COMP 3049 Intermediate Wireless Technology

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Winter 2004

CWNA Exam Objectives

- Identify some of the different uses for spread spectrum technologies:
  - Wireless LANs
  - Wireless PANs
  - Wireless WANs
- Explain the differences between and apply the different types of spread spectrum technologies
  - FHSS
  - DSSS

CWNA Exam Objectives

- Identify and apply the concepts which make up the functionality of spread spectrum technologies
  - Co-location
  - Channels
  - Dwell time
  - Throughput
  - Hop time

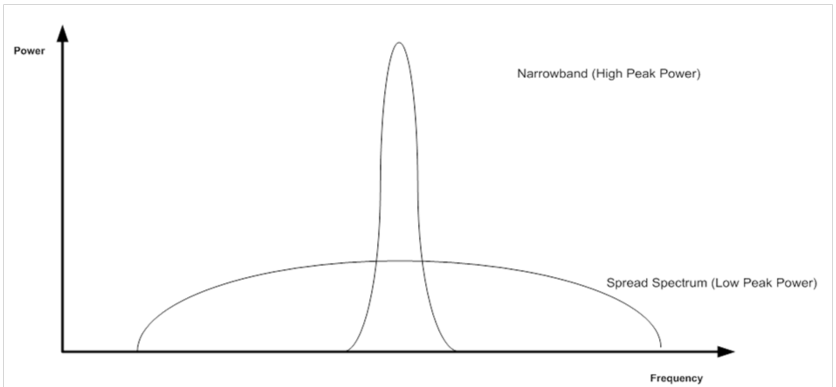
Introducing Spread Spectrum

- A communications technique characterized by wide bandwidth and low peak power
- Uses various modulation techniques
- Many advantages over narrowband
- Signals are “noise-like,” hard to detect and even harder to intercept or demodulate, without the proper equipment

Spread Spectrum vs. Narrowband

- Narrowband uses only enough of the frequency spectrum to carry the data signal
  - Human voice can be transmitted using only 4,000 Hertz of bandwidth
  - Bits can be transmitted using only two frequencies but this would make it far too sensitive to interference and/or detection
  - The regulation authorities have a policy of conserving frequency usage
  - *Spread spectrum uses a much wider band than is required to send the data*

Spread Spectrum vs. Narrowband



Narrowband vs. Spread Spectrum on a frequency domain

Spread Spectrum vs. Narrowband

- More power is required to send a transmission when using a smaller frequency range
- Signals must stand out significantly, above the “noise floor”
- Narrowband may require 10W of power against spread spectrum using only 100mW

Spread Spectrum

- Reduces the probability that the data will be corrupted or jammed
- Narrowband jamming of spread spectrum would only affect a small fraction of the data
- Today’s radios are able to retransmit only the lost data
- Signal must also *use low power* to be considered a spread spectrum transmission technology

Uses of Spread Spectrum

- Since the 1980’s spread spectrum technology has been used in
  - Cordless phones
  - Digital cellular telephony (CDMA)
  - Cellular telephony (PCS)
  - GPS
  - Wireless LANs (802.11)
  - Wireless PANs (Bluetooth)
  - Wireless WANs (802.16)
  - Military communications

Wireless LANs

- 802.11
- 802.11a/b/g
- Mobile users
- Fixed users
- Building-to-building connectivity
- Across-campus connectivity
- All use spread-spectrum

Wireless Personal Area Networks

- Bluetooth and 802.15, HomeRF,
- Regulations are broad, allowing for different types of implementations
- Frequency hopping, compared
  - The transmitting and receiving system “hop” from frequency to frequency within the band
  - Bluetooth hops 1600 times per second
  - HomeRF hops 50 times per second
  - 802.11 WLAN hops 5-10 times per second

Wireless Metropolitan Area Networks

- Mostly point-to-point links creating a city-wide network
- Most use licensed frequencies
- Alternatively can be “mesh” topology using 802.11 technologies
- Use of licensed frequencies avoids worry about interfering networks

