Networking and Protocol Architectures

ITS323: Introduction to Data Communications

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Layering and Protocol Architectures

TCP/IP Protocol Architecture

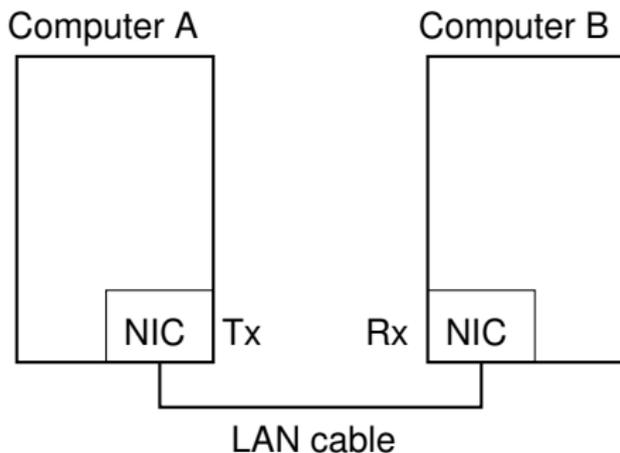Example of TCP/IP Operation

Data Communications Across a Link
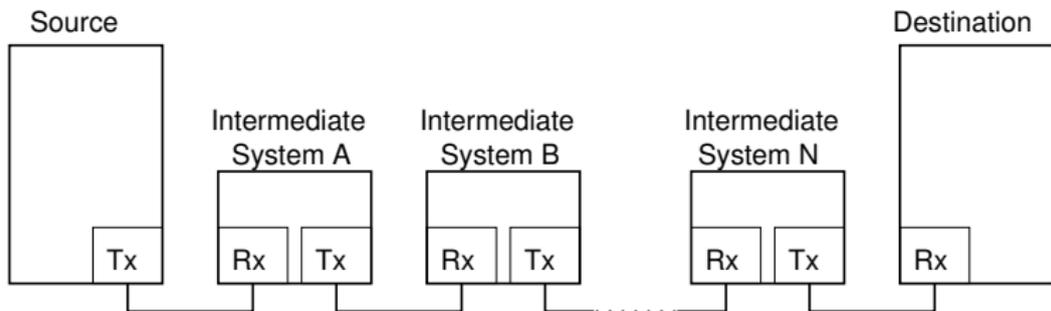

- Converting data (e.g. bits) into signals to be sent across the link (Physical layer)
- Ensuring link is ready for data transmission, reliable/efficient transmission of data (Data link layer)

Data Communications Across a Network

Source

Destination

Intermediate System A

Intermediate System B

Intermediate System N

Tx | Rx | Tx | Rx | Tx | Rx | Tx | Rx

- Data traverses multiple links; each link may have its own Physical and Data Link layer protocols
- How do intermediate systems receive/send data? How to select which intermediate systems to send via? (Network layer)
- What happens if failures within intermediate systems? How to create applications without knowing the details of underlying network and technologies?

Layers

Divide-and-Conquer

- ▶ As data communications is complex, separate tasks into layers
- ▶ Design and implement protocols for each layer

Advantages

- ▶ Simplify design and implementation
- ▶ Change/upgrade protocols without modifying the whole system
- ▶ Select implementations from different vendors

Disadvantages

- ▶ Sub-optimal designs, overheads of each layer

General Layered Architecture
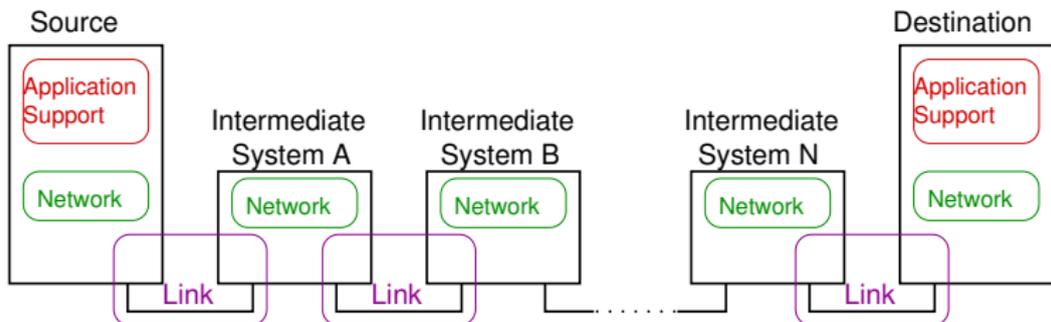
- Layers to support:
    - Communications across a link
    - Communications across a network
    - Applications to operate efficiently on end devices
- Different specific layered architectures have been developed
- Some are standards (e.g. OSI); others are loosely defined (e.g. Internet stack)

