File Systems

Example: NFS Protocol

- NFS: Network File System
  - Developed by Sun Microsystems in late 1980s; RFC 1094 (March 1989)
  - Current version is NFS v4.2, RFC 7862 (Nov. 2016)
- Kernel sees it as just another file until you reach the *mount point*
  - At that point, kernel acts as client to (remote) NFS server

Mounting Remote File System

- Kernel. server exchange messages to make file system available to client (kernel)

- Access modes controlled by various configuration files

- Common mounting options:
  - *soft*: file system calls that fail after a certain number of retries return failure rather than continuing to try
  - *rdonly*: mount file system read-only
  - *nodev*: ignore any device files on NFS file system
  - *nosuid*: ignore any setuid bits

Opening a File

- Given file name, handle it as usual until you reach the mount point of the NFS file system

- System then uses *file handles* identifying remote files to find right file
  - File handles are all that is needed for access
  - Fine handles include generation number to detect conflicts
  - *Every* file access uses this handle

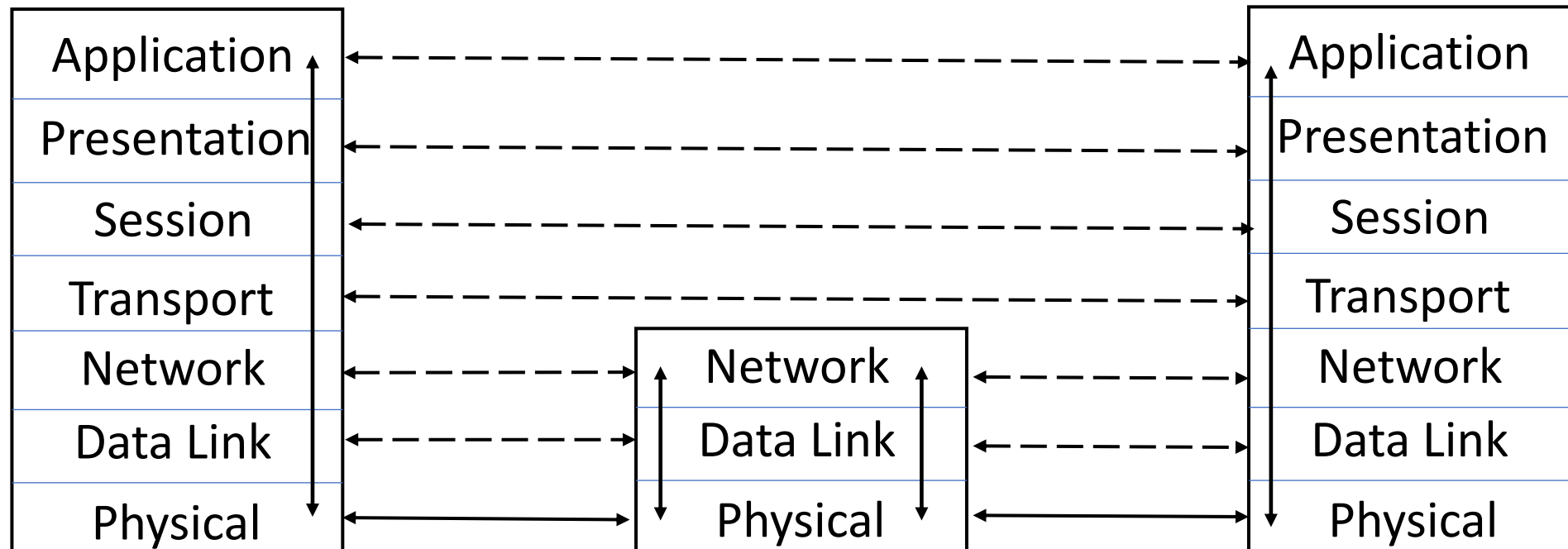# Networks

What Is a Network?

