COS 461: Computer Networks

Spring 2011

Lectures: MW 10-10:50am in Bowen 222

Prof. Mike Freedman

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

Preceptors: Matvey Arye, Jacopo Cesareo, Prem Gopalan

http://www.cs.princeton.edu/courses/archive/spr11/cos461/

What You Learn in This Course

- Knowledge: how the Internet works
  - IP protocol suite
  - Internet architecture
  - Applications (Web, DNS, P2P, …)
- Insight: key concepts in networking
  - Protocols, layering, resource allocation, naming
- Skill: network programming
  - Many nodes are general-purpose computers
    - And increasingly, even special-purpose switches are programmable!
  - You can program the nodes
  - Very easy to innovate and develop new uses of network
  - Contrast: Ma Bell owned the telecom network, no innovation

Learning the Material: People

- Lecture (Prof. Mike Freedman)
  - Slides available online at course Web site
  - Office hours: Immediately following lectures
- Teaching Assistants office hours TBD
- Main email: cos461-staff at lists.cs.princeton.edu
  - Email to individual TAs will not be answered
- Main Q&A form: www.piazzza.com
  - We will add all your email addresses to the course
  - Graded on class participation: so ask *and* answer!

Learning the Material: Books

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

Grading and Schedule

- Four assignments (10% each)
  - 95% 3 hours, 70% 2 days late, 50% > 3 days late
  - One free late day during semester
  - Must complete all assignments to pass
- Two exams (50% total)
  - Midterm exam before spring break (25%)
  - Final exam during exam period (25%)
- Class participation (10%)
  - In lecture and precept
  - In the forums

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

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**.

Networking is Relevant

Information wants to be free because it has become so cheap to distribute, copy, and recombine... It wants to be expensive because it can be immeasurably valuable to the recipient. (1985)

Stewart Brand

YouTube

Google news

WIKIPEDIA

facebook

twitter

BBC Mobile
NEWS TECHNOLOGY

26 January 2011 Last updated at 12:59 ET

Confusion over Egyptian blocks on web protest tools

Confusion surrounds the use of web tools such as Twitter and Facebook that have been used by protestors in Egypt to co-ordinate action.

The Egyptian government denied taking any action to restrict use of the web, saying it respected freedom of expression.

However, Twitter said it is being blocked but said many people have found ways round the restrictions.

Egyptian anti-government activists clashed with police in defiance of a ban on protests

A Swedish mobile video site also reported that it had been blocked.

"The government would not resort to such methods," the government's Magdy Rady said of the blocks.

However, overnight Twitter put a message on its official PR stream saying that use was being restricted.

"Egypt continues to block Twitter & has greatly diminished traffic. However, some users are using apps/proxies to successfully tweet," **it said on the twitterglobalpr stream**.

Related stories

Egypt threatens protester arrests

Tear gas fired at Egyptian protesters

Eyewitness accounts

InformationAge
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

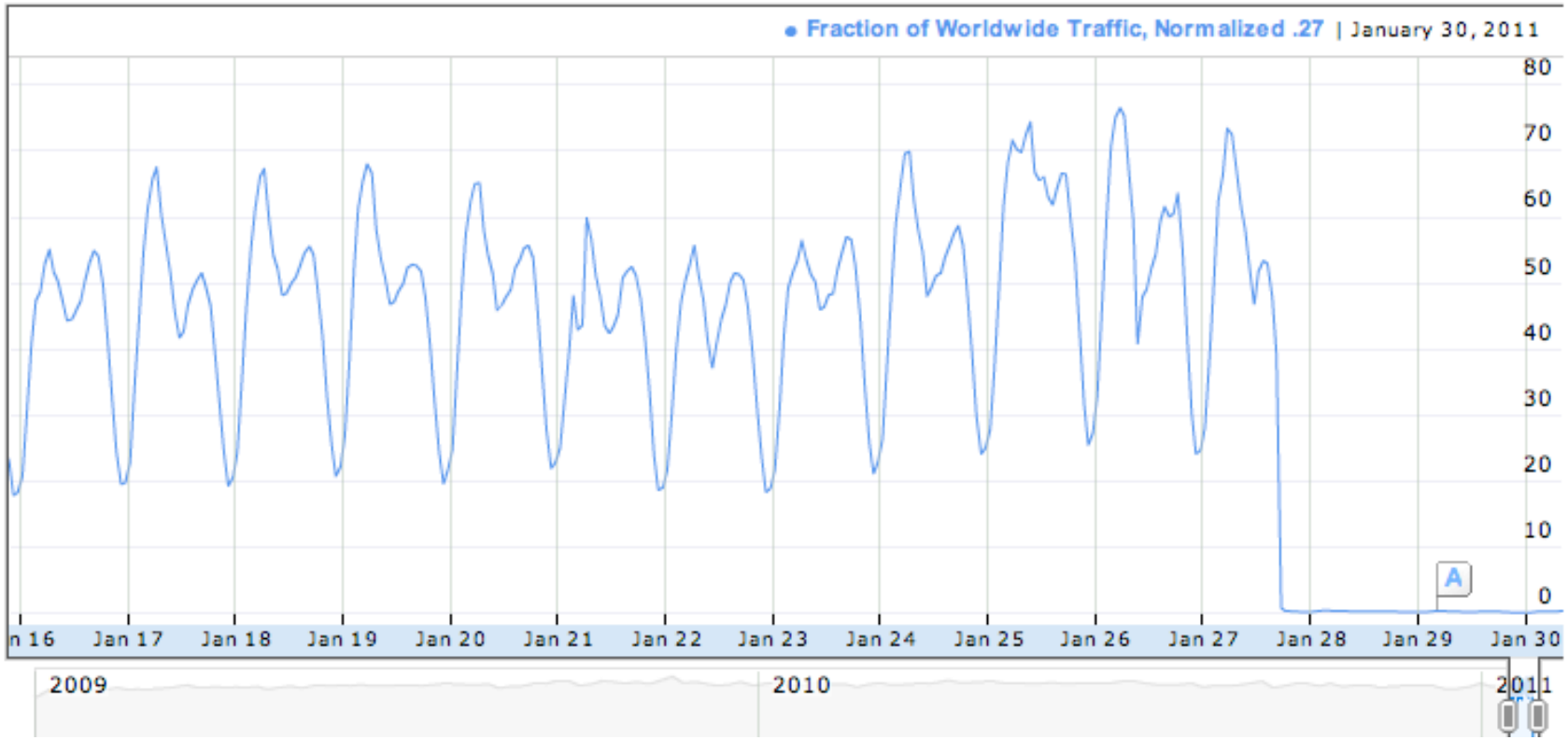
The Egyptian government has called on telecommunications providers in the country to block access to the Internet in response to widespread civil unrest.

