Proposal for 2.4-GHz PAR
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Key Features

- 32-Mchip/s Transmission Bandwidth
- 16-ary DBOK (Constrained 4x4-ary DBOK)
- MSK Modulation
- Multi-Signal CCA

- \( N_c = 16 \)
- \( \text{Low Acquisition Time} \)
- \( \text{Saturated PA} \)
- \( \text{Spectral Confinement} \)

- \( 12 \text{dB Processing Gain} \)
- \( 10 \text{-Mbps Data Rate} \)
- \( \text{Freq. Channelization} \)

- \( \text{Good PN Codes} \)
- \( \text{Low } E_b/N_0 \)
- \( \text{FEC} \)
- \( \text{Code Channelization} \)

- \( \text{Multipath Resolution} \)
- \( \text{10-Mbps Data Rate} \)
- BSAs Isolation; Coexistence & Interoperability With Legacy 802.11

- \( \text{Inter-Symbol Multipath} \)
- \( \text{Low Preamble Overhead} \)
- \( \text{Freq. Channelization} \)

- \( \text{Changing Codes} \)
- \( \text{Low Slot Time} \)
- \( \text{BSAs Isolation; Coexistence & Interoperability With Legacy 802.11} \)

- \( \text{Inter-Symbol Multipath} \)
- \( \text{Low Acquisition Time} \)
- \( \text{Low Battery Drain} \)

- \( \text{MSK Modulation} \)
- \( \text{Low Slot Time} \)
- \( \text{Power-Efficiency} \)

- \( \text{Low Acquisition Time} \)
- \( \text{Low Preamble Overhead} \)
- \( \text{Low Battery Drain} \)

- \( \text{Robust Links} \)
- \( \text{High Throughput} \)
- \( \text{Low Battery Drain} \)
Robust Links

- Resolving paths gives more independent trials
- D11-97/119 demonstrates for diffuse Rayleigh
- Even better with specular multipath
- Rayleigh Channel Detection Performance:

![Graph showing Rayleigh Channel Detection Performance](image)

- Gaussian- and Noiseless Rayleigh-Channel Results:

![Graph showing Gaussian- and Noiseless Rayleigh-Channel Results](image)
Robust Links

Perspective on “Reduced-Complexity” Implementation

Wider bandwidth gives “multipath diversity” as shown here for simple Gaussian-Channel receivers operating in 50-ns Delay Spread.

- For 16-DBOK @ 32-Mchip/s Using Channel Matched Filter
  - CMG enables operation for >100 ns at cost of ~2K gates
  - FEC adds ~2 dB at cost of ~1K gates
  - Diversity adds ~1 dB at cost of antenna, Div. Switch (&connector)
- No Leverage in Carrying Two Chip Designs (Nearly the Same)
- Great Leverage in PCMCIA Board Design Leaving out Diversity
Robust Links

- Processing gain of 12 dB
- 10-Mbps Operation with
  - Arbitrary Interference 2-dB Below Signal
  - CW Interference Equal to Signal
- D11-97/116 shows PG for CW vs. Gaussian
- 3 dB increase in PG is Factor of two in (free-space) area coverage

High Throughput

10 Mbps

18 Mbps
High Throughput

- 20-µs PHY Preamble
- No PLL Settling Time
- Multiple Correlators for Rx Detection
- Matched-Filter Assist for Adaptation
- Matched Filter for CSMA Detection
- Slot Time = SIFS = 9 µs

Power Efficiency

- Expands data bandwidth to spread bandwidth
- 7.4 dB E_b/N_0 for 10^-6 P_ek
- Approximately 3 dB more efficient than DPSK
- MSK allows operation into power-amp saturation
- PA efficiency greatly improves
- D11-97/118 describes low-cost implementation
Coexistence/Interoperability

- Multi-signal CCA described in D11-97/128
- Matched-filter detection of 11-Mchip/s Barker code
  - Interoperability with Legacy DSSS Possible
- Aliased Detection of Legacy FH in 10-Mbps passband
- Allows 10-Mbps transmissions to defer to legacy systems
  - as non-cooperative measure, where desired
  - cooperative measures (DS & FH) also possible
- CCA operates only for slot time before 10-Mbps transmission
  - no impact on power dissipation

Code Channelization

- Best 8 (of 2048) Code Cosets for Demodulation
  - used in two groups of 4 cosets each
  - 48 cyclic channels (best in multipath)
  - 64K pseudorandom channels (for un-coordinated BSAs)
- Best 8 (of 16K) Codes for Search and Acquisition
- Many Strategies for Code Assignment
- Combined With Frequency Channels for BSA lay-down
  - Rejection of Interference from Closest Neighboring BSAs
Frequency Channelization

- Legacy Channel Center Frequencies
- 32-mchip/s Possibilities
  - two 10-/18-Mbps
  - one 10-/18- plus one 2-Mbps
- Possibilities If 16-mchip/s Included
  - one 10- plus one 2- or 5-Mbps
  - three total 5- and/or 2-Mbps
- May Be Mixed Spatially as Required

Channelization

- Three-Frequency/One-Code Deployment
  - Re-use of frequency channels demands sharing capacity (802.11)
- Two-Frequency/Many-Code Deployment
  - Re-use of frequency channels can be shared or independent
- Isolation for High System Capacity:
  - Three-Frequencies/One-Code vs. Two-Frequencies/Many-Codes
    - Interference Rejection Stronger
    - Leakage Rejection Weaker
    - Interference Rejection Weaker
    - Leakage Rejection Stronger
- Cell-Overlap vs. Spatial-Re-Use
Channelization

- Interference Rejection
  - Interference > Signal on same frequency = CDMA Failure
  - Near-in Frequency Re-Use
- Leakage Rejection
  - Weak signal above threshold
  - Can limit capacity
- Deployment dependent

Channelization

- Interference Range
- Leakage Range
- Reliable BSA Range

- Two-Ray Propagation ($R_4$)
- Free-Space Propagation ($R_2$)

Fade Margin

Range from 10-mW Transmitter (m)

Signal Strength Re: Threshold

0 10 20 30 40 50 60

10 100 1000

Two-Ray Propagation ($R_4$)

Free-Space Propagation ($R_2$)
Channelization

3 vs. 2 Frequency Channels Does Not Ensure Performance

Three-Frequency-Channel Deployment
4 re-use neighbors at 1.66 relative separation
Nearest separation not = zero

Two-Frequency-Channel Deployment
4 re-use neighbors at 1.41 relative separation
Nearest separation = zero

Channelization

3-Frequency/1-Code Deployment
2-Frequency/Many-Code Deployment

Three frequency channels lessens same-frequency-channel interference
(CDMA failure) but does not help same-frequency-channel re-use
Channelization

1 of 3 Frequencies on Same Code  
1 of 2 Frequencies on Different Codes

Throughput per BSA  
using 10-Mbps  
@ .5 Mbps/STA  
Offered Traffic

 Courtesy of Bob O'Hara

This needs refinement, but the effect is real.  
Leakage Assumed 0% for Green and 100% for Red; Interference not Included Here  
Near/Far Interference Examined in Separate Simulation (Mori/Clarion)  
For Next Time: One Simulation to Include Both Near/Far and Leakage Effects