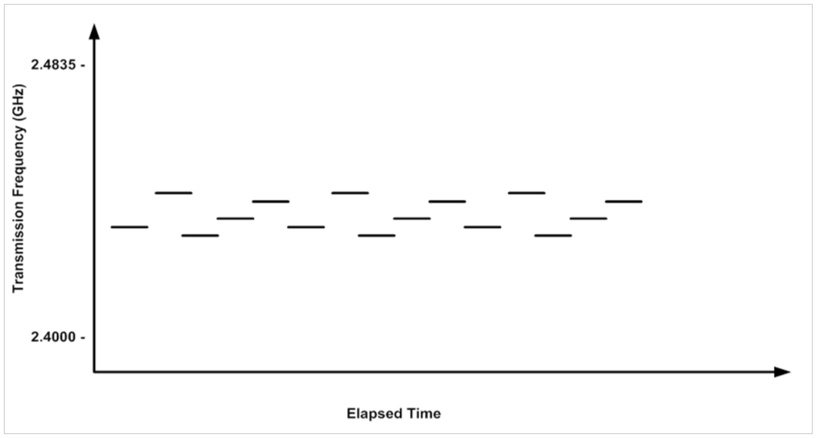
FHSS – Frequency Hopping Spread Spectrum

- Spreads data over a band 83.5 MHz wide
  - per FCC and IEEE 802.11 specs.
- Carrier changes frequency (*hops*) according to a pseudorandom sequence
- A *pseudorandom sequence* is a list of several frequencies to which the carrier will *hop* at specified time intervals before repeating the pattern

FHSS – Frequency Hopping Spread Spectrum

- Carrier remains at a certain frequency for a specified time
  - *Dwell time*
- Then *hops* to another frequency
  - This takes a certain amount of time as well
  - Called *Hop time*
- The receiver radio is synchronized to the transmitting radio’s hop sequence

FHSS – Frequency Hopping Spread Spectrum



Single Frequency Hopping System

FHSS – Frequency Hopping Spread Spectrum

- Effects of narrowband interference
  - FHSS is resistant but not immune
  - In the previous example, interference on 2.451GHz would cause the receiver to lose only the portion of the data sent on this frequency
  - The lost data would be retransmitted
  - Although narrowband interference may occur over several MHz
  - Since the FHSS band is over 83 MHz wide, this would mean little degradation of the signal

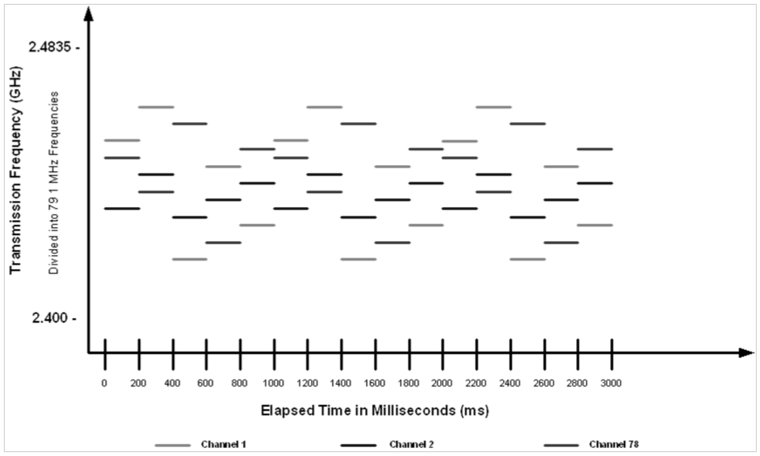
FHSS – Frequency Hopping Spread Spectrum

- IEEE and OpenAir (defunct) standards describe:
  - What frequency bands may be used (ISM)
    - 2.4000 GHz to 2.4835 GHz
  - Hop sequences
  - Dwell times
  - Data rates
- IEEE 802.11
  - 1 Mbps and 2Mbps
- OpenAir
  - 800 kbps and 1 Mbps

