Chapter 7: Wireless Networks

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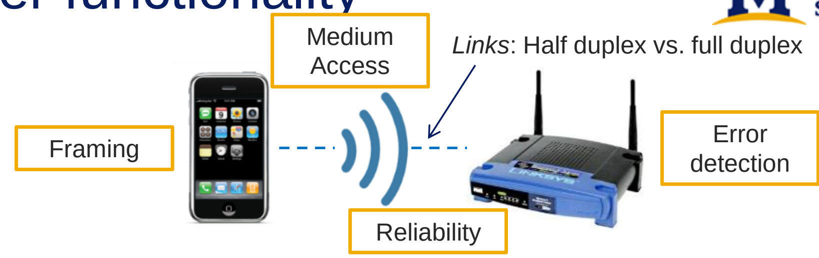
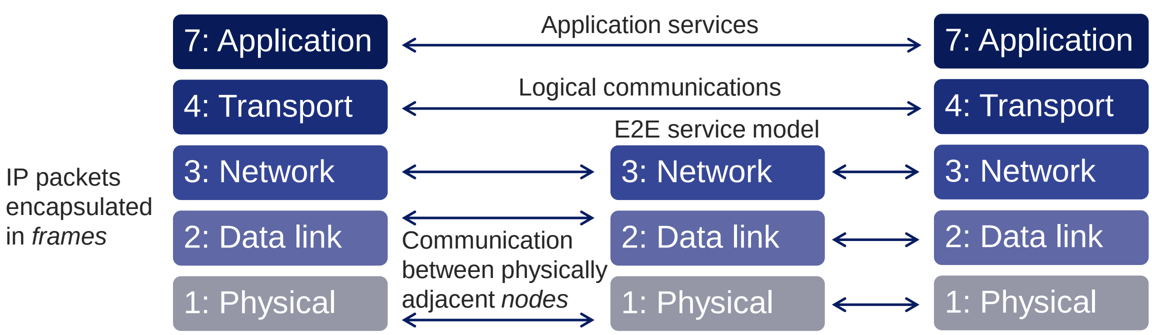
Link layer functionality





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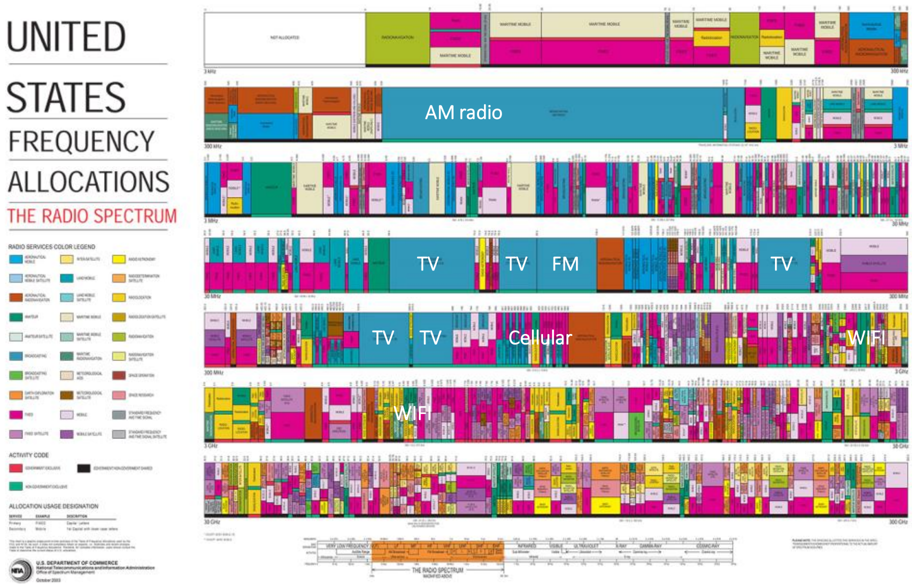
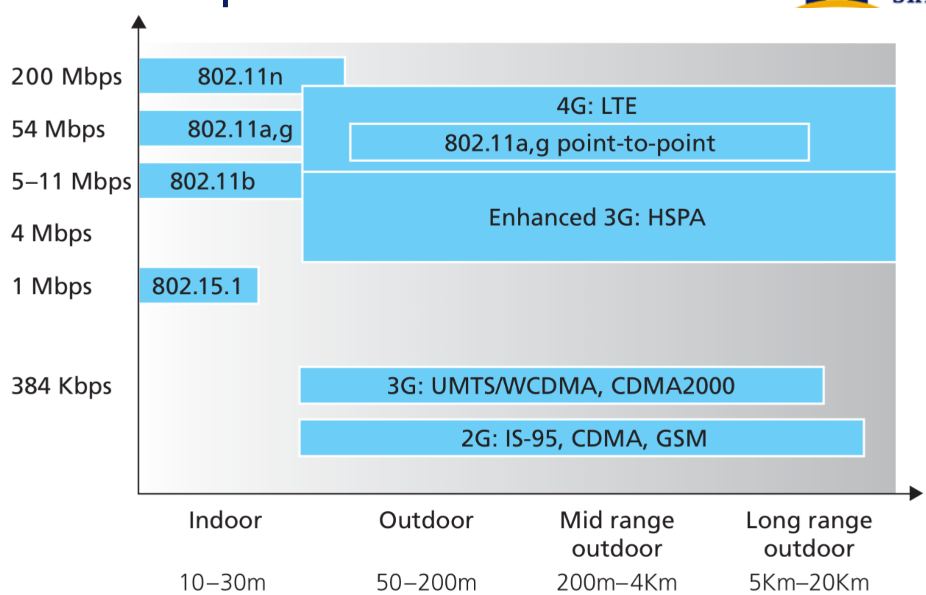
Radio spectrum



