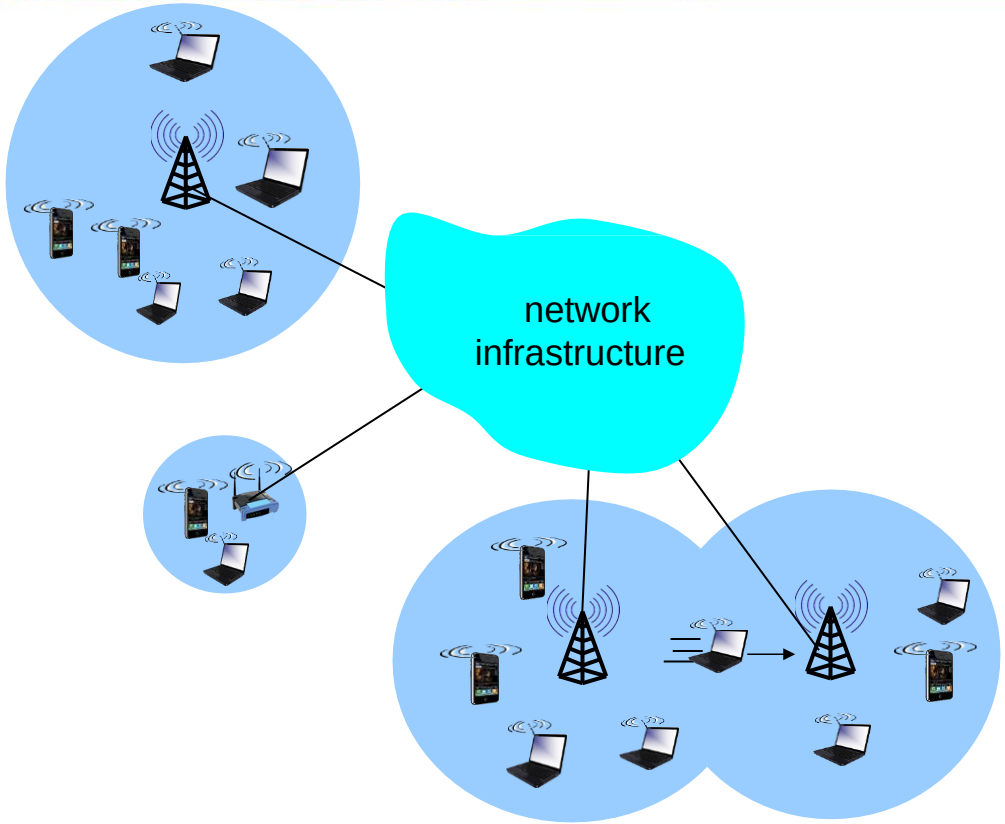
IF2230 Jaringan Komputer

Wireless Network

Robithoh Annur
Andreas Bara Timur
Monterico Andrian
Prof. Nana Rachmana

Elements of a wireless network



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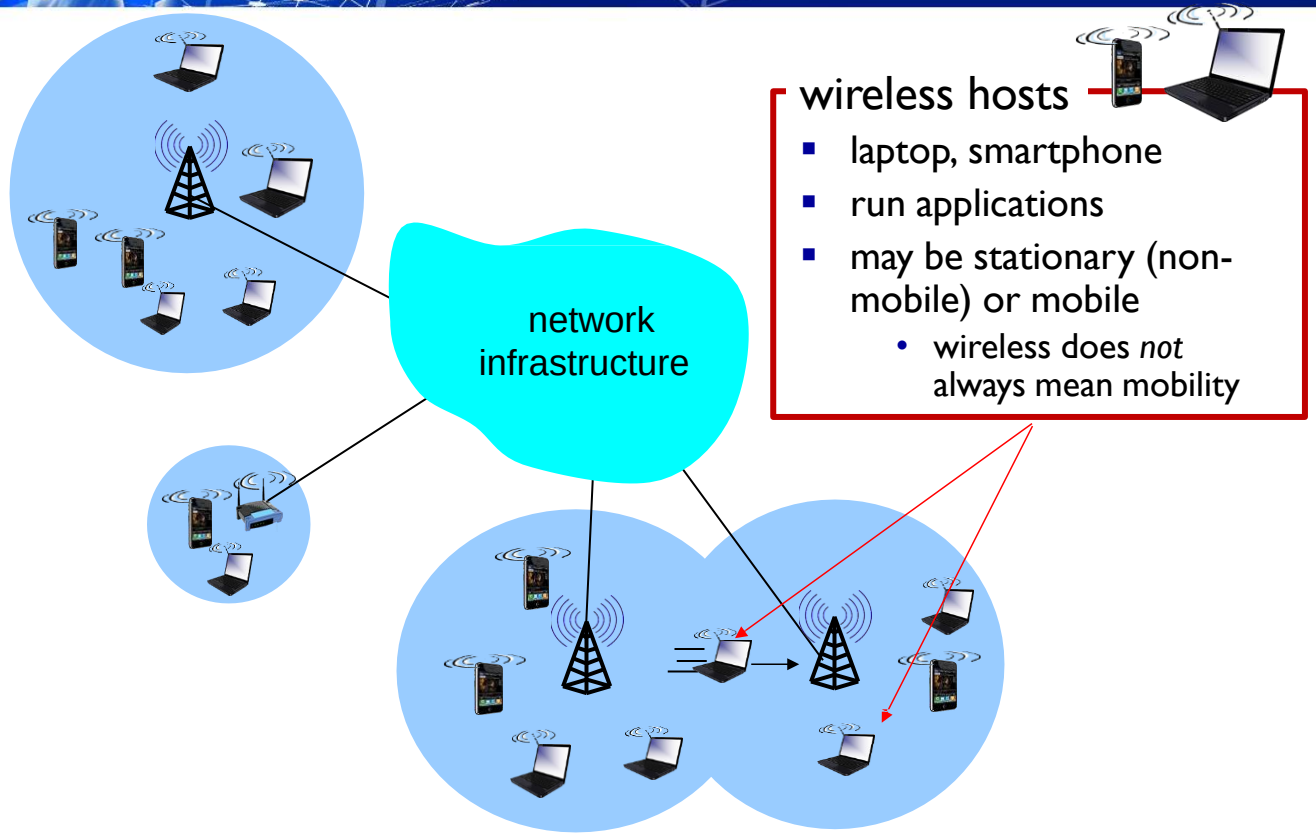

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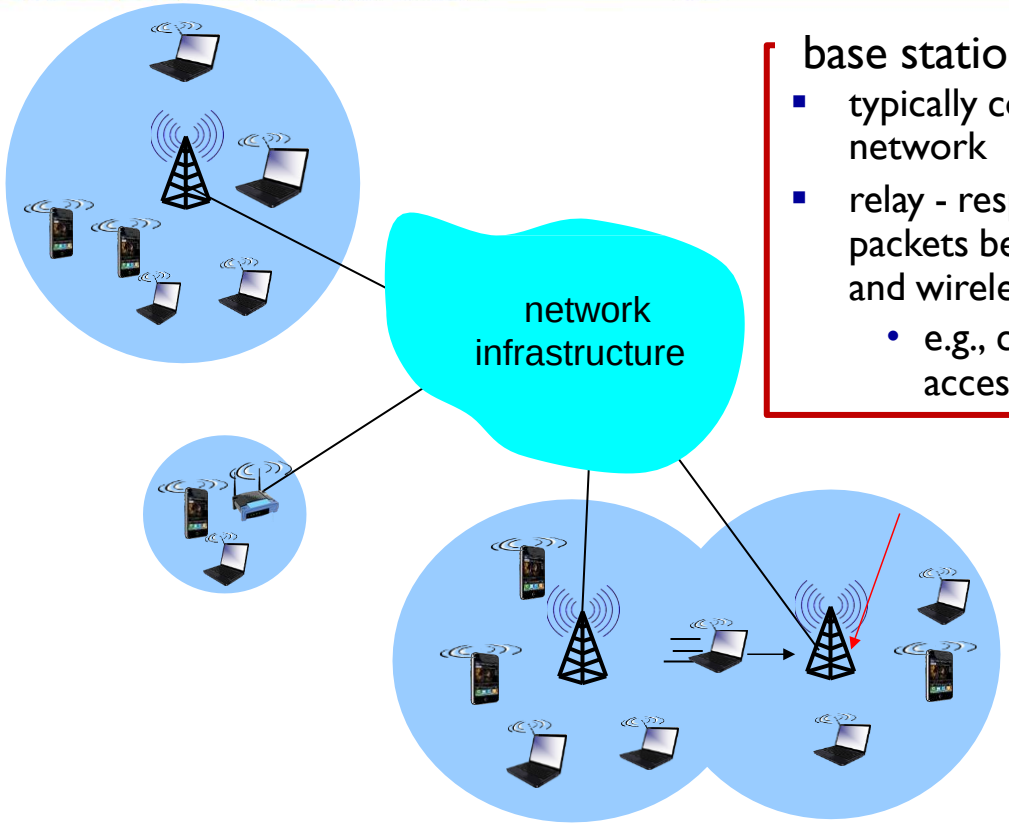
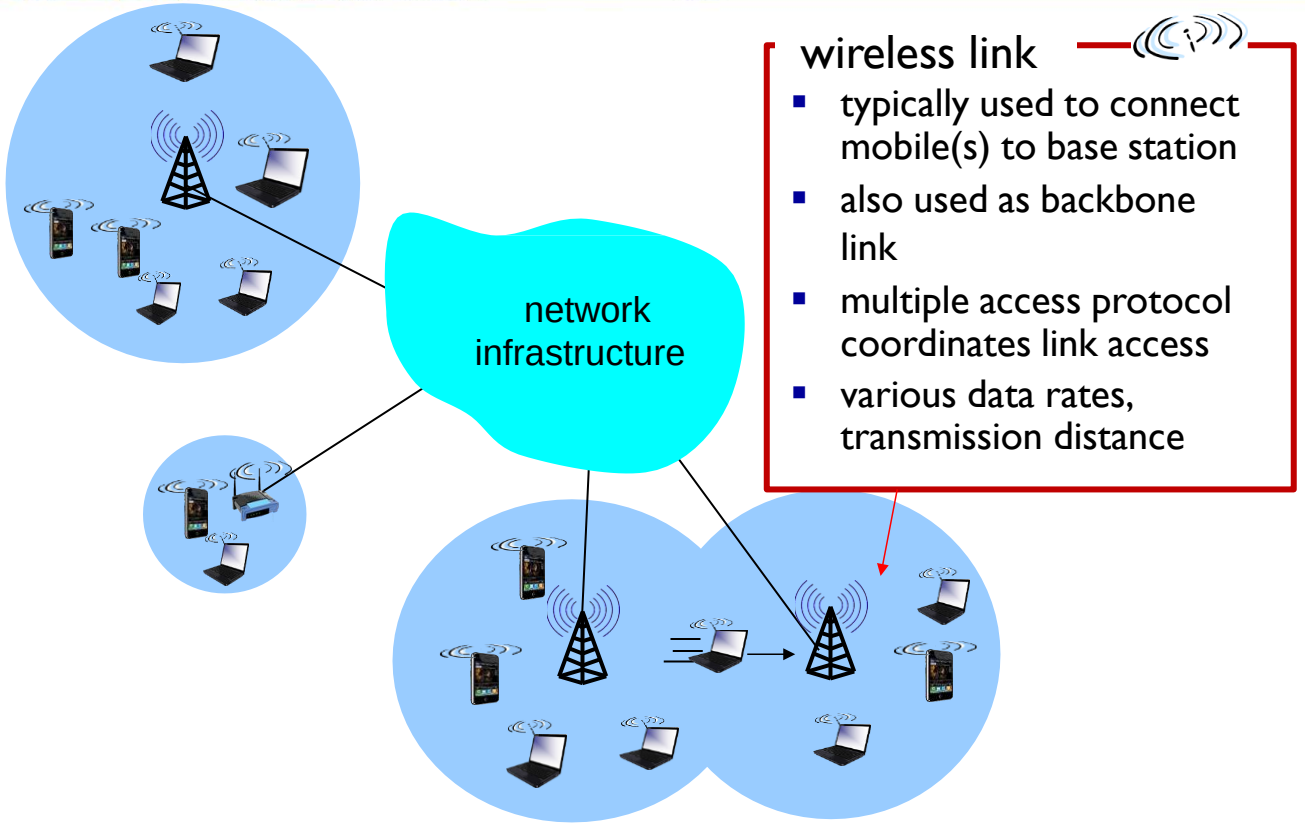


base station

- typically connected to wired network
- relay - responsible for sending packets between wired network and wireless host(s) in its "area"
  - e.g., cell towers, 802.11 access points

