Lecture 7-8
WIRELESS NETWORKS

Reference
"INTRODUCTION TO WIRELESS AND MOBILE SYSTEMS ", *DHARMA ARAWAL."*
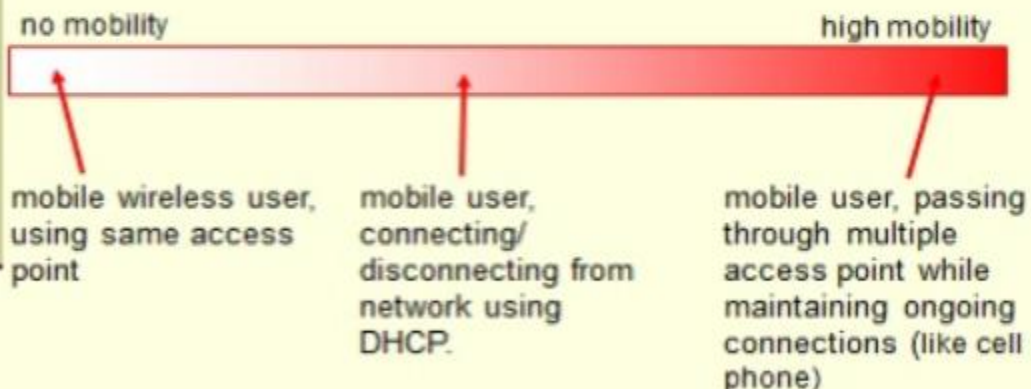
Contents

1- Mobility
2-Direct & Indirect routing
3-Handling mobility in cellular networks (Handoff)
4-Location Management

What is mobility?

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

no mobility   high mobility

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)
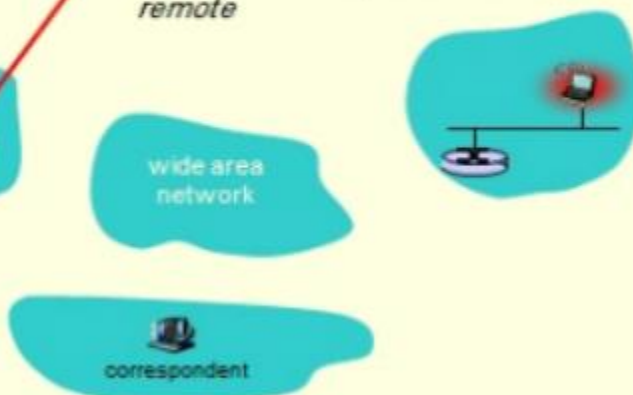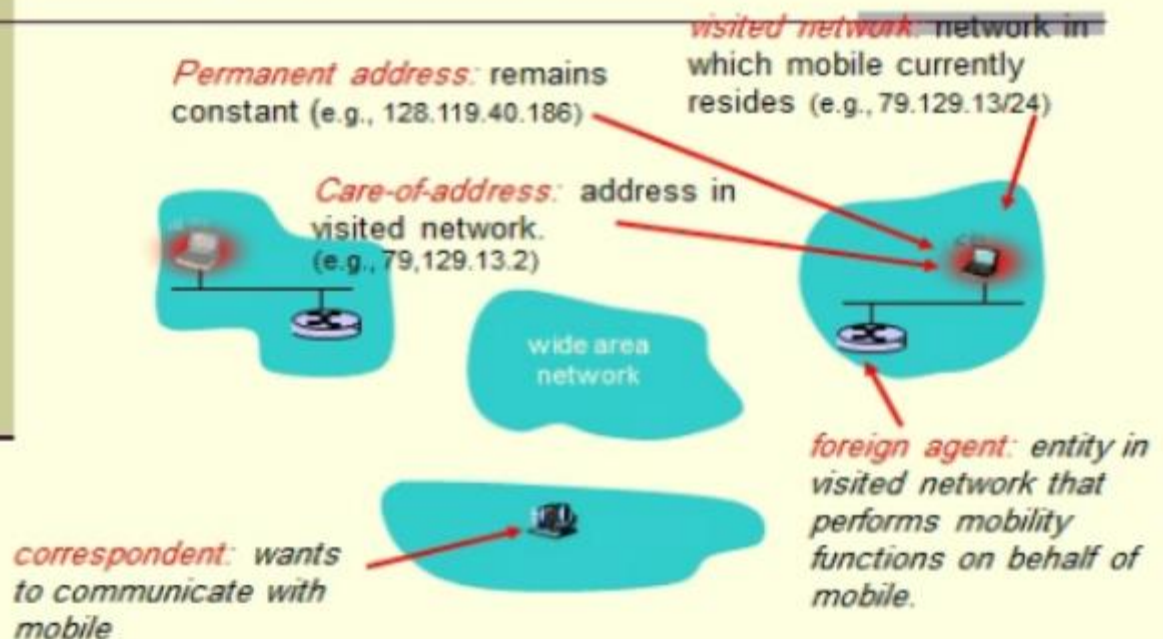
Mobility: Vocabulary

