multiple users by assigning each user a specific time slot within a repeating frame structure. Unlike FDMA, which uses separate frequency channels,

TDMA efficiently utilizes the available time dimension to enable multiple users to communicate simultaneously. Each user is assigned a non-overlapping time slot within a frame to transmit their data. A TDMA frame typically consists of  $K$  user slots for data transmission and  $K$  guard times to prevent interference between users. The user data rate depends on the overall system transmission rate and the number of available time slots ( $K$ ).

TDMA's advantage lies in its efficient use of the time dimension, allowing multiple users to share a single frequency channel without interference. This makes TDMA a suitable choice for applications where spectrum efficiency is crucial [7].



**Figure I.2 :** TDMA multiple access technique.

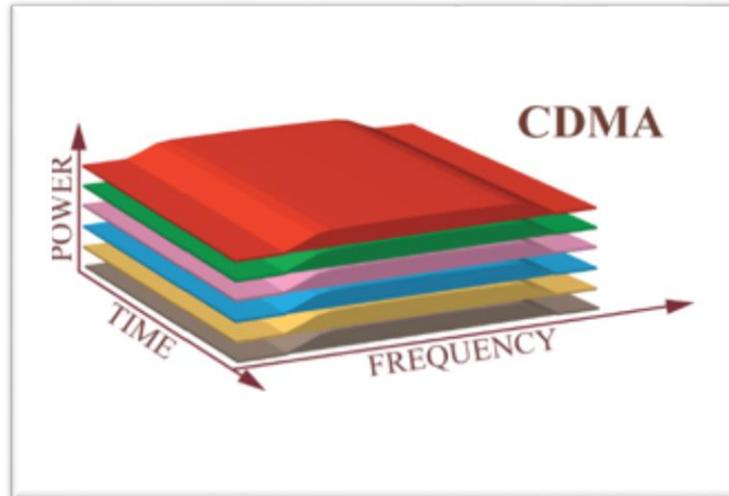
### I-2-3 Code Division Multiple Access:

CDMA (Code Division Multiple Access) stands apart from other multiple-access techniques like FDMA and TDMA. Unlike them, CDMA allows multiple users to share the same frequency band simultaneously. How does it achieve this feat?

*The Power of Spread Spectrum:* The secret lies in spread spectrum technology. Each user's signal is spreaded using a unique code, expanding its bandwidth far beyond what's necessary for the actual data rate. Imagine transforming a narrow bandwidth of data into a broad spectrum of signal using a specialized coding technique. This spreading technique enables multiple CDMA signals to coexist in the same frequency band without interference.

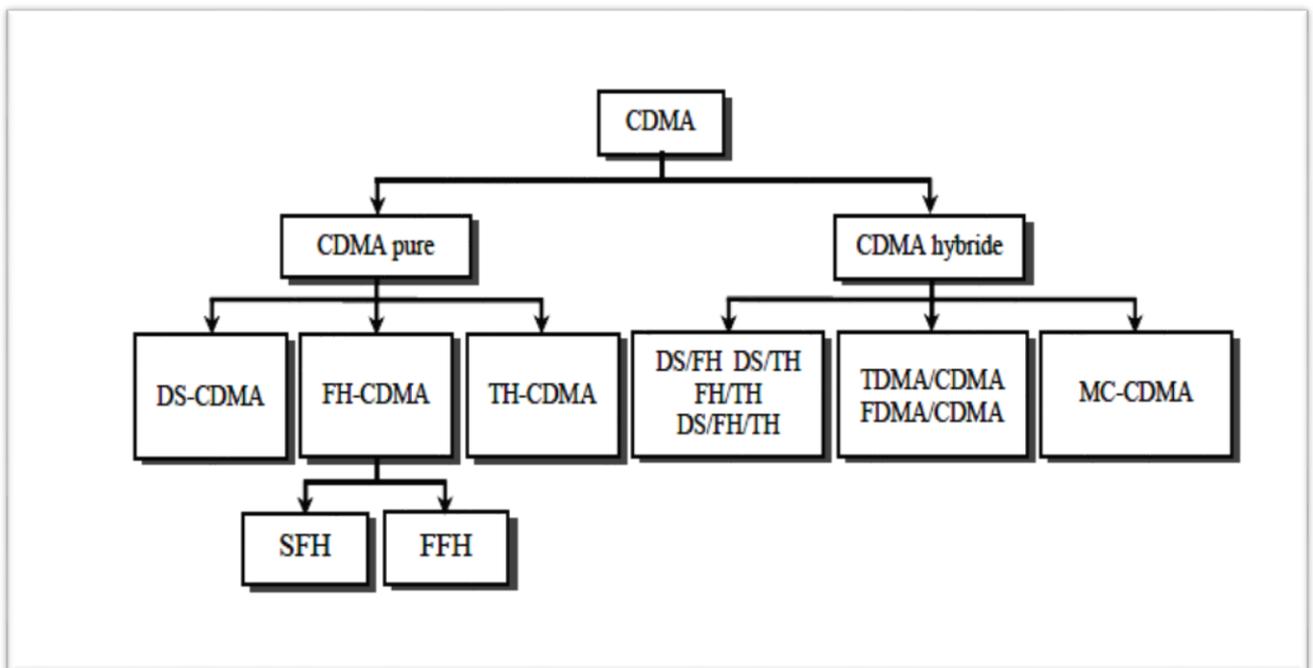
*CDMA's Key Advantage:* The main advantage of CDMA lies in its ability to significantly improve bandwidth efficiency. By spreading signals, CDMA can accommodate

more users within a limited frequency range, making it a valuable choice for certain cellular communication applications[8].



**FigureI. 3** : CDMA multiple access technique.

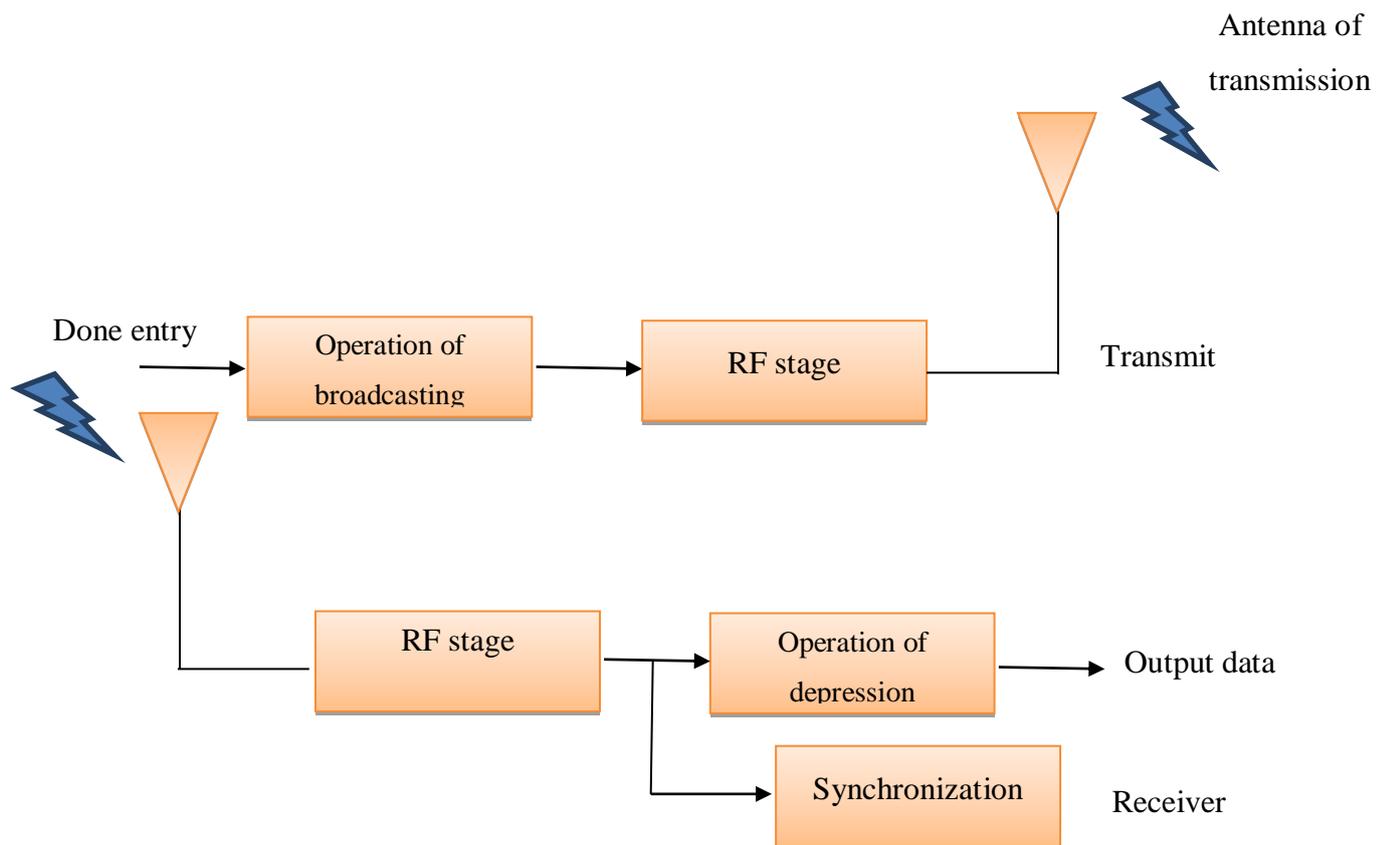
CDMA capabilities have been enhanced through integration with other multiplexing methods leading to improved performance and resulting in two main coding categories. Pure CDMA includes Direct Sequence CDMA (DS-SS) which is the fundamental technique using direct sequence spread spectrum. Frequency Hopping CDMA (FH-SS) which combines CDMA with slow or fast frequency hopping for enhanced security and Time Hopping CDMA (TH-SS) which utilizes CDMA coding with hopping across time slots. Hybrid CDMA: This category integrates CDMA coding with other multiplexing techniques for enhancing the performance. By offering various coding options, CDMA becomes more flexible and adaptable. It can be combined with other methods to optimize performance for specific applications[9].



**Figure I.4:** Different CDMA techniques

### I-3 Spectrum Spreading:

Spread spectrum is a method of transmitting signals where the bandwidth used exceeds the minimum necessary for transmitting the information. This spreading is achieved through the use of a code that is independent of the data being transmitted. Synchronized reception with the receiver's code is employed for signal demodulation and subsequent data retrieval. Initially developed for military communications in the mid-50s, spread spectrum systems had primary objectives including concealing the presence of the signal, safeguarding it from interception, and providing high resistance to deliberate interference (jamming). Over time, it became apparent that this technique offered significant advantages such as anti-interference capabilities, facilitating multiple user access to communications, and enabling high-resolution imaging[10], as depicted in Figure I.5 .



