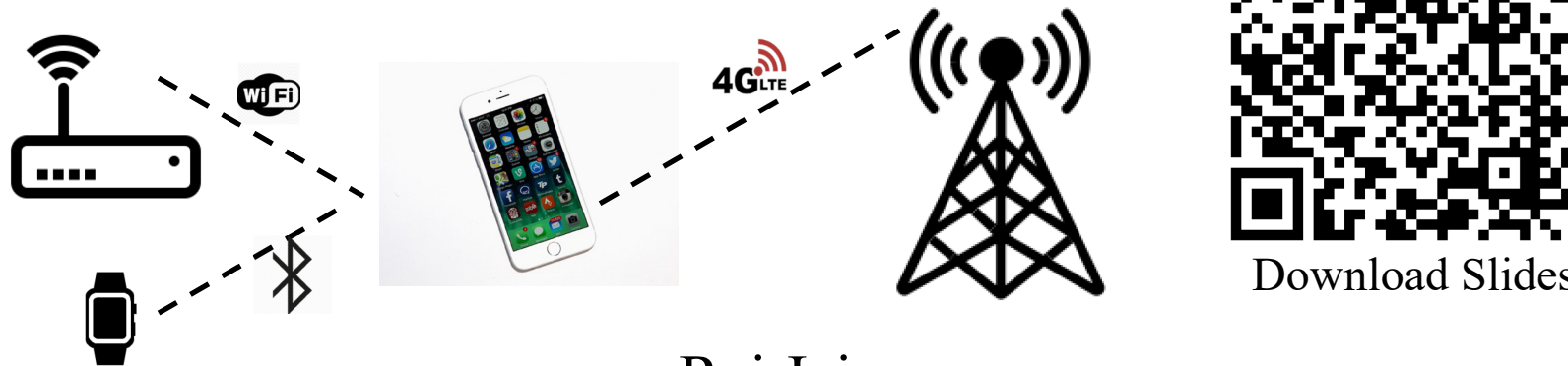


# CSE 574S: Recent Advances in Wireless and Mobile Networking



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

<http://www.cse.wustl.edu/~jain/cse574-20/>

Student Questions



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

Student Questions

# Why Networking?

- ❑ Networking companies are among the most valued companies: Apple, AT&T, Samsung, Verizon, Microsoft, China Mobile, Alphabet, Comcast, NTT, IBM, Intel, Cisco, Amazon, Facebook, ...

⇒ All tech companies that are hiring currently are networking companies

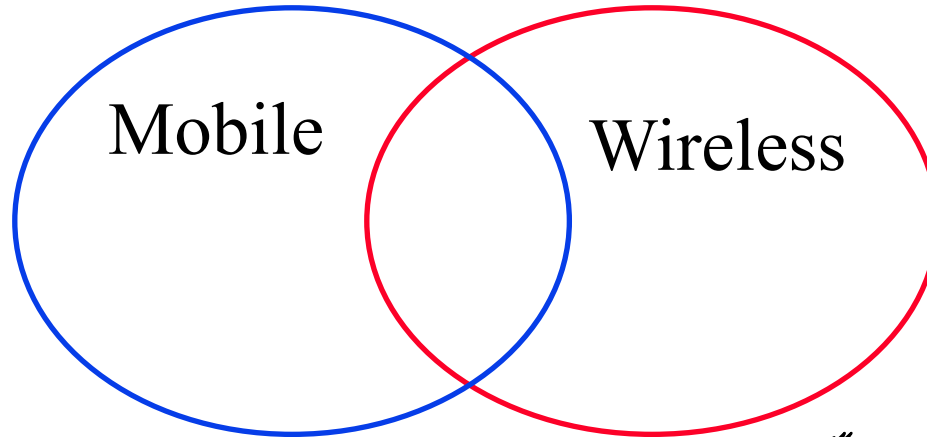
- ❑ Note: Apple became highly valued only after it switched from computing to communications (iPhone)



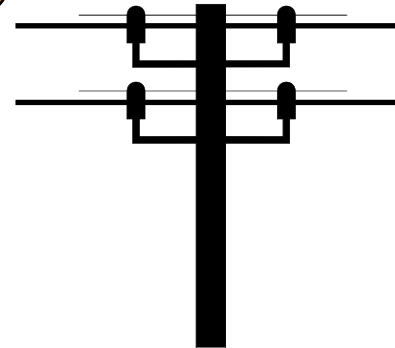
Networking is Fueling All Sectors of Economy

