

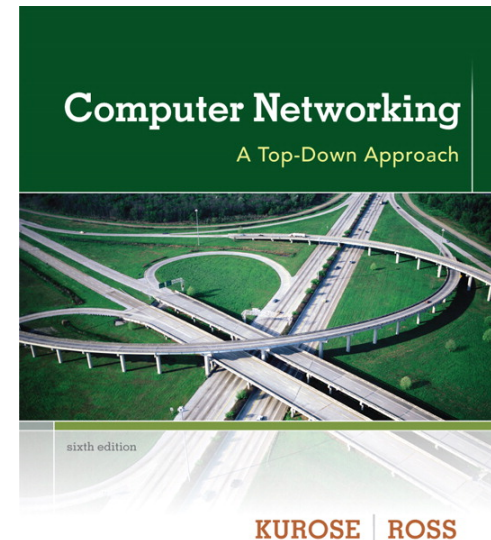
Chapter 6

Wireless and

Mobile Networks

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*Computer
Networking: A Top
Down Approach*
6th edition
Jim Kurose, Keith Ross
Addison-Wesley
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Chapter 6 outline

Wireless

- 6.1 Background & Introduction
- 6.2 Wireless links, characteristics
- 6.3 IEEE 802.11 wireless LANs (“Wi-Fi”)
- 6.4 Cellular Internet Access
 - Cellular Architecture

Mobility

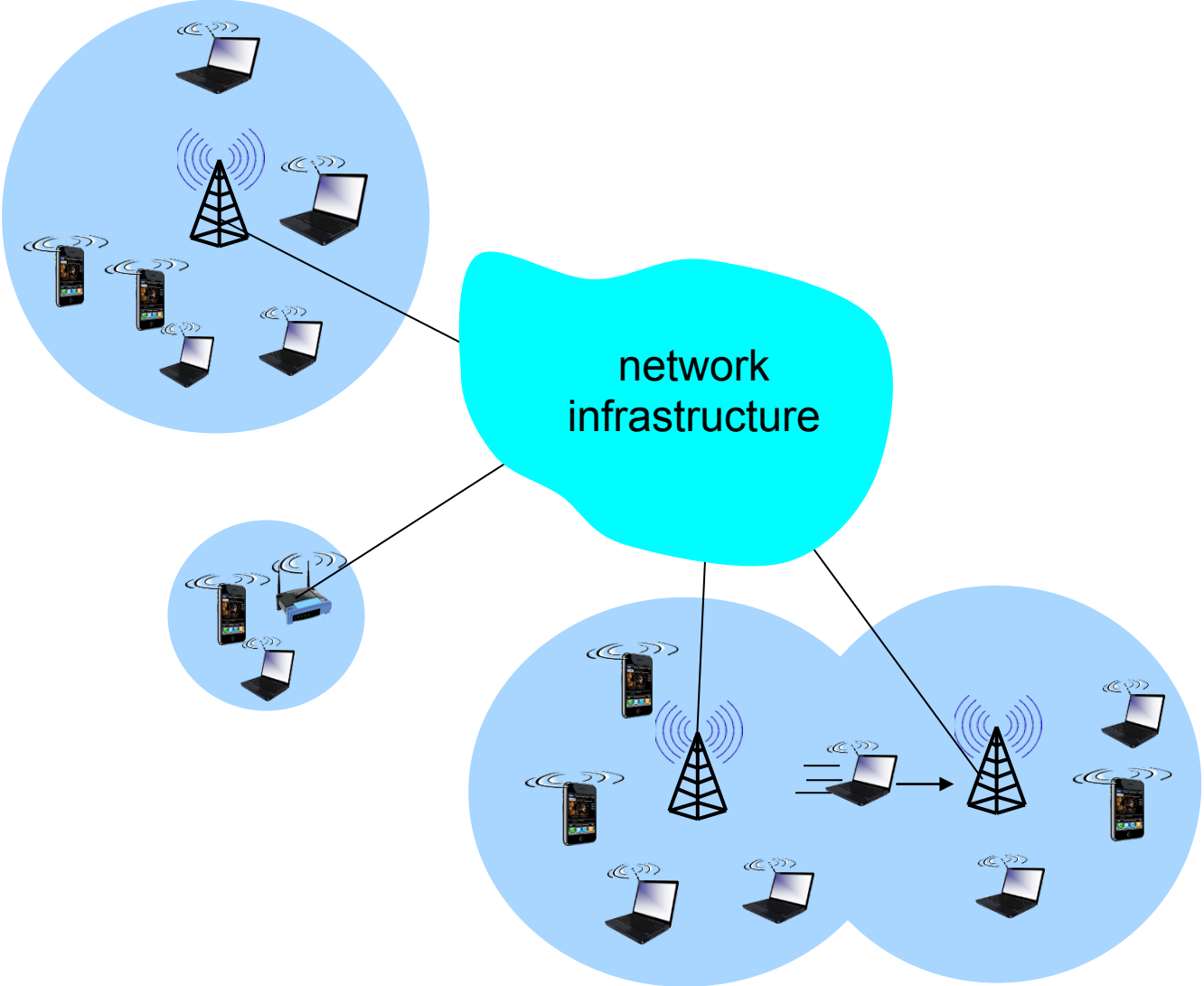
- 6.5 Principles: addressing, routing to mobile users
 - Home, Visited networks
 - *Care-of-addresses*, foreign agent
 - Indirect & direct routing

Ch. 6.1: Wireless and Mobile Networks

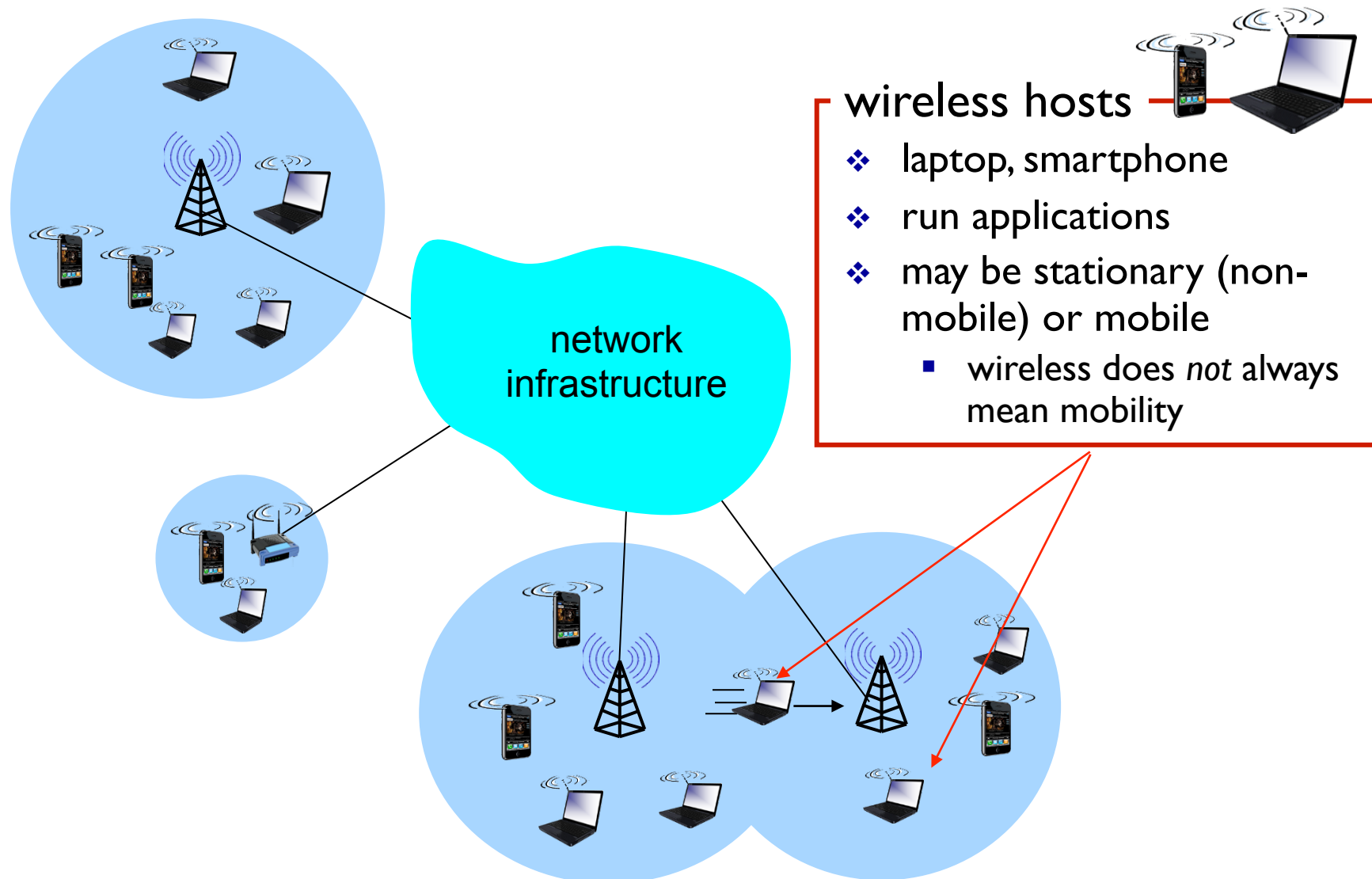
Background:

- ❖ # wireless (mobile) phone subscribers now exceeds # wired phone subscribers (5-to-1)!
- ❖ # wireless Internet-connected devices equals # wireline Internet-connected devices
 - laptops, Internet-enabled phones promise anytime untethered Internet access
- ❖ two important (but different) challenges
 - *wireless*: communication over wireless link
 - *mobility*: handling the mobile user who changes point of attachment to network

