Application Layer

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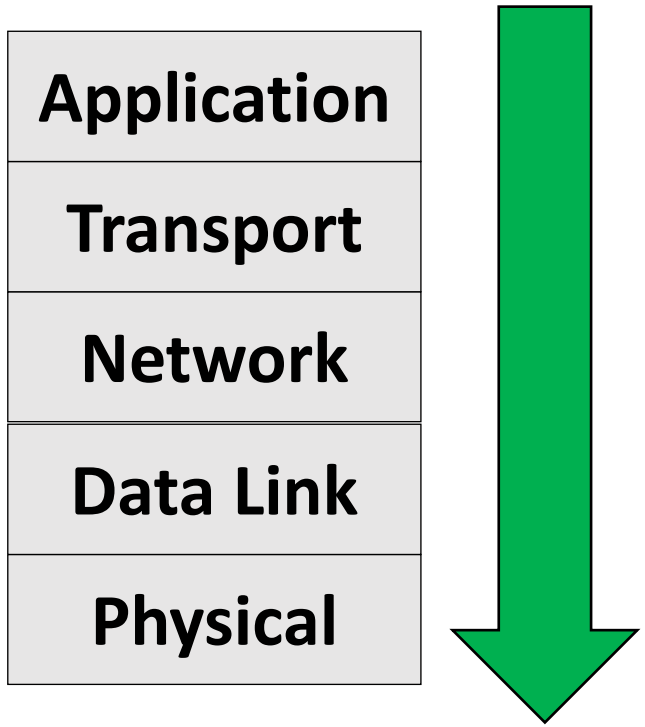
