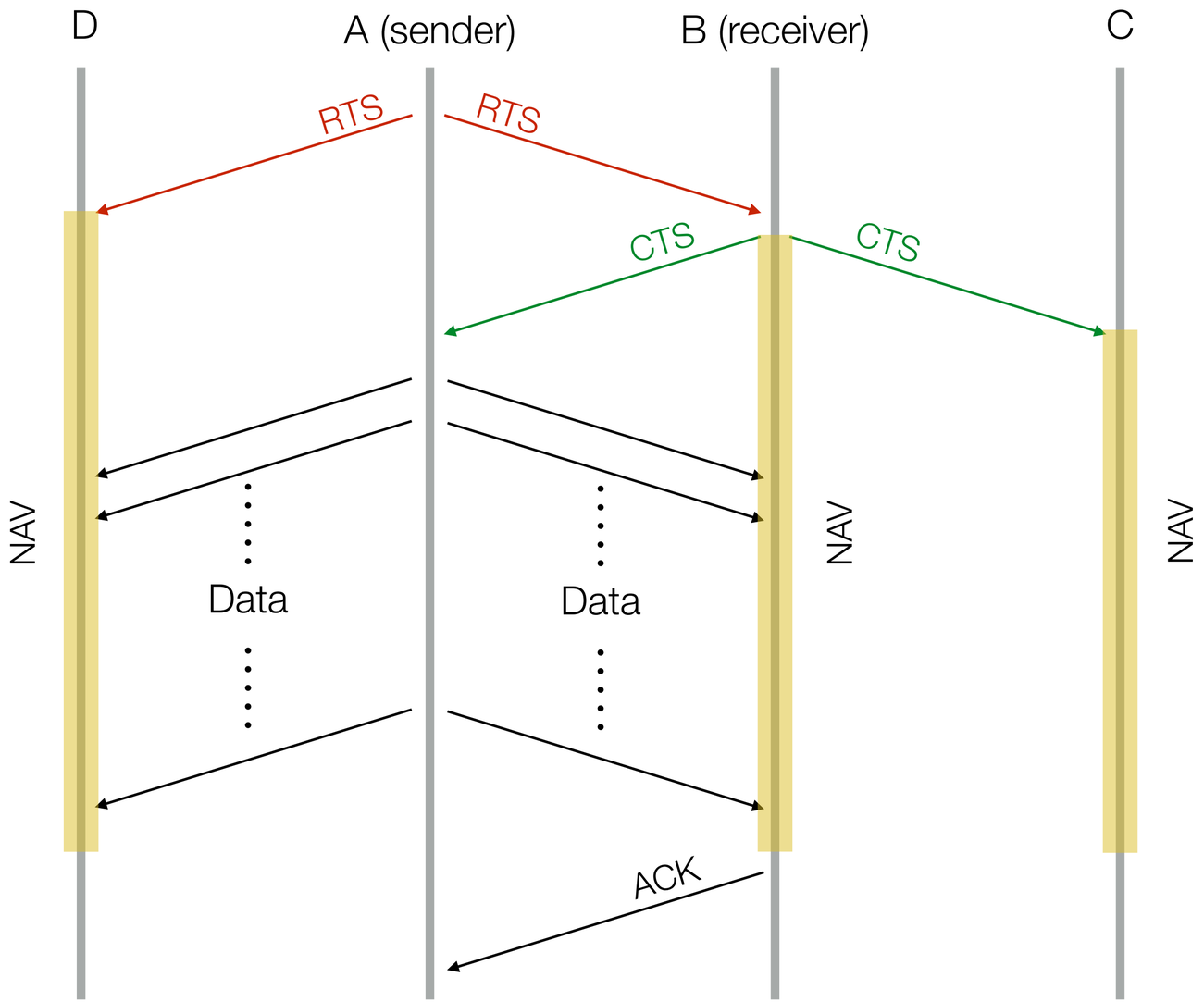
CS 725/825 & IT 725

Lecture 25

Link Layer

December 8, 2025

CSMA/CA



RTS - request to send
CTS - clear to send
NAV - node cannot send

IEEE 802.11 (WiFi)

