

Network Architecture and the OSI Reference Model



Advanced Computer Networks
D12

Architecture Outline

- The Internet and IP
- Network Architecture
 - Protocols and Layers
 - Encapsulation
- The OSI Reference Model
 - The Seven OSI Layers
- The TCP/IP Internet Stack
- Layering Example
- Tiered Internet Architecture

The Internet versus an internet

An **internet** :: involves the **interconnection** of multiple networks into a single large networks. [LG&W]

The **Internet** :: refers to the successor to ARPANET. The modern **Internet** is **multi-tiered** and includes industrial participation.

IP (the Internet Protocol) :: provides **connectionless** transfer of packets across an internet.

The Internet

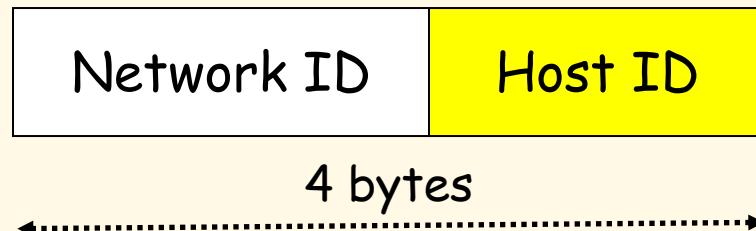
- Provides a *name space* to refer to machines connected to the Internet (e.g. **chablis.cs.wpi.edu**).
- The name space is hierarchical, but it is only administrative and not used in network routing operations.
- **DNS (Domain Name Service)** provides automatic translation of names to addresses.

IP

- Currently IP provides **best-effort service**.
 - packets may be lost (i.e., IP is unreliable).
- General IP design philosophy
 - Keep internal operations simple by relegating complex functions to the edge of the subnet.
 - IP can operate over **any** network.
 - This design allows IP to scale!!!
 - **The end-to-end mechanisms are responsible for recovery of packet losses and congestion control.**

IPv4

- Uses 32 bit *hierarchical address space* with location information embedded in the structure.



- IP address is usually expressed in *dotted-decimal notation*

e.g.,

128.100.11.56

IPv6

- IPv6 addresses are 128 bits long.
- 16 bytes of IPv6 address are represented as a group of hexadecimal digits, separated by colons. e.g.

[D&C]

2000:fdb8:0000:0000:0001:00ab:853c:39a1

- Shorthand - leave out groups of zeros and leading zeros.

2000:fdb8::1:ab:853c:39a1

Layering and Abstraction

- Layering accommodates incremental changes.
- It is possible to have alternative abstractions at each layer.

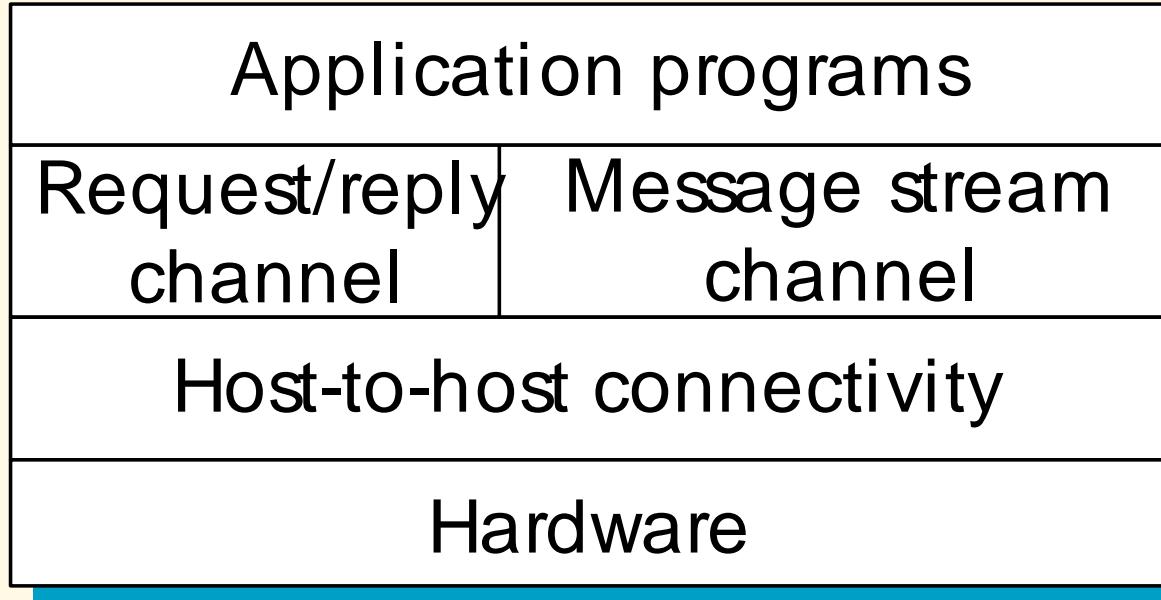


Figure 1.9 Layered system with alternate abstractions available at a given layer.

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Applications and Layered Architectures

- . In the 1970's vendor companies (IBM and DEC) developed **proprietary networks** with the common feature of grouping communication functions into related and manageable sets called **layers**.

network architecture :: a set of **protocols** that specify how every **layer** is to function and the defined **interfaces** between the **layers**. [LG&W]

Protocols

- Protocols are the building blocks of a network architecture.
- Each protocol object has two different interfaces:
 - *service interface* :: operations on this protocol
 - *peer-to-peer interface* :: messages exchanged with peer

Interfaces

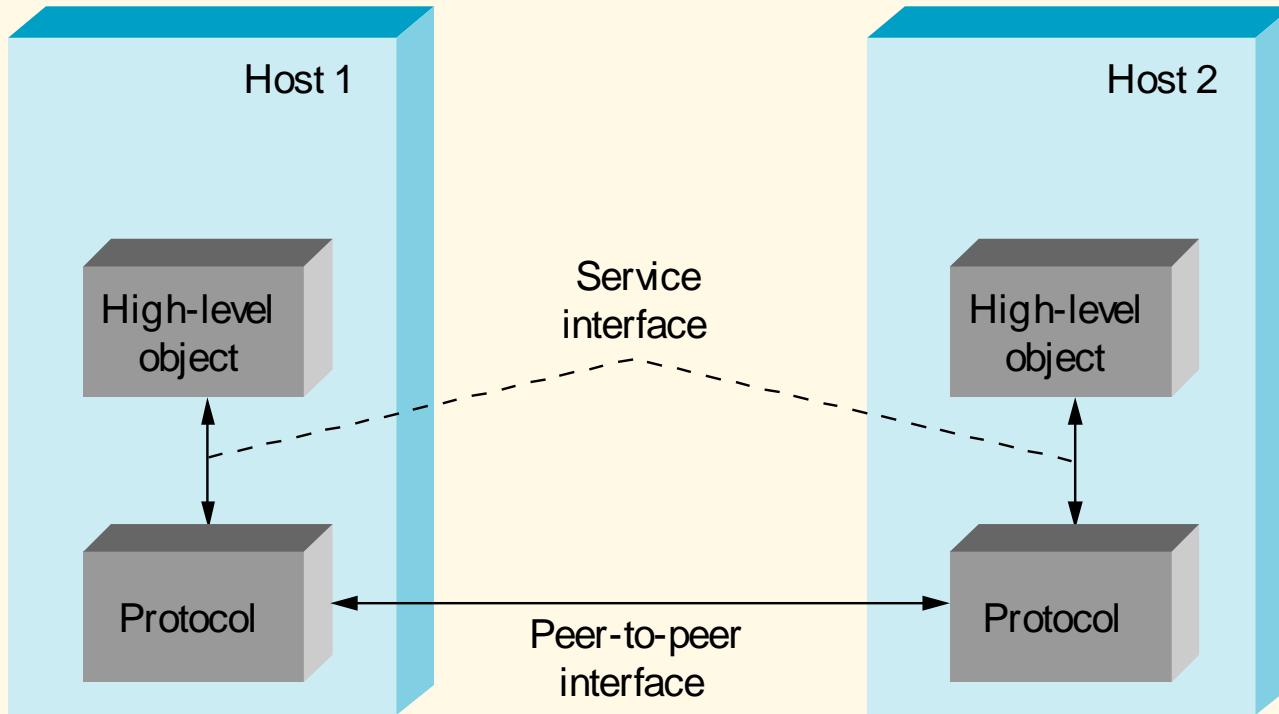


Figure 1.10 Service interfaces and peer interfaces

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What's a protocol?

human protocols:

- “what's the time?”
- “I have a question”
- introductions

... specific msgs sent

... specific actions
taken when msgs
received, or other
events

network protocols:

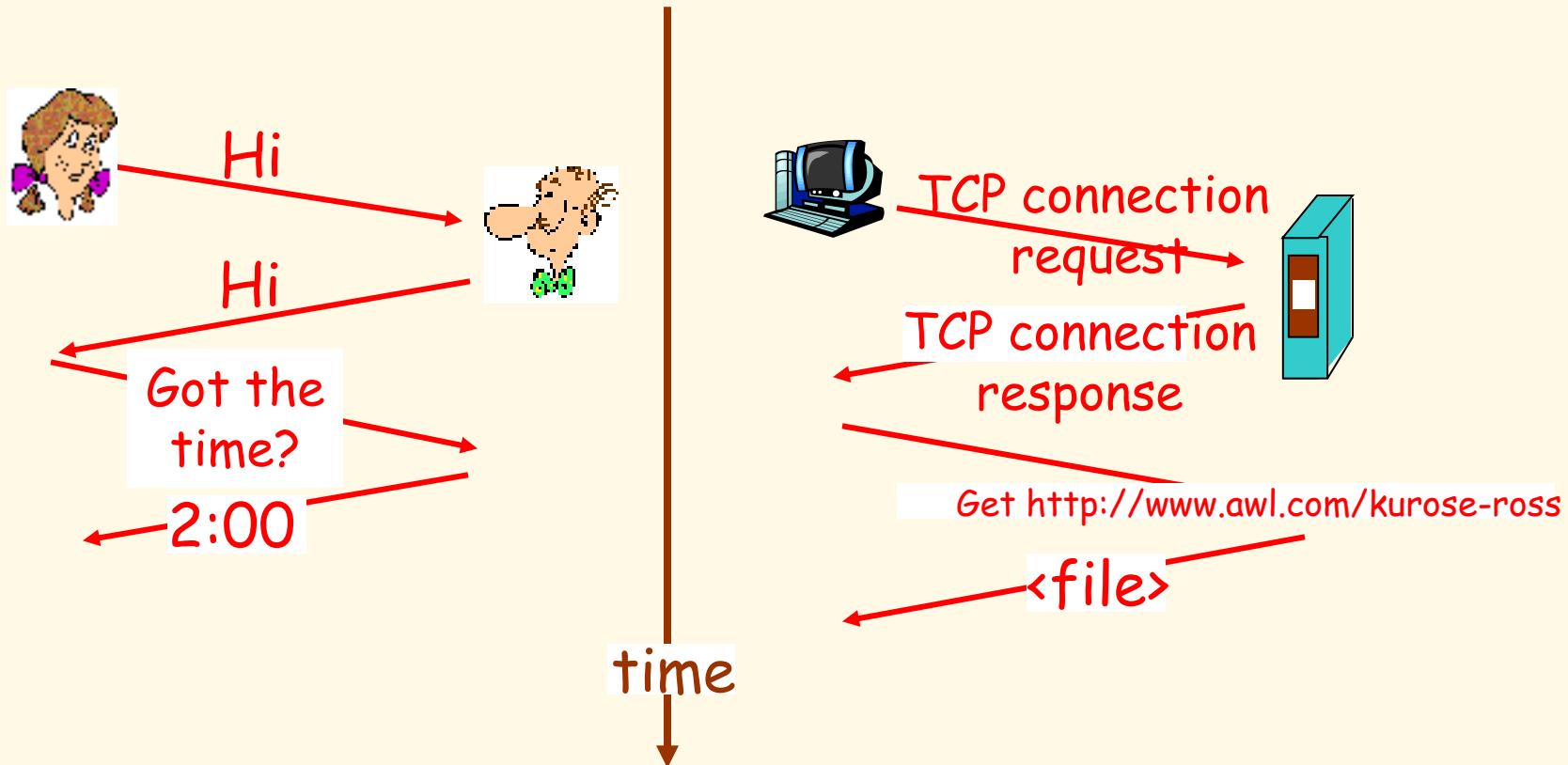
- machines rather than humans
- all communication activity in Internet governed by protocols

protocols define format,
order of msgs sent and
received among network
entities, and actions
taken on msg transmission
and receipt.

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What's a protocol?

a human protocol and a computer network protocol:



Q: Other human protocols?

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International Standards Organization

Open Systems Interconnect (OSI) Reference Model



Network Architecture

ISO Architecture

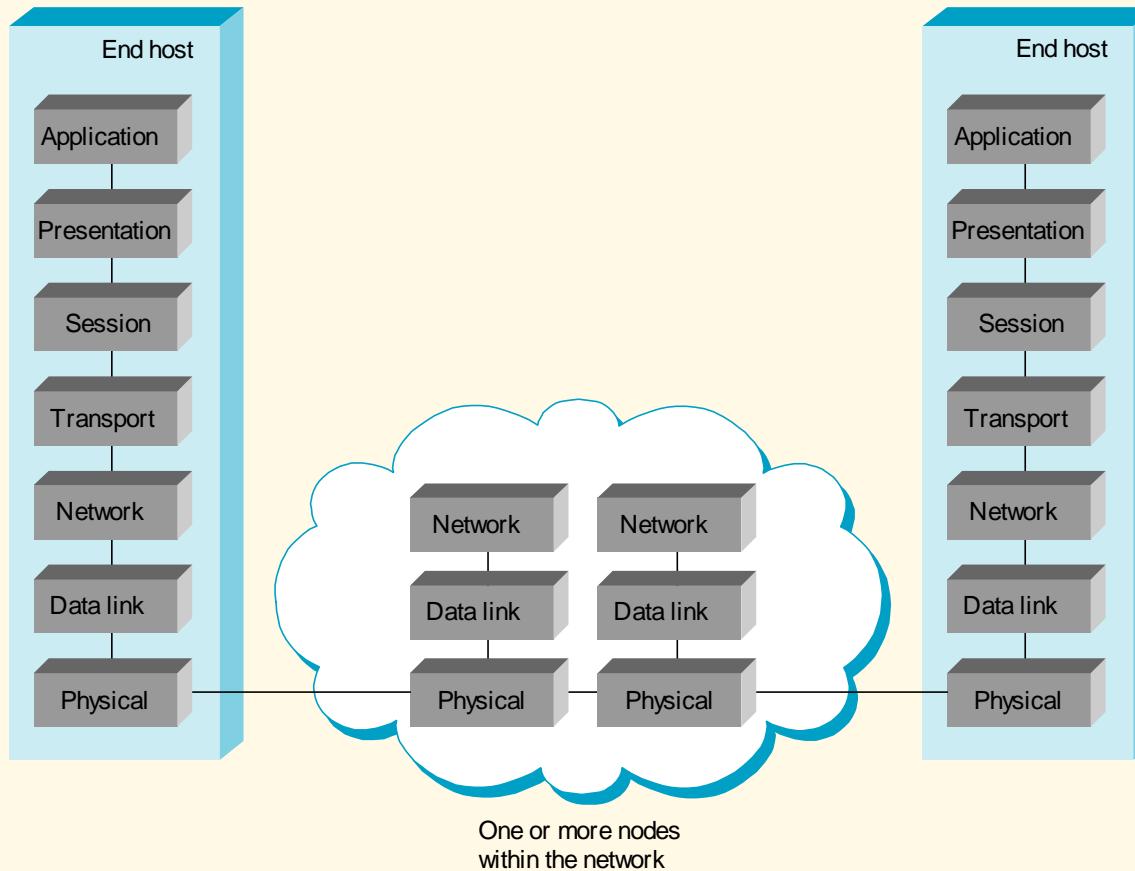
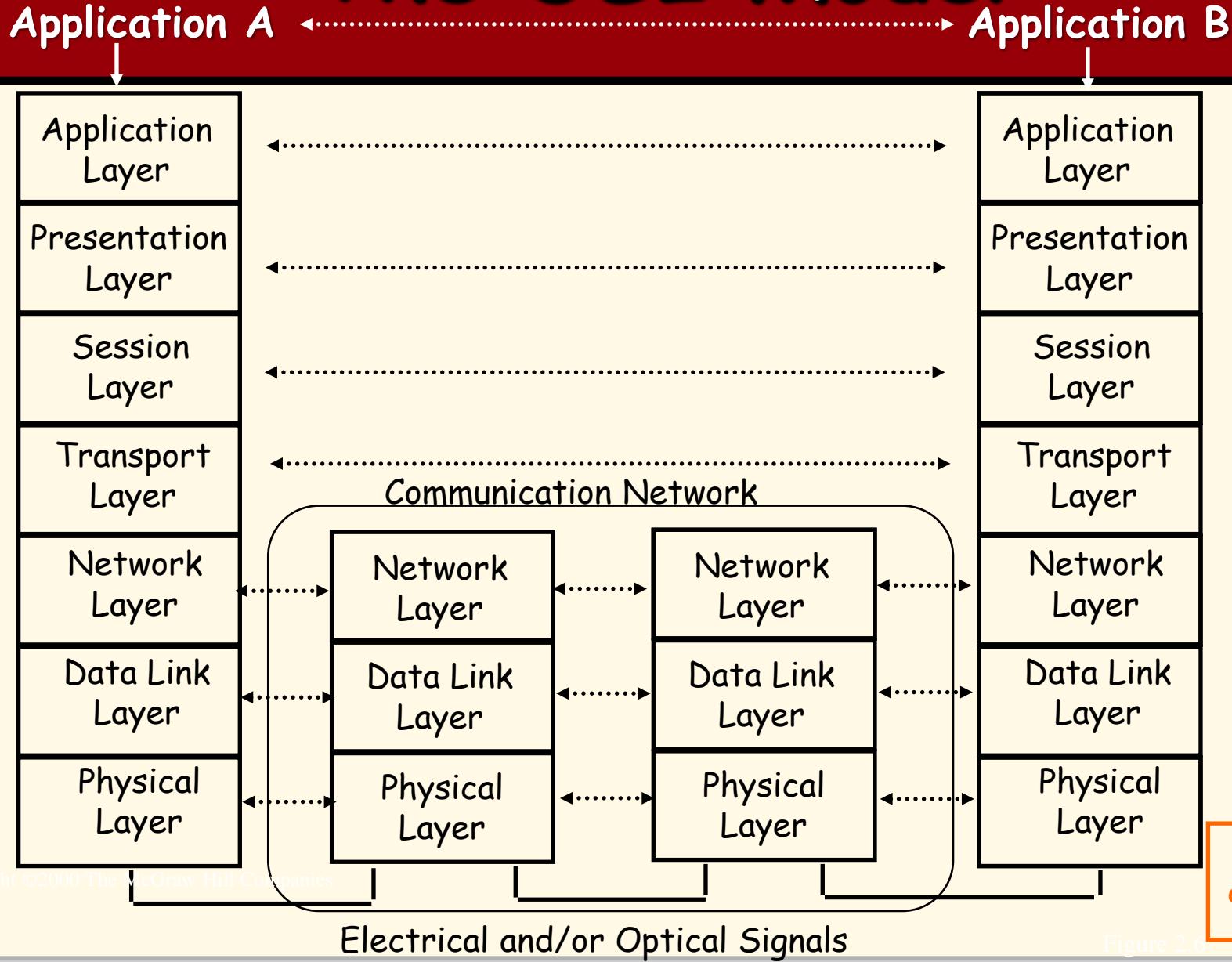


