The Network Behind the Web

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Surfing the Web

- What happens behind the scene?
Clients and Servers

Client

Get page

Here it is

Server
Location?

CA, USA

Get page

Australia

Here it is

Server NY, USA

Finland

India

Australia

Finland

India
How do they communicate?
Communication networks

- CA, USA
- NY, USA
- Finland
- India
- Australia
What’s a network?

“A fabric or structure of cords or wires that cross at regular intervals...” and

“A system of computers, terminals and databases connected by communication lines” [Merriam-Webster Dictionary].

“A computer network is defined as the interconnection of 2 or more independent computers.” [Ramteke, “Networks”, pg. 24].
Why network?

Before networks:

- One large computer (mainframe) used for all processing in businesses, universities, etc.

Smaller, cheaper computers...

- Personal computers or workstations on desktops.
- Interconnecting many smaller computers is advantageous! Why?
Why network?

- Resource sharing!
  - Hardware: printers, disks, terminals, etc.
  - Software: text processors, compilers, etc.
  - Data.
- Robustness.
  - Fault tolerance through redundancy.
- Load balancing.
  - Processing and data can be distributed over the network.
- Location independence.
  - Users can access their files, etc. from anywhere in the network.
Examples of networks

- Postal network.
- Telephone network.
- Internet.
Data communication networks

- Components:
  - End systems (hosts).
  - Routers, switches, bridges.
  - Links.
Data networks

Australia

CA, USA

NY, USA

Finland

India
CA is surfing – what happens?
CA is surfing – what happens?
CA is surfing – what happens?
Functions

- Routing,
- Forwarding,
- Reliability,
- Flow control,
- Congestion control...

Complex system!
Layering

- **Building complex systems is hard!**
  - Approach: “Divide and conquer”.
  - *Split job into smaller jobs, or layers.*

- Analogy:
  - Building a house: digging, foundation, framing, etc.
  - Car assembly line...

- Basic idea: each step dependent on previous but no need to be aware of how previous step was done.
Analogy: Air Travel

- Departing airport
  - Arrival
  - Check-in
  - Boarding
  - Takeoff

- Intermediate air traffic sites
  - Airplane routing

- Arriving airport
  - Departure
  - Baggage claim
  - Deplane
  - Landing
The Internet

TCP/IP

- Application
- Transport
- Internet
- Network Access
- Physical
Protocols

- Diplomats use rules, called **protocols**, as guides for formal interactions.
  
  - A *communication protocol* is a set of rules that specify the format and meaning of messages exchanged between computers across a network.
Human and Computer Protocols

Human Protocol:
- Hi
- Hi
- Got the time?
- 2:00

Computer Protocol:
- Web client
  - open connection
  - OK
  - send me data
  - data

- Web server
The Internet revolution

- Exponential growth.
  - Number of connected hosts doubles every 9-12 months.
  - Over 175M hosts connected.
Challenges

- Scalability.
- Robustness.
- Decentralization.
- Autonomy.

- Open system...
“Next-Generation” Internet

- Wireless.
- Mobility.
- Heterogeneity.
- Self-organizing networks.
  - Impromptu deployment.
  - No need for infrastructure.
  - E.g., sensor networks.
What are sensor networks?
Technology

- Circuit integration.
  - Ability to integrate more functions into chip.
- Wireless communication.
Result?
Result: sensing nodes

PC-104+ (off-the-shelf)

UCLA TAG (Girod)

UCB Mote (Pister/Culler)
Sensing nodes

Include:

- Processing,
- Sensing, and
- Communication capabilities.
Vision

• **Network** these devices so that they can execute more complex tasks.

• **Embed** numerous sensing nodes to monitor and interact with physical world.

Images from UCLA CENS
More applications...

- Seismic response
- Soil contaminant transport
- Ecosystem monitoring
- Marine life monitoring

Images from UCLA CENS
The UCSC coyote project

- Understand the physiology and behavior of large predators and their interaction with their ecosystem.
- To date, very little information on terrestrial mammals.
- Critical to understand their energetic and habitat needs (e.g., ecosystem balance, conservationism, etc.)
Interdisciplinary research

- Use of sensor network technology to provide biologists with information they need.
  - Example: obtain physiology information by correlating movement patterns, eating behavior, daily activities, etc.
Heterogeneous network

- Static sensors.
  - Continuous power.
  - High bandwidth.

- Mobile sensors.
  - Animal-borne.
  - Anemic: low power, low bandwidth.
Multi-tiered sensor network

- Static sensor <-> static sensor.
- Static sensor <-> mobile sensor.
- Mobile sensor <-> mobile sensor.
Self-configuring network

- Network adapts based on what it learns about the behavior of target objects.
  - Example: deployment of additional nodes based on acquired knowledge of animals whereabouts; tuning protocol parameters (e.g., when to transmit data) for performance versus energy efficiency balance.
Where are we now?
SEA-LABS

Sensor Exploration Apparatus utilizing Low-power Aquatic Broadcasting System
Overview

- Real-time, low-cost, low-power consumption environmental monitoring system for use in shallow-water reef habitats.

- Goal is to measure several important physical and chemical variables to study the growth and calcification of corals and coralline algae.
The Networks Track in CE

- EE 103.
- CE 150 (will become CE 150/L).
- CS 111.
- CE 156/L.
- CE 151.
- EE 151.
- CE 154.
Exercises

- Find your IP address (*ipconfig*)
- Ping your friend
- Using *tracert* (*traceroute* in *nix OSes)
  - Find route to [www.google.com](http://www.google.com)
  - Find route to [www.yahoo.com](http://www.yahoo.com)
- Investigate *tracert* using *Wireshark*
  - How does it work?
- Paste *tracert* output into:
  - Visualize the route your packets take!