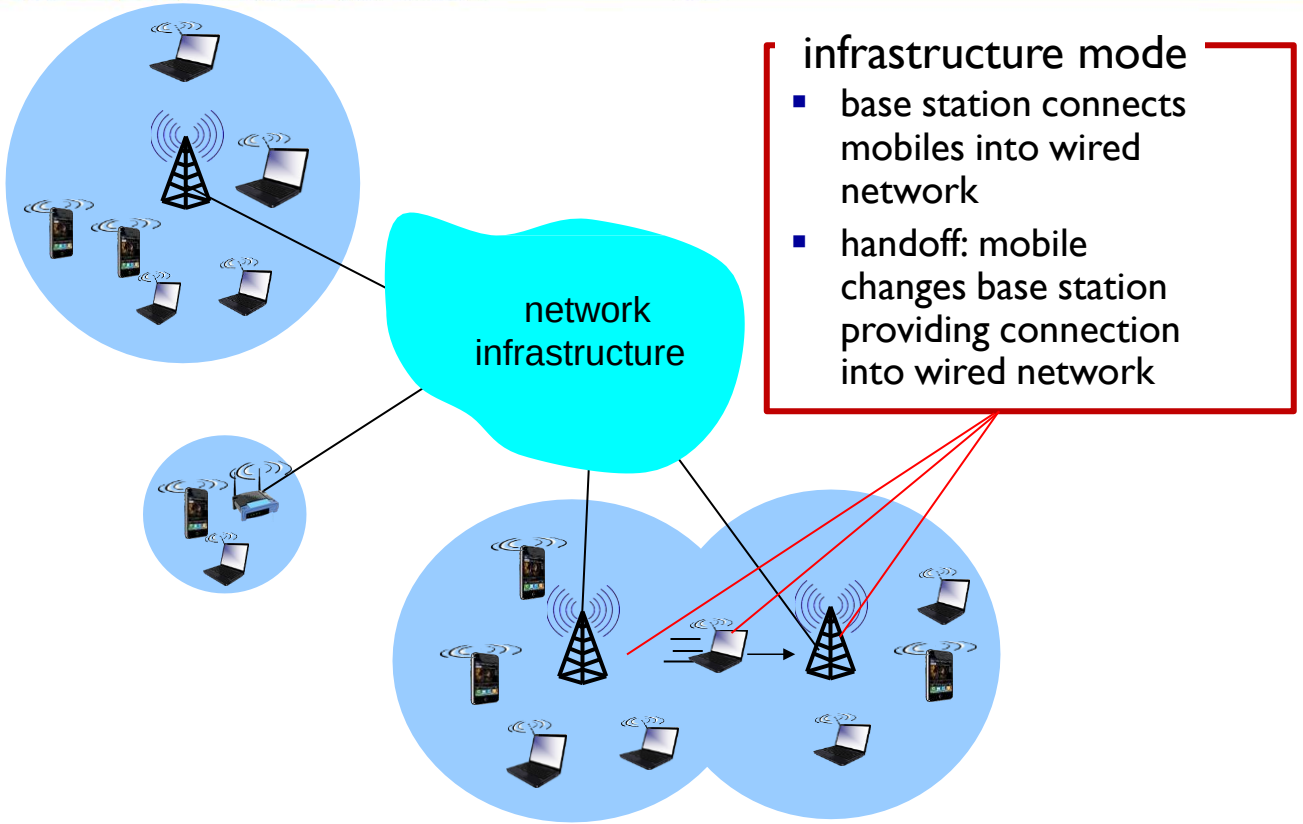
Elements of a wireless network



wireless link

- typically used to connect mobile(s) to base station
- also used as backbone link
- multiple access protocol coordinates link access
- various data rates, transmission distance

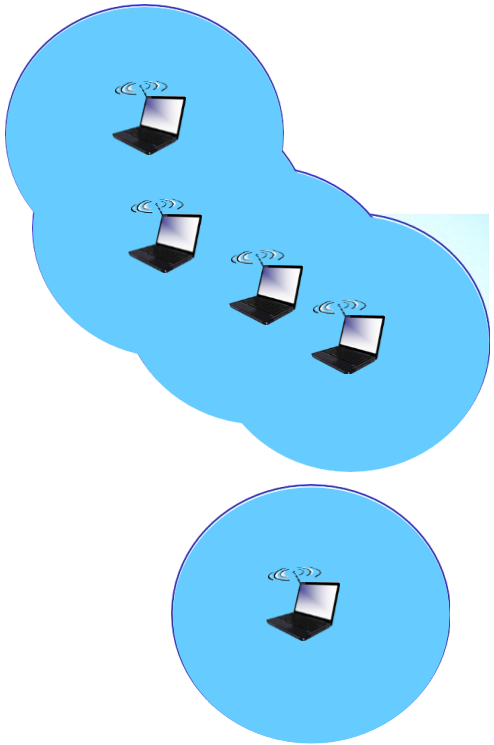
Elements of a wireless network



infrastructure mode

- base station connects mobiles into wired network
- handoff: mobile changes base station providing connection into wired network

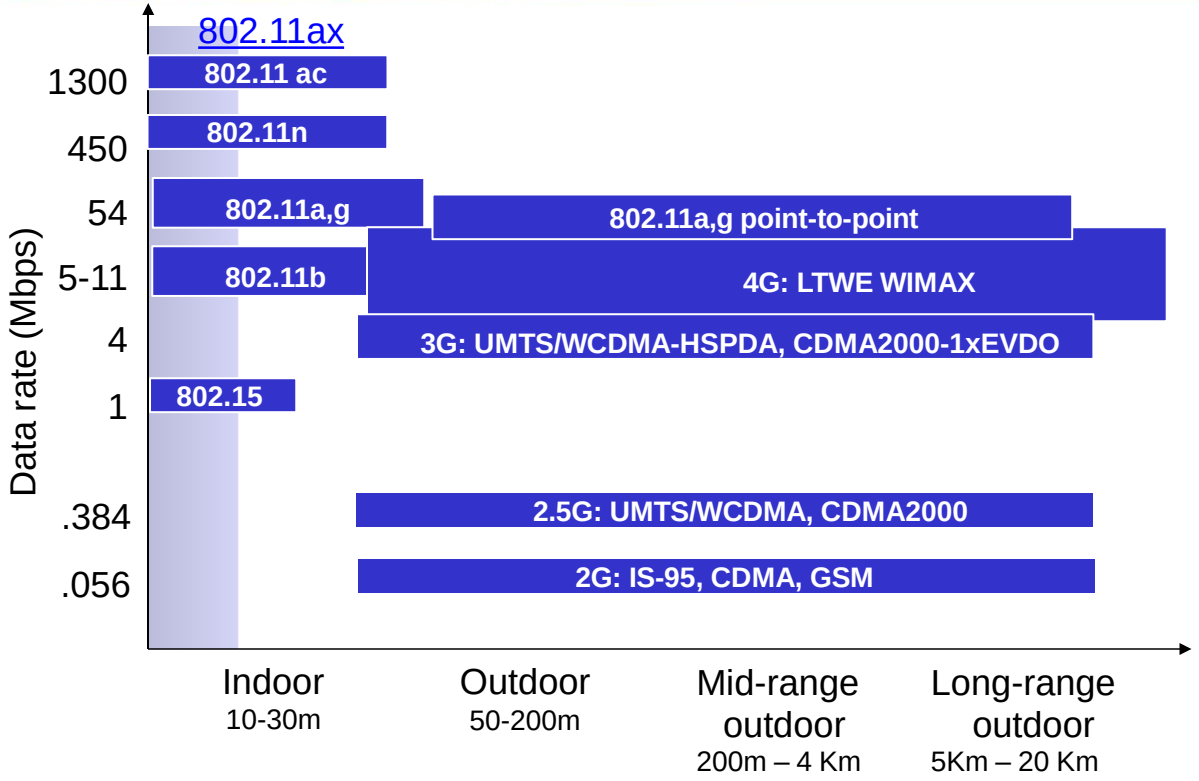
Elements of a wireless network



ad hoc mode

- no base stations
- nodes can only transmit to other nodes within link coverage
- nodes organize themselves into a network: route among themselves

Characteristics of selected wireless links



Wireless network taxonomy

	single hop	multiple hops
infrastructure (e.g.,APs)	host connects to base station (WiFi, WiMAX, cellular) which connects to larger Internet	host may have to relay through several wireless nodes to connect to larger Internet: *mesh net*
no infrastructure	no base station, no connection to larger Internet (Bluetooth, ad hoc nets)	no base station, no connection to larger Internet. May have to relay to reach other a given wireless node MANET,VANET

Wireless Link Characteristics (1)

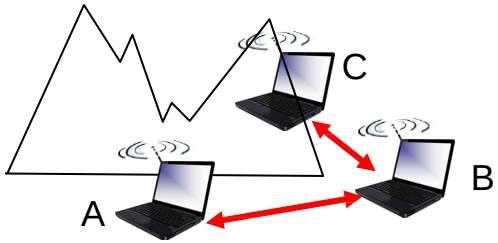
important differences from wired link ….

