CSE 5700S: Recent Advances in Networking

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These slides and audio/video recordings are available online at:

http://www.cse.WashU.edu/~jain/cse5700-25/

Student Questions

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Overview

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

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

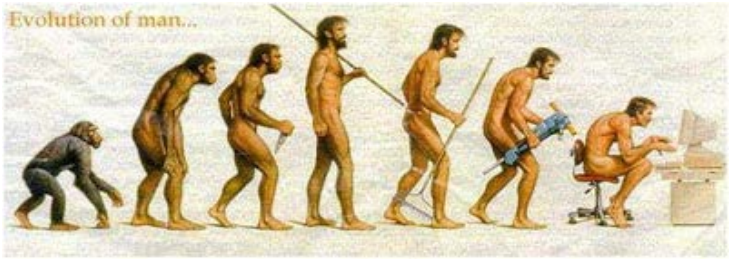
- Note: Apple became highly valued, only after it switched from computing (Mac) to communications (iPhone)



Networking = Economic Indicator

Student Questions

Iron Age to Internet Age



Everything requires the Internet

Can't do much without the Internet

- Wars
- Shopping (Amazon)
- Travel (Expedia)
- Social Networking (Facebook)
- Entertainment
- Education (YouTube)
- AI
- Most fields today – Education, Health, Environment – are advancing simply because of advances in networking.



Student Questions

Goal of This Course

- Recent networking topics
- Topics of interest to the industry
- Topics of interest to researchers
- Comprehensive course – covers many topics
- 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?

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

Student Questions

Data Center Networking

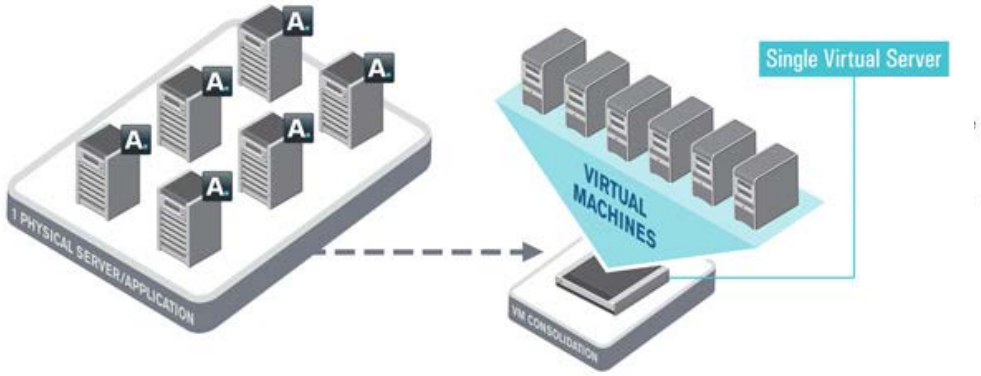
1. How are data centers networks different from those in homes or offices?
2. What are the standards for data center layout?
3. How have Ethernet and other protocols been changed to accommodate data centers?
4. How and why connect multiple data centers on a single Ethernet?



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 the new networking standards related to virtualization?



Student Questions

Cloud Computing

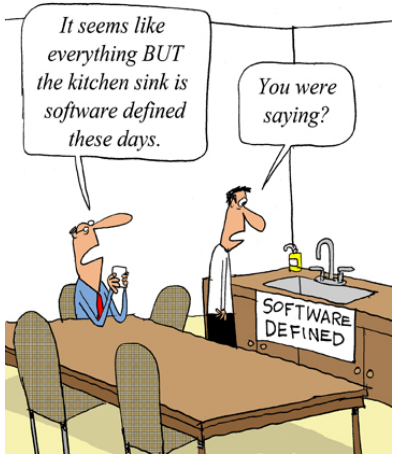
1. What is cloud computing?
2. How is it different from other forms of computing: Grid, Cluster,…
3. What new networking technologies are required to enable cloud computing?
4. What is fog (vs. cloud) computing?



