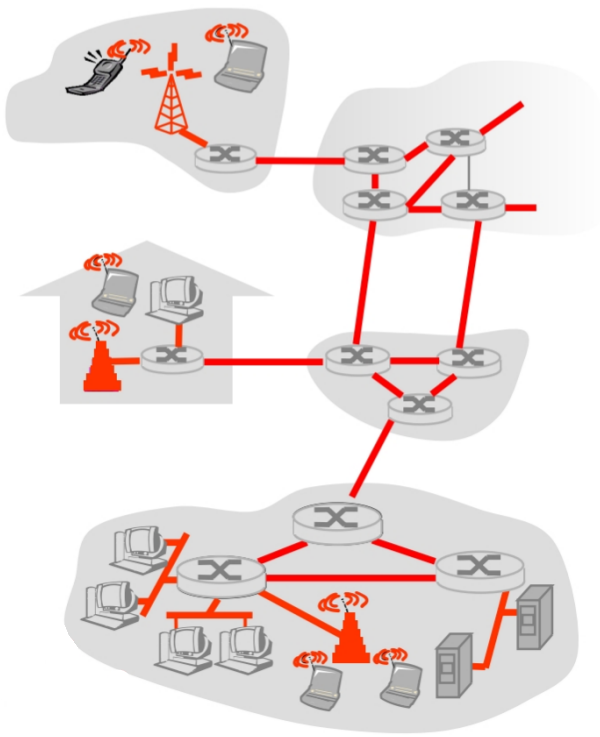
Week 9 – Link Layer and LANs



Terminologi :

- Host & Router = Nodes
- Communication channels that connect adjacent nodes along communication path = Links
  - ↳ Wired links
  - ↳ Wireless
  - ↳ LANs
- Layer-2 packet = Frame = Encapsulates datagram

- Layer data-link bertanggung jawab → Transfer datagram antar node melalui link
- Datagram transferred by link protocol beda over link beda
  - ↳ Ethernet on first link, frame on intermediate link, 802.11 on last link
- Tiap link protocol menyediakan layanan beda
- Analogi transportation : Medan $\xrightarrow[\text{limo}]{}$ Jakarta $\xrightarrow[\text{plane}]{}$ Bali
  - ↳ Tourist = Datagram
  - ↳ Transport segment = Communication link
  - ↳ Transportation mode = Link layer protocol
  - ↳ Travel agent = Routing algorithm

- Layanan link layer :

1) Framing, link access
   - ↳ Encapsulasi datagram menjadi frame, ditambah header, trailer
   - ↳ Channel access kalau shared medium
   - ↳ MAC address dipakai dalam frame header utk identify source & destinasi

2) Reliable delivery between adjacent nodes
   - ↳ Jarang dipakai dlm low bit-error link (Fiber, TP)
   - ↳ Wireless link → High error rates

3) Flow control
   - ↳ Pacing between adjacent sending & receiving nodes

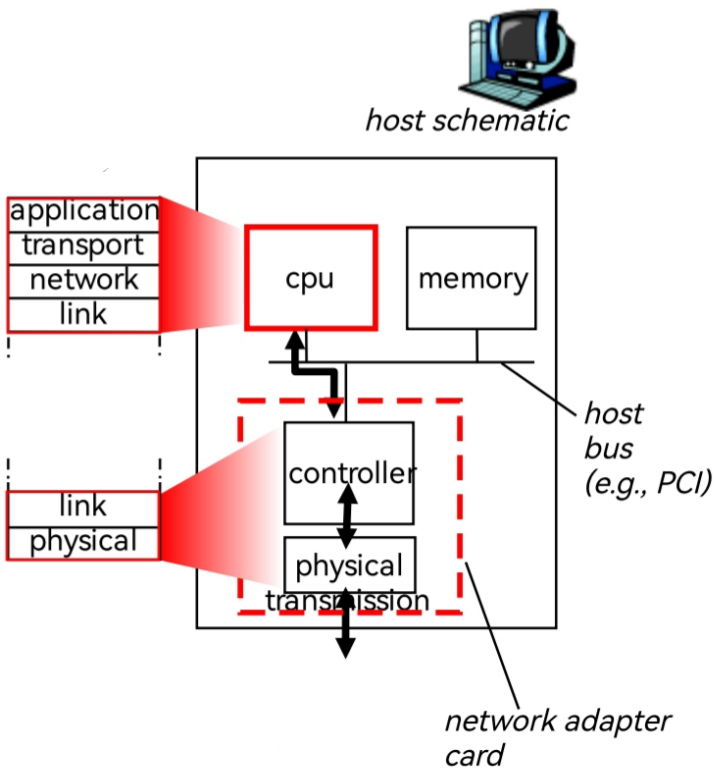
4) Error detection
   - ↳ Error caused by signal attenuation, noise
   - ↳ Receiver detects presence of errors

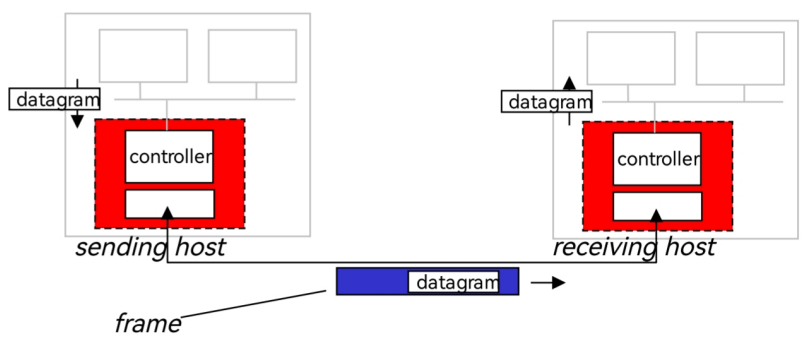
5) Error correction
   - ↳ Receiver identifies and corrects bit error(s) without resorting to retransmission

