# Lecture 23 Overview

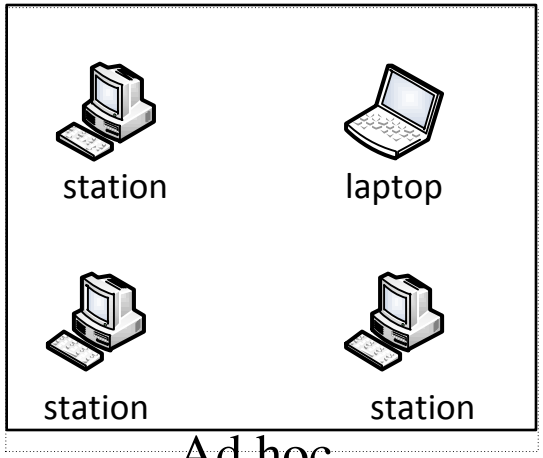
- Last Lecture
  - ADSL, ATM
- This Lecture
  - Wireless Technologies (1)
    - Wireless LAN, CSMA/CA, Bluetooth
    - Source: chapters 6.2, 15
- Next Lecture
  - Wireless Technologies (2)
  - Source: chapter 16, 19.3

# Wireless LAN (Wi-Fi)

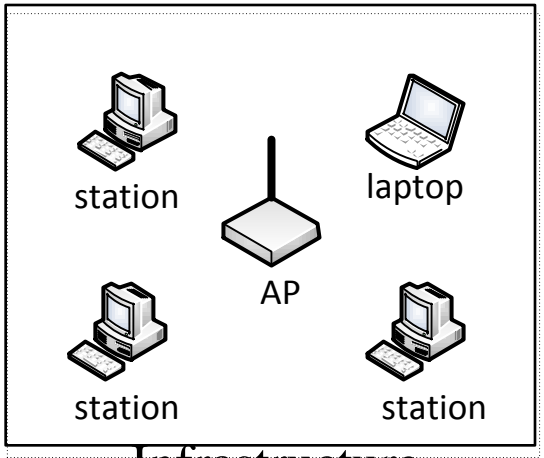
- Covered by IEEE 802.11
- 802.11 variations
  - Original 802.11 (1997)
    - 1-2Mbps  900 MHz  or 2.4 GHz
  - 802.11a (1999)
    - 54Mbps in 5GHz range
  - 802.11b (Wi-Fi) (1999)
    - 11Mbps in 2.4GHz range
  - 802.11g (2003)
    - 54Mbps in 2.4GHz range
  - 802.11n (2009)
    - multiple-input multiple-output antennas (MIMO), 54Mbit/s to 600Mbit/s.

# IEEE 802.11 Architectures

- Basic Service Set (BSS)
  - Stationary or mobile wireless stations
  - An optional access point (AP)
- Configurations
  - ad-hoc architecture: without an AP, can not send data to other BBSs (WiFi-Direct)
  - Infrastructure: with an AP (most commonly used)



