Operating System Concepts

Lecture 10: Distributed Systems

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MWF 12:00-12:50 VVC 2 215

Today's class

- Distributed systems
  - Motivation
  - Design issues
- Communication basics
  - Network structure
  - Network protocol

Distributed systems

- Definition: a set of physically separate, **loosely coupled** nodes connected by a communication network (high-speed buses or the Internet)
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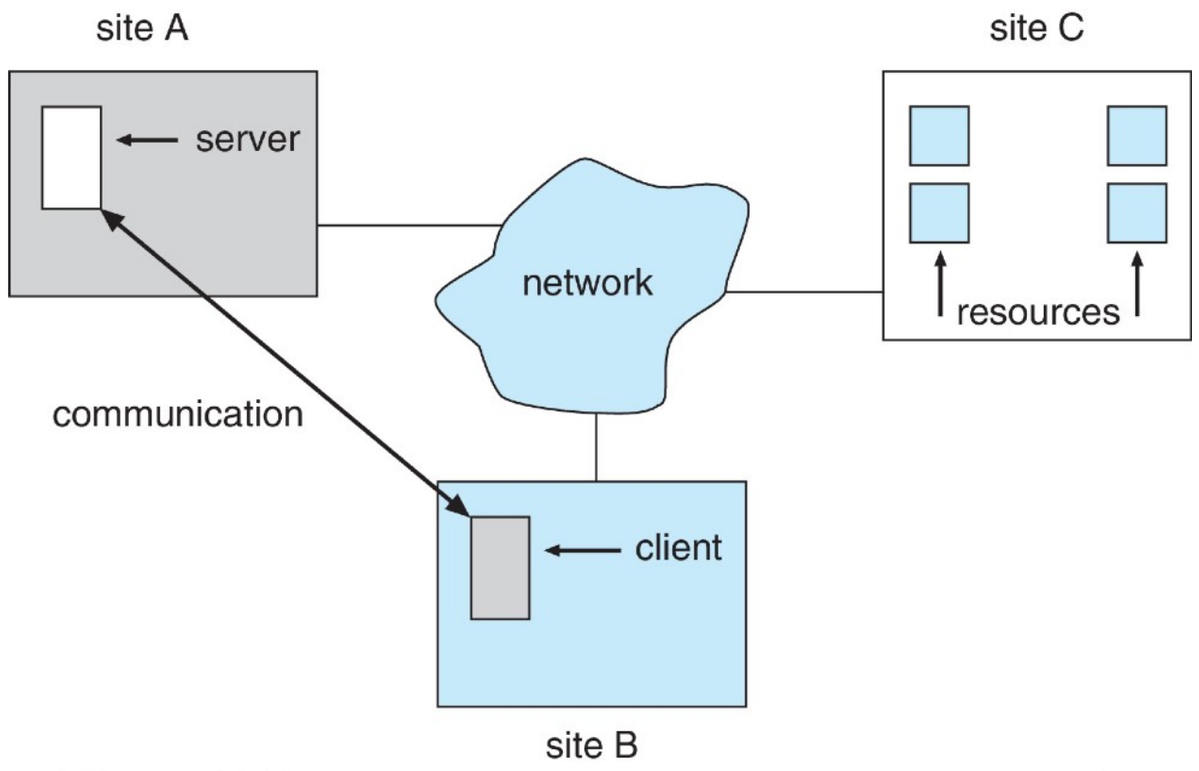

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- nearly all systems today are distributed in some way
  - complex services are built from a large collection of machines cooperating to provide the particular service of the site
  - networks hook them together

Why distributed systems are popular?

- resource sharing
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- reliability and availability
  - resource replication yields fault tolerance (no single point of failure)
    - performance will degrade but system remains operational
  - must be able to detect and recover from site failure (function transfer, reintegrate failed sites, etc.)

Design issues of distributed systems

- robustness — the system should withstand failures
  - including failure of a link, failure of a site, and loss of messages
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- transparency to user — in terms of where files are stored and user mobility
  - the distributed system should appear as a conventional, centralized system to the user
    - user interface should not distinguish between local and remote resources
    - user mobility allows users to log into any machine in the environment and see his/her environment

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- consistency — the cached copy of the data must be consistent with the master copy
  - consistency checks must be performed periodically
  - nodes must keep track of the cached data to detect potential inconsistencies

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- users must change paradigms – establish a **session**, give network-based commands (might be different from the normal OS commands)
  - session is a complete round of communication

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  - execute the entire process (computation and data), or parts of it, at different sites

Communication Basics

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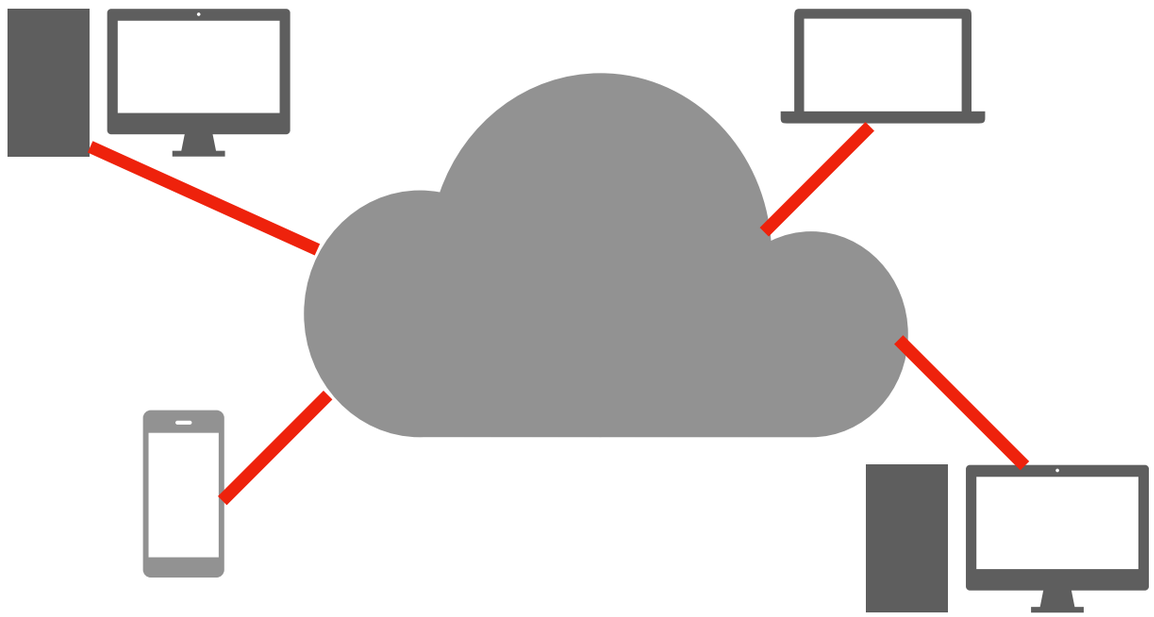
  - each computer has a network address



