Wireless and Mobile Networks

Lecture 7

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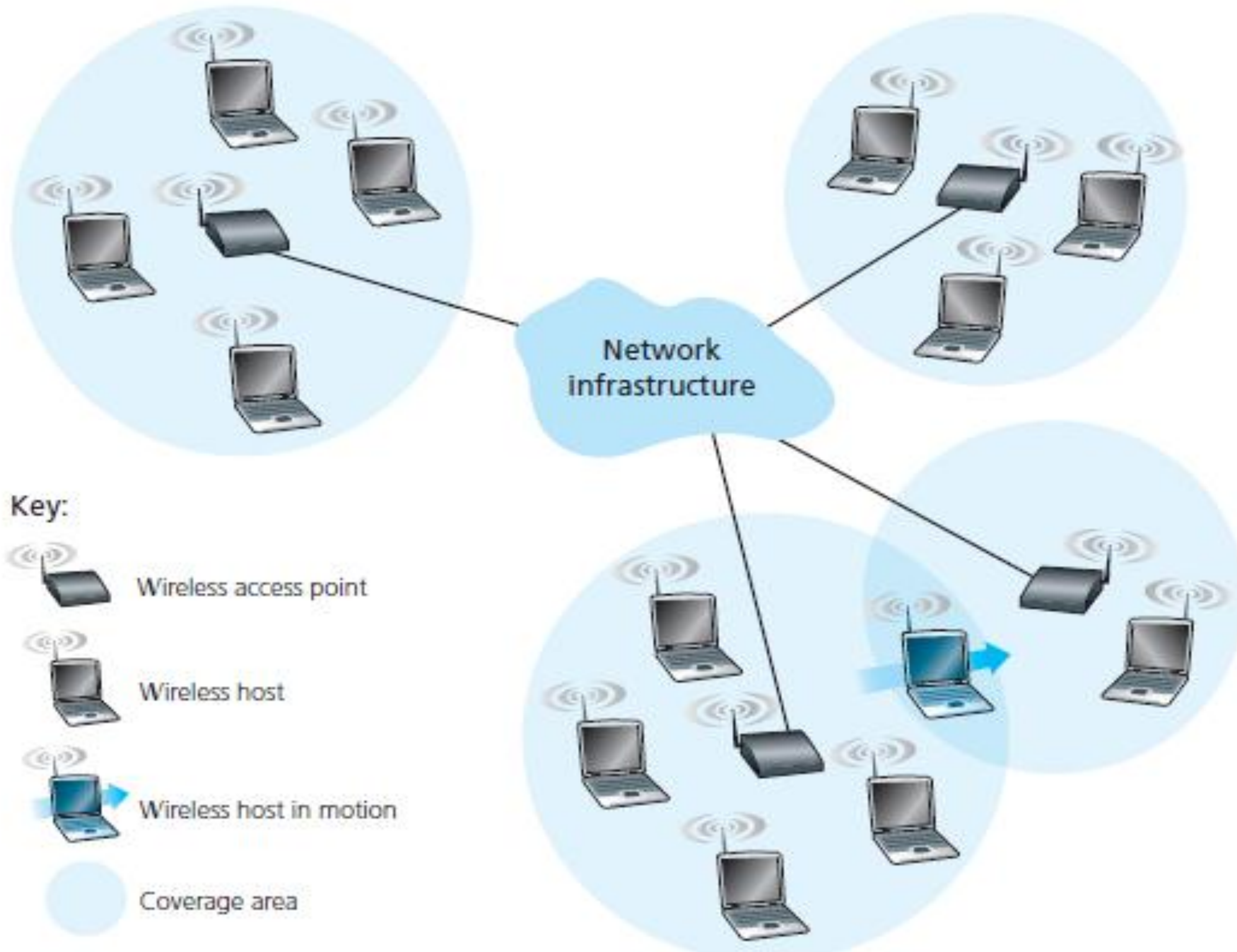
wireless network

- Wireless data communication and mobility, which cover a wide range of networks, including both wireless LANs such as IEEE 802.11 and cellular networks such as a 3G network.
- Elements in a wireless network:
  - ***Wireless hosts:*** hosts are the end-system devices that run applications. A **wireless host** might be a laptop, palmtop, smartphone, or desktop computer. The hosts themselves may or may not be mobile.

wireless network

- ***Wireless links:*** A host connects to a base station (defined below) or to another wireless host through a **wireless communication link**.
- ***Base station:*** The **base station** is a key part of the wireless network infrastructure. Unlike the wireless host and wireless link. Abase station is responsible for sending and receiving data (e.g., packets) to and from a wireless host that is associated with that base station. A base station will often be responsible for coordinating the transmission of multiple wireless hosts with which it is associated.

Elements of a wireless network



WiFi: 802.11 Wireless LANs

- In the workplace, the home, educational institutions, cafés, airports, and street corners, wireless LANs are now one of the most important access network technologies in the Internet today.
- The **IEEE 802.11 wireless LAN**, also known as **WiFi**.
- There are several 802.11 standards for wireless LAN technology:
  - 802.11b
  - 802.11a, and
  - 802.11g.