Ad hoc



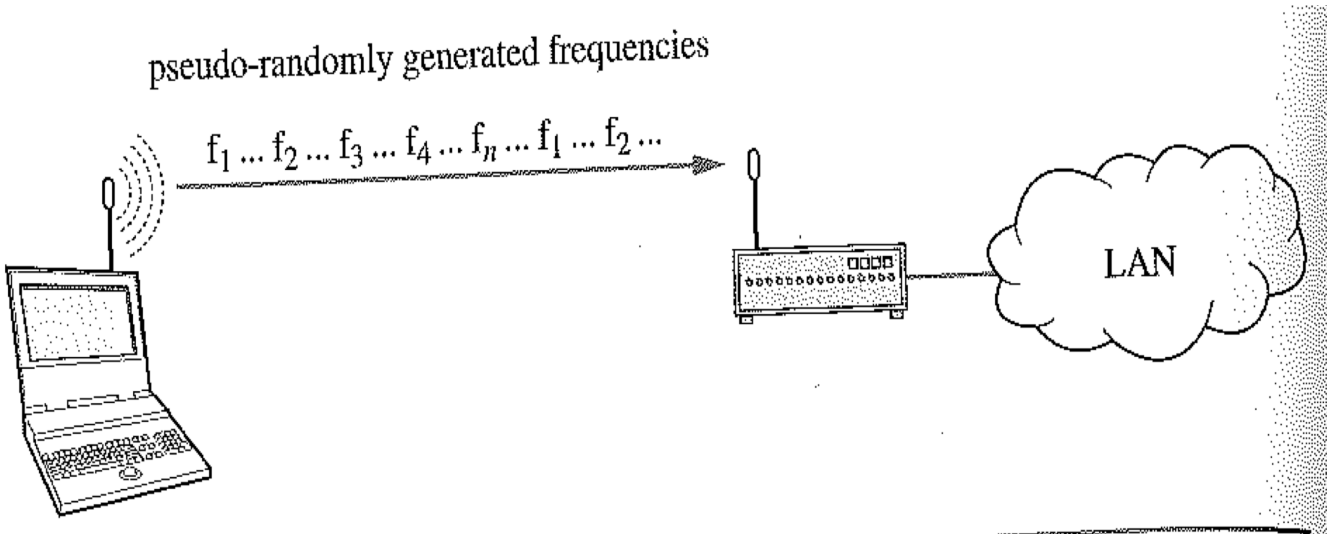
Infrastructure

# IEEE 802.11 Physical Layer

- Spread spectrum: spreads the signal's spectral energy over a wide range of frequencies (i.e., larger bandwidth)
  - Less prone to interference
  - More secure as a intruder trying to listen at a particular frequency gets only a small part of the signal.
- Two spread spectrum technologies
  - Frequency-hopping spread spectrum (FHSS)
  - Direct-sequence spread spectrum (DSSS)

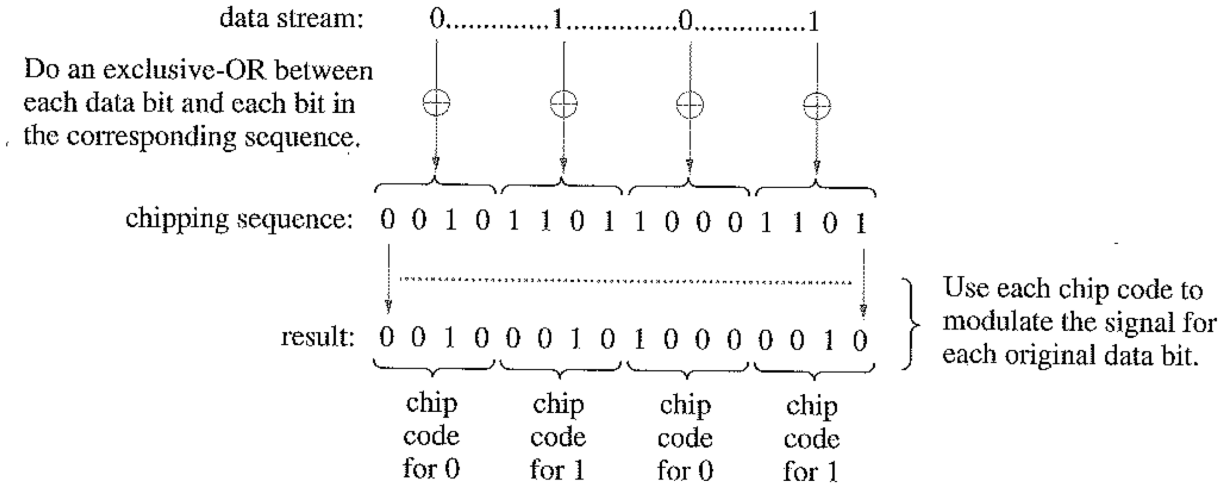
# FHSS

- Developed in the early 1940s
  - Operate on a set of frequencies that all lie in the broadcast range
  - Transmit using one frequency for a fixed period of time and then switches to the next frequency
  - Using a pseudo-random number generator to generate the frequency sequence so that both the transmitter and the receiver have the same sequence



# DSSS

- DSSS expands a single data bit into *n* bits
  - The transmitter starts with a string of data bits
  - For each bit, generate a pseudorandom bit string, called a **chipping sequence**, containing *n* bits.
  - Combine each data bit and the chipping sequence to create a **chip code** and transmit the chip code.

