MOBILE COMPUTING
CSE 40814/60814
Fall 2014

Course Overview
• Instructor: Christian Poellabauer
  • 325D Cushing Hall
  • cpoellab@cse.nd.edu
  • 574-631-9131
  • Office hours: fixed hours TBD and by appointment
  • Website!!

Grading
• Homework Assignments 20%
• Project Progress Reports 15%
• Project Demonstration 15%
• Final Project Deliverables 20%
• Special Topic Presentation 15%
• Class Participation 15%
Homework Assignments

- Papers, reports, websites, chapters, handouts, ...
- Exercises, examples, code snippets, etc.
- Solution, report, summary, ...
- Quiz at beginning of class

Project

- Semester-long development project in broad area of mobile computing
- Individual
- Platform/devices of your choice:
  - SW: Android, iOS, Windows, Blackberry, TinyOS, ...
  - HW:
    - Smartphones, tablets
    - Embedded devices & development boards
    - Sensor devices
    - Wearables
    - Robots, UAVs
    - ...

Project Characteristics

- Portable solution/app
- Context/location awareness
- Mobile – cloud integration
- Sensors on mobile devices
- Device embedded into mobile system
- Wireless network technology
- Communication-oriented (should talk to something/body else)
Project Structure
• 3-4 progress reports (written, possibly with Q&A)
• Final report, delivered with code
• In-class demo of project

• Resources:
  • B30 Lab & other Engineering labs
  • Plenty of mobile/sensing/embedded devices (can purchase if needed)
  • Collaboration is encouraged!!

Special Topic Presentation
• “Seminar” given by you
• Topic of your choice
• 2-3 presentations per class with Q&A
• Handouts before presentation; may include homework assignment/quiz
• List of topics will be provided

Class Participation
• Attend, participate, discuss, etc.
Course Goal

- To understand what are the fundamental challenges in Mobile Computing and what are some of the solutions towards solving these fundamental challenges
- But also:
  - To get you a high-paying job
  - To enrich you with new ideas
  - To train you in (mobile) systems oriented thinking
  - To provide you with skills in mobile development

Mobile Developer Jobs

  - Mobile applications developer
    - 2012 salary range: $85,000-$122,500
    - 2013 salary range: $92,750-$133,500
    - Net: 9% increase
    - #1: Mobile App Developer Employment Projections | 2010 - 2020
      - 10-Year Growth Pct: 32% (much faster than avg.)
      - 10-Year Growth Volume: 252,000 new jobs
      - Average Salary: $95,000

Mobile Computing

- Computing enabled by presence of wireless enabled portable devices (PDAs, cell phones etc.)
- Many other names/overlapping computing paradigms:
  - Pervasive Computing
  - Ubiquitous Computing
  - Wireless Computing
  - Embedded Computing
  - Nomadic Computing
  - Wireless Sensor Networks
  - Ad-Hoc Networks
  - Mesh Networks
  - Vehicular Networks
  - …
Between 2010 and 2015, the global installed base of smartphones will increase at a compound annual growth rate (CAGR) of 33 percent. The tablet market will move even faster, achieving a CAGR of 81 percent during the same period. Along with this incredible explosion of devices, network capacity, applications, video, mobile transactions and M2M deployments will grow to match global demand – Yankee Group.

By 2015, more U.S. Internet users will access the Internet through mobile devices than through PCs – IDC.

Global mobile subscriptions will reach over six billion by the end of this year and the Asia-Pacific region will account for more than half of the worldwide figure in 2011 – ABI Research.

Demand for tablets in Asia-Pacific will increase by 95 percent in 2012, outstripping equivalent shipments in North America or Europe – Gartner.

In 2012, mobile workers and consumers will embrace tablets, mobile content, mobile video and personal cloud services at unprecedented levels – Yankee Group.

"Mobile Revolution" by the Numbers

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>2010</th>
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</thead>
<tbody>
<tr>
<td>Internet Users</td>
<td>2.8 million</td>
<td>1.8 billion</td>
</tr>
<tr>
<td>Mobile Phone Subscribers</td>
<td>12.4 million</td>
<td>6.2 billion (79% of world population)</td>
</tr>
</tbody>
</table>

- US: 100% rate of cell phone penetration
- More than 10T SMS in 2013
- Almost 200B apps downloaded
- Angry Bird: 550 million downloads (across all platforms)
- 6.5B mobile phones (4.2B toothbrushes) (2012)
- 900,000+ iPhone apps
- 450,000+ Android apps
- 18 Facebook members (2011)
- ½ of all searches are done via mobiles (smartphone, tablet)
Mobile Revolution

- Mobile is global
- Cost effective, convenient
- Anytime and anywhere
- Contextual

- Cellphone: special-purpose device
- Smartphone: general-purpose device

The Rise of the Apps

There's An App For That

- Some App Store stats (sometime in 2012):
  - 574,607 apps
  - 706 submissions/day
  - $1.92 average price

5: Lifestyle: 47,351
4: Education: 55,772
3: Entertainment: 58,062
2: Books: 61,175
1: Games: 99,795
Universities and the Mobile Revolution

Enablers

- **Wireless communication networks**
  - multiple networks “covering” the globe
  - world-wide deregulation and spectrum auctions
  - standard communication systems and air link interfaces

- **Portable information appliances**
  - laptops, notebooks, sub-notebooks
  - hand-held computers, tablets
  - smartphones

- **Internet**:
  - TCP/IP & de-facto application protocols
  - ubiquitous web content
Wireless Networks

- The edge of the Internet becoming wireless
  - Single hop networks
  - Multi-hop networks

Wireless versus Fixed Networks

- Higher loss-rates due to interference
- Emissions of, e.g., engines, lightning
- Restrictive regulations of frequencies
- Frequencies have to be coordinated, useful frequencies are almost all occupied
- Low transmission rates
  - Local some Mbit/s, regional currently, e.g., 53kbit/s with GSM/GPRS or about 150 kbit/s using EDGE
- Higher delays, higher jitter
- Connection setup time with GSM in the second range, several hundred milliseconds for other wireless systems
- Lower security, simpler active attacking
  - Radio interface accessible for everyone, base station can be simulated, thus attracting calls from mobile phones
- Always shared medium
  - Secure access mechanisms important

Advantages of Wireless

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

- Ease
  - Minimum infrastructure - scatter and play

- Unrestricted mobility
  - Unplugged from power outlet

- Ubiquity
  - Available like water/electricity - holy grail
The Future

- Internet
- Citywatchers
- Walmart
- Intel, Philips, Bosch
- RFID and Sensor Networks
- Motorola, Intel, Samsung
- Personal Area Networks
- Mesh Networks and Wireless Backbones

Mobile + Wireless

- Ubiquitous Services
- Incentives
- Loss Discrimination
- Energy Savings
- Spatial Reuse

Applications that exploit ubiquity and mobility
Challenges underlying such applications

- Privacy
- Eavesdropping
- Mobility
- Interference Mgmt.
- Channel fluctuations
Mobile + Wireless

- Ubiquitous Services
- Incentives
- Loss Discrimination
- Energy Savings
- Spatial Reuse

Wireless Networking

Mobile Computing

- Application
- Security
- Transport
- Network
- MAC / Link
- PHY

- Privacy
- Eavesdropping
- Mobility
- Interference Mgmt.
- Channel fluctuations

Wireless Networking