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.

Google Transparency Report

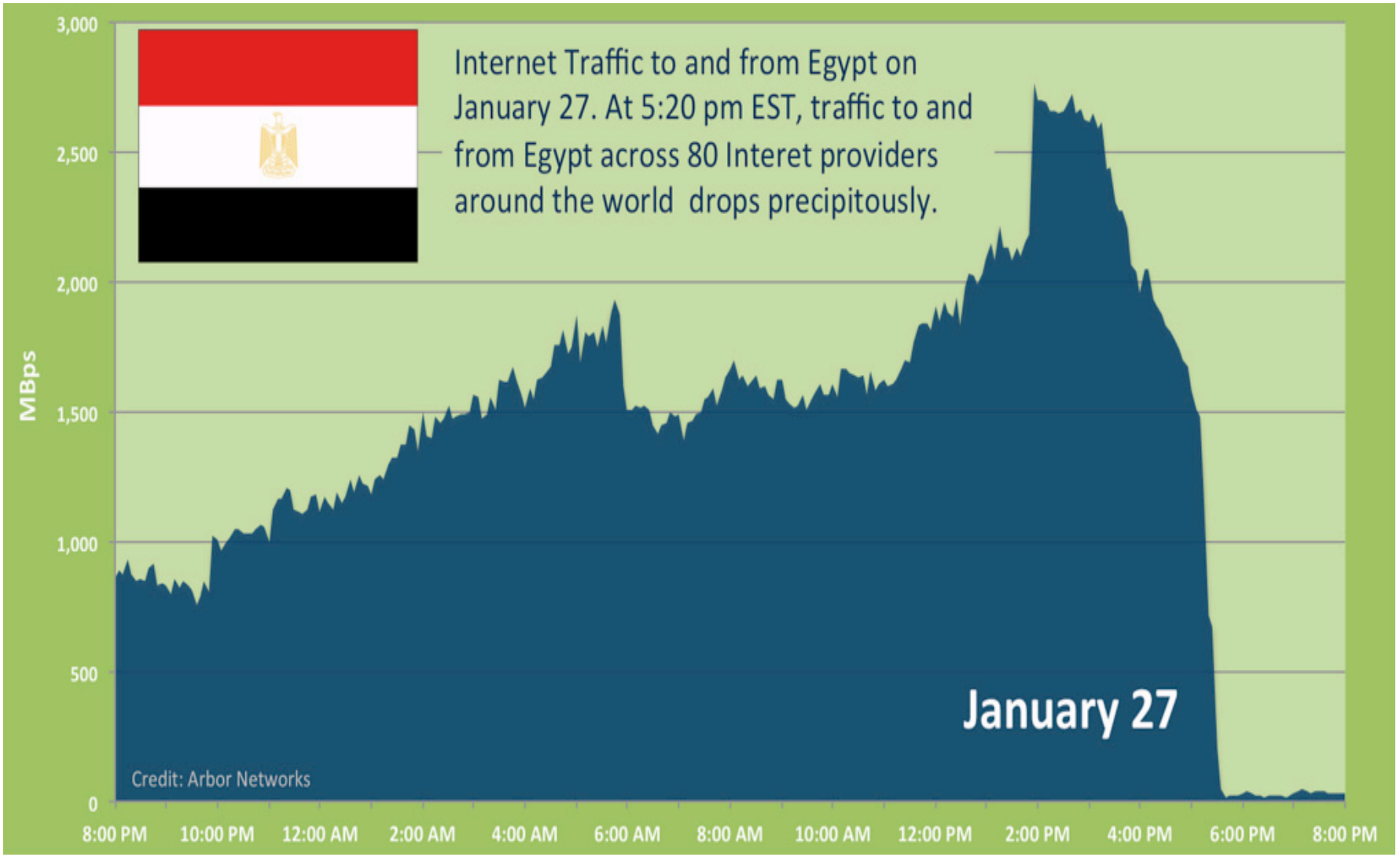
Egypt | YouTube

YouTube, Egypt Traffic Divided by Worldwide Traffic and Normalized



http://www.google.com/transparencyreport/traffic/

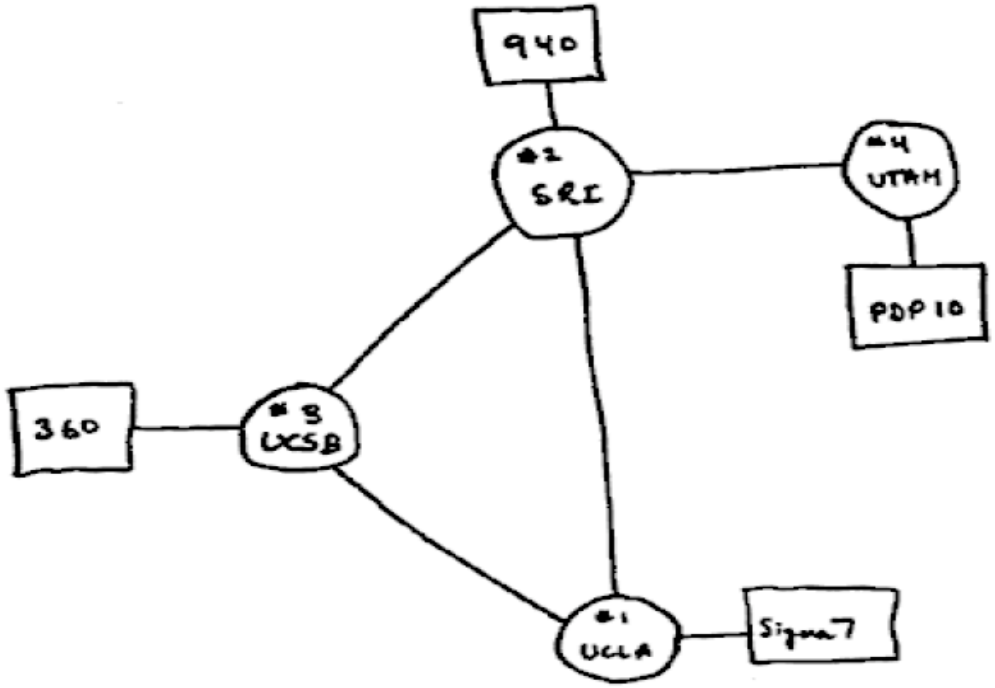
ARBOR NETWORKS



The monolithic view

Why “Internet”

