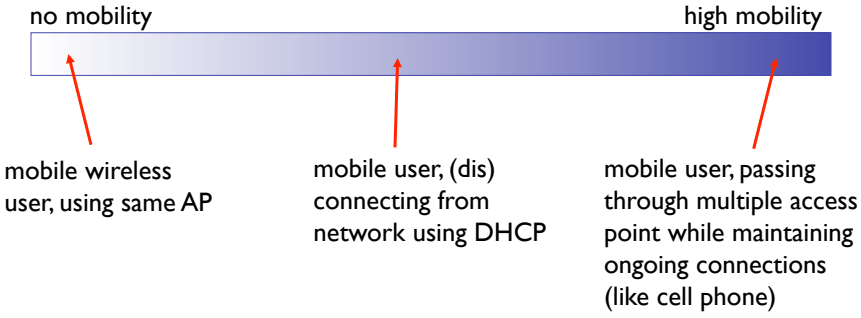
What is Mobility?

Spectrum of mobility, from the *network* perspective:

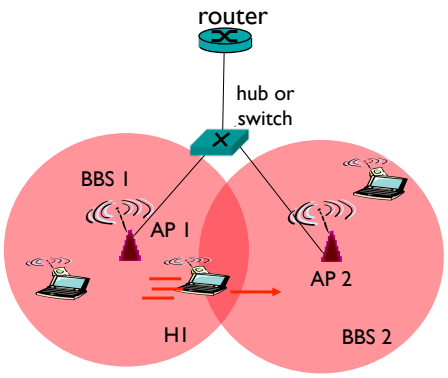


802.11: Mobility Within Same Subnet

H1 remains in same IP subnet: IP address can remain same

switch: which AP is associated with H1?

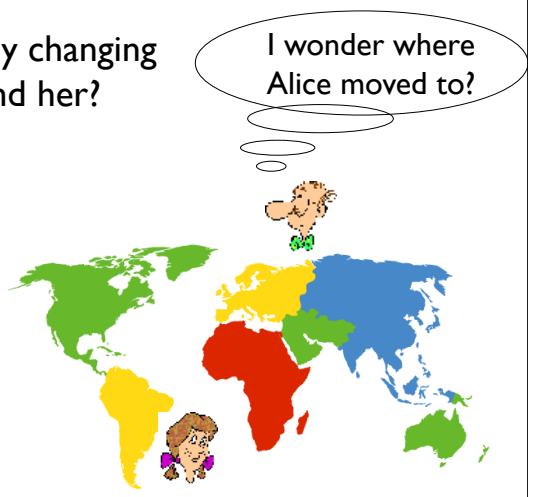
- self-learning (Ch. 5): switch will see frame from H1 and "remember" which switch port can be used to reach H1



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?



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

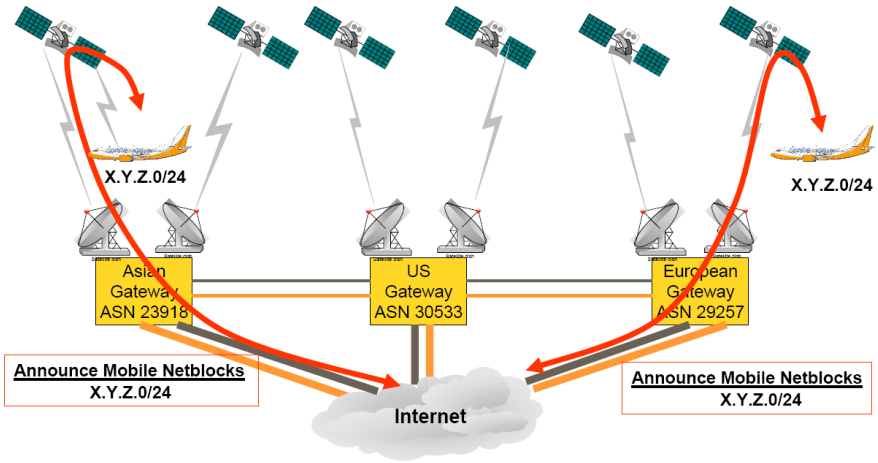
not scalable to millions of mobiles

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

Boeing Connexion Mobility Service

Using BGP for mobile routing



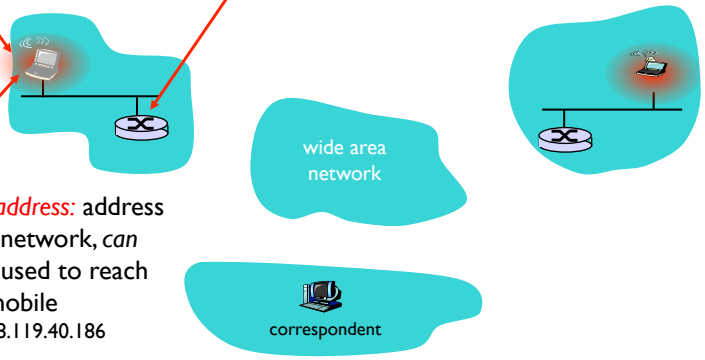
Commercial passenger traffic is released at each Ground Station.
Each Ground Station only advertises the IP's for the planes it is serving.
When a plane leaves a region, that gateway stops advertising its IP's.