6) Half-duplex & Full-duplex
   - ↳ With half-duplex, nodes di ujung link hs transmit, tp ga bs barengan

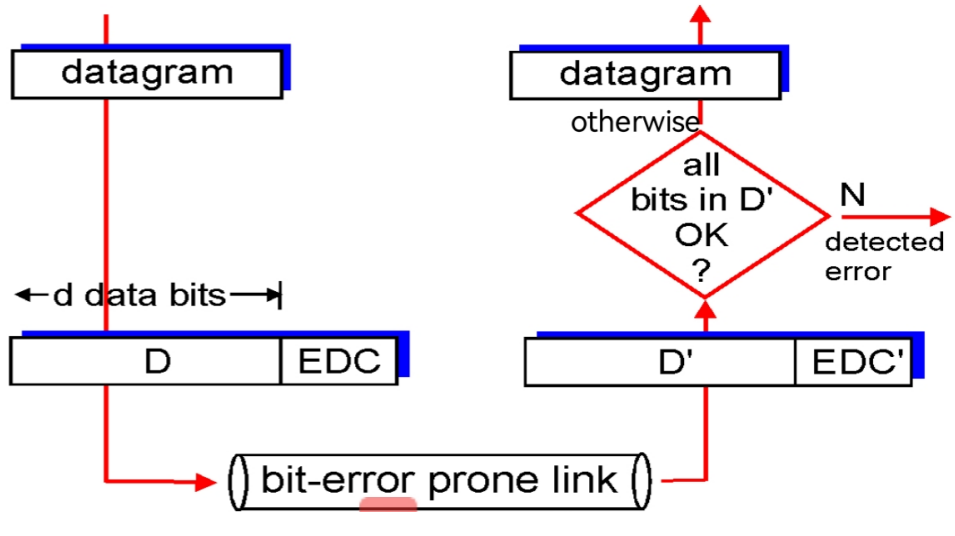
- Link layer diimplementasikan pada tiap host dalam adaptor (NIC/Network Interface Card)

- Link layer attach pada host's system bus





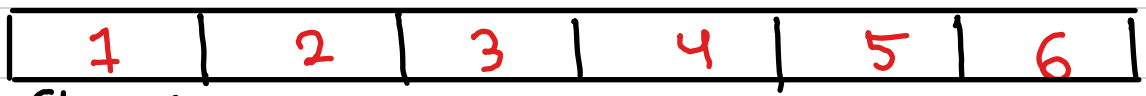
- sending side:
  - encapsulates datagram in frame
  - adds error checking bits, rdt, flow control, etc.
- receiving side
  - looks for errors, rdt, flow control, etc
  - extracts datagram, passes to upper layer at receiving side



- EDC = Error Detection & Correction bits
- D = Data protected by error checking, may include header fields

- Error detection tidak 100% reliable

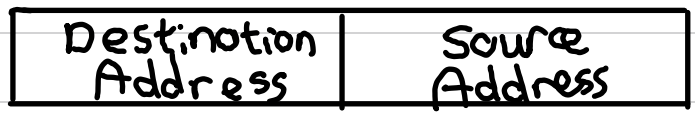
- Data link ibaratkan polisi = Cek sblm ditampil ke medium
- Format frame



Start of frame (Head)

1 = Serial HDLC ⇒ Flag (Bit stream) = 01111110 = 7E
Ethernet ⇒ Preamble (Byte stream)

2 = Alamat ⇒



3 = Control field/type
4 = Payload ⇒ Data asli dari kontennya
5 = FCS ⇒ Frame Check System
6 = End of frame (Tail) *opsional

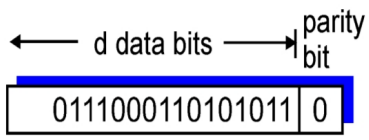
Krn di HDLC kan 7E jd hrs ada tail
Klo ethernet gausah

- Data kalau dikirim misalkan 01111110 11111101 11111001
  - Pakai teknik stuffing = Insert bit/byte
  - Kalau bit stuffing = '0'
    - Stasiun transmit = Σbit '1' = 5 → Nextnya insert bit '0' sbg bit stop agar data berbeda dgn flag, jgn sama spt 7E
    - Stasiun terima = Check Σbit '1' = 5 → Nextnya itu kalau '0' → Remove
      '1' → Flag

Parity Checking

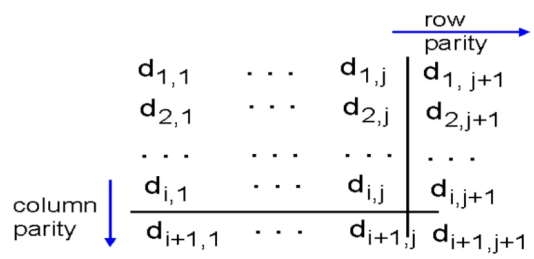
Single Bit Parity:

