Overview

EECS 122: Lecture 1

Department of Electrical Engineering and Computer Sciences
University of California
Berkeley

Today's Outline

- Course Information and Goals
- Overview
  - Applications, Protocols and Components
  - The Network Edge and Core Divsion
  - Packet and Circuit Switching
  - Examples of Networks
  - What is the Internet?
- Great way to familiarize you with some terms and concepts
- The rest of course will delve deeper into what you hear about today…

Administrivia

- Instructors
  - Abhay Parekh (parekh@eecs.berkeley.edu, 223 Cory)
  - David Tse (dtse@eecs.berkeley.edu, 224 Cory)
- TAs
  - Marghoob Mohiyuddin (marghoob@eecs, Office hours: TBA)
  - Nikhil Shetty (nikhils@eecs, Office Hours: TBA)
- Recitations:
  - W
  - F
- Lecture time
  - Tues/Thursday, 12:30 – 2pm
- Office hour:
  - Tues/Thursday, 2-3pm in the Qualcomm Room (200 Cory)
- Class Web page
  - http://inst.eecs.berkeley.edu/~ee122/ (not up yet)
- Text
  - Computer Networking: A Top Down Approach Featuring the Internet (3rd Edition) by Kurose and Ross

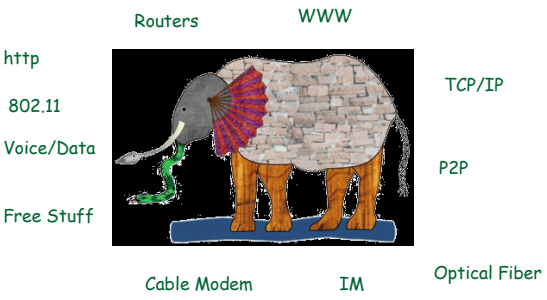
Course Structure

- Prerequisites:
  - C and Java (you don't have to be a great programmer, but comfortable with the syntax)
  - Algorithms and their analysis – no difficult math, but you have to be comfortable looking at problems analytically
- Grading
  - Homework Assignments: 15%
  - Projects: 30%
  - Midterm: 20%
  - Final: 35%
- Homework: Paper-pencil problems and "Ethereal Lab" problems
- Projects:
  - Network Simulator (NS2) based project
  - Several shorter programming projects based on C and Java

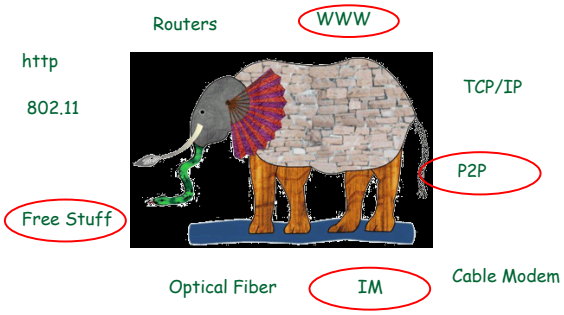
Course Structure

- This is a big class so please
  - Attend Lecture
  - Be on Time
  - Ask Questions
  - Utilize the course resources: Lectures, Recitations, Labs, Office Hours, Companion Website for the book
- Networking is a very complex subject
  - try to focus on concepts, not just details.
- Late Hand-ins:
  - 25% off for the first late day
  - Nothing accepted that is more late than one day

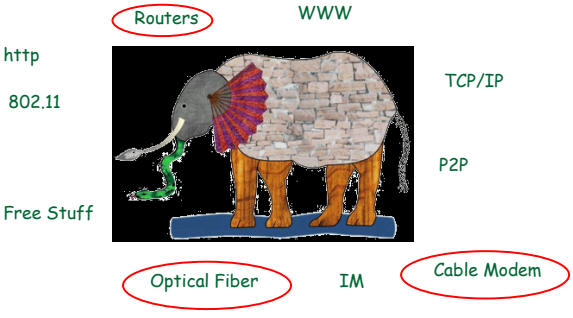
What is networking?



