COS 461: Computer Networks

Jennifer Rexford

Lectures: MW 10-10:50am in Architecture N101

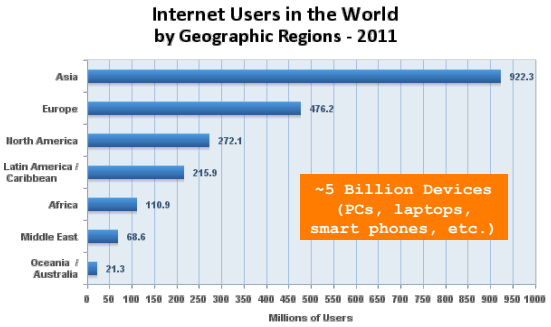
Preceptors: Rob Kiefer, Xiaozhou Li, and Peng Sun

Precepts: F 10-10:50am, F 11-11:50am

http://www.cs.princeton.edu/courses/archive/spr12/cos461/

The Internet is an Exciting Place

Two Billion Internet Users



Internet Applications (2010)

- Email
  - 1.9B people used email
  - 294B emails sent per day
- Web
  - 255M Web sites
  - 21.4M new Web sites
- YouTube
  - 2B videos watched per day
  - 35 hours of video uploaded per minute
- Blogs
  - 152M blogs
- Twitter
  - 100M new Twitter accounts
  - 25B tweets
- Facebook
  - 20M Facebook apps installed per day
  - 36B photos uploaded
  - Estimated 1B users by 2012

http://mashable.com/2011/01/25/internet-size-infographic/

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

The Internet is a Tense Place

Information Age
News, analysis & insight for IT & business leaders

Egypt blocks Internet access amid protests

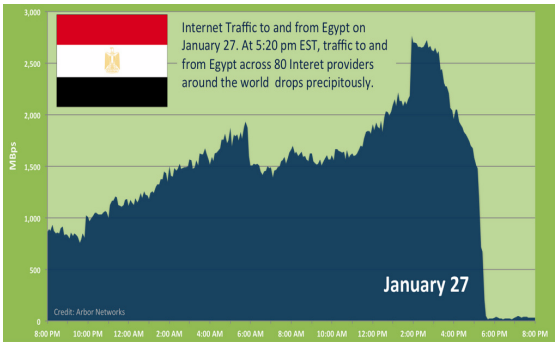
28 JANUARY 2011 **Daniel Shane**

Government orders telcos to block web access as protestors take to the streets

The Egyptian government has called on telecommunications providers in the country to block access to the Internet in response to widespread civil unrest.

Vodafone Egypt, one of the largest operators in the country not controlled by the state, today said it has disabled access following pressure from authorities.

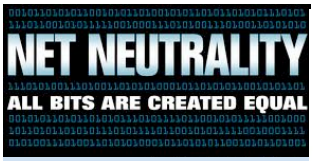
Internet Traffic to/from Egypt



Stop Online Piracy Act (SOPA)

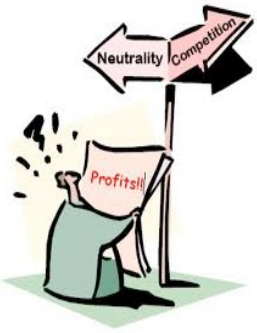
9

Network Neutrality



FCC Rules Against Comcast P2P Throttling

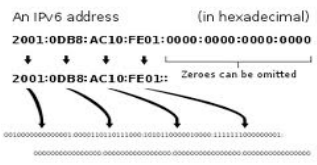
The U.S. Federal Communications Commission has ordered Comcast to stop interfering with peer-to-peer traffic on its broadband network…



10

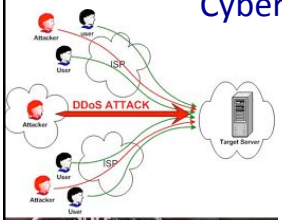
IP Address Space Exhaustion

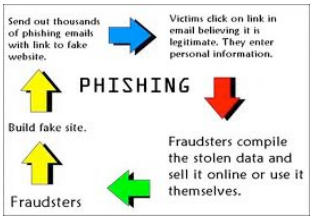
"Currently, the Internet is built using IPv4, but on February 3, 2011, the global supply of unassigned IPv4 Internet addresses was exhausted. On that date, the Internet Assigned Numbers Authority has distributed the final five blocks of approximately 16 million IPv4 addresses among the five Regional Internet Registries."