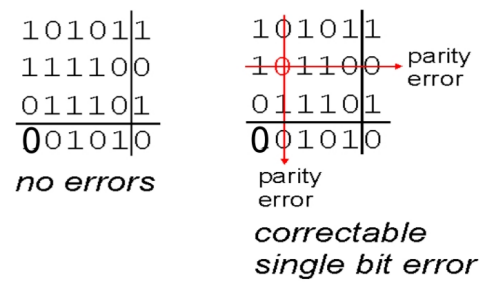
Detect single bit errors



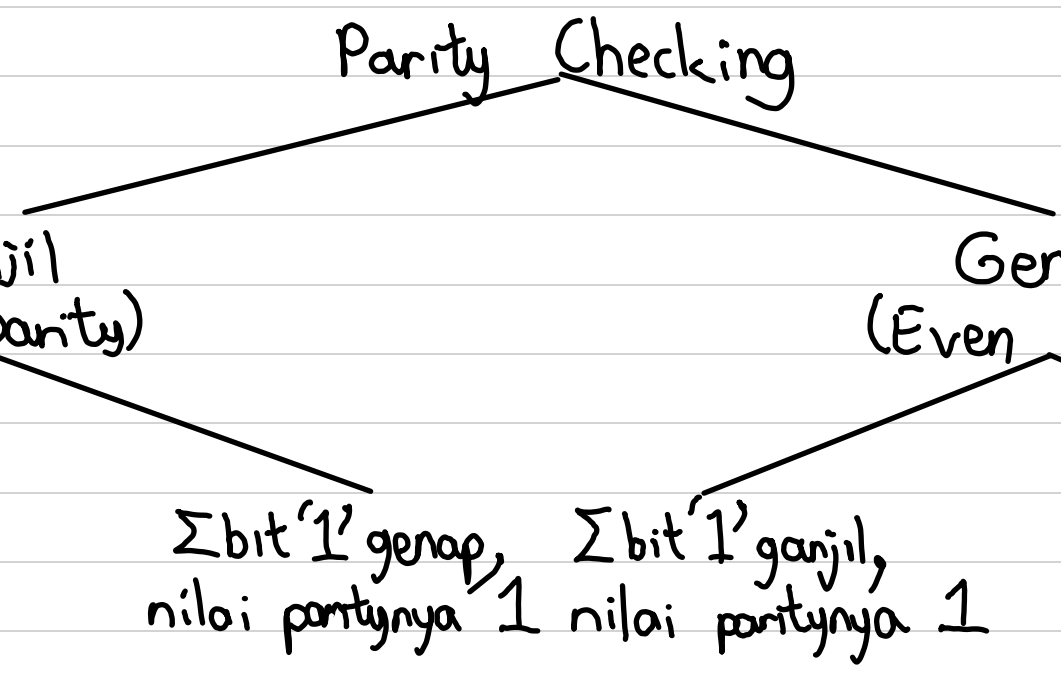
Two Dimensional Bit Parity:

Detect *and correct* single bit errors





- Parity Checking = Menghitung Σ bit '1'



- Contoh Odd parity : Data → 01111101 1 = 0
  01111100 = 1
- Contoh Even parity : Data → 0111110 = 1

- Cara cepatnya ada 2 yaitu :

1) Half Adder / Ex-or / ⇒▷— / Jumlah tanpa Carry

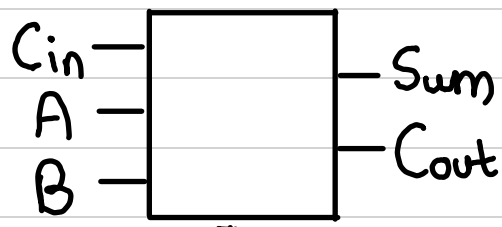
↳

A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

2) Full Adder / Jumlah dengan carry

↳ Outputnya sum & carry

↳



↳

In			Out	
Cin	A	B	Sum	Cout
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

- Metode ex-or dipakai di even parity
  - ↳ Contoh :

Data → 0 | | | | | | | 0 | | | 1 = 1

0 0 0 0 0 0

0 | | | | 0 = 0

0 0

- Cara di atas tergolong single bit parity, dimana unggulnya bisa cek bit ganjil tepat. Tapi bisa saja data misalkan 0 | | | | | 1 = 1 bs terjadi altenation noise / Signal tinggi jadi lemah & intermodulation signal / 0 jadi stonks

0 1 (0 → 1)

1 0 (1 → 0)

- Two Dimensional Bit Parity

  - Horizontal / LRC (Longitudinal Redundancy Check)
  - Vertical / VRC (Vertical Redundancy Check)

- Misalkan ada data mau kirim huruf UMN :

Pakai ASCII:

U = 01110111 = 0 (VRC ↓, LRC →)
M = 11000110 = 0
N = 11110001 = 1

01000000 = 1 → BCC (Block Check Character)

* Mgh di data pengirim

a) Jadi dikirim / transmit :

U 01110111 0 | M 11000110 0 | N 11110001 1 | + 01000000 1 (BCC)

a) Unggul 2D parity = LRC kalau ada noise bisa cek ada mslh di bit yang mana, tapi kalau slh di LRC & VRC maka jd tidak unggul

- Internet checksum bertujuan untuk deteksi error di transmitted packet (Pakai di transport layer aja)

  ↳ Sender :
  - Treat segment contents as sequence of 16-bit integers
  - Checksum : Addition (1's complement sum) of segment contents
  - Sender puts checksum value into UDP checksum field

  ↳ Receiver :
  - Compute checksum of received segment
  - Cek jika computed checksum = Checksum field
    - ↳ NO = Error detected
    - ↳ YES = No error detected

```
                1 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0
                1 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1
              ---------------------------------
wraparound  1 1 0 1 1 1 0 1 1 1 0 1 1 1 0 1 1
              ---------------------------------
sum           1 0 1 1 1 0 1 1 1 0 1 1 1 1 0 0
checksum      0 1 0 0 0 1 0 0 0 1 0 0 0 0 1 1
```

- CRC = Pembagian polynomial / polynomial checking
  = Cyclic Redundancy Check

- Bilangan polinomial → $f(x) = a_1 x_1^1 + a_2 x_2^2 + \text{oooo} + a_n x_n^n$, dimana
  a = '0' atau '1'