Mobile Routing Overview - 2004

Mobility: Vocabulary

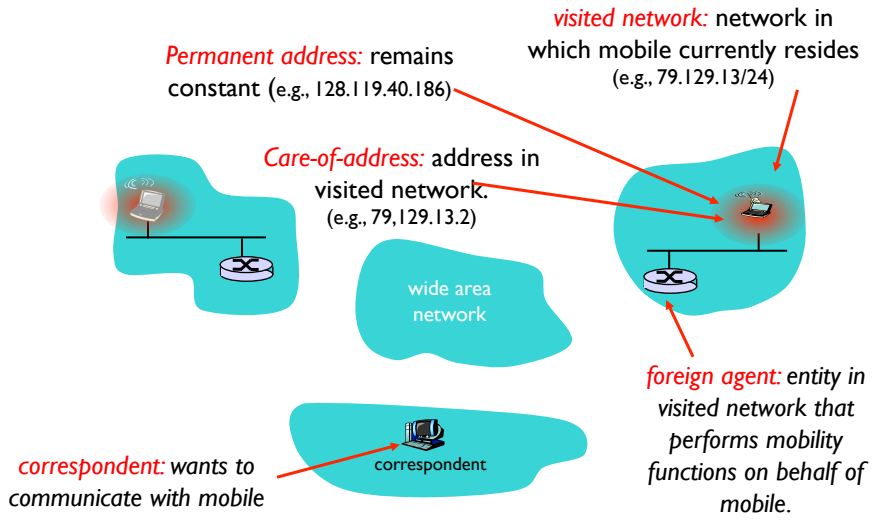
home network: permanent "home" of mobile (e.g., 128.119.40/24)

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

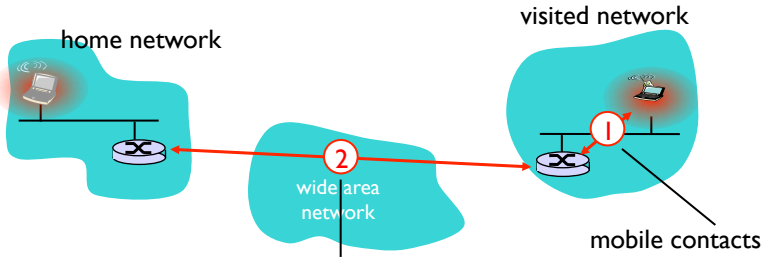


Permanent address: address in home network, *can always* be used to reach mobile
e.g., 128.119.40.186

Mobility: More Vocabulary



Mobility: Registration

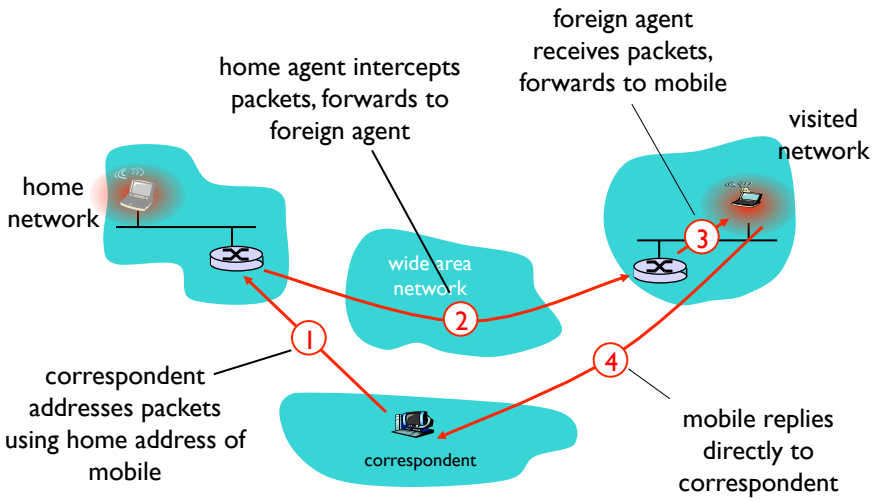


End result:

