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/cse473-26/

Student Questions

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Overview

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

Student Questions

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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.

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Student Questions

- What is the internet of things?

Non-computer devices, such as thermostats and cameras connected to the Internet, are called "Things."

- How are all the fields related to each other? Only through networks or by other means as well? Does one impact the other?

One enables the other. Cloud computing will only be possible with the Internet, and distributed computing will not be possible without networking.

- Which network-based areas of computing make the most money?

It depends. Apple is currently the most valued company. It makes money by selling network-based communication devices.

- Is Web3 plumbing as well? Or does it carry more information than the internet we usually use?

Web3 is just another interface to the Internet, so it is a part of it.

Networking = "Plumbing"

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Student Questions

- How important is software policy or operating systems for networking/managing networks?

OS came first, and so networks ran on top of OS. Now, OS and networks are intertwined. Networking software uses OS, and OS uses networking for distributed operations.

- What is distributed computing?

Multiple computers collaborate on various parts of a single task, e.g., grid, edge, and cloud computing…

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Networking is Fueling All Sectors of Economy

- Networking companies are among the most valued: 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

- How do Ethernet, ATM, Optical, and Wireless Networks differ? Do we need to have a specific or general understanding?

You don't need to know. These will be covered in this course.

- How do networking companies impact overall economic growth and job creation in business analytics sectors?

By providing the networking infrastructure required for analytics.

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Selecting the Right Field

- An 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
  - …
  - 2025: Whatever is being **hyped** this year?



Industries adapt by necessity.
Academics continue to develop deeper expertise in what they already know.

Student Questions

- Is Ethereum built based on Ethernet? Any relationships between them?

The Internet makes all cryptocurrencies possible. Without the Internet, virtual currencies, shopping, and education…

- What do you think are the limitations of the current network paradigm? The hardware, software, or even politics? How can we get breakthroughs from them?

All of the above.

- Why did you use the word "adapt" during your lecture? It sounds like a passive word. Why can a company not create/invent a new paradigm but only adapt to it?

Yes, industries invent "new areas" by necessity. Academics invent by "their interests." This means some academics need to switch to the latest/relevant issues.

- What are some key differences between the original Ethernet and the later development versions (ATM, Optical, Wireless...)?

To be covered in Chapter 6.

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Student Questions

- What trends can you see from the internet changes throughout the years? What do you think will be the next hype?

See Slide 0.64.

- How can one distinguish between hype and a true paradigm shift in technology and industries?

I don't know of a way.

- What is being hyped this year?

Quantum, AI

- Regarding paradigm shifts, what made it important to change to new networks over time? What was different because of these shifts?

Need for improvement in throughput, response time, quality drives new research. New technologies help move humanity forward.

- How does networking play a role in software engineering careers?

Almost all software today uses networking and the Internet.

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Selecting the Right Field

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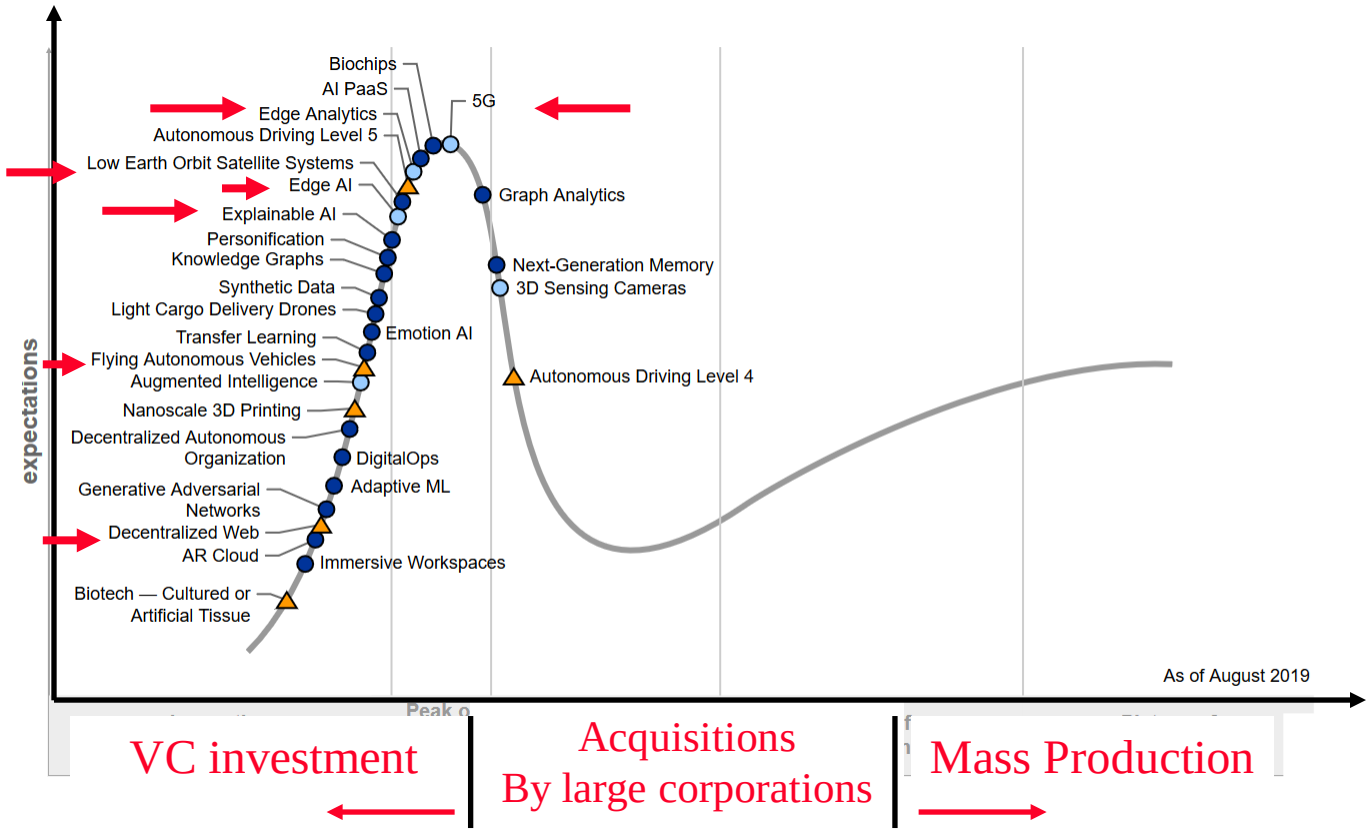
Student Questions

- What does ATM stand for?

Asynchronous Transfer Mode was a technology developed by phone companies in which all packets are small and the same size. It is no longer used.

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Gartner Hype Cycle of Emerging Tech 2019



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

Student Questions

- Are there technologies (in networking or anything else) that are vital, but since they don't bear economic interest, they don't get any funding from VC?

One example is networking for the least developed nations. Humanitarian organizations, rather than VCs, handle such issues.

- How could we get involved in these hot topics as students or workers in the industry? Or how to improve ourselves after graduation?

Keep aware of the latest developments. Choose your fields carefully. Reevaluate your directions every year.

- How does the Gartner Cycle determine "hype" for relatively obscure topics?

By talking to industry experts.

- How does the Gartner Hype Cycle evaluate the trend of the internet/tech?

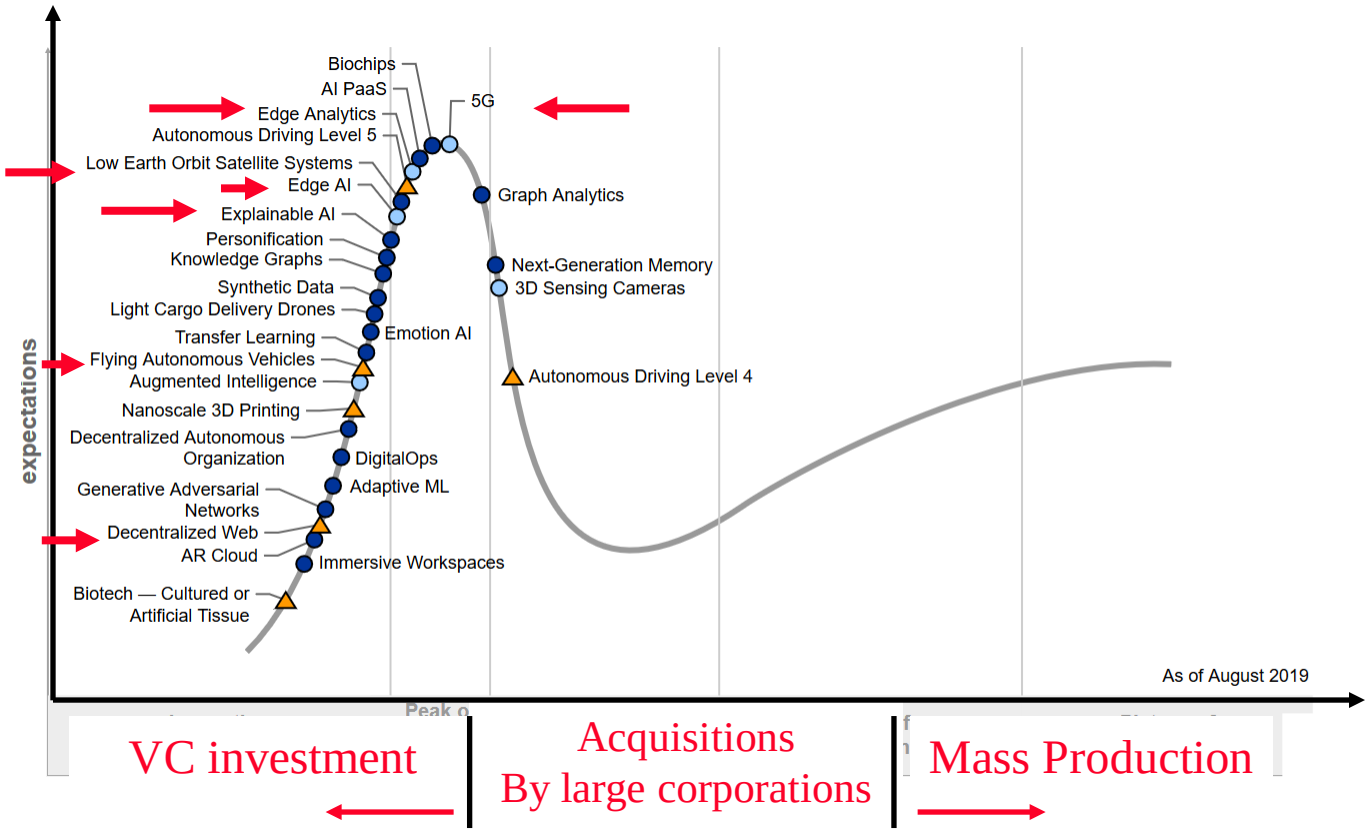
By talking to industry experts.