11

Cyber Attacks





12

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

13

What *is* the Internet?

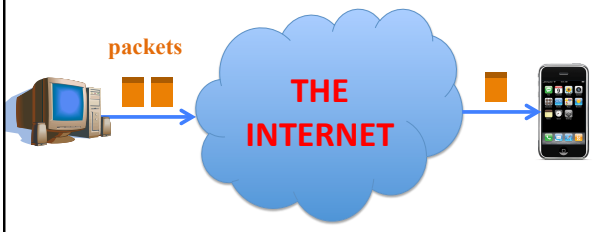
14

I Can Haz 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, such as electronic mail, online chat, file transfer, and the interlinked Web pages and other documents of the World Wide Web.

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

"Best-Effort Packet Delivery Service"



16

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.

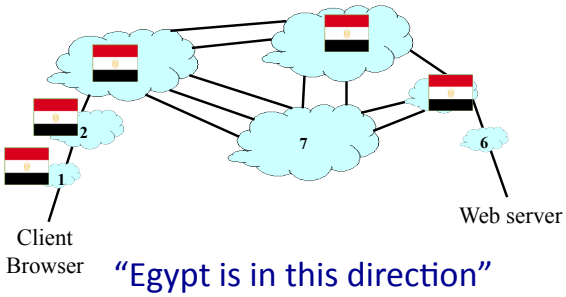
And then end hosts became powerful and ubiquitous….

"A Network of Networks"

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

18

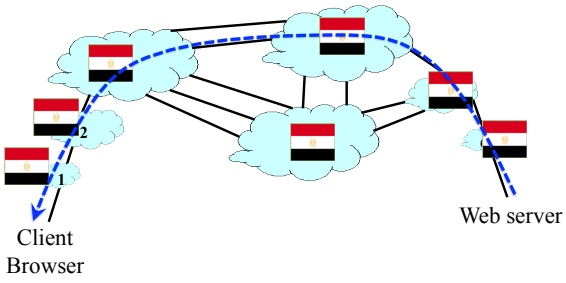
Announcing a Route



"Egypt is in this direction"

19

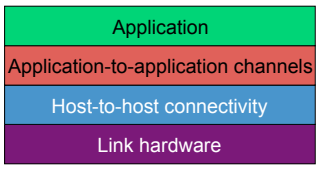
Forwarding Traffic



20

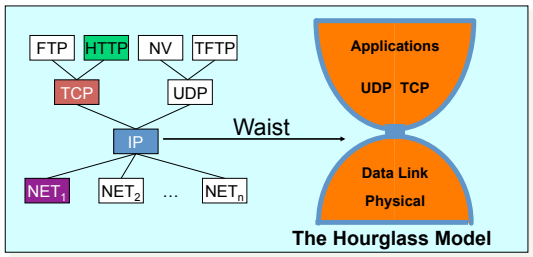
"A Stack of Protocol Layers"

- Modularity
  - Each layer relies on services from layer below
  - Each layer exports services to layer above
- Interfaces
  - Hides implementation details
  - Layers can change without disturbing other layers



21

The Internet Protocol Suite



The "narrow waist" facilitates interoperability

22

Example: HyperText Transfer Protocol

Request

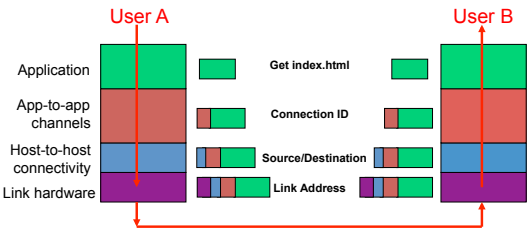
```
GET /courses/archive/spr12/cos461/ HTTP/1.1
Host: www.cs.princeton.edu
User-Agent: Mozilla/4.03
CRLF
```

