



CSCI 4273/5273: Network Systems

Sangtae Ha

Fall 2015

Lectures: T/TH 11-12:15pm in ECCS 1B12

Teaching Assistants: Ranga Dheeraj Chinni

<http://ngn.cs.colorado.edu/~sangtaeha/courses/csci4273/fall15/>

Note: The slides are adapted from the materials from Prof. Richard Han at CU Boulder and Profs. Jennifer Rexford and Mike Freedman at Princeton University.

What You Learn in This Course

- **Knowledge:** how the Internet works
 - IP protocol suite
 - Internet architecture
 - Applications (Web, E-Mail, DNS, P2P, VoIP, ...)
- **Insight**
 - Protocols
 - Layering
 - Resource allocation
 - Naming
- **Skill:** network programming
 - Socket Programming
 - Basis for designing and implementing network systems

Learning the Material: People

- **Lecture**

- When: TTH 11:00-12:15pm in ECCS 1B12
- Office hours: TTH 12:30-1:30pm, and by appointment
- <http://ngn.cs.colorado.edu/~sangtaeha/courses/csci4273/fall15/>

- **Student Assistant**

- Ranga Dheeraj Chinni
 - Office hours: TBD
 - Email: Ranga.Chinni@Colorado.EDU

- **Education Officer**

- Required for distance students (if you are in campus, you do not need proctors)

Grading and Schedule

- 4 programming assignments (40% total)
 - Assignments 1 & 2 before the midterm
 - Assignments 3 & 4 before the final
- 2 exams (45% total)
 - Midterm exam on Oct. 20 (20%)
 - Final exam on Sunday, Dec. 14 (25%)
- 2 labs (5 % total)
 - Optional for distance students (but happy to accommodate labs if you are in campus)
- 5 problem sets (10 % total)
- No class on Sept. 15
- **No late HW, lab report, and assignment are accepted**

Policies: Write Your Own Code

Programming in an individual creative process.

While thinking about a problem, discussions with friends are encouraged. However, when the time comes to write code that solves the problem, the program must be your own work.

If you have a question about how to use some feature of C, UNIX, etc., you can certainly ask your friends or the TA, but **do not, under any circumstances, copy another person's program.**

Letting someone copy your program or using someone else's code in any form is a **violation of academic regulations.**

Policies

- **Disability Services:**

- If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs may be addressed.
(303-492-8671, www.Colorado.edu/disabilityservices)

- **Religious Observance:**

- I encourage students to notify me of anticipated conflicts as early in the semester as possible so that there is adequate time to make necessary arrangements.
(www.colorado.edu/policies/fac_relig.html)

- **Discrimination and Harassment**

- (303-492-2127, www.colorado.edupoliciesdiscrimination.html)

The Internet is an Exciting Place

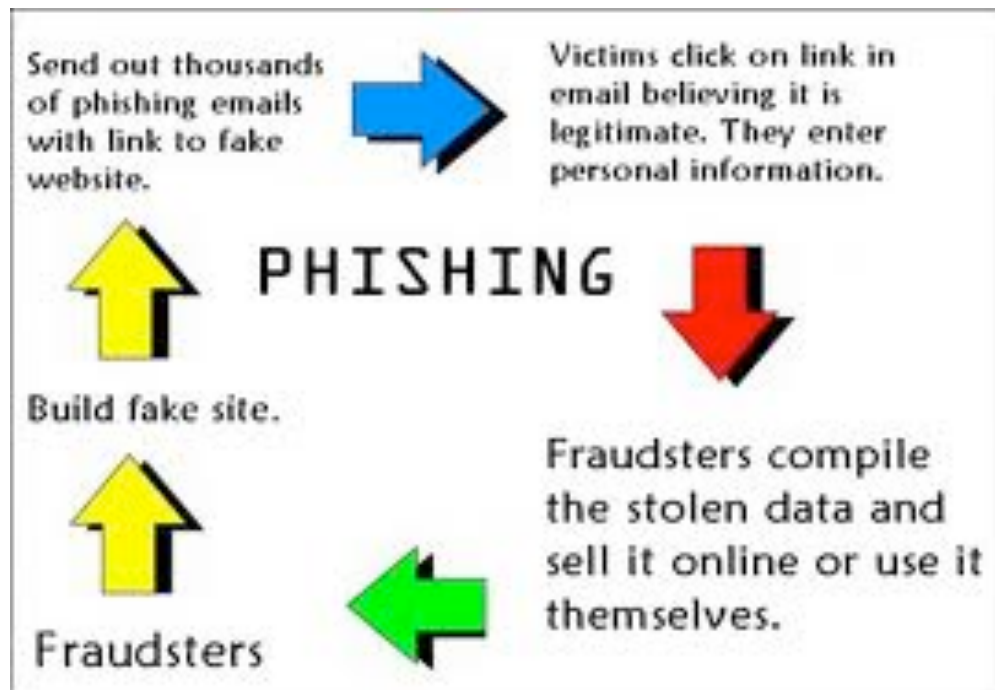
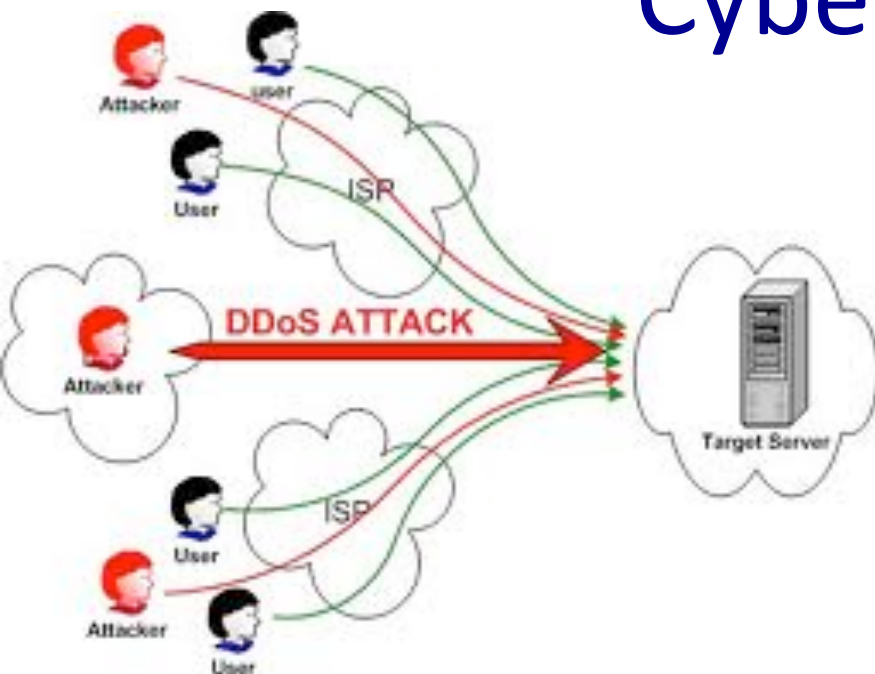
Internet growth

World Regions	Internet Users (Dec 31, 2000)	Internet Users (June 30, 2012)
Asia	114 M	1077 M
Europe	105 M	519 M
North America	108 M	274 M
Latin America / Caribbean	18 M	255 M
Africa	5 M	167 M
Middle East	3 M	90 M
Oceania / Australia	8 M	24 M
World Total	361 M	2406 M