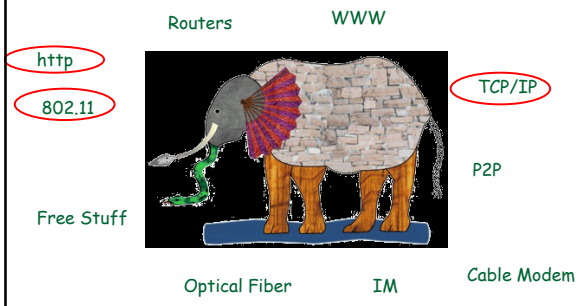
Applications



Components



Protocols



What's a protocol?

human protocols:

- Meal time
- "I have a question"
- introductions

… specific msgs sent

… specific actions taken when msgs received, or other events

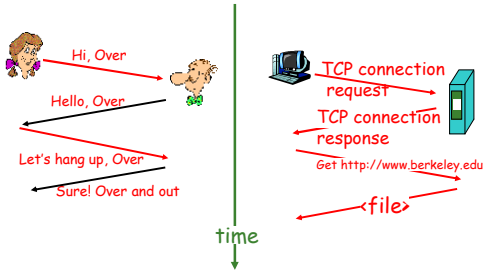
network protocols:

- machines rather than humans
- all communication activity in Internet governed by protocols

protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt

What's a protocol?

a human protocol and a computer network protocol:



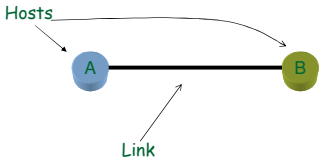
Applications, Protocols, Components… How do they all come together?

- Our Focus will be on the internet
  - What is its structure?
  - How does it scale?
  - Who owns it?
  - How can we make it better?
    - How does one write a new network application?
    - How does one insert a new component (a faster router for example)?
- This will help us understand other kinds of networks (e.g. the voice network) as well

Course Goals

- To gain a fundamental understanding of what the internet is and how it works today
  - This is a "first course" so we may be more wide than deep!
- To understand how the internet may evolve in the future

The Simplest Network…



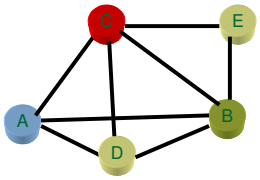
Networks are created from a need to communicate…

Hundreds of Millions of End Nodes or Hosts

Web Servers

Skype Phones

Inevitably, Networks Grow

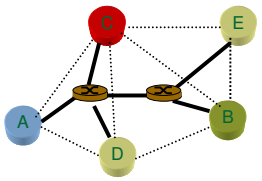


Directly connecting n hosts takes $O(n^2)$ links!

Complications: Hosts
1. must forward
2. choose among multiple paths

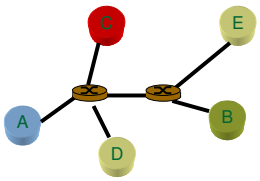
1. The forwarding function becomes a performance bottleneck
2. There too many alternative paths – the overhead to select among them becomes prohibitive

Enter Routers…



Hosts connect to specialized devices called Routers.
Routers are built (HW and Software) to discover the topology, select good paths and forward messages
quickly. They respond to changing network conditions.

Enter Routers…



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Routers are built (HW and Software) to discover the topology, select good paths and forward messages
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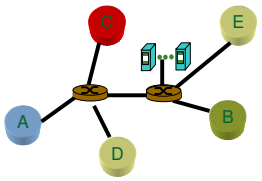
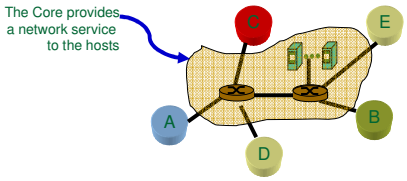
Enter More Network Infrastructure



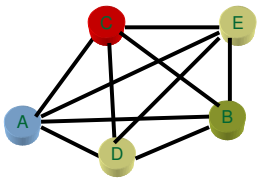
A directory server that helps an application node figure out which network address(es) it should send its messages to.
In the internet, this is DNS

Host-Core Division



The devices inside the network cloud are what make the internet tick
The applications in end hosts make the internet useful and powerful
- The end hosts form the Network Edge

Special Case: Broadcast



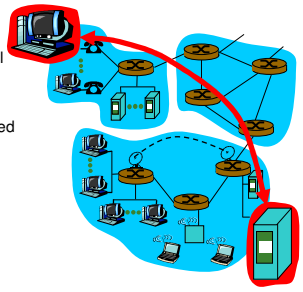
Directly connecting n hosts takes $O(n^2)$ links!

