ETSF15: Lecture 4
- Topologies
- Multiplexing/Access methods
- Domains
- Switching
- Ethernet

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Some notes on Lab 1

- Task 1

```
selected_led=generate_message();
```

- Task 2

```
for (i=0;i<LEN_BUFFER;i++) {
   digitalWrite(PIN_TX,test_frame[i]);
   delay(T_S);
}
digitalWrite(PIN_TX,LOW);
```

Some notes on Lab 1 (cont…)

- Task 3
  - Set payload = selected_led
  - Set all other FDU fields
  - Send PREAMBLE, SFD and FDU
- Task 4
  - Wait for 0-to-1 transition (PREAMBLE)
  - Delay Ts/2 before start sampling so we sample in the center of a pulse.
  - Sample 8+8+32 bits

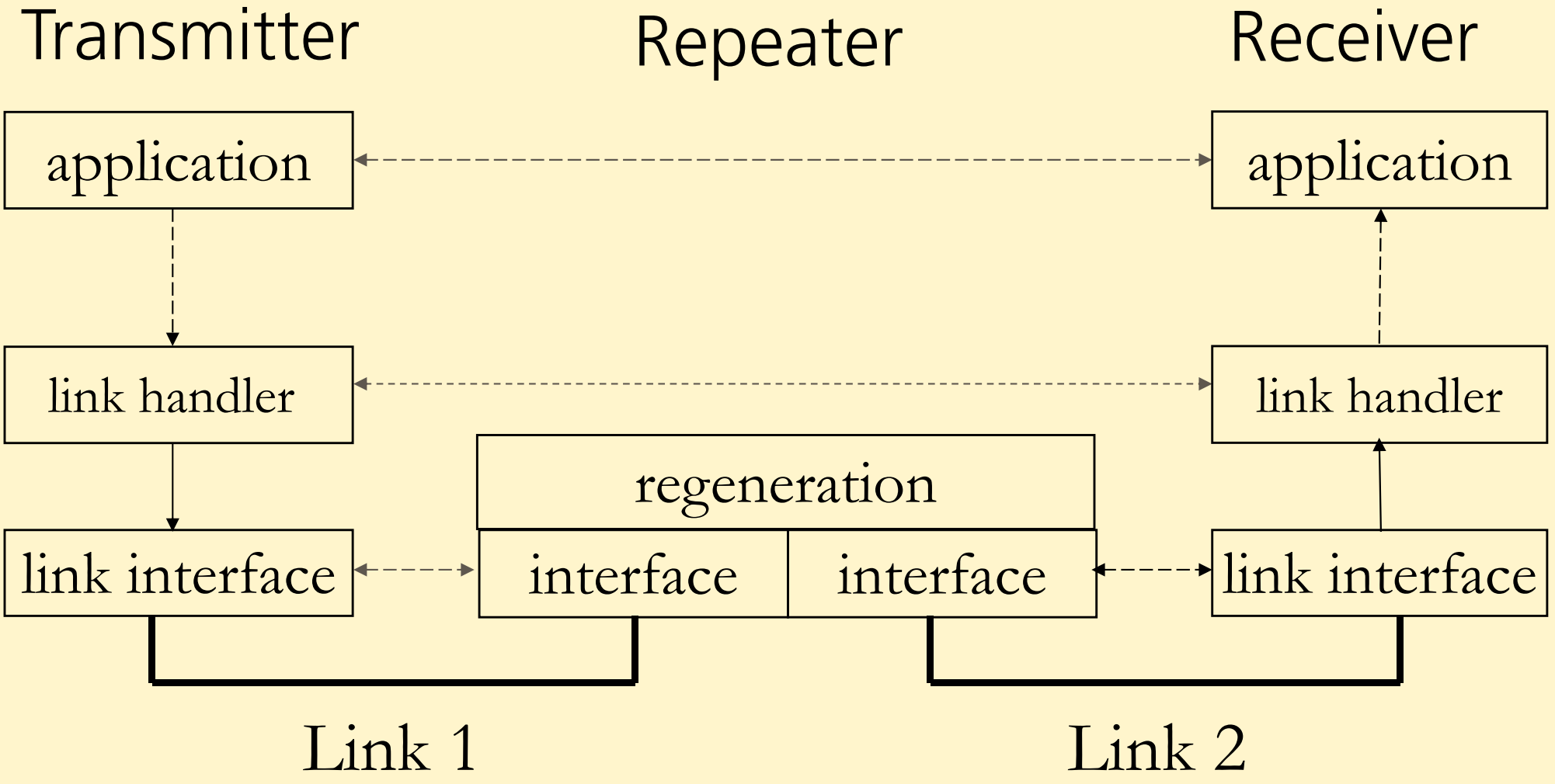
Some notes on Lab 1 (cont…)

