Welcome to …

TDTS21 Advanced Networking

Niklas Carlsson, Associate Professor
http://www.ida.liu.se/~nikca/

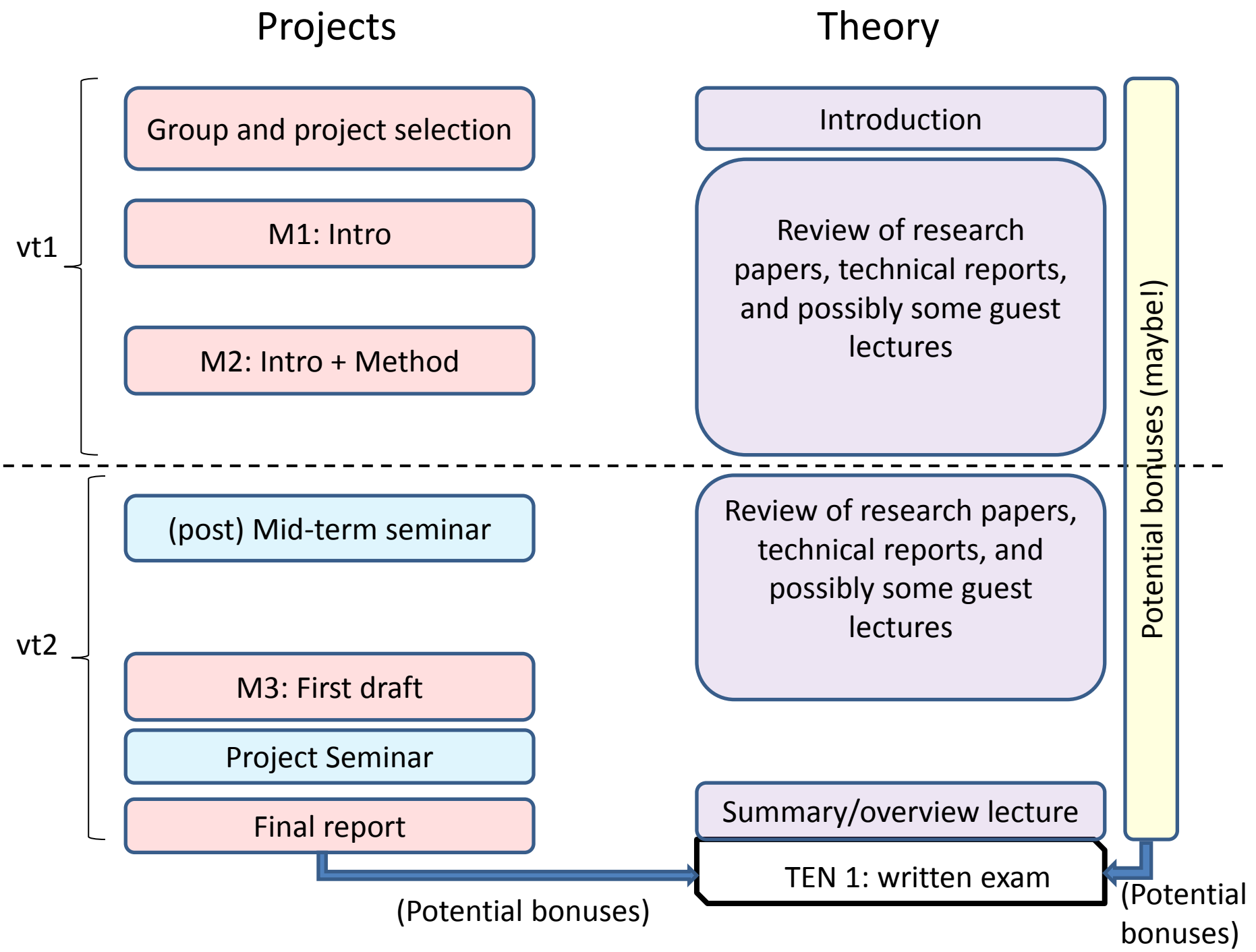
People

- Examiner and lecturer
  - Niklas Carlsson, Associate Professor

    Research area: Design, modeling, and performance evaluation of distributed systems and networks
- Course secretary
  - Madeleine Häger Dahlqvist
- Director of studies
  - Patrick Lambrix

Structure of the Course

- Reading and analyzing research papers
  - Design and evaluation of protocols and applications
  - Summarize, critique, and compare papers
- Classroom time
  - Brief overview of background material
  - Discussion and debate about the research papers
- Research project
  - Milestones and deliverables


Projects
Theory
vt1
Group and project selection
M1: Intro
M2: Intro + Method
Introduction
Review of research papers, technical reports, and possibly some guest lectures
Potential bonuses (maybe!)
vt2
(post) Mid-term seminar
M3: First draft
Project Seminar
Final report
Review of research papers, technical reports, and possibly some guest lectures
Summary/overview lecture
TEN 1: written exam
(Potential bonuses)
(Potential bonuses)