- $f(x) = x^4 + x^2 + 1 \rightarrow 1 \cdot x^4 + 0 \cdot x^3 + 1 \cdot x^2 + 0 \cdot x^1 + 1 \cdot x^0 = 10101$

  1100 111 → $x^6 + x^5 + x^2 + x + 1$

  $x^6 x^5 x^4 x^3 x^2 x^1 x^0$

  01011101 → $x^5 + x^3 + 1$

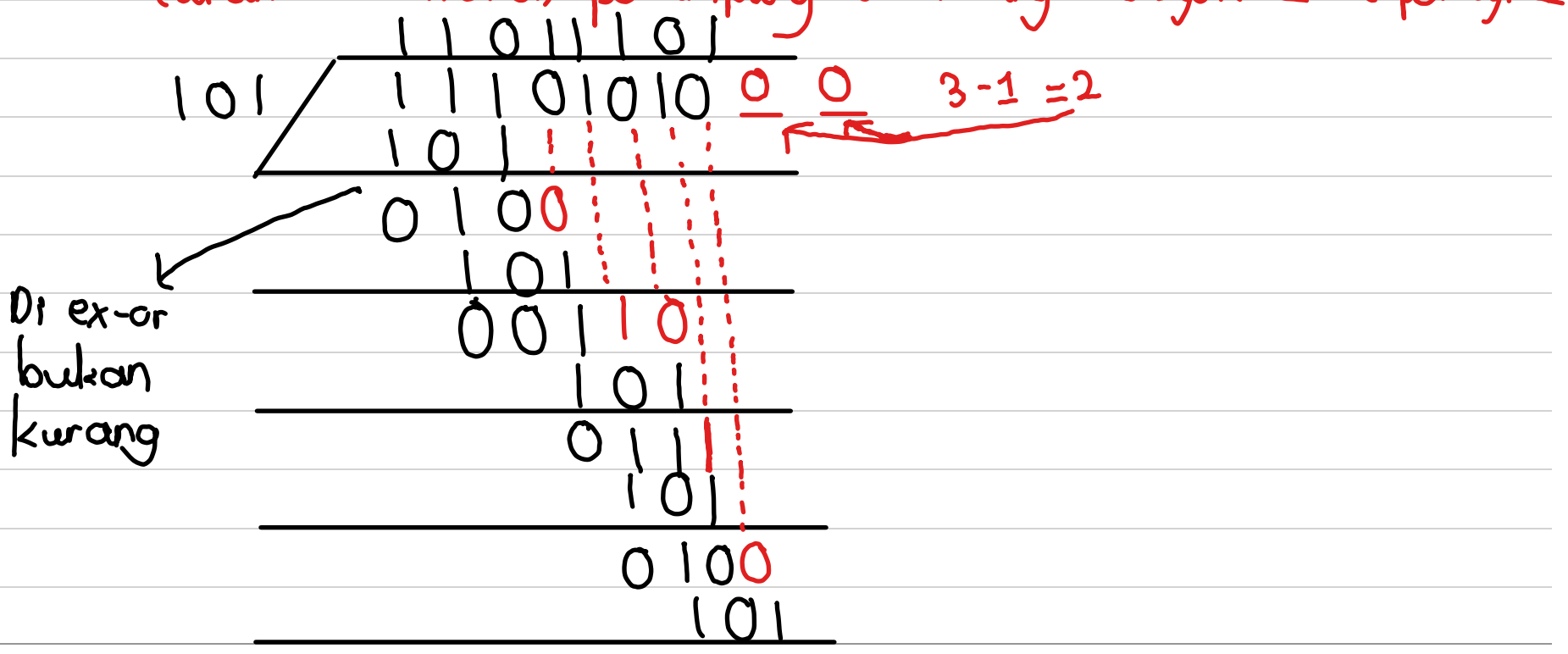
  100100 → $x^6 + x^2$

- Teknik CRC → Pembagian polynomial pakai ex-or

- Data = 11101010

  Pembagi polinomial = $x^2 + 1$ = 101 (Divisor)

  Aturan : Sediakan penampung dibelakang sebanyak Σ bit pembagi - 1



```
  00100
 ------
101 | 001   → Sisa remainder (FCS)
```