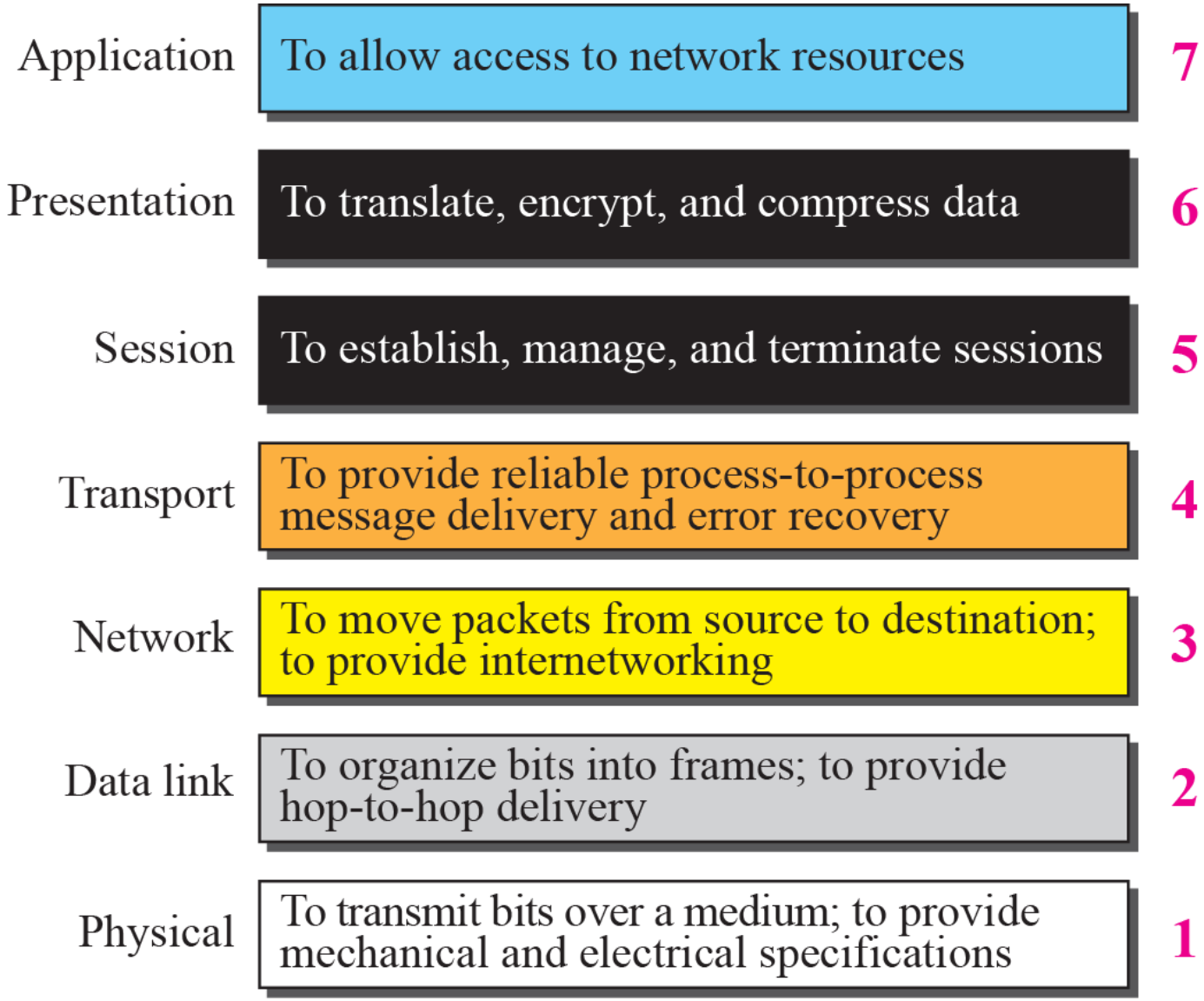
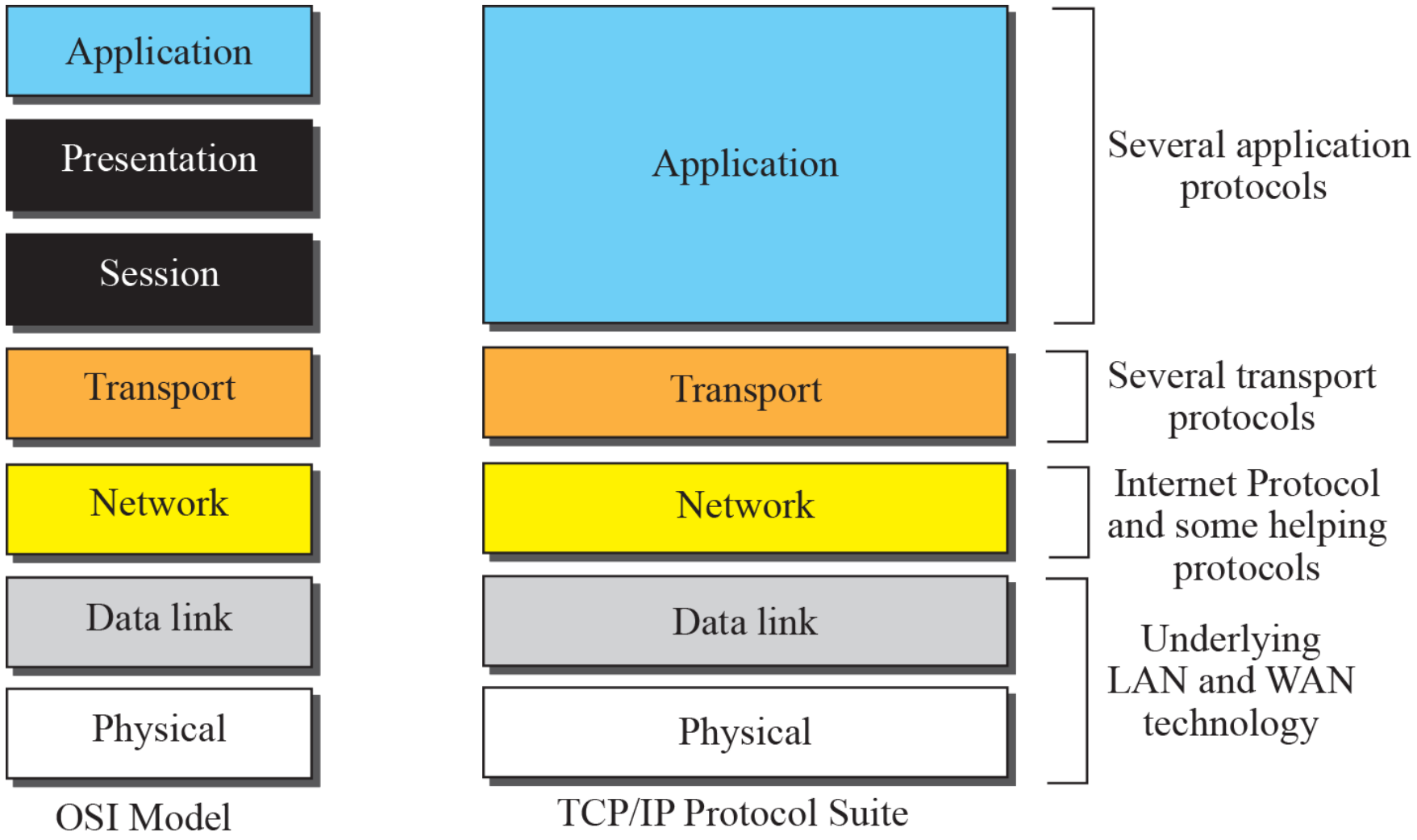
Top Down Approach



