Networking Overview

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Cpt. S 464/564 Lecture

Textbook, Chapter 3 (parts), plus extras

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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 networkig
  - 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

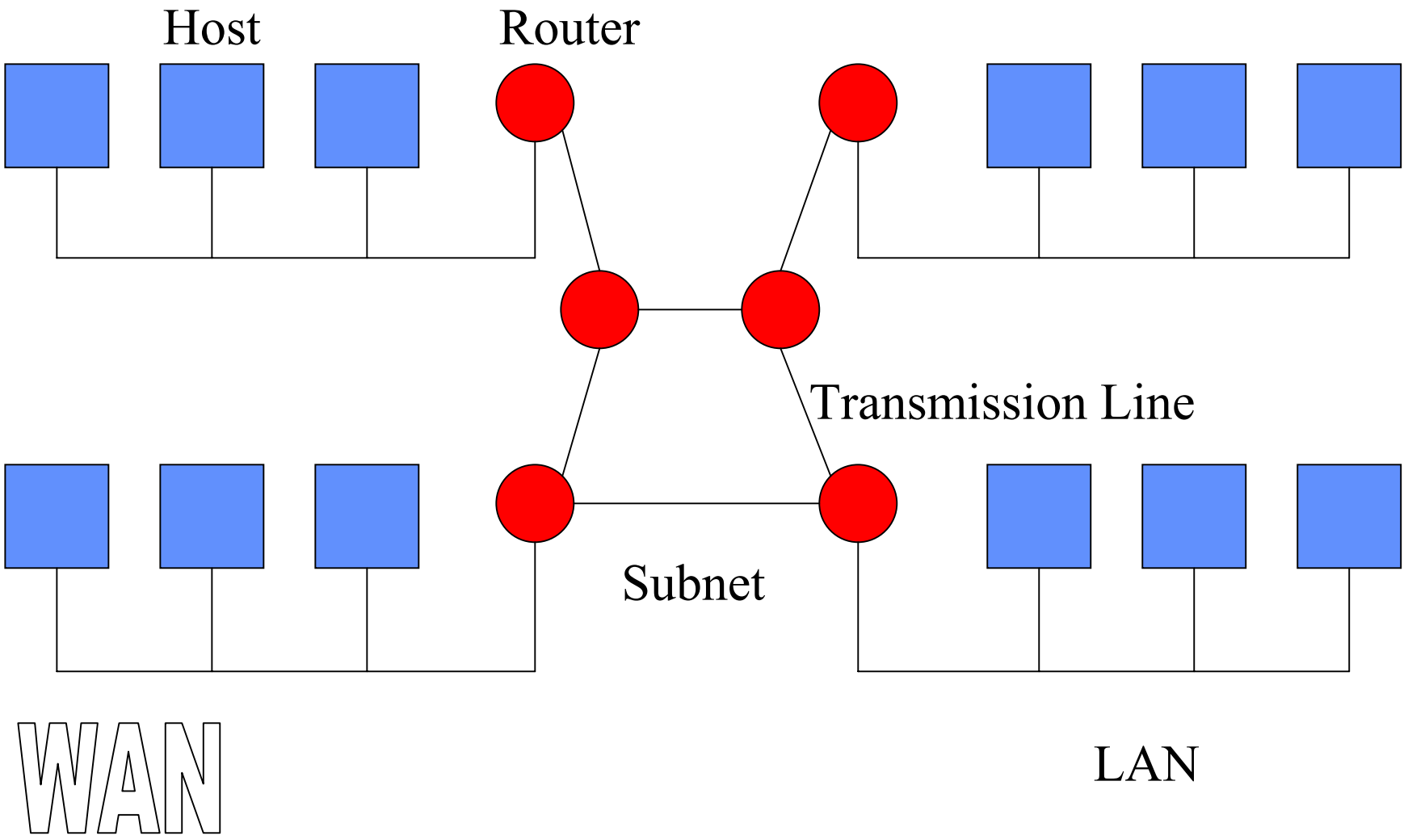
Classifying Networks by Scale

- 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.

