SESSION: Network Architectures and Interconnectivity

- Network types (LANs, MANs, WANs)
- Network Architectures and OSI
- Network stacks (TCP/IP, SNA, Telephone)
- Interconnectivity (routers, gateways)

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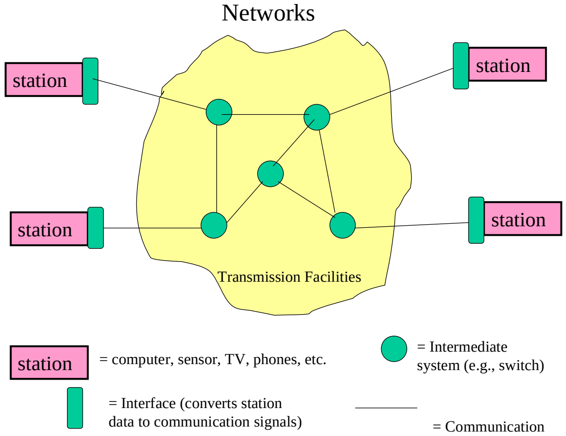
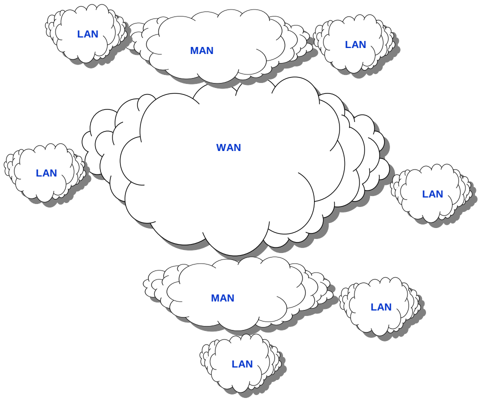
Networks



Network Categories

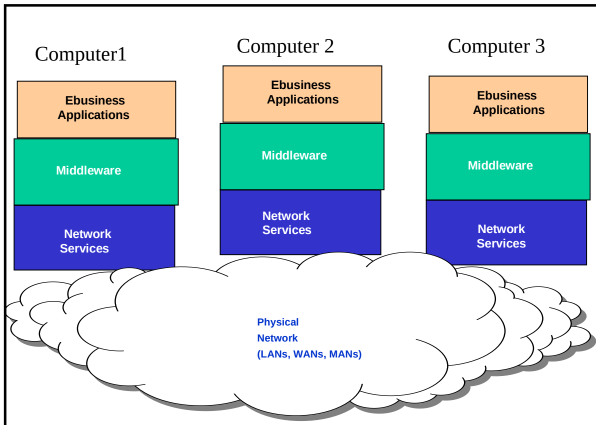
- At present by distance (changing)
- Local area networks (LANs):
  - Private ownership
  - Typically short distances (building, campus)
  - Ethernet, Token Ring
  - Data rates: 10 Mbps, 100 Mbps, higher
- Metropolitan area networks (MANs):
  - One agency ownership (e.g., cable company)
  - Typically a city or a suburb
  - FDDI (100 Mbps)
- Wide area networks (WANs):
  - Common carrier ownership (e.g., telephone company)
  - Typically long distances (state, country)
  - Typically packet switching (break message into packets and route)e.g., ATM, frame Relay, X.25, ISDN
  - Data rates: 56 Kbps (voice), 1.54 Mbps (T1), 43 Mbps (T3), 100+ Mbps (Sonet), many in between



Network Architectures

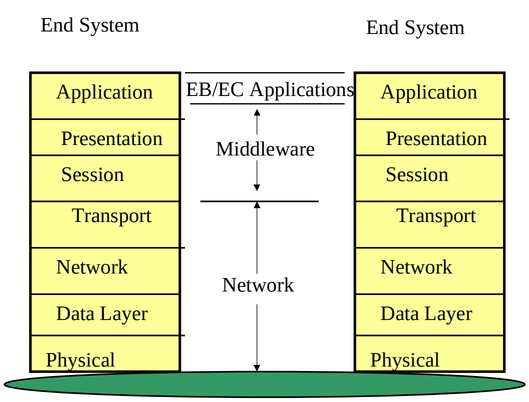
- How to design, manage and support networks
  - Needed: a standard framework (network architecture)

