

CSE 473S: Introduction to Computer Networks



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Audio/Video recordings of this lecture are available on-line at:

<http://www.cse.wustl.edu/~jain/cse473-21/>

Student Questions



- ❑ Why Study Computer Networking?
- ❑ Goal of This Course
- ❑ Instructor
- ❑ Grading
- ❑ Contents of the course
- ❑ Tentative Schedule

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.



We are in the Internet Age.

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

Selecting the Right Field

- ❑ Important question for **students**, academics, entrepreneurs, and companies
- ❑ Goal: To impact
- ❑ Follow the **paradigm shifts**:
 - 1980: Ethernet
 - 1990: ATM Networks
 - 2000: Optical Networks
 - 2005: Wireless Networks
 - 2008: Next Generation Internet/SDN
 - ...
 - 2019: Whatever is being **hyped** this year?

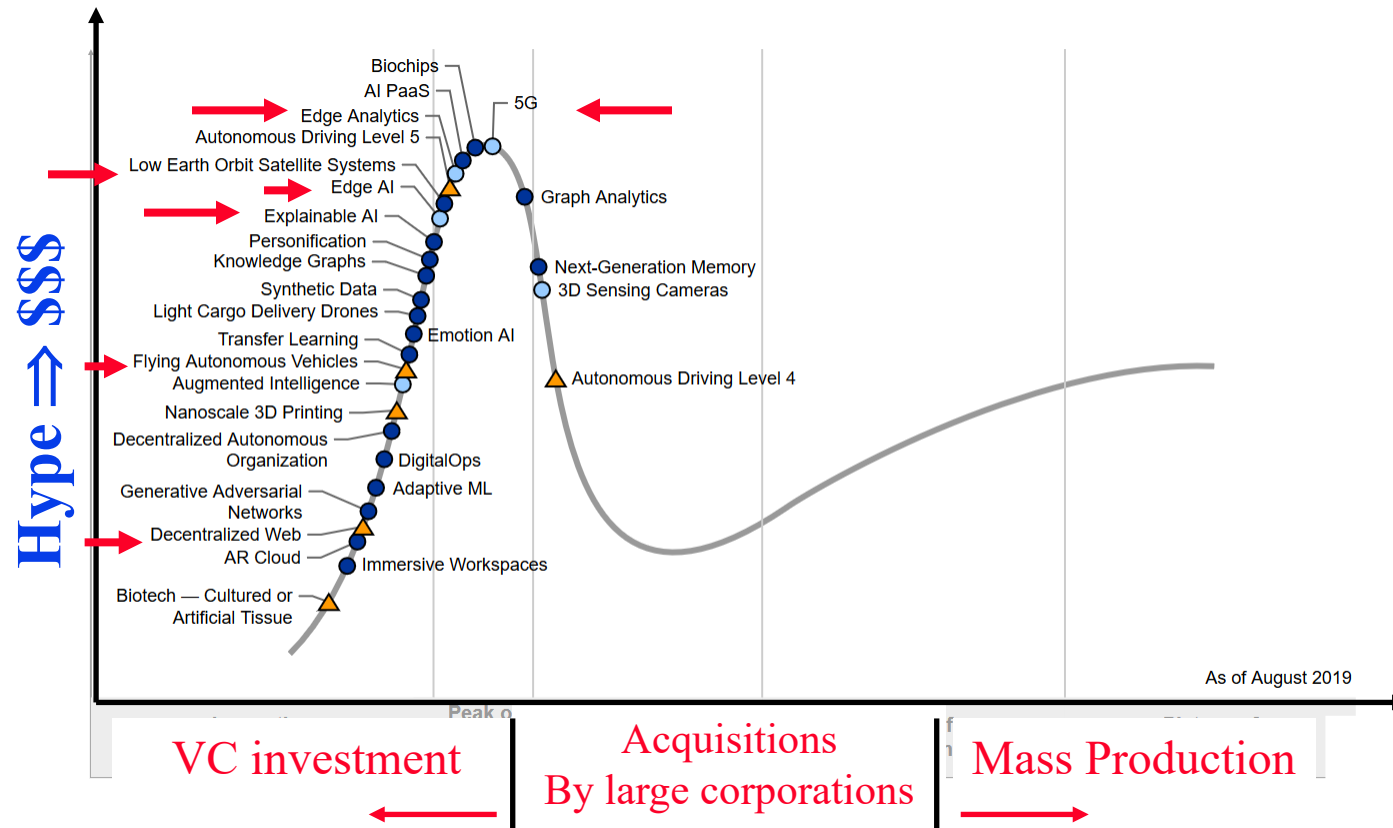


Student Questions

Industries adopt by necessity.