Task 5, find SFD

- In the receiver code, for each received symbol:
  - bit_bufffer, SFD declared byte

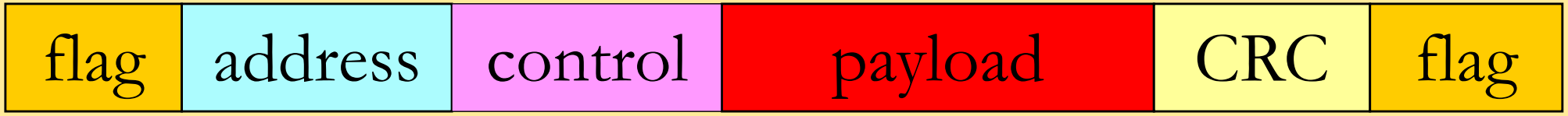
```
if (start_FDU < 0) { // check if SFD found
  bit_buffer <<= 1; // shift the buffer
  bit_buffer |= symbol & 1; // set LSB = received symbol
  if ((bit_buffer ^ SFD) == 0) { // check if buffer equals SFD
  start_FDU = rx_buffer_ptr; // SFD found
}
```

Protocol structure so far



One link layer protocol: HDLC

- HDLC = High-level Data Link Control

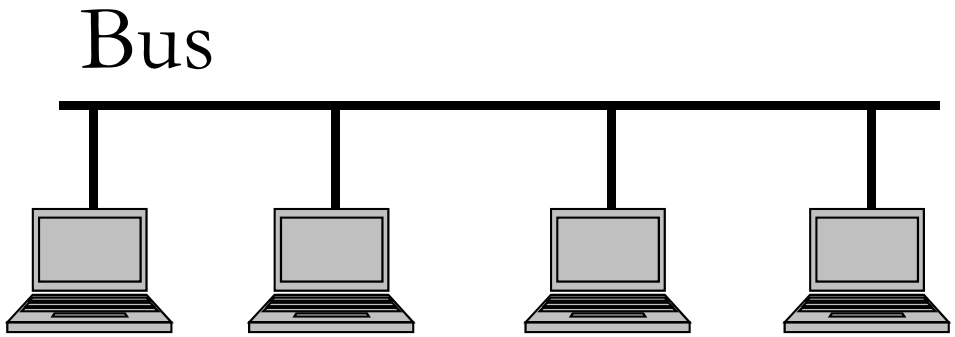


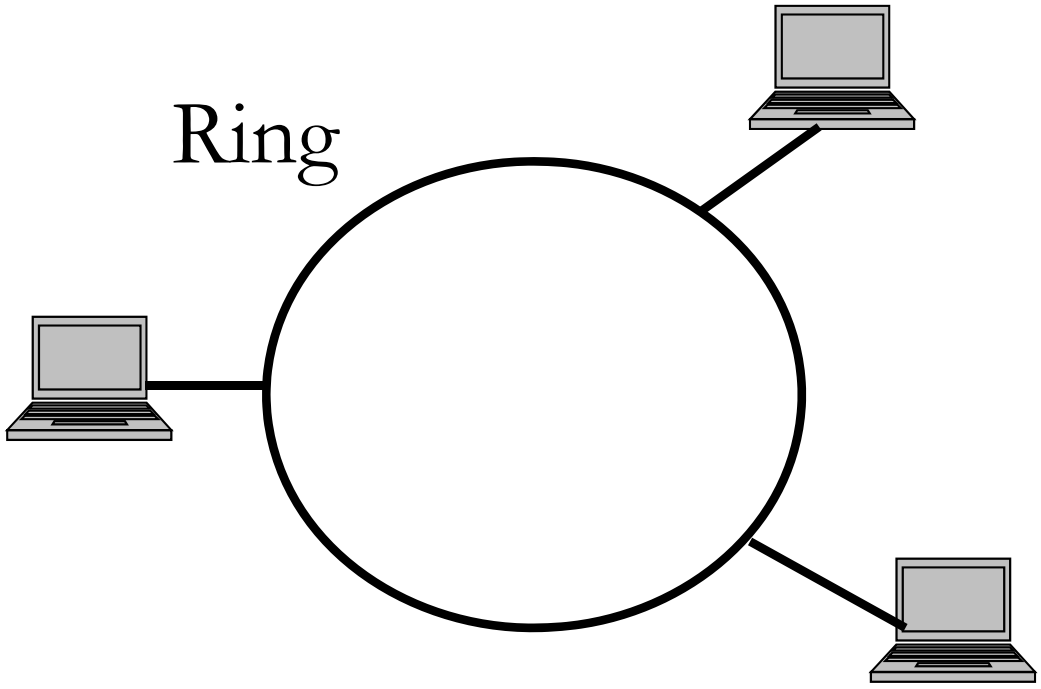
Flag = 01111110

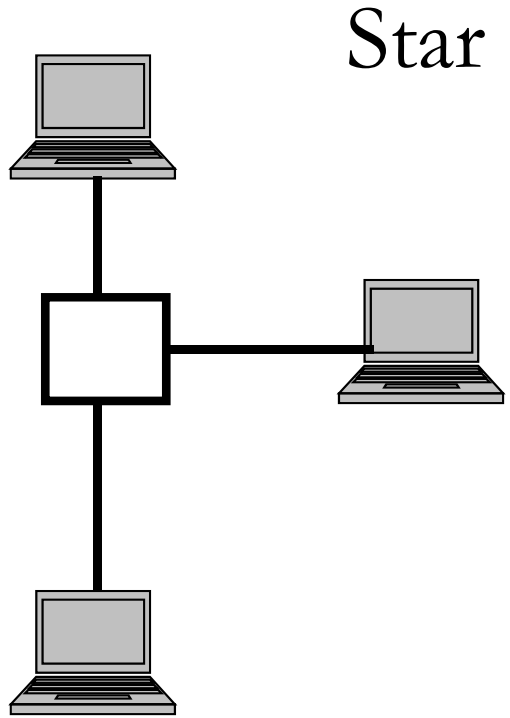
16 or 32 bits CRC

Go-back-N or Selective-repeat ARQ

Link topologies

