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Foundations

COS 460 & COS 550

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Foundations

- Applications
- Requirements
- Architecture
- Performance
- Writing Code

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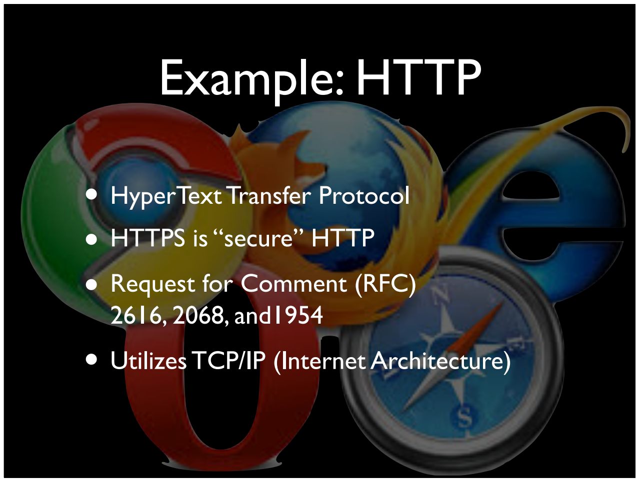
Applications

...and these are just the web "social media" ones


Example: HTTP
HyperText Transfer Protocol
HTTPS is "secure" HTTP
Request for Comment (RFC) 2616, 2068, and1954
Utilizes TCP/IP (Internet Architecture)

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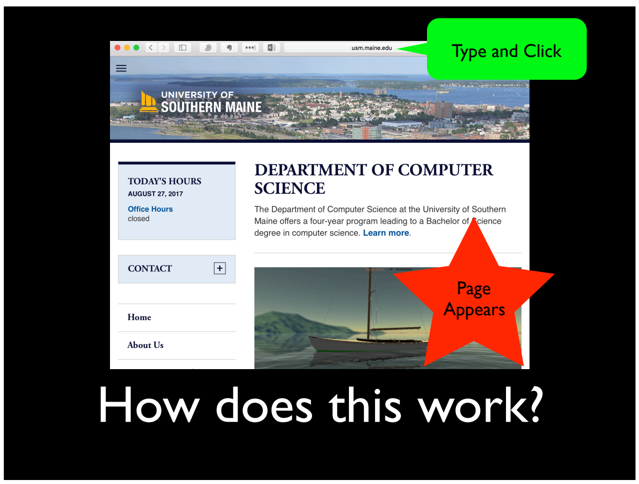
Type and Click
UNIVERSITY OF SOUTHERN MAINE
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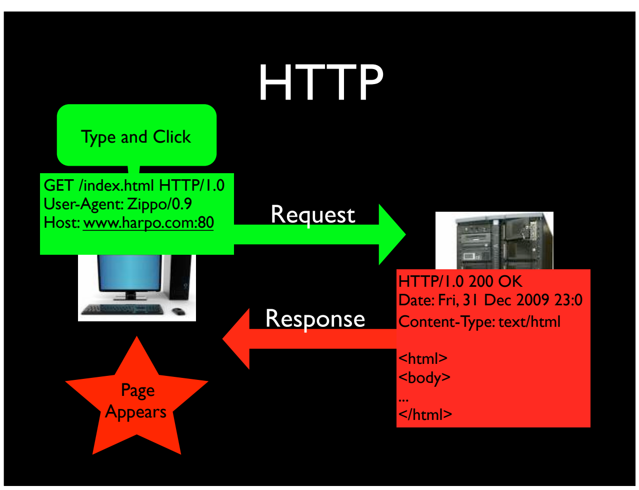
DEPARTMENT OF COMPUTER SCIENCE
The Department of Computer Science at the University of Southern Maine offers a four-year program leading to a Bachelor of Science degree in computer science. Learn more.
Page Appears
How does this work?

5


HTTP
Type and Click
GET /index.html HTTP/1.0
User-Agent: Zippo/0.9
Host: www.harpo.com:80
Request
HTTP/1.0 200 OK
Date: Fri, 31 Dec 2009 23:0
Content-Type: text/html
<html>
<body>
...
</html>
Response
Page Appears

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HTTP, TCP

Setup Connection
- Request Connection
- Accept/Request Connection
- Accept Connection

GET /index.html HTTP/1.0
...

HTTP/1.0 200 OK
...

Close Connection
- Request Close
- Accept/Request Close
- Accept Close

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HTTP

- HTTP is essentially **file transfer**
- Every bit is important
- Similar to Email, Printing, File Servers...