Summary of OSI Layers

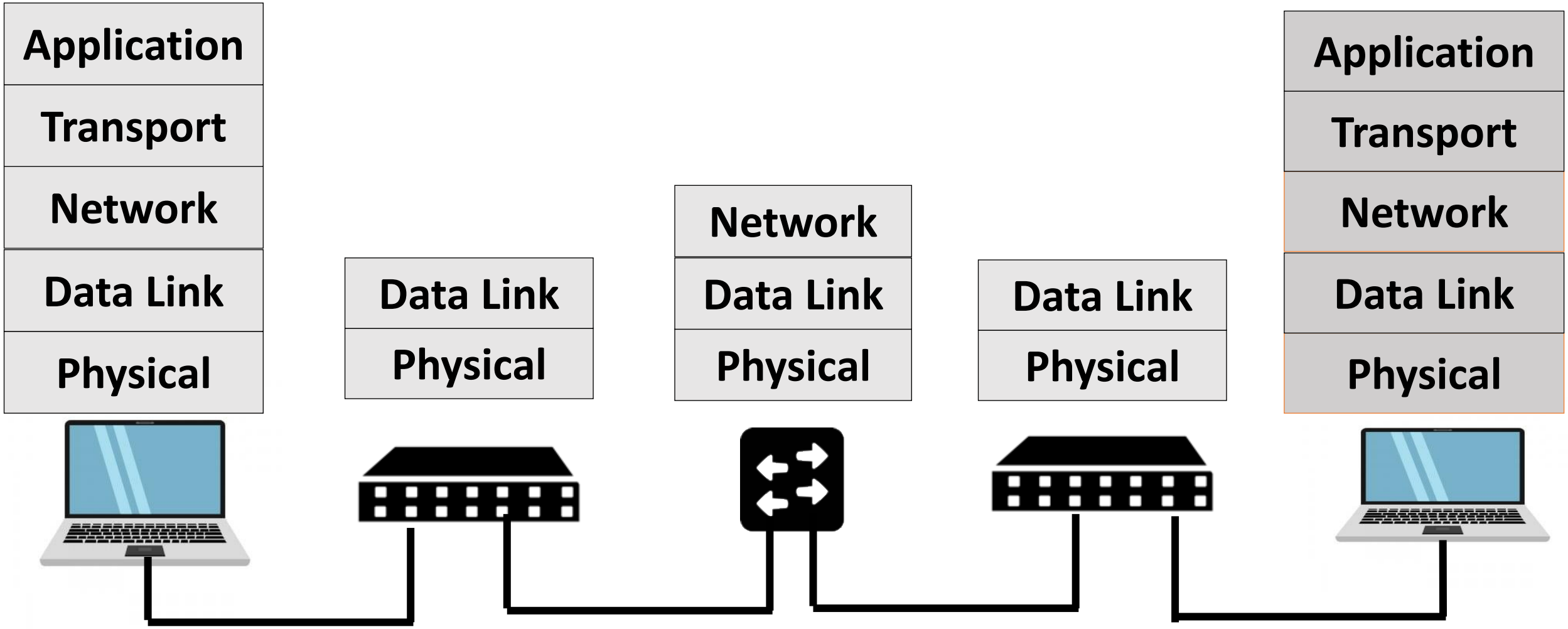


Source: TCP-IP protocol suite by Forouzan

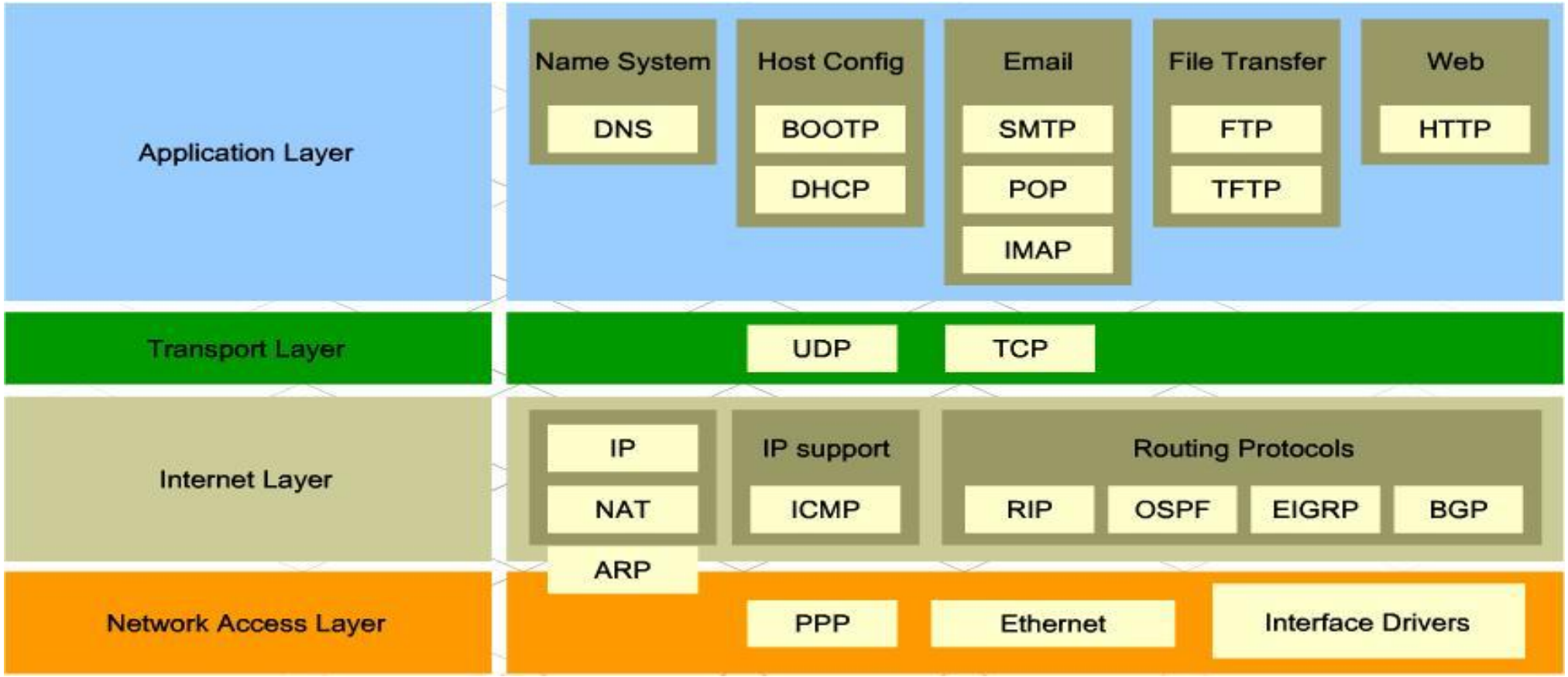


Source: TCP-IP protocol suite by Forouzan

Communication between two remote Machine



Protocols @ Different layers



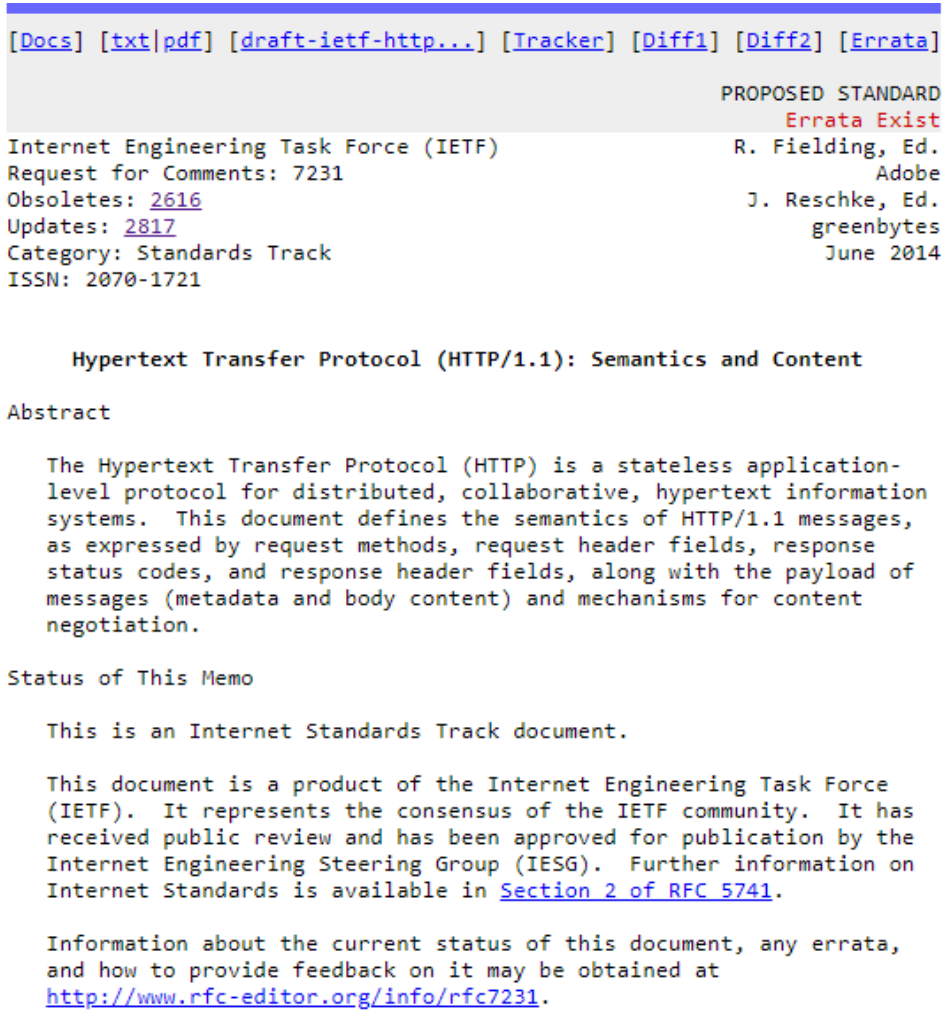
Source: http://walkwidnetwork.blogspot.com/2013/04/application-layer-internet-protocol.html

List of Application Layer protocols

Protocol Acronym	Protocol Name
BitTorrent	BitTorrent (peer-to-peer file sharing protocol)
FTP	File Transfer Protocol
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
IMAP	Internet Message Access Protocol
NTP	Network Time Protocol
POP3	Post Office Protocol (version 3)
RDP	Remote Desktop Protocol
Skype	Skype (peer-to-peer VoIP protocol)
MSNP	Microsoft Notification Protocol
SIP	Session Initiation Protocol
SMB/CIFS	Server Message Block/Common Internet File System
SMTP	Simple Mail Transfer Protocol
SSH	Secure Shell
TELNET	Terminal Network
OpenVPN	OpenVPN (Virtual Private Network)
IPsec	IPsec (IP security)
PPTP	Point-to-Point Tunneling Protocol

Source: https://www.researchgate.net/publication/283613112_Practical_evaluation_of_stateful_NAT64DNS64_translation/figures?lo=1

RFCs for Application Layer Protocol-HTTP



[Docs] [txt|pdf] [draft-ietf-http...] [Tracker] [Diff1] [Diff2] [Errata]

