# Distributed Systems

# Mobile networking

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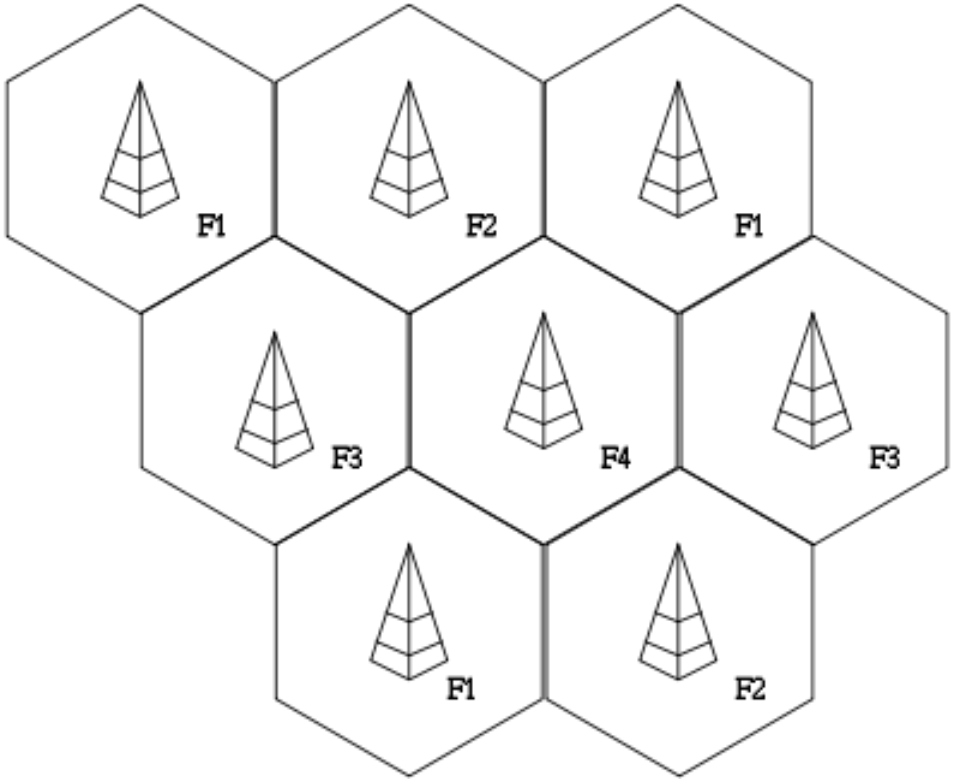
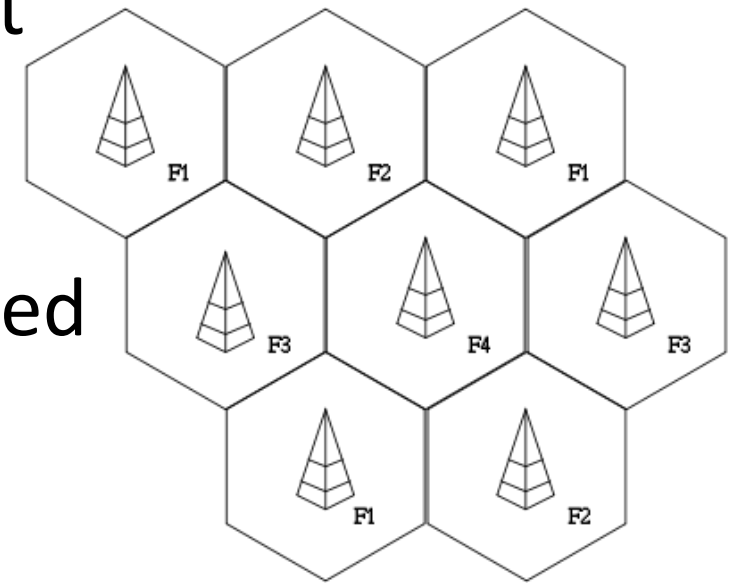
# How do mobile phones work?