The core is very simple for broadcast networks although other problems (to be studied later) arise

Every transmission is received by all the other hosts
Examples:
1. Satellite Transmission
2. Local Area Networks

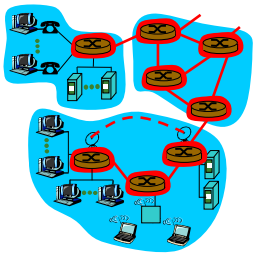
The network edge:

- client/server model
  - client host requests, receives service from always-on server
  - e.g. Web browser/server; email client/server
- peer-peer model:
  - minimal (or no) use of dedicated servers
  - e.g. Gnutella, KaZaA, Skype



The Network Core

- Many interconnected "sub-networks"
- Many different architectures
- Advertises a "service" to the end devices
  - E.g. Phone network v/s the Internet

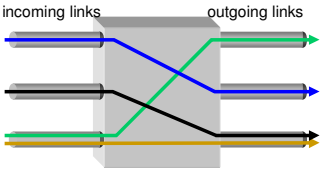


Two fundamentally different ways to forward information

- **Circuit Switched**
  - Information is exchanged in units of "calls"
  - Network resources are reserved for the duration of the call
  - Example: The Phone Network
    - Once a call goes through, subsequent calls cannot degrade call quality
- **Packet Switched**
  - Information is exchanged in units of "packets"
  - Typically, no resources are reserved
  - **Datagram**: Each packet is forwarded independently
    - Example: The Internet
  - **Virtual Circuit**: All the packets from a given stream take the same path through the network
    - Example: ATM, ISDN

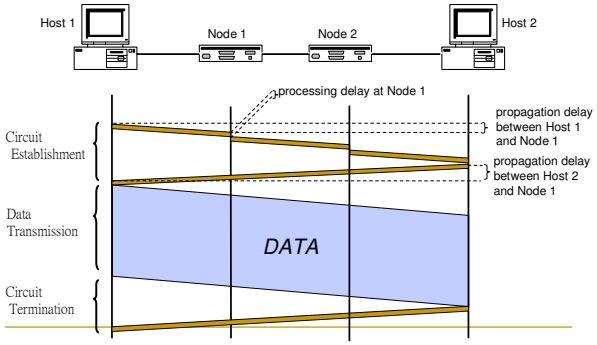
Circuit Switching

- Three phases
  1. circuit establishment
  2. data transfer
  3. circuit termination
- If circuit not available: "Busy signal"
- Examples
  - Telephone networks
  - ISDN (Integrated Services Digital Networks)

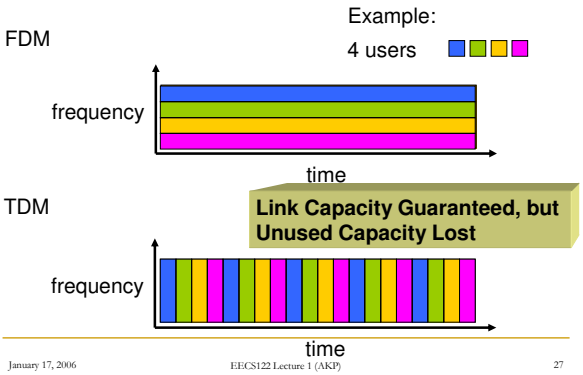


A Forwarding Node

Timing in Circuit Switching



Multiple Calls on a link: FDM and TDM



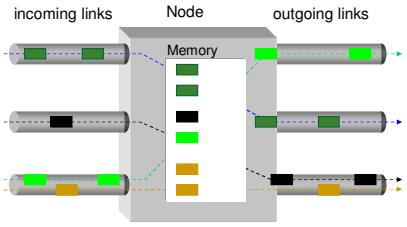
Packet Switching

- Data are sent as formatted bit-sequences, so-called packets.
- Packets have the following structure:

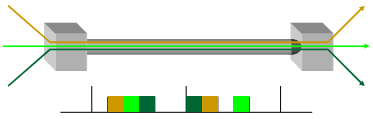
  - Header and Trailer carry control information (e.g., destination address, check sum)
- Each packet is passed through the network from node to node along some path (**Routing**)
- At each node the entire packet is received, stored briefly, and then forwarded to the next node (**Store-and-Forward Networks**)
- Typically no capacity is allocated for packets

