

CSE 570S: Recent Advances in Networking

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These slides and audio/video recordings are available on-line at:

<http://www.cse.wustl.edu/~jain/cse570-23/>

Student Questions



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

Student Questions

Networking = “Plumbing”

- ❑ Networking is the “plumbing” of computing
- ❑ Almost all areas of computing are network-based.
 - Distributed computing
 - Big Data
 - Cloud Computing
 - Internet of Things
 - Smart Cities
- ❑ Networking is the backbone of computing.



Networking is already great!

Student Questions

Networking is Fueling All Sectors of Economy

- ❑ 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 = Economic Indicator

Student Questions

Goal of This Course

- ❑ Recent networking topics
- ❑ Topics of interest to the industry
- ❑ Comprehensive course – covers many topics
- ❑ Data Center Networking, Virtualization, Software Defined Networking, Big Data, Cloud Computing, Internet of Things
- ❑ Breadth First
- ❑ Graduate course: (Advanced Topics)
 - ⇒ A lot of independent reading and writing
 - ⇒ Project/Survey paper (Research techniques)

Student Questions

Objectives: What You Will Learn?

Top 10 Topics in Networking

1. Data Center Networking
2. Virtualization
3. Cloud Computing
4. Software Defined Networking (SDN)
5. Network Function Virtualization (NFV)
6. Internet of Things (IoT)
7. Software-Defined Intelligence
8. Blockchains
9. Quantum Communications

Student Questions

Data Center Networking

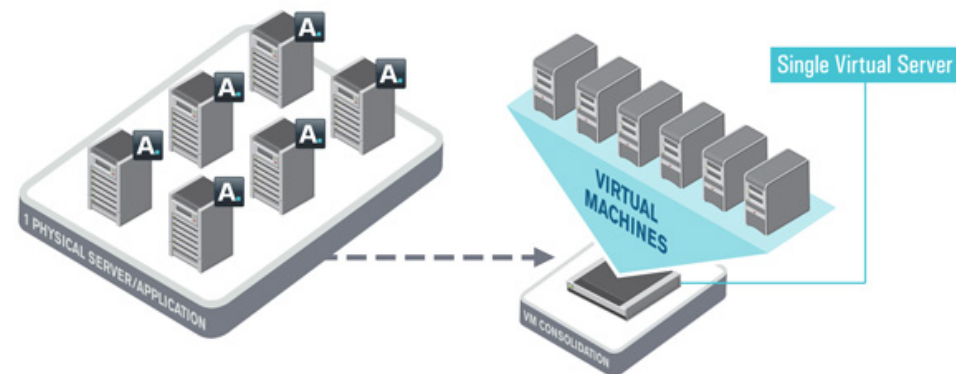
1. How are data centers networks different from those in homes or offices?
2. What are the standards for data center layout?
3. How have Ethernet and other protocols been changed to accommodate data centers?
4. How and why connect multiple data centers on a single Ethernet?



Student Questions

Virtualization

1. Why virtualize?
2. How are servers virtualized?
3. How is storage virtualized?
4. What networking components are virtualized and how?
5. What are new networking standards related to virtualization?



Student Questions

Cloud Computing

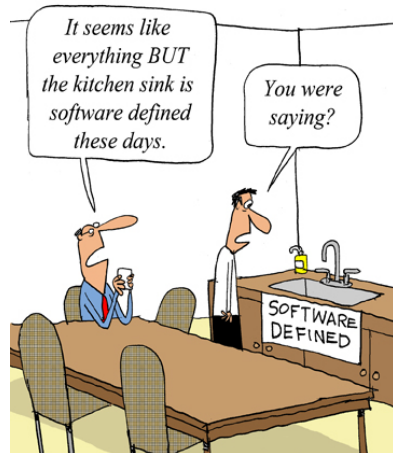
1. What is cloud computing?
2. What are the different types of cloud services?
3. How is it different from other forms of computing:
Grid, Cluster,...
4. What new technologies are required to enable cloud computing?
5. What is fog (vs. cloud) computing?