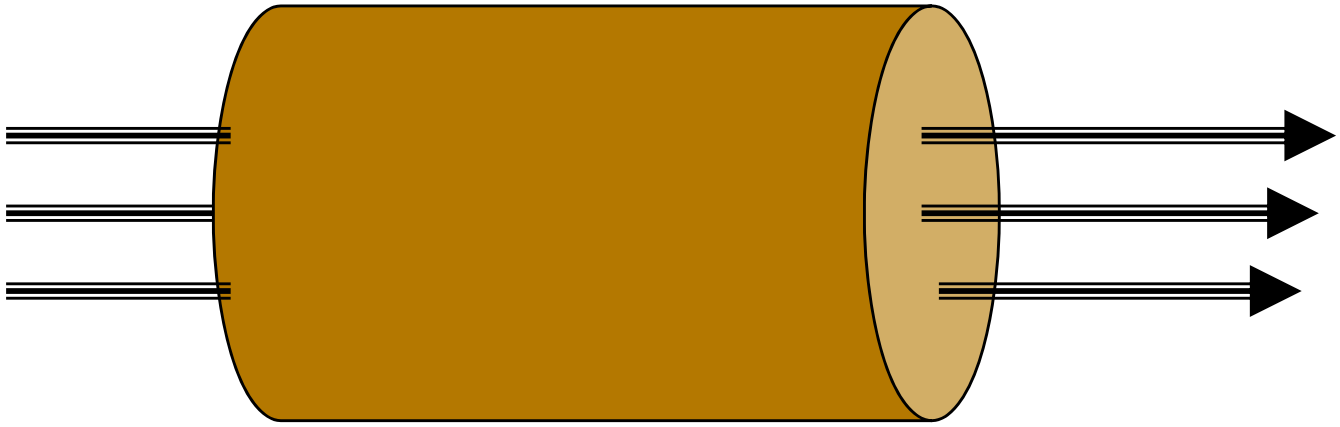






Generic multiplexing

Allocate channels in the available transmission medium

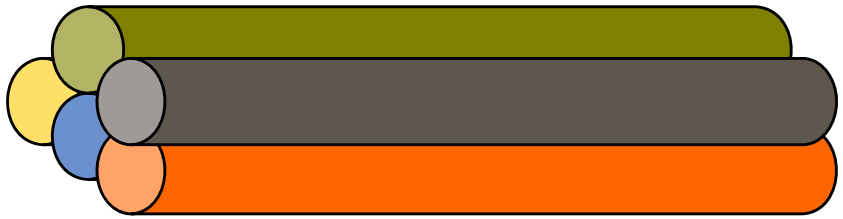


Multiplexing

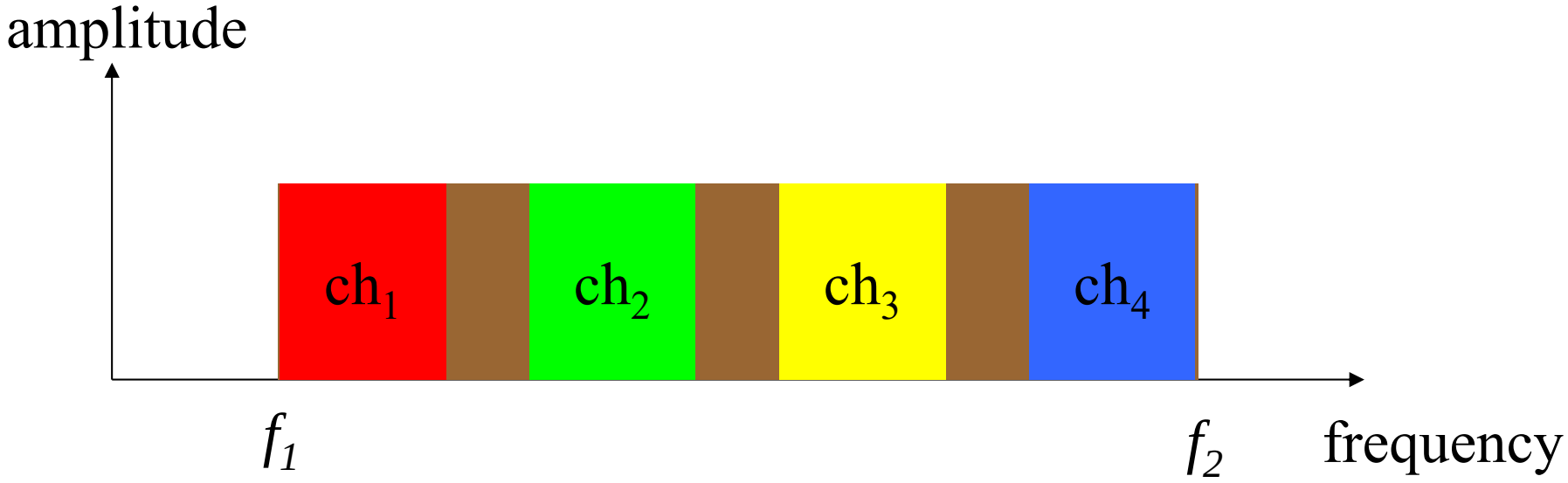
1. Spatial multiplex
2. Frequency multiplex (FDM)
3. Time multiplex (TDM)
   - ⌘ Synchronous
   - ⌘ Statistical
4. Code division multiplexing (CDM)

