

Networking Overview

Mr. A. David McKinnon

Cpt. S 464/564 Lecture
Textbook, Chapter 3 (parts), plus extras
Sept 6, 2000

Administrative Items

- Handouts today
 - Middleware encyclopedia article (read for next Monday)
 - Lecture slides for today
- Textbooks are in at the Bookie!
- This is an overview of networking
 - We assume most are familiar
 - We will not test in great depth or cover all of Chapter 3
- Study only parts of chapter 3 mentioned in these notes...

Outline of Topics

1. Scope of Networking
2. Network Layers
3. OSI Reference Model
4. Internet and TCP/IP
5. Bandwidth Reservation

Classifying Networks by Transmission Technology

- Broadcast networks (small, localized)
 - Single communication channel shared by all machines.
 - Multicasting
- Point-to-point networks (large geographically)
 - Many individual connections between pairs of machines.
 - Routing = packet switching

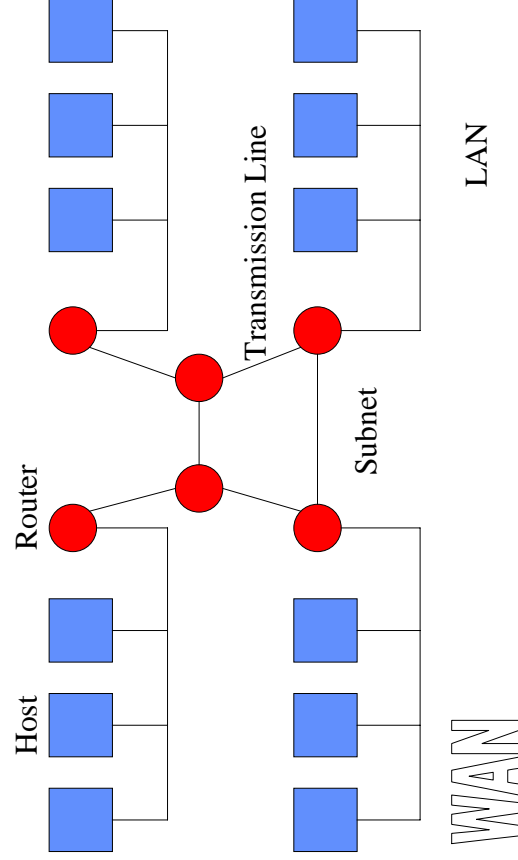
Classifying Networks by Scale

- Local Area Networks (LAN)
 - Restricted in size
 - Broadcast transmission (10-100 Mbps)
 - static: divvy up time, round-robin allocation
 - dynamic: centralized/decentralized arbitration
 - Topologies
 - bus (e.g. Ethernet: bus, 10-100 Mbps)
 - ring (e.g. IBM Token Ring, 4-16 Mbps)

Large Geographic Networks

- Metropolitan Area Network (MAN)
 - big LAN, no packet switching.
 - Standard: Distributed Queue Dual Bus (DQDB)
 - 2 unidirectional buses
- Wide Area Network (WAN)
 - Hosts on a LAN are connected to a *subnet*.
 - Most WAN subnets are *point-to-point*.
 - packet-switched, use *routers*

Example Network Configuration



Wireless Networks

- Portable Office
 - Notebook computers, PDA's, ...
 - e.g. UPS Trucks, Military, ...
- Wireless LANS
 - Originally slow (1-2 Mbps), high error-rate
 - Bluetooth (10 meters) is coming....
- Digital Cellular

Internetworks

- Communication between different (perhaps incompatible) networks.
- *Gateways* handle the translation.
- *internet*: Collection of interconnected networks.
 - e.g. LANs connected to a WAN
- *Internet*: **the** worldwide internet.

