COMP 635: WIRELESS & MOBILE COMMUNICATIONS

COURSE INTRODUCTION

http://wireless.web.unc.edu

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Introductions

- Names
- BS/MS, First-year Grad, Senior Grad?
- If you’re new, where have you come from?
- Your CS interests?
- Why this course?
- What are you expecting to learn from this course?
“Wireless” vs. “Mobile”

- Two aspects of mobility:
  - User mobility:
    - Users can communicate “anytime, anywhere, with anyone”
  - Device portability:
    - Devices can connect anytime, anywhere to the “network”

- Wireless vs. mobile

Examples

| ✓  | ✗  | Stationary computer |
| ✗  | ✓  | Notebook on a hotel Ethernet |
| ✓  | ✗  | Wireless LANs in historic buildings |
| ✓  | ✓  | Personal Digital Assistant (PDA) |

Our focus: wireless (including non-mobile)

THE IMPORTANCE OF WIRELESS COMMUNICATION

Why Should We Care?
**Explosion of User Base**

Global ICT Developments

Note: Estimations Source: ITU World Telecommunication ICT Indicators database.

- ~ 7 billion current mobile phone service subscriptions ➔ more than 96% of world population!

Explosive growth in developing countries

**Benefits of Wireless**

- Unrestricted mobility
  - Unplugged from power outlet

- Significantly lower cost
  - No cable, low labor cost, low maintenance

- Ease
  - Minimum infrastructure - scatter and play

- Ubiquity
  - Available everywhere like water/air - holy grail

90% of world's populated areas (in 2011) covered by a mobile cellular network!
Example Application Environments

- Personal communication
- Replacement of fixed networks
  - Access to remote areas
  - Sensors in difficult terrains (weather, earth activities)
  - Flexibility for trade shows
  - LANs in historic buildings

Location-based Services: Opportunities

- Location aware services
  - Resource-discovery, e.g., printer, fax, phone, server etc.
- Follow-me services
  - Call-forwarding, mobile desktop
- Information services
  - “push”: e.g., current special offers in the supermarket
  - “pull”: e.g., where is the Black Forrest Cheese Cake?
- Privacy services
  - Who should gain knowledge about the location?
  - What information should environment gain about you?
Example Application Environments

- **Vehicular Traffic:**
  - Personal communication using GSM/UMTS
  - News, road condition, weather, music via DAB/DVB-T
  - Position via GPS
  - Local ad-hoc network with vehicles close-by
    - To prevent accidents, guidance system, redundancy
  - Transport networks (buses, trains)

- **Emergencies**
  - Early transmission of patient data to the hospital
    - Current status, first diagnosis
  - Quick replacement of a fixed infrastructure in case of
    earthquakes, hurricanes, fire etc.
  - Crisis, war, ...
    - Only wireless ad-hoc networks survive

- **Traveling salesmen/employee**
  - Access to central (consistent) customer database
  - Mobile office
  - Location-aware services (call-forwarding, hotel printer)

- **Entertainment, education, ...**
  - Outdoor Internet access
  - Intelligent travel guide with up-to-date location-dependent information
  - Ad-hoc networks for multi user games
Example Application Environments

- **Wireless sensing**
  - Using RF signals for geolocation
  - Using RF signals to sense physical objects
    - Even behind walls
  - “Piggy-back” RF signals for no-power communication
  - ...

### Explosion of Mobile Devices

- **Pager**
  - receive only
  - tiny displays
  - simple text messages

- **PDA**
  - graphical displays
  - character recognition
  - simplified WWW

- **Smartphone**
  - tiny keyboard
  - simple versions of standard applications

- **Laptop/Notebook**
  - fully functional
  - standard applications

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Sensors, embedded controllers

No clear separation between device types possible (e.g. smart phones, embedded PCs, ...)

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Prof. Dr.-Ing. Jochen H. Schiller  www.jochenschiller.de  MC - 2009
Explosion of Technologies

- Wide-area communications (cellular, satellite-based):
  - GSM, AMPS, UMTS, cdma2000, DAB, DVB-T

- Wireless LANs:
  - 802.11x series
  - Small-to-medium range, higher bit-rates

- Short-range:
  - Bluetooth
  - Low bit-rates

ITU efforts for standardization/convergence

Mobile communications greatly influenced by merging of telecommunications and computer networks

The Future

Courtesy: Romit Roy Choudhary, Duke University

Internet
WHAT’S DIFFERENT ABOUT WIRELESS SYSTEMS?
What Issues are Unique to These?