- *decreased signal strength:* radio signal attenuates as it propagates through matter (path loss)
- *interference from other sources:* standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- *multipath propagation:* radio signal reflects off objects ground, arriving ad destination at slightly different times

…. make communication across (even a point to point) wireless link much more "difficult"

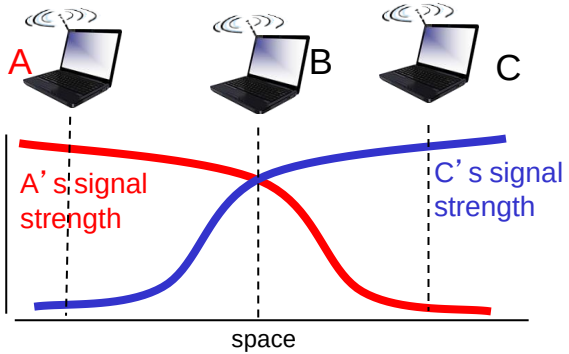
Wireless network characteristics

Multiple wireless senders and receivers create additional problems (beyond multiple access):



Hidden terminal problem

- B,A hear each other
- B, C hear each other
- A, C can not hear each other means A, C unaware of their interference at B



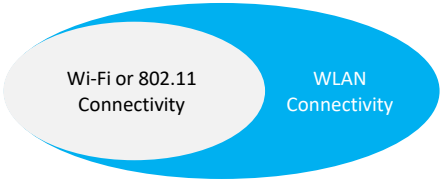
Signal attenuation:

- B,A hear each other
- B, C hear each other
- A, C can not hear each other interfering at B

WiFi - Introduction

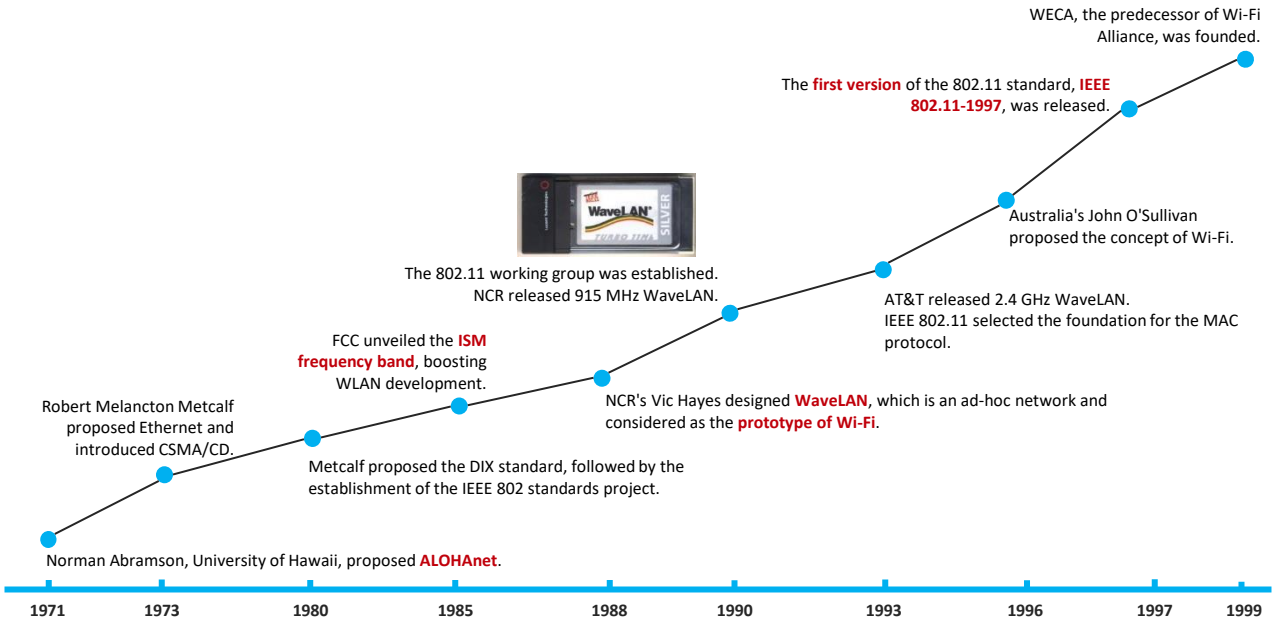
- Also written as Wi-Fi or Wifi.
- A networking technology that uses radio waves to allow high-speed data transfer over short distances.
- The Wi-Fi Alliance defines Wi-Fi as any "wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards".

WLAN vs. Wi-Fi

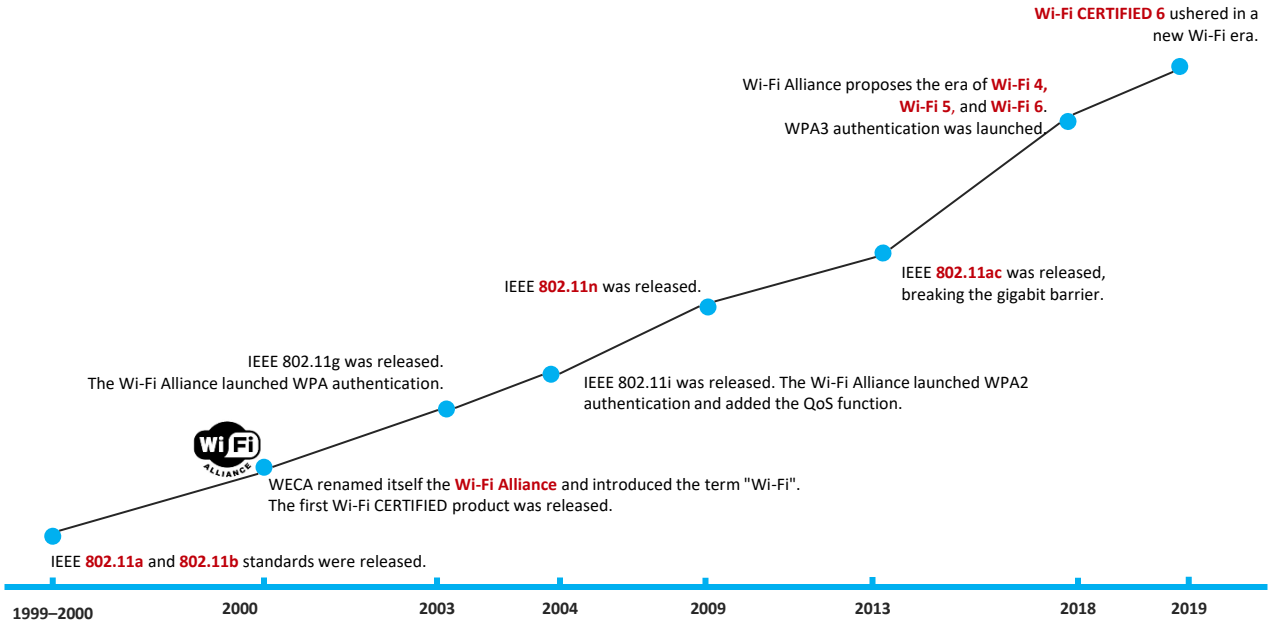
WLAN	Wi-Fi
 WLAN is a combination of computer networks and wireless communication technologies. It is an extension of wired networks. Wireless connections facilitate network construction and allow users to move around without interrupting communication.	**Wi-Fi** is a trademark of the Wi-Fi Alliance. It is **a WLAN technology based on the IEEE 802.11 standard.**

The difference between Wi-Fi and WLAN is that IEEE 802.11 is a WLAN standard while Wi-Fi is an implementation of IEEE 802.11 standard.

Origin and Development of Wireless Networks (1)



Origin and Development of Wireless Networks (2)



IEEE 802.11 Standards and Wi-Fi Generations

Standard		Released In	Frequency Band	PHY Technologies	Modulation Scheme	Number of Spatial Streams	Channel Bandwidth (MHz)	Theoretical Rate
-	802.11	1997	2.4 GHz	IR, FHSS, DSSS	-	-	20	2 Mbps
-	802.11b	1999	2.4 GHz	DSSS/CCK	-	-	22	11 Mbps
-	802.11a	1999	5 GHz	OFDM	-	-	20	54 Mbps
-	802.11g	2003	2.4 GHz	OFDM	64-QAM	-	20	54 Mbps
Wi-Fi 4	802.11n	2009	2.4 GHz, 5 GHz	OFDM DSSS/CCK	64-QAM	4	20, 40	2.4 GHz: 450 Mbps 5 GHz: 600 Mbps
Wi-Fi 5	802.11ac Wave 1	2013	5 GHz	OFDM SU-MIMO	64-QAM	4+4	20, 40	3.74 Gbps
	802.11ac Wave 2	2015	5 GHz	OFDM DL MU-MIMO	256-QAM	8	20, 40, 80, 160, 80+80	6.9 Gbps
Wi-Fi 6	802.11ax	2019	2.4 GHz, 5 GHz	OFDMA DL MU-MIMO UL MU-MIMO	1024-QAM	4+8	20, 40, 80, 160, 80+80	2.4 GHz: 1.15 Gbps 5 GHz: 9.6 Gbps

WiFi – The implementation

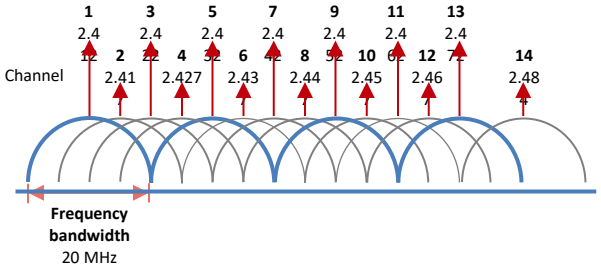
- Many devices can use Wi-Fi, e.g., personal computers, video-game consoles, smartphones, some digital cameras, tablet computers and digital audio players.
- These can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (65 feet) indoors and a greater range outdoors.
- Hotspot coverage can comprise an area as small as a single room with walls that block radio waves, or as large as many square miles achieved by using multiple overlapping access points.

WiFi – The implementation

- The 802.11 workgroup currently documents use in four distinct frequency ranges: 2.4 GHz, 3.6 GHz, 4.9 GHz, 5 GHz, and 5.9 GHz bands.
- Each range is divided into a multitude of channels.
- Countries apply their own regulations to both the allowable channels, allowed users and maximum power levels within these frequency ranges.

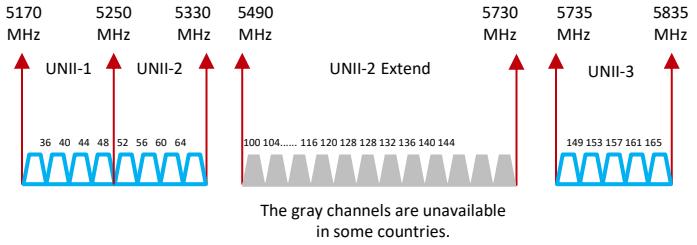
2.4 GHz and 5 GHz Channels

Channels on the 2.4 GHz frequency band



The 2.4 GHz frequency band is divided into 14 overlapping channels each with a frequency bandwidth of 20 MHz (except in 802.11b). Typically, channels 1, 5, 9, and 13 are non-overlapping channels.

Channels (non-overlapping) on the 5 GHz frequency band



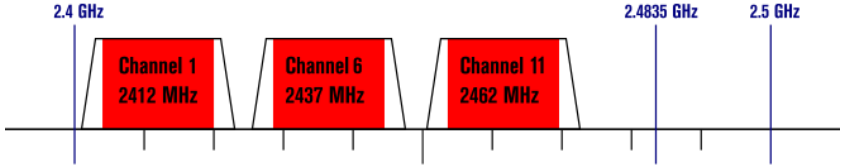
The gray channels are unavailable in some countries.

The 5 GHz frequency band has richer spectrum resources and non-overlapping channels. The available channels on the 5 GHz band vary depending on countries and regions.