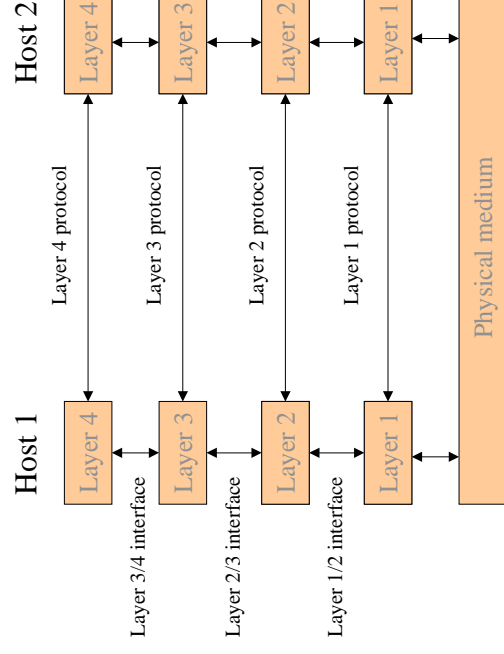
Outline of Topics

1. Scope of Networking
2. **Network Layers**
3. OSI Reference Model
4. Internet and TCP/IP
5. Bandwidth Reservation

Network Software

- Original network design focused on hardware.
- Network software is now highly structured.
- **Protocol Hierarchies**
 - Networks are organized as a series of *layers*.
 - Each layer offers a *service* to the layer above.
 - Hides implementation detail from higher layers.
 - Layer n on one machine (logically) converses with layer n on another machine.

Layers, protocols, and interfaces



Network layer terms

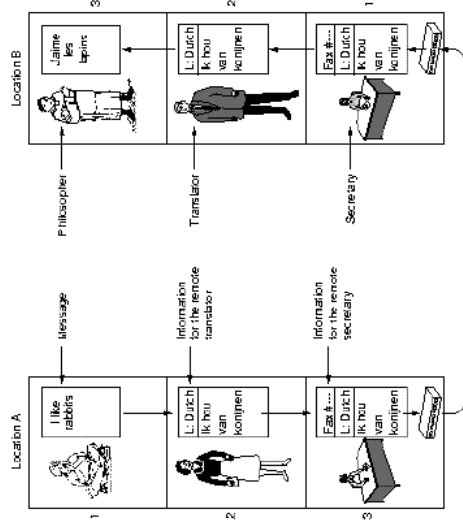
- *Protocol*: rules and conventions of communication.
- *Peers*: entities comprising the corresponding layers on different hosts.
 - Peers communicate using the protocol.
- *Interface*: defines which primitive operations and services the lower layer offers the upper one.

Network Architecture

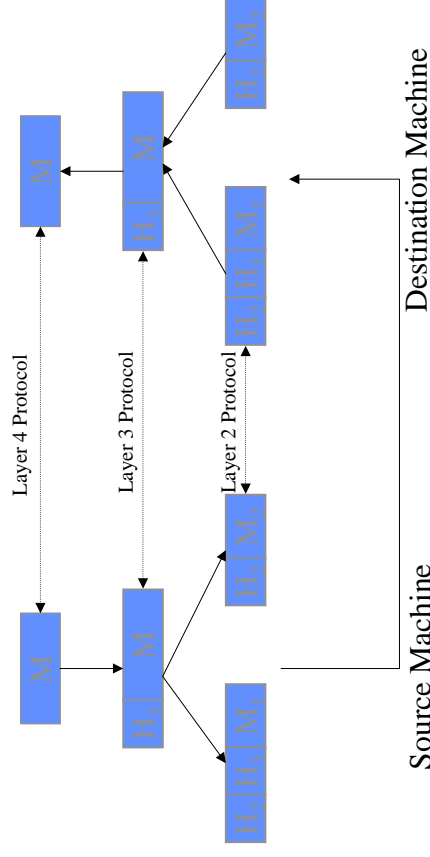
- *Network Architecture*: layers + protocols
 - Does *not* contain...
 - Details of the implementation
 - Specification of the interfaces
- *Protocol Stack*: List of protocols used for each layer.
 - Lower layers can change without affecting higher layer.

