# Cellular and Mobile Wireless Networks (part 2)



**Advanced Computer Networks** 

### Cellular/Mobile Wireless Outline

- . Cellular Architecture
- Cellular Standards
  - GSM, 2G, 2.5G, 3G and 4G LTE
- . Mobile Definitions
  - Agents, addresses, correspondent
- Mobile Architecture
  - Registering
  - Indirect Routing
  - Direct Routing



### Cellular Network Architecture





### Cellular Networks: The First Hop



- Communications (GSM):
  - 200 kHz frequency bands
  - Each band supports 8 TDM calls.
  - Speech encoded at 12.2 and 13 kbps.







### Cellular Standards: Brief Survey

# 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



Don't drown in a bowl of alphabet soup: use this for reference only



### 2G Network Architecture





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### Cellular Standards: Brief Survey

2.5G systems: voice and data channels {For those who could not wait for 3G service} Provide 2G extensions: push came from Iphone users

- 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 Network Architecture





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#### **3G (Voice+Data) Network Architecture**



data network operates in parallel •

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#### 3G (Voice+Data) Network Architecture





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### **3G Cellular - Brief Overview**

**3G systems:** voice/data with digital technology

- higher data rates than 2.5G
- Universal Mobile Telecommunications Service (UMTS)
  - Leaves the existing 2.5G system in place.
  - data service: High Speed Uplink/Downlink Packet Access (HSDPA/HSUPA) up to 14 Mbps.
- CDMA-2000: CDMA in TDMA slots
  - data service: 1xEVolution Data Optimized (1xEVDO) up to 14 Mbps
    - 1.67 ms slots
    - Wireless AT sends DRC back to BS to adjust sending rate
    - Proportional Fair Scheduler
    - Uses 'turbo code' FEC on multiple slots with 'early completion'.

Many K&R details later in chapter not covered!!



# **3GPP LTE (Long Term Evolution)**

#### 4G LTE == 3GPP LTE

- Uses OFDM on downlink in cellular space.
  Uplink is SC-FDMA (Singular Carrier).
- Has a CP (cyclic prefix) to avoid symbol distortion over a 'slot'.
- LTE frames (10 msec) are divided into 10 1msec subframes which in turn are divided into 2 two slots (0.5 msec).
- Slots consist of 6 or 7 OFDM symbols.



## **3GPP LTE (Long Term Evolution)**

- OFDMA allocates a PRB (Physical Resource Block) to users. A PRB consists of 12 consecutive subcarriers (15 kHz bandwidth) for one slot.
- PRB is then (6 or 7) symbols x 12 subcarriers.
- Instead of PHY preambles (802.11), reference symbols are embedded in the PRB.
- . LTE also employs MIMO.



### What is Mobility?

# Spectrum of mobility, from the network layer perspective:





#### 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?





### Mobile Network Architecture





### More Mobility Vocabulary





### **Mobility Approaches**

- Let routing handle it: Routers advertise permanent address of mobile-nodes-inresidence via usual routing table exchange.
  - routing tables indicate where each mobile node is located. {use OSPF intradomain & interdomain routing info}
  - 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**

- Let routing handle it: Routers advertise permanent addres f mobile-nodes-inresidence via v not scalable
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#### Mobility 'Registration'



#### - Foreign agent knows about mobile node.

- Home agent knows location of mobile node.



#### 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 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





### 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
  - 2G, GSM
    - BSS, BTS, BSC, MSC
  - 2.5G
    - GPRS, EDGE, CDMA-2000
  - 3G
    - UTMS, CDMA-2000 (EVDO)
  - 4G LTE
    - OFDM, MIMO



### 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