WiFi: 802.11 Wireless LANs

Standard	Frequency Range (United States)	Data Rate
802.11b	2.4–2.485 GHz	up to 11 Mbps
802.11a	5.1–5.8 GHz	up to 54 Mbps
802.11g	2.4–2.485 GHz	up to 54 Mbps

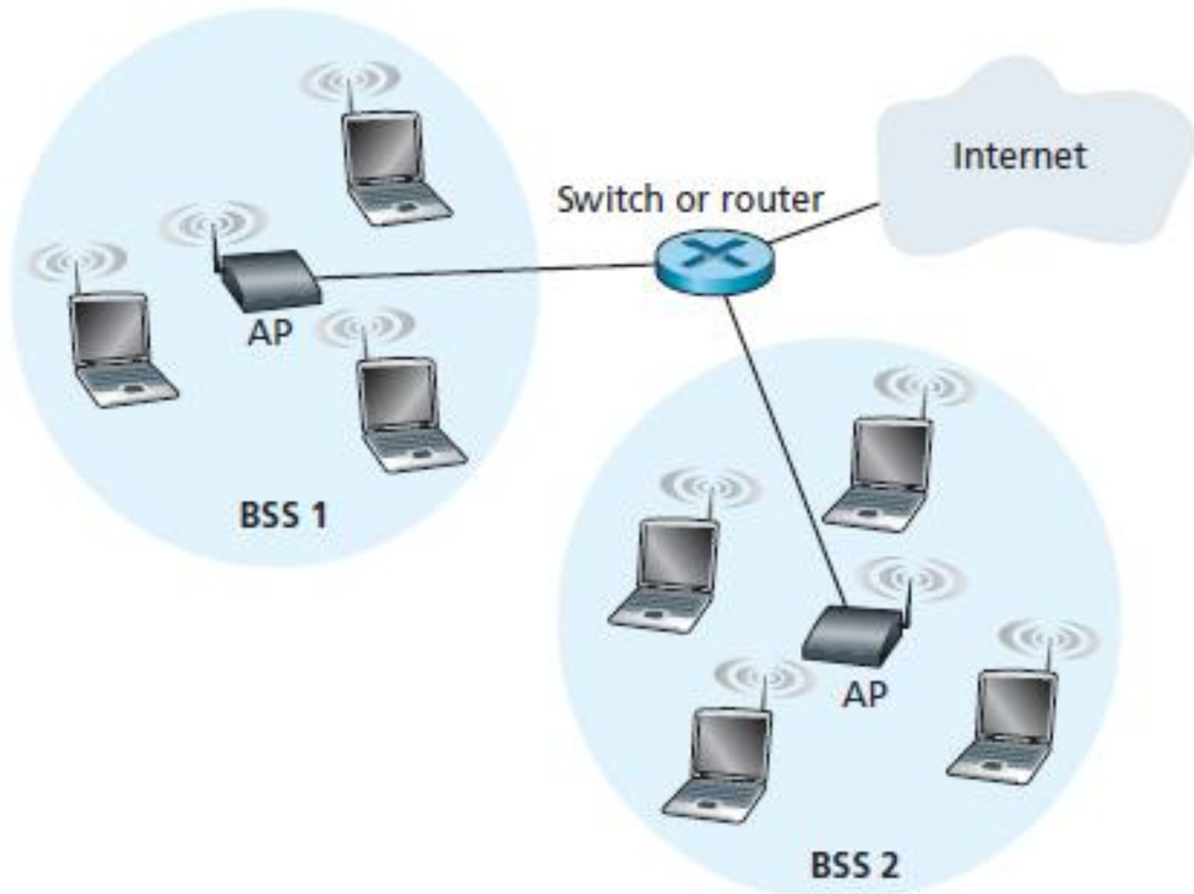
Table 6.1 ♦ Summary of IEEE 802.11 standards

WiFi: 802.11 Wireless LANs

- The three 802.11 standards share many characteristics:
  - They all use the same medium access protocol, CSMA/CA.
  - All three use the same frame structure for their link-layer frames as well.
  - All three standards have the ability to reduce their transmission rate in order to reach out over greater distances.
  - All three standards allow for both “infrastructure mode” and “ad hoc mode”.

The 802.11 Architecture

- The principal components of the 802.11 wireless LAN architecture.
- The fundamental building block of the 802.11 architecture is the **basic service set (BSS)**.



The 802.11 Architecture

- **Basic Service set (BSS)**:
  - A BSS contains one or more wireless stations and a central **base station**, known as an **access point (AP)** in 802.11 parlance.
  - The AP in each of two BSSs connecting to an interconnection device (such as a switch or router), which in turn leads to the Internet.
  - In a typical home network, there is one AP and one router (typically integrated together as one unit) that connects the BSS to the Internet.

The 802.11 Architecture

- Each AP also has a MAC address for its wireless interface. As with Ethernet, these MAC addresses are administered by IEEE and are (in theory) globally unique.
- Wireless LANs that deploy APs are often referred to as **infrastructure wireless LANs**, with the “infrastructure” being the APs along with the wired Ethernet infrastructure that interconnects the APs and a router.

The 802.11 Architecture

– IEEE 802.11 stations can also group themselves together to form an **ad hoc network**—a network with no central control and with no connections to the "outside world."

Figure 6.8 ♦ An IEEE 802.11 ad hoc network

The 802.11 Architecture

– Here, the network is formed “on the fly,” by mobile devices that have found themselves in proximity to each other, that have a need to communicate, and that find no preexisting network infrastructure in their location.