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

wide area network

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

correspondent

Mobility: more vocabulary

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

Care-of-address: address in visited network. (e.g., 79.129.13.2)

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

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

wide area network

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?

I wonder where Alice moved to?
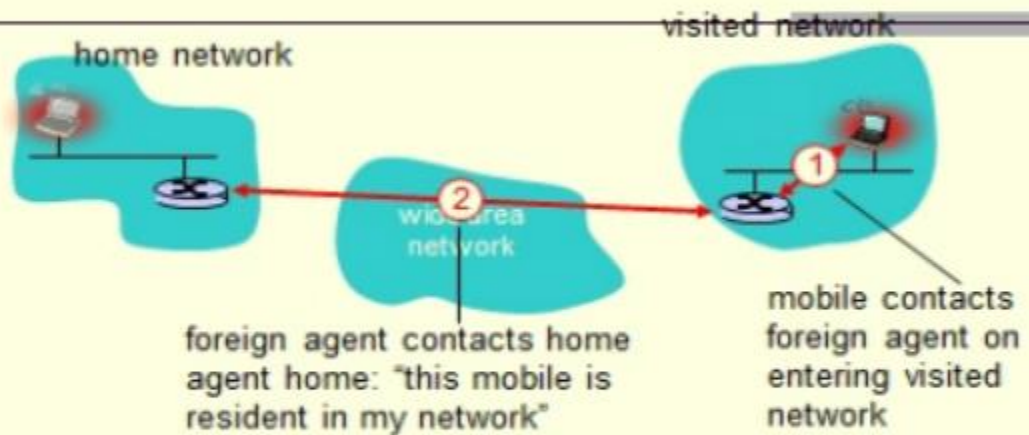
Mobility: approaches

- *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

Mobility: approaches

- *Let routing handle it:* routers advertise permanent address of mobil   sidence via usual routing table exchange.

not scalable to millions of mobiles

  - routing tables   ere each mobile located
  - no changes to end-systems
- *let end-systems handle it:*
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  - *direct routing:* correspondent gets foreign address of mobile, sends directly to mobile

Mobility: registration

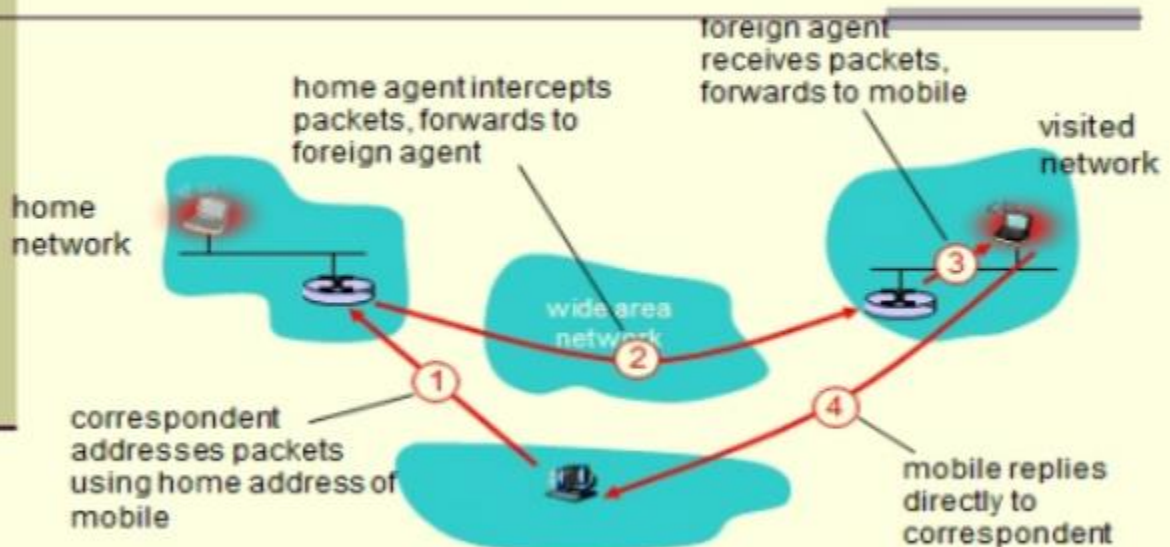home network

visited network

2 — foreign agent contacts home agent home: "this mobile is resident in my network"

