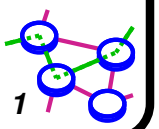
CS551
Computer Communications

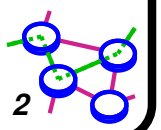
Bill Cheng

http://merlot.usc.edu/cs551-f12



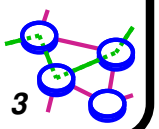
Course Topics (Tentative)

- Introduction
- Design principles
- Unicast routing
- Inter-domain routing
- TCP and congestion
- Peer-to-peer systems
- Integrated and differentiated services
- Measurements
- Wireless systems
- Multicast routing
- Tentative topics
  - Topology modeling
  - Traffic modeling
  - Security
  - Web performance and caching
  - Current topics

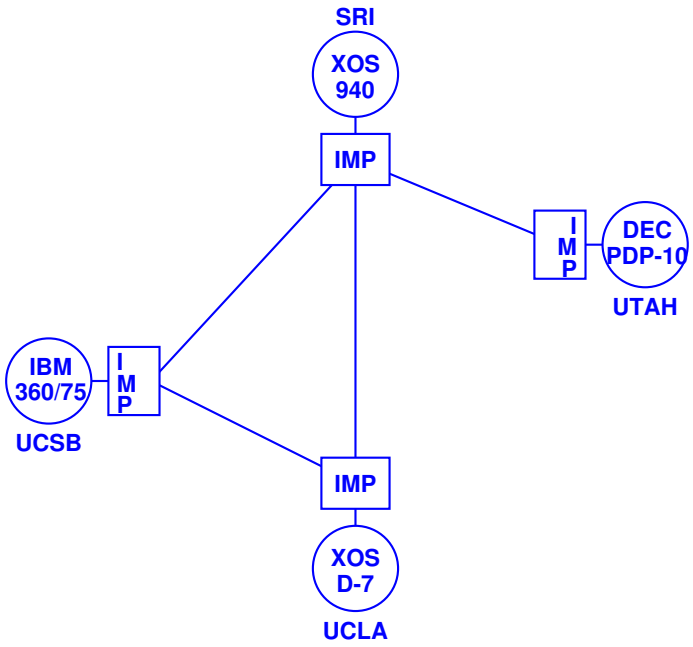


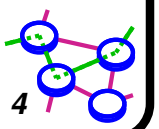
Focus of the Class

- ***Protocols*** **and** ***mechanisms***
  - **We will not deal with how bits move in physical media - you did this in your undergrad class**
- **We will deal with:**
  - **Protocol rules and algorithms**
  - **Investigate mechanism tradeoffs**
  - **Why this way and not another?**