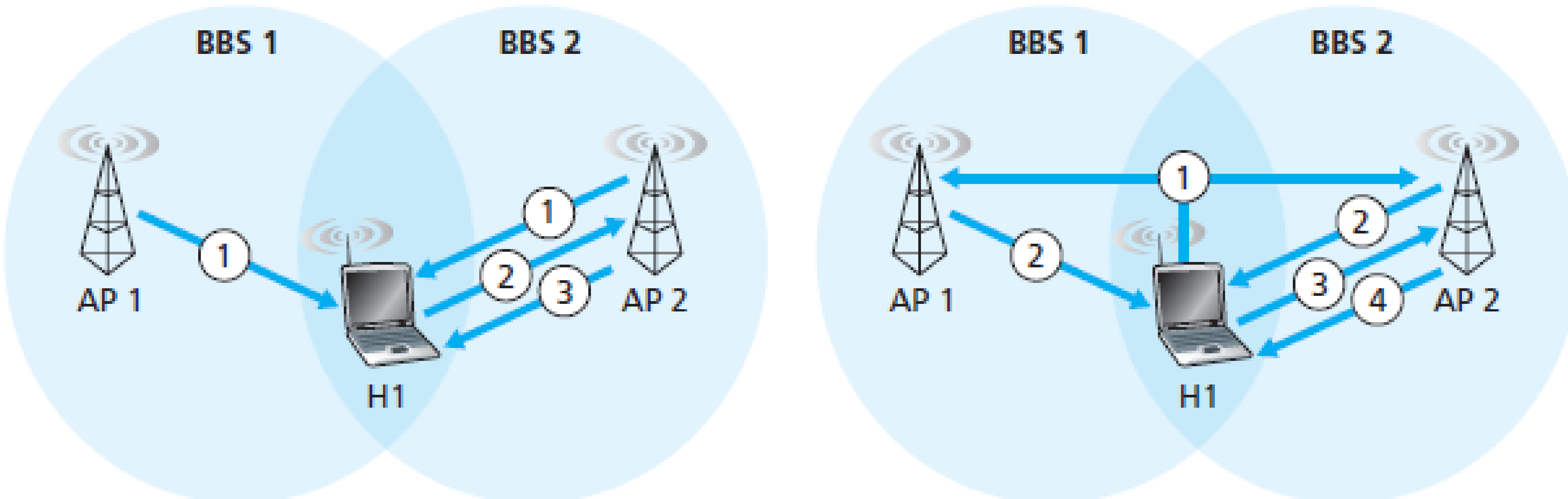
Channels and Association

- **Service Set Identifier (SSID)-**a list is displayed showing the SSID of each AP in range.
- **Beacon frames-** The 802.11 standard requires that an AP periodically send **beacon frames**, each of which includes the AP's SSID and MAC address.

Channels and Association

- **Passive scanning -**The process of scanning channels and listening for beacon frames is known as **passive scanning**.
- **Active scanning-** A wireless host can also perform **active scanning**, by broadcasting a probe frame that will be received by all APs within the wireless host's range. APs respond to the probe request frame with a probe response frame.

Channels and Association



a. Passive scanning

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

a. 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
4. Association Response frame sent: Selected AP to H1

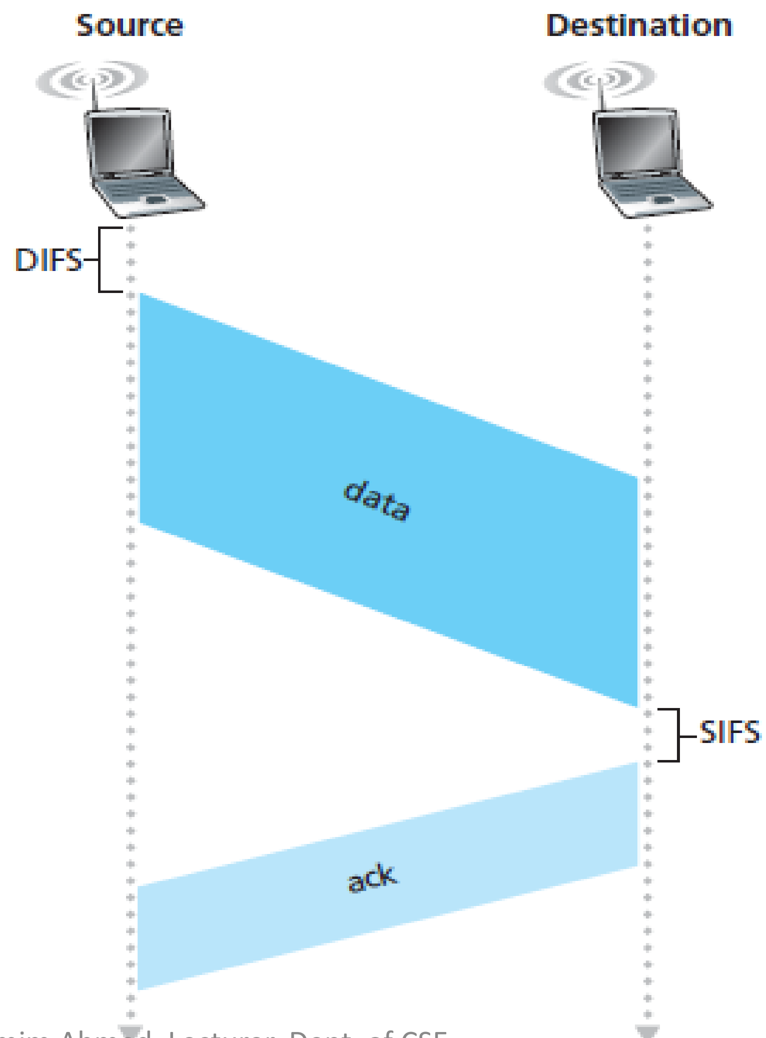
Figure 6.9 ♦ Active and passive scanning for access points

The 802.11 MAC Protocol

- Once a wireless station is associated with an AP, it can start sending and receiving data frames to and from the access point.
- But because multiple stations may want to transmit data frames at the same time over the same channel, a multiple access protocol is needed to coordinate the transmissions.

The 802.11 MAC Protocol

- **Short Inter-frame Spacing (SIFS)**
- **Distributed Inter-frame Space (DIFS)**



The 802.11 MAC Protocol

1. If initially the station senses the channel idle, it transmits its frame after a short period of time known as the **Distributed Inter-frame Space (DIFS)**; see Figure 6.10.
2. Otherwise, the station chooses a random backoff value using binary exponential backoff (as we encountered in Section 5.3.2) and counts down this value when the channel is sensed idle. While the channel is sensed busy, the counter value remains frozen.
3. When the counter reaches zero (note that this can only occur while the channel is sensed idle), the station transmits the entire frame and then waits for an acknowledgment.
4. If an acknowledgment is received, the transmitting station knows that its frame has been correctly received at the destination station. If the station has another frame to send, it begins the CSMA/CA protocol at step 2. If the acknowledgment isn't received, the transmitting station reenters the backoff phase in step 2, with the random value chosen from a larger interval.

