Welcome to

CSC-8220: Advanced Computer Networks

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Today's Agenda

- Administrative aspects of this class
- A brief overview of the course
- Overview of Computer Networks

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Who Am I ?

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When/Where to talk to me ?

Algorithm 1 (to be made distributive)

1: send questions to me at cao@gsu.edu
2: else
    use office hours (temporarily) Wed. 11:00-12:00pm
3: else
    sneak in whenever the door is open
4: goto 1

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Tell us about yourself

- Name
- Major, interests
- What's your **expectation** for this course (if possible)?

and
- Anything you'd like to share with us

What is 8220 ?

Advanced grad course about Network:

- Modern computer networks: algorithms, protocols, analysis, SDN, NFV, and ?
- Both communication theory and practice

Course Objectives
(i.e what you'd achieve from this course)

- Have fun!!
- Learn the essential ideas of modern networking
- Some topics : broad
  - know where to look for details,
  - be able to *talk* about a topic w/o knowing the details (interviews, managers)
- Other topics: deeper
  - What X is
  - How X works
  - Implement X
  - Even improve X

Course Materials

- **Textbook:**
  - **No required one**
  - reference, we suggest several texts:
    - Larry Peterson and Bruce Davie, "Computer Networks: A Systems Approach," the Fifth Edition, Morgan Kaufmann, (ISBN: 978-0-12-385059-1)
    - David Tse, Pramod Viswanath, "Fundamentals of Wireless Communications," Cambridge Univ. Press, 2005, ISBN # 0-521-84527-0 (available online: http://www.eecs.berkeley.edu/~dtse/book.html)
    - Dimitri Bertsekas and Robert Gallager, "Data Networks", 2nd edition, Prentice Hall, (ISBN: 0-13-200916-1)
- **Online Materials:** (including lecture notes)
  - http://www.cs.gsu.edu/cao/Teaching/19SP8220/
- Other Recommended References: see website
- Plus other online (reading) materials provided

Work Load

- Course Plan
  - You and Me determine, together
  - Prefer flexibility, how about on-demand?
- Heavy? So, start early!!
- Plenty of reading
- 3-5 homework assignments (25%)
- In class Quizzes/Exams (35%)
- Presentations (5%)
- 1 research project (30%)
- Class Participation (5%)

Late submission penalty

- Homework, paper, project
  - 1 day late: 10% reduction
  - 2 days late: 30% reduction
  - >2 days late: no points

- Incomplete/make-up: not given, except in **provably** extraordinary cases

Grade Policy

- You may participate in this also
- Just for reference:
  - **A-/A/A+**: 85-100+
  - **B-/B/B+**: 75-84
  - **C-/C/C+**: 60-74
  - **F and below**: you don't want to know

No lame excuses, please!!!

- I have to go home early, please allow me to take exam on Nov. 11st:
  - NO, NO, NO, NO: not even a day before the exam
- I had a fight with my girlfriend
  - … you can get my deepest condolences, just not the grade
- I've studied very hard, I understood the stuff very well, but I got a C – please consider giving an A-
  - … you could easily win "Last Comic Standing"

Academic Honesty

- No tolerance on plagiarism:
  - Consult the University Code of Conduct for details on consequences of academic misconduct
- Group study/discussion is encouraged, but the submission must be your own work
- On the Assignments: discussions of ideas are welcome, but **NO** exchanges or Copy/Paste, please.

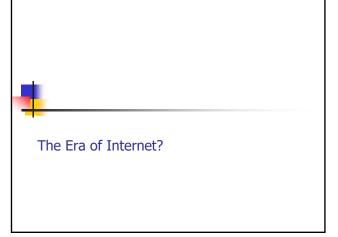- **Please read course syllabus for More detail.**

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How to Make It More Interesting ? How to Do Well in This Course ?

- Participate: discuss & answer and ask questions ("the only stupid question is the question you don't ask")
  - You will get credit also
  - "how you learn/participate" >> "how I teach" -☺
- Give suggestions: I'll take them seriously

- Do the assigned readings and surf the web to read related things
- **Start early** on assignments and projects
- Make use of the reading materials and online resources (and occasionally me ☺)

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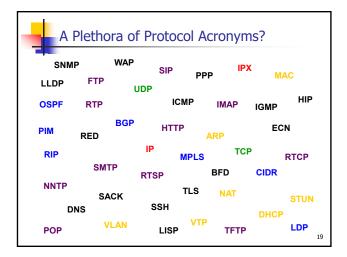## The Era of Internet?