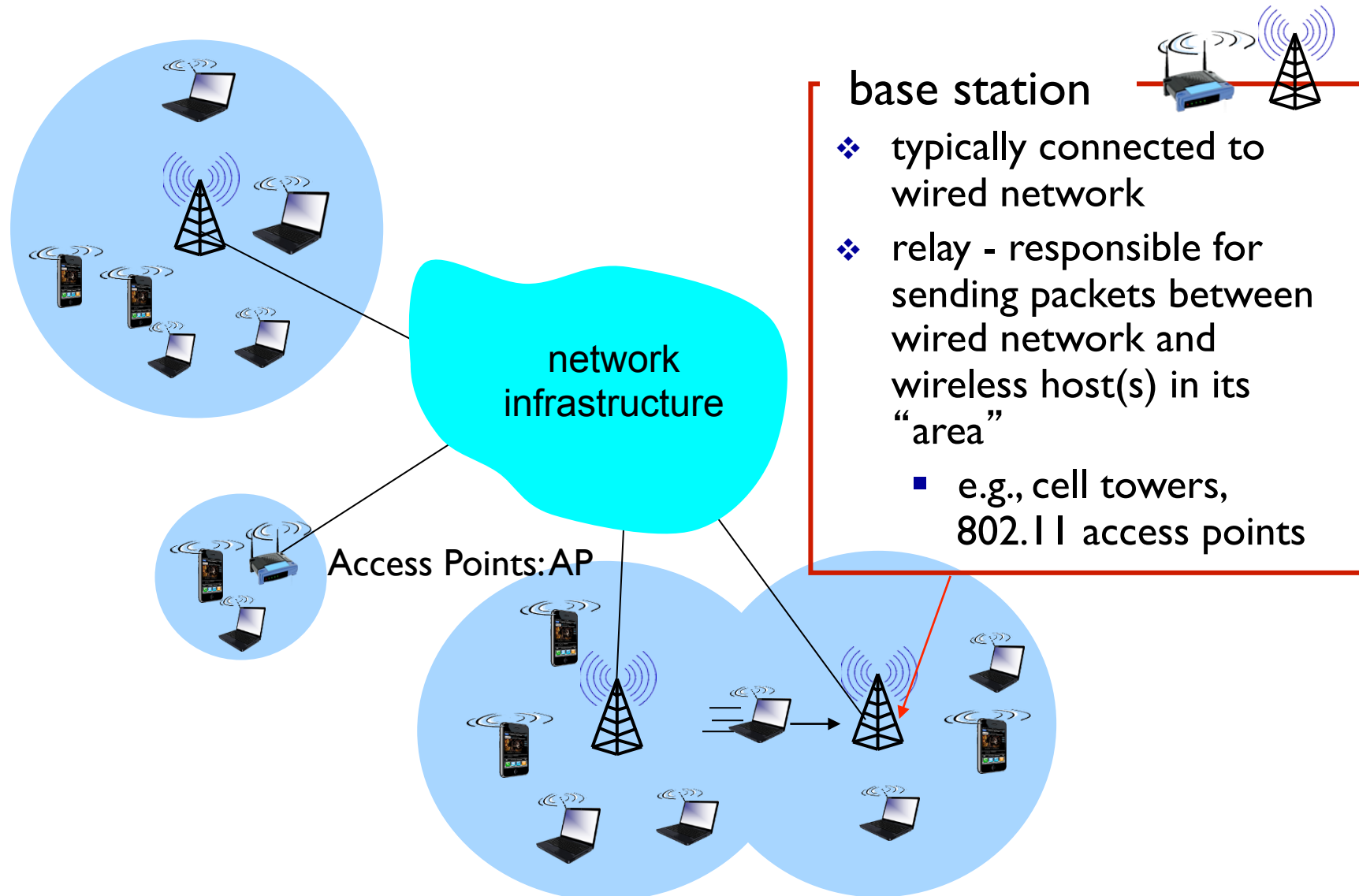
Elements of a wireless network



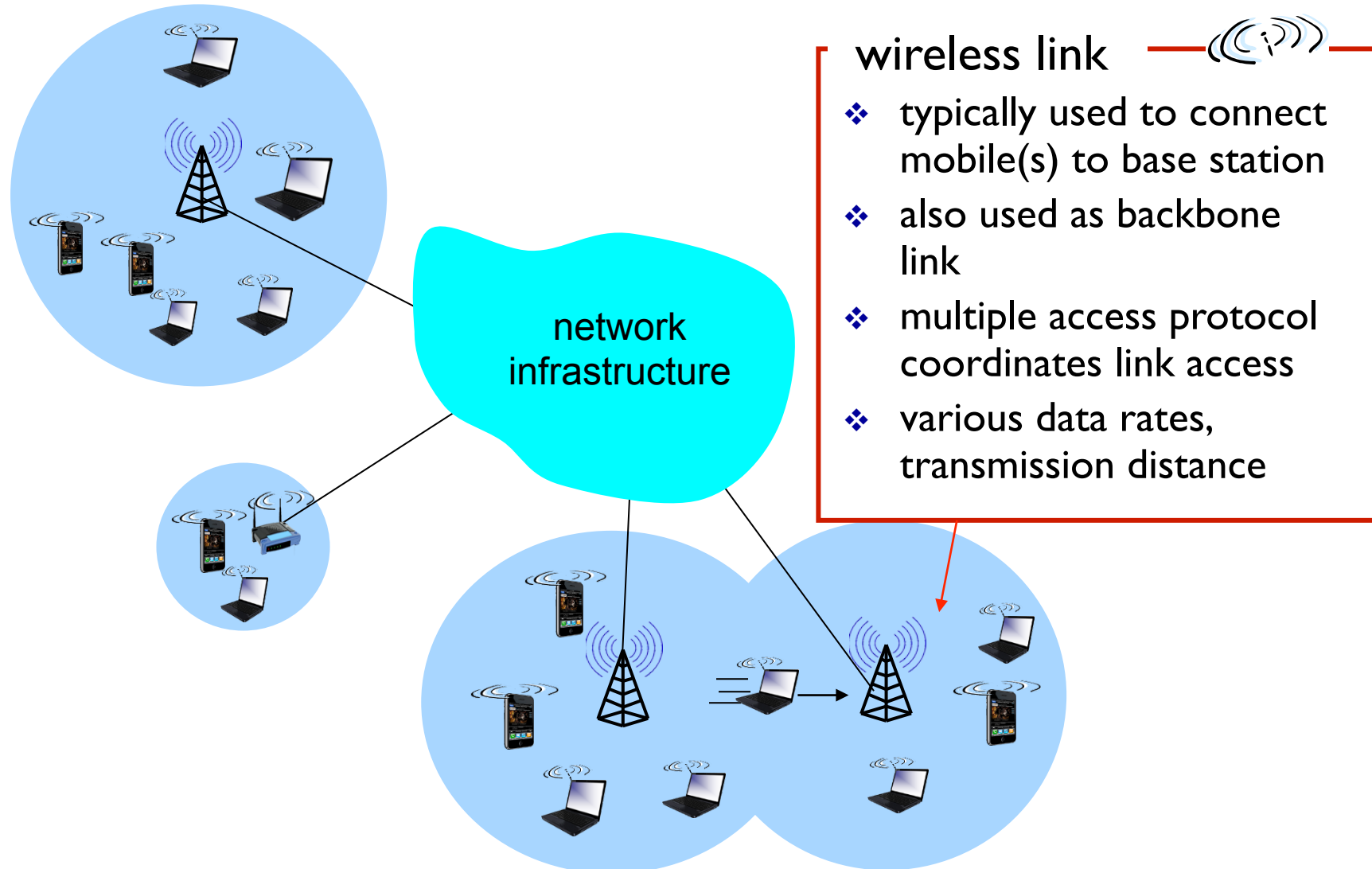
Elements of a wireless network



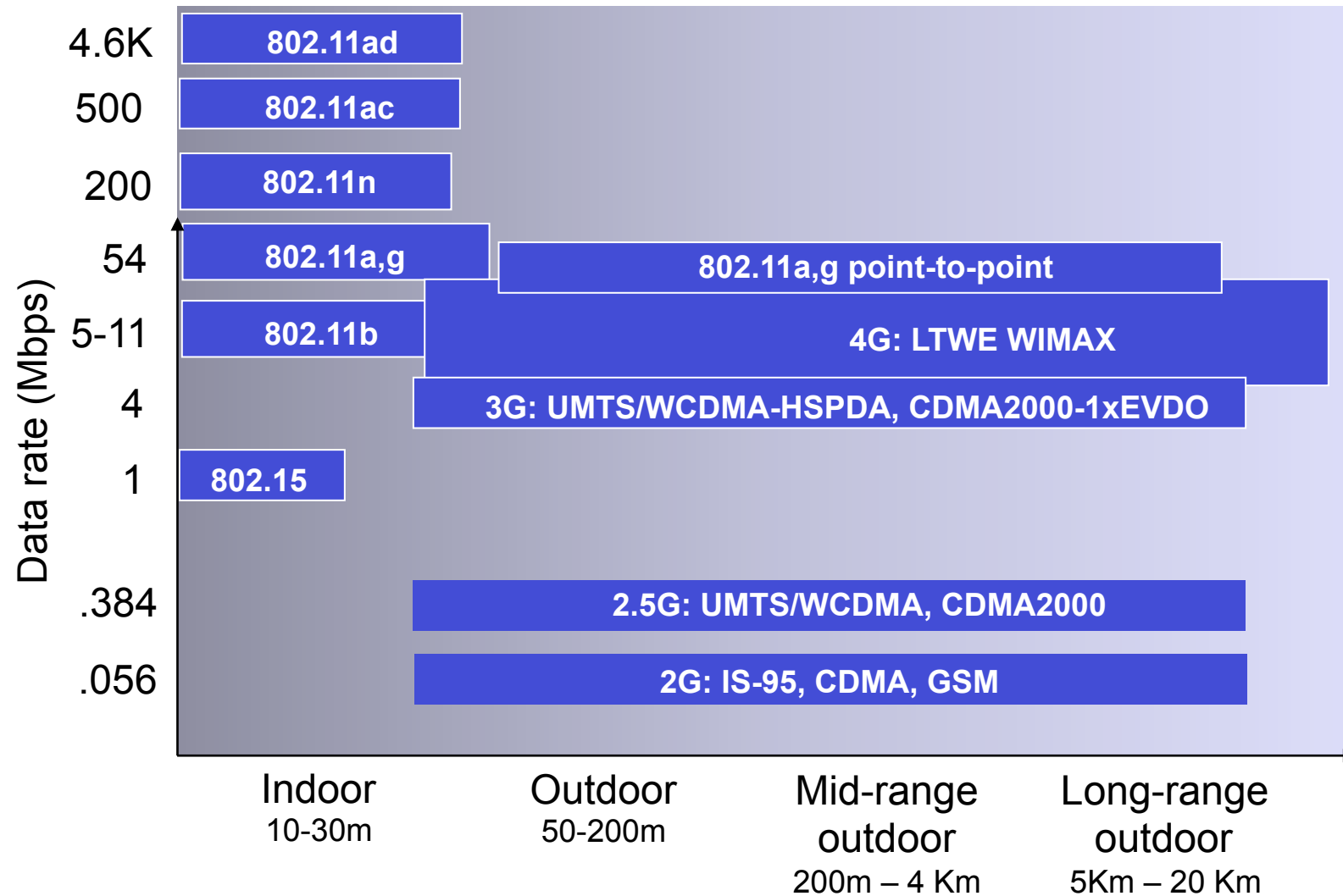
Elements of a wireless network



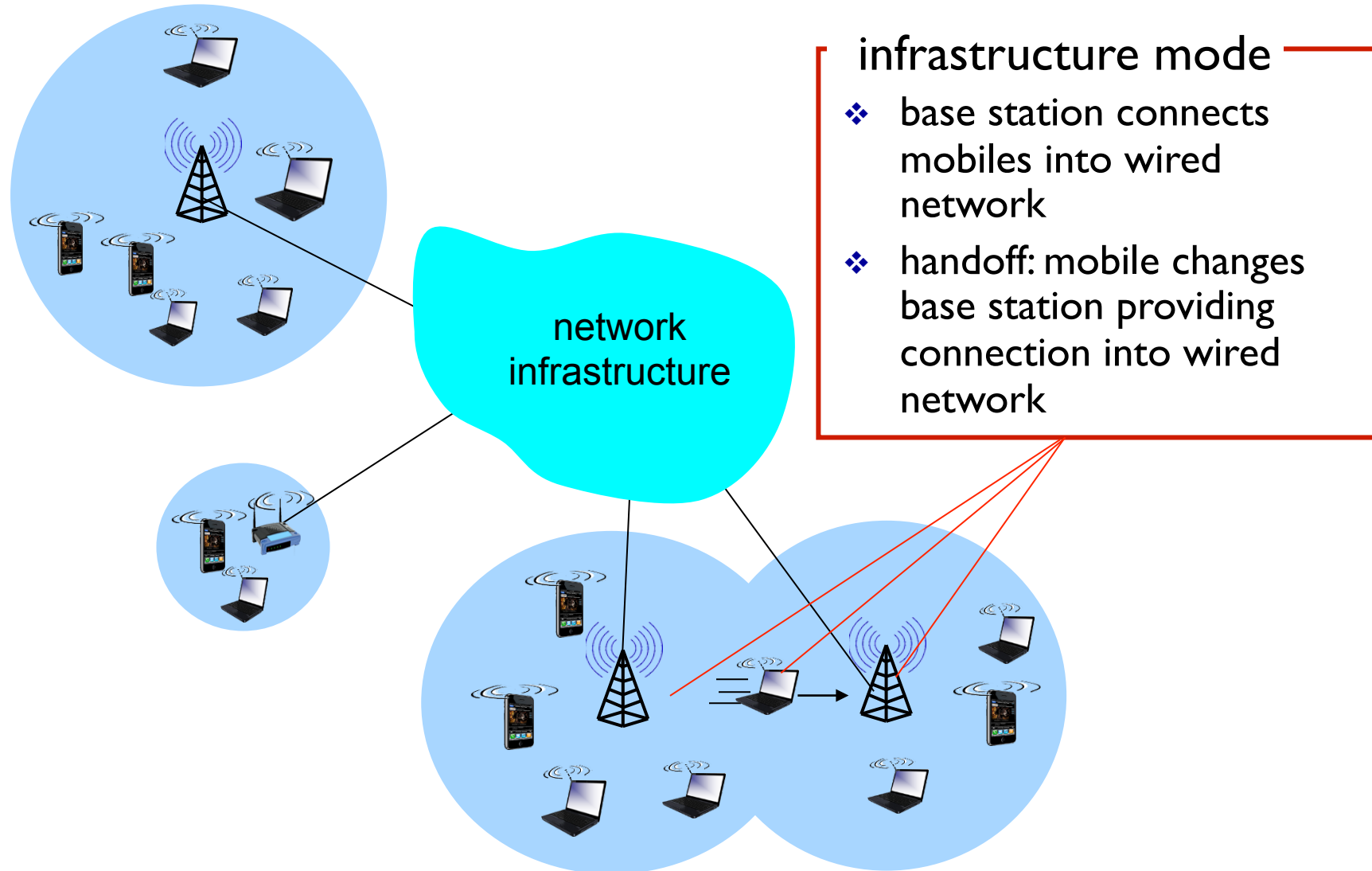
Elements of a wireless network



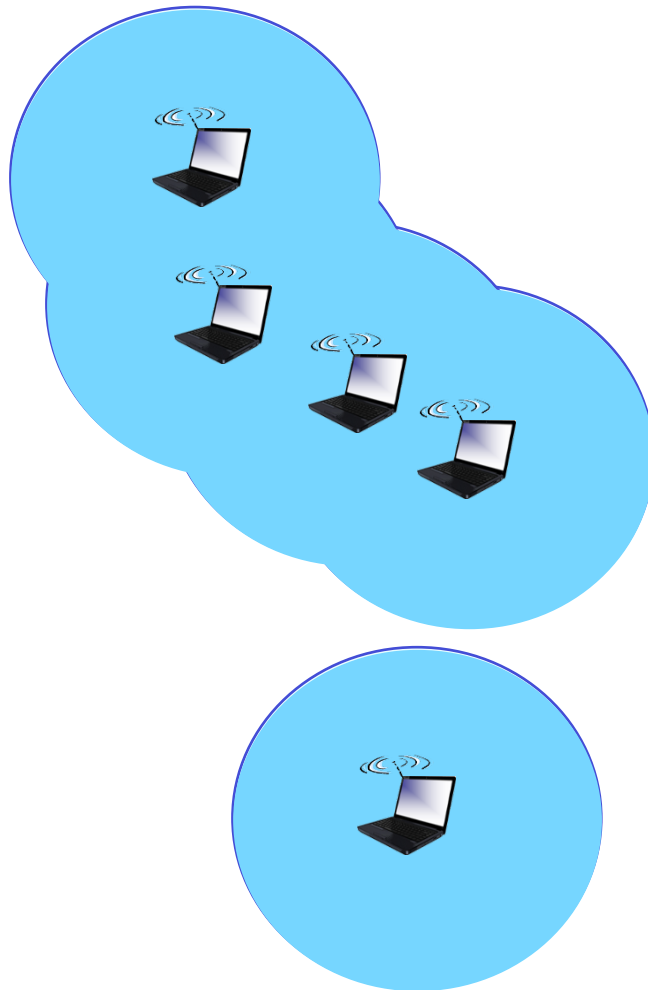
Characteristics of selected wireless links: Capacity (Data rates) & Distance



Elements of a wireless network



Elements of a wireless network



ad hoc mode

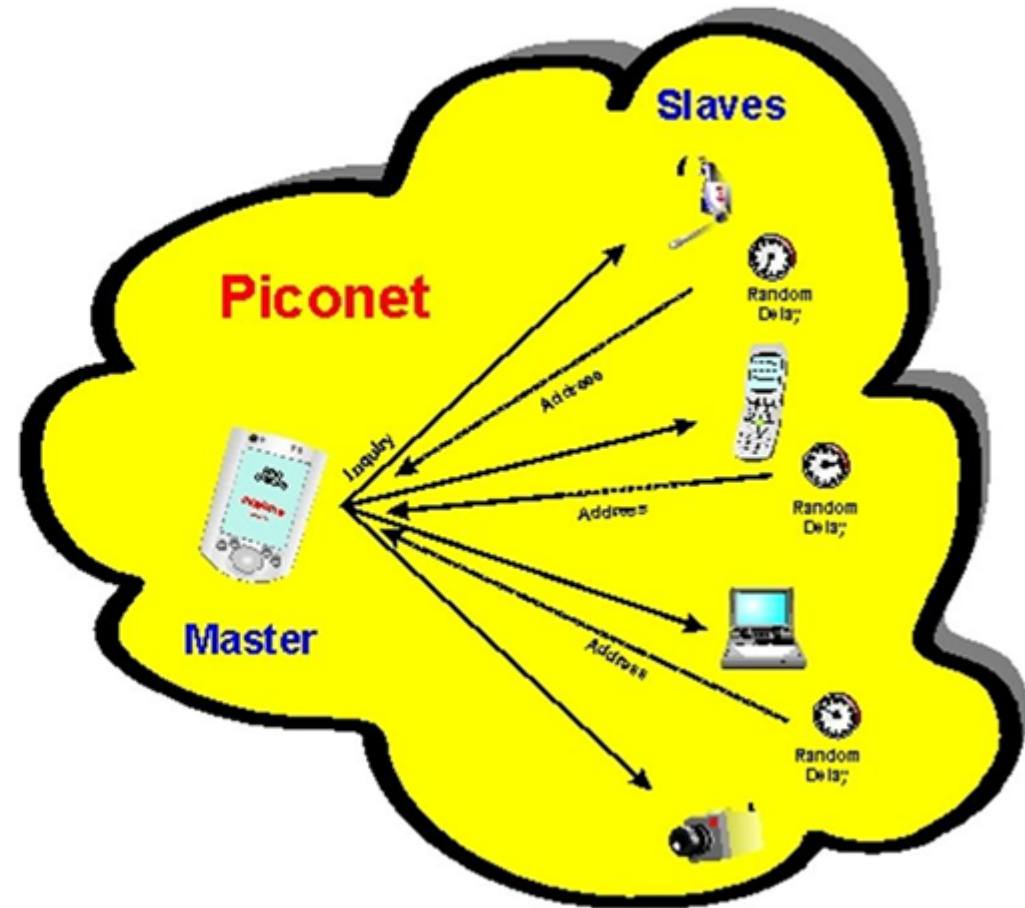
- ❖ no base stations
