OS & Network

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Chapter 1

Parts of a Network

Component	Function	Example

Application, or app, user	Uses the network	Skype, iTunes, Amazon
Host , or end-system, edge device, node, source, sink	Supports apps	Laptop, mobile, desktop
Router, or switch, node, hub, intermediate system	Relays messages between links	Access point, cable / DSL moden
Link, or channel	Connects nodes	Wires, wireless

Key interfaces

- Network-application interfaces define how apps use the network (Sockets widely used)
- Network-network interfaces define how nodes work together (ex : Traceroute)

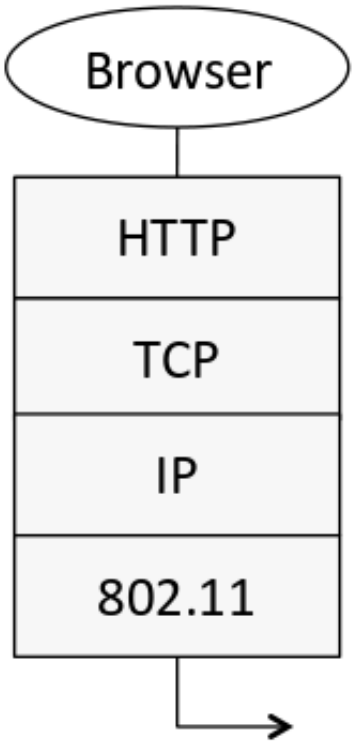
Network service API hides details (Apps don’t know what is inside the network)

Protocols and layers

To divide up network functionality

- Each instance of a protocol talks virtually to its peer using the protocol
- Each instance of a protocol uses only the services of the lower layer

Protocol stack example :



Encapsulation : Lower layer wraps higher layer content and add its own information

Advantage of layering : Information hiding and reusability
Disadvantages of layering : Overhead and hides information

OSI “7 layer” Reference Model

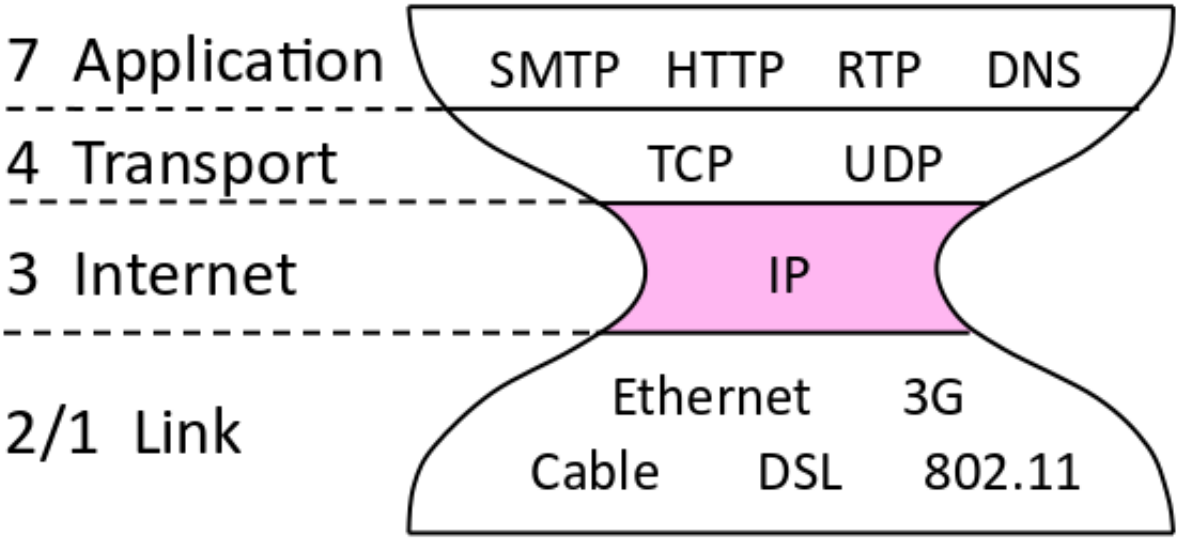
	Layer	Description
7	Application	Provides functions needed by users
6	Presentation	Converts different data representations
5	Session	Manages task dialogs
4	Transport	Provides end-to-end delivery
3	Network	Sends packets over multiple links
2	Data link	Sends frames of information
1	Physical	Sends bits as signals