- Something that connects two or more systems

- Messages are sent over the network
  - Messages placed in packets (possibly broken up and placed in multiple ones)
- Packets sent over the network from source to destination

Organization of Transmission

- Circuit switching: first few packets set up a continuous route (called a circuit), reserving enough resources to guarantee the connection lasts as long as the peers communicate

- Store-and-forward, message switching: forwards messages in their entirety, one hop at a time

- Packet switching: packets are sent to destination in one of two ways
  - Connection: create a virtual circuit, which is set up before message packets are transferred, and packets delivered in order sent
  - Connectionless: packets sent to destination independently; no guarantee of arrival or that packets will arrive in order

Network Peers

- ISO/OSI model
- Conceptually, each host communicates with peer at each layer

ISO/OSI Layers

- Physical: transfer of bit streams over some physical medium

- Data link: creation of frames, or organization of data, so the peer can read the message

- Network: handles the routing, traffic control, etc. of packets; also handles management request

- Transport: provides address translation (host to IP address), handles acknowledgement, retransmission, etc.

- Session: manages sessions, authentication, etc.

- Presentation: handles compression, end-to-end encryption, virtual terminals

- Application:

Internet Protocol Model

- Link layer: local area network communication methods, including protocols to describe local network topology
    - Examples: Ethernet, 802.11n

- Internet layer: exchanges packets across network boundaries; defines addressing, routing structures; internetworking
    - Examples: IP, ICMP

- Transport layer: handles host-to-host communications
    - Examples: UDP, TCP

- Application layer: processes work at this layer
    - Examples: SSH, SMTP, HTTP
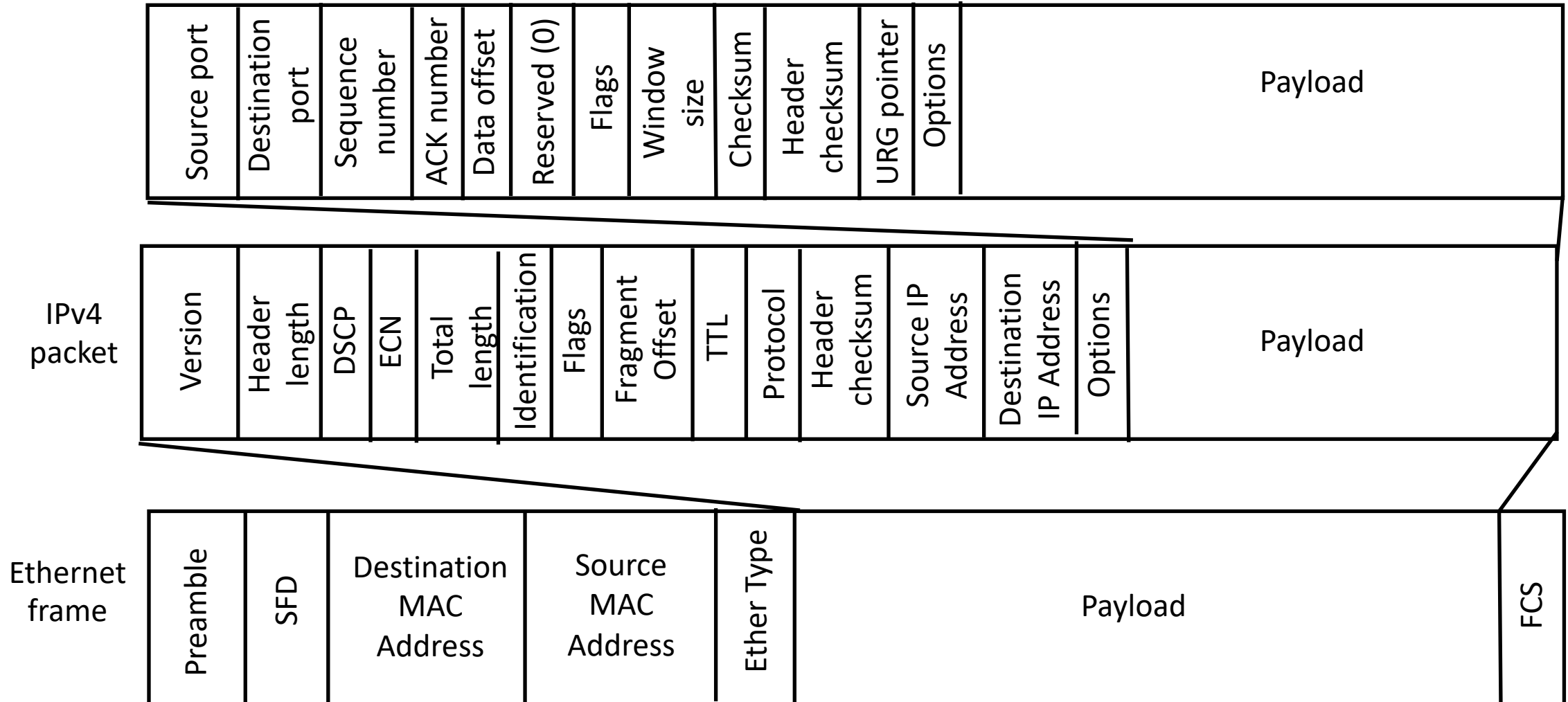
Link and End-to-End Protocols

