Overview

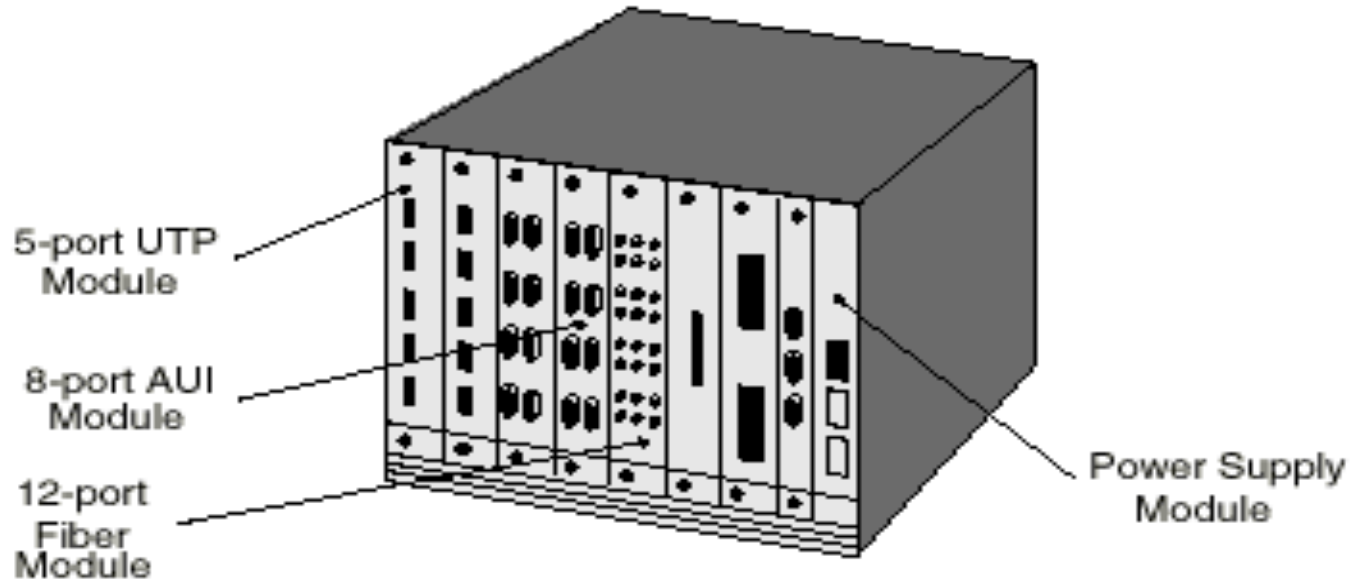
- Last Lecture
  - Introduction
- This Lecture
  - Network hardware
  - Reference: *Ethernet: The Definitive Guide*, Charles E. Spurgeon, O'Reilly
- Next Lecture
  - Basic system/network administration
  - Reference:
    - *Linux Network Administrators Guide*, O. Kirch & T. Dawson, O'Reilly
    - http://en.tldp.org/LDP/nag2/index.html

OSI model

- OSI model
  - Seven layers
  - Protocol encapsulation
  - Five layers in Internet: physical, data link, network, transport (including presentation and session layers of OSI model), application
- A guideline for writing network software and understanding the principle of internetworking
- You can't see the layers as a network user

