Computer Networks II

Lecture No. 6

Wireless WANs
Cellular Telephone and Satellite Networks

4th Year/ 1st semester

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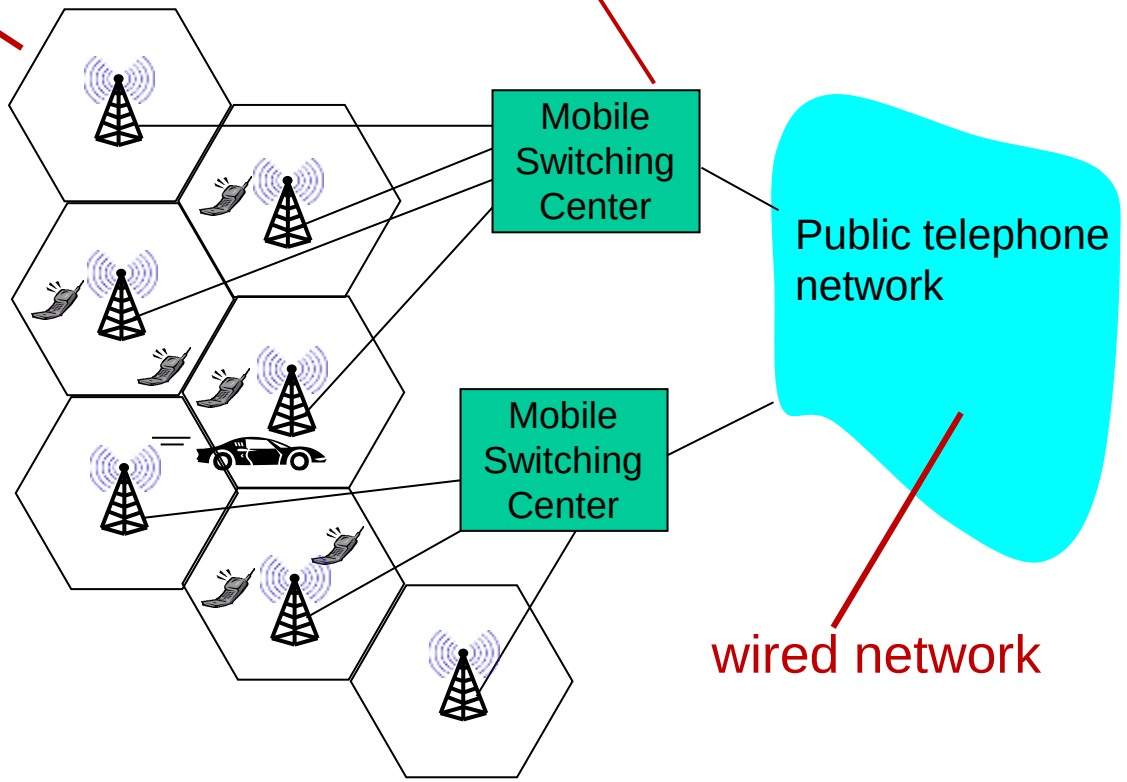
Components of cellular network architecture

MSC
- connects cells to wired tel. net.
- manages call setup (more later!)
- handles mobility (more later!)

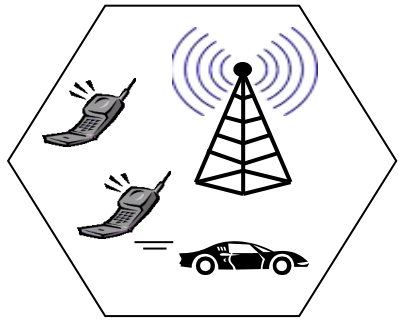
cell
- covers geographical region
- *base station* (BS) analogous to 802.11 AP
- *mobile users* attach to network through BS
- *air-interface:* physical and link layer protocol between mobile and BS

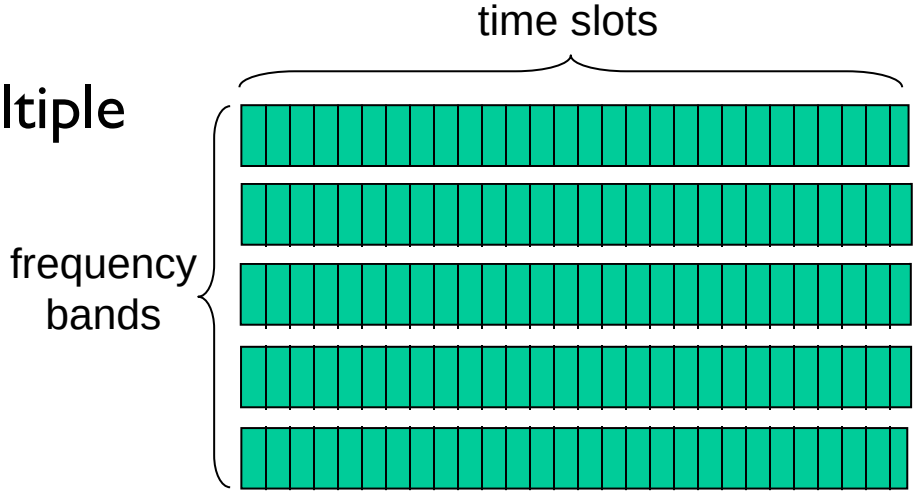


Cellular networks: the first hop

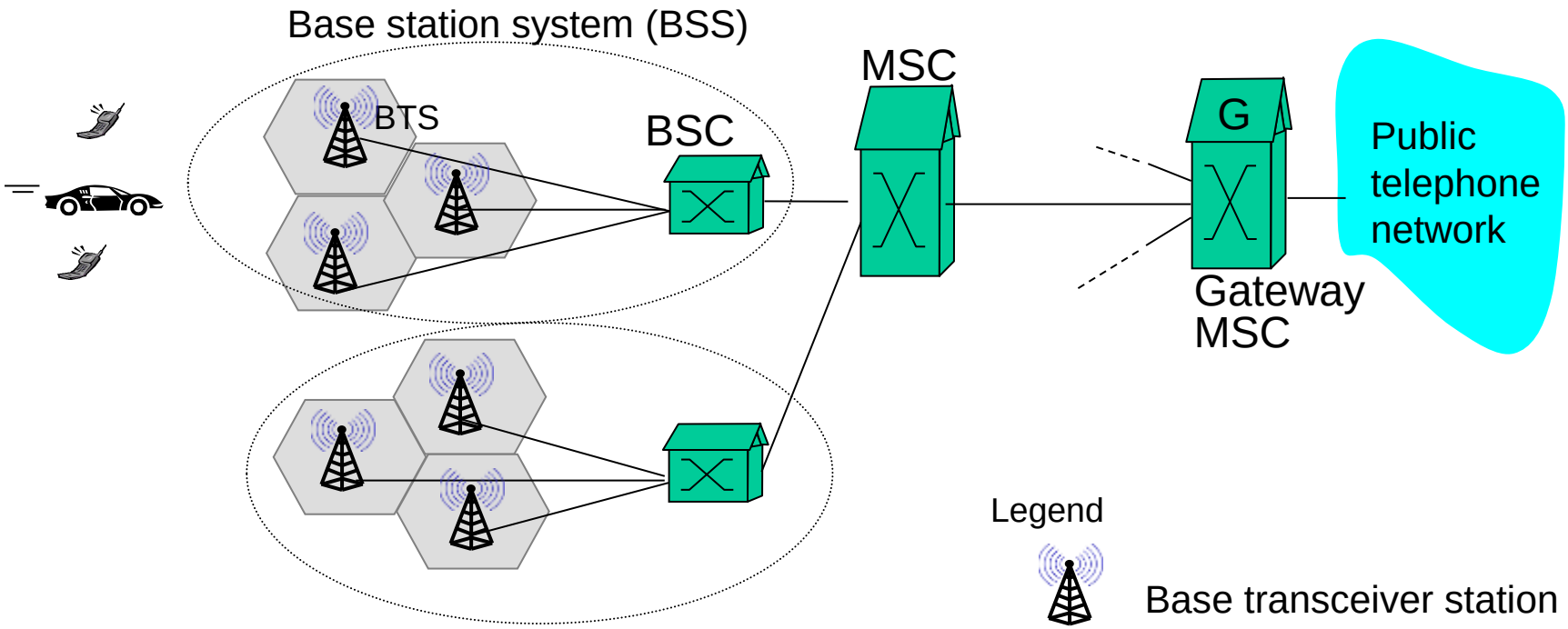
Two techniques for sharing mobile-to-BS radio spectrum