- Cellular base stations (antennas + cpu) with hexagonal cells



# Channel assignments

- Each base station uses a set of "channels" (e.g. frequencies) to communicate with mobile nodes in its cell
- Usually adjacent cells do not use same channel
  - To avoid interference
- But same channel can be used at distant base stations



# Spatial Reuse

- This feature of using the same channel in different cells is called “spatial reuse”
  - Same channel can be used in different parts of “space”
- Distance between base stations can vary
  - Few hundred meters in urban region
  - Several kilometers in open spaces/rural regions

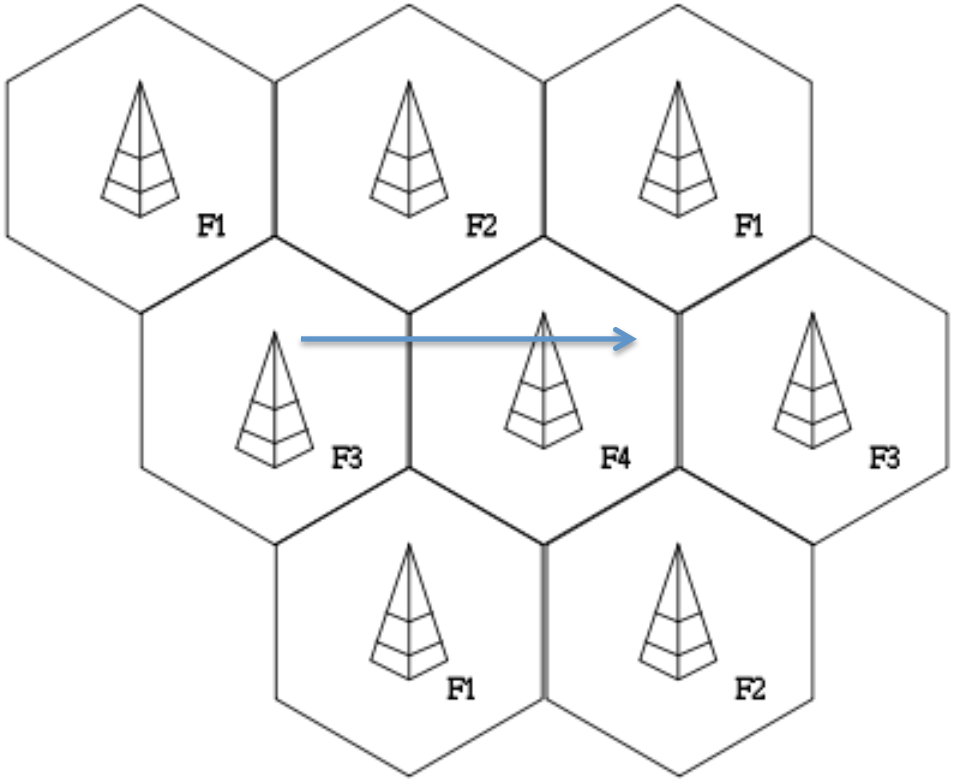
- One antenna has a fixed number of channels
- If its cell is large, there may be many people in it, and the antenna may not be able to handle
- Hence closer antenna placement in cities
- But still limited capacity due to interference from other antennas using same channel

# Channel assignments

- In a region, there may be different mobile operators
- They usually bid for rights to use different parts of the spectrum
  - Depending on where they need more channels or less etc
  - Spectrum auctions
  - Then decide which channel to use in which cell

# The real mobility issue

- What happens when a mobile phone moves from one cell to another cell?



# Terminology

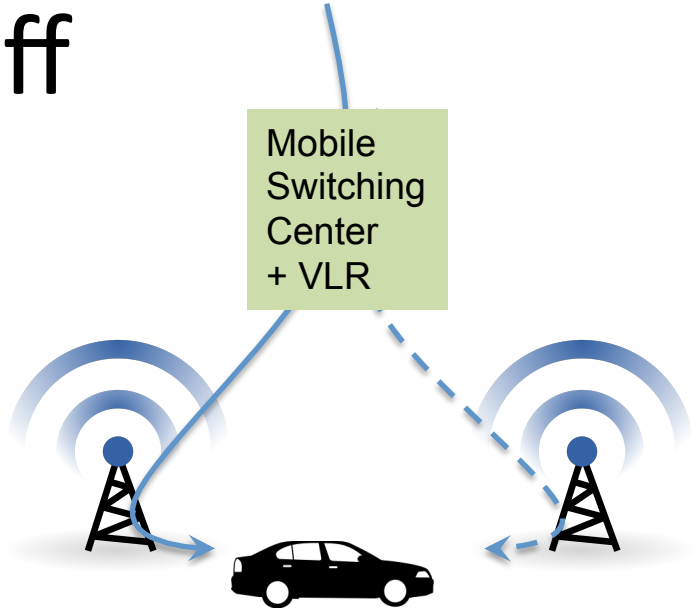
- Mobile node
- Home network
  - The network that “owns” the mobile number
    - Eg. EE or vodafone or O2…
    - Local
- Home location register
  - Database of profile, current location etc of mobile numbers
- Visited network
  - Where the mobile currently resides
  - Visitor location register : database of nodes currently in region