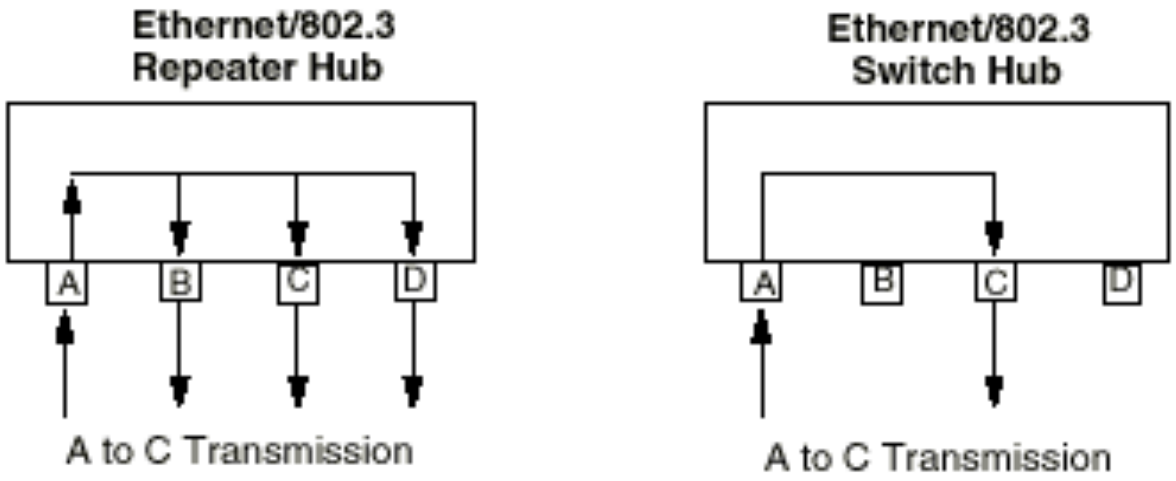
Basic components

- Repeaters
  - Regenerate signals
- Hubs
  - Similar to repeaters but with multiple ports



Basic components (cont.)

- Repeater hubs
  - a repeater with many ports
- Switching hubs
  - Parallel transmission paths
  - Smarter (understand MAC layer)



Autonegotiation and flow control

- Autonegotiation is defined in IEEE 802.3
  - Two connected devices can choose common transmission parameters such as speed
- How can a NIC work with different cables with different speed?
  - Media Independent Interface (MII) defined by IEEE 802.3u
- How can a slow NIC handle fast traffic from a fast NIC?
  - PAUSE frame in IEEE 802.3x
  - Eventually should be handled by higher layer protocols

Basic components (cont.)

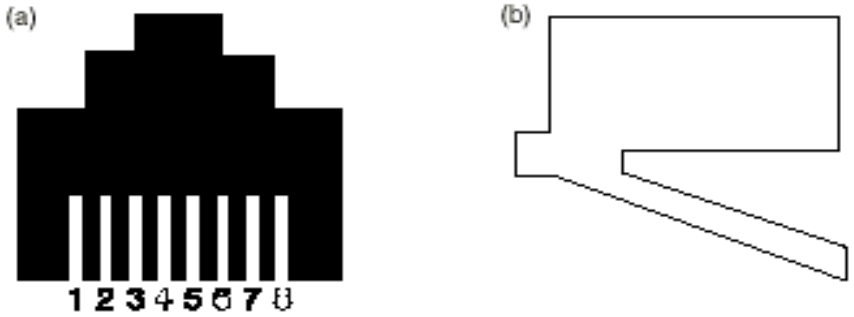
- Bridges (with multiple ports)
  - Store and forward frames (OSI layer 2)
- Switches: similar to multiport bridges
  - has multiple simultaneous data transmission paths between ports; mainly work at MAC sublayer.
- Router
  - Route and forward network packets (OSI layer 3)
- Modems
  - ADSL modem/router

Basic components (cont.)

- Firewall
  - a dedicated software (maybe with hardware support), which inspects network traffic passing through it, and denies or permits passage based on a set of rules.
- Gateway
  - a device that serves as an entrance to a network.
  - Similar to a firewall, but has more knowledge of application protocols and better security.

Network hardware

- Cables
  - Twisted pair, coaxial cable, optical fibre
- Connectors
  - RJ-45 for UTP



Twisted-pair cables

- Twisted-pair categories
  - Cat 1 and 2, Cat 3, Cat 4, Cat 5 and 5e, Cat 6
- Crosstalk
  - Signal crosstalk occurs when the signals in one wire are eletromagnetically coupled (or cross over) into another wire. This happens because wires in close proximity to one another can pick up each other's signal.
  - Problem: phantom collisions can be detected.
- Crossover cable
  - Directly networking two computers.

Structured cabling

- High-quality cabling is essential to network performance
- Structured cabling provides a reliable and manageable cabling system
- TIA/EIA cabling standards
  - Telecommunications Industries Association (TIA)
  - Electronic Industries Association (EIA)
  - Refer to *Ethernet: The Definitive Guide*

Structured cabling (cont.)