**Figure I.5** :Spectrum spreading system.

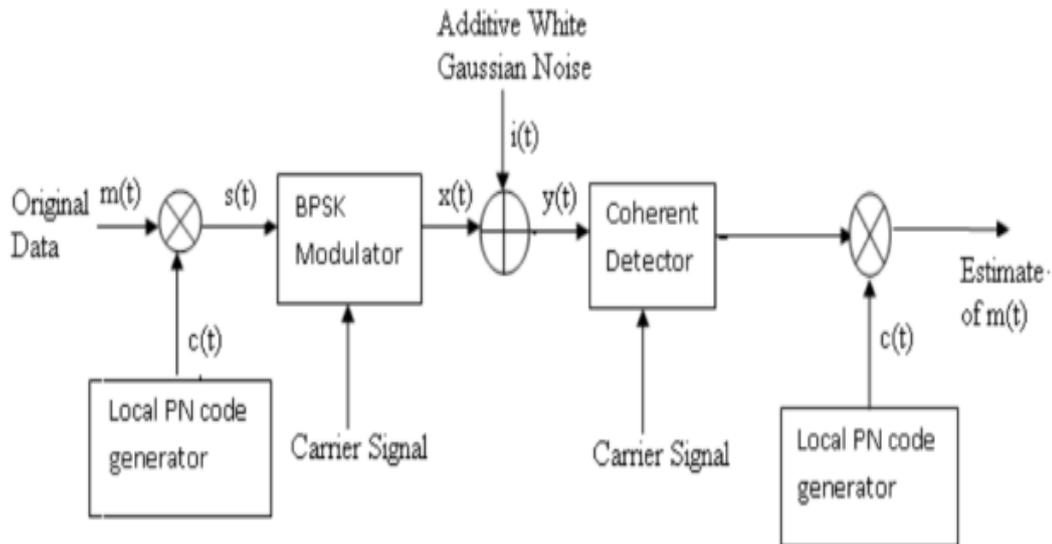
#### **I-4Type Of Spread Spectrum:**

Spread spectrum technologies encompass various techniques, with Direct Sequence Spread Spectrum (DS-SS) and Frequency Hopping Spread Spectrum (FH-SS) being among the most prevalent. Both methods rely on pseudo-random noise (PN) code sequences to generate broadband signals [10].

DS-SS, in particular, stands out as a widely employed modulation technique due to its straightforward implementation. It involves spreading a narrowband data signal by directly multiplying it with a PN code sequence before modulation and transmission. Since the PN sequence's rate exceeds the data rate, the resulting signal occupies a significantly broader bandwidth. This broadening of the signal's bandwidth effectively reduces its power level, as measured by the area under the spectral density curve. Consequently, the signal power disperses into the noise, making it less susceptible to interference [10].

Figure I.6 illustrates the DS-SS spreading signal occupying the entire frequency band continuously, with its carrier maintaining a fixed frequency. Upon reception, the local PN code sequence is employed to disperse the received broadband signal, recovering the original

narrowband signal. Additionally, DS-SS exhibits resistance against interference, as any jamming signals encountered undergo spreading upon multiplication with the PN code. Consequently, the impact of jamming is significantly mitigated, contributing to the robustness of spread-spectrum communication systems [10].



**Figure I.6** : Principle of the spread of the spectrum by direct sequence

Frequency Hopping Spread Spectrum operates differently from Direct Sequence Spread Spectrum. Instead of spreading a narrowband signal across a wide bandwidth by increasing its total power, FH-SS achieves spread by rapidly switching frequencies within a broad frequency band at regular intervals. This switching is facilitated by a pseudo-random sequence generated (PN code).

### I-5 Synchronization:

The analysis of performance in any CDMA system necessitates synchronization between the phase of the received signal and that of the transmitted signal. Synchronization plays a pivotal role, particularly in direct sequence systems, where it is executed in two stages: acquisition, which denotes initial synchronization, and tracking, which represents fine synchronization. Acquisition stands out as the most critical and challenging phase. Once acquisition is successfully accomplished, maintaining code tracking becomes comparatively simpler, often achieved through a Delay Lock-Loop (DLL) circuit [11].

In a spread spectrum receiver, the spread spectrum generator must produce a spreading sequence synchronized with the received sequence. Any misalignment typically results in a

reduction in the signal amplitude at the demodulator output, in line with the self-correlation function or partial self-correlation. Various factors such as clock drifts, distance uncertainty, and Doppler shifts can introduce synchronization issues. However, most spread-spectrum receivers possess the capability to acquire code synchronization directly from the received signal.

### **I-6 Acquisition:**

In spread spectrum communications, achieving synchronization between the locally generated PN code sequence at the receiver and the received PN code sequence is imperative for despreading the received signal and subsequent detection. This synchronization needs to occur within a small fraction of the duration of a chip of the PN sequence. Failure to achieve this timely synchronization results in insufficient signal energy reaching the data demodulator of the receiver due to the orthogonality principle.

We focus on direct sequence systems. To estimate the maximum likelihood of the code phase or the time shift of the spreading sequence, several hypotheses are formulated. Because data modulation hinders code synchronization, it is assumed that the transmitter aids synchronization by transmitting the spreading sequence without any data modulation.

In almost all applications requiring code synchronization, it's unlikely that the Signal-to-Noise Ratio (SNR) is sufficiently high to enable the carrier to be tracked by a phase-locked loop. The received signal is represented as:

$$y(t) = x(t) + n(t) \quad (\text{I.1})$$

Where  $x(t)$  is the transmitted signal and  $n(t)$  is the white Gaussian additive noise.

### **I-7 System Double Dwell:**

The double-dwell search method, which is studied in the present work, received much attention because of:

- (i) its simplicity in hardware implementation.
- (ii) the ability to reduce the mean acquisition time and
- (iii) for its low false locks.

The integration time of the second dwell  $N_2$  is usually chosen very long compared to that of the first dwell, in order to check the correctness of the decision made by this last one. Therefore, the double-dwell system reduces the false alarms occurrence and rejects the  $H_0$  cells quickly. By constructing the two correlators in this manner, the two adaptive detectors

work separately, hence their output distributions are statistically independent[12]. This system will be described and analysed in the second chapter.

### I-8 CFAR Detection:

The false alarm rate (CFAR) detection determines the noise level and adaptively sets a threshold based on the local data. A detection threshold that is comparatively insensitive to changes in noise level is the aim of the CFAR design. Its fundamental idea is to determine whether a signal is present or absent based on comparisons to a threshold that is determined by multiplying the value of the estimated noise power  $X$  by a constant  $T$  calculated by setting the false alarm probability at a desired minimal value[13].

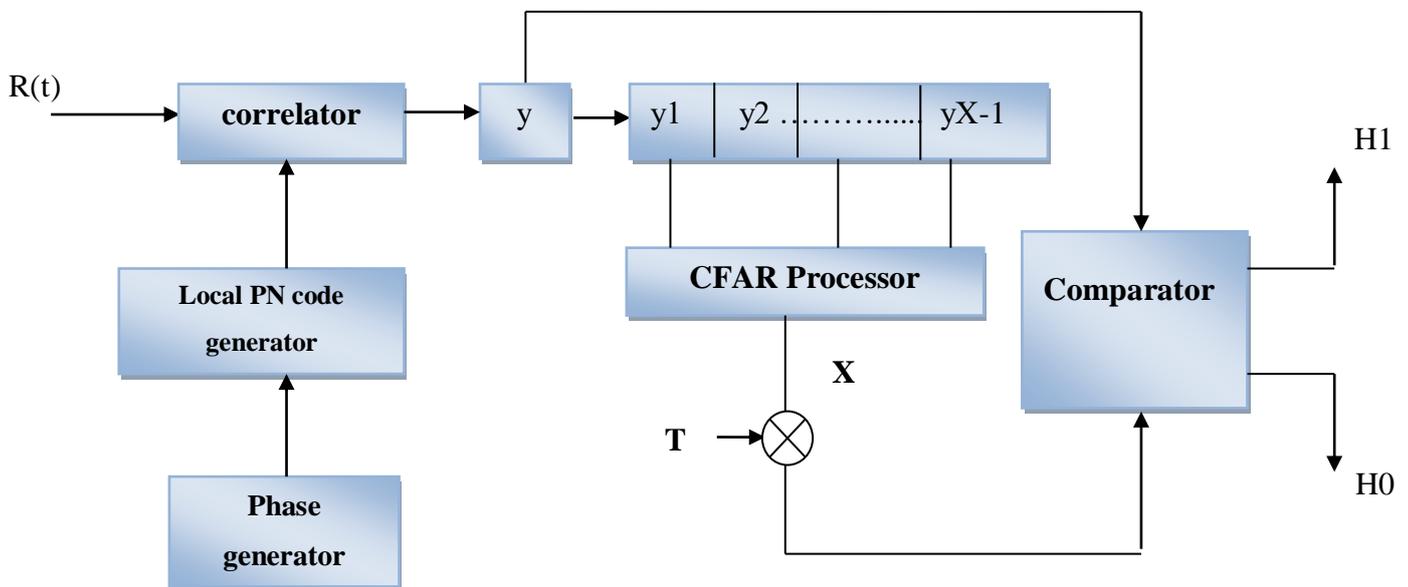


Figure I.7: Principle diagram of a CFAR detector.

### I-8-1 Types of CFAR detection:

#### I-8-1-1 CA-CFAR Detector:

In the Cell Averaging-CFAR (CA-CFAR) detector, the noise level is estimated by averaging the outputs of the reference cells. As the number of cells used to estimate the noise level increases, the detection probability approaches to that of the optimal Newman-Pearson detector, provided that these cells contain only homogeneous samples. The CA-CFAR detector, consists of  $M$  cells preceding the Cell Under Test (CUT). The average noise level is estimated by taking the arithmetic sum of the reference cells[14].

**I-8-1-2 GO-CFAR and SO-CFAR Detectors:**

However, most CFAR processors struggle to maintain optimal performance. Consequently, in non-homogeneous environments, the GO-CFAR detector is deemed more suitable. This detector employs two local noise level estimators, with the final estimator of the background noise level selecting the maximum value from these two estimators. The concept involves dividing the reference window into two halves, computing the noise level estimation separately for each half window, and then selecting the maximum of the two results. The transient behavior of the GO-CFAR detector at clutter edges exceeds that of the CA-CFAR detector, but is lower in the case of stationary clutter [14]. Whenever interfering signals occur in one of the two reference windows, the performance of GO-CFAR detectors degrades. Hence, the utilization of the SO-CFAR detector (Smallest-Of CFAR) is suggested. In the SO-CFAR detector, the contents of the two half-reference windows are summed, and the smaller of the two sums is used as a noise level estimator. Figure I.8 illustrates these types of detectors [15].

