PN Acquisition Using Adaptive Thresholding and Smart Antenna for Direct Sequence CDMA Mobile Communication

By

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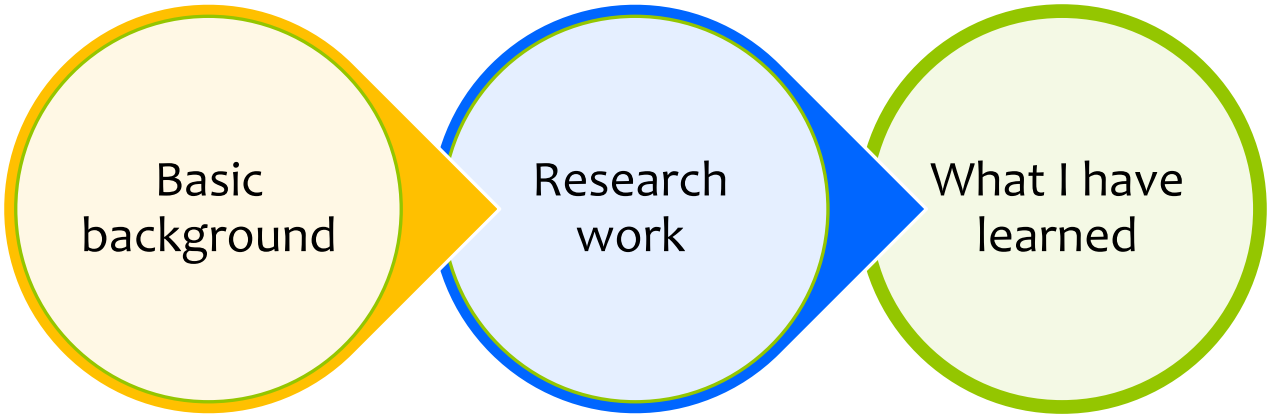
Outline

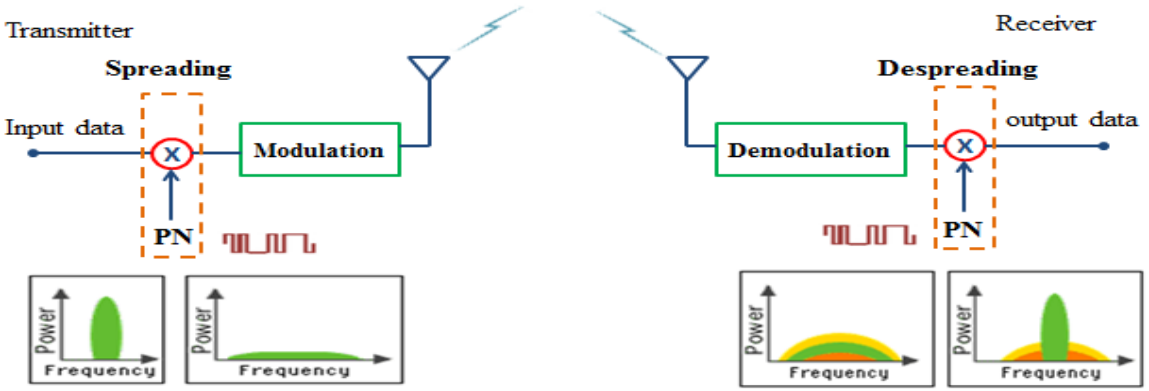


DS-CDMA Technique

* For years, direct sequence code division multiple access (DS-CDMA) appears as one of the most favored technique for cellular communication systems.
* In its generic form, DS-CDMA is a technique for simultaneously transmitting a number of information message signals from a multitude of users over a channel employing a common carrier.