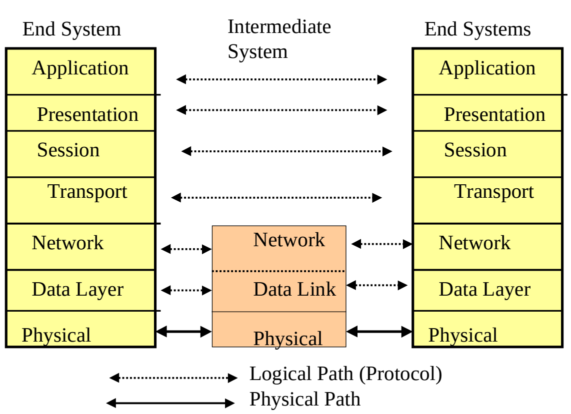
    Architecture describes:
  - Components (what are the pieces of a system?)
  - Functions of components (what do they do?)
  - Interfaces (how do they interact with each other?)
- Open System Interconnection (OSI) Model is such a framework.
- TCP/IP, SNA, and Novell IPX/SPX are popular examples.



Open System Interconnection (OSI)

- Proposed by ISO committee 97 in 1977
- Model for different system interconnection
- Divide distributed systems into 7 layers
  - Lower 4 layers (network related), higher 3 layers (applications)
  - Each layer performs a unique function
  - Layer N can use the facilities of N-1 only and provide services to N+1 only
  - Services of each layer specified precisely
  - Complexity of system by layers (1, 2, 3,...)
- Not an implementation model
- Protocol: rules between same level layers (e.g., link protocol, network protocol, application protocol)





Layer 7 - Application Layer
Function: User defined functions, commands, and databases
Examples: Email, File Transfer, order processing, EDI, Transactional applications

Layer 6 - Presentation Layer
Function: Display, encryption/decryption, compression/decompression
Examples: compression packages, encryption routines

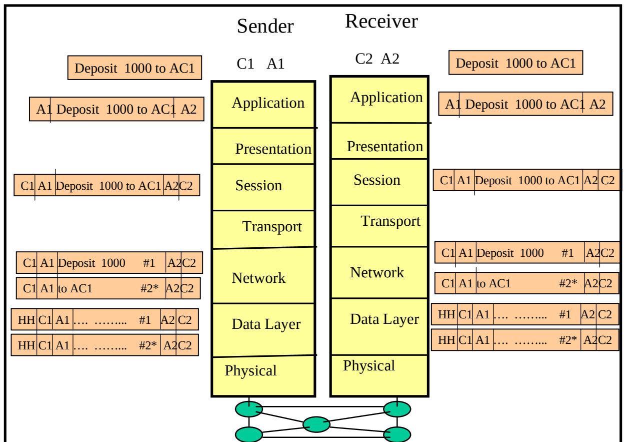
Layer 5 - Session Layer
Function: Establishment and administration of remote sessions
Examples: X.215, X.225

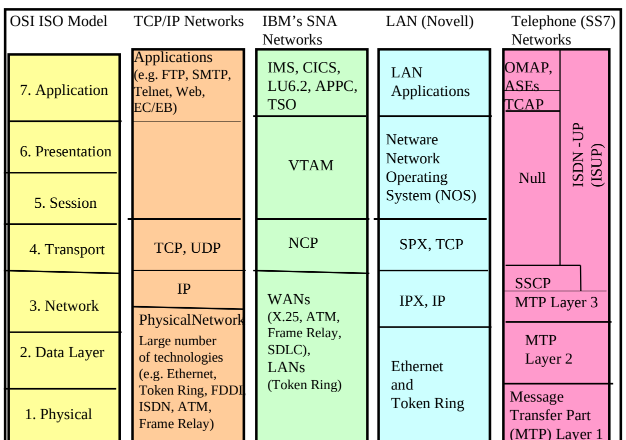
Layer 4 - Transport Layer
Function: End to end transport of data and optimization of communication services
Examples: TCP and UDP

