Wireless and Mobile Networks

CMPE 257

Spring 2006
Lecture 1
Class Information

- **Meeting time:** Mon and Wed 5 - 6:45pm.
- **Location:** BE 156.
Instructors

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Class Web Page

- www.cse.ucsc.edu/classes/cmpe257/Spring06.
- Everything will be posted there, including:
  - Syllabus.
  - News.
  - Projects, etc.
Course Objective

- Cover topics on wireless mobile networking.
- Emphasis on wireless ad hoc networks.
- Emphasis on MAC- and above protocols.
Class Format

- Research papers.
- *In-class discussion.*
  - *All students must have read papers beforehand.*
Grading

• 1 exam: 30%.
• Homeworks: 10%.
• Project: 55%.
• In-class participation: 5%.
• Projects, homeworks, and the exam are INDIVIDUAL.

• Academic integrity violations will not be tolerated.
  – Results in failing the class automatically and more…
  – If there are questions, don’t hesitate to ask.
Projects

• Projects will be graded based on:
  – Content: 20%
  – Report: 20%
  – In-class presentation/demo: 15%.
• List of suggested projects will be available soon.
• Project suggestions are also welcome.
Reading List

• Initial set of papers provided on the class Web page.

• Papers will be updated as we go.
  – Stay tuned for updates as papers get added.

• Lot’s of papers!
Topics (Tentative)

- Introduction.
- MAC layer issues.
- Unicast routing in MANETs.
- Multicast routing in MANETs.
- Disruption tolerant routing
- Wireless internetworking (mobile IP, FLIP...)

- Topology management.
- E2E protocols.
- Bluetooth.
- Tracking and location management.
- Applications.
- Security.
Today

- Introduction.
- Basic concepts.
- Terminology.
The Wireless Revolution
Wireless everywhere…

- Remote control
- Cordless telephone
- Headsets
- Garage openers
- Badges
- Cell phones/modems
- Radio!
- Pagers
- Satellite TV
- Wireless LAN cards
- Cordless headsets, mouse, keyboards, etc.
- PDAs.
Wireless evolution

• Wireless telegraph: Marconi (1896).
• Between then and now…
  – Radio,
  – TV,
  – Mobile phones,
  – Satellites (1960s).
Wireless Technologies

- Cellular wireless.
- Wireless local loop.
- Wireless local area networks.
  - Mesh networks.
- Satellites.
- Multi-hop wireless.
Cellular Concept: Motivation

• Early mobile radio systems:
  – Large coverage with single, high-powered transmitter.
  – But, no frequency re-use due to interference.

• With limited spectrum allocation, capacity (in terms of number of users) is limited.
Some Cellular Terminology

- Mobile.
- Base station.
- Mobile Switching Center (MSC).
- Handoff.
- Cell.
Cellular Fundamentals

- System-level idea, no major technological changes.
  - Many low-power transmitters instead of single, high power one (large cell).
  - Service area divided into small cells covered by each low power transmitter.
  - Each transmitter (or base station) allocated a portion of the spectrum.
  - Nearby BSs assigned different channel groups to minimize interference.
  - Scalability: as more users subscribe, more BSs can be added using lower transmission power): mini-cells.
Frequency Reuse
Handoff/Handover

- Mobile hosts can change cells while communicating.
- **Hand-off** occurs when a mobile host starts communicating via a new base station.
- Handoff decision made based on signal strength.
Handoff Strategies: Network-initiated

- Used in 1G.
- Based solely on measurements of received signals from MH.
- Each BS monitors signal strengths of mobiles with calls in progress.
- MSC decides if handoff necessary.
Mobile-assisted Handoffs

- MAHO.
- 2G.
- Mobile measures received power from close-by BSs; continually reports to serving BS.
- Handoff begins when power received from neighbor BS exceeds power from serving BS.
Cellular Networks: Evolution