The Internet: An Exciting Time

- One of the most influential inventions
  - A research experiment that escaped from the lab
  - … to be a global communications infrastructure
- Ever wider reach
  - Today: >4.2 billion users, >3.4 billion were social media users
  - Tomorrow: more users, computers, sensors
- Near-constant innovation
  - Architecture: SDN NFV
  - Apps: Web, P2P, social networks, virtual worlds
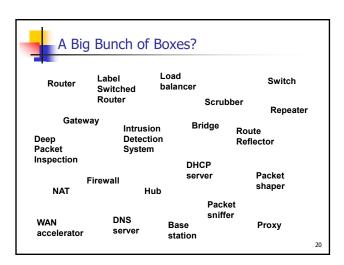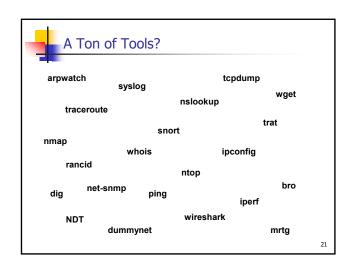 - Links: optics, WiFi, cellular, WiMax, …
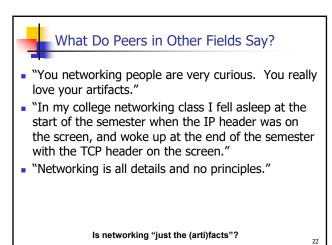
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Transforming Everything

- The ways we do business
  - E-commerce, advertising, cloud computing, ...
- The way we have relationships
  - E-mail, IM, Facebook friends, virtual worlds
- How we think about law
  - Interstate commerce? National boundaries?
- The way we govern
  - E-voting and e-government
  - Censorship and wiretapping
- The way we fight
  - Cyber-attacks, including nation-state attacks

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But, What *is* Networking?

A Plethora of Protocol Acronyms?

SNMP WAP SIP PPP IPX MAC
LLDP FTP UDP
OSPF RTP ICMP IMAP IGMP HIP
PIM BGP HTTP ECN
RED ARP
RIP IP MPLS TCP RTCP
SMTP BFD CIDR
RTSP
NNTP TLS NAT
SACK SSH STUN
DNS DHCP
POP VLAN LISP VTP TFTP LDP

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A Big Bunch of Boxes?

Router	Label Switched Router	Load balancer	Switch
		Scrubber	Repeater
Gateway	Intrusion Detection System	Bridge	Route Reflector
Deep Packet Inspection			
		DHCP server	Packet shaper
NAT	Firewall	Hub	
		Packet sniffer	
WAN accelerator	DNS server	Base station	Proxy

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A Ton of Tools?

arpwatch

syslog

traceroute

nmap

rancid

dig net-snmp ping

NDT

dummynet

tcpdump

wget

nslookup

trat

snort

whois   ipconfig

ntop

bro

iperf

wireshark

mrtg

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What Do Peers in Other Fields Say?

- "You networking people are very curious. You really love your artifacts."
- "In my college networking class I fell asleep at the start of the semester when the IP header was on the screen, and woke up at the end of the semester with the TCP header on the screen."
- "Networking is all details and no principles."

Is networking "just the (arti)facts"?

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An Application Domain?

Application Domain for Theory?

- Algorithms and data structures
- Control theory
- Queuing theory
- Optimization theory
- Game theory and mechanism design
- Formal methods
- Information theory
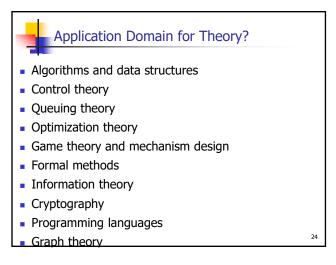- Cryptography
- Programming languages
- Graph theory

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Application Domain for Systems?

- Distributed systems
- Operating systems
- Computer architecture
- Software engineering
- …

What Peers in Other Fields Say?

- "Networking papers are strange. They have a lot of text."
- "What are the top ten classic problems in networking? I would like to solve one of them and submit a paper to SIGCOMM." After hearing that we don't have such a list: "Then how do you consider networking a discipline?"
- "So, these networking research people today aren't doing theory, and yet they aren't the people who brought us the Internet. What exactly are they doing?"
- "Networking is an opportunistic discipline."

Is networking a problem domain or a scholarly discipline?

Now That I've Bummed You Out…

Or, Why Should You Stay in
This Class, and This Field?

So, Why is Networking Cool?