Response

```
HTTP/1.1 200 OK
Date: Mon, 6 Feb 2012 13:09:03 GMT
Server: Netscape-Enterprise/3.5.1
Last-Modified: Mon, 7 Feb  2011 11:12:23 GMT
Content-Length: 21
CRLF
Site under construction
```

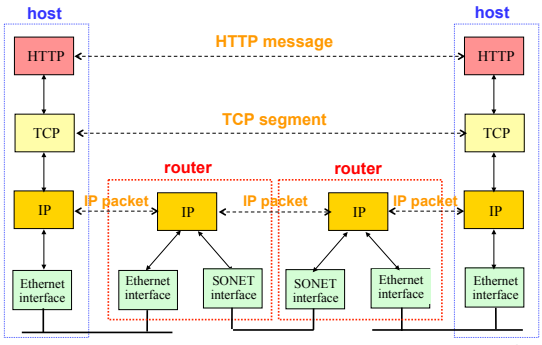
23

Layer Encapsulation in HTTP



24

End Hosts vs. Routers



25

Key Concepts in Networking

- Naming
  - What to call computers, services, protocols, …
- Layering
  - Abstraction is the key to managing complexity
- Protocols
  - Speaking the same language
  - Syntax and semantics
- Resource allocation
  - Dividing scare resources among competing parties
  - Memory, link bandwidth, wireless spectrum, paths

26

Course Organization

27

What You Learn in This Course

- **Knowledge:** how the Internet works, and why
  - Protocol stack: link, network, transport, application
  - Resource allocation: congestion control, routing
  - Applications: Web, P2P, IPTV, VoIP, …
  - Networks: enterprise, cloud, backbone, wireless, …
- **Insight:** key concepts in networking
  - Naming, layering, protocols, resource allocation, …
- **Skill:** network programming (in precept!)
  - Many nodes are general-purpose computers
  - Can innovate and develop new uses of networks

28

Learning the Material: People

- Lecture: Jen Rexford
  - Slides available online at course Web site
  - Office hours: TBA
- Precept
  - Rob Kiefer, Xiaozhou Li, and Peng Sun
  - Office hours: TBA
- Main Q&A forum: www.piazza.com
  - Sign up on Piazza now, using your real name ☺
  - Graded on class participation: so ask and answer!
  - Can send private messages on Piazza

29

Precepts

- Precept assignments sent at 8:45am today
  - 10am precept: Friend 109
  - Two 11am precepts: Friend 108 and 109
- Not assigned to a precept?
  - Contact Colleen Kenny-McGinley at ckenny@CS.Princeton.EDU
- We *do* have precept this Friday
- If you need to attend a different precept…
  - … let both preceptors know ahead of time

30

Learning the Material: Books

- Required textbook
  - *Computer Networks: A Systems Approach* (5th edition), by Peterson and Davie
  - Okay to use the 3rd or 4th edition
- Books on reserve
  - Networking textbooks
    - *Computer Networking: A Top-Down Approach Featuring the Internet*, by Kurose and Ross
    - *Computer Networks*, by Tanenbaum
  - Network programming references
    - *TCP/IP Illustrated, Volume 1: The Protocols*, by Stevens
    - *Unix Network Programming, Volume 1: The Sockets Networking API*, by Stevens, Fenner, & Rudolf

31

Grading

- Four assignments (12% each)
  - 95% 3 hours, 70% 2 days late, 50% > 3 days late
  - One free late day during the semester
  - Must complete all assignments to pass
- Two exams (45% total)
  - Midterm exam before spring break (20%)
  - Final exam during exam period (25%)
- Class participation (7%)
  - In lecture and precept
  - On Piazza

32

Graduate Students: Two Choices

- Pick one of two options
  - Do the four programming assignments
  - Or, first two assignments, plus research project
- Research projects
  - Networking-related research problem
  - Must have a *systems* programming component
  - Talk to me

33

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**.

34

Conclusions

- Internet
  - Diverse, ever-changing applications
  - … communicating over a network of networks
  - … using multiple layers of protocols
- Wednesday lecture
  - Links: how do two *computers* communicate?
- Friday precept
  - Sockets: how do two *applications* communicate?

35