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 H1 (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 (H0) cells.

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 H1 cells are uniformly spread over the uncertainty region

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

Step 2: H0 Cell Segregation

- Let Cb be the number of cells that passed the first phase of the fine acquisition stage.
- We denote their indices by Xj, 1 < j < Cb.
- For a particular cell Xb, we calculate tjb, the time difference between Xb and its closest neighboring survivor cell Xb+1.
- If tjb exceeds a predefined constant t0, then cell Xb 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 H0 cell.

Results

Performance of Fine Acquisition in ranging. Spreading Gain = 64. Ebf/N0 = 10 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.