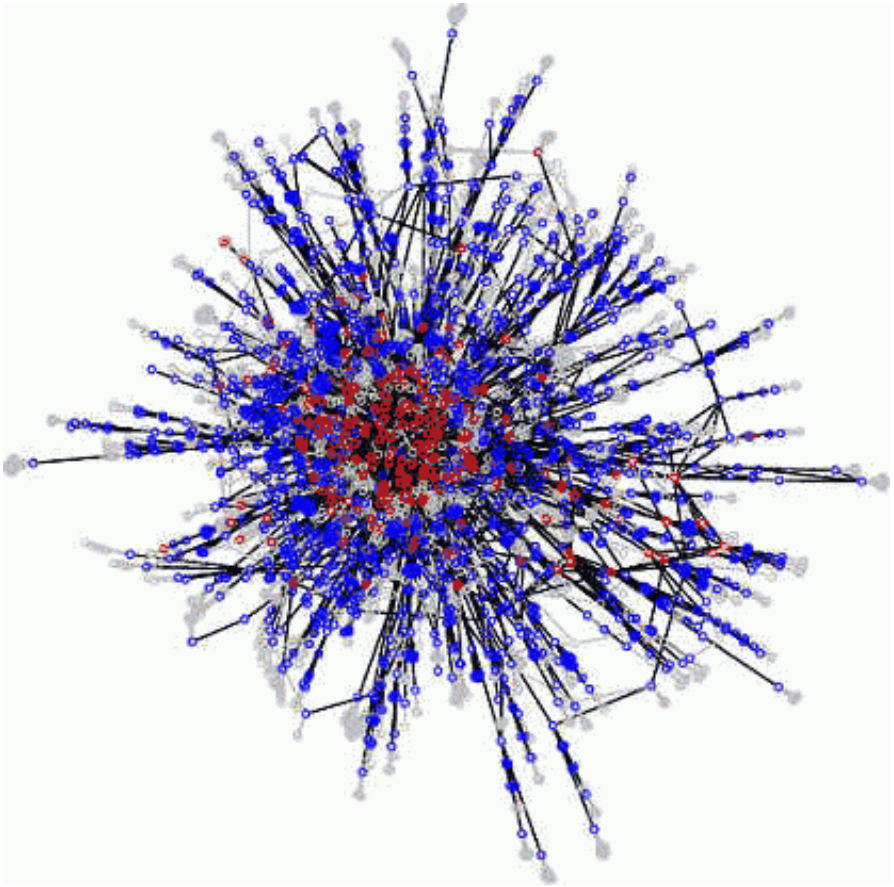


The Internet, Circa 1969

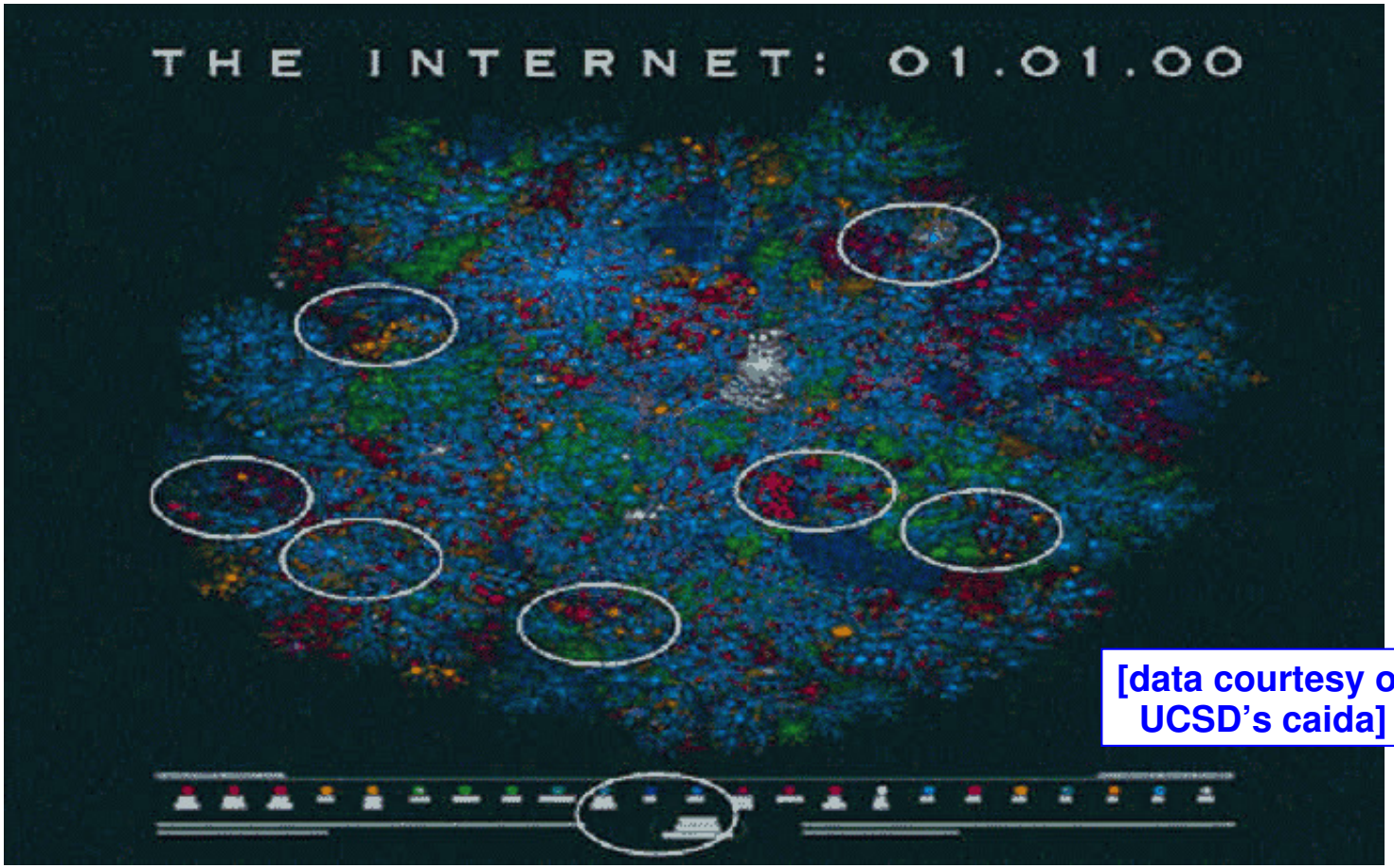




A Recent Internet ISP Map



The Internet, on a Poster, Circa 2000

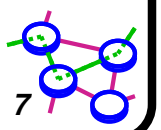


[data courtesy of UCSD's caida]

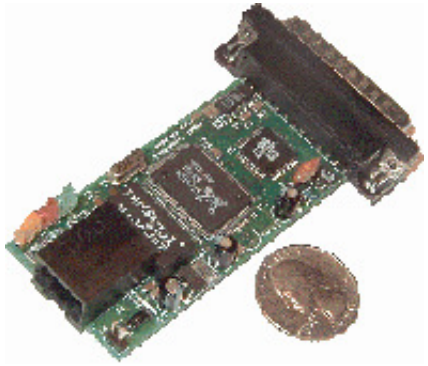
Internet Development Mantra

Quote from a t-shirt commonly worn at IETF meetings:

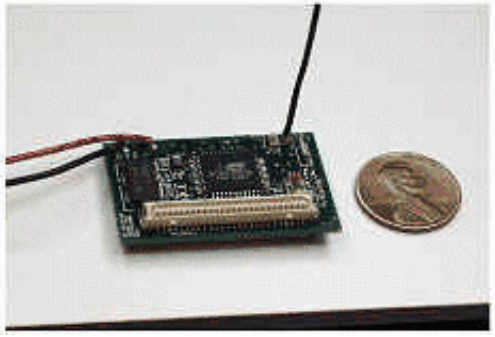
"We reject kings, presidents and voting. We believe in rough consensus and running code." **[Dave Clark]**



Glimpses of the Future?



http://www.picoweb.net/
(an 8-bit web server with Ethernet)

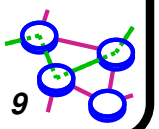


UCB mote:
an 8-bit sensor node with non-IP based networking

a sensor network
(tracking the truck)

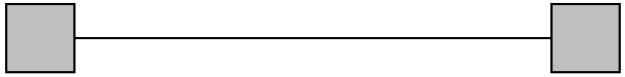
Some Definitions

- Host: computer, PDA, light switch, ...
- Link: path followed by bits.
  - Wire or wireless.
  - Broadcast or switched (or both).
- Switch: moves bits between links.
  - Packet switching: stateless, store&forward.
  - Circuit switching: stateful, cut through.