- What makes 5G so different?

To be covered in Chapter 7.

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Gartner Hype Cycle of Emerging Tech 2019



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

Student Questions

- Are there other similar reports that people use? How commonly is this report used?

Many industry analysts issue reports. Gartner is the most popular.

- Did the graph imply that VC investment became lower after 5G?

The graph always looks like this. The technologies on the right are becoming mainstream, and manufacturing is on the extreme right.

- Where is the estimated position/trend of Quantum networking?

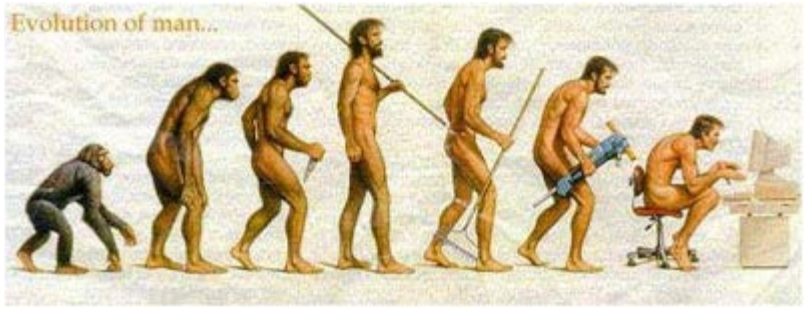
It is on the top right now.

- Is it possible for a Tech to regain "hype," even if it's already past its time on the curve?

Yes, sometimes the needs of the society change. For example, COVID brought remote collaboration into the limelight.

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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

- What do you think will be the age after the Internet Age? Cyborg Age?

The future is everyone's guess. I don't know the future. I try to keep at the leading edge of the "present." Also, I think only about issues that I can impact.

- How do you think cloud computing will evolve? Is AWS too far ahead to be caught, or is there room for innovation?

Cloud computing is now mainstream. The innovations are mostly implementation-oriented

- "Most fields today. Education, Health, Environment advancing mainly because of advances in Networking" Advancing how? Are they faster, more reliable, etc.

They are dependent on networking. Can you imagine a hospital without networking?

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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

- What would the future hot topics in networking look like?

We are working on applying AI and Blockchains for Cybersecurity.

- Is cloud sustainability a hot topic nowadays?

Sustainability is a hot topic in general. We worked on green computing in 2014.

- What are you working on in the past year?

Security, blockchains, and quantum computing.

- Have quantum networks become a hot topic, or are they still being developed?

Hot for research

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Trend: Smart Everything

 Smart Watch	 Smart TV	 Smart Car
 Smart Health	 Smart Home	 Smart Kegs
 Smart Space	 Smart Industries	 Smart Cities

Student Questions

- It has been a long time since auto-driving was invented. But people like us still seem far away from it. Why is it not so common everywhere in the world? What are the limitations to that? Can it be the manufacturer or something else?

Old habits die hard. We have been talking about virtualization for the last 40 years. COVID forced the world to virtualize in one year. No more need for travel to attend conferences.

- How long does it take from a new theory to manufacturing, which can be used by most people worldwide? For example, 6G.

Necessity and cost are often the obstacles.

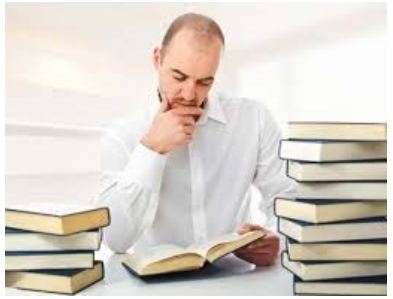
- Do you think the "smart" hype is overdone? It is terrible that your house or car can be hacked, especially when the internet is not 100% needed to run these products.

Every coin has two sides. I am enjoying smart devices. I need to know the technology to protect myself from hackers and hacks.

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What's Smart?

- Old: Smart = Can think ⇒ Computation
  = Can Recall ⇒ Storage
- Now: Smart = Can find quickly, Can Delegate
  ⇒ 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

- Is smart an overused term?

Because everything is now smart.

- What's the difference between IoT and smart devices? Are they the same thing?

Smartness is defined differently at different times. IoT is the current definition of smart devices.

- Are smart/IoT devices overused, potentially creating problems? A smart lightbulb connected to Wi-Fi seems risky.

Any technology can be overused or misused. Extremes are good and bad.

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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

- ❑ Is being a smart device a prerequisite to being an intelligent device?

No. You can have AI without networking.

- ❑ Does the shift from smart to intelligent require any additional improvements in networking?

Networking is benefitting from AI.

- ❑ Could you review the difference between smart and intelligent?

Smart = Internet
Intelligent = AI

- ❑ If smart devices are connected to a private network instead of the internet, are they still "smart"?

Yes.

- ❑ What is the difference between *smart and intelligent devices?*

Smart = Connected
Intelligent=AI

- ❑ How would you define smart vs. intelligent?

See above.

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

- How would internet service providers or cloud services scale up their operations to keep up with the increased internet traffic that these new smart devices may cause as they become used more in the future?

Researchers and industry are working on this challenge. They need more networking engineers to achieve it.

- How does networking benefit from AI?

Automated fault detection, resolution, capacity planning, energy savings, etc.

- What challenges do researchers and innovators face in transitioning from "smart" to "intelligent" devices?

AI techniques are different for different problems and areas.

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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, the US set up US Cyber Command
- UK, China, Russia, Israel, and 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

- Do you ever foresee soldiers fighting on the battlefield being obsolete and warfare being fought entirely remotely via drones, missiles, cyber warfare, etc.?

It is happening now.

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 and causing a **Denial of Service** Attack.



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

Student Questions

- Do you think hackers will become more prevalent as smart technologies/cloud computing becomes more widely used? What steps can/should companies and users take to prevent this in the future?

Hackers are intelligent people. They exploit weaknesses and help improve the technology.

- Do you personally use many smart devices? I have met people who work in the security space who will not use them because of the possibility of these attacks.

I am an "early adapter." However, I use technology wisely to avoid security pitfalls like cloud-based applications.

- Is there any way consumers can tell what smart/intelligent devices are secure? How do we limit our exposure to being hacked through innovative technology?

Know the technology's strengths and weaknesses. How to protect, defend, and benefit from it.

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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 and causing a **Denial of Service** Attack.



Student Questions

- Considering the price of IoT service, is it possible to protect IoT devices without increasing the product price too much?

Cost-performance tradeoff determines the success of any product.

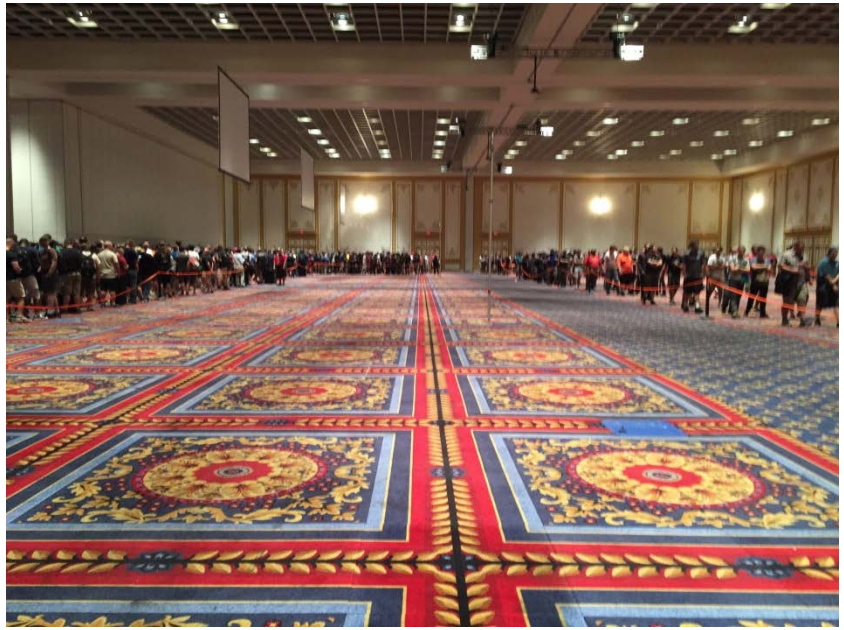
Ref: http://www.computerworld.com/article/2486502/security0/worm-may-create-an-internet-of-harmful-things--says-symantec--take-note--amazon-.html

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DEFCON







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

Student Questions

- Do you think Las Vegas is a good place for a conference like DEFCON?

