

L2: Introduction to Communication Networks: Internet



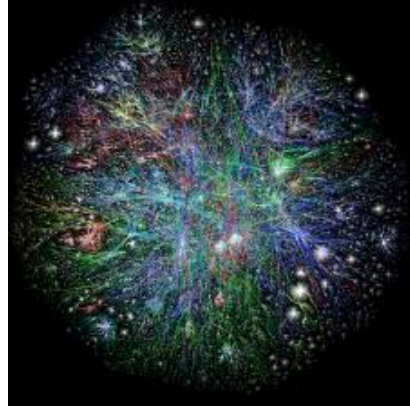
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Outline

- ARPANET
 - A connectionless datagram network
- Internet
 - A connectionless/connection-oriented datagram network
 - best-effort service
- Local Area Networks
 - Ethernet: connectionless protocol, medium access control

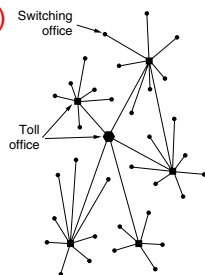
Internet

- An internetwork
- Multi-tiered, decentralized organization
- A network of computers
 - Powerful processing at network edge
 - Move communication complexity towards the edge
 - Develop sophisticated protocols

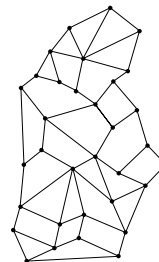


Telephone vs. Internet

Public Switched Telephone Network (PSTN)



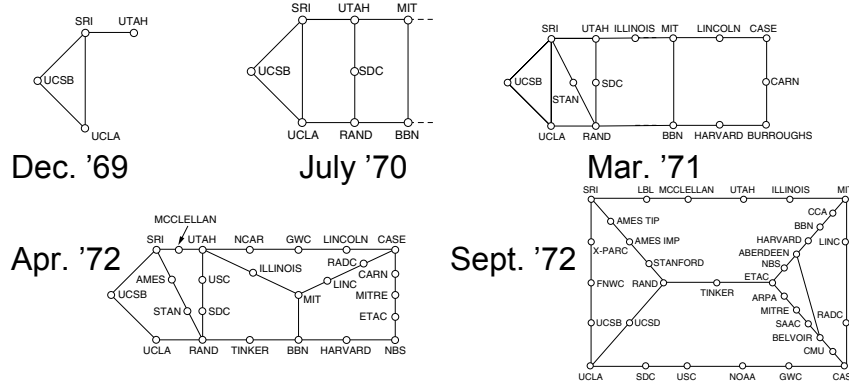
Distributed Switching System



- U.S. military dependent on PSTN in 50's
- Easy to cripple by taking out switching centers
- RAND Corp. (Paul Baran) proposes a distributed network
- AT&T rejected the idea when asked to build prototype

ARPANET

- RAND idea implemented in late 60's as network of computers between research centers



- Retired in '90 at >100 hosts
 - California - Norway

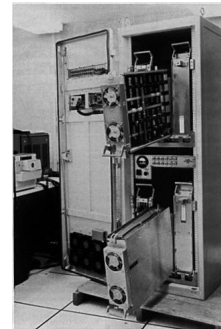
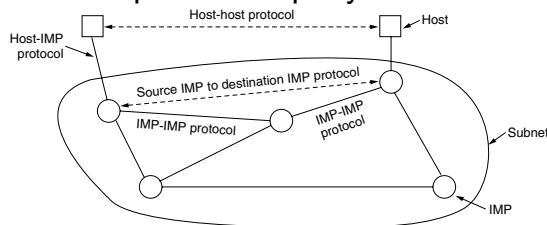
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ARPANET: Basic Structure

- Nodes consisted of minicomputers connected to **hosts**
 - Interface Message Processors (IMPs)
- Linked by 56-kbps lines leased from telephone company



- **Protocols** developed for communication
 - agreement/rules on how communications are to proceed
 - IMP-IMP, S/IMP-D/IMP, Host-IMP, Host-Host

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Key ARPANET Characteristics

- Datagram service (just like telegraph)
 - connectionless (contrast with connection-oriented)
 - unreliable (unacknowledged)
- Packet switched
 - messages up to 8063 bits could be sent
 - BUT...IMPs broke it up into 1008 bit (max) packets
- Automated routing
 - no connection setup prior to packet transmission
 - distributed routing algorithm to update routing tables
- Error control
- Congestion control
- Flow control

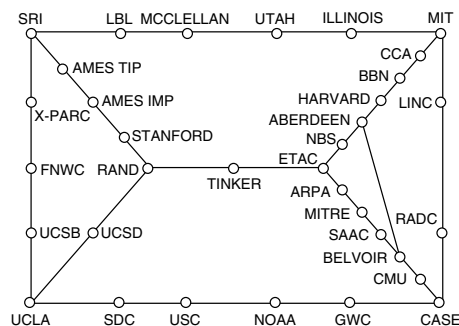
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ARPANET Applications

- ARPANET introduced many new applications
 - Email
 - remote login
 - file transfer...



