Overview

- Goal of this Course
- Grading
- Contents of the course
- Tentative Schedule
Mobile vs Wireless

- Mobile vs Stationary
- Wireless vs Wired
- Wireless ⇒ Media sharing issues
- Mobile ⇒ Routing, addressing issues
Wireless Networking

Impact of Wireless on Networking:
1. Not tied to walls/infrastructure ⇒ Ad-hoc networking
2. Error-prone ⇒ Traffic Management
3. Frequent Disconnections ⇒ Resource Management
   Quality of Service for multimedia
4. Battery operated ⇒ Media access and networking while sleep
   ⇒ Time synchronization
5. Broadcast ⇒ Security
Mobile Networking

Impact of Mobility on Networking:
- Location
- Addressing
- Handoff
Goal of This Course

- Comprehensive course on wireless and mobile networking
- Broad coverage of current key areas
- Intro to physical layer “Wireless Communication”
- Emphasis on Higher layers: Layers 2, 3
- Emphasize both present (Industry standards and products) and near future (Research)
- Graduate course: (Advanced Topics)
  - Less reliance on one textbook
  - Lot of independent reading and writing
  - Survey paper (Research techniques)
  - Peer-Reviews
Why Study Wireless Networking?

- Wireless, in the form of WiFi, started in 1999.
  - First it was an option.
  - Now it is standard in all computing devices
- Most of the access (end user connectivity) is wireless
  - Smart phones, Tablets, and many laptops (Ultrabooks) have no wired Ethernet connections
- For telecommunication carriers, most of the revenue is in wireless
Why Wireless (Cont)

- US Wireless industry is valued at $195.5 billion which is larger than publishing, agriculture, hotels and lodging, air transportation, and motion picture and recording industries.
- Wireless industry directly/indirectly provides more than 2.6% of all US employment.
- Wireline revenue is contracting while wireless is expanding.

Washington University in St. Louis http://www.cse.wustl.edu/~jain/cse574-14/
# Tentative Schedule

<table>
<thead>
<tr>
<th>#</th>
<th>Day</th>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monday</td>
<td>1/13/2014</td>
<td>Course Overview</td>
</tr>
<tr>
<td>2</td>
<td>Wednesday</td>
<td>1/15/2014</td>
<td>Wireless Networking Trends</td>
</tr>
<tr>
<td></td>
<td>Monday</td>
<td>1/20/2014</td>
<td>MLK Holiday (No Class)</td>
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<tr>
<td>3</td>
<td>Wednesday</td>
<td>1/22/2014</td>
<td>Wireless Physical Layer Concepts</td>
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<tr>
<td>4</td>
<td>Monday</td>
<td>1/27/2014</td>
<td>WiFi: 802.11abgn</td>
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<td>5</td>
<td>Wednesday</td>
<td>1/29/2014</td>
<td>60GHz: 802.11ad</td>
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<tr>
<td>6</td>
<td>Monday</td>
<td>2/3/2014</td>
<td>White Spaces: 802.11af and 802.22</td>
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<tr>
<td>7</td>
<td>Wednesday</td>
<td>2/5/2014</td>
<td>Vehicular Networks: 802.11p</td>
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<td>8</td>
<td>Monday</td>
<td>2/10/2014</td>
<td>Mesh networking: 802.11s</td>
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<tr>
<td>9</td>
<td>Wednesday</td>
<td>2/12/2014</td>
<td>BlueTooth: 802.15.1</td>
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<tr>
<td>10</td>
<td>Monday</td>
<td>2/17/2014</td>
<td><strong>Mid-Term Exam 1</strong></td>
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<tr>
<td>#</td>
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<tr>
<td>11</td>
<td>Wednesday</td>
<td>2/19/2014</td>
<td>WPANs: 802.15.4 and 802.15.3</td>
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<tr>
<td>12</td>
<td>Monday</td>
<td>2/24/2014</td>
<td>UWB, mm Wave: 802.15.3a, 802.15.3c</td>
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<tr>
<td>13</td>
<td>Wednesday</td>
<td>2/26/2014</td>
<td>ZigBee, NFC, WirelessHD, RFID</td>
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<tr>
<td>15</td>
<td>Wednesday</td>
<td>3/5/2014</td>
<td>2.5G and 3G: EDGE, GPRS, HSPA+, UMTS</td>
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<td></td>
<td>Monday</td>
<td>3/10/2014</td>
<td><em>Spring Break (No Class)</em></td>
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<tr>
<td></td>
<td>Wednesday</td>
<td>3/12/2014</td>
<td><em>Spring Break (No Class)</em></td>
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<td>16</td>
<td>Monday</td>
<td>3/17/2014</td>
<td>WiMAX</td>
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<td>17</td>
<td>Wednesday</td>
<td>3/19/2014</td>
<td>LTE</td>
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<tr>
<td>18</td>
<td>Monday</td>
<td>3/24/2014</td>
<td><em>Mid-Term Exam 2</em></td>
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## Tentative Schedule (Cont)

