Multiuser Channel Estimation

Channel Effects
• Multiple Users
• Multiple Access Interference
• Multipath Delays
• Fading
• Additive White Gaussian Noise

The Wireless Channel

- Noise + MAI
- Base Station
- Direct Path
- Reflected Paths

- User 1
- User 2

Third Generation Communication Systems

- W-CDMA - Wideband CDMA (5 MHz)
- 3G Communication Systems
  - Integrating Multimedia
  - Quality of Service (QoS)
  - Multi-rate Services
  - Higher Data Rates
  - 2 Mbps, 364 Kbps, 144 Kbps

<table>
<thead>
<tr>
<th>Spreading Factor</th>
<th>Number of Bits / Frame</th>
<th>Data Rate Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>10240</td>
<td>1024 Kbps</td>
</tr>
<tr>
<td>32</td>
<td>1280</td>
<td>128 Kbps</td>
</tr>
<tr>
<td>256</td>
<td>160</td>
<td>16 Kbps</td>
</tr>
</tbody>
</table>

Multiuser Channel Estimation

- Need to know the Channel for proper detection
- Delays and Amplitudes of each user and each path
- Code-Multiplexed with Data
- Time-Multiplexed with Data

Multiuser Detection

- Use knowledge of channel for reliable detection

Die-Stat Receiver

- Data + Pilot
- Demodulator + Base
- Multiuser Detection
- Channel Estimation
- Decoder

Detected Bits

- Subspace
- Maximum Likelihood

Joint Estimation and Detection

- Computationally Efficient
- Better BER Performance

DSP Implementation

- TI TMS3701, projected at 250 MHz.
- 1953 cycles available for detection of 1 bit assuming data rate of 128 Kbps.
- In-depth profiling to find bottlenecks.
- Multiuser Detection
  - needs to be performed continuously to meet data rate requirements
- Channel Estimation
  - can be updated less frequently
- Single DSP does not meet real-time requirements
- Multiuser Detection - Bottleneck!

Real-Time Implementation

VLSI

DSP

FPGA

High Performance Processors

Joint Work with
Praful Kaul (UIUC)
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Dr. Sarita Adve (UIUC)

Exploiting Pipelining and Parallelism

Channel Estimation

- Parameters
  - N - Spreading Code Length
  - K - Number of Users
  - A - [A0 A1] - Channel Estimate
  - D - Multiuser Detection Window
  - r - Received bits of K users
  - b - Known Pilot bits at the receiver
  - d - Detected Data bits
  - Data' - Data synchronized with d

Accelerating the blocks in Multistage Detection to meet real-time requirements.

Meeting Real-Time Requirements

Graph shows the data rates achieved by different levels of acceleration for multiuser detection.