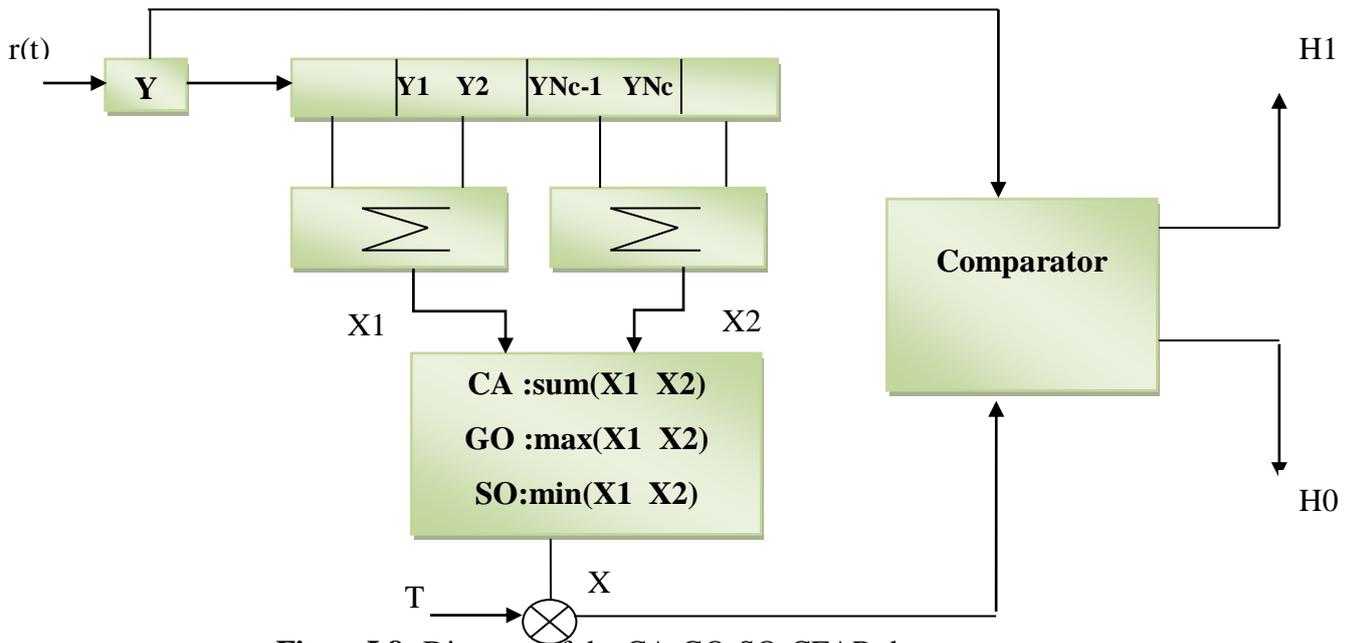


Figure I.8: Diagram of the CA-GO-SO-CFAR detectors

**I-8-1-3 OS-CFAR Detector:**

The OS-CFAR detector is developed to address the performance degradation experienced by CA-CFAR and GO-CFAR detectors in the presence of interfering signals. It represents a modified iteration of the CA-CFAR detector tailored for non-homogeneous environments. Initially, it arranges the samples of the reference window in ascending order based on their amplitudes. Subsequently, it estimates the noise power using a subset of the ordered sequences samples [16], as shown in Figure I.9.

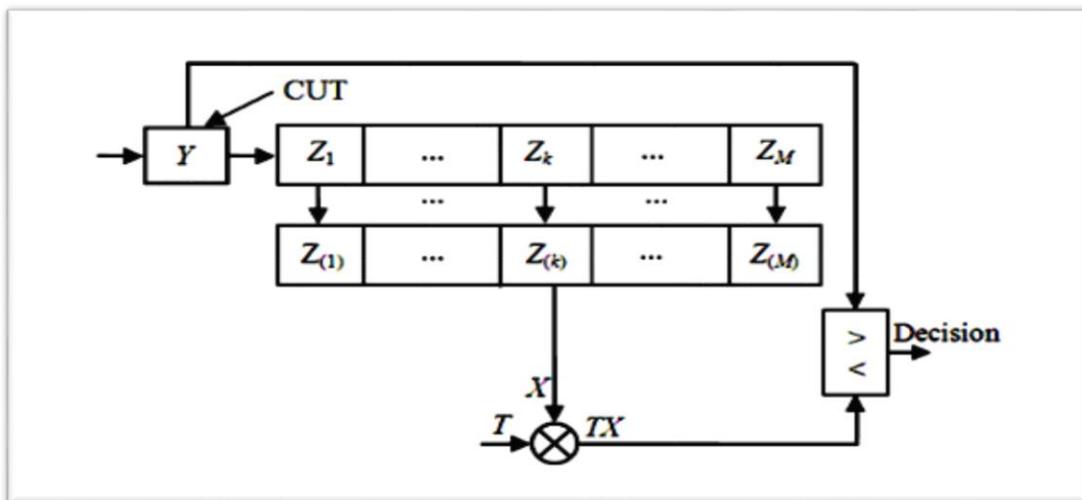
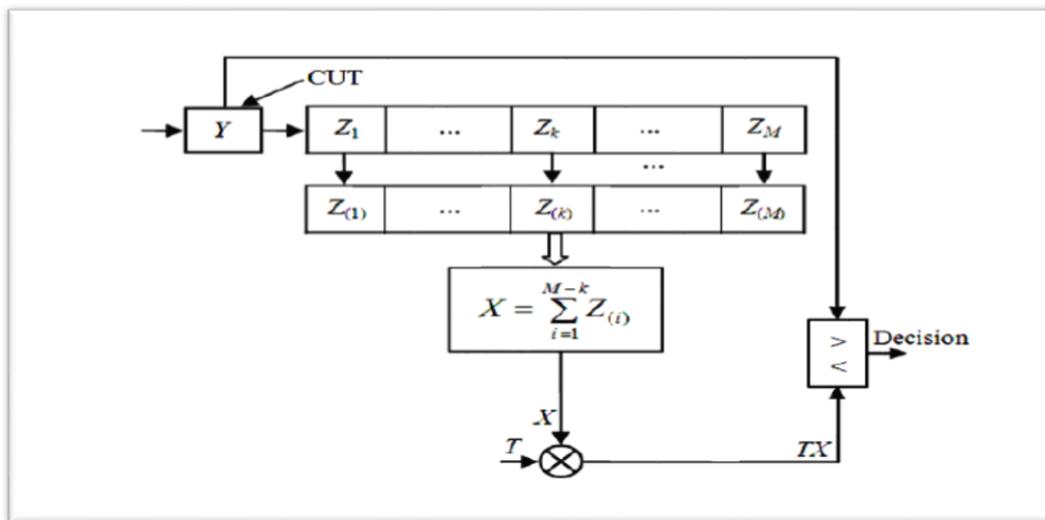


Figure I.9: Functional diagram of the detector OS-CFAR.

**I-8-1-4 CMLD-CFAR Detector:**

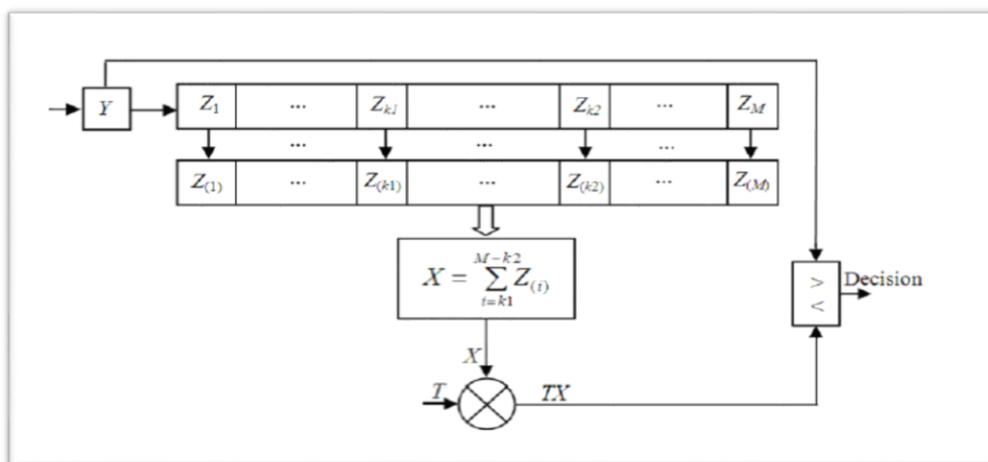
The CMLD-CFAR detector (Censored Mean Level Detector-CFAR) was proposed by Rickard and Dillard. The samples are arranged in ascending order, and the largest samples are censored. The noise level is estimated using the remaining  $(M-k)$  samples. When there are fewer interfering targets than censored cells (also known as the censoring point), the processor performs very well, with very little detection loss in a homogenous environment[17].



**Figure I.10:**Block diagram of the detector CMLD-CFAR.

**I-8-1-5 TM-CFAR Detector:**

The TM-CFAR (Trimmed Mean - CFAR) detector was proposed by Gandhi and Kassam, it can be schematically shown in the following figure:



**Figure I.11:** Functional diagram of the detector TM-CFAR.

The reference cells are arranged in ascending order, and then the cells with the lowest values ( $k_1$ ) and highest values ( $k_2$ ) are removed. The predetermined numbers  $k_1$  and  $k_2$  denote the lower and upper ends of the censored cells, respectively. This method is reliable when used in the reference cells' existence of interference and when the environment's congestion is not uniform. As a result, the noise power's estimated value is determined by [18]:

$$X = \sum_{j=k_1+1}^{N-k_2} z(j) \quad (\text{I.2})$$

This detector will be detailed in the next chapter, since it is the basis of our work.

### **I-9 Conclusion:**

In this chapter, we discussed the most commonly used multiplexing techniques in the field of communication systems: Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), and Code Division Multiple Access (CDMA). We then explored the principles of spread spectrum propagation, focusing particularly on those employing direct sequences. At the receiver, extracting the informative signal necessitates synchronization between the received codes and locally generated ones. This synchronization involves two steps: acquisition of the code and tracking of the code, both of which are elaborated upon in this chapter. The chapter concludes with a discussion on CFAR detection. In the subsequent chapter, we will introduce the necessity of employing metaheuristic optimization techniques to enhance the performance of adaptive acquisition of PN sequence using double-dwell acquisition systems. This later can be considered as a special case of the distributed detection, when the number of local detectors is two and the fusion rule is “And”.

# *Chapter II*

## *System Description and Analysis*

**II-1 INTRODUCTION:**

In this chapter, we will begin by providing an overview and analysis of the proposed system. Next, we will delve into the derivation of mathematical expressions for the probabilities of detection and false alarm using the "and" fusion rule. In addition, we will clarify the problem statement and identify the contribution made by our study. Finally, the chapter will culminate with a presentation of the various optimization techniques used in this research, with a special focus on the competitive Imperial algorithm ICA (Imperialist Competitive Algorithm), CMA-ES (Covariance Matrix Adaptation Evolution Strategy), WOA (Whale Optimization Algorithm) and PSO-GSA (Particle Swarm Optimization - Gravitational Search Algorithm)

**II-2 Description and analysis of the proposed system**

The considered system can be represented by Figure III.1. It is a system with Double-dwell serial search strategy. It is composed of two adaptive detectors (AD). The latter consists of two basic blocks. The first block is just the conventional non-coherent detector. The second is the decision making block based on the TM-CFAR algorithm. Each AD gives a partial decision regarding the acquisition situation; we will make a detailed explanation of each part of the system.