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



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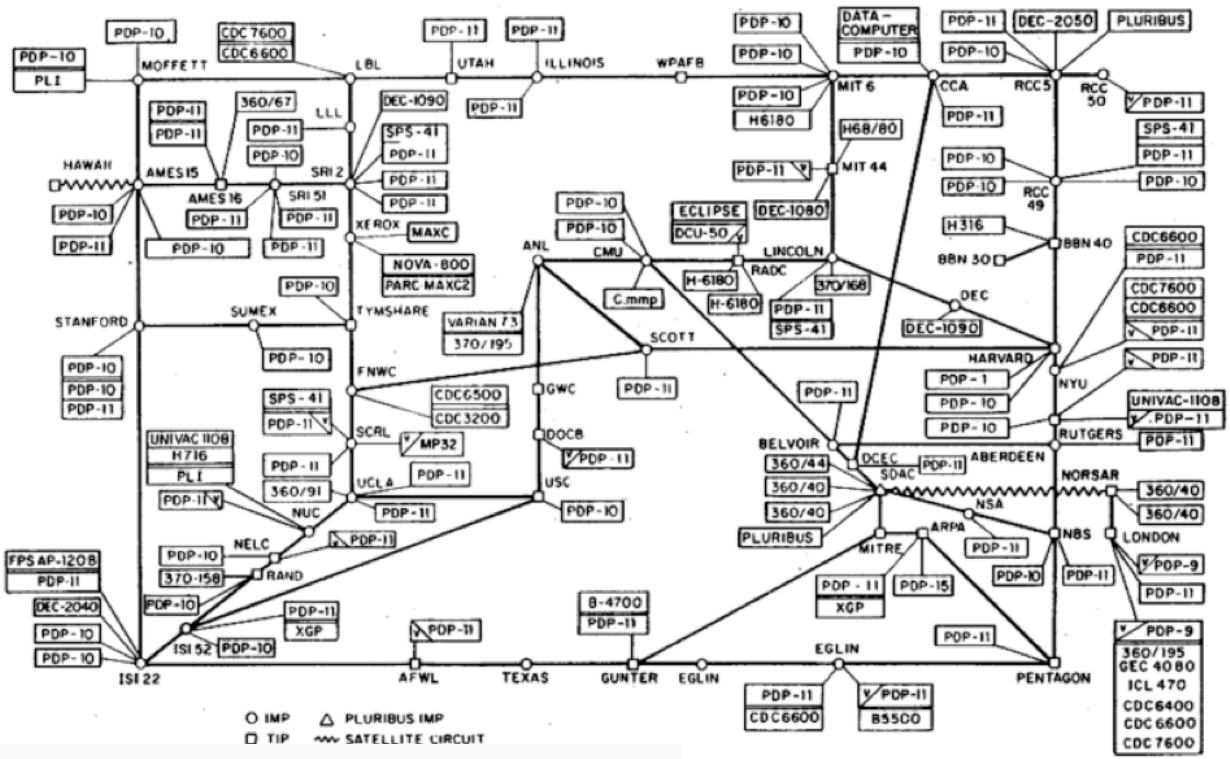
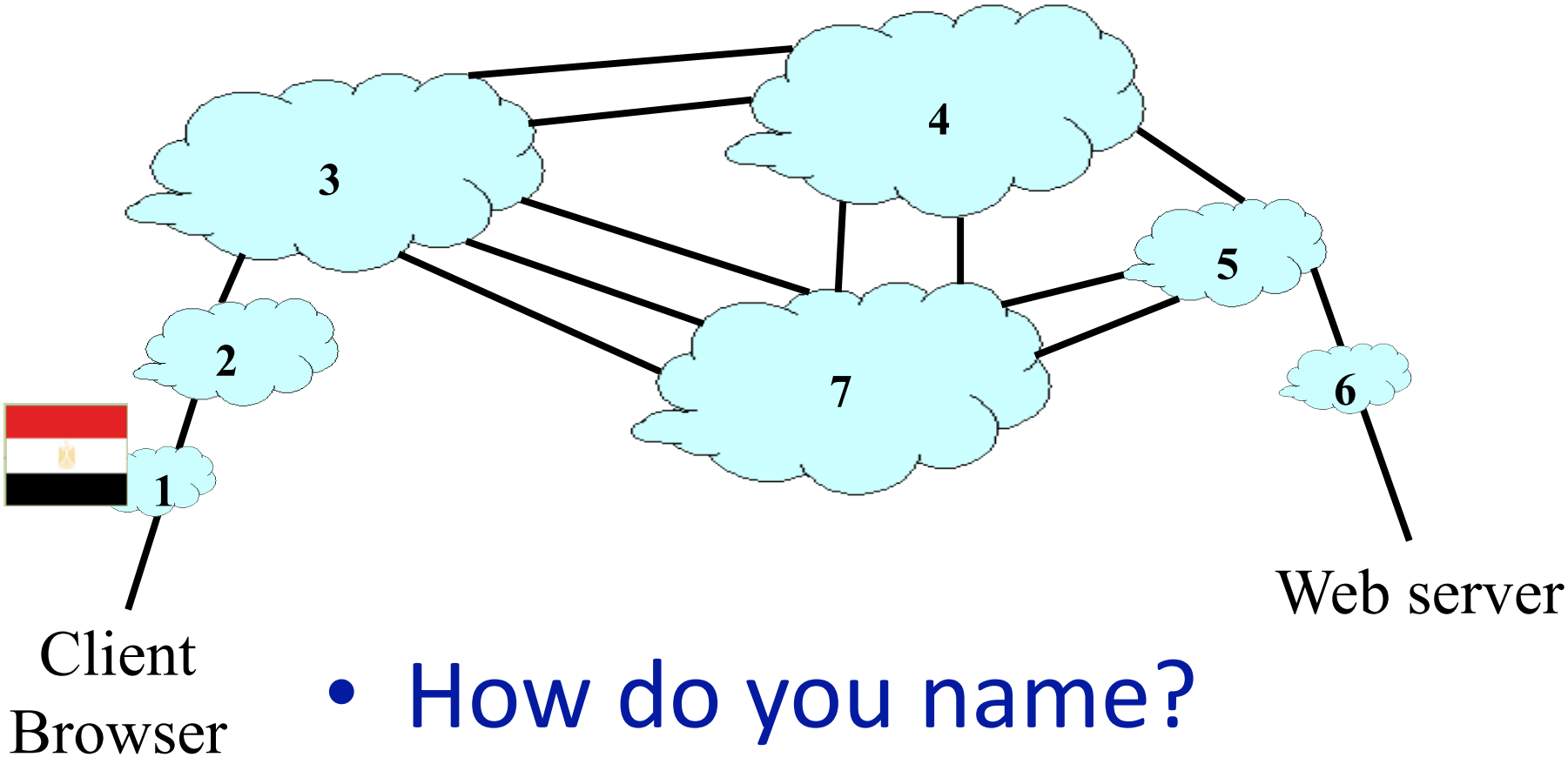