FHSS – Frequency Hopping Spread Spectrum

- Channels
  - A hopping pattern is called a channel
  - FCC specifies 26 standard hopping patterns
  - FHSS systems may also use a subset of the above patterns
  - Some systems allow custom hopping patterns
  - Others may even allow synchronization between devices to avoid collisions when devices are co-located

FHSS – Frequency Hopping Spread Spectrum



Co-located frequency hopping systems

FHSS – Frequency Hopping Spread Spectrum

- Although it is possible to have 79 sync'd. co-located access points the cost would be prohibitive
- For synchronized co-located radios, the practical maximum is 12
- A maximum of 26 non-synchronized radios can be co-located when traffic is medium
- In high-traffic networks (e.g.: large file transfers), a maximum of 15 non-synchronized access points can be co-located to prevent excessive collisions

FHSS – Frequency Hopping Spread Spectrum

- Dwell time
  - FHSS systems must transmit on a particular frequency for a specified amount of time
  - The transmitter then switches to another frequency
  - Measured in Milliseconds (ms)
  - In 802.11 FHSS typically 100 to 200 ms

FHSS – Frequency Hopping Spread Spectrum

- Hop time
  - To jump from one frequency to another the transmitter can either:
    - Switch to another circuit tuned to that frequency or
    - Change some element of the circuit to tune to the new frequency
  - The radio cannot transmit when switching frequencies
  - Measured in microseconds (μs)
  - In 802.11 FHSS typically 200 to 300 μs

FHSS – Frequency Hopping Spread Spectrum

- Dwell time limits
  - FCC maximum is 400 ms per carrier frequency in any 30 sec time period
  - Using 100 ms dwell time plus hop time an entire sequence of 75 hops would take slightly over 7.5 seconds
  - Hopping through the sequence four consecutive times would mean *dwelling* on each frequency for 400 ms during a time period of barely over 30 seconds
  - Hop time affects system throughput
    - The more you hop the less data you can send

FHSS – Frequency Hopping Spread Spectrum

- FCC rules affecting FHSS
  - Pre 8/31/200 or Post 8/31/2000
  - Manufacturers cannot use both; they must comply with one or the other
  - Read the details of these rule changes on pages 73 and 74 of the course book
  - IEEE did not make any changes to 802.11 to reflect Post 8/31/2000
  - HomeRF is the only standard that adopted the new rules

DSSS – Direct Sequence Spread Spectrum

- Widely know and most used type due to ease of implementation and high data rates
- A 22 MHz wide set of frequencies allows more information to be transmitted at a higher rate than current FHSS systems
- Combines data signal at the sending station with a higher data rate bit sequence
  - *Chipping code* or *Processing gain*

DSSS – Direct Sequence Spread Spectrum

- High processing gain increases the signal’s resistance to interference
- FCC mandated a minimum processing gain of 10; most systems operated under 20
- On May 16, 2002 the FCC removed all processing gain requirements
- IEEE set their minimum processing gain requirements at 11

DSSS – Direct Sequence Spread Spectrum

- The process begins with a carrier being modulated with a code sequence
- The number of *chips* in the code determines how much spreading occurs
- The number of *chips* per bit and speed of the code (in chips per second) determines the data rate
- Changes in modulation + chipping code allows higher data rates

DSSS – Direct Sequence Spread Spectrum

- In the 2.4 GHz ISM band, IEEE specifies use of DSSS at a data rate of 1 or 2 Mbps under the 802.11 standard
- Under 802.11b or high-rate wireless, data rates of 5.5 and 11 Mbps are also specified
- 802.11b devices are able to communicate with 802.11 devices operating at 1 or 2 Mbps

