IEEE 802.11 RF Basics

-or-

What I learned on summer vacation

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RF Basics

- Omni-directional
- Need line-of-sight or “transparent” walls
- Power decreases as 1/R^2
- Power x= S/N
- Max. data rate x= log(S/N)
- So 10x power means 3x distance,
- … but NOT 3x data rate

Modulation

- Bit-stream is converted to “symbols”
- Symbol is an integral number of bits
- Symbols → Modulation parameters:
  - Phase
  - Amplitude
  - Frequency
- Data rate x= log(nbr of symbols)

Working in the ISM bands

- Available bands:
  - 902Mhz: 26Mhz band
  - 2.4Ghz: 83Mhz band (802.11)
  - 5.725Ghz: 125Mhz band
- Max 1W power (sometimes less)
- Must “spread the spectrum” to avoid interference.

Spreading the Spectrum

- FCC requirement to avoid interfering
- Helps to reject noise
- Reduces the available bandwidth,
- … but increases the number of users
- Two techniques:
  - Frequency-hopping (FHSS)
  - Direct Sequence (DSSS)

FHSS

- Band is divided into 1Mhz channels
- Channels grouped into hopping sets
- Hopping sets are non-interfering
- Noise rejection is statistical
- … in other words noise manifests as percentage of packets lost.
- 79 channels available in 2.4Ghz

DSSS

- Multiply symbols by *chip* sequence
- 1M/sec symbol rate spreads to 22Mhz
- Receiver correlates with chip sequence
- Three channels available in 2.4Ghz
- Spreads interference over channel
- Better noise rejection than FHSS

IEEE 802.11 PHY Layers

- Transmits at 100mw
- Range of 50m
- Operates in 2.4Ghz band
- Uses either FHSS or DSSS
- Data rates of 1, 2, 5.5 or 11 Mbps
- Three logical channels
  - In FHSS these are hopping sequences
  - In DSSS these are actual bands

FHSS IEEE 802.11

- 78 1Mhz channels; 3 hopping sequences
- Symbol stream is “whitened”
- More adjacent users than DSSS
- 1Mbps:
  - One bit per symbol
  - Differential Binary Phase Shift Keying
- 2Mbps:
  - Two bits per symbol
  - Differential Quadrature Phase Shift Keying
  - Less noise rejection than 1Mbps

DSSS IEEE 802.11

- Most current products use this
- Three 22Mhz channels
- 1, 2, 5.5 or 11 Mbps
- Symbol stream is “whitened”

DSSS IEEE 802.11

- 1 or 2 Mbps:
  - 1 or 2 bits per symbol, respectively
  - Multiply symbols by 11-bit “barker” word
  - Receiver does the same multiplication
  - Processing gain is 10db

DSSS IEEE 802.11b

- 5.5 or 11 Mbps “high data rate”
- Interoperates with 1 or 2 Mbps
- Symbol rate is 1.375Mbps = 11/8
- Chip rate is 11M/sec
- 8 chips per symbol
- Chips are complex numbers

5.5 Mbps operation

- Bits stream grouped into 4-bit symbols
- Two bits of symbol select modulation
- Two bits select 8-chip sequence
- Receiver deduces chip sequence by correlation
- Processing gain < 10db

11 Mbps operation

- Bits stream grouped into 8-bit symbols
- Two bits of symbol select modulation
- Six bits select 8-chip sequence
- Receiver deduces chip sequence by correlation
- Processing gain < 10db

More reading

- IEEE 802.11Handbook (O’Hara and Petrick)
- Mobile Data and Wireless LAN Technologies. (Dayem)
- Spread Spectrum Systems with Commercial Applications (Dixon)

Shameless plug

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