ARPANET logical map, March 1977

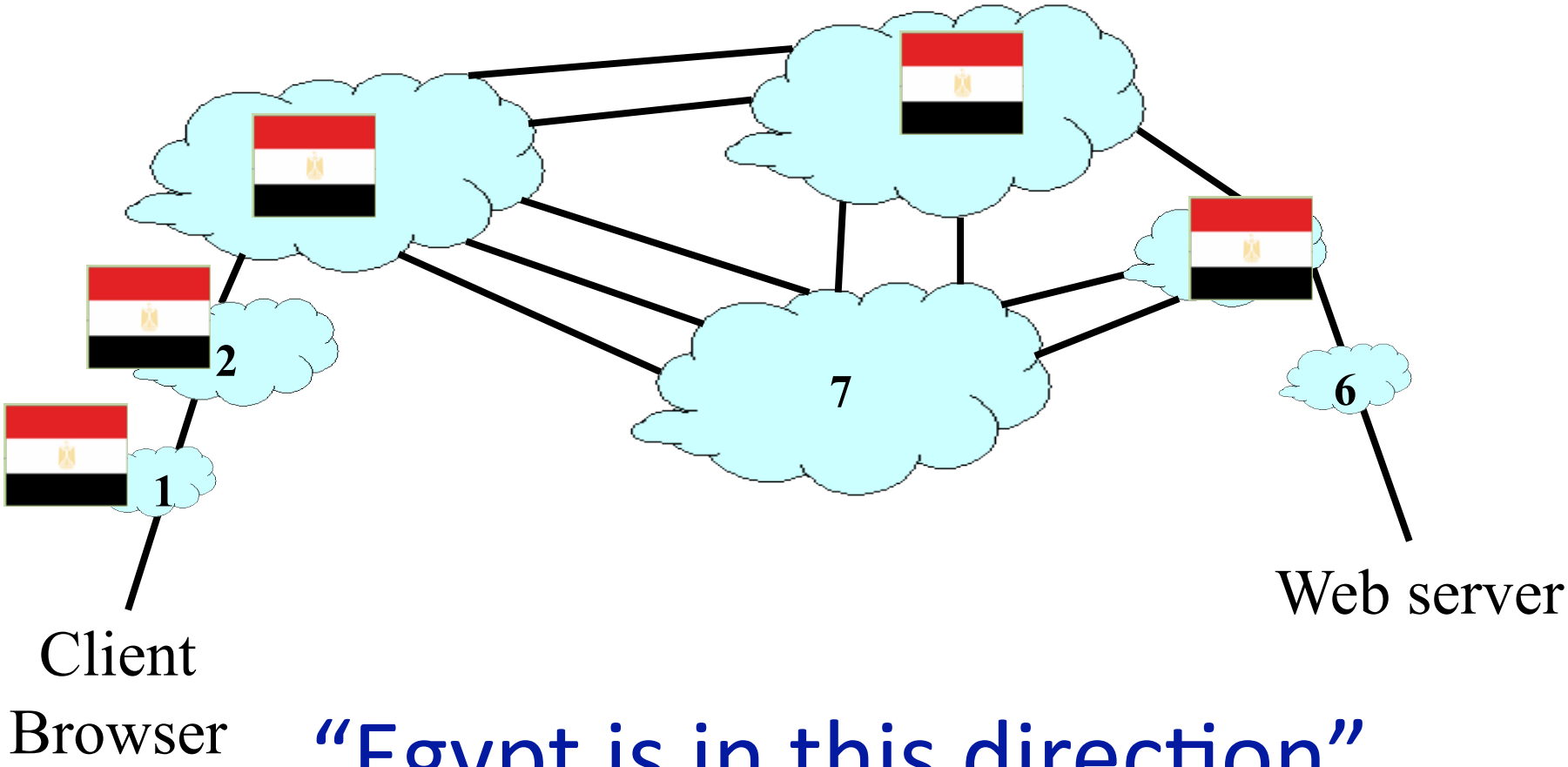
The monolithic view

A network of "Autonomous Systems"



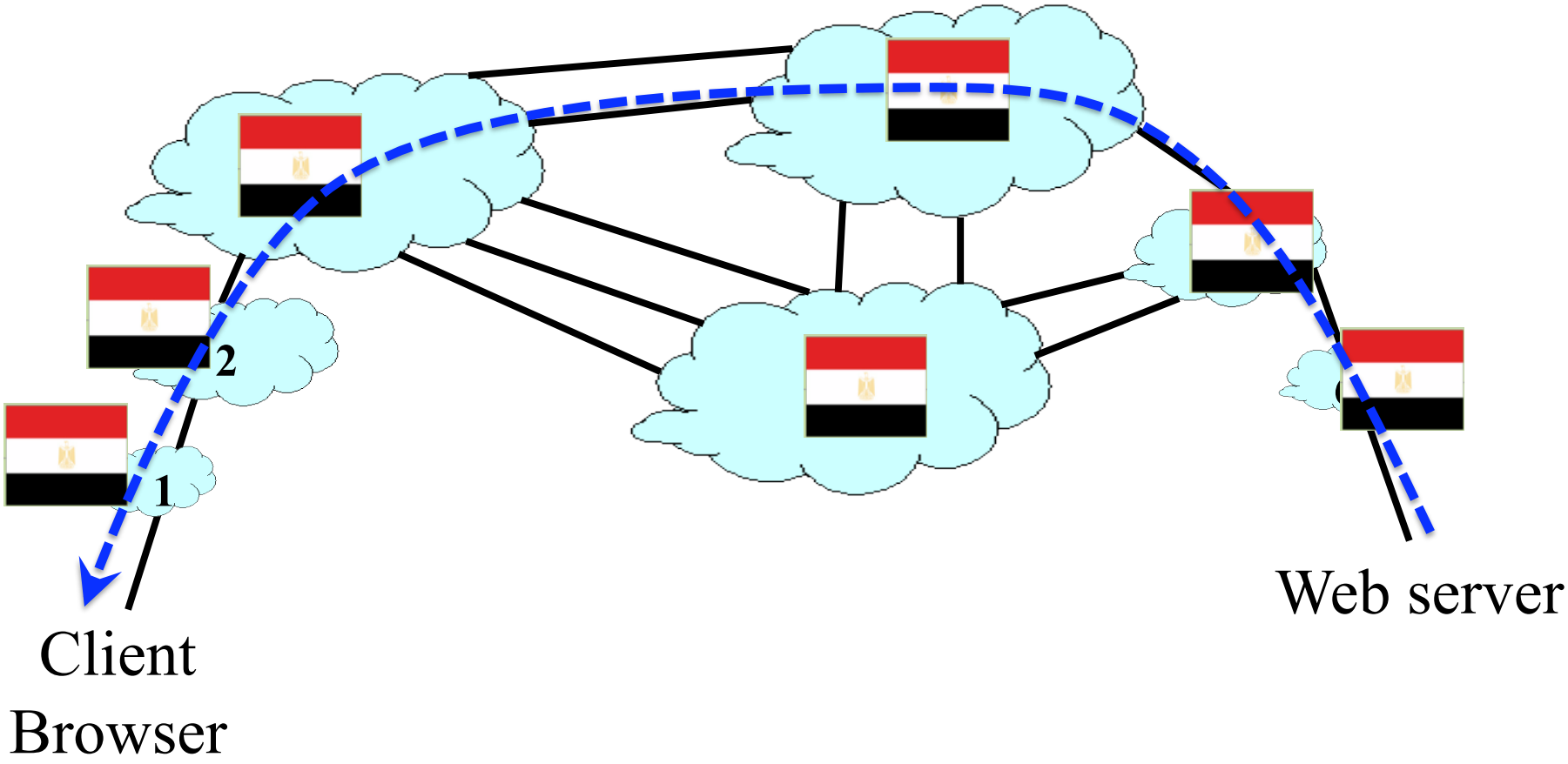
- How do you name?
- How do you find a name?