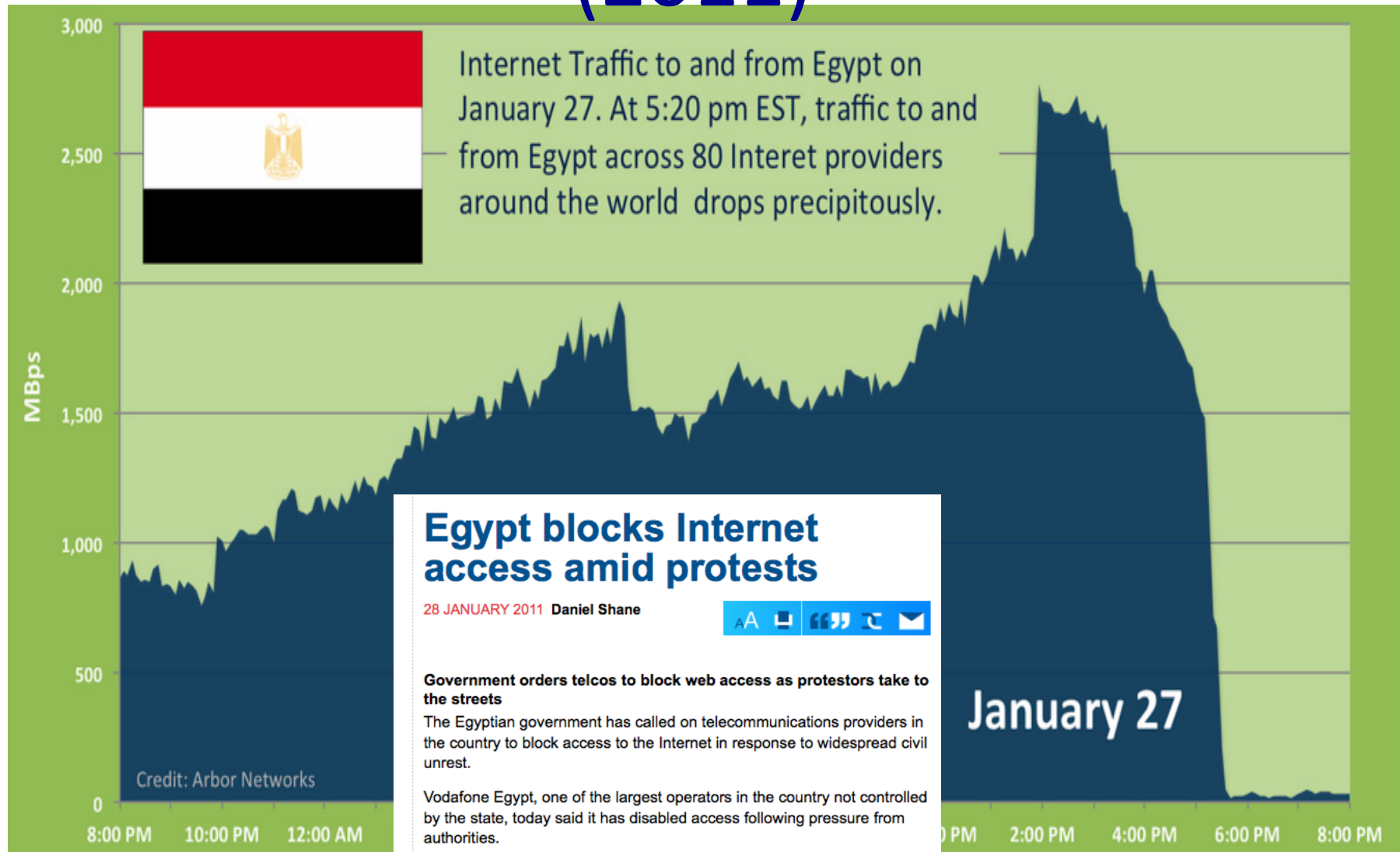
How does the design of the
Internet support **growth** and
foster **innovation**?

The Internet is a Tense Place

Cyber Attacks



Internet Traffic to/from Egypt (2011)



Stop Online Piracy Act (SOPA)