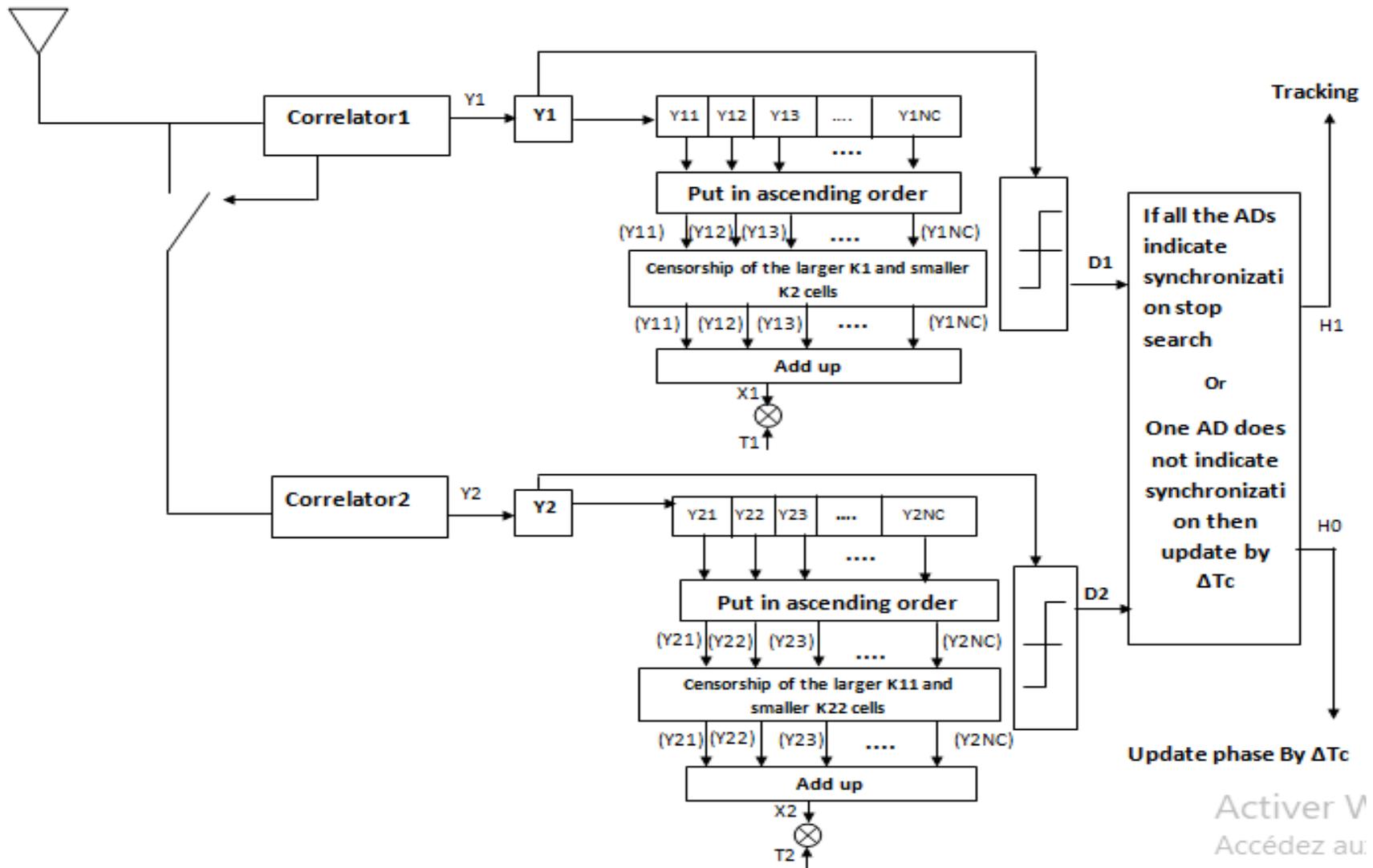


Figure II.1 :Functional diagram of the proposed communication system.

**II-2-1 Correlator:**

The correlator following the antenna element. The equivalent baseband signal at the correlator can be written as follows

$$\begin{aligned}
 r_m^I(t) = & 2\sqrt{P_s} \left\{ \sum_{l=0}^{L-1} \alpha_{1l} c_1(t - \tau_1 - lT_c) \cos(\omega_c t + \varphi_{1l}) \right. \\
 & \times \cos(\omega_c t) \exp(-j\pi(m-1) \sin \theta_s) \left. \right\} \\
 & + 2 \left\{ \sum_{i=2}^D \sqrt{P_{I_{i-1}}} \sum_{l=0}^{L-1} \alpha_{il} c_i(t - \tau_i - lT_c) \right. \\
 & \times \cos(\omega_c t + \varphi_{il}) \cos(\omega_c t) \exp(-j\pi(m-1) \sin \theta_{i-1}) \left. \right\} \\
 & + n_m(t)
 \end{aligned} \tag{II.1}$$

Inphase and quadrature components (I-Q) of the correlator are multiplied by the locally generated PN code  $c(t-j, T_c/2)$ ,  $j=0, 1, \dots, N_c$  ( $N_c$  represents the size of the reference window of the CFAR processor), and integrated over a time interval  $\tau_D = RT_c$ , where  $R$  is the length of partial correlation, to give the branch components I and Q,  $Y_m^I$  and  $Y_m^Q$ , respectively. Next, the exit  $Y_m$  of each branch of the correlator gives the first user signal component, the MAI (Multiple Access Interference), and the AWGN (Additive White Gaussian Noise) which can be expressed as

$$\begin{aligned}
 Y_m = & \left\{ \sum_{l=0}^{L-1} (Y_{Sl}^I + jY_{Sl}^Q) \exp(-j\pi(m-1) \sin \theta_s) \right\} \\
 & + \left\{ \sum_{i=2}^D \sum_{l=0}^{L-1} (Y_{MAIil}^I + jY_{MAIil}^Q) \right. \\
 & \times \exp(-j\pi(m-1) \sin \theta_{i-1}) \left. \right\} + n_m
 \end{aligned} \tag{II.2}$$

where,  $(Y_{Sl}^I + jY_{Sl}^Q)$  designates the component I-Q of the first user,  $(Y_{MAIil}^I + jY_{MAIil}^Q)$  designates the component I-Q of MAI and  $n_m(t) = N_m^I(t) + jN_m^Q(t)$  denotes noise thermique. The inphase component of the signal in (II.3) due to the first user is given by

$$\begin{aligned}
 Y_{Sl}^I &= \sqrt{P_s} \alpha_{1l} \cos(\varphi_{1l}) [\Delta_1 R_p(j_c, N+1) + (T_c - \Delta_1) R_p(j_c, N)] \\
 &= \sqrt{P_s} R_{Sl}^I
 \end{aligned} \tag{II.3}$$

With,

$$R_{Sl}^I = \alpha_{1l} \cos(\varphi_{1l}) [\Delta_1 R_p(j_c, N+1) + (T_c - \Delta_1) R_p(j_c, N)] \tag{II.4}$$

Where,  $\Delta_1$  is a uniformly distributed random variable in  $[0, T_c]$  and  $R_p(j_c, N)$  is the partial self-correlation function of the first user's code. The component of the quadrature phase signal of

the first user can be obtained by substituting  $\cos(\varphi_{il})$  by  $\sin(\varphi_{il})$  in (II.5) the term MAI in phase can be defined as follows :

$$\begin{aligned}
 Y_{MAIil}^l &= \sqrt{P_{I_{i-1}}} \alpha_{il} \cos(\varphi_{il}) \left[ \Delta_l R_t^{(01)}(j_c, N + 1) \right. \\
 &\quad \left. + (T_c - \Delta_l) R_p^{(i)}(j_c, N) \right] \\
 &= \sqrt{P_{I_{i-1}}} R_{MAIil}^l
 \end{aligned} \tag{II.5}$$

With,

$$R_{MAIil}^l = \alpha_{il} \cos(\varphi_{il}) \left[ \Delta_l R_p^{(i)}(j_c, N + 1) + (T_c - \Delta_l) R_p^{(i)}(j_c, N) \right] \tag{II.6}$$

Where,  $R_p^{(i)}(j_c, N)$  is the partial inter-correlation of the code between the received sequence from the  $1^{eme}$  user and the locally generated sequence. The term  $R_{MAIil}^l$  decreases the power of the jamming signal at the output of the correlator, which is affected by the factor  $R_p^{(i)}(j_c, N)$ . The term of signal in quadrature of the MAI can be obtained by replacing  $\cos(\varphi_{il})$  by  $-\sin(\varphi_{il})$  in (II.5). The noise term is determined by :

$$N_m^l = \int_0^{RT_c} n_m^l c_1(t - jT_c/2) \sqrt{2} \cos(\omega_c t) dt \tag{II.7}$$

The quadrature phase of the noise term is obtained by substituting with  $-\sin(\varphi_{il})$ .

### II-2-2 Trimmed-Mean Constant False Alarm Rate Processor:

TM-CFAR is an extension of the Ordered Statistic (OS) CFAR scheme, where the noise power estimation involves a linear combination of ordered range samples. This approach is expected to yield improved results compared to simple averaging methods seen in other CFAR processors like the Cell Averaging (CA) and Greatest-Of (GO) CFAR schemes. In the TM-CFAR processor, the range cells (M) are initially sorted by magnitude. Then, a certain number of cells ( $k_1$  cells) are trimmed from the lower end and another set ( $k_2$  cells) from the upper end before summing the remaining cells. A specific case of this method, known as the symmetric trimming ( $k_1 = k_2$ ), has been utilized in signal and image restoration applications. The statistic Z in the TM-CFAR processor is represented as:

$$X = \sum_{j=k_1+1}^{M-k_2} z(j) \tag{II.8}$$

#### Analysis :

The assumptions for deriving expressions of detection and false alarm probabilities, as well as the mean acquisition time, are as follows:

- (i) All samples in the reference window are independent.
- (ii) The correlation lengths of the first and second dwell ( $N_1$  and  $N_2$ , respectively) are selected to be much greater than 1, ensuring that the correlation between the received and local PN sequences is zero if there is no synchronization ( $H_0$  cell).
- (iii) A selective slow Rayleigh fading channel is considered, meaning the amplitudes remain
- (iv) There are many resolvable paths, implying the existence of more than one synchronized cell ( $H_1$  cell) in the uncertainty region.
- (v) The self-noise of the desired signal, caused by the multipath and multiple access interference (MAI) of the  $(U - 1)$  users who finished the acquisition stage and started transmitting data

**II-2-3 Rayleigh attenuated channel:**

The environment has a great influence on the signal power level. Mobility of the receiver and the reflection of the signal by obstacles are the two main reasons for the phenomenon of multipath propagation. The attenuation channels can be modeled at the help of different distributions. In this work, the Rayleigh attenuation channel is considered.

**II-2-4 Detection and False Alarm Probabilities:**

$$P_{fa_i} = \prod_{j=1}^{M-k_1-k_2} M_{V_j}(T), i = 1,2, \dots, N \quad (II. 9)$$

Where

$$M_{V_1}(T) = \frac{M!}{k_1! (M - k_1 - 1)! (M - k_1 - k_2)} \times \sum_{l=0}^{k_1} \frac{\binom{k_1}{l} (-1)^{k_1-l}}{\frac{M-l}{M-k_1-k_2} + T} \quad (II. 10)$$

and

$$M_{v_j}(T) = \frac{a_j}{a_j + T}, j = 2, \dots, M - k_1 - k_2 \quad (II. 11)$$

Where

$$a_j = \frac{M - k_l - j + 1}{M - k_l - k_2 - j + 1} \quad (II. 12)$$

The detection probability  $P_{di}$  is obtained by replacing  $T$  with  $T/(1+\mu)$  in (II. 10) To obtain the global decision, the fusion rule “And” considered, where  $(\mu)$  is the average signal-to-total noise ratio (SNR).

**II-2-5 Acquisition Time:**

The acquisition time defined as follows can also be applied to conventional double-dwell systems [19].

$$\begin{aligned}
 E(T_{acq}) &= \left. \frac{dH(z)}{dz} \right|_{z=1} \\
 &= \frac{N_1 T_C}{P_D} + \frac{N_2 T_C}{P_{D2}} + (L - 1)[N_1 T_C \\
 &+ N_2 T_C P_{FA1} + K(N_1 + N_2) T_C P_{FA}] \\
 &\quad \times \left( \frac{1 - P_D}{P_D^2} + \frac{1}{2} \right).
 \end{aligned}
 \tag{II.13}$$

Where,  $K$  is the penalty time constant and KTC is the additional time required to re-enter the next acquisition state.