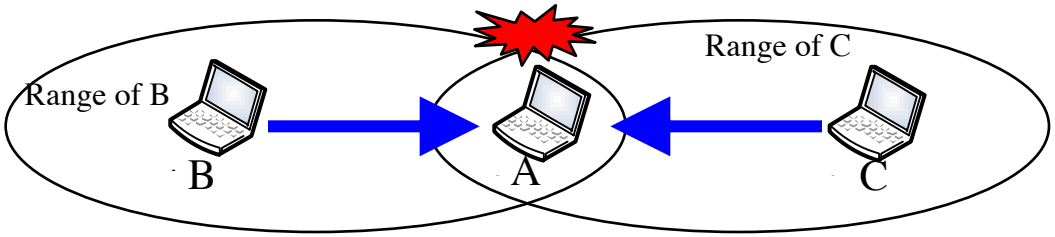



1Mbps data rate

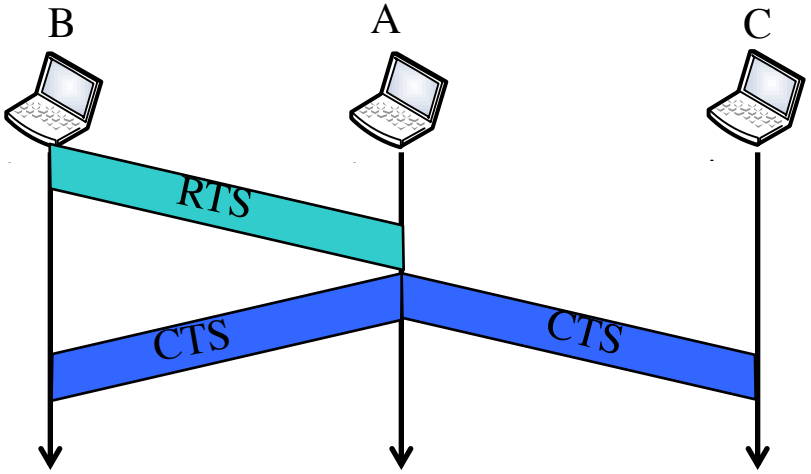
4Mbps transmission rate

# Hidden Station Problem

- Different stations may have different transmission range.

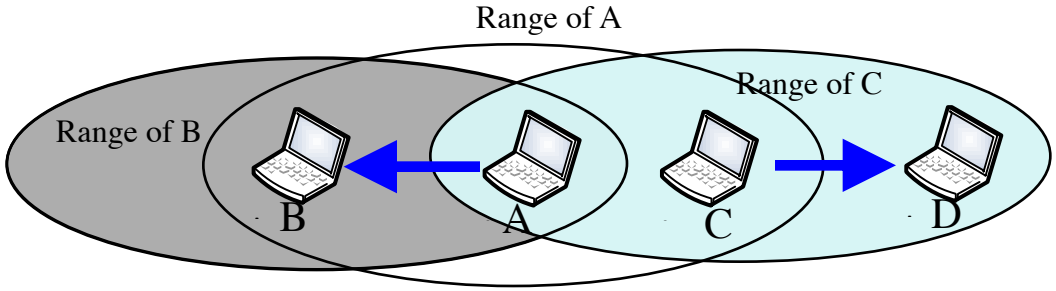



- Solution: handshaking
  - RTS/CTS
    - Request To Send (RTS)/Clear To Send (CTS)