∞ Yang ditransmit = Data + FCS = 11101010 01

- Pada stasiun penerima,

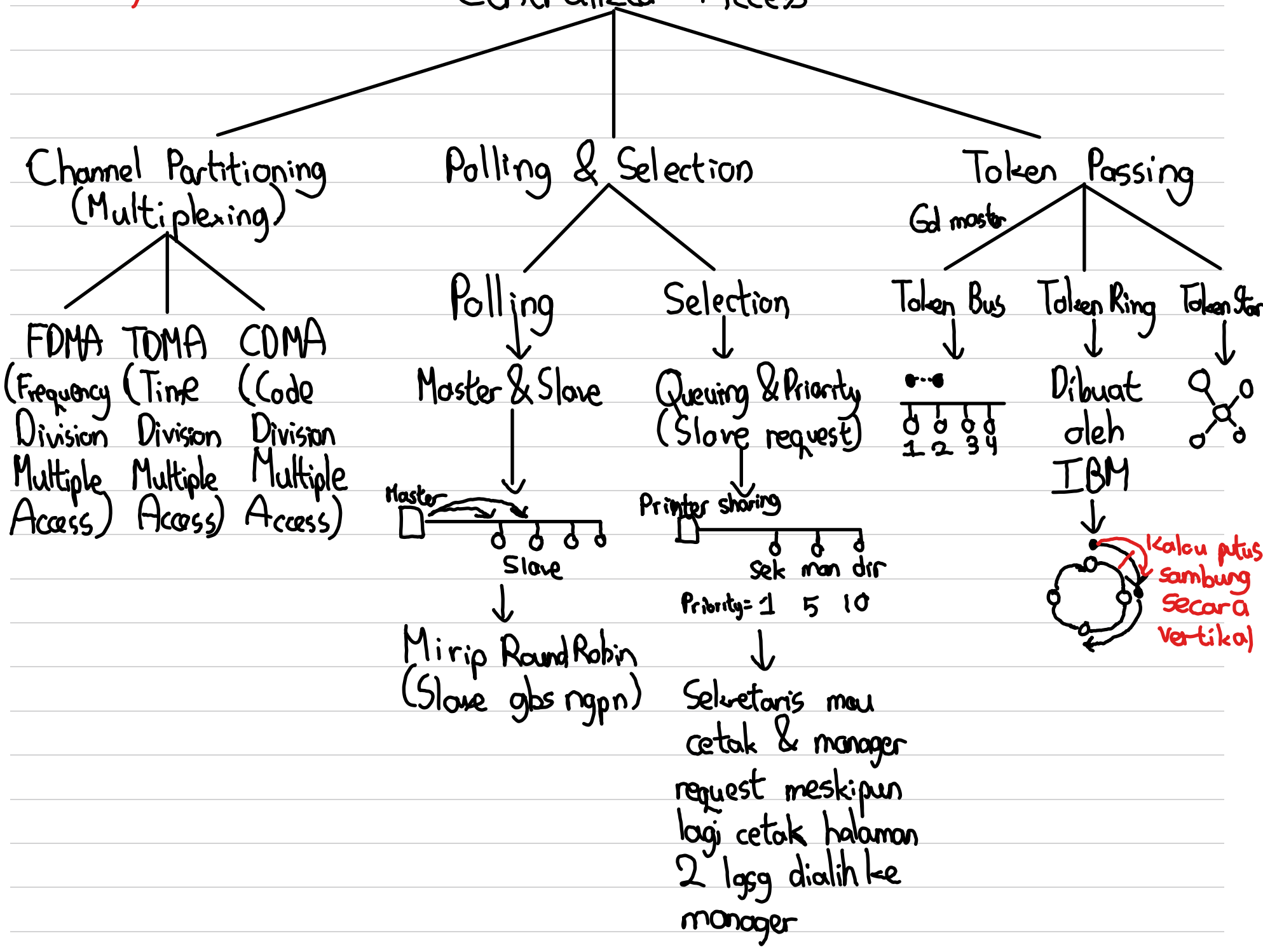
```
    110111
 ------------
101 | 11101010001
      101
      ---
       100
       101
       ---
        00110
        101
        ----
         0111
         101
         ---
          0100
          101
          ----
          00101
          101
          ---
            0   → Tidak bersisa
```

- Jika stasiun penerima menghitung hasil tidak bersisa, maka data tersebut valid

- Medium Access Control (MAC)

  a) Undedicated channel / Share medium (Dedicated = PPP)
  a. Centralized Access / Ada yang ngatur (Master / Token)
  b. Uncentralized Access

o) Centralized Access



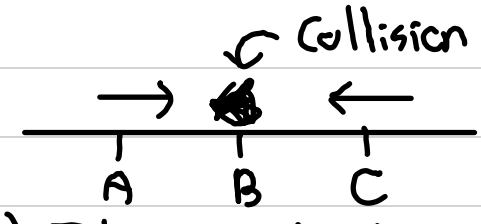
o) Uncentralized Access / Random

1) Pure Aloha → Listen while talk mkny bs collision
2) CSMA → Listen before talk
   → Prinsip contention = FCFS = Pendudukan channel

o) CSMA
- CD → Collision with Detection → Wired ethernet
- CA → Collision with Avoidance → Wireless ethernet

Req To Send
RTS dulu

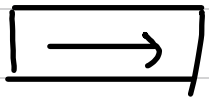
- Mekanisme CSMA/CD :
  1) Semua stasiun akan deteksi sinyal carrier dalam medium
  2) Jika idle, maka stasiun berlomba-lomba kirim data