Student Questions

# Mobile vs Wireless




- ❑ Mobile vs. Stationary
- ❑ Wireless vs Wired
- ❑ Wireless → Media sharing issues
- ❑ Mobile → Routing, addressing issues



Student Questions

# How is Wireless different from Wired Networking?

1. Device is not tied to walls/infrastructure  
→ Allows mobility
2. Works even without additional infrastructure  
→ Ad-hoc networking The diagram illustrates ad-hoc networking. On the left, a small white Bluetooth device is connected to a smartphone via a blue lightning bolt icon labeled "Bluetooth". On the right, a laptop is connected to another laptop via a blue lightning bolt icon labeled "Wi-Fi".
3. Error-prone → Traffic Management issues
4. Frequent Disconnections  
→ Resource Management, QoS issues
5. Battery operated → Power reduction  
→ Networking while sleep
6. Broadcast → Security issues

## Student Questions

- I was planning to get back to the video recording to review the difference between the first two points and and might have better understanding of Ad-hoc networking

# Impact of Mobility on Networking

- Your location changes continuously
- What is your current location?
- What is your current address?
- How do we continue communicating while you are going from one tower to the next? → Handoff

## Student Questions

- Are we going to cover the Handoff?

# Why Wireless Networking?

1. Wireless (Wi-Fi) is ubiquitous (Intel Centrino)
2. Most of the access (end user connectivity) is wireless
  - Smart phones, Tablets, and many laptops (Ultra books) have no wired Ethernet connections
3. Most of telecommunication carriers' revenue is in wireless
4. New Developments:
  - 5G: 1 Gbps Metropolitan Area Networks
  - Vehicular Networking (802.11p)



## Student Questions

- How do portable **Wi-Fi** Networks work?

# Mobile Internet

- ❑ June 29, 2007: Apple announced iPhone
  - ➔ Birth of Mobile Internet, Mobile Apps
  - Almost all services are now mobile apps: Google, Facebook, Bank of America, ...
- ❑ 2014 **mobile** data traffic was  $2.5 \times 10^{18}$  B/month. 30× the size of the entire global Internet in 2000 (75 PB/month).
- ❑ Between 2016-21:
  - PC traffic will be only 1/4<sup>th</sup> compared to 1/2 in 2016.
  - **Smart phone** traffic will be 1/3<sup>rd</sup> compared to 1/8<sup>th</sup> in 2016
  - **Mobile traffic** will grow twice as fast as fixed IP traffic
- ❑ Issues: Errors, Disconnection, Limited bandwidth, Limited distance



## Student Questions

Ref: Cisco, "Cisco Visual Networking Index: Forecast and Methodology, 2016-2021," June 6, 2017,

<https://www.cisco.com/c/dam/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.pdf>