Hidden
inside

Philosopher - Translator - Secretary Architecture



Flow of info supporting virtual communication in layer 4



Layer Design Issues

- Mechanism for identifying senders and receivers (*addressing*).
- *Simplex, half-duplex, or full-duplex* communication.
- Error detection/correction.
- Fragmentation
- Preserving message order.
- Fast sender vs. slow receiver.
- Routing

Connection-Oriented vs. Connectionless Services

- Connection-oriented service
 - Connection established and terminated.
 - Modeled after the telephone system.
 - Message arrive in the order they are sent.
 - e.g. TCP
- Connectionless service (*datagram service*)
 - Modeled after the postal system.
 - No guarantees on message ordering.
 - *Unreliable*: Messages may be lost.
 - e.g. UDP

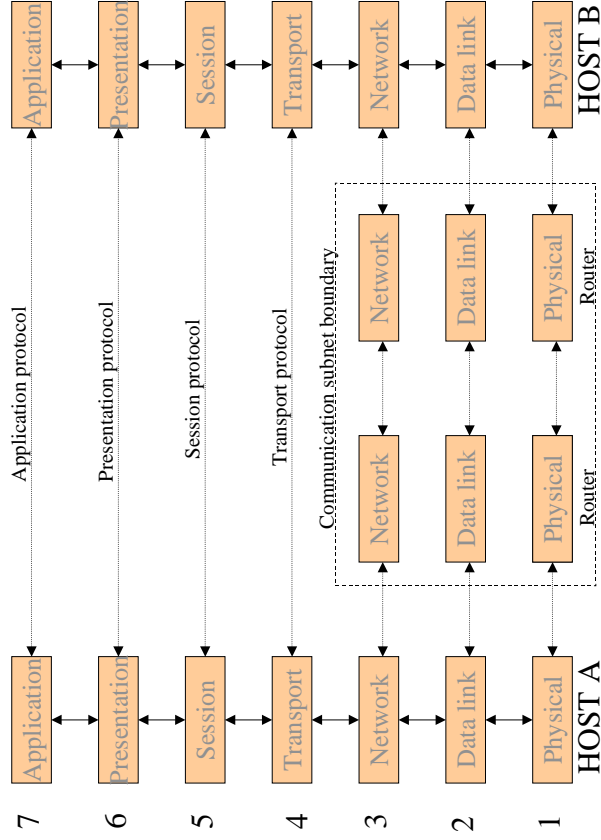
Outline of Topics

1. Scope of Networking
2. Network Layers
3. **OSI Reference Model**
4. Internet and TCP/IP
5. Bandwidth Reservation

OSI Reference Model

- ISO OSI
 - Importance of Open Standards
- 7 layer model
 - Each layer performs a well-defined function in the context of the overall communication subsystem.
 - *Peers* exchange messages according to *protocol*.
 - *Message* = user data + control information.
 - Lower layers are *network dependent*.
 - Higher layers are *application oriented*.
 - Each layer provides an *interface* for the layer above.

OSI Reference Model



Network Dependent Layers

- Physical Layer (exchanged unit: *bit*)
 - Transmits/Receives “raw” bits over comm. channel.
 - Mechanical and electrical network interface definitions.
- Data Link Layer (exchanged unit: *frame*)
 - Transforms (i.e. “cleans up”) raw transmission.
 - Frames data using special bit patterns at the beginning and end of the frame.
 - Serial/Parallel conversion.
 - **Medium Access Sublayer** (broadcast networks)
 - controlling shared channel

Network Dependent Layers, cont.

- Network Layer (exchanged unit: packet)
 - Operation of the subnet.
 - Addressing
 - Routing (point-to-point networks).
- Transport Layer
 - End-to-end message transfer.
 - Connection management
 - Error control
 - Fragmentation
 - Error Control

Application Oriented Layers

- Session Layer
 - Dialogue control
 - Synchronization (i.e. “who does what when”)
 - “Thin” layer
- Presentation Layer
 - Syntax and semantics of transferred data.
 - Data representation transformations.
 - e.g. Floating point number format.
 - e.g. Encryption
 - e.g., CORBA CDR

Application Oriented Layers, cont.

- Application Layer
 - Variety of protocols:
 - File Transfer
 - Remote access and management
 - Document/message interchange
 - Email
- Note:
 - To the network layers, middleware is an application!
 - Thus this “application” above is not our distributed application
 - Applications include HTTP, FTP, SMTP, CORBA IIOP
 - See the “Middleware” encyclopedia article...