Academics continue to develop deeper expertise on what they already know.

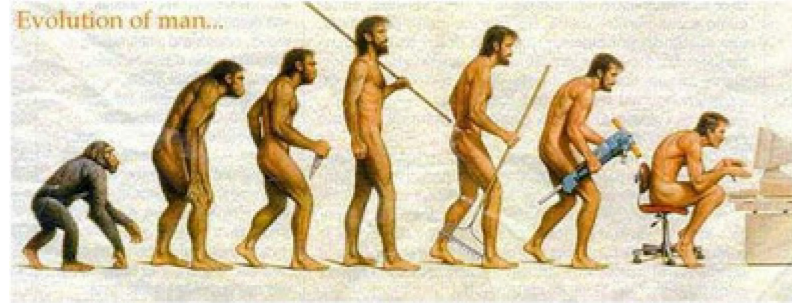
Gartner Hype Cycle of Emerging Tech 2019



Student Questions

Ref: B. Burke, D. Smith, "Hype Cycle for Emerging Technologies, 2019," Gartner Report G00370466, 6 Aug. 2019, 68 pp.

Internet Age



- ❑ Distributed Computing
- ❑ Cloud Computing
- ❑ Mobile Computing ⇒ Smart Phones
- ❑ Streaming Video ⇒ YouTube
- ❑ Social Networking ⇒ FaceBook
- ❑ Big Data
- ❑ Machine Learning ⇒ Artificial Intelligence
- ❑ Online Shopping ⇒ Amazon, Ebay, Google
- ❑ Most fields today – Education, Health, Environment – are advancing simply because of advances in networking

Student Questions

Current Hot Topics in Networking



1. Internet of Things (IoT)
2. Cybersecurity
3. Cloud Computing
4. Software Defined Networking
5. Wireless Networking
6. Streaming Media

Student Questions

Trend: Smart Everything



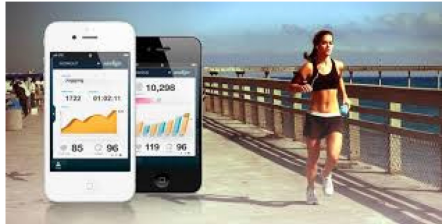
Smart Watch



Smart TV



Smart Car



Smart Health



Smart Home



Smart Kegs



Smart Space



Smart Industries

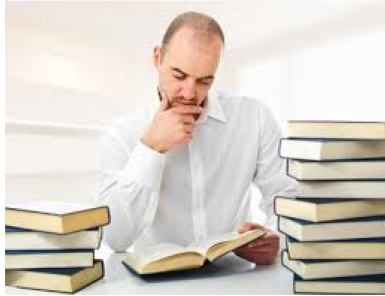


Smart Cities

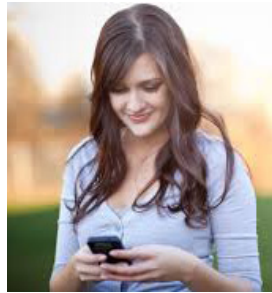
Student Questions

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

- ❑ Smart = Apply the latest **technology** to solve problems

Student Questions

Trend: Smart to Intelligent



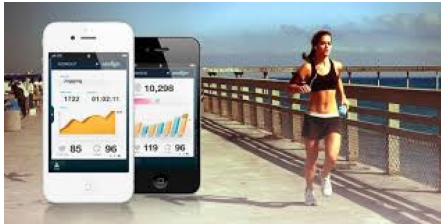
Intelligent Clock



Intelligent TV



Intelligent Car



Intelligent Health



Intelligent Home Security



Intelligent Microwave



Intelligent Light



Amazon Alexa



Google Assistant

Student Questions

Trend: Security & Cyber Warfare

- ❑ Security of computers, companies, smart grid, and nations
- ❑ Nation States are penetrating other nations computers
5th domain of warfare (after land, sea, air, space)
- ❑ In 2010, US set up US Cyber Command
- ❑ UK, China, Russia, Israel, North Korea have similar centers
- ❑ Many cyber wars: North Korea vs. USA, Israel vs. Syria, South Korea vs. North Korea, India vs. Pakistan, ...