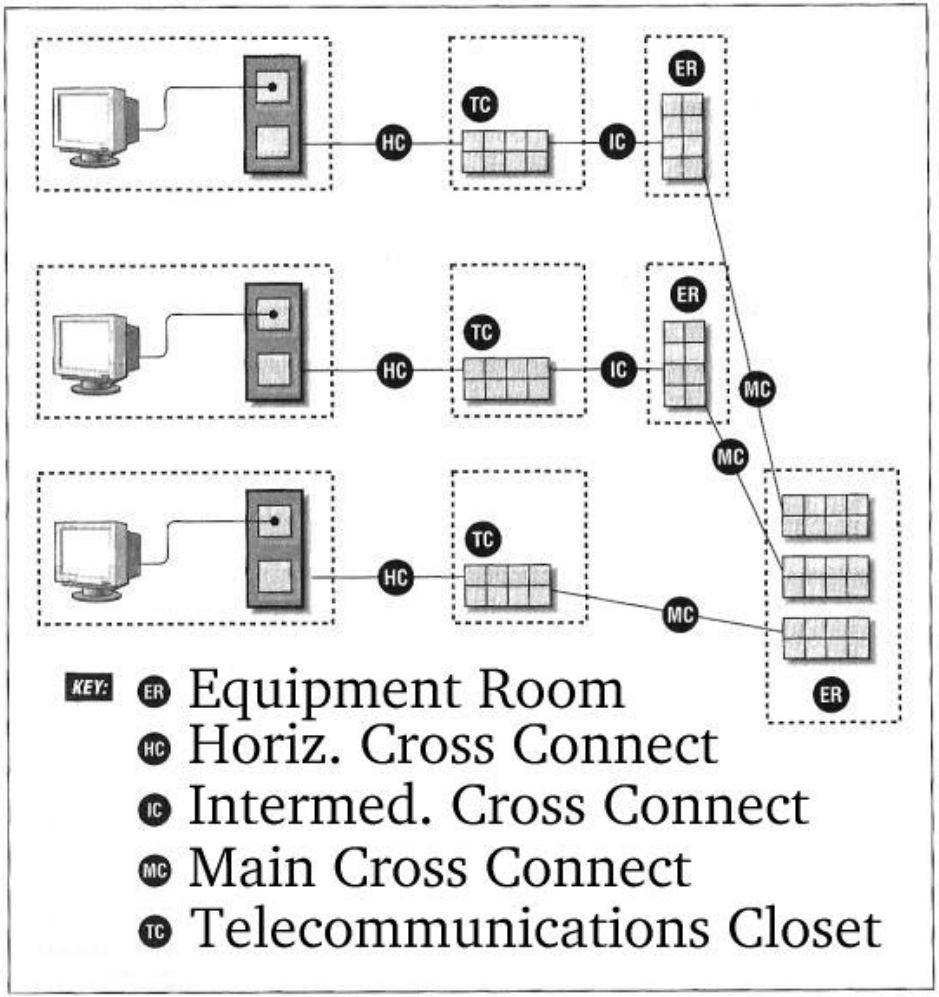
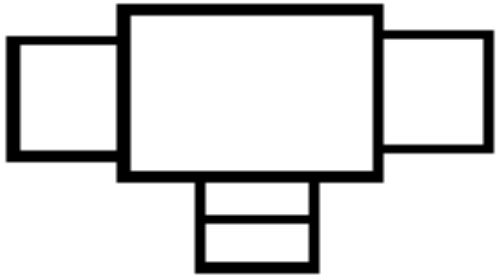