Where else can you find hotels for 20,000 attendees.

- Can you go more into depth on smart vs intelligent?

Smart=Networked
Intelligent=Uses AI

- I know some intelligent devices can have access to the Internet, but does an intelligent device require that it also have AI capabilities without internet access?

Intelligence=AI

- Which village at DEFCON did you find the most interesting?

Wireless (2019)

- Is DEFCON open to anyone who shows up? Do you think it would be informative for a student to go if they don't have the same level of knowledge as the rest of the attendees?

Anyone can go. Many people bring their kids.

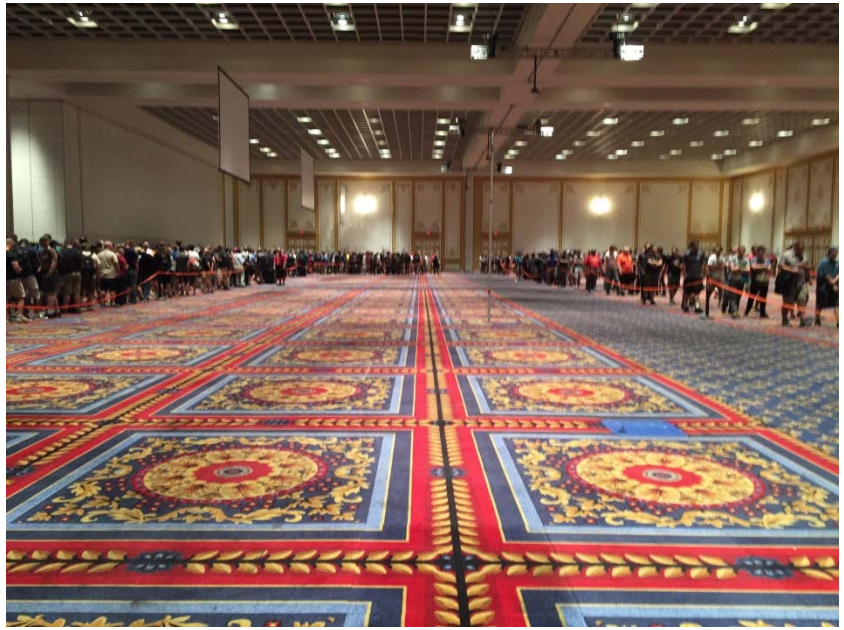
Ref: https://www.ethicalhacker.net/features/opinions/first-timers-experience-black-hat-defcon

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DEFCON







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Student Questions

- Is smart technology really that impressive anymore? Will intelligent technology completely overshadow smart technology in the future?

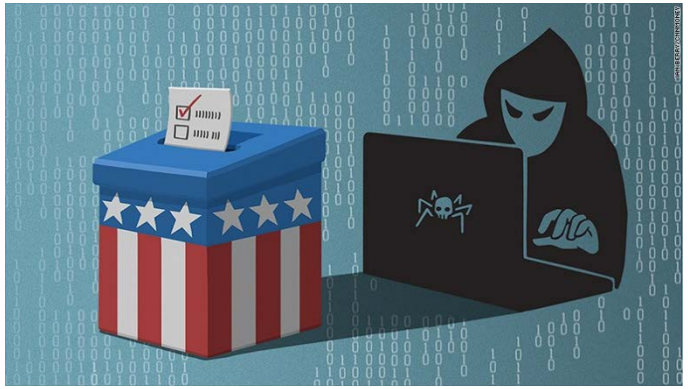
Both networking and AI are required.

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

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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

- How hard is it to hack a voting machine? Is there reason to believe that many of them might be hacked?

Voting machines have to be secured like any other Internet device. They are probably as secure as manual voting.

- Do you think more ethics courses about tech should be taught?

Sorry, not my field.

- What is the security risk associated with breaking Bitcoin hardware wallets?

You lose your bitcoins.

- Why the smart devices are always connected? I thought the connectivity of a smart device can depend on various factors, including the type of device, its features, the availability of an internet connection and so on.

Yes. Is your smartphone always connected?

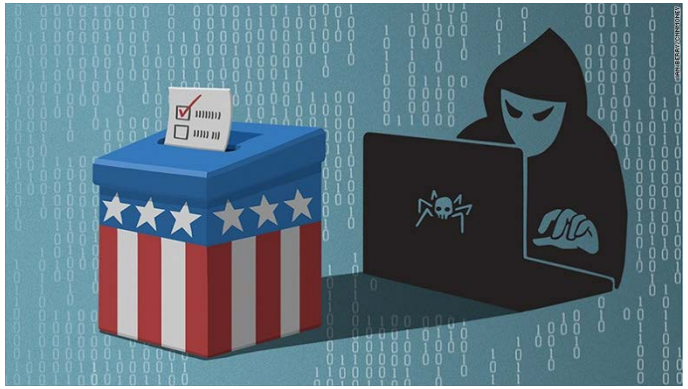
- Have you seen the show "Mr. Robot"? What are your thoughts?

No. I have not seen it.

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Recent DEFCON Topics

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Student Questions

- Will we talk about AI in networking in this course?

No. CSE574S: Recent Advances in Networking.

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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 the Internet (Google Docs)
  - Computing through Internet (Amazon EC3)
  - Storage and backup through the Internet (iCloud, Google Drive)

Student Questions

- Will we learn more in-depth about cloud computing during this class?

No. More in "CSE 570: Recent Advances in Networking."

- I am not sure about the relationship between cloud computing and the Internet.

You can't reach a cloud without the Internet.

- Does a different kind of cloud computing use the same server? Or are there different servers and computers that do different jobs, such as storage and computing?

A cloud is simply a remote data center. It has compute servers, storage servers, load balancers, etc.

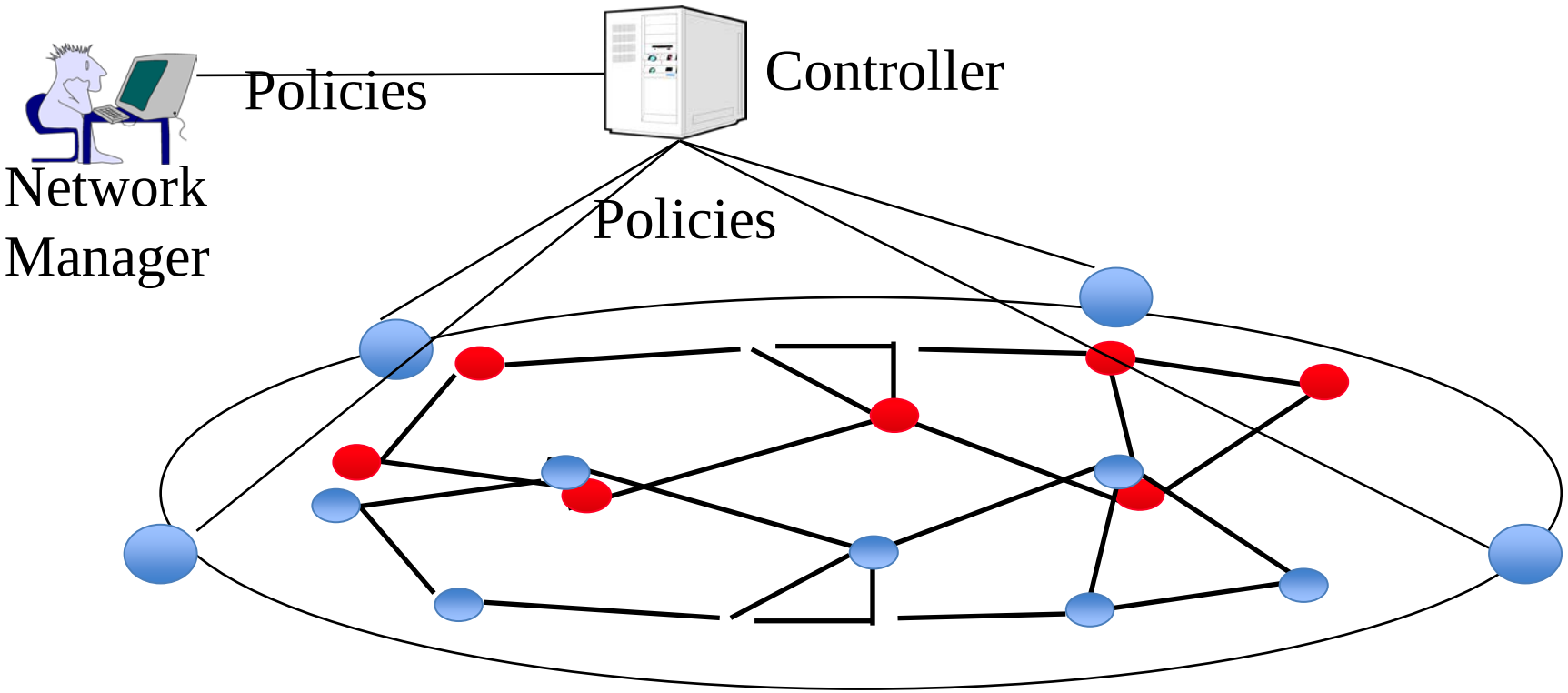
- Is the data transfer between EC2 and the renter's device secure?