Example: Research paper lectures

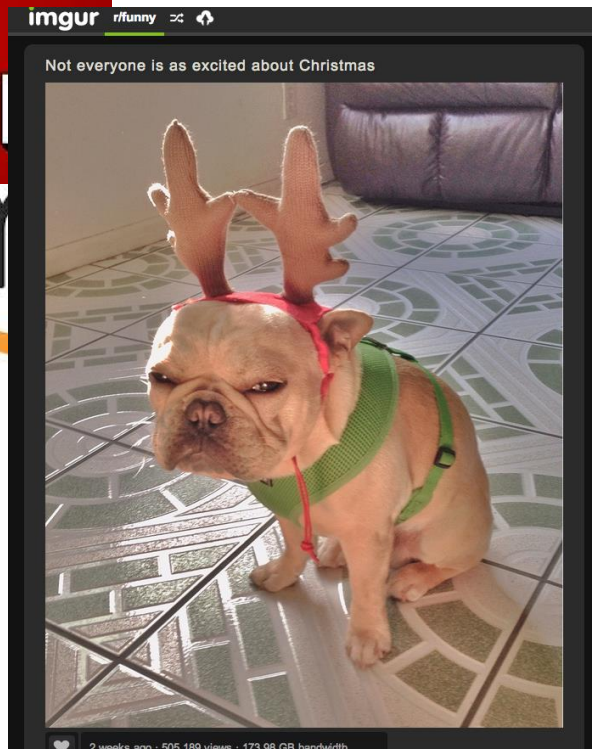
- Overview (some introduction to topic)
- Discussion of research papers
  - Expected to have read at different depths
  - Typically, roughly one “deep” read and one “lighter” read per week
- Lead the discussion for some paper(s)
  - You will not be alone: At least, two students will be assigned per such discussion paper

Why Take This Course?

- How many of you have checked your e-mail, FB, text …
  - Today?
  - In the past hour?
  - Since I started talking?

Computer networks are ubiquitous

- Networks touch every part of our daily life
  - Web search
  - Social networking
  - Watching movies
  - Ordering merchandise
  - Wasting time



…but …

Kick starting science ...

What do you have in the future?

What do you have in the future?

How does it keep going?

… well, cable into wall …

What happens there?

What happens there?