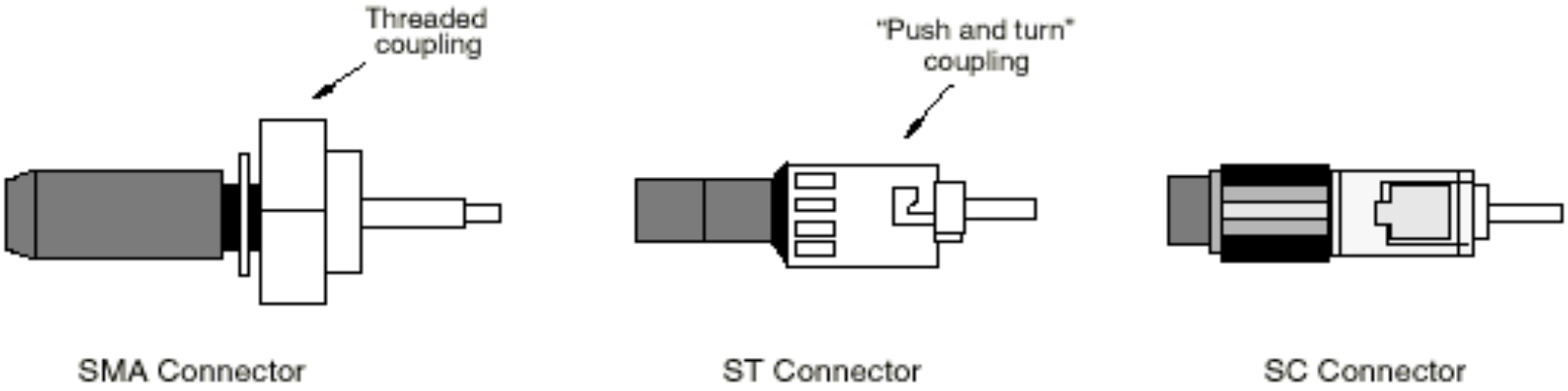
Figure 14-1. Elements of a structured cabling system

Network hardware (cont.)