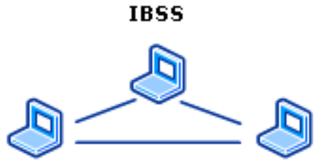
- IEEE 802.11: a, b, g, n, ac, ax, be …
- 2.4, 5, 6 GHz bands

Protocol*	Generational name	Release	Bands(s) (GHz)
IEEE 802.11n	WiFi 4	2009	2.4/5
IEEE 802.11ac	WiFi 5	2013	5
IEEE 802.11ax	WiFi 6	2019	2.4/5
IEEE 802.11ax	WiFi 6E	2020	2.4/5/6
IEEE 802.11be	WiFi 7	2025	2.4/5/6

(*) Early versions (a, b, and g) omitted

IEEE 802.11 (WiFi)

- Modes of operation:
  - ad hoc mode



  - infrastructure mode

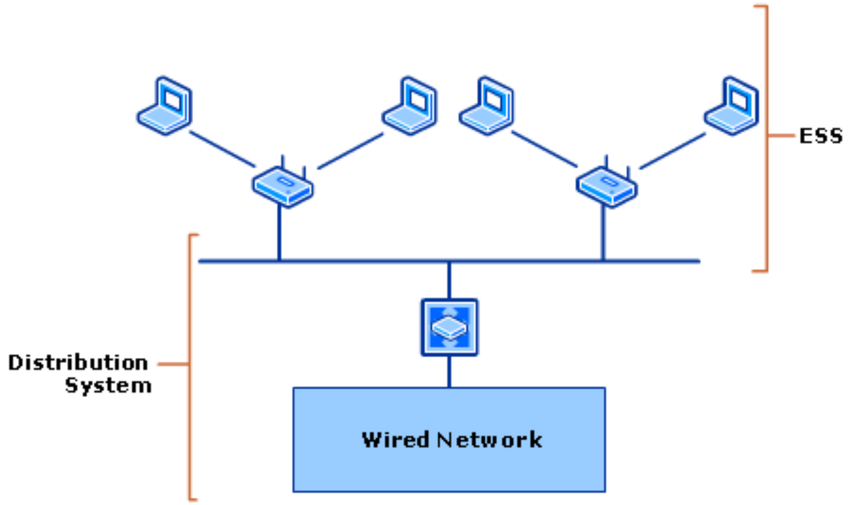


Image source: http://technet.microsoft.com/en-us/library/cc757419.aspx

IEEE 802.11 Terminology

- station (STA)
- wireless access point (AP)
- basic service set (BSS)
- independent basic service set (IBSS)
- distribution system (DS)
- extended service set (ESS)