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

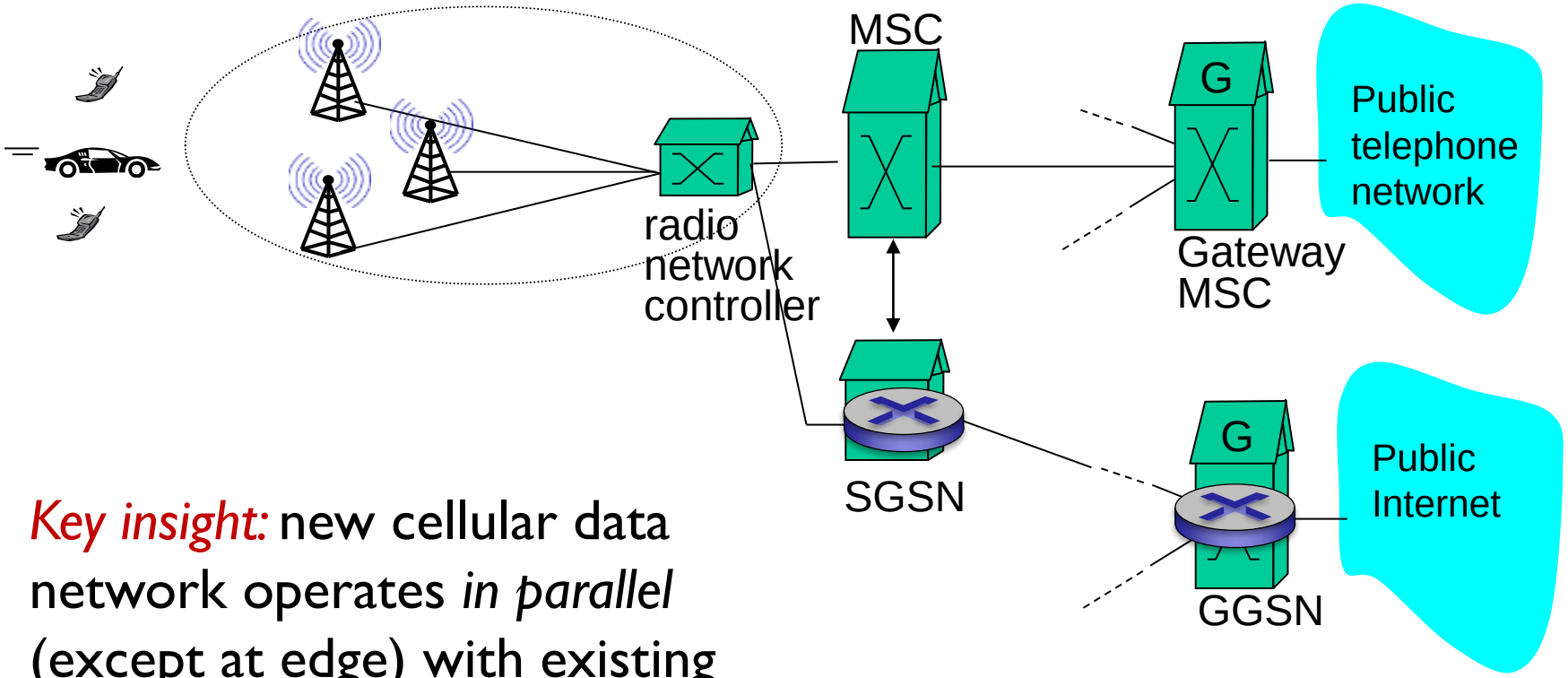




2G (voice) network architecture



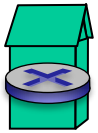
3G (voice+data) network architecture



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)



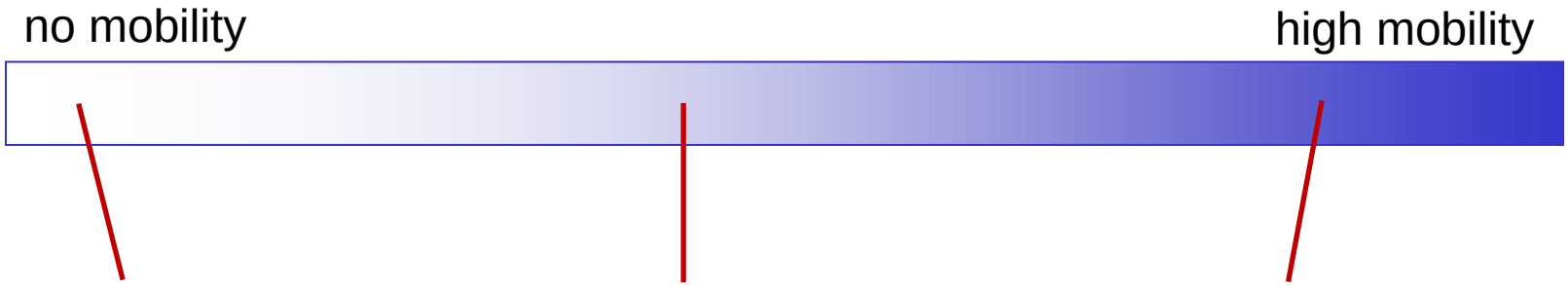
Gateway GPRS Support Node (GGSN)

1G to 5G Wireless Communications Generations comparison

Gen. / Service	1G	2G	3G	4G	5G
Voice	Analog	Digital		VoLTE	
SMS	x	o	o	o	o
MMS	x	x	o	o	o
Video call	x	x	o	o	o
Data Rate	x	14.4kbps-384kbps	384kbps-10Mbps	100Mbps-1Gbps	20Gbps
(800MB)		30min-6hours	10min-30min	6sec-1min	-0.5sec
Transmission	FM	Digital			?
Multiple Access	FDMA	TDMA/CDMA	CDMA	OFDMA	OFDMA
Service/ Standards	NMT TACS AMPS	GSM/CDMA US-TDMA PDC GPRS/EDGE	WCDMA CDMA 2000	LTE	Single spec

What is mobility?