- BNC T connector for coaxial

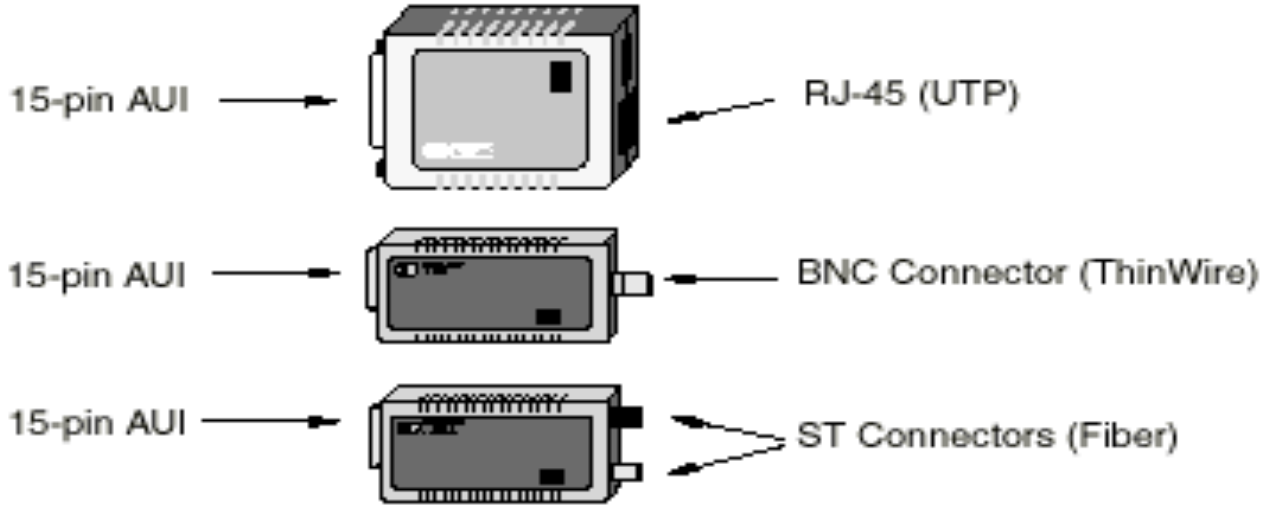


- SMA, ST and SC connectors for optical fibre



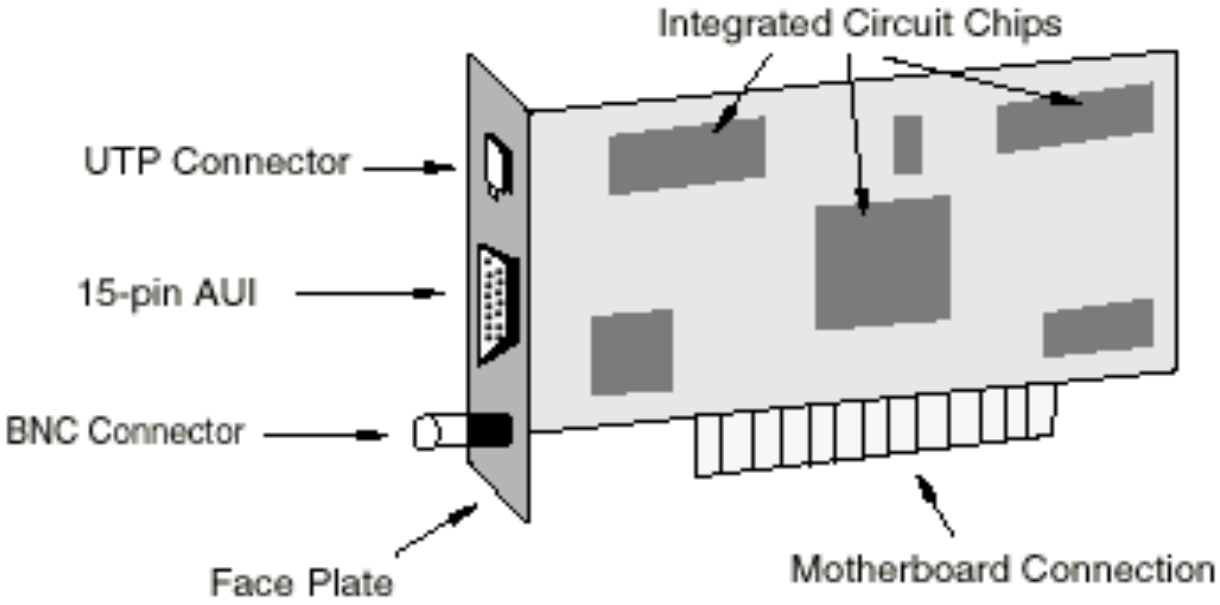
Network hardware (cont.)

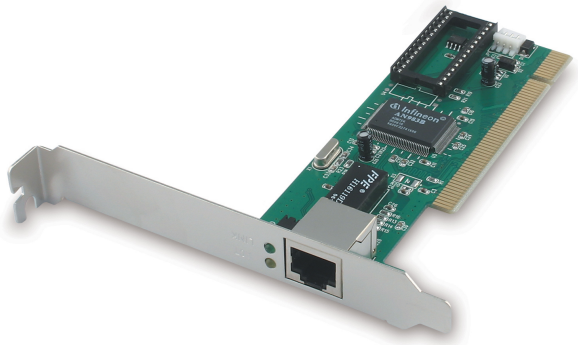
- Transceivers (normally embedded)
  - Used in Ethernet to connect nodes to the physical medium



Network hardware (cont.)

- Network Interface Card (NIC)





Network hardware (cont.)

- Network Interface Card (NIC)
  - CSMA/CD
  - Network device driver is used by OS to interact with NIC. An interrupt is used when a request is completed or when a packet arrives.
  - DMA: Direct Memory Access is used to copy data from NIC (device) memory to main memory (RAM)
  - Protocol stack: layer 1, layer 2 (MAC)

Internet Protocol

- MAC address
  - Six octets for Ethernet NIC
    - 3b-00-65-fa-4a-68
- IP address (IPv4)
  - 4 bytes (octets), e.g. 132.65.33.24
  - Traditionally addresses are divided into class A, B and C
  - Classless Inter-Domain Routing (CIDR)

Internet Protocol

- Subnets
  - Use net mask to identify a subnet
  - E.g. divide class B network 132.65. into 254 subnets. Net mask is 255.255.255.0
  - Subnets are
    - 132.65.1/24
    - 132.65.2/24
    - …
    - 132.65.254/24
- Broadcast address and network address
  - E.g. 132.65.255.255, 132.65.0.0
- More exercises for subnetting in Lab 19.