Operational spaces



WiFi Networks

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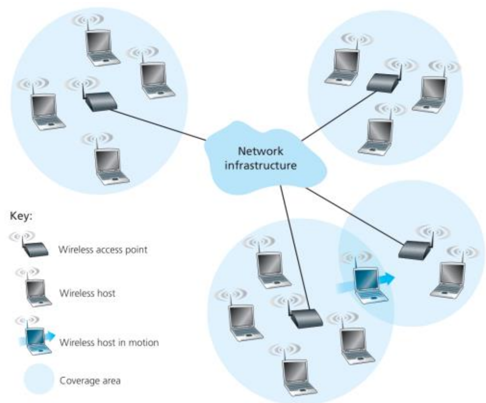
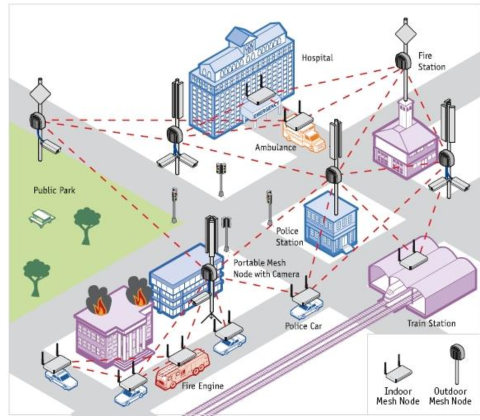
Infrastructure Mode



Much like a traditional Ethernet network (but with mobile nodes)

Mesh (Ad Hoc) Mode



Nodes themselves must provide services such as DNS and DHCP

Mobile Networks (not cellular)

