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
  - Its 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
  – ...

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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 at 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 bandwidth
  - Current infrastructure is not sufficient
- New technologies
- Simultaneously, detection of collective context, groups etc for better adaptive services