You need to encrypt it to secure it.

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Software Defined Networking

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



Student Questions

- Does SDN power newer networking technologies e.g. 5G, 6G networks. If so, are traditional networks (non-SDN) becoming less relevant?

Yes, slowly. For example, we no longer use 1G.

- Is the software-defined networking decentralized? And who is responsible for managing all these connections?

SDN is centralized. The network manager is responsible for managing the entire network.

- Since everyone is sharing the same hardware, would there be any constraint? Or what will happen if the workload of all the network users exceeds the capacity of the hardware they're sharing?

Overload. Slow service. Crashes.

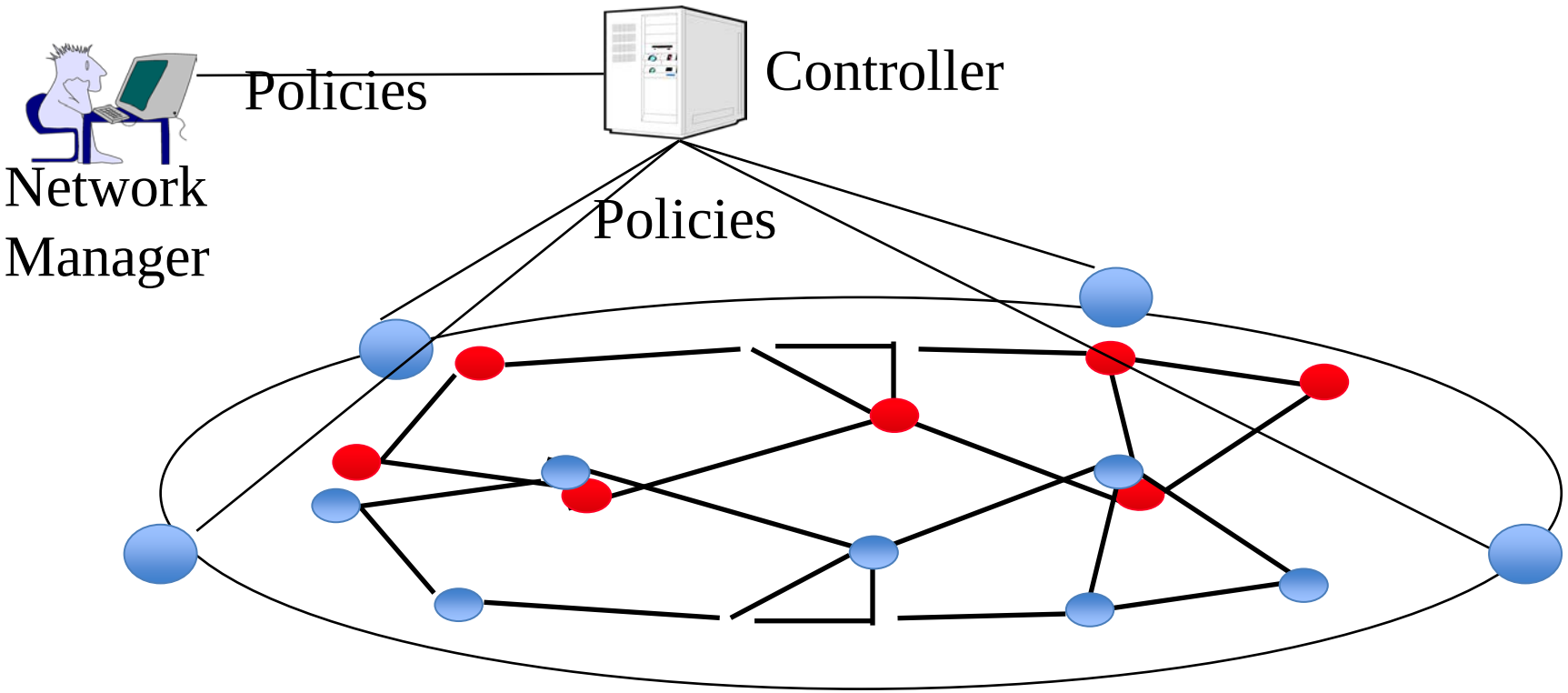
- What is the difference between software-defined networking and cloud computing?

Both are covered in Chapter 4.

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Software Defined Networking

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Student Questions

- What does it mean to "connect a router" and "define a network?" It felt like a self-referential definition.

Links, networks, and routers are defined in the next chapter. This is just a course overview.

- Software-defined networks are great because they allow for easier managing of large networks. Does this increased size increase the risk of cyber-attacks, and if so, is there an alternative that allows for greater security?

SDN proponents would argue that it is more secure than non-SDN networks.

- You mentioned that “once you connect the router to something, that is how it connects forever.” Why is that? Why can’t we change what the router connects to?

Generally, you have to walk to the router to change connections. With SDN, you don’t have to.

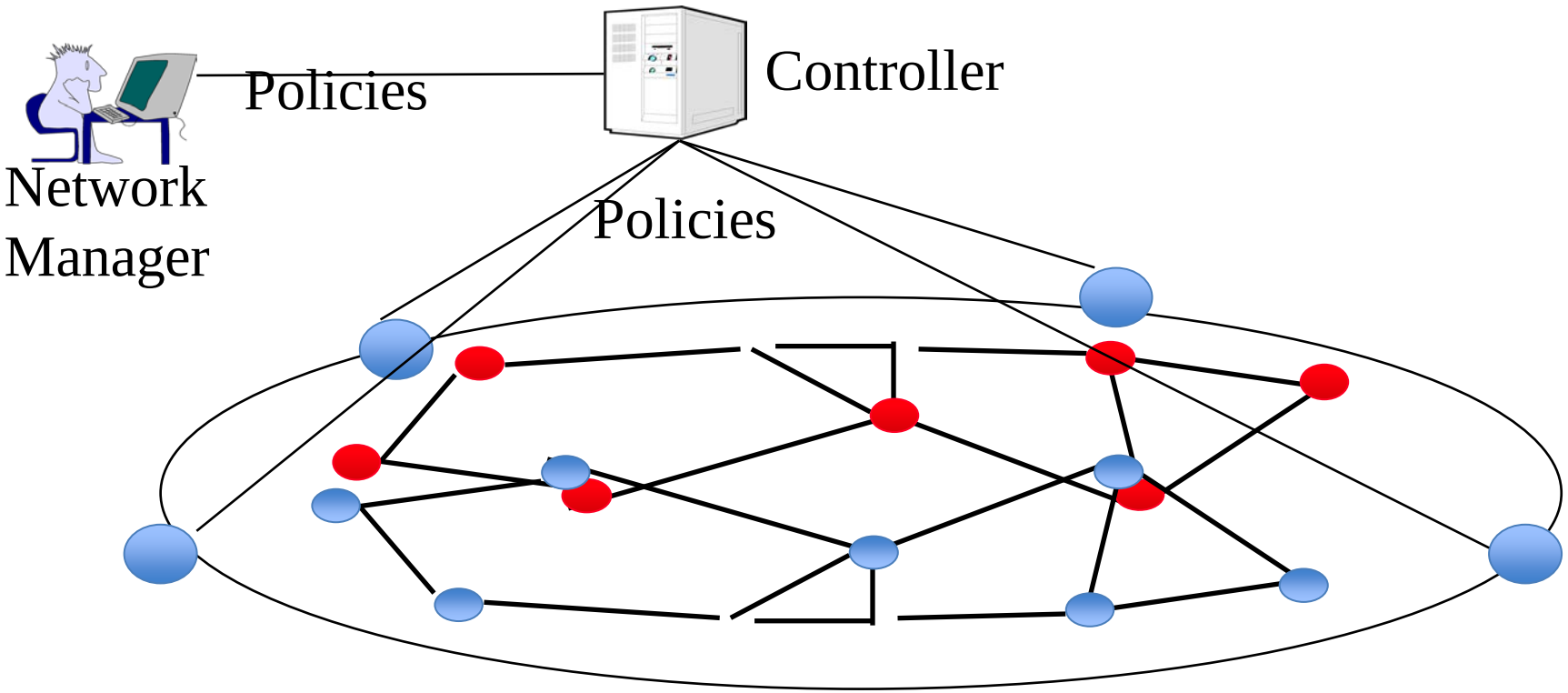
- What are examples of policies?

For example, students should not be allowed to access WebFac.

