Two-Stage Acquisition for UWB in Dense Multipath

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Motivation

Two major challenges for UWB acquisition in dense multipath:

1) **Very long acquisition time**
   Extremely short, low duty cycle pulses result in a huge number of potential delays (cells) in uncertainty region
2) **Presence of multiple H_1 (in-phase) cells**
   - Tens or hundreds of multipath delays can terminate acquisition.
   - Locking into an arbitrary multipath might result in significant symbol energy loss, or very large ranging error.

Proposed System

Two-Stage Acquisition Model

1) **Coarse Acquisition**
   - Locks onto an arbitrary multipath.
   - Achieves rough symbol timing
2) **Fine Acquisition**
   - Searches for first arriving path in reduced uncertainty region.
   - Takes advantage of an estimate of noise variance to construct more reliable threshold.
   - Exploits clustered nature of multipath to better segregate noise (H_0) cells.

Coarse Acquisition

Serial Search:

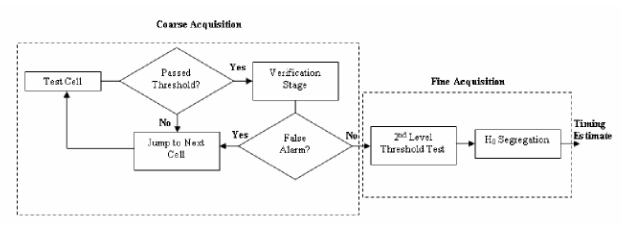
- Cells in the uncertainty region are searched consecutively, in the order in which they occur in time.
- Approximately half of the cells are searched on average.
- Does not take advantage of the multipath channel, which is a highly suboptimal approach.

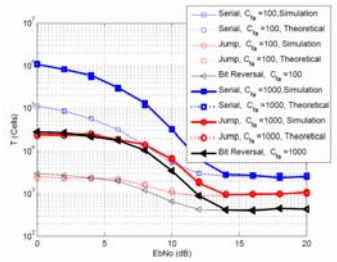
Jump-Phase Search:

- Search the multipath components in non-consecutive order.
- Simpler than bit reversal search.
- Jump by a spreading code duration.
- The H_1 cells are uniformly spread over the uncertainty region

Serial Search

Jump-phase Search





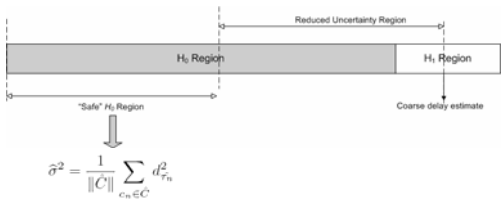
Mean Acquisition Time. 32-length Spreading Code.

Fine Acquisition

Step 1: Second Level Threshold Crossing

In coarse acquisition, the noise power is unknown, and the threshold setting mechanism cannot take SNR information into account with a simple procedure. After coarse acquisition, since the *H1* region has been identified to within a spreading length, an estimate of the noise variance can now be obtained by calculating the average of the decision statistics over the *H0* region.

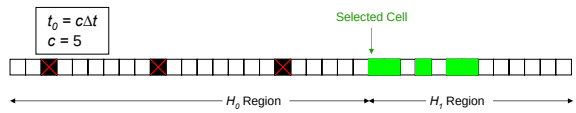
Input to step 2: Cells that survived threshold test



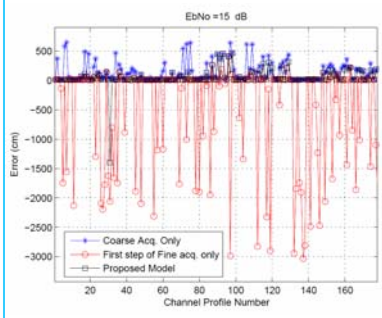
$$\hat{\sigma}^2 = \frac{1}{\|C\|} \sum_{c_n \in C} d^2_{\tau_n}$$

Step 2: H_0 Cell Segregation

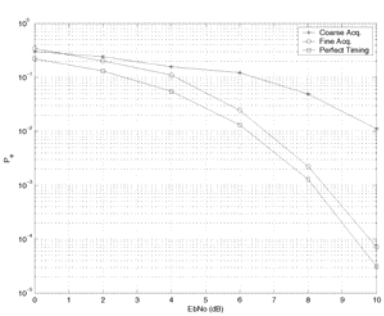
- Let C_s be the number of cells that passed the first phase of the fine acquisition stage.
- We denote their indices by X_j, $1<j< C_s$.
- For a particular cell X_k, we calculate t_k, the time difference between X_k and its closest neighboring survivor cell X_{k+1} .
- If t_k exceeds a predefined constant t_0, then cell X_k is eliminated.
- After all cells are tested, the earliest surviving cell is selected.
- Rationale based on the clustered nature of multipath. Since multipath occurs in clusters, it is most likely that the multipath cluster will result in a group of neighboring surviving cells. If, on the other hand, an isolated cell exceeds the threshold, it is most likely an H_0 cell.



Results



Performance of Fine Acquisition in ranging. Spreading Gain = 64. E_b/N_o = 15 dB.



Performance of pilot-assisted receiver in presence of acquisition error. Spreading Gain = 256.

Relevant Publications

- J. Ibrahim and R.M. Buehrer, "Two-Stage Acquisition for UWB in Dense Multipath", *IEEE Journal on Selected Areas in Communications, UWB Communications Special Issue,* April 2006.
- J. Ibrahim and R.M. Buehrer, "Two-Stage Acquisition for UWB in Dense Multipath," *IEEE Military Communication Conference, MILCOM 2005,* October •2005.