PROPOSED STANDARD
Errata Exist

Internet Engineering Task Force (IETF) — R. Fielding, Ed., Adobe
Request for Comments: 7231 — J. Reschke, Ed., greenbytes
Obsoletes: 2616
Updates: 2817
Category: Standards Track — June 2014
ISSN: 2070-1721

Hypertext Transfer Protocol (HTTP/1.1): Semantics and Content

Abstract

The Hypertext Transfer Protocol (HTTP) is a stateless application-level protocol for distributed, collaborative, hypertext information systems. This document defines the semantics of HTTP/1.1 messages, as expressed by request methods, request header fields, response status codes, and response header fields, along with the payload of messages (metadata and body content) and mechanisms for content negotiation.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 5741.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc7231.

https://tools.ietf.org/html/

RFC: 7231

https://tools.ietf.org/html/rfc7231

RFCs for Application Layer Protocol-DNS

Network Working Group
Request for Comments: 1035

P. Mockapetris
ISI
November 1987

Obsoletes: RFCs 882, 883, 973

DOMAIN NAMES - IMPLEMENTATION AND SPECIFICATION

1. STATUS OF THIS MEMO

This RFC describes the details of the domain system and protocol, and assumes that the reader is familiar with the concepts discussed in a companion RFC, "Domain Names - Concepts and Facilities" [RFC-1034].