Old



New

Student Questions

Ref: http://en.wikipedia.org/wiki/Cyber_war

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Internet of Harmful Things

Researchers at DEFCON 3, hacked a smart toilet, making it flush incessantly and closing the lid repeatedly and unexpectedly. Causing a **Denial of Service** Attack.



Student Questions

Ref: <http://www.computerworld.com/article/2486502/security0/worm-may-create-an-internet-of-harmful-things--says-symantec--take-note--amazon-.html>

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DEFCON



- ❑ Hacker's conference
- ❑ Held in Las Vegas every July
- ❑ 20,000+ attendees
- ❑ All anonymous

Ref: <https://www.ethicalhacker.net/features/opinions/first-timers-experience-black-hat-defcon>

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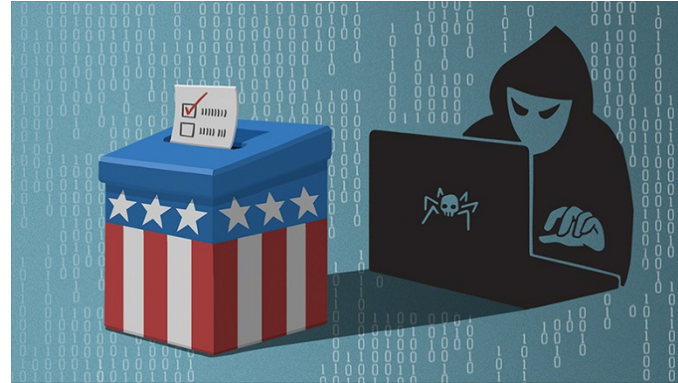
<http://www.cse.wustl.edu/~jain/cse473-21/>

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Student Questions

Recent DEFCON Topics

- ❑ Hacking voting machines
- ❑ Hack connected vehicles
- ❑ Hacking the cloud
- ❑ Hacking travel routers
- ❑ Clone RFID in real time
- ❑ Breaking the Uber badge ciphers
- ❑ Counterfeit hardware security devices, RSA tokens
- ❑ Fool antivirus software using AI
- ❑ How to track government spy planes
- ❑ Break bitcoin hardware wallets
- ❑ DARPA Cyber Grand Challenge (2015, 2016)



Student Questions

Trend: Cloud Computing

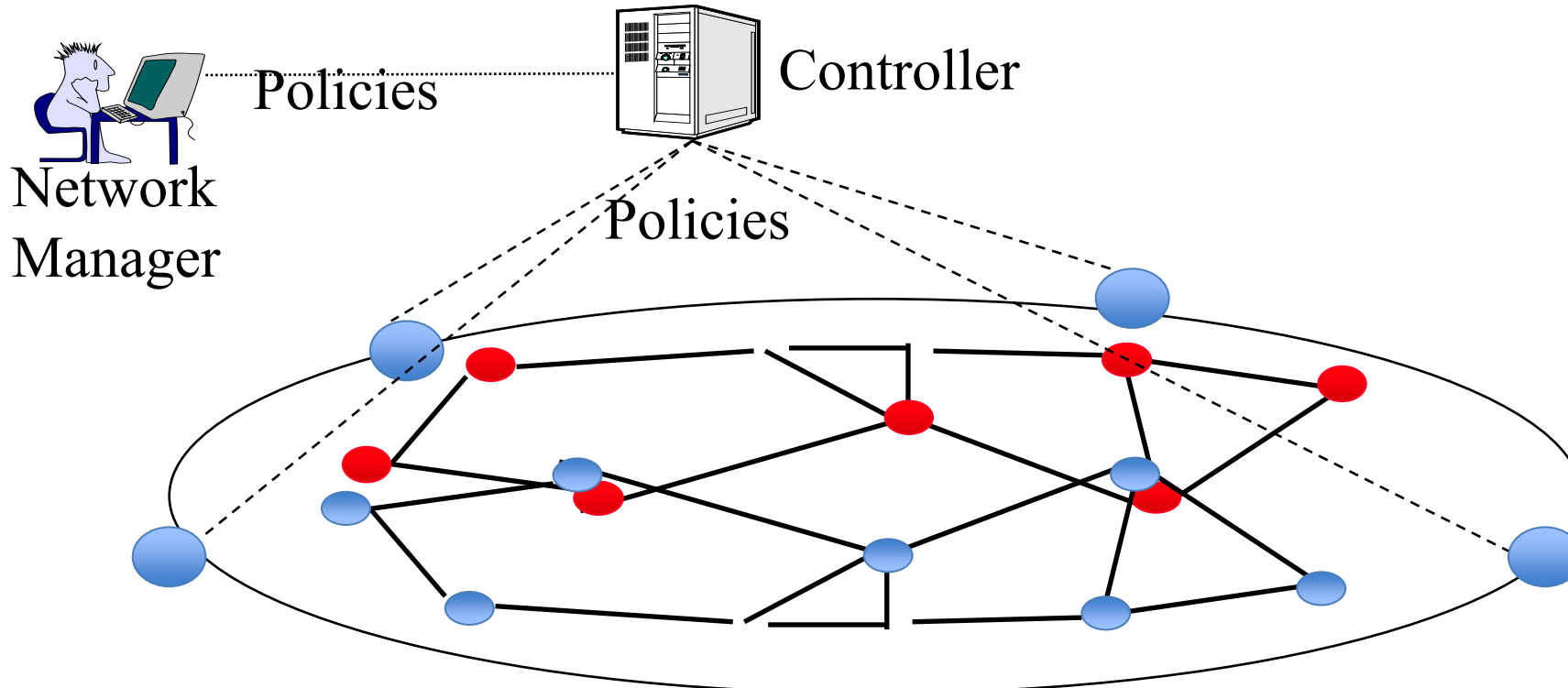
- ❑ August 25, 2006: Amazon announced EC2
⇒ Birth of Cloud Computing in reality
(Prior theoretical concepts of computing as a utility)
\$10 B in 2016, a growth rate of 49% with 17% margins, much higher than the overall Amazon business
- ❑ Cloud Computing:
 - Applications through Internet (Google Docs)
 - Computing through Internet (Amazon EC3)
 - Storage and backup through Internet (iCloud, Google Drive)