- Evidence of the wireless success!
  - Since 1996, number of new mobile phone subscribers exceeded number of new fixed phone subscribers!
  - FDMA.
  - Analog FM.
Second Generation (2G)

- Most of today’s cellular networks use 2G standards.
- Early 90s.
- Digital technology.
  - Digital modulation.
  - TDMA and CDMA.
  - Lighter, smaller devices with longer battery life.
  - Better reception and channel utilization.
Example 2G Standards

- **TDMA standards:**
  - **Global System Mobile (GSM).**
    - Europe, Asia, Australia, South America.
  - **Interim Standard 13 (IS-136 or NDSC).**
    - North and South America and Australia.
  - **Pacific Digital Cellular (PDC).**
    - Similar to IS-136.
    - Japan.

- **CDMA standard**
  - **Interim Standard 95 (IS-95)**
  - North and South America, Korea, Japan, China, Australia.
2G Evolution

- Shift from voice to data.
- New wireless devices: pagers, PDAs.
- New services: Web access, e-mail, instant messaging, etc.
- New “data-centric” standards.
  - “Retrofit” 2G to support higher data throughput.
  - 2.5G standards.
  - Support higher data rates for Web browsing (e.g., WAP), e-mail, m-commerce, etc.
3G Wireless Networks

- Multi-megabit Internet access, VoIP, ubiquitous “always-on” access.
- Single mobile device for everything (integrated service approach).
- New, world-wide standard.
  - International Mobile Telephone 2000 (IMT 2000)
Wireless Local Loop (WLL)
WLL

• Wireless “last mile”.
  – Between central office and homes and businesses close-by.

• Fixed wireless service.

• Developing countries, remote areas.

• Broadband access.

• Microwave or millimeter radio frequencies.
  – Directional antennas.
  – Allow for very high data rate signals (tens or hundreds Mbs).
  – But need LOS: no obstacles!
Wireless Local Area Networks

- Local area connectivity using wireless communication.
- IEEE 802.11 WLAN standard.
- Multitude of commercially available devices: WaveLan, Aironet, etc.
- Wireless LAN may be used for
  - Last hop to a wireless host.
  - Wireless connectivity between hosts on the LAN.
802.11 Evolution

- Standard came out in 1997.
- Includes infrared.
- Originally featured FH and DS.
  - But as of late 2001, only DS-SS modems had been standardized for high rates (11Mbps).
- 802.11a: up to 54 Mbps in 5 GHz band.
- 802.11b: 5.5 and 11 Mbps.
- 802.11g and more…
Other WLAN Standards

• HomeRF
  – Proponents of 802.11 frequency hopping-spread spectrum (FH-SS).
  – HomeRF 2.0
  – 10 Mbps FH-SS.

• HIPERLAN
  – Europe, mid 1990s.
  – Similar capability to IEEE 802.11b.
Bluetooth and PANs

- **PAN**: personal area network.
- Open standard for enabling various devices to communicate short-range (10 m range).
- Named after King Harald Bluetooth (10th century Viking united Denmark and Norway).
- Home appliances, office equipment, “wearable” computing equipment.
Satellite Communications

- Satellite-based antenna(e) in stable orbit above earth.
- Two or more (earth) stations communicate via one or more satellites serving as relay(s) in space.
- Uplink: earth->satellite.
- Downlink: satellite->earth.
- Transponder: satellite electronics converting uplink signal to downlink.
Satellite Communications

ground stations
Orbits

- **Shape**: circular, elliptical.
- **Plane**: equatorial, polar.
- **Altitude**: geostationary (GEO), medium earth (MEO), low earth (LEO).
GEO Satellites

- Most common type.
- Orbit at 35,863 Km above earth and rotates in equatorial plane.
- Many GEO satellites up there!
GEO: Plus’s and minus’s

• Plus’s:
  – Stationarity: no frequency changes due to movement.
  – Tracking by earth stations simplified.
  – At that altitude, provides good coverage of the earth.