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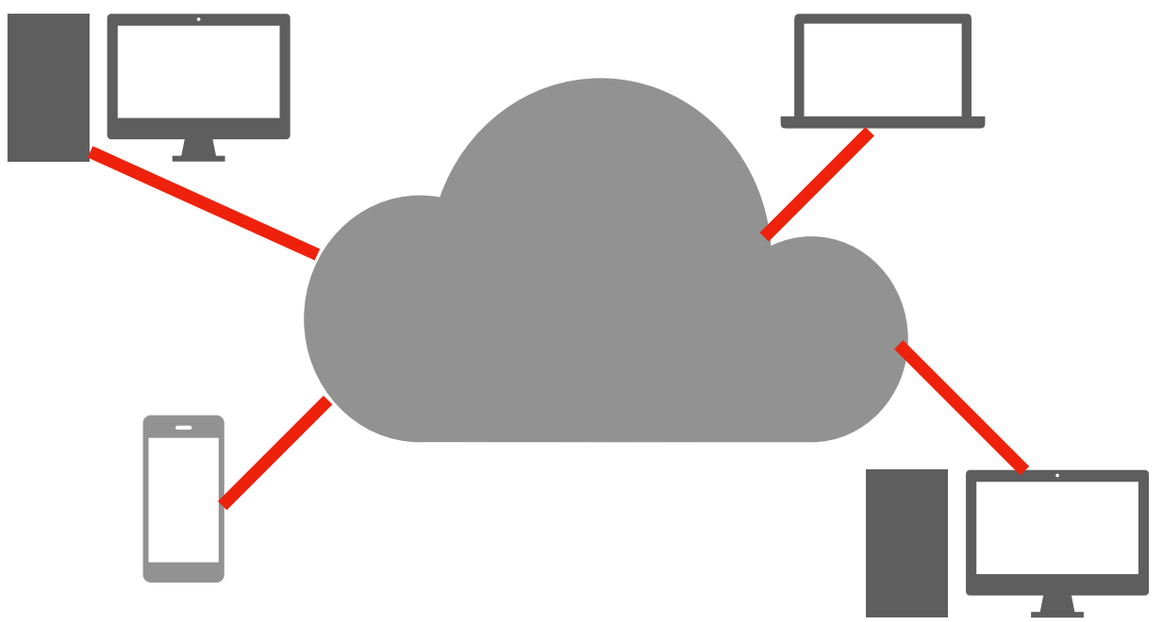

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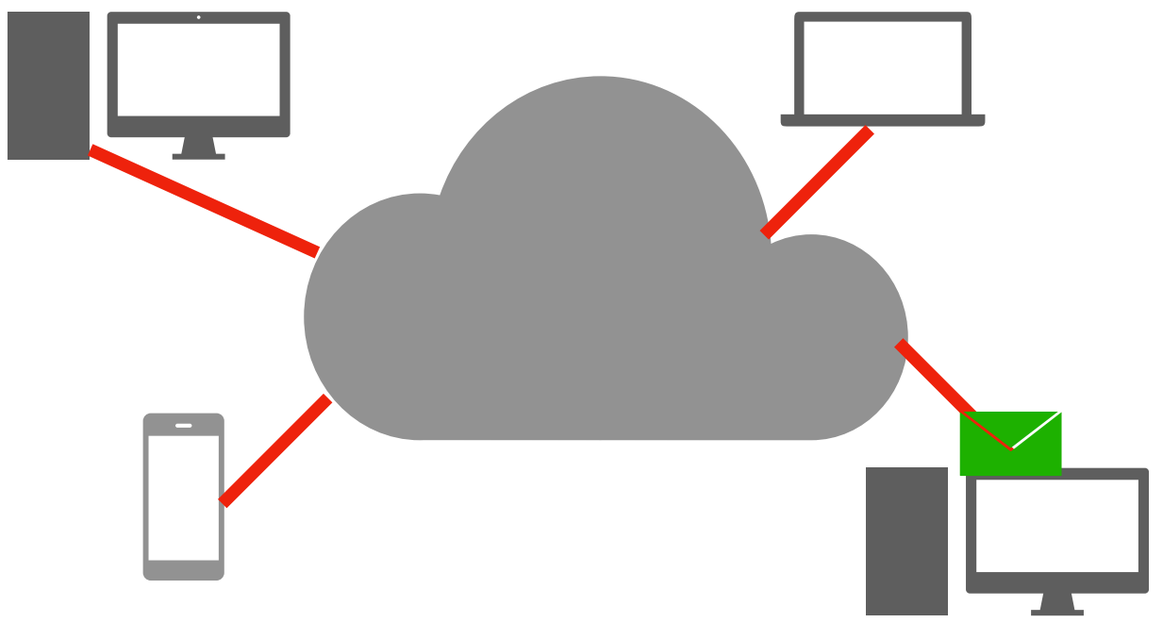

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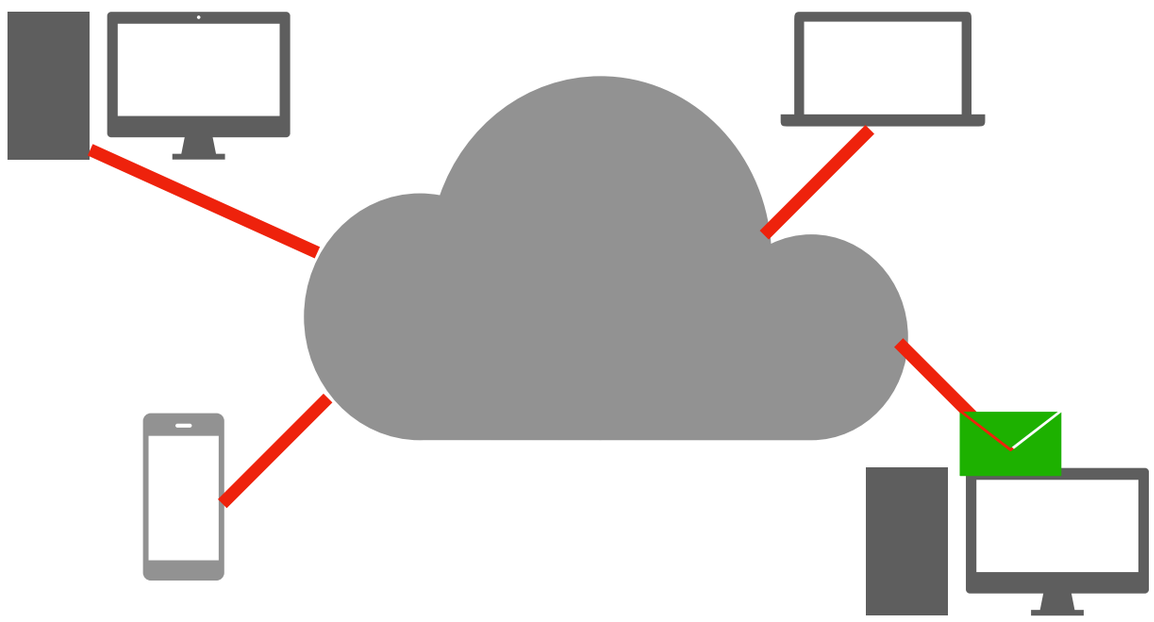