Or maybe more realistically …

- Work at company …

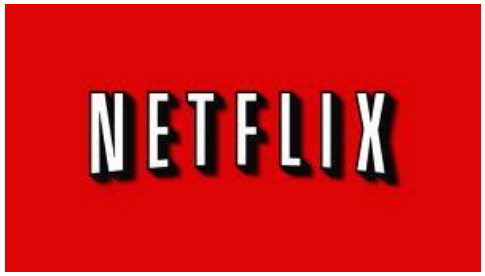
How do we build services that are …

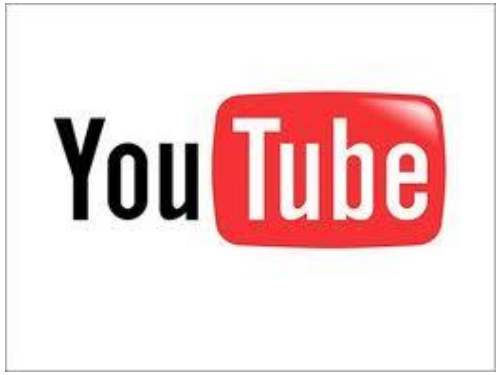
Efficient

Secure

Reliable

Important problem faced every day by many companies, including …



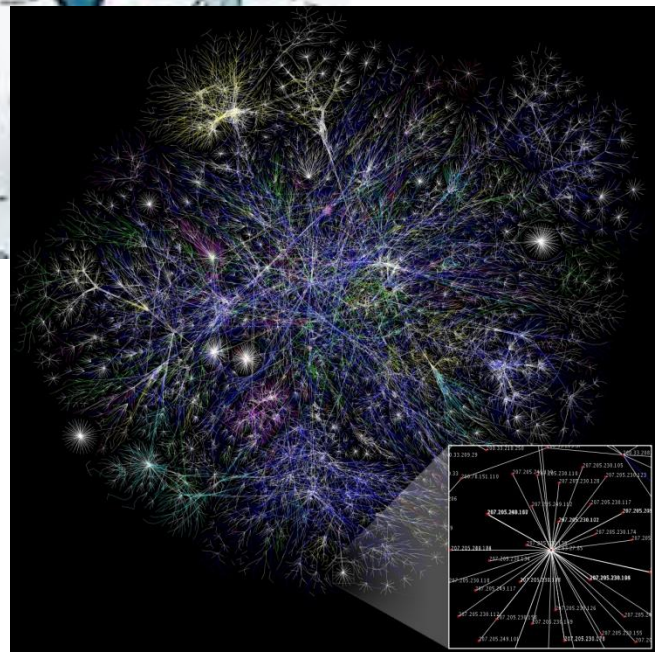


In this course we will look at things such as …

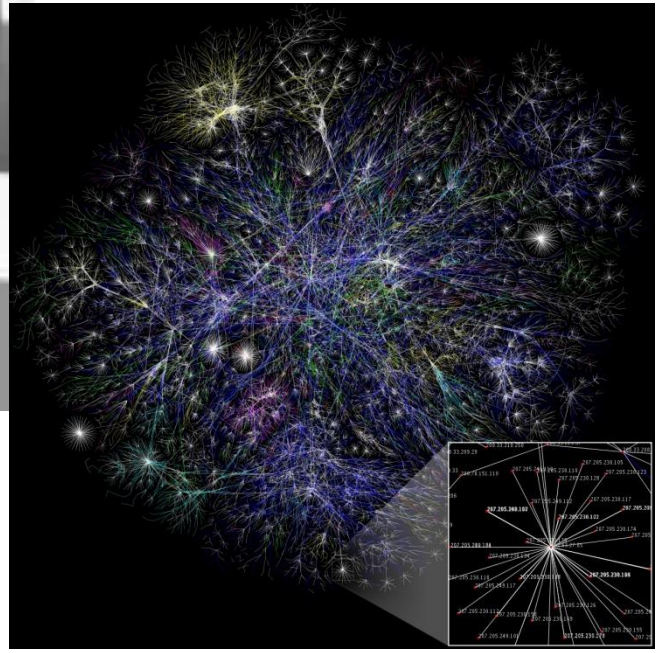
How do we build scalable, efficient, secure, and reliable services?

How do we communicate with a machine across the world?

How do we find out who to talk to?



How do we find a path?



How do we **avoid sending too much** for the receiver and network to handle?

What happens at our machine? Inside the network? Along the path?

What happens at our machine? Inside the network? Along the path?

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: nearly 3 billion users
  - Tomorrow: more users, computers, things, …
- Near-constant innovation
  - Apps: Web, P2P, social networks, virtual worlds
  - Links: optics, WiFi, cellular, WiMax, ...

Transforming Everything

- The ways we do business
  - E-commerce, advertising, cloud computing, ...
- The way we have relationships
  - E-mail, IM, Facebook, virtual worlds, online dating
- 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

The Study of Networking is Cool

- Tangible, relates to reality
  - Can measure/build things
  - 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,…

The Study of Networking is Cool

- 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, NetFPGA
  - Routing software: Quagga, XORP, and Bird
  - Testbeds: Emulab, PlanetLab, Orbit, GENI, …
  - Measurements: RouteViews, traceroute, Internet2, …

First, let’s look at some of the big players …

Today's service/company landscape include ...

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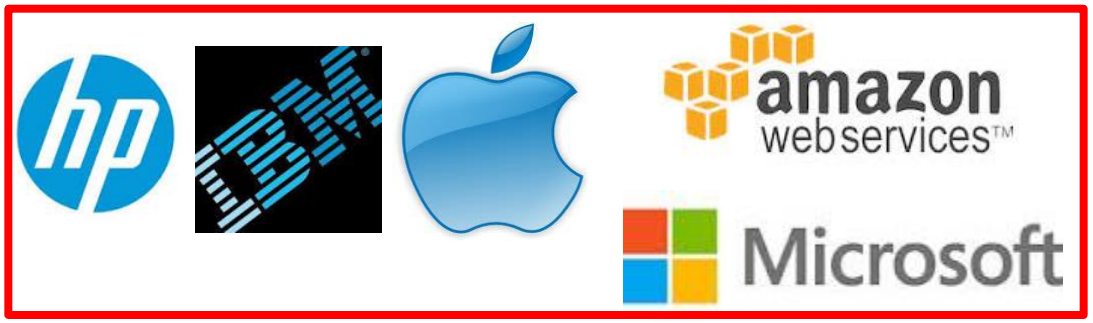
Equipment manufacturers
(also sell services and help
Operate networks)

Today's service/company landscape include ...

Network operators

Equipment manufacturers (also sell services and help Operate networks)

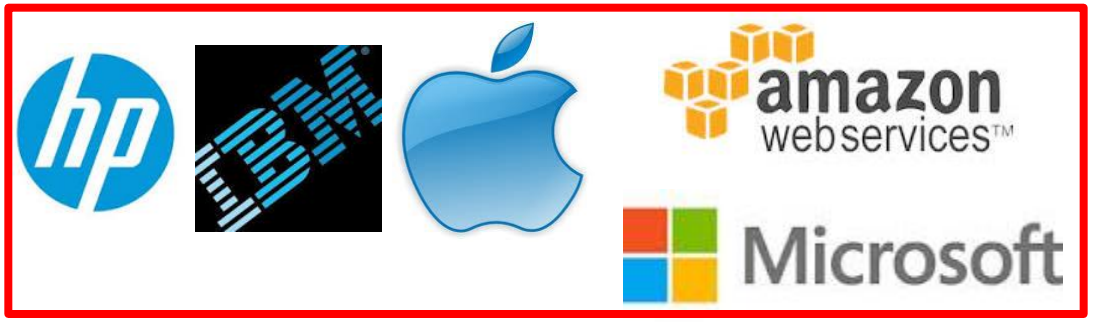
Today's service/company landscape include ...