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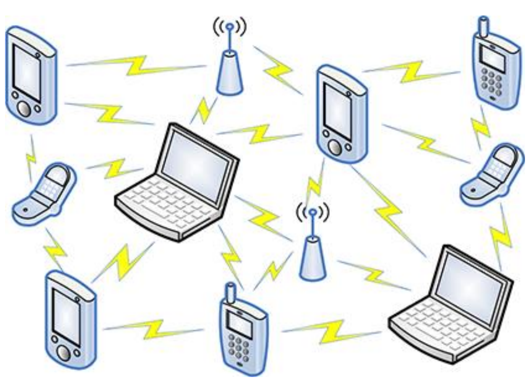
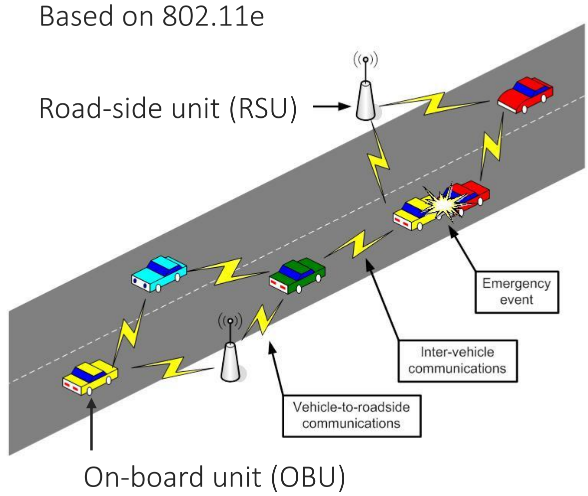
Mobile Ad Hoc Nets (MANETs)



No central administration

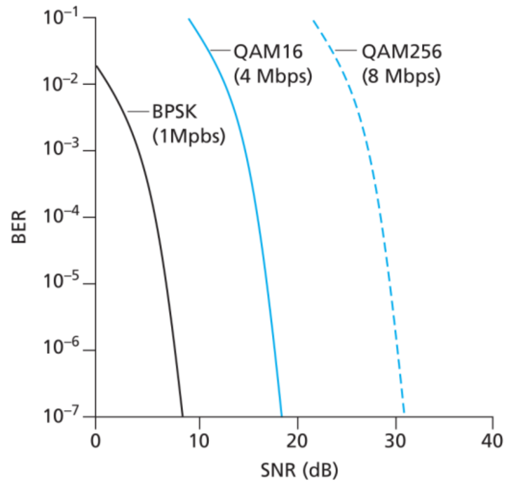
Vehicular Ad Hoc Nets (VANET)

Based on 802.11e



Properties of wireless networks

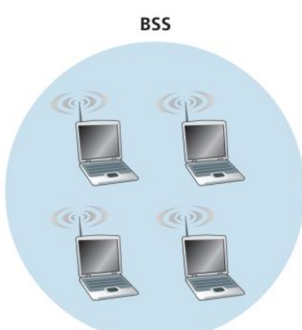
- Path loss
  - Signal disperses with distance
  - Signal absorbed (60GHz absorbed by moisture)
  - Lower signal strength
- Interference
  - Other sources of radiation
  - Other transmissions, microwaves in 2.4GHz
  - Received signal strength and interference (RSSI)
- Multipath propagation
  - Reflected signals obscure direct transmission at receiver
- Lower signal to noise ratio (SNR) leads to higher bit error rate (BER)

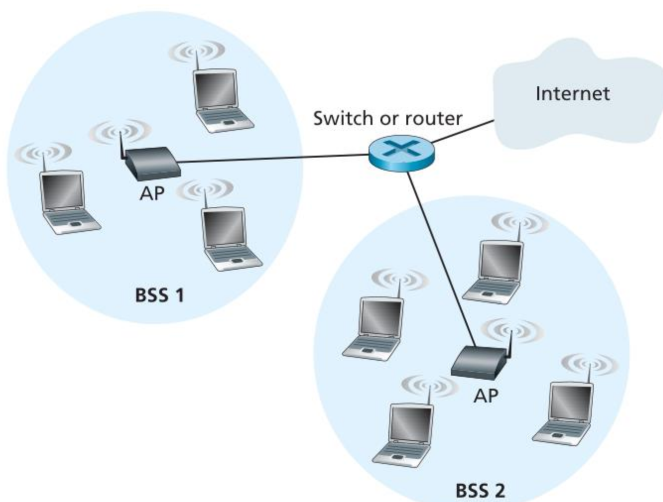


Why not just increase transmission signal strength?

