CSE590 Wireless and Mobile Networks

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ACK: Slides borrowed from Richard Y. Yang.
Outline

• Introduction to wireless networks and mobile computing

• Challenges facing wireless networks and mobile computing

• Introduction to wireless physical layer
Goal of Wireless Networking and Mobile Computing

“People and their machines should be able to access information and communicate with each other easily and securely, in any medium or combination of media – voice, data, image, video, or multimedia – any time, anywhere, in a timely, cost-effective way.”

Dr. G. H. Heilmeier, Oct 1992
Enabling Technologies

• Development and deployment of wireless/mobile technology and infrastructure
• Miniaturization of computing machinery
  ... -> PCs -> laptop -> PDAs/smart phones -> embedded computers/sensors
• Improving device capabilities/software development environments, e.g.,
  – android: http://code.google.com/android/
  – windows mobile
Pervasive Use of Mobile Wireless Devices

• There are ~4 billion mobile phones
  – Over 50 countries have mobile phone subscription penetration rates higher than that of the population (Infoma 2007)
  – http://en.wikipedia.org/wiki/Mobile_phone_penetration_rate

• The mobile device will be the primary connection tool to the Internet for most people in the world in 2020.

  PEW Internet and American Life Project, Dec. 2008
At Home

At Home: Last-Mile

• Many users still don’t have broadband
  – reasons: out of service area; some consider expensive

• Broadband speed is still limited
  – DSL: 1-6 Mbps download, and 100-768Kbps upload
  – Cable modem: depends on your neighbors
  – Insufficient for several applications (e.g., high-quality video streaming)
On the Move

Source: http://www.ece.uah.edu/~jovanov/whrsms/
On the Move: Context-Aware

Source: http://www.cs.cmu.edu/~aura/docdir/sensay_iswc.pdf
On the Road

GSM/UMTS, cdmaOne/cdma2000, WLAN, GPS, DAB, TETRA, ...

road condition, weather, location-based services, emergency
Example: IntelliDrive (Vehicle Infrastructure Integration)

- Traffic crashes resulted in more than 41,000 lives lost in 2007
- Establishing vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and vehicle-to-hand-held-devices (V2D) communications
  - safety: e.g., intersection collision avoidance/violation warning/turn conflict warning, curve warning
  - mobility: e.g., crash data, weather/road surface data, construction zones, emergency vehicle signal pre-emption

Collision Avoidance: V2V Networks

- stalled vehicle warning
- bland spots

Collision Avoidance at Intersections

- Two million accidents at intersections per year in US

Mobile and Wireless Services – Always Best Connected

LAN, WLAN 780 kbit/s
GSM 53 kbit/s
Bluetooth 500 kbit/s

UMTS Rel. 5
400 kbit/s

LAN
100 Mbit/s,
WLAN
54 Mbit/s

UMTS, DECT 2 Mbit/s

GSM/EDGE 135 kbit/s,
WLAN 780 kbit/s

GSM 115 kbit/s,
WLAN 11 Mbit/s

UMTS Rel. 6
400 kbit/s
Disaster Recovery/Military

• 9/11, Tsunami, Hurricane Katrina, South Asian earthquake ...
• Wireless communication and mobile computing capability can make a difference between life and death!
  – rapid deployment
  – efficient resource and energy usage
  – flexible: unicast, broadcast, multicast, anycast
  – resilient: survive in unfavorable and untrusted environments

http://www.att.com/ndr/
Habitat Monitoring: Example on Great Duck Island

A 15-minute human visit leads to 20% offspring mortality
Wireless and Mobile Computing

• Driven by technology and vision
  – wireless communication technology
  – global infrastructure
  – device miniaturization
  – mobile computing platforms

• The field is moving fast
Why is the Field Challenging?
Challenge 1: Unreliable and Unpredictable Wireless Coverage