- ❖ nodes can only transmit to other nodes within link coverage
- ❖ nodes organize themselves into a network: route among themselves

Wireless network taxonomy

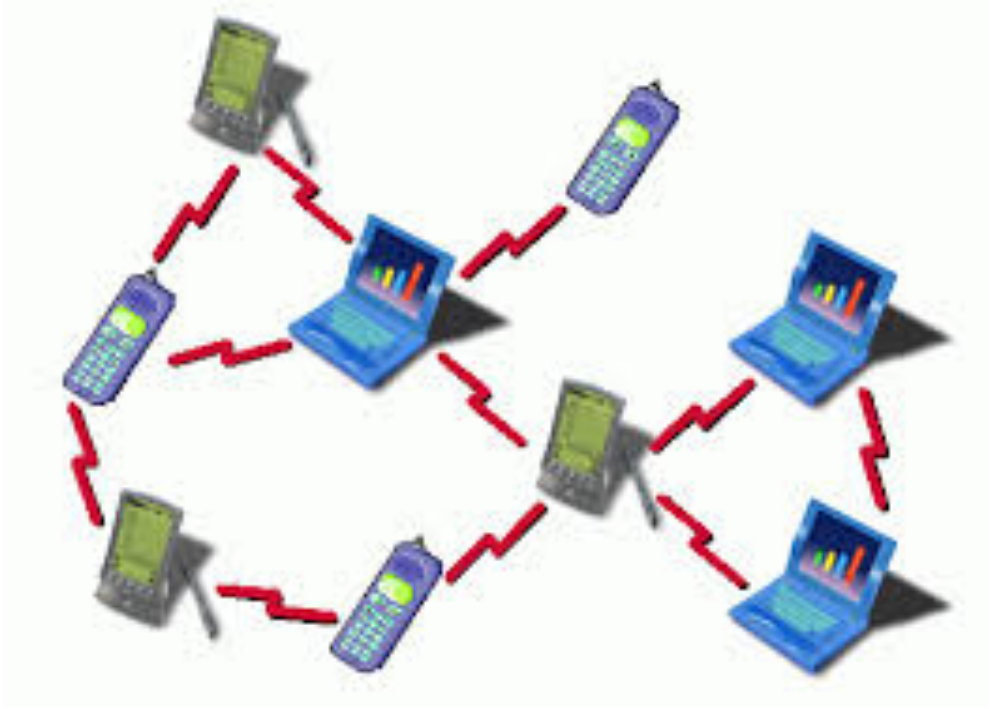
	single hop	multiple hops
infrastructure (e.g., APs)	host connects to base station (WiFi, WiMAX, cellular) which connects to larger Internet	host may have to relay through several wireless nodes to connect to larger Internet: <i>mesh net</i>
no infrastructure	no base station, no connection to larger Internet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