The domain system is a mixture of functions and data types which are an official protocol and functions and data types which are still experimental. Since the domain system is intentionally extensible, new data types and experimental behavior should always be expected in parts of the system beyond the official protocol. The official protocol parts include standard queries, responses and the Internet class RR data formats (e.g., host addresses). Since the previous RFC set, several definitions have changed, so some previous definitions are obsolete.

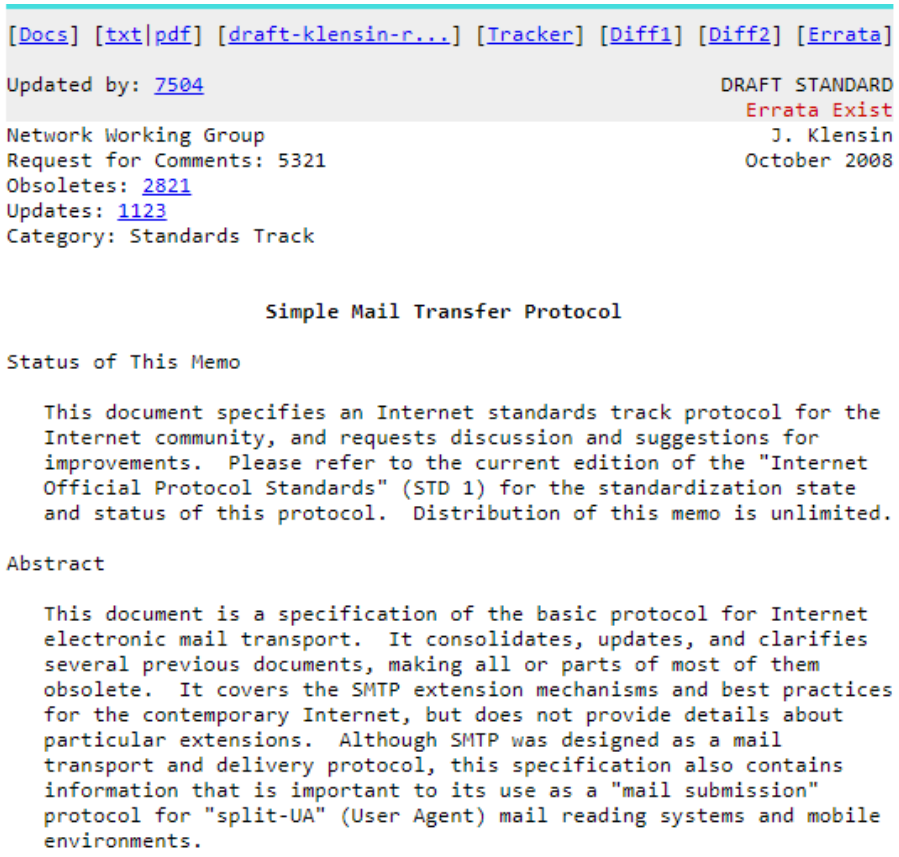
Experimental or obsolete features are clearly marked in these RFCs, and such information should be used with caution.

The reader is especially cautioned not to depend on the values which appear in examples to be current or complete, since their purpose is primarily pedagogical. Distribution of this memo is unlimited.

RFC: 1035

https://www.ietf.org/rfc/rfc1035.txt

RFCs for Application Layer Protocol-SMTP



[Docs] [txt|pdf] [draft-klensin-r...] [Tracker] [Diff1] [Diff2] [Errata]

Updated by: 7504 DRAFT STANDARD
Errata Exist

Network Working Group J. Klensin
Request for Comments: 5321 October 2008
Obsoletes: 2821
Updates: 1123
Category: Standards Track

Simple Mail Transfer Protocol

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

Abstract

This document is a specification of the basic protocol for Internet electronic mail transport. It consolidates, updates, and clarifies several previous documents, making all or parts of most of them obsolete. It covers the SMTP extension mechanisms and best practices for the contemporary Internet, but does not provide details about particular extensions. Although SMTP was designed as a mail transport and delivery protocol, this specification also contains information that is important to its use as a "mail submission" protocol for "split-UA" (User Agent) mail reading systems and mobile environments.

RFC: 5321

https://en.wikipedia.org/wiki/List_of_RFCs

https://tools.ietf.org/html/rfc5321

Chapter 2
Application Layer

A note on the use of these PowerPoint slides:

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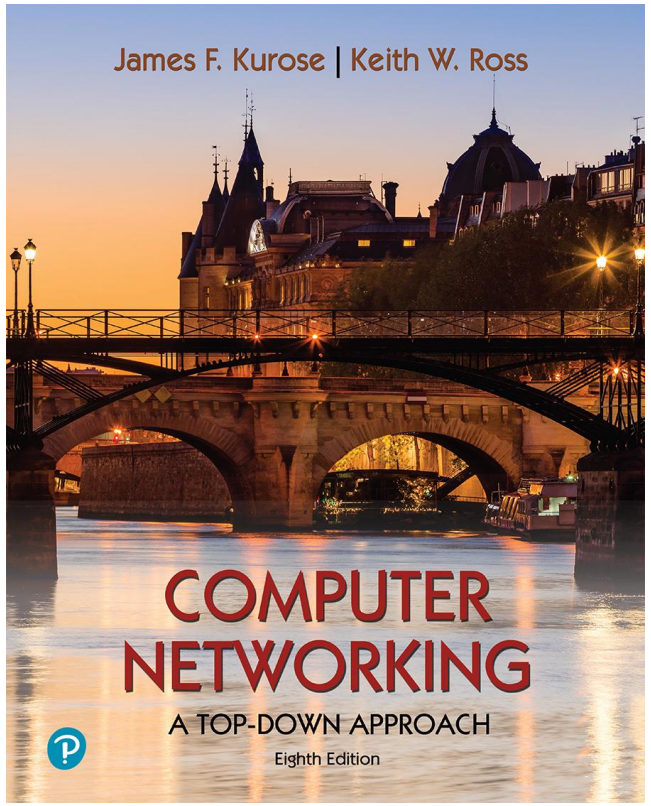