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



mobile wireless user, using same access point

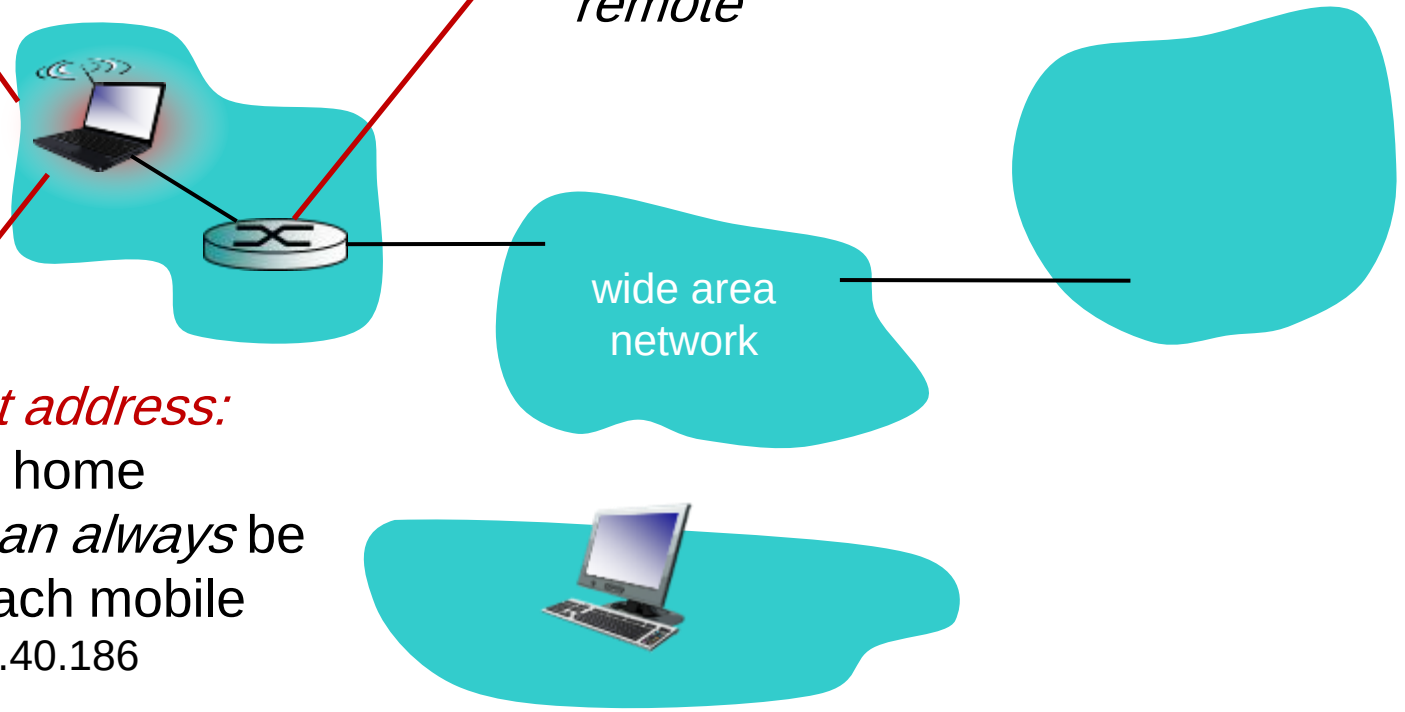
mobile user, connecting/ disconnecting from network using DHCP.

mobile user, passing through multiple access point while maintaining ongoing connections (like cell phone)

Mobility: vocabulary

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



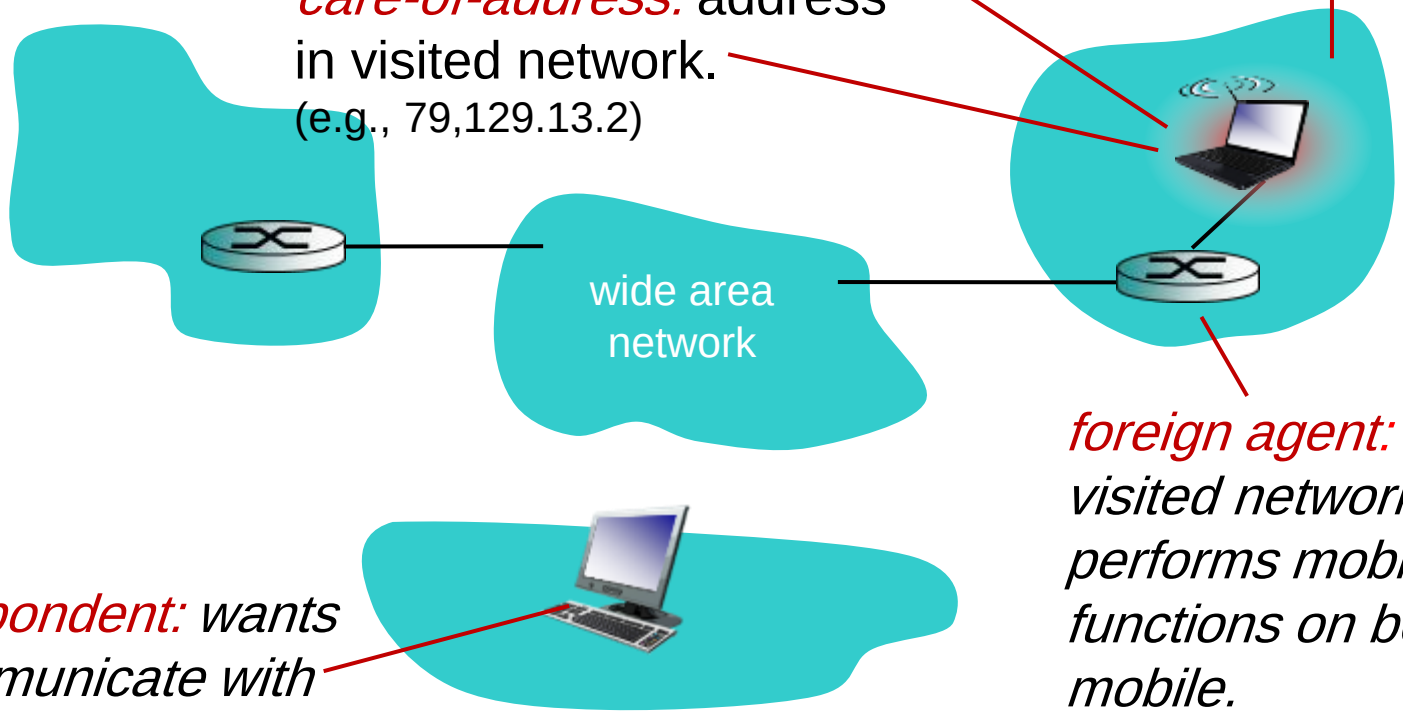
permanent address: address in home network, *can always* be used to reach mobile
e.g., 128.119.40.186

Mobility: more vocabulary

permanent address: remains constant (e.g., 128.119.40.186)

visited network: network in which mobile currently resides (e.g., 79.129.13/24)

care-of-address: address in visited network. (e.g., 79,129.13.2)