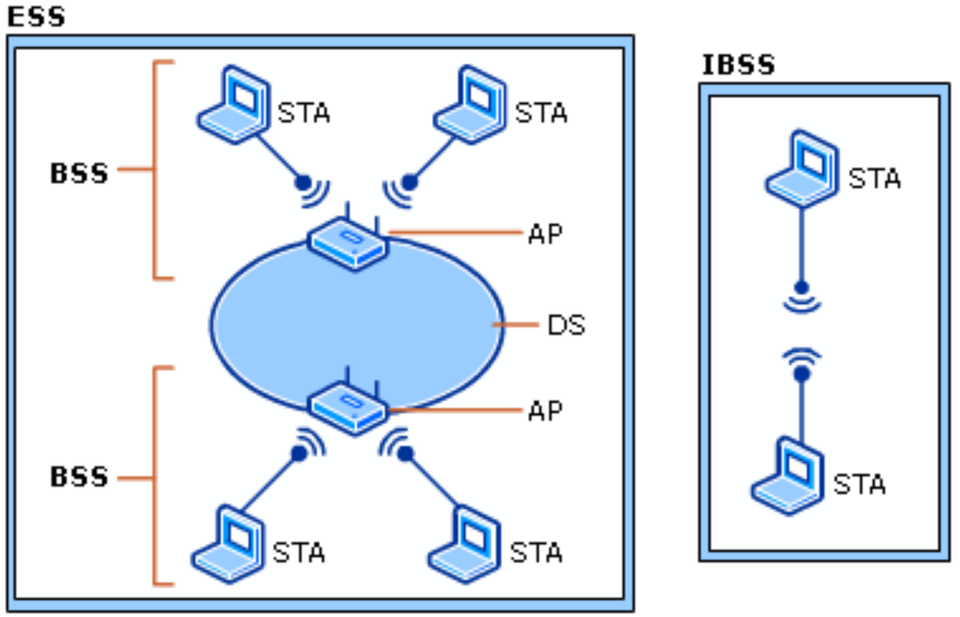
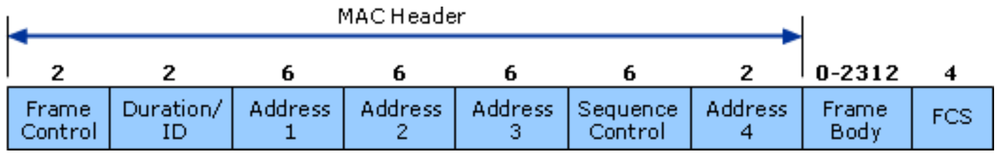


Image source: http://technet.microsoft.com/en-us/library/cc757419.aspx

IEEE 802.11 Frame Format

- Destination Address (DA): final destination to receive the frame.
- Source Address (SA): the original source that initially transmitted the frame.
- Receiver Address (RA): next immediate STA on the wireless medium to receive the frame
- Transmitter Address (TA): STA that transmitted the frame onto the wireless medium