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Software Defined Networking

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Student Questions

- In the image, what is a "policy"? What are some examples of policies that a network manager would have to oversee?

Answered on the previous slide.

- Will shared devices through software cause big security issues

All sharing decreases security.

- Will SDN be detailed in this course?

Yes.

- What it means by devices being able to connect virtually vs by hardware. For example, how can devices access services like AWS or Azure if they're not connected via hardware?

You may need to be physical somewhere but virtually somewhere else.

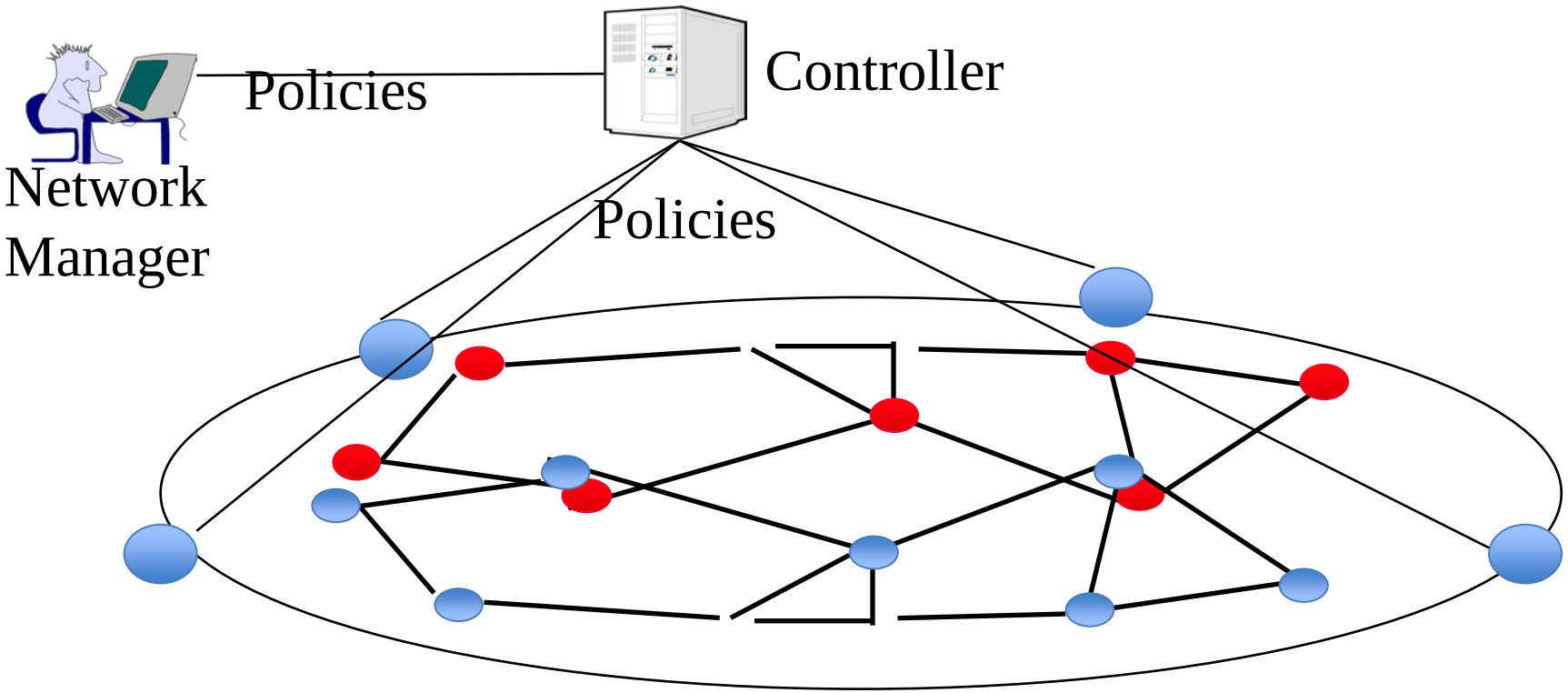
- How does the controller decide where to allocate resources for SDN?

This will be covered in detail later in this course.

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Software Defined Networking

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  ⇒ Allows managing large networks using the software.



Student Questions

- Does it mean that each piece of hardware that contains various software defining different policies is connected to other hardware?

This will be covered in detail later in this course.

- Could you go further in depth about how cloud computing works on the backend?

This will be covered briefly later in this course. More in advance networking course CSE570S.

- What is the difference between a managed and unmanaged switch related to Software-Defined Networking?

This will be covered in detail in the SDN module.

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Goal of This Course

- The 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 networking course.
- The basis for more advanced networking courses

Student Questions

- How would you define a good networking architecture?

If it is good, it will be adopted.

- Is the course more theoretical or applicational? Could you explain more about what the course is designed to help us do? Will it help us build/design better computer programs?

This is a system (S) course. It is not a software /hardware /theory (T) course. It will help you efficiently use networks in your field, including programming.

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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 do the names such as www.google.com get translated to IP addresses such as 74.125.73.104?
4. What is done to avoid congestion under overload?
5. How is the path on the Internet determined?
6. What happens if bits in a packet get corrupted?
7. How does WiFi or Ethernet work?
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

- How does email protocol guarantee the delivery of mail? How does the email server know to discard the email when it's read/received?

To be covered in Chapter 2.

- Will we discuss network security for each protocol we study or just a general overview of basic networking security principles?

Chapter 8 is on basic principles of security. After this course, you can take many other courses on security.

- If I want to learn about how high-frequency trading system trade with the exchanges, which class would be the best resource?

Sorry, I don't know.

- Will we cover matters in depth in this class? In addition to IoT

Yes.

- Will the course cover the physical layer of networking?

Yes, briefly. More details are available in Computer Communications courses in ESE.

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6. What happens if bits in a packet get corrupted?
7. How does WiFi or Ethernet work?
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

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Networking Courses at WUSTL

1. **CSE 473: Introduction To Computer Networks** (Spring 2022) – 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 (Fall 2021)
5. **CSE 574S**: **Wireless and Mobile Networking** (Fall 2020)
6. **CSE 571S: Network Security**
7. CSE 7700: Research Seminar On Networking and Communications



Student Questions

- Is it valuable to design a new, better email system? Will NSF support such kinds of projects?

You have to show the need and cost-to-benefit tradeoff of any idea you want to sell to anyone.

- Will CSE 570S be available next semester?

Yes.

- Since you mentioned there are non-network security methods, what do those include? Is there a hierarchy of security (some are more secure than others), or does each just accomplish something different?

A locked room is a non-network security method.

- Do you plan to offer CSE 570S next semester?
- No. My four-semester sequence is CSE570-CSE473-CSE574-CSE473

This semester

- Are servers from cloud computing more reliable than trying to make and run your servers?

Is a rental apartment more reliable than owning a house? There are fewer management issues.

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Networking Courses at WUSTL

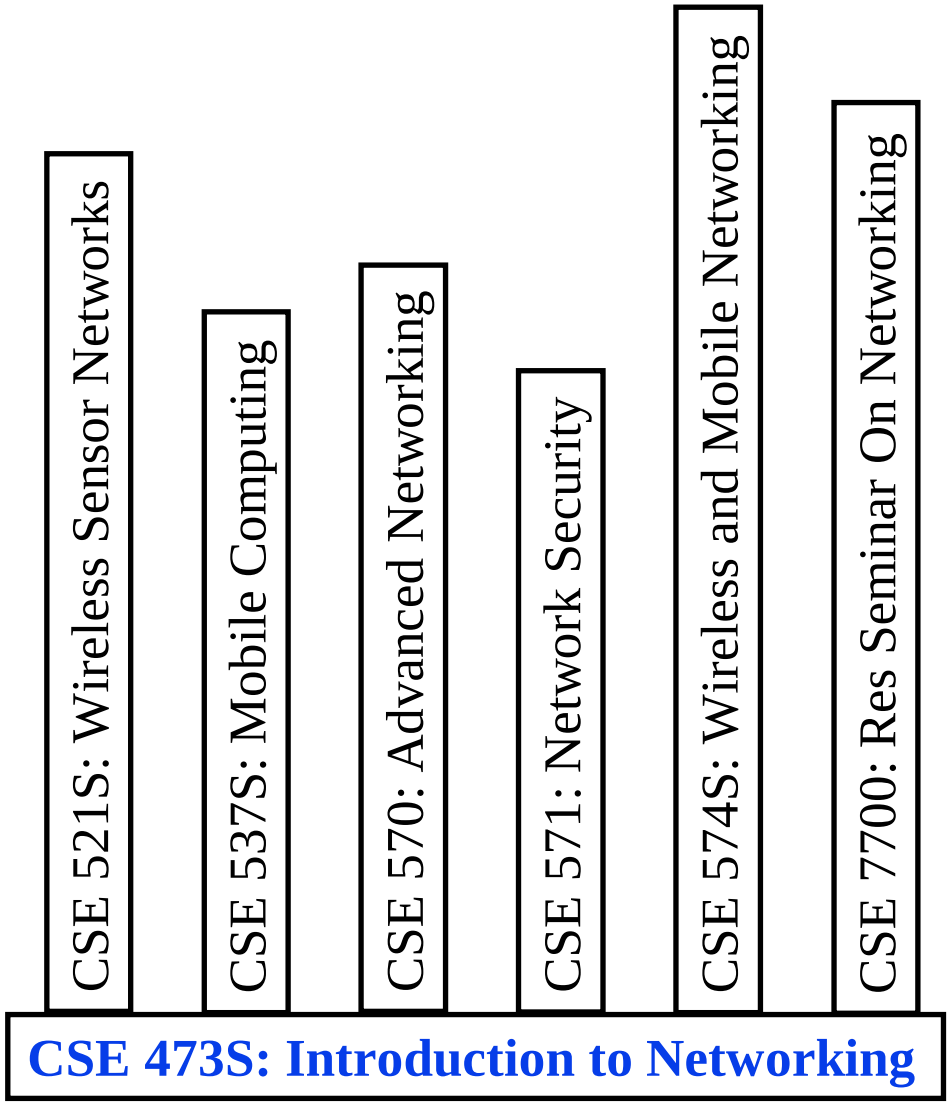
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Student Questions