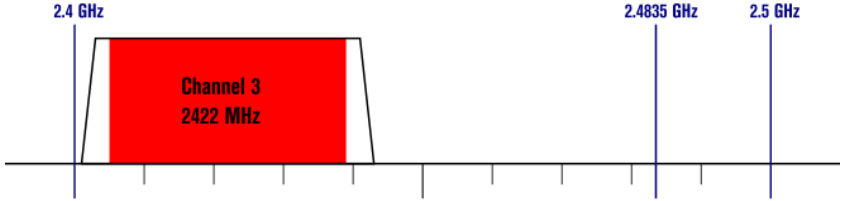
Non-Overlapping Channels for 2.4 GHz WLAN

802.11b (DSSS) channel width 22 MHz

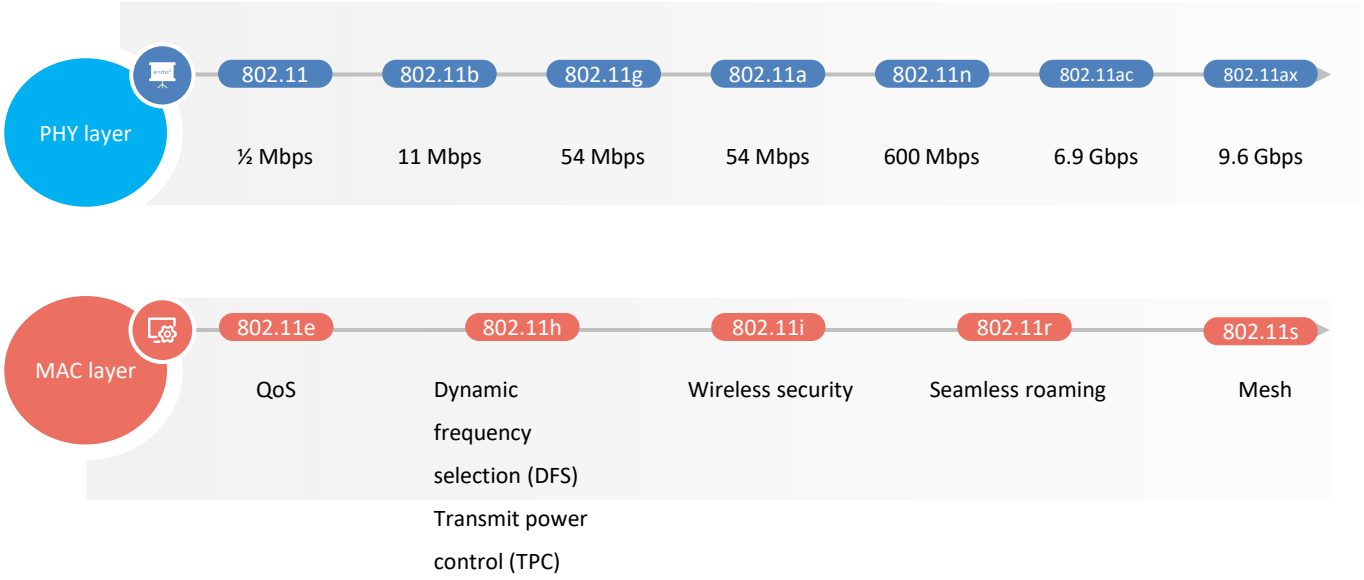
802.11g/n (OFDM) 20 MHz ch. width – 16.25 MHz used by sub-carriers



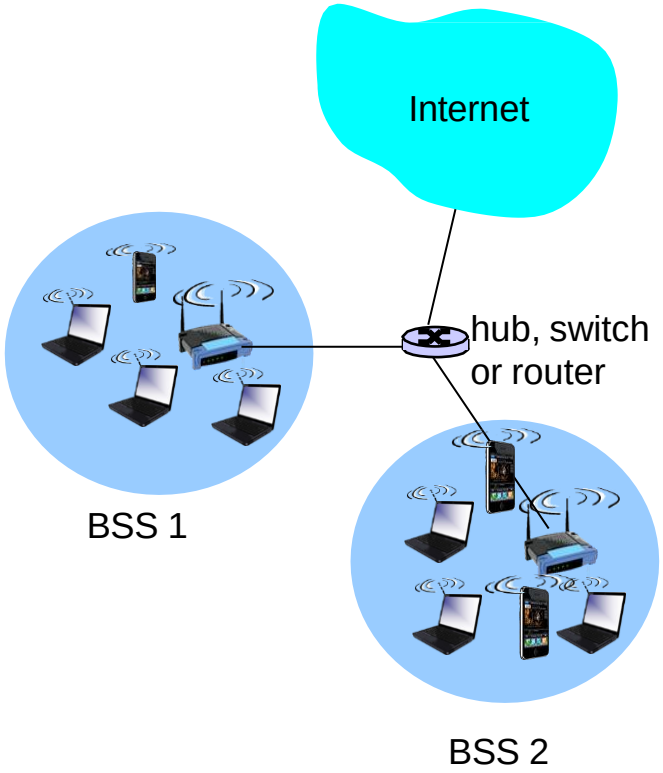
802.11n (OFDM) 40 MHz ch. width – 33.75 MHz used by sub-carriers



IEEE 802.11 Family

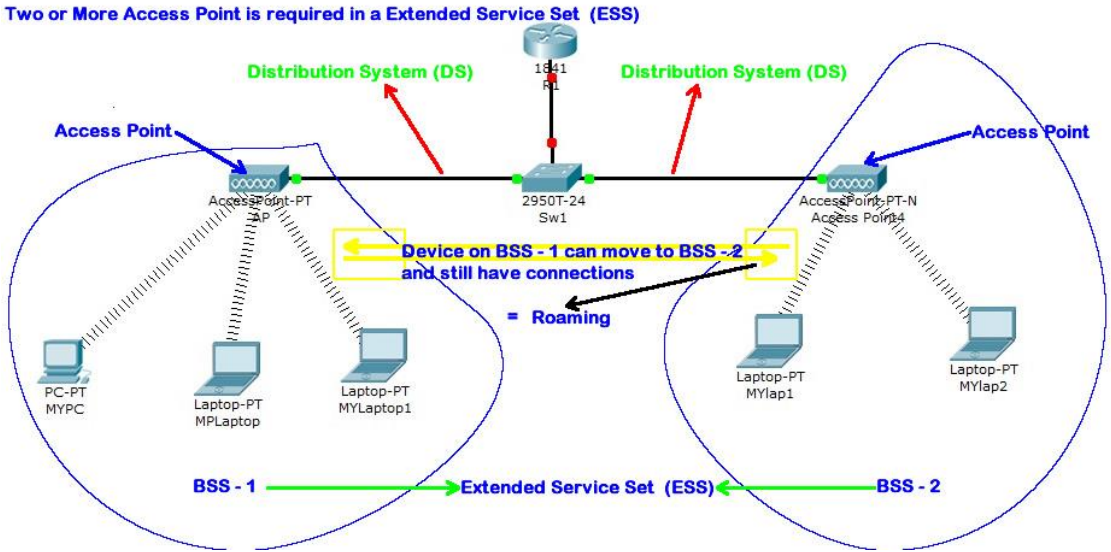


802.11 LAN-The architecture

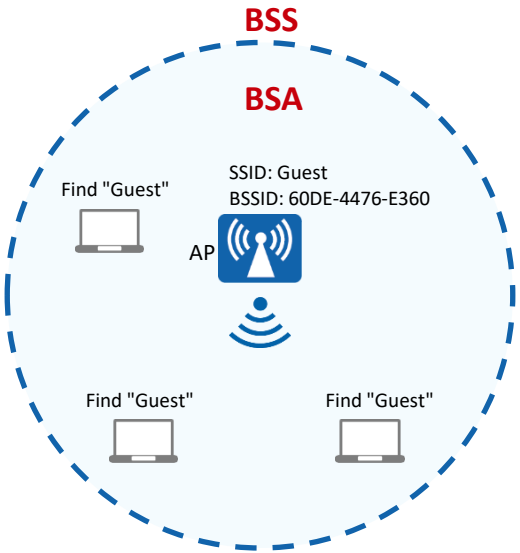


- wireless host communicates with base station
  - base station = access point (AP)
- Basic Service Set (BSS) (aka "cell") in infrastructure mode contains:
  - wireless hosts
  - access point (AP): base station
  - ad hoc mode: hosts only

802.11 LAN – The architecture

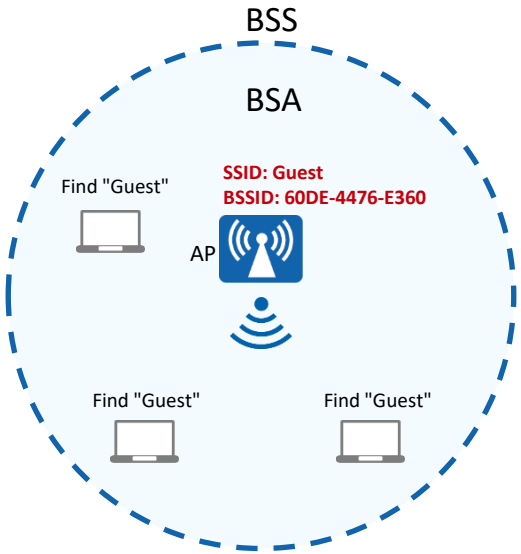


BSS and BSA



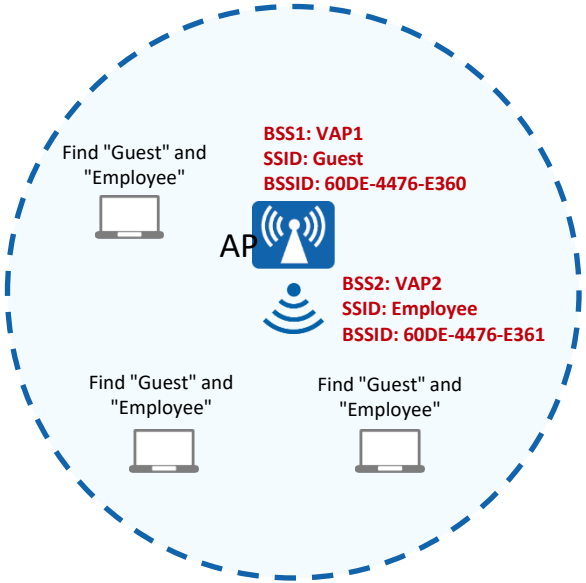
- A basic service set (BSS) is the basic building block of a WLAN, and each BSS includes one fixed AP and more than one STA. The AP is used as a WLAN infrastructure that provides wireless communication services for STAs.
- The AP is in the center of the BSS and has a relatively fixed location. The BSS is located in the place where an AP resides. STAs in a BSS are distributed around the AP, and their locations are not fixed relative to the AP. Therefore, STAs can move freely, close to or away from the AP. The coverage area of an AP is referred to as a basic service area (BSA). STAs can freely enter or leave a BSA, and only STAs entering a BSA can communicate with the corresponding AP.
- There are two types of BSS: Independent BSS (also referred to as IBSS), and infrastructure BSS. An independent BSS (IBSS) is an ad hoc network that contains no access points, which means they can not connect to any other basic service set.

SSID and BSSID



- To discover an AP, a STA requires the AP to notify it of its identity, that is, the basic service set identifier (BSSID).
- A STA can see multiple BSSIDs in one airspace with multiple BSSs deployed, and only the desired BSSID needs to be selected. A STA does not automatically select a BSSID. Instead, you need to select one for it. As a BSSID is typically the MAC address of the AP in the BSS, you may not know which BSSID is the desired one if you see just character strings of MAC addresses. Therefore, to identify an AP's identity more easily, a character string that can be set is required as the name of an AP. This character string is called service set identifier (SSID).