Example of Piconet

- ❑ Temporary Network
- ❑ Up to 8 Active Devices
- ❑ Master Coordinates the Piconet and Slaves follow the Master
- ❑ Each Bluetooth Device may Operate as Either Master or Slave



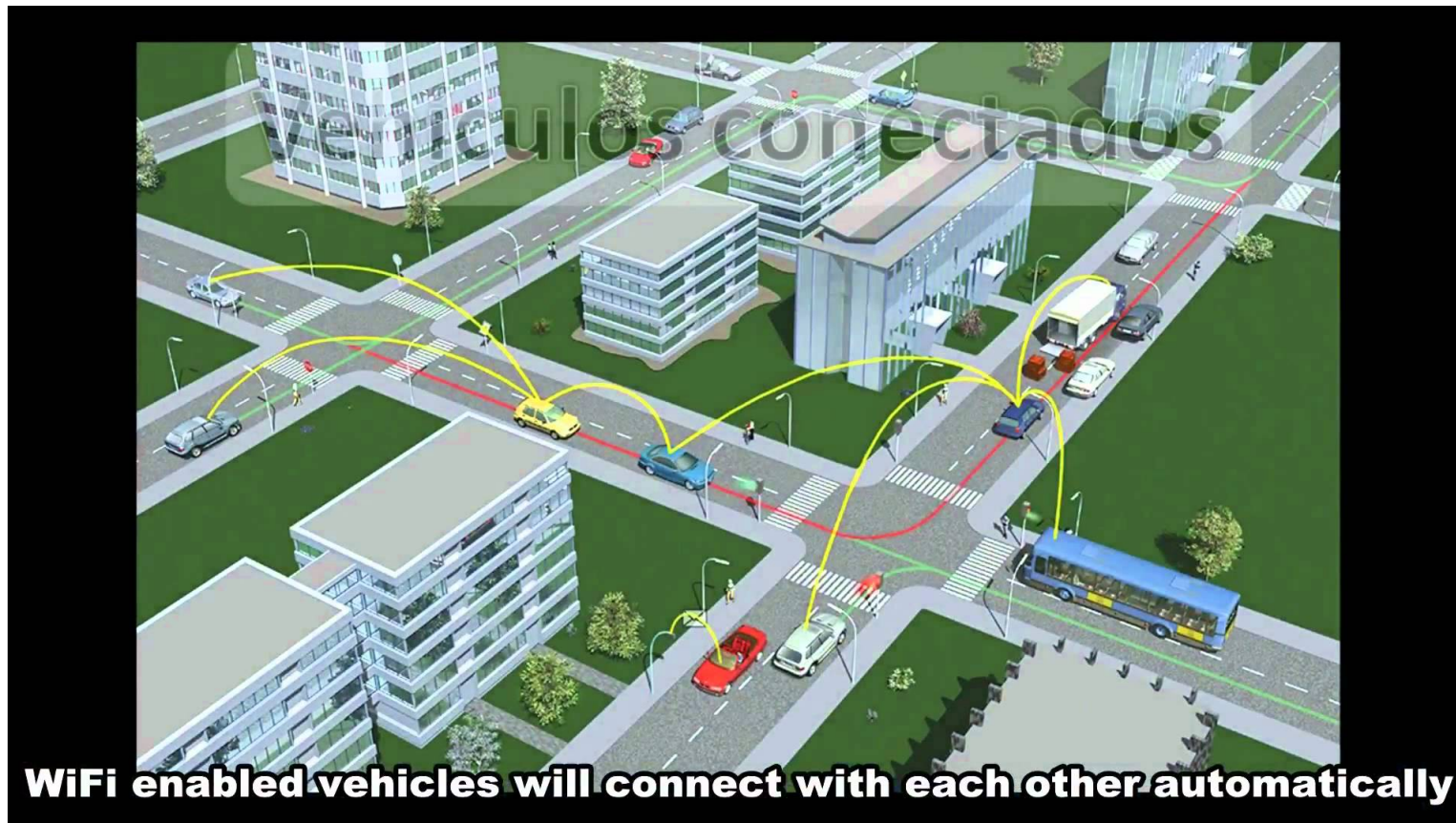
Example of MANET



- ❑ Mobile Ad Hoc Network (*MANET*): e.g for mobil device
- ❑ Non-heterogeneous nodes connected wirelessly.
- ❑ Node communicate through WiFi in Ad Hoc Mode

Example of VANET

- ❑ Vehicular Ad-Hoc Network (VANET): e.g. for moving car
- ❑ Heterogeneous nodes connected wirelessly.
- ❑ Node communicate through WiFi in Ad Hoc Mode



6.2: Wireless Link Characteristics (I)

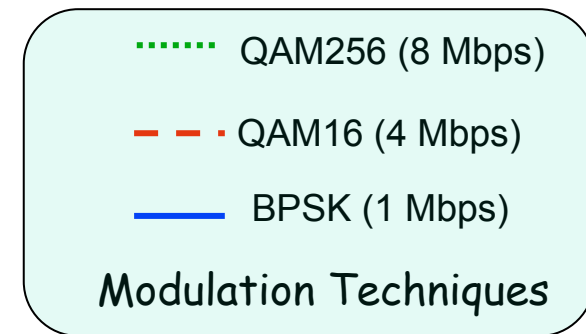
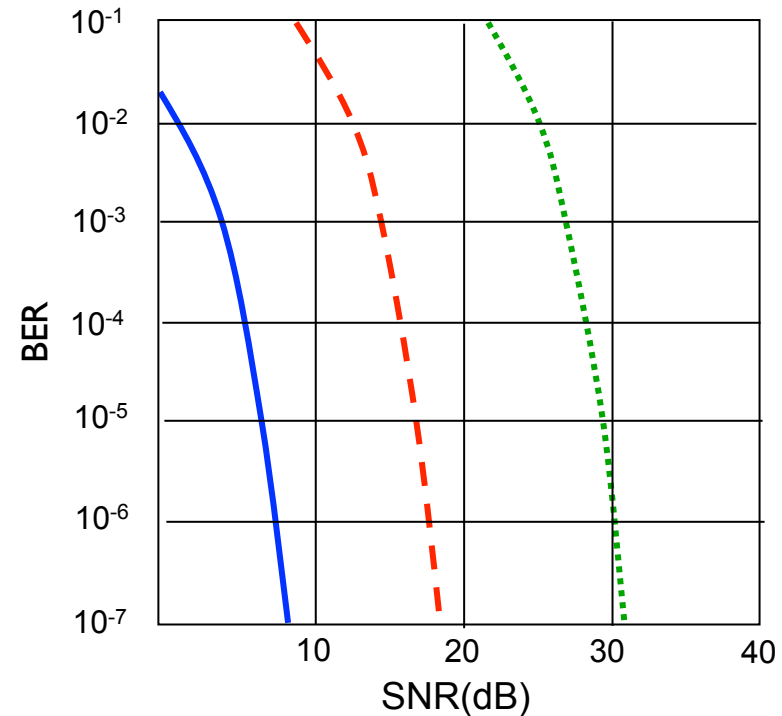
- *important* differences from wired link as wireless link can have:
 - *decreased signal strength*: radio signal attenuates as it propagates through matter (path loss)
 - *interference from other sources*: standardized wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone);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

.... make communication across (even a point to point) wireless link much more “difficult”

Wireless Link Characteristics (2)

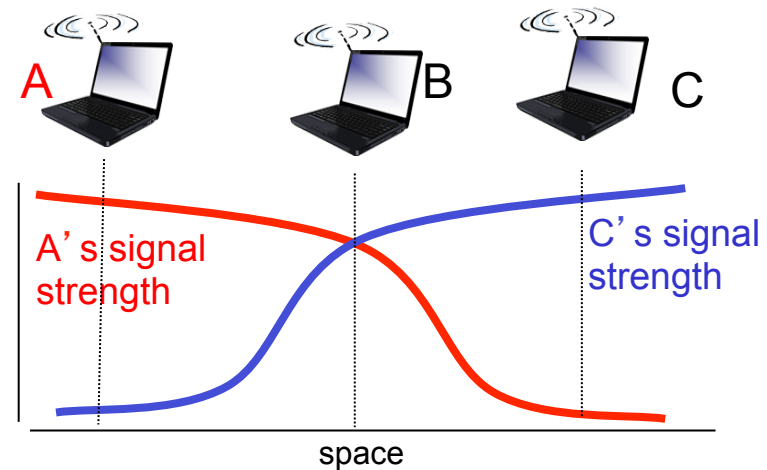
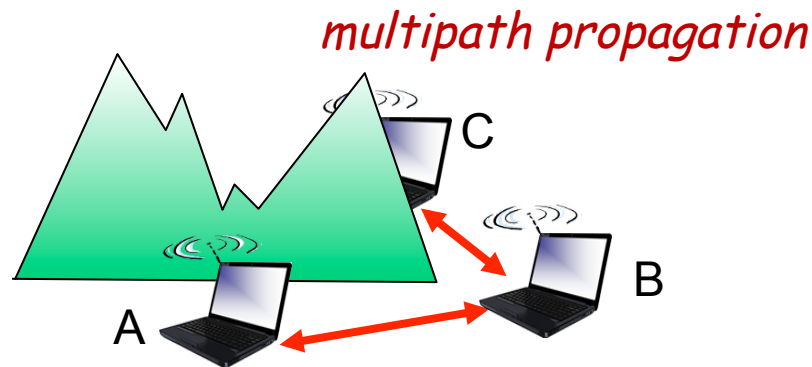
decreased signal strength