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<tr>
<td>19</td>
<td>Wednesday</td>
<td>3/26/2014</td>
<td>LTE-Advanced, WiMAX 2, Femto Cells</td>
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<td>20</td>
<td>Monday</td>
<td>3/31/2014</td>
<td>Media Independent Handover</td>
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<tr>
<td>21</td>
<td>Wednesday</td>
<td>4/2/2014</td>
<td>Mobile IPv4</td>
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<td>22</td>
<td>Monday</td>
<td>4/7/2014</td>
<td>Mobile IPv6</td>
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<td>23</td>
<td>Wednesday</td>
<td>4/9/2014</td>
<td>Multicast, Distributed, Network based Mobility</td>
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<td>24</td>
<td>Monday</td>
<td>4/14/2014</td>
<td>IPv6 over 802.15: 6lo, 6lowpan, 6tisch</td>
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<td>25</td>
<td>Wednesday</td>
<td>4/16/2014</td>
<td>TCP over Wireless</td>
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<td>26</td>
<td>Monday</td>
<td>4/21/2014</td>
<td>Ad Hoc Networks: Issues and Routing</td>
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<td>27</td>
<td>Wednesday</td>
<td>4/23/2014</td>
<td>Wireless Sensor Networks</td>
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<tr>
<td>28</td>
<td>Monday</td>
<td>4/28/2014</td>
<td>Final Exam</td>
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</table>
Prerequisite: CSE473S

- Protocol Layers: ISO/OSI reference model
- Physical Layer: Nyquist/Shannon theorems, Coding, Manchester
- Transmission Media: UTP, Cat 5, Microwave, Radio
- Data Communication: Asynchronous vs synchronous, Baud, bit, and Hz, Half-Duplex vs Full-duplex, Modulation/Demodulation
- Packet Transmissions: Framing, Bit stuffing, byte stuffing
- Flow Control: On-Off, Window
- Error Detection: Parity, Checksum, Cyclic Redundancy Check
Prerequisites (Cont)

- Error Recovery: Start and Stop, Go back $n$, Selective Reject
- LANs: Aloha, CSMA/CD, Ethernet, IEEE 802.3
- LAN Addressing: Unicast vs multicast, Local vs Global
- LAN wiring: 10Base5, 10Base2, 10Base-T, 100Base-T4, 100Base-TX, 100Base-FX
- Extended LANs: Hubs, Bridges, Routers, Switches
- Routing: Distance Vector vs Link State, Spanning tree, source routing
- Network Layer: Connectionless vs connection oriented
Text Book

- There is no one book that covers the breadth of the material in this course.
- There will be a reading list with each lecture. The list will include some books, web sites, and Wikipedia links.
- Mostly books available as “Safari Books” will be used.
- WUSTL has a subscription to Safari Books ⇒ All WUSTL students and faculty have free online access.
Grading

- Midterm Exam (Best of 2) 30%
- Final Exam 30%
- Class participation 5%
- Homeworks 15%
- Project 20%
Project

- A survey paper on a recent topic.  
  A list of topics will be provided in the class.
- A hands-on (implementation or measurement) project of your choice approved by the instructor.
- Teams of 2 allowed for hands-on project.
- Stages:
  - Literature search
    - CD ROMs: Compendex, Books in Print, WWW
  - Reading
  - Writing
- Average 6 Hrs/week/person on project
- Average 9 Hrs/week/person on class
Examples of Projects

2010:
- 802.16m and WiMAX Release 2.0
- Current Status and Overview of the CAPWAP Protocol
- Femtocell: Indoor Cellular Communication Redefined
- Long Term Evolution (LTE)
- An Overview of Long Term Evolution Advanced (LTE-Advanced)
- Mobile Based Augmented Reality
- Mobile Cloud Computing
- Smart Grid
- Smart Grid: Trends in Power Market
- The Future of Networking: The Green Movement
Examples of Project (Cont)