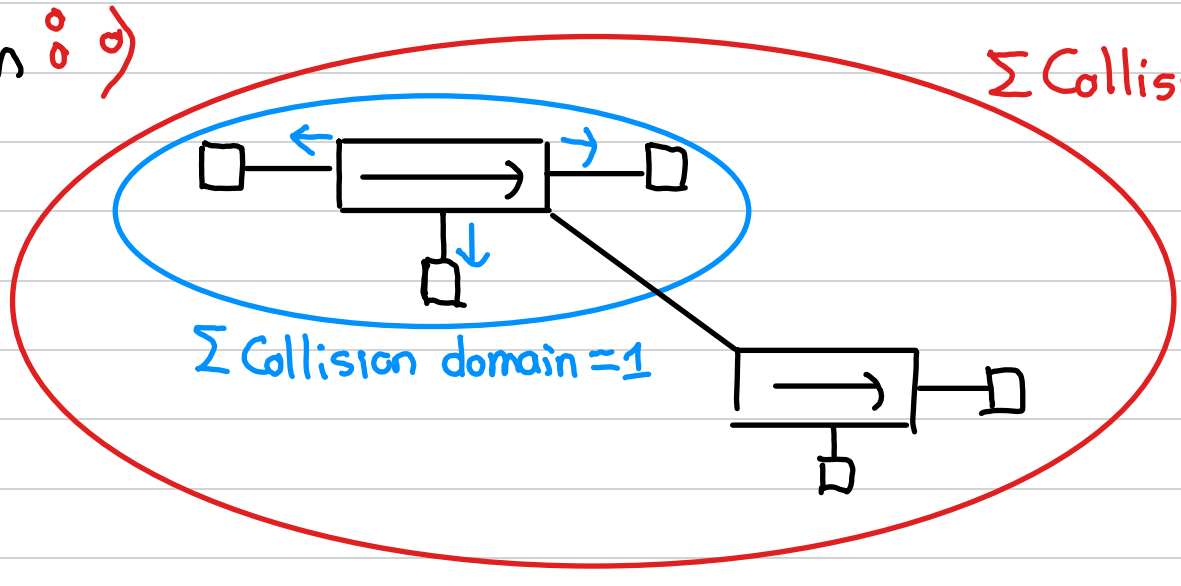


  3) Jika terdeteksi collision, maka stasiun akan kirim sinyal jamming
  4) Stasiun akan hold & tunda/delay sampai collision free
  5) Ulangi Step 1

Collision Domain :

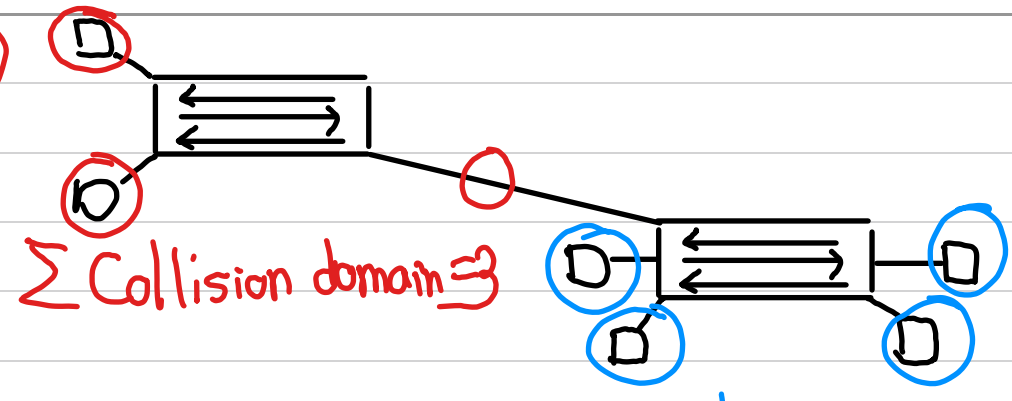
- 2 prinsip :
  - Σ collision domain semakin besar, semakin bagus
  - Size collision domain semakin kecil, semakin bagus

-  = Hub = Passive Hub
-  = Switch = Active Hub
- Contoh :



Σ Collision domain = 1
↓
Problem krn size semakin besar
↓
Atasi pakai switch

o)

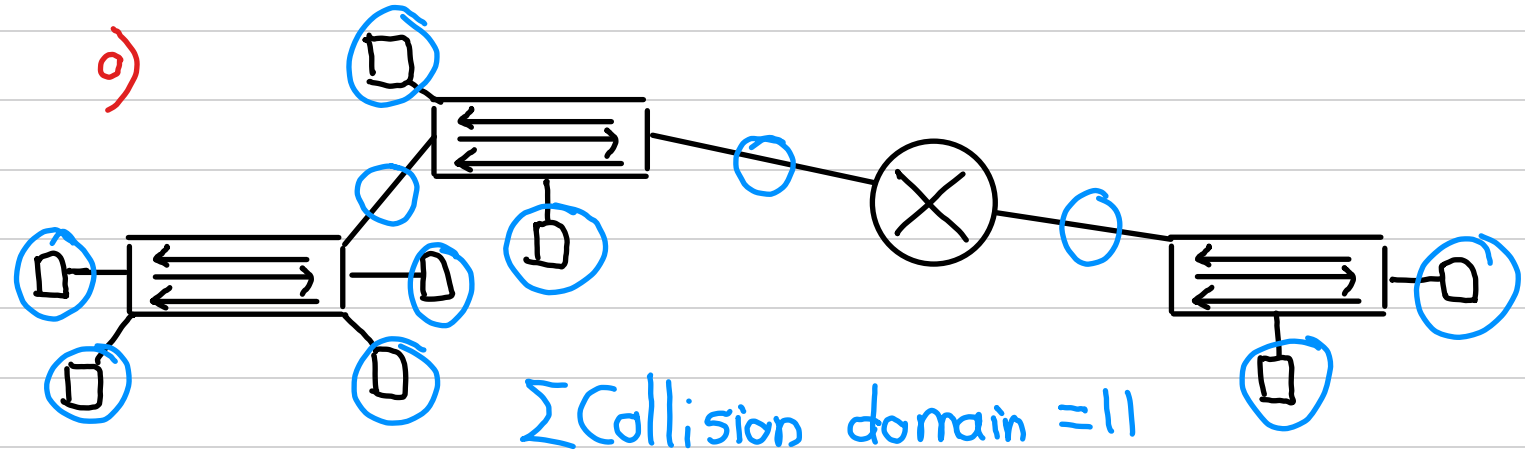


Σ Collision domain = 3

Σ Collision domain = 4

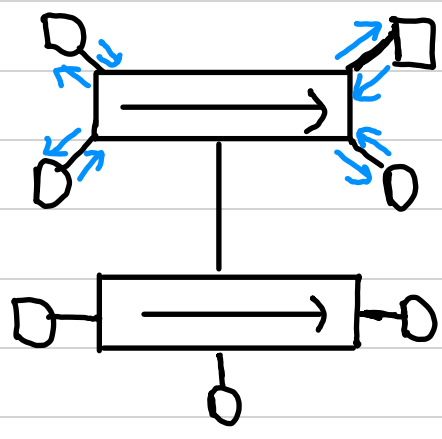
Total Σ Collision domain = 7

o)