# Call

- Goes first to home network
- Which returns the current location of the mobile (its visited network)
- Then the call goes to the actual location

# Handoff

- When mobile moves from one cell to another
  - It's communication is handed off to the new cell
- Detected by weak signal from cell 1 but strong signal for cell 2
- Or for load balancing
- Executed by base stations and MSC



# Internet issues

# Internet issues

- Cellular systems are fine for calling, not for internet
- Internet routing is IP – based
- IP is geography based
- What happens when a mobile phone moves to a different area? Or simply to a different cell?

# Internet issues

- So communication from MN is disrupted.
- MN may be able to re-initialize everything, but that is undesirable

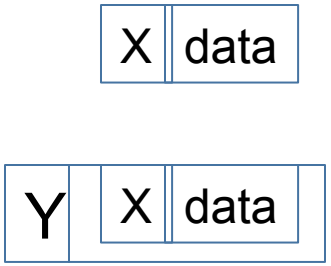
- We want a packet for IP X to still be delivered to MN

# Internet issues

- Suppose an MN had IP address X in its initial subnet (local area network) s1 (in cell 1)
- Now the MN moves to a different subnet s2
  - X is not a valid address in s2
  - Routers on the internet will send packets for IP X to s1, never to s2.

# Solution: IP in IP encapsulation

- When MN moves, it informs visited network of its IP X
- Home agent
  - A process on home network that intercepts packets for IP X
  - Sends it to IP Y (IP of foreign agent)
- Foreign agent (corresponding process on visited network)
  - Receives packet
  - Unpacks to see it is intended for X
  - Delivers through MAC layer address



# Mobile IP

- Solves the routing problem
- However, on initial move, some packets or acks may get lost/delayed
  - Transport layer thinks there is congestion
  - Slows down
  - …

# More advanced things

- With advancing technology
- New features are cropping up in mobile nets
- New issues are appearing

# Localization in wireless networks

- Can be done based on signal strengths
  - Decreases with distance
- Trilateration – three distances suffice to locate a point
  - Signal strength from three or more wireless transmitters with known location
  - Approximate localization due to variation in signal propagation, noise etc

# Location in mobile nets

- Can be done using three cellular towers
  - Either at the mobile phone
  - Or at cell network
- New possibilities
  - Predict handoffs from motion, make preparations early
  - Learn/predict user behavior
  - Give location based recommendations etc…

# Privacy issues

- Location is considered private information
- Tracking location all the time is considered intrusive
- No way to prevent cell companies from doing it…
- At the mobile phone end, efforts are being made to fuzz locations
  - Give some information for location based services to run
  - Avoid some other information, or avoid precise locations
- Context/activity information is also private…

# Femto-cell networks

- Small personalized cell antennas (~10m range )
  - Plug into your wireless router
- Even better spatial reuse
- Less organized, trickier to coordinate channel assignment etc
- Possibility of channel clash with macro cells

# Beamforming directed communication

- Sends signals in a particular direction
  - Uses multiple antennas together transmitting st different phases
  - Destructive interference ensures that signal does not travel in other directions
  - Easy to change directions quickly
- Angle can range from 20 or 30 degrees to a few degrees (narrow beam)

# Beamforming directed communication

- Usually around 60GHz frequency
- High supported bandwidth
- Good for hi def video, large data volumes etc
- At this range, signal has high attenuation from air
  - Short range (few meters to 100 meters)
- Together with directionality implies very effective spatial reuse

# Beamforming directed communication

- Challenges
  - Easily affected by obstacles
  - Both transmitter and receiver need to be "looking" at each-other at the right time
    - Medium access becomes harder
  - Mobility can create a challenge of "tracking" a device

# Mobile computing

- Mobile wireless devices are going to be even more popular
- More apps/services/media
- Great need for wireless beandwidth
  - Current infrastructure is not sufficient
- New technologies
- Simultaneously, detection of collective context, groups etc  for better adaptive services