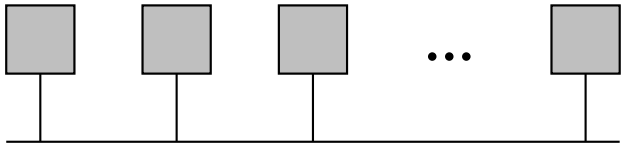


Networks

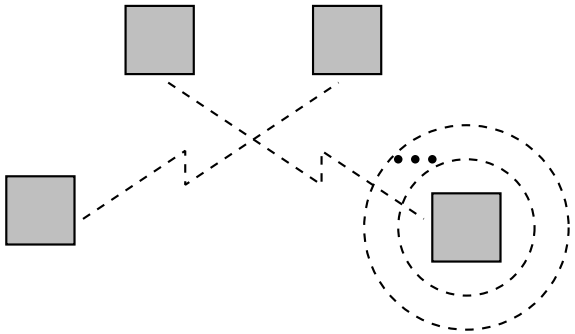
Point-to-Point

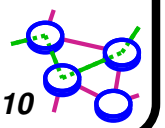


Multiple Access



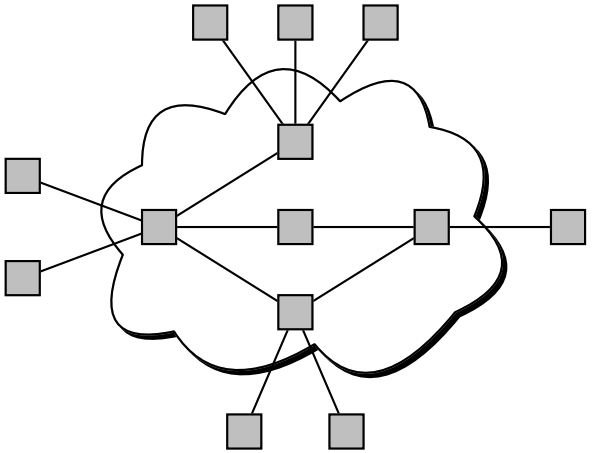
Wireless

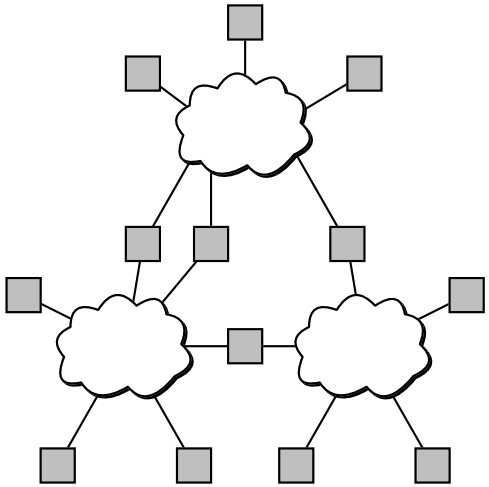




Switched Networks

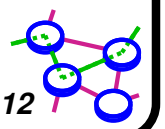
- A network can be defined recursively as...
  - Two or more nodes connected by a link, or
  - Two or more networks connected by one or more nodes