Hidden terminal problem

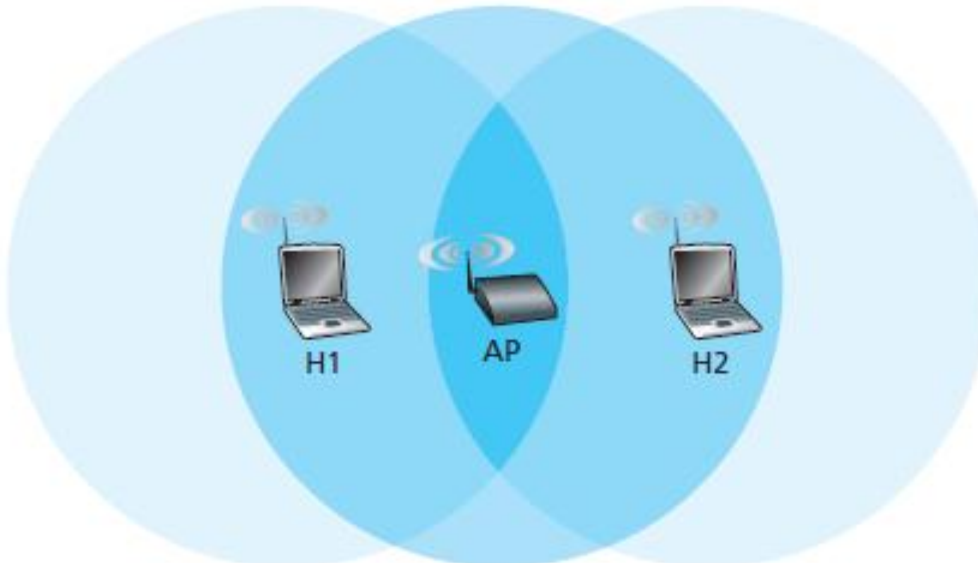


Figure 6.11 ♦ Hidden terminal example: H1 is hidden from H2, and vice versa

- H1 is transmitting a frame and halfway through H1's transmission, Station H2 wants to send a frame to the AP. H2, not hearing the transmission from H1, will first wait a DIFS interval and then transmit the frame, resulting in a collision.

Dealing with Hidden Terminals: RTS and CTS

- In order to avoid hidden terminal problem, the IEEE 802.11 protocol allows a station to uses-
  - a short **Request to Send (RTS)** control frame and
  - a short **Clear to Send (CTS)** control frame to *reserve* access to the channel.

Dealing with Hidden Terminals: RTS and CTS

- When a sender wants to send a DATA frame, it can first send an RTS frame to the AP, indicating the total time required to transmit the DATA frame and the acknowledgment (ACK) frame.
- When the AP receives the RTS frame, it responds by broadcasting a CTS frame.
- This CTS frame serves two purposes: It gives the sender explicit permission to send and also instructs the other stations not to send for the reserved duration.