Spatial multiplex

Individual pairs or fibres are bundled in one cable



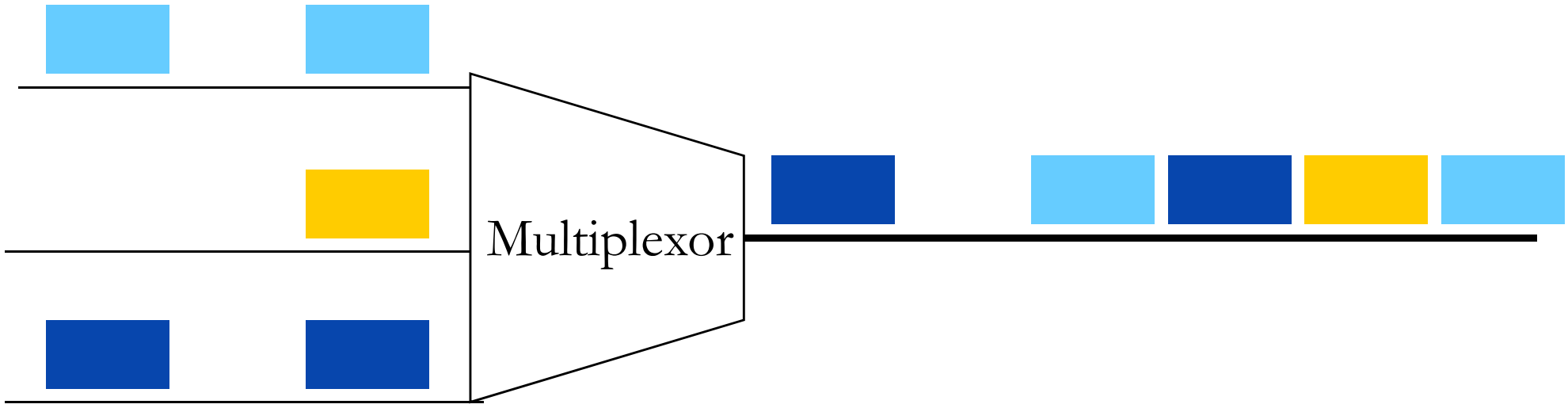
Frequency division multiplex



Each channel uses a its own frequency band

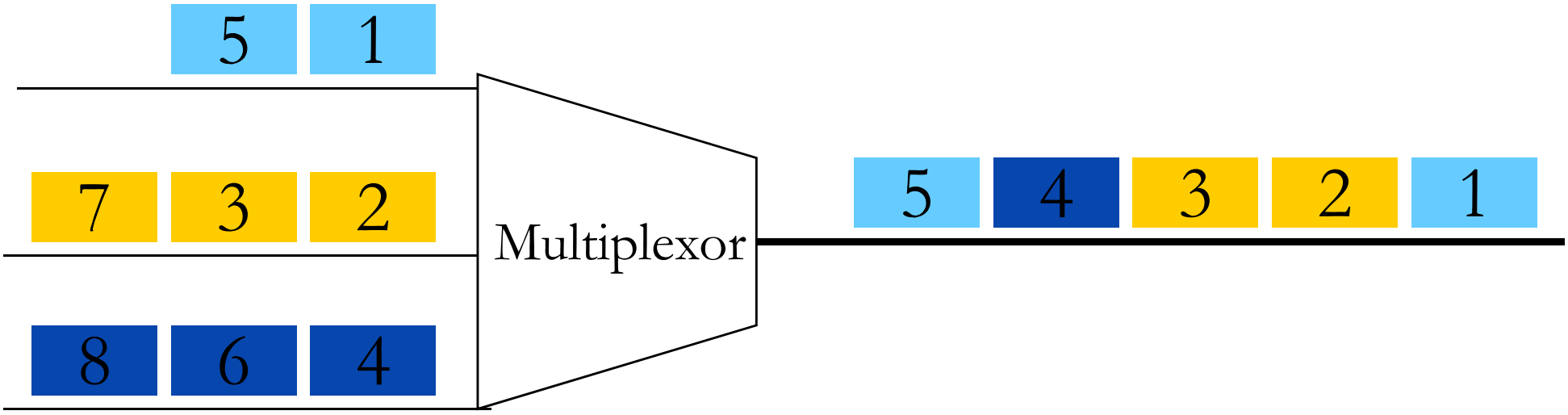
Synchronous time division multiplex

- Forwards one frame per channel in round robin
- If channel has nothing to send, corresponding time slot is i empty.