**II-2-6 Fusion rule ‘AND’:**

For the AND fusion rule, the global decision at the fusion center is ‘1’, if and only if, the two detectors decide ‘1’. The overall probabilities of detection, and of false alarm are given by:

$$P_d = \prod_{i=1}^2 P_{di}
 \tag{II.14}$$

$$P_{fa} = \prod_{i=1}^2 P_{fai}
 \tag{II.15}$$

**II-4 Metaheuristic Techniques:**

**II-4-1 Hybrid PSO GSA Algorithm:**

There are numerous hybridization techniques available for metaheuristic algorithms. They can be hybridized at a high level or low level with succession or coevolution, according to two algorithms. Is the process heterogeneous or homogeneous? In this study, we employ low-level coevolution to merge PSO with GSA, creating a mixed-race hybrid. This low-end hybridization integrates the capabilities of both algorithms. This approach is co-evolutionary because it doesn't solely rely on either algorithm; rather, they operate concurrently. The heterogeneity stems from the involvement of two distinct algorithms in determining the outcome. The fundamental concept of PSO GSA is to combine the social reasoning (gbest) capabilities from PSO with the local search capacity of GSA[20]. The process of merging these algorithms is illustrated in Figure 14.[21]

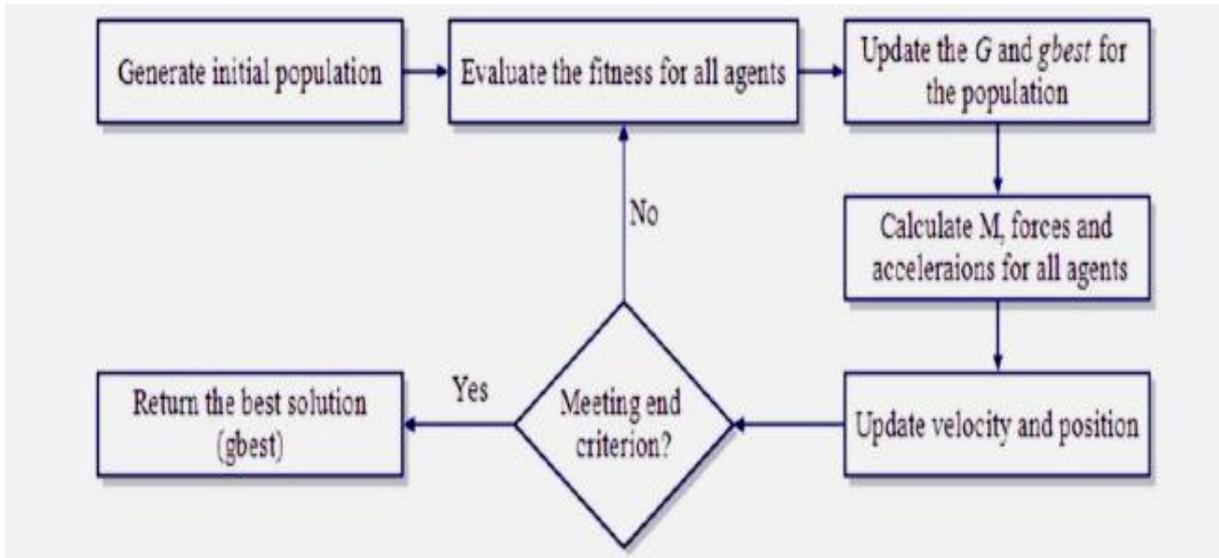


Figure II.2. Flowchart of the PSO-GSA algorithm.

II-4-2 ICA Techniques:

An optimization algorithm called ICA was just released. This optimization algorithm is based on the idea of imperialistic competition. The ICA flowchart is shown in FigureII.3 [22].The assimilation strategy that imperialist nations have embraced since the 19th century is exploited by ICA. In order to gain the allegiance of their various colonies, the imperialists seek to enhance the political, cultural, and economic conditions of each one. An imperialist and its colonies are referred to as an "empire" in this theory. The strength of an empire's colonists and imperialists determine that empire's power. More powerful empires win colonies from weaker imperialists in imperialistic competitions. These colonies begin their journey toward their respective imperialist after all colonies were divided among imperialists and the first empires were established.

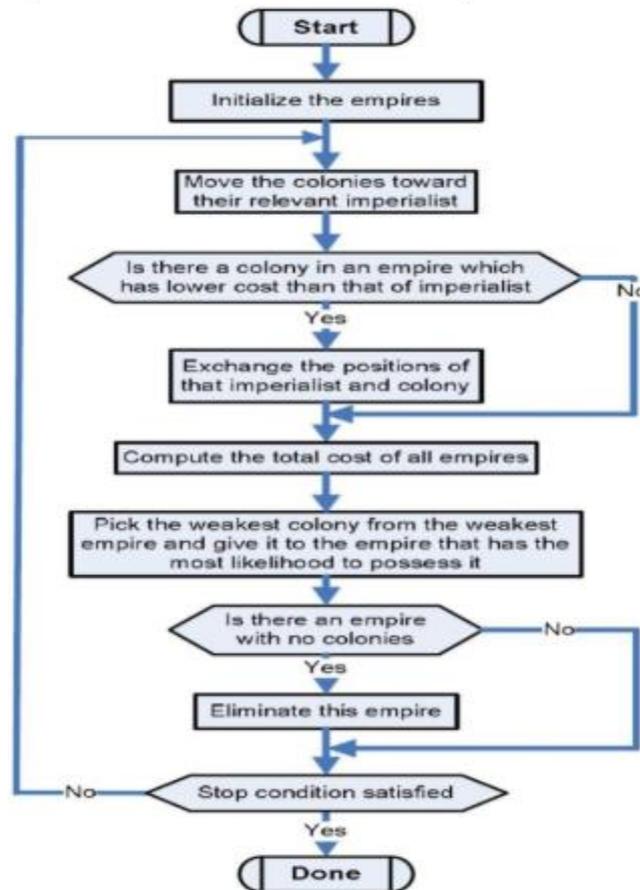


Figure.II.3:Flowchart of Imperialist Competitive Algorithm.

**II-4-3 CMA-ES Technique:**

An evolutionary algorithm based on deterministic selection and Gaussian mutation is called the Covariance Matrix Adaptation Evolution Strategy (CMA-ES). Stochastic search techniques known as evolutionary strategies were influenced by the generally, a multivariate normal mutation distribution is used to illustrate biological evolution concepts. They use a set of search criteria to function. In the continuous domain, CMA-ES is regarded as one of the best options for solving non-convex, ill-conditioned black-box optimization problems. The general method for resolving the black-box problem involves sampling multiple independent points from a distribution P, assessing these points according to their performance metrics f, and then making adjustments to the distribution parameters. These actions are all carried out up until the termination requirement is satisfied. P is a multivariate normal distribution, which is a generalization of the CMA-ES algorithm[23].

**II-4-4 WOA Technique:**

WOA, or Whale Optimization Algorithm, is a swarm intelligence approach designed for solving continuous optimization problems. It has been shown to exhibit performance comparable to or better than other existing algorithms. Drawing inspiration from the hunting behavior of humpback whales, each potential solution in WOA is likened to a whale. These whales attempt to explore new areas in the search space, guided by the best-performing element in the group. The algorithm employs two main mechanisms for locating prey: encircling and creating bubble nets. During the exploration phase, whales encircle their prey, while during the attack phase, they create bubble nets. Exploration of the search space occurs when whales are in search of prey, whereas exploitation takes place during the attack behavior. Numerous studies have been conducted on WOA, with this paper serving as a review that collected materials using "WOA" as a keyword from reputable publishers such as Elsevier, Springer, and IEEE [24].

**II-5 Conclusion:**

In this chapter, we provided an overview of the proposed system. Subsequently, we utilized an adaptive acquisition system employing distributed TM-CFAR detection, examining its representation and analysis. We also illustrated false alarms and detection probabilities within a Rayleigh channel. Finally, we outlined the proposed optimization methods aimed to improve the detection performance of the acquisition system.

# *Chapitre III*

*RESULTS AND*

*DISCUSSION*

### III-1 Introduction:

This chapter contains a performance study of the proposed system used in DS-CDMA systems. We employ optimization to calculate the optimal parameters for the two local TM-CFAR detectors. The chapter begins by specifying simulation parameters. The second part of the chapter focuses on presenting, comparing, and discussing simulation results obtained using MATLAB for various optimization techniques (ICA, PSO, GSA, CMA-ES, and WOA), taking into account the AND fusion rule.

### III-2 Results and Discussion:

In this section we consider, for the purposes of the simulations, the following hypotheses

- different values of the false alarm rate constant  $P_{fa} = 10^{-4}, 10^{-6}, 10^{-8}$ ;
- different lengths of partial correlation  $N_1$  and  $N_2$ ;
- Number of reference cells  $M = 16, 24$  and  $32$ ;
- Duration of chips  $T_c = 10^{-6}$ s;
- A periodic PN code of length  $L = 1024$ ;
- A penalty constant  $K = 1000$ .

### III-3 Discussion Of The Results:

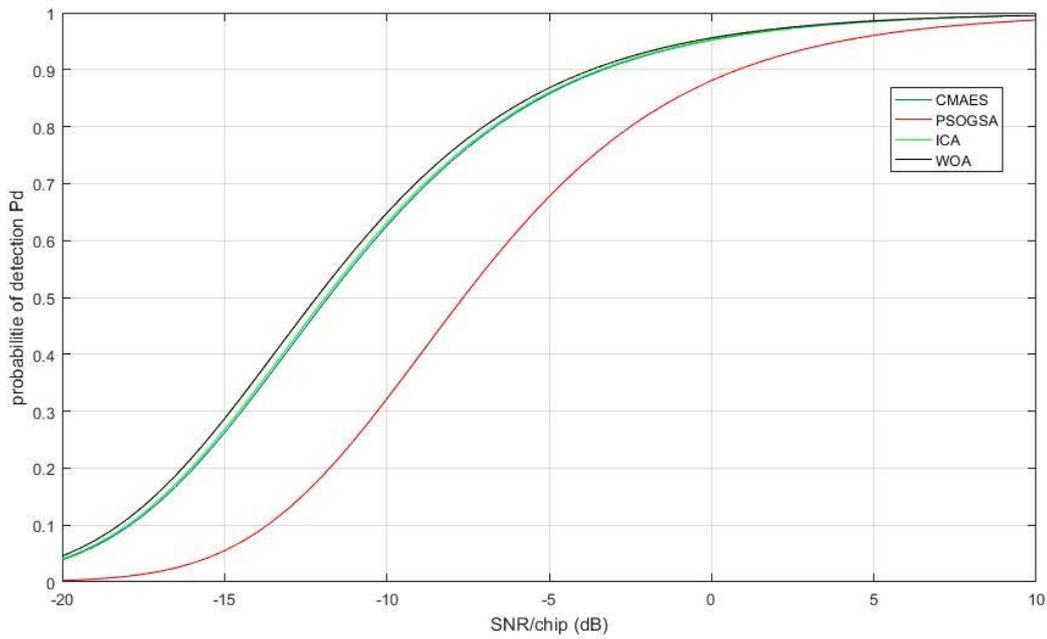
Table 1 gives the estimated parameters of the two local TM-CAR detectors by the four optimization algorithms (CA, CMA-ES, PSO, GSA, and WOA), using the fusion rule AND, with an SNR equal to  $-5$  dB,  $M = 32$ ,  $N_1 = 64$  and  $N_2 = 256$ ,  $P_{fa} = 10^{-4}$ . In this case, it can be noted that the best results are those obtained for the system which use the WOA optimization technique.