Mobile Devices: Unique Issues

- **Power consumption**
  - Low quality displays, small disks due to limited battery
  - Limited compute power: CPU power consumption ~ CV^2f
    - C: internal capacity, reduced by integration
    - V: supply voltage, can be reduced to a certain limit
    - f: clock frequency, can be reduced temporarily

- **Limited memory**
  - Limited usage of mass memories with moving parts
  - Flash-memory as alternative

- **Limited user interfaces**
  - Compromise between size of fingers and portability
  - Integration of voice recognition, abstract symbols

- **Loss of data**
  - E.g., errors, theft
Wireless Networks: Unique Issues

- Providing seamless support for mobility
  - Without disrupting users or applications

- Signal propagation:
  - Signal attenuation (as signal propagates)
    - How long should the “wireless link” be?
  - Higher loss-rates due to interference
    - Emissions of engines, lightning
    - How to ensure reliability of “wireless link”?

- Frequency-usage:
  - Restrictive regulations of frequencies
    - Useful frequencies are almost all occupied
  - Spatial reuse (facilitated by signal attenuation)
    - How to reuse frequency spectrum?

Wireless Networks: Unique Issues

- Constraints on performance:
  - Low transmission rates (few Mbps)
  - Higher delays, higher jitter
    - Connection setup time: GSM (seconds), others (ms)

- Exploiting/dealing with diversity / dynamism:
  - Antenna selection, Time diversity, Frequency selection

- Energy conservation:
  - Wireless devices often battery-powered

- Security-related issues:
  - Lower security, simpler active attacking
    - Radio interface accessible for everyone
    - Base station can be simulated (attracting mobile calls)
  - Broadcast medium easier to snoop or tamper with
    - How to provide integrity and privacy?
**WHAT IS THIS COURSE ABOUT?**

Syllabus and Structure

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### Impact of Wireless on the Layer Model

<table>
<thead>
<tr>
<th>Layer</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application layer</strong></td>
<td>service location</td>
</tr>
<tr>
<td></td>
<td>new/adaptive applications</td>
</tr>
<tr>
<td></td>
<td>multimedia</td>
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<tr>
<td><strong>Transport layer</strong></td>
<td>congestion/flow control</td>
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<td></td>
<td>quality of service</td>
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<tr>
<td><strong>Network layer</strong></td>
<td>addressing, routing</td>
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<td></td>
<td>device location</td>
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<td></td>
<td>hand-over</td>
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<tr>
<td><strong>Data link layer</strong></td>
<td>authentication</td>
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<td></td>
<td>media access/control</td>
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<tr>
<td></td>
<td>multiplexing</td>
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<td>encryption</td>
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<td>interference</td>
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<tr>
<td></td>
<td>attenuation</td>
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<tr>
<td><strong>Physical layer</strong></td>
<td>frequency</td>
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</tbody>
</table>

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Course Syllabus

- **Background:**
  - Physical Layer (modulation, interference, attenuation)
  - MAC Protocols (coordinated access, random access)
  - Mobile IP
  - Ad-hoc Routing Protocols
  - TCP in Wireless
- **Recent proposals:**
  - Enhance physical performance, make MAC more efficient, provide seamless mobility, ...

Focus: protocol and physical mechanisms for optimal performance

Course Structure

- **Initial set of lectures (by me):**
  - Will cover all background material
- **Review of recent publications**
  - Paper presentations (by you)
  - Critical reviews (by you)
- **Semester-long projects (groups of 2 welcome)**
  - Topics: investigating, designing something new
    - Experimental study
    - Formal analysis
    - Design and evaluation of new mechanism
  - Preferably on one of the focus topics for this course
    - Unless motivated by strong interest in other topics
Example Project Types

- **Project topics:** investigating or designing something
  - Experimental study
    - Characterization of traffic generated by a popular app
    - Simulator-based comparison of two protocols
    - Measurement of a WiFi deployment
    - Wireless trace analysis
  - Formal analysis
    - Expanding on the analysis of a paper you’ve read
  - Design and evaluation of new mechanisms/application
    - How best to use all sensors in a smartphone to best manage (communication in) a dream app
    - How best to use network & cloud to support a dream app
    - Bandwidth estimation on wireless “links”
    - Localization using signal strengths

Course Grading

- **Paper Presentations:** 25%
- **Critical Reviews:** 20%
- **Projects (groups of 2 are welcome):**
  - Progress: 30%
  - Presentation + report: 10%
- **Final Exam (oral):** 15%
- **Class Participation:**
  - Will be used to potentially bump up (or down) half a grade
- **All percentage points above are flexible by 5-10%**
References For Background Material

- Several reputable texts for background material:
  - Jochen Schiller, “Mobile Communications”.
  - William Stallings, “Wireless Communications & Networks”.
  - Theodore S. Rappaport, “Wireless Communications”.
  - Pahlavan & Krishnamurthy, “Principles of Wireless Networks”.
- Unfortunately, none is sufficient by itself for this course
- Nearly half the course will cover recent research papers

QUESTIONS ?

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