STA and VAP

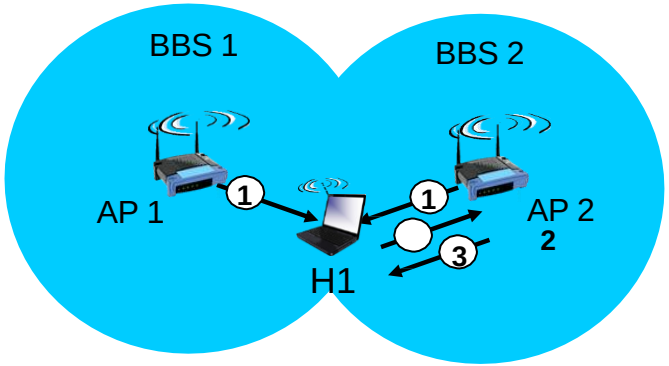


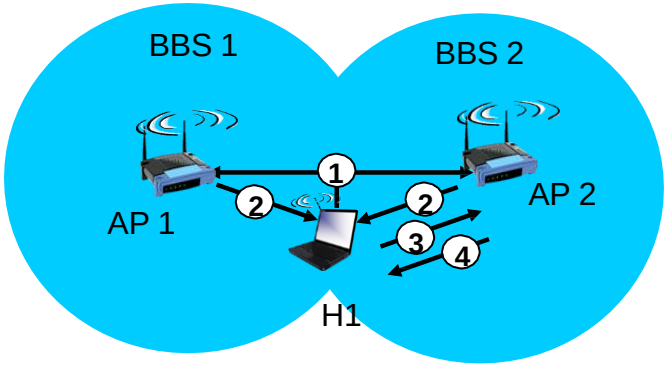
- Stations - All components that can connect into a wireless medium in a network are referred to as stations. All stations are equipped with wireless network interface controllers (WNICs). Wireless stations fall into one of two categories: access points, and clients. Access points (APs), normally routers, are base stations for the wireless network. They transmit and receive radio frequencies for wireless enabled devices to communicate with. Wireless clients can be mobile devices such as laptops, personal digital assistants, IP phones and other smartphones, or fixed devices such as desktops and workstations that are equipped with a wireless network interface.
- An AP can be configured with multiple virtual access points (VAPs), and each VAP corresponds to one BSS. Therefore, only one AP needs to be deployed to provide multiple BSSs, for which different SSIDs can be set. By doing so, multiple WLANs can coexist in one airspace, which is also referred to as "multi-SSID".

ESS and DS

- Extended service set - An extended service set (ESS) is a set of connected BSSs. Access points in an ESS are connected by a distribution system. Each ESS has an ID called the SSID which is a 32-byte (maximum) character string.
- Distribution system - A distribution system (DS) connects access points in an extended service set. The concept of a DS can be used to increase network coverage through roaming between cells. DS can be wired or wireless. Current wireless distribution systems are mostly based on WDS or MESH protocols, though other systems are in use.

802.11: passive/active scanning





passive scanning:

(1)beacon frames sent from APs

(2)association Request frame sent: H1 to selected AP

(3)association Response frame sent from selected AP to H1

active scanning:

(1)Probe Request frame broadcast from H1

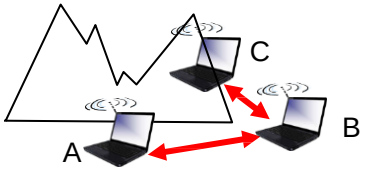
(2)Probe Response frames sent from APs

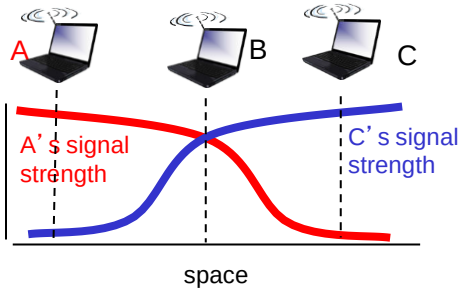
(3)Association Request frame sent:
H1 to selected AP

(4)Association Response frame sent from selected AP to H1

IEEE 802.11: multiple access

- avoid collisions: 2^+ nodes transmitting at same time
- 802.11: CSMA - sense before transmitting
  - don't collide with ongoing transmission by other node
- 802.11: *no* collision detection!
  - difficult to receive (sense collisions) when transmitting due to weak received signals (fading)
  - can't sense all collisions in any case: hidden terminal, fading
  - goal: *avoid collisions:* CSMA/C(ollision)A(voidance)





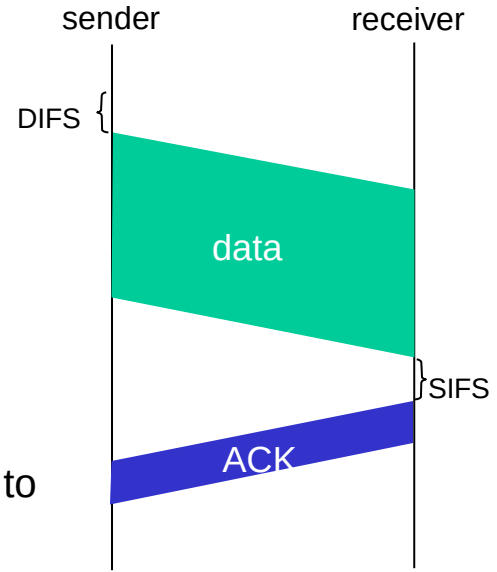
IEEE 802.11 MAC Protocol: CSMA/CA

802.11 sender

1 if sense channel idle for **DIFS** then
transmit entire frame (no CD) 2 if sense channel busy then
start random backoff time
timer counts down while channel idle transmit when timer expires
if no ACK, increase random backoff interval, repeat 2

802.11 receiver

- if frame received OK
return ACK after **SIFS** (ACK needed due to hidden terminal problem)



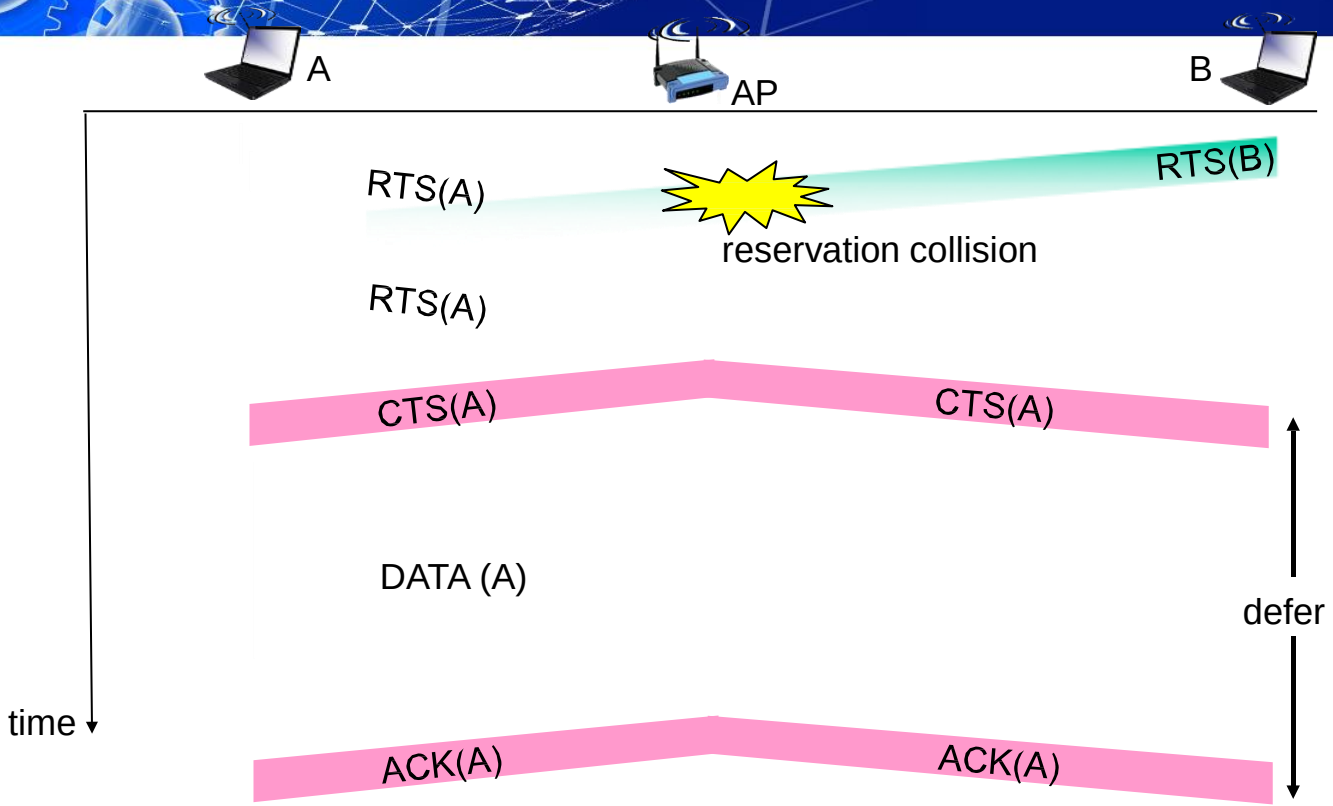
Avoiding collisions (more)

idea: allow sender to "reserve" channel rather than random access of data frames: avoid collisions of long data frames

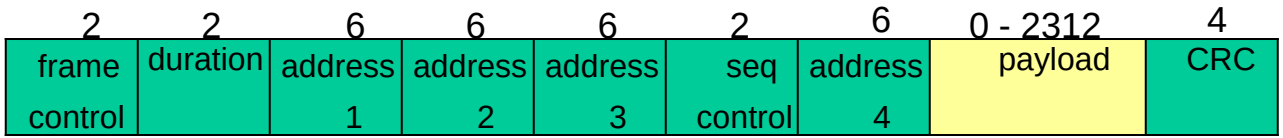
- sender first transmits *small* request-to-send (RTS) packets to BS using CSMA
  - RTSs may still collide with each other (but they're short)
- BS broadcasts clear-to-send CTS in response to RTS
- CTS heard by all nodes
  - sender transmits data frame
  - other stations defer transmissions

avoid data frame collisions completely using small reservation packets!

Collision Avoidance: RTS-CTS exchange



802.11 frame: addressing



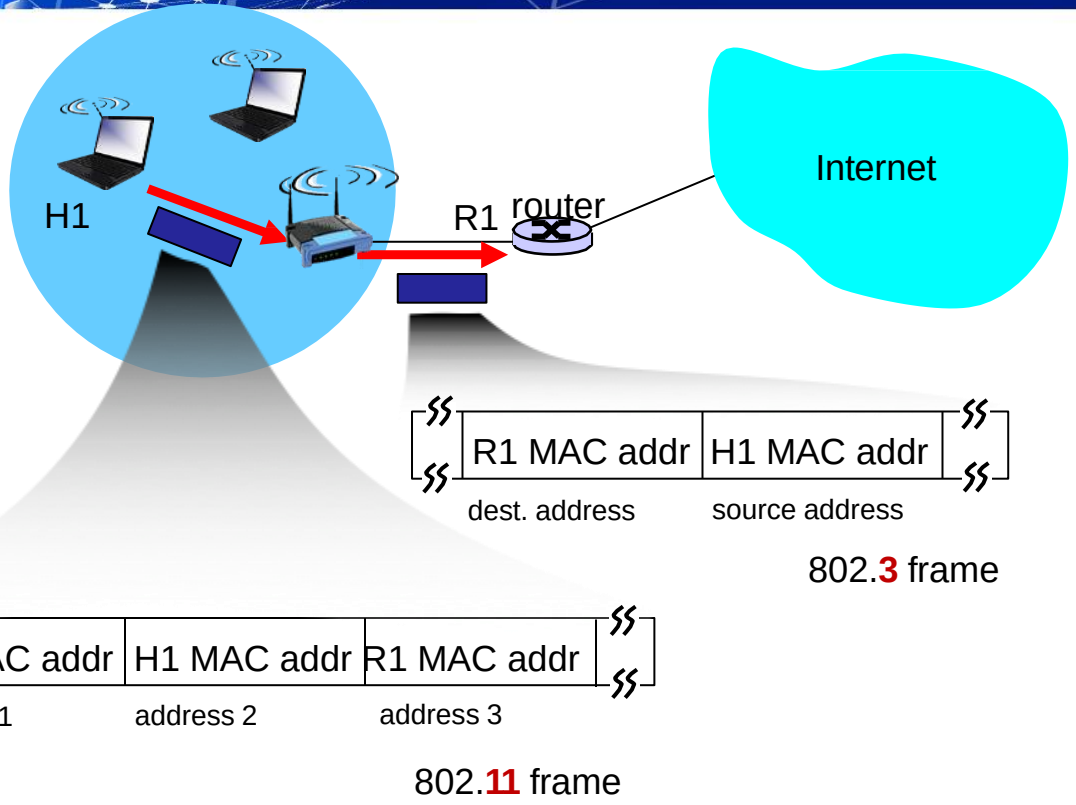
Address 1: MAC address of wireless host or AP to receive this frame