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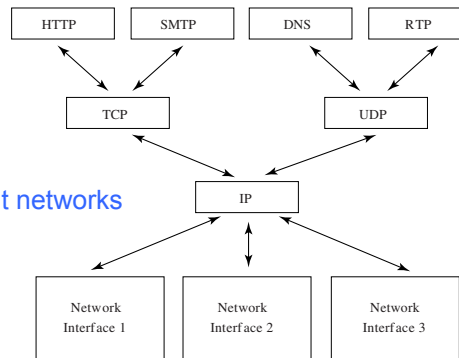
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Internetworking

- ARPANET was a great **WAN** demonstration
 - A robust network
 - Capable of supporting a variety of applications
- But...
 - Its **protocol structure** did not support the merging of various networks well
 - Not an **internet**
 - E.g. ARPANET + packet radio + satellite performed poorly
- A reorganized design was proposed...

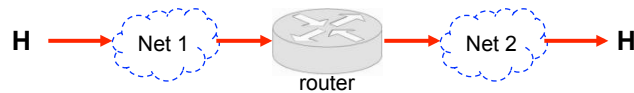
TCP/IP

- New set of rules proposed to enable internetworking
- Kahn & Cerf argued for **common rule layer**
 - Hide differences between different networks instead of translation
- The layer was eventually separated into 2 protocols
 - IP (Internet Protocol)
 - A means of getting messages moving over multiple links: **connectionless**
 - TCP (Transmission Control Protocol)
 - A means of strengthening delivery guarantees between end-points: **connection-oriented**



Layers & Structural Ideas

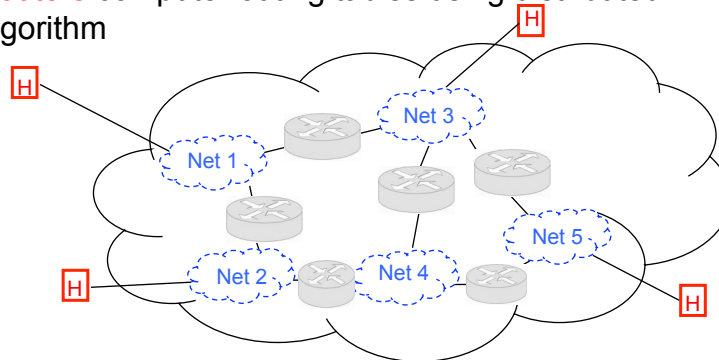
- With universally understood communication rules hosts in different types of network can talk to each other



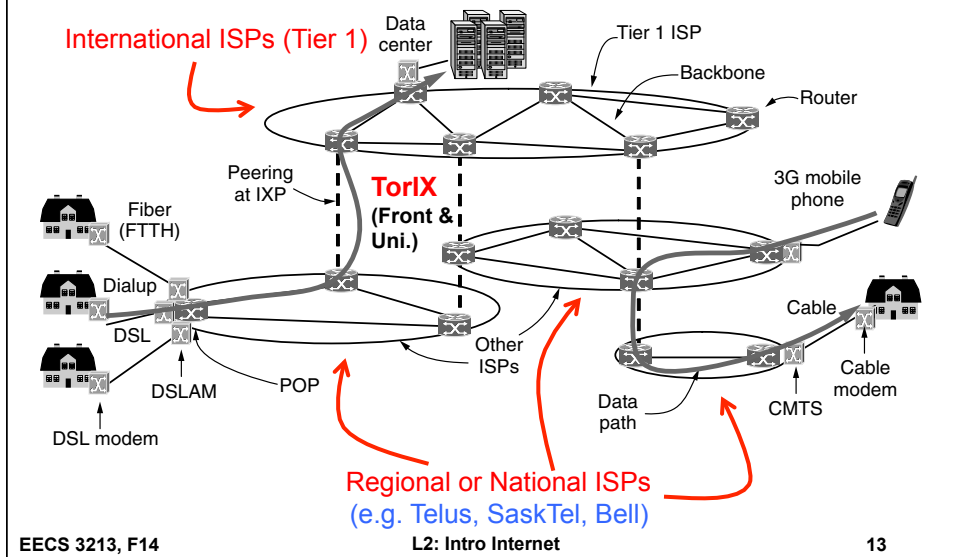
- Routers talk **IP**, hosts talk **TCP & IP**
 - Encapsulation