Announcing a traffic route

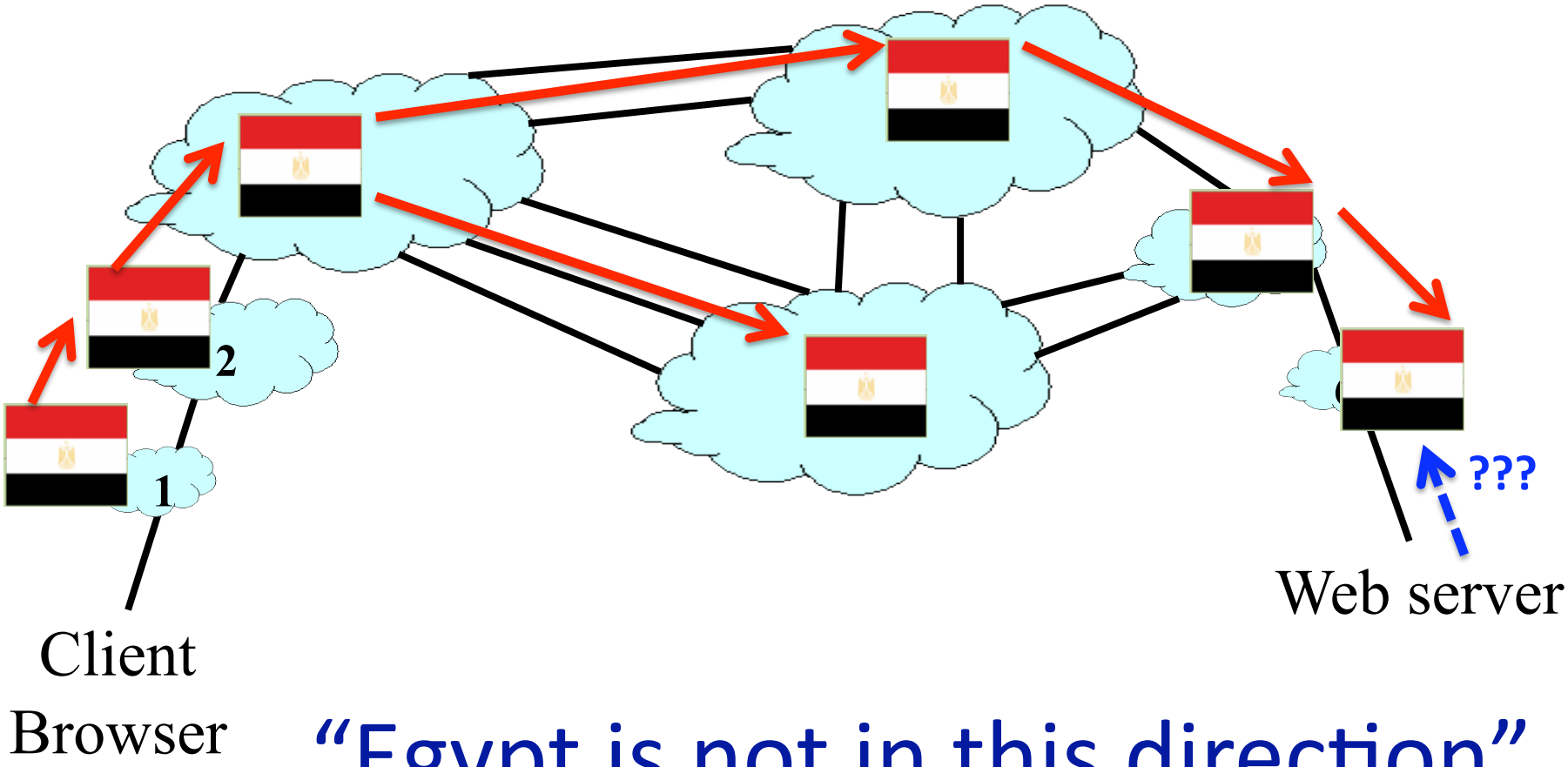


"Egypt is in this direction"

“Routing” traffic to a destination



Withdrawing a traffic route



"Egypt is not in this direction"

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.

renesys | blog

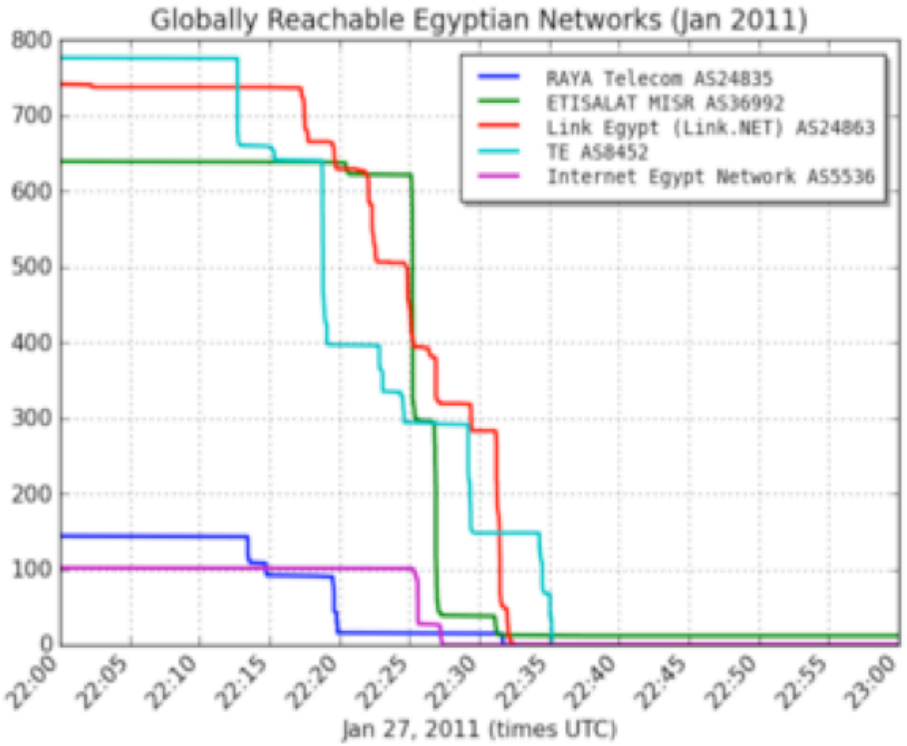
Egypt Leaves the Internet

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

Our new observation is that this was not an instantaneous event on the front end; each service provider approached the task of shutting down its part of the Egyptian Internet separately.