Address 2: MAC address of wireless host or AP transmitting this frame

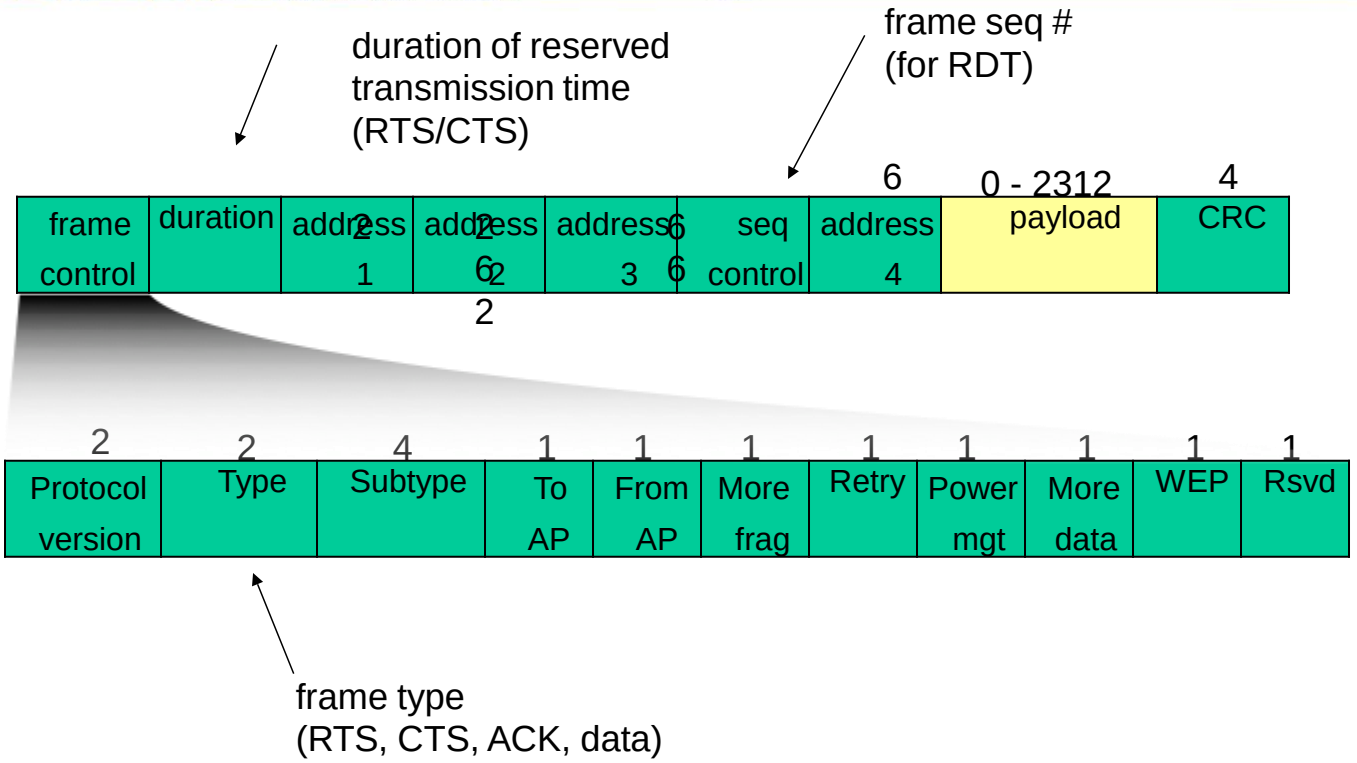
Address 4: used only in ad hoc mode

Address 3: MAC address of router interface to which AP is attached

802.11 frame: addressing

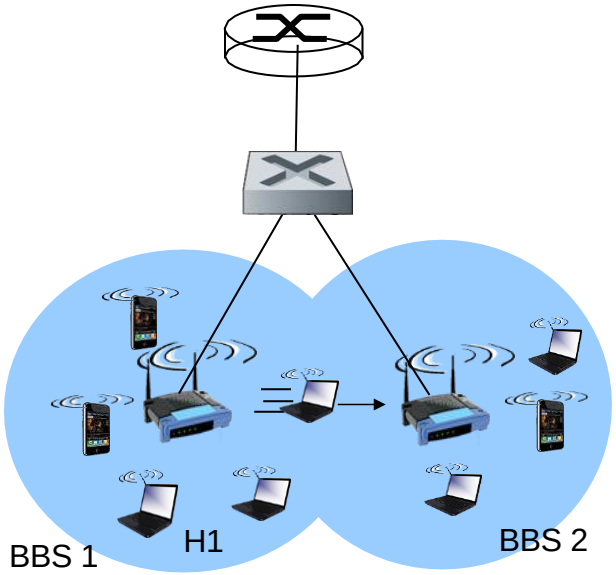


802.11 frame: more



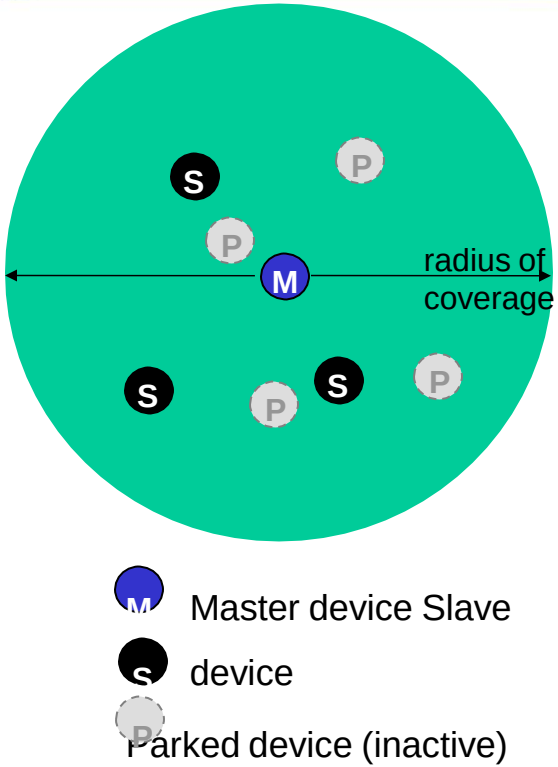
802.11: mobility within same subnet

- H1 remains in same IP subnet: IP address can remain same
  - switch: which AP is associated with H1?
    - self-learning (Ch. 5): switch will see frame from H1 and "remember" which switch port can be used to reach H1



802.15: personal area network

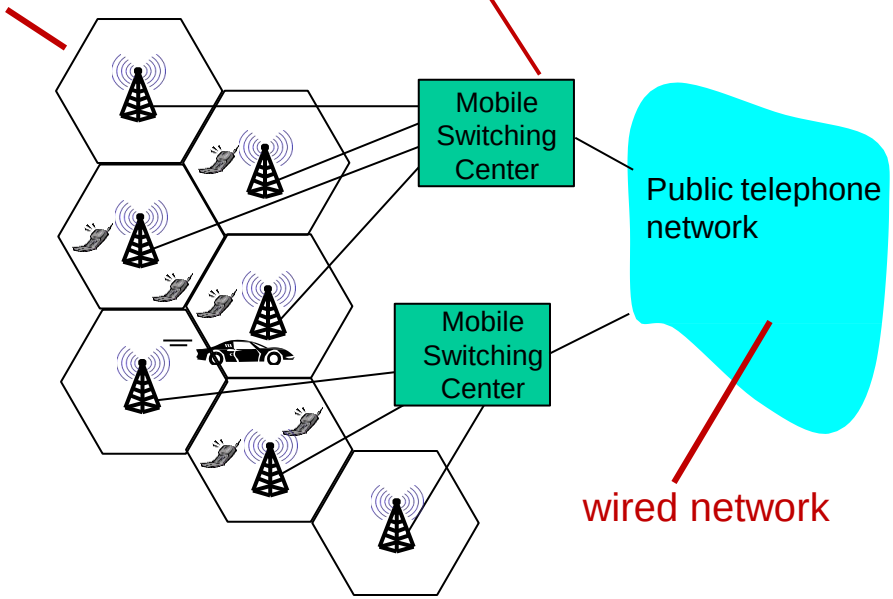
- less than 10 m diameter
- replacement for cables (mouse, keyboard, headphones)
- ad hoc: no infrastructure
- master/slaves:
  - slaves request permission to send (to master)
  - master grants requests
- 802.15: evolved from Bluetooth specification
  - 2.4-2.5 GHz radio band
  - up to 721 kbps



Components of cellular network architecture

MSC
- connects cells to wired tel. net.
- manages call setup
- handles mobility

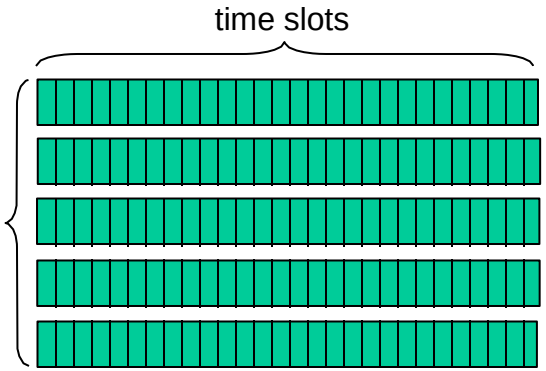
cell
- covers geographical region
- *base station* (BS) analogous to 802.11 AP
- *mobile users* attach to network through BS
- *air-interface:* physical and link layer protocol between mobile and BS



