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/cse570-18/

Overview

❑ 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
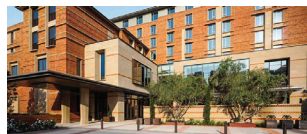
Networking is already great!

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. Big Data
5. OpenFlow
6. Software Defined Networking (SDN)
7. Network Function Virtualization (NFV)
8. Internet of Things (IoT)
9. Software Defined Intelligence
10. NETCONF and YANG

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?
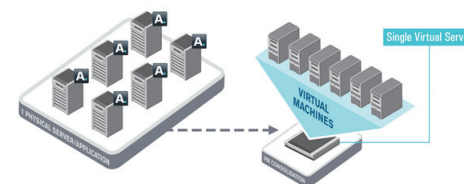
Cloud Computing

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?

Big Data

1. What is big data?
2. Why sudden surge of interest in big data?
3. What are the key technologies for big data?
4. How can networking help in solving big data problems?
5. What is the relationship between clouds and big data?

OpenFlow

1. Planes of Networking
2. What is OpenFlow protocol and why it was needed
3. OpenFlow Operation
4. OpenFlow Evolution
5. Current Limitations and Issues

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

netconf

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

Reference Books

❑ G. Santana, "Data Center Virtualization Fundamentals," Cisco Press, 2013, ISBN:1587143240

❑ V. Josyula, M. Orr, and G. Page, "Cloud Computing: Automating the Virtualized Data Center," Cisco Press, 2012, 392 pp., ISBN: 1587204347

❑ H. Saboowala, M. Abid, S. Modali, "Designing Networks and Services for the Cloud: Delivering business-grade cloud applications and services," Cisco Press 2013, ISBN:1587142945

❑ K. Hess, A. Newman, "Practical Virtualization Solutions: Virtualization from the Trenches," Prentice Hall, 2009, ISBN:0137142978

❑ C. Poelker, A. Nikiti, "Storage Area Networks For Dummies," For Dummies, 2009, ISBN:9780470385135

Reference Books (Cont)

❑ J. Hurwitz, et al., "Big Data for Dummies," Wiley, 2013, ISBN:978-1-118-50422-2

❑ S. Azodolmolky, "Software Defined Networking with OpenFlow," Packt Publishing, October 2013, 152 pp., ISBN:978-1-84969-872-6

❑ T. Nadeau and K. Gray, "SDN," O'Reilly, 2013, 384 pp, ISBN:978-1-449-34230-2B

❑ O. Hersent, et al., "The Internet of Things: Key Applications and Protocols," Wiley, 2013, 344 pp., ISBN: 9781119994350

❑ H. Chaouchi, "The Internet of Things: Connecting Objects," Wiley, Jun 2010, 288 pp., ISBN: 9781848211407

❑ H. Zhou, "The Internet of Things in the Cloud: A Middleware Perspective,¨ CRC Press, 2013, 365 pp., ISBN: 9781439892992

Note: All of the above books are available online to WUSTL students via **Safari 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

CSE 570S	CSE 571s	CSE 573s	CSE 574s	CSE 777s
CSE 473s				
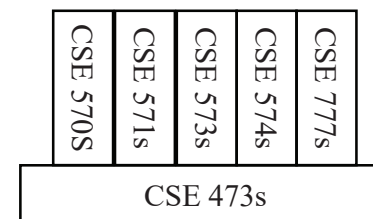
Prerequisite: CSE473S

- 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

Date	Topic
1/17	Course Overview
1/22	Networking Trends
1/24	Data Center Network Topologies
1/29	Data Center Ethernet
1/31	Carrier IP: MPLS
2/5	Carrier Ethernet
2/7	Server and Storage Virtualization
2/12	Virtual Bridging
2/14	LAN Extension and Virtualization
2/19	**Exam 1**

- Note: Exam dates are fixed.

Tentative Schedule (Cont)

Date	Topic
2/21	Virtual Routing Protocls
2/26	Internet of Things
2/28	Datalink Protocols for IoT
3/5	Network Layer Protocols for IoT
3/7	Messaging Protocols for IoT
3/12	Spring Break
3/14	Spring Break
3/19	OpenFlow
3/21	OpenFlow
3/26	**Exam 2**

- Note: Exam dates are fixed.

Tentative Schedule (Cont)

Date	Topic
3/28	Software Defined Networking
4/2	Software Defined Networking
4/4	Network Function Virtualization
4/9	Network Function Virtualization
4/11	Big Data
4/16	Networking Issues for Big Data
4/18	NETCONF and YANG
4/23	NETCONF, YING and YANG, BEEP
4/25	**Final Exam**

- Note final exam is in the last class before the reading period.

Projects

- Hands-on project or a survey paper related to the 6 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/cse570-13/index.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 2/26   Topic Selection

Mon 3/5   References Due

Mon 3/19   Outline Due

Mon 4/2   Final Paper Due -> Peer reviewed

Mon 4/9   Reviews Returned

Mon 4/16   Revised Report Due

Office Hours

❑ Monday/Wednesday:11 AM to 12 Noon (By Appointment)

❑ Office: Jolley 208

❑ Teaching Assistant:
  ➢ Tara Salman, tara.salman@wustl.edu Jolley 218 or 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.
  ➥ 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
- 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

Class Discussions

❑ We will use Piazza for class discussion.

❑ Find our class page at:

❑ https://piazza.com/wustl/spring2018/cse570/home

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.

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. Network Virtualization
  4. Cloud Computing
  5. Software Defined Networking
  6. Big Data
  7. Internet of Things
- On the web try the following search points:
  - http://library.wustl.edu/findart.html
  - http://library.wustl.edu/fulltext/
  - http://scholar.google.com
  - http://books.google.com
  - http://dl.acm.org/

Project Homework 1 (Cont)

- http://www.scirus.com/srsapp/
- http://searchnetworking.techtarget.com/bestWebLinks/
- Ignore all entries dated 2013 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@wustl.edu. The mail should have a subject field of "CSE 570S Project Homework 1" (Please note the subject carefully. Do not 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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THANK YOU

Raj Jain
http://rajjain.com

Related Modules

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

CSE473S: Introduction to Computer Networks (Fall 2011),
https://www.youtube.com/playlist?list=PLjGG94etKypJWOSPMh8Azcgy5e_10TiDw

Wireless and Mobile Networking (Spring 2016),
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