1 Block access to infringing domain names

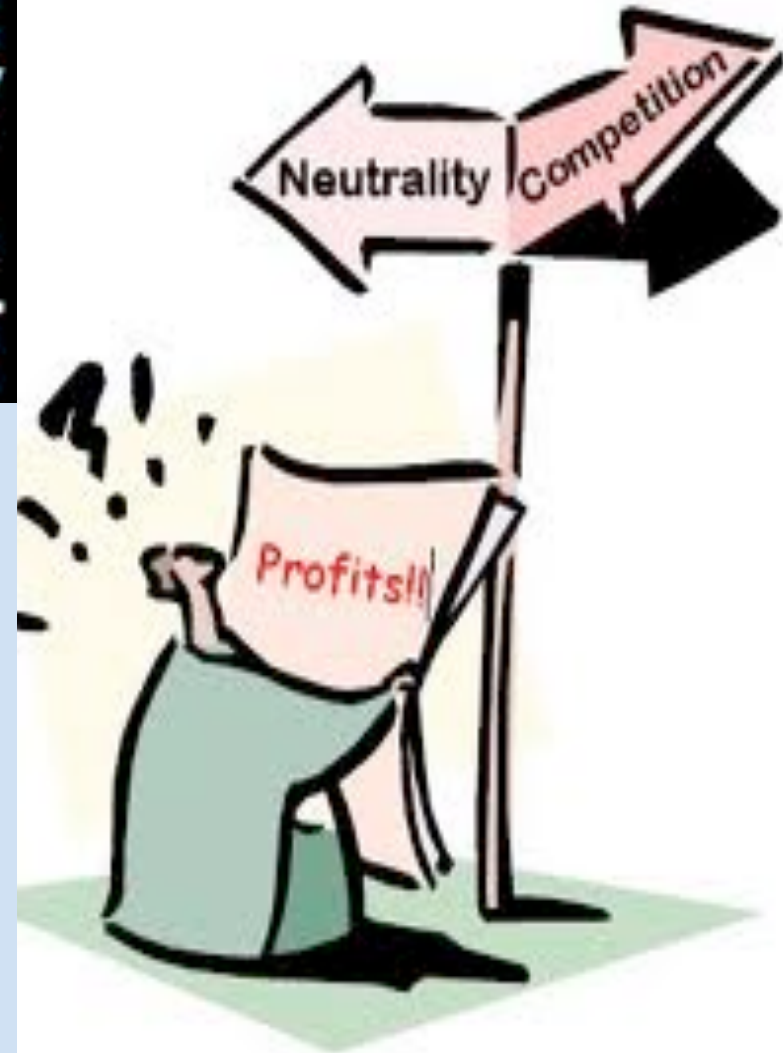


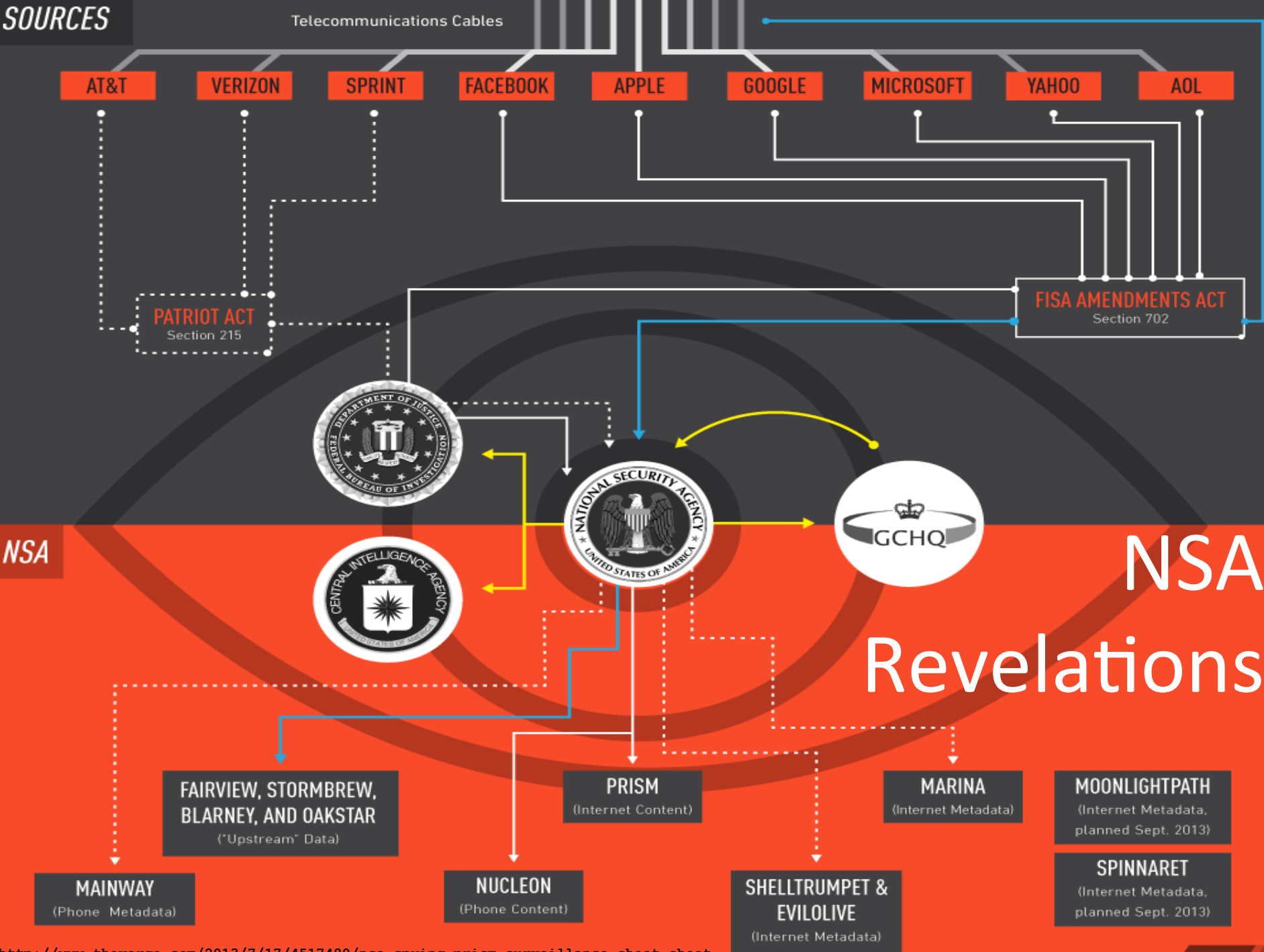
Network Neutrality



FCC Rules Against Comcast P2P Throttling

The U.S. Federal Communications Commission has ordered Comcast to stop interfering with peer-to-peer traffic on its broadband network





How does the design of
the Internet **create** or
exacerbate these tensions?

What *is* the Internet?

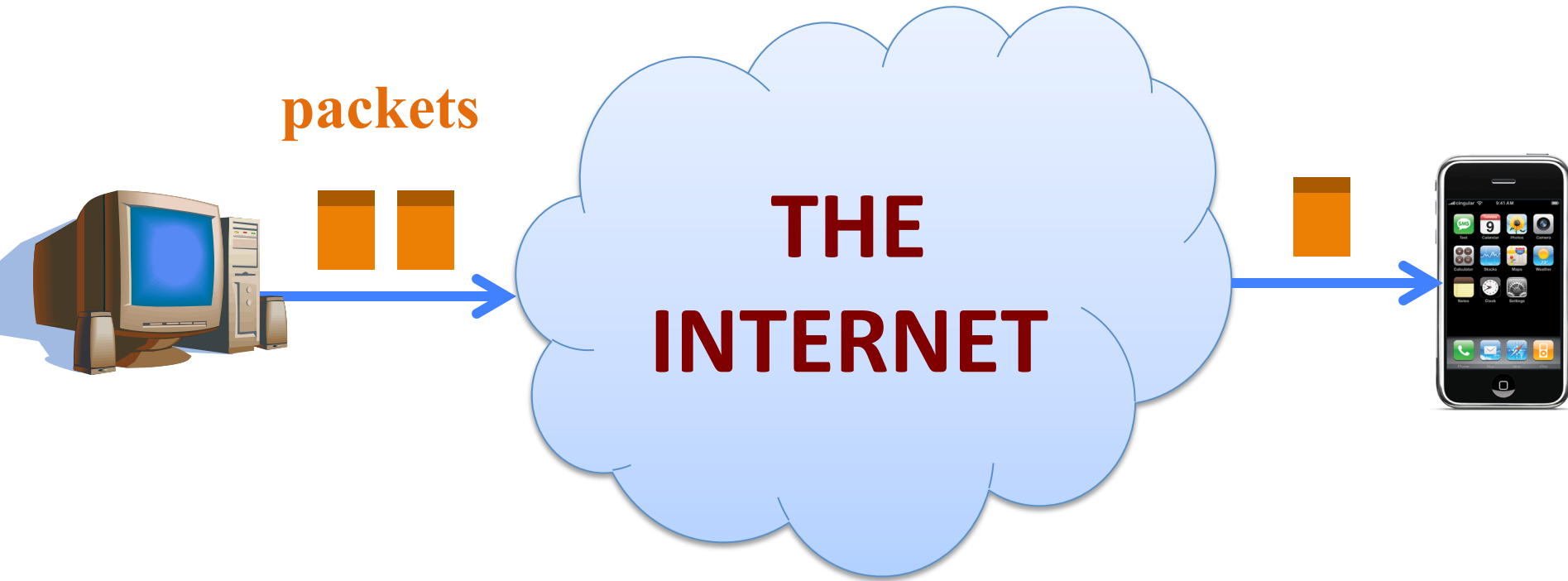
Wikipedia

The Internet is the worldwide, **publicly accessible** network of interconnected computer networks that transmit data by **packet switching** using the **standard** Internet Protocol (IP).

It is a "**network of networks**" that consists of millions of smaller domestic, academic, business, and government networks, which together carry **various information and services**.

<http://en.wikipedia.org/wiki/Internet>

“Best-Effort Packet Delivery Service”

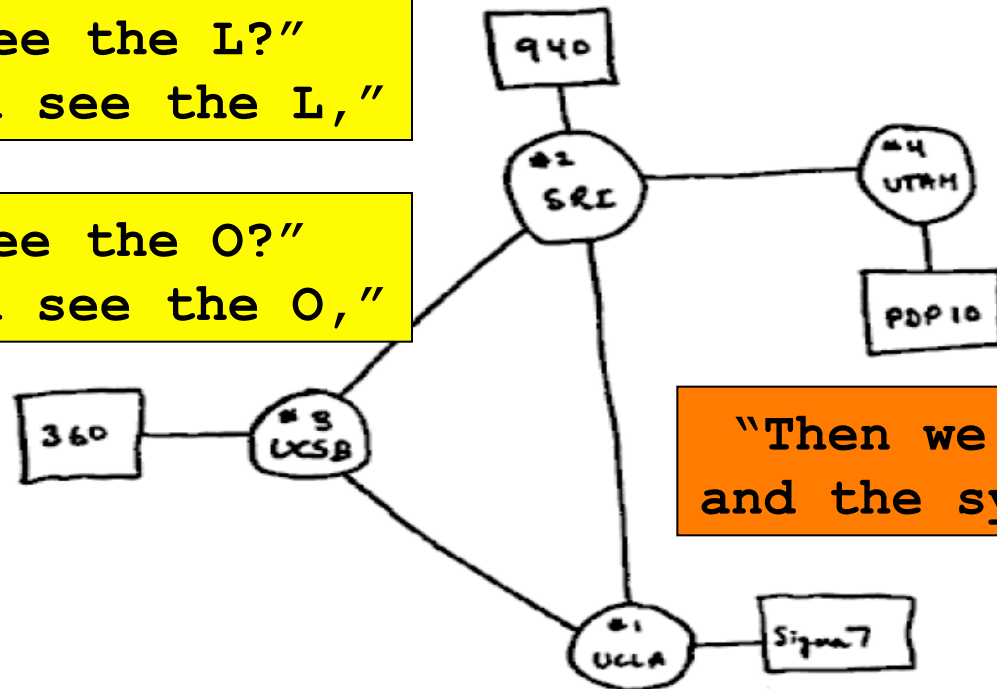


Why “Internet”

