Cellular and Mobile Wireless Networks (part 2)
Cellular/Mobile Wireless Outline

- Cellular Architecture
- Cellular Standards
  - GSM, 2G, 2.5G and 3G
- Mobile Definitions
  - Agents, addresses, correspondent
- Mobile Architecture
  - Registering
  - Indirect Routing
  - Direct Routing
Cellular Network Architecture

**MSC**
- connects cells to wide area net
- manages call setup
- handles mobility

**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

MSC connects cells to wide area network, and Internet

Wired network
Two techniques for sharing mobile-to-BS radio spectrum:

- **combined FDM/TDM**: divide spectrum in frequency channels, divide each channel into time slots.

- **CDMA**: Code Division Multiple Access

- **Global System for Mobile Communications (GSM)**:
  - 200 kHz frequency bands
  - Each band supports 8 TDM calls.
  - Speech encoded at 12.2 and 13 kbps.
2G Systems: voice channels/digital technology

- IS-136 TDMA: combined FDM/TDM (North America)
- GSM (Global System for Mobile Communications): combined FDM/TDM
  - most widely deployed **
- IS-95 CDMA: Code Division Multiple Access
2G Network Architecture

Base station system (BSS)

MSC

Gateway MSC

Public telephone network

Legend

Base transceiver station (BTS)
Base station controller (BSC)
Mobile Switching Center (MSC)
Mobile subscribers

2G: Voice Connections to the Telephone Company
2.5G systems: voice and data channels

{For those who can’t wait for 3G service}

Provide 2G extensions:

- **General Packet Radio Service (GPRS)**
  - evolved from GSM.
  - data sent dynamically on multiple channels (if available).
  - Data rates up to 115 Kbps.

- **Enhanced Data Rates for Global Evolution (EDGE)**
  - also evolved from GSM, using enhanced modulation.
  - data rates up to 384 Kbps.

- **CDMA-2000 (phase 1)**
  - data rates up to 144 Kbps.
  - evolved from IS-95.
2.5G Voice-Data Network

**Key insight:** new cellular data network operates *in parallel* (except at edge) with existing cellular voice network.
- voice network is unchanged in core.
- data network operates in parallel.

**Diagram:**
- BSC (Base Station Controller)
- MSC (Mobile Switching Center)
- SGSN (Serving GPRS Support Node)
- GGSN (Gateway GPRS Support Node)
- Public telephone network
- Public Internet

**Legends:**
- G: Gateway
- Serving GPRS Support Node (SGSN)
- Gateway GPRS Support Node (GGSN)
3G systems: voice/data

- **Universal Mobile Telecommunications Service (UMTS)**
  - Leaves the existing 2.5G system in place.

- **CDMA-2000**: CDMA in TDMA slots
  - data service: 1xEVolution Data Optimized (1xEVDO) up to 14 Mbps

Many details later in K&R chapter not covered!!
What is Mobility?

Spectrum of mobility, from the network layer perspective:

- **no mobility**: User only moves within the same wireless access network.
- **high mobility**: User passes through multiple access networks while maintaining ongoing connections (like cell phone).
- **medium mobility**: User moves between access networks, disconnecting while between networks.
Human Analogy: How to Contact a Mobile Friend?

Consider a friend frequently changing residence addresses. How do you find her?

- Search all phone books?
- Call her parents or her friends?
- Expect her to let you know where he/she now lives?

I wonder where Alice moved to?
Mobile Network Architecture

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

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

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

**Correspondent:** wants to communicate with mobile node.
More Mobility 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.

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.
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 node is located.
  - no changes to end-systems.

- **Let end-systems handle it:**
  - **indirect routing:** communication from correspondent to mobile node goes through home agent, then forwarded to remote network.
  - **direct routing:** correspondent gets foreign address of mobile node, sends directly to mobile node.
Mobility Approaches

  - Routing tables indicate where each mobile node is located.
  - No changes to end systems

- Let end-systems handle it:
  - **Indirect routing**: Communication from correspondent to mobile node goes through home agent, then forwarded to remote network.
  - **Direct routing**: Correspondent gets foreign address of mobile node, sends directly to mobile node.

*Not scalable to millions of mobiles*
Mobility Registration

End result:

- Foreign agent knows about mobile node.
- Home agent knows location of mobile node.

Mobile node contacts foreign agent upon entering visited network.

Foreign agent contacts home agent home: “This mobile node is resident in my network”.

Visit network

Wide area network

Home network

Advanced Computer Networks
Cellular and Mobile Wireless
Mobility via Indirect Routing

Correspondent addresses packets using home address of mobile node.

1. Home network
   - Home agent intercepts packets, forwards to foreign agent.

2. Wide area network
   - Foreign agent receives packets, forwards to mobile node.

3. Visited network
   - Mobile node replies directly to correspondent.

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 node via foreign agent.

- Foreign agent functions may be done by mobile node itself (e.g., use DHCP).

- **Triangle routing**: correspondent-home-network-mobile
  - inefficient when the correspondent and mobile are in the same network.
Indirect Routing
Moving between Networks

- Suppose the mobile node moves to another network:
  - registers with new foreign agent.
  - new foreign agent registers with home agent.
  - home agent updates COA for mobile node.
  - packets continue to be forwarded to mobile node (but with new care-of-address).

- Mobility involving multiple foreign networks is transparent.
  - On-going connections can be maintained!
  - However, potential for datagram loss when disconnection/reattachment time is not short.
Mobility via Direct Routing

1. Correspondent requests and receives foreign address of mobile node.
2. Correspondent forwards to foreign agent.
3. Foreign agent receives packets, forwards to mobile node.
4. Foreign agent forwards to mobile node.
5. Mobile node replies directly to correspondent.

Home network

Visited network

Wide area network

Correspondent agent
Mobility via Direct Routing

- Overcomes the triangle routing problem.
- **Non-transparent to correspondent:** Correspondent must get care-of-address from home agent.
- What if mobile node 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 node moves: new FA arranges to have data forwarded from old FA (chaining).
Cellular/Mobile Wireless Summary

- **Cellular Architecture**
  - FDM/TDM, CDMA

- **Cellular Standards**
  - GSM, 2G,
    - BSS, BTS, BSC, MSC
  - 2.5G
    - GPRS, EDGE, CDMA-2000
  - 3G
    - UTMS, CDMA-2000 (EVDO)
Cellular/Mobile Wireless Summary

- **Mobile Definitions**
  - Home and foreign agents, permanent and care-of-addresses, correspondent, home and foreign networks.

- **Mobile Architecture**
  - Move routing to edge, use agents.
  - Registering with agents
  - Indirect Routing
    - Triangular routing
  - Direct Routing
    - Anchor foreign agent