Student Questions

Software Defined Networking

- Using standard networking hardware
⇒ Allows managing large networks using software



Student Questions

Goal of This Course

- ❑ First course in networking
- ❑ Fundamentals
- ❑ Broad coverage of key areas of networking
- ❑ Networking background for networking applications in other areas of computing
- ❑ This is a course on Networking Architecture
- ❑ This is not a course on network building or usage
- ❑ You will be able to understand protocols
- ❑ An example of the difference between architecture and implementation is the computer architecture course and a course on Intel Pentium Chip.
- ❑ This is the first course on networking.
- ❑ Basis for more advanced networking courses

Student Questions

What Will You Learn?

1. What messages and messages are exchanged when you fetch a web page?
2. What messages are used to send/receive emails?
3. How the names such as www.google.com gets translated to IP addresses such as 74.125.73.104?
4. What is done to avoid congestion under overload?
5. How is the path in the Internet determined?
6. What happens if bits in a packet get corrupted?
7. How WiFi or Ethernet works?
8. What is the difference between WiFi, Ethernet, IP, and TCP?
9. What is done to handle audio/video on the Internet?
10. How can you guarantee security on the Internet?

Student Questions

Networking Courses at WUSTL

1. **CSE 473: Introduction To Computer Networks**

(Spring 2019) – Prerequisite for all other networking classes

2. CSE 521S: Wireless Sensor Networks

3. CSE 537S: Mobile Computing

4. **CSE 570S: Advanced Networking:**

Clouds, Big Data, SDN, IoT (Spring 2018)

5. **CSE 574S: Wireless and Mobile Networking** (Fall 2018)

