COS 461: Computer Networks

Mike Freedman

Spring 2013

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

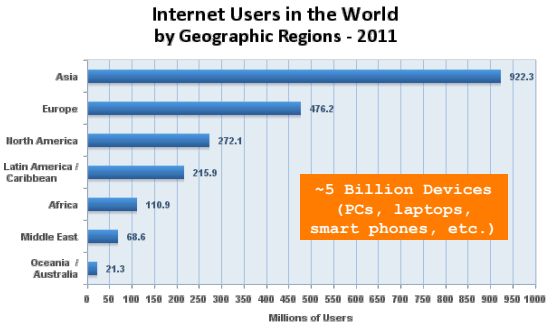
Preceptors: Aaron Blankstein, Scott Erickson, Naga Katta

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

http://www.cs.princeton.edu/courses/archive/spr13/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

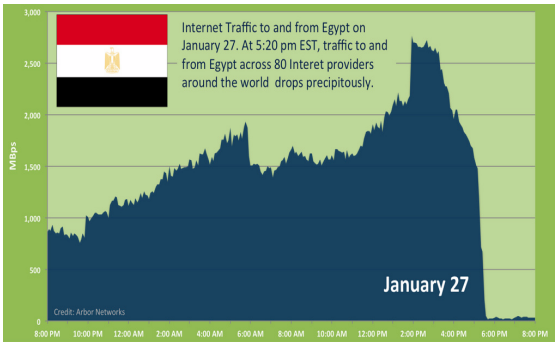
28 JANUARY 2011 **Daniel Shane**

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)

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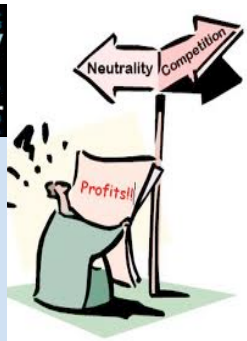
Network Neutrality

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…



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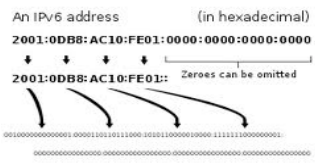
IP Address Space Exhaustion

"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."



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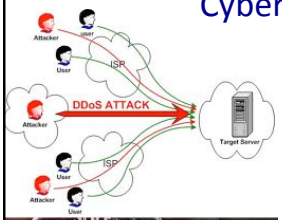
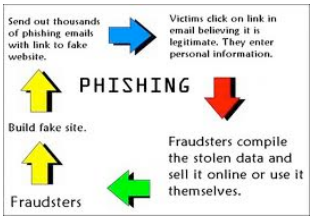
Cyber Attacks





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

What *is* the Internet?

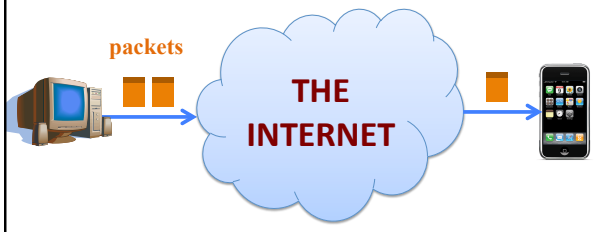
I Can Haz Wikipedia

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"



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

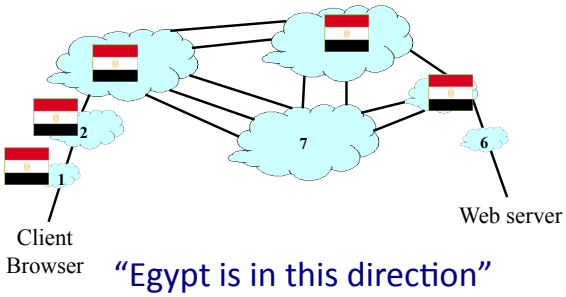
With programmable end hosts, new network services can be added at any time, by anyone.

And end hosts became powerful and ubiquitous….

"A Network of Networks"

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

Announcing a Route



"Egypt is in this direction"

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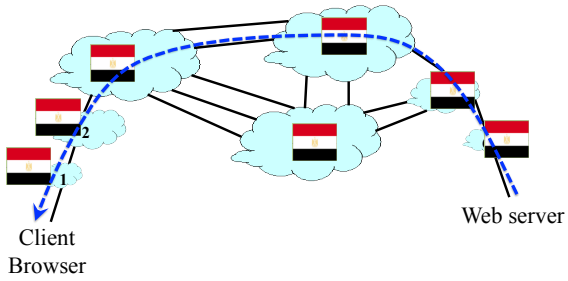
Forwarding Traffic



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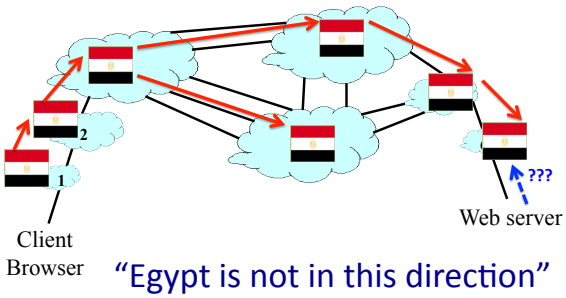
Withdrawing a traffic route



"Egypt is not in this direction"

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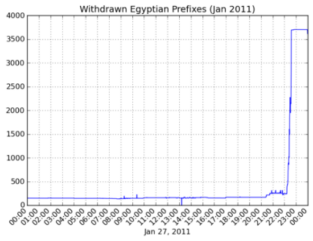
renesys | blog

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.