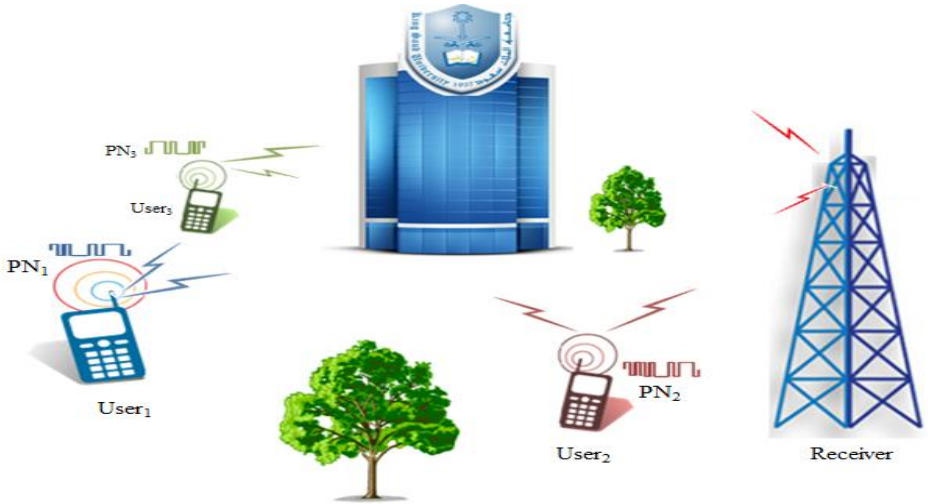
Direct Sequence (DS) System

* To transmit a data signal in the DS communication systems, the sender uses a pseudo-noise (PN) code to spread the signal before transmission.
* This same code is then used by the receiver for the despreading operation.



Code Division Multiple Access (CDMA) Technique

* CDMA is one of the most common used multiple access techniques.
* In the CDMA, channels are created by assigning each user a unique PN code that is uncorrelated with other users' codes.