OSI 7-layer Protocol Architecture

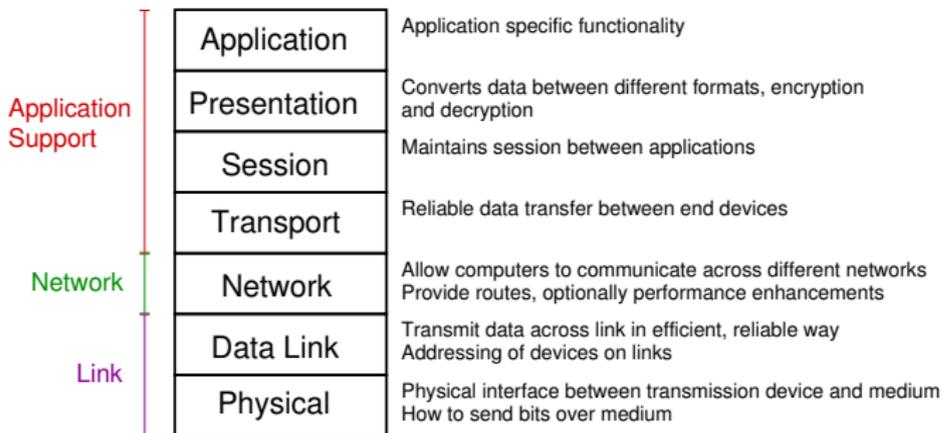|	Layer	Description
Application Support	Application	Application specific functionality
	Presentation	Converts data between different formats, encryption and decryption
	Session	Maintains session between applications
	Transport	Reliable data transfer between end devices
Network	Network	Allow computers to communicate across different networks Provide routes, optionally performance enhancements
Link	Data Link	Transmit data across link in efficient, reliable way Addressing of devices on links
	Physical	Physical interface between transmission device and medium How to send bits over medium

- ISO developed Open Systems Interconnection (ISO) in 1970's
- TCP/IP became more popular; but concepts and terminology still used today
- Others: IBM SNA, Appletalk, Novel IPX; SS7, UMTS, IEEE 802, . . .

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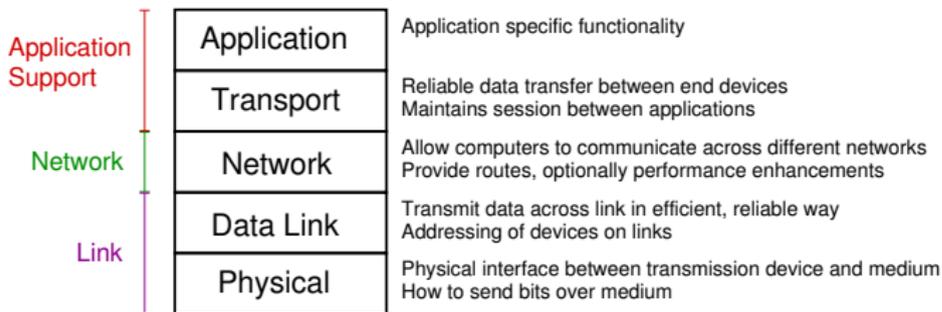
Layering and Protocol Architectures

TCP/IP Protocol Architecture

Example of TCP/IP Operation

TCP/IP Protocol Architecture

- ▶ ARPANET used two key protocols, TCP and IP; together (as well as other related protocols) referred to as TCP/IP protocol suite
- ▶ Used in global Internet today
- ▶ Many protocol standardised by Internet Architecture Board (IAB) and Internet Engineering Task Force (IETF)
- ▶ No official protocol architecture; generally divided into 5 layers
- ▶ Different names: TCP/IP protocol architecture, TCP/IP protocol suite, Internet stack, . . .