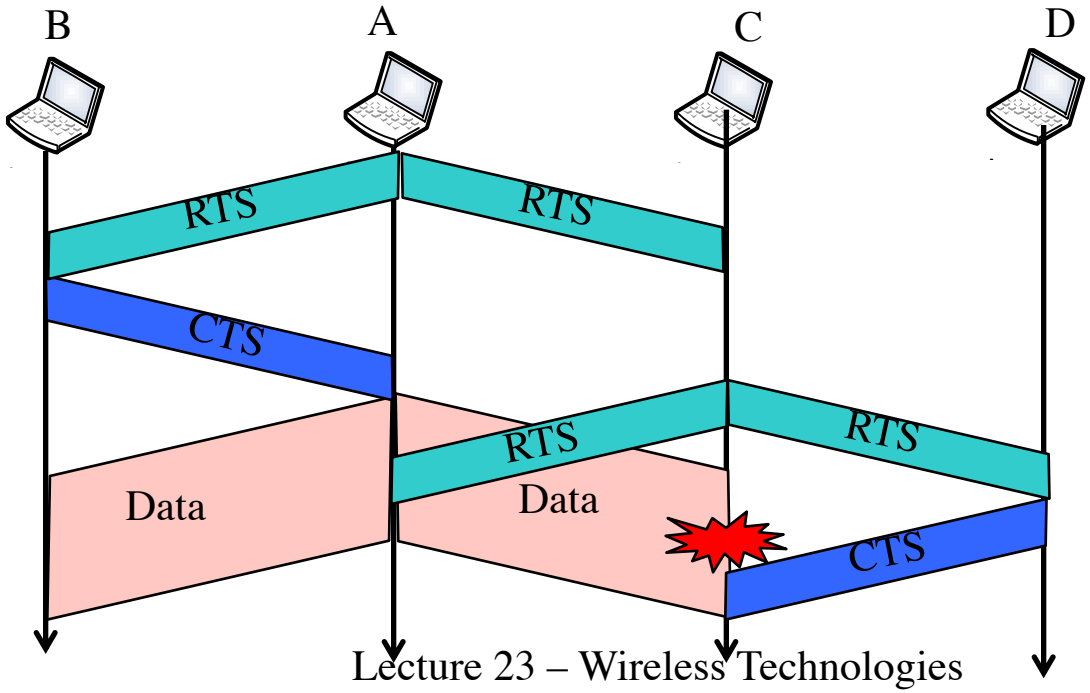


# Exposed Station Problem

- The reverse of the hidden station problem




- Handshaking can not help



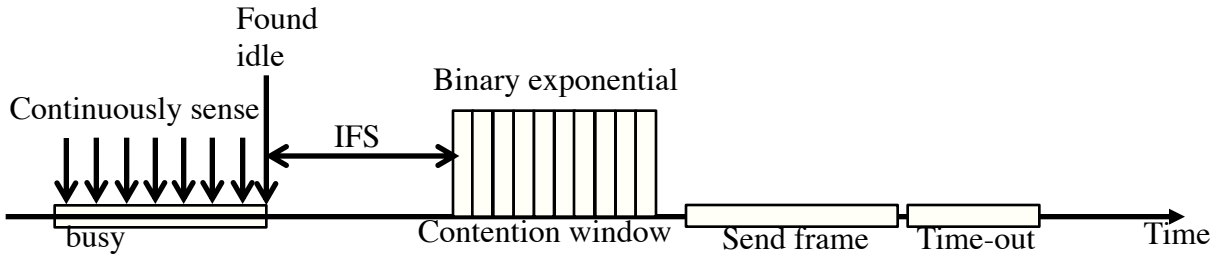
# IEEE 802.11 MAC Sublayer

- Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)
- Why cannot Wireless LANs use CSMA/CD?
  - To detect collision, a station must be able to transmit and listen at the same time.
  - Collision may not be detected because of the hidden station problem
  - The distance between stations can be large. Signal fading could prevent a station at one end from detecting a collision at the other end.