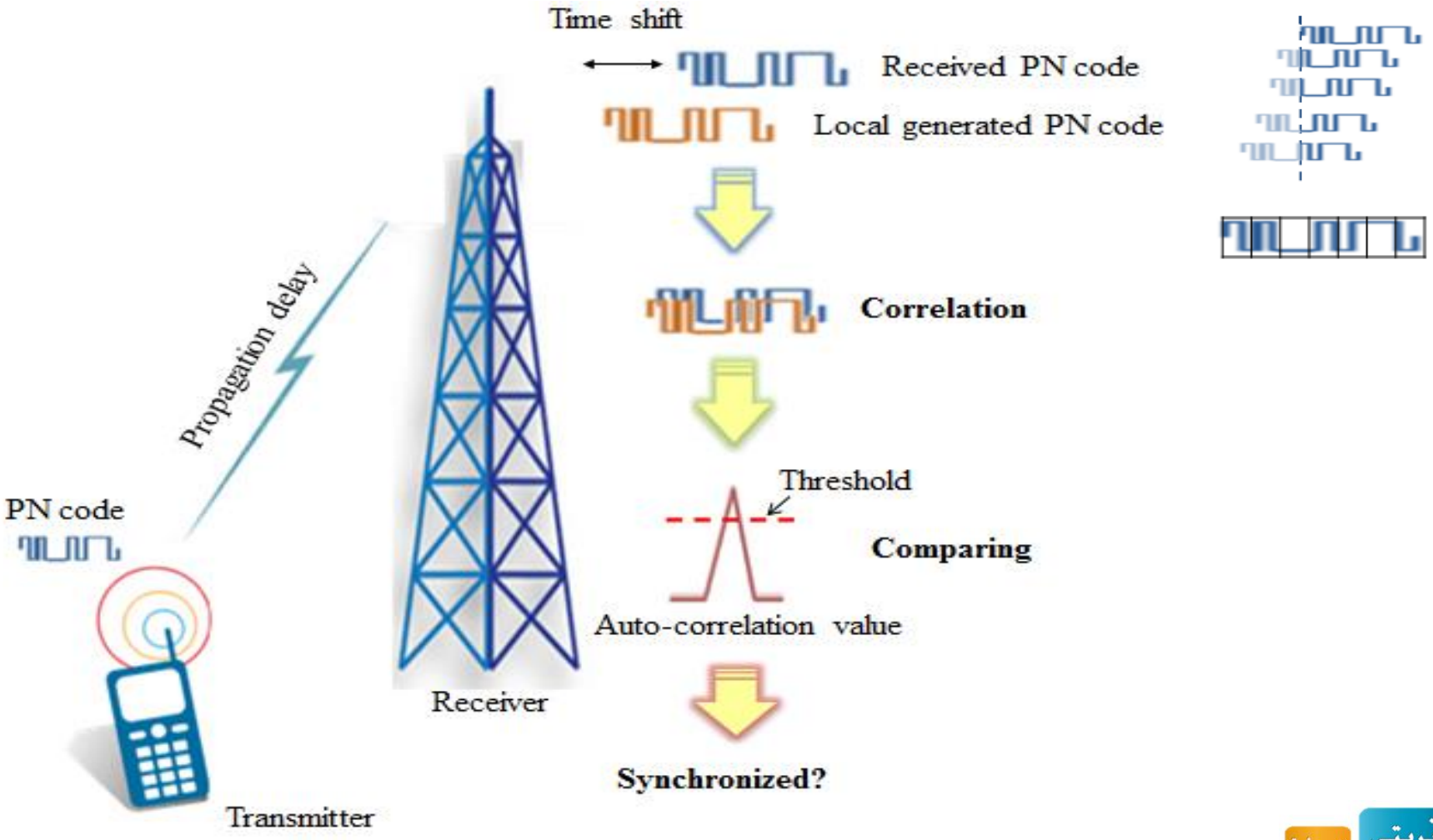


PN Codes Synchronization

* To be able to demodulate properly the received signal, the receiver must first perform the *PN codes synchronization* between the received PN code and the locally generated one.
* The goal of this process is to align these two PN code sequences, which is achieved in two stages:
  1. PN acquisition.
  2. PN tracking.

PN Code Acquisition

* Due to the unknown time delay between the transmitter and the receiver, the phase of the received PN code is unknown.
* In the acquisition process, the receiver searches through the uncertainty phases of the PN sequence and test them.
* To determine whether the tested phase is a synchronized code phase the correlation between these two PN codes is computed and compared to a threshold value to make the synchronization decision.


Time shift
Received PN code
Local generated PN code
Correlation
Threshold
Comparing
Auto-correlation value
Synchronized?
Propagation delay
PN code
Receiver
Transmitter

* In detection-theory terms, acquisition can be formulated as a binary testing problem.

Tested code phase cell

→ Correct phase (synchronization)
H_1 hypothesis

→ incorrect code phase (non-synchronization)
H_0 hypothesis

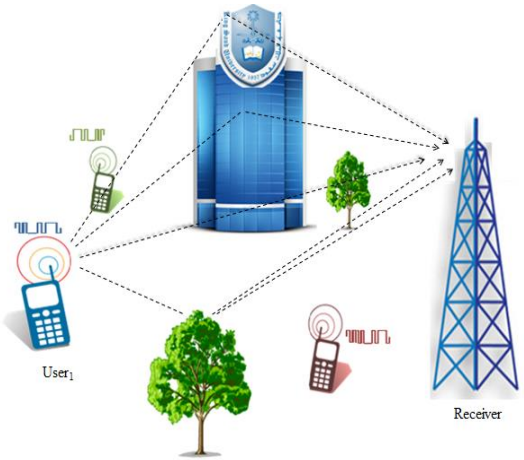
* There are 4 possible situations

Correct detection	*Correct rejection*	*Missed detection*	*False alarm*
Tested phase: H1 Decision: H1	Tested phase: Ho Decision: Ho	Tested phase: H1 Decision: Ho	Tested phase: Ho Decision: H1
✓	✓	✗	✗