Packet Switching

- A Packet Router

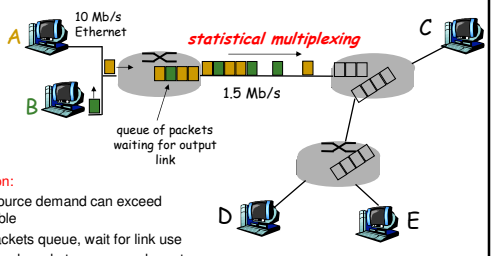


Packet Switching:



- Data from any conversation can be transmitted at any given time
  - A single conversation can use the entire link capacity if it is alone

Sharing a link: Statistical Multiplexing



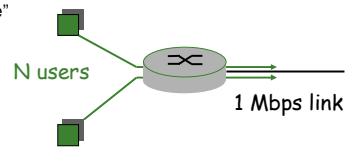
resource contention:

- aggregate resource demand can exceed amount available
- congestion: packets queue, wait for link use
- store and forward: packets move one hop at a time
  - Node receives complete packet before forwarding

Packet switching versus circuit switching

Packet switching allows more users to use network!

- 1 Mb/s link
- each user:
  - 100 kb/s when "active"
  - active 10% of time
- circuit-switching:
  - 10 users
- packet switching:
  - with 35 users, probability > 10 active less than .0004



Packet switching versus circuit switching

Is packet switching a "slam dunk winner?"

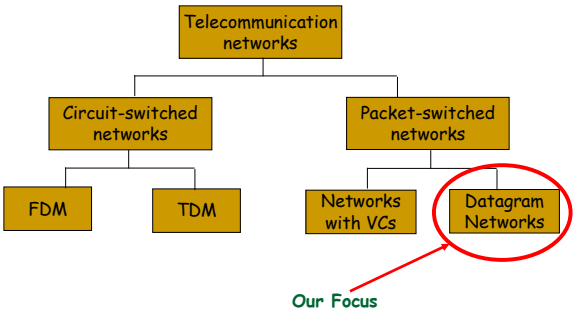
- Great for bursty data
  - resource sharing
  - simpler, no call setup
- Excessive congestion: packet delay and loss
  - protocols needed for reliable data transfer, congestion control
- Q: How to provide circuit-like behavior?
  - bandwidth guarantees needed for audio/video apps
  - still an unsolved problem
  - we will study this under "Multimedia Networking"

Transport model in a packet switched network

- Underlying infrastructure ensures that packets are routed to their correct destinations
  - All the network devices follow a protocol called the "Internet Protocol" which provides scalable addressing and routing

  BUT
- Service is BEST EFFORT
  - Packet delays are uncertain and they may be lost
- Solution: The hosts follow a protocol, TCP, to establish a "connection" between them
  - *reliable, in-order* byte-stream data transfer
    - loss: acknowledgements and retransmissions
  - *flow control:*
    - sender won't overwhelm receiver
  - *congestion control:*
    - senders "slow down sending rate" when network congested
- Other protocols such as HTTP use TCP to ensure reliable data transfer

Network Taxonomy



The Network Core

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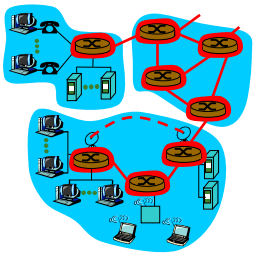
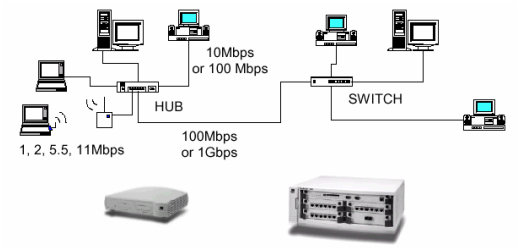
- Many different architectures