Link Protocol
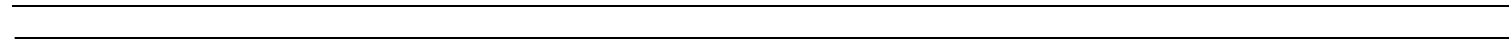
End-to-End (or E2E) Protocol
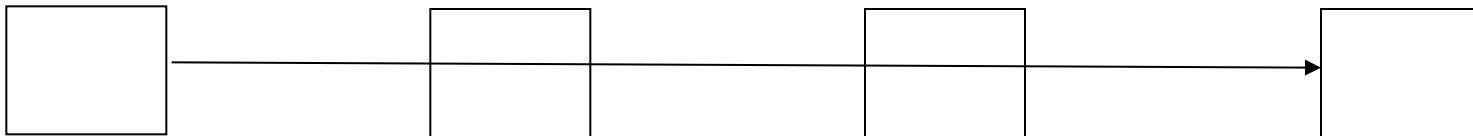
Addressing

- MAC address: the address of the specific network card
  - Manufacturers have agreements on how to do this
- IP address (IPv4 protocol): network protocol
  - aaa.bbb.ccc.ddd – 4 octets of 8 bits each
  - 127.0.0.1 – loopback address
  - 10.x.y.z, 172.16.x.y through 172.31.x.x, 92.168.x.x: private IP addresses
- TCP/UDP address: host name
  - Domains: .edu, .com, .net, .mil, .gov, .org, .int, .us, .za, .uk, . . .
- MAC address ⟷ IP address: ARP protocol
- IP address ⟷ TCP/UDP address: DNS protocol

Encapsulation of Data in Internet

| Source port | Destination port | Sequence number | ACK number | Data offset | Reserved (0) | Flags | Window size | Checksum | Header checksum | URG pointer | Options | Payload |

IPv4 packet

| Version | Header length | DSCP | ECN | Total length | Identification | Flags | Fragment Offset | TTL | Protocol | Header checksum | Source IP Address | Destination IP Address | Options | Payload |

Ethernet frame

| Preamble | SFD | Destination MAC Address | Source MAC Address | Ether Type | Payload | FCS |

Well-Known Internet Protocols

- SMTP, ESMTP: (Extended) Simple Mail Protocol
  - For sending, receiving electronic mail
- SSH: Secure SHell
  - For getting a remote terminal on a system
- HTTP: HyperText Transfer Protocol
  - Used by web browsers and servers
- DHCP: Dynamic Host Configuration Protocol
  - Used to obtain a dynamically assigned IP address
- ARP: Address Resolution Protocol
  - Used to obtain an IP address from a MAC address or vice versa

Security

Security Basic Components

- Confidentiality
  - Keeping data and resources hidden
- Integrity
  - Data integrity (integrity)
  - Origin integrity (authentication)
- Availability
  - Allowing access to data and resources