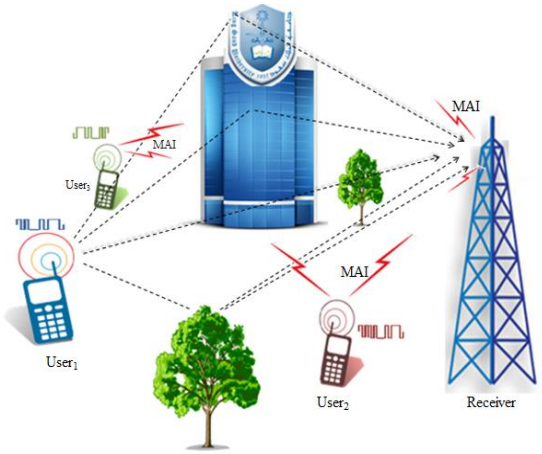
Facts

* PN acquisition is the most challenging stage in code synchronization.

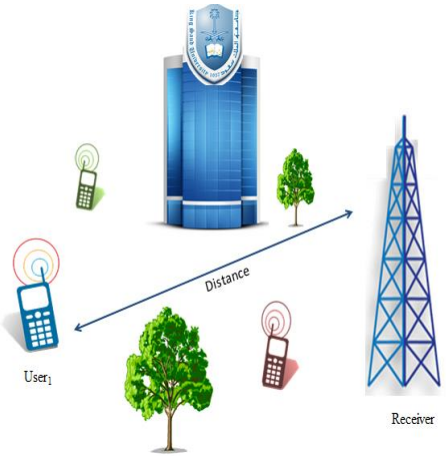
Multipath Signals



MAI signals



Received signal power



* All these circumstances have serious effects on the PN code acquisition performance. ☹

Problems

* Moreover, since the received signal levels are unknown and location varying, using a *fixed threshold* may cause too many false alarms and/or low detection probability according to the selected threshold value.
  * If the threshold value is too low, the *false alarm probability* will increase seriously.
  * On the other hand, if it is too high the *probability of miss* is increased.

Requirements

* An efficient PN code acquisition is a significant requirement for DS-CDMA wideband communication receivers.
* It is essential to acquire the PN code sequence both *quickly* and *accurately* in order to provide a high quality communication.