Figure 1.13 The OSI seven-layer model

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The OSI Model

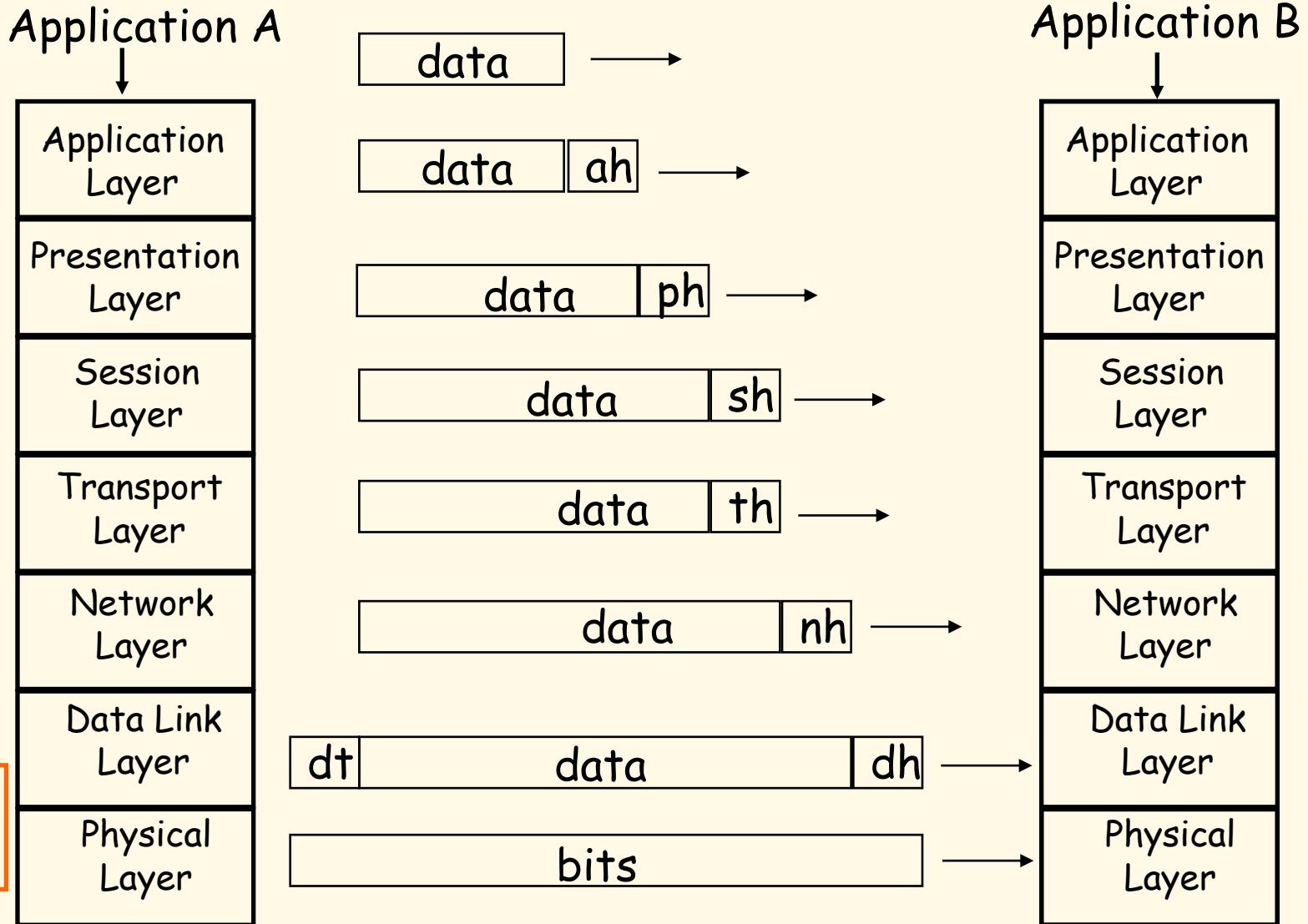


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Leon-Garcia
& Widjaja:
Communication
Networks

Figure 2.6

OSI Layer Encapsulation



Seven Layer OSI Model

Application Layer

Provides users access to the OSI environment and distributed information services.

Presentation Layer

Provides application processes independence from differences in data representations.

Session Layer

Provides the control structure for communicating between applications.
Establishes, manages and terminates session connections between cooperating applications.

Transport Layer

Provides reliable transparent transfer of data between end points.
Provides end-to-end flow control and error recovery.

Network Layer

Provides independence from the data transmission, routing/switching technologies used to connect systems. Responsible for establishing, managing and terminating connections.

Data Link Layer

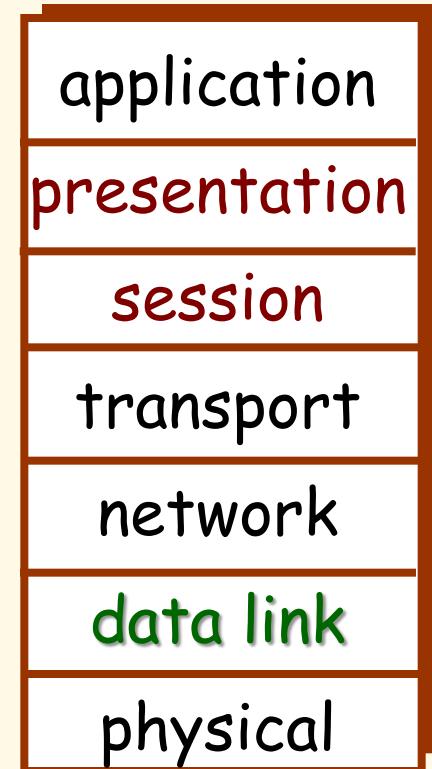
Provides for reliable transfer of information across the physical layer. Sends and receives frames with the necessary synchronization, flow control and error control.

Physical Layer

Concerned with transmission of unstructured bit stream over a physical medium. Deals with mechanical, electrical, functional and procedural characteristics to access the physical medium.

ISO/OSI Reference Model

- **Presentation layer:** allow applications to interpret meaning of data, e.g., encryption, compression, machine-specific conventions
- **Session layer:** synchronization, check-pointing, recovery of data exchange
- The TCP/IP Internet stack is “missing” these two layers!
 - these services, *if needed*, must be implemented in an application.
 - needed?



