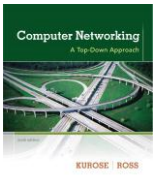
Chapter 6
Wireless and Mobile Networks



Computer Networking: A Top Down Approach
6th edition
Jim Kurose, Keith Ross
Addison-Wesley
March 2012

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Thanks and enjoy! JFK/KWR

The course notes are adapted for Bucknell's CSCI 363
Xiannong Meng
Spring 2016

Chapter 6 outline

6.1 Introduction

Wireless
6.2 Wireless links, characteristics
- CDMA

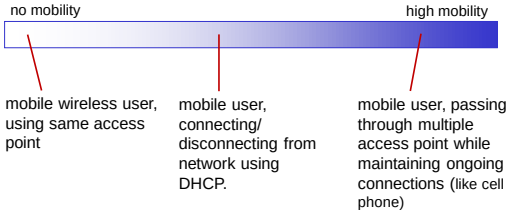
6.3 IEEE 802.11 wireless LANs ("Wi-Fi")
6.4 Cellular Internet Access
- architecture
- standards (e.g., GSM)

Mobility
6.5 Principles: addressing and routing to mobile users
6.6 Mobile IP
6.7 Handling mobility in cellular networks
6.8 Mobility and higher-layer protocols

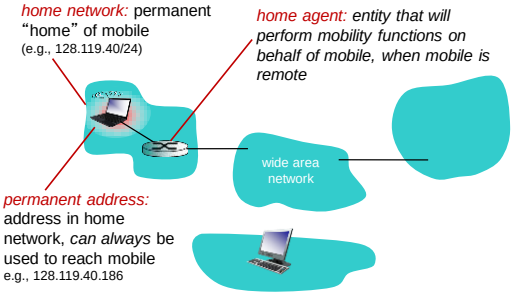
6.9 Summary

What is mobility?

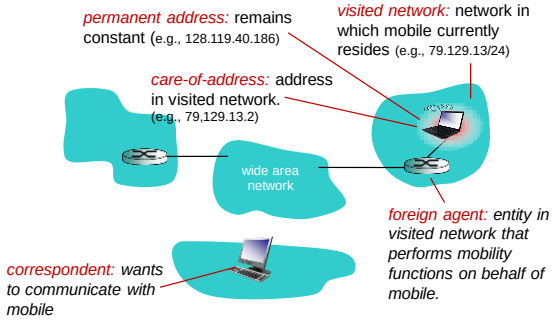
- spectrum of mobility, from the *network* perspective:



Mobility: vocabulary

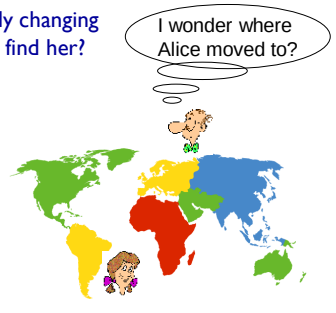


Mobility: more vocabulary



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: how to handle it?

- *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 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
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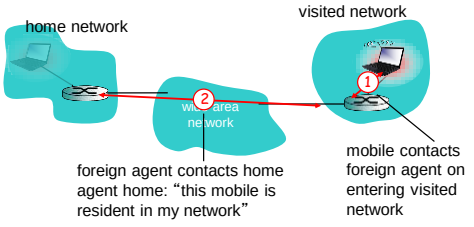
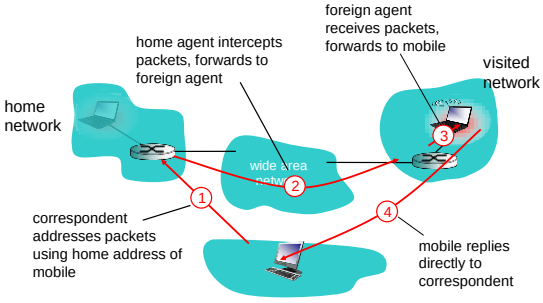
Mobility: registration



end result:

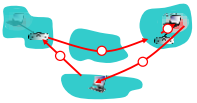
- foreign agent knows about mobile
- home agent knows location of mobile

Mobility via indirect routing



Indirect Routing: comments

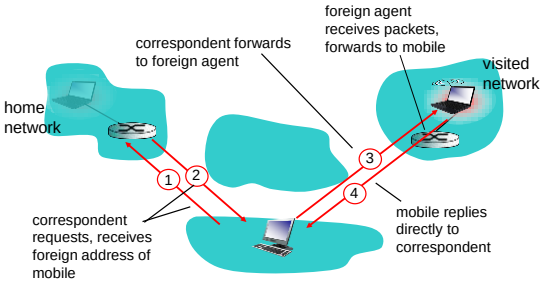
- mobile uses two addresses:
  - permanent address: used by correspondent (hence mobile location is *transparent* to correspondent)
  - care-of-address: used by home agent to forward datagrams to mobile
- foreign agent functions may be done by mobile itself
- triangle routing: correspondent-home-network-mobile
  - inefficient when correspondent, mobile are in same network or close to each other.