# CSMA/CA

- Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)
  - Try to avoid collisions instead of detecting collisions.
  - Collisions can still occur. Use the binary exponential backoff algorithm.
- Three strategies to reduce collisions
  - Interframe space
  - Contention window
  - Acknowledgment

# CSMA/CA (cont.)

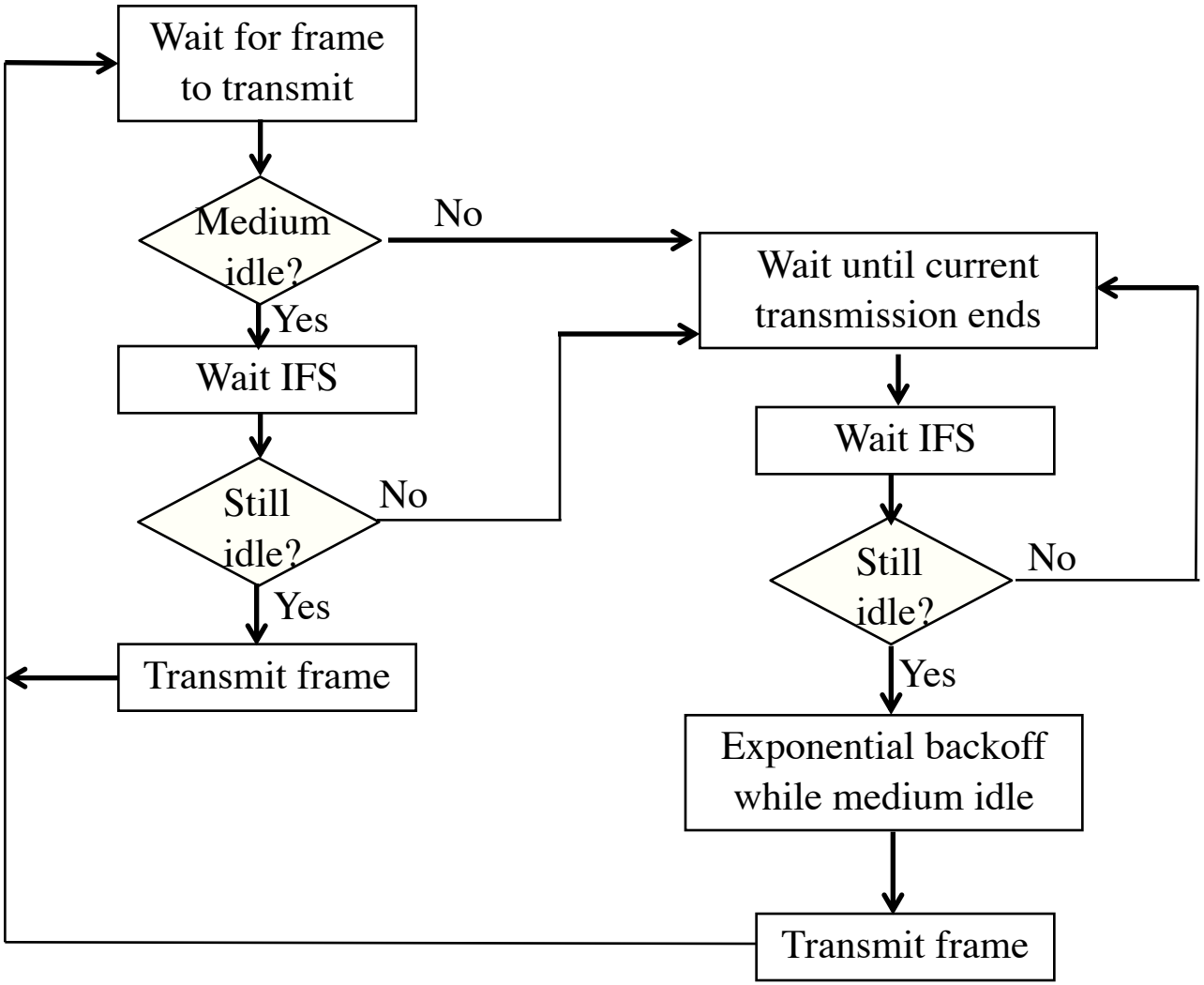



- Interframe Space (IFS)
  - A period of time waited after an idle channel is found
    - Another station may have already started transmitting, but the signal has not reach this destination.
    - Prioritize stations or frame types, e.g., a station that is assigned a shorter IFS has a higher priority.