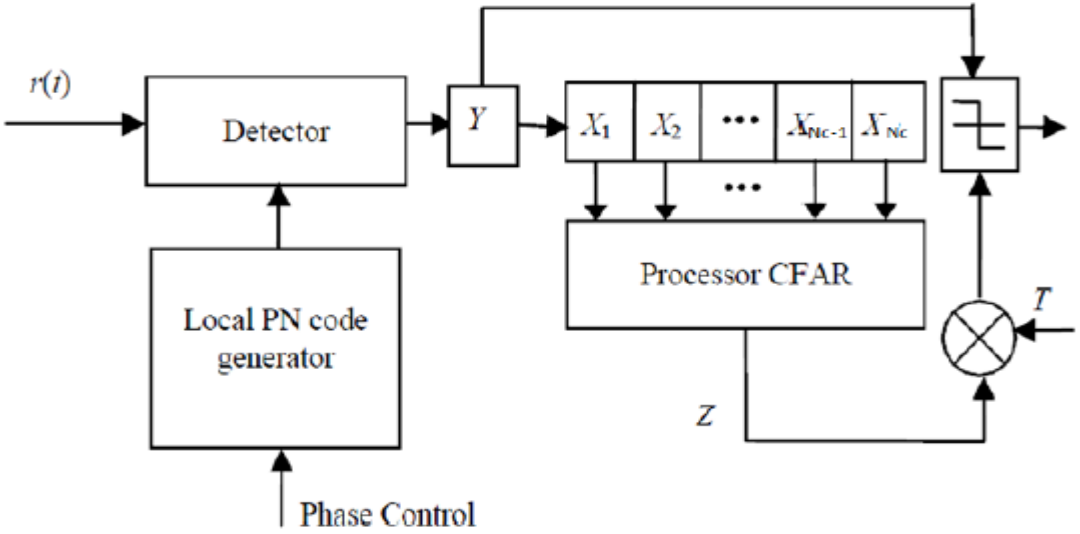

problem
problem
problem
problem
problem
problem
problem
problem
problem
solution

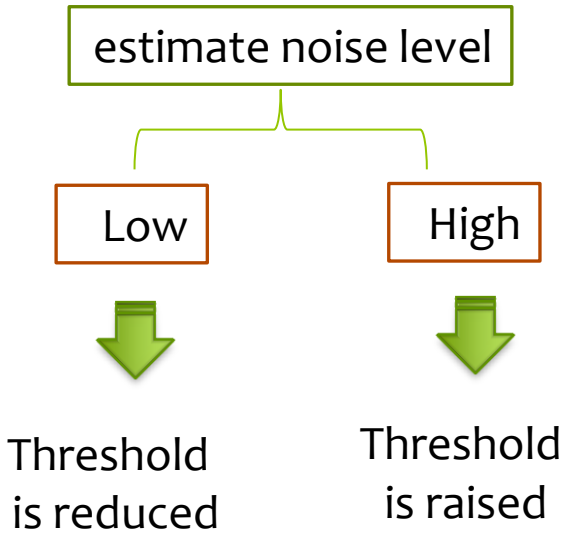
PN Acquisition Using Adaptive Thresholding and Smart Antenna

Adaptive Threshold

* To overcome the excessive false alarms that may result from using the fixed threshold, a threshold value set adaptively according to the surrounding environment is needed.
* Using constant false alarm rate (CFAR) algorithms, which is well developed in automatic and adaptive radar signal detection, to set an adaptive threshold for the PN acquisition has proved its effectiveness.
* The function of the adaptive threshold is to keep a CFAR (constant false alarm rate) under variations in the background noise level.

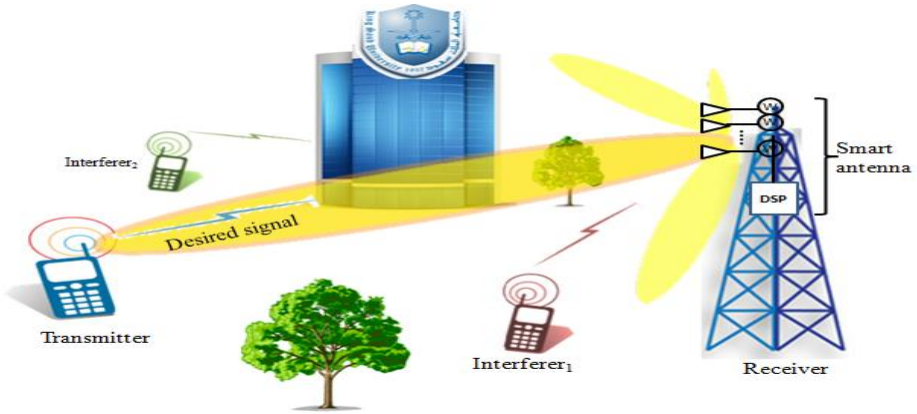
* The main idea of the CFAR is to estimate the background noise variance or power, which is not known, from a reference window consisting of a number of cells to set the threshold adaptively.