Indirect routing: moving between networks

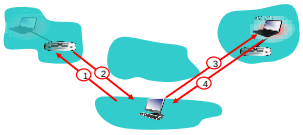
- suppose mobile user moves to another network
  - registers with new foreign agent
  - new foreign agent registers with home agent
  - home agent update care-of-address for mobile
  - packets continue to be forwarded to mobile (but with new care-of-address)
- mobility, changing foreign networks transparent: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

Mobility via direct routing



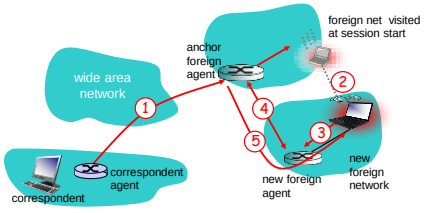
Mobility via direct routing: comments

- 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)



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6.6 Mobile IP

6.7 Handling mobility in cellular networks

6.8 Mobility and higher-layer protocols

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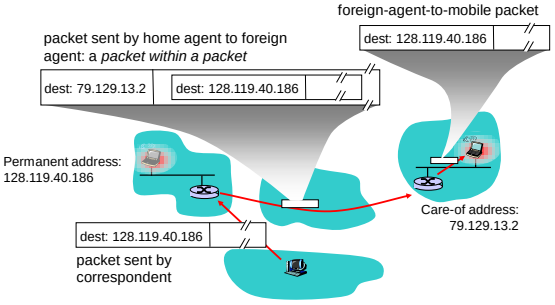
Mobile IP

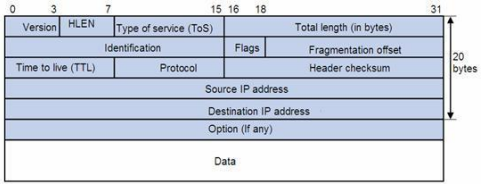
- Specified in RFC 3344 (2002)
- has many features we've seen:
  - home agents, foreign agents, foreign-agent registration, care-of-addresses, encapsulation (packet-within-a-packet)
- three components to standard:
  - indirect routing of datagrams
  - agent discovery
  - registration with home agent

Mobile IP: indirect routing



IP and ICMP

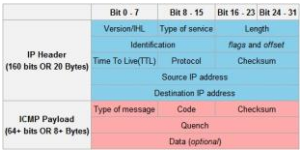
Mobile IP uses ICMP for router management (advertising home/mobile agents)



List of IP protocols:
http://en.wikipedia.org/wiki/List_of_IP_protocol_numbers

When "Protocol" equals 0x01, the IP packet carries an ICMP as Its payload (data)

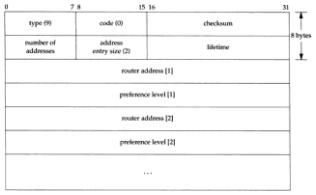
ICMP: Internet Control Message Protocol review



A combination of "type of message" and "code" specifies the meaning of this ICMP packet. Among others
-- Type 9 is for "route advertising"
-- See a complete list from Wikipedia at
http://en.wikipedia.org/wiki/Internet_Control_Message_Protocol#Header
-- Run IP packet analysis lab solution (no-pcap) using "icmp-etherreal-trace-1" as data to see Type 8 and Type 0 ICMP messages (Echo request and Echo reply)

ICMP Type 9 message (route discovery)

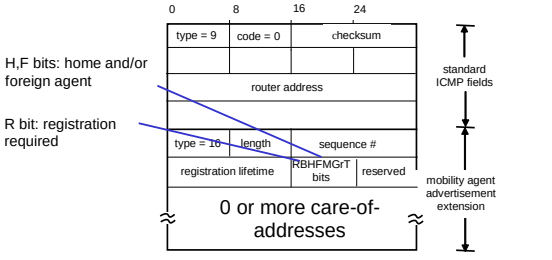
- Specification at RFC
  http://www.ietf.org/rfc/rfc1256.txt



http://flylib.com/books/3/223/1/html/2/files/09fig07.gif

Mobile IP: agent discovery

- *agent advertisement:* foreign/home agents advertise service by broadcasting ICMP messages (typefield = 9)