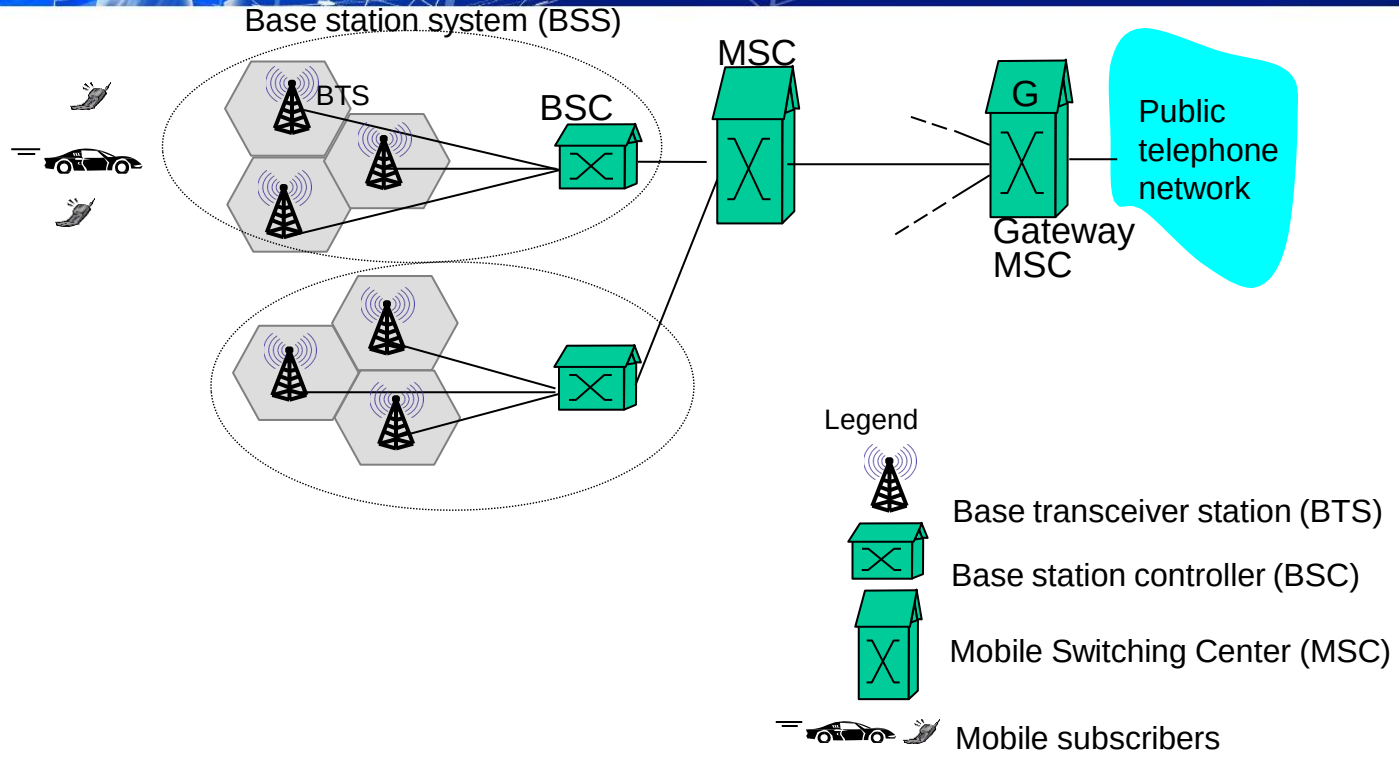
Cellular networks: the first hop

Two techniques for sharing mobile-to-BS radio spectrum

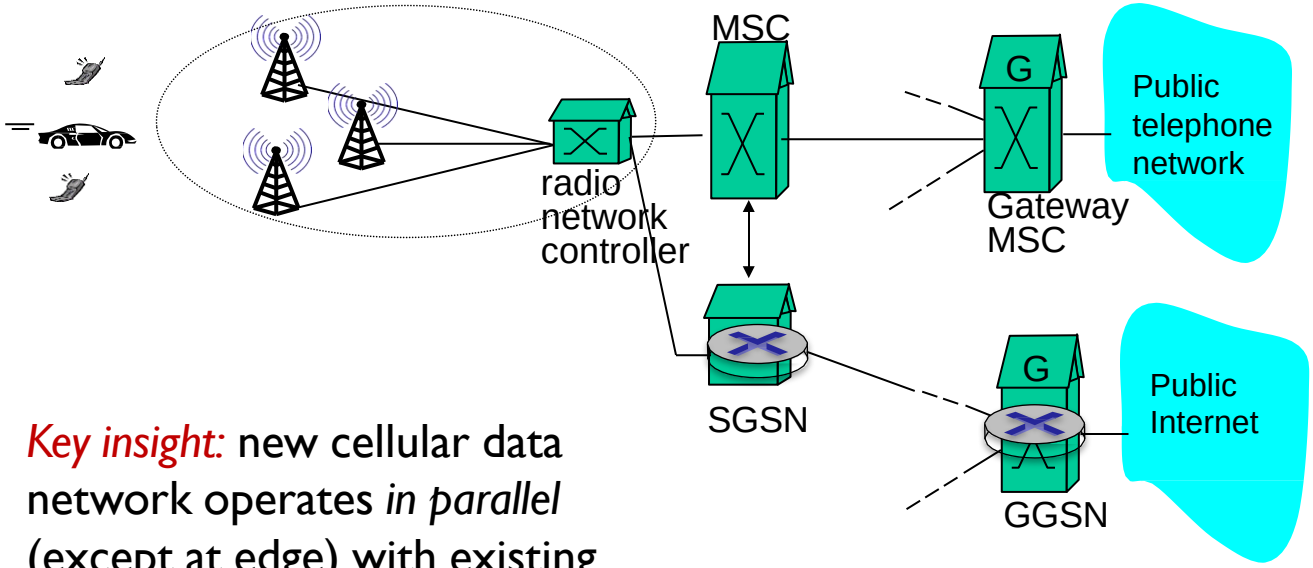
- combined FDMA/TDMA: divide spectrum in frequency channels, divide each channel into time slots
- CDMA: code division multiple access



2G (voice) network architecture



3G (voice+data) network architecture



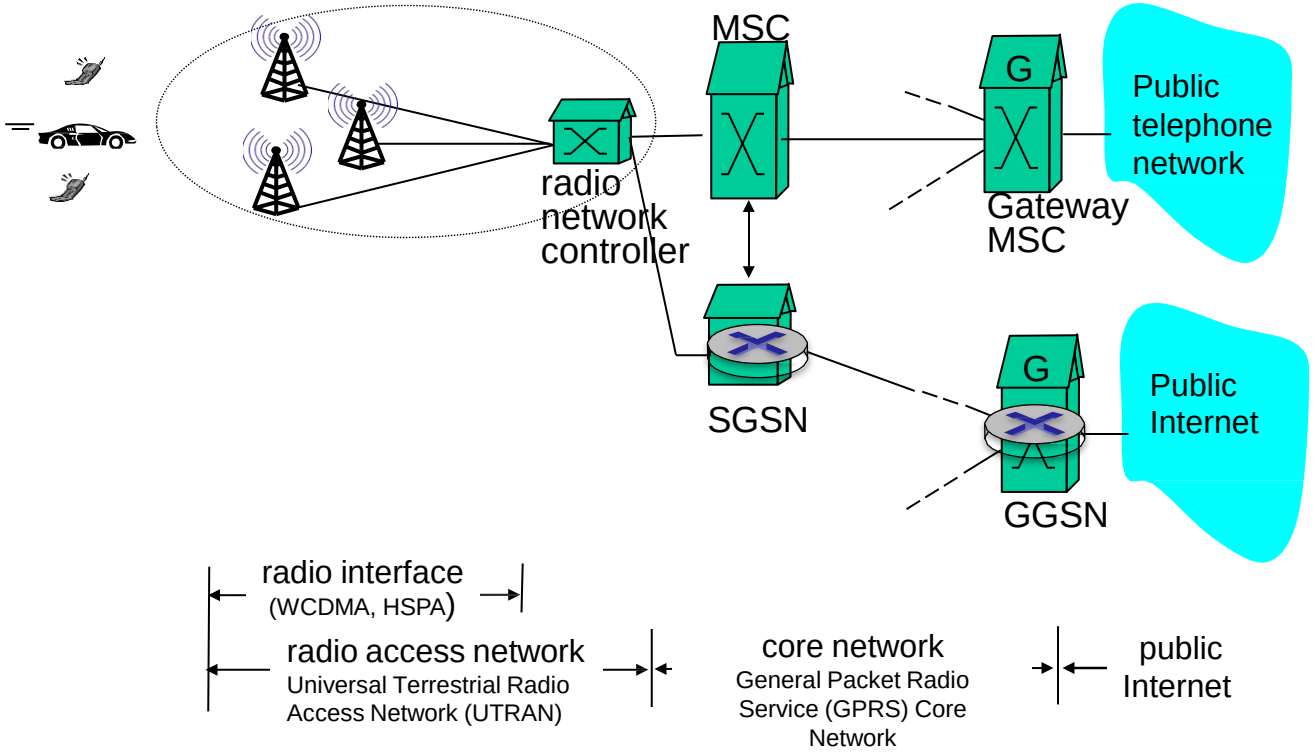
Key insight: new cellular data network operates *in parallel* (except at edge) with existing cellular voice network

- voice network *unchanged* in core
- data network operates in parallel

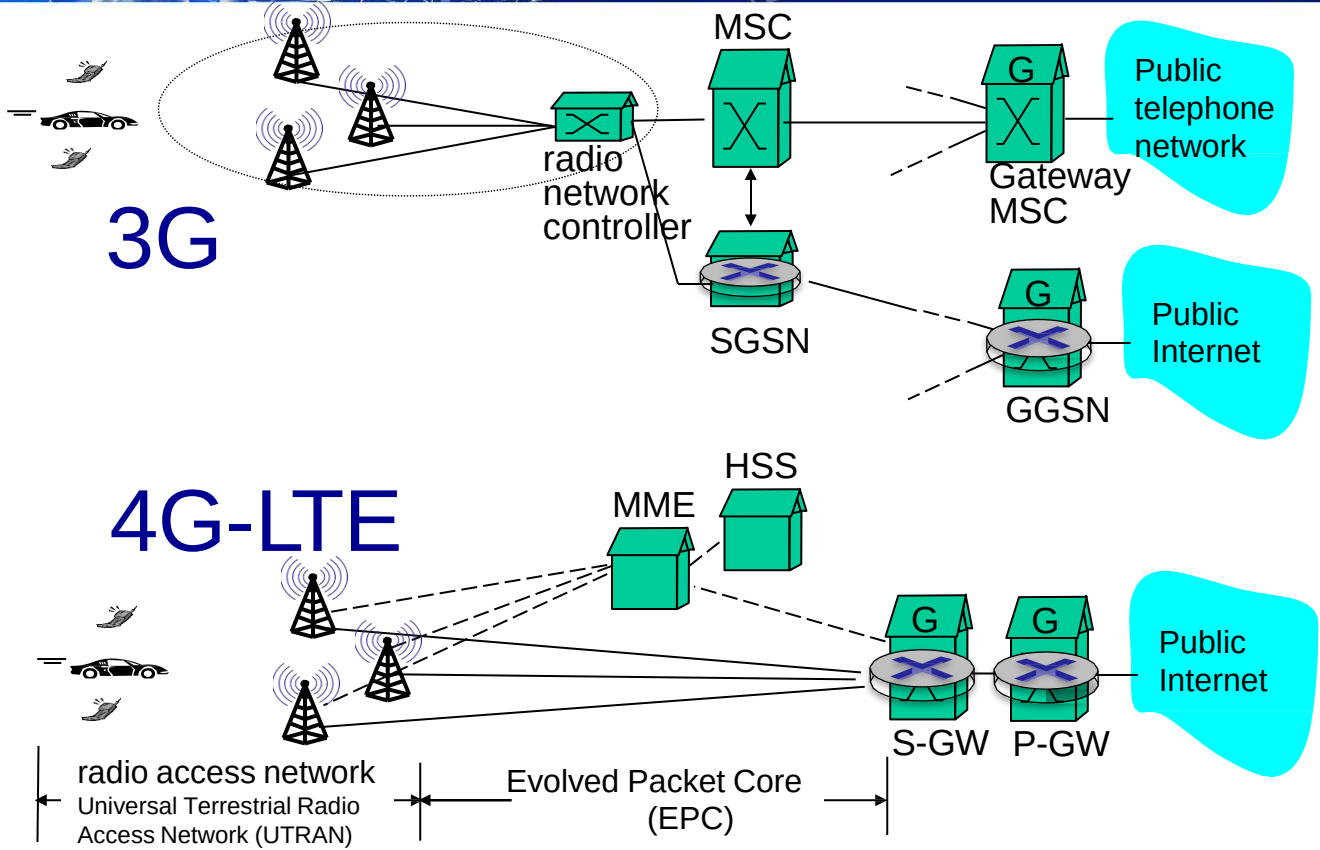
Serving GPRS Support Node (SGSN)

