How to cope with last hop impairments?

Part 4
Fading
#7

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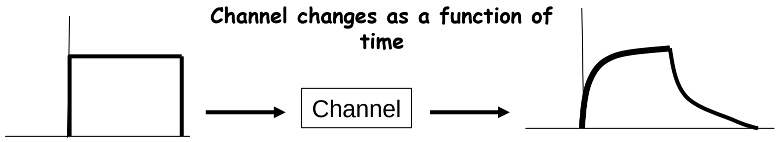
How to cope with last hop impairments?

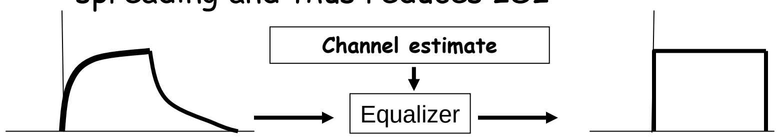
- Techniques for coping with noise
  - Forward error detection/correction coding
  - Automatic Repeat reQuest (ARQ)
  - Co-existance or modifications to end-to-end protocols
- Techniques for coping with multipath fading→ fading mitigation techniques, e.g.,
  - Equalizers
  - Diversity
  - RAKE receivers
  - OFDM

Equalizers

- Fading can be viewed as transmission through a linear time varying system.



- An equalizer estimates the channel response as a function of time and compensates for the pulse spreading and thus reduces ISI



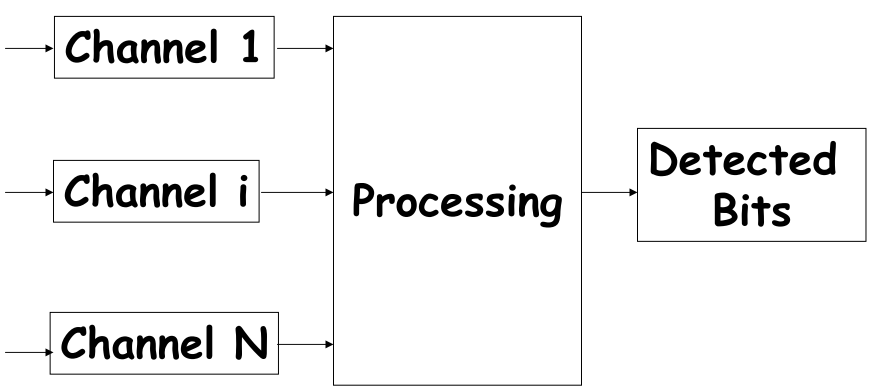
Equalizers

- Equalizers are
  - Common
    - Dial-up modems
    - Cellular systems
  - Often use training signals
    - A known signal is transmitted
    - At the receiver the known transmitted signal and the corresponding distorted waveform are used to estimate the expected channel characteristics
    - Assume the channel is "constant" between transmissions of training signals
    - Training signals add overhead and reduce efficiency
  - Can be non-linear
- Equalizers differ in the computational complexity and performance

Equalizers→ Diversity

- Equalizers rely on one received waveform
- That maybe in a deep fade
- Diversity can provide significant performance when one of the independent paths are in a deep fade.

Diversity



Diversity

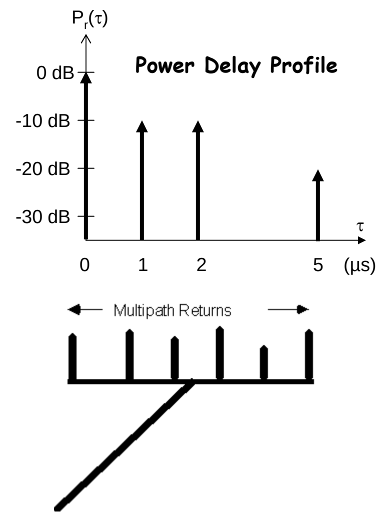
- Obtain multiple independent samples of the received signal
- Process the multiple independent samples to reduce the BER
- Independent samples maybe obtained via spatial diversity,
  - Multiple receive antennas
    - Separated on the order of ½ wavelength
    - MIMO (multiple in/multiple out) uses more multiple transmit and receive antennas