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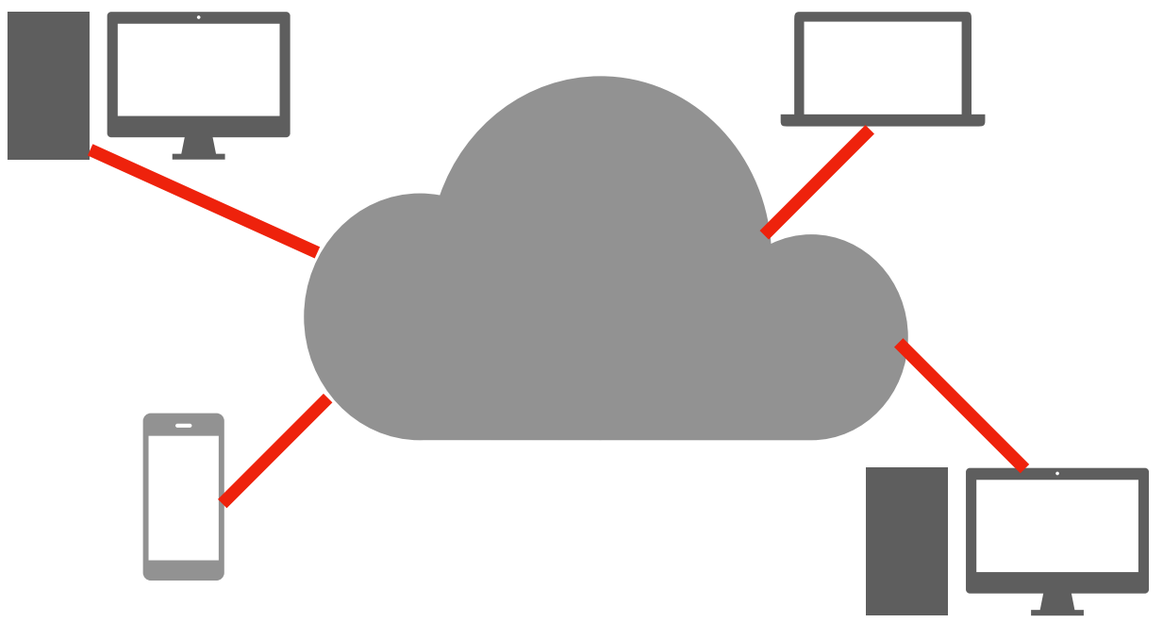

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- Ethernet and/or Wireless (WiFi) most common way to construct LANs
  - Ethernet defined by IEEE 802.3 standard with speeds typically varying from 10Mbps to over 10Gbps
    - everyone taps into a single wire
    - everyone gets packets and discards them if it is not the target
  - WiFi defined by IEEE 802.11 standard with speeds typically varying from 11Mbps to over 400Mbps

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- WANs and LANs interconnect

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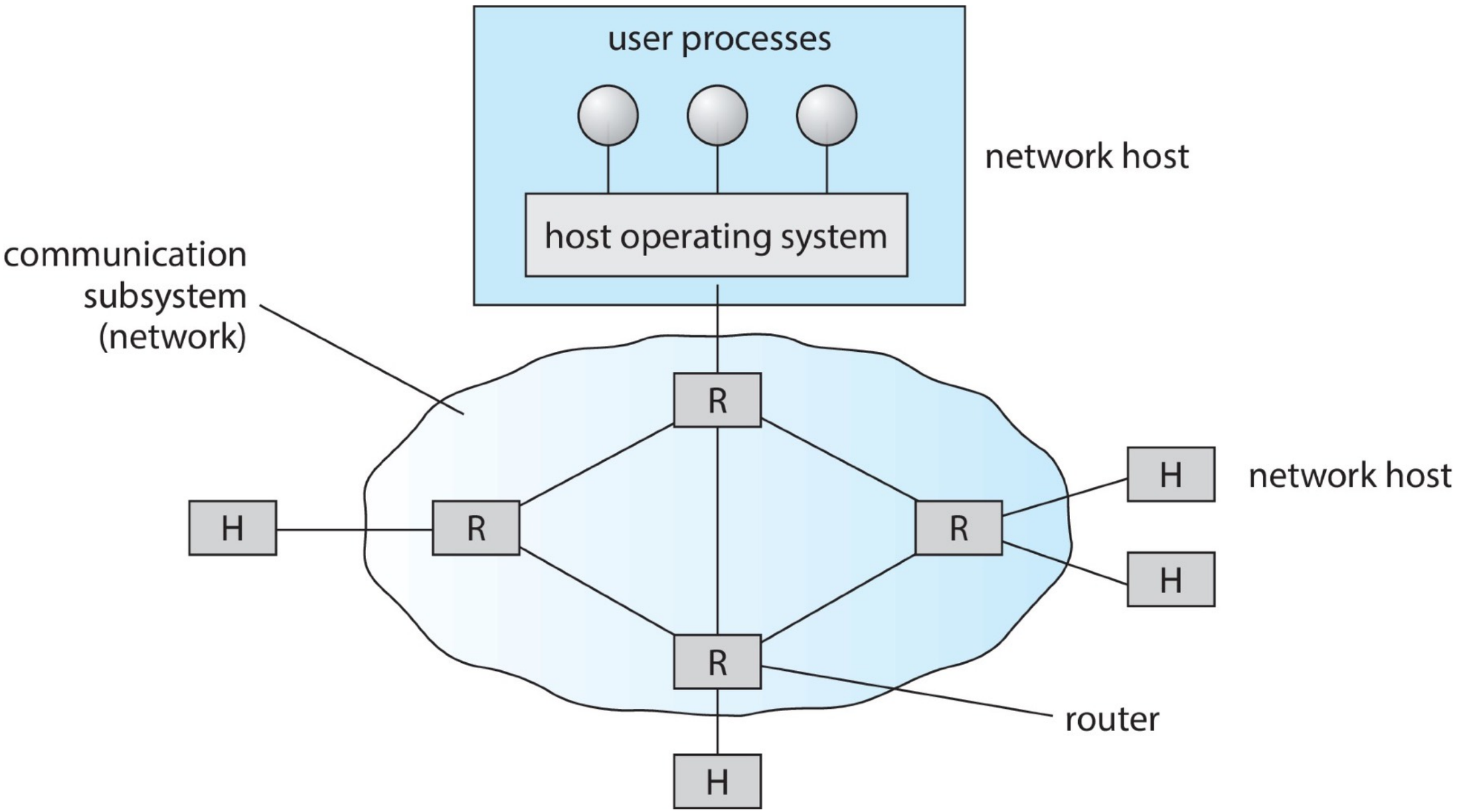
- the destination computer is interrupted when a packet arrives

