

# 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/cse570-19/>



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

# 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!

# 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

# Goal of This Course

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

# 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

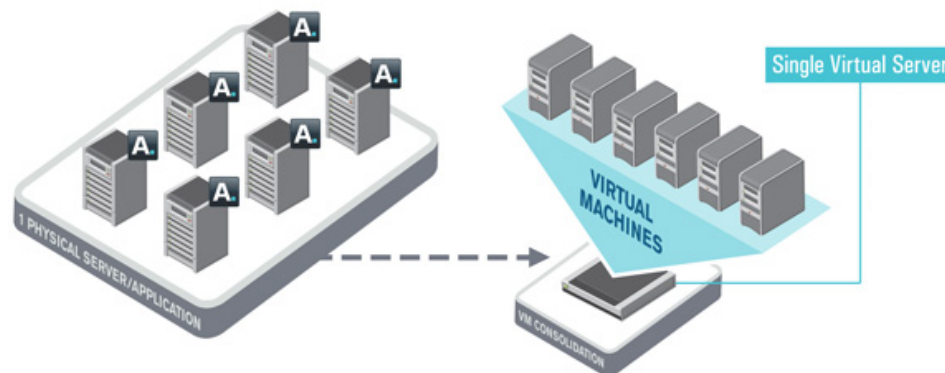
# Data Center Networking

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?



# 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?





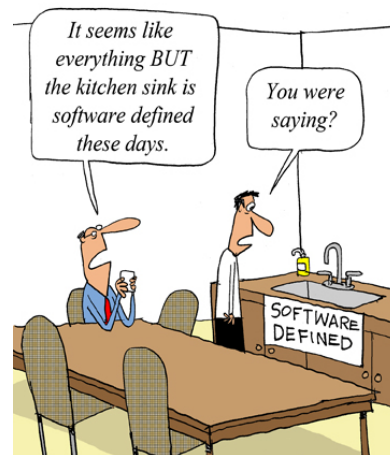
# Cloud Computing

1. What is cloud computing?
2. What are different types of cloud services?
3. How is 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?



# 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 different flavors of SDN?



# 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]

# Internet of Things

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



# NETCONF and YANG

1. Why is NETCONF needed?
2. What can we do with NETCONF?
3. Message formats
4. What is YANG data modeling language



# 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 for its success
  - Blockchains can be leveraged for other applications

# Other Topics

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

# Non-Goals

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

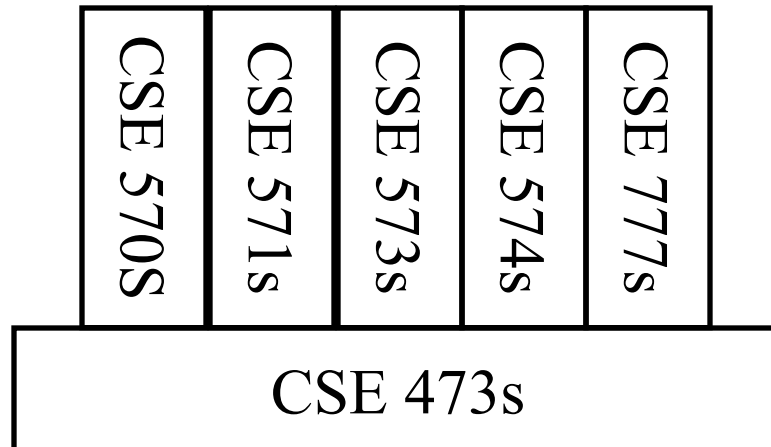


# Reading Material

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

# 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



# 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)

# Tentative Schedule 1

Date	Topic
8/26	Course Overview
8/28	Networking Trends
9/2	<i>Labor day holiday</i>
9/4	Data Center Network Topologies
9/9	Data Center Ethernet (Part 1)
9/11	Data Center Ethernet (Part 2)
9/16	Carrier Ethernet
9/18	Project Guidelines
9/23	<b>Exam 1</b>

# Tentative Schedule 2

Date	Topic
9/25	Server and Storage Virtualization
9/30	Virtual Bridging
10/2	LAN Extension and Virtualization Using L3 Protocols
10/7	Virtual Routing Protocols
10/9	Internet of Things (IoT)
10/14	<i>Fall Break</i>
10/16	Data-Link Layer and Management Protocols for IoT
10/21	Networking Layer Protocols for Internet of Things: 6LoWPAN and RPL
10/23	Messaging Protocols for Internet of Things: MQTT
10/28	<b>Exam 2</b>

# Tentative Schedule 3

Date	Topic
10/30	Software Defined Networking (SDN) (Part 1)
11/4	SDN (Part 2)
11/6	Network Function Virtualization (NFV)
11/11	Network Function Virtualization (NFV) (Part 2)
11/13	Cloud Computing
11/18	Blockchains (Part 1)
11/20	<i>Blockchains (Part 2)</i>
11/25	Quantum Communications (Part 1)
11/27	<i>Thanksgiving break</i>
12/2	Quantum Communications (Part 2)
12/4	<b>Final Exam</b>

# 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

# 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.



# Example of Projects

- ❑ 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
- ❑ Naming in the Internet of Things
- ❑ Survey of Recent Research Progress and Issues in Big Data
- ❑ Survey of Recent Research Issues in Data Center Networking
- ❑ SDN: Development, Adoption and Research Trends
- ❑ Semantic Web Core Technologies

# Example of Projects

- ❑ A Survey of Networking Issues in Smart Grid
- ❑ The Effects of the Green Networking Initiative on Power Consumption
- ❑ IP Based Smart Services
- ❑ Survey of Next-Generation Broadband Aggregation Networks
- ❑ Routing and Security in Vehicular Networking
- ❑ For a sample of previous projects reports, see  
<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.