Gateway GPRS Support Node (GGSN)

3G (voice+data) network architecture

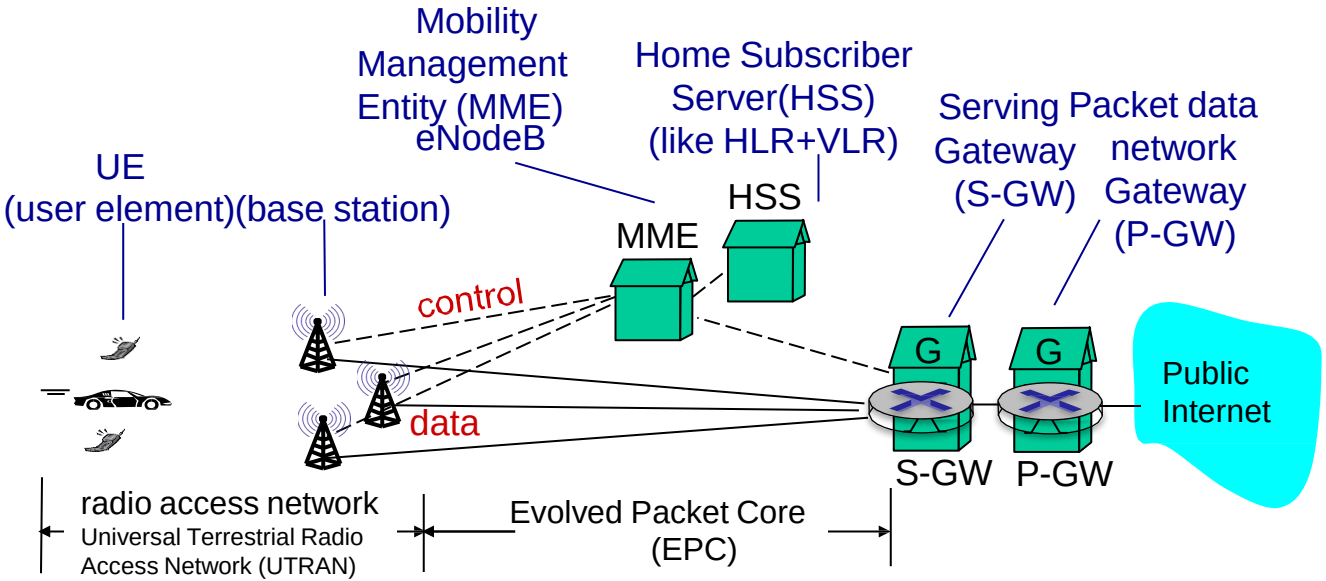


3G versus 4G LTE network architecture

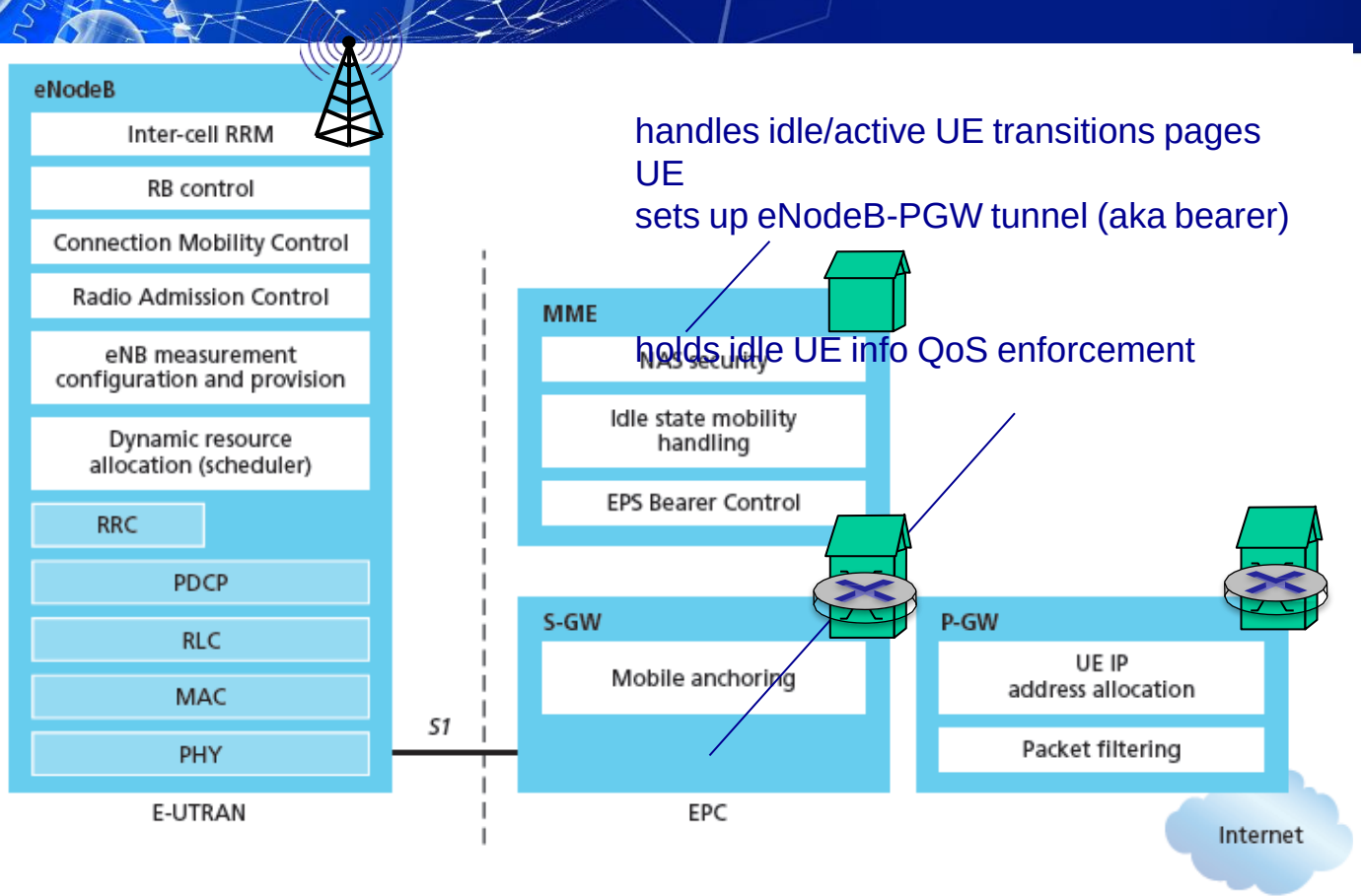


4G: differences from 3G

- all IP core: IP packets tunneled (through core IP network) from base station to gateway
- no separation between voice and data – all traffic carried over IP core to gateway



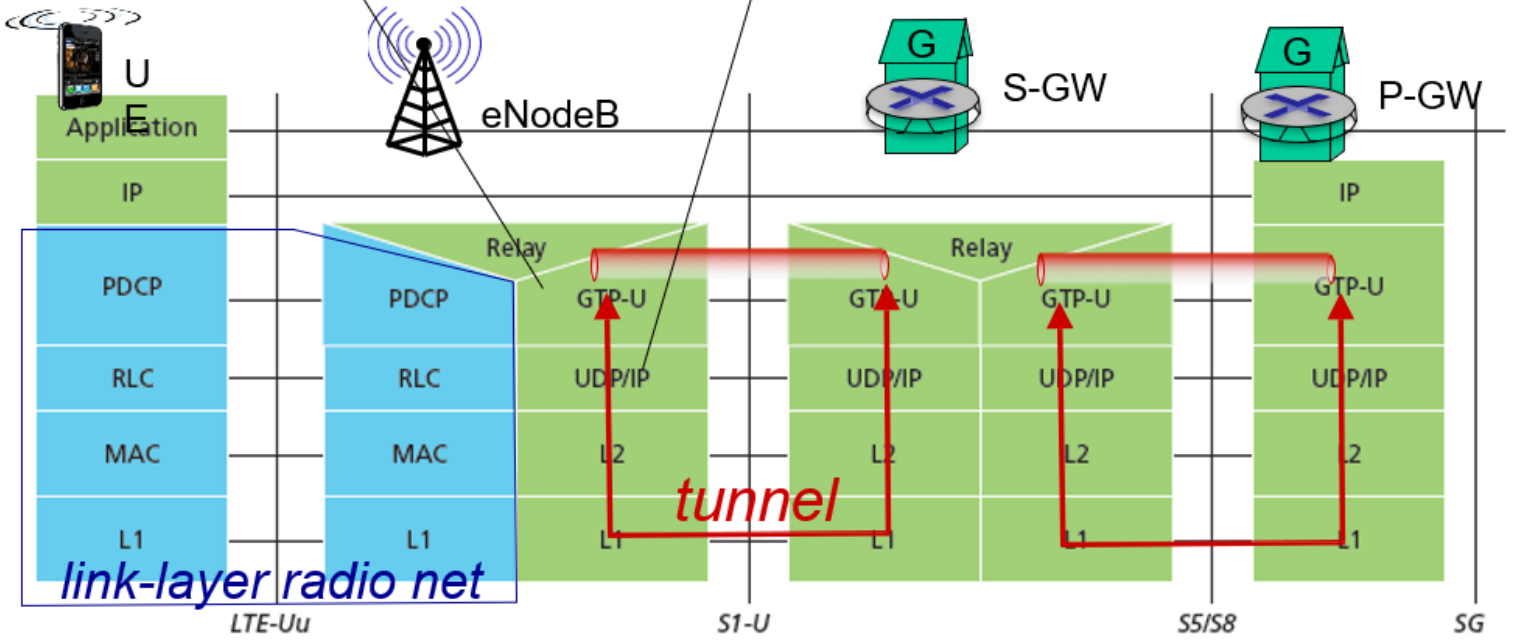
Functional split of major LTE components



Radio+Tunneling: UE – eNodeB – PGW

IP packet from UE encapsulated in GPRS Tunneling Protocol (GTP) message at ENodeB

GTP message encapsulated in UDP, then encapsulated in IP. large IP packet addressed to SGW



Quality of Service in LTE

- QoS from eNodeB to SGW: min and max guaranteed bit rate
- QoS in radio access network: one of 12 QCI values

QCI	RESOURCE TYPE	PRIORITY	PACKET DELAY BUDGET (MS)	PACKET ERROR LOSS RATE	EXAMPLE SERVICES
1	GBR	2	100	10^{-2}	Conversational voice
2	GBR	4	150	10^{-3}	Conversational video (live streaming)
3	GBR	5	300	10^{-6}	Non-conversational video (buffered streaming)
4	GBR	3	50	10^{-3}	Real-time gaming
5	Non-GBR	1	100	10^{-6}	IMS signaling
6	Non-GBR	7	100	10^{-3}	Voice, video (live streaming), interactive gaming
7	Non-GBR	6	300	10^{-6}	Video (buffered streaming)
8	Non-GBR	8	300	10^{-6}	TCP-based (for example, WWW, e-mail), chat, FTP, p2p file sharing, progressive video and others
9	Non-GBR	9	300	10^{-6}	

END