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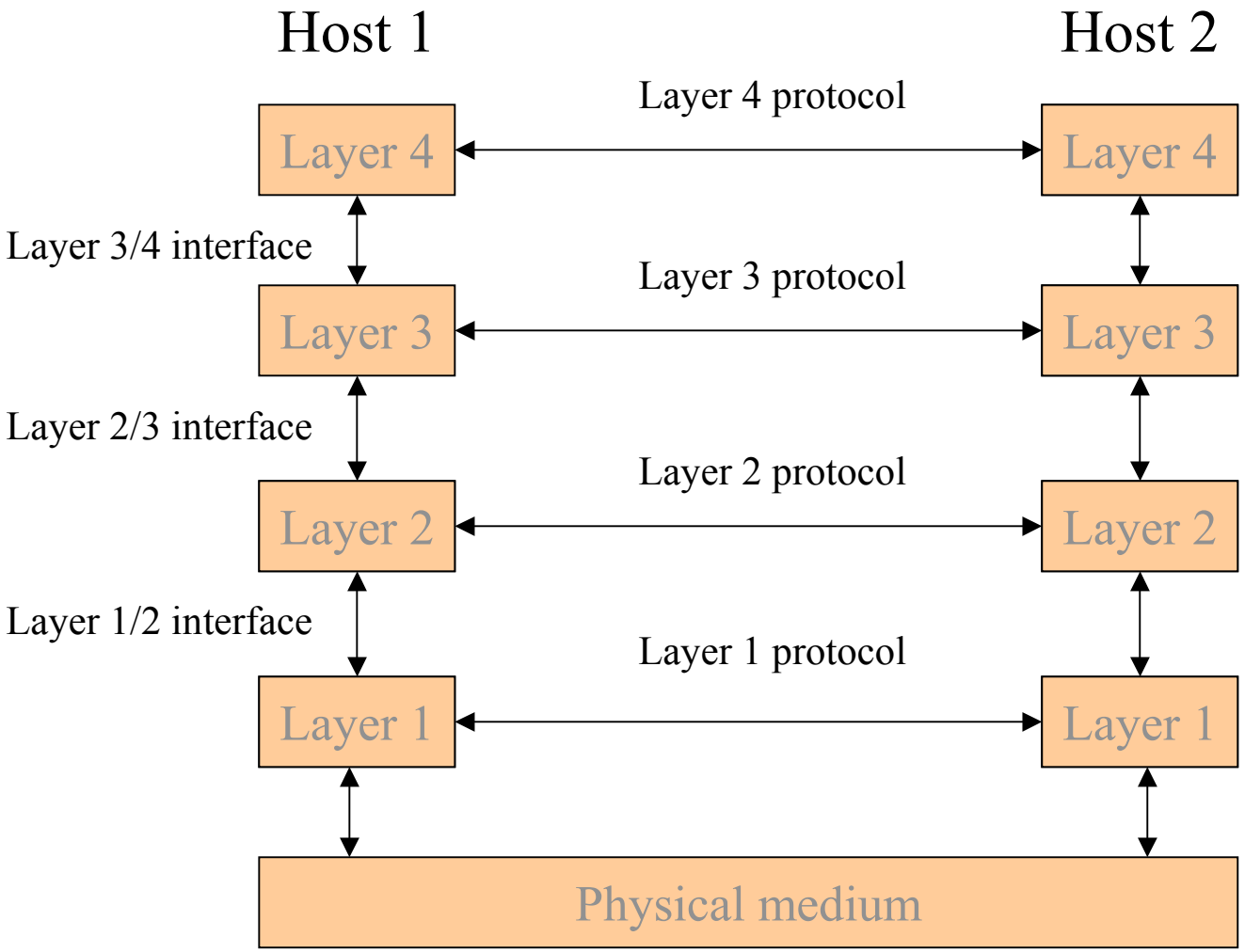
Network Software

- 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

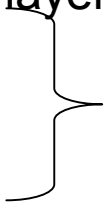


Network layer terms

- *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.