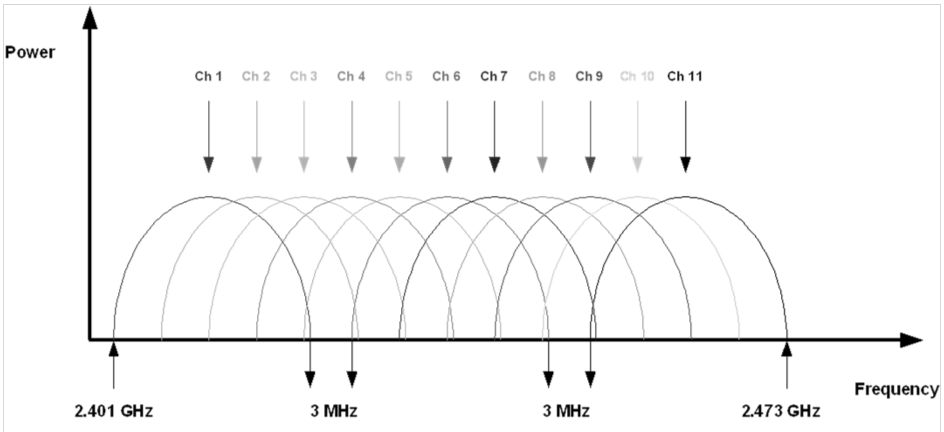
DSSS – Direct Sequence Spread Spectrum

- 802.l1a specifies units that can operate at up to 54 Mbps
- Not compatible with 802.11b since it uses 5 GHz UNII band
- 802.11g makes it possible to mix these devices without upgrading the entire network

DSSS – Direct Sequence Spread Spectrum

- Channels
  - Uses a contiguous band of frequencies to define channels instead of hop sequences (FHSS)
  - Each carrier frequency is 1 MHz wide
  - Channel 1 operates from 2.401 GHz to 2.423 GHz (2.412 GHz ± 11 MHz)
  - Channel 2 operates from 2.406 GHz to 2.429 GHz

DSSS – Direct Sequence Spread Spectrum



DSSS Channel Allocation and Spectral Relationship

DSSS – Direct Sequence Spread Spectrum

- IEEE 802.11b specifies 11 channels for use in North America
- Each adjacent channel overlaps the next by a significant amount
- Channel frequencies in the following slide specify centre frequencies
  - Add and subtract 11 MHz to get the usable 22 MHz channel

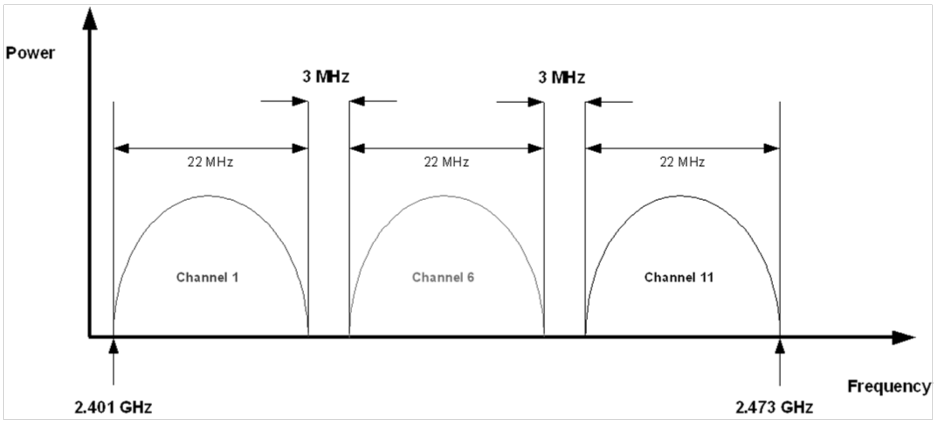
DSSS – Direct Sequence Spread Spectrum

Channel ID	FCC Channel Freq. (GHz)	ETSI Channel Freq. (GHz)
1	2.412	N/A
2	2.417	N/A
3	2.422	2.422
4	2.427	2.427
5	2.432	2.432
6	2.437	2.437
7	2.442	2.442
8	2.427	2.427
9	2.452	2.452
10	2.457	2.457
11	2.462	2.462