Statistical time division multiplexing

- Frames are transmitted as they arrive.
- Need buffering if outgoing link is occupied.
- Need ‘address’ for channel identification

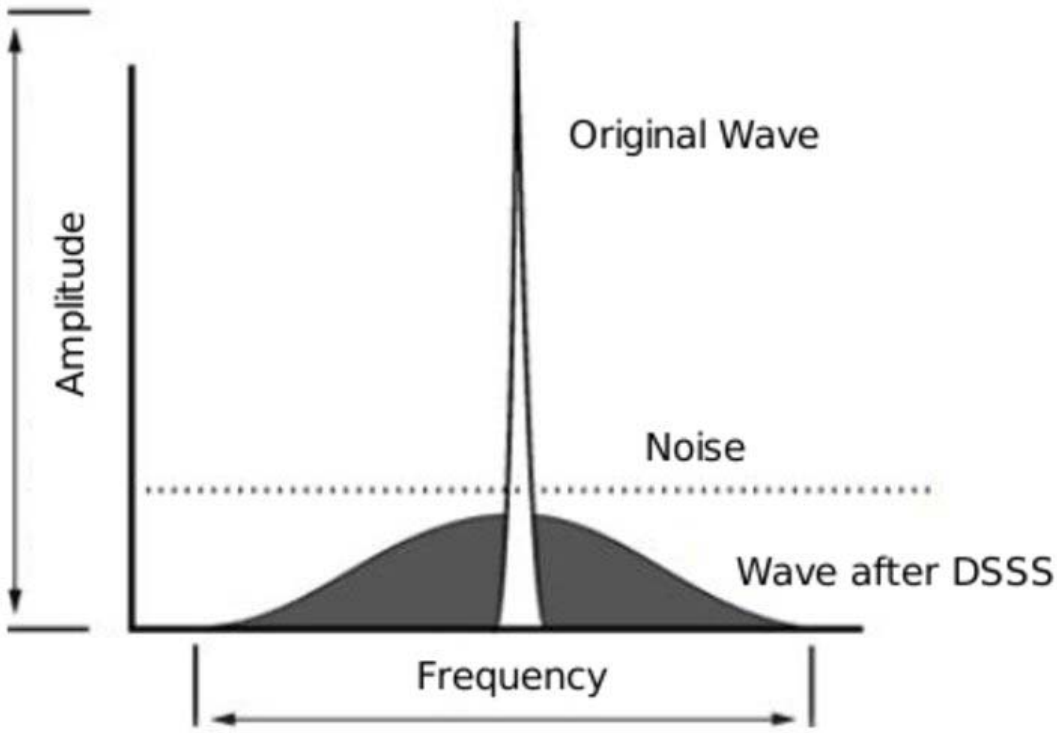


Code division multiplex

- Works only on wireless links
- Stations share frequency band
- Each station separated by code (pseudo noise or chip sequence)

Direct Sequence Spread Spectrum (DSSS)

- Multiply signal with pseudo noise (PN)
- Signal spread out
- Receiver multiplies with same PN, brings original signal back



Frequency Hop Spread Spectrum (FHSS)

- Signal's frequency changes rapidly in pseudo random order
- Transmitter and receiver must be in synch.
- Example: Bluetooth changes fq 1600 times per second
- Adaptive FHSS: Avoid crowded fqs