TCP/IP 5-layer Protocol Architecture

Application Support	Application	Application specific functionality
	Transport	Reliable data transfer between end devices Maintains session between applications
Network	Network	Allow computers to communicate across different networks Provide routes, optionally performance enhancements
Link	Data Link	Transmit data across link in efficient, reliable way Addressing of devices on links
	Physical	Physical interface between transmission device and medium How to send bits over medium

- ▶ There is no standard definition of the layers
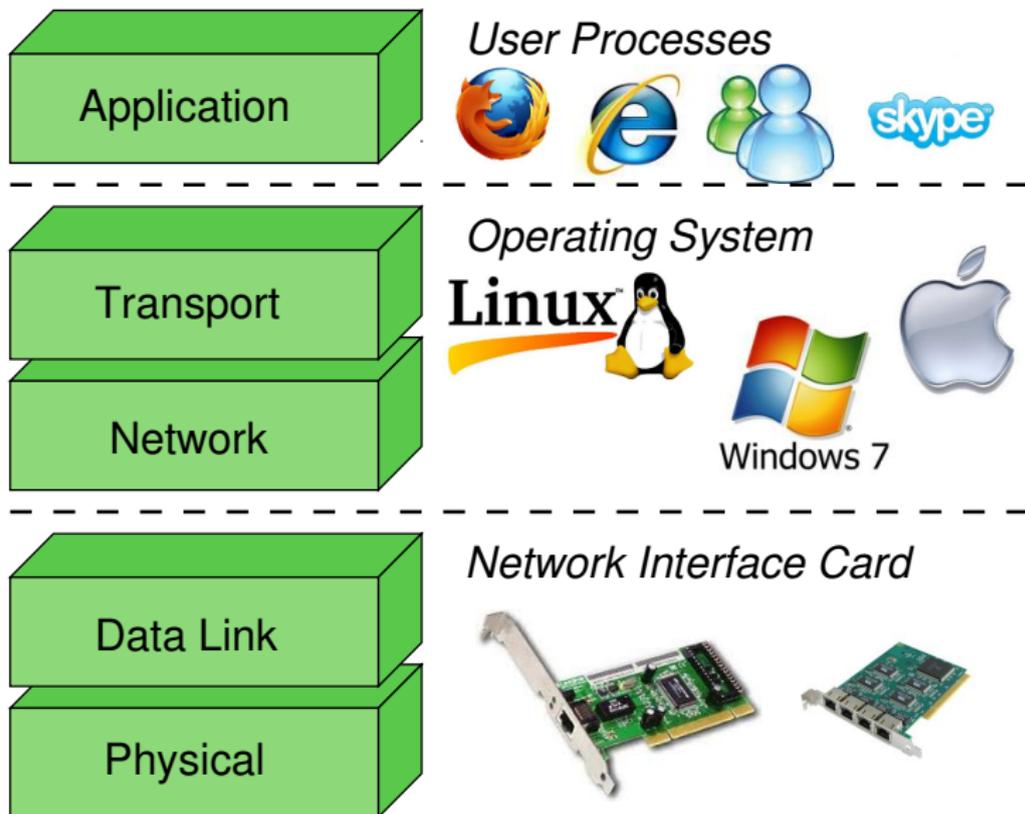- ▶ Sometimes have different names, and overlap between functionality

Layers and Devices

▶ One or more protocols are implemented in each layer in a device

▶ End devices (hosts) implement all layers in stack

▶ Intermediate devices usually do not implement all layers

▶ May refer to device by highest layer it implements, e.g. "layer 2 device"

    ▶ Modems, amplifiers and repeaters are related to physical layer, layer 1 devices

    ▶ Layer 2 switches, Ethernet switches, WiFi access points are layer 2 devices

    ▶ Routers are layer 3 devices

Implementing Layers

Application — User Processes

Transport / Network — Operating System (Linux, Windows 7, Apple)