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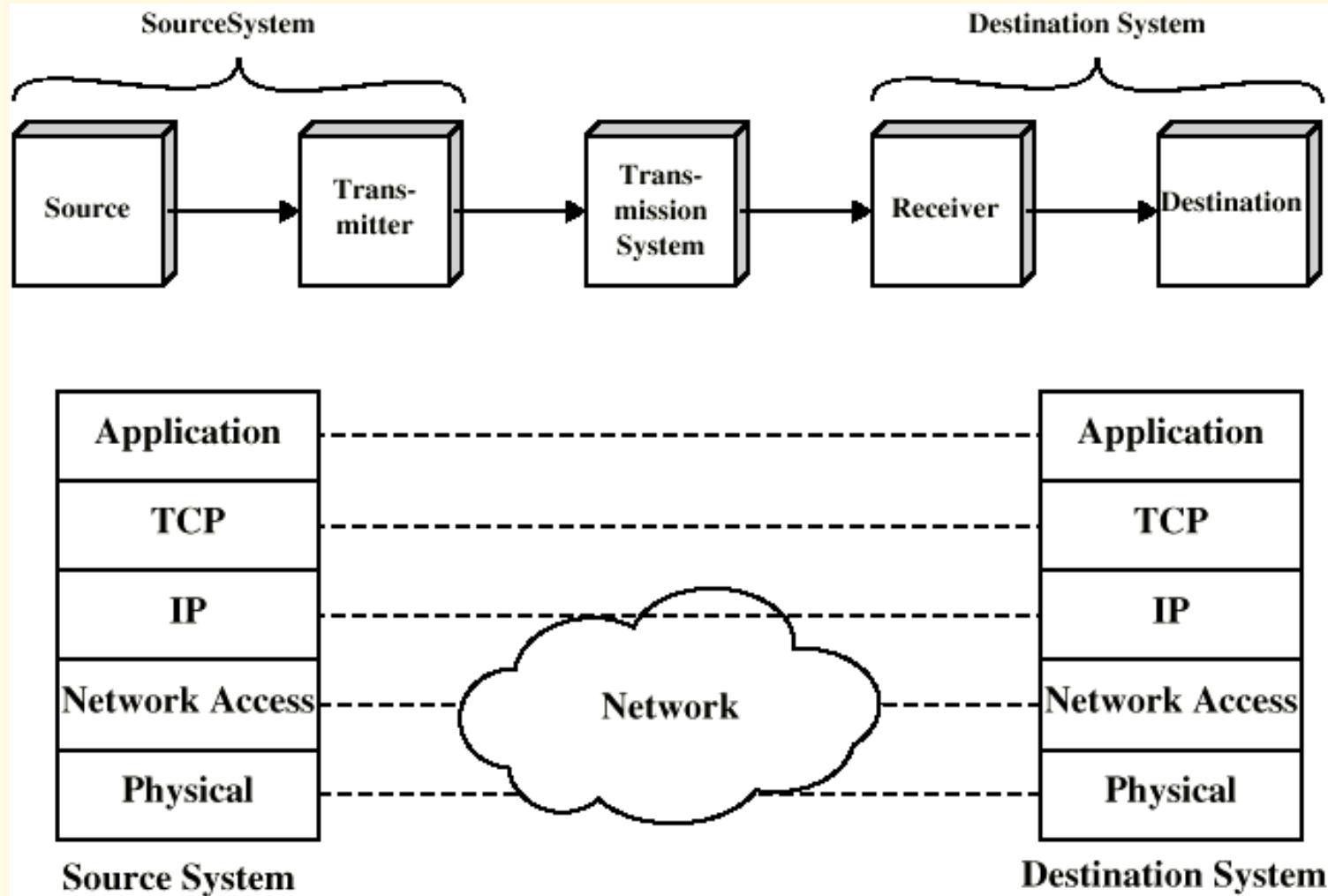
Advantages of Layering Design

- An explicit structure for dealing with a complex system:
 - allows identification and structures the relationship of complex system's pieces.
 - layered reference model for discussion.
- Provides an abstraction for functional locality.
- Simplifies the design process.

Advantages of Layering Design

- Modularity of layers eases maintenance and updating of system components:
 - change in implementation of a layer's service is transparent to rest of the system.
 - Led to flexibility in modifying and developing network architectures.
 - Accommodates incremental changes.

TCP/IP Architectural Model



DCC 6th Ed., W. Stallings

OSI versus TCP/IP

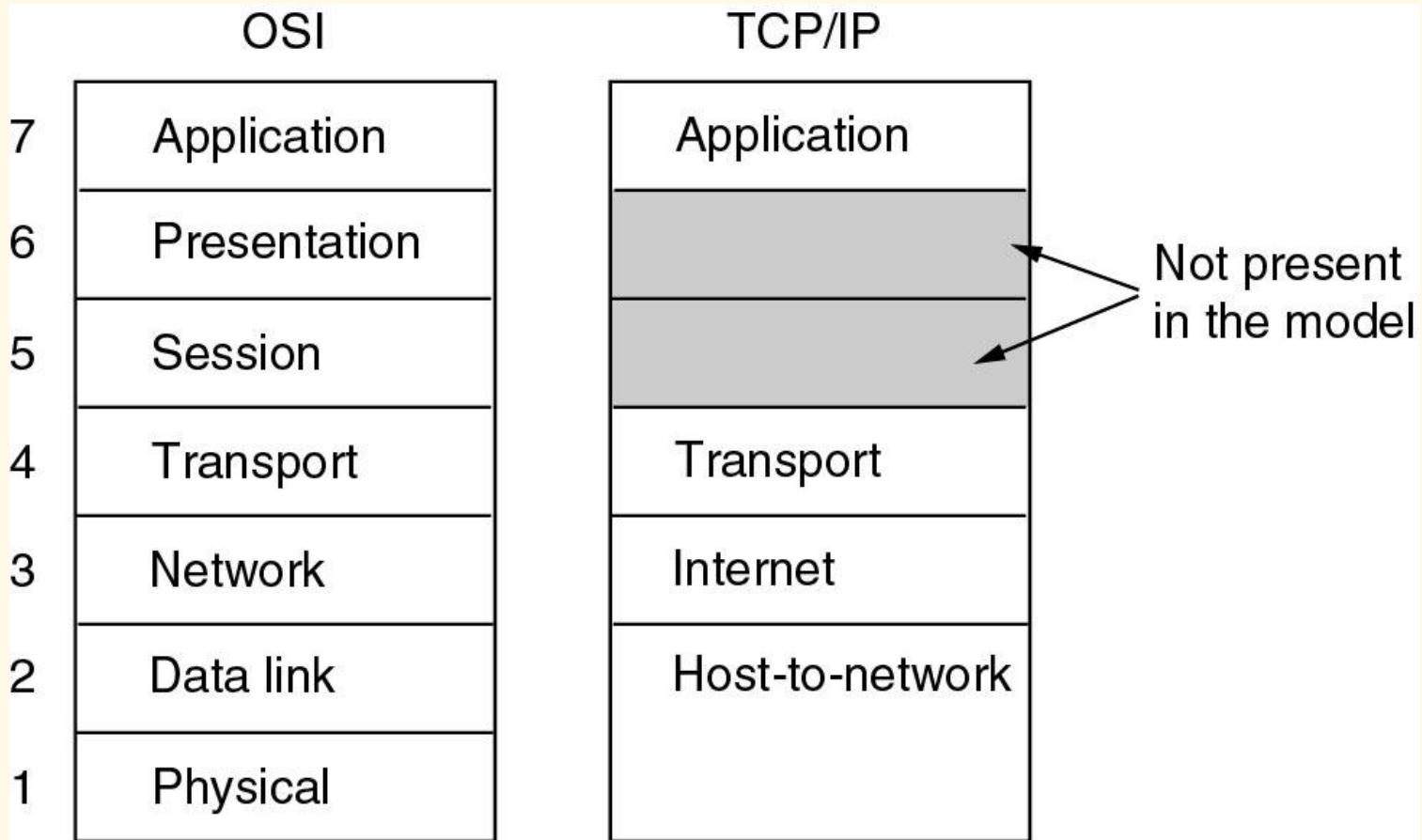
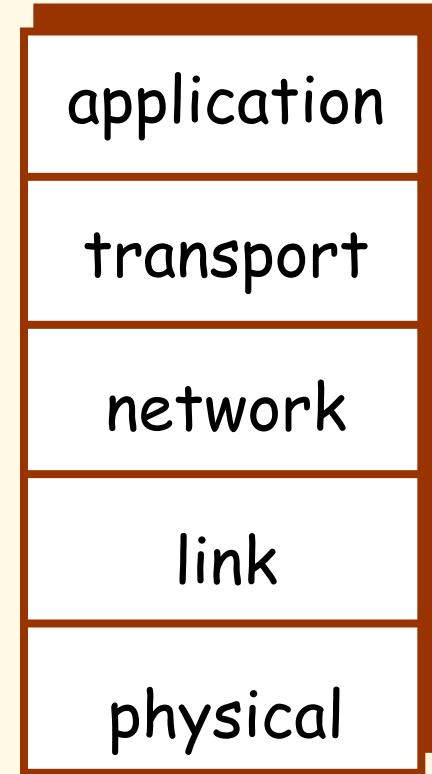


Figure 1-21. [old] The TCP/IP reference model.