- ❖ *SNR: signal-to-noise ratio*
 - larger SNR – easier to extract signal from noise (a “good thing”)
- ❖ *SNR versus BER tradeoffs*
 - Bit error rate (*BER*) is the number of bit errors divided by the total number of transferred bits
 - *given physical layer*: increase power - > increase SNR->decrease BER
 - *given SNR*: choose physical layer that meets BER requirement, giving highest throughput
 - SNR may change with mobility: dynamically adapt physical layer (modulation technique, rate)



Wireless network characteristics (3)

Multiple wireless senders and receivers create additional problems (beyond multiple access): *interference from other sources*



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

6.3: IEEE 802.11 Wireless LAN

802.11b

- ❖ 2.4-5 GHz unlicensed spectrum
- ❖ up to 11 Mbps
- ❖ direct sequence spread spectrum (DSSS) in physical layer
 - all hosts use same chipping code

802.11a

- 5-6 GHz range
- up to 54 Mbps

802.11g

- 2.4-5 GHz range
- up to 54 Mbps

802.11n: multiple antennae

- 2.4-5 GHz range
- up to 200 Mbps

802.11ac: multiple antennae

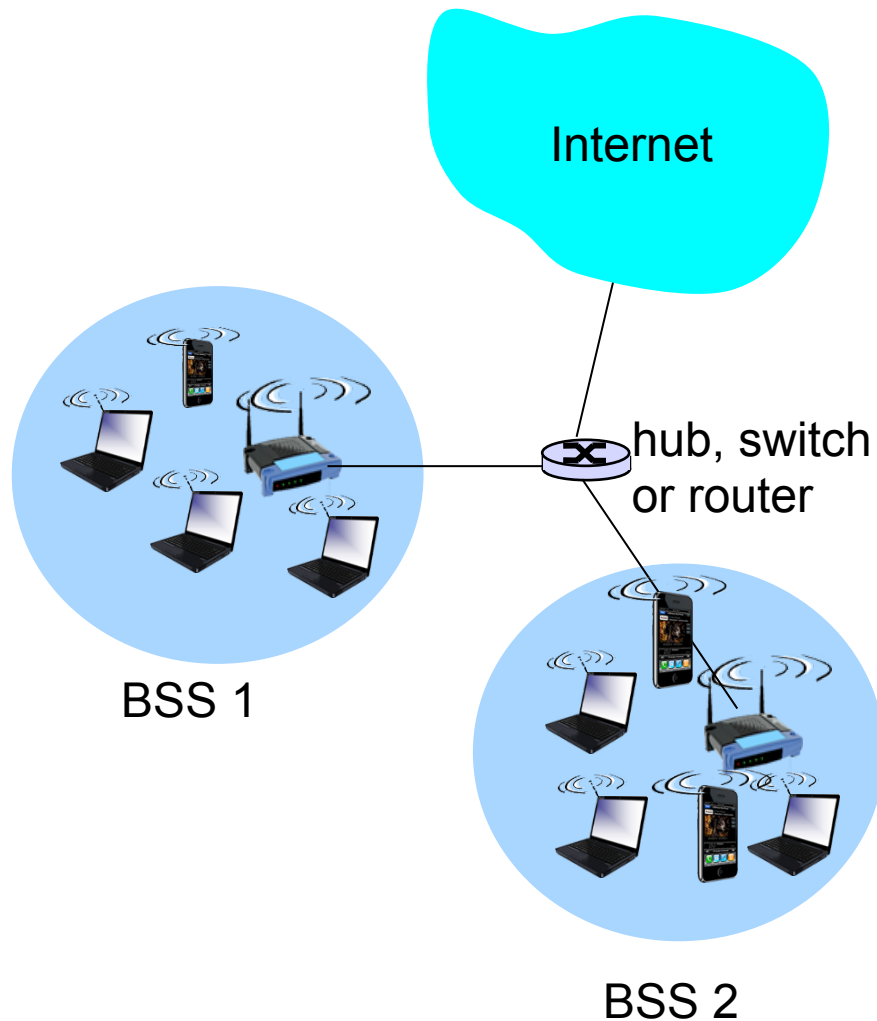
- 5 GHz range
- 500 Mbps – 1 Gbps

802.11ad: multiple antennae

- 60 GHz range
- 4.6 Gbps

- ❖ all use CSMA/CA for multiple access
- ❖ all have base-station and ad-hoc network versions

802.11 LAN 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: Channels, association (Host-AP)

- ❖ **802.11b: 2.4GHz-2.485GHz** spectrum divided into **11 channels** at different frequencies
 - AP admin chooses frequency for AP
 - interference possible: channel can be same as that chosen by neighboring AP!
- ❖ **host: must *associate* with an AP**
 - scans channels, listening for *beacon frames* containing AP's name and MAC address
 - selects AP to associate with
 - may perform authentication [Chapter 8]
 - will typically run DHCP to get IP address in AP's subnet

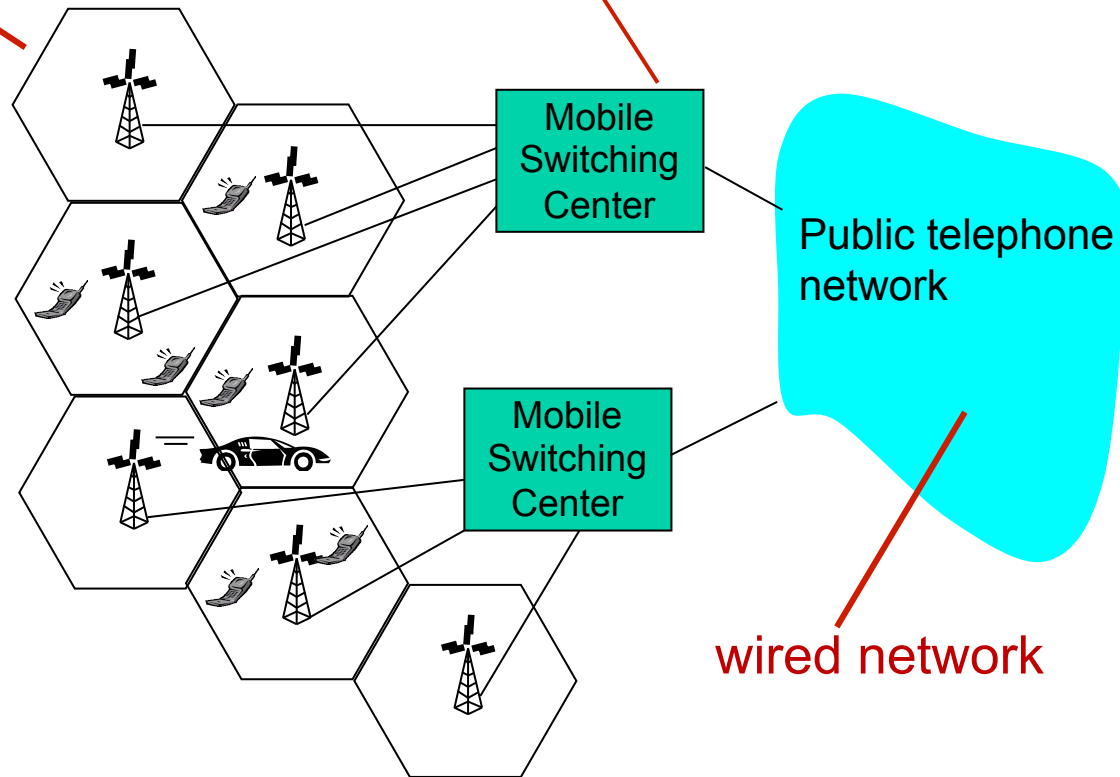
6.4: Cellular Network Architecture: Components

cell

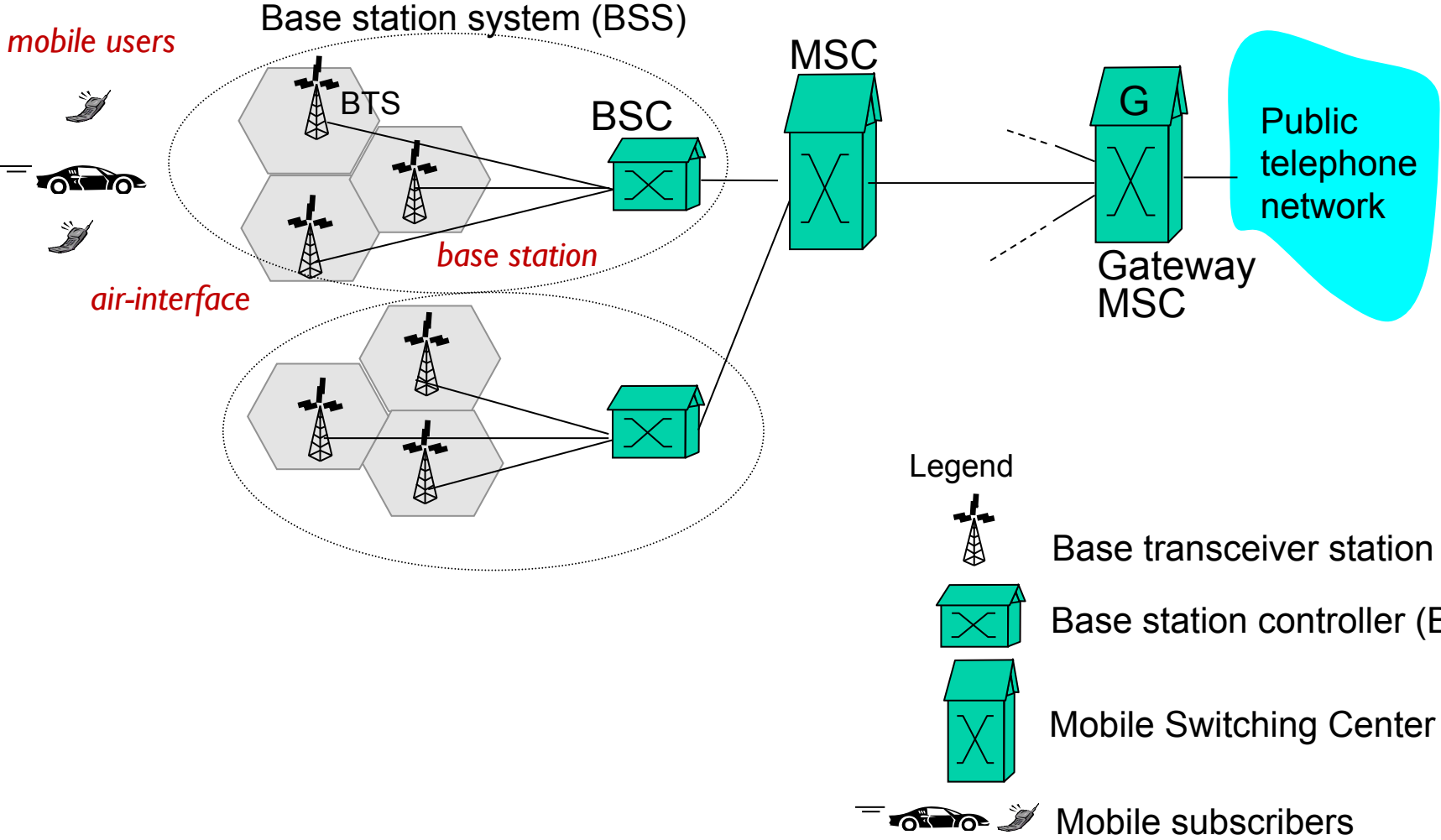
- ❖ covers geographical region
- ❖ *base station* (BS) analogous to 802.11 AP
- ❖ *mobile users* attach to network through BS
- ❖ *air-interface*: physical and link layer protocol between mobile and BS