Hedy Lamarr

Spread Spectrum for multipel access

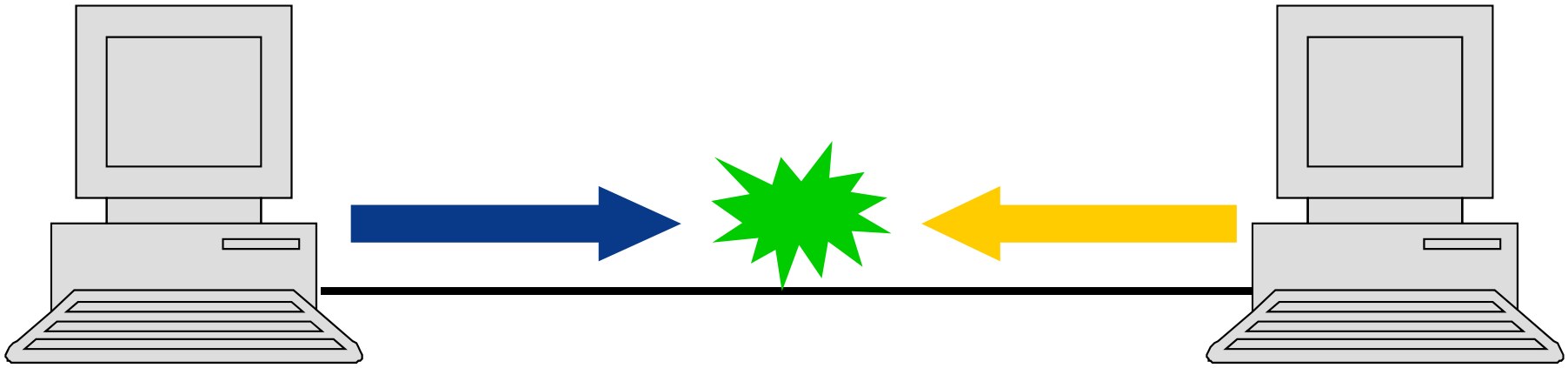
DS-CDMA:

- Turn PN into code (chip sequence)
- Each station gets its own unique chip sequence