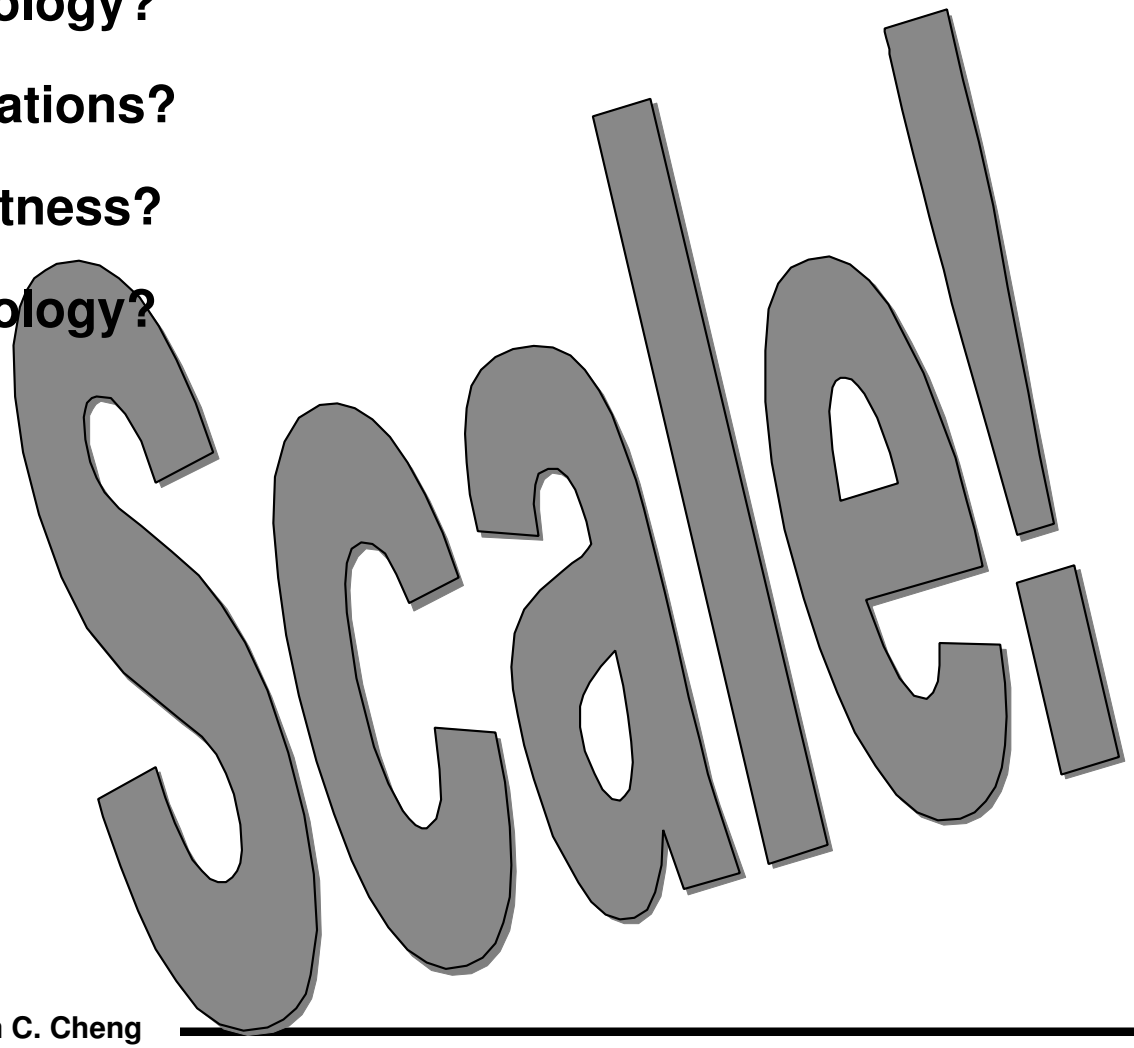
What Is the Problem?

- Technology?
- Applications?
- Robustness?
- Technology?



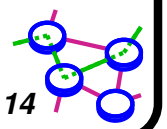
What Is the Problem?

- Technology?
- Applications?
- Robustness?
- Technology?



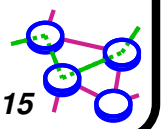
But What to Scale?

- Always define what *kind* of ***scale*** you mean
  - Number of hosts, globally routable
  - Network should support many link layers
  - Geographic distance
  - Many versions of software, hardware technologies
  - Range of bandwidths
  - Different application needs (QoS, etc)
  - Levels of trust / administrative boundaries
  - Range of price points for hardware
- Lots of dimensions of ***scaling*** to consider



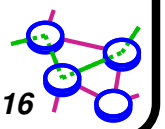
Applications Rule!

- Sometimes easy to forget in this course
- Aside: What are the implications of global connectivity?
  - Technological issues
  - Societal issues
  - Economic issues
  - Security issues
  - etc.



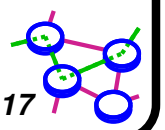
Application Considerations

- Application input to network
  - Traffic data rate
  - Traffic pattern (bursty or constant bit rate)
  - Traffic target (multipoint or single destination, mobile or fixed)
- Network service delivered to application
  - Delay sensitivity
  - Loss sensitivity
- Application examples:
  - reliable file transfer
  - remote login
  - network audio
  - network video
  - web



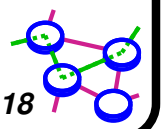
Application Examples

- Reliable file transfer
  - Loss sensitive
  - Not delay sensitive relative to round trip times
  - Point-to-point or multipoint
  - Bursty
- Remote login
  - Loss sensitive
  - Delay sensitive
    - subject to interactive constraints
    - can tolerate up to several hundreds of milliseconds
  - Bursty
  - Point to point



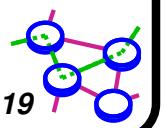
Application Examples (Cont...)