The general detection probability-and the average acquisition time ( $T_{eq}$ ) as a function of the SNR/chip (dB)

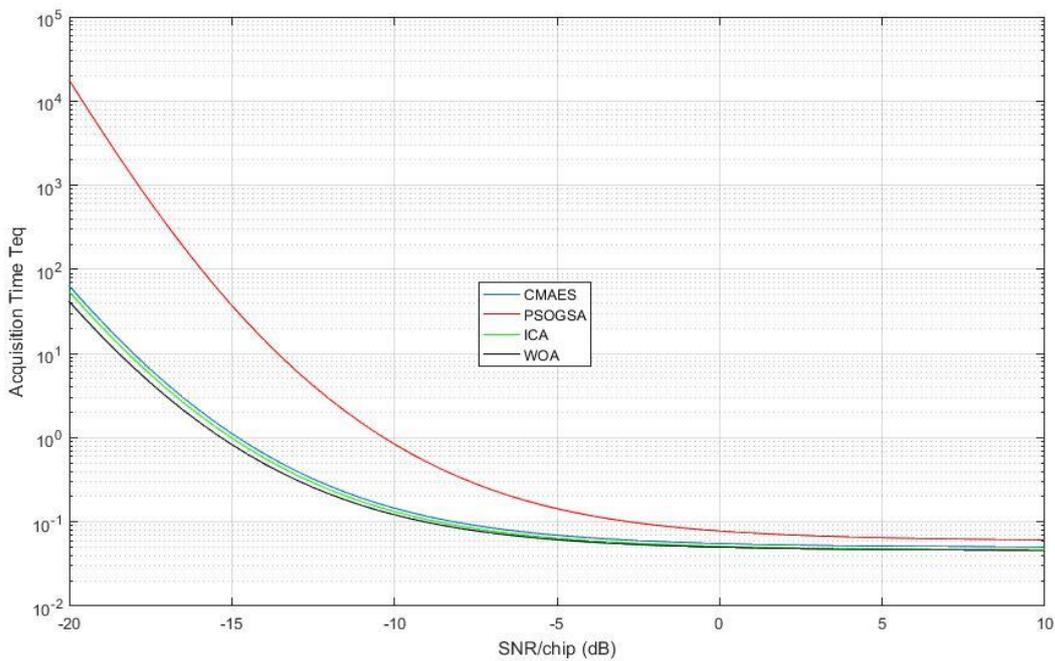
The evolution of the mean acquisition time as a function of the variation of the SNR / Chip (dB) is represented in Figure III.2 for different optimization methods. It is noted that, the value of the mean acquisition time becomes less long for all optimization methods, and specifically for the WOA technique.

**TableIII.1:**Best estimated parameters using the four optimization algorithms for different values of Pfa and SNR/Chip=-5dB

|                      | WOA   | ICA  | PSOGSA   | CMA_ES  |
|----------------------|---|--|--|---|
| Pfa=10 <sup>-4</sup> | T <sub>1</sub> = 1.687*10 <sup>-6</sup><br>T <sub>2</sub> = 0.5281<br>K <sub>1</sub> = 3<br>K <sub>2</sub> = 7<br>K <sub>11</sub> = 4<br>K <sub>22</sub> = 3<br>Pd = 0.8681 | T <sub>1</sub> =1.7456*10 <sup>-4</sup><br>T <sub>2</sub> = 1.2115<br>K <sub>1</sub> = 2<br>K <sub>2</sub> =2<br>K <sub>11</sub> = 5<br>K <sub>22</sub> = 10<br>Pd = 0.8602  | T <sub>1</sub> = 0.523<br>T <sub>2</sub> = 0.4273<br>K <sub>1</sub> = 0<br>K <sub>2</sub> = 10<br>K <sub>11</sub> = 4<br>K <sub>22</sub> = 2<br>Pd = 0.8572  | T <sub>1</sub> = 0.0063<br>T <sub>2</sub> = 1.4066<br>K <sub>1</sub> = 0<br>K <sub>2</sub> = 10<br>K <sub>11</sub> = 2<br>K <sub>22</sub> = 5<br>Pd = 0.8576  |
| Pfa=10 <sup>-6</sup> | T <sub>1</sub> = 0.0101<br>T <sub>2</sub> = 0.7065<br>K <sub>1</sub> = 2<br>K <sub>2</sub> = 1<br>K <sub>11</sub> = 0<br>K <sub>22</sub> = 2<br>Pd = 0.7970                 | T <sub>1</sub> = 1.0119*10 <sup>-5</sup><br>T <sub>2</sub> =2.0879<br>K <sub>1</sub> = 5<br>K <sub>2</sub> = 2<br>K <sub>11</sub> = 10<br>K <sub>22</sub> = 9<br>Pd = 0.7756 | T <sub>1</sub> = 0.2168<br>T <sub>2</sub> = 0.4950<br>K <sub>1</sub> = 0<br>K <sub>2</sub> = 8<br>K <sub>11</sub> = 3<br>K <sub>22</sub> = 1<br>Pd = 0.7392  | T <sub>1</sub> = 0.0020<br>T <sub>2</sub> = 2.1471<br>K <sub>1</sub> = 0<br>K <sub>2</sub> = 5<br>K <sub>11</sub> = 8<br>K <sub>22</sub> = 10<br>Pd = 0.7798  |
| Pfa=10 <sup>-8</sup> | T <sub>1</sub> = 5.5129*10 <sup>-4</sup><br>T <sub>2</sub> = 1.1920<br>K <sub>1</sub> = 0<br>K <sub>2</sub> = 3<br>K <sub>11</sub> = 3<br>K <sub>22</sub> = 3<br>Pd = 0.725 | T <sub>1</sub> = 0.120<br>T <sub>2</sub> = 1.2343<br>K <sub>1</sub> = 4<br>K <sub>2</sub> = 4<br>K <sub>11</sub> = 6<br>K <sub>22</sub> = 3<br>Pd = 0.7153                   | T <sub>1</sub> = 0.2541<br>T <sub>2</sub> = 1.9973<br>K <sub>1</sub> = 5<br>K <sub>2</sub> = 3<br>K <sub>11</sub> = 6<br>K <sub>22</sub> = 10<br>Pd = 0.6046 | T <sub>1</sub> = 0.0640<br>T <sub>2</sub> = 2.7417<br>K <sub>1</sub> = 4<br>K <sub>2</sub> = 10<br>K <sub>11</sub> = 0<br>K <sub>22</sub> = 10<br>Pd = 0.6797 |



**Figure III.1 :** Detection probability as a function of the SNR/Chip (dB), using the four optimization algorithms for the AND fusion rule .



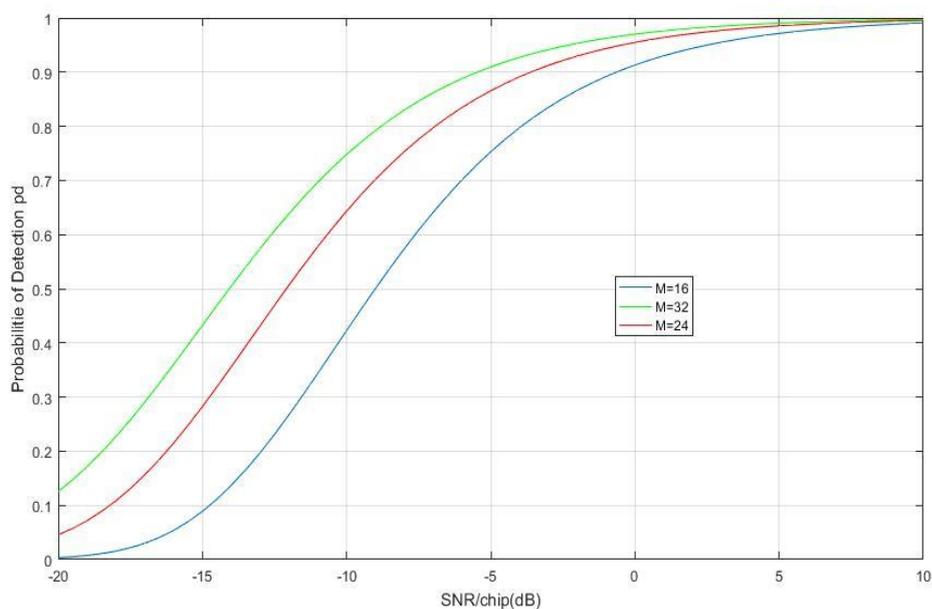
**Figure III.2:** Acquisition time (s) as a function of the SNR (dB), using the four optimization algorithms for the fusion rule AND.

**TableIII.2:**Best estimated parameters using the four optimization algorithms for different values of M and SNR/Chip=-5dB.

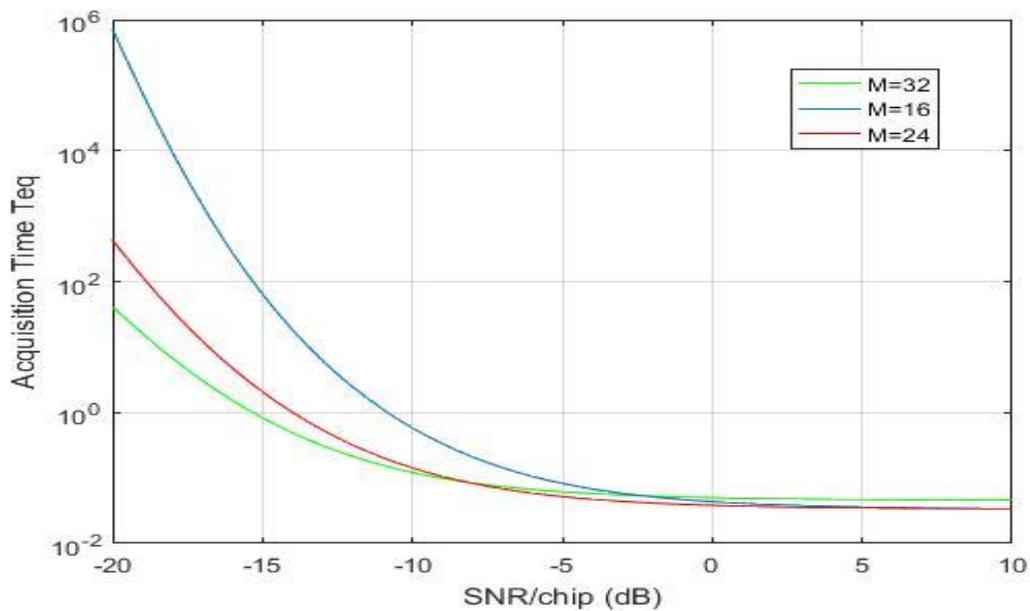
|        | WOA   | ICA  | PSOGSA  | CMA_ES  |
|--------|---|--|---|---|
| M = 16 | T <sub>1</sub> =0.0123<br>T <sub>2</sub> =1.3007<br>K <sub>1</sub> =0<br>K <sub>2</sub> =2<br>K <sub>11</sub> =0<br>K <sub>22</sub> =2<br>Pd = 0.8445                       | T <sub>1</sub> =0.0054<br>T <sub>2</sub> =1.3567<br>K <sub>1</sub> =1<br>K <sub>2</sub> =0<br>K <sub>11</sub> =1<br>K <sub>22</sub> =2<br>Pd = 0.8425                        | T <sub>1</sub> =0.2354<br>T <sub>2</sub> =0.7495<br>K <sub>1</sub> =1<br>K <sub>2</sub> =2<br>K <sub>11</sub> =0<br>K <sub>22</sub> =1<br>Pd = 0.7967       | T <sub>1</sub> =0.0028<br>T <sub>2</sub> =1.3193<br>K <sub>1</sub> =0<br>K <sub>2</sub> =2<br>K <sub>11</sub> =0<br>K <sub>22</sub> =2<br>Pd = 0.8477         |
| M = 24 | T <sub>1</sub> =0.0012<br>T <sub>2</sub> =0.6768<br>K <sub>1</sub> =0<br>K <sub>2</sub> =2<br>K <sub>11</sub> =1<br>K <sub>22</sub> =2<br>Pd = 0.8657                       | T <sub>1</sub> =0.000019878<br>T <sub>2</sub> =1.1705<br>K <sub>1</sub> =4<br>K <sub>2</sub> =2<br>K <sub>11</sub> =3<br>K <sub>22</sub> =5<br>Pd = 0.8518                   | T <sub>1</sub> =0.0913<br>T <sub>2</sub> =0.7003<br>K <sub>1</sub> =2<br>K <sub>2</sub> =4<br>K <sub>11</sub> =2<br>K <sub>22</sub> =3<br>Pd = 0.8316       | T <sub>1</sub> =0.0042<br>T <sub>2</sub> =0.8329<br>K <sub>1</sub> =2<br>K <sub>2</sub> =6<br>K <sub>11</sub> =6<br>K <sub>22</sub> =3<br>Pd = 0.8553         |
| M = 32 | T <sub>1</sub> = 1.687*10 <sup>-6</sup><br>T <sub>2</sub> = 0.5281<br>K <sub>1</sub> = 3<br>K <sub>2</sub> = 7<br>K <sub>11</sub> = 4<br>K <sub>22</sub> = 3<br>Pd = 0.8681 | T <sub>1</sub> =1.7456*10 <sup>-4</sup><br>T <sub>2</sub> = 1.2115<br>K <sub>1</sub> = 2<br>K <sub>2</sub> = 2<br>K <sub>11</sub> = 5<br>K <sub>22</sub> = 10<br>Pd = 0.8602 | T <sub>1</sub> = 0.523<br>T <sub>2</sub> = 0.4273<br>K <sub>1</sub> = 0<br>K <sub>2</sub> = 10<br>K <sub>11</sub> = 4<br>K <sub>22</sub> = 2<br>Pd = 0.8572 | T <sub>1</sub> = 0.0063<br>T <sub>2</sub> = 1.4066<br>K <sub>1</sub> = 0<br>K <sub>2</sub> = 10<br>K <sub>11</sub> = 10<br>K <sub>22</sub> = 10<br>Pd = 0.857 |