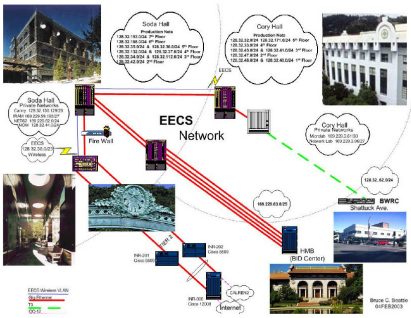


Example: The Local Area Network

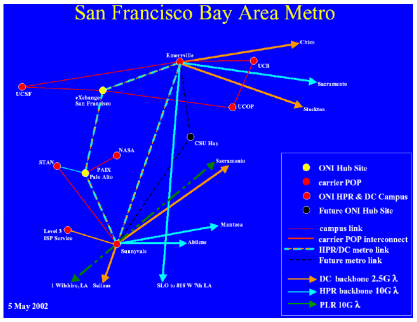


Broadcast Network

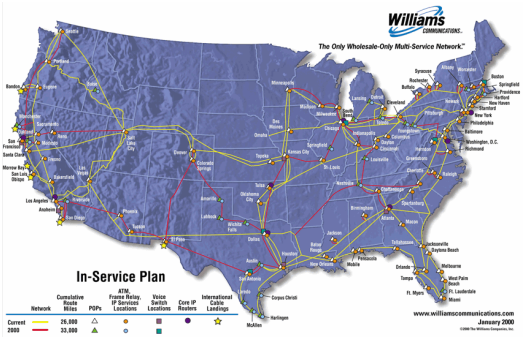
Example: Campus/Enterprise Network



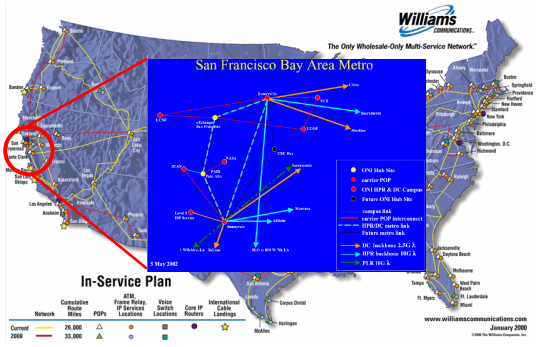
Example: Metropolitan Area Network



Example: Backbone Network



The Internet is Hierarchical



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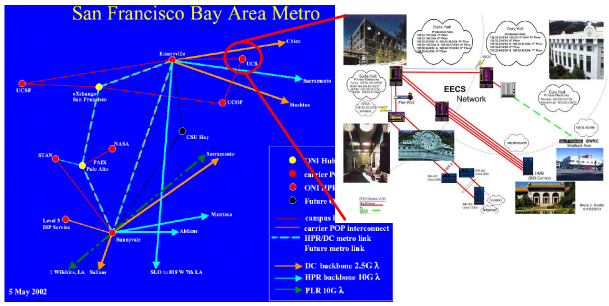

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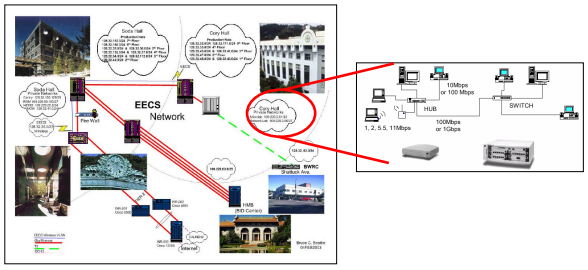
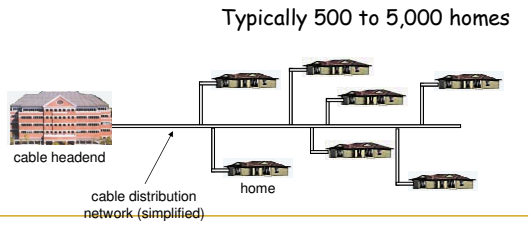
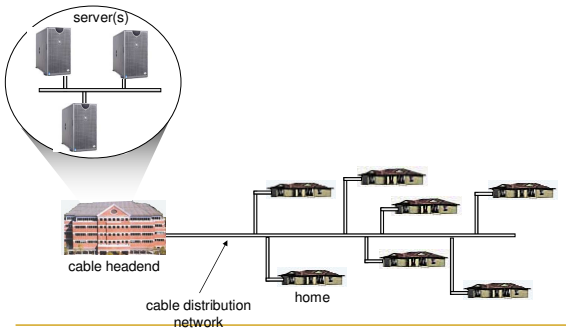