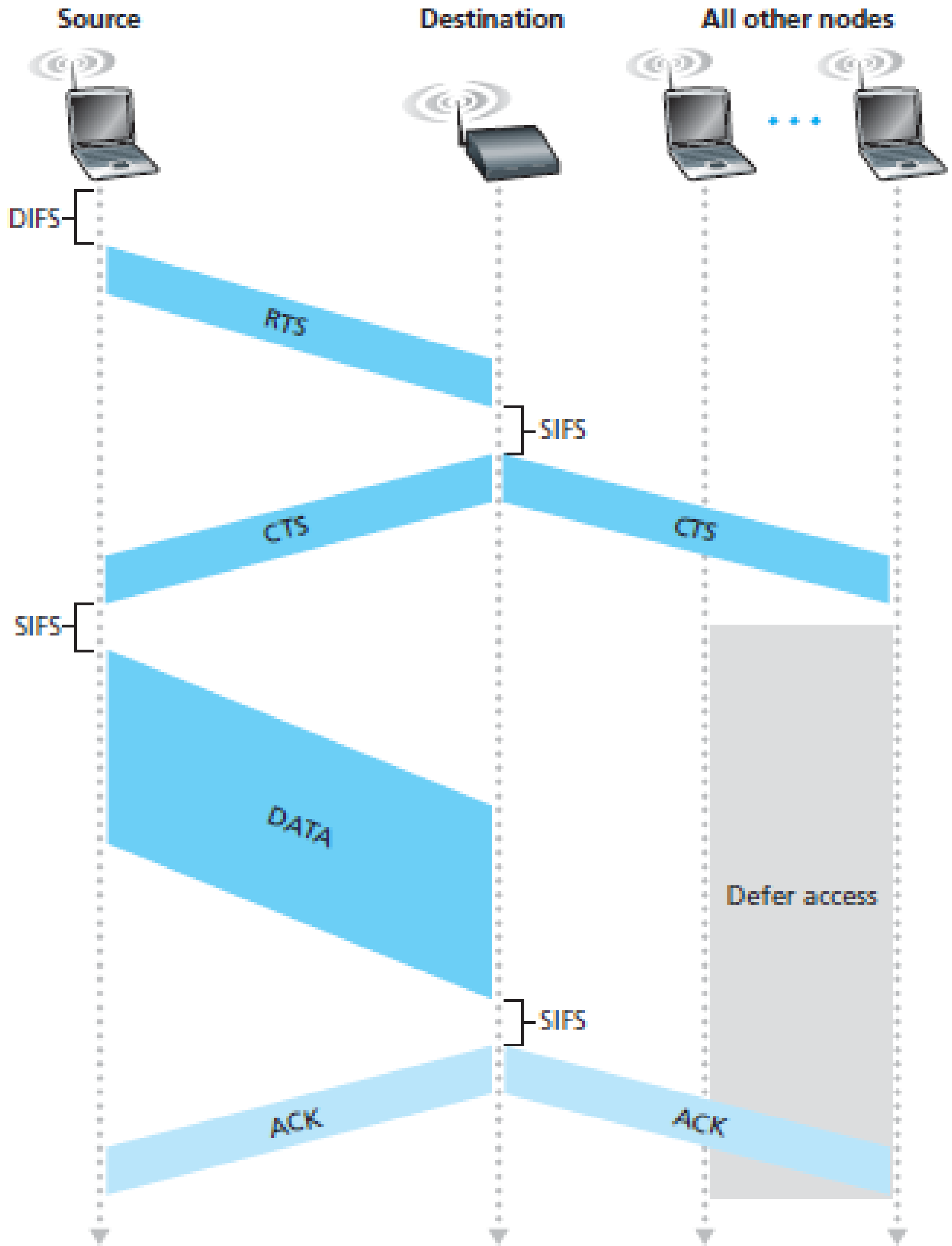


Figure 6.12 ♦ Collision avoidance using the RTS and CTS frames

The IEEE 802.11 Frame

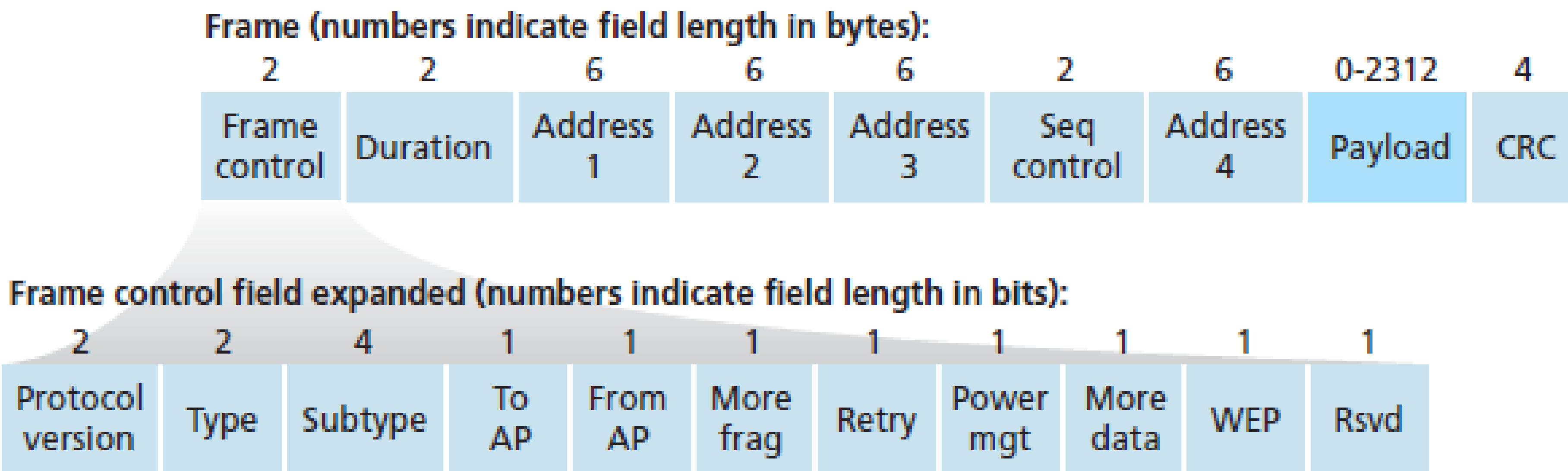


Figure 6.13 ♦ The 802.11 frame

An Overview of Cellular Network Architecture

- The *Global System for Mobile Communications* (***GSM***) standards.
- First generation (1G) systems were analog FDMA systems designed exclusively for voice-only communication.
- The original 2G systems were also designed for voice, but later extended (2.5G) to support data (i.e., Internet) as well as voice service.
- The 3G systems that currently are being deployed also support voice and data, but with an ever increasing emphasis on data capabilities and higher-speed radio access links.