How a packet is delivered to destination if the hosts are located on separate networks?



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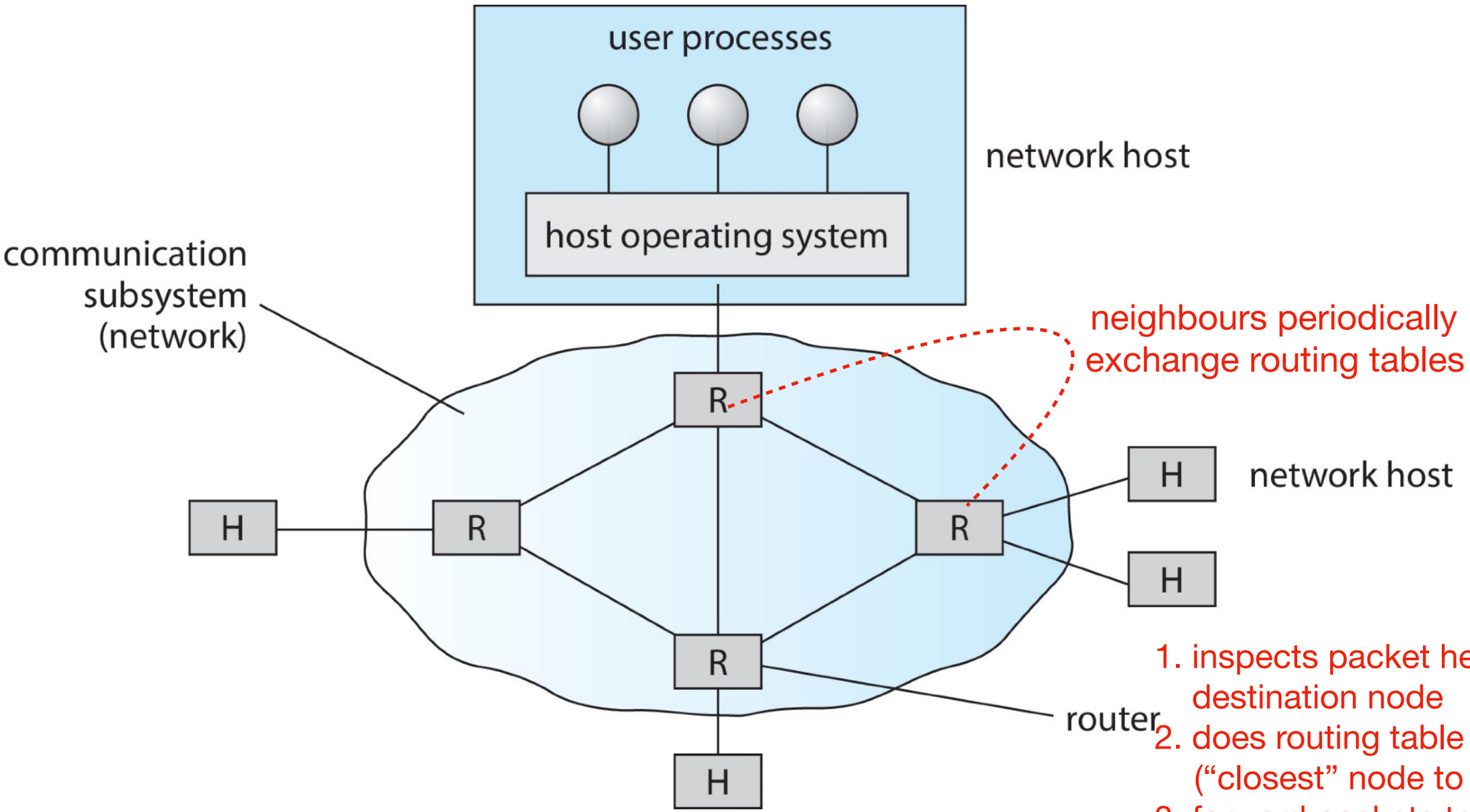

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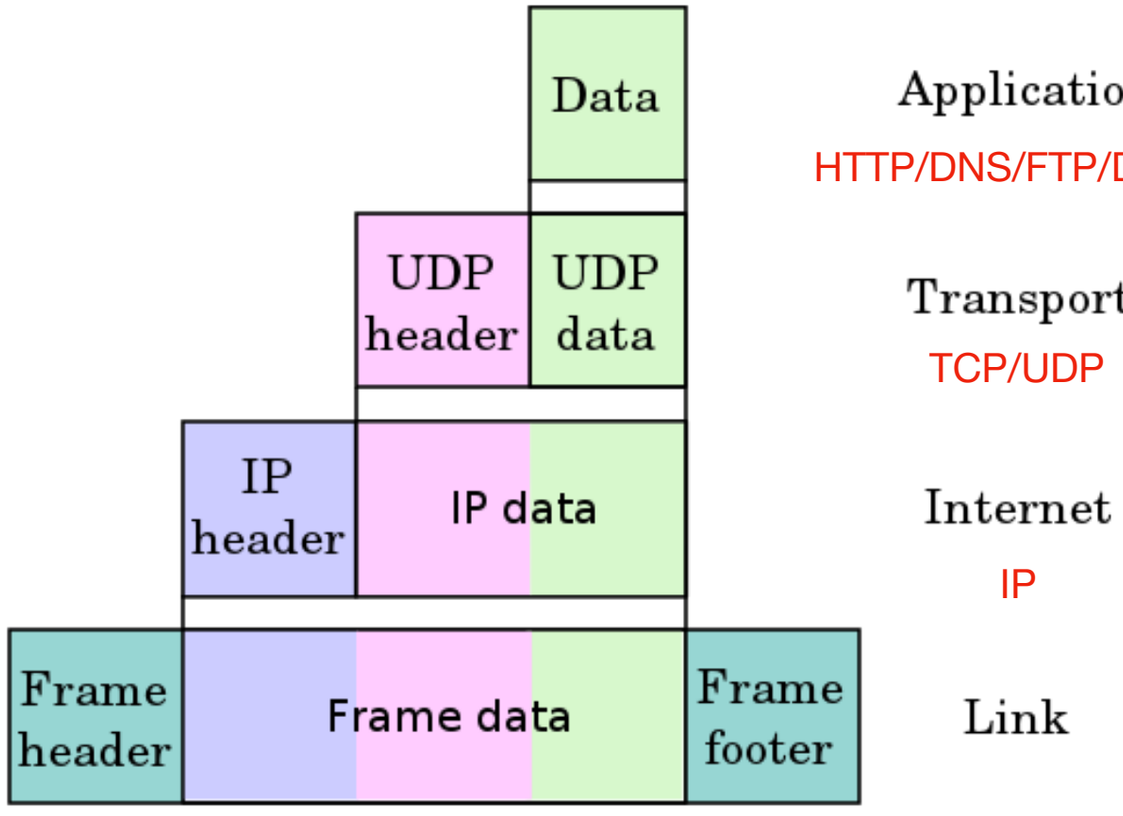
- each process in a given system has a unique name (process-id)
- each computer system in the network has a unique name
  - Domain Name System (DNS): a global distributed database system for resolving hostname-IP address mappings
    - 32-bit (IPv4) address: e.g., 129.128.5.180
    - humane readable names: e.g., gpu.srv.ualberta.ca