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Networking Foundation



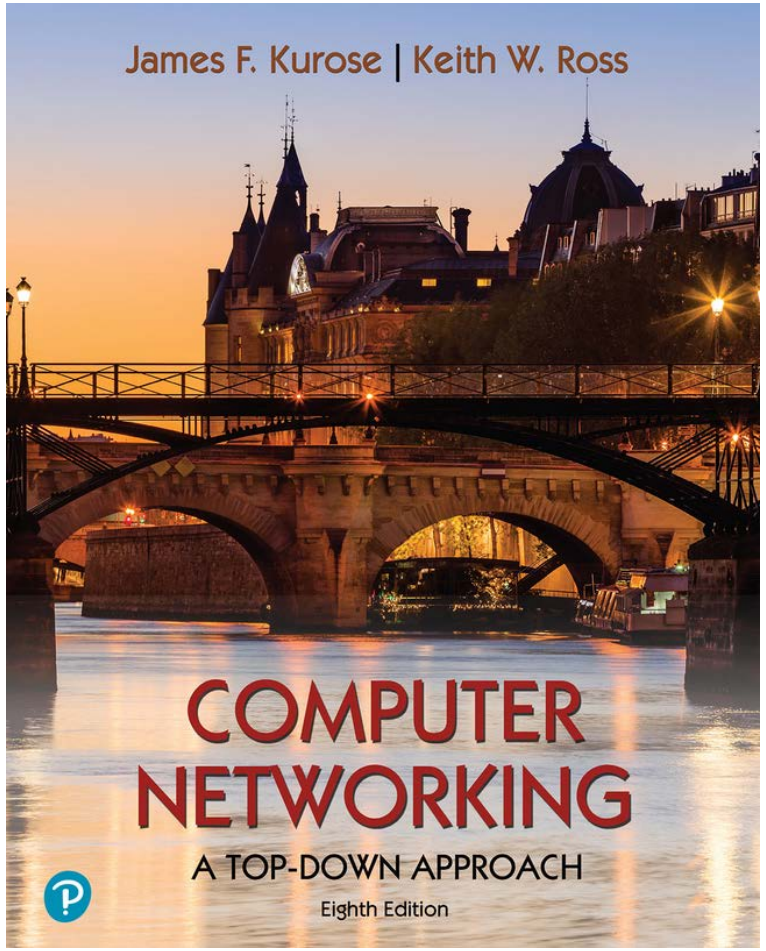
Student Questions

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Textbook

- J.F. Kurose and K.W. Ross, "Computer Networking" **8th Edition**, Pearson, 2021, ISBN: 9780136681557, 764 pp. **Required**.

- Get the latest edition. Do not use older editions. If you use the international edition, it should be dated later than 2020 and have 764 pages.



Student Questions

- When should we have the textbook by?

Today

- Is a digital copy of the textbook sufficient/okay?

Yes, as long as you get them legally.

- Is it necessary that we have the 8th edition of the textbook? Are there major differences between the 7th and 8th editions of the textbook?

Yes. Yes. Yes.

- Is the book required? Is it available for rent in the library?

Yes, the textbook is a must. You can rent it from the publisher.

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Textbook (Cont)

- It is recommended that you read the relevant chapter of the book 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 of the book.
- Please ask questions in the next class about any concepts that are not clear to you.
- The material covered in the class will include some concepts from other textbooks. Please pay attention to the class lecture.

Student Questions

- When we return to in-person class will we still be required to watch videos before coming to lecture instead of reading the text?

Yes. Video is not "a substitute for" reading the text. Both are required. Videos provide an overview of the text.

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Prerequisite

- General knowledge of computer systems organization
  - Memory
  - System bus
  - Interrupt
  - CPU
  - Binary, decimal, and hexadecimal representations
  - Bits, bytes
  - Storage: Memory and disk
- CSE 131: Computer Science I or equivalent

Student Questions

- I have learned the term System bus in a computer systems course, but it was used to describe the transferring of data between CPU and memory, so how would it be connected to networking?

You read/write data to network devices just like the memory.

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Tentative Schedule

Class	Day	Date	Topic	Chapter
1	Monday	1/12	Course Overview	
2	Wednesday	1/14	Computer Networks and the Internet (Part 1)	1
	Monday	1/19	MLK Jr. Holiday	
3	Wednesday	1/21	Computer Networks and the Internet (Part 2)	1
4	Monday	1/26	Application Layer (Part 1): HTTP	2
5	Wednesday	1/28	Application Layer (Part 2): SMTP,DNS,P2P	2
6	Monday	2/2	Transport Layer (Part 1): Design Issues	3
7	Wednesday	2/4	Transport Layer (Part 2): UDP,Flow Control	3
8	Monday	2/9	Transport Layer (Part 3): TCP,TCP Congestion Control	3
			The Network Layer: Data Plane (Part 1: Network Layer Basics)	4
9	Wednesday	2/11	Network Layer Data Plane (Part 2: IP Datagram,NAT,UPNP,DHCP)	4
10	Monday	2/16	Exam 1 review	1-3
11	Wednesday	2/18	Exam 1	1-3

Student Questions

- Will the exams be offered only during class time? Or will there be, say, a 24-hour window of time when we can begin the exam?

Fixed time: 1:00 PM to 1:50 PM.

- The timing of the exams on the slides is different from what is said in the video (the video on the course website seems to have been recorded in a previous semester), which is a little confusing to me since I joined the class after the first lecture. What is the expected timing of exams?

All recordings posted are live recordings of the previous lecture. Recordings take several days to prepare. Recordings of the class sometimes fail, so discussion recordings are not guaranteed. You have to attend the class to get the discussion and ask questions.

- Will exam papers from the past few years be provided before exams?

No.

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Student Questions

- Would we have in-person classes after the first two weeks or totally online?

Exams will be in-person.

- The schedule on the slides and the schedule spoken are different. Which one should we follow?

In this course, slides will always supersede the speech.

- Will we get any practice questions/exams to prepare for exams in this course?

Yes. Most homework and the reading lists for each module are for this purpose. Fill in the blanks, and actual/false questions are added to ensure your understanding of the concepts.

- Can all ideas in Chapters 1-3 from the book be asked in Exam 1?

The slides specifically indicate sections that must be read. We cover as much of the book as possible.

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Tentative Schedule (Cont)

Class	Day	Date	Topic	Chapter
12	Monday	2/23	Network Layer Data Plane (Part 3: SDN)	4
			The Network Layer: Control Plane (Part 1: Dijkstra's, Bellman-Ford Algorithms)	5
13	Wednesday	2/25	The Network Layer: Control Plane (Part 2: OSPF and BGP)	5
14	Monday	3/2	The Network Layer: Control Plane (Part 3: SDN Controller + ICMP + SNMP)	5
15	Wednesday	3/4	The Link Layer and LANs (Part 1): Functions	6
	Monday	3/9	Spring Break - No class	
	Wednesday	3/11	Spring Break - No class	
16	Monday	3/16	The Link Layer and LANs (Part 2): CRC	6
17	Wednesday	3/18	The Link Layer and LANs (Part 3): Multiple Access, Ethernet, VLANs, MPLS, Data	6
18	Monday	3/23	Exam 2 Review	3-6
19	Wednesday	3/25	Exam 2	3-6

Student Questions

- Do I need to read all the content of chapters 1-8 in the textbook, even if some of the contents don't appear in the slides? In other words, does the exam only test the knowledge in the slides, or all the book content may be tested?

The sections you need to read are identified in the slides.

- If you cover everything in the video, is the textbook required?

We do not cover everything in the video.

- We have three exams in total. I would like to know if the coverage of each exam will be different or not. (e.g. exam1 covers C1-C4, exam2 covers C5-C6. etc.)

Modules are different for each exam. No overlap. But you can't understand Module 2 if you did not study Module 1.

- Are we going to talk about the deep/dark web at all in this class? Even if it is just a brief discussion, I never fully understood how it works/what it is.

It is taught in network security courses. We cover security briefly.