Data Link / Physical — Network Interface Card

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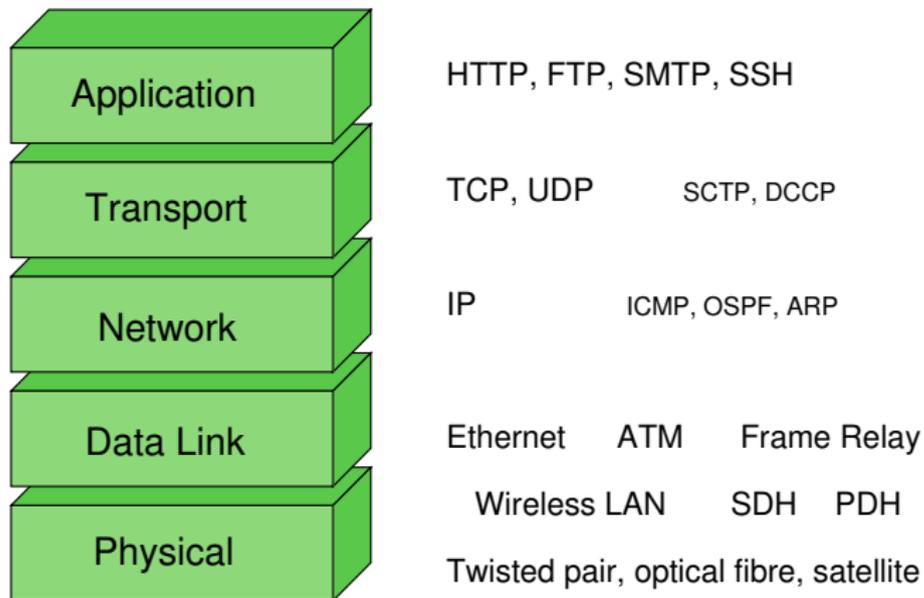
Layering and Protocol Architectures

TCP/IP Protocol Architecture

Example of TCP/IP Operation

Example Protocols in the TCP/IP

Application	HTTP, FTP, SMTP, SSH
Transport	TCP, UDP SCTP, DCCP
Network	IP ICMP, OSPF, ARP
Data Link	Ethernet ATM Frame Relay
Physical	Wireless LAN SDH PDH

Application   HTTP, FTP, SMTP, SSH

Transport   TCP, UDP   SCTP, DCCP

Network   IP   ICMP, OSPF, ARP

Data Link   Ethernet   ATM   Frame Relay

Wireless LAN   SDH   PDH

Physical   Twisted pair, optical fibre, satellite

Example Application: Web Browsing with HTTP
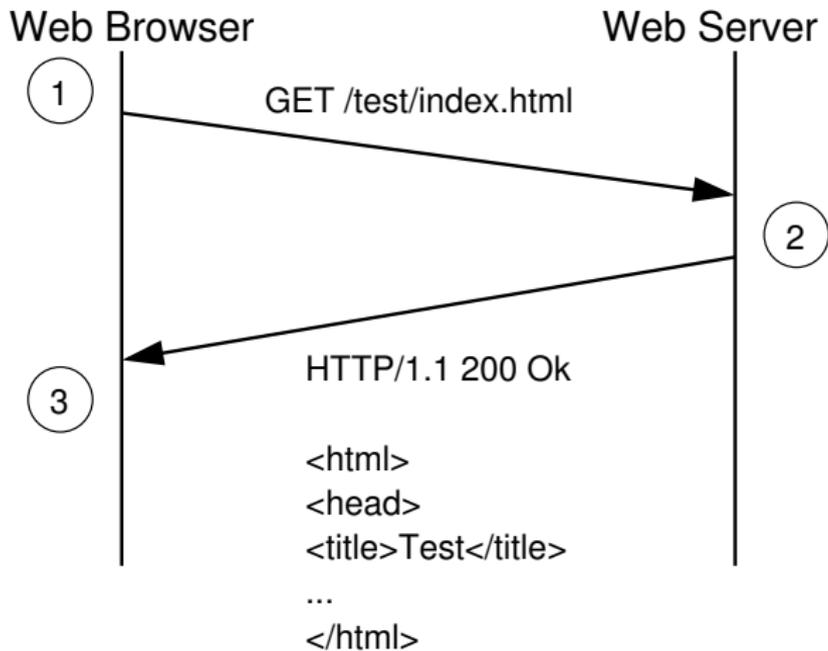
Encapsulation in TCP/IP

Example: web browser has requested web page from server; server needs to send the page requested back to browser

Data	*User data*
HTTP header	*Application message*
TCP header	*TCP segment*
IP header	*IP datagram*
Ethernet header / Ethernet trailer	*Ethernet frame*
1010011011011101001010101...1001011101011010001101011010	*Physical bits*
	Physical signal