Computer Networking: A Top-Down Approach

8th edition n
Jim Kurose, Keith Ross
Pearson, 2020

Application layer: overview

- Principles of network applications
- Web and HTTP
- E-mail, SMTP, IMAP
- The Domain Name System DNS

- P2P applications
- video streaming and content distribution networks
- socket programming with UDP and TCP

Some network apps

- social networking
- Web
- text messaging
- e-mail
- multi-user network games
- streaming stored video (YouTube, Hulu, Netflix)
- P2P file sharing
- voice over IP (e.g., Skype)
- real-time video conferencing
- Internet search
- remote login
- …

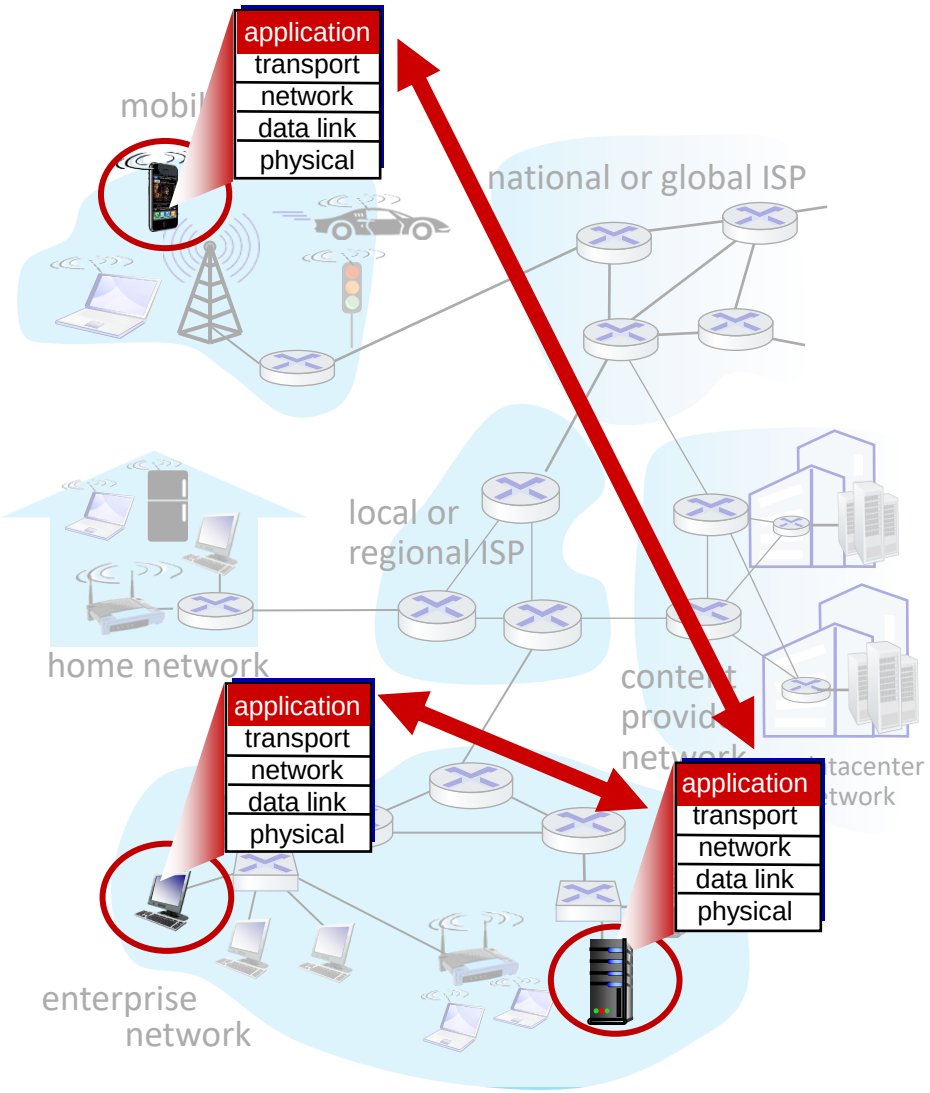
Creating a network app

write programs that:

- run on (different) end systems
- communicate over network
- e.g., web server software communicates with browser software

no need to write software for network-core devices

- network-core devices do not run user applications
- applications on end systems allows for rapid app development