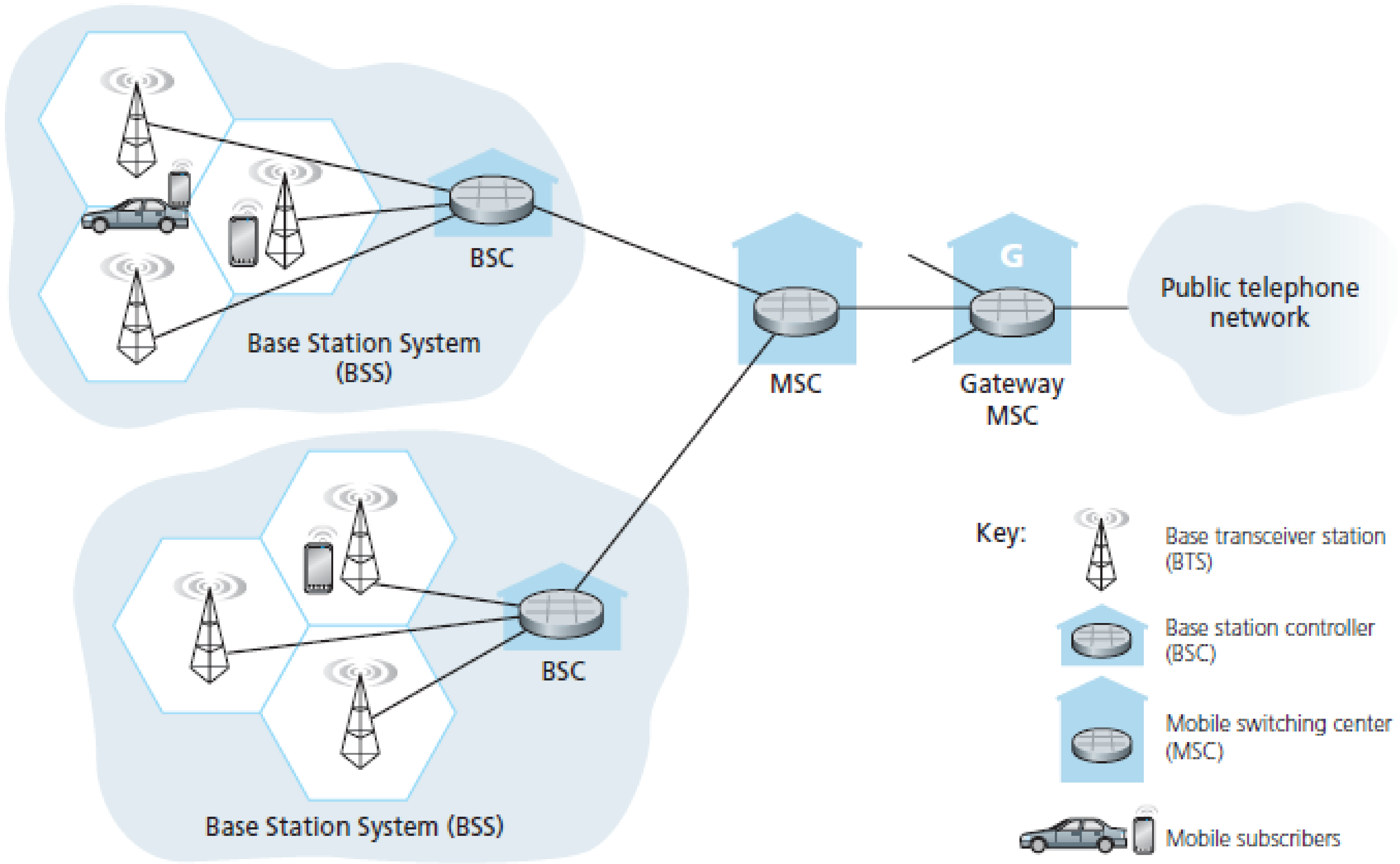


Figure 6.18 ♦ Components of the GSM 2G cellular network architecture

An Overview of Cellular Network Architecture

- The region covered by a cellular network is partitioned into a number of geographic coverage areas, known as **cells.**
- Each cell contains a **base transceiver station (BTS)** that transmits signals to and receives signals from the mobile stations in its cell.
- Each cell containing one base transceiver station residing in the middle of the cell, many systems today place the BTS at corners where three cells intersect, so that a single BTS with directional antennas can service three cells.

An Overview of Cellular Network Architecture

- A GSM network's **base station controller (BSC)** will typically service several tens of base transceiver stations. The role of the BSC is to allocate BTS radio channels to mobile subscribers, perform **paging** (finding the cell in which a mobile user is resident), and perform handoff of mobile users.
- The base station controller and its controlled base transceiver stations collectively constitute a GSM **base station system (BSS)**.

An Overview of Cellular Network Architecture

- The **mobile switching centre (MSC)** plays the central role in user authorization and accounting (e.g., determining whether a mobile device is allowed to connect to the cellular network), call establishment and teardown, and handoff. A single MSC will typically contain up to five BSCs.
- A cellular provider's network will have a number of MSCs, with special MSCs known as gateway MSCs connecting the provider's cellular network to the larger public telephone network.