2008:
- Body Area Networks (BAN)
- OSPF Extensions for Mobile Ad-hoc Networks
- 4G Wireless and International Mobile Telecommunication (IMT) - Advanced
- The 700 MHz Band: Recent Developments and Future Plans
- Wireless Options for Providing Internet Services to Rural America
- Long Term Evolution (LTE) & Ultra-Mobile Broadband (UMB) Technologies for Broadband Wireless Access
- Medical Applications of Ultra-Wideband (UWB)
- Medical Applications of Wireless Networks
- New and Emerging Energy Efficient Wireless Protocols
- Applications of Recent Wireless Standards in Satellite Networking
Examples of Projects (Cont)

2006:
- Metropolitan and Regional Wireless Networks: 802.16, 802.20 and 802.22
- Wireless Personal Area Networks
- RFID
- Recent Advances in the Wireless Physical Layer
- Location Management in Wireless Data Networks
- Location Management in Wireless Cellular Networks
- Time Synchronization in Wireless Networks
- Power Management in Wireless Networks
- Energy Efficient Routing in Wireless Networks
- Mobile IP
- Network Mobility
- Network Architectures for Mobility
Examples of Projects (Cont)

- IEEE802.21 Media Independent Handover Services
- QoS over WiMAX
- QoS in Wireless Data Networks
- QoS in Cellular Networks
- TCP Optimizations for Wireless
- VoIP/Multimedia over WiMAX
- Wireless Mesh Networks
- Voice over Wireless
- Security in Wireless Data Networks
- Security In Wireless Cellular Networks
- Aircraft Wireless Networks
- Inter/Intra-Vehicle Wireless Communication
- Medical Applications of Wireless Networks
Project Requirements

- Recent Developments: Last 3 to 5 years
  ⇒ Generally not in books
- Comprehensive Survey:
  Technical Papers, Industry Standards, Products
- Will be published on my website,
  Better ones may be submitted to magazines or journals
- No copyright violations:
  ⇒ You need to re-draw all figures
  ⇒ You need to summarize all ideas in your *own* words
  ⇒ Cannot copy any part of text or figure unmodified
  ⇒ Short quotes ok
  ⇒ Any unmodified figures need permissions
Any infringement will result in forfeiture of grades even after graduation.
## Project Schedule

<table>
<thead>
<tr>
<th>#</th>
<th>Day</th>
<th>Date</th>
<th>Project</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Wednesday</td>
<td>1/22/2014</td>
<td>Search Sample Due</td>
<td>1</td>
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<tr>
<td>6</td>
<td>Monday</td>
<td>2/3/2014</td>
<td>HTML Sample Due</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>Monday</td>
<td>2/10/2014</td>
<td>Topic Selection Due</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Wednesday</td>
<td>2/19/2014</td>
<td>References Due</td>
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<tr>
<td>14</td>
<td>Monday</td>
<td>3/3/2014</td>
<td>Outline Due</td>
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<tr>
<td>20</td>
<td>Monday</td>
<td>3/31/2014</td>
<td>Final Report Due</td>
<td>5</td>
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<tr>
<td>22</td>
<td>Monday</td>
<td>4/7/2014</td>
<td>Reviews Due</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>Monday</td>
<td>4/14/2014</td>
<td>Revised Report Due</td>
<td>7</td>
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</tbody>
</table>

**HTML** 2

**Total** 20
Exams

- Exams consist of numerical, fill-in-the-blank and multiple-choice (true-false) questions.
- There is negative grading on incorrect multiple-choice questions. Grade: +1 for correct. -1/(n-1) for incorrect.
  ⇒ For True-False: +1 for Correct, -1 for Incorrect
  This ensures that random marking will produce an average of 0.
- Everyone including the graduating students are graded the same way.
- Highest score achieved becomes 100% for that exam.
  ⇒ Measures relative performance of the student
  Effect of all other factors, such as time allotted, hardness of questions are eliminated.
Exams (Cont)

- All exams are closed book. One 8.5”X11” cheat sheet with your notes on both sides is allowed.
- No smart phones allowed. Only simple TI-30 or equivalent calculator allowed for calculations.
- Exam dates are fixed and there are no substitute exams ⇒ Plan your travel accordingly.
- Best of the two mid-terms is used.
Homeworks

- All homeworks are due on the following Monday at the beginning of the class unless specified otherwise.
- Any late submissions, if allowed, will *always* have a penalty.
- There will be a short 5-minute quiz at the beginning of each class to check if you have read the topics covered in the last class.
Office Hours

- **Monday:** 11:00 to 12:00 noon
  - **Wednesday:** 11:00 to 12:00 noon

- **Office:** Bryan 523

- **Teaching Assistant:** Hila Ben Abraham, Bryan 522E,
  - hila (at) wustl.edu
  - **Office Hours:** Thursday 3:00-4:00PM
  - **Office Hours:** Friday 3:00-4:00PM
Summary

- There will be a lot of self-reading and writing
- Goal: To prepare you for a career in wireless networking
- Get ready to work hard
Google Search Modifiers

- filetype:pdf, doc, ppt, pptx
- site:wustl.com
- intitle:trend
- inurl:trend
- allintitle:Networking Trends
- Allinurl:
- “ “ ⇒ Exact Phrase
- OR
- AND
- + ⇒ Must include
- - ⇒ Not include
- ~X ⇒ X or similar
- * ⇒ Wildcard
Project Homework 1

- Search web pages, books, and journal articles from IEEE XPlorer, ACM Digital Library, MOBIUS, Safari books, ILLIAD at Olin Library for one of the following topics:
  1. Wireless Networking Trends
  2. Mobile Networking Trends

- On the web try the following search points:
  - http://library.wustl.edu/findart.html
  - http://library.wustl.edu/fulltext/
  - http://mobius.umsystem.edu/screens/opacmenu.html
  - http://scholar.google.com
  - http://books.google.com
  - http://dl.acm.org
  - http://ieeexplore.ieee.org/Xplore/home.jsp
  - http://searchnetworking.techtarget.com/
Project Homework 1 (Cont)

- Ignore all entries dated 2009 or before. Also ignore all entries that do not indicate topic or similar words in the title. List others in the following format (up to 5 each):
  - Author, “Title,” publisher, year, ISBN. (for 5 books)
  - “Title,” URL [One line description] (for 5 web pages)
  - Author, “Title,” source (for 5 technical/magazine articles)

- For the books, include whether the book is available at WUSTL, MOBIUS, Safari, or ILLiad

- Serially number the references and submit electronically to jain@cse.wustl.edu. The mail should have a subject field of “CSE 574S Project Homework 1” (Please note the subject carefully. Do not use any other characters in the subject). Your answers should be the content of the message and not in an attachment.
Quiz 0: Prerequisites

True or False?

T  F

1. □ □ Datalink refers to the 2nd layer in the ISO/OSI reference model
2. □ □ Cat 5 unshielded twisted pair cable is better than Cat 3 cable.
3. □ □ Finding path from one node to another in a large network is a transport layer function.
4. □ □ It is impossible to send 3000 bits/second through a wire which has a bandwidth of 1000 Hz.
5. □ □ Bit stuffing is used so that characters used for framing do not occur in the data part of the frame.
6. □ □ For long delay paths, on-off flow control is better than window flow control.
7. □ □ Ethernet uses a CSMA/CD access method.
8. □ □ 10Base2 runs at 2 Mbps.
9. □ □ The packets sent in a connection-oriented network are called datagrams.
10. □ □ Spanning tree algorithm is used to find a loop free path in a network.

Marks = Correct Answers ___ - Incorrect Answers __ = ______
Acronyms

- BAN: Body Area Networks
- CAPWAP: Protocol
- CSMA/CD: Carrier Sense Multiple Access with Collision Detection
- IEEE: Institution of Electrical and Electronic Engineers
- ILLIAD: Inter/Library Loan
- IMT: International Mobile Telecommunication
- IPv4: Internet Protocol Version 4
- IPv6: Internet Protocol Version 6
- ISO: International Standards Organization
- LAN: Local Area Network
- LTE: Long-Term Evolution
- MAC: Media Access Control
- MHz: Mega Hertz
- OSI: Open System Interconnection
- OSPF: Open Shortest Path First
- QoS: Quality of Service
Acronyms (Cont)

- RF Radio Frequency
- RFID Radio Frequency Identification
- TCP Transmission Control Protocol
- UMB Ultra-Mobile Broadband
- URL Uniform Resource Locator
- UTP Unshielded Twisted Pair
- UWB Ultra-Wideband
- VoIP Voice over IP
- WAP Wireless Access Protocol
- WiFi Wireless Fidelity
- WiMAX Wireless Micro-wave Access
- WUSTL Washington University in Saint Louis
- WWW World-Wide Web
Student Questionnaire

- Name: 
- Email: 
- Phone: 
- Degree: _________  Expected Date: ____________
- Technical Interest Areas:
  - 
  - 
  - 

- Prior networking related courses/activities:
  - 
  - 
  - 

- Prior wireless networking related courses/activities:
  - 
  - 
  - 