Washington University in St. Louis

<http://www.cse.wustl.edu/~jain/cse574-20/>

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# Internet of Things



Smart Watch



Smart TV



Smart Car



Smart Health



Smart Home



Smart Kegs



Smart Space



Smart Industries

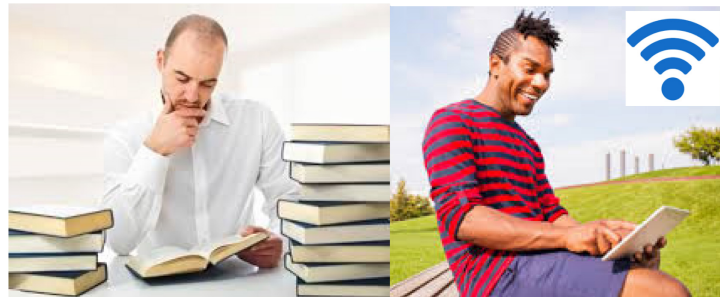


Smart Cities

## Student Questions

# What's Smart?

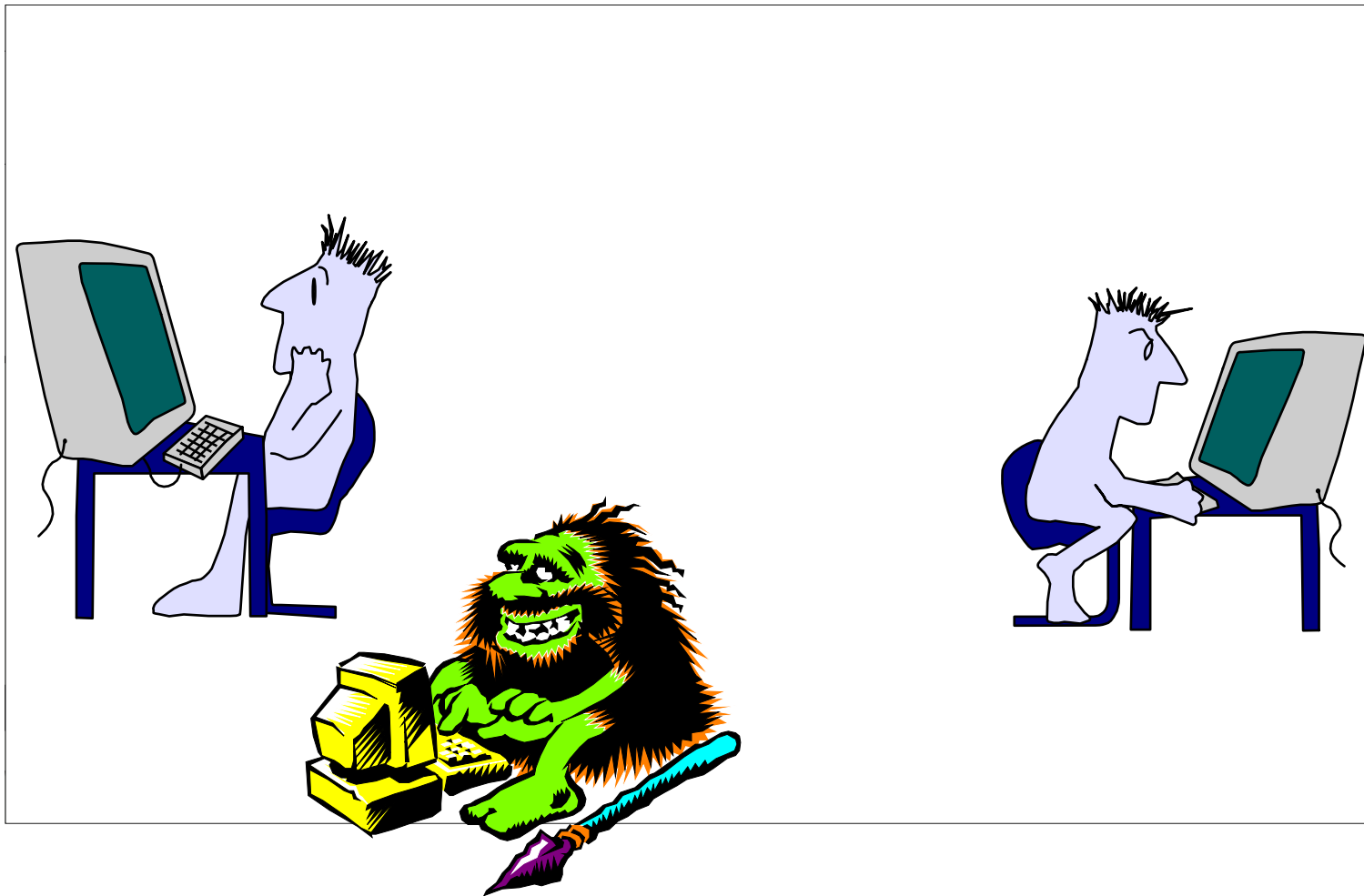
- ❑ Old: Smart = Can think  $\Rightarrow$  Computation  
= Can Recall  $\Rightarrow$  Storage
- ❑ Now: Smart = Can find quickly, Can Delegate  
 $\Rightarrow$  Communicate = Networking
- ❑ Smart Grid, Smart Meters, Smart Cars, Smart homes, Smart Cities, Smart Factories, Smart Smoke Detectors, ...