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Tentative Schedule (Cont)

Class	Day	Date	Topic	Chapter
12	Monday	2/23	Network Layer Data Plane (Part 3: SDN)	4
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17	Wednesday	3/18	The Link Layer and LANs (Part 3): Multiple Access, Ethernet, VLANs, MPLS, Data	6
18	Monday	3/23	Exam 2 Review	3-6
19	Wednesday	3/25	Exam 2	3-6

Student Questions

Tentative Schedule (Cont)

Class	Day	Date	Topic	Chapter
20	Monday	3/30	Wireless and Mobile Networks (Part 1): Wireless Characteristics, LANs and PANs	7
21	Wednesday	4/1	Wireless and Mobile Networks (Part 2): Mobility Management	7
22	Monday	4/6	Security in Computer Networks (Part 1): Cryptography	8
23	Wednesday	4/8	Security in Computer Networks (Part 2)	8
24	Monday	4/13	Security in Computer Networks (Part 3)	8
25	Wednesday	4/15	Security in Computer Networks (Part 4)	8
26	Monday	4/20	Exam 3 Review	7-8
27	Wednesday	4/22	Exam 3	7-8

- **Note that Exam 3 is on Wednesday, April 22, 2026.**
- **The dates for all exams are fixed. No substitute exams.**
- **Everyone has to take the first two exams.**

Student Questions

- The final exam is on the last day of class, 4/22, now the same as last year's schedule in slide 5/3, right?

Slides are updated regularly. Video recordings are static. Whenever there is a difference, slides take precedence.

- The WebSTAC page states we have a time slot for a final exam on May 13, 2021, but the last exam is on May 3rd. Is there some other assignment tied to the date of May 13, 2021?

No. There are no activities after Exam 3. There is no final exam.

- Are the exams cumulative?

No.

- Will each exam cover only the previous section or all previous sections?

Only previous sections.

- Do the exams cover all the materials learned or just materials between each exam?

Between each exam

- Will the exams contain content from the textbook as well as content from the lectures? *Yes.*

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Tentative Schedule (Cont)

Class	Day	Date	Topic	Chapter
20	Monday	3/30	Wireless and Mobile Networks (Part 1): Wireless Characteristics, LANs and PANs	7
21	Wednesday	4/1	Wireless and Mobile Networks (Part 2): Mobility Management	7
22	Monday	4/6	Security in Computer Networks (Part 1): Cryptography	8
23	Wednesday	4/8	Security in Computer Networks (Part 2)	8
24	Monday	4/13	Security in Computer Networks (Part 3)	8
25	Wednesday	4/15	Security in Computer Networks (Part 4)	8
26	Monday	4/20	Exam 3 Review	7-8
27	Wednesday	4/22	Exam 3	7-8

- **Note that Exam 3 is on Wednesday, April 22, 2026.**
- **The dates for all exams are fixed. No substitute exams.**
- **Everyone has to take the first two exams.**

Student Questions

- Are there any online resources that have example exercises with real-time feedback?

The textbook has exercises, but there is no real-time feedback.

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Grading

- Exams (Best 2 of 3) 60%
- Class participation 5%
- Video Reviews 10%
- Homeworks 15%
- Labs 10%
- Grading is by your percentile in the class as follows:

Percentile	87%	74%	61%	48%	35%	22%	9%
Grade	A+	A	A-	B+	B	B-	C+ and below

- **Pass/Fail:** Anyone getting over **66**% 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

- Can you explain how class participation works?

Answering question. Attendance. Bringing up interesting issues in class discussions.

- How many HWs/Labs do we have throughout the semester? How long do you expect them to take?

26 homework and 12 labs. All home works are short but requires reading/understanding. Labs may require programming.

- Is there a grade distribution scheme?

No. You get points for the method and result.

- About the pass/fail policy, you said that pass fail is the 70% of the highest grade, slide says that anything above 66% will pass. So does this mean that what might end up being a B or B- will end up not passing the class?

Slide overrides the speech. Grade distribution varies. Only those that skip most of the essential work will fail.

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Student Questions

- Is the calculator still relevant? I have a Casio fx-991CN X and a fx-82ES PLUS A at hand. Am I allowed to use one of them instead?

Nothing that can store a paragraph of text or formula is allowed.

- Were we supposed to Zoom on Monday?

Monday was the MLK holiday for WUSTL.

- What if we genuinely do not have any questions on the slides one day? Do we automatically get a 0 in class participation?

If you don't ask any question any day on any slide…

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Exams

- There are three exams.
- All exams are 50 minutes long.
- One note sheet of 8.5” x 11” (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.
- All students, including the graduating seniors, are graded similarly.
- Your grade in an exam depends upon the performance of the rest of the class on that exam.

Student Questions

- It's said in the video that you receive zero points for not answering a quiz question. From class, my understanding was that we lose a point by not answering. What happens if we don't answer a quiz question?

For true/false questions, if you answer correctly, you get 1 point. If you answer incorrectly, you get -1 point. You get 0 points if you don’t answer.
For all other questions, there is no negative grading. You get 0 points if you don’t answer.
The points depend upon the method and the final answer.

- Are exams during the normal class period?

Yes

- The PowerPoint says that there is a negative grading on incorrect multiple-choice questions. Grade: +1 for correct -1/(n-1)for incorrect. What does the number n mean? Is it the number of the selection?

Yes. n=# of choices in a multiple choice question. n=2 for true/false.

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Student Questions

- Do exams involve programming?

No.

- Are exams in person or online?

In-person.

- What does the "n" mean in -1/(n-1) for incorrect values on exam questions?

n=Number of choices.
n=2 for true/false

- Are all tests remote? If so, Is the camera on my laptop acceptable for remote testing?

All exams are in person—no camera is required for exams.

- Will we need a calculator? I only have a TI-84 (maybe too smart) or nothing.

It would save you some time if you invest in a $7 calculator.

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Student Questions

- For multiple choice, if the answer is left blank, will negative points still be received for the answer being incorrect?

Zero for blank.

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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 computer

Student Questions

- Which language will the programming portion of the labs use?

Python and C.

- I don't have any experience with Python. It's never been required in any of my CS curricula. Should I learn Python for this class?

We follow the textbook as much as possible. Each chapter has some lab exercises. Some exercises require programming, and the author has selected common languages for those exercises.

- Are labs to be completed individually as well?

Yes.

- Can we work in groups of 2-3 for labs?

All labs are short programming or data analysis exercises.

- How in-depth is the programming? Does it go down to programming protocols or up to using the protocols? For example, using TCP to do Task A rather than programming TCP (or some part of it) itself.

Check out the previous year's lectures.

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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 computer

Student Questions

- What programming language do we need to learn in order to finish the lab?

C and Python.

- What language will we be writing our labs in? C?

C and Python

- Should we do some socket programming?

Maybe in Lab 2

- Are there any software or programming tools that cannot be used in the Macbook in our course? I only have a Macbook!

Any operating system should be fine: Mac/Windows/Linux.

- Are any labs architecture specific (wondering about using my M2 Mac).

No. Any OS is fine.

- Will the labs have specific instructions and pre-written code, or will everything be done from scratch?

Some labs have pre-written code.

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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 computer

Student Questions

- When will labs be due?

Each lab has a due date on Canvas, just like homework.

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Homework Submission

- All homework assignments 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 homework assignments should be submitted to Canvas unless specified otherwise.
- The class handout number identifies all homework assignments.
- All homework assignments should be on a separate sheet/file. Your name should be on every page.
- Please write CSE473 in the subject field of all emails related to this course.
- Use "Home Work" in the subject field on emails related to homework assignments. Also, indicate the homework number.

Student Questions

- Will we need any software for the homework?

Yes. Only free network utilities. It will be indicated in the homework or lab.

- Will the homework be coding? or writing paragraphs, like answering questions? What about the lab?

Most homework is paragraphs and calculations. Most labs are network activities. Only some labs have coding.

- Can we see the homework template to clarify the requirement?

Check out the previous year's slides and recordings.

- Will there be regular weekly homework assignments and lab assignments? Is there a copy of a full schedule for the semester, including homework assignments/labs?

*Yes. This is an **intensive** course. The full schedule was presented earlier.*

- When doing homework, do we need to use Latex or Word, or can we just handwrite on an iPad and export to PDF?

Any of the above

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- Please write CSE473 in the subject field of all emails related to this course.
- Use “Home Work” in the subject field on emails related to homework assignments. Also, indicate the homework number.

Student Questions

- If we would like to submit the homework via email, should we use "CSE473 Home Work # " as the subject line?

All homework submission now is via Canvas.

- Would it be possible to list all the assignments (homework, labs, etc.) on the class website? Something like adding another column to the website that says due and listing whatever assignment is due underneath.

Canvas has most of it, and it will remind you of things to do.

- Do you advise students to start homework as early as possible, or is the homework generally manageable enough to start and finish the weekend before it is due?

Homework is not excessive. However, it is always best to work first, enjoy later.

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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 a page. (See Page Setup)

Student Questions

- If using code in the homework, does the whole code need to be included as well?

Yes.

- What format do homework questions take? Are they more free response or multiple choice/True-False?

Short calculations.