Student Questions

Software Defined Networking

1. What is software-defined networking?
2. Why is the industry running to adopt this new technology so fast?
3. What new facilities are enabled by SDN?
4. What is the difference between SDN and OpenFlow?
5. What are the different flavors of SDN?



Student Questions

Network Function Virtualization (NFV)

1. What is NFV?
2. NFV and SDN Relationship
3. ETSI NFV ISG Specifications
4. Concepts, Architecture, Requirements, Use cases
5. Proof of Concepts and Timeline



[Source: LightReading]

Student Questions

Internet of Things

1. What is so unique about the Internet of Things (compared to the current Internet)?
2. What are the new IEEE/IETF protocols for IoT?
3. What are different kinds of things: M2M, Sensors, RFID, ...
4. How can clouds help IoT?



Student Questions

Blockchain

- ❑ Blockchain is the technology that made Bitcoin secure
- ❑ Blockchain was invented by the inventor of Bitcoin
- ❑ After Bitcoin became successful, people started looking into the technology behind Bitcoin and found:
 - Blockchain is the key to its success
 - Blockchains can be leveraged for other applications

Student Questions

Other Topics

- ❑ Machine Learning and Deep Learning applications for networking
- ❑ Quantum communication

Student Questions

Non-Goals

- ❑ The following current issues are not covered in this course:
 - Wireless developments – 4G, 5G, Picocell, Femtocell (Covered in CSE 574 – Wireless Networking)
 - Security – Are clouds secure?
Security and Privacy issues of IoT.
(Covered in CSE 571 – Network security)
- ❑ These issues require background not covered in CSE 473.

Student Questions

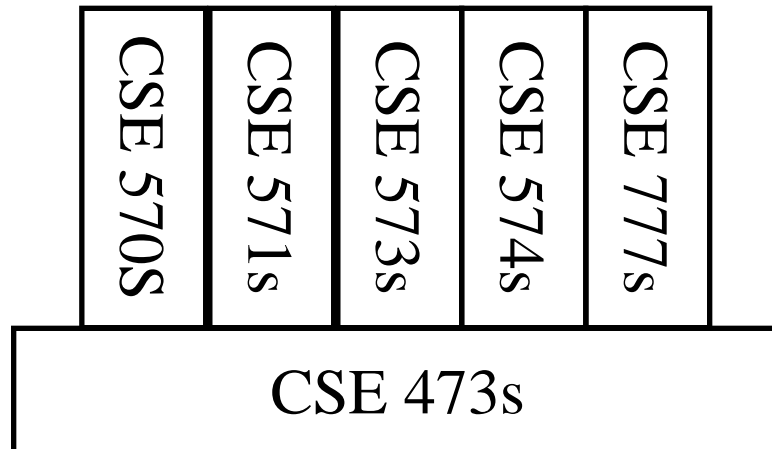
Reading Material

1. Technical Papers
2. Industry whitepapers
3. Standards documents
4. Wikipedia, <http://en.wikipedia.org/wiki/>
5. Books

Student Questions

Networking Courses at WUSTL

- ❑ CSE 473s: Introduction to Computer Networks
- ❑ CSE 570S: Recent Advances in Networking
- ❑ CSE 571S: Network Security
- ❑ CSE 573s: Protocols for Computer Networks
- ❑ CSE 574s: Wireless and Mobile Networking
- ❑ CSE 777s: Research Seminar in Networking



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
- ❑ VLANs
- ❑ IPv4 and IPv6 Address: Public vs. Private Addresses
- ❑ Subnets
- ❑ Address Resolution Protocol (ARP)
- ❑ Internet Control Message Protocol (ICMP)
- ❑ TCP connection setup, Checksum (pseudo-header), Slow start
- ❑ TCP vs. UDP
- ❑ Hypertext Transfer Protocol (HTTP)

Student Questions

Tentative Schedule 1

Date	Day	Topic
8/28	Monday	Course Overview
8/30	Wednesday	Networking Trends 2021
9/4	Monday	Labor day holiday
9/6	Wednesday	Data Center Network Topologies (Part 1)
9/11	Monday	Data Center Network Topologies (Part 2)
		Data Center Ethernet (Part 1)
9/13	Wednesday	Data Center Ethernet (Part 2)
9/18	Monday	Carrier IP
9/20	Wednesday	Carrier Ethernet
9/25	Monday	Exam 1