Not-Smart      Smart

Student Questions

# Cave Persons of 2020



Wireless  $\Rightarrow$  Any where, Any time, Any place, Any dress, Any task

Student Questions

# Goal of This Course

- ❑ Comprehensive course on wireless and mobile networking
- ❑ Broad coverage of current key areas
- ❑ Topics of interest to industry
- ❑ Intro to physical layer “Wireless Communication”
- ❑ Emphasis on lower layers: Layers 2, 3
- ❑ Emphasize both present (Industry standards and products) and near future (Research)
- ❑ Graduate course: (Advanced Topics)
  - ➔ Less reliance on one textbook

Student Questions

# What Will You Learn?

1. How is wireless different from wired communication?
2. How does Wi-Fi work?
  1. How is the speed of Wi-Fi increasing from 10 Mbps to 10 Gbps?
  2. What is the difference between a/b/g/n/ac/ad/...
3. How is Bluetooth different from Wi-Fi?
4. How is ZigBee different from Wi-Fi?
5. What are the protocols that are used in IoT?
6. Why do we need new protocols for IoT?
7. What is the basic difference between 1G/2G/3G/4G/5G?
8. What new features came in with 4G?
9. What new techniques enabled 5G?
10. What about 6G? When and how?

## Student Questions

- Do you think Satellites will be vital in the future of the internet infrastructure? Or not because of slow speeds?

{Range, Speed, Cost}

# Tentative Schedule

#	Date	Topic
1	9/14/20	Course Overview
2	9/16/20	<b>Wireless Coding and Modulation (Part 1)</b>
3	9/21/20	Wireless Coding and Modulation (Part 2)
4	9/23/20	Wireless and Mobile Networking: Facts, Statistics, and Trends
5	9/28/20	Wireless Signal Propagation
6	9/30/20	IEEE 802.11 Wireless LANs. Part I: Basics
7	10/5/20	Wireless LANs Part II: 802.11a/b/g/n/ac
8	10/7/20	60 GHz Millimeter Wave Gigabit Wireless Networks
9	10/12/20	Vehicular Wireless Networks
<b>10</b>	<b>10/14/20</b>	<b>Mid-Term Exam 1</b>

## Student Questions

# Tentative Schedule (Cont)

#	Date	Topic
11	10/19/20	Wireless Networking in White Spaces
12	10/21/20	IoT
13	10/26/20	Wireless Protocols for IoT Part I: Bluetooth and Bluetooth Smart
14	10/28/20	Wireless Protocols for IoT Part II: IEEE 802.15.4 WPAN
15	11/2/20	Wireless Protocols for IoT Part III: Zigbee
16	11/4/20	Wireless Protocols for IoT Part III: Zigbee
17	11/9/20	Low Power WAN Protocols for IoT
18	11/11/20	Introduction to 6LoWPAN and RPL
<b>19</b>	<b>11/16/20</b>	<b>Mid-Term Exam 2</b>

Student Questions

# Tentative Schedule (Cont)

#	Date	Topic
20	11/18/20	Low Power WAN Protocols for IoT
21	11/23/20	Cellular Networks: 1G/2G/3G
22	11/25/20	LTE
23	11/30/20	4G/LTE-Advanced
24	12/2/20	LTE Advanced Pro (4.5G)
25	12/7/20	5G
26	12/9/20	5G
27	12/14/20	TBD
<b>28</b>	<b>12/16/20</b>	<b>Final Exam</b>

Student Questions



# Prerequisite: CSE473S

- ❑ Protocol Layers: ISO/OSI reference model
- ❑ TCP/IP protocol stack
- ❑ LAN Addressing: Unicast vs. multicast, Local vs. Global
- ❑ Extended LANs: Hubs vs. Bridges vs. Routers vs. Switches
- ❑ IPv4 and IPv6 Address: Public vs. Private Addresses
- ❑ Subnets
- ❑ Address Resolution Protocol (ARP)
- ❑ TCP connection setup, Checksum (pseudo-header), Slow start
- ❑ TCP vs. UDP

## Student Questions

# 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 may 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

## Student Questions

# Grading

- ❑ Exams (Best 2 of 3 Exams) 60%
- ❑ Video Reviews 20%
- ❑ Class participation 5%
- ❑ Home works/Class Quizzes 15%
  
- ❑ **Pass/Fail:** Anyone getting over 70% of the highest achieved grade in the course will pass. For example, if 96 is the highest score (after combining exams, *labs*, quizzes, and home works), the passing grade will be 67.2

## Student Questions

- ❑ Do homeworks include programming and/or Research? *Labs do have some programming.*

# Class Participation

- ❑ Zoom reports include the time you join and leave and also how much “attention” you were paying on the session. Multiple monitors, unnecessary keyboard and mouse activities on other applications is counted as a lack of attention.
- ❑ Students should join with their full name and email. That way I can associate your participation.
- ❑ The classes are being recorded as usual.
- ❑ Zoom recordings will be made available on a best effort bases.