- Telecom Egypt (AS8452), the national incumbent, starts the process at 22:12:43.
- Raya joins in a minute later, at 22:13:26.
- Link Egypt (AS24863) begins taking themselves down 4 minutes later, at 22:17:10.
- Etisalat Misr (AS32992) goes two minutes later, at 22:19:02
- Internet Egypt (AS5536) goes six minutes later, at 22:25:10.

First impressions: this sequencing looks like people getting phone calls, one at a time, telling them to take themselves off the air. Not an automated system that takes all providers down at once; instead, the incumbent leads and other providers follow meekly one by one until Egypt is silenced.



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 scare resources among competing parties
  - Memory, link bandwidth, wireless spectrum, paths,
- Naming
  - What to call computers, services, protocols, …

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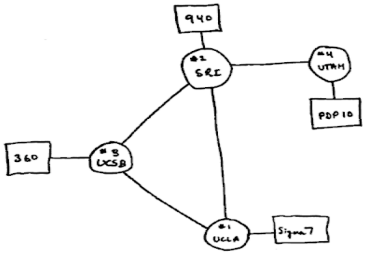
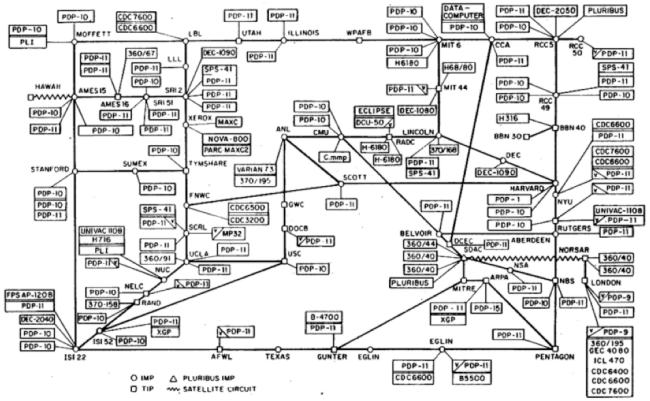
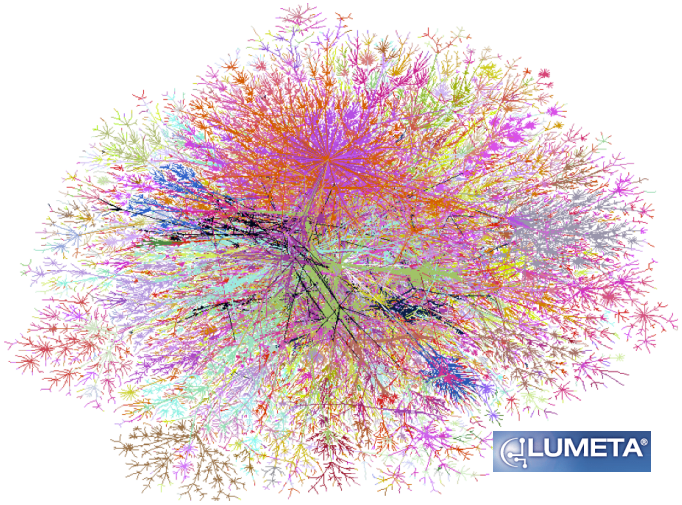


1969



1977



1998

All speak IPv4

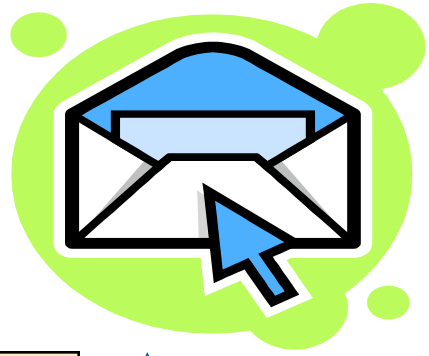
"Internet Protocol version 4"

Protocol design is about tradeoffs

- How should hosts and routers communicate?
  - Standard protocol
  - Fast: Machine readable in hardware at line rates

- Browsers, web servers, and proxies?
  - Can be slower: software readable
  - Human readable
  - Extensible and forward-compatible
  - Not everybody might be familiar with extensions

IPv4 Packet



4-bit Version	4-bit Header Length	8-bit Type of Service (TOS)	16-bit Total Length (Bytes)
16-bit Identification		3-bit Flags	13-bit Fragment Offset
8-bit Time to Live (TTL)	8-bit Protocol	16-bit Header Checksum	
32-bit Source IP Address			
32-bit Destination IP Address			
Options (if any)			
Payload			

20-byte header

Example: HyperText Transfer Protocol

Request

```
GET /courses/archive/spr09/cos461/ HTTP/1.1
Host: www.cs.princeton.edu
User-Agent: Mozilla/4.03
CRLF
```

Response

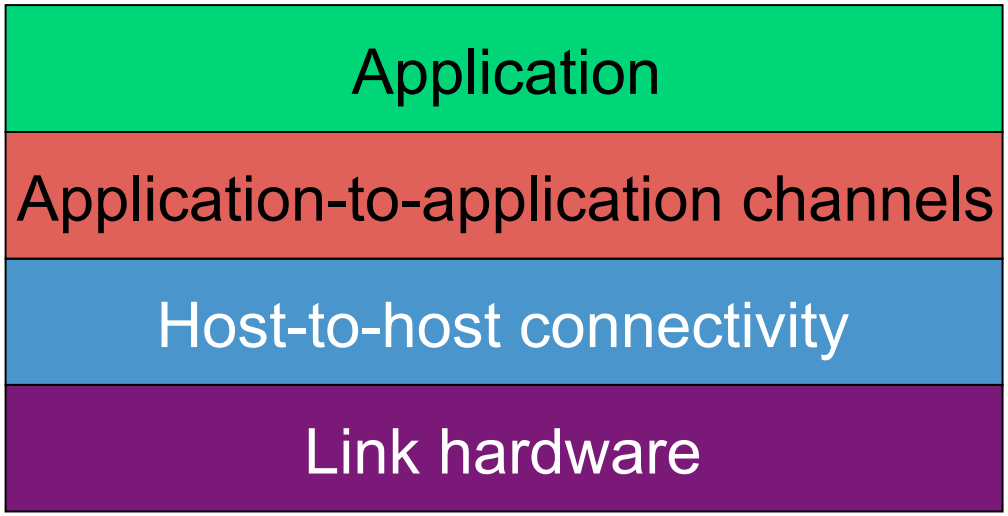
```
HTTP/1.1 200 OK
Date: Mon, 2 Feb 2009 13:09:03 GMT
Server: Netscape-Enterprise/3.5.1
Last-Modified: Mon, 42 Feb  2009 11:12:23 GMT
Content-Length: 21
CRLF
Site under construction
```