- Network of networks
- Standardized format and protocols for speaking between HETEROGENEOUS networks

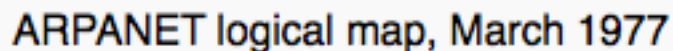
“Do you see the L?”
“Yes, we can see the L,”

“Do you see the O?”
“Yes, we can see the O,”

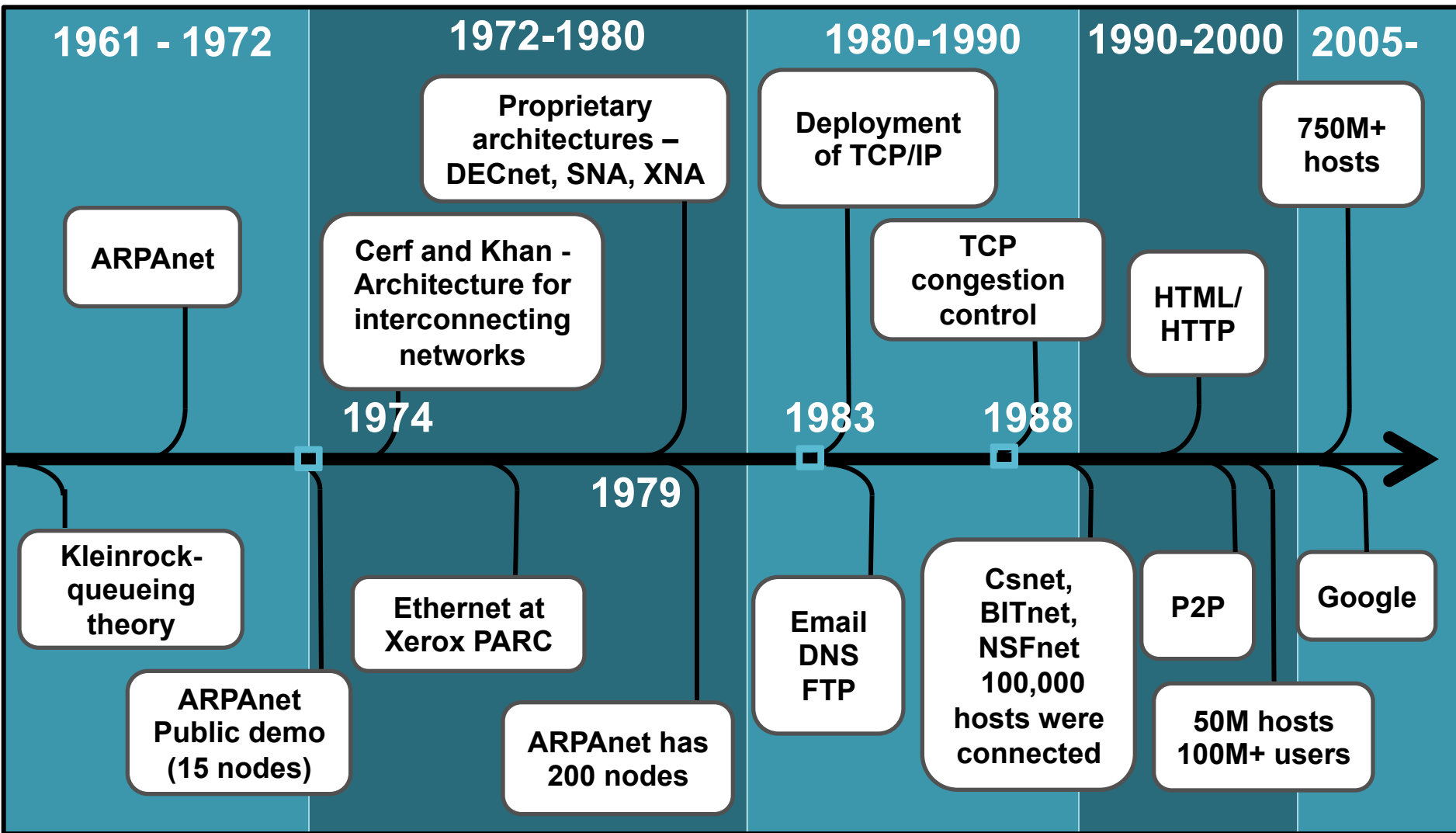


“Then we typed the G,
and the system crashed”

- Network of networks
- Standardized format and protocols for speaking between HETEROGENOUS networks



Internet History



Power at the Edge

End-to-End Principle

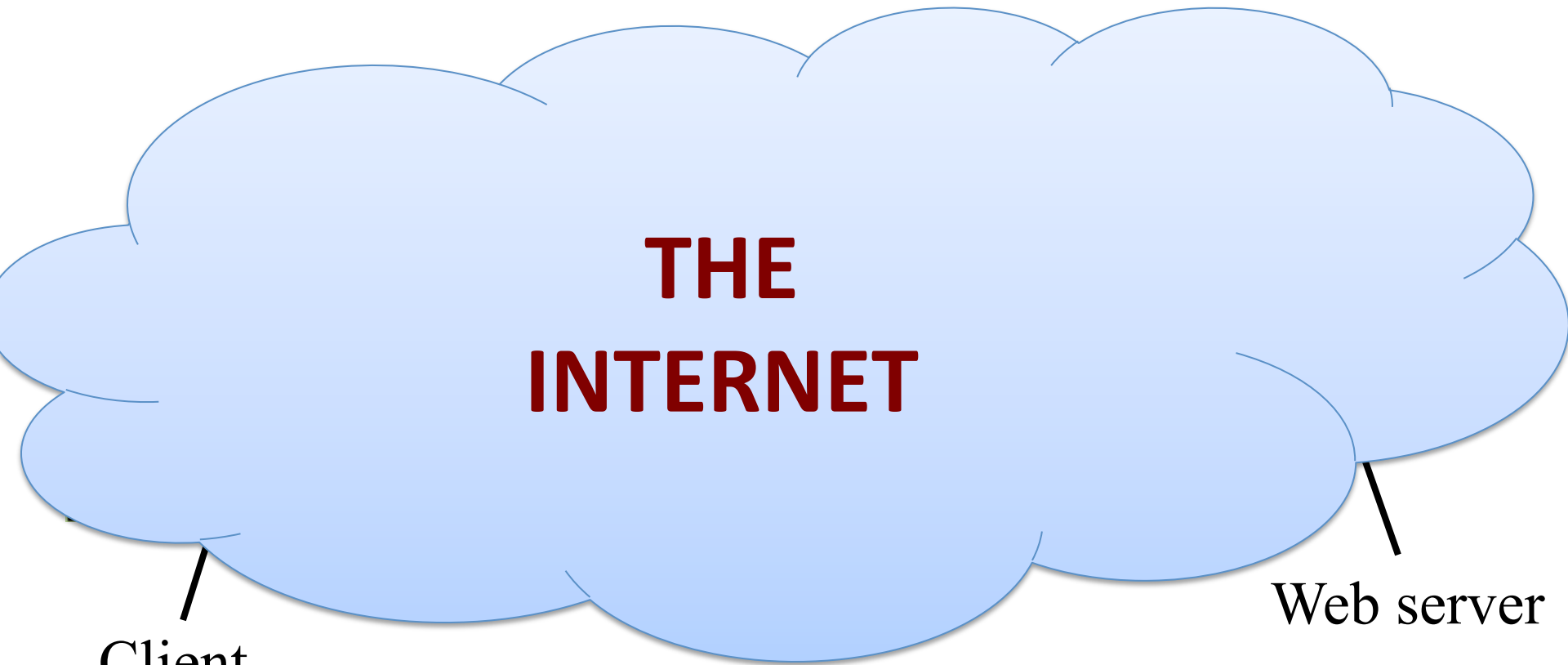
Whenever possible, communications protocol operations should be defined to occur at the **end-points** of a communications system.