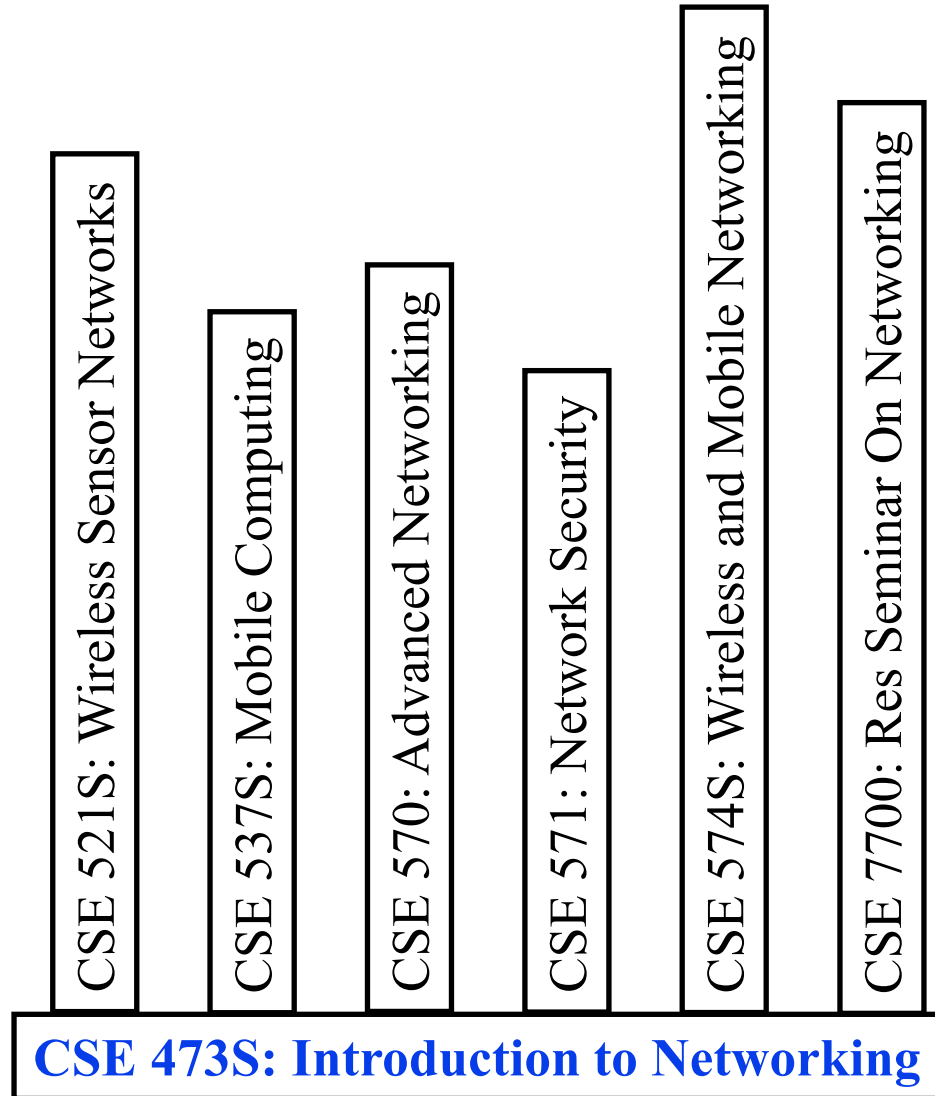
6. **CSE 571S: Network Security**

7. CSE 7700: Research Seminar On Networking and Communications



Student Questions

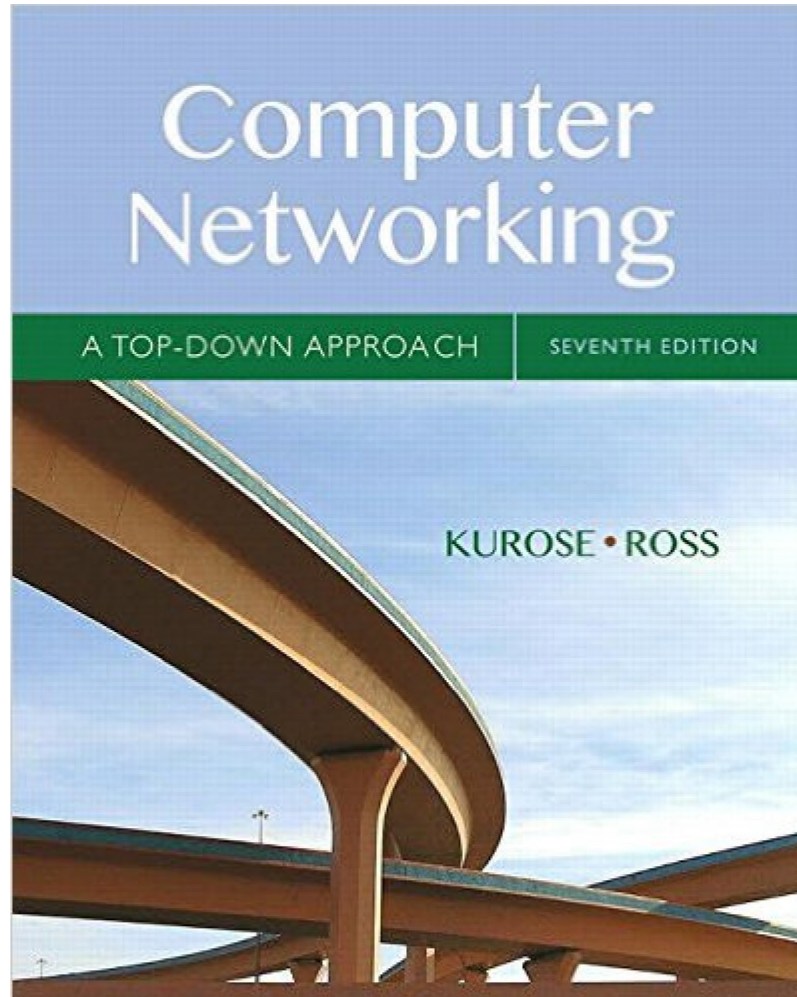
Networking Foundation



Student Questions

Textbook

- ❑ J.F. Kurose and K.W. Ross, “Computer Networking” 7th Edition, Addison-Wesley, 2017, ISBN: 9780133594140 or 9780134296135, 864 pp. **Required.**
- ❑ Get the latest edition. Do not use older editions. If you use international edition, it should be dated later than 2016, should have 864 pages.



Student Questions

Textbook (Cont)

- ❑ It is recommended that you read the relevant chapter of the book chapter before coming to the class
⇒ Class time will be used for discussing and clarifying key concepts
- ❑ Only key concepts will be covered in the class.
You are expected to read the rest from the book.
- ❑ Please ask questions in the next class about any concepts that are not clear to you
- ❑ Material covered in the class will include some concepts from other textbooks. Please pay attention to the class lecture.

Student Questions

Prerequisite

- ❑ General knowledge of computer systems organization
 - Memory
 - System bus
 - Interrupt
 - CPU
 - Binary, decimal, hexadecimal representations
 - Bits, bytes
 - Storage: Memory and disk

- ❑ CSE 131: Computer Science I or equivalent

Student Questions

Tentative Schedule

1/25	Course Overview	
1/27	Computer Networks and the Internet (Part 1)	1
2/1	Computer Networks and the Internet (Part 2)	1
2/3	Application Layer (Part 1): HTTP	2