Four layer model

Based on experience

	Layer	Description
7	Application	Programs that use network service
4	Transport	Provides end-to-end data delivery
3	Internet	Send packets over multiple networks
2 (/1)	Link (/Physical)	Send frames over a link (/Sends bits using signals)

Internet Reference Model



Layer-based names

Layer	Unit of Data
Application	Message
Transport	Segment
Network	Packet
Link	Frame
physical	Bit

Devices in the network :

- Repeater (Hub) : Physical/Physical
- Switch (bridge) : Link/Link
- Router : Network+Link / Network+Link
- Proxy (middlebox, gateway) : App+Transport+Network+Link

Chapter 2 : Physical Layer

Socket API

Primitive	Meaning
SOCKET	Create a new communication endpoint
BIND	Associate a local address with a socket

LISTEN	Announce willingness to accept connections; give queue size
ACCEPT	Passively wait for an incoming connection
CONNECT	Actively attempt to establish a connection
SEND	Send some data over the connection
RECEIVE	Receive some data from the connection
CLOSE	Release the connection

Simple link model

Properties : Rate, Delay/Latency, wether the channel is broadcast, its error rate

Rate

Or bandwith, capacity, speed
in bits/second

Delay / latency

- Transmission delay T: Time to put M-bit message on the wire

$$T = \frac{M[bits]}{Rate\left[\frac{bits}{s}\right]} = \frac{M}{R}\,[s]$$

- Propagation delay D : time for bits to propagate across the wire

$$D = \frac{Length}{Speed of signals} = \frac{L}{\frac{2}{3}\,C}$$

- Latency L : delay to send a message over a link

$$L = T + D = \frac{M}{R} + \frac{L}{\frac{2}{3}\,C}$$

Bandwidth-delay product

The amount of data “in flight”

$$BD = R \cdot D$$

Types of Media

Media propagate signals that carry bits information.
Common types :

- Wires
- Fiber
- Wireless

Wireless

- Travel at speed of light
- Spread out and attenuate faster than $\frac{1}{d^2}$
- Interference between signals on the same frequency (=> spatial reuse of same freq)
- Multipath : signal interferes with itself after reflexion

Modulation

How the signals represent bits

- NRZ : A high voltage +V represents a 1 and a low voltage -V represents a 0

Clock recovery

Receiver needs frequent signal transitions to decode bits (syncronisation)

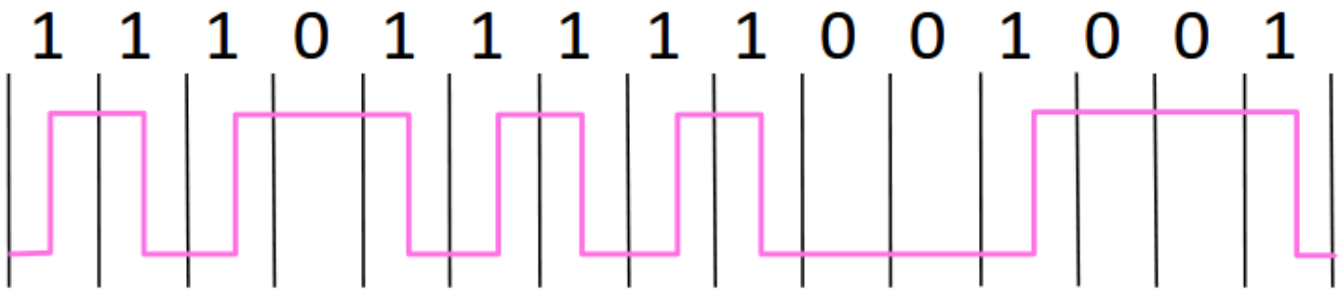
4b/5b

- Map every data bits into 5 code bits without long runs of zeros

4b	5b
0000	11110
0001	01001
1110	11100
...	...
1111	11101

- Invert signal level on every 1 (NRZI)

