UWB based on Pulsed Multiband

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Overview:

- UWB MULTIBAND
- SYSTEM MODEL
- SIMULATION PARAMETERS AND ASSUMPTIONS
- RESULTS
- CONCLUSIONS
- FUTURE WORKS
Ultra Wideband (UWB)

- UWB is a wireless technology for transmitting digital data at very high rates over a wide frequency with very low power.

- UWB is not a new technology.

- February 14, 2002, the FCC defined UWB as any signals that have -10 dB bandwidth at least 500 MHz in unlicensed 3.1 - 10.6 GHz bandwidth frequency and should meet the following spectrum mask.
UWB spectral mask for indoor communications system according to FCC
UWB underlay

Graph source Intel research and development
• Wide bandwidth means high channel capacity, high data rate. Shannon's capacity limit equation:

\[ C = BW \times \log_2(1 + SNR) \]

• Limited power means limited distance (< 10 m)

**UWB is suitable for high data rate communications system in a short range**
UWB Singleband and Multiband

Time Domain

Singleband

Multiband

Frequency Domain

\[ \frac{1}{T_p} \]

\[ \frac{1}{T_s} \]
Why UWB Multiband?

- Adaptive band selection:
  - UWB coexistence with IEEE 802.11a (WLAN) is improved
  - Compliance with worldwide regulation

- Flexible in data rate

**UWB system based on pulsed multiband in a single user link with data rate 100 Mbps.**
SYSTEM MODEL

- UWB system based on pulsed multiband
- IEEE UWB channel model
- Coherent receivers
- Channel estimation
Ease of implementation
• Half-sine with duration 4 ns

• -10 dB bandwidth $\approx 500$ MHz
Data is transmitted sequentially in each band

**Figure 1:** In time domain  
**Figure 2:** In frequency domain

- **Pulse Repetition Frequency (PRF)** = $6 \times 4\text{ns} = 24\text{ns}$
- **Pulse rate** = $6 \times \frac{1}{6 \times 4\text{ns}} = 250\text{Mpps}$
- **Repetition code** 2 pulses/1 bit, **Bit rate** = $125\text{Mbps}$
IEEE UWB Channel Model

- Based on Saleh-Valenzuela where multipath components arrive in clusters
- Taps has log-normal fading and phase is ± 1 (equally probable)
- Log-normal shadowing with $\sigma = 3$ dB and $\mu = 0$ dB, with expected energy is 1.2695 or +1 dB
- Four different channels models:
  - CM1: LOS 0-4 m  CM3: NLOS 4-10 m
  - CM2: NLOS 0-4 m  CM4: NLOS RMS delay spread 25 ns
- Interarrival time for clusters and rays follow exponential distribution
Coherent Receivers

- Coherent receivers need to estimate channel phase, amplitude and delay

- Selective Rake with MRC and pulse matched filter
  - Chip-spaced Rake receiver (pulse or chip rate)
  - Fractional-spaced Rake receiver (Nyquist rate)
Figure 5: System Model
Channel Estimation

- Sliding Window
- Maximum-Likelihood criterion or Least Squares (ML)
- Iterative Channel Estimation
SIMULATION PARAMETERS
AND ASSUMPTIONS

- Uncoded data rate is in order of 100 Mbps
- Channel is constant during transmission of 1 packet
- Number of data bit in 1 packet is 2400 bits
- 6 bands 500 MHz from 3.1 to 6.1 GHz
- Sampling rate in the transmitter is 20 GHz
- Half sine pulse with duration 4 ns and -10 dB bandwidth $\approx$ 500 MHz
- BPSK modulation
- Spread the bits in different bands and transmit it sequentially
- Repetition gain 3 dB or 2 pulses per 1 bit
- Long code system with ML sequence period 255
- Perfect synchronization
- Effect from equipment has been neglected
Comparisons Rake 1 finger between SW, ML and ICE SW channel estimation
Comparisons Rake 2 finger
between SW, ML and ICE SW channel estimation

![Graph showing BER vs. Eb/N0 for different Rake techniques and channel models.]
Result SW channel estimation

\[ \text{BER} \] vs. \( \frac{E_b}{N_0} \) [dB]

- SW CS RAKE−1 CM4
- SW CS RAKE−2 CM4
- SW CS RAKE−3 CM4
- SW CS RAKE−1 CM3
- SW CS RAKE−2 CM3
- SW CS RAKE−3 CM3
- SW CS RAKE−1 CM2
- SW CS RAKE−2 CM2
- SW CS RAKE−3 CM2
- SW CS RAKE−1 CM1
- SW CS RAKE−2 CM1
- SW CS RAKE−3 CM1
- Perfect FS full−RAKE
CONCLUSIONS

- Performances of FS and CS Rake are comparable, therefore CS is preferable due to its lower sampling rate

- For Rake 1 finger, ML and SW show the same performance and ICE only gives a small improvement with the cost longer processing time

- Diversity gain is attainable in CM2, CM3 and CM4

- ML estimation needs to know the maximum excess delay time of the channel to determine the optimum sampling point

- Pulse separation gives improvement in CM3 and CM4 but the bit rate is lower

- System proposal: UWB pulsed multiband using sliding window estimation method with chip spaced Rake 1 for CM1 and 2 fingers for CM2, CM3 and CM4