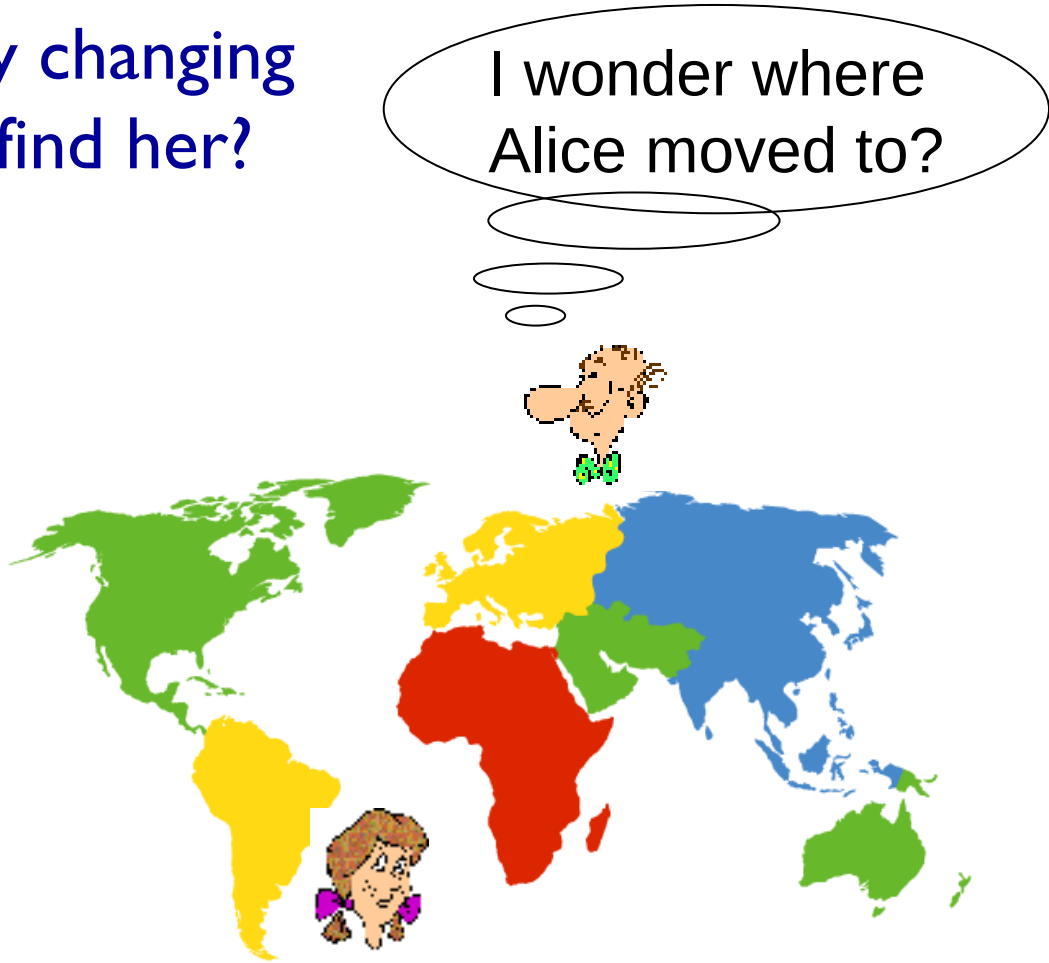
foreign agent: *entity in visited network that performs mobility functions on behalf of mobile.*

correspondent: *wants to communicate with mobile*

How do *you* contact a mobile friend:

Consider friend frequently changing addresses, how do you find her?

- search all phone books?
- call her parents?
- expect her to let you know where he/she is?
- Facebook!

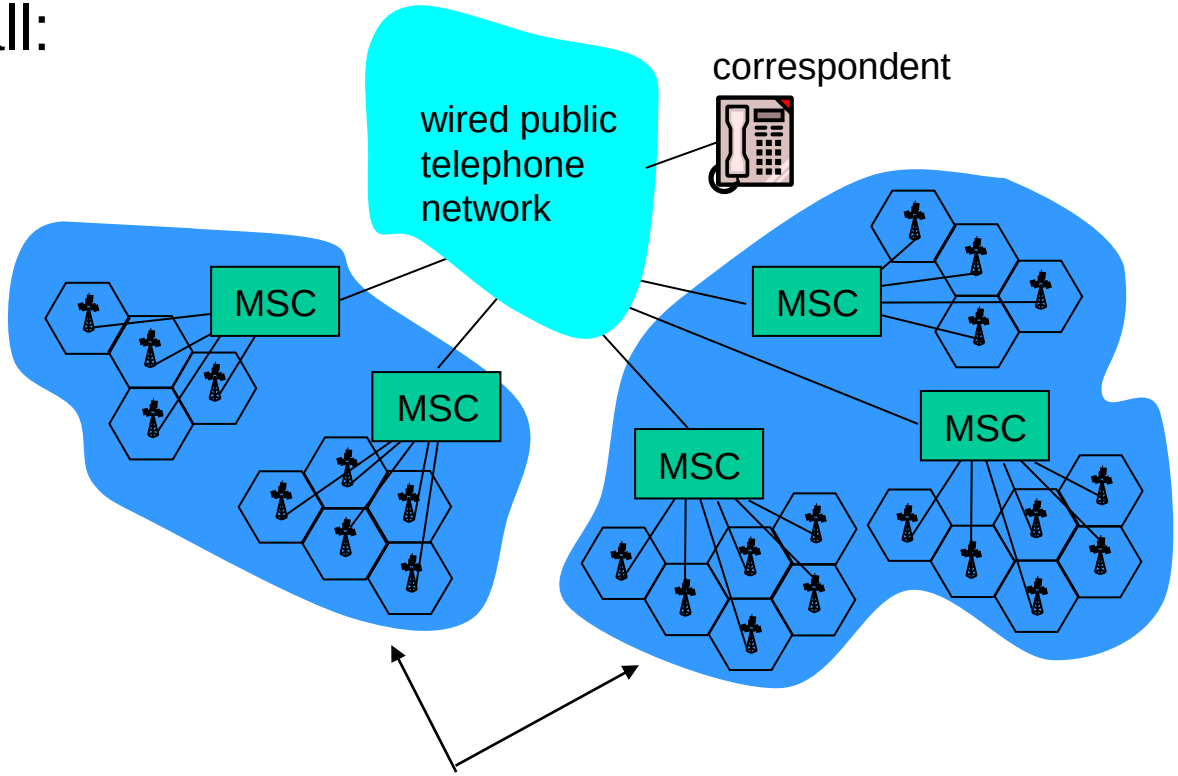


Mobility: approaches

- *let routing handle it:* routers advertise permanent address of mobile-nodes-in-residence via usual routing table exchange.
  - routing tables indicate where each mobile located
  - no changes to end-systems
- *let end-systems handle it:*
  - *indirect routing:* communication from correspondent to mobile goes through home agent, then forwarded to remote
  - *direct routing:* correspondent gets foreign address of mobile, sends directly to mobile

Components of cellular network architecture

recall:

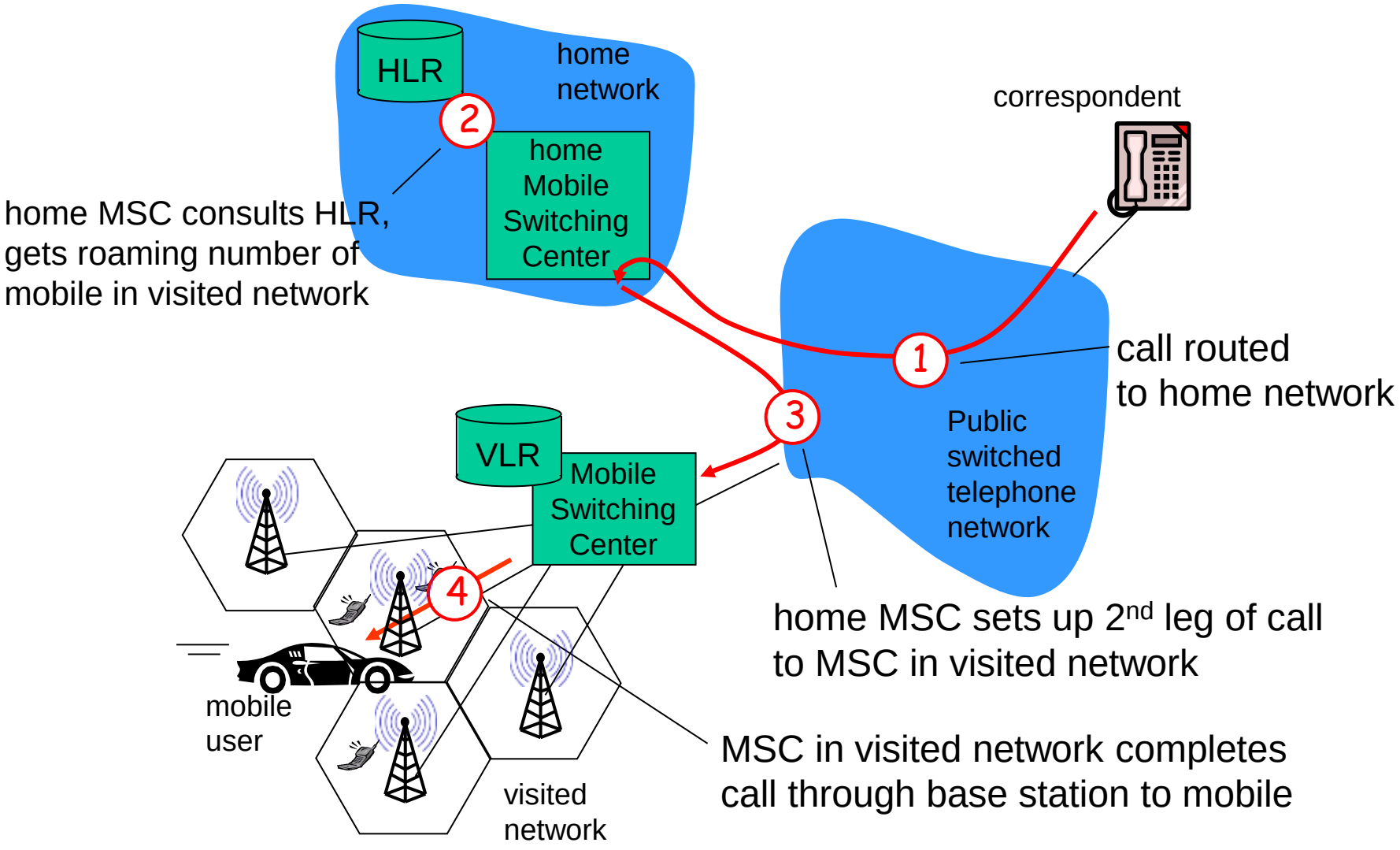


different cellular networks,
operated by different providers

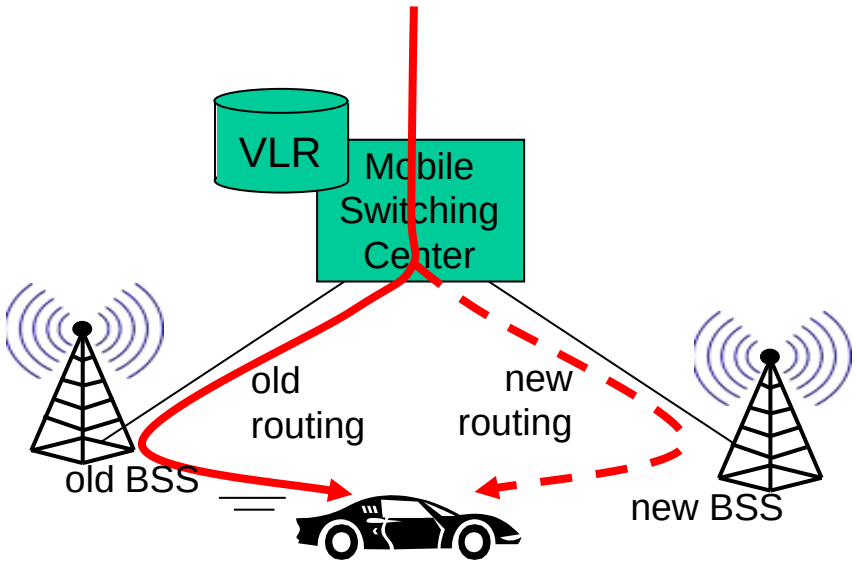
Handling mobility in cellular networks

- *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)
- *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

GSM: indirect routing to mobile



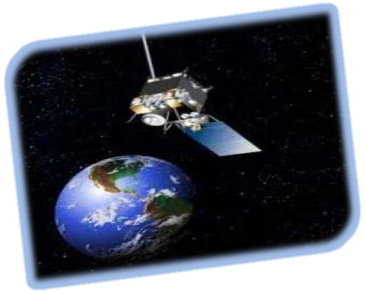
GSM: handoff with common MSC



- *handoff goal:* route call via new base station (without interruption)
- reasons for handoff:
  - stronger signal to/from new BSS (continuing connectivity, less battery drain)
  - load balance: free up channel in current BSS
  - GSM doesn't mandate why to perform handoff (policy), only how (mechanism)
- handoff initiated by old BSS

SATELLITE

- An artificial body placed in orbit around the earth to collect information or for communication.



SATELLITE COMMUNICATION

- A communications satellite is a radio relay station in orbit above the earth.
- It receives, amplifies, and redirects analog and digital signals carried on a specific radio frequency.
- Satellite communications play a vital role in the global telecommunications system.

Satellite Networks

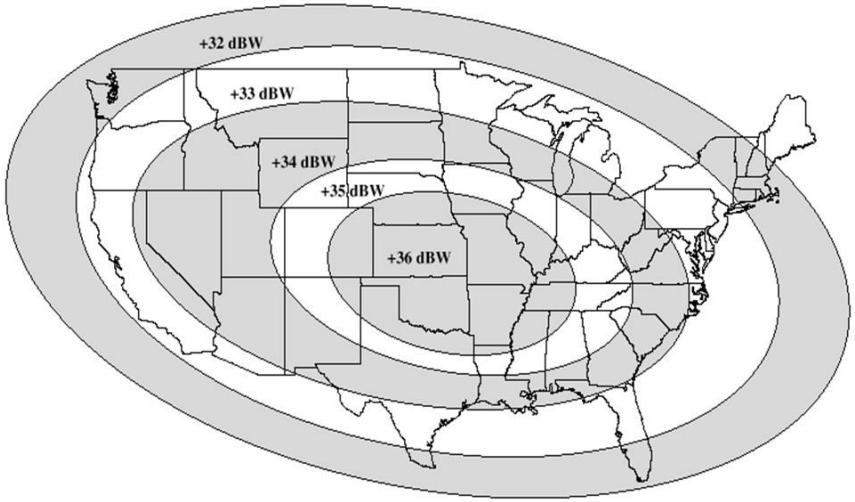
A *satellite network* is a combination of nodes, some of which are satellites, that provides communication from one point on the Earth to another. A node in the network can be a satellite, an Earth station, or an end-user terminal or telephone. Although a natural satellite, such as the moon, can be used as a relaying node in the network, the use of artificial satellites is preferred because we can install electronic equipment on the satellite to regenerate the signal that has lost its energy during travel.