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

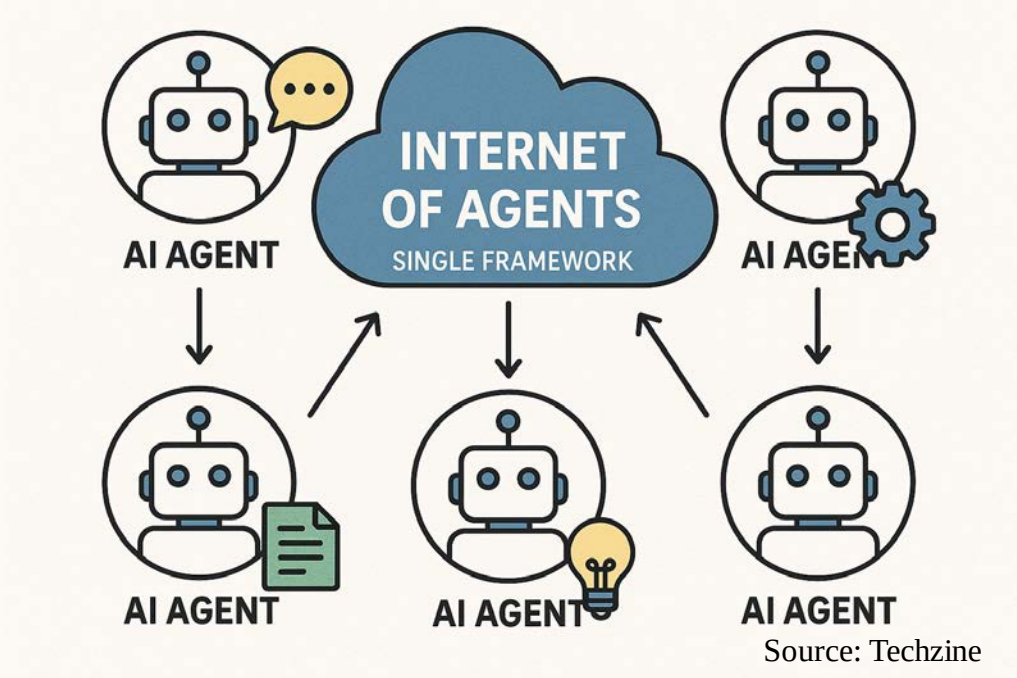
1. What is so unique about the Internet of Things (compared to the current Internet)?
2. What are the new IEEE/IETF protocols for IoT?
3. What are different kinds of things: M2M, Sensors, RFID, …
4. How can clouds help IoT?



Student Questions

Internet of AI Agents (IOAA)

- What is an AI agent
- What is the Internet of AI agents
- How is it different from IoT?



Source: Techzine

Ref: https://www.techzine.eu/blogs/infrastructure/133408/cisco-donates-agntcy-to-linux-foundation-internet-of-agents-on-its-way /

Student Questions

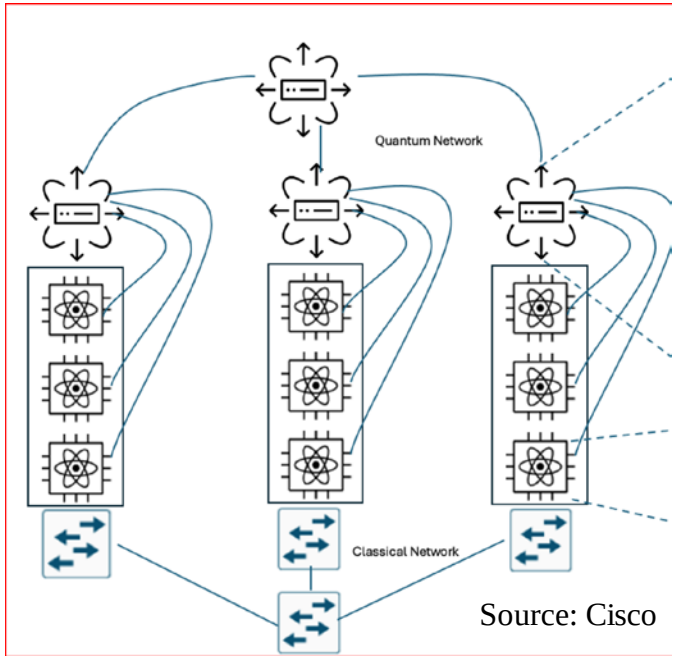
Blockchain

- 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

Quantum Communication

- Basics of quantum computing
- How to connect quantum computers
- Datacenter of Quantum Computers



Source: Cisco

Ref: https://research.cisco.com/quantum-research/quantum-data-center

Student Questions

Non-Goals

- The following current issues are not covered in this course:
  - **Wireless developments** – 4G, 5G, Picocell, Femtocell (Covered in CSE 5740 – Wireless Networking)
  - **Security** – Are clouds secure?
    Security and Privacy issues of IoT.
    (Covered in CSE 5701 – Network security)
- These issues require background not covered in CSE 4730.