# CSMA/CA (cont.)

- Contention window
  - An amount of time divided into slots
    - A station that is ready to send choose a random number of slots as its wait time.
    - Binary exponential back-off: double the window size each time the station cannot detect an idle channel after the IFS time.
- Acknowledgement
  - Frame may still get collided.
  - Guarantee the receiver has received the frame

# CSMA/CA (cont.)

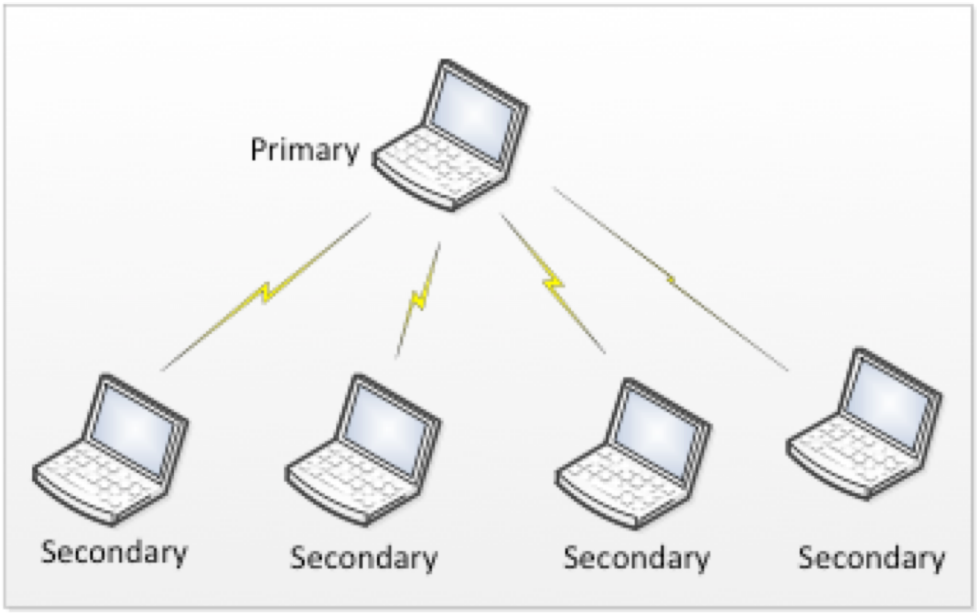

Wait for frame to transmit
Medium idle?
No
Yes
Wait IFS
Still idle?
No
Yes
Transmit frame
Wait until current transmission ends
Wait IFS
Still idle?
No
Yes
Exponential backoff while medium idle
Transmit frame

# Bluetooth

- A technology in which a microchip containing a radio transceiver is embedded in electronic devices and allows the devices to communicate without wires or cables
  - Communication between wireless mouse or keyboard with the computer
  - Share information between different mobile phones
- Bluetooth LAN
  - An ad hoc network that formed spontaneously by Bluetooth devices
- Wireless Personal-area Network (PAN)
  - IEEE 802.15