1 — mobile contacts foreign agent on entering visited network

wide area network

End result:
- Foreign agent knows about mobile
- Home agent knows location of mobile

Mobility via Indirect Routing

home agent intercepts packets, forwards to foreign agent

foreign agent receives packets, forwards to mobile

visited network

home network

wide area network

1 — correspondent addresses packets using home address of mobile

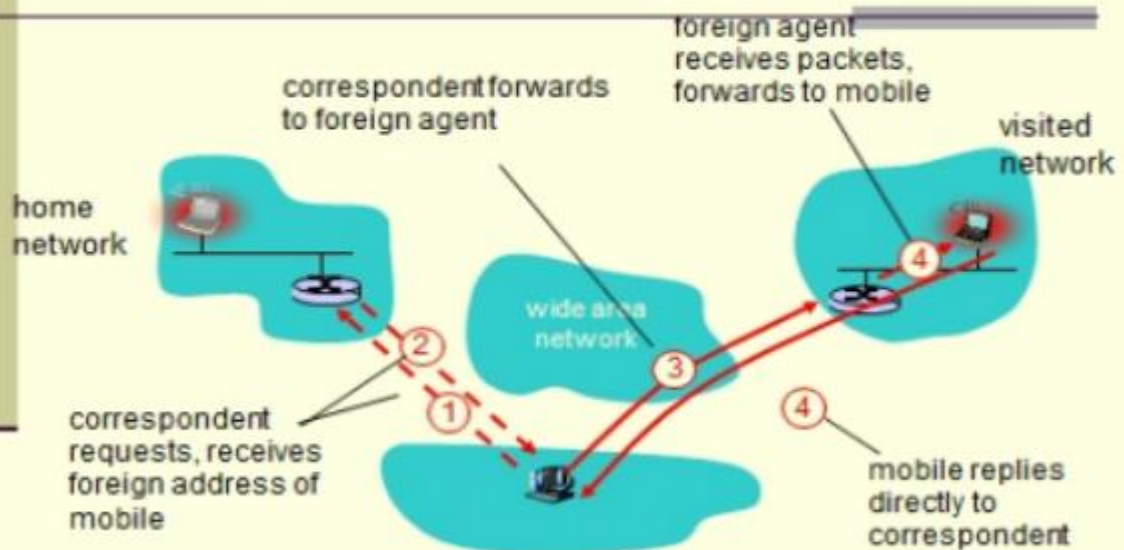4 — mobile replies directly to correspondent

Indirect Routing: comments

- 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
- foreign agent functions may be done by mobile itself
- triangle routing: correspondent-home-network-mobile
    - inefficient when correspondent, mobile are in same network
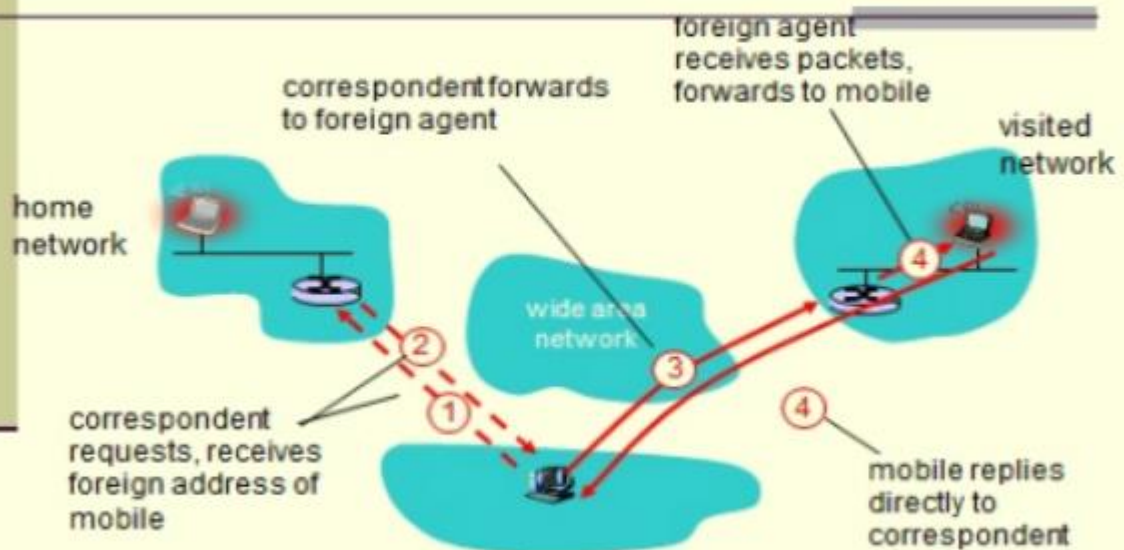

