



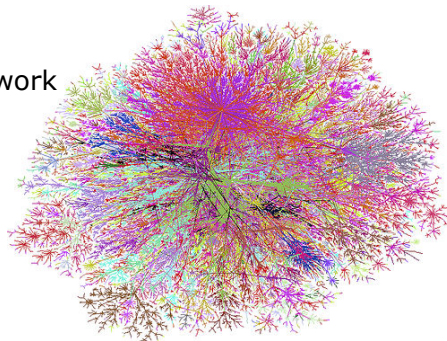
University of
Massachusetts
Amherst

Lecture 10–Internet

ECE 197SA – Systems Appreciation

Internet

- Computer networks
 - Infrastructure for large-scale distributed application
 - Global data exchange between computers
 - Essential for today's society
- Today's lecture:
 - System components of a network
 - Communication protocols



Wide Use of Internet

- What can the Internet be used for?

- Business
- Personal communication
- News, information, etc.
- Government, military, etc.
- Entertainment
- ...



"This is where our trails divide, Luke.
You have my E-mail address, right?"



"Hi. My name is Barry, and I check my
E-mail two to three hundred times a day."



"I swear I wasn't looking at smut—
I was just stealing music."

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Societal Impact of Internet

- Access to Internet becoming more critical



@twitterglobalpr
Twitter Comms

Egypt continues to block Twitter & has greatly diminished traffic. However, some users are using apps/proxies to successfully tweet.

45 minutes ago by cpen via web ☆ Favorite □ Retweet ↻ Reply



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What if the Internet Goes Down?

- How is your life impacted if the Internet is down?

Cost of Internet Downtime

- Cost of 1 hour of downtime

Brokerage operations	\$6,450,000
Credit card authorization	\$2,600,000
Ebay	\$225,000
Amazon.com	\$180,000
Package shipping services	\$150,000
Home shopping channel	\$113,000
Catalog sales center	\$90,000
Airline reservation center	\$89,000
Cellular service activation	\$41,000
On-line network fees	\$25,000
ATM service fees	\$14,000
<i>Cost of one hour of downtime. From InternetWeek 4/3/2000 and Fibre Channel: A Comprehensive Introduction, R. Kembel 2000, p.8. "...based on a survey done by Contingency Planning Research."</i>	

- Internet is critical for business, personal, government, and military use.

Why Does the Internet Go Down?

- Example causes for outages:



The New York Times
nytimes.com

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January 31, 2008

2 Communication Cables in the Mediterranean Are Cut

By [HEATHER TIMMONS](#)

NEW DELHI — Two undersea telecommunication cables were cut on Tuesday evening, knocking out Internet access to much of [Egypt](#), disrupting the world's back office in [India](#) and slowing down service for some [Verizon](#) customers.

One cable was damaged near Alexandria, Egypt, and the other in the waters off Marseille, France, telecommunications operators said. The two cables, which are separately managed and operated, were damaged within hours of each other. Damage to undersea cables, while rare, can result from movement of geologic faults or possibly from the dragging anchor of a ship.

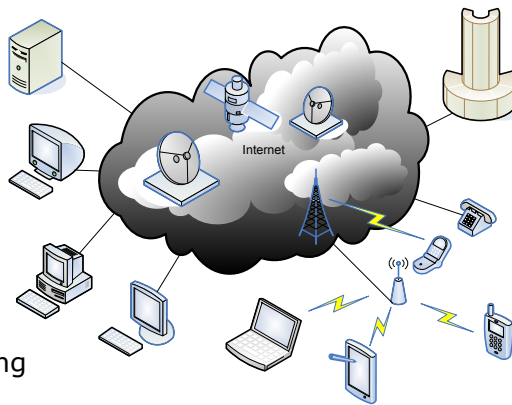
Hundreds of undersea cables often owned and managed by international consortiums keep telecommunications running worldwide. A surge in phone and Internet connections in Asia and to new financial

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What is the Internet?

- End-systems
 - Desktops/laptops
 - Servers
 - Wireless devices
- Network infrastructure
 - Cables, optical fiber
 - Routers, switches
 - Satellites, radio links
- Software
 - WWW, e-mail, file sharing
 - Network protocols
- Key aspects of Internet:
 - Network of independent networks ("autonomous systems")
 - "Open" system that support many diverse network components and applications

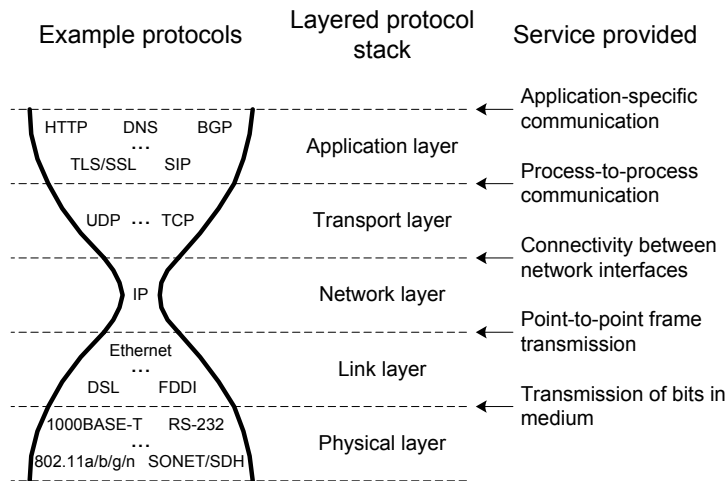


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Structure of Internet Architecture

- How to organize such a large and diverse system?
- Layered network architecture



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Network Protocols

- Network “protocols” used widely in Internet
 - Exchange of information
 - » Example: web page request
 - Trigger functions on other systems
 - » Example: remote database search operation
 - Exchange of control and management information
 - » Example: routing protocol to find path to destination
- Protocol specifies interactions
 - “A protocol defines the format and the order of messages exchanged between two or more communicating entities, as well as the actions taken on the transmission and/or receipt of a message or other event.”
- Protocols important for computer systems in general
 - Computer systems not good at handling ambiguity
 - Protocols ensure precise interactions

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Example Protocol

- Reliable data transfer
 - Important for most application on the Internet
- Network layer is unreliable
 - Packets may make it to destination or not
 - Packets may be reordered, delayed, lost, altered, etc.
- How to design a protocol for reliable data exchange?

Example Protocol

- Goal:
 - Sender wants to send packets A, B, C
- Protocol design:
 - What information needs to be added to packets?
 - What does the sender do? What does the receiver do?
- Scenario 1: completely reliable channel

Example Protocol

- Scenario 2: channel with bit errors

Example Protocol

- Scenario 3: channel with bit errors and packet loss

Example Protocol

- Scenario 3: channel with bit errors and packet loss
- Information in packet header
 - Checksum of packet (to allow detection of bit errors)
 - Sequence number (to allow ordering)
 - Acknowledgement information (to respond to sender)
- Sender operation
 - Add checksum, sequence number, send, and start timer
 - If timer expires, resend
 - If "old" acknowledgement, resend
 - If correct acknowledgement, move to next packet
- Receiver operation
 - Check checksum, check sequence number
 - If error, send old acknowledgement
 - If correct, send correct acknowledgement
- Many possible improvements (e.g., pipelining)

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Courses in ECE Curriculum

- ECE 374 – Computer Networks and the Internet
- ECE 671 – Computer Networks

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Upcoming...

- Next Wednesday: Information Security
 - Cryptographic protocols
- And: Senior Design Projects
- Moodle quiz