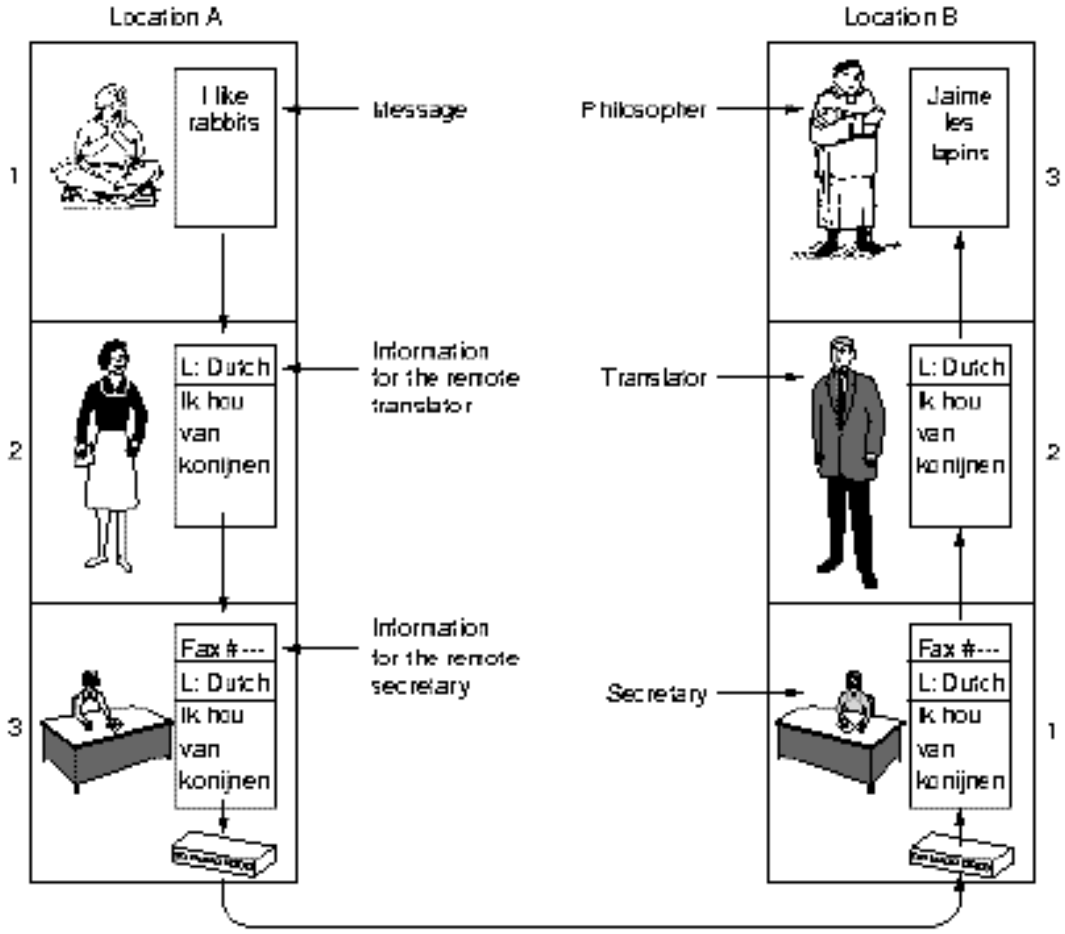
Network Architecture

- *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.