IEEE 802.11 – WiFi

- Basic service set (BSS)
  - Access point (AP)
  - Authenticated clients
  - Or clients in ad-hoc mode
  - Identified by Service Set Identifier (SSID)





Establishing connectivity

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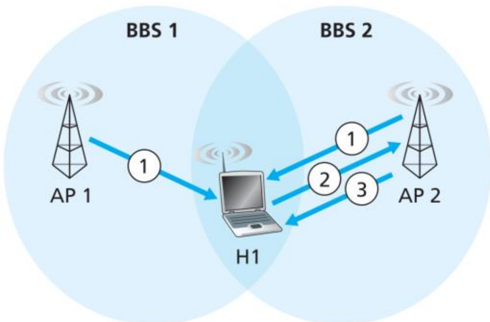
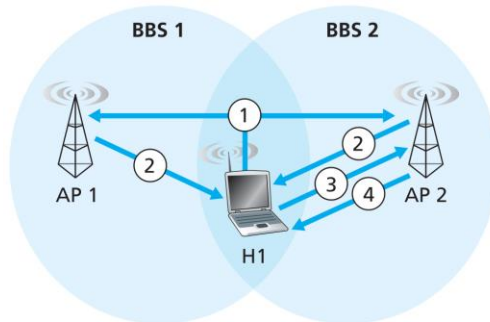
Passive Scanning



1. Beacon frames sent from APs
2. Association Request frame sent: H1 to selected AP 2
3. Association Response frame sent: Selected AP 2 to H1

Active Scanning



1. Probe Request frame broadcast from H1
2. Probes Response frame sent from APs
3. Association Request frame sent: H1 to selected AP 2
4. Association Response frame sent: Selected AP 2 to H1

Useful for hiding APs – need to know SSID to beacon

WiFi channels

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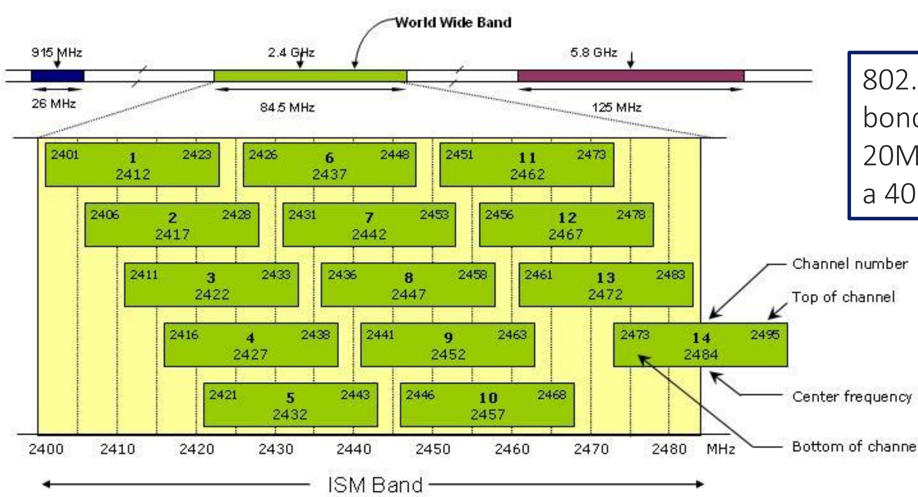

802.11n allows channel bonding, where adjacent 20Mhz channels can form a 40 Mhz channel

WiFi MAC – CSMA/CA

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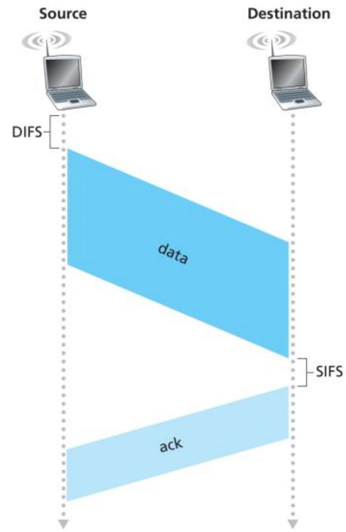
- Carrier sensing multiple access with collision avoidance
  - Based on Ethernet
  - In turn based on Aloha
- Properties
  - Random access
  - Plus: link layer ACKs, because high wireless BER



Distributed Inter Frame Spacing (DIFS) is longer then Short Inter Frame Spacing (SIFS). Why?