Key Concepts in Networking

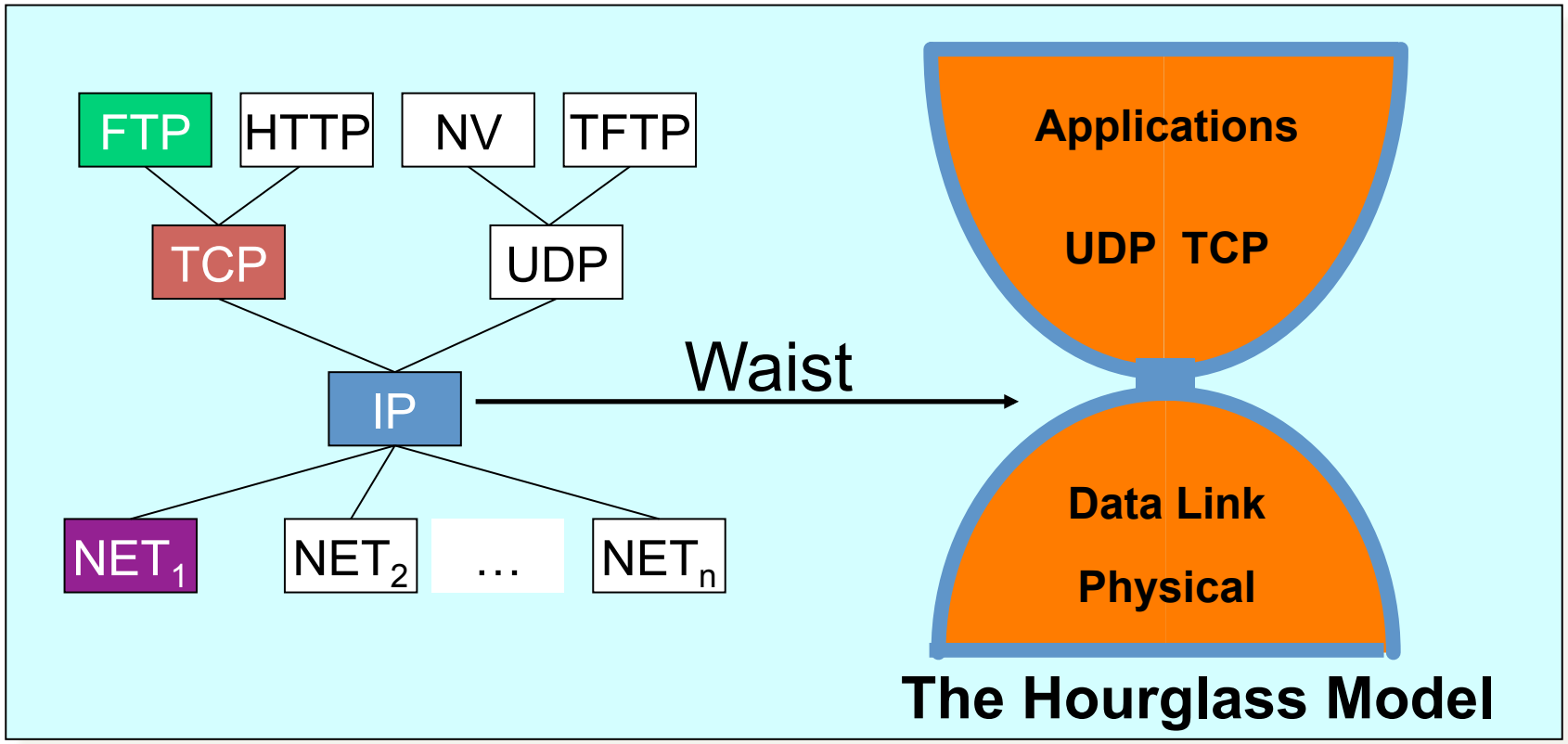
- Protocols
  - Speaking the same language
  - Syntax and semantics
- Layering
  - Standing on the shoulders of giants
  - A key to managing complexity

Layering = Functional Abstraction

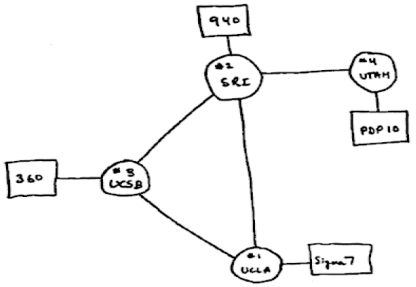
- Sub-divide the problem
  - Each layer relies on services from layer below
  - Each layer exports services to layer above
- Interface between layers defines interaction
  - Hides implementation details
  - Layers can change without disturbing other layers