• Minus’s:
  – Weakening of signal.
  – Polar regions poorly served.
  – Delay!
  – Spectral waste for point-to-point communications.
LEO Satellites

- Circular or slightly elliptical orbit under 2,000 Km.
- Orbit period: 1.5 to 2 hours.
- Coverage diameter: 8,000 Km.
- RTT propagation delay < 20ms (compared to > 300ms for GEOs).
- Subject to large frequency changes and gradual orbit deterioration.
LEO Constellations

• Advantages over GEOs:
  – Lower delay, stronger signal, more localized coverage.
• But, for broad coverage, many satellites needed.
• Example: *Iridium* (66 satellites).
LEOs

constellation

ground stations
In Summary...

- **GEOs**
  - Long delay - 250-300 ms.
- **LEOs**
  - Relatively low delay - 40 - 200 ms.
  - Large variations in delay - multiple hops/route changes, relative motion of satellites, queuing.
MANETs

- Mobile, (wireless), multi-hop ad-hoc networks.
- Formed by wireless hosts which may be mobile.
- Without (necessarily) using a pre-existing infrastructure.
- Routes between nodes may potentially contain multiple hops.
- Challenges posed by wireless medium accentuated.
- Mobility cause routes to change.
Multi-hop

- May need to traverse multiple hops to reach destination.
Why MANETs?

- Ease of deployment.
- Speed of deployment.
- Decreased dependence on infrastructure.
Many Applications

• Personal area networking.
  – Cell phone, laptop, ear phone, wrist watch.
• Military environments.
  – Soldiers, tanks, planes.
• Civilian environments.
  – “Smart” environments.
• Emergency operations
  – Search-and-rescue
  – Policing and fire fighting
  – Monitoring and surveillance.
Many Variations

- **Fully Symmetric Environment**
  - All nodes have identical capabilities and responsibilities.

- **Asymmetric Capabilities**
  - Transmission ranges, battery life, processing capacity, and speed of movement may vary.

- **Asymmetric Responsibilities**
  - Only some nodes may route packets.
  - Some nodes may act as leaders of nearby nodes (e.g., cluster head).
Many Variations (cont’d)

- Traffic characteristics may differ in different ad hoc networks.
  - Bit rate,
  - Timeliness constraints,
  - Reliability requirements,
  - Unicast / multicast / geocast.

- May co-exist (and co-operate) with an infrastructure-based network
Many Variations (cont’d)

- Mobility patterns may be different
  - People sitting at an airport lounge,
  - New York taxi cabs,
  - Students moving on campus,
  - Military movements,
  - Personal area network.
Many Variations (cont’d)

- Mobility characteristics
  - Speed,
  - Predictability
    - direction of movement
    - pattern of movement
  - Uniformity (or lack thereof) of mobility characteristics among different nodes
Challenges

- Limited wireless transmission range.
- Broadcast nature of the wireless medium.
  - Hidden terminal problem.
- Packet losses due to transmission errors.
- Mobility-induced route changes.
- Mobility-induced packet losses.
- Battery constraints.
- Potentially frequent topology changes.
- Ease of snooping on wireless transmissions.
Sensor Networks

• Special case of MANETs.
• Data driven.
• Nodes may have severe limitations.
  – Power,
  – Processing,
  – Storage,
  – Communication.
• Deployment in harsh environments.
  – Network should self-organize and manage.
Research on MANETs

Variations in capabilities & responsibilities *
Variations in traffic characteristics, mobility models, etc. *

Performance criteria (e.g., optimize throughput, reduce energy consumption) *

Increased research funding

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Significant research activity
One-size-fits-all?

- Perhaps using an adaptive/hybrid approach that can adapt to situation at hand.
- Difficult problem.
- Solutions usually try to address a sub-space of the problem domain.
References

• Nitin Vaidya’s tutorials (www.crhc.uiuc.edu/~nhv/presentations.html).

• Stallings’s “Wireless Communications and Networks”.

• Rappaport’s “Wireless Communications, Principles and Practice”.