Foreign agent knows about mobile

Home agent knows location of mobile

Mobility via Indirect Routing



Indirect Routing

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

Moving between networks: suppose mobile user moves to another network

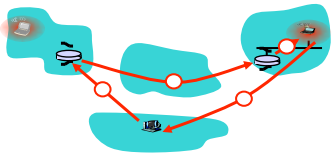
- registers with new foreign agent
- new foreign agent registers with home agent
- home agent update care-of-address for mobile
- packets continue to be forwarded to mobile (but with new care-of-address)

mobility, changing foreign networks is transparent: *on going connections can be maintained!*

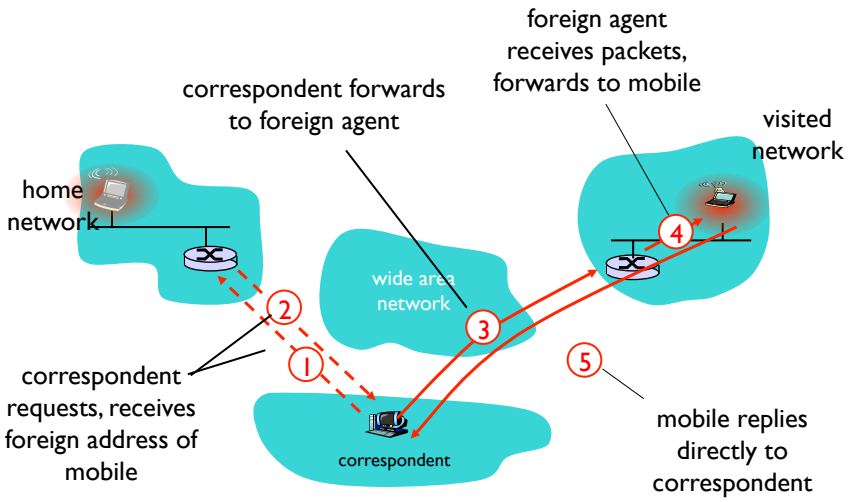
Triangle routing:

correspondent-home-network-mobile

- inefficient when correspondent, mobile are in same network



Mobility via Direct Routing

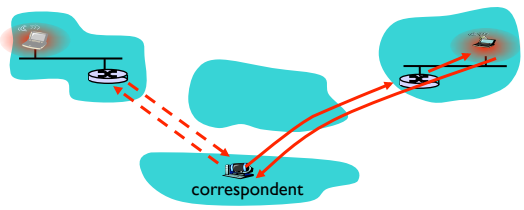


Mobility via Direct Routing Comments

overcome triangle routing problem

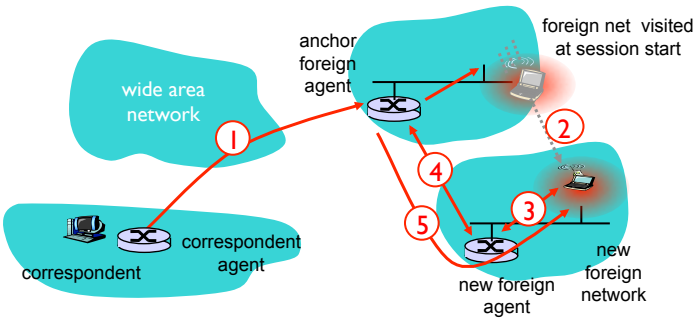
non-transparent to correspondent: correspondent must get care-of-address from home agent

- 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)



Mobile IP [RFC3220]

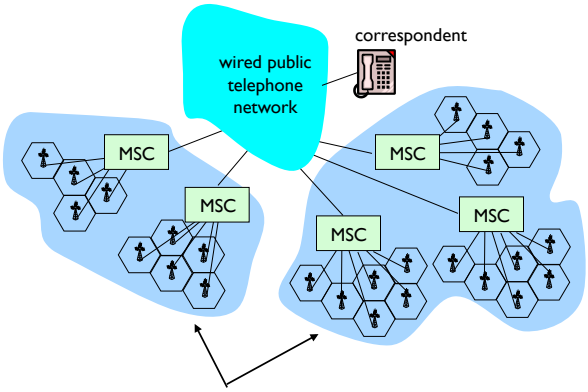
Has many features we've seen:

- home agents, foreign agents, foreign-agent registration, care-of-addresses, encapsulation (packet-within-a-packet)

three components to standard:

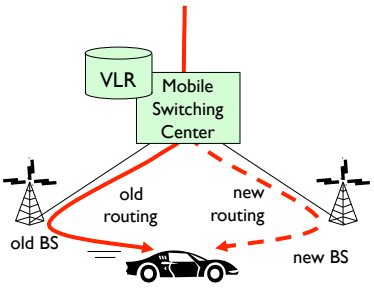
- indirect routing of datagrams
- agent discovery
- registration with home agent