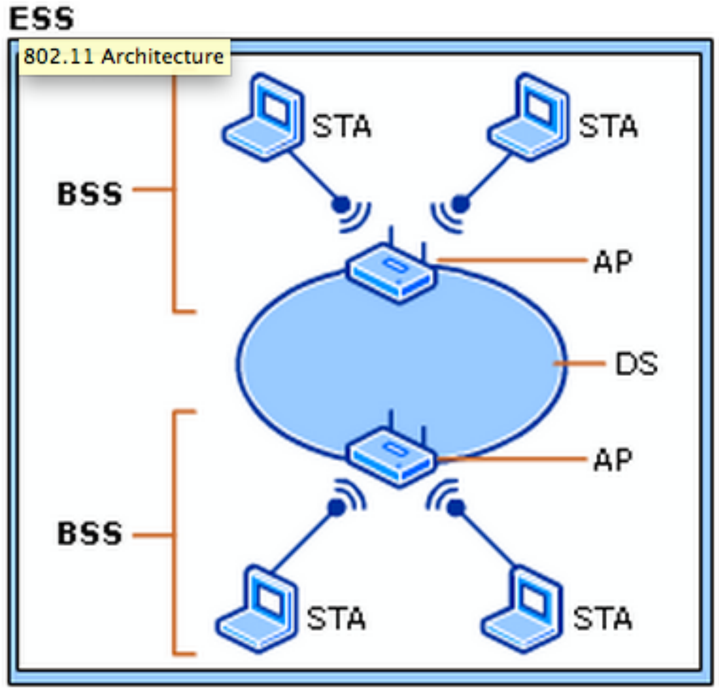
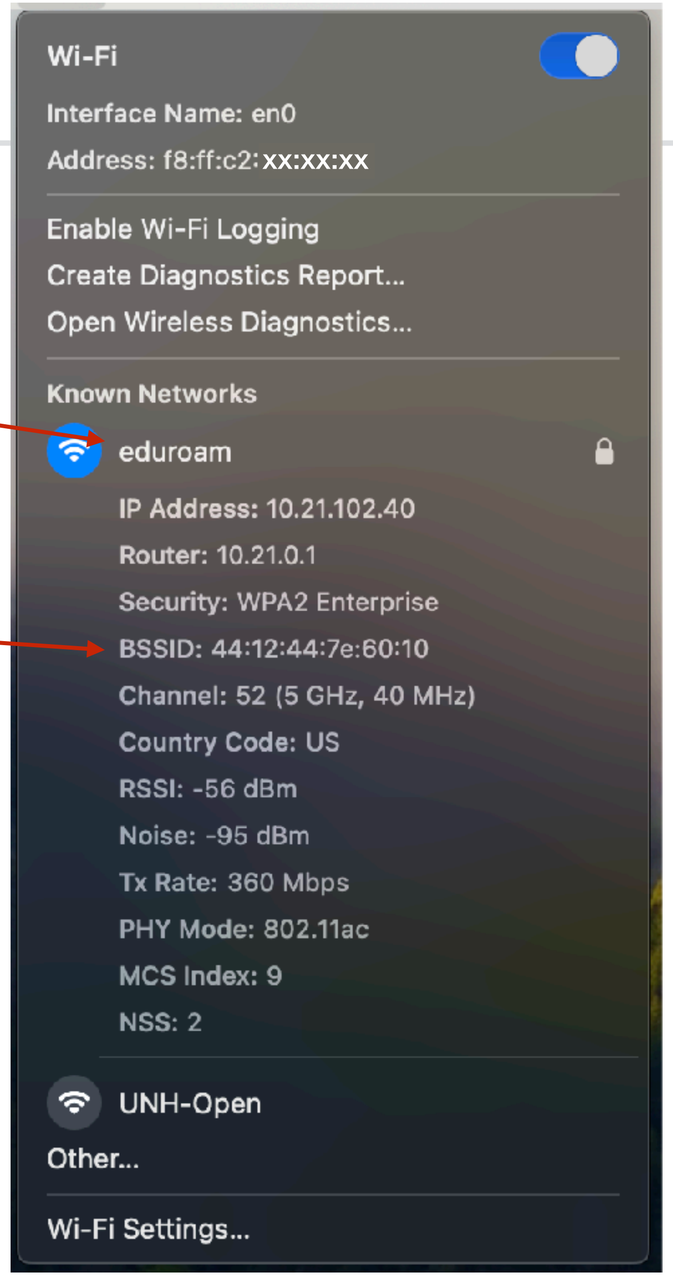


Image source: http://technet.microsoft.com/en-us/library/cc757419.aspx

SSID vs BSSID

- SSID
  - string identifier of a WLAN
- BSSID
  - MAC of a specific access point on the WLAN



WiFi Addresses

Table 4-2. Use of the address fields in data frames

Function	ToDS	FromDS	Address 1 (receiver)	Address 2 (transmitter)	Address 3	Address 4
IBSS	0	0	DA	SA	BSSID	Not used
To AP (infra.)	1	0	BSSID	SA	DA	Not used
From AP (infra.)	0	1	DA	BSSID	SA	Not used
WDS (bridge)	1	1	RA	TA	DA	SA