Student Questions

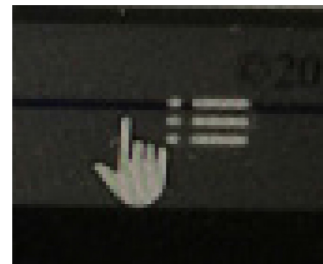
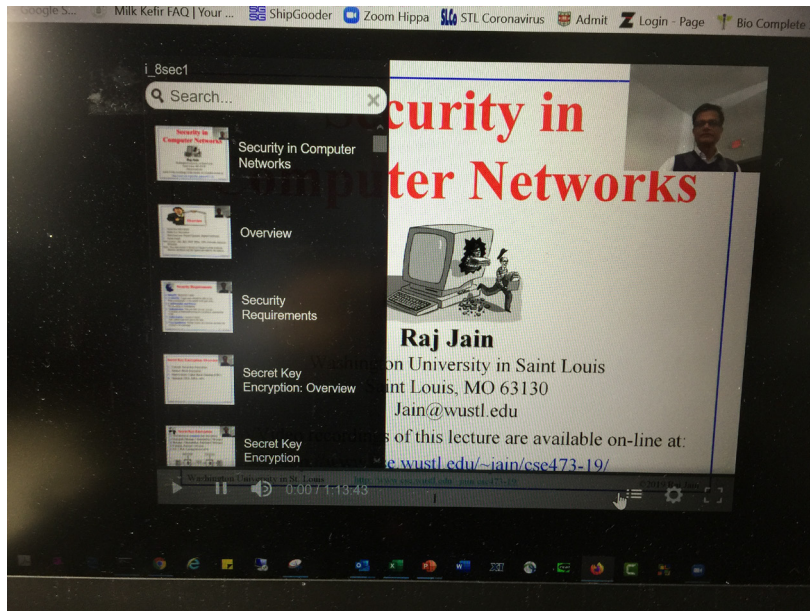
# Video Review Task

- ❑ Video Review question form closes 2 hours before the class time so that the questions can be incorporated in the class presentation. This is the absolute deadline (Until Date). The desirable deadline (Due Date) is midnight of the day before.
- ❑ After each video review, please complete the answers to questions on Canvas. These questions are simple and have 10 grade points.
- ❑ Also, remember to write your questions about each slide on the Google form. Anyone who submits the form will get 4 points. This does not depend on the number of questions asked.
- ❑ If you do not have any questions on a slide, you should leave it blank. You can leave the entire form (except your name and email) blank if there are no questions.

## Student Questions

# Video Table of Contents

- ❑ A table of contents shows up when you mouse-over the bottom of the play area. Click on the “TOC” symbol. This allows you to jump to the particular slide in the video.
- ❑ This feature is available only on some recordings played directly from the course website. Not available on YouTube.



TOC

Student Questions

# 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.

## Student Questions

## 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 two of the 3 exams are used.
- ❑ Everyone should take all 3 exams.
- ❑ Respondus will be used to monitor the exam.
- ❑ You will need a webcam separate from the one on your laptop for Respondus. Also get a good headset with a microphone.

### Student Questions

- ❑ Should we buy a webcam just for the exam? I checked the library website for webcam loan and they are temporary unavailable.



# Homework Submission

- ❑ All homework's are due on the following Monday just before the beginning of the class unless specified otherwise. This gives you the weekend to work on the homework.
- ❑ Any late submissions, if allowed, will *\*always\** have a penalty.
- ❑ All homework's should be submitted on canvas
- ❑ All homework's are identified by the class handout number.
- ❑ All homework's should be in a separate file.
- ❑ Home works will have Due Date/time and Until Date/time. Please try to do the homework before the due date. Submissions will be allowed up to the “until date/time” without penalty. Canvas will not accept any submission after until date/time.

Student Questions

# Homework Grading

- ❑ Grading basis: Method + Correct answer
- ❑ Show how you got your answer
  - Show intermediate calculations.
  - Show equations or formulas used.
  - If you use a spreadsheet, a statistical package, or write a program, print it out and turn it in with the homework.
  - For Excel, set the print area and scale the page accordingly to fit to a page. (See Page Setup)
- ❑ **Quizzes:** There may be questions or quizzes during the class to check if you have understood the material.