MSC

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



Cellular Network Architecture: 2G (voice)



Cellular Network Architecture: 3G (voice+data)

Overview

- To enable users access to the Internet requires technology beyonds 2G.
 - read email, access the Web, and watch streaming video - required a full TCP/IP protocol stack and connect into the Internet via the cellular data network.
- focus on the UMTS (Universal Mobile Telecommunications Service) 3G standards

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

Cellular Network Architecture: 3G (voice+data)

There are two types of nodes in the 3G core network:

Serving GPRS Support Nodes (SGSNs)

Gateway GPRS Support Nodes (GGSNs)

Serving GPRS Support Nodes (SGSNs)

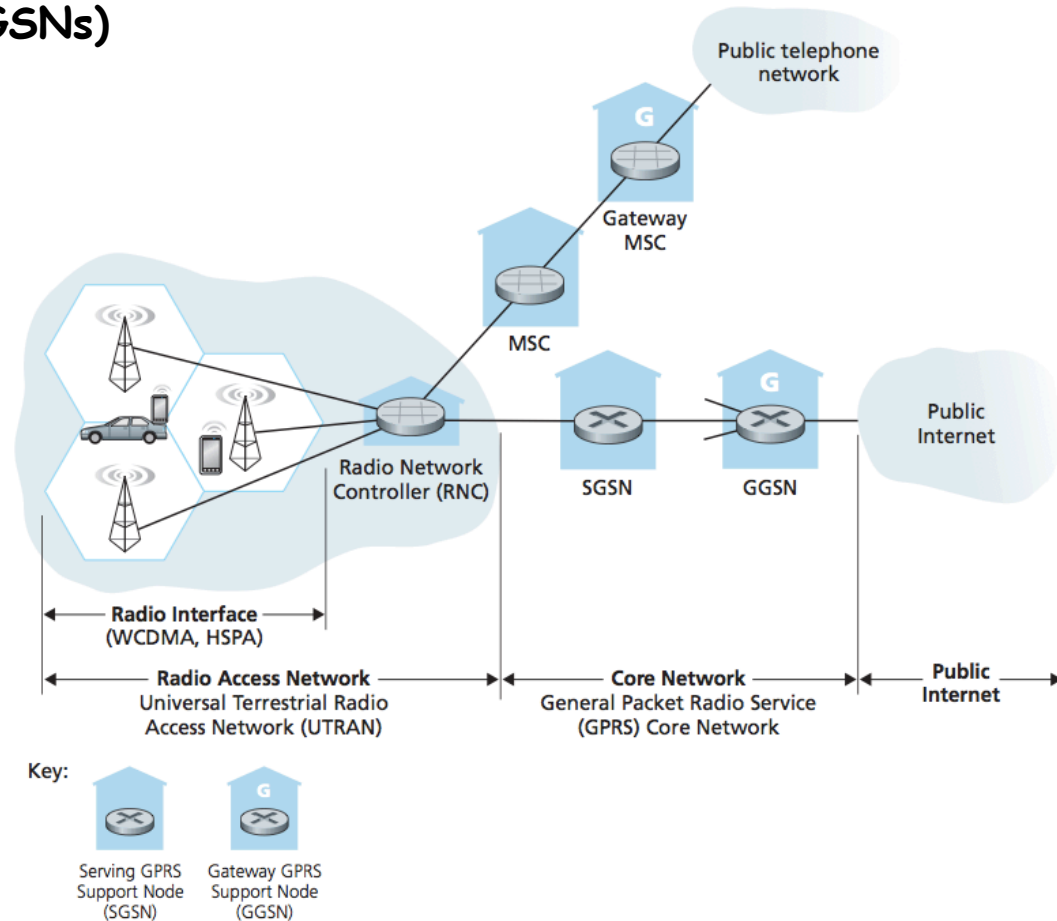
responsible for delivering datagrams to/from the mobile nodes in the radio access network to which the SGSN is attached.

interacts with the cellular voice network's MSC for that area, providing:

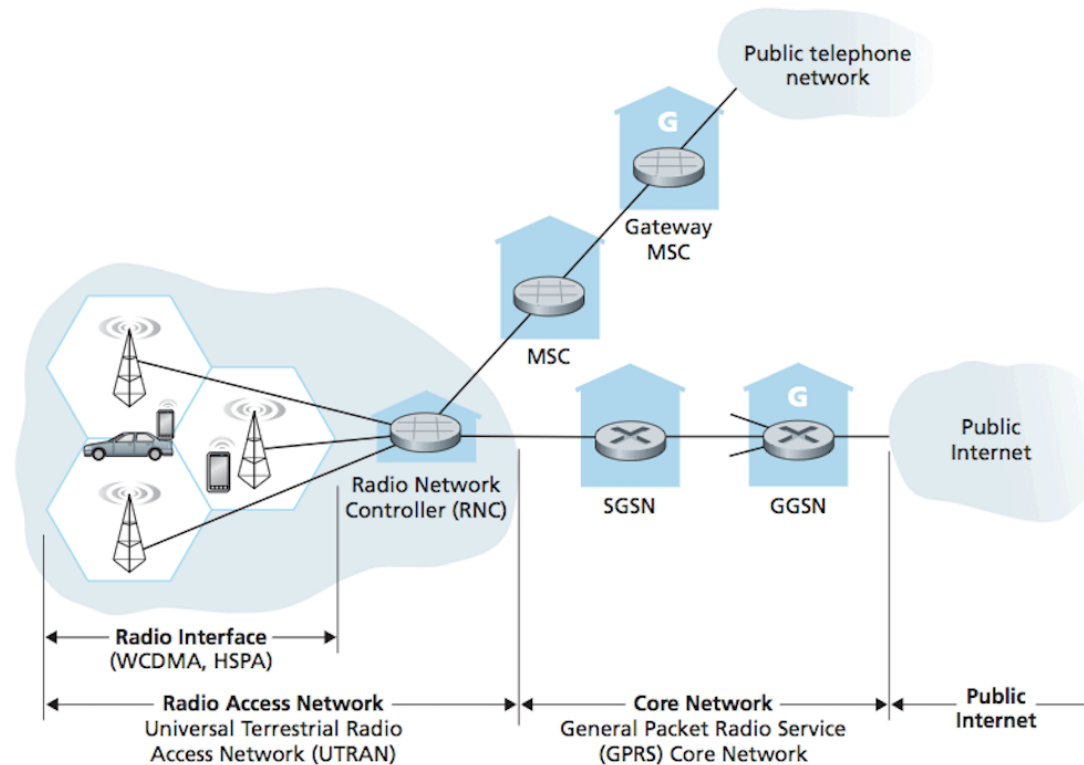
- user authorization and handoff

- maintaining location (cell) information about active mobile nodes

- performing datagram forwarding between mobile nodes in the radio access network and a GGSN.



Cellular Network Architecture: 3G (voice+data)

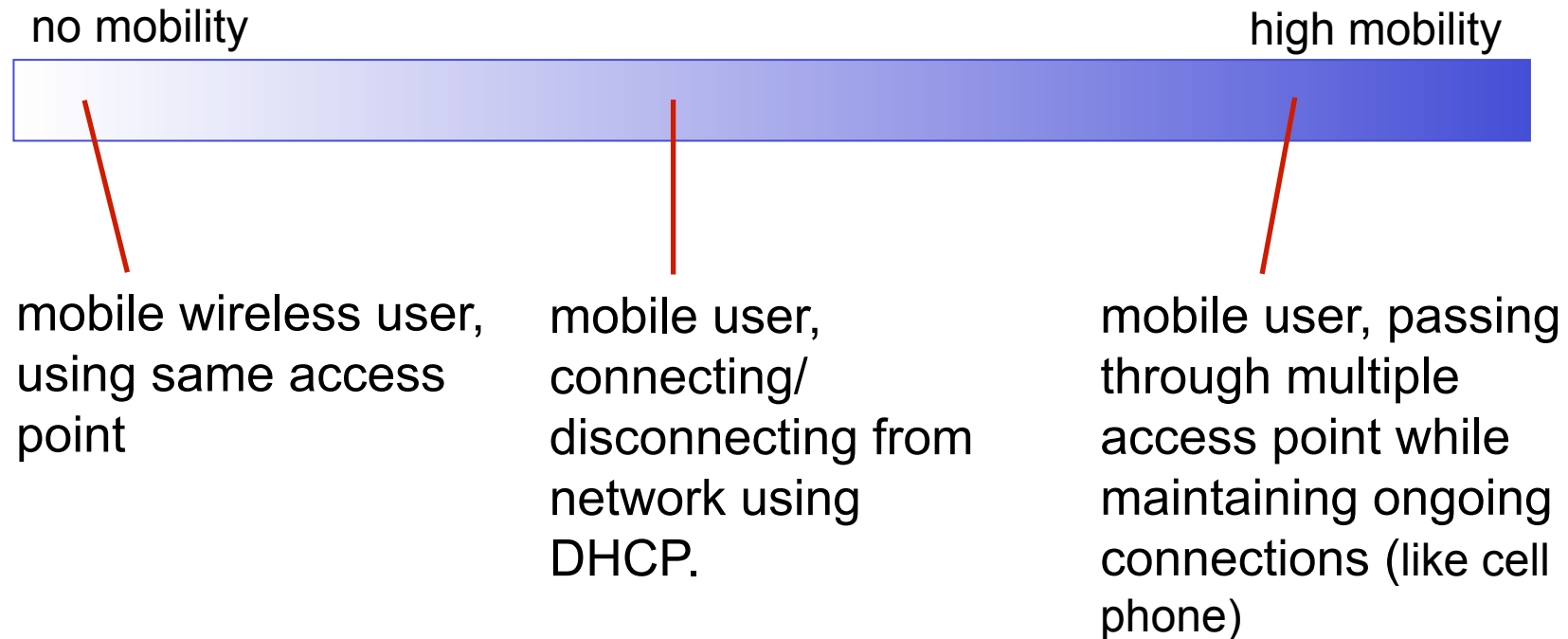


Gateway GPRS Support Nodes (GGSNs)

acts as a gateway, connecting multiple SGSNs into the larger Internet. It is the last piece of 3G infrastructure that a datagram originating at a mobile node encounters before entering the larger Internet. To the outside world, the GGSN looks like any other gateway router.

6.5: What is mobility?

- ❖ spectrum of mobility, from the *network* perspective:



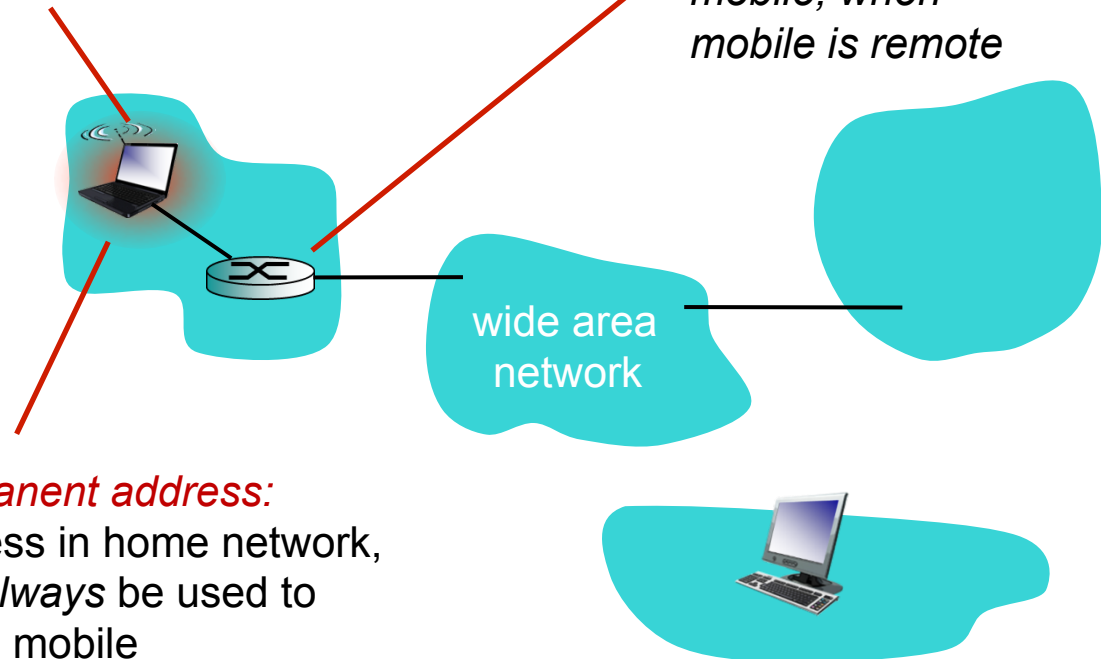
Mobility: vocabulary

❖ **home network:** network of cellular provider you subscribe to (e.g., Sprint PCS, Verizon)

❖ **home location register (HLR):** database in home network containing permanent cell phone #, profile information (services, preferences, billing), information about current location (could be in another network)

home network: permanent “home” of mobile (e.g., 128.119.40/24)

home agent: entity that will perform mobility functions on behalf of mobile, when mobile is remote



permanent address: address in home network, can always be used to reach mobile
e.g., 128.119.40.186

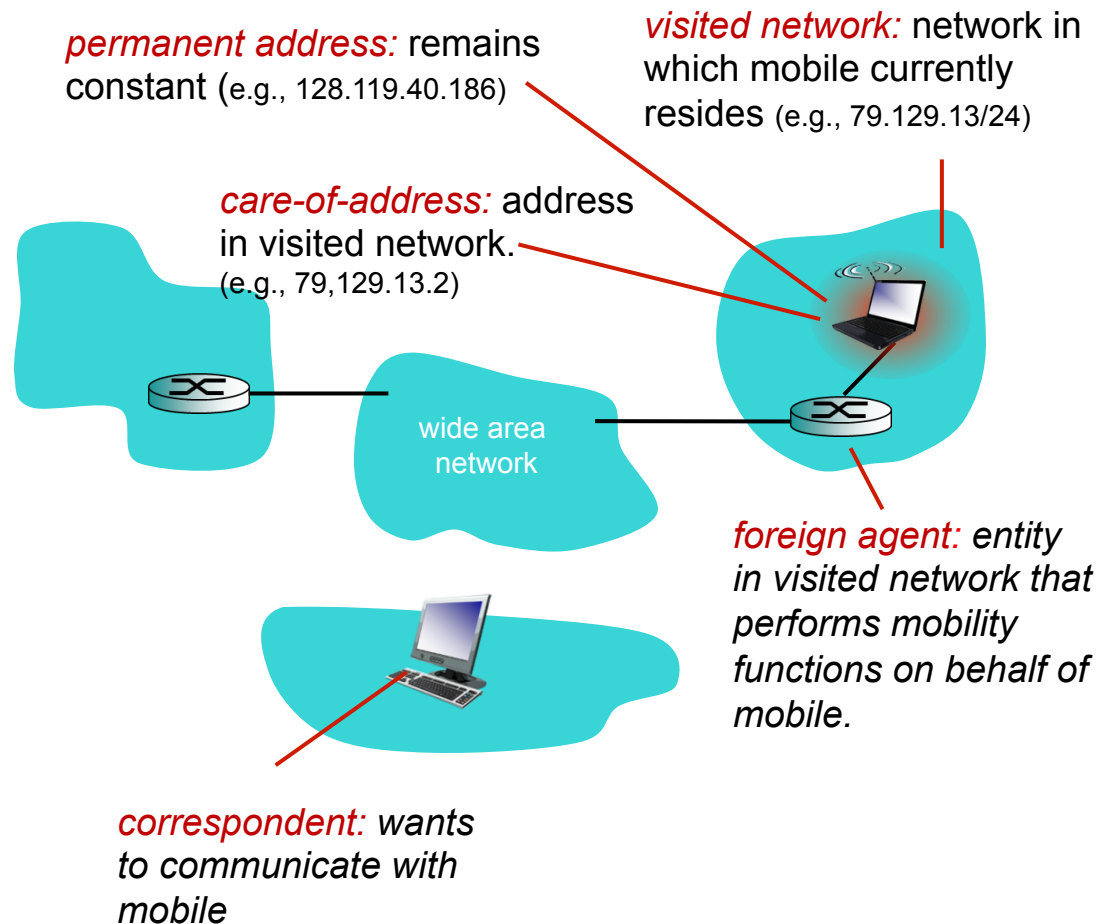
Mobility: more vocabulary

❖ mobile uses two addresses:

- **permanent address:** used by correspondent (hence mobile location is *transparent* to correspondent)
- **care-of-address:** used by home agent to forward datagrams to mobile

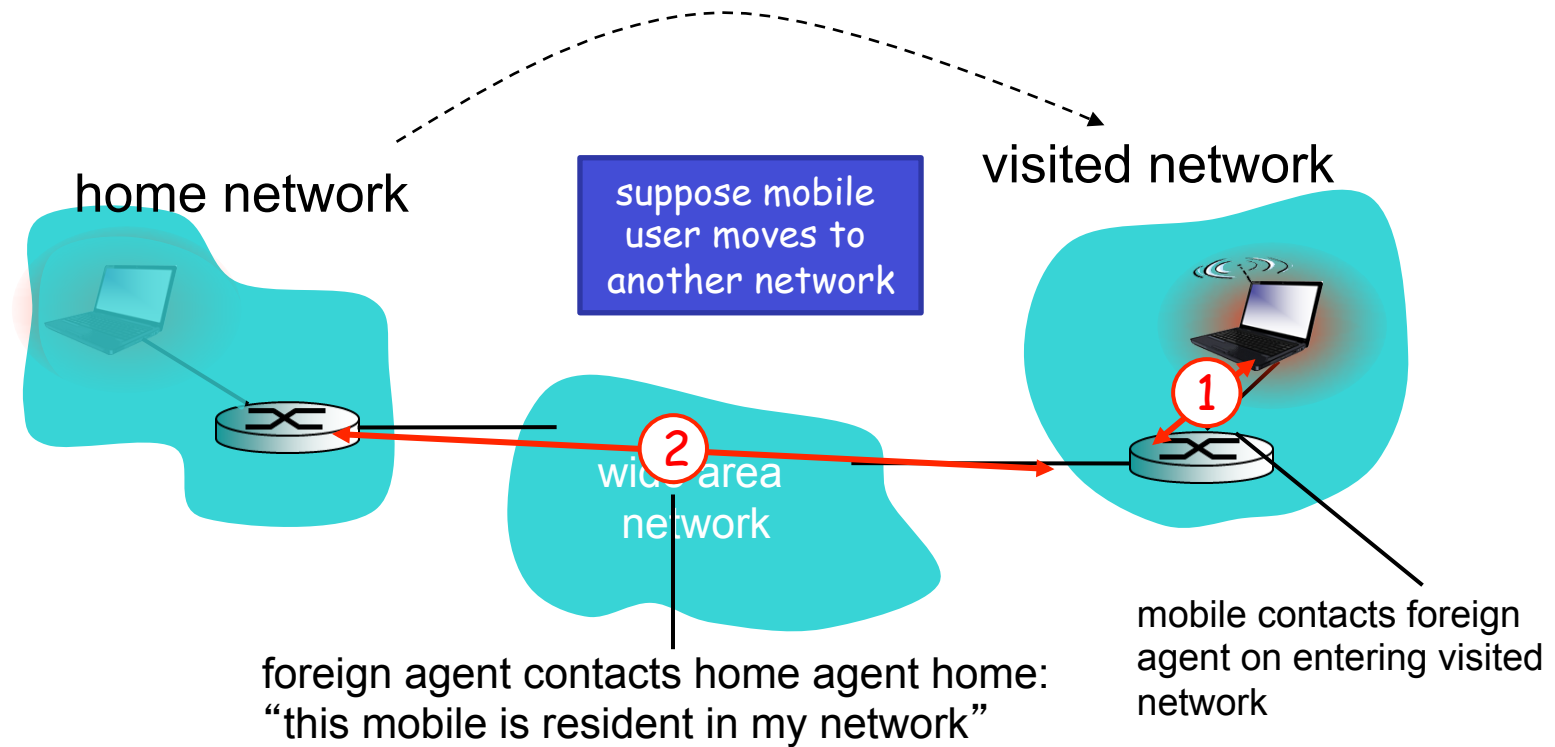
❖ **visited network:** network in which mobile currently resides