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Audio & Video

Every bit is not **important** but their **timing** is

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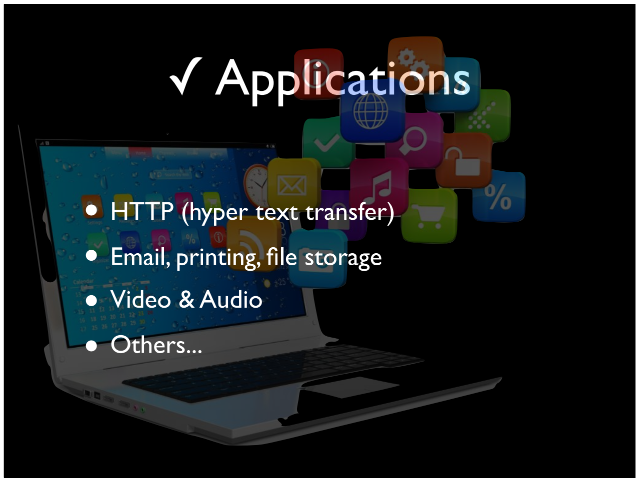

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Foundations

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Requirements

- Connectivity
- Cost-effective
- Supports (common) Services

Who's Requirements?

- Application Programmer
- Network Provider (ISP)
- Network Designer

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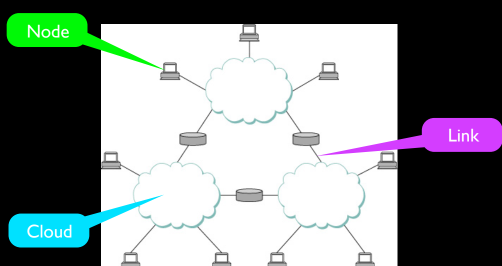
Connectivity



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Cost-Effective

How do we get as **much information** as possible, from **multiple** sources to multiple sources across the "wire"?

...one bit at a time is slow.

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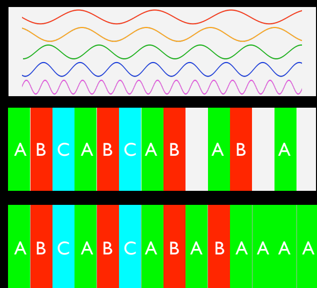
Multiplexed

Frequency Division

Time Division

Packet-Switched



Imagine A has 2x B's data needs and B has 2x C's
FDM – Unused allocation for D and E as well as B and C not using all
TDM – Imagine A has more data, unused time slots
PSwitched – Quality of Service & Congestion problems

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Common Services

Define **useful channels** that understands the **application needs** and the **networks ability**.

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Common Services

- File transfer vs. Streaming
- Reliable vs. Unreliable
- Bandwidth vs. Latency
- Large vs. Small

✓ Requirements

- **Connectivity**
  Links, Nodes, Clouds
- **Cost-Effective**
  Packet Switched
- **Support (common) Services**
  File transfer, streaming, bandwidth...

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Foundations

✓ Applications
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Architecture

How do we build a Network so it is...

- understandable
- programmable
- flexible
- useful

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Layers make everything better

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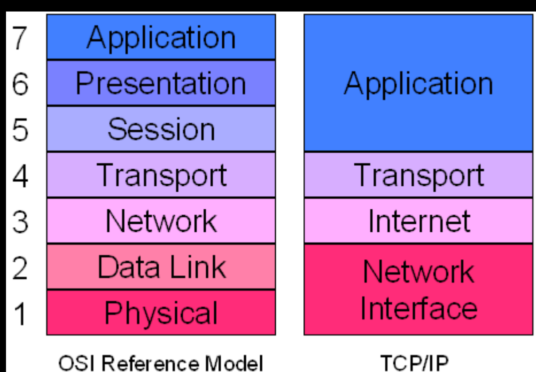

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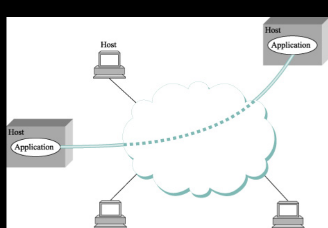

Application View

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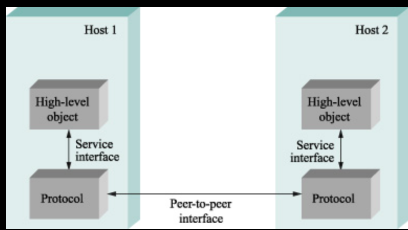