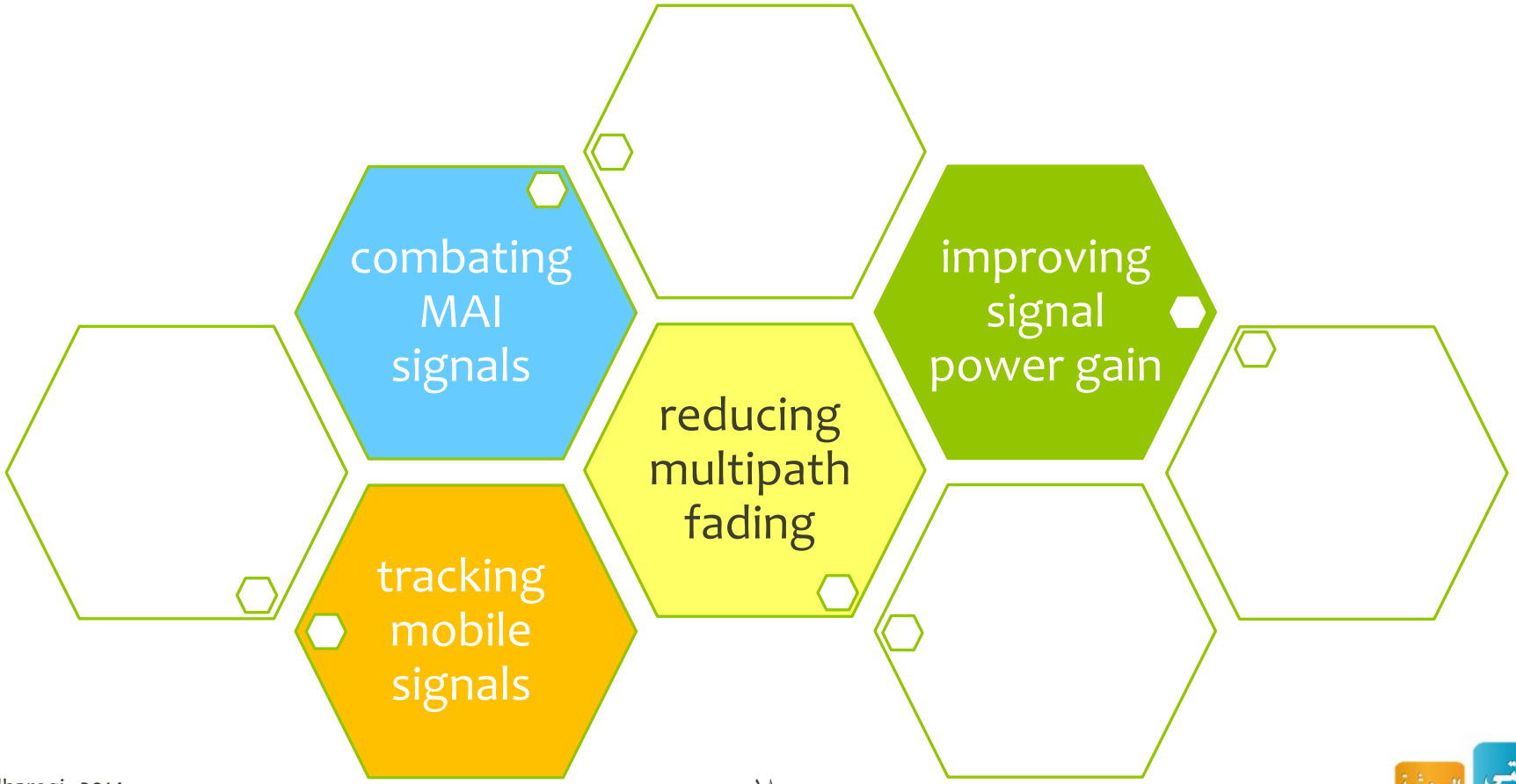


Smart Antenna

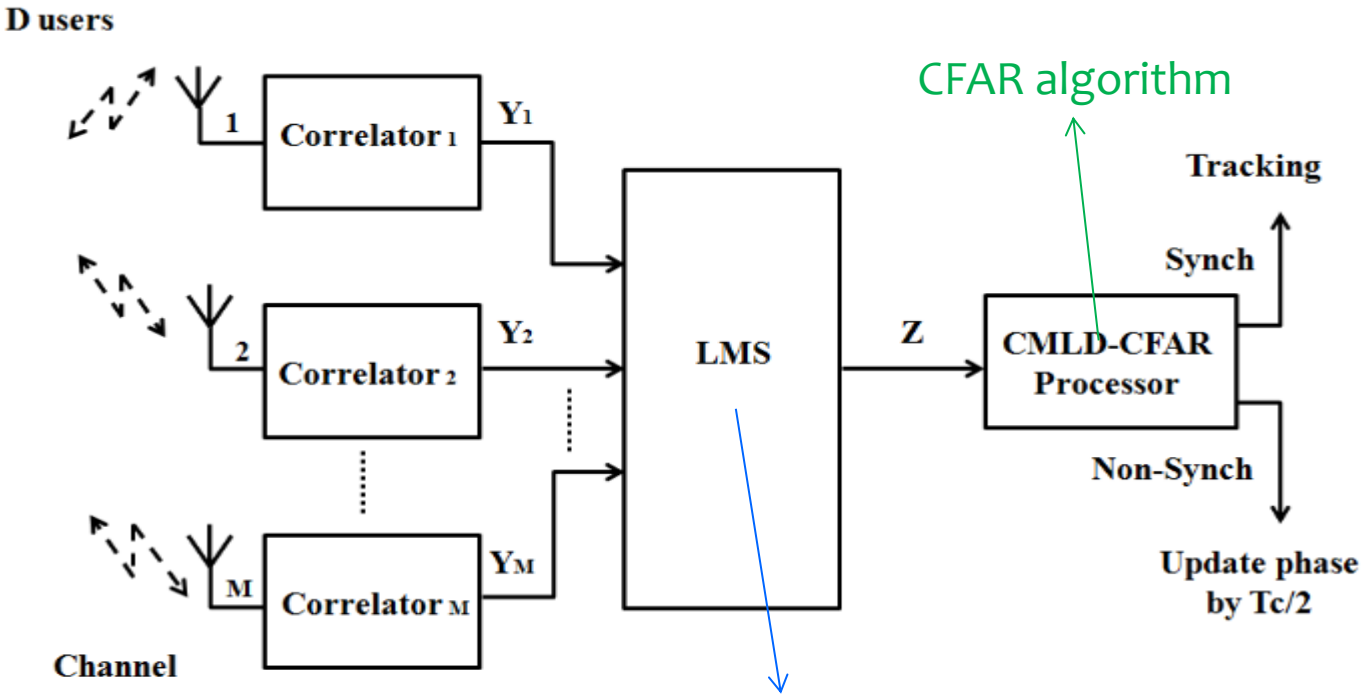
* The smart antenna is a combination of an antenna array and a digital signal processing (DSP) unit that automatically optimizes its radiation or/and reception pattern in response to its signal environment in order to emphasize signals of interest and to minimize interfering signals.



* Smart antenna has a good ability in



The Proposed System



System Analysis

Probability of false alarm