TCP/IP protocol stack (Internet protocol suite)

enables end-to-end communications using functions organized into four abstraction layers



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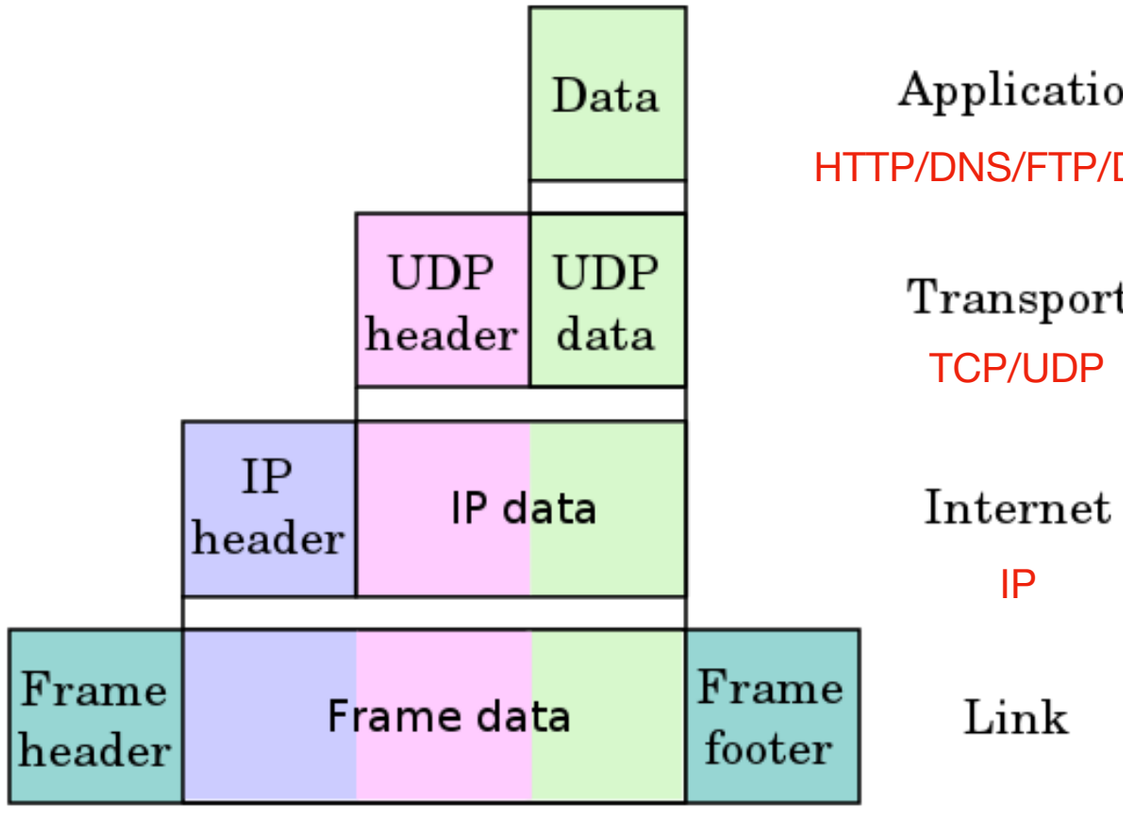

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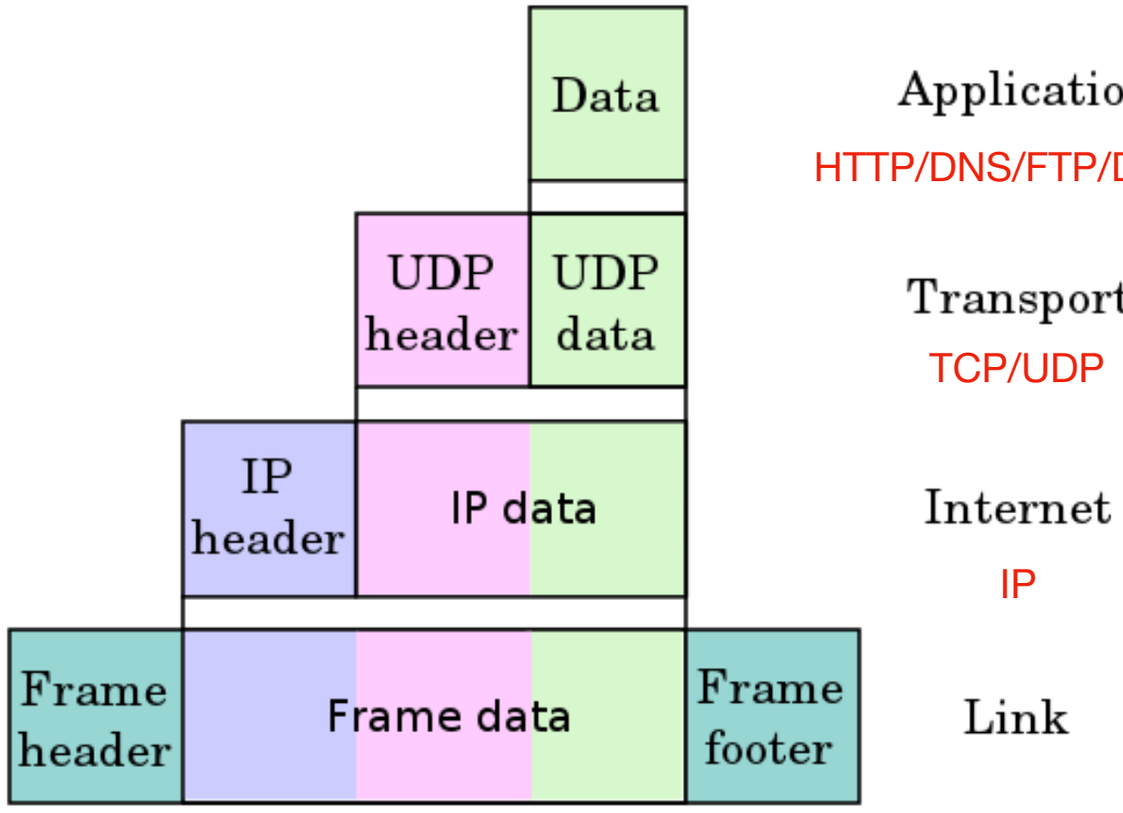