# Project Schedule

Mon 9/30	Topic Selection
Mon 10/7	References Due
Mon 10/21	Outline Due
Mon 11/11	Final Paper Due -> Peer reviewed
Mon 11/18	Reviews Returned
Mon 11/25	Revised Report Due

# Office Hours

- ❑ Monday/Wednesday: 11 AM to 12 Noon  
(By Appointment)
- ❑ Office: Jolley 208
  
- ❑ Teaching Assistant:
  - Ali Ghubaish, [aghubaish@wustl.edu](mailto:aghubaish@wustl.edu)  
In front of Jolley 323 (Networking Lab)
  - Thursday, Sunday (1-2 PM)

# Grading

- ❑ Exams (Best of 2 mid terms + Final) 60%
- ❑ Class participation 5%
- ❑ Homeworks 15%
- ❑ Project 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.  
P 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.

# 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.

# Homework Submission

- ❑ 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.
- ❑ All homeworks should be submitted in hardcopy unless specified otherwise
- ❑ All homeworks are identified by the class handout number.
- ❑ All homeworks should be on a separate sheet.  
Your name should be on every page.
- ❑ Please write CSE570 in the subject field of all emails related to this course.
- ❑ Use word “Homework” in the subject field on emails related homework.  
Also indicate the homework number.
- ❑ **The first page of all homeworks submitted should be blank with only your name on the top-right corner**



# Homework Grading

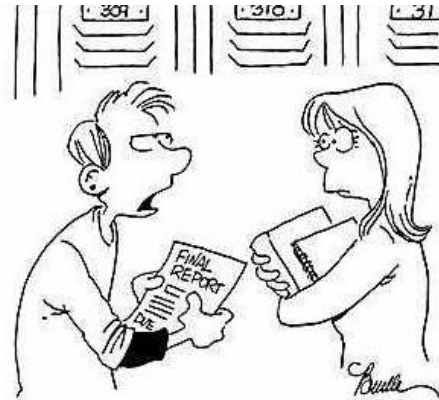
- ❑ Grading basis: Method + Correct answer
- ❑ Show how you got your answer
  - Show intermediate calculations.
  - Show equations or formulas used.
  - If you use a spreadsheet, a statistical package, or write a program, print it out and turn it in with the homework.
  - For Excel, set the print area and scale the page accordingly to fit to a page. (See Page Setup)

# Quizzes

- ❑ There may be a short 5-minute quiz at the beginning of each class to check if you have read the topics covered in the last class.

# Academic Integrity

- ❑ Academic integrity is expected in homeworks
- ❑ All solutions submitted are expected to be yours and not copied from others or from solution manuals or from Internet
- ❑ All integrity violations will be reported to the department and action taken



"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>

Washington University in St. Louis

<http://www.cse.wustl.edu/~jain/cse570-19/>

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# Class Discussions

- ❑ We will use Piazza for class discussion.
- ❑ Find our class page at:
- ❑ <https://piazza.com/wustl/fall2019/cse570>



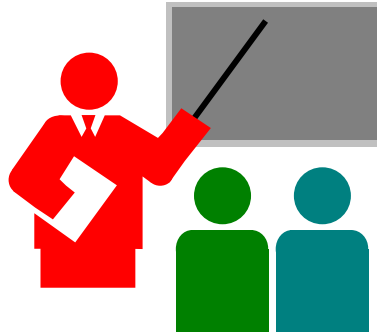
# Class Attendance

- ❑ Attendance on arkaive.com
- ❑ Download the mobile app
- ❑ Free version allows checking in
- ❑ Use Code



85Q1

# Summary



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

# Google Search Modifiers

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

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

# 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. 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:
  - <http://library.wustl.edu/findart.html>
  - <http://scholar.google.com>
  - <http://books.google.com>
  - <http://dl.acm.org/>
  - <http://searchnetworking.techtarget.com/bestWebLinks/>
  - <http://ieeexplore.ieee.org>



# Project Homework 1 (Cont)

- ❑ Ignore all entries dated 2014 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 electronically to [jain@wustl.edu](mailto:jain@wustl.edu). The mail should have a subject field of “**CSE 570S 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.
- ❑ Make a list of other interesting search points and share in class.

# Common Mistakes in Project Homework #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, pages.
- ❑ Missing journals. Need names of journals dealing with the topic chosen.

# Quiz 0: Prerequisites

True or False?

T F

- 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 Questionnaire

Name: \_\_\_\_\_

Email: \_\_\_\_\_

Phone: \_\_\_\_\_

Degree: \_\_\_\_\_ Expected Date: \_\_\_\_\_

Technical Interest Areas:  
\_\_\_\_\_  
\_\_\_\_\_

Prior networking related courses/activities:  
\_\_\_\_\_  
\_\_\_\_\_

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Raj Jain

<http://rajain.com>

# 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)



Wireless and Mobile Networking (Spring 2016),

[https://www.youtube.com/playlist?list=PLjGG94etKypKeb0nzyN9tSs\\_HCd5c4wXF](https://www.youtube.com/playlist?list=PLjGG94etKypKeb0nzyN9tSs_HCd5c4wXF)

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>