In the third Table III.2 and fig. III.3, we offer the system parameter estimated by the WOA algorithm and the probability of detecting different numbers from the number of cells  $M=16$ ,  $M=24$  and  $M=32$  the probability of a false alarm is fixed at  $10^{-4}$  and the duration of partial correlations  $N_1=64$  and  $N_2=256$ . We note that there is an interesting increase in the probability of detection after the increase of the number of reference cells  $M$ .

Figure III.4 represents the evolution of the mean acquisition time as a function of the variation of the SNR / chip (dB). This figure shows that the decrease at the time of acquisition also corresponds to an increase in the number of reference cells  $M$ .



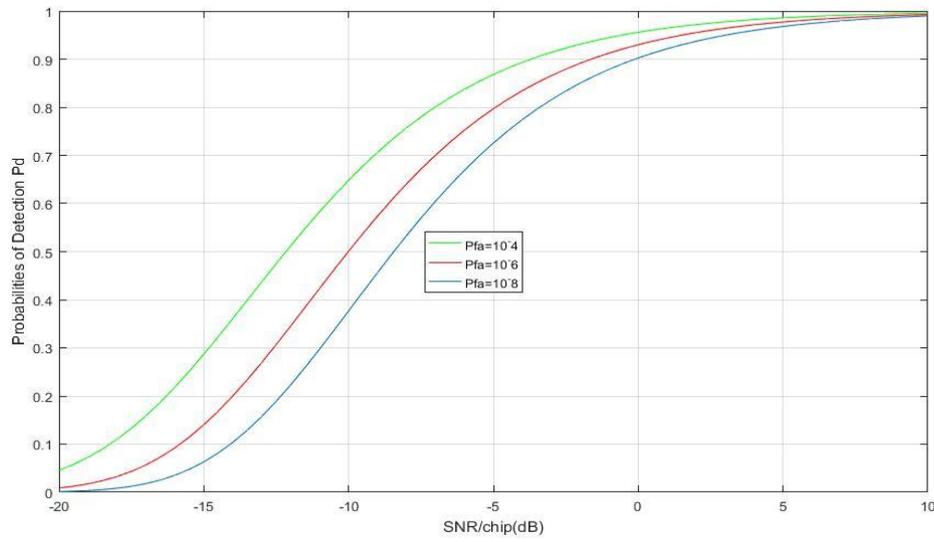
**Figure III.3:** probability of detection as a function of SNR (dB), using optimization algorithms WOA for the Fusion rule AND with the change in the number of reference cells.



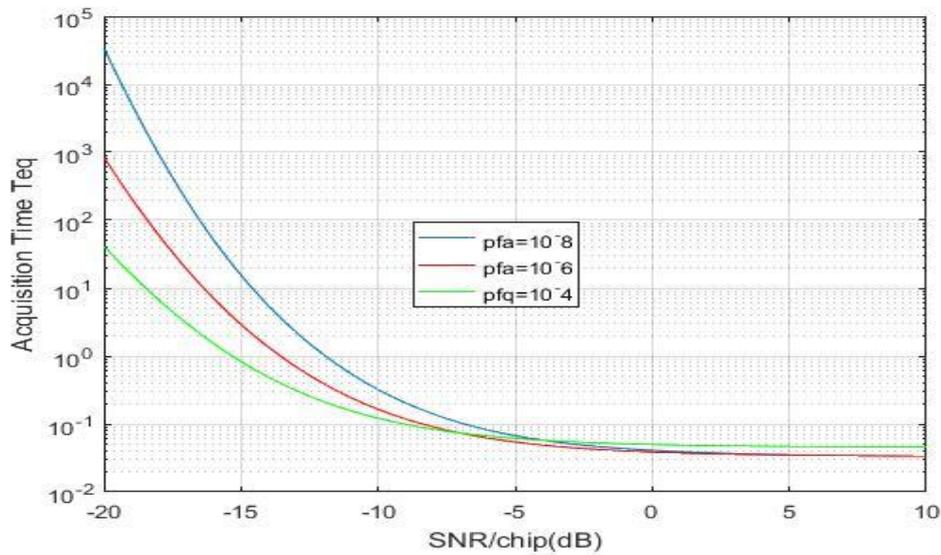
**Figure III.4:** Acquisition Time (s) as a function of SNR (dB), using optimization algorithms WOA for the Fusion rule AND with the change in the number of reference cells.

In the third Table III.1 and fig.III.5, The algorithm (WOA) estimates the probability of detecting different numbers of false alarms with constancy at the top of the number of reference cells. We note that there is an interesting increase in the probability of detection after the reduction in the number of false alarms rate  $P_{fa}$ .

Fig.III.6 represents the evolution of the mean acquisition time as a function of SNR/chip (dB). This figure shows that the decrease in the acquisition time also corresponds to the decrease in the false alarms rate.



**Figure III.5:** Probability of detection as a function of SNR (dB), using WOA optimization algorithms for the Fusion rule AND with the change in false alarm probability  $P_{fa}$ .



**Figure III.6:** Acquisition Time (s) as a function of SNR (dB), using WOA optimization algorithms for the Fusion rule AND with the change in false alarm probability  $P_{fa}$ .

**Table III.3:** Best estimated parameters using the optimization algorithm WOA for different values of  $N_2$  and SNR/Chip=-5dB

| N2    | 96             | 128            | 256            |
|-------|----------------|----------------|----------------|
| N1=64 | $T_1 = 0.4568$ | $T_1 = 0.0370$ | $T_1 = 0.0033$ |
|       | $T_2 = 0.2744$ | $T_2 = 0.3691$ | $T_2 = 0.6213$ |
|       | $K_1 = 9$      | $K_1 = 1$      | $K_1 = 1$      |
|       | $K_2 = 10$     | $K_2 = 1$      | $K_2 = 5$      |
|       | $K_{11} = 1$   | $K_{11} = 6$   | $K_{11} = 0$   |
|       | $K_{22} = 2$   | $K_{22} = 1$   | $K_{22} = 5$   |
|       | $Pd = 0.6618$  | $Pd = 0.7482$  | $Pd = 0.8695$  |

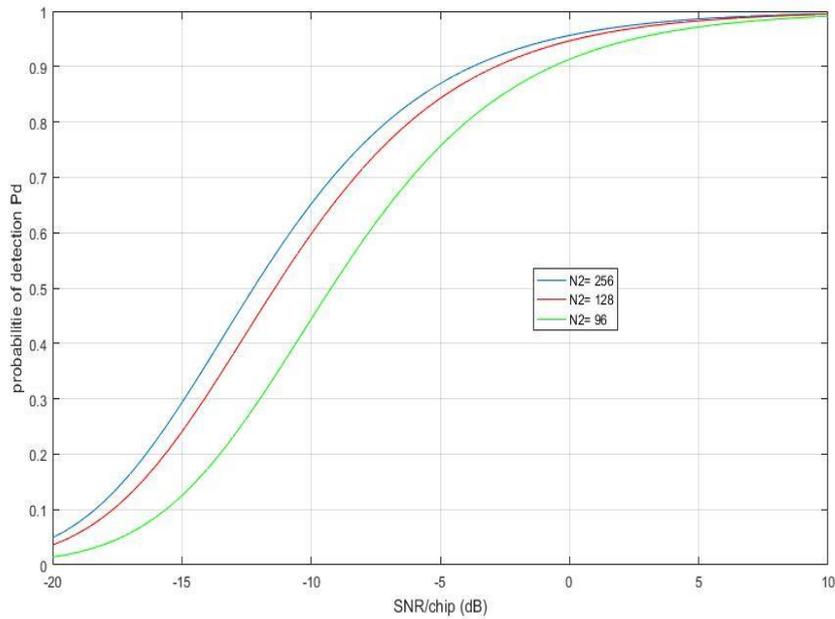
**Table III.4:** Best estimated parameters using the optimization algorithm WOA for different values of  $N_1$  and SNR/Chip=-5dB

| N1     | 64             | 96             | 128            |
|--------|----------------|----------------|----------------|
| N2=256 | $T_1 = 0.0068$ | $T_1 = 0.0168$ | $T_1 = 0.0131$ |
|        | $T_2 = 0.5094$ | $T_2 = 0.4395$ | $T_2 = 0.4415$ |
|        | $K_1 = 3$      | $K_1 = 1$      | $K_1 = 1$      |
|        | $K_2 = 6$      | $K_2 = 5$      | $K_2 = 1$      |
|        | $K_{11} = 2$   | $K_{11} = 3$   | $K_{11} = 4$   |
|        | $K_{22} = 3$   | $K_{22} = 2$   | $K_{22} = 2$   |
|        | $Pd = 0.8667$  | $Pd = 0.8678$  | $Pd = 0.8687$  |

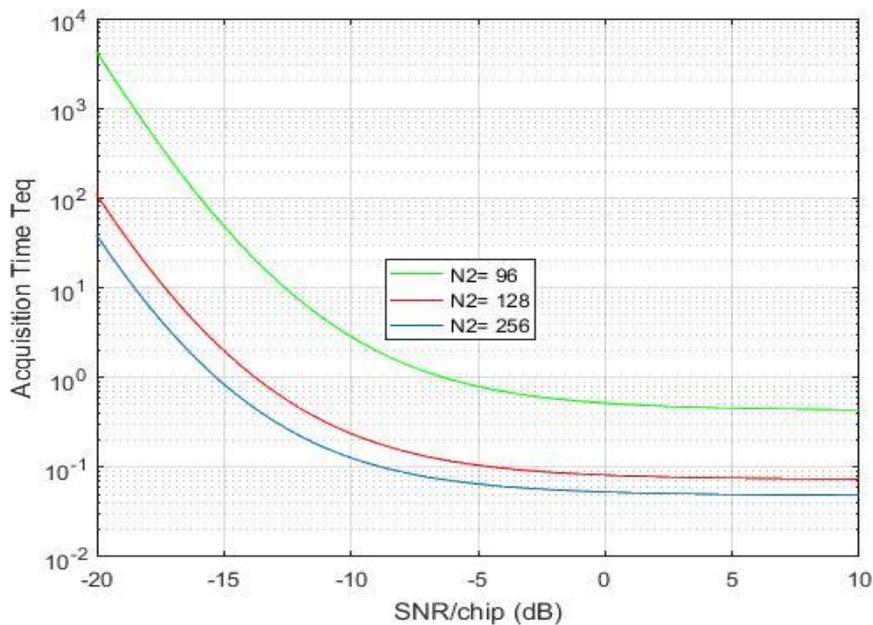
In Table III.3 presents a comparison of the detection probability values when the length of the partial correlation  $N_1$  is kept constant and the value of the partial correlation  $N_2$  varies. Conversely, Table III.4 shows the comparison when the value of the partial correlation  $N_2$  is kept constant and the length of the partial correlation  $N_1$  changes.