WiFi MAC – CSMA/CA

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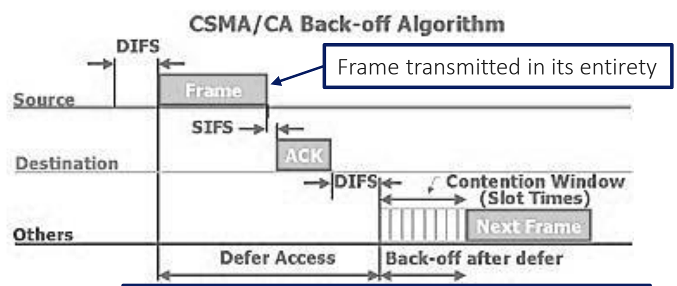

Others wait until:
1. Channel free
2. DIFS elapses
3. Randomly chosen exponential backoff elapses

Should the access point also have to contend for transmission opportunity?

- Point coordination function (PCF)
  - PIFS (PCF inter frame spacing) < DIFS
  - Allows the AP to take over the channel for contention free traffic

CSMA/CA and hidden terminals

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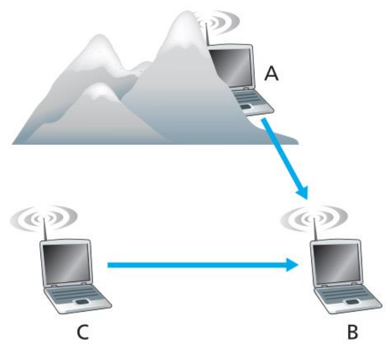

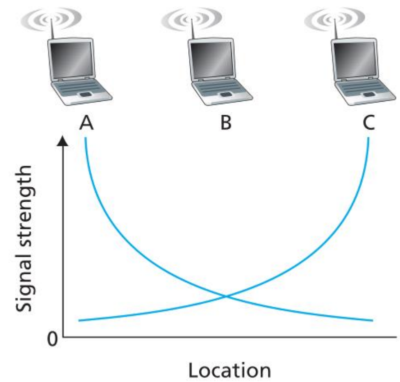

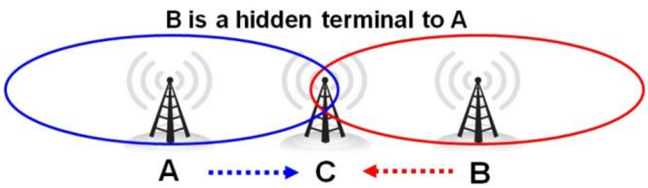

Nodes A and C cannot detect each others' transmission. They both transmit and collide at B.

CSMA/CA and exposed terminals

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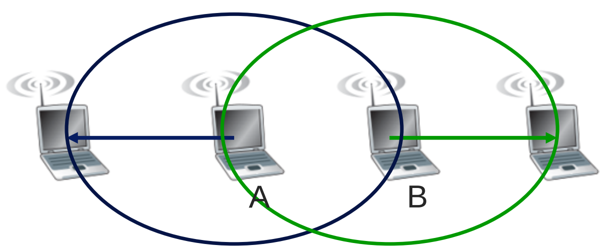
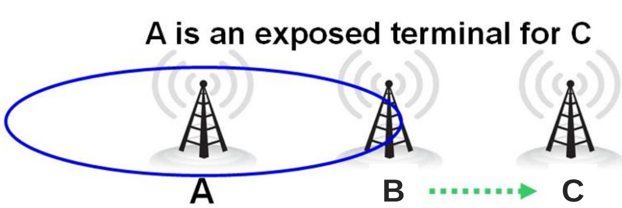
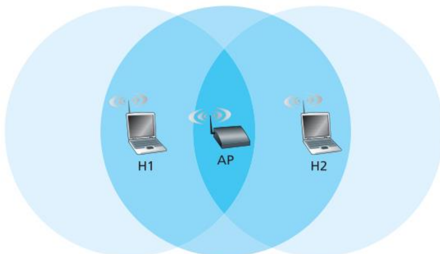




Nodes A and B could transmit simultaneously, but B detects A's transmission and defers.