Programmability

With programmable end hosts, new network services can be added at **any time, by anyone**.

And end hosts became powerful and ubiquitous....

“A Network of Networks”

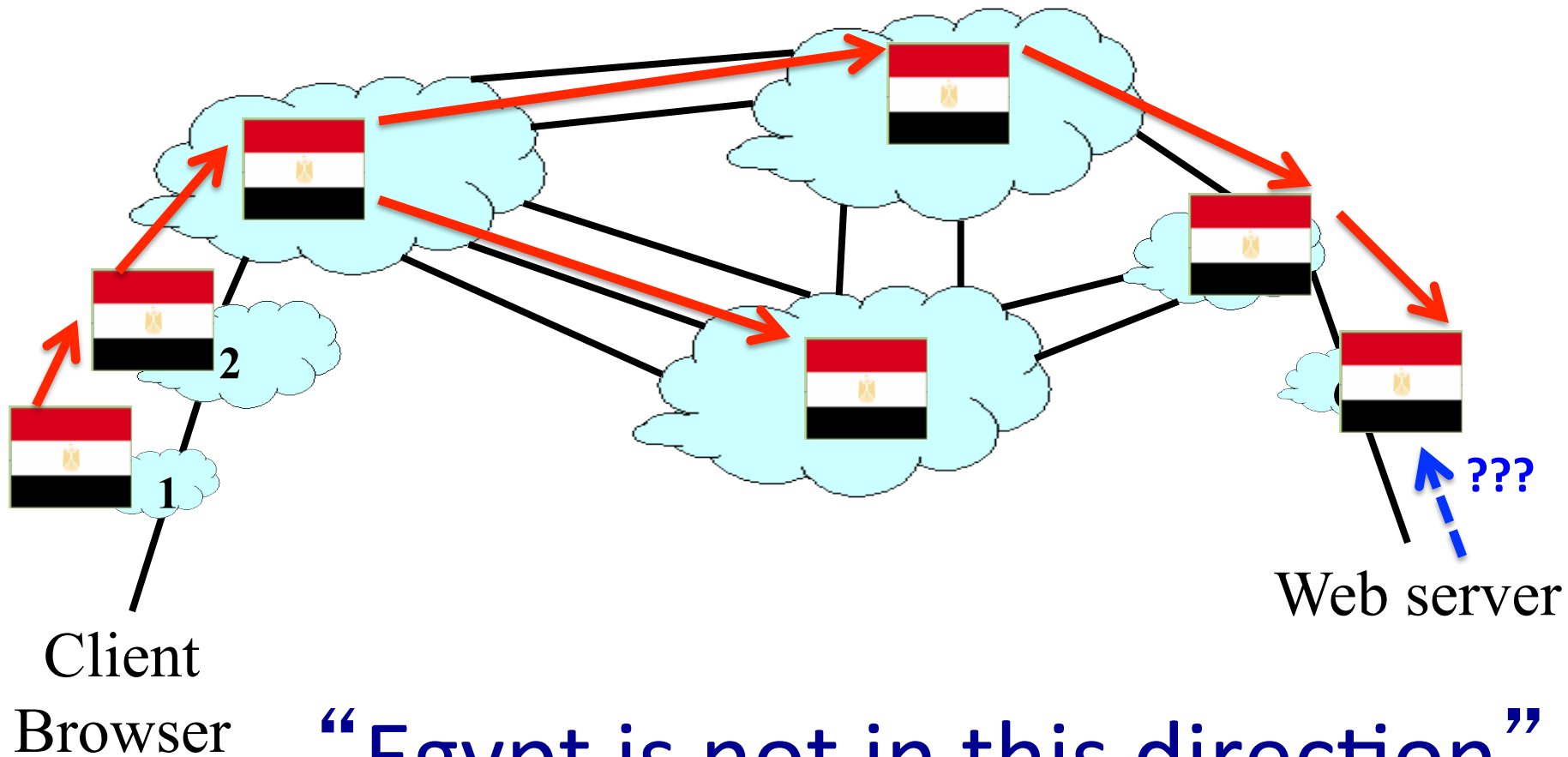


Client
Browser

Web server

- How do you name?
- How do you find a name?

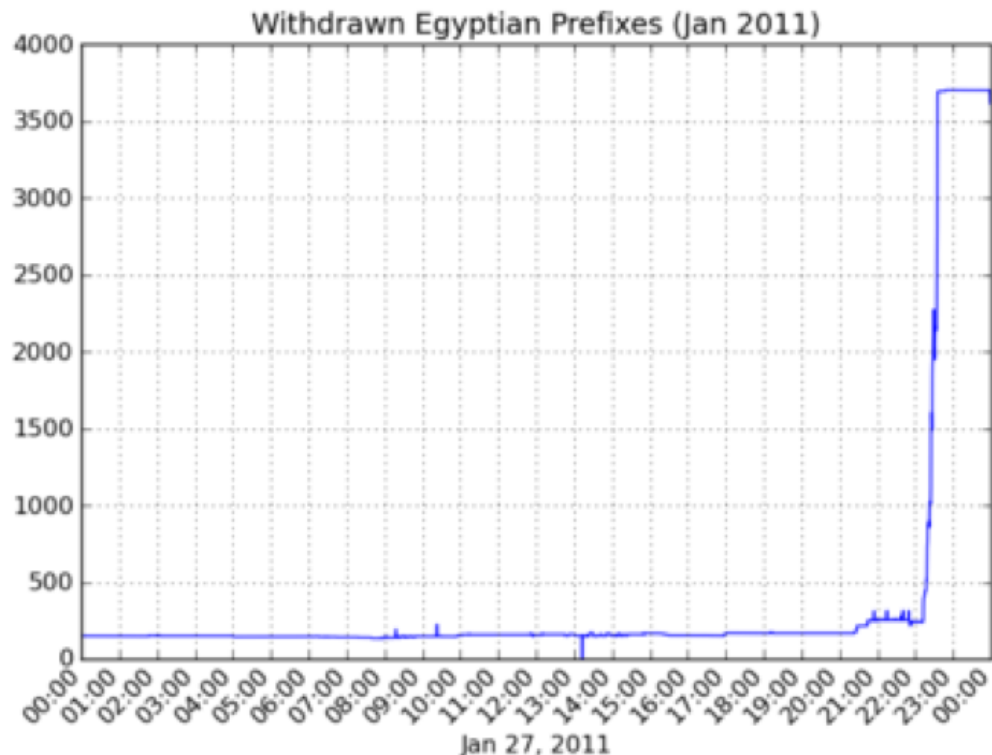
Withdrawing a traffic route



Egypt Leaves the Internet

By James Cowie on January 27, 2011 7:56 PM

At 22:34 UTC (00:34am local time), Renesys observed the virtually simultaneous withdrawal of all routes to Egyptian networks in the Internet's global routing table. Approximately 3,500 individual BGP routes were withdrawn, leaving no valid paths by which the rest of the world could continue to exchange Internet traffic with Egypt's service providers. Virtually all of Egypt's Internet addresses are now unreachable, worldwide.