Ethernet frame

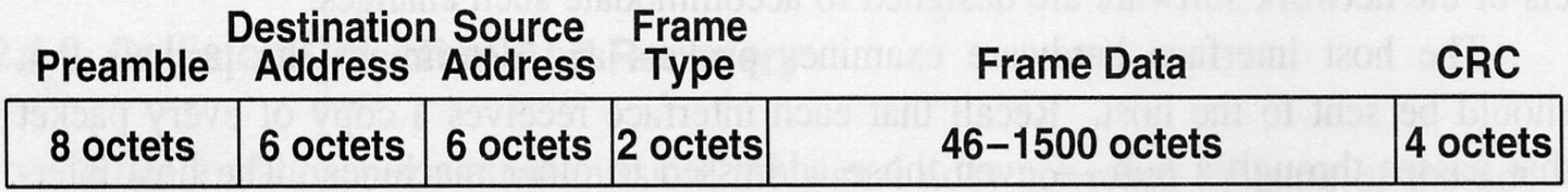


Figure 2.7 The format of a frame (packet) as it travels across an Ethernet preceded by a preamble. Fields are not drawn to scale.

- Frame type serves two purposes
  - Length (<=1500)
  - Frame type (>= 1536 or 0x0600)

IP packet

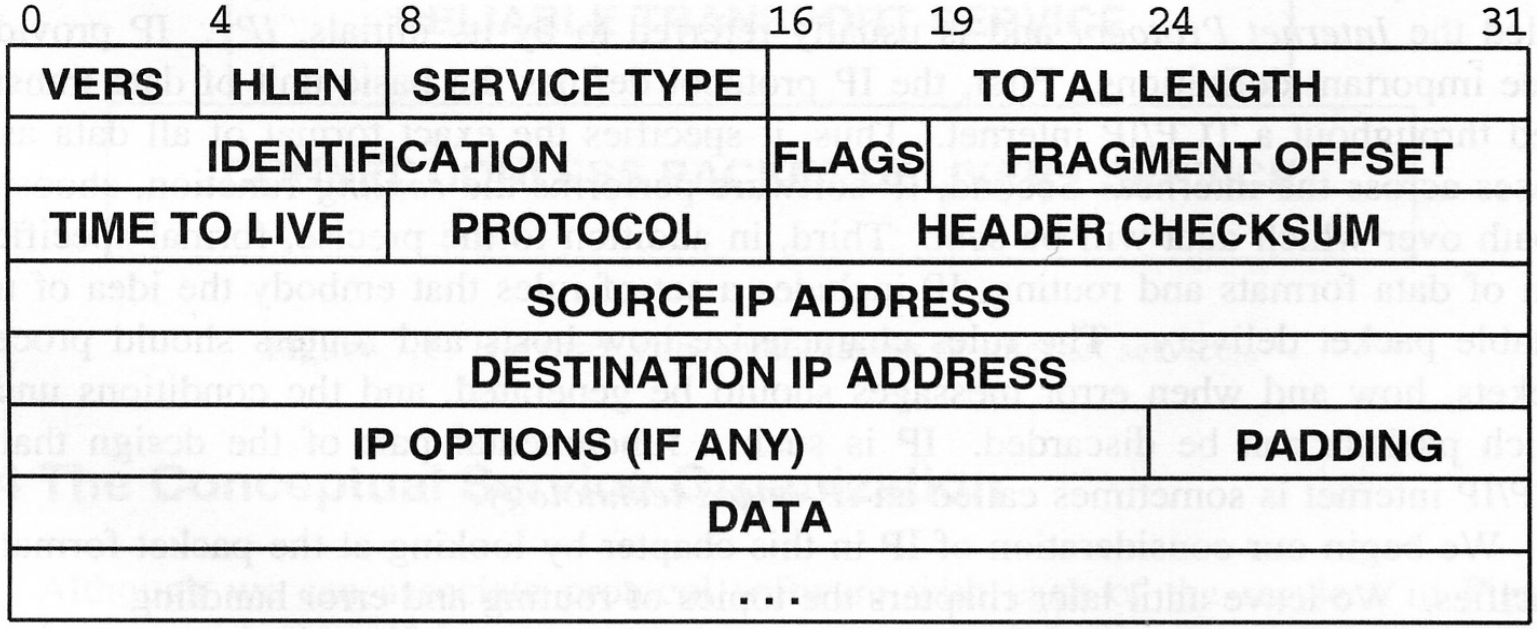


Figure 7.3 Format of an Internet datagram, the basic unit of transfer in a TCP/IP internet.