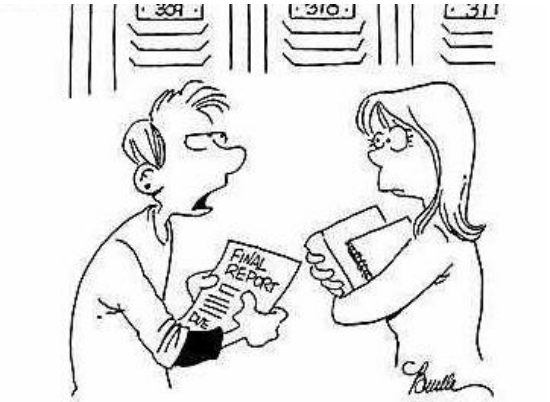
- What type of calculations do we expect from the homework? Why do we need Excel for this?

Yes, sometimes Excel is better than other tools. Any other spreadsheet program will be fine.

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Academic Integrity

- Academic integrity is expected in homework, quizzes, and exams.
- All submitted solutions are expected to be yours and not copied from others, solution manuals, the Internet, or **AI.**
- The school requires us to report all integrity violations 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

- So how will the solutions to the homework be posted?

When needed, I will discuss the solutions in class.

- I understand the labs are to be completed individually but do you think it would be helpful to /is it allowed to consult with other students about homework questions?

When providing any advice, show only a way to the solutions and not the solutions. This applies to Piazza also. Do not post your solutions. We have TA sessions if you still need help.

- There are questions during the video and this google form. For the participation grade, we need to ask at least one question here in the form. Do we also need to answer the questions during the video?

Participation does not include asking questions anywhere.

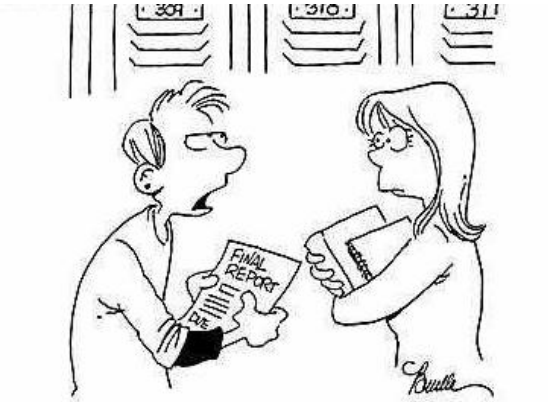
- Are quizzes graded? If so, are they graded on correctness?

Graded on correctness.

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

Student Questions

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Office Hours

- By Appointment: Office: Zoom
- Teaching Assistants: TBD
- TA Hours: TBD. Only on demand.
- All meetings with the TA will be via Zoom.
  The link will be posted on Piazza or Canvas.

Student Questions

- If the semester switches to in-person instruction as planned, will we have any in-person office hours?

To be determined.

- Will the office hours be posted on Zoom?

I added to this slide.

- Will the relevant sections be posted so we can read the suitable material?

Sections to read are in the slides.

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After-Class Discussions

- We will use Piazza for in-between class urgent questions.
- No participation points for questions on Piazza.
  Get points if you help by answering a question.

  Help by pointing to the correct direction and not by giving the correct answer to be submitted.

  Publishing an answer anywhere online, including on Piazza, is unethical.
- If a question is not urgent and can wait till the next class, please bring it up in the class or via Google Forms ⇒ Get points.
- Find our class page at:
  https://piazza.com/wustl/spring2025/cse473s

Student Questions

- Why is piazza not included in participation?

We want to encourage discussions in class as much as possible. Offline activities (such as Google forms) have specific marks assigned to them.

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Attending Classes via Zoom

- Keep your microphone mute.
- All questions should be broadcast on the chat.
  All answers to my questions should be private 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.
- Although, the class discussions are being recorded. However, videos will not be posted.

Student Questions

- Will we lose points if we don't add a profile picture to Zoom?

No.

- What if I switch windows to look up the Internet of Things? Will it say I'm not paying attention?

Yes.

- Regarding Zoom's report on attention, what should I do if I want to look at some course-related materials? Is there any way to pull up the slides with Zoom simultaneously, which will not flag us for not paying attention?

If it's urgent, just look it up. Otherwise, try to pay attention to the current discussion as much as possible.

- I have in-person classes right before and after this class, so it would be ideal for me to watch recordings later.

Q&A sessions are mandatory. Many students join the classes from the cafeteria, empty classrooms, or any open space. You can go to the assigned classroom.

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Attending Classes via Zoom

- Keep your microphone mute.
- All questions should be broadcast on the chat.
  All answers to my questions should be private 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

- Can you post some links for us to buy the camera?

Cameras on laptops are sufficient.

- When are cameras required to be turned on?

In all classes. All the time.

- Is the only requirement for our camera is to be mountable?

It should be able to show your face while you are looking at the screen.

- Can I type notes while Zoom is open, or will that alert you that I'm not paying attention? If I can't type notes, is there any way around this system since taking notes is integral to how I retain information?

Taking notes is fine. Working on many windows is considered a distraction.

- Do we need to ask a question on Zoom to check in and earn points?

Creative participation is rewarded. Do not hesitate if something is not clear. Do not waste class time just for fun.

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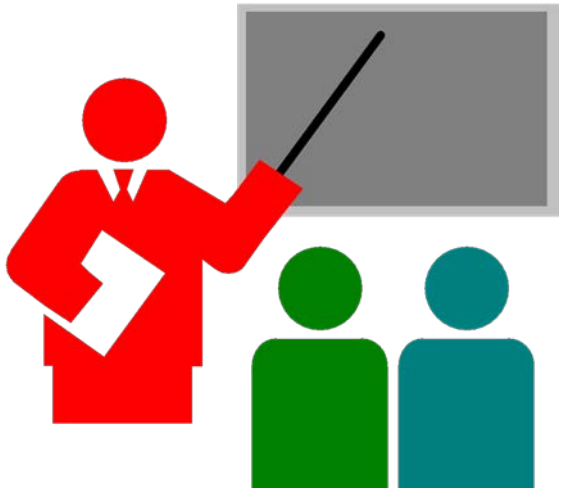
Attending Classes via Zoom

- Add your photo to your Zoom profile.
  There is no need to start your video.
  The photo is sufficient. Keep your microphone mute.
- All questions should be broadcast on the chat.
  All answers to my questions should be private 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

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Summary



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

Student Questions

- Is this class still remote? If not, what is different about the class now? Do we still need the camera? Is class participation through asking questions in class?

The class is remote. Exams are in person. Class participation includes answering questions in class or on the Piazza. You need a camera to attend the class.

- Who should I speak to if I want to set up WebSocket to connect MongoDB on cloud?

Sorry, I don't know.

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 the same as that with 2GB disk.
4. ☐ ☐ The CPU uses interrupts 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 (2πft+ φ), 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.
11. ☐ ☐ The sum of two vectors [1, 1] and [1, 2] is [1, 2].

Marks = Correct Answers _____ - Incorrect Answers _____ = _____

Student Questions

- Problem understanding problem 7

You need to know trigonometry.

- Would every video have such quizzes besides the video embedded quizzes?

No.

- Are we required to finish it and upload it somewhere? Are these topics covered in exams?

No.

- Where should I submit this quiz?

Nowhere.

- Will the exams be online in 2024?

No. In-person in a room.

- Will you publish the answers to quiz0?

Yes. I will show you today.

- For the quiz, if I don't know questions 3, 4, and 7, should I drop the class?

Yes.

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http://rajjain.com

http://www.cse.wustl.edu/~jain/cse473-26/i_0int.htm

Student Questions

- Will you share your industry experiences related to some Network topics?

Yes. Yes. Yes.

- In the video, you say we can take the quiz as many times as we want, but in my case, after I filled in my answer and submitted it, the quiz was just gone, and I got nowhere to do it again. Is that an updated policy?

No. If you play the video again, your previous score will be overridden.

- What is your favorite part (section, module, etc.) of this course to teach?

Entire course. Each topic builds on the previous one. This course is the foundation for the next course.

- What makes software-designed networking more secure than each company having its own hardware?

Security policies are consistently enforced on all devices from a central point.

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Student Questions

- Can I still get full points for Video Review 0? I joined the course on 1/19 after the first class.

There is always a small penalty for all late submissions.

- How can I know which page to read before the next class and what I will achieve after reading it?

Marked in the slides

- The exam grading is best 2 of 3, which means that no matter what happens, we will always get the top 2 grades as a result.

Yes.

- To what extent is DARPA involved in pushing forward new smart technologies that we will discuss in this class?

DARPA invented the Internet and is still funding the latest technologies. But this is only a foundation course on Networking.

- How does real-time cloud computing differ from traditional computing in the network field?

Unlimited computing power and other advantages of cloud computing.

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Student Questions

- How can I download the class slides in Canvas? When I opened the link posted in Canvas, it said the page was not found.

Complain on Piazza. It will be fixed.

- Are the Student Questions in the slide pdf at the latest? Have we switched to in-person already, or are we still doing remote?

Remote.

- Do we need a webcam that is separate from the one on the laptop?

No. A laptop webcam is all you need.

- What is the purpose of the Session and Presentation layers in the OSI model?

Discussed in the next module.

- Will we be discussing subjects like bonding/link aggregation in 802.3ad?

CSE 574S: Recent Advances in Networking.

- Are the "Student Questions" on the slides we downloaded before class from previous years?

Yes. We keep a cumulative list of all questions ever asked.

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Student Questions

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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

Student Questions

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