Indirect Routing: moving between networks

- 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!*

Mobility via Direct Routing

correspondent forwards
to foreign agent

foreign agent
receives packets,
forwards to mobile

visited
network

home
network

wide area
network

correspondent
requests, receives
foreign address of
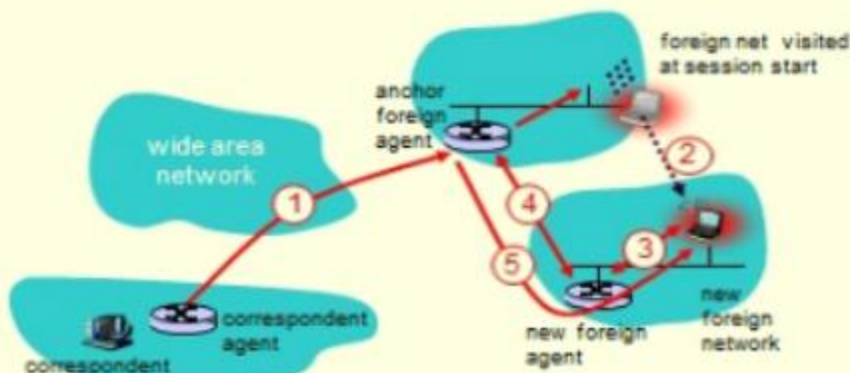mobile

mobile replies
directly to
correspondent

Mobility via Direct Routing: comments

- overcome triangle routing problem
- **non-transparent to correspondent:** correspondent must get care-of-address from home agent
 - what if mobile changes visited network?

Accommodating mobility with direct routing

- anchor foreign agent: FA in first visited network
- data always routed first to anchor FA
- when mobile moves: new FA arranges to have data forwarded from old FA (chaining)

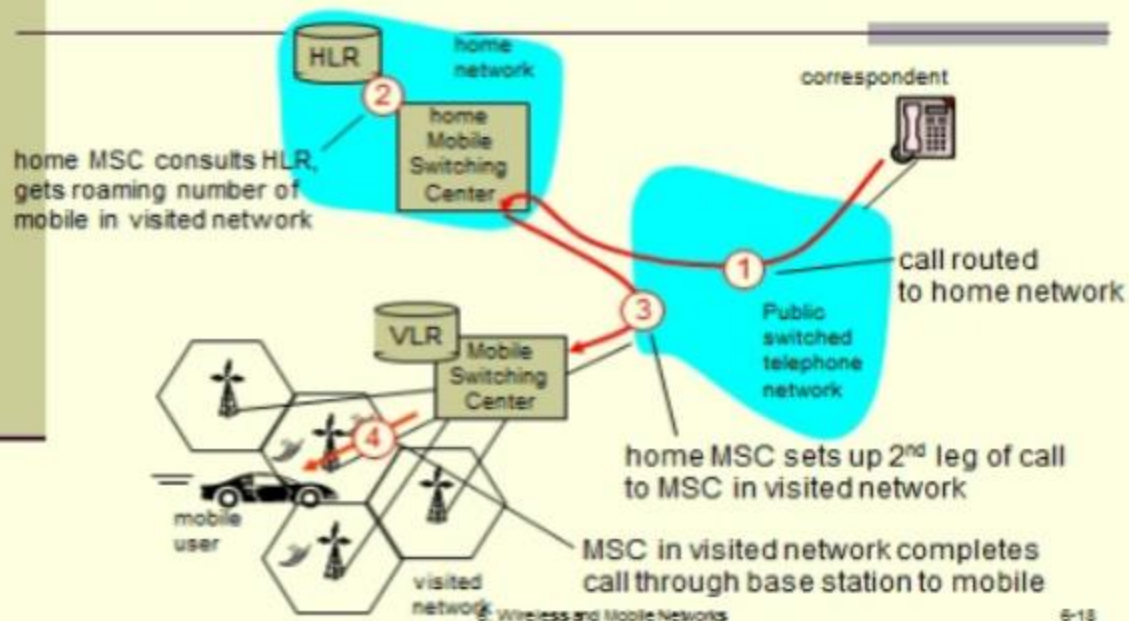# Components of cellular network architecture