Student Questions

Reading Material

1. Technical Papers
2. Industry whitepapers
3. Standards documents
4. Wikipedia, http://en.wikipedia.org/wiki/
5. Safari Books: https://www.oreilly.com/library-access/

Student Questions

Prerequisite: CSE 4730S

- 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
8/25/25	Monday	Course Overview
8/27/25	Wednesday	Networking Trends
9/1/25	Monday	**Labor day holiday**
9/3/25	Wednesday	Data Center Network Topologies
9/8/25	Monday	Data Center Ethernet (Part 1)
9/10/25	Wednesday	Data Center Ethernet (Part 2)
9/15/25	Monday	Carrier IP
9/17/25	Wednesday	Carrier Ethernet
9/22/25	Monday	Exam 1 Review
9/24/25	Wednesday	**Exam 1**

Student Questions

Tentative Schedule 2

Date	Day	Topic
9/29/25	Monday	Project Guidelines (Part 1)
10/1/25	Wednesday	Virtual Bridging
10/6/25	Monday	**Fall Break**
10/8/25	Wednesday	LAN Extension and Virtualization Using L3 Protocols
10/13/25	Monday	Project Guidelines (Part 3)
10/15/25	Wednesday	Data-Link Layer and Management Protocols for
10/20/25	Monday	Networking Layer Protocols for Internet of Things: 6LoWPAN and RPL (Part 1)
10/22/25	Wednesday	Networking Layer Protocols for Internet of Things: 6LoWPAN and RPL (Part 2)
10/27/25	Monday	Exam 2 Review
10/29/25	Wednesday	**Exam 2**

Student Questions

Tentative Schedule 3

Date	Day	Topic
11/3/25	Monday	Internet of AI Agents
11/5/25	Wednesday	Introduction to OpenFlow(Part 1)
11/10/25	Monday	Introduction to Software Defined Networking (SDN)
11/12/25	Wednesday	Introduction to Network Function Virtualization (NFV)
11/17/25	Monday	Introduction to Blockchains for Computer Networking
11/19/25	Wednesday	Introduction to Quantum Computing and Its Applications to Networking
11/24/25	Monday	Introduction to Quantum Computing and Its Applications to Networking
11/26/25	Wednesday	Thanksgiving break
12/1/25	Monday	Exam 3 Reviews
12/3/25	Wednesday	**Exam 3**

Student Questions

Projects

- Hands-on project or a survey paper related to the topics of the course
- Some hands-on projects 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
  $\Rightarrow$ 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 redraw all figures.
  ⇒ You need to summarize all ideas in your ***own*** words.
  ⇒ Cannot copy any part of the 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

- Digital Twin Network and Network Digital Twin
- A Survey on Secure Network Device Identity
- A Survey on Augmented Reality in the Data Center
- The Journey to Net Zero Data Centers
- The Ubiquity of AI in Networking
- Leo Satellites for IoT
- A Survey of Edge Management and Orchestration in Edge Computing
- Blockchain Applications in IoT: A Literature Review
- A Survey of Generative Cybersecurity AI

Student Questions

Example of Projects (Cont.)

- For a sample of previous project reports, see

http://www.cse.WashU.edu/~jain/cse570-23/index.html
http://www.cse.WashU.edu/~jain/cse570-21/index.html
http://www.cse.WashU.edu/~jain/cse570-19/index.html
http://www.cse.WashU.edu/~jain/cse570-18/index.html
http://www.cse.WashU.edu/~jain/cse570-15index.html
http://www.cse.WashU.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 9/29	Topic Selection
Mon 10/6	References Due
Mon 10/20	Outline Due
Mon 11/3	Final Paper Due ⇒ Peer reviewed
Mon 11/10	Reviews Returned
Mon 11/17	Revised Report Due

Student Questions

Office Hours

- By Appointment
- Teaching Assistant: None

Student Questions

Grading

- Exams (Best of 2 mid terms + Final) 60%
- Class participation 5%
- Homework + Quiz 10%
- Project 25%

Student Questions

Exams

- Exams consist of numerical, fill-in-the-blank, and multiple-choice (true-false) questions.
- There is negative grading on 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.
- The highest score achieved becomes 100% for that exam.

Student Questions

Exams (Cont.)

- All exams are closed-book.
  One 8.5” x 11” 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.
- The best two of the three exams are used.

Student Questions

Homework Submission

- All homework is due on the following Monday before the class unless specified otherwise.
- Any late submissions, if allowed, will *always* have a penalty. 10% per day until the solutions are disclosed in the class.
- All homework should be submitted online on Canvas
- The class handout number identifies all homework.
- All homework should be in a separate file.
  Your name should be on every page.
- Please write CSE5700 in the subject field of all emails related to this course.
- Use the word "Homework" in the subject field on emails related to homework. Also, indicate the homework number.