We note from Figure III.7 and Figure III.9 that there is an interesting increase in the probability of detection in the case of an increase in the values of the partial correlation length  $N_1$  and  $N_2$ .

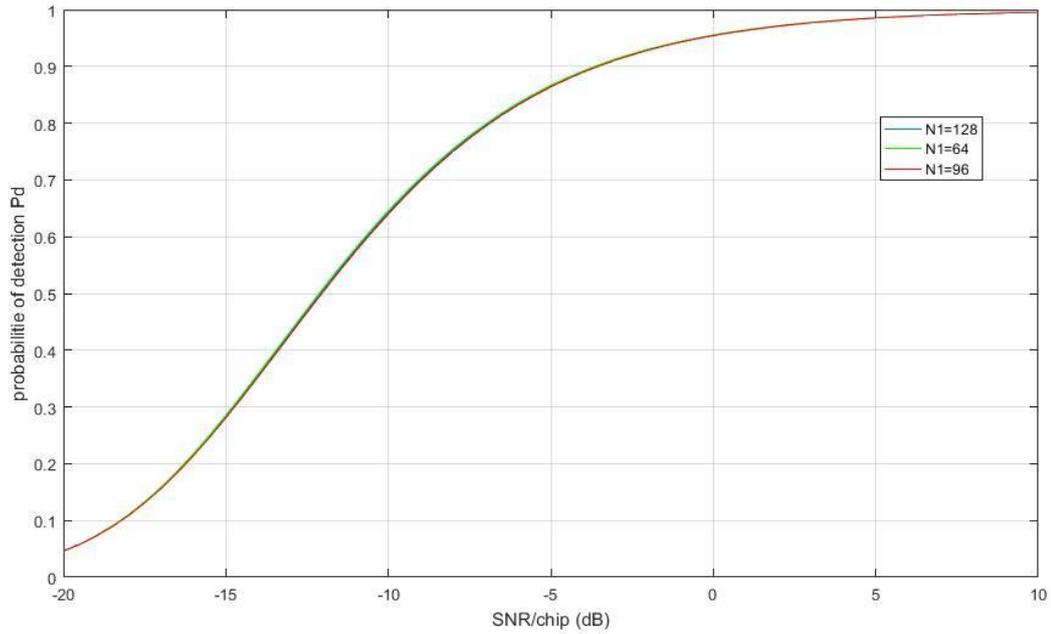
Figures III.8 and III.10 represent the evolution of the mean acquisition time as a function of the SNR / chip (dB). This figure shows that the decrease in the acquisition time also corresponds to an increase in the length of the partial correlations  $N_1$  and  $N_2$ .



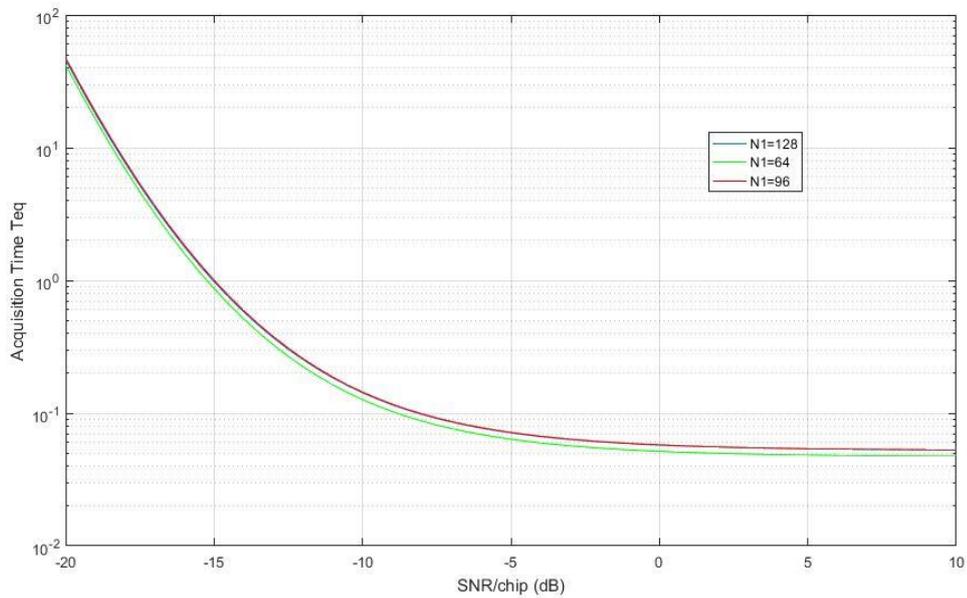
**FigureIII.7:** Probability of detection as a function of SNR (dB), using WOA optimization algorithms for the Fusion rule AND with the change in the length of the partial correlation N2.



**FigureIII.8:** Acquisition Time (s) a function of SNR (dB), using WOA optimization algorithms for the Fusion rule AND with the change in the length of the partial correlation N2.



**FigureIII.9:** Probability of detection as a function of SNR (dB), using WOA optimization algorithms for the Fusion rule AND with the change in the length of the partial correlation N1.



**FigureIII.10:** Acquisition Time (s) a function of SNR (dB), using WOA optimization algorithms for the Fusion rule AND with the change in the length of the partial correlation N1.

**III-4CONCLUSION:**

We examined the simulation results for the detection probability and the mean acquisition time in order to assess the effectiveness of the suggested system. The impact of different functional parameters, including the number of reference cells, the false alarm rate and the duration of the partial correlations are represented and compared. The obtained results show that the best optimization method used is WOA.

*General Conclusion*

*n*

### **General Conclusion**

In this study, we aimed to demonstrate the effectiveness of metaheuristic methods for improving the detection threshold in double-dwell serial search systems. We developed TM-CFAR, which can enhance adaptive acquisition performance using pseudo-random sequences in DC/CDMA systems. Communication in these systems requires synchronization between the transmitter and the receiver, involving two stages: acquisition and tracking. Due to environmental changes and signal instability, a fixed threshold does not yield optimal results. Therefore, we employed an adaptive detection threshold based on the principle of the distributed CFAR detection. The objective of distributed CFAR systems is to maximize the overall probability of detection while maintaining a constant false alarm rate.

Classical optimization methods are not recommended for real-time systems due to their lengthy processing times. Thus, we proposed solving the problem intelligently using optimal metaheuristic algorithms, namely WOA, CMAES, ICA, and PSO GSA.

In the first chapter, we presented the main transmission techniques used in communication systems (FDMA, TDMA, and CDMA), including the spectral spreading technique. We also introduced the principle of CFAR detection using various algorithms.

In the second chapter, we described and analyzed the proposed system and explaining several optimization techniques such as WOA, CMAES, ICA, and PSO GSA.

In the third chapter, we applied various metaheuristic optimization techniques (WOA, CMAES, ICA, and PSO GSA) to solve the acquisition problem of the double-dwell serial search system with the TM-CFAR processor. We considered the influence of several parameters on the acquisition system. The obtained results from the optimization were presented and compared based on two performance criteria: the probability of detection and the mean acquisition time. By applying the fusion AND at the data fusion center of the distributed system, we found that the best performance was achieved with the WOA algorithm.

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## الملخص :

يهدف هذا العمل الى تحسين عملية الاكتساب التكيفي للتسلسلات العشوائية الزائفة (PN) في أنظمة الإستعمال المتعددة بتقسيم الرموز بمتتالية مباشرة DS/CDMA عبر إستخدام منهجية البحث التسلسلي المزدوج . تعاني أنظمة الإستحواذ التقليدية ذات العتبة الثابتة من عدم القدرة على التكيف مع البيئات المتغيرة بسرعة في الإتصالات المتنقلة , مما ينتج عنه معدلات عالية من الإنذارات الكاذبة أو إنخفاض في احتمالية الكشف . يهدف هذا العمل الى تحسين أداء الكاشف الموزع (TM-CFAR) من خلال اقتراح ودراسة ومقارنة عدة خوارزميات تحسين متنوعة , تشمل ( WOA, ICA, CMA-ES,PSOGSA) تم تقييم أداء النظام المقترح من خلال قياس احتمال الكشف ومتوسط وقت الإستحواذ بإستخدام قاعدة الدمج "و" , وأظهرت النتائج أن خوارزمية التحسين WOA تتفوق على باقي الخوارزميات

**الكلمات الرئيسية :** DS-CDMA ,الكشف الموزع TM-CFAR , طرق التحسين الفوقي.. قناة رايلي .

## Abstract:

The objective of this work is to improve the adaptive acquisition of pseudo-random sequences (PN) in multiple-use systems by splitting codes in a direct sequence DS/CDMA using the dual sequence search methodology . Traditional fixed-threshold acquisition systems suffer from the inability to adapt to rapidly changing environments in mobile communications , resulting in high rates of false alarms or reduced probability of detection . This work aims to improve the performance of the distributed detector (TM-CFAR) by proposing, studying and comparing several various optimization algorithms, including (WOA, ICA, CMA-ES, PSOGSA), the performance of the proposed system was evaluated by measuring the detection probability and average acquisition time using the integration rule "And", the results showed that the (WOA) optimization algorithm outperforms the rest of the algorithms.

**Keywords :** DS-CDMA , distributed detection , TM-CFAR , meta-heuristic optimization methods , Rayleigh channel.

## Résumé:

L'objectif de ce travail est d'améliorer l'acquisition adaptative de séquences pseudo-aléatoires (PN) dans des systèmes à usages multiples en divisant les codes en une séquence directe DS/CDMA en utilisant la méthodologie de recherche à double séquence . Les systèmes d'acquisition traditionnels à seuil fixe souffrent de l'incapacité de s'adapter à des environnements en évolution rapide dans les communications mobiles , ce qui entraîne des taux élevés de fausses alarmes ou une probabilité réduite de détection . Ce travail vise à améliorer les performances du détecteur distribué (TM-CFAR) en proposant, étudiant et comparant plusieurs algorithmes d'optimisation variés, notamment (WOA, ICA, CMA-ES, PSOGSA) les performances du système proposé ont été évaluées en mesurant la probabilité de détection et le temps moyen d'acquisition en utilisant la règle d'intégration "And", les résultats ont montré que l'algorithme d'optimisation (WOA) surpasse le reste des algorithmes.

**Mots clés :** DS-CDMA ,détéction distribuée ,TM-CFAR , les méthodes méta-heuristiques d'optimisation , Canal Rayleigh.