recall:

different cellular networks,
operated by different providers
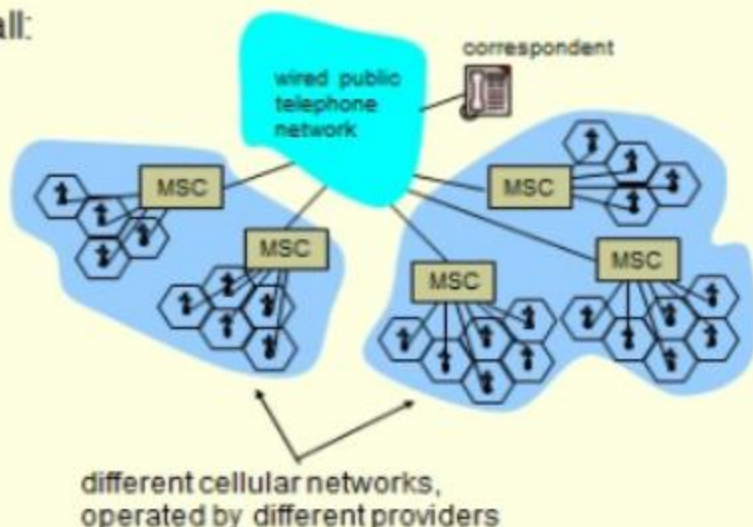
Handling mobility in cellular networks

- *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
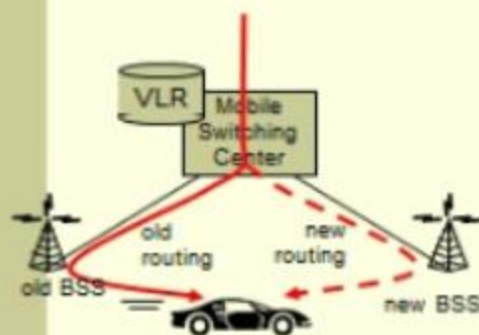 - could be home network

GSM: indirect routing to mobile

home MSC consults HLR, gets roaming number of mobile in visited network

HLR

home network

(2)

home Mobile Switching Center

correspondent

(1)

call routed to home network

Public switched telephone network

VLR

Mobile Switching Center

(3)

(4)

mobile user

visited network

home MSC sets up 2nd leg of call to MSC in visited network

MSC in visited network completes call through base station to mobile

6: Wireless and Mobile Networks

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GSM: handoff with common MSC

VLR

Mobile Switching Center

old routing

new routing

old BSS

new BSS

- 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

6: Wireless and Mobile Networks

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GSM: handoff with common MSC
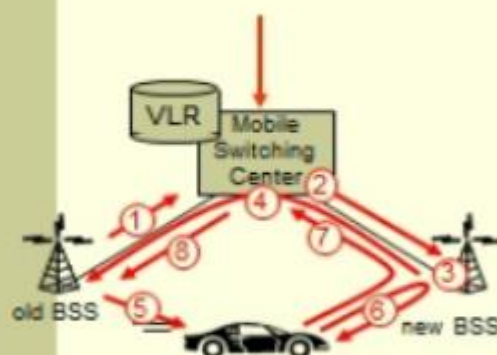
1. old BSS informs MSC of impending handoff, provides list of 1+ new BSSs
2. MSC sets up path (allocates resources) to new BSS
3. new BSS allocates radio channel for use by mobile
4. new BSS signals MSC, old BSS: ready
5. old BSS tells mobile: perform handoff to new BSS
6. mobile, new BSS signal to activate new channel
7. mobile signals via new BSS to MSC: handoff complete. MSC reroutes call
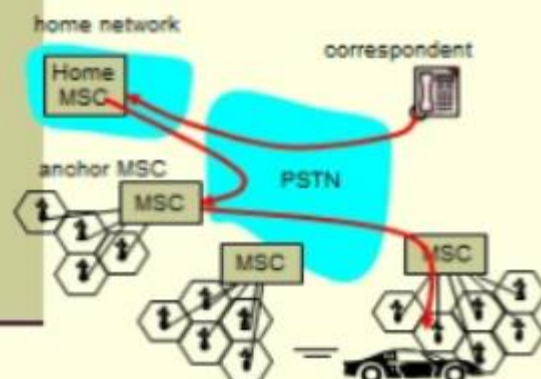8 MSC-old-BSS resources released