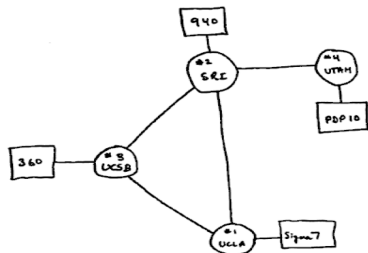
Central concepts in networking

Key Concepts in Networking

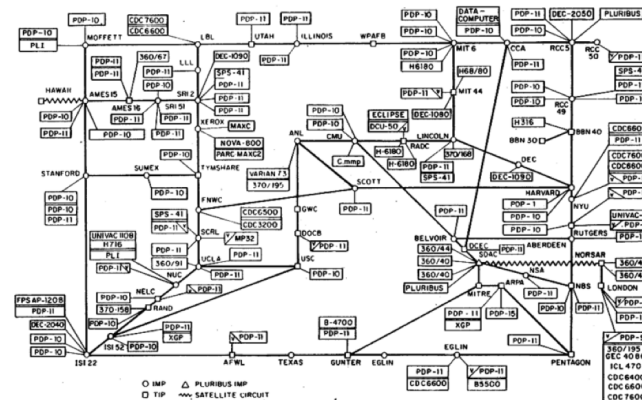
- **Protocols**
 - Speaking the same language
 - Syntax and semantics
- **Layering**
 - Standing on the shoulders of giants
 - A key to managing complexity
- **Resource allocation**
 - Dividing scarce resources among competing parties
 - Memory, link bandwidth, wireless spectrum, paths,
- **Naming**
 - What to call computers, services, protocols, ...

Key Concepts in Networking

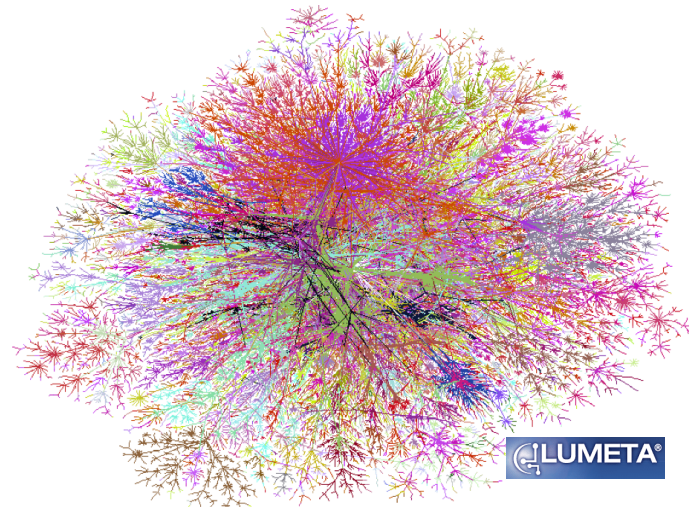
- **Protocols**
 - Speaking the same language
 - Syntax and semantics



1969



1977



1998

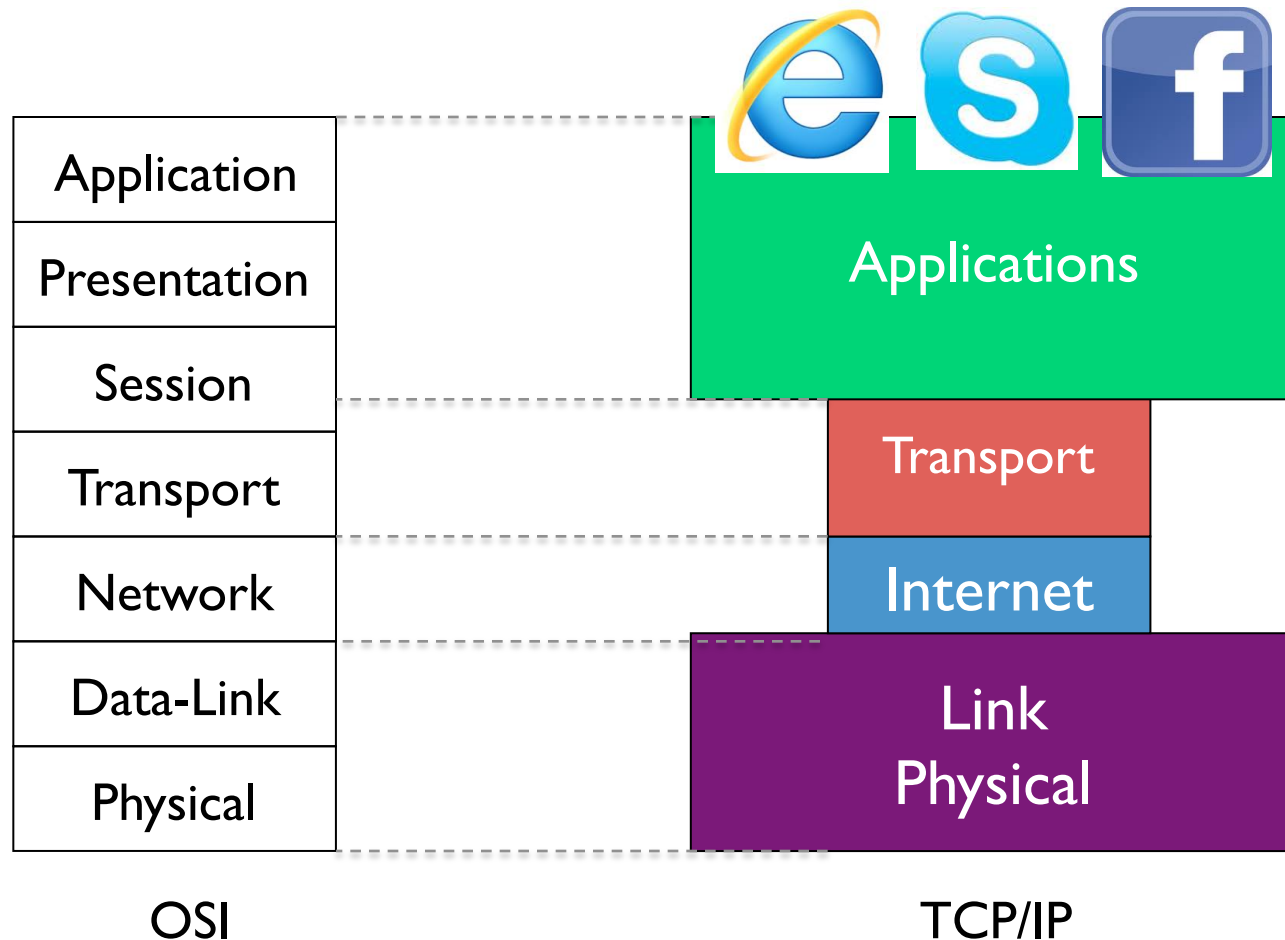
All speak IPv4
“Internet Protocol version 4”

