SNS COLLEGE OF TECHNOLOGY
Coimbatore – 35

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

16EC401 / Wireless Communication

IV ECE/ VII SEMESTER

Unit IV **- MULTIPATH MITIGATION TECHNIQUES**

Topic : RAKE RECEIVER

Introduction

- Time Diversity → transmit repeatedly the information at different time spacings
  - Time spacing > coherence time (coherence time is the time over which a fading signal can be considered to have similar characteristics)
  - So signals can be considered independent
  - Main disadvantage is that BW efficiency is significantly worsened – signal is transmitted more than once
    - BW must ↑ to obtain the **same** R_d (data rate)

Introduction

- RAKE Receiver
  - Powerful form of time diversity available in spread spectrum (DS) systems → CDMA
  - Signal is only transmitted once
  - Propagation delays in the MRC provide multiple copies of Tx signals **delayed** in time

Introduction

- Time diversity repeatedly transmits information at the time spacing that exceeds the coherence time of the channel.
- Multiple repetitions of the signals will be received with independent fading conditions, thereby providing diversity.
- Our modern implementation of time diversity involves the use of RAKE receiver for spread spectrum CDMA.

RAKE RECEIVER

– Attempts to collect the time-shifted versions of the original signal by providing a separate correlation receiver for each of the multipath signals.
– Each correlation receiver may be adjusted in time delay, so that a microprocessor controller can cause different correlation receivers to search in different time windows for significant multipath.
– The range of time delays that a particular correlator can search is called a *search window*.

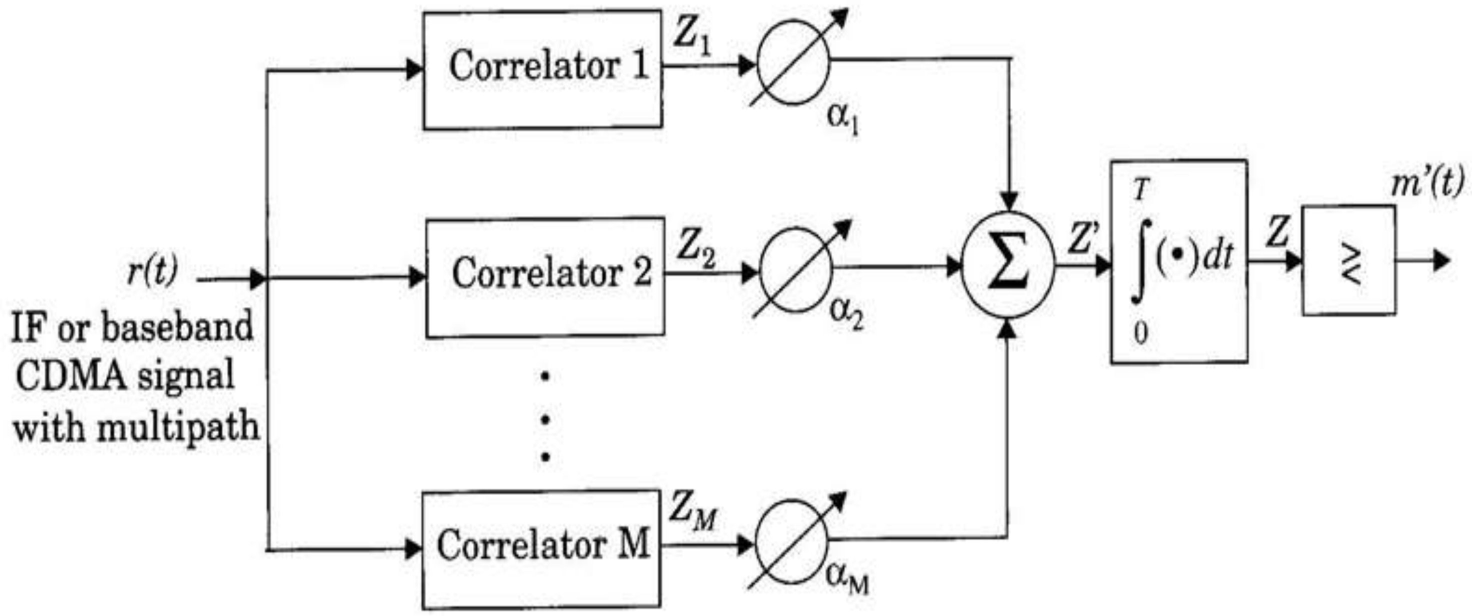
RAKE RECEIVER

- If time delay between multiple signals > chip period of spreading sequence (T_c) → multipath signals can be considered uncorrelated (independent)
  - In a basic system, these delayed signals only appear as noise, since they are delayed by more than a chip duration. And ignored.
  - Multiplying by the chip code results in noise because of the time shift.
  - But this can also be used to our advantage, by shifting the chip sequence to receive that delayed signal separately from the other signals.