Service/Peer Interfaces

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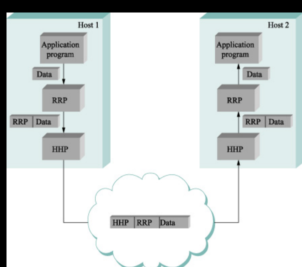

Encapsulation

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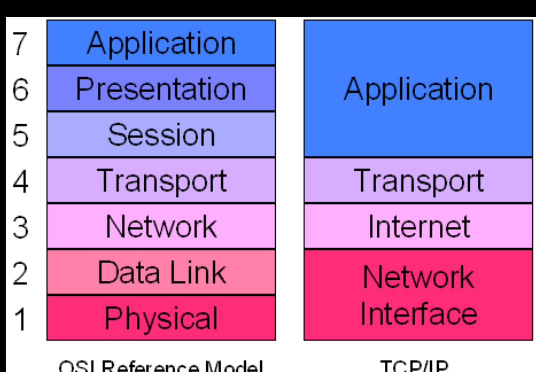

✓ Architecture

Network Layers

- Subdivide the problem
- Address one at a time
- Do a good job at each layer

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Foundations

✓ Applications
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- Performance
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Performance

- Bandwidth
- Latency
- Delay X Bandwidth
- High-Speed Networks

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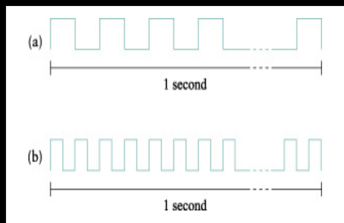
Bandwidth



Bits transmitted per unit of time

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Bandwidth

- 10 Mbps
  - 10 million bits per second
  - 0.1µS for each bit
- 20 Mbps; 0.5µS for each bit
- 100 Mbps; 0.01µS for each bit

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Latency

How long does it take to get there?

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Latency

- = Propagation + Transmit + Q-Delay
  - Propagation Delay (distance / c)
  - Transmit Time (size / bandwidth)
  - Queueing Delays

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Latency

- Speed of Light (c)
  - copper = 2.3×10^8 m/s
  - vacuum = 3.0×10^8 m/s
  - fiber = 2.0×10^8 m/s

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Latency

- One Way Latency
- Round Trip Time (RTT)

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Bandwidth vs Latency

For...

- HTTP?
- File Transfer?
- Audio?
- Video?

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Bandwidth vs Latency

Consider a 1-byte message and a 1-byte response over a 10Mbps link with a 10ms RTT.

...Does **bandwidth** or **latency** dominate the transmission?

...When will bandwidth dominate?

0.8us + 10ms = 10.0008ms — Latency dominates
Even at 1Gbps — 0.008us + 10ms = 10.000008 Latency dominates

@10Mbps; 10,000bits = 1ms; 100,000bits = 10ms; 12,500 bytes or ~12kB

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Delay x Bandwidth

Amount of data "in-flight"

10 Mbps x 50 mS

(10×10^6) bits/sec x (50×10^{-3}) sec

500×10^3 = 500Kb

62.5KB

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High-Speed Networks

- Very large **bandwidth**
- Latency does **not** change
- Delay X Bandwidth goes **up**
- More data in-flight during RTT
- Latency begins to dominate transfer times.

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✓ Performance

- Bandwidth
- Latency
- Delay x Bandwidth
- High-Speed networks

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Foundations

✓ Applications
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✓ Performance
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Code

It Takes Two to Tango

- Server (passive)
- Client (active)

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Server

- **Binds** to a “port”
    - Passively **listens** for connection request
        - **Accepts** connections
            - reads and writes data
                - **Closes** connection when done

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Client

- Actively **connects** to server’s port
    - reads and writes on connection
        - **Closes** connection when done

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Java Server

```
// passive bind and listen
ServerSocket srv = new ServerSocket(port);
Socket s = srv.accept();
    s.getInputStream() & read()
    s.getOutputStream() & write()
 s.close();
```

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Java Client

```
// active connect
Socket s = new Socket("server", port);
    s.getOutputStream() & write()
    s.getInputStream() & read()
s.close()
```

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✓ Code

- Client (active) - Server (passive)
- Peer to Peer networks?
  - Who's the server?
- Distributed networks
  - Multiple servers and clients

Foundations

- ✓ Applications
- ✓ Requirements
- ✓ Architecture
- ✓ Performance
- ✓ Writing Code

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Foundations

End

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