2/8	Application Layer (Part 2): SMTP,DNS,P2P	2
2/10	Transport Layer (Part 1): Design Issues	3
2/15	Transport Layer (Part 2): UDP,Flow Control	3
2/17	Transport Layer (Part 3): TCP,TCP Congestion Control	3
2/22	The Network Layer: Data Plane (Part 1: Network Layer Basics)	4
2/24	Network Layer Data Plane (Part 2: IP Datagram,NAT,UPNP,DHCP)	4
3/1	Exam 1	

Student Questions

Tentative Schedule (Cont)

Date	Topic	Chapter
3/3	Wellness Day (No Class)	
3/8	Network Layer Data Plane (Part 3: SDN)	4
3/10	The Network Layer: Control Plane (Part 1: Dijkstra's, Bellman-Ford Algorithms)	5
3/15	The Network Layer: Control Plane (Part 3: SDN Controller + ICMP + SNMP)	5
3/17	The Link Layer and LANs (Part 1): Functions	6
3/22	The Link Layer and LANs (Part 2): CRC	6
3/24	The Link Layer and LANs (Part 3): Multiple Access, Ethernet, VLANs, MPLS, Data Centers	6
3/29	Wireless and Mobile Networks (Part 1): Wireless Characteristics, LANs and PANs	7
3/31	Exam 2	

Student Questions

Tentative Schedule (Cont)

Date	Topic	Chapter
4/5	Wireless and Mobile Networks (Part 2): Mobility Management	7
4/7	Wireless and Mobile Networks (Part 3): Mobility Management	7
4/12	Security in Computer Networks: Cryptography (Part 1)	8
4/14	Security in Computer Networks (Part 2)	8
4/19	Multimedia Networking (Part 1: Basic concepts)	9
4/21	Multimedia Networking (Part 2: VOIP,RTP,SIP)	9
4/26	TBD	
4/28	TBD	
5/3	Exam 3	

- **Note that the Exam 3 is on Monday, May 3, 2021.**
- **The dates for all exams are fixed. No substitute exams.**
- **Every one has to take the first two exams.**