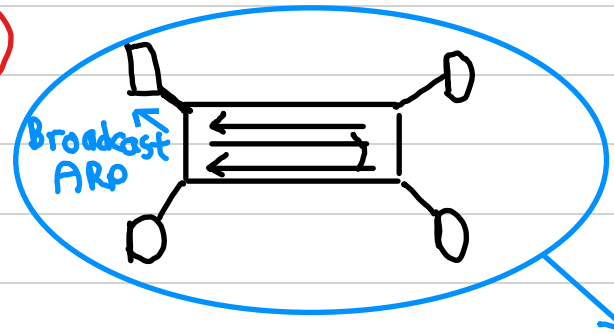
Σ Collision domain = 11

- Broadcast Domain :
  - o) 2 prinsip :
    - Σ broadcast domain semakin besar, semakin bagus
    - Size broadcast domain semakin kecil, semakin bagus
  - o) Contoh :
    - o)



Σ Collision domain tetap 1 mkny BD gbs atasi Collision domain

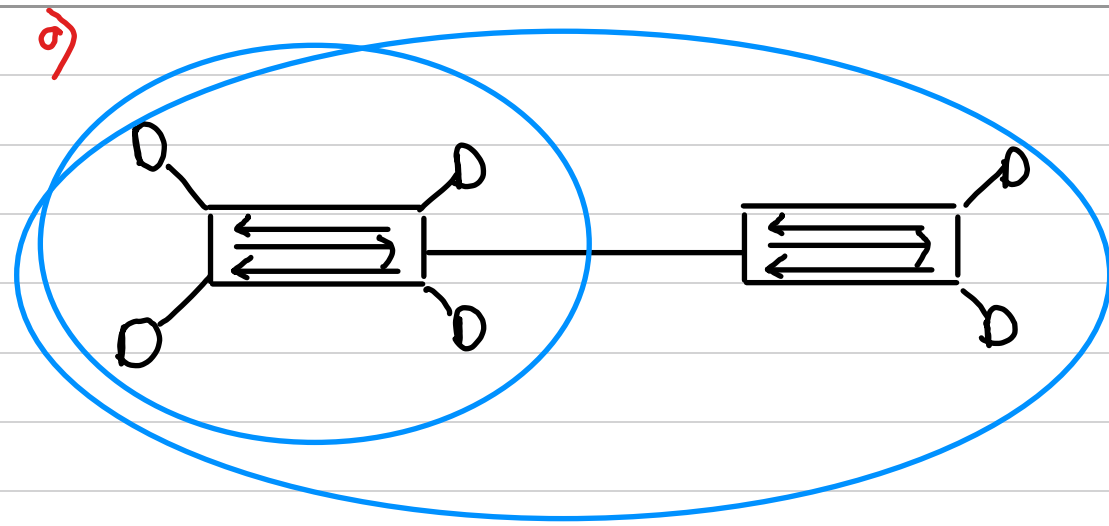
- o)



Tanya semua broadcast ARP "Ini IP pny siapa" kpd masing-masing pengirim

Σ Broadcast domain = 1

a)

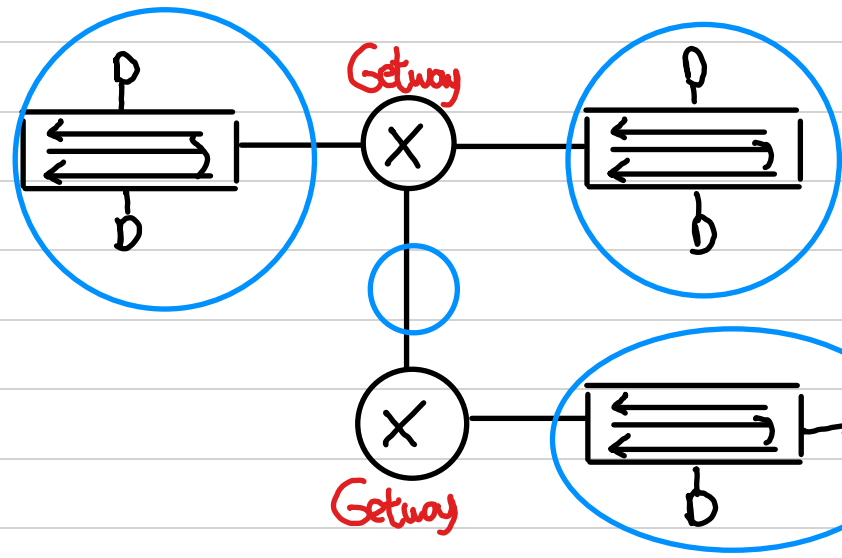


Σ Broadcast domain tetap 1, artinya switch gbs atasi broadcast domain

↓

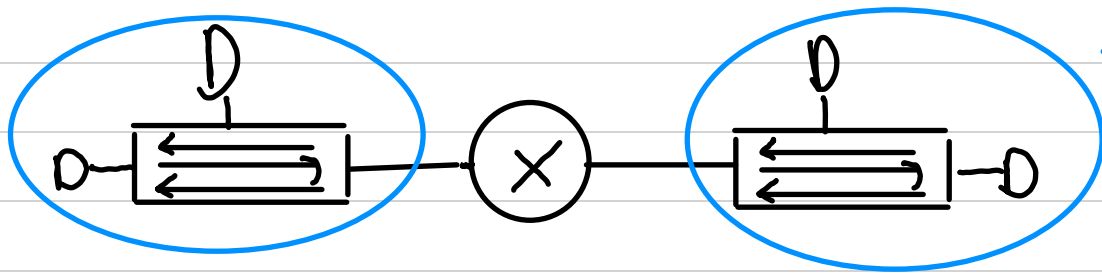
Atasi pakai router

b)