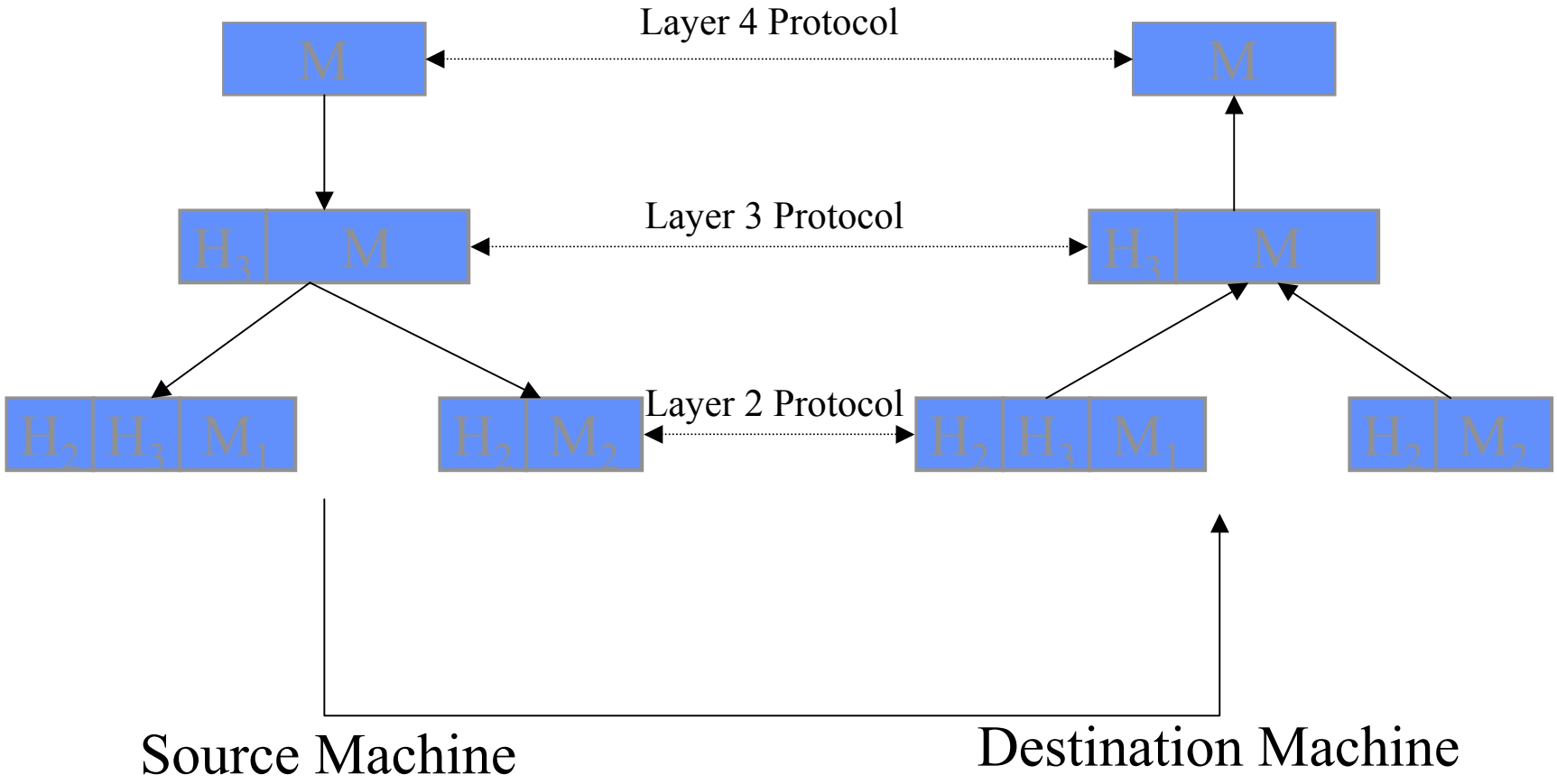


Hidden inside

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 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