Components of Cellular Network Architecture



different cellular networks, operated by different providers

GSM: Handoff within Common MSC



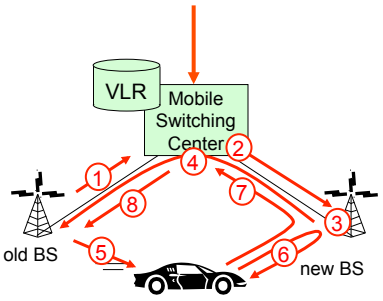
Handoff goal: route call via new base station (without interruption)

Reasons for handoff:

- stronger signal to/from new BS (continuing connectivity, less battery drain)
- load balance: free up channel in current BS
- GSM doesn't mandate why to perform handoff (policy), only how (mechanism)

Handoff initiated by old BS

GSM: Handoff with Common MSC



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

Handling Mobility in Cellular Networks

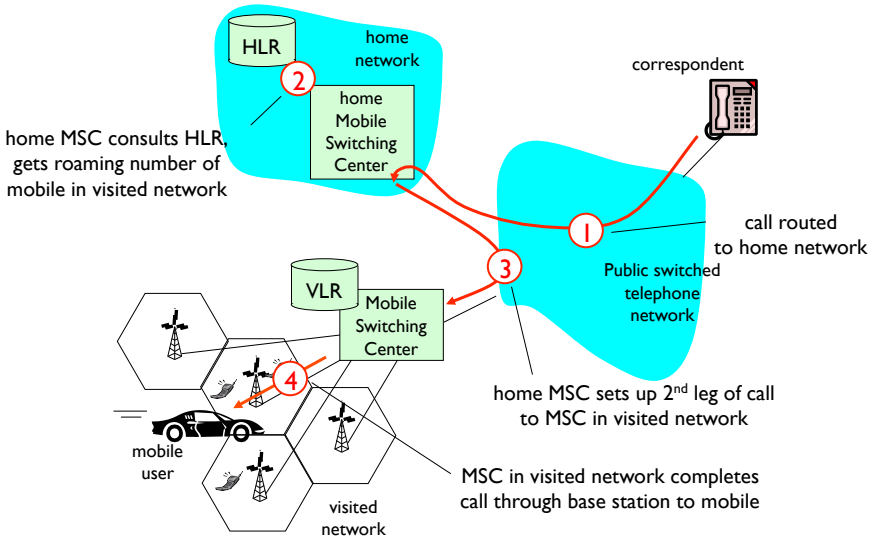
Home network: network of cellular provider you subscribe to (e.g., Sprint PCS, Verizon)

- 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)

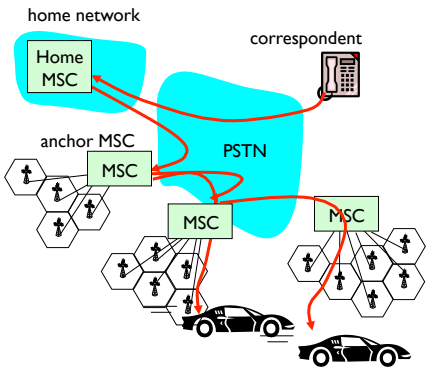
Visited network: network in which mobile currently resides

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

GSM: Indirect Routing to Mobile



GSM: Handoff Between MSCs



Anchor MSC: first MSC visited during call

- 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

Session Initiation Protocol (SIP)

Comes from IETF

SIP long-term vision

- All telephone calls and video conference calls take place over the Internet
- People are identified by names or e-mail addresses, rather than by phone numbers
- You can reach the callee, no matter where the callee roams, no matter what IP device the callee is currently using

Included as part of 3GPP's IP Multimedia Subsystem (IMS)

SIP Services

Setting up a call

- provides mechanisms for caller to let callee know she wants to establish a call
- provides mechanisms so that caller and callee can agree on media type and encoding
- provides mechanisms to end call