Student Questions

Grading

- ❑ Exams (Best 2 of 3) 60%
- ❑ Class participation 5%
- ❑ Video Reviews 10%
- ❑ Home works 15%
- ❑ Labs 10%
- ❑ Letter grade are assigned based on the entire class's performance.
Break points vary every year. Examples:
 - **2020:** 90+: A+, 85+: A, 80+: A-, 75+: B+, 70+: B, 65+: B-, 60+: C+, 55+: C, 50+: C-
 - **2019:** 90+:A+, 84-90:A, 78-84:A-, 72-78:B+, 66-72:B, 60-66:B-, 54-60:C+, 48-54:C, 42-48:C-
- ❑ **Pass/Fail:** Anyone getting over 70% of the highest achieved grade in the course will pass. For example, if 96 is the highest score, the passing grade will be 67.2

Student Questions

Exams

- ❑ There are three exams.
- ❑ All exams are 50 minutes long.
- ❑ One note sheet of 8.5”x11” (both sides) is allowed along with a simple calculator (TI-30).
- ❑ Exams consist of numerical as well as multiple-choice (true-false) questions.
- ❑ There is a negative grading on incorrect multiple-choice questions. Grade: +1 for correct. $-1/(n-1)$ for incorrect.
- ❑ Everyone including the graduating seniors are graded the same way.
- ❑ Your grade depends upon the performance of the rest of the class.

Student Questions

Lab Exercises

- ❑ Most modules will have a lab component
- ❑ Some labs require writing a short program to do what the protocol would do
- ❑ You should be able to do most labs on your own computer

Student Questions

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 to Canvas 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 CSE473 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.

Student Questions

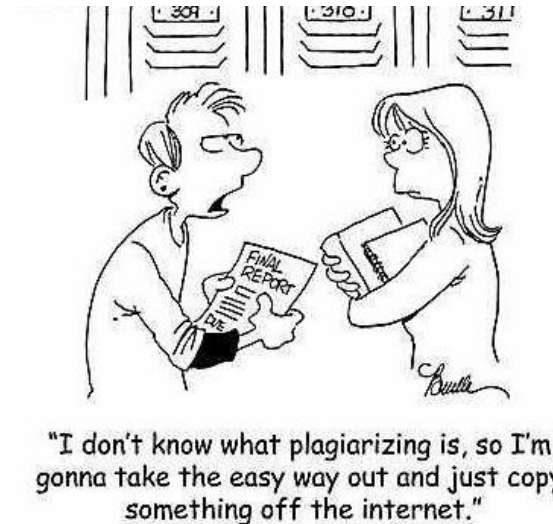
Homework Grading

- ❑ 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)

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



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

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<http://www.cse.wustl.edu/~jain/cse473-21/>

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Student Questions

Office Hours

- ❑ By Appointment: Office: Zoom
- ❑ Teaching Assistants:
 - Dean Yu xiaobing at wustl.edu
 - Gan Xu, gan.xu at wustl.edu
- ❑ TA Hours:
 - ❑ Friday 3:00 PM to 4:00 PM Dean Yu
 - ❑ Saturday 3:00 PM to 4:00 PM Gan Xu
 - ❑ Sunday 1:00 PM to 2:00 PM Dean Yu
 - ❑ Sunday 3:00 PM to 4:00 PM Gan Xu
- ❑ All meetings with TA will be via zoom
 - Gan Xu, <https://wustl.zoom.us/my/ganxu>
 - Dean Yu, <https://wustl.zoom.us/my/deanyu>

Student Questions

- ❑ What is the questions
- ❑ What is the 21nd question

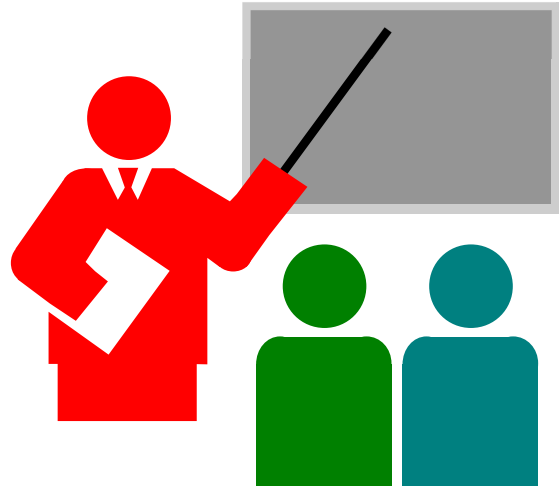
After-Class Discussions

- ❑ We will use Piazza for in-between class urgent questions.
- ❑ No participation points for questions on Piazza
- ❑ If a question is not urgent and can wait till the next class, please bring it up in the class \Rightarrow Get points
- ❑ Find our class page at:
<http://piazza.com/wustl/spring2021/cse473s>