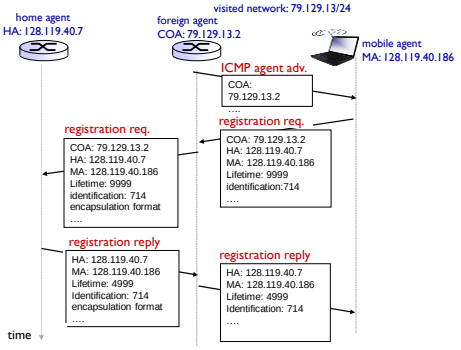
Flags in ICMP mobile extension

- H: home agent bit
- F: foreign agent bit
- R: registration required bit
- M,G: encapsulation bits (minimal or GRE encapsulation)
- B: busy
- r: reserved
- T: reverse tunneling

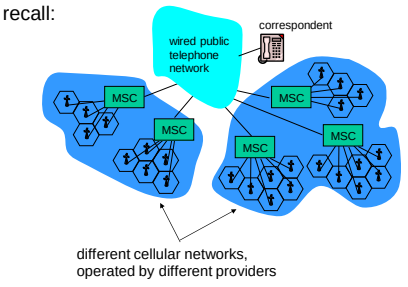
Other ICMP Messages Used by Mobile IP

- Type 10 : agent solicitation, mobile agent is looking for COA without advertisement
- Type 35 : mobile registration request
- Type 36 : mobile registration reply

Mobile IP: registration example



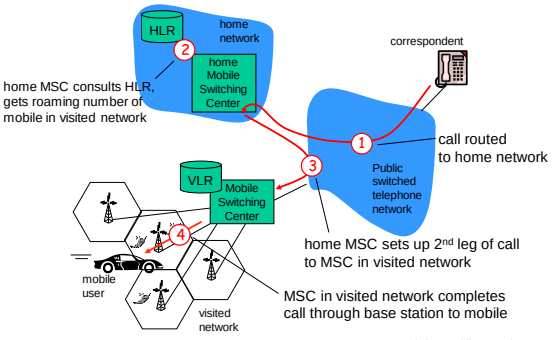
Components of cellular network architecture



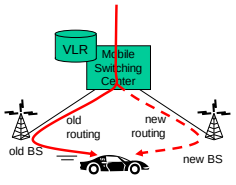
Handling mobility in cellular networks

- *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

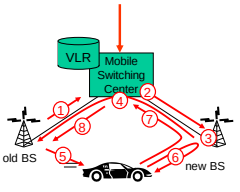


GSM: handoff with common MSC



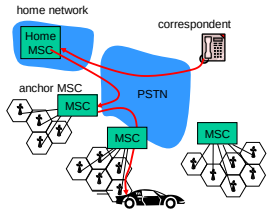
- *handoff goal:* route call via new base station (without interruption)
- reasons for handoff:
  - stronger signal to/from new BS (continuing connectivity, less battery drain)
  - load balance: free up channel in current BS
  - GSM doesn't mandate why to perform handoff (policy), only how (mechanism)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

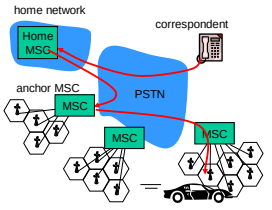
GSM: handoff between MSCs



(a) before handoff

- *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
- optional path minimization step to shorten multi-MSC chain

GSM: handoff between MSCs



(b) after handoff

- *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
- 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**

Wireless, mobility: impact on higher layer protocols

- logically, impact *should* be minimal …
  - best effort service model remains unchanged
  - TCP and UDP can (and do) run over wireless, mobile
- … but performance-wise:
  - packet loss/delay due to bit-errors (discarded packets, delays for link-layer retransmissions), and handoff
  - TCP interprets loss as congestion, will decrease congestion window un-necessarily
  - delay impairments for real-time traffic
  - limited bandwidth of wireless links

Chapter 6 summary

Wireless

- wireless links:
  - capacity, distance
  - channel impairments
  - CDMA
- IEEE 802.11 ("Wi-Fi")
  - CSMA/CA reflects wireless channel characteristics
- cellular access
  - architecture
  - standards (e.g., GSM, 3G, 4G LTE)

Mobility

- principles: addressing, routing to mobile users
  - home, visited networks
  - direct, indirect routing
  - care-of-addresses
- case studies
  - mobile IP
  - mobility in GSM
- impact on higher-layer protocols