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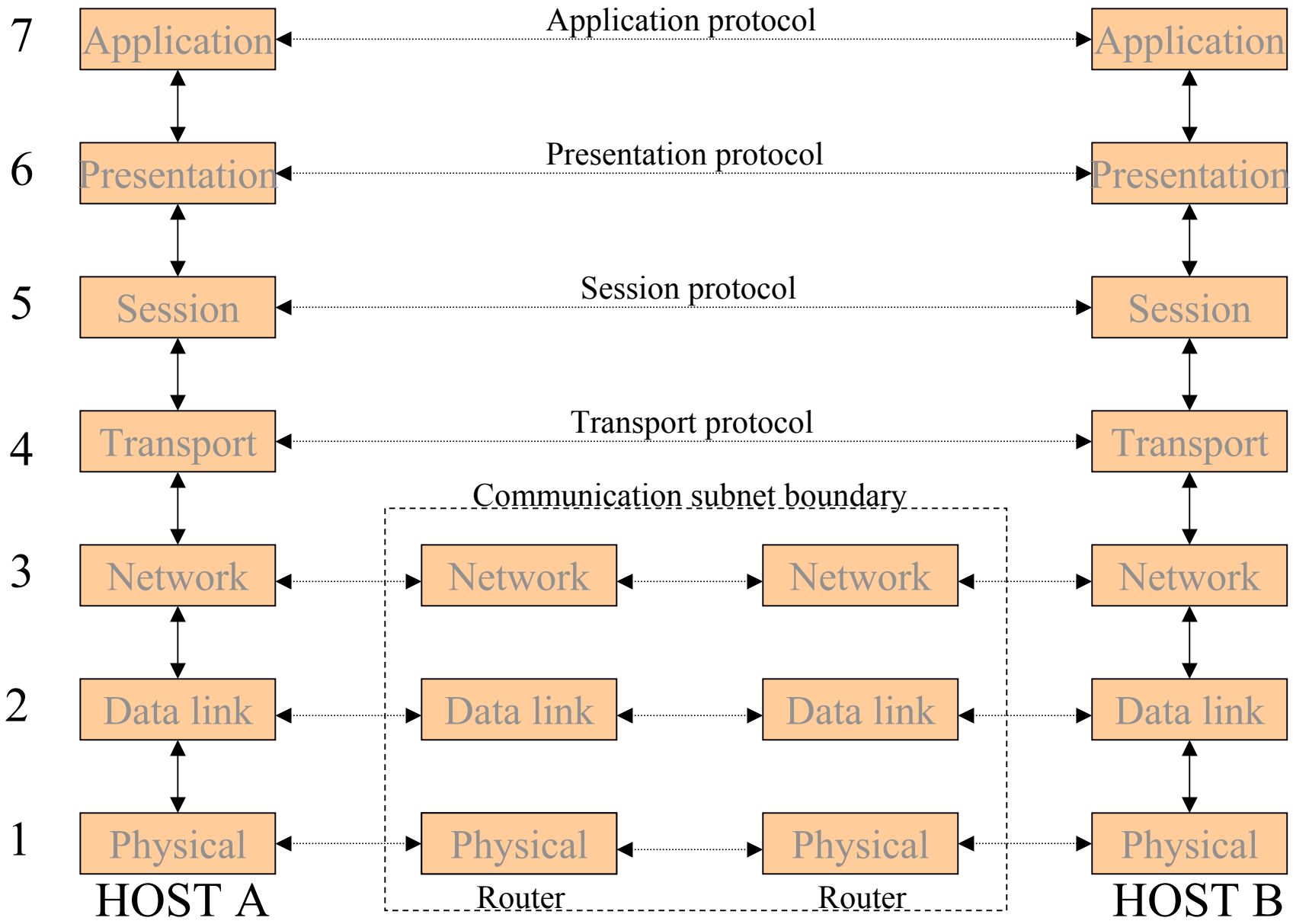
OSI Reference Model

- 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)*

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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.

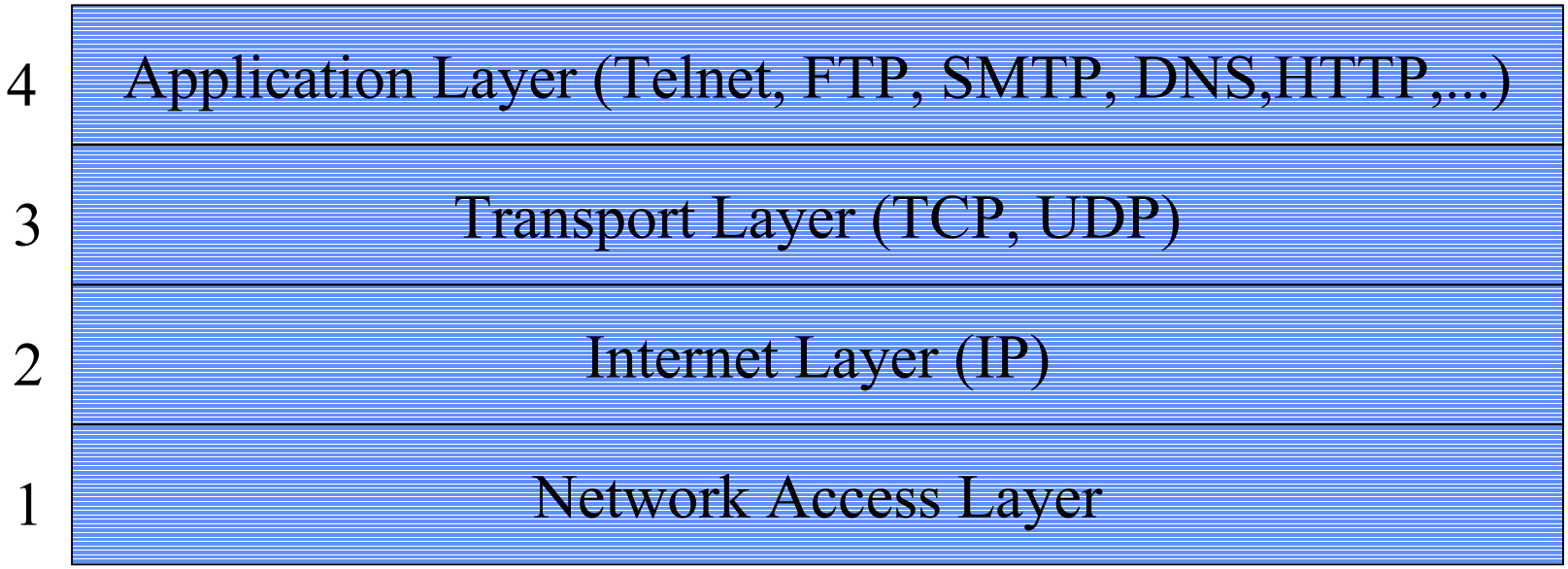
"On the Internet"