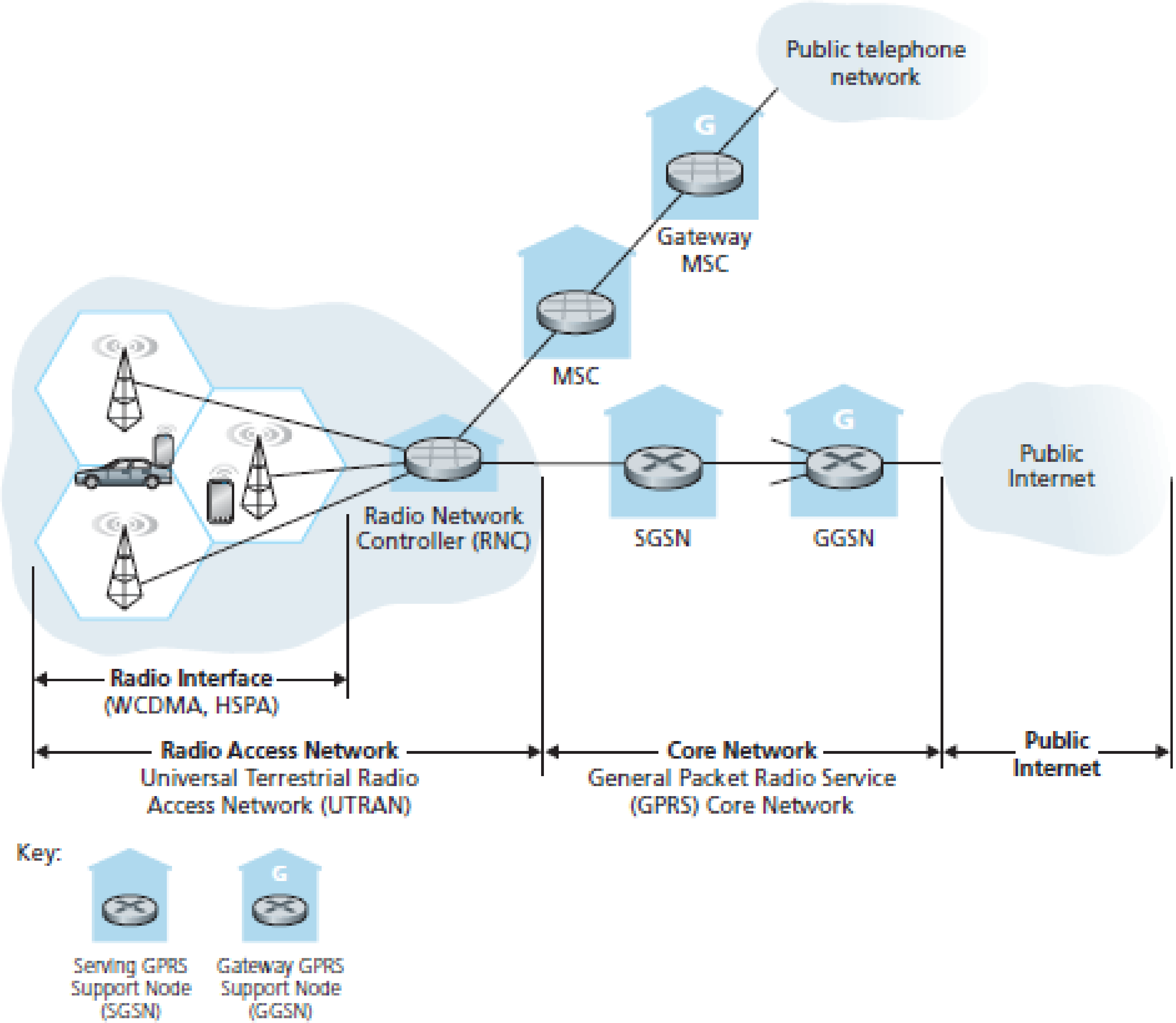


Figure 6.19 ♦ 3G system architecture

Handoffs in GSM

- **Handoffs in GSM:** A **handoff** occurs when a mobile station changes its association from one base station to another during a call.