- Network audio
  - Relatively low bandwidth
    - digitized samples, packetized
  - Delay variance sensitive
  - Loss tolerant
  - Possibly multipoint, long duration sessions
    - natural limit to number of simultaneous senders
  - Compressed audio, bursty
- Network video
  - High bandwidth
  - Compressed video, bursty
  - Loss tolerance function of compression
  - Delay tolerance a function of interactivity
  - Possibly multipoint
  - Larger number of simultaneous sources



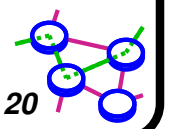
Application Examples (Cont...)

- Web
  - Transactional traffic
    - short requests, possibly large responses
  - Loss (bug?) tolerant
  - Delay sensitive
    - human interactivity
  - Point-to-point (multipoint is asynchronous)



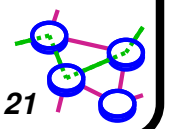
Disruptive Applications

- Applications that *disrupt* business as usual
- Not easy to predict: multicast case in point
- Web was arguably the first, and not many saw that coming
- Napster is the poster child
- Gnutella, Kazaa, Morpheus, BitTorrent (?)
- Others? What's next?

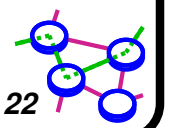


Why A Single Network?

- **Efficiency**
  - can use excess capacity more efficiently
- **Ease of introducing new applications**
  - compare phone networks: voice calls, fax, modems
  - to Internet: mail, remote login, file transfer, games, online transactions, blogging, information retrieval, uploads

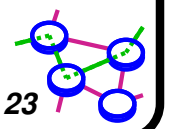


The Global Network



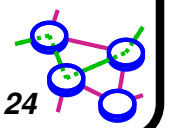
The Global Network

- Getting started
  - Host configuration
  - Network configuration
  - ISP
- Metrics
- Failure modes



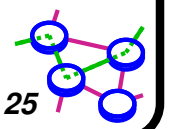
Host Configuration

- Host configuration needs:
  - a physical network cable (Ethernet, etc.)
  - an IP address
  - a network mask
  - a gateway
  - a DNS server (and other servers)
- Automated with DHCP



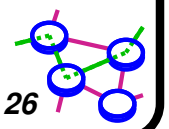
A Network

- Network configuration needs:
  - wires (from the phone or cable company)
  - Router(s)
  - a firewall?
  - an ISP to connect to the Internet
  - network addresses (e.g., 192.168.1.xxx)
  - servers



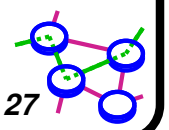
An ISP

- ISP needs:
  - a (big?) block of addresses
  - connections to one or more other ISPs, peerings
  - multiple routers, probably at exchange points
  - servers for your users: mail, web, etc.
  - servers for you: monitoring, etc.
  - competent network admins (recommended)
  - an AUP (Acceptable Use Policy)
  - a lawyer



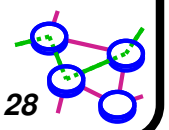
Network Metrics

- Bandwidth
  - Transmission capacity (a.k.a. How many bits can fit in a section of a link?)
- Delay
  - Queueing delay
  - Propagation delay (limited by c)
- Delay-bandwidth product
  - Important for control algorithms



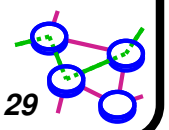
Network Failures

- Packet loss
  - Queue overflows
  - Line noise / wireless losses
- Node or link failures
- Routing transients or failures
- Application level service failures
- Some failure is expected (e.g., congestive loss), but too much failure is bad



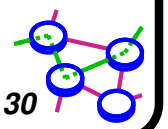
Some Backsliding About Robustness

- NAT Boxes
- Application-level gateways
- Layer-3 caches
- User tweaking
- All violate the *End-to-End Principle*, and can reduce robustness



(Lack of) Security in the Network

- Many things are too easy:
  - eavesdropping: creditcard numbers or passwords in packets
  - using other people's resources: worms, DDoS
  - breaking into machines: software bugs, poor configuration, trojan horses
  - other things: physical security, social engineering
- But, strong security is possible
  - requires all of good protocols, implementations, and people



Engineering Trade-offs

- Network can be engineered to provide:
  - Reliability
  - Low delay
  - Cost
- Pick any two