Networks

References for this chapter

Network protocols & standards

OSI network reference model

Standardized as the Open Systems Interconnection (OSI) reference model by the International Standardization Organization (ISO) in 1977

- 7 layer architecture
- Connection oriented

Handily implemented anywhere in full ...

... but its concepts and terminology are widely used, when describing existing and designing new protocols ...

1: Physical Layer

- Service: Transmission of a raw bit stream over a communication channel
- Functions: Conversion of bits into electrical or optical signals
- Examples: X.21, Ethernet (cable, detectors & amplifiers)

2: Data Link Layer

- Service: Reliable transfer of frames over a link
- Functions: Synchronization, error control, flow control
- Examples: HDLC (high level data link control protocol), LAP-B (link access procedure, balanced), LAP-D (link access procedure, D-channel), LLC (link level control), ...

3: Network Layer

- Service: Transfer of packets inside the network
- Functions: Routing, addressing, switching, congestion control
- Examples: IP, X.25

4: Transport Layer

- Service: Transfer of data between hosts
- Functions: Connection establishment, management, termination, flow control, multiplexing, error detection
- Examples: TCP, UDP, ISO TP0-TP4

5: Session Layer

- Service: Coordination of the dialogue between application programs
- Functions: Session establishment, management, termination
- Examples: RPC
6: Presentation Layer
- Service: Provision of platform-independent coding and encryption
- Functions: Code conversion, encryption, virtual devices
- Examples: ISO code conversion, PGP encryption

7: Application Layer
- Service: Network access for application programs
- Functions: Application/OS specific
- Examples: APIs for mail, ftp, ssh, scp, discovery protocols...
Network protocols & standards

Ethernet / IEEE 802.3

Local area network (LAN) developed by Xerox in the 70s:
- 10 Mbps specification in 1980 (10 Mbps over thick coax cables).
- First standard as IEEE 802.3 in 1985.
- Current standard 802.3ab copper cable ports used in most desktops and laptops.
- More than 85% of current LAN lines worldwide (according to the International Data Corporation (IDC)).

Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

Wireless local area network (WLAN) developed in the 90s:
- First standard as IEEE 802.11 in 1997 (1-2 Mbps over 2.4 GHz).
- Typical usage at 54 Mbps over 2.4 GHz carrier at 20 MHz bandwidth.
- Current standards up to 780 Mbps (802.11ac over 5 GHz carrier at 866 MHz bandwidth).
- Future standards are designed for up to 10 Gbps over 60 GHz carrier.
- Direct relation to IEEE 802.3 and similar OSI layer association.

Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

Direct Sequence Spread Spectrum (DSSS)

Token Ring / IEEE 802.5

Fibre Distributed Data Interface (FDDI)

Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

Unlike CSMA/CD: Token ring is deterministic (with respect to its timing behaviour)

FDDI is deterministic and failure resistant

None of the above is currently used in performance oriented applications.

Token ring was developed by IBM in the 70s.

IEEE 802.5 standard is modified after the IBM Token Ring architecture (specifications are slightly different, but basically compatible).

IBM Token Ring networks are start topology as well as twisted pair cables, while IEEE 802.5 is unspecified in topology and medium.

Fibre Distributed Data Interface combines a token ring architecture with a cabling, fibre optical, physical network.
Fibre Channel

- Developed in the late 80's.
- ANSI standard since 1994.
- Current standards allow for 16Gbps per link.
- Allows for three different topologies:
  - Point-to-point: 2 addresses
  - Arbitrated loop (similar to token ring): 127 addresses, deterministic, real-time capable
  - Switched fabric: 2^24 addresses, many topologies and concurrent data links possible
- Defines OSI equivalent layers up to the session level.
- Mostly used in storage arrays, but applicable to supercomputers and high integrity systems as well.

Network layer models
- Open Systems Interconnection (OSI) reference model

Practical network standards
- Serial Peripheral Interface (SPI)
- Ethernet / IEEE 802.3 (CSMA/CD)
- Token ring / IEEE 802.5 / FDDI
- Wireless networks / IEEE 802.11 (CSMA/CA, DSSS)
- Fibre Channel