Activity

- Imagine folding a paper in half once
- Then take the result and fold it in half again; and so on
- How many times can you do that?

RAKE RECEIVER



An *M*-branch (*M*-finger) RAKE receiver implementation.

RAKE RECEIVER

– *M* branches or “fingers” = # of correlation Rx’s
– Separately detect the *M* strongest signals
– Weighted sum computed from *M* branches

- faded signal → low weight
- strong signal → high weight
- overcomes fading of a signal in a **single** branch

RAKE RECEIVER

- A **rake receiver** is a radio receiver designed to counter the effects of multipath fading, It does this by using several "sub-receivers" called *fingers.*

- The rake receiver was patented in the US in 1956 by “Price and Green”.

- Each correlator detects a time-shifted version of the original transmission, and each finger correlates to a portion of the signal, which is delayed by at least one chip in time(1/Rc) from the other fingers.

- This will result in higher SNR (E_b/N_0) in a multipath environment than in a "clean" environment.

RAKE RECEIVER

- Multipath component appears like uncorrelated noise at a CDMA receiver and equalization is not required.
- The outputs of each correlator are weighted to provide better estimate of the transmitted signal than is provided by a single component.
- The weighting coefficients are based on the power or the SNR from each correlator output.
  - If the power or SNR is small out of a particular correlator, it will be assigned a small weighting factor or vice versa.

RAKE RECEIVER

- In outdoor environments
  - the delay between multipath components is usually large, the low autocorrelation properties of a CDMA spreading sequence can assure that multipath components will appear nearly uncorrelated with each other.

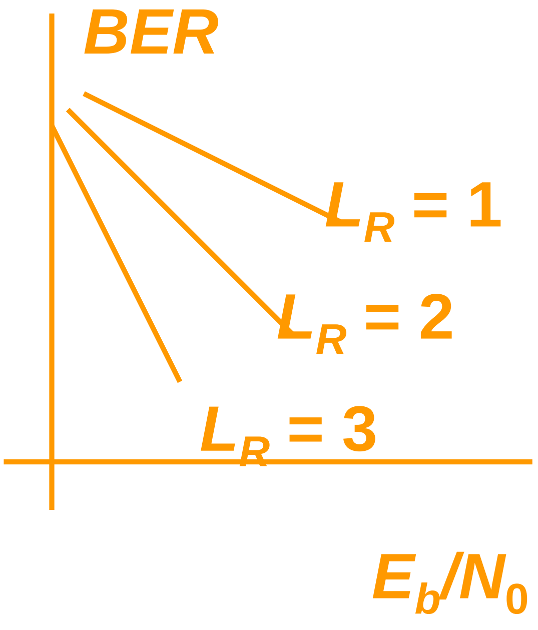
RAKE RECEIVER

- In indoor environments
  - RAKE receiver in IS-95 CDMA has been found to perform poorly
    - since the multipath delay spreads in indoor channels (≈100 ns) are much smaller than an IS-95 chip duration (≈ 800 ns).
    - In such cases, a RAKE will not work since multipath is unresolveable
    - Rayleigh flat-fading typically occurs within a single chip period.

RAKE RECEIVER-BER

- Ignoring ISI, the local-mean BER is

$$BER = \frac{1}{2}\sum_{j=0}^{L_R} \pi_j \left[1 - \sqrt{\frac{\gamma_j}{\gamma_j + 1}}\right]$$



- where

$$\pi_j = \prod_{\substack{i=1 \\ i \neq j}}^{L_R} \frac{\gamma_j}{\gamma_j - \gamma_i}$$

- with γ_i the local-mean
- SNR in branch *i*.

Assessment

- **What are the modes of adaptive equalizer?**
  a) Training mode
  b) Tracking mode
  c) Both of the mentioned
  d) None of the mentioned

- **The ISI and adjacent channel interference is removed by**
  a) Cancelling filter
  b) Port processing equalizer
  c) Both of the mentioned
  d) None of the mentioned

THANK YOU