Enterprise solutions and network service (e.g., data center solutions and cloud providers)

Today's service/company landscape include ...

Content delivery networks



Enterprise solutions and network service (e.g., data center solutions and cloud providers)

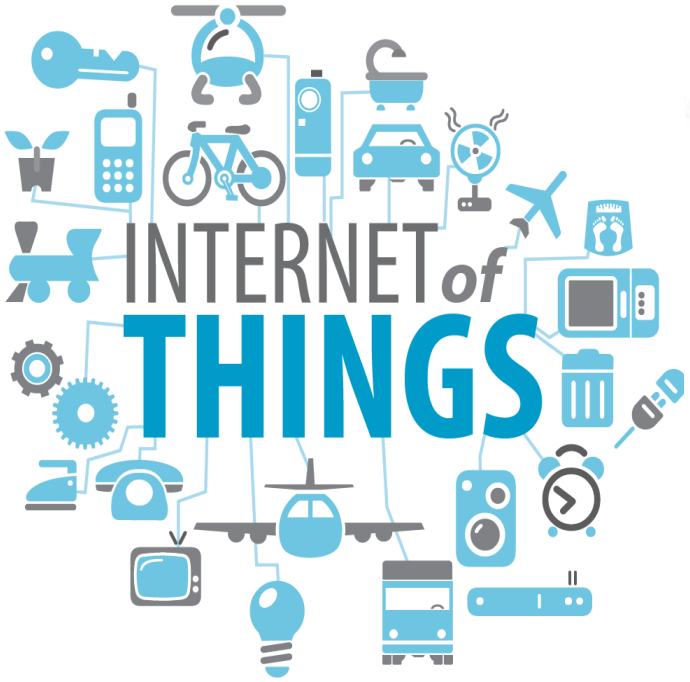
Today's service/company landscape include ...

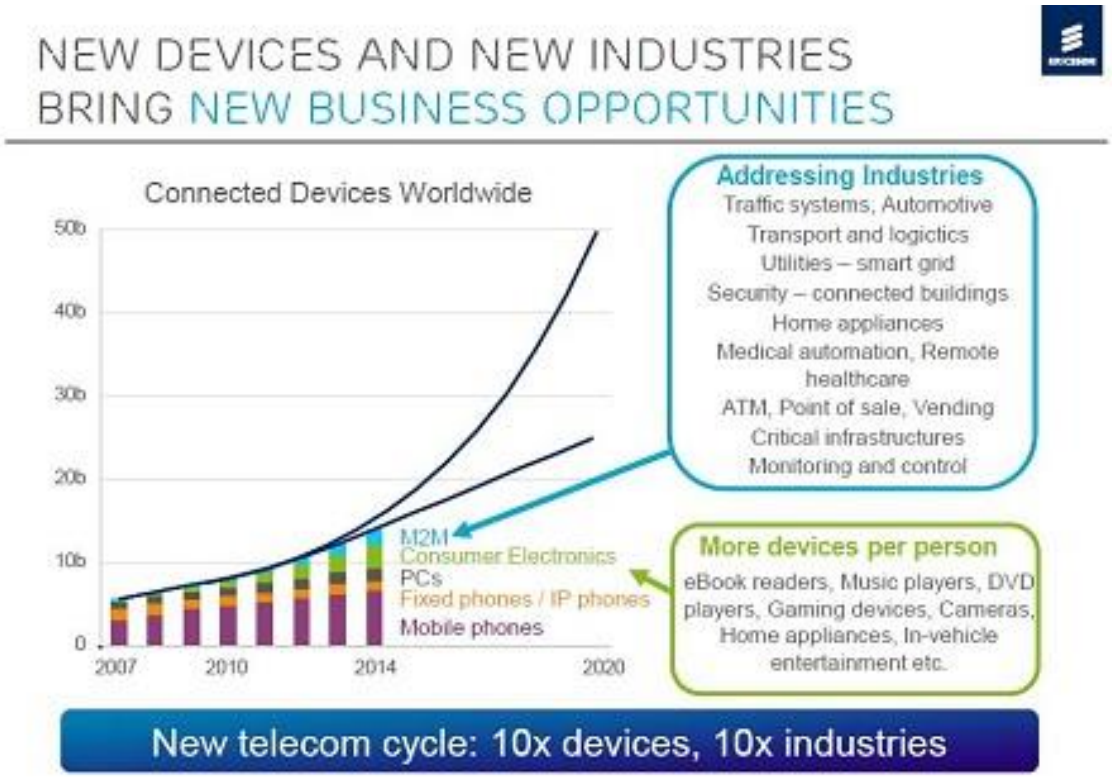
End user services (e.g., web-based social networks, search, communication, and streaming)