Tanenbaum

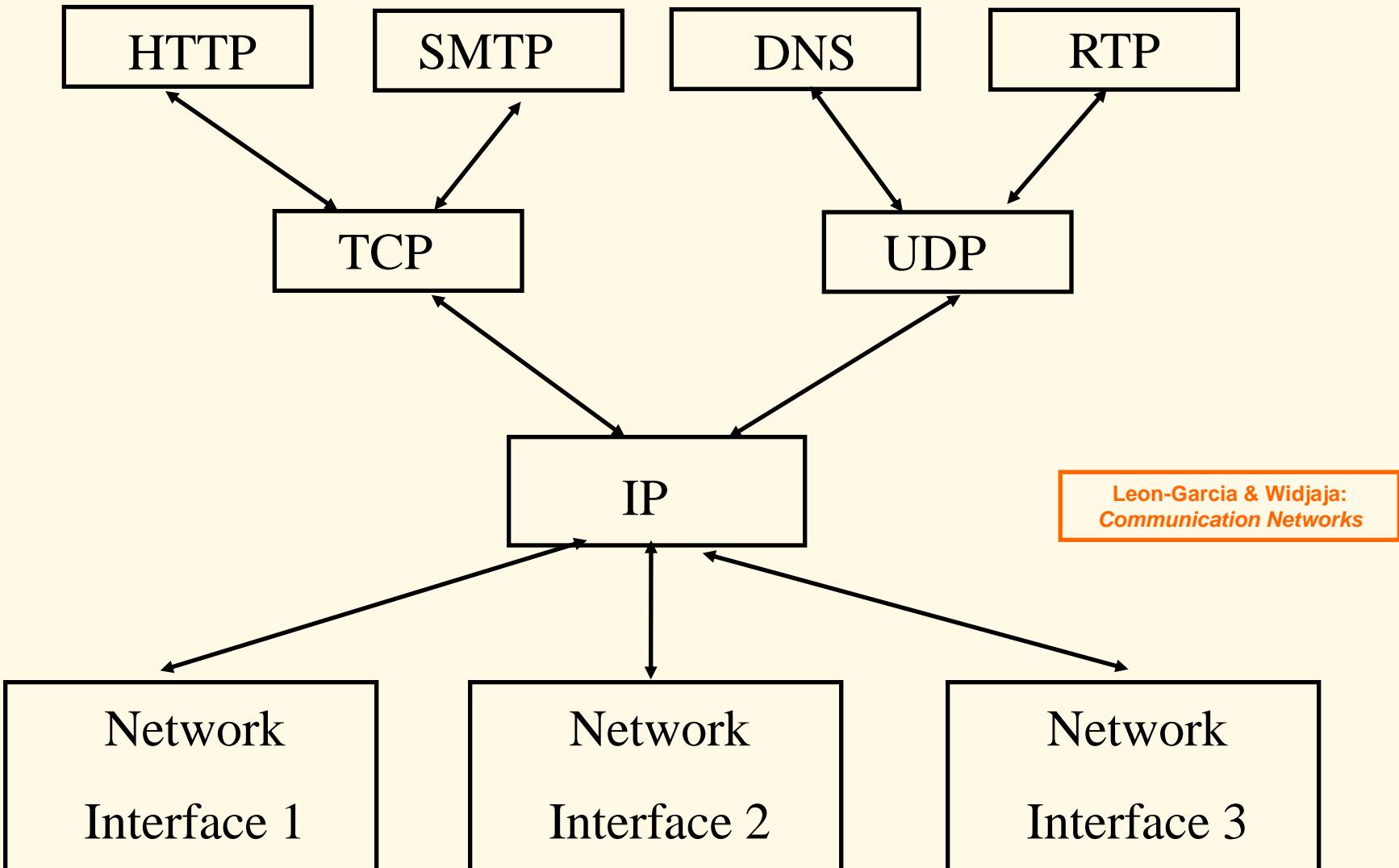
Internet Protocol Stack

- **application:** supporting network applications
 - FTP, SMTP, HTTP
- **transport:** process-process data transfer
 - TCP, UDP
- **network:** routing of datagrams from source to destination
 - IP, routing protocols
- **link:** data transfer between neighboring network elements
 - PPP, Ethernet
- **physical:** bits “on the wire” or in the air



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TCP/IP Protocols



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Alternate View

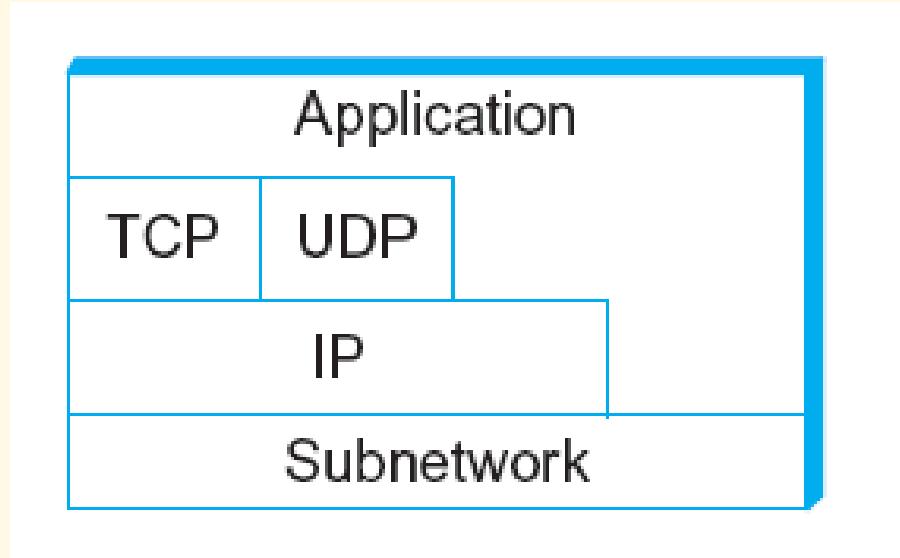


Figure 1.15 Alternate view of the Internet architecture

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Layering Example

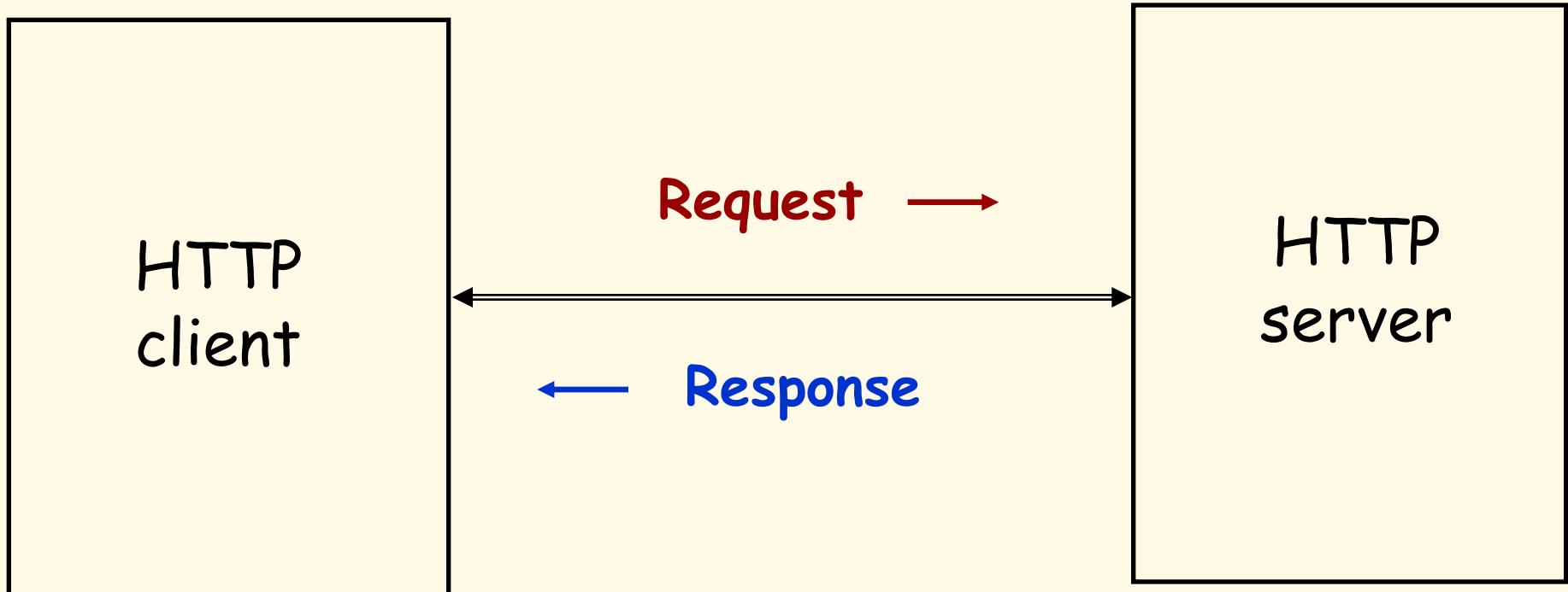
Client/server relationship

- Server process waits for incoming requests by listening to a **port**.
- Client process makes requests as required.
- Server process provides responses to these requests.
- The server process usually runs in the background as a daemon (e.g. httpd is the server daemon). for HTTP).