GSM: handoff between MSCs
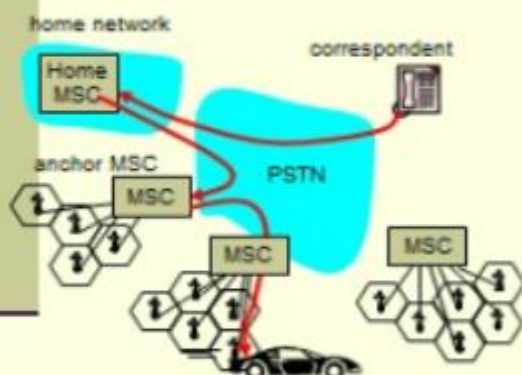
(a) before handoff

- *anchor MSC:* first MSC visited during cal
  - call remains routed through anchor MSC
- new MSCs add on to end of MSC chain as mobile moves to new MSC
- IS-41 allows optional path minimization step to shorten multi-MSC chain

GSM: handoff between MSCs

home network

Home MSC

correspondent

anchor MSC

MSC

PSTN

MSC

MSC

(b) after handoff

- *anchor MSC*: first MSC visited during cal
  - call remains routed through anchor MSC
- new MSCs add on to end of MSC chain as mobile moves to new MSC
- IS-41 allows optional path minimization step to shorten multi-MSC chain

Mobility: GSM versus Mobile IP

GSM element	Comment on GSM element	Mobile IP element
Home system	Network to which mobile user's permanent phone number belongs	Home network
Gateway Mobile Switching Center, or "home MSC". Home Location Register (HLR)	Home MSC: point of contact to obtain routable address of mobile user. HLR: database in home system containing permanent phone number, profile information, current location of mobile user, subscription information	Home agent
Visited System	Network other than home system where mobile user is currently residing	Visited network
Visited Mobile services Switching Center. Visitor Location Record (VLR)	Visited MSC: responsible for setting up calls to/from mobile nodes in cells associated with MSC. VLR: temporary database entry in visited system, containing subscription information for each visiting mobile user	Foreign agent
Mobile Station Roaming Number (MSRN), or "roaming number"	Routable address for telephone call segment between home MSC and visited MSC, visible to neither the mobile nor the correspondent.	Care-of-address

Location Management

- How does the network track a user's current cell to deliver a call?
- **Two main operations:**
  - **Location update** (MS sends location to BS)
  - **Paging** (cellular network sends location request to BSs)
- Number of cells to be paged depends on how location update is performed

Location Management

- Location update is **global** or **local**
  - **Global**: all subscribers update their location
  - **Local**: subscriber chooses when and where to update location
- Location update is **static** or **dynamic**
  - **Static**: predetermined set of cells at which location updates must be performed
  - **Dynamic**: location update is generated by MS based on its mobility

Location Management

- **Mobility Models** are models for the movement of mobile users, and how their location, velocity and acceleration change over time
- Examples
  - **Random Walk**
  - **Random Waypoint**
  - **City Section**
  - **Cell Residence Time-based**
  - **Markov Walk**
  - **Activity-based**

Mobility Models

- **Random Walk** → at each time slot, subscriber decides to either stay at cell or move to adjacent cell. MS moves from current location to new location by randomly choosing a direction & speed of travel from pre-defined ranges, [*speedmin*; *speedmax*] and [$0;2\pi$]. Movement is in either a constant time interval t or a constant distance traveled d

Mobility Models

- **Random Walk** → at each time slot, subscriber decides to either stay at cell or move to adjacent cell. MS moves from current location to new location by randomly choosing a direction & speed of travel from pre-defined ranges, [*speedmin*; *speedmax*] and [*0;2π*]. Movement is in either a constant time interval *t* or a constant distance traveled *d*