Some common applications today …

- World Wide Web (WWW)
- Remote login (telnet, rlogin, ssh)
- File transfer
- Peer-to-peer file sharing
- Cloud computing/services
- Instant messaging (chat, text messaging, etc.)
- Live and video-on-demand streaming
- Internet phone (Voice-Over-IP)
- Distributed games

… and tomorrow





The 2020 vision

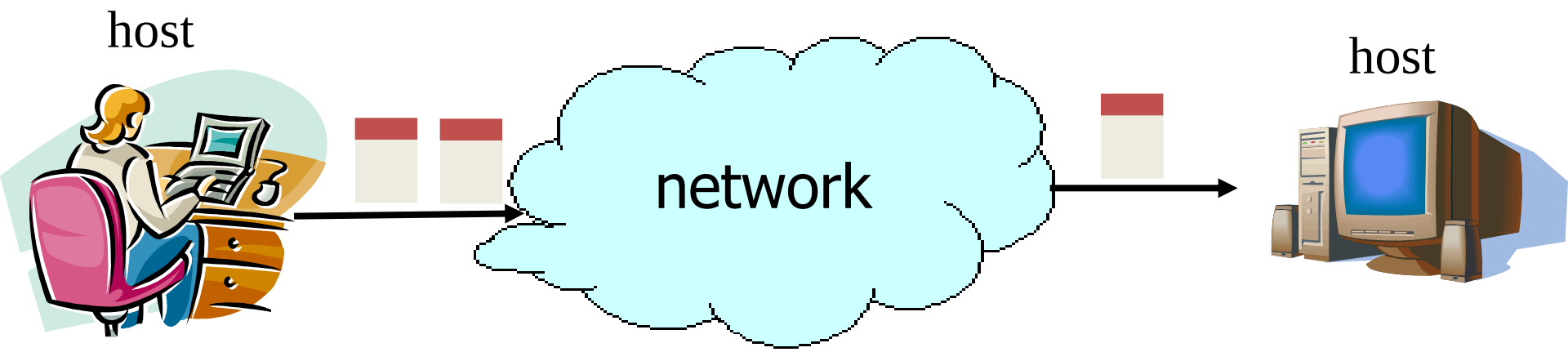
- Everything that can be connected will be connected
  - 50B devices (perhaps more like 500B …)
- IoT and smart cities
  - Machine-to-machine
- High-definition 3D streaming to heterogeneous clients

Best-Effort Packet-Delivery Service

This subset of slides are
Based on slides by Jennifer Rexford

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-Network Interface: Why Packets?

- Data traffic is bursty
  - Logging in to remote machines
  - Exchanging e-mail messages
  - Request webpage
- Don’t want to waste bandwidth
  - No traffic exchanged during idle periods
- Better to allow multiplexing
  - Different transfers share access to same links
- Packets can be delivered by most anything