Cable Network Architecture: Overview



More Network Examples: Cable Network Architecture



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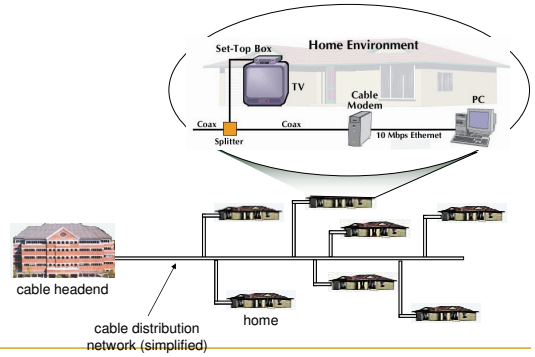

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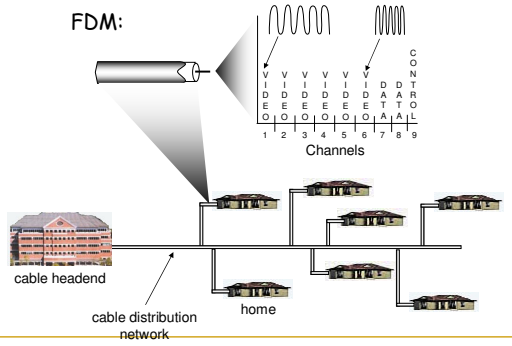
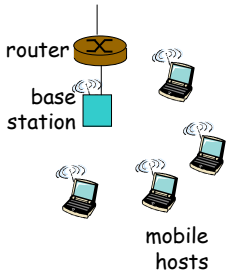
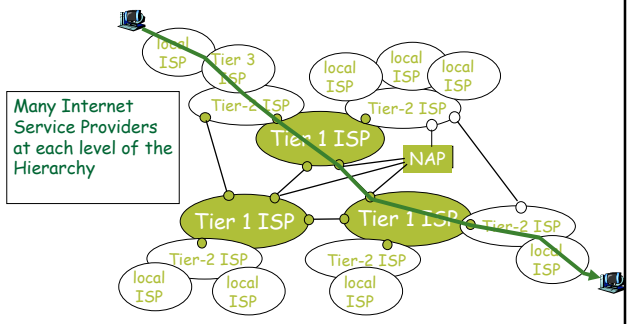


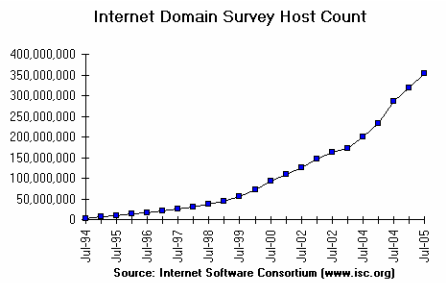
Wireless access networks

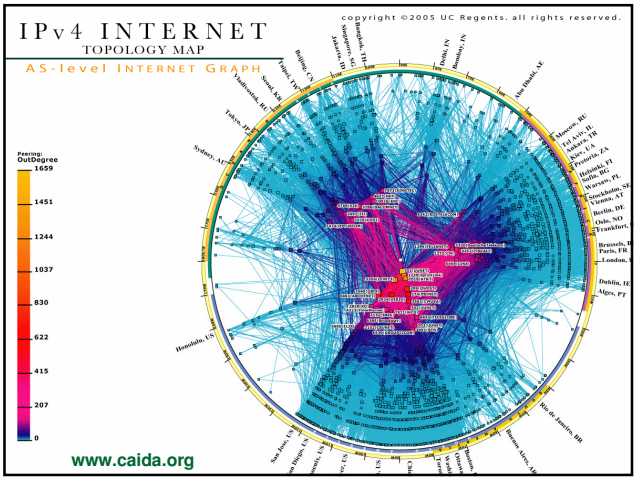
- shared *wireless* access network connects end system to router
  - via base station aka "access point"
- wireless LANs:
  - 802.11b (WiFi): 11 Mbps
- wider-area wireless access
  - provided by telco operator
  - 3G ~ 384 kbps
    - Will it happen??
  - WAP/GPRS in Europe



The internet consists of many networks







What is the internet?

- The **Internet**, or simply the **Net** is the
  - publicly accessible
  - worldwide system
  - of interconnected computer networks
  - that carries digital information in packets
  - using a standardized Internet Protocol (IP).
- It is made up of thousands of commercial, academic, domestic and government networks and millions of end devices