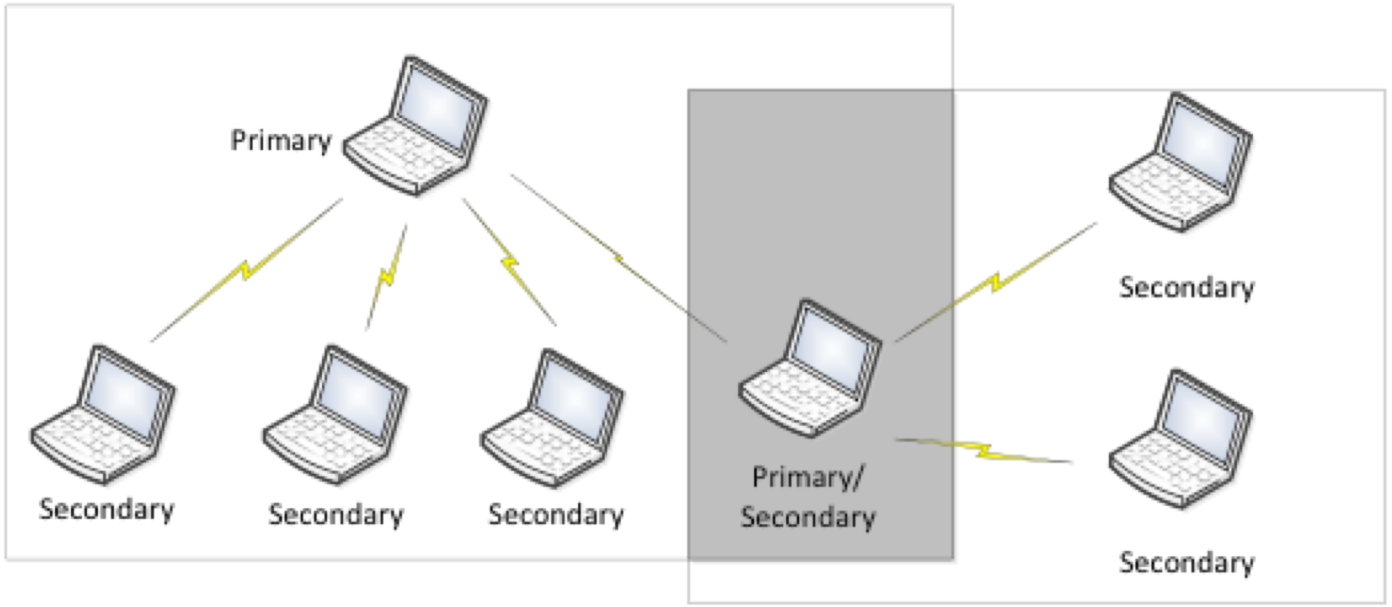
# Bluetooth Architecture

- Piconets (small net)
  - Up to eight stations
  - One called **primary**, the rest called **secondaries**



# Bluetooth Architecture (cont.)

- Scatternet
  - Consist of two or more piconets.
  - A secondary station in one piconet can be the primary in another piconet

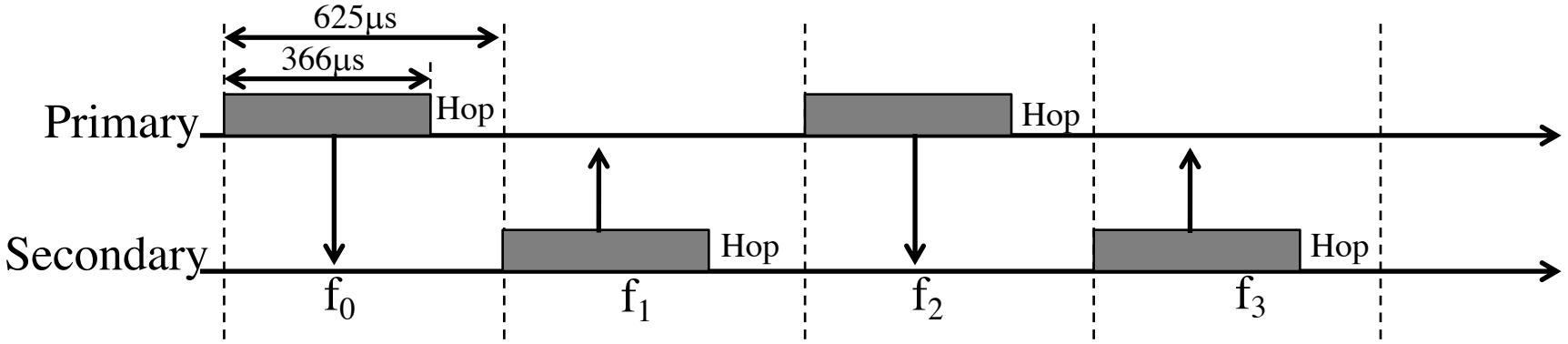


# Bluetooth Radio Layer

- Roughly equivalent to the physical layer in the Internet model
- Low power short-range transmission
- FHSS
  - Hops 1600 times per second,
  - Uses each frequency for only 625 μs (1/1600 s)