DSSS – Direct Sequence Spread Spectrum

- DSSS systems using adjacent channels should not be co-located to prevent interference
  - Centre frequencies are 5 MHz apart and channels are 22 MHz wide
- Co-located systems must be 5 channels apart
  - 1 and 6, 2 and 7 do not overlap
- A maximum of 3 co-located DSSS systems is possible because 1, 6 and 11 are the only *theoretically** non-overlapping channels
  - * Note: see Troubleshooting in Chapter 9

DSSS – Direct Sequence Spread Spectrum



DSSS – Direct Sequence Spread Spectrum

- Effects of Narrowband Interference
  - Like FHSS, DSSS is also resistant
  - More susceptible because the band (each channel) is much smaller
    - 22 MHz vs. 79 MHz
    - Data sent across entire band instead of one freq. at a time
    - Frequency agility of FHSS ensures interference influences the transmission for a small amount of time

DSSS – Direct Sequence Spread Spectrum

- FCC Regulations
  - Max. 1 W of power in point-to-multipoint configurations
  - Power maximum is independent of channel selection
  - Regulation applies to ISM and parts of UNII bands

DSSS vs. FHSS

- Both have their advantages and disadvantages
- Wireless LAN administrator must decide which to implement, considering:
  - Narrowband interference
  - Co-location requirements
  - Cost
  - Equipment compatibility and availability
  - Data rate and throughput
  - Security
  - Standards support

DSSS vs. FHSS

- Narrowband interference
  - FHSS is more resistant
- Cost
  - DSSS cost is lower due to its popularity
- Co-location
  - FHSS supports more co-located equipment

DSSS vs. FHSS

- Cost
  - Both FHSS and DSSS operate at 50% of the rated bandwidth
  - DSSS 3 access points x 11 Mbps = 33 Mbps
  - 33 Mbps/2 = 16.5 Mbps throughput
  - FHSS 16 access points x 2 Mbps = 32 Mbps
  - 32 Mbps/2 = 16 Mbps
  - Decision must be based on whether there is a need to segment network by using more access points

DSSS vs. FHSS

- Throughput and Data Rate
  - FHSS devices that operate at 3 Mbps or more are available but are not 802.11 compliant
  - HomeRF uses FHSS, gets 5 Mbps but operates at a max. power of 125mW, limiting distance
  - Interframe spacing is also longer with FHSS
  - Some wireless LAN systems use proprietary physical layer protocols to achieve higher throughput
    - Up to 108 Mbps in 802.11g and 802.11a
    - Not part of the standard so equipment from different manufacturers will not interoperate at the higher speeds

DSSS vs. FHSS

- Equipment Compatibility and Availability
  - The Wi-Fi Alliance provides testing to make sure 802.11b equipment will interoperate
  - Wi-Fi™ = Wireless Fidelity
  - Devices that pass the tests can use the Wi-Fi™ logo

DSSS vs. FHSS

- Security
  - It’s a myth that FHSS is more secure
  - FHSS radios are only produced by a handful of manufacturers
  - All adhere to standards such as 802.11 or OpenAir
  - Each uses a standard set of hop sequences which generally complies with a published, pre-determined list
  - Channel no. and MAC address is broadcast in the clear with each beacon
  - Spectrum analyzers or laptop can be used to track the hopping patterns in a matter of seconds

DSSS vs. FHSS

- Standards Support
  - DSSS has gained wide acceptance due to low cost, high speed, Wi-Fi Alliance interoperability, etc.
  - Wi-Fi will soon cover 802.11a and g
  - New standards such as HomeRF 2.0 and 802.15 (WPANs and Bluetooth) exist but are not advancing FHSS for enterprise systems