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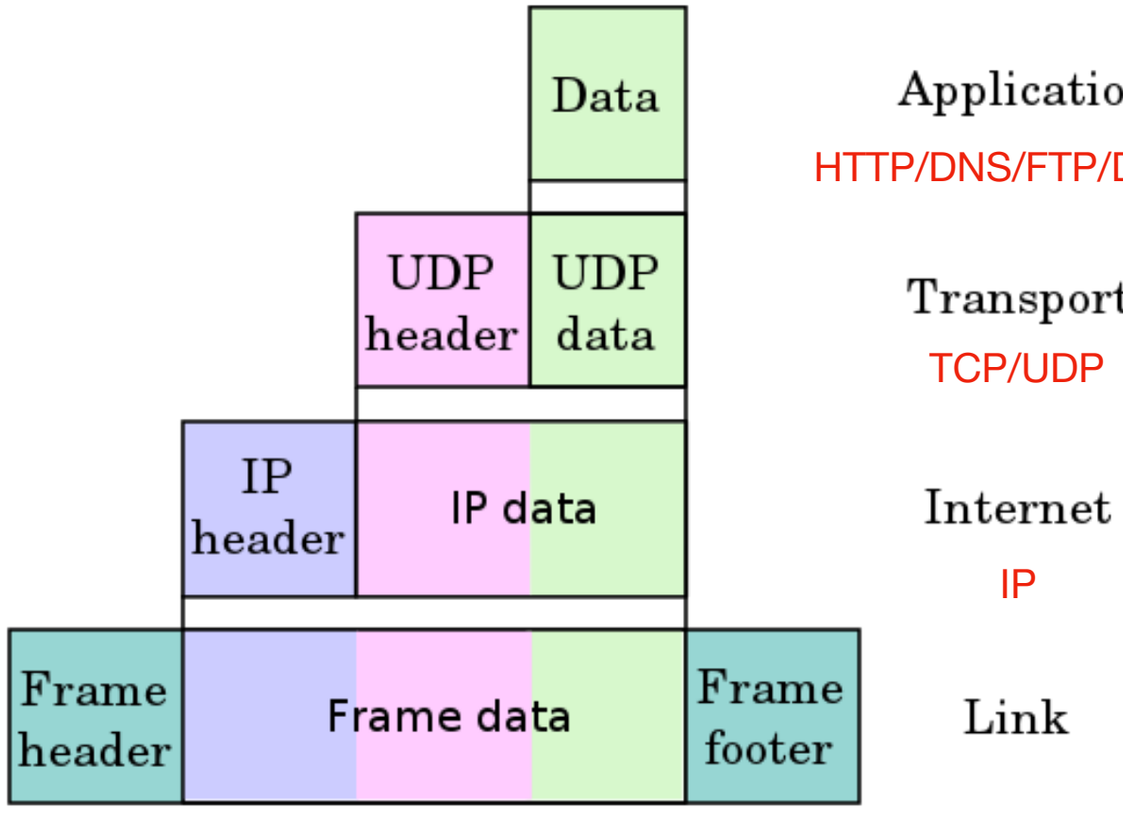

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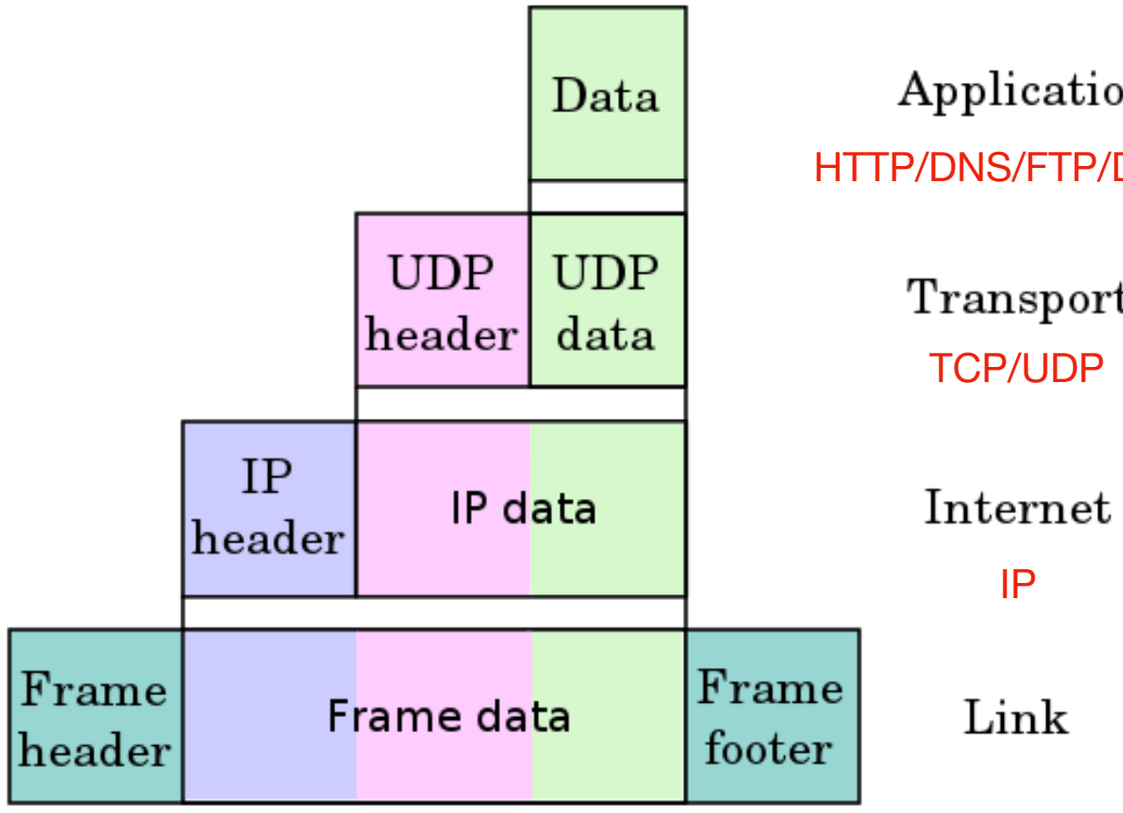
- Link layer
  - handles the frames, or fixed-length parts of packets, including transmission over over a physical medium, and any error detection and recovery that occurred in the physical layer