Wireless links are not reliable: they may vary over time and space

*Cerpa, Busek et. al*
Challenge 2: Open Wireless Medium

- Wireless interference
  
  S1 → R1
  
  S2 → R1
Challenge 2: Open Wireless Medium

• Wireless interference
  \[ S1 \rightarrow R1 \]  
  \[ S2 \rightarrow R1 \]

• Hidden terminals
  \[ S1 \leftrightarrow R1 \leftrightarrow S2 \]
Challenge 2: Open Wireless Medium

- **Wireless interference**
  
  \[ \text{S1} \rightarrow \text{R1} \]
  
  \[ \text{S2} \rightarrow \text{R1} \]

- **Hidden terminals**
  
  \[ \text{S1} \rightarrow \text{R1} \leftarrow \text{S2} \]

- **Exposed terminal**
  
  \[ \text{R1} \leftarrow \text{S1} \quad \text{S2} \rightarrow \text{R2} \]
Challenge 2: Open Wireless Medium

- Wireless interference
  - S1 → R1

- Hidden terminals and
  - S2 → R1

- Exposed terminal
  - S1 → R1 ← R2

- Wireless security
  - eavesdropping, denial of service, ...
Challenge 3: Mobility

• Mobility causes poor-quality wireless links

• Mobility causes intermittent connection
  – under intermittent connected networks, traditional routing, TCP, applications all break

• Mobility changes context, e.g., location
Challenge 4: Portability

- Limited battery power
- Limited processing, display and storage

Sensors, embedded controllers

Mobile phones
- voice, data
- simple graphical displays
- GSM/3G

PDA phone
- data
- simpler graphical displays
- 802.11/3G

Laptop
- fully functional
- standard applications
- battery; 802.11

Performance/Weight/Power Consumption
Challenge 5: Changing Regulation and Multiple Communication Standards

- **cellular phones**
  - 1981: NMT 450
  - 1986: NMT 900
  - 1992: GSM
  - 1994: DCS 1800
  - 2000: GPRS
  - analogue
  - digital

- **satellites**
  - 1982: Inmarsat-A
  - 1988: Inmarsat-C
  - 1992: Inmarsat-B
  - 1998: Iridium
  - 2001: IMT-2000

- **cordless phones**
  - 1980: CT0
  - 1984: CT1
  - 1987: CT1+
  - 1989: CT 2
  - 1991: DECT
  - 1992: Inmarsat-B
  - 1993: PDC
  - 1991: D-AMPS
  - 1993: CDMA

- **wireless LAN**
  - 1997: IEEE 802.11
  - 1999: 802.11b, Bluetooth
  - 2000: IEEE 802.11a
  - 2001: IMT-2000

**Fourth Generation (Internet based)**
Evolution of Mobile Systems to 3G
## 3G Networks

### Cellular Carriers Rule the Market

No Wi-Fi or WiMAX deployment can match cellular carriers for coverage. Here are the major networks:

<table>
<thead>
<tr>
<th>Technology</th>
<th>Peak rate downlink</th>
<th>Peak rate uplink</th>
<th>Average downlink</th>
<th>Average uplink</th>
<th>Typical latency to Internet site</th>
<th>Major U.S. operators</th>
<th>Deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDMA2000 1xRTT</td>
<td>153 Kbps</td>
<td>153 Kbps</td>
<td>50-70 Kbps</td>
<td>50-70 Kbps</td>
<td>500 msec</td>
<td>Alltel, Sprint/Nextel, Verizon</td>
<td>Available nationwide</td>
</tr>
<tr>
<td>CDMA2000 EV-DO Rev 0</td>
<td>2.4 Mbps downlink</td>
<td>153 Kbps</td>
<td>400-700 Kbps</td>
<td>50-70 Kbps</td>
<td>250 msec</td>
<td>Alltel, Sprint Nextel, Verizon</td>
<td>Top 100 metro areas by year end; currently available in more areas than HSDPA</td>
</tr>
<tr>
<td>CDMA2000 EV-DO Rev A</td>
<td>3.1 Mbps downlink</td>
<td>1.8 Mbps</td>
<td>450-800 Kbps</td>
<td>300-400 Kbps</td>
<td>Improved over EV-DO Rev 0</td>
<td>Sprint and Verizon have announced intentions to deploy</td>
<td>Expected 2007</td>
</tr>
<tr>
<td>EDGE</td>
<td>200 Kbps</td>
<td>200 Kbps</td>
<td>70-135 Kbps</td>
<td>70-135 Kbps</td>
<td>450 msec</td>
<td>Cingular, T-Mobile</td>
<td>Available nationwide</td>
</tr>
<tr>
<td>HSDPA (UMTS Release 5)</td>
<td>1.8, 3.6, 7.2 Mbps¹</td>
<td>128 Kbps or 384 Kbps¹</td>
<td>400-700 Kbps</td>
<td>110 Kbps or 300 Kbps</td>
<td>150 msec</td>
<td>Cingular; T-Mobile also plans deployment</td>
<td>Top 100 metro areas by year end</td>
</tr>
<tr>
<td>HSDPA with HSUPA (UMTS Release 6)</td>
<td>1.8, 3.6, 7.2 Mbps¹</td>
<td>1.46, 2.0, 5.76 Mbps²</td>
<td>400-700 Kbps</td>
<td>Likely 300 to 400 Kbps</td>
<td>Improved over UMTS Release5</td>
<td>Cingular; T-Mobile likely</td>
<td>Expected 2007</td>
</tr>
</tbody>
</table>

¹ Depends on market; most markets are being upgraded to 384 Kbps. ² Depends on device capabilities.

What Will We Cover?
Class Goals

• Learn both fundamentals and applications of wireless networking and mobile computing

• Obtain experience on developing mobile, wireless systems

• Discuss challenges and opportunities in wireless networking and mobile computing
The Layered Reference Model

Often we need to implement a function across multiple layers.
Course Topics

• Communications:
  – physical layer: channel and diversity
  – link layer: MAC (sharing and power management), reliability
  – network layer: routing, mobility management
  – transport over wireless

• Mobile foundational services
  – localization, security

• Application developments
  – app. adaptation to handle mobility, portability
  – develop for heterogeneous devices
Course Topics

Application Development

Communications
- Transport
- Network
- Data Link
- Physical

Locations
- Location Management
- Localization

Security
Class Materials

• Chapters of reference books

• Selected conference and journal papers

• Other resources
  – MOBICOM, SIGCOMM, INFOCOM Proceedings
  – IEEE Network, Communications, Pervasive magazines
Suggested Reference Books

- Wireless Networking, Anurag Kumar, D. Manjunath, Joy Kuri, Morgan Kaufmann.
Suggested Reference Books (2)


• Principles of Wireless Networks, by Kaveh Pahlavan, Prashant Krishnamurthy, Prentice Hall.
What You Need to Do

• Your prerequisite
  – motivated, critical
  – basic programming skill
  – Undergrad level computer networking & operating systems

• Your workload
  – class participation
    • actively participate in class discussions
    • paper presentation
  – homework assignments
  – Final project
  – Midterm exam (no final)
Class Project

• Goal: obtain hands-on experience

• Initial proposal due 1 week after midterm + 1-page progress report every 2 weeks (due Friday night) + final report + [presentation]

• Read Mobicom papers from 2000-2009 and choose a paper on which you can improve.

• Discuss with me & I’ll give suggestions.

• No collaboration allowed.
## Grading

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
<td>30%</td>
</tr>
<tr>
<td>Assignments</td>
<td>20%</td>
</tr>
<tr>
<td>Exam</td>
<td>30%</td>
</tr>
<tr>
<td>Presentation</td>
<td>10%</td>
</tr>
<tr>
<td>Attendance</td>
<td>10%</td>
</tr>
</tbody>
</table>
Instructor

- Jie Gao
- jgao@cs
- Office hour: Thursday 2:15-4:15pm @ CS1415 (or check my webpage) or by appointment
- TA: TBA
Questions?