Client-server paradigm

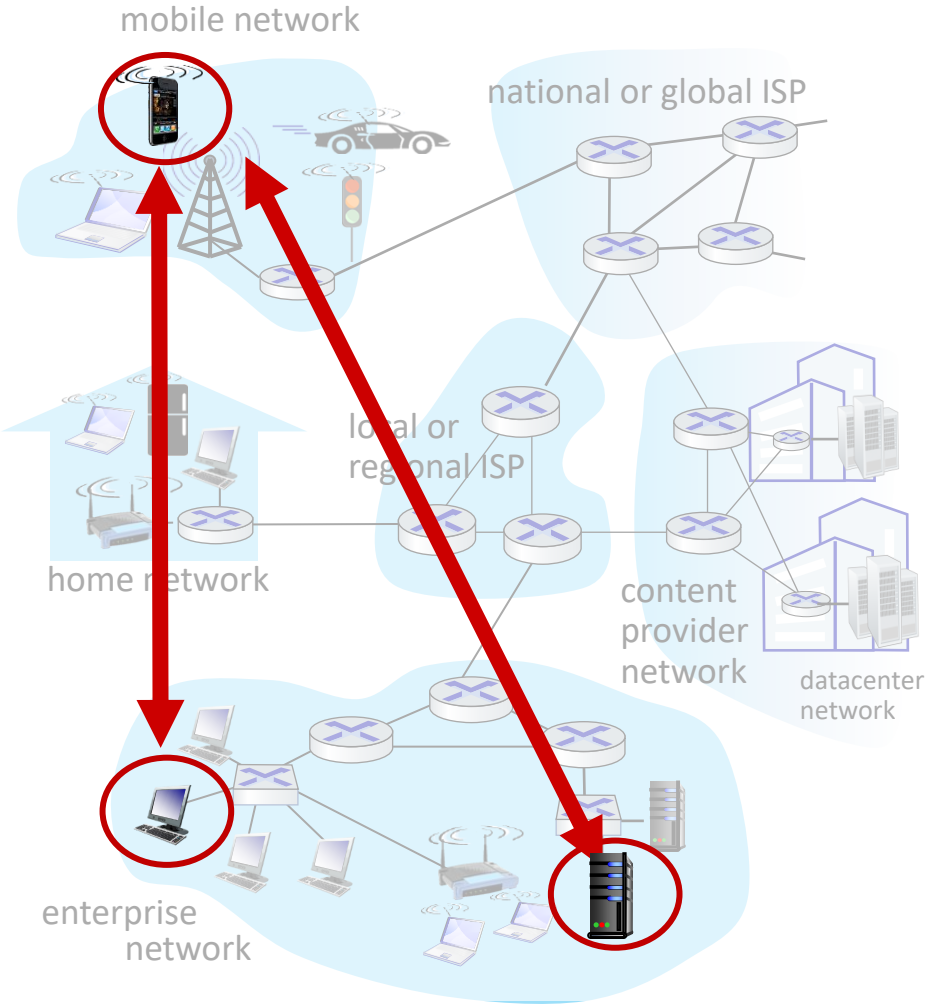
server:

- always-on host
- permanent IP address
- often in data centers, for scaling

clients:

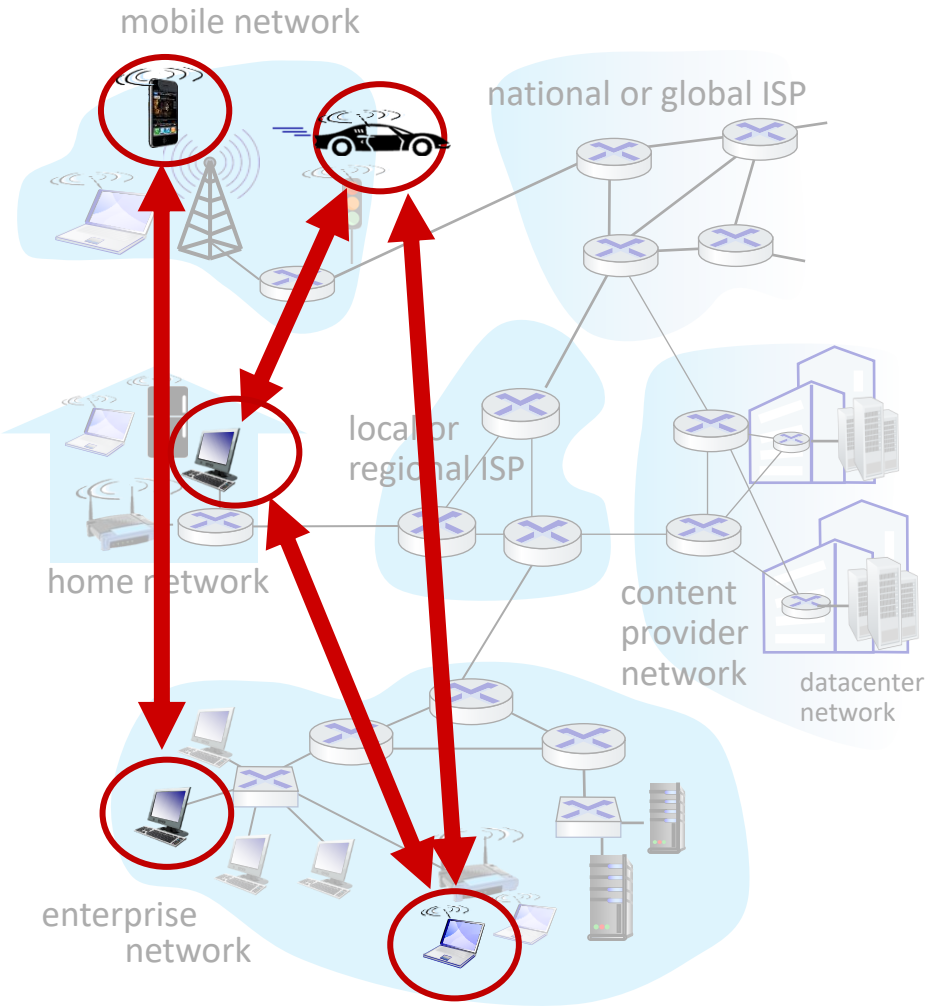
- contact, communicate with server
- may have dynamic IP addresses
- do *not* communicate directly with each other