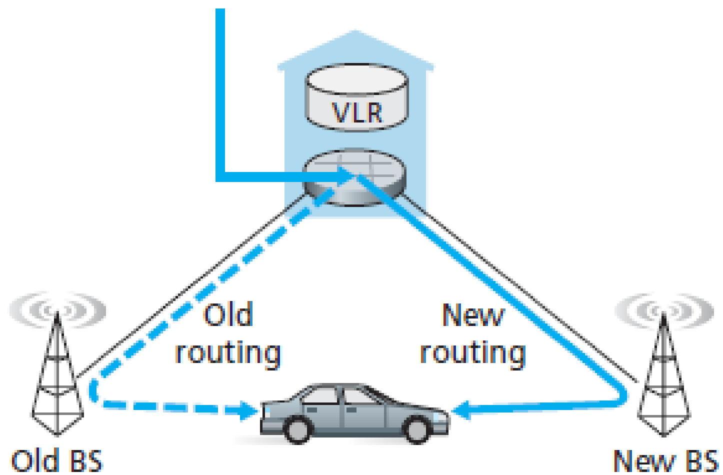


Figure 6.30 ♦ Handoff scenario between base stations with a common MSC

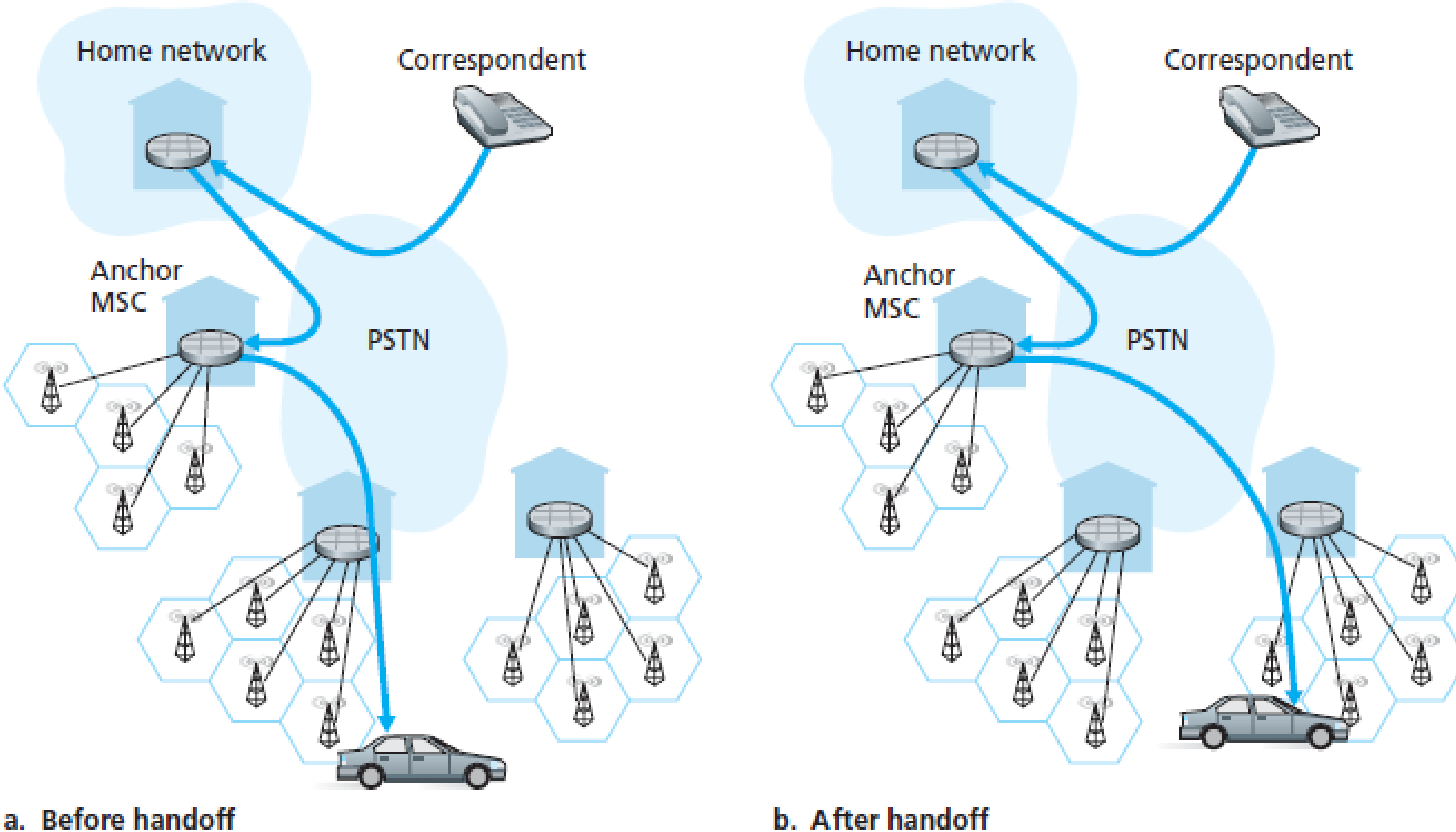


Figure 6.32 ♦ Rerouting via the anchor MSC

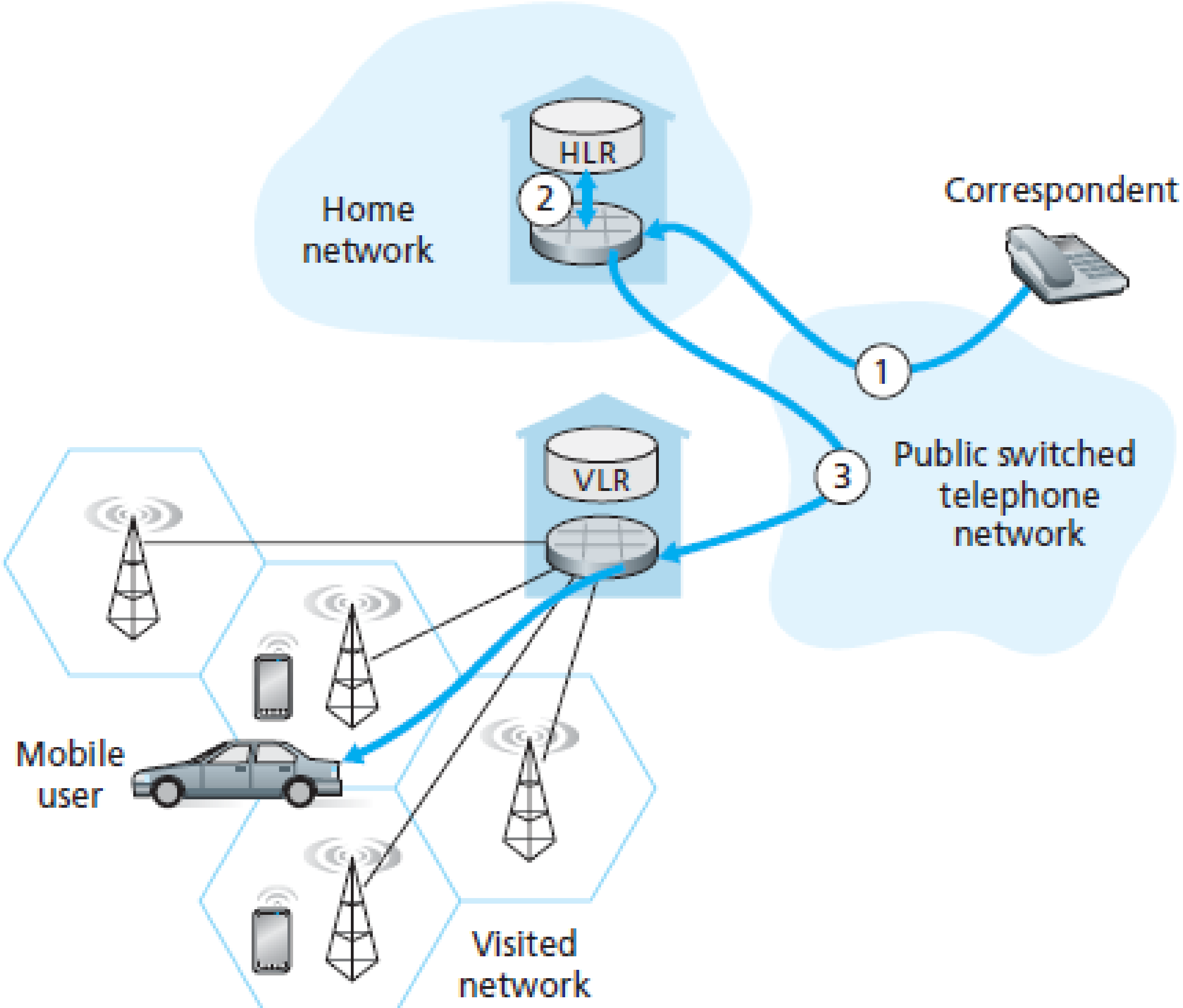


Figure 6.29 ♦ Placing a call to a mobile user: indirect routing

1. The correspondent dials the mobile user's phone number. This number itself does not refer to a particular telephone line or location (after all, the phone number is fixed and the user is mobile!). The leading digits in the number are sufficient to globally identify the mobile's home network. The call is routed from the correspondent through the PSTN to the home MSC in the mobile's home network. This is the first leg of the call.
2. The home MSC receives the call and interrogates the HLR to determine the location of the mobile user. In the simplest case, the HLR returns the **mobile station roaming number** (MSRN), which we will refer to as the **roaming number**. Note that this number is different from the mobile's permanent phone number, which is associated with the mobile's home network. The roaming number is ephemeral: It is temporarily assigned to a mobile when it enters a visited network. The roaming number serves a role similar to that of the care-of address in mobile IP and, like the COA, is invisible to the correspondent and the mobile. If HLR does not have the roaming number, it returns the address of the VLR in the visited network. In this case (not shown in Figure 6.29), the home MSC will need to query the VLR to obtain the roaming number of the mobile node. But how does the HLR get the roaming number or the VLR address in the first place? What happens to these values when the mobile user moves to another visited network? We'll consider these important questions shortly.
3. Given the roaming number, the home MSC sets up the second leg of the call through the network to the MSC in the visited network. The call is completed, being routed from the correspondent to the home MSC, and from there to the visited MSC, and from there to the base station serving the mobile user.

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