$$P_{fa} = \prod_{i=1}^{N_c-k} M_{V_i}\left(\frac{T}{a}\right)$$

$$M_{V_1}\left(\frac{T}{a}\right) = \frac{N_c}{(N_c-k)\,(T+\frac{N_c}{N_c-k})}$$

$$M_{V_i}\left(\frac{T}{a}\right) = \frac{g_i}{T+g_i}$$

Probability of detection

$$P_{d_l} = \prod_{i=1}^{N_c-k} M_{V_i}\left(\frac{T}{b}\right)$$

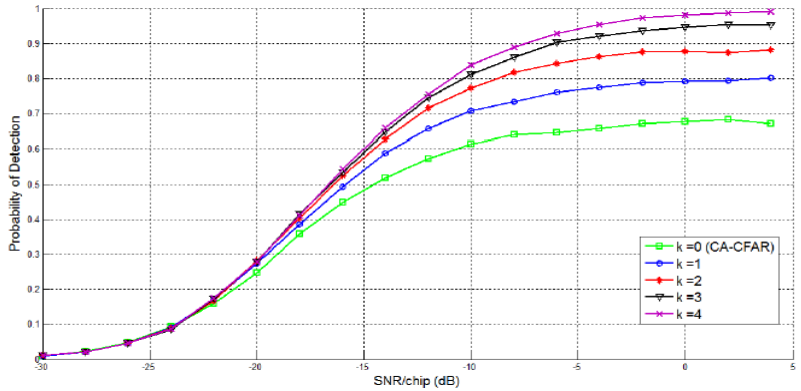
$$M_{V_1}\left(\frac{T}{b}\right) = \frac{bN_c}{aT(N_c-k)+bN_c}$$

$$M_{V_i}\left(\frac{T}{b}\right) = \frac{b(N_c-i+1)}{aT(N_c-k-i+1)+b(N_c-i+1)}$$

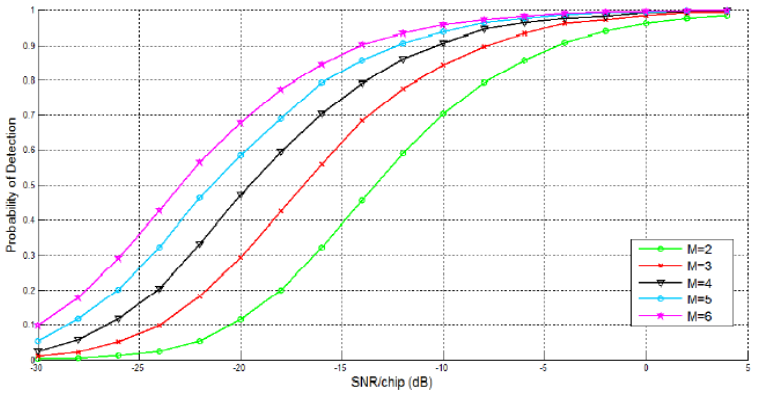
Mean acquisition time

$$T_{acq} = \frac{1}{H_D(1)}\left[H'_D(1)+H'_M(1)+(v-1)H'_0(1).\left(1-\frac{H_D(1)}{2}\right)\right]$$

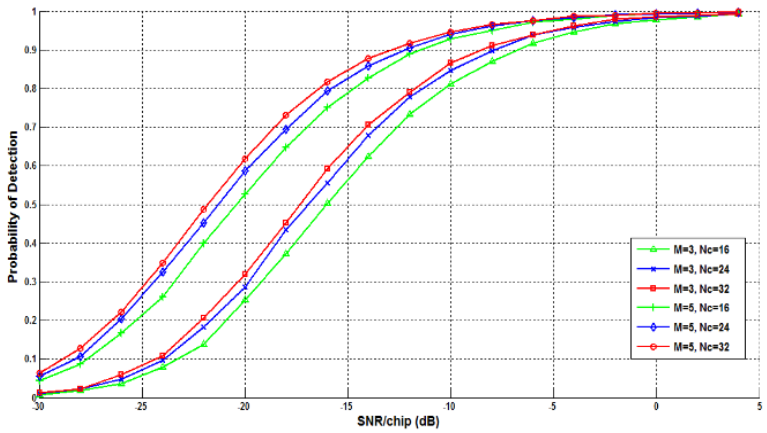
Results



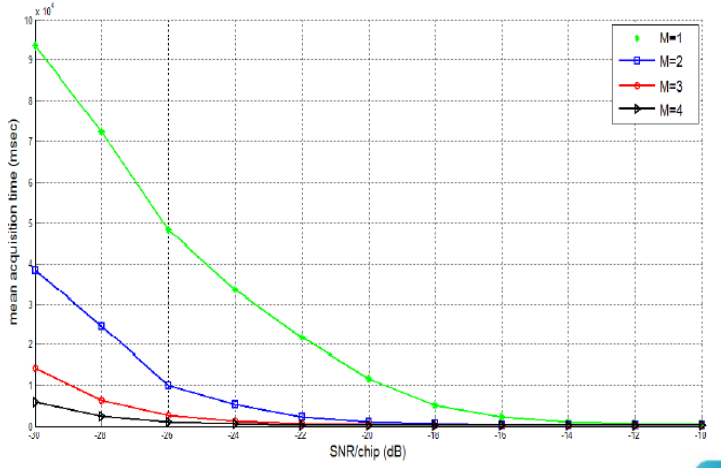
CMLD



Increasing M



Increasing Nc



Increasing M

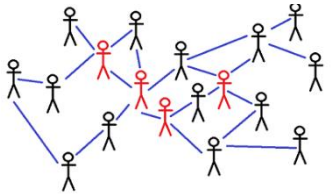
What I Have Learned












THANK
YOU