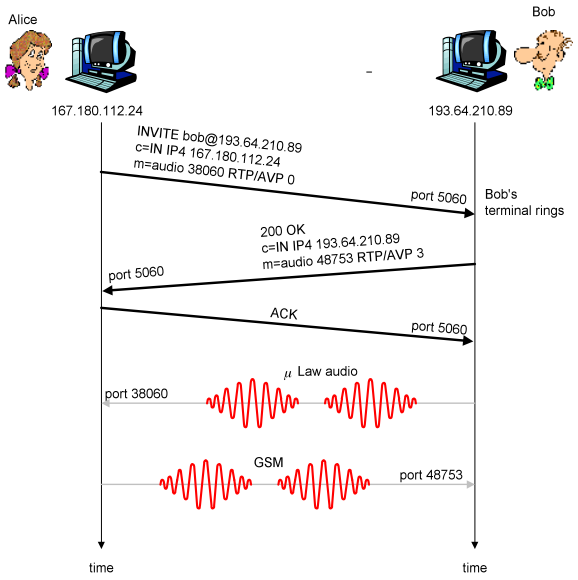
Determine current IP address of callee

- maps mnemonic identifier to current IP address

Call management

- add new media streams during call
- change encoding during call
- invite others
- transfer and hold calls

Setting up a Call to an IP Address



- Alice's SIP invite message indicates her port number & IP address, and encoding that Alice prefers to receive (PCM ulaw)
- Bob's 200 OK message indicates his port number, IP address & preferred encoding (GSM)
- SIP messages can be sent over TCP or UDP; here sent over RTP/UDP
- Default SIP port number is 5060

Setting up a Call (more)

Codec negotiation:

- suppose Bob doesn't have PCM ulaw encoder
- Bob will instead reply with 606 Not Acceptable Reply and list encoders he can use
- Alice can then send a new INVITE message, advertising an appropriate encoder

Rejecting the call

- Bob can reject with replies "busy," "gone," "payment required," "forbidden"

Media can be sent over RTP or some other protocol

Name Translation and User Location

Caller wants to call callee, but only has callee's name or e-mail address

Need to get IP address of callee's current host:

- user moves around
- DHCP protocol
- user has different IP devices (PC, PDA, car device)

Result can be based on:

- time of day (work, home)
- caller (don't want boss to call you at home)
- status of callee (calls sent to voicemail when callee is already talking to someone)

Service provided by SIP servers:

- SIP registrar server
- SIP proxy server

Example of SIP Message

```
INVITE sip:bob@domain.com SIP/2.0
Via: SIP/2.0/UDP 167.180.112.24
From: sip:alice@hereway.com
To: sip:bob@domain.com
Call-ID: a2e3a@pigeon.hereway.com
Content-Type: application/sdp
Content-Length: 885

c=IN IP4 167.180.112.24
m=audio 38060 RTP/AVP 0
```

Notes:
HTTP message syntax
sdp = session description protocol
Call-ID is unique for every call

- Here we don't know Bob's IP address, intermediate SIP servers will be necessary
- Alice sends and receives SIP messages using the SIP default port number 5060
- Alice specifies in "Via: header" that SIP client sends and receives SIP messages over UDP

SIP Registrar

When Bob starts SIP client, client sends SIP REGISTER message to Bob's registrar server (similar function needed by Instant Messaging)

Register Message:

```
REGISTER sip:domain.com SIP/2.0
Via: SIP/2.0/UDP 193.64.210.89
From: sip:bob@domain.com
To: sip:bob@domain.com
Expires: 3600
```

SIP Proxy

Alice sends invite message to her proxy server
- contains address sip:bob@domain.com

Proxy responsible for routing SIP messages to callee
- possibly through multiple proxies

Callee sends response back through the same set of proxies

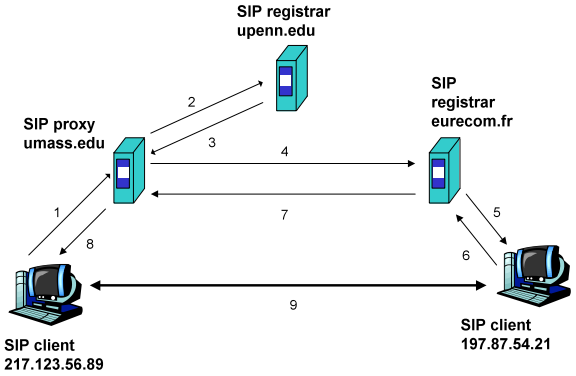
Proxy returns SIP response message to Alice
- contains Bob's IP address

Note: proxy is analogous to local DNS server

Example

Caller jim@umass.edu with places a call to keith@upenn.edu

(1) Jim sends INVITE message to umass SIP proxy (2) Proxy forwards request to upenn registrar server
(3) upenn server returns redirect response, indicating that it should try keith@eurecom.fr



(4) umass proxy sends INVITE to eurecom registrar (5) eurecom registrar forwards INVITE to 197.87.54.21, which is running keith's SIP client (6-8) SIP response sent back (9) media sent directly between clients
Note: also a SIP ack message, which is not shown