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

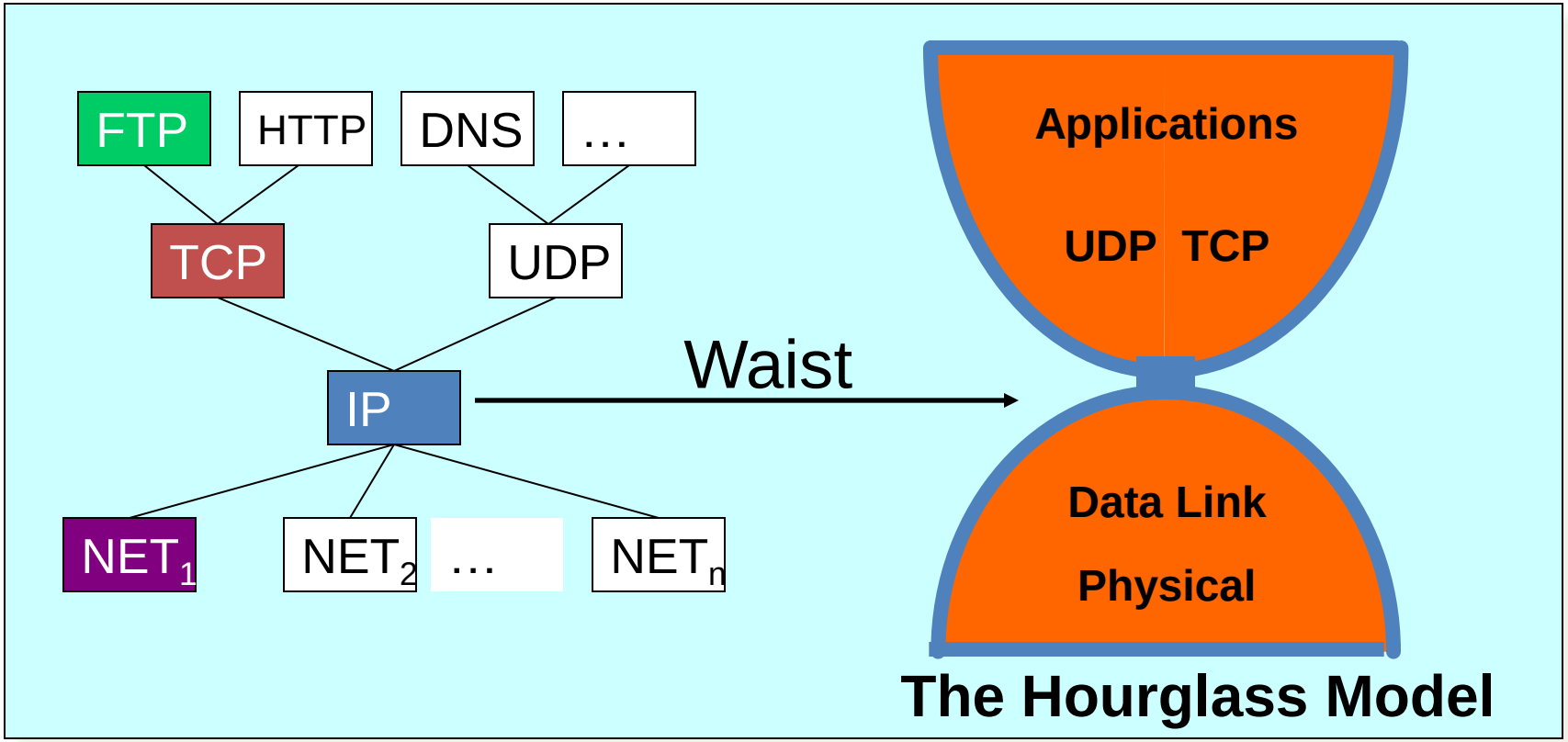
Intermediate Transport Layer

- But, *applications* want efficient, accurate transfer of data in order, in a timely fashion
  - Let the end hosts handle all of that
  - (An example of the "end-to-end argument")
- Transport layer can optionally…
  - Detect and retransmit lost packets
  - Put out-of-order packets back in order
  - Detect and handle corrupted packets
  - Avoid overloading the receiver
  - <insert your requirement here>