- 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*

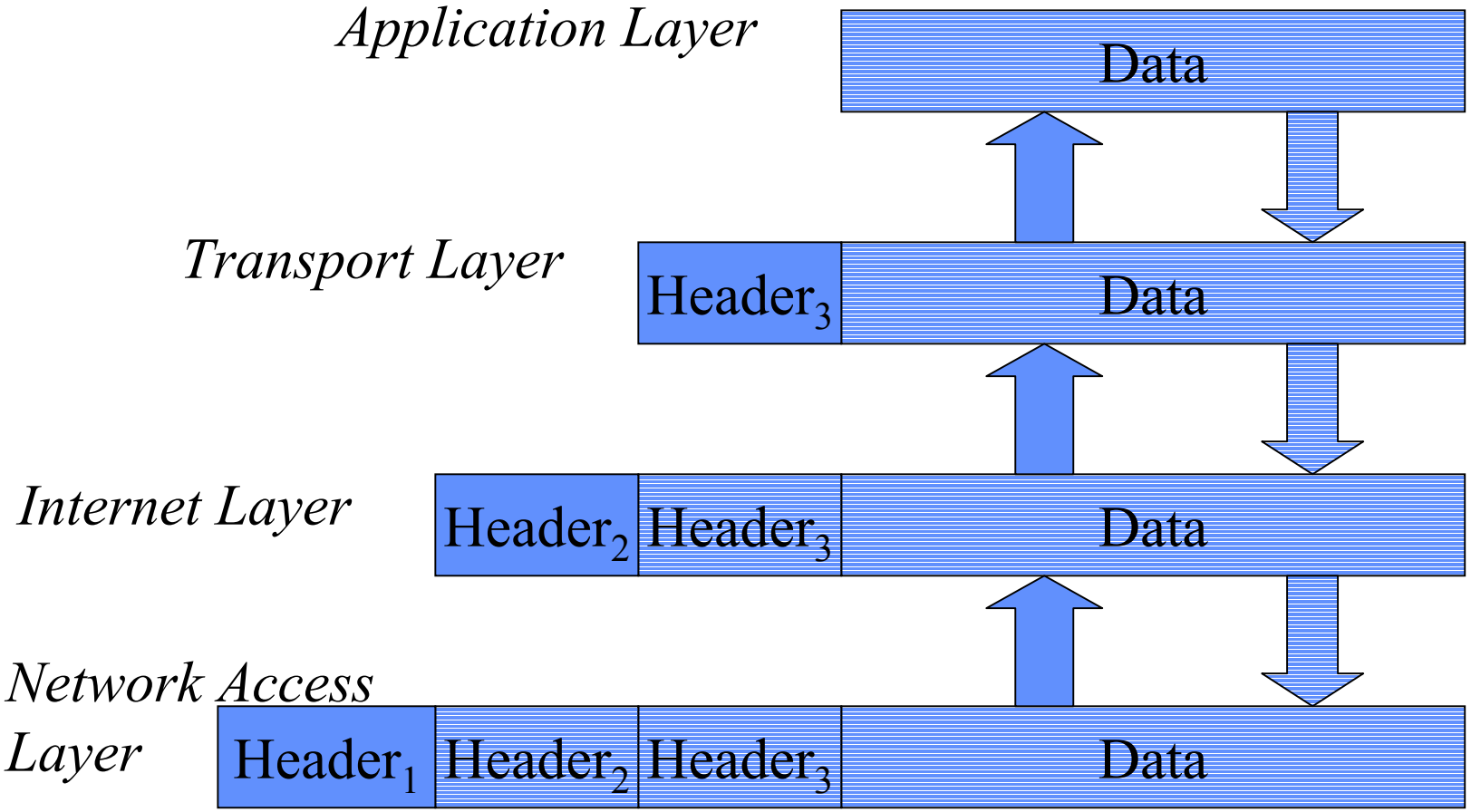
TCP/IP Features

- 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

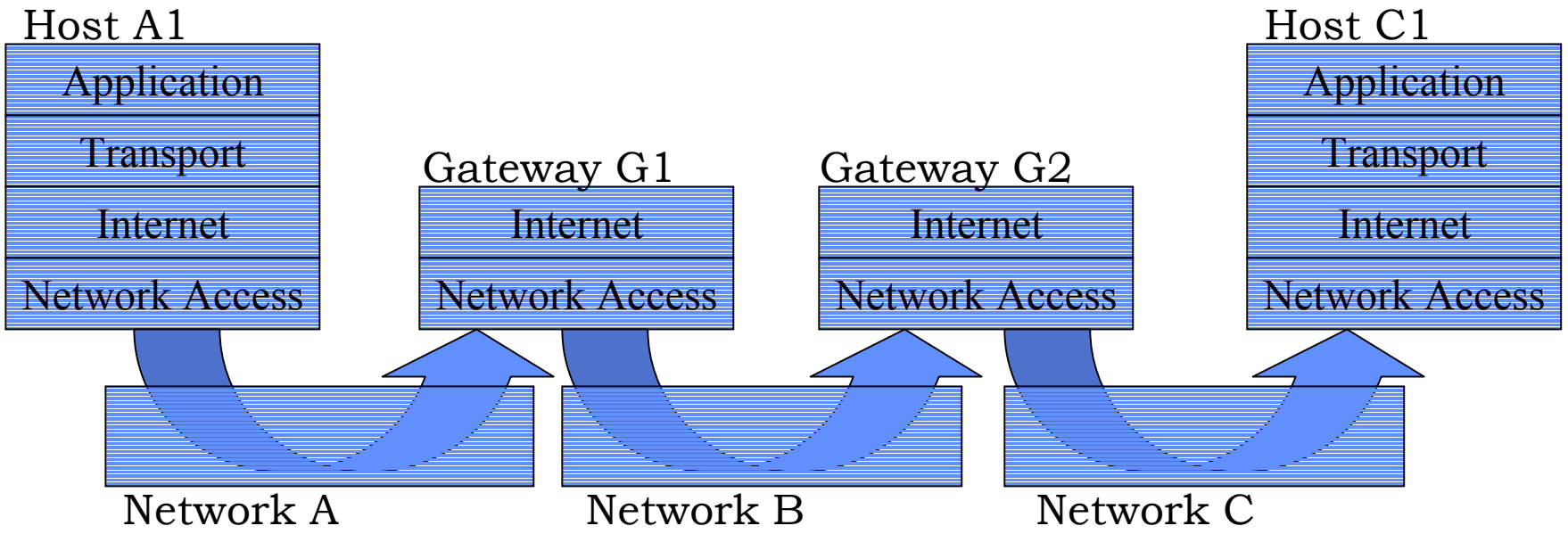
- Internet Protocol (IP), RFC 791
  - Basic packet delivery service defining...
    - *Datagram*: basic unit of transmission.
    - Internet addressing scheme.
    - Interfaces with Network Access Layer and Host-to-Host Transport Layer.
    - Routing datagrams to remote hosts.
    - Fragmentation and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



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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 effor).
  - 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)