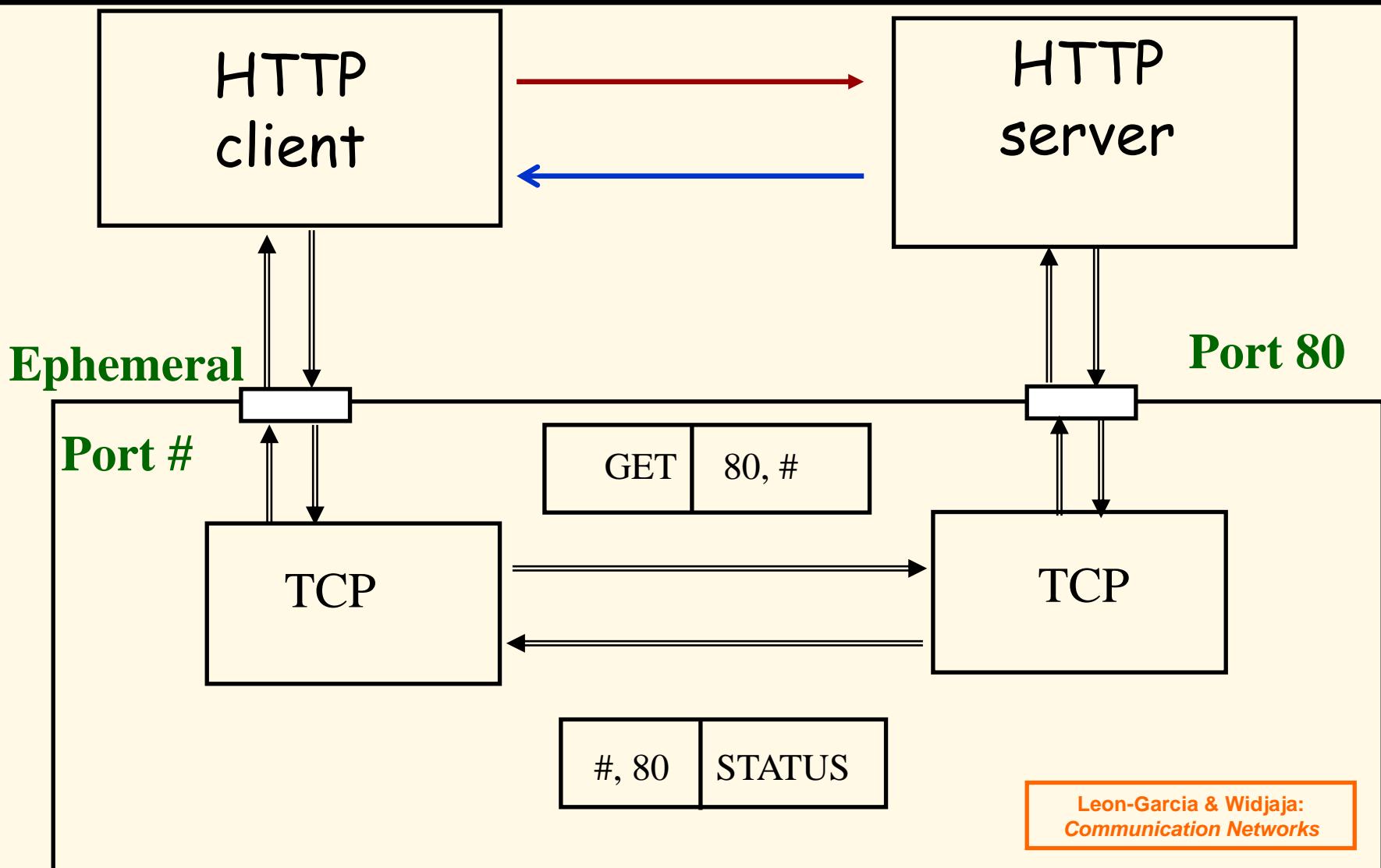
HTTP Example

- HTTP (HyperText Transfer Protocol) specifies rules by which the client and the server interact so as to retrieve a document.
- The protocol assumes the client and the server can exchange messages directly.
- The client software needs to set up a two-way connection prior to the HTTP request.