- ❖ **visitor location register (VLR):** database with entry for each user currently in network
- ❖ could be home network



Mobility: registration

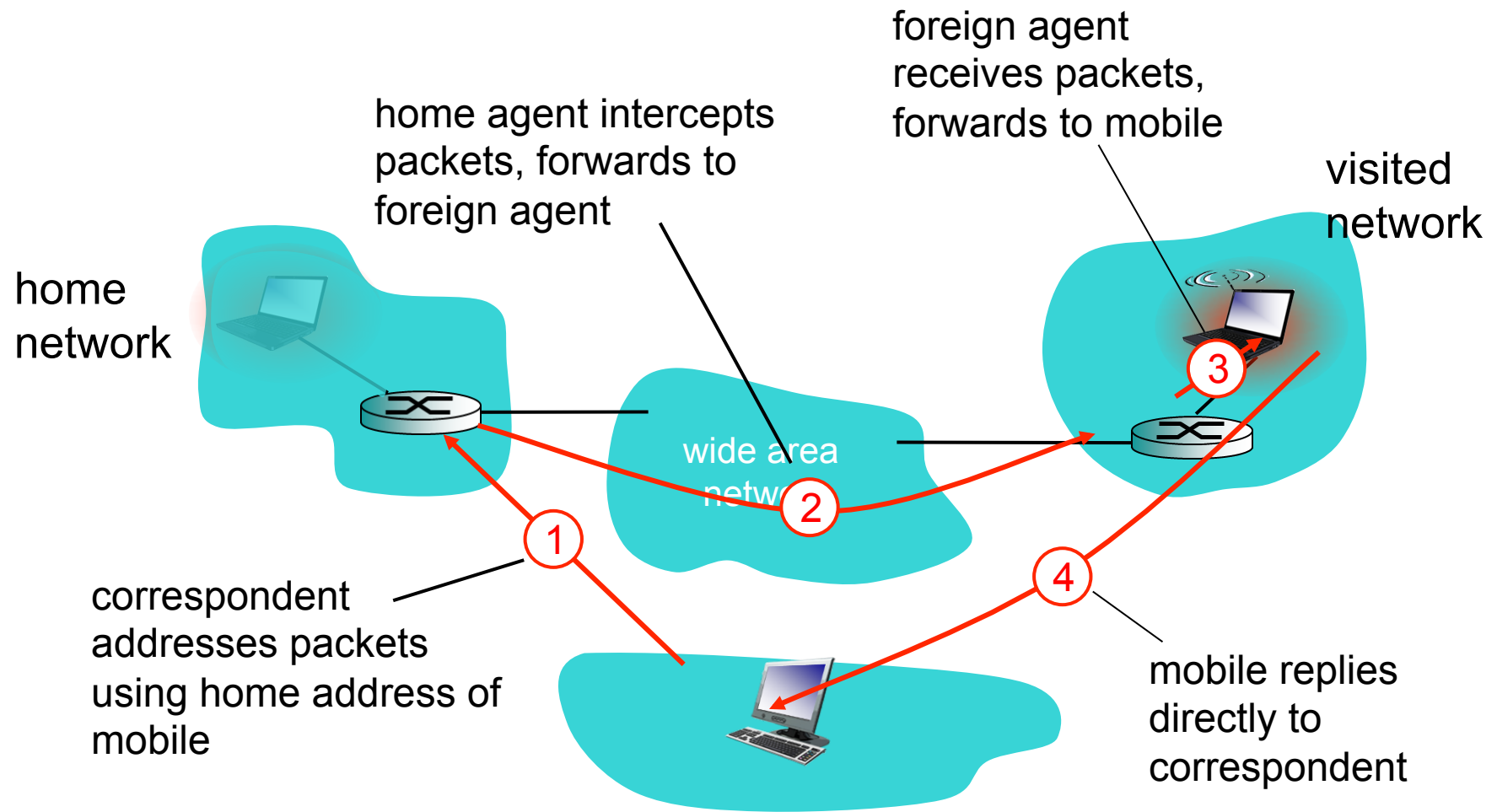
- Mobility's registration end result:
- ❖ foreign agent knows about mobile
 - ❖ home agent knows location of mobile



How correspondent user wants to communicate with mobile user?

- Mobility via indirect routing
- Mobility via direct routing

Mobility via indirect routing

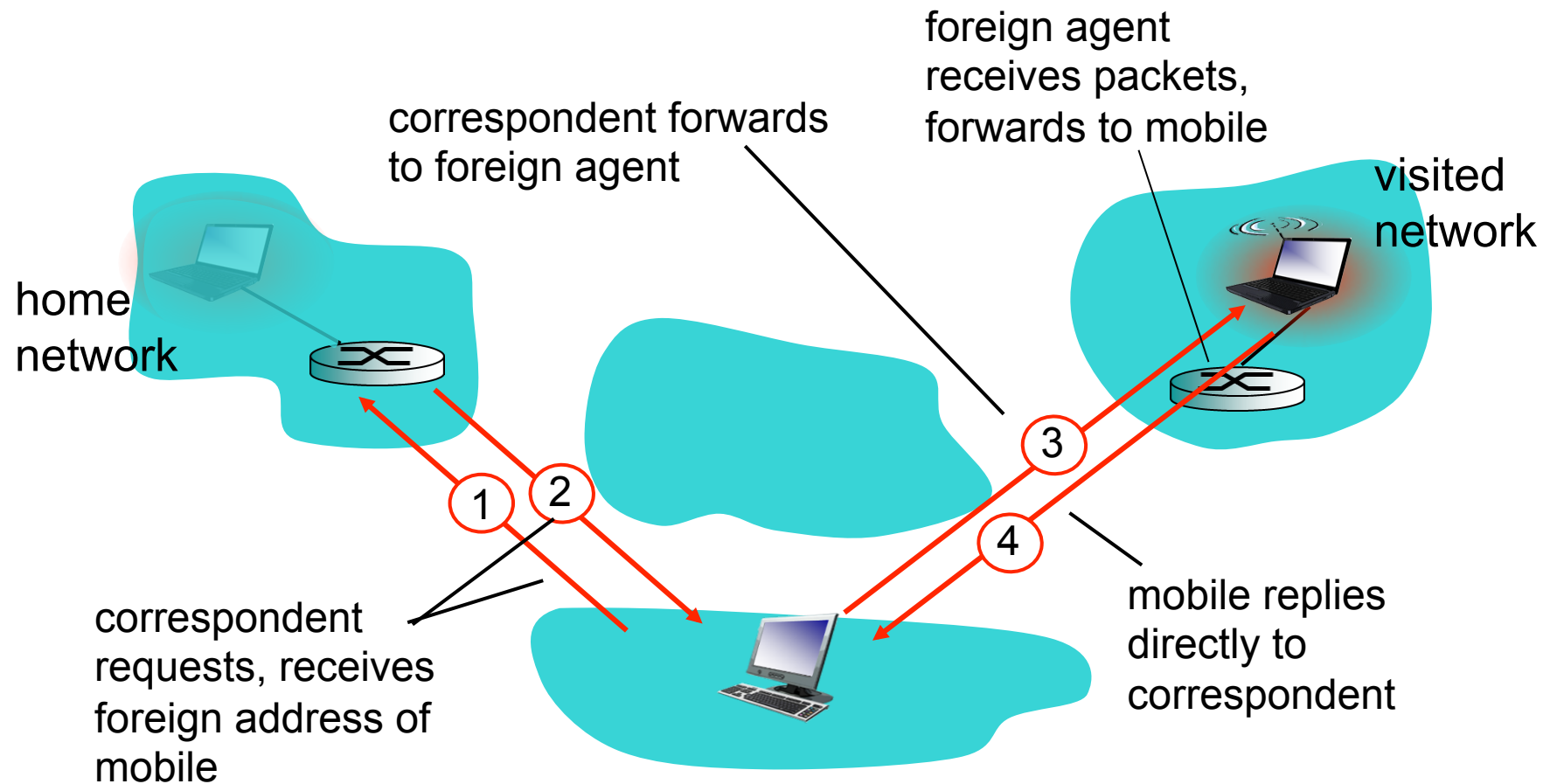


Indirect routing: moving between networks

- ❖ suppose mobile user moves to another network
 - registers with new foreign agent
 - new foreign agent registers with home agent
 - home agent update *care-of-address* for mobile
 - packets continue to be forwarded to mobile (but with new *care-of-address*)
- ❖ mobility, changing foreign networks transparent: *on going connections can be maintained!*

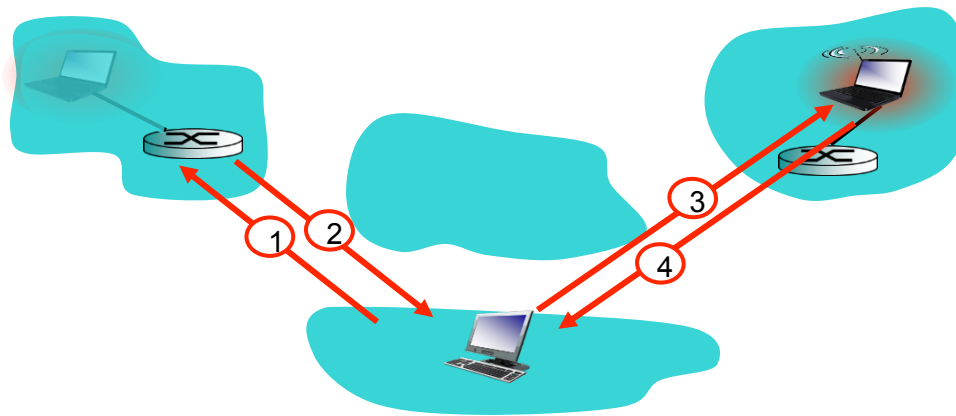
Indirect routing Introduce → triangle routing problem

Mobility via direct routing



Mobility via direct routing: comments

- ❖ overcome triangle routing problem
- ❖ *non-transparent to correspondent*: correspondent must get care-of-address from home agent
- ❖ packets continue to be forwarded to mobile (with new *care-of-address*)



Chapter 6 summary

Wireless

- 6.1 Background & Introduction
- 6.2 Wireless links, characteristics
- 6.3 IEEE 802.11 wireless LANs (“Wi-Fi”)
- 6.4 Cellular Internet Access
 - Cellular Architecture

Mobility

- 6.5 Principles: addressing, routing to mobile users
 - Home, Visited networks
 - *Care-of-addresses*, foreign agent
 - Indirect & direct routing