Student Questions

Summary



- ❑ Computer networking is important for all areas of computing
- ❑ First course in computer networking
- ❑ Goal: To prepare you for a career in networking
- ❑ Get ready to work hard

Student Questions

Reading

- ❑ Read Chapter 1 of Kurose and Ross

Student Questions

Quiz 0: Prerequisites

- ❑ True or False?
- ❑ T F
- 1. Transmitting 100 bytes @ 800 bit/sec will take 1 sec.
- 2. A system with 32kB memory can hold only 16000 ASCII characters
- 3. A system with 2GB memory is same as that with 2GB disk.
- 4. Interrupts are used by CPU to stop an ongoing I/O.
- 5. Binary representation of 9 is 1001
- 6. 0A in Hexadecimal is 11 in decimal system.
- 7. For $I = A \sin(2\pi ft + \phi)$, the frequency is f .
- 8. 5 modulo 2 is 1
- 9. Two entries “P” and “Q” are pushed sequentially on a stack.
A “pop” operation on the stack will produce P.
- 10. If x is 0, then after $x++$, x will be 1.

Marks = Correct Answers _____ - Incorrect Answers _____ = _____

Student Questions

Remote Classes

- ❑ **All** classes of this course throughout this semester will be remote using Zoom.
- ❑ The class is **flipped**: you review the material in video before the class and submit your questions on a form.
- ❑ Class time will be used to answer those questions and any additional ones that come up.

Student Questions

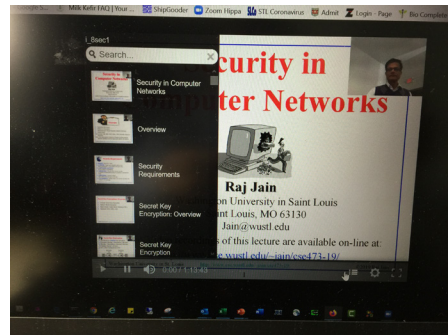
Attending Classes via Zoom

- ❑ Add your photo to your zoom profile.
There is no need to start your video.
Photo is sufficient. Keep your microphone mute.
- ❑ All questions should be broadcast on the chat.
All answers to my questions should be either private to me or broadcast to the class depending on the situation.
- ❑ 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
- ❑ Students should join with their full name and email. That way I can associate your participation.
- ❑ The class discussions are being recorded. Videos will be posted whenever possible.

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 generates an email that is used for part of your score for video review homework.
- ❑ Some of these features may not be available on some recordings. Many may not be available on the same video played from YouTube.



ToC

Student Questions

Video Review Task

- ❑ You are required to view the video and fill out two forms:
 - Video Review form on Canvas: Need to answer a few simple questions to ensure that you have seen the video. This will get you 10 points.
 - Google Form: To ask questions on each slide. If you do not have a question about a slide, leave the corresponding question on Google form blank. This gets you 4 points.
- ➡❑ Both forms are due at midnight before the class day.
- ➡❑ You are supposed to read the book also and ask any relevant questions in the Google form as the last question on each form.
- ❑ 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

Exams

- ❑ All exams are **closed book**.
- ❑ You are permitted **one** cheat sheet of 8.5'x11" written or printed on both sides.
- ❑ You should have several blank sheets of paper to write details of your answers. You email these right after the exam.
- ❑ We use Respondus system to monitor the exam remotely.
- ❑ You will need a webcam with a stand separate from the one in the laptop. Low-cost examples:
<http://www.amazon.com/dp/B088829MV3>
<http://www.amazon.com/dp/B088BK488W>
- ❑ No calculators, smart phones, smart pads allowed in the exam. Respondus has a built in scientific calculator for your use.



Student Questions

Scan This to Download These Slides



Raj Jain

<http://rajjain.com>

http://www.cse.wustl.edu/~jain/cse473-21/i_0int.htm

Student Questions

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=PLjGG94etKypJWOSPMh8Azcg5e_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>

Student Questions