Mobility Models

- **Random Waypoint** → node selects a random destination & a random speed. Node moves to destination and **pauses for a fixed period** before another random location & speed are chosen

Mobility Models

- **City section** → nodes are located in intersections. Based on speed & block length, time to move in a path can be computed. MS chooses destination intersection. Path with least amount of travel time is found, and node moves along it

Mobility Models

- **Gauss-Markov Walk** → at fixed intervals of time, movement is determined by updating current speed & direction of MS. Values of speed & direction at movement n are calculated based on values of speed & direction at the $n - 1$ *movement*

Mobility Models

- **Cell Residence Time-based** → follow random or Gamma distribution to determine cell residence time
- **Activity-based** → determine route based on next activity to be performed by user

Location Management

General Schemes

1. **Never Update Scheme**

2. **Always Update Scheme**

3. **Location Area Scheme**

4. **Reporting Cells**

5. **Time-based**

6. **Movement -based**

Location Management

- How does the network track a user's current cell to deliver a call?

1. Never Update Scheme

- MS never tells its home MSC where it is
- When network needs to forward new call to MS, it *pages* all service area
- Very expensive for network in terms of bandwidth use

Location Management

- How does the network track a user's current cell to deliver a call?

2. Always Update Scheme

- Whenever MS detects that it entered a new cell, it sends a location update to MSC
- Network always knows where the MS is
- Expensive to MS

Location Management

- How does the network track a user's current cell to deliver a call?

3. Location Area Scheme

- Tradeoff between network paging and MS updates
- Divide service area into *location areas* (LAs)
- Each LA consists of a number of adjacent cells
- Each LA has a unique ID
- Each BS broadcasts the ID of the LA to which it belongs
- When an MS enters a new LA, it updates its location with MSC (usually the manager of the LA)
- When the network needs to find an MS, it pages its current LA
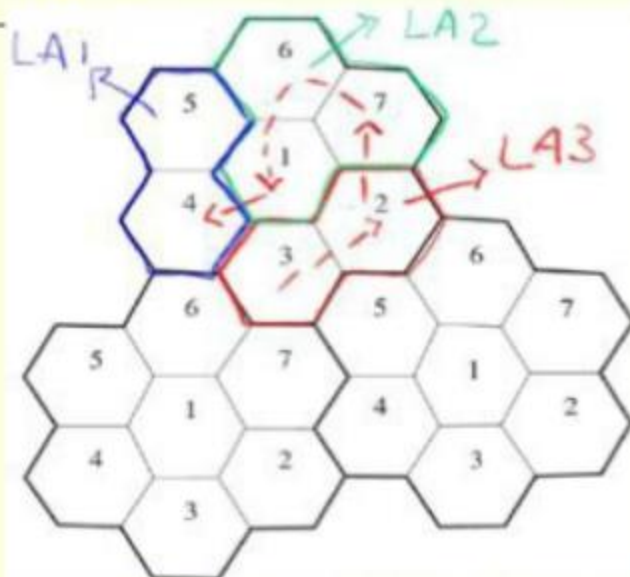
Location Management

Location Management

- How does the network track a user's current cell to deliver a call?

4. Reporting Cells

- Select subset of cells as reporting cells
- Cell broadcasts a signal to indicate if it is reporting or not
- Reporting cell i **vicinity** is all non-reporting cells reachable from cell i without crossing another reporting cell
- MS updates location when it moves to a new reporting cell
- Cellular network pages MS in reporting cell and its vicinity
- Cost of paging increases with size of vicinity

Location Management

- How does the network track a user's current cell to deliver a call?

5. Time-based

- Given a time threshold T, a MS updates its location every T units of time
- When cellular system has incoming call for MS, it pages cell i where last update was made
- If MS is not found at cell i, cells $i + j$ and $i - j$ are paged, where j starts at 1, until MS is found
- T can be determined on a per-user basis

Location Management

- How does the network track a user's current cell to deliver a call?

6. **Movement-based**
   - MS keeps counter that is increased by 1 when MS crosses the boundary to a new cell
   - Boundary crossing can be detected by comparing BS IDs
   - When counter reaches a predetermined threshold M, MS updates its location and resets counter to zero
   - MS is guaranteed to be within distance M from its last reported cell (**residing area**)

Thanks- Questions !