This is a completely different situation from the modest Internet manipulation that took place in Tunisia, where specific routes were blocked, or Iran, where the Internet stayed up in a rate-limited form designed to make Internet connectivity painfully slow. The Egyptian government's actions tonight have essentially wiped their country from the global map.



Central concepts in networking

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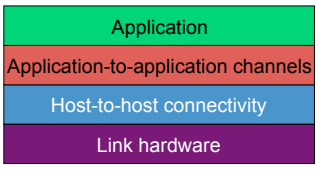
Abstraction through Protocol Layering

- 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



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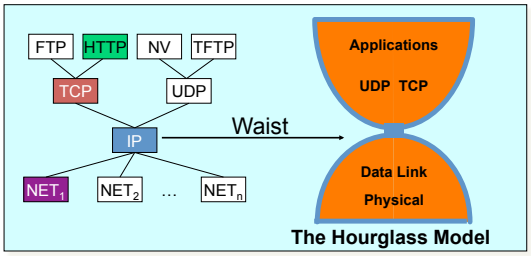
The Internet Protocol Suite



The "narrow waist" facilitates interoperability

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Example: HyperText Transfer Protocol

```
GET /courses/archive/spr13/cos461/ HTTP/1.1
Host: www.cs.princeton.edu
User-Agent: Mozilla/4.03
CRLF
```

Request

Response

```
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
```

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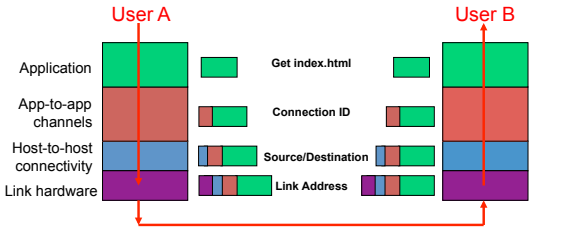
Layer Encapsulation in HTTP



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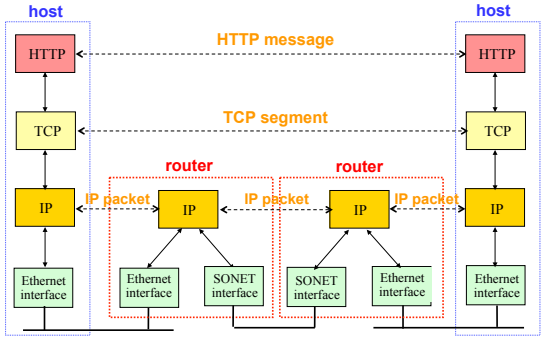
End Hosts vs. Routers



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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

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Course Organization

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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, 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

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iClickers: Quick Surveys

Growth/innovation vs. create/exacerbate tensions

- Does Internet design prevent misuse?
  - A. Individual endpoints can only use addresses given to them when connect to the network
  - B. Individual end-points can "spoof" any IP address

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iClickers: Quick Surveys

Growth/innovation vs. create/exacerbate tensions

- Does Internet design prevent misuse?

  Networks are assigned unique IP address blocks from a central authority ("IANA"): Princeton has 128.112.*
  - A. Network can only announce assigned addresses
  - B. Networks can spoof any address

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iClickers: Quick Surveys

Growth/innovation vs. create/exacerbate tensions

- Does "Internet" provide reliable packet delivery?
  - A. Yes, that's necessary for protocols like HTTP that require in-order streams
  - B. No, packets may be arbitrary dropped or reordered

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Learning the Material: People

- Lecture: Mike Freedman
  - Slides available online at course Web site
- Precept
  - Aaron Blankstein, Scott Erickson, Naga Katta
  - Office hours: TBD, based on assignment schedule
- Main Q&A forum: www.piazza.com
  - Sign up on Piazza now, using your real name ☺
  - Graded on class participation: so ask and answer!
  - No anonymous posts or questions
  - Can send private messages to instructors

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Precepts

- Sign up for precept assignments
  - 10am precept: COS Building, 102
  - Two 11am precepts: Sherrerd 101, Friend 004
  - See Colleen Kenny-McGinley if problems: *ckenny@cs*
- We *do* have precept this Friday
- Contact both preceptors ahead of time if need to attend a different precept.

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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

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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

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Policies: Write Your Own Code

While thinking about a problem, discussions with friends are encouraged. However, when the time comes to write code, 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.

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

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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?

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