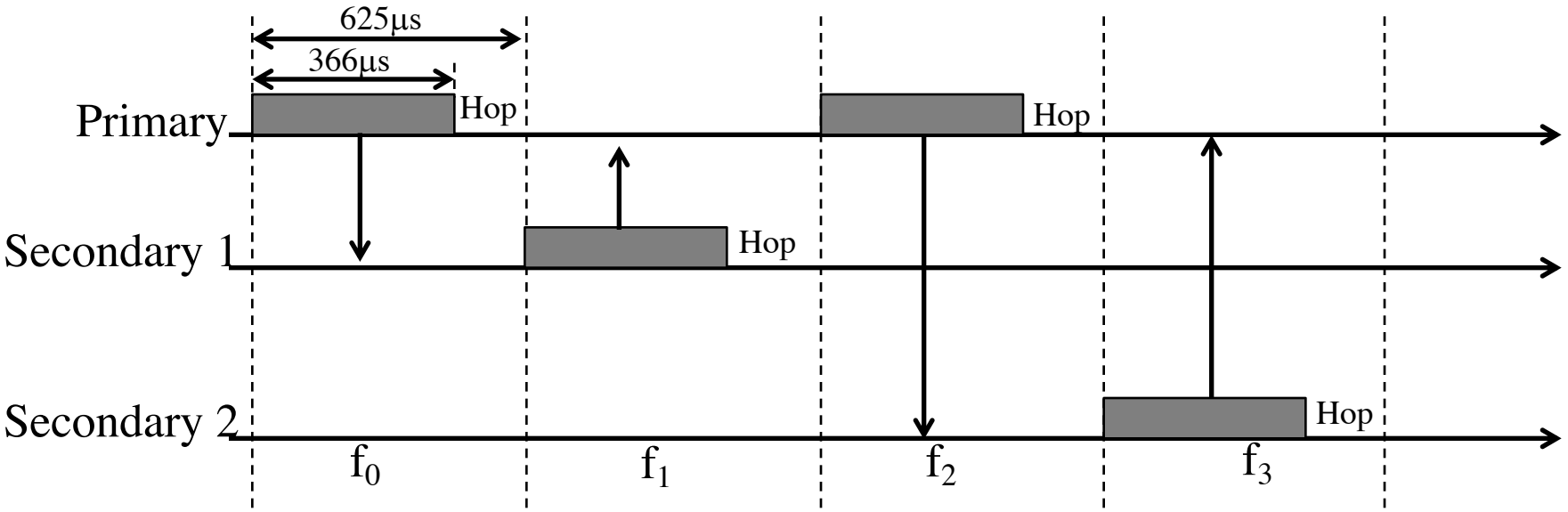
# Bluetooth Baseband Layer

- Roughly equivalent to the MAC layer in LANs
- TDD-TDMA (time-division duplex TDMA)
  - Half-duplex communication
  - Time slot is 625 μs
  - Single-secondary communication
  - Primary uses even-numbered slots (0, 2, 4, …)
  - Secondary uses odd-numbered slots (1, 3, 5, …)



# Bluetooth Baseband Layer (cont.)

- Multiple-secondary communication
  - Primary uses even-numbered slots (0, 2, 4, …)
  - A secondary sends in the next odd-numbered slot if the packet in the previous slot was addressed to it.



# Summary

- IEEE 802.11
  - FHSS
  - DSSS
  - Hidden/Exposed Station Problem
  - CSMA/CA
- Bluetooth