Layer 3 - Network Layer
Function: Form and route packets over networks of networks
Examples: IP (roughly), X.25, ATM, Frame Relay, ISDN routing

Layer 2 - Link Layer
Function: Flow and control of data on communication media, termination, recovery
Examples: Ethernet, Token Ring, FDDI, ISDN Frames

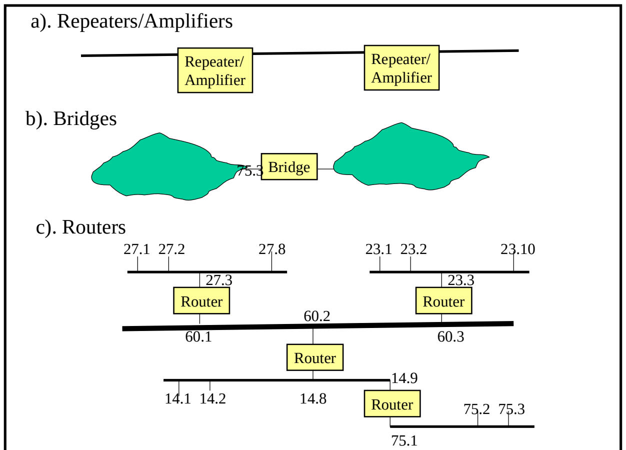
Layer 1 - Physical Layer
Function: Electrical/Mechanical Interfaces (e.g., voltages, bit rates) to Communication Media (cables, wireless)
Examples: RS232, Physical interfaces for ISDN, X.25, ATM, Frame Relay, FDDI





Network Interconnectivity

- Amplifiers/Repeaters:
  - Perform layer 1 (physical functions)
  - Amplify (regenerate) signals
- Bridge:
  - Objective: connects two similar networks together
  - Performs layer 1 and 2 functions
  - Examples:Two Ethernets in two buildings (Ethernet bridge)
- Router (Switch):
  - Objective: routes messages between networks)
  - Performs layer 1, 2 and 3 functions
  - Can use sophisticated routing algorithms
  - Security is often built into the router <u>(FIREWALL)</u>
  - Routers are becoming bottlenecks

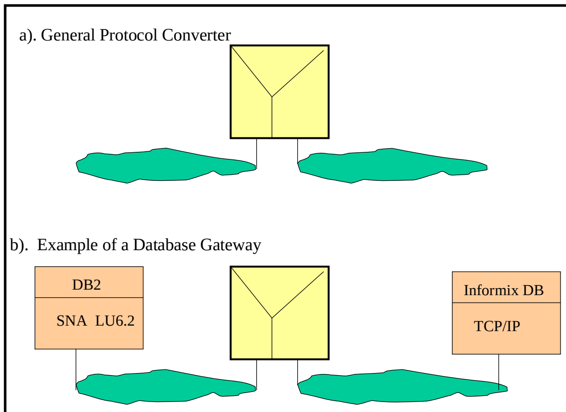


Hubs versus Switches versus Routers

- Hub:
  - A “meeting place” (e.g., an airline hub)
  - Ethernet 10Base-T uses a hub model (twisted pair wires connected to the hub)
- Switch
  - Origin- telephone switching center (circuit and packet switching)
  - Typically fixed from input to output
- Router
  - Origin TCP/IP routers
  - Typically dynamic routing based on traffic

