Administrivia

- No lecture on Thurs.
- Last homework will be out this week (not due, covers wireless)
- Extra office hours for next week and the week after.

CSMA/CA: Recap

- Sensing in wireless medium is limited by hidden terminal problem.
- Collision detection is limited by half-duplex nature of radios (cannot talk and listen at the same time)
- Collision avoidance is the key!
  - Random backoff after sensing busy slot
  - RTS/CTS reservation protocol
**Channel Partitioning, Random Access and Scheduling**

- Channel partitioning (GSM, CDMA, etc) is inflexible in accommodating bursty traffic.
- Random access allows “on-demand” allocation, but has significant overhead due to collision or RTS/CTS.
- 4th generation cellular systems are shifting to explicit centralized scheduling of resources by the BS.
Mobility Management

- General principles
- Cellular network examples.
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)

Example (simple): mobility within same 802.11 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
**Wide-Area Mobility Management**

- In the 802.11 example, mobility is handled at the link layer.
- For wide-area roaming, it must be handled at the network layer.
- Issues:
  - How to find the destination?
  - How to route stuff to the destination?
  - How to update and keep track of its location?

**Mobility: Vocabulary**

- **home network**: permanent "home" of mobile (e.g., 128.119.40/24, Verizon)
- **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, (510) 642-5807

**correspondent**

**wide area network**
**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)
- **wide area network**
- **foreign agent**: entity in visited network that performs mobility functions on behalf of mobile.
- **correspondent**: wants to communicate with 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
- **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

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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
- 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**

1. Correspondent requests, receives foreign address of mobile
2. Correspondent forwards to foreign agent
3. Foreign agent receives packets, forwards to mobile
4. 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)
Examples

- Mobile IP
- Cellular networks

Will focus on latter.

Components of cellular network architecture

recall:

- wired public telephone network
- correspondent
- different cellular networks, operated by different providers
Handling mobility in cellular networks

- **home network**: network of cellular provider you subscribe to (e.g., Sprint, 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

1. call routed to home network
2. Mobile Switching Center consults HLR, gets roam number of mobile in visited network
3. MSC in visited network completes call through base station to mobile
4. HLR sends roam number to VLR, VLR sends roaming number to mobile user
**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**

0. Mobile measures signal strength from adjacent BS’s based on beacons.
1. Old BS informs MSC of impending handoff, provides list of 1+ new BS’s
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 BSS: 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**

- **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

(a) before handoff

(b) after handoff
**Soft vs Hard Handoff**

- In GSM, a mobile is connected to only one BSS at any one time.
- Handoff entails changing channels.
- In CDMA, all users occupy the entire bandwidth (1.25 MHz).
- Two BSS’s can be simultaneously listening to the mobile and pass their decisions and their reliability to the MSC.
- The MSC decides based on the better decision at the moment.
- Soft handoff provides a form of macrodiversity.