FH-CDMA

- Hopping sequence is code

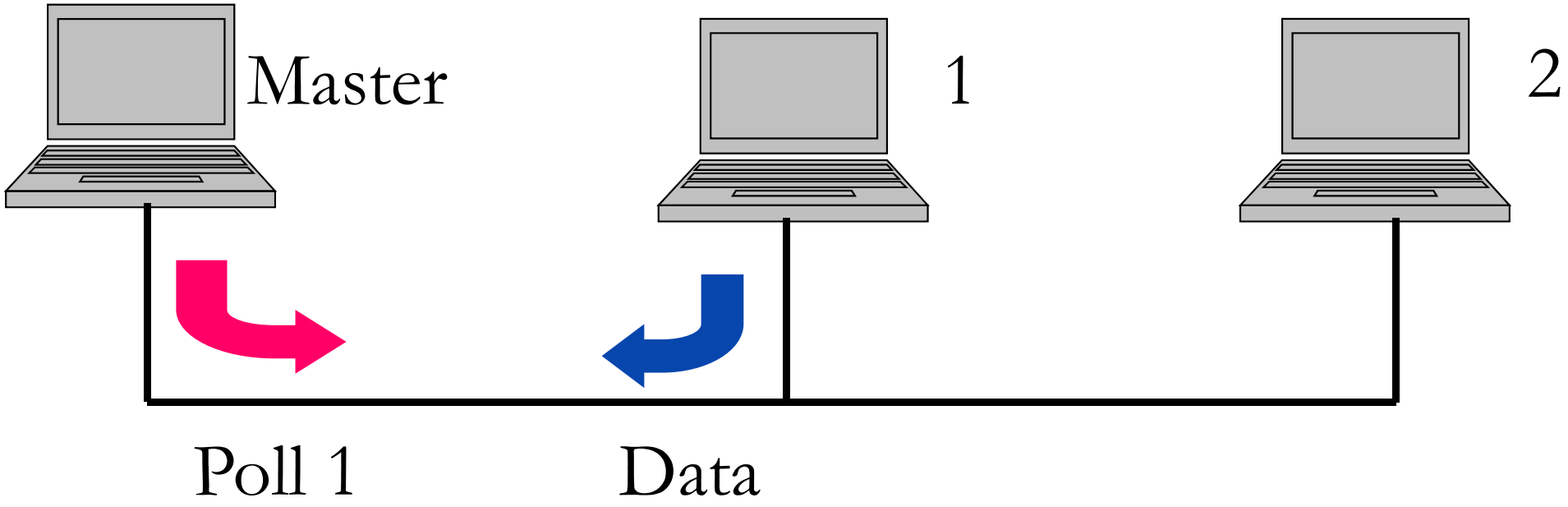
Access methods



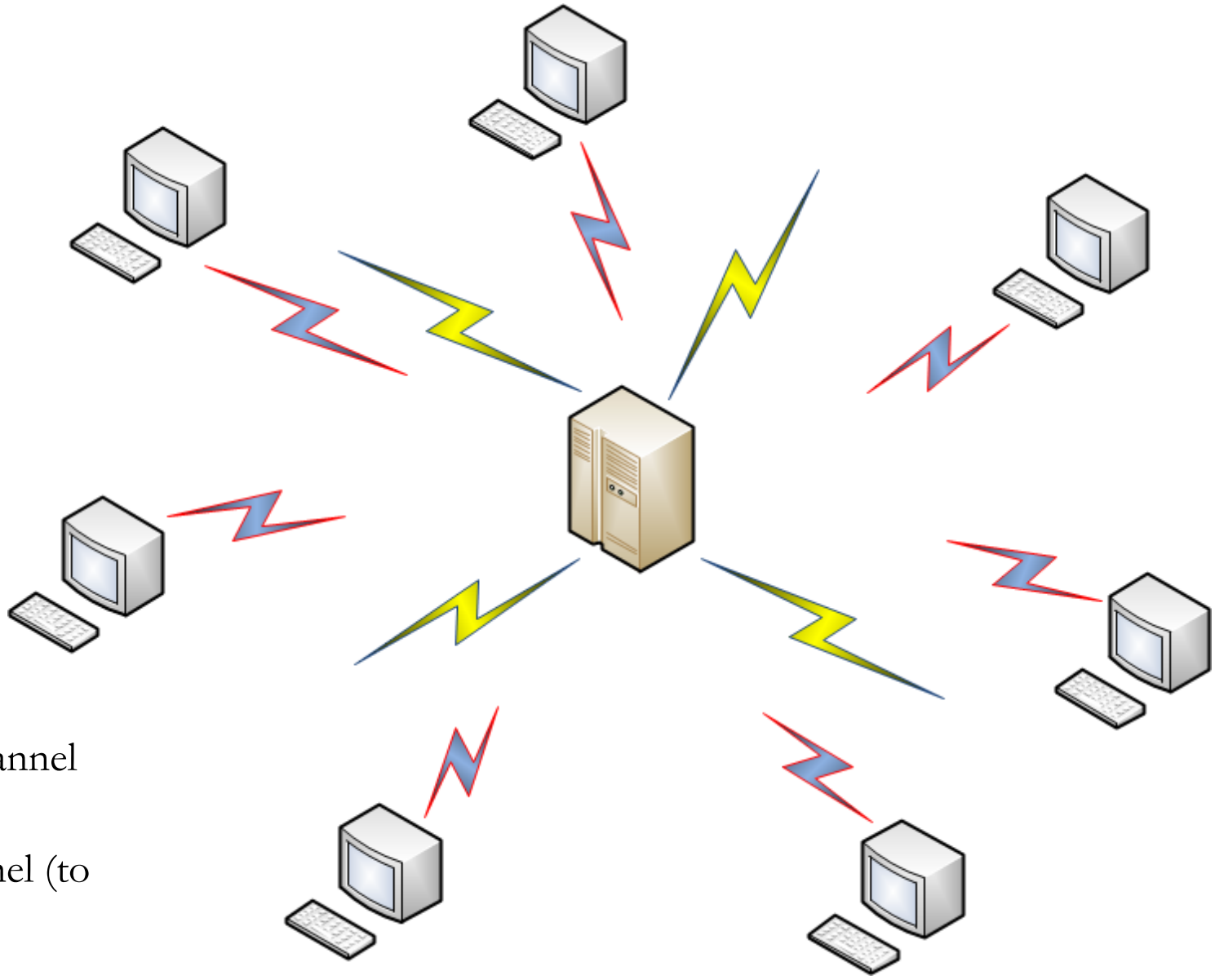
Multiple access requires ordered access!

Polling

Master/slave configuration



ALOHA



Yellow=Broadcast channel (from central node)