- Tangible, relates to reality
  - Can measure/build things (we *do* "love our artifacts")
  - Can truly effect far-reaching change in the real world
- Inherently interdisciplinary
  - Well-motivated problems + rigorous solution techniques
  - Interplay with policy, economics, and social science
- Widely-read papers
  - Many of the most cited papers in CS are in networking
  - Congestion control, distributed hash tables, resource reservation, self-similar traffic, multimedia protocols,…
  - Three of top-ten CS authors (Shenker, Jacobson, Floyd)
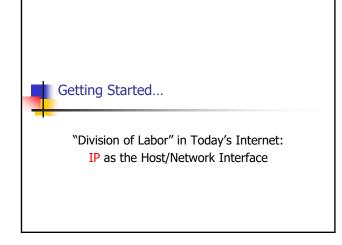 - So, *somebody* is interested in reading this stuff… ☺

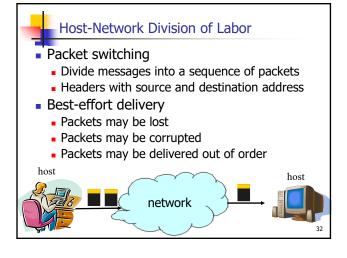## So, Why is Networking Cool? (Cont)

- Young, relatively immature field
  - Great if you like to make order out of chaos
  - Tremendous intellectual progress is still needed
  - *You* can help decide what networking really is
- Defining the problem is a big part of the challenge
  - Recognizing a need, formulating a well-defined problem
  - … is at least as important as solving the problem…
- Lots of platforms for building your ideas
  - Programmability: Click, OpenFlow/NOX, NetFPGA
  - Routing software: Quagga, XORP, and Bird
  - Testbeds: Emulab, PlanetLab, Orbit, GENI, …
  - Measurements: RouteViews, traceroute, Internet2, …

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One Take on Defining Networking

- How to
  - Design and operate *components and protocols*
  - That can be used and *combined in many ways*
  - To do *many things*
- Definition and placement of function
  - What to do, and where to do it
- The "division of labor"
  - Between the host, network, and management systems
  - Across multiple concurrent protocols and mechanisms
- But, how to judge a *good* division of labor?
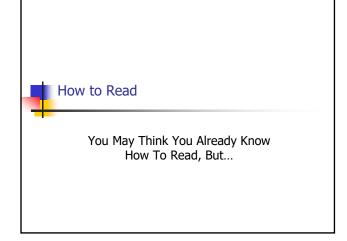 - We need some sort of "user" in mind

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Getting Started…

"Division of Labor" in Today's Internet:
IP as the Host/Network Interface

Host-Network Division of Labor

- Packet switching
  - Divide messages into a sequence of packets
  - Headers with source and destination address
- Best-effort delivery
  - Packets may be lost
  - Packets may be corrupted
  - Packets may be delivered out of order

host   host

network

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Host-Network Interface: Why Best-Effort?

- Never having to say you're sorry…
  - Don't reserve bandwidth and memory
  - Don't do error detection & correction
  - Don't remember from one packet to next
- Easier to survive failures
  - Transient disruptions are okay during failover
- Can run on nearly any link technology
  - Greater interoperability and evolution

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How to Read

You May Think You Already Know
How To Read, But…

You Spend a Lot of Time Reading

- Reading papers for grad classes (like this one!)
- Reviewing papers for conferences/journals
- Giving colleagues feedback on their papers
- Keeping up with work related to your research
- Staying broadly educated about the field
- Transitioning into a new research area
- Learning how to write better papers ☺

So, it is worthwhile to learn to read *effectively*

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Keshav's Three-Pass Approach: Step 1

- A ten-minute scan to get the general idea
  - Title, abstract, and introduction
  - Section and subsection titles
  - Conclusion
  - Bibliography
- What to learn: the five C's
  - Category: What type of paper is it?
  - Context: What body of work does it relate to?
  - Correctness: Do the assumptions seem valid?
  - Contributions: What are the main research contributions?
  - Clarity: Is the paper well-written?
- Decide whether to read further…

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Keshav's Three-Pass Approach: Step 2

- A more careful, one-hour reading
  - Read with greater care, but ignore details like proofs
  - Figures, diagrams, and illustrations
  - Mark relevant references for later reading
- Grasp the content of the paper
  - Be able to summarize the main thrust to others
  - Identify whether you can (or should) fully understand
- Decide whether to
  - Abandon reading the paper in any greater depth
  - Read background material before proceeding further
  - Persevere and continue on to the third pass

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Keshav's Three-Pass Approach: Step 3

- Several-hour virtual re-implementation of the work
  - Making the same assumptions, recreate the work
  - Identify the paper's innovations and its failings
  - Identify and challenge every assumption
  - Think how you would present the ideas yourself
  - Jot down ideas for future work
- When should you read this carefully?
  - Reviewing for a conference or journal
  - Giving colleagues feedback on a paper
  - Understanding a paper closely related to your research
  - Deeply understanding a classic paper in the field

http://ccr.sigcomm.org/online/?q=node/234　38

Other Tips for Reading Papers

- Read at the right level for what you need
  - "Work smarter, not harder"
- Read at the right time of day
  - When you are fresh, not sleepy
- Read in the right place
  - Where you are not distracted, and have enough time
- Read actively
  - With a purpose (what is your goal?)
  - With a pen or computer to take notes
- Read critically
  - Think, question, challenge, critique, …

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Words for Today

- You will learn as much from me as I will learn from you
- Welcome, again!!

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