OSI layer index

- Application
- Presentation
- Session
- Transport
- Network (*packets*)
- Data Link (*frames*)
- Physical (*raw bits*)

Outline of Topics

1. Scope of Networking
2. Network Layers
3. OSI Reference Model
4. **Internet and TCP/IP**
5. Bandwidth Reservation

TCP/IP and the Internet

- ARPANET (1969)
 - R&D network funded by DARPA, built by BBN
 - Packet Switching
 - Survive nuclear war.
 - Experimental to operational (1975).
 - Not suitable for internetworking.
 - Solution: TCP/IP
 - Berkeley UNIX, Sockets.

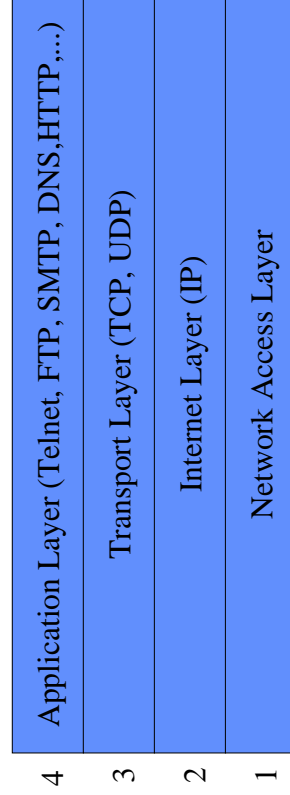
"On the Internet"

- What does it mean to be "on the Internet"?
 - Your machine speaks TCP/IP,
 - You have an IP address,
 - You can communicate with other hosts on the Internet.
- WWW (1993)
 - Everybody and their dog is "on the Internet."
- WSU on Internet2 www.internet2.edu

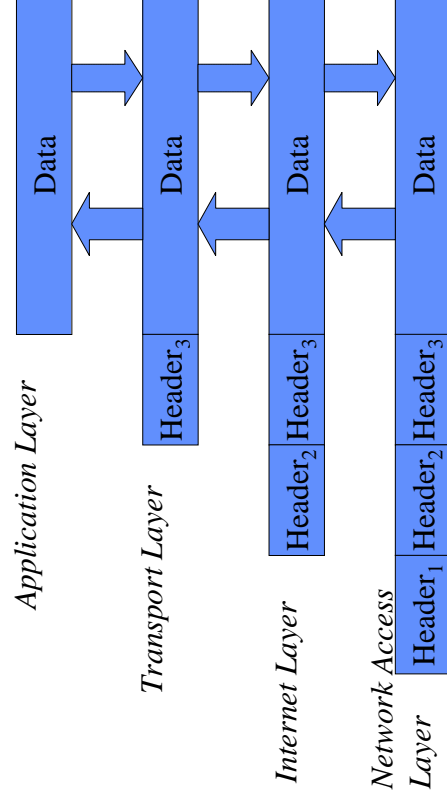
TCP/IP Features

- Why did TCP/IP become so popular?
 - Right place at the right time.
 - Open protocol standards.
 - Freely available, *Requests for Comments (RFC)*.
 - Not tied to a specific architecture or operating system.
 - Network Independence
 - TCP/IP can run over Ethernet, token ring, X.25, ...
 - Common addressing Standard.
 - Unique address for any TCP/IP device
 - Standard protocols for high-level services.
 - Email, Usenet, rlogin/telnet, FTP, WWW

TCP/IP Reference Model



Data Encapsulation



Network Access Layer

- Encompasses the 3 lower layers of OSI.
 - Network Layer
 - Data Link Layer
 - Medium Access Control
 - Physical Layer
- Example Protocols
 - Address Resolution Protocol (ARP), RFC 826
 - IP datagrams over ethernet, RFC 894
 - Ethernet, IEEE 802.3