Student Questions

Tentative Schedule 2

Date	Day	Topic
9/27	Wednesday	Project Guidelines (Part 1)
10/2	Monday	Virtual Bridging
10/4	Wednesday	LAN Extension and Virtualization Using L3
10/9	Monday	Virtual Routing Protocols
10/11	Wednesday	Virtual Routing Protocols (Part 2)
10/16	Monday	<i>Fall Break</i>
10/18	Wednesday	Project Guidelines (Part 3)
10/23	Monday	IoT (IoT)
10/25	Wednesday	Data-Link and Management Protocols for IoT
10/30	Monday	Exam 2

Student Questions

Tentative Schedule 3

Date	Day	Topic
11/1	Wednesday	Routing Protocols for IoT: 6LoWPAN and RPL I
11/6	Monday	Routing Protocols for IoT: 6LoWPAN and RPL II
		Messaging Protocols for Internet of Things: MQTT
11/8	Wednesday	Introduction to OpenFlow(Part 1)
11/13	Monday	Introduction to Software Defined Networking (SDN)
11/15	Wednesday	Introduction to Network Function Virtualization
11/20	Monday	Introduction to Blockchains for Computer
11/22	Wednesday	<i>Thanksgiving break</i>
11/27	Monday	Introduction to Quantum Computing and Its
11/29	Wednesday	TBD
12/4	Monday	Final Exam

Student Questions

Projects

- ❑ Hands-on project or a survey paper related to the topics of the course
- ❑ Some hands-on project and survey topics will be assigned.
Some you can suggest for approval.
- ❑ Average 6 Hrs./week/person on project + 9 Hrs./week/person on class
- ❑ Recent Developments: Last 2 to 4 years
⇒ Not in books
- ❑ Will be published on my website,
Better ones may be submitted to magazines or journals

Student Questions

Project Requirements

- ❑ Comprehensive Survey:
Technical Papers, Industry Standards, Products
 - ❑ 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.

Student Questions

Example of Projects

- ❑ Current Autonomic Networking Models and Architectures
- ❑ Automotive Ethernet Technologies and Protocols
- ❑ 10 Gigabit Ethernet and Backplane Ethernet
- ❑ An Enterprise Blockchain Solution for an Infrastructure-as-a-Service Platform
- ❑ Decentralized Internet
- ❑ A Survey of Information-Centric Networking Approaches
- ❑ The State of Intent-Based Networking
- ❑ Machine Learning Techniques for Intrusion Detection Systems
- ❑ Quantum Communications and its Recent Advances
- ❑ Time-Sensitive Networking for Real-Time Ethernet

Student Questions

Example of Projects (Cont.)

- ❑ Performance Comparison of Big Data Analysis using Hadoop in Physical and Virtual Servers
- ❑ A Survey of Balloon Networking Applications and Technologies
- ❑ Recent Information-Centric Networking Approaches
- ❑ Recent Advances in Named Data Caching and Routing
- ❑ For a sample of previous projects reports, see
<http://www.cse.wustl.edu/~jain/cse570-19/index.html>
<http://www.cse.wustl.edu/~jain/cse570-18/index.html>
<http://www.cse.wustl.edu/~jain/cse570-15index.html>
<http://www.cse.wustl.edu/~jain/cse570-13/index.html>

You can suggest a topic for approval or select from a list of topics that will be provided.

Student Questions

Project Schedule

- Mon 10/2 Topic Selection
- Mon 10/9 References Due
- Mon 10/23 Outline Due
- Mon 11/6 Final Paper Due \Rightarrow Peer reviewed
- Mon 11/13 Reviews Returned
- Mon 11/20 Revised Report Due

Student Questions

Office Hours

□ By Appointment

□ Teaching Assistant:

➤ Zebo Yang, zebo at wustl.edu

Student Questions

Grading

- ❑ Exams (Best of 2 mid terms + Final) 60%
- ❑ Class participation 5%
- ❑ Home Works 15%
- ❑ Project 20%

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, is 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 smartphones allowed.
Only a simple TI-30 or equivalent calculator is 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.