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- every Ethernet/WiFi device has a unique medium access control (MAC) address
- if a system wants to send data to another system, it needs to perform the IP to MAC address mapping
  - using **address resolution protocol (ARP)**
  - run `arp -a` to see the content of your arp table

Internet Protocol (IP) address

- every host has a name and an associated **IP address**
  - 32-bit (IPv4) address: approximately 4.3 billion addresses
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- the destination system receives the packet
  - it may be complete message, or it may need to be reassembled into larger message spanning multiple packets

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- transport protocols, TCP and UDP, identify receiving and sending processes through the use of a port number (16 bits)
  - allows a host with a single IP address to have multiple processes sending and receiving packets
  - system or well-known ports are used to implement **standard** services: 0 through 1023
    - FTP – port 21/TCP; ssh – port 22/TCP; SMTP – port 25/TCP; HTTP – port 80/TCP; NTP – port 123/UDP
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- transport protocol can be simple or can add reliability to network packet stream

User Datagram Protocol (UDP)

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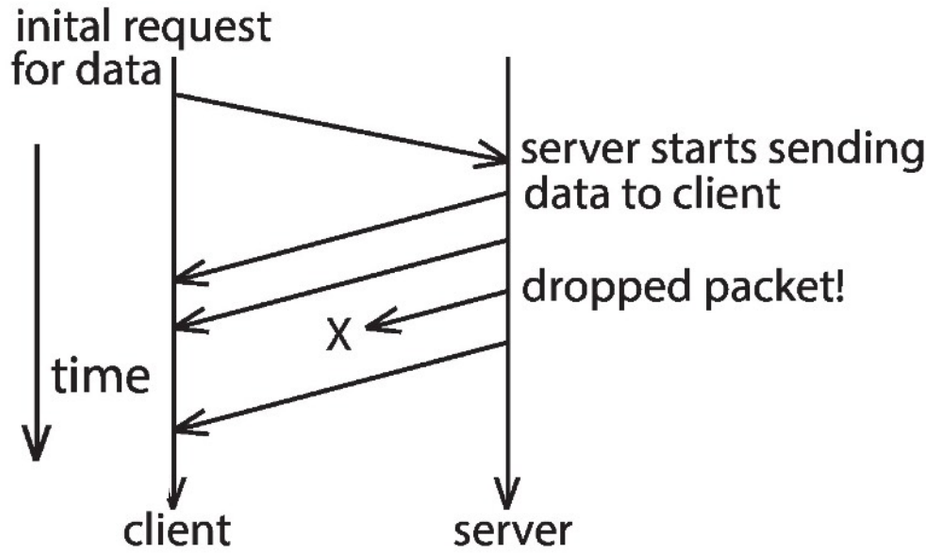

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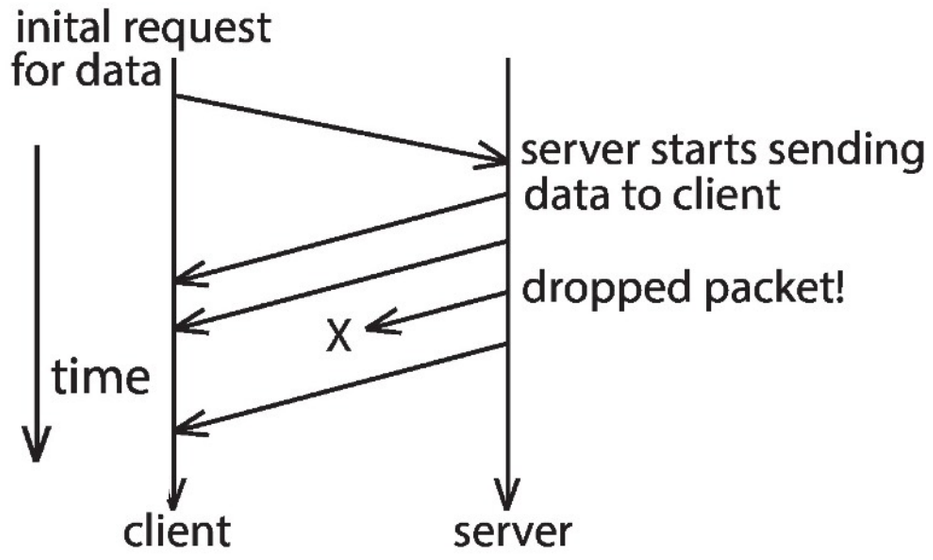

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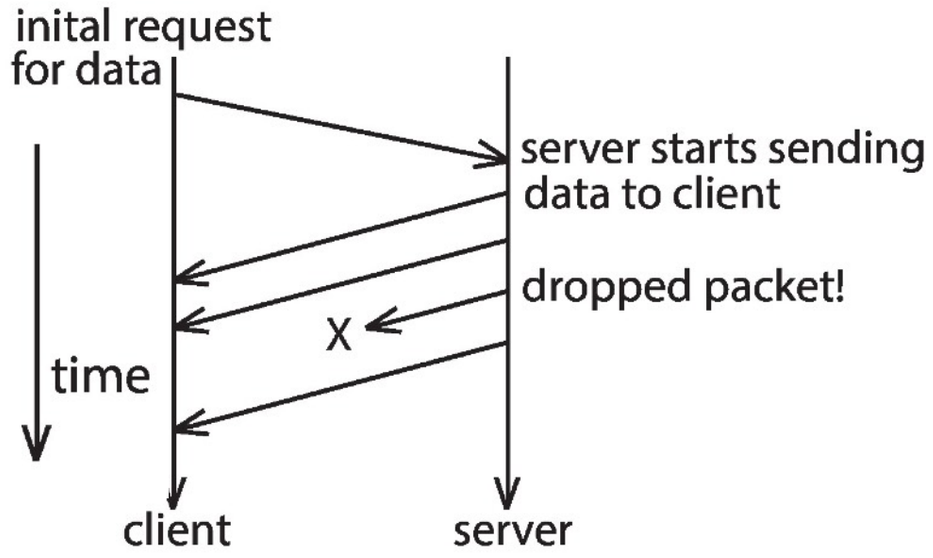