Key Concepts in Networking

- **Protocols**
 - Speaking the same language
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- **Layering**
 - Standing on the shoulders of giants
 - A key to managing complexity

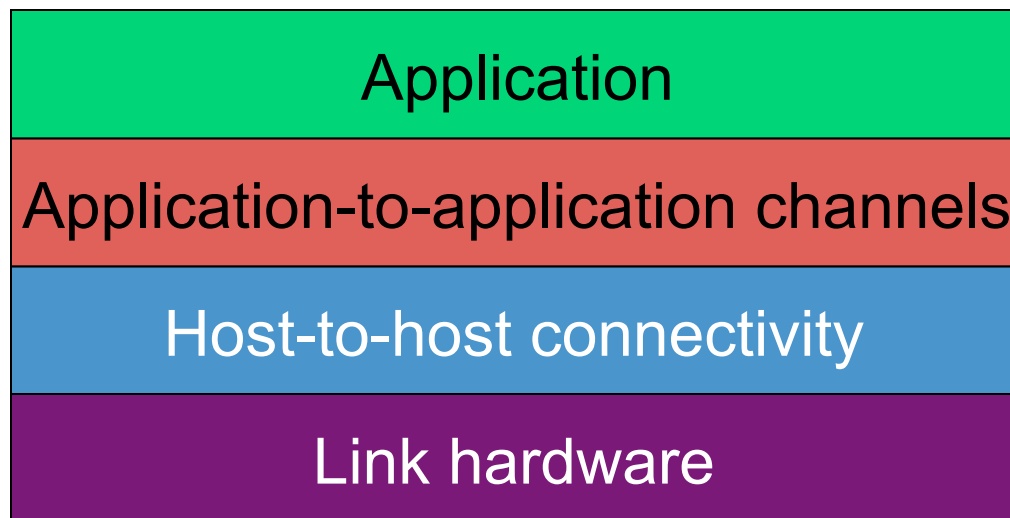
The Layered Network Stack

- The OSI Model vs. TCP/IP Model

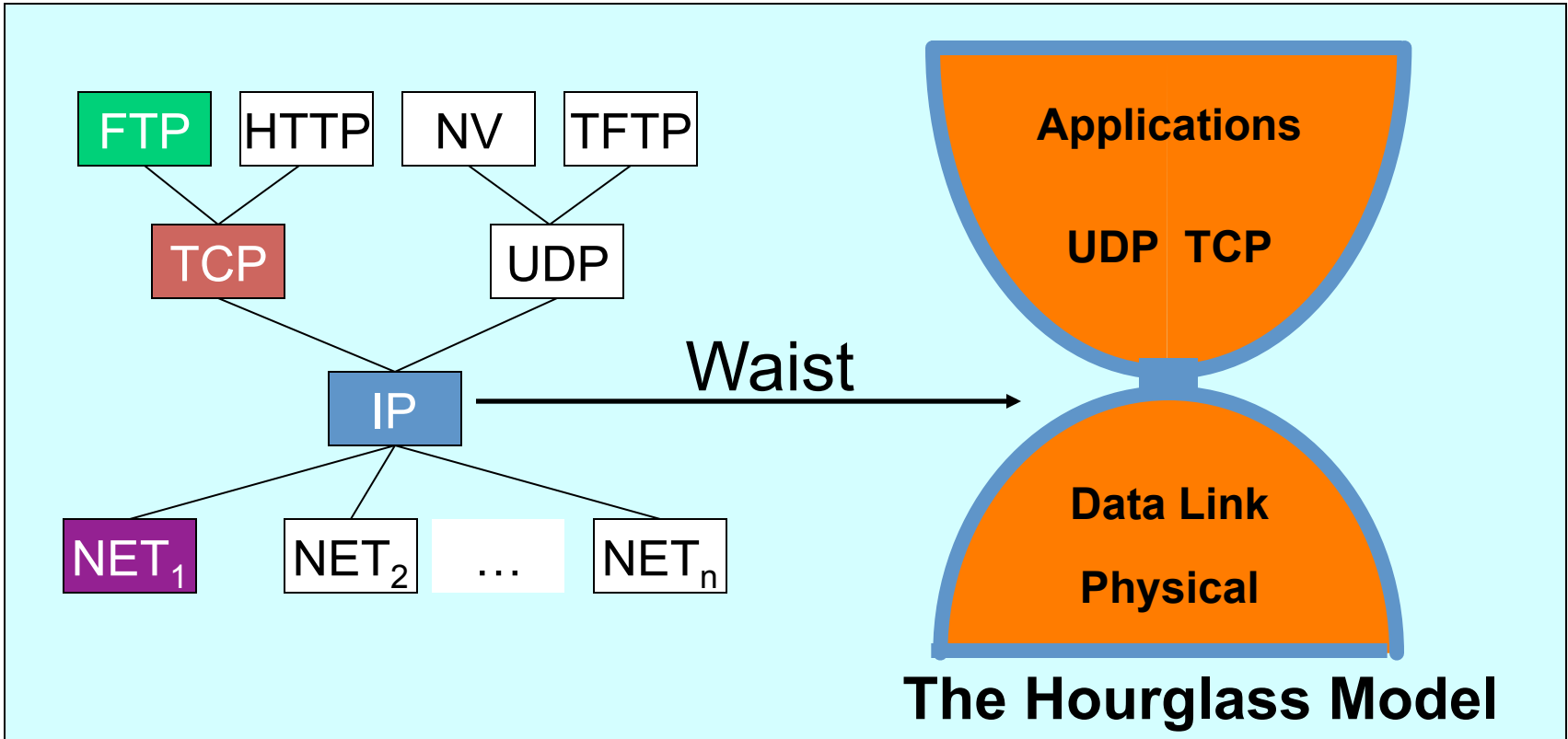


Layering = Functional Abstraction

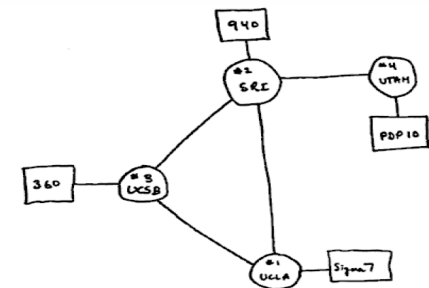
- Sub-divide the problem
 - Each layer relies on services from layer below
 - Each layer exports services to layer above
- Interface between layers defines interaction
 - Hides implementation details
 - Layers can change without disturbing other layers