Example :
message : 1111 0000 0001

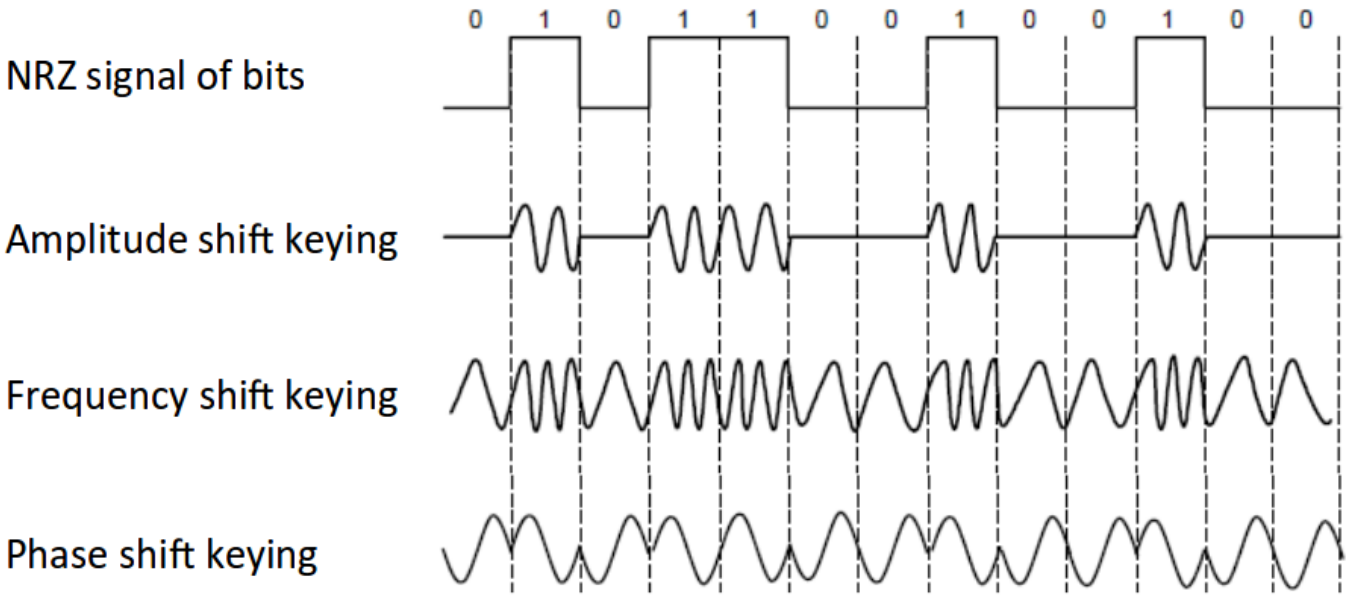


Baseband vs Passband modulation

Baseband : Signal is sent directly on a wire (wires)
Passband : Modulation carries a signal by modulating a carrier (fiber / wireless)

Passband

Carrier is a signal oscillating at desired frequency. We modulate it by changing amplitude, frequency or phase



Fundamental limits

Key channel properties

- Bandwidth B
- Signal strength S
- Noise strength N

Nyquist limit/frequency

If we have a channel with a bandwidth B, the maximum symbol rate is $2B$.
If we have V signal levels ($log_2 V$ different bits), the maximum bit rate is

$$R = 2B \cdot log_2 V \left[\frac{bits}{s}\right]$$

Shannon capacity

The number of levels we can distinguish on a channel depends on the SNR (~ S/N)

The Shannon capacity C is the maximum information carrying rate of the channel

$$C = B \cdot log_2 \left(1 + \frac{S}{N}\right) \left[\frac{bits}{s}\right]$$

Wires / Fiber :
Engineer SNR for data rate

Wireless :
Adapt data rate to SNR (can't design for worst case)

Acronyms

Acronym	Meaning	Description
Pan	Personal Area Network	ex : Bluetooth
Lan	Local Area Network	ex : WiFi, Ethernet
Man	Metropolitan Area Network	ex : Cable, DSL
Wan	Wide Area Network	Large ISP
NRZ	Non Return to Zero	
SNR	Signal to Noise Ratio	S/N