Student Questions

Home Work Submission

- ❑ All home works are due on the following Monday before the class unless specified otherwise.
- ❑ Any late submissions, if allowed, will **always** have a penalty.
- ❑ All home works should be submitted online on canvas
- ❑ All home works identified by the class handout number.
- ❑ All home works should be on a separate file.
Your name should be on every page.
- ❑ Please write CSE570 in the subject field of all emails related to this course.
- ❑ Use the word “Home work” in the subject field on emails related to homework. Also, indicate the homework number.

Student Questions

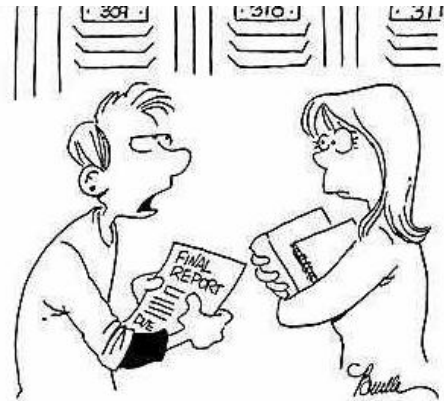
Home Work Grading

- ❑ 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)

Student Questions

Academic Integrity

- ❑ Academic integrity is expected in home works
- ❑ All solutions submitted are expected to be yours and not copied from others or from solution manuals or from Internet
- ❑ All integrity violations have to be reported to the department.



"I don't know what plagiarizing is, so I'm gonna take the easy way out and just copy something off the internet."

Cartoon Source: <https://www.tarleton.edu/stulife/judicial/integrity/index.html>

Student Questions

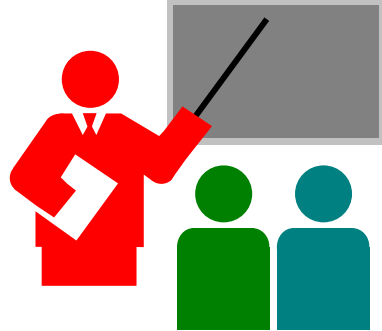
Class Discussions

- ❑ We will use Piazza for class discussion.
- ❑ Find our class page at:
- ❑ <https://piazza.com/wustl/fall2023/cse570s>



Student Questions

Summary



- ❑ Goal: To prepare you for the current job market in networking
- ❑ Teach you how to keep up with the latest in your field
- ❑ There will be a significant amount of self-reading and writing
- ❑ Get ready to work hard

Student Questions

Google Search Modifiers

- ❑ filetype:pdf, doc, ppt, pptx
- ❑ site:wustl.edu
- ❑ intitle:trend
- ❑ inurl:trend
- ❑ allintitle:Networking Trends
- ❑ Allinurl:
- ❑ “ “ \Rightarrow Exact Phrase
- ❑ OR
- ❑ AND
- ❑ + \Rightarrow Must include
- ❑ - \Rightarrow Not include
- ❑ ~X \Rightarrow X or similar
- ❑ * \Rightarrow Wildcard

Ref: <https://bynd.com/news-ideas/google-advanced-search-comprehensive-list-google-search-operators/>

Student Questions

Project Home Work 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. Networking Trends
 2. Data Center Networking
 3. Software-Defined Networking
 4. Internet of Things
 5. Quantum Communications
 6. Blockchains
- ❑ On the web, try the following search points:
 - <https://library.wustl.edu>
 - <https://scholar.google.com>
 - <https://books.google.com>
 - <https://dl.acm.org/>
 - <https://searchnetworking.techtarget.com/>
 - <https://ieeexplore.ieee.org>

Student Questions

Project Home Work 1 (Cont.)

- ❑ Ignore all entries dated 2016 or before. Also, ignore all entries that do not indicate topic or similar words in the title. List others in the following format (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 them electronically
- ❑ Make a list of other interesting search points and share them in class.