Diversity

- Independent samples maybe obtained via frequency diversity,
  - Same information over different frequency channels
  - Expands the required bandwidth
- Independent samples maybe obtained via time diversity,
  - Same information transmitted at different times
  - For fixed rate this also increases the bandwidth requirements
- Diversity can provide significant performance inprovement

RAKE receiver

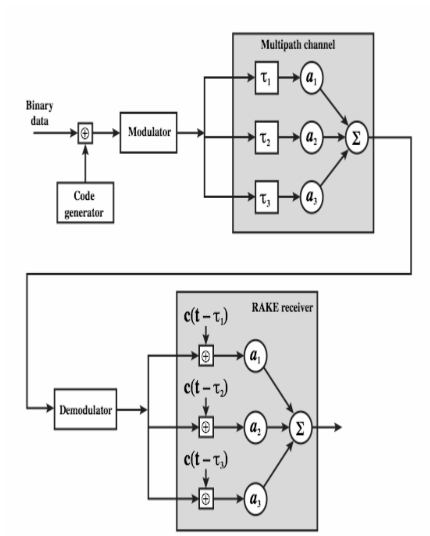
- With CSMA a bit, lasting T_b sec is divided into N chips of length T_c
- The sequence of the N chips are selected to have a low autocorrelation
- Thus for CDMA the delay profile of the channel provides multiple versions of the transmitted signal at the receiver.



RAKE receiver

- A RAKE receiver estimates the delay and amplitude of the delay profile
- Obtains independent samples
- Thus providing a form of time diversity.
- Only a few 2-3 samples provide significant performance improvement
- IS-95 cell systems use a RAKE receive in both the base stations and hand sets

Rake Receiver



From: W. Stallings, Data and Computer Communications, Pearson, 2006

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Orthogonal Frequency-division Multiplexing-OFDM

- Multicarrier Modulation
- Uses a large number of parallel narrow-band channels, each on a unique sub carrier
- Combats
  - Multipath
  - Narrow-band interference
- Problems
  - Sensitive of frequence and phase noise
  - Has large Peak-to-average ratio resulting is inefficient use of power amplifiers

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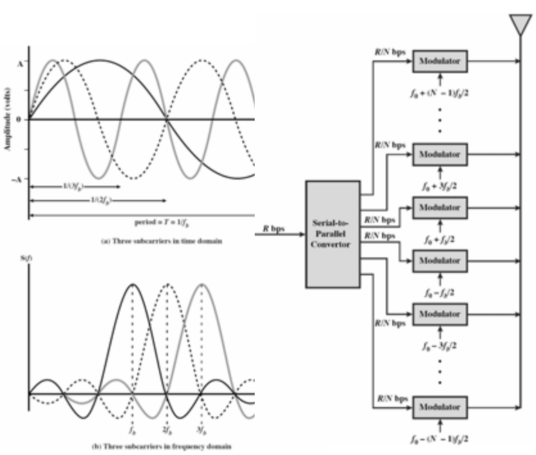
Orthogonal Frequency-division Multiplexing-OFDM

- Assume for a a base system
  - Bit rate = R
  - Channel bandwidth = Nf_b @ f_c
  - Using all the channel bandwidth the bit duration would be $1/R=T_b$
- Process the R b/s stream into N streams each at a rate of R/N, now for each stream the symbol time is N/T.
- Note because the symbol time has increased its susceptibility to multi-path induces ISI is decreased

Orthogonal Frequency-division Multiplexing-OFDM

- The data is "distributed" over the N sub-carriers in a special way, specifically, the frequencies are selected to be orthogonal
- Different types of modulation can be used, e.g., QPSK
- Equalizers may not be needed when using OFDM



From: W. Stallings, Wireless Communications & Networks, Pearson 2005

Orthogonal Frequency-division Multiplexing-OFDM

- Examples:
  - IEEE 802.11a uses 52 subcarriers
  - MMDS uses 512 subcarriers
  - Powerline systems

References #7

- W. Stallings, Data and Computer Communications, Pearson, 2006
- W. Stallings, Wireless Communications & Networks, Pearson 2005

References