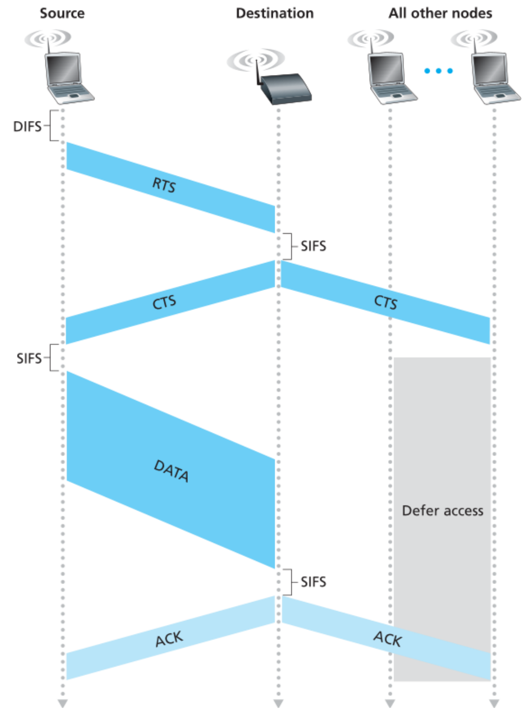
Dealing with hidden terminals



- Idea: allow sender to “reserve” channel rather than random access of data frames
- Sender first transmits small request-to-send (RTS) packets to AP using CSMA

RTSs may still collide with each other. Why no big deal?

- AP broadcasts clear-to-send CTS in response to RTS
- CTS heard by all nodes
  - sender transmits data frame
  - other stations defer transmissions



What happens when MAC gets it wrong?

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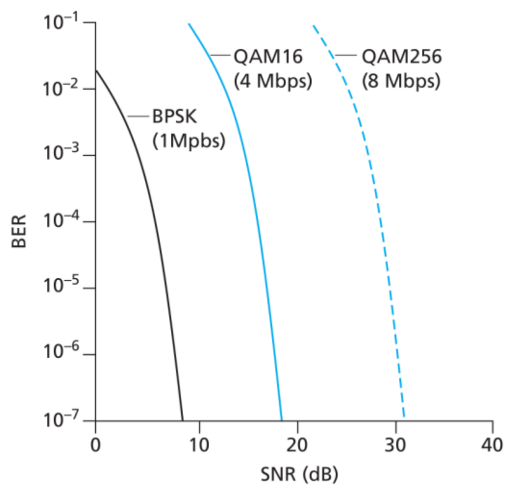
- Excessive fading
- Interference
- Collisions

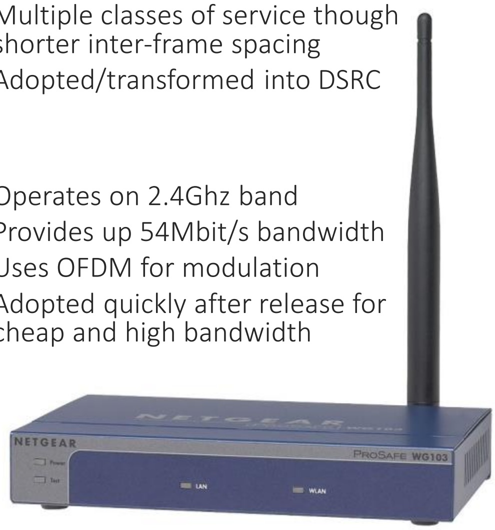
BER too high in all cases!