Another restriction on using natural satellites is their distances from the Earth, which create a long delay in communication.

Satellite networks are like cellular networks in that they divide the planet into cells. Satellites can provide transmission capability to and from any location on Earth, no matter how remote. This advantage makes high-quality communication available to undeveloped parts of the world without requiring a huge investment in ground-based infrastructure.

Satellite Footprint

Satellites process microwaves with bidirectional antennas (line-of-sight). Therefore, the signal from a satellite is normally aimed at a specific area called the ***footprint.*** The signal power at the center of the footprint is maximum. The power decreases as we move out from the footprint center. The boundary of the footprint is the location where the power level is at a predefined threshold.



Typical Satellite Footprint

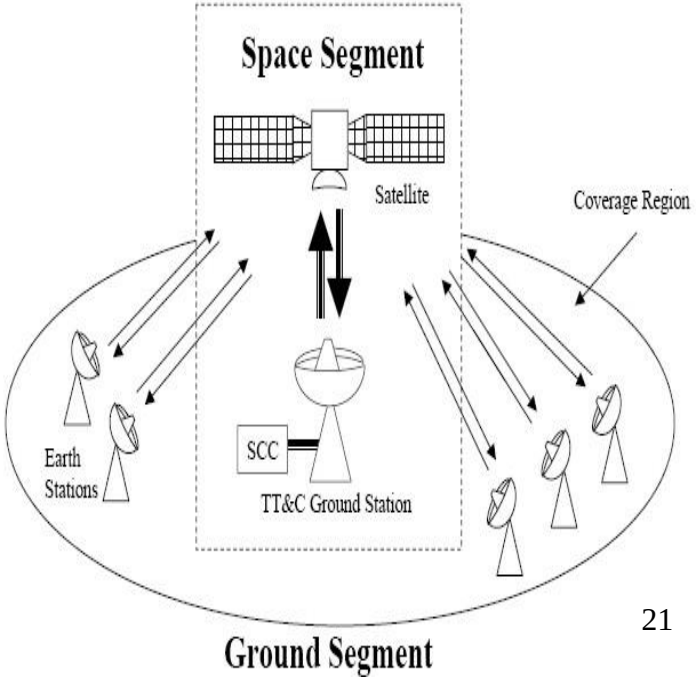
- **Two major elements of Satellite Communications Systems are:**

  - **Ground Segment**
  - **Space Segment**

Ground Segment

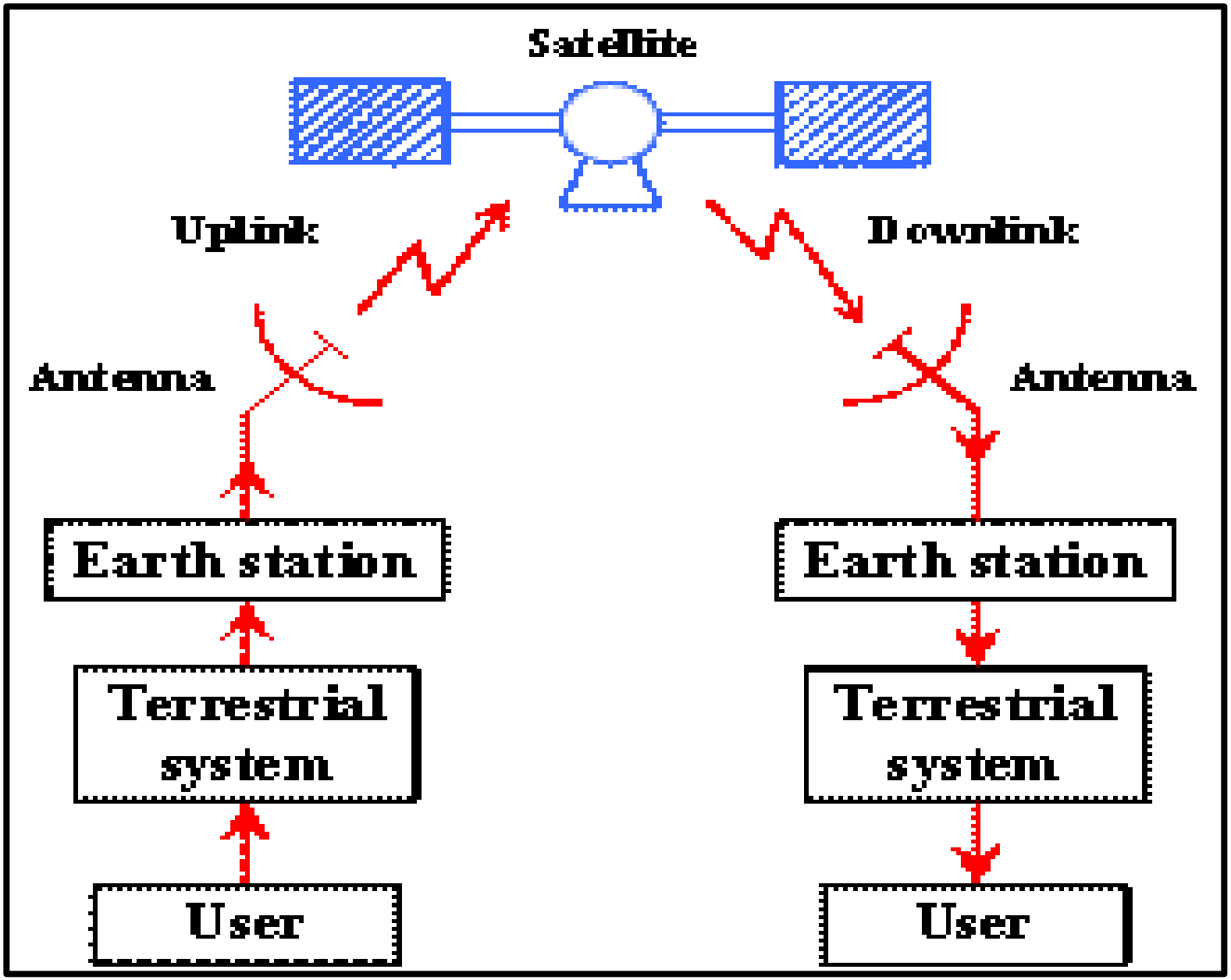
Ground segment is basically consist of an earth station.

An earth station provides a complete uplink and downlink chain for the signal. It transmits and receives the signal to and from the satellite. It is also consist of an antenna. Since the user baseband signal cannot be transmitted directly, it is also consist of amplifiers, modulators and demodulators, frequency up- and down- converters.