The Internet Protocol Suite



The waist facilitates interoperability



Example: HyperText Transfer Protocol

GET /courses/csci4273/fall15/ HTTP/1.1

Host: www.cs.colorado.edu

User-Agent: Mozilla/4.03

CRLF

Request

HTTP/1.1 200 OK

Date: Mon, 4 Feb 2013 11:09:03 GMT

Server: Netscape-Enterprise/3.5.1

Last-Modified: Mon, 2 Feb 2013 19:12:23 GMT

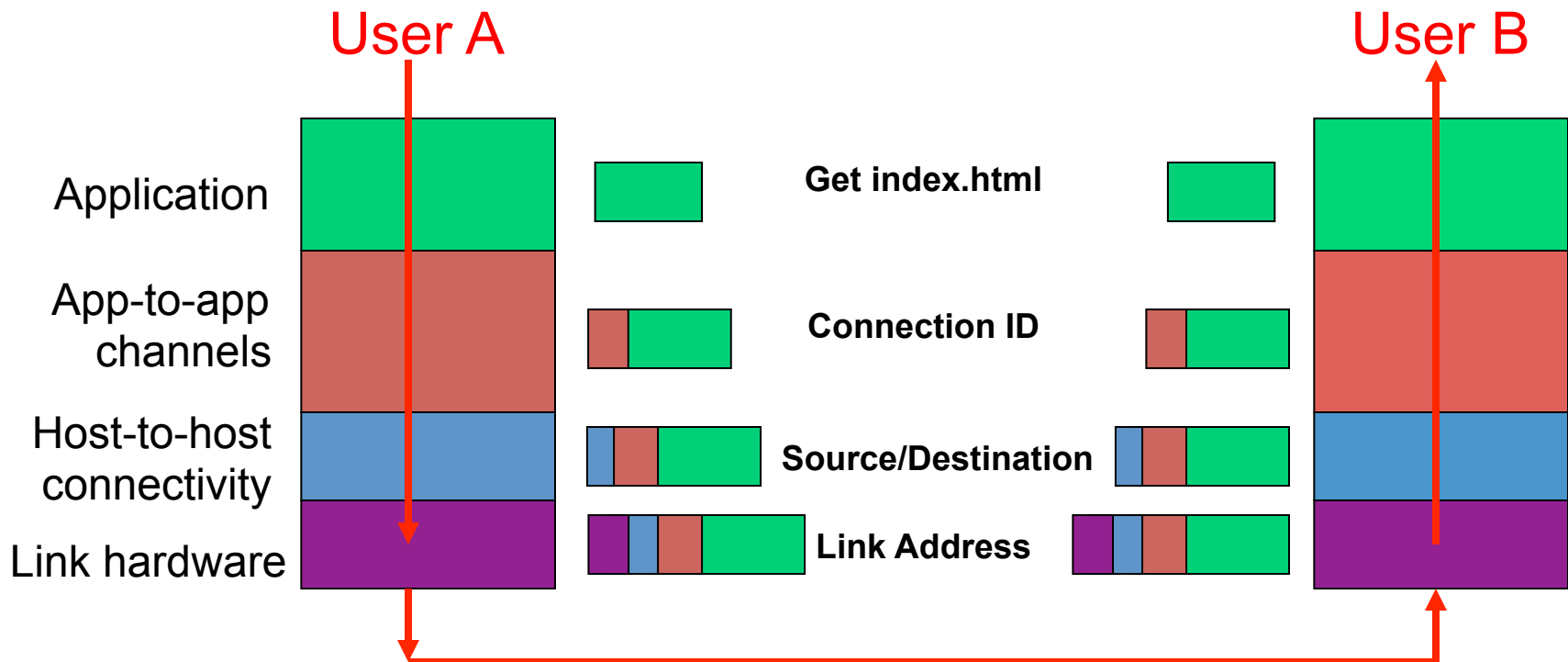
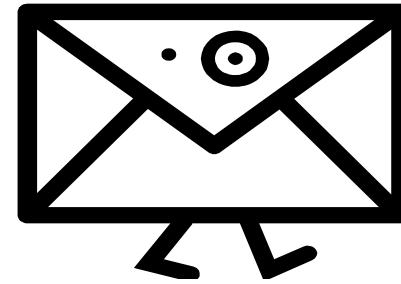
Content-Length: 21

CRLF

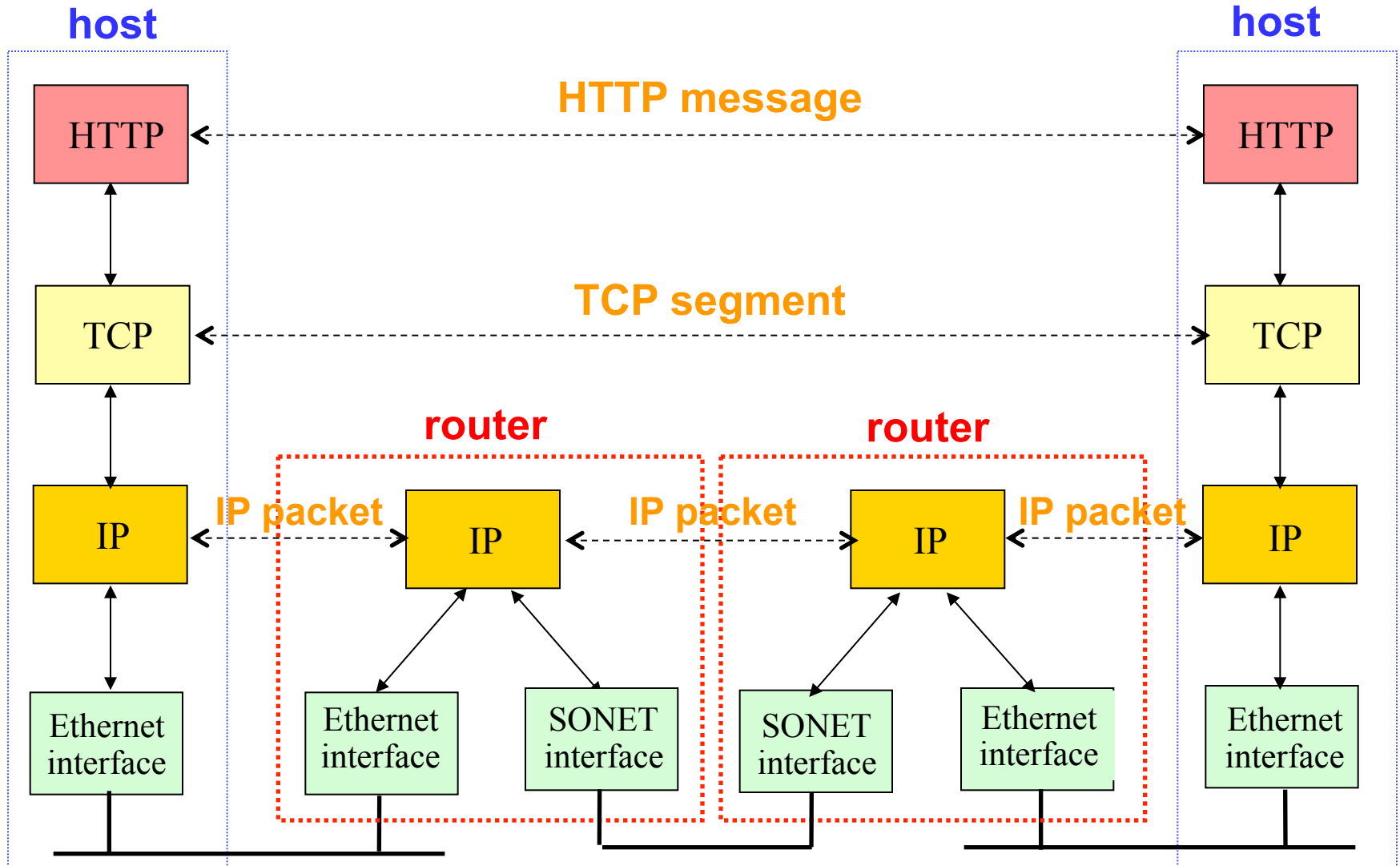
Site under construction

Response

Layer Encapsulation in HTTP



IP Suite: End Hosts vs. Routers



Conclusions

- Internet is a network of networks
 - How hosts and networks name one another, find one another, and talk with one another
- Key concepts in networking
 - Protocols, layers, resource allocation, and naming
- Next lecture: layering and UNIX sockets
 - Socket abstraction (important for assignment #1)
 - Read Chapter 1 of the Peterson/Davie book
 - Skim the online reference materials on sockets