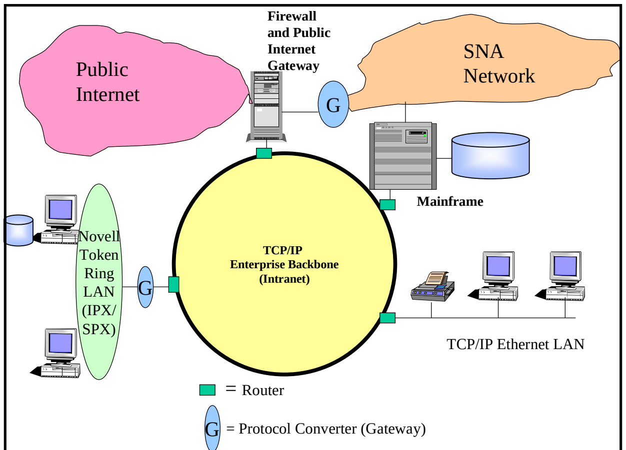
Gateways (protocol converters)

- Objective: convert one or more protocol to another
  - Can connect two dissimilar networks together (translates one network architecture to another)
  - Can cover one layer or many layers
- Examples:
  - Token Ring to Ethernet Protocol converters
  - LAN gateway: connects a LAN to connect to host (e.g., Novell/MS Gateways to SNA)
  - EMail gateway: connects different electronic mail packages (example: Soft Switch)
  - Database gateway: converts database calls from one vendor to another. Example: Informix to DB2 gateway
  - Application gateway: new to legacy applications (e.g., Web gateways)



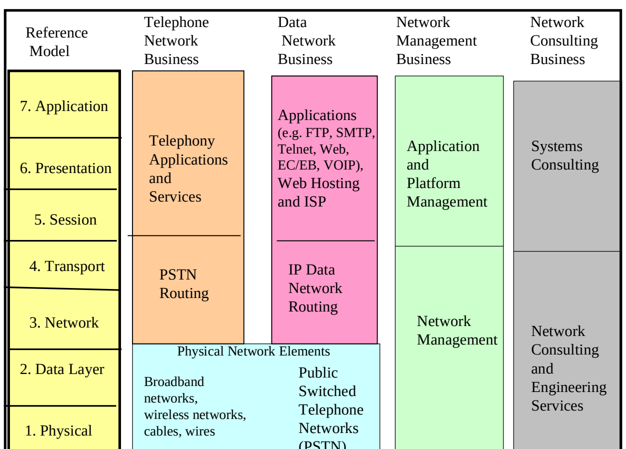
Open Networks

- Open network: Vendor independent network
- How to implement it
  - Use one network architecture throughout
  - Use one common backbone - use gateways where needed
  - Use gateways extensively
- Which architecture to use as backbone?
  - TCP/IP is the winner (OSI, SNA also ran)
- Typical networks are mixtures with routers and gateways

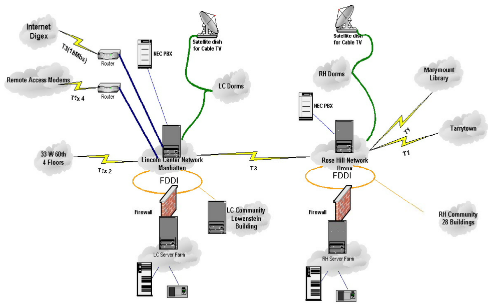


Telecom Business at a Glance

- Many different opportunities in telecom
- Businesses can be formed at the following levels (see next figure)
  - Physical network elements (e.g., build routers, cable, etc)
  - Telephony business (e.g., build and/or supply telephony services)
  - Data network business (e.g., build and/or supply data networks for Internet)
  - Network management business (build network management platforms)
  - Network consulting business (provide consulting services at all levels of networks in telephony or data network segments)



Sample Network: Fordham University Network



Fordham University

NETWORK PERFORMANCE

. Performance means different things: we assume response time

. Response time per request = sum of all service times

S = s1 + s2 + s3 + ...

where s = service time, I/O time, transmission time,,

. Example: file transfer from computer C1 to C2 :

S = ∑ s1 + s2 + s3

s1=read time, s2=transmission time, s3=write time

Simple performance analysis (Best Case)

Assume that there is no queuing (lower bound) or assume that service time includes all queuing

Example 1: 12 node LAN, 1 Mbps, disk i/o = 0.5 sec.