UDP datagram

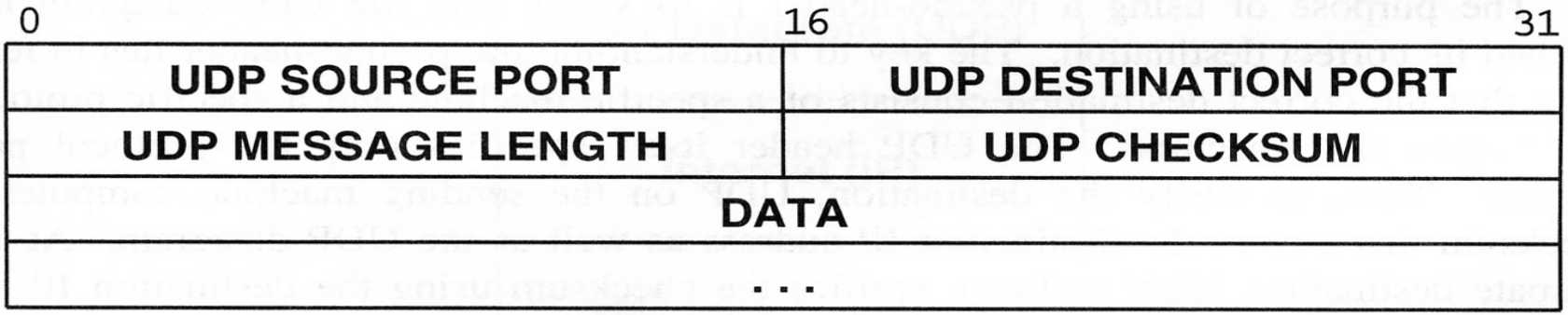


Figure 12.1 The format of fields in a UDP datagram.