- examples: HTTP, IMAP, FTP



Peer-peer architecture

- *no* always-on server
- arbitrary end systems directly communicate
- peers request service from other peers, provide service in return to other peers
  - *self scalability* – new peers bring new service capacity, as well as new service demands
- peers are intermittently connected and change IP addresses
  - complex management
- example: P2P file sharing



Processes communicating

process: program running within a host

- within same host, two processes communicate using inter-process communication (defined by OS)
- processes in different hosts communicate by exchanging messages

clients, servers

client process: process that initiates communication

server process: process that waits to be contacted

- note: applications with P2P architectures have client processes & server processes

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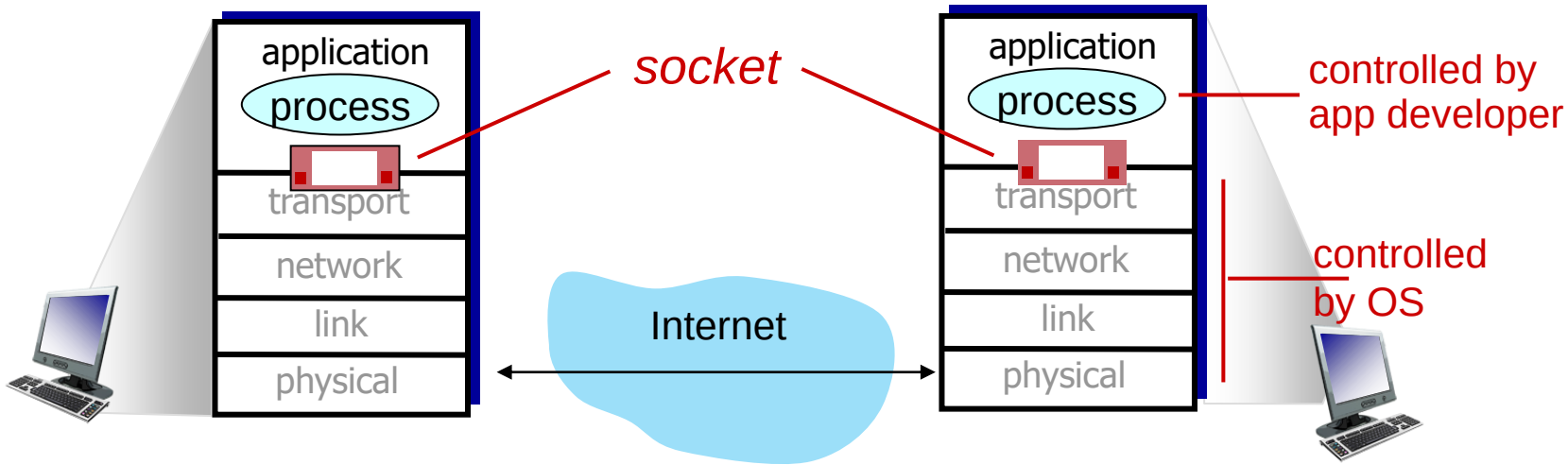
Sockets

- process sends/receives messages to/from its socket
- socket analogous to door
  - sending process pushes message outdoor
  - sending process relies on transport infrastructure on other side of door to deliver message to socket at receiving process
  - two sockets involved: one on each side



Addressing processes

- to receive messages, process must have *identifier*
- host device has unique 32-bit IP address
- *Q:* does IP address of host on which process runs suffice for identifying the process?
  - *A:* no, *many* processes can be running on same host

- *identifier* includes both IP address and port numbers associated with process on host.
- example port numbers:
  - HTTP server: 80
  - mail server: 25
- to send HTTP message to gaia.cs.umass.edu web server:
  - IP address: 128.119.245.12
  - port number: 80
- more shortly…

An application-layer protocol defines:

- types of messages exchanged,
  - e.g., request, response
- message syntax:
  - what fields in messages & how fields are delineated
- message semantics
  - meaning of information in fields
- rules for when and how processes send & respond to messages

open protocols:

- defined in RFCs, everyone has access to protocol definition
- allows for interoperability
- e.g., HTTP, SMTP

proprietary protocols:

- e.g., Skype

What transport service does an app need?

data integrity

- some apps (e.g., file transfer, web transactions) require 100% reliable data transfer
- other apps (e.g., audio) can tolerate some loss

timing

- some apps (e.g., Internet telephony, interactive games) require low delay to be "effective"

throughput

- some apps (e.g., multimedia) require minimum amount of throughput to be "effective"
- other apps ("elastic apps") make use of whatever throughput they get

security

- encryption, data integrity, …

Transport service requirements: common apps

application	data loss	throughput	time sensitive?
file transfer/download	no loss	elastic	no
e-mail	no loss	elastic	no
Web documents	no loss	elastic	no
real-time audio/video	loss-tolerant	audio: 5Kbps-1Mbps video:10Kbps-5Mbps	yes, 10's msec
streaming audio/video	loss-tolerant	same as above	yes, few secs
interactive games	loss-tolerant	Kbps+	yes, 10's msec
text messaging	no loss	elastic	yes and no