- **one file server**
- **assume that users at each workstation issue 1 request per minute and each request requires 60 accesses of local file, 20 of server files**
- **each remote message is 100 bytes, 10 bits per byte**

Response time per transaction =

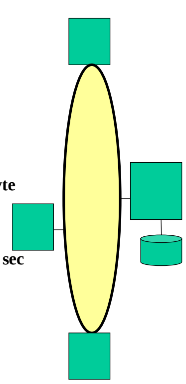
s1: origin node = 60 x 0.5 = 30 sec

s2: server node (without queuing) = 20 x 0.5 = 10 sec

s3: transmission proc = 20 x 100 x 10 /1000000 = 0.02 sec

. resp. time = 30 + 10 + .02 = 40 secs

Bottleneck =?



Queuing Analysis

Queuing causes waits, increases service time

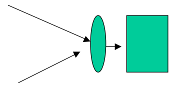
A = arrival rate at

S = service time

U = utilization = A x S

To avoid queuing, U should be below 0.5

Q = no. of people waiting = U / 1-U = A.S / 1-A.S



If U = .1 Q =
U = .5 Q =
U = .8 Q =
U = .9 Q =

To reduce queuing, reduce U

<u>Example 2</u>**: same as example 1, include queuing**

. need to calculate queuing at server

. arrival rate A at server = 12x 20 = 240/min = 240/60 = 4 per sec

. service time S at server = 0.5 sec

. server utilization = U = 4 x 0.5 = 2.0 (serious trouble, infinite queues)

<u>Example 3</u>**: workstations on LAN**

. One ethernet LAN (10 MBPS)

. Each workstation generates 1 message per second, each message is 1000 bytes long (about a screen)

. How many workstations can be supported on this LAN

. Solution: Assume 10 bits per byte for communications

S = service time per message=1000x10/10,000,000=.001 sec

A = arrival rate = 1 per second for one workstation

U = A x S = 1 x .001 = .001 (Virtually no queuing)

For 100 workstations with similar traffic, A = 1 x 100

U = 0.1

For 100 workstation with color graphic data

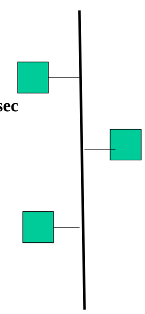
Message = 40 times bigger

S = 40 x 10000 /10,000,000 = .04 sec

A = 100 per second

U = 100 x .04 = 4 (too high, forget it)

For 10 workstations: U = 0.4 (still may be too high)



Multimedia Performance Analysis

Large screen sizes, with images and sound sent across the network very rapidly

Example:

Consider a high definition large screen 1024x1024 = 1 million bits

Very fancy, extremely large colors= 2Million bits

Moving video at 30 screens per second

Traffic sent per second=1 million bits x 24 x30 =720 Mbps

Cannot be handled by fast networks (e.g., FDDI LAN)

Tradeoffs:

- Use compression (can be a by a factor of 50)
- Reduce the number of colors to 10 bits
- Reduce moving video ro 20 per second
- Reduce screen size and ressolution
- Carry only differences in images
- Many multimedia systems at present operate at 1 to 1.5 Mbps per user

Summary Of Network Issues

- Networks play a key role in EC/EB
- ISO/OSI Reference Model provides
  - Basic vocabulary and framework for discussion
  - Separation of issues (networks, applications)
  - Foundation for interconnectivity
- Layering concept has many applications in EB/EC
- TCP/IP is becoming a defacto standard (foundation of Internet)