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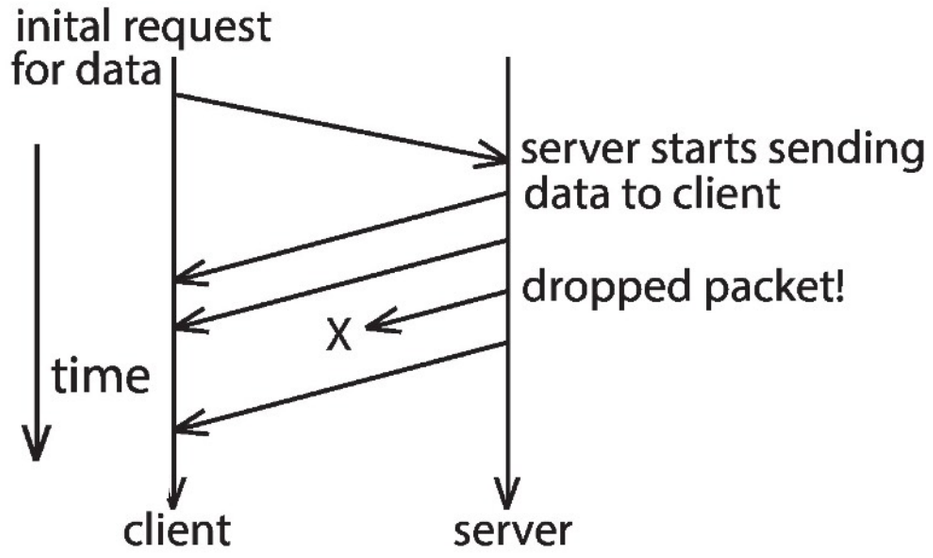
Why to use unreliable communication?
many applications simply want to send data
to a destination and not worry about packet loss



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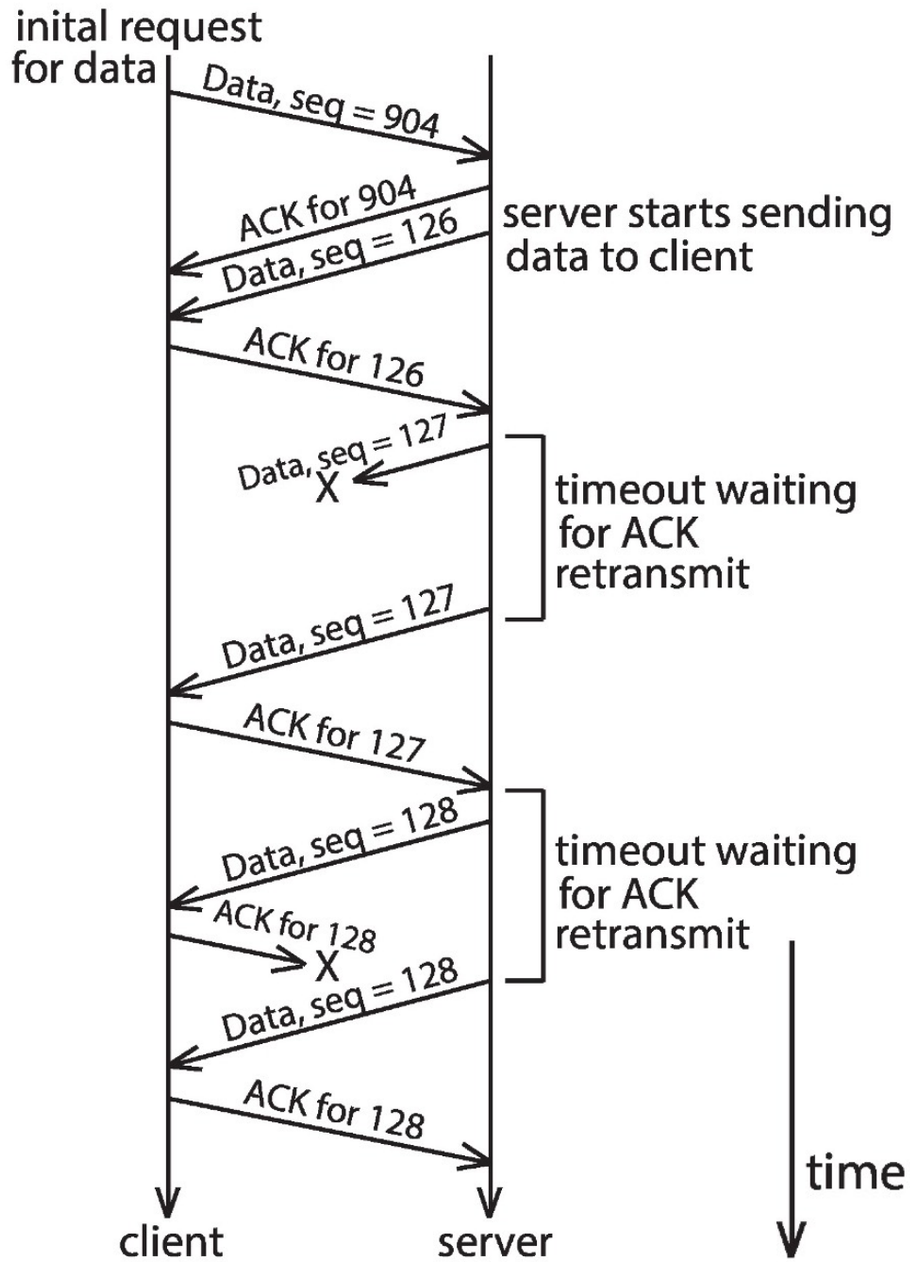
- connections are initiated with series of control packets
  - three-way handshake (SYN, SYN+ACK, ACK)
- connections also closed with series of control packets

TCP data transfer

- receiver can send a cumulative ACK to acknowledge series of packets
  - server can also send multiple packets before waiting for ACKs
  - takes advantage of network throughput



TCP data transfer

- receiver can send a cumulative ACK to acknowledge series of packets
  - server can also send multiple packets before waiting for ACKs
  - takes advantage of network throughput
- flow of packets regulated through flow control and congestion control
  - **flow control** – prevents sender from overrunning capacity of receiver
  - **congestion control** – approximates congestion of the network to slow down or speed up packet sending rate