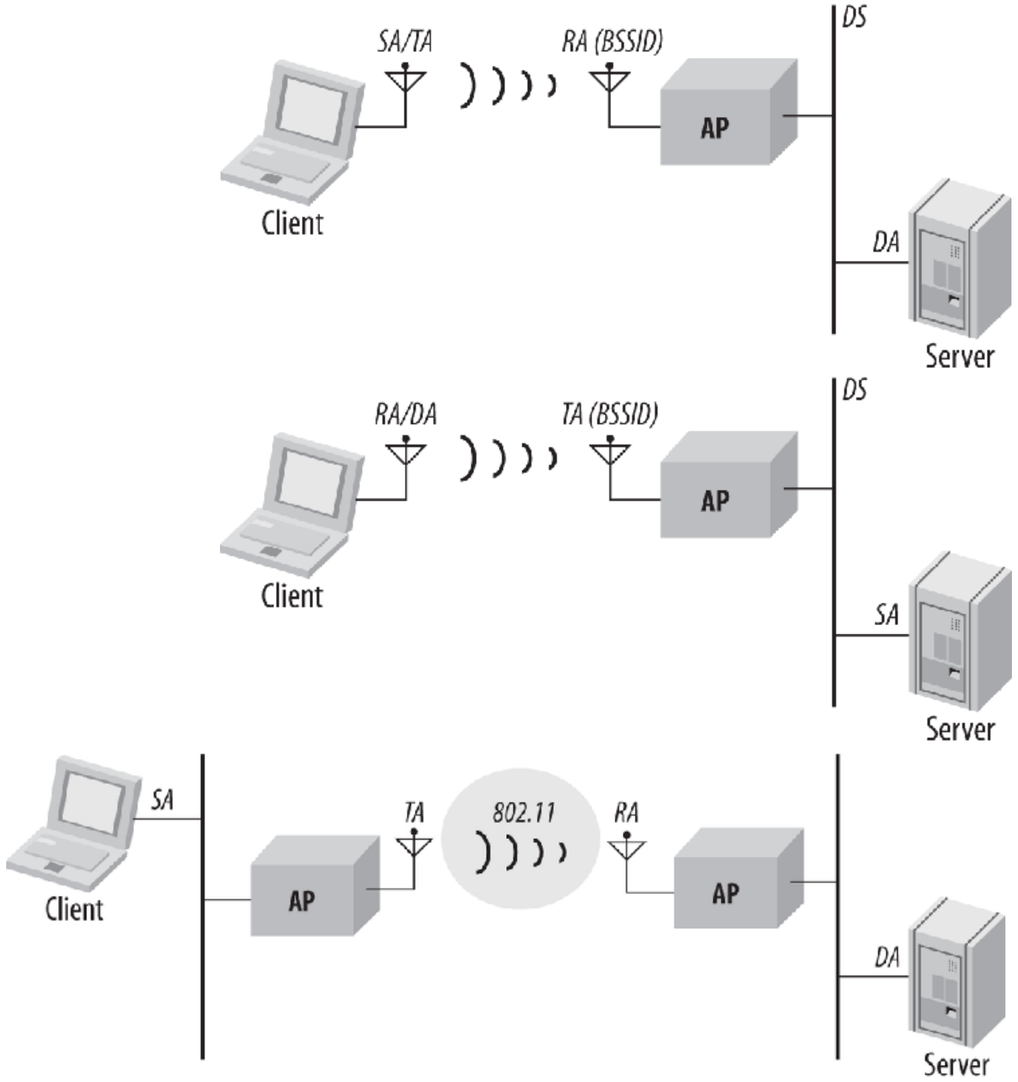


Table and image source: Matthew S. Gast, 802.11 Wireless Networks: The Definitive Guide, 2nd Edition, https://www.oreilly.com/library/view/80211-wireless-networks/0596100523/ch04.html

Wrap up

Wrapping up…

- Basic principles of networking
  - addressing, layers, performance evaluation
- Application protocol design
  - sockets, client/server communication, HTTP
- Securing data transmission
  - encryption, authentication/certificates, integrity, attacks
- Support services in the application layer
  - DNS, network management

Wrapping up…

- Principles of reliable transport, TCP and UDP
  - ARQ, sliding window
  - flow control and network congestion control
- Network layer and routing in the Internet, IP
  - routing algorithms and protocols, scalability
  - QoS, virtual circuit switching, MPLS, SDN
- Link layer, Ethernet, bridging
  - MAC protocols and wireless networks
  - scaling of L2 networks, bridging, virtualization

Thank you!