Student Questions

Common Mistakes in Project Home Work #1

- ❑ Not indicating where the book can be found in WUSTL
- ❑ Listing books/Magazines/journals that have little to do with the topic – may show up in search engines because of a minor mention of the topic or words
- ❑ Web Pages – No one-line descriptions
- ❑ Incomplete bibliographic data for journal articles.
Need volume, issue, year, and pages.
- ❑ Missing journals. Need names of journals dealing with the topic chosen.

Student Questions

Quiz 0: Prerequisites

True or False?

T F

- A Subnet mask of 255.255.255.254 will allow 254 nodes on the LAN.
- Time to live (TTL) of 8 means that the packet can travel at most 8 hops.
- IP Address 128.256.210.12 is an invalid IP address
- Network Address Translator (NAT) connects a private network to Internet.
- DHCP server is used for automatic assignment of IP address
- DNS helps translate a name to a MAC address
- Port 80 is used for FTP.
- IPv6 addresses are 32 bits long.
- New connection setup message in TCP contains a syn flag.
- 192.168.0.1 is a public address.
- Spanning tree algorithm is used to find a loop free path in a layer 2 network.

Marks = Correct Answers _____ - Incorrect Answers _____ = _____

Student Questions

Student Questionnaire

Name: _____

Email: _____

Phone: _____

Degree: _____ Expected Date: _____

Technical Interest Areas:

Prior networking related courses/activities:

Student Questions

Scan This to Download These Slides



Raj Jain

<http://rajain.com>

http://www.cse.wustl.edu/~jain/cse570-23/m_01int.htm

Student Questions

Instructions for Watching Class Videos

- ❑ This video uses recordings from a live class in the recent past. However, the slides have been updated.
- ❑ The key advantage of using actual class recording is that the material is presented at the right speed.
- ❑ Whenever there is a difference in the audio and the text on the slides, the slides supersede the audio since they have been updated.
- ❑ In general, the changed text is shown in red. Since we use red color for slide titles, new slides are shown with underlined red text (as in this slide).
- ❑ Most modules will include a few new slides at the end after the “related modules slide.” These slides are not in the video and will be discussed during the Q&A session of the class.

Student Questions

- ❑ These additional slides are not in the video and will be discussed in the class.

Instructions for Watching Class Videos (Cont)

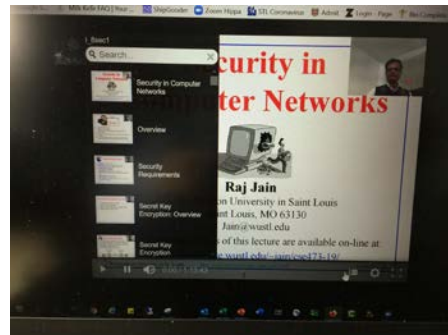
- ❑ Flipping the class results in a very interactive class and students learn much more than in a normal class.
- ❑ We have been successfully using flipped classes for the last 3 semesters.
- ❑ Please download the slides pdf from the course website before watching the video. Use the soft/hard copy of the slides to write your own notes and questions.
- ❑ Scan the QR Code shown here to download these slides
- ❑ The course website URL is on every slide. All URLs on our pdfs are clickable.



Student Questions

Video Features

- ❑ Our videos have embedded quizzes, table of contents, closed captions, and full screen capability.
 - Click CC on the bottom of the video to enable or disable closed captions.
 - Click on the menu symbol to see a table of contents. This allows you to jump to any particular slide.
 - The square symbol allows you to switch to/from full-screen mode.
 - When a quiz appears, answer it correctly. This gets you points that are used as your score for video review homework.
- ❑ Some of these features may not be available on some recordings. Quizzes are not included on the same video played from YouTube or course website.



ToC

Student Questions

Related Modules



CSE 567: The Art of Computer Systems Performance Analysis

https://www.youtube.com/playlist?list=PLjGG94etKypJEKjNAa1n_1X0bWWNyZcof

CSE473S: Introduction to Computer Networks (Fall 2011),

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 (Spring 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