HTTP Client/Server Interaction

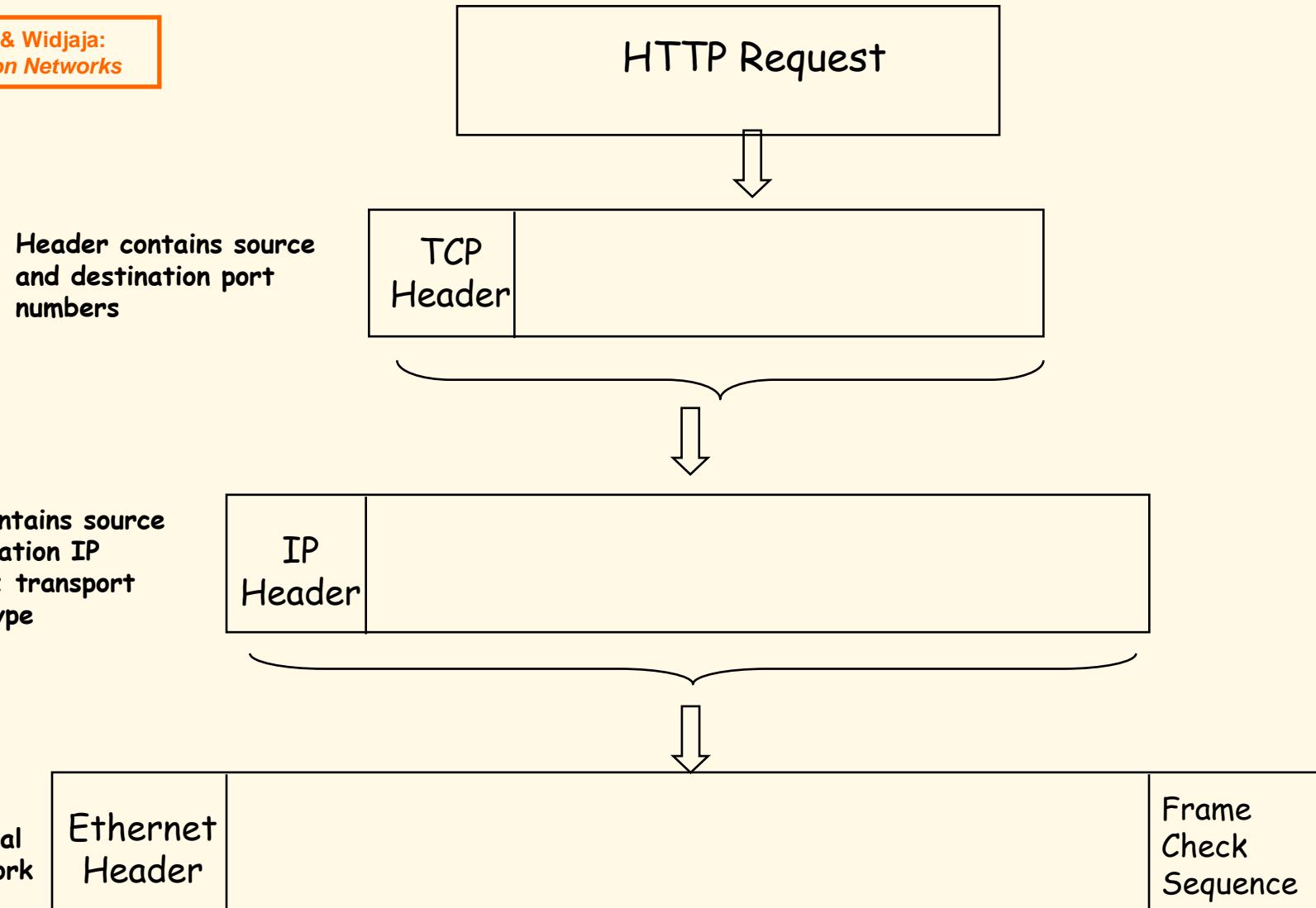


HTTP/TCP Layering Interface

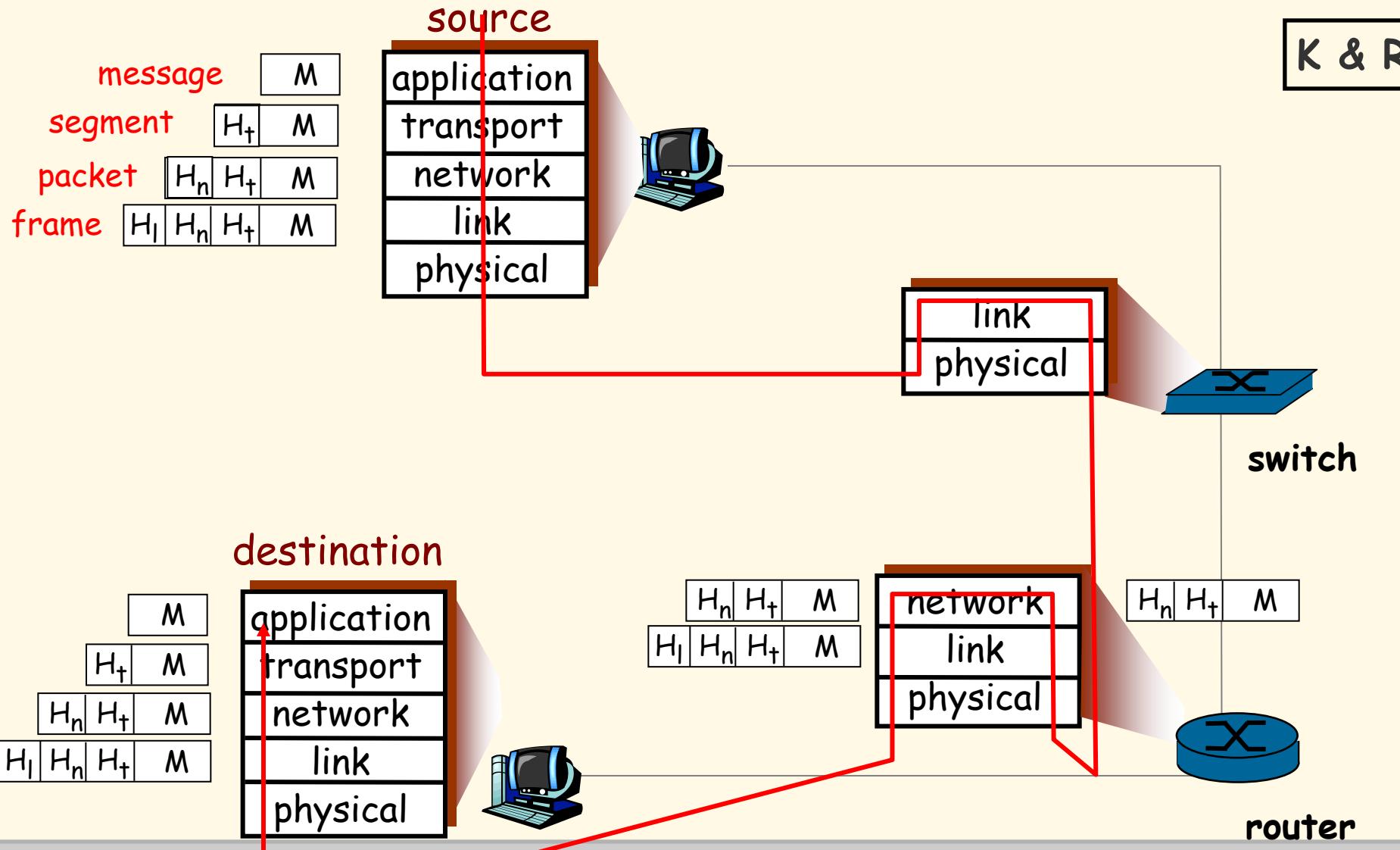


HTTP Encapsulation Example

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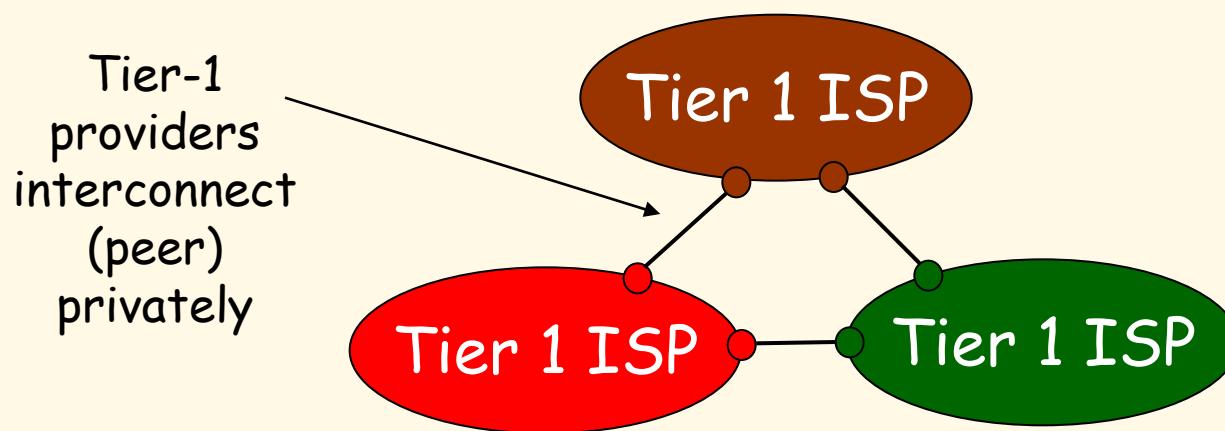


Encapsulation Animation



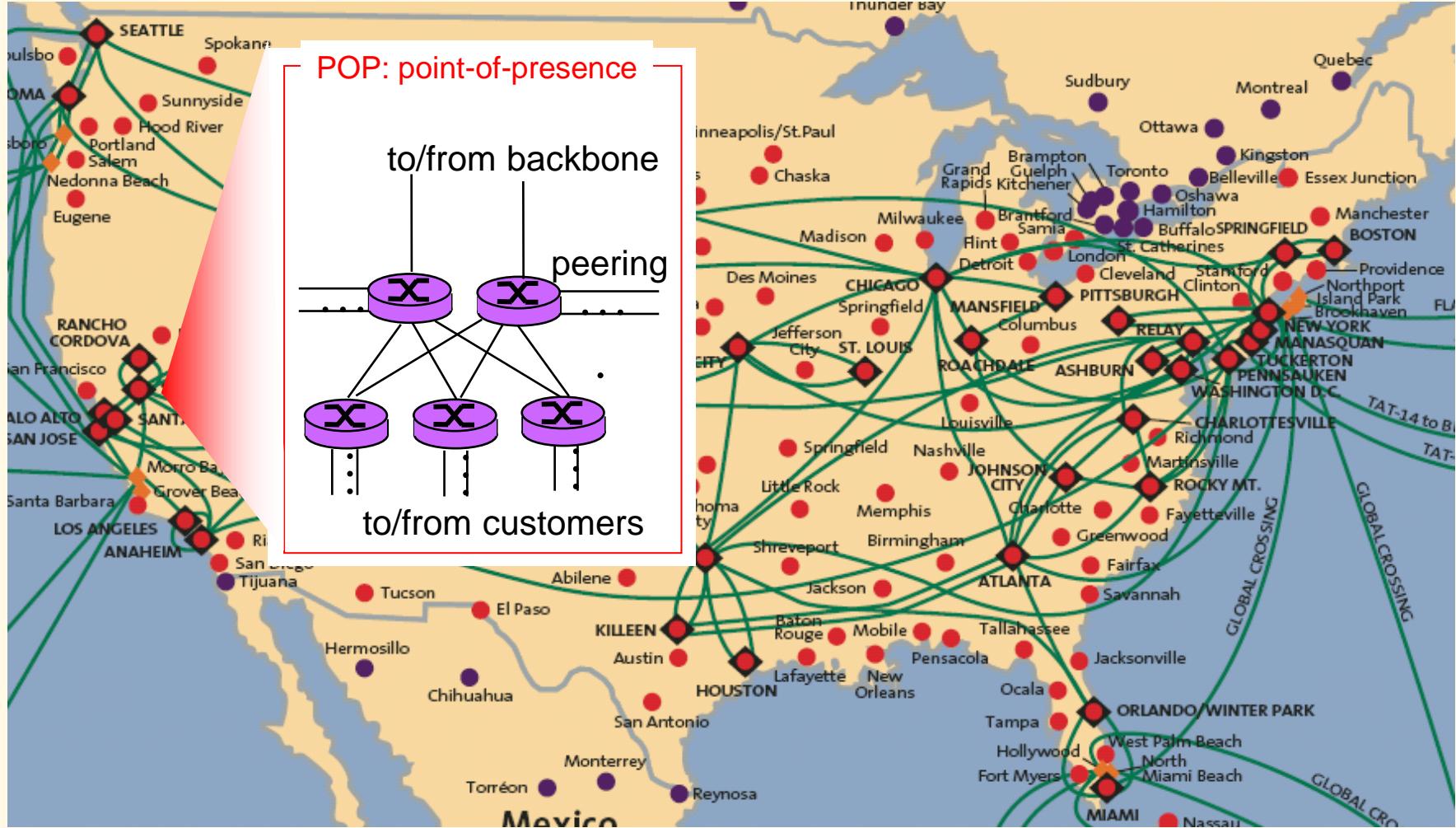
Internet Structure: Network of Networks

- roughly hierarchical
- at center: “tier-1” ISPs (e.g., Verizon, Sprint, AT&T, Cable and Wireless), national/international coverage
 - treat each other as equals



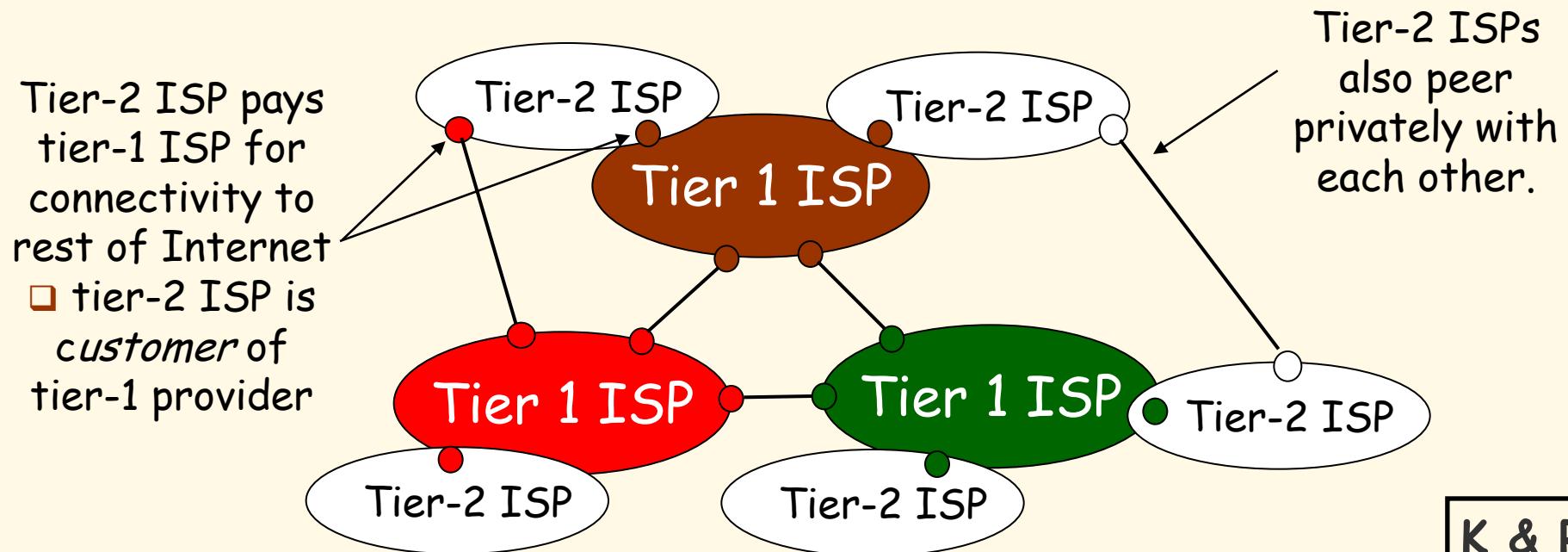
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Tier-1 ISP: e.g., Sprint