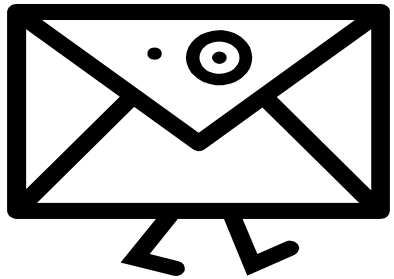
The Internet Protocol Suite

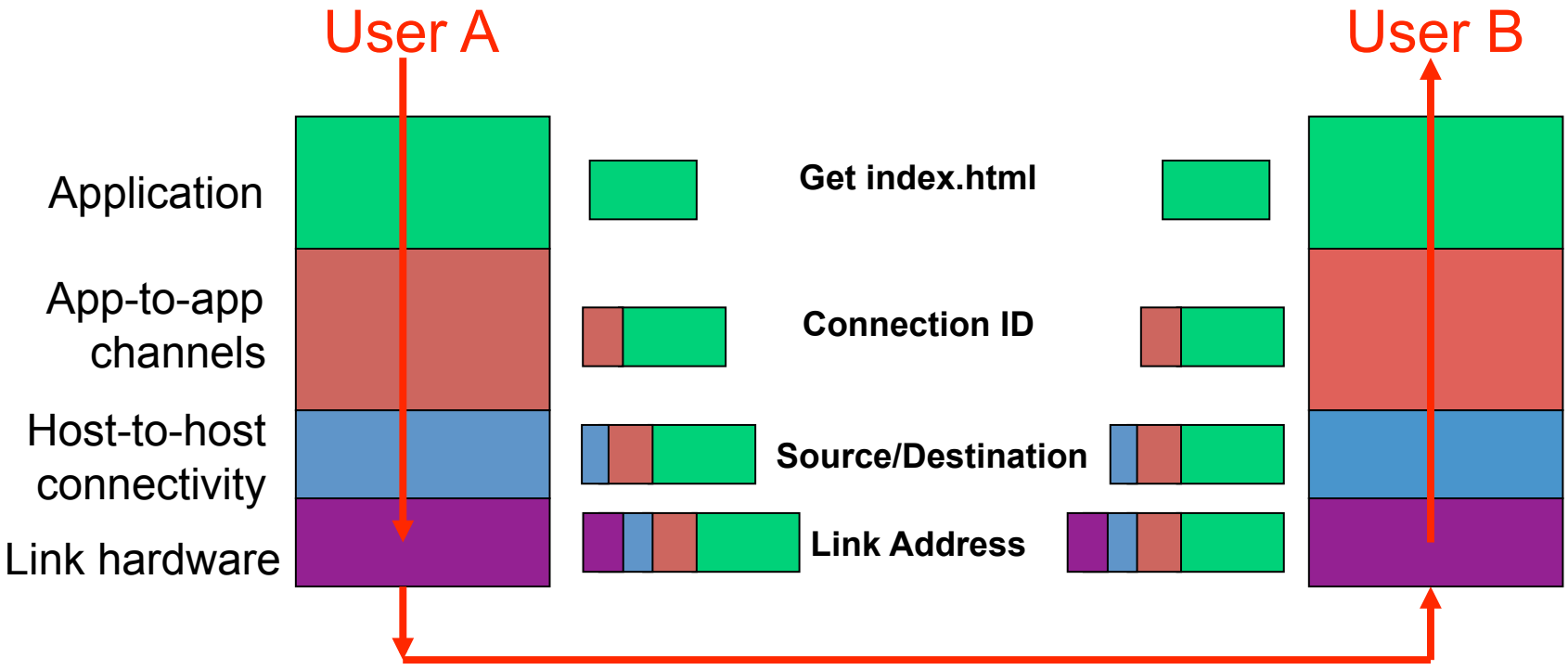


The waist facilitates interoperability

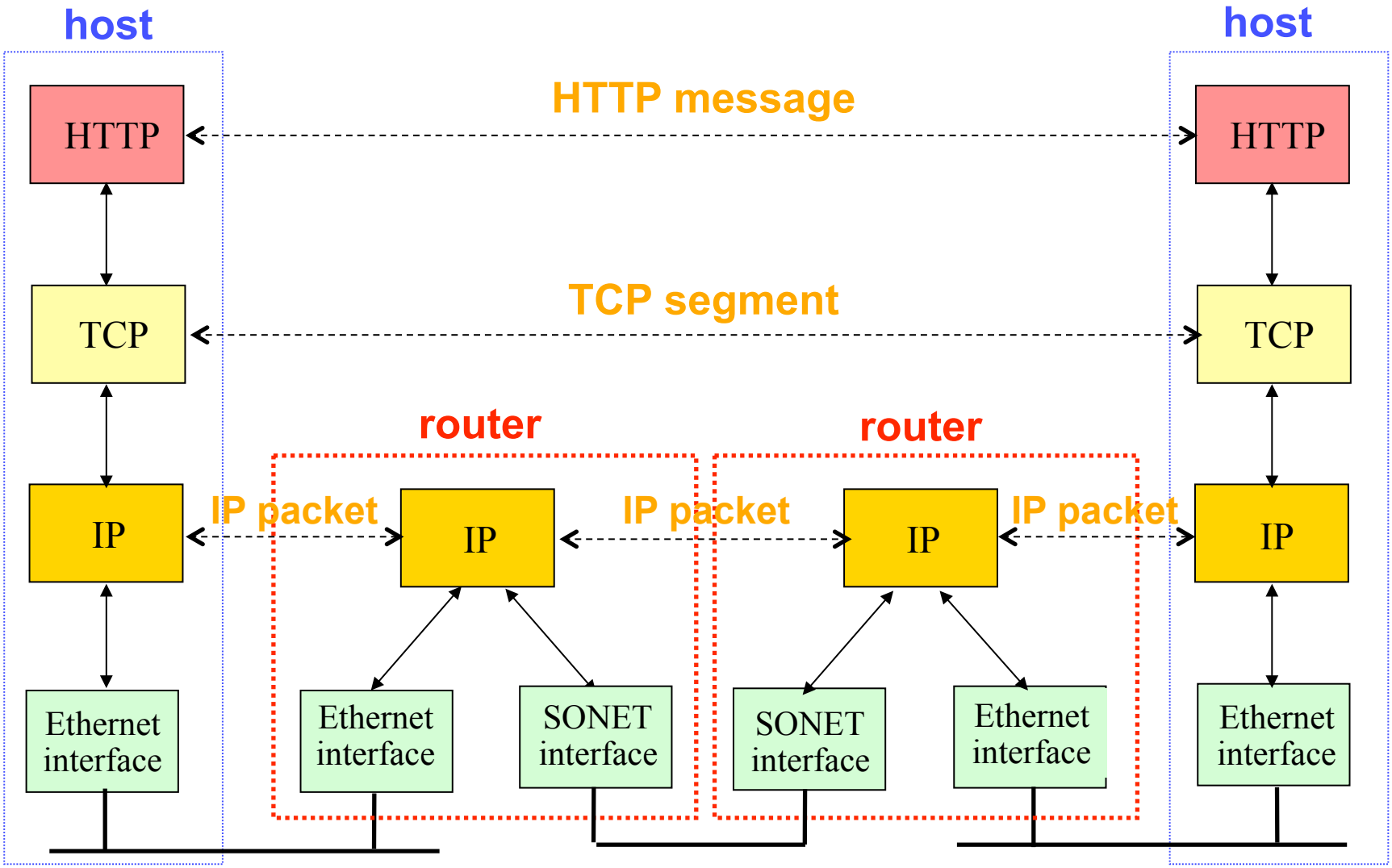


Layer Encapsulation in HTTP





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:
  - How does YouTube and Netflix serve you videos?
  - E.g., HTTP, DNS, and content distribution networks
- Next week:
  - Back to the 1960s