Space Segment

The space segment is consist of the satellite itself.
A satellite has various transmitting and receiving antenna, transponders and other control systems like temperature control, power supply control, orbit and altitude control, tracking, telemetry and command equipment etc..

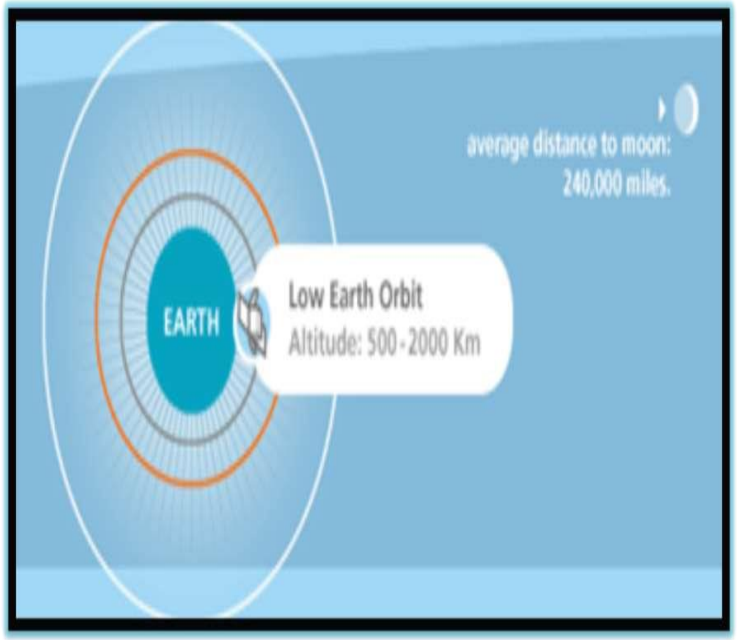

Satellite
Uplink
Downlink
Antenna
Antenna
Earth station
Earth station
Terrestrial system
Terrestrial system
User
User

Types of satellite orbits on the basis of altitude

An orbit is the path that a satellite follows as it revolves around Earth. In terms of commercial satellites, there are three main categories of orbits:

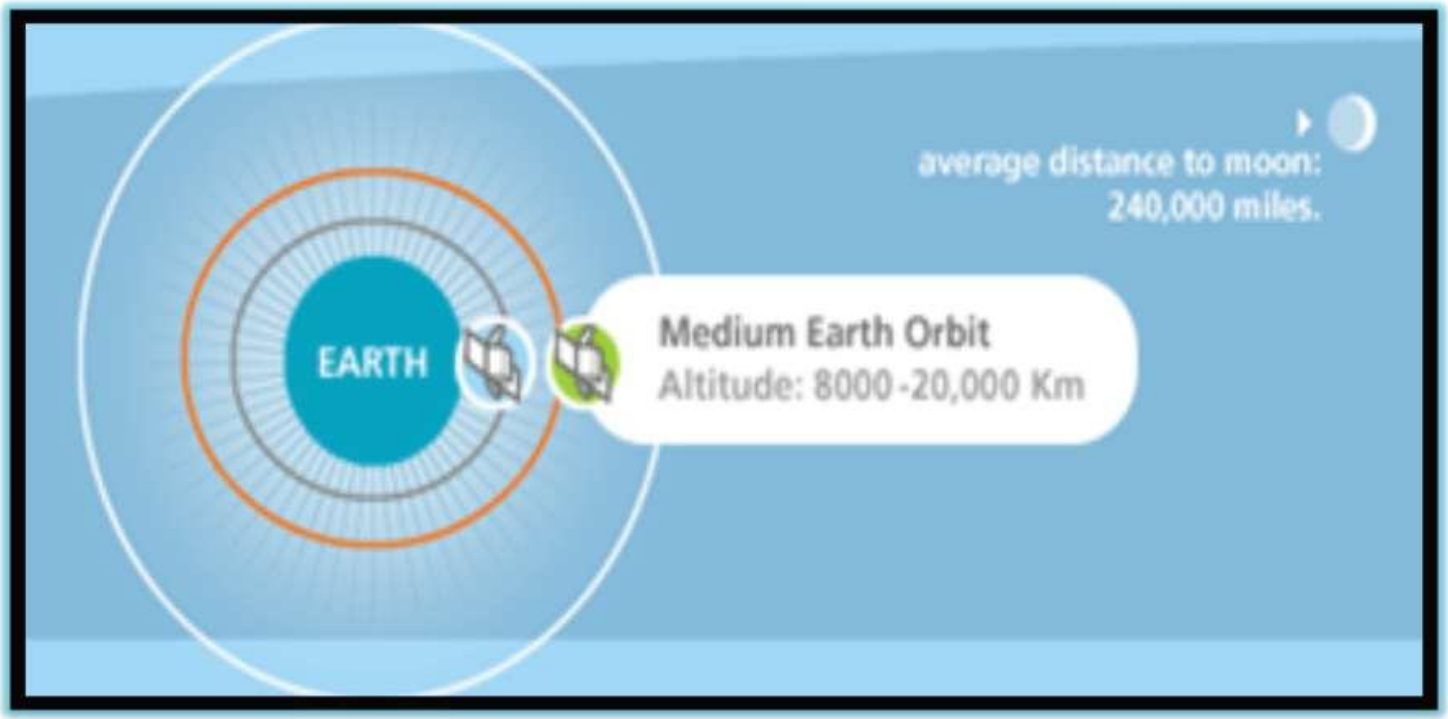
I LEO(Low Earth Orbit)

- **500-2,000 km above the earth**
- **These orbits are much closer to the Earth, requiring satellites to travel at a very high speed in order to avoid being pulled out of orbit by Earth's gravity**
- **At LEO, a satellite can circle the Earth in approximately one and a half hours**



2. MEO(Medium Earth Orbit)

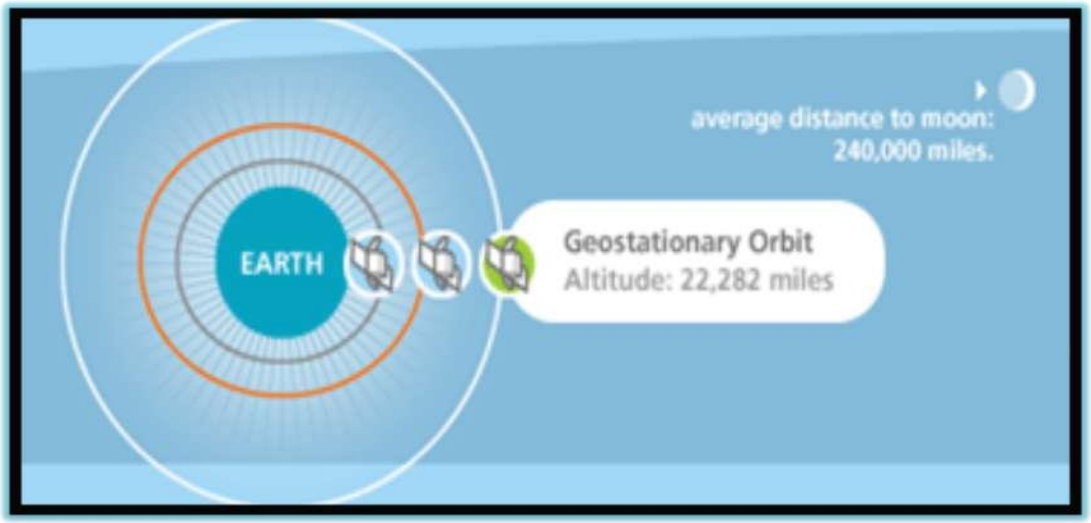
- 8,000-20,000 km above the earth
- These orbits are primarily reserved for communications satellites that cover the North and South Pole
- MEO's are placed in an elliptical (oval- shaped) orbit

