communication → types → flow
- real / non real — email
- modes: half duplex, full duplex
- partities: 2, multi
- one way / two way → simplex, duplex

components → challenges → 2 models

internet model

layered archi
- A - direct access (mark based appl → user) — HTTP
- P - format data (encrypt)
- S - ctrl dialog two ways — TCP/IP
- N → multiplex
- D → routing (diff networks)
- P → switching (same networks)
- encoding, error check, sec hamming code 7,4, CRC

data, seg, packets, frames, bits

err detect → IP

MAC

A, T, N (Internet layer) ⟹ err detection

D, Physical — Network access layer

modulation rate → mark & space

Bandwidth → analog / digital

data rate = baud rate × n (bits in sig component for time)

= (2f) log₂ B (# distinct lvls; sampling at least)

= B log₂ [1 + S/N]

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physical layer

encoding: digi → digi; digi → Analog; Analog → digi; Analog → Analog

modulation

Baseband vs broadband (digi / analog)

diff
- NRZL, NRZI
- Multi lvl bin: B AMI, pseudo ternary
- Biphase: Manchester, diff manchester

ASK, PSK, FSK; PTSN; 1.5 change; 8 FSK; MFSK

PCM; Delta M; PAM; AM, PM, FM

QAM, ASK, PSK + PSK

IEEE 802 Ethernet

- dc comp
- easy impl
- err detection
- good use of BW

QPSK shifts by 90°

Scrambling: B8ZS, HDB3, 4 zero

err detect, Node constr

Transport layer

modes
- serial
  - synchronous + asynchronous
  - Isochronous
  - Keyboard input, start/end
  - overhead
- parallel

err check → preamble (sync), header → ctrl, payload → data, trailer → err + end

Multiplexing: Mux → util link ⟹ cost, data rate

FDM (TV)
- BW medium >> exceed requirement
- channel
- analog → channel → modulated → subcarrier
- baseband
- crosstalk → intermodulation noise
- amplifier → long links

TDM
- Synchronous (STDM): timeslots preassigned [fixed]; speed mismatch → buffered; data rate >>; time quantum; with interleaving; buffered [1 bit]; segmentation combined; frames (start / end); Mux; demux
- Statistical TDM: dynamically allocate slots based on demand → support more devices or can lower data rate to match synchronous TDM

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fiber optics
- diff freq
- [WDM]
- wave lengths → max → same fiber size

ADSL → downstream more cap

DMT

S/N ratio ↓

attenuation at ↑ f → ↑ loss of sig strength over distance through medium

POTS

FDM or echo cancellation ↑ ↓ same time

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err / noise
- types: white, thermal / hot, random, crosstalk, echo (reflective feedback), jitter, shielding (STP), time irregularities, by distance
- Coaxial cable

transmission impairments

err prevention

- delay distortion } equalizers
- attenuation } amps, repeaters
- interference } optics, STP → less lossy medium
- reflection
- dispersion (scatter)

shape, strength, wireless

⟹ err detection
- redundancy bits (frame)
- seperate code, data code, err check → simple parity codes (odd, even) → cannot identify where but if there? :)
- non seperable → CRC

⟹ err correction & single err correcting → SEC

Hamming code 7, 4

msg 1010 1101

crc poly 1101

crc bits 3

sent 1001100

recieved 1011100

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media
- guided
  - TP: UTP, STP
  - coaxial
  - fiber
    - immune to external noise
    - can transmit data long distance without boxes
    - speed ↑ due to ↑ bandwidth
    - cost
    - complex (digi ⇄ light converter)
    - modal dispersion → single mode, diff speed; multi mode → FDM
- unguided / wireless
  - infrared, TV remote
  - microwave → Antenna (transmission, recieving)
    - isotropic antenna (theoretical pt) radiates every dir equally (sphericity)
    - parabolic reflective
    - Antenna gain = power output parabolic dir / isotropic
  - Broadcast radio FM, AM, omnidirectional
    - free space loss, refraction, atmos absorption, multipath interference
    - wireless propagation: ground, sky
    - Wireless standards: IEEE 802, LAN, Ethernet, AMEIA
  - satellite
    - terrestrial: repeaters, attenuation, rain
    - amplify, resize, transmit, TV, Telephone, GPS
    - geo stationary orbit

dB = 10 log (P1/P2)

WLAN

Why?
- mobile
- ad hoc networking (P2P, Airplay)

no infrastructure to connect to nodes themselves or BS → IBSS

Challenges
- loss, interference [propagation]
- finding loc of nodes
- service (address / Routing)
- Handoff: calls while travelling, terminals from terminal, AP → one base station to another

Wireless LAN tech ⟹ IEEE 802.11
- encoding → spread spectrum
  - larger BW → signal jam avoid
  - mult users → multiplex
  - freq hopping → spreading code → pseudorandom (not really random) seq 1/0s; channel hop
  - direct sequence spread: Data input ⊕ XOR → PN → output (sent) → spread → reversed; ⊕ PN → data; despread
- BSS (basic service set): infrastructure mode — nodes associated with base stations; smallest building block (same MAC protocol); access pt (AP) router; phone lap; university; LAN to create extended SS
- DS (distributed sys)
- IBSS (independent BSS) → hotspot: IP routing, MAC allocation embedded

same channel → collision → distributed: CSMA/CA; centralized: PCF polling (Point coordination)

cellular
- GSM (Geographical Service area)
- RF channels: ↑ link, ↓ links
- concept: freq reuse, handoff, small BS

traffic / voice, ctrl

MTSO, switching office

FDMA, AMPS

TDMA, GSM

CDMA [code division mult access]
- break each bit into chips by fixed ptrn
- chipping code → specific user
- orthogonal → mult all user chipping codes ⟹ 0

shared channel: u1, u2, u3, u4; t, f

u1: d1 × c1

sent ⟹ d1×c1 + d2×c2 + ...

decoded ✓

c1 × c1 ⟹ # participants

c1 × c2 × c3 × c4 ⟹ 0

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cellular sys ops

mobile unit init → broadcast into access channel → ctrl sys

mobile originated call → id destination, mobile → BS; voice channel info, BS → mobile } call starts

Ntwrk " " → paging channel, let reciever know

handoff & power ctrl: if poor signal, reduce battery life; MSC switching station

location updating: Home user HLR; visiting user VLR

roaming