- Solutions
  - More control overhead to coordinate transmissions
  - More error correction, i.e. larger symbols
  - Rate adaptation



802.11 family

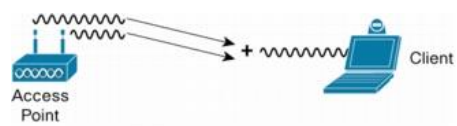
- .11a and .11b introduced at the same time
- Both use CSMA/CA
- 802.11a
  - Faster
  - More expensive to manufacture
  - Operated in 5Ghz band
  - Mainly used in industrial settings
- 802.11b
  - Slower
  - Cheaper to manufacture
  - Operated in 2.4Ghz band
  - Mainly used in residential settings
- .11e
  - Multiple classes of service though shorter inter-frame spacing
  - Adopted/transformed into DSRC
- .11g
  - Operates on 2.4Ghz band
  - Provides up 54Mbit/s bandwidth
  - Uses OFDM for modulation
  - Adopted quickly after release for cheap and high bandwidth



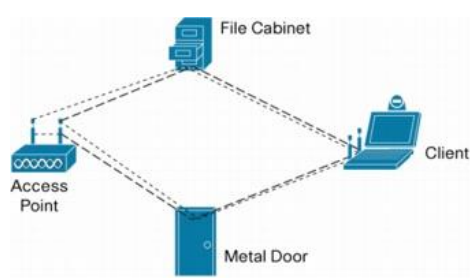
Newer standards

- 802.11n - 600Mbit/s
  - Introduces MIMO
    - Multiple-Input Multiple-Output
    - Needs spatial diversity
  - Frame aggregation
    - Aggregate multiple frames destined for a specific AP and send them together to reduce overhead
- 802.11ac – up to 1300 Mbit/s
  - Channel bonding - 80 or 160 MHz versus 40 MHz
  - Higher-order modulation - up to 256-QAM
- 802.11ad
  - 60 GHz spectrum
- 802.11ag
  - White spectrum (TV)
- 802.11ax - planned 4x throughput of .11ac
  - 1 and 6 GHz when available for 802.11 use
  - Higher throughput, but much lower latency

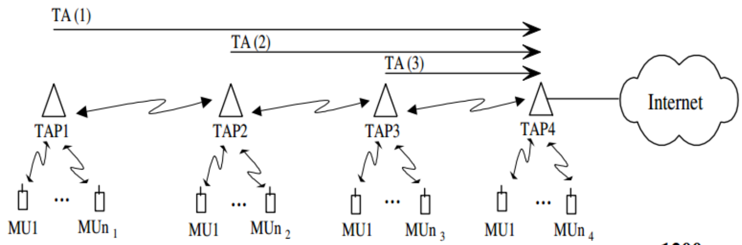
Constructive interference improves signal strength at the receiver



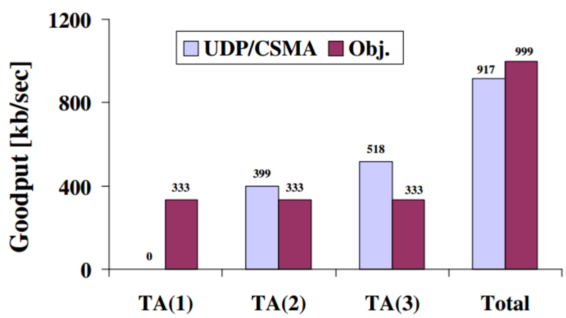
MIMO allows for simultaneous transmission of multiple signals

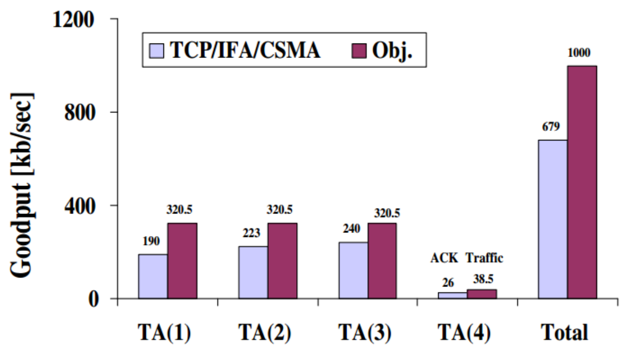


Problems with multi-hop networks



Need fairness mechanisms that allows relayed traffic to compete





"End-to-End Performance and Fairness in Multihop Wireless Backhaul Networks" by Gambiroza et al.

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