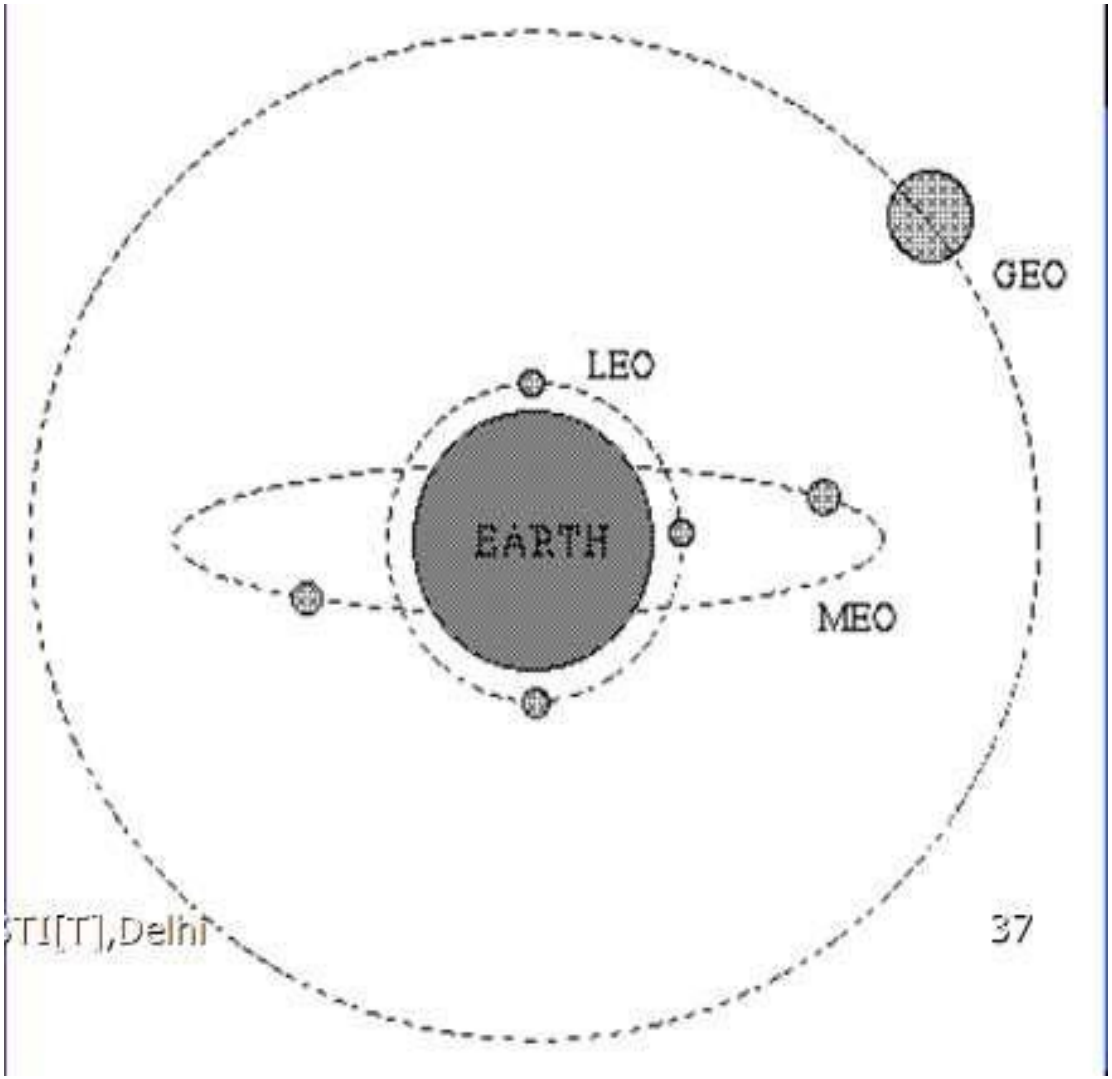


3. GEO (Geosynchronous Orbit)

- 35,786 km above the earth
- Orbiting at the height of 22,282 miles above the equator (35,786 km), the satellite travels in the same direction and at the same speed as the Earth's rotation on its axis, taking 24 hours to complete a full trip around the globe. Thus, as long as a satellite is positioned over the equator in an assigned orbital location, it will appear to be "stationary" with respect to a specific location on the Earth.
- A single geostationary satellite can view approximately one third of the Earth's surface.

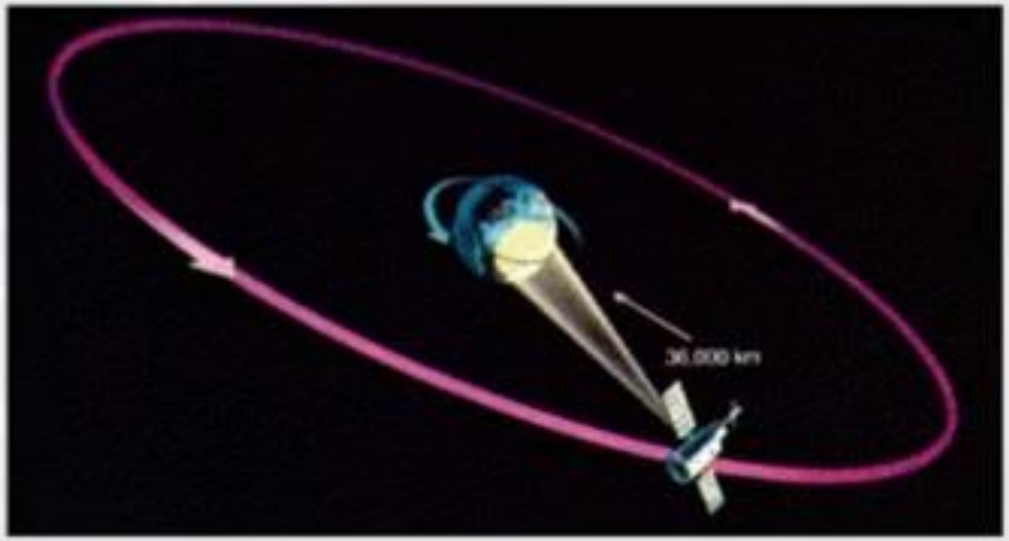
If three satellites are placed at the proper longitude, the height of this orbit allows almost all of the Earth's surface to be covered by the satellites.




GEO
LEO
EARTH
MEO
STI[T],Delhi
37

The satellites that are used in the VSAT system?

- VSAT system used geostationary earth orbit (GEO) satellites that revolve around the equator at the same rotational speed as the earth.
- Appearing as though they are not moving at all, GEOs are always in the same place above the earth. They also cover a large geographic area.
- Distance from earth: 36,000 km (22,282 miles).
- Speed: 11,300 Km/h.



Thank you for listening

Taqwa Altameemi