TCP segment

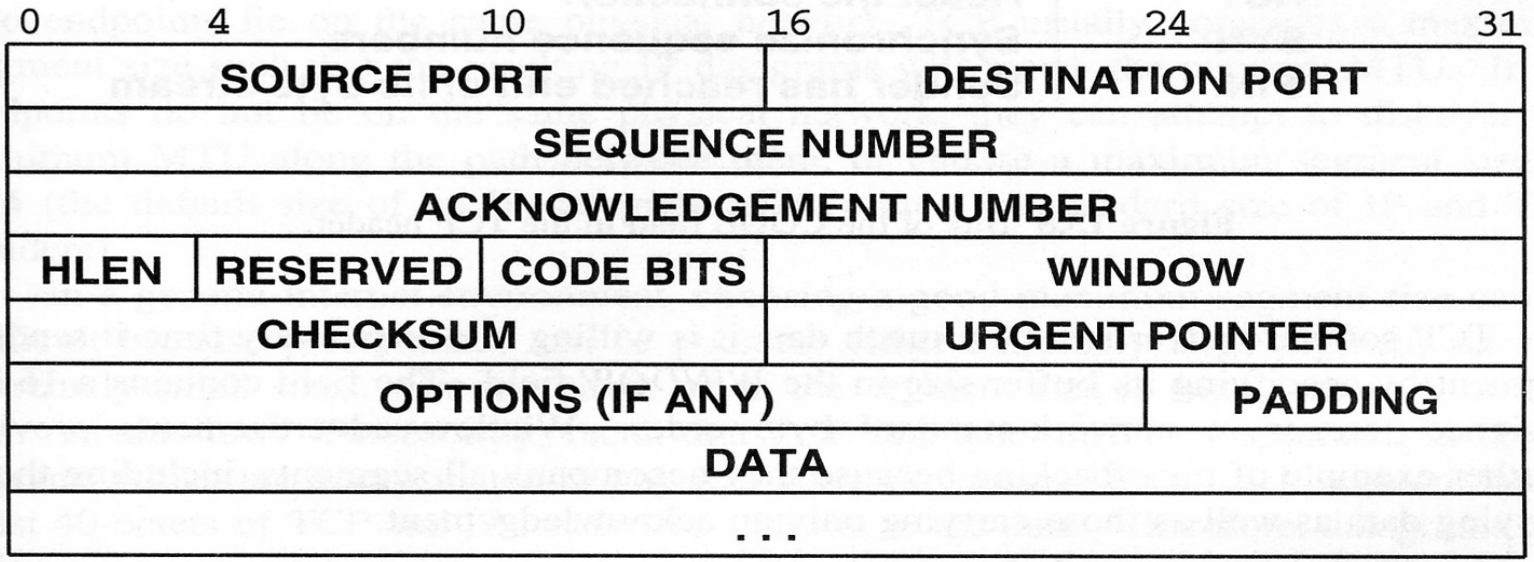


Figure 13.7 The format of a TCP segment with a TCP header followed by data. Segments are used to establish connections as well as to carry data and acknowledgements.

Topology & Protocols

- Network topology
  - Star, bus, ring, mesh, hybrid
  - Physical vs. logical topology
- LAN protocols
  - Ethernet/Fast Ethernet/Gigabit Ethernet/10 Gigabit
  - Token ring
  - Token bus
  - FDDI
  - IPX

Protocols

- WAN protocols
  - X.25
  - Frame relay
  - ATM
  - ISDN
- Internetworking
  - TCP/IP
  - IPv4 vs IPv6
  - PPP for dial up networking
  - ARP/RARP

High speed interconnects

- DSL e.g. ADSL, VDSL
  - Use telephone line, with upstream 128kbps, and downstream up to 8Mbps
- InfiniBand
  - Primarily used for high performance computing
  - Point to point bi-directional link, 2.5 Gbps in each direction, between processor and storage device
  - 12x links are used for cluster computers
- FibreChannel
  - Gigabit speed network technology similar to InfiniBand

IEEE standards

- 802.3 for Ethernet
  - Includes supplements for fast Ethernet, Gigabit Ethernet, and 10 Gigabit Ethernet
- 802.5 for Token Ring
- 802.4 for Token Bus
- 802.11 for wireless LAN
  - Includes supplements a, b and g

I/O Bus standards

- Industry Standard Architecture (ISA)
  - Good old standard
  - Used for slower devices such as mice and modem
- Peripheral Component Interconnect (PCI)
  - Used to connect performance critical devices such as video card and NIC to memory
  - Will be succeeded by PCI Express
- Refer to http://www.techfest.com/hardware/bus.htm for other I/O bus standards

Client/server model

- Many network functions are implemented in client/server model
  - Client: make a request
  - Server: process requests from clients and reply
- Clients and servers are programs.
  - Many servers are just installed on a single powerful machine for easy administration. Therefore that machine is normally called a “server” machine.
  - Port numbers/well-known port numbers
- The counterpart is Peer-to-Peer (P2P) model.

Client/server model (cont.)

- Typical servers
  - Name server: provide a mapping between IP addresses and IP names.
    - Try **dig www.hotmail.com**
  - File server: provide network file service
    - Exmple - NFS
  - email server: provide email service
    - Example - sendmail, smtpd
  - www server: provide web service
    - Example - apache
  - Printer server: provide print service
    - Example - lpd
  - ftp server: ftpd
  - ssh server: sshd

Data path between two PCs

- Copy data from the user process (user memory) to socket in OS kernel (kernel memory)
- Add headers to the data to make a frame
- Copy to NIC memory using DMA
- Send the frame by NIC to the other PC
- Receive the frame by the NIC of the other PC
- NIC sends interrupts to CPU
- CPU invokes NIC driver to copy the frame to RAM (using DMA)
- Headers are processed by related protocols
- Copy data from the receiving socket (kernel memory) to the buffer of the user process
- Issue: zero copy for improving networking performance.

Linux commands today

- touch
- find
  - find /bin –name wh*
- grep