Internet Layer

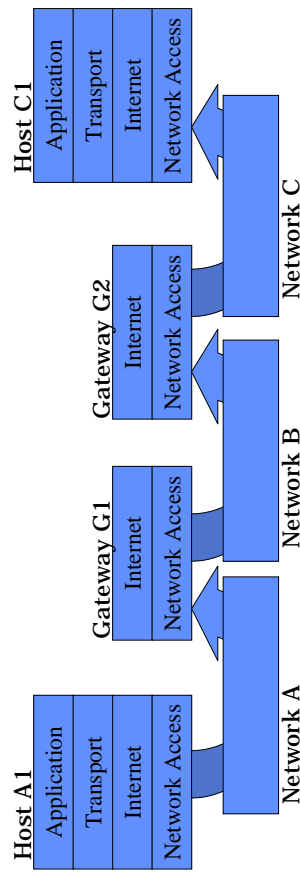
- Internet Protocol (IP), RFC 791
 - Basic packet delivery service defining...
 - *Datagram*: basic unit of transmission.
 - Internet addressing scheme.
 - Interfaces with Network Access Layer and Host-to-Host Transport Layer.
 - Routing datagrams to remote hosts.
 - Fragmentation and Re-assembly of datagrams.

Characteristics of IP

- Connectionless, unreliable protocol.
- Designed for packet-switching network.
 - Gateways switch packets between different physical networks.
 - Decoding which gateway to use is called *routing*.
 - *Fragmenting* datagrams.
 - Each network has a *Max. Transmission Unit (MTU)*.
 - Passing datagrams to transport layer.
 - *Protocol number* in IP header.
 - TCP = 6
 - UDP = 17

Routing IP Datagrams

- 2 types of network devices
 - Gateways (Often called routers)
 - Routers move data between networks.
 - Gateways move data between protocols.
 - Hosts
 - Multi-homed hosts can act as gateways.



Outline of Topics

1. Scope of Networking
2. Network Layers
3. OSI Reference Model
4. Internet and TCP/IP
5. **Bandwidth Reservation**

Integrated Services (INTSERV)

- Flow = stream of packets with common Source Address, Destination Address and port number.
- Requires router to maintain state information on each flow; router determines what flows get what resources based on available capacity
- Classes of Service:
 - Guaranteed Service: guarantees bandwidth for the application traffic, and deterministic upper bound on delay. It is important for interactive applications or real time applications.
 - Controlled Load Service: the average delay is guaranteed, but the end-to-end delay experienced by some arbitrary packet cannot be determined deterministically.
- Resource reSerVation Protocol (RSVP): the signaling (set up) protocol
 - "Path" msg from src to dest collect info along the path; the dest gauges what the network can support, then generates a "Resv" msg.
 - If routers along the path have sufficient capacity, then resources back to the receiver are reserved for that flow; otherwise, RSVP error msgs are generated and returned to the receiver.
 - Reservation state is maintained until the RSVP "Path" and "Resv" msgs stop coming. This is called "soft state"

Differentiated Services (DIFFSERV)

- Instead of maintaining individual flows on all routers, flows are aggregated into an aggregate flow that receives "treatment" (per class or per service state).
 - Service classes are identified, packet is marked as belonging to a particular service, sent on its way; routers in path examine header to determine treatment.
- Necessary functions:
 - Admission control: ability of network to refuse customers when demand exceeds capacity
 - Packet scheduling: method for treating different customers' data differently as needed
 - Traffic classification: ability to sort streams into "substreams" that receive different treatments
 - policies and rules for allocating the network's resources
- Services types:
 - Premium: "virtual leased line", low delay, loss and jitter.
 - Assured - emulates a lightly loaded network ("drop me last").
 - CoS - relative, precedence-based service classes (better best effort).
 - Default - usual "best effort" service.

INTSERV/DIFFSERV Problems

- IntServ
 - IntServ doesn't scale well to large backbones due to number of individual flows and control msgs. Also the needs to classify a large number of packets and schedule numerous queues make the router extremely complex.
 - RSVP is purely receiver based. The reservations are initiated by willing receivers. But in many cases, it is the sender who has the onus of initiating a Quality of Service based flow.
 - There is no negotiation and backtracking.
- DiffServ
 - Providing quality of service to traffic flows on a per-hop basis often cannot guarantee end-to-end QoS.
 - DiffServ is sender-oriented. Once again, in many flows, the receivers' requests have to be accounted for.
 - Some long flows like high bandwidth video-conferencing require per-flow guarantees. But DiffServ only provides guarantees for the aggregates.
- Overcoming these problems is a very active research area!
- Expect to see bandwidth reservation from ISPs in the next few years (some big ones already offer it to big customers)