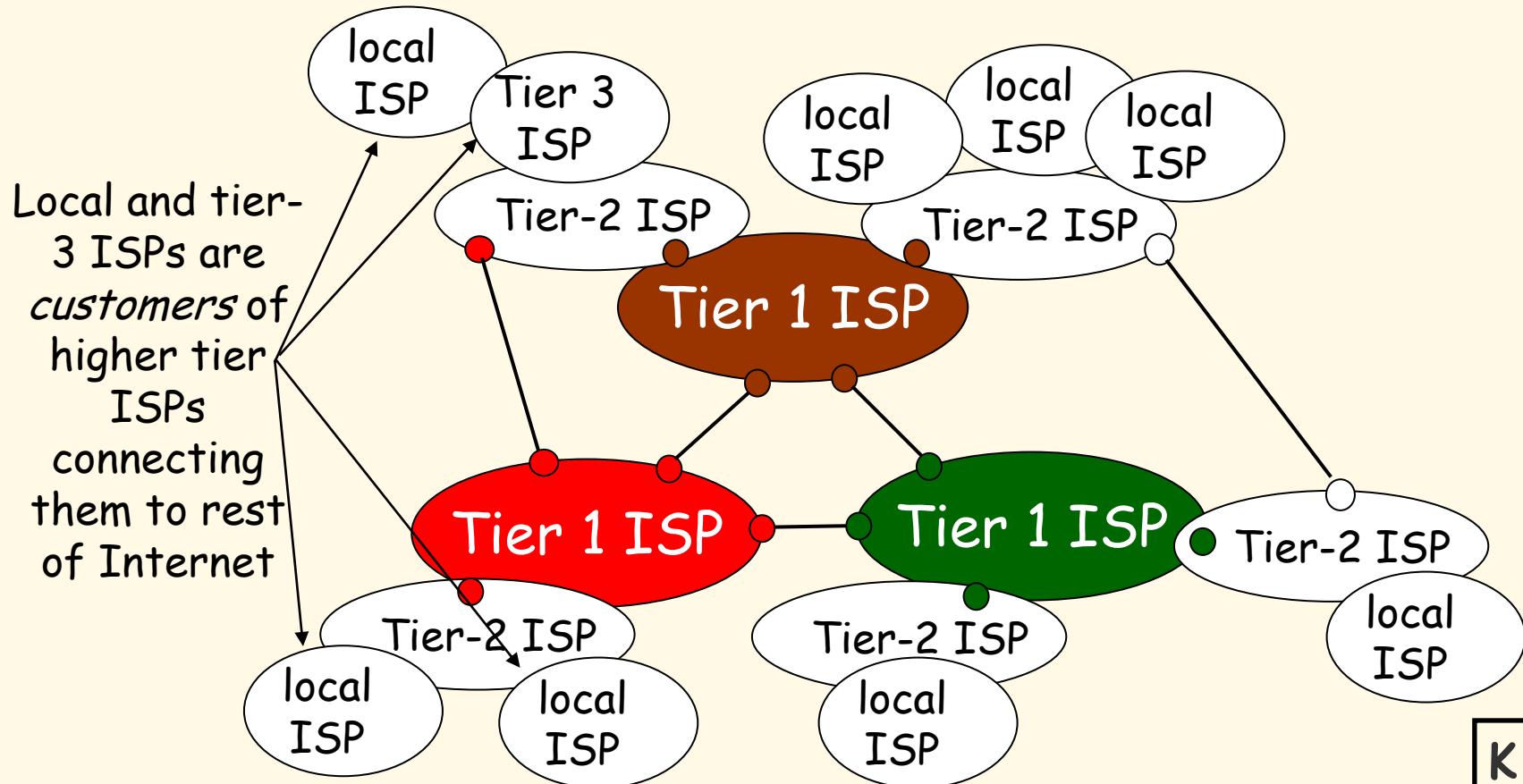
Internet Structure: Network of Networks

- “Tier-2” ISPs: smaller (often regional) ISPs
 - Connect to one or more tier-1 ISPs, possibly other tier-2 ISPs



Internet Structure: Network of Networks

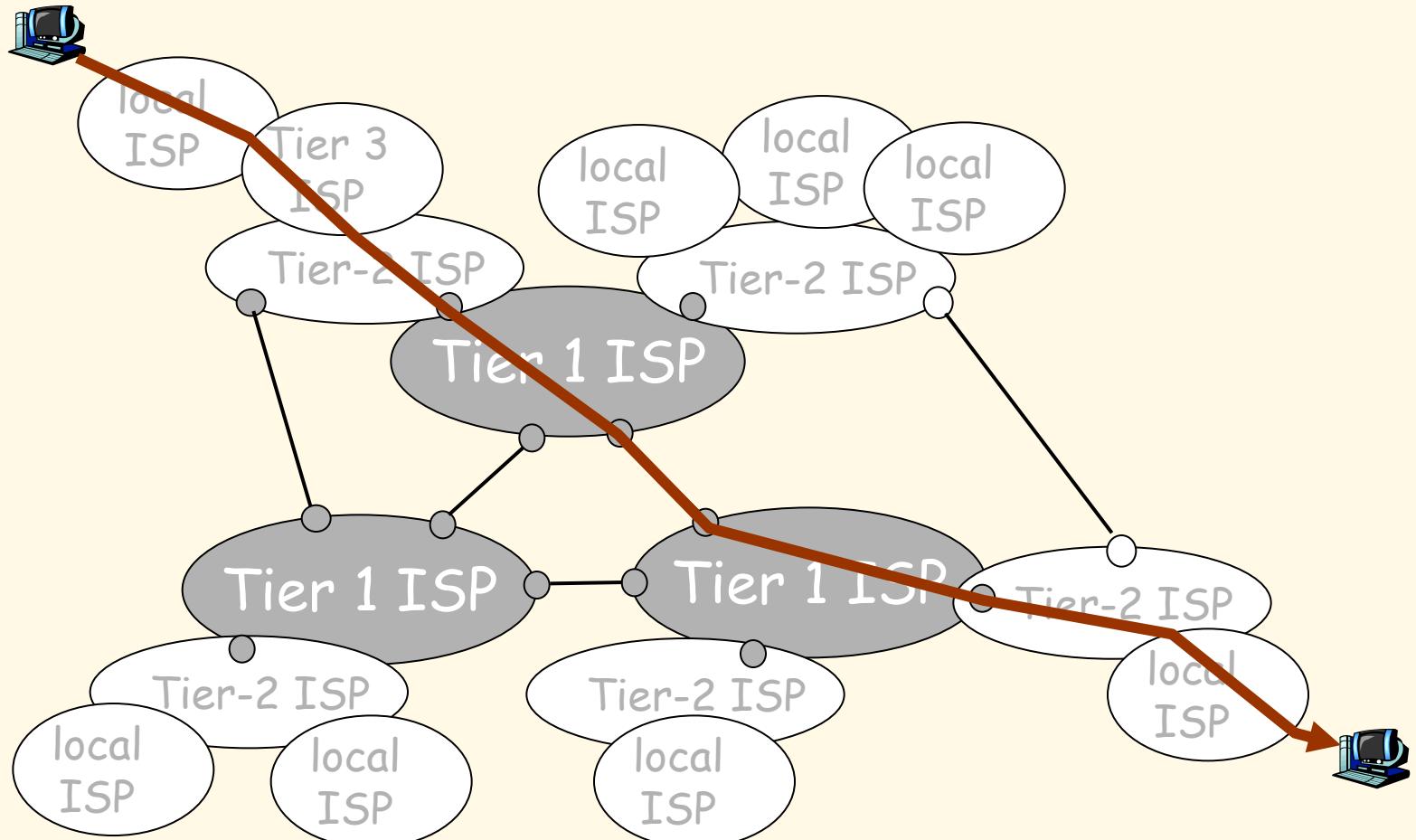
- “Tier-3” ISPs and local ISPs
 - last hop (“access”) network (closest to end systems)



Internet Structure: Network of Networks

- a packet passes through many networks!

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