Student Questions

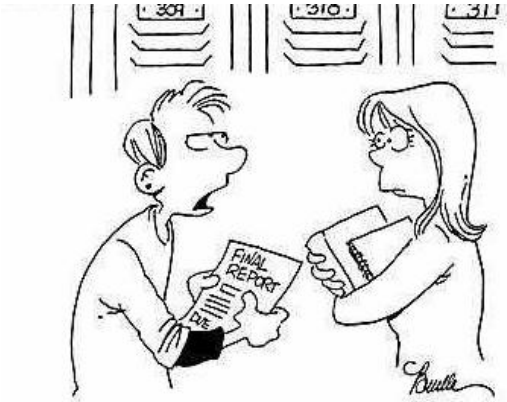
Homework and Exam Grading

- 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 on a page. (See Page Setup)

Student Questions

Academic Integrity

- Academic integrity is expected in homework
- All solutions submitted are expected to be yours and not copied from others, from solution manuals, from the Internet, or AI-generated
- 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

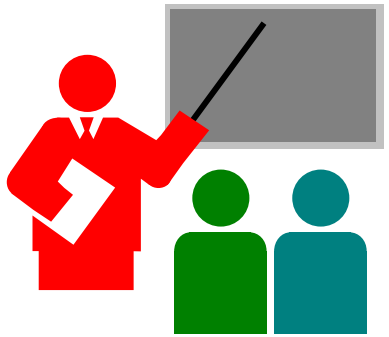
Class Discussions

- We will use Piazza for class discussion.
- Find our class page at:
- https://piazza.com/WashU/fall2025/cse5700/info



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:WashU.edu
- intitle:trend
- inurl:trend
- allintitle:Networking Trends
- Allinurl:
- " " ⇒Exact Phrase
- OR
- AND
- + ⇒ Must include
- - ⇒ Not include
- ~X ⇒ X or similar
- * ⇒ Wildcard

Ref: https://ahrefs.com/blog/google-advanced-search-operators/

Student Questions

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. Software-Defined Networking
  3. Quantum Communications
  4. Blockchains
- On the web, try the following search points:
  - https://ieeexplore.ieee.org
  - https://scholar.google.com
  - https://library.WashU.edu
  - https://books.google.com
  - https://dl.acm.org/
  - https://searchnetworking.techtarget.com/
- Ignore all entries older than 5 years. Also, ignore all entries that do not indicate the topic or similar words in the title.

Student Questions

Project Homework 1 (Cont.)

- List others in the following format (5 each):
  - Author, "Title," publisher, year, ISBN. (for five books)
  - "Title," URL [One line description] (for five web pages)
  - Author, "Title," source (for five technical/magazine articles)
- For the books, include whether the book is available at
  - WashU: https://library.washu.edu/
  - MOBIUS: https://library.washu.edu/research-support/tools-and-guides/mobius/
  - Safari: https://one.washu.edu/launch-task/all/safaribooks?terms=safari
  - ILLiad: https://library.washu.edu/services/interlibrary-loan/
- Serially number the references and submit them electronically

Student Questions

Common Mistakes in Project Homework #1

- Not indicating where the book can be found in WashU
- 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.
- ❑❑ A time-to-live (TTL) of 8 means that the packet can travel at most 8 hops.
- ❑❑ IP Address 128.256.210.12 is invalid
- ❑❑ A Network Address Translator (NAT) connects a private network to the Internet.
- ❑❑ A DHCP server is used for the automatic assignment of an IP address
- ❑❑ DNS helps translate a name to a MAC address
- ❑❑ Port 80 is used for FTP.
- ❑❑ IPv6 addresses are 32 bits long.
- ❑❑ The new connection setup message in TCP contains a SYN flag.
- ❑❑ 192.168.0.1 is a public address.
- ❑❑ The spanning tree algorithm is used to find a loop-free path in a Layer 2 network.

Marks = Correct Answers _____ - Incorrect Answers _____ = _____

Student Questions

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Raj Jain
http://rajjain.com

http://www.cse.WashU.edu/~jain/cse5700-25/m_01int.htm

Student Questions

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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=PLjGG94etKypJWOSPMh8Azcgy5e_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

Attending Classes via Zoom

- Keep your camera on, but keep the microphone muted.
- Enable "Show Captions" (not available in a physical class)
- To ask questions, raise your digital hand 
- When I ask a question, raise your digital hand if you know the answer.
- You should join with your WashU email and name exactly as in your WashU records. That way, Zoom can accurately track your attendance.
- Zoom report also shows when a student joined, when they left, and how much attention they were paying (probably based on your other activities on the same computer). ⇒ Please pay full attention
- Although the class discussions are being recorded. However, videos will NOT be available.

Student Questions