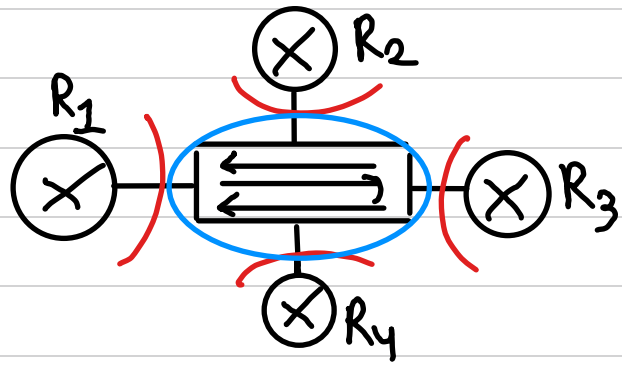
Σ Broadcast domain = 4

c)



Σ Broadcast domain = 2

d)



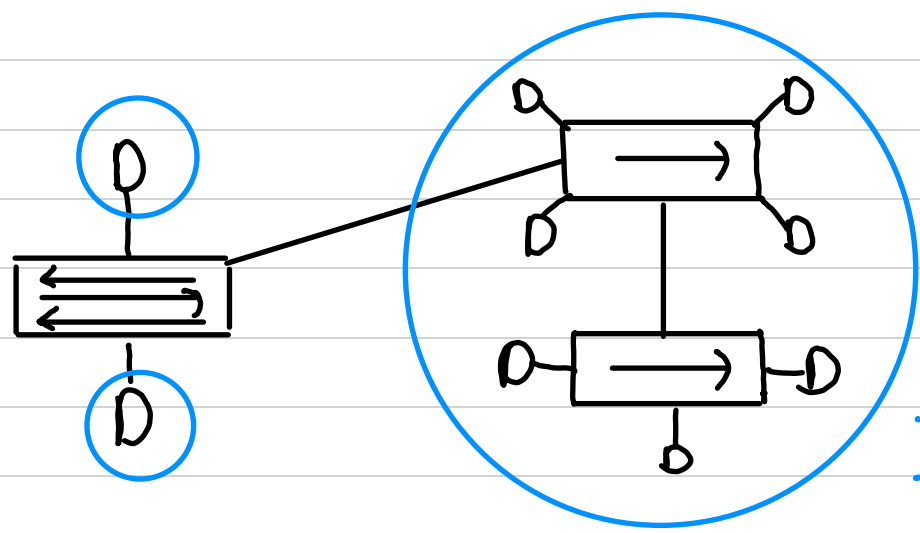
Σ BD = 1

Σ CD = 4

Jlh subnet = 1 (Lihat dr BD)

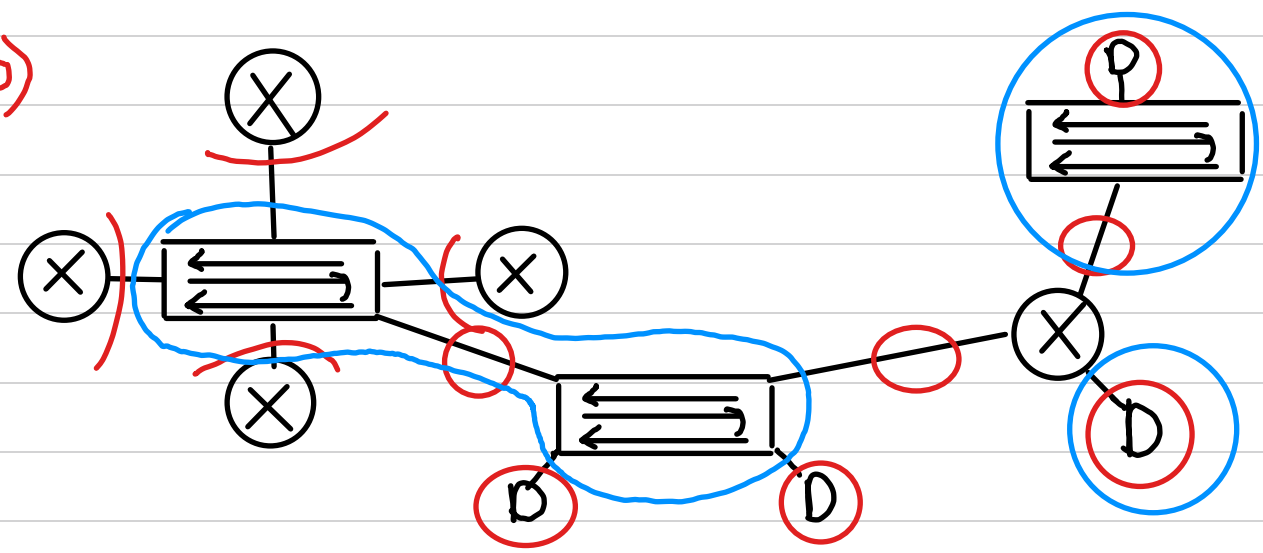
Jlh getway = 4 (Lihat dr router)

a)



Σ CD = 3

b)



Σ CD = 11
Σ BD = 3
Jlh getway = 5
Jlh Subnet = 3

- Switch bebas collision, tapi ga bebas broadcast
- Router ada on/off, switch no
- Address Resolution Protocol (ARP) = Dari IP ke MAC
  Inverse ARP = Dari MAC ke IP