IP Addressing and Routing

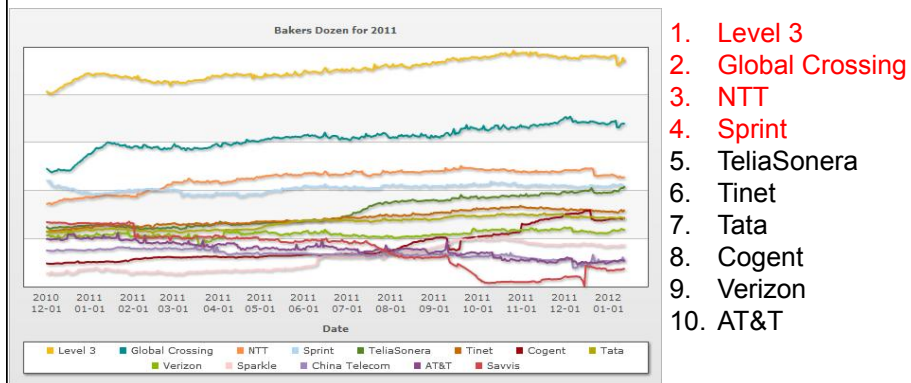
- Location based addressing
- Hierarchical address: **Net ID** + **Host ID**
- IP packets routed according to **Net ID**
- **Routers** compute routing tables using distributed algorithm



Internet Today



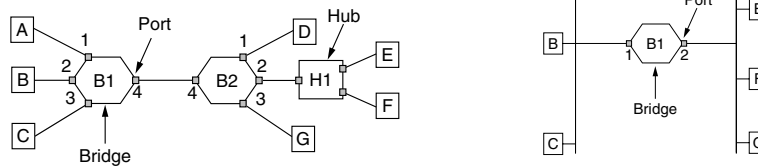
Tier-1 ISPs



- Google, Facebook, etc. also setting up private pathways to move data between centers

Local Area Networks

- A major component of the internet are concentrated networks of computers
 - university, business
- These simpler networks interface to the internet via routers but what happens inside?
- Basic components
 - hubs
 - bridges/switches



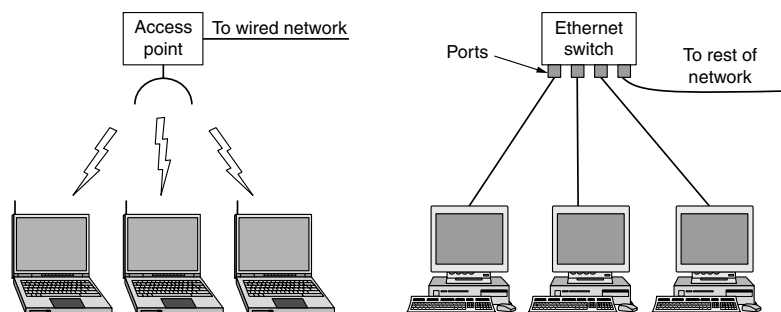
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Popular LANs

- IEEE 802.11 (WiFi) & IEEE 802.3 (Ethernet)
 - Best-effort connectionless service



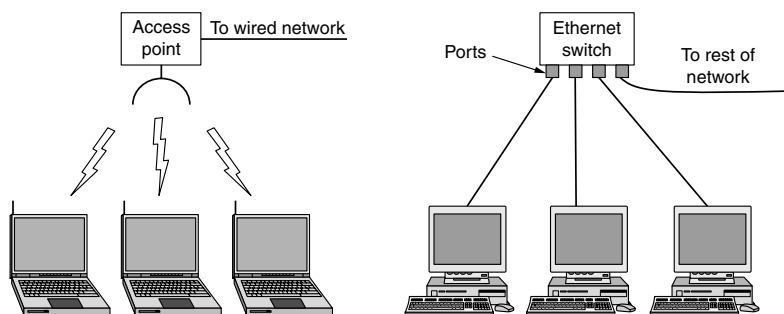
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Medium Access Control (MAC)

- A common challenge: communicating with multiple nodes over a **shared medium**
- **Medium Access Controls** for sharing were developed
- Example: Polling protocol on a multidrop line



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LAN Addressing

- How do LANs identify themselves?
 - If they share a medium some means of identification is necessary
- Globally unique address
 - MAC address, MAC-48, physical address
 - consists of 48-bits
 - burned inside network interface card (NIC)
- How does this work with IP?
 - The layering concept

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Summary of Some Network Terms

- **connectionless**
 - Send to source before you know that source is accepting
- **connection-oriented**
 - Send to source only after you hear that it is willing to accept
- **packet-switching**
 - Non-dedicated link to source made on fly for each chunk of message
- **circuit-switching**
 - Dedicated link created to source for duration of message
- **best-effort service**
 - not guaranteed
- **datagram service**
 - unacknowledged connectionless service