Student Questions

# Academic Integrity

- ❑ Academic integrity is expected in homework's, quizzes, and exams.
- ❑ All solutions submitted are expected to be yours and not copied from others or from solution manuals or from Internet
- ❑ School requires us to report all integrity violations to the department

Student Questions

# Class Discussions

- ❑ We will use Piazza for class discussion.
- ❑ Find our class page at:
- ❑ <https://piazza.com/wustl/fall2020/cse574/home>

Student Questions

# Office Hours

- ❑ Office Hours: On Zoom, by appointment
- ❑ **Teaching Assistant:** Zebo Yang Zebo at wustl.edu
  - Office Hours on Zoom: Friday 1:30-2:30PM  
Sunday 1:30-2:30PM
- ❑ Please write **CSE574** in the subject field of all emails related to this course.
- ❑ Use word “**Homework xx**” in the subject field on emails related homework xx. Remember to indicate the homework number.

## Student Questions

# Summary



- ❑ We are living in the Internet age. Most activities including work and play require Internet.
- ❑ Networking companies are among the most valued companies in the world.
- ❑ Wireless networking is taking over the edge fueled by the smart phone and smart devices (IoT).
- ❑ Goals of this course:
  - To prepare you for the current job market in networking
  - To teach you how to keep up with the latest in wireless and mobile networking

## Student Questions

- ❑ The audio during the zoom session was poor (during first 5-10 min) -- afterwards it was OK.
- ❑ How can we video recordings of lectures that we haven't take yet and have no videos for the same semester offering? *Previous years videos are available on my website.*

# Acronyms

- ❑ BAN            Body Area Networks
- ❑ 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
- ❑ LRLP        Long Range Low Power
- ❑ LTE         Long-Term Evolution
- ❑ MAC         Media Access Control
- ❑ OSI         Open System Interconnection
- ❑ OSPF        Open Shortest Path First

## Student Questions

# Acronyms (Cont)

- ❑ RFID Radio Frequency Identification
- ❑ TCP Transmission Control Protocol
- ❑ TV Television
- ❑ UMB Ultra-Mobile Broadband
- ❑ URL Uniform Resource Locator
- ❑ UWB Ultra-Wideband
- ❑ VoIP Voice over IP
- ❑ Wi-Fi Wireless Fidelity
- ❑ WUSTL Washington University in Saint Louis
- ❑ WWW World-Wide Web

## Student Questions



**Scan This to Download These Slides**



Raj Jain

<http://rajjain.com>

Student Questions

[http://www.cse.wustl.edu/~jain/cse574-20/j\\_01int.htm](http://www.cse.wustl.edu/~jain/cse574-20/j_01int.htm)

# Related Modules



CSE567M: Computer Systems Analysis (Spring 2013),  
[https://www.youtube.com/playlist?list=PLjGG94etKypJEKjNAa1n\\_1X0bWWNyZcof](https://www.youtube.com/playlist?list=PLjGG94etKypJEKjNAa1n_1X0bWWNyZcof)

CSE473S: Introduction to Computer Networks (Fall 2011),  
[https://www.youtube.com/playlist?list=PLjGG94etKypJWOSPMh8Azcg5e\\_10TiDw](https://www.youtube.com/playlist?list=PLjGG94etKypJWOSPMh8Azcg5e_10TiDw)



CSE 570: Recent Advances in Networking (Spring 2013)  
<https://www.youtube.com/playlist?list=PLjGG94etKypLHyBN8mOgwJLHD2FFIMGq5>

CSE571S: Network Security (Fall 2011),  
<https://www.youtube.com/playlist?list=PLjGG94etKypKvzfVtutHcPFJXumyyg93u>



Video Podcasts of Prof. Raj Jain's Lectures,  
<https://www.youtube.com/channel/UCN4-5wzNP9-ruOzQMs-8NUw>

## Student Questions

## Exam 2

- Exam 2 is one in which typically everyone does better than Exam 3. This is because no other courses have an exam at this time. Exam 3 usually happens when every other course also has exam the same week or same day.

Student Questions

## Exam 3

- ❑ Send me email in advance to indicate that you will not be taking Exam 3.
- ❑ There is no other makeup exam. Exam 3 is the make up exam for those who scored low on the first two exam or were sick or had other emergencies.

Student Questions