Modularity Through Layering

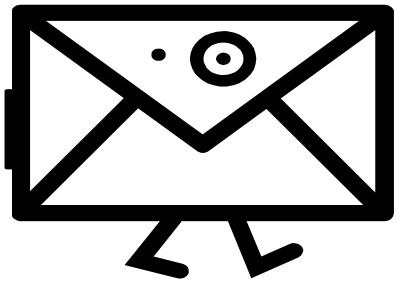
IP Protocol Stack

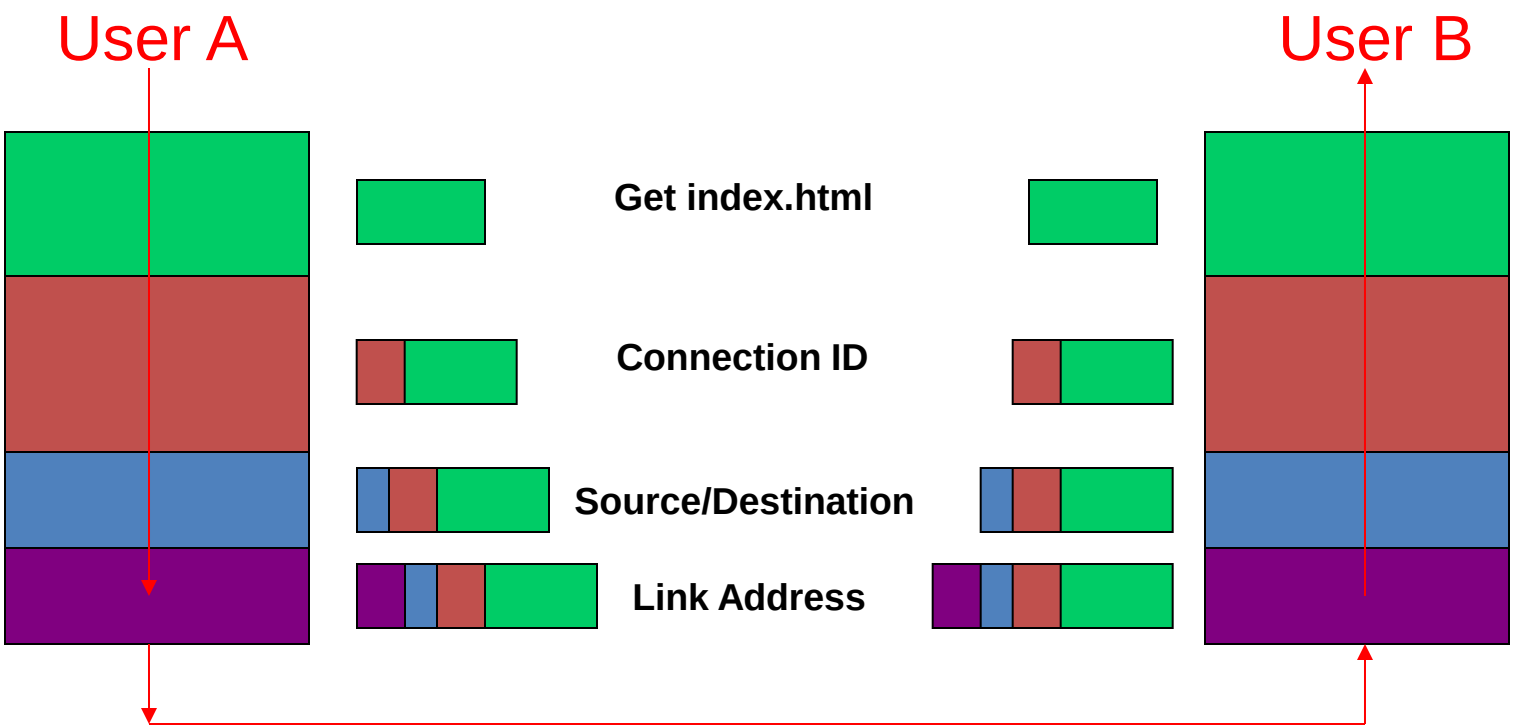
The "Narrow Waist" of IP



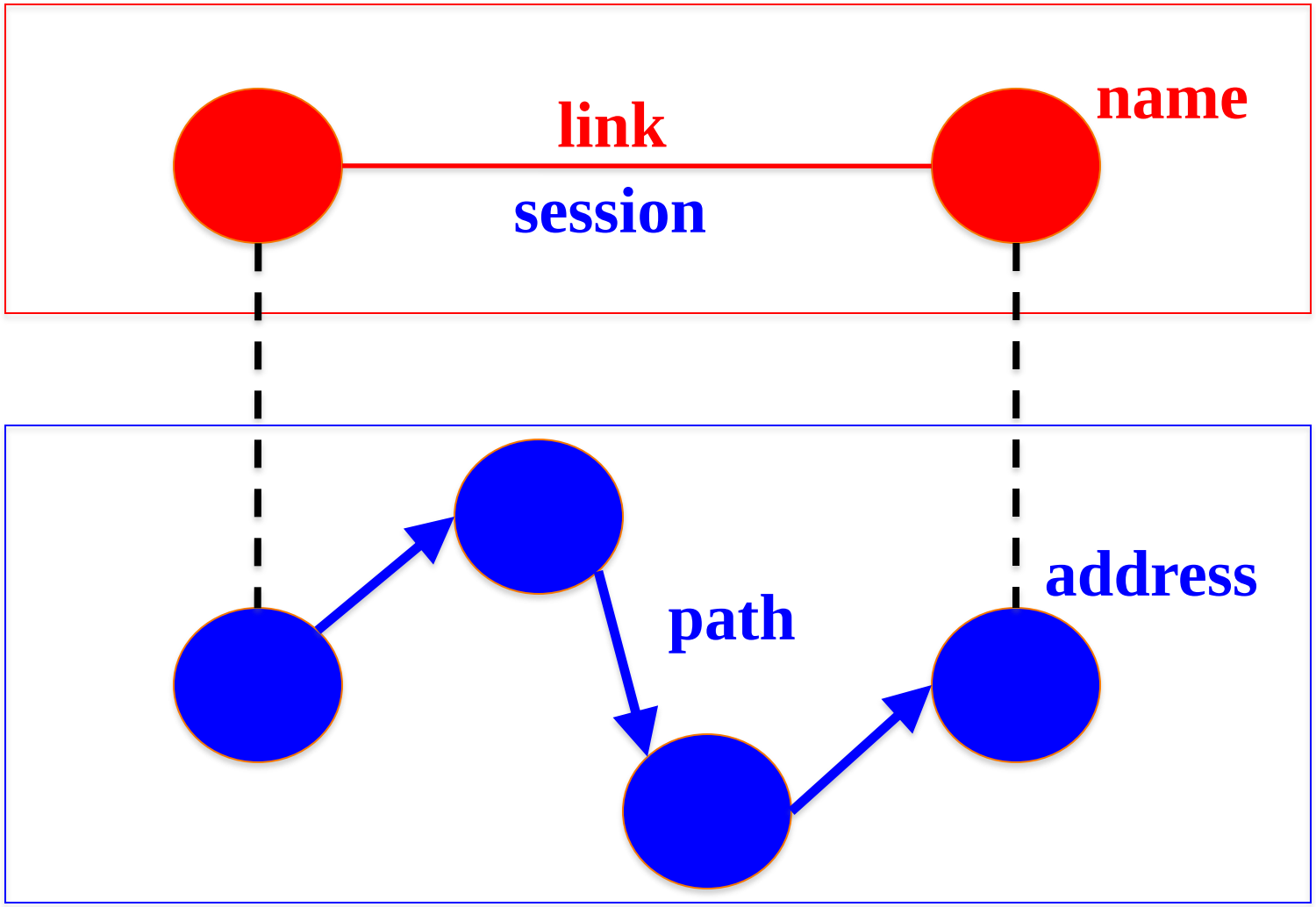
The waist facilitates interoperability

Layer Encapsul

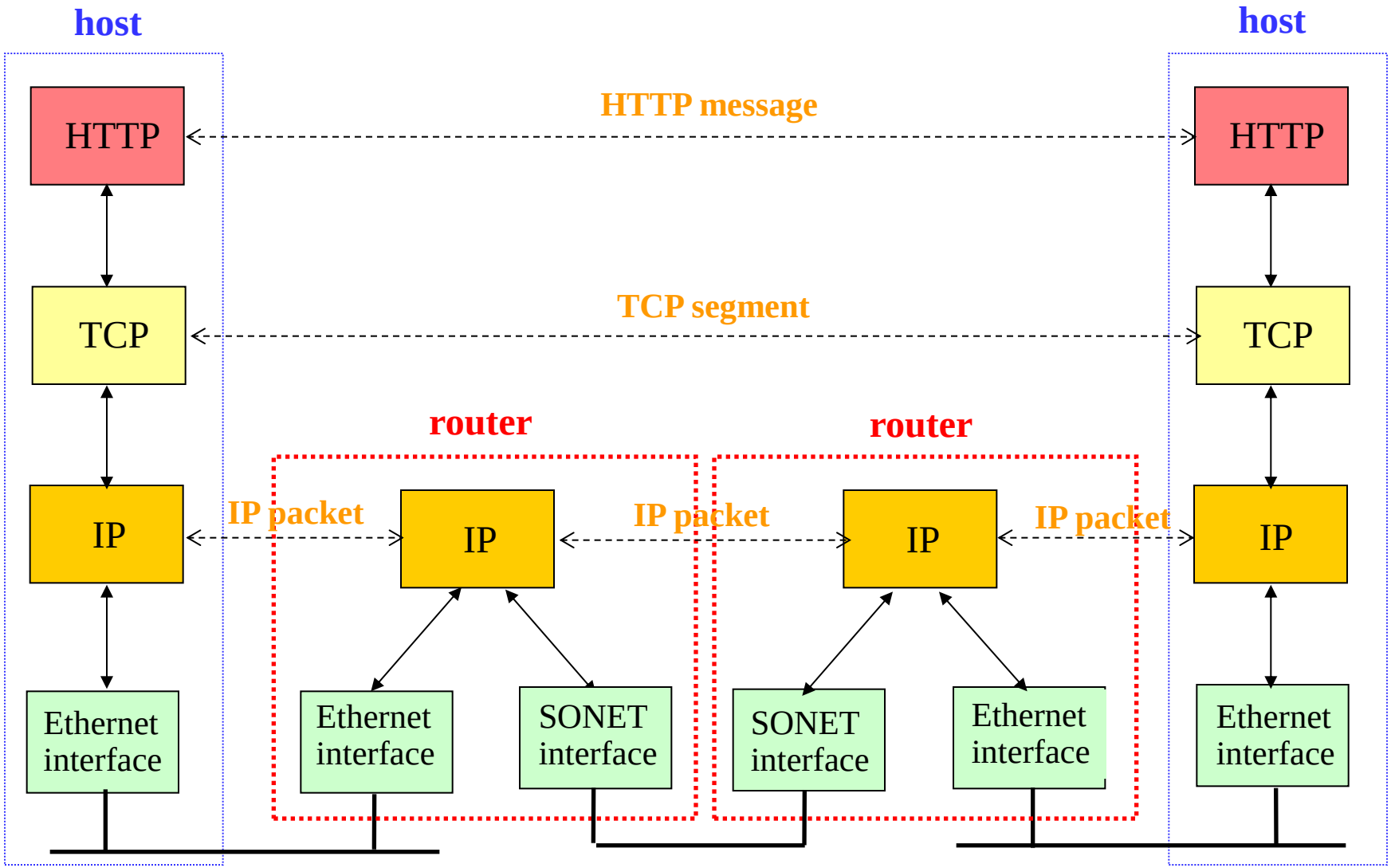




Relationship Between Layers



IP Suite: End Hosts vs. Routers



How to Read

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

This subset of slides are
Based on slides by Jennifer Rexford

You Spend a Lot of Time Reading

- Reading for grad classes
- Reviewing conference submissions
- Giving colleagues feedback
- Keeping up with your field
- Staying broadly educated
- Transitioning into a new areas
- Learning how to write better papers ☺

It is worthwhile to learn to read *effectively*

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…

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 idea
  - Identify whether you can (or should) fully understand
- Decide whether to
  - Abandon reading in greater depth
  - Read background material before proceeding further
  - Persevere and continue for a third pass

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

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, …

Again, research paper lectures

- Overview (some introduction to topic)
- Discussion of research papers
  - Primary: At least “three-pass read”
  - Secondary: At least “two-pass read”
  - Optional: At least “one-pass read”
- Lead the discussion for some paper(s)
  - You will not be alone: At least, two students will be assigned per such discussion paper
  - Expected to have done at least “three-pass read”