

CSE 574S

Wireless and Mobile Networking

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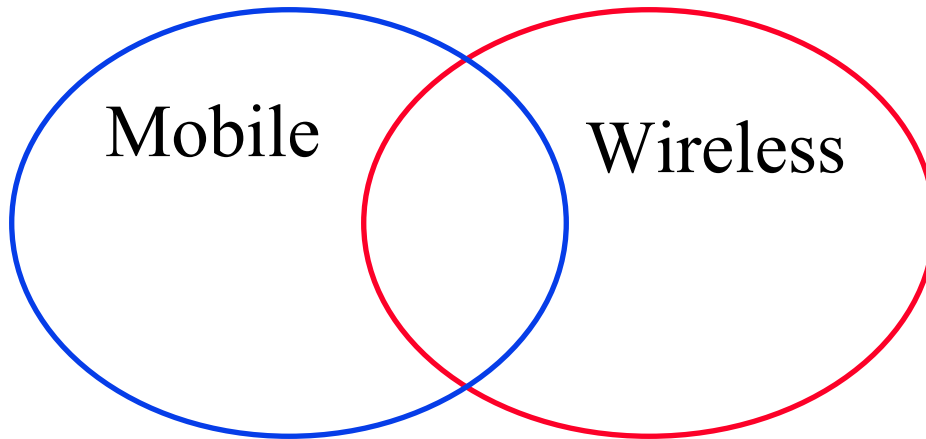
Audio/Video recordings of this class lecture are available at:

<http://www.cse.wustl.edu/~jain/cse574-14/>

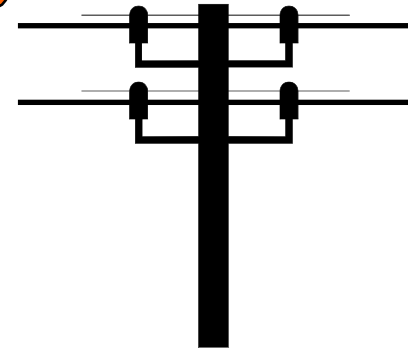


- ❑ Goal of this Course
- ❑ Grading
- ❑ Contents of the course
- ❑ Tentative Schedule

Mobile vs Wireless



- ❑ Mobile vs Stationary
- ❑ Wireless vs Wired
- ❑ Wireless \Rightarrow Media sharing issues
- ❑ Mobile \Rightarrow 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:

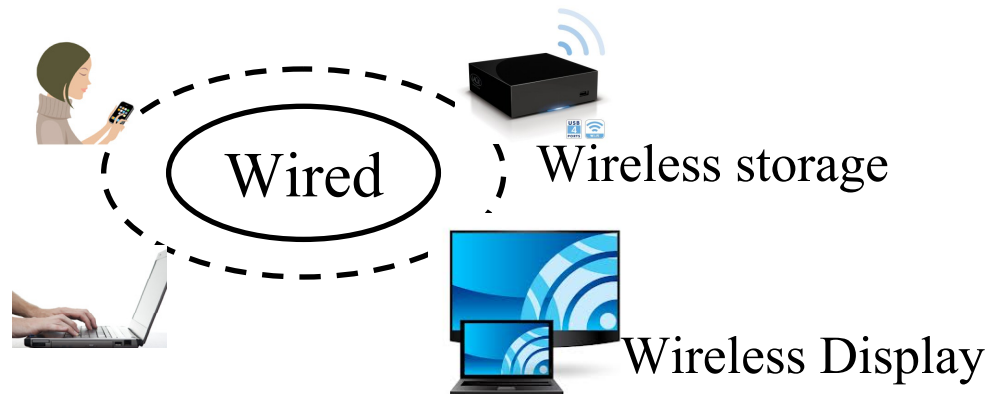
- ❑ Location
- ❑ Addressing
- ❑ Handoff

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

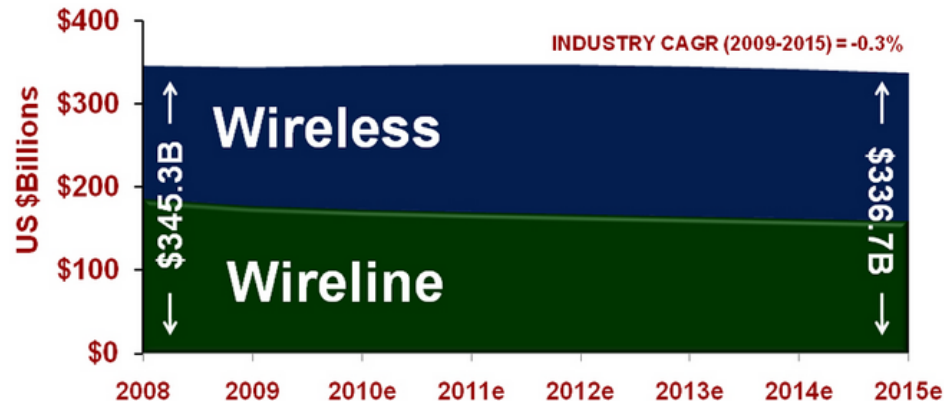
Why Study Wireless Networking?

- ❑ 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



Ref: <http://www.ctia.org/your-wireless-life/how-wireless-works/wireless-quick-facts>

http://atlantic-acm.com/index.php?option=com_content&view=article&id=557%3Avisual-dataline-us-telecom-wireless-and-wireline-service-revenues-2010-2015&catid=46%3A2010-datalines&Itemid=20

Tentative Schedule

#	Day	Date	Topic
1	Monday	1/13/2014	Course Overview
2	Wednesday	1/15/2014	Wireless Networking Trends
	Monday	1/20/2014	<i>MLK Holiday (No Class)</i>
3	Wednesday	1/22/2014	Wireless Physical Layer Concepts
4	Monday	1/27/2014	WiFi: 802.11abgn
5	Wednesday	1/29/2014	60GHz: 802.11ad
6	Monday	2/3/2014	White Spaces: 802.11af and 802.22
7	Wednesday	2/5/2014	Vehicular Networks: 802.11p
8	Monday	2/10/2014	Mesh networking: 802.11s
9	Wednesday	2/12/2014	BlueTooth: 802.15.1
10	Monday	2/17/2014	<i>Mid-Term Exam 1</i>

Tentative Schedule (Cont)

#	Day	Date	Topic
11	Wednesday	2/19/2014	WPANs: 802.15.4 and 802.15.3
12	Monday	2/24/2014	UWB, mm Wave: 802.15.3a, 802.15.3c
13	Wednesday	2/26/2014	ZigBee, NFC, WirelessHD, RFID
14	Monday	3/3/2014	1G and 2G: GSM
15	Wednesday	3/5/2014	2.5G and 3G:EDGE, GPRS, HSPA+, UMTS
	Monday	3/10/2014	<i>Spring Break (No Class)</i>
	Wednesday	3/12/2014	<i>Spring Break (No Class)</i>
16	Monday	3/17/2014	WiMAX
17	Wednesday	3/19/2014	LTE
18	Monday	3/24/2014	<i>Mid-Term Exam 2</i>

Tentative Schedule (Cont)

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

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

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

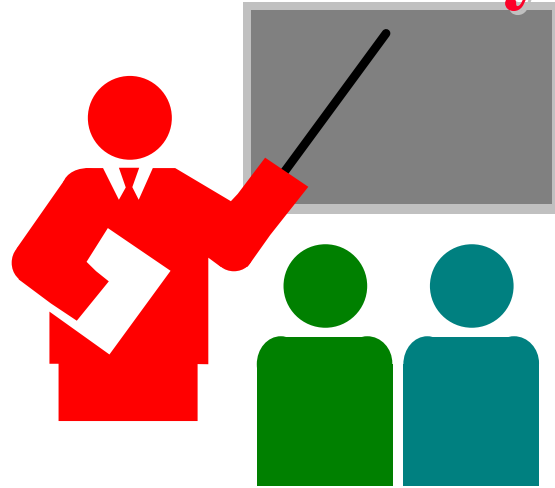
Office Hours

- ❑ 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
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:

