802.11a PHY overview

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What is 802.11?

- Wireless LANs in the 2.4 GHz band
- Produced a standard in 1997
  - Single MAC, three PHYs: FHSS, DSSS, IR
  - Connectionless services
- Today the group works on
  - High speed PHY in the 5 GHz band
  - Higher speed PHY in the 2.4 GHz band
  - Wireless PAN (Personal Area Networks)

Presentation Overview

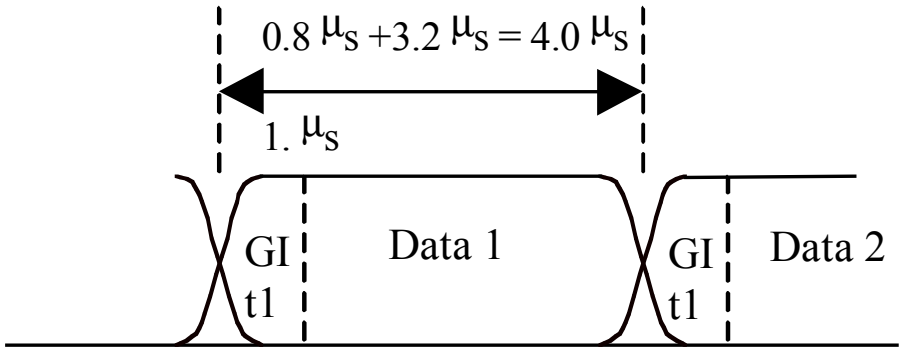
- 802.11a PHY
- Comparison of Single Carrier and Multicarrier modulations performed by 802.11a

Main Parameters

- 20 MHz channel spacing
- Multiple data rates- 6 to 54 Mbit/s
  - optimized for 24 Mbit/s
- OFDM modulation
  - coherent pilot assisted detection
- Frequency accuracy tolerance 250 KHz
  - Tx+Rx overall inaccuracy
  - up to 500 KHz acquisition

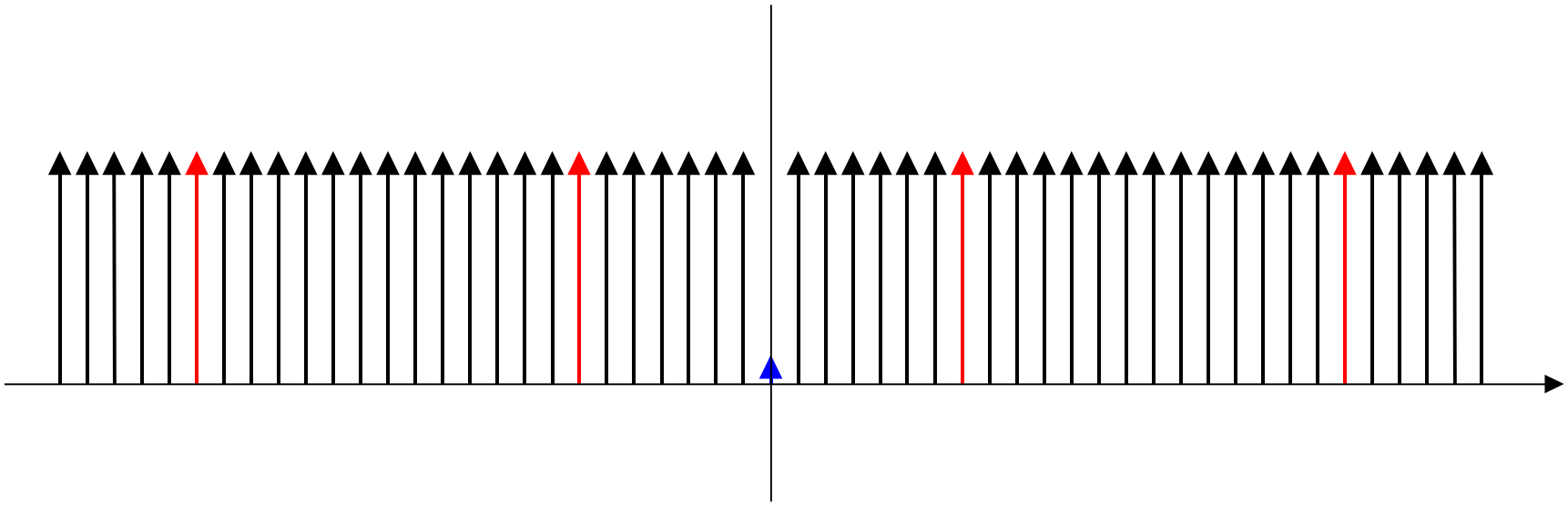
OFDM Frame Structure

- Carrier spacing is 312.5 KHz
- Fourier transform performed over 3.2 microseconds
- 0.8 microsecond Guard Interval for ISI rejection



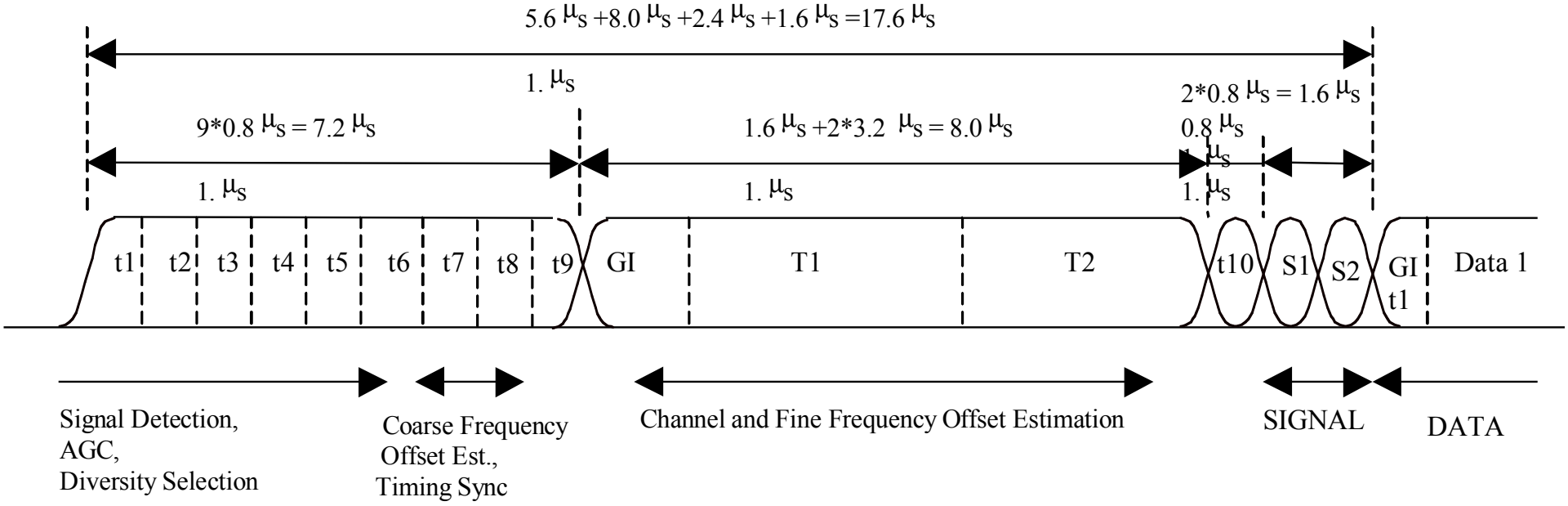
Data and Pilot subcarriers

- 52 non zero subcarriers
  - 48 data subcarriers
  - 4 carrier pilot subcarriers
- Center frequency subcarrier not used



Preamble Structure

- Nine repetitions of short sequence in the beginning
  - Signal Detection, AGC convergence, Diversity resolution, Timing estimation, Coarse frequency estimation
- Two repetitions of long sequence with Guard Interval
  - Fine frequency estimation, Channel Estimation



Supported Rates and Modulations

Constellation	**coding rate**		
	1/2	**2/3**	**3/4**
BPSK	6 Mbit/s		9 Mbit/s
QPSK	12 Mbit/s		18 Mbit/s
16 QAM	24 Mbit/s		36 Mbit/s
64 QAM		48 Mbit/s	54 Mbit/s

- 4 rate signaling bits, 8 combinations utilized
- Additional data rates considered by other projects: 27 Mbit/s (BRAN), 42 Mbit/s (MMAC)

Error Correction Coding

- ECC is a must - some subcarriers may fade
- Bit Interleaved Convolutional Coding used
  - more robust that trellis in Rayleigh fading
- Industry standard K=7, R=1/2 code
  - higher coding rates derived by puncturing
  - tail zero bits added to message (trellis termination)
- Interleaver spans one OFDM symbol
  - latency and complexity considerations

Comparison Criteria

- Sensitivity
- Multipath tolerance
- PA Backoff requirements
- ACI and CCI tolerance
- Phase noise tolerance
- Implementation complexity estimation
- Cell Throughput comparison

Qualitative Results

- OFDM and SC have comparable performance!!
- OFDM eases equalization implementation
  - SC equalizer fast initialization is difficult, especially in long multipath
  - SC makes difficult to combine long equalizers and strong codes
- OFDM showed good phase noise robustness with pilot subcarriers.
- OFDM was just slightly inferior to SC with large constellations in terms of PA backoff

Comparison Table OFDM vs. SC

Proposal and Rate	AWGN Sensitivity @NF=10 dB	CCI immunity [dB]	ACI immunity [dB]	Trms at PER=10%, noise free, 1000b	Phase noise tolerance, [dBc]
OFDM 5 Mb	-89.6 dBm	-3.1dB	23.8dB	> 500 ns	-8.0 dBc
OFDM 10 Mb	-86.3 dBm	-6.6dB	21.3dB	460 ns	-12.5dBc
OFDM 15 Mb	-83.5 dBm	-9.4dB	17.8dB	240 ns	-14.1dBc
OFDM 20 Mb	-81.0 dBm	-12.3 dB	16.5 dB	225 ns	-11 dB
OFDM 30 Mb	-77.2 dBm	-16.5 dB	12.5 dB	150 ns	-12.5 dB
SC 21 Mb	-82.5 dBm	-9 dB	22.5 dB (2 dB OBO)	200 nsec	-10.5 dBc
SC 25 Mb	-80 dBm	-10 dB	20.5 dB (2 dB OBO)	200 nsec	-12 dBc
SC 42 Mb	-75.5 dBm	-16 dB	14 dB (4 dB OBO)	140 nsec	-17.5 dBc
SC 50 Mb	-73 dBm	-17 dB	11.5 dB (4 dB OBO)	140 nsec	-19.5 dBc

Comparison Summary

- OFDM enables very good multipath robustness with smaller complexity.
- OFDM eases incorporation of strong Error Correcting Codes
- The phase noise robustness is comparable to SC.
- The backoff of OFDM is inferior vs QPSK, bur comparable for high order modulation

802.11a PHY for N-WEST

- PHY which will be joint to several worldwide projects in the 5 GHz band (BRAN, MMAC)
  - Wide availability
  - Competitive pricing
- Performance relevant to mm-wave frequencies
  - High spectral efficiency
  - High sensitivity and multipath tolerance
  - Reasonably good PA backoff
  - Good phase noise and frequency offset tolerance