

## PROBABILISTIC DATA ASSOCIATION ALGORITHM

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### 11.1 INTRODUCTION

Over the past decades, the Wireless communication system has a challenge of accommodating many users in a small area. With the advent of spread spectrum and hence CDMA, fixed bandwidth was used to accommodate many users by making use of certain coding properties over the bandwidth. However, the standardization of conventional DS-CDMA system has the major problem of multi-access interference (MAI). The MAI occurs in multi-access communication systems is unavoidable because receiver's deal with information interferes with each other.

To overcome these limitations, Multi-user Detection (MUD) emerges as a promising approach to increase the system capacity over conventional CDMA receiver. MUD is basically the design of signal processing algorithms that algorithms take into account the correlative structure of the MAI.

In this chapter, we are only concerned with the family of PDA's and their application as an optimization tool to the problem of multi-user detection in CDMA based wireless communication systems.

### 11.2 SYSTEM MODEL

This CDMA system model shows that the number of users transmitting their signal data simultaneously, passed from the channel having multi-path environment. These faded signals are applied in to the receiver, which have been processed by the PDA method, shown in Fig.11.1

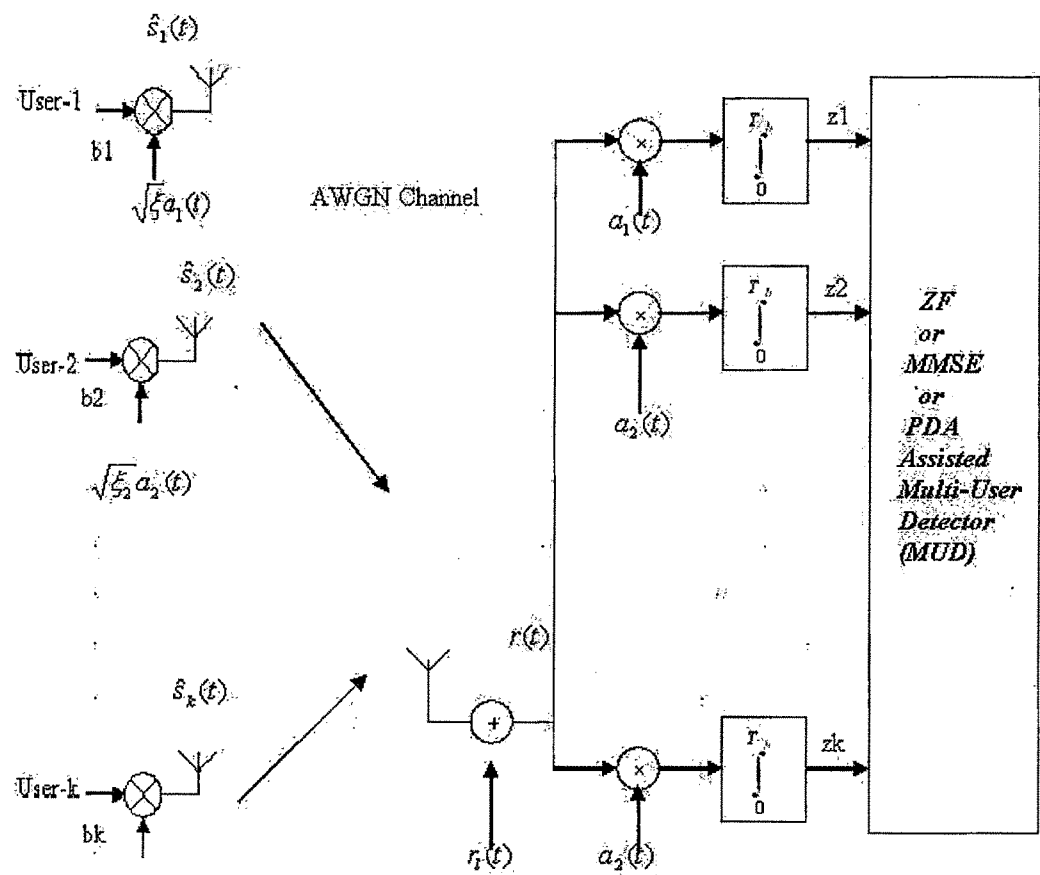


Figure. 11.1 CDMA system model with PDA algorithm

11.3 FLOW OF PDA ALGORITHM

Basic approach of a Probability Data Association Algorithm (PDA) employed in optimizing a specific problem defined by an objective function is shown in flow chart given in Fig.11.2

First, all the users at the receiver sides are distinguish according to their equally probable data. Based on this, the users can be distinguish each other and if required, converge the probability and update it. Finally, the users can be identified based on their data association with higher SNRs.

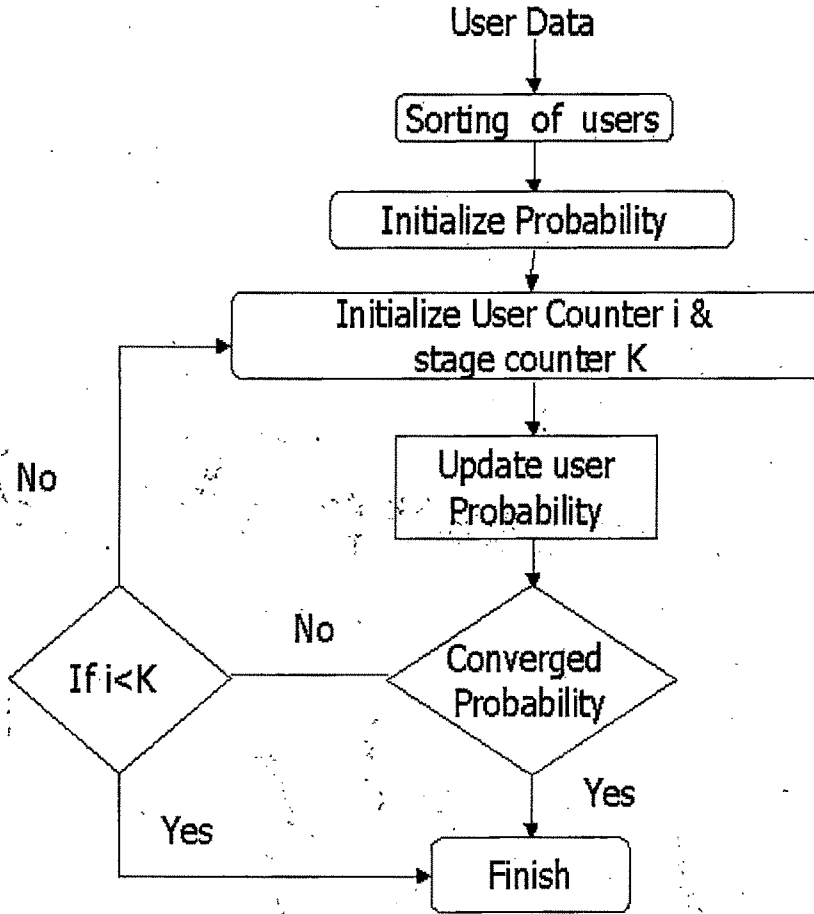


Figure.11.2 Flow of PDA

#### 11.4 PDA DETECTOR

The  $k$ -length vector gives a discrete time equivalent model for the matched filter outputs at the receiver.

$$y = RWb + Z \quad (1)$$

Where  $b \in \{1, -1\}^K$  denotes the  $K$  length vector of bits transmitted by the  $K$  active users. The matrix  $H = W^{1/2}RW^{1/2}$  is a signature waveform correlation matrix and is thus nonnegative definite.  $R$  is the normalized correlation matrix.  $W$  is a diagonal matrix whose  $K^{\text{th}}$  diagonal element  $\omega_k$  is the received signal energy per bit

of the  $K^{\text{th}}$  user and  $Z$  is real-valued zero mean Gaussian random vector with a covariance matrix that is equal to  $\sigma^2 H$  where  $\sigma^2$  is the power of the white noise before the matched filter. This model applied to additive white Gaussian noise channel.

Multiply by  $W^{-1}R^{-1}$  on both sides of the (1) from the left; the system model can be reformulated as

$$\tilde{y} = b + \tilde{z} = b_i e_i + \sum_{j \neq i} b_j e_j + \tilde{z} \quad (2)$$

Where  $\tilde{y} = W^{-1}R^{-1}y$  and  $\tilde{z} = W^{-1}R^{-1}z$ . The variable  $b_i$  represent the  $i^{\text{th}}$  element of vector  $b$ ,  $e_i$  is the column vector whose  $i^{\text{th}}$  component is 1 and whose other components are 0.

### 11.5 BASIC ALGORITHM

In these system model, we take the user's  $b_i$  as binary random variables and for any user  $i$ , we associate a probability of  $P_b(i)$  with the user signal  $b_i$  where,  $P_b(i)$  is the current estimation of the probability that  $b_i = 1$  and  $1 - P_b(i)$  is the corresponding estimation of  $b_i = -1$ . For the user signal data  $b_i$ , take the other user signals as  $b_j (j \neq i)$  as binary random variables and take  $\sum_{j \neq i} b_j e_j + \tilde{z}$  as noise. Also,  $p(b_i = 1 | \tilde{y}, \{P_b(j)\}_{j \neq i})$  and  $p(b_i = -1 | \tilde{y}, \{P_b(j)\}_{j \neq i})$  can be serve as updated information on user signals  $b_i$ .

The condition under which the PDA detector follows is:

- 1) Initialize  $P_b(i) = 0.5$ , Also, Initialize, the stage counter  $S = 1$ .
- 2) Initialize the user counter  $i = 1$ .
- 3) Based on the current value of  $P_b(j)_{j \neq i}$  for user  $i$ , update  $P_b(i)$  by,

$$p(b_i = 1 | \tilde{y}, \{P_b(j)\}_{j \neq i}) \quad (3)$$

- 4) If  $i < S$ , let  $i = i + 1$  and go to step 3).
- 5)  $\forall i, P_b(i)$  Has converged, go to step 6). Otherwise, let  $S = S + 1$  & return to step 2).

6)  $\forall i$ , Make a decision on user signal  $i$

$$b_i = \begin{cases} +1, & P_b(i) \geq 0.5 \\ -1, & P_b(i) < 0.5 \end{cases} \quad (4)$$

## 11.6 SUMMARY

In this chapter we have presented a brief overview's of PDA algorithm. Specially, we introduce a terminologies and procedures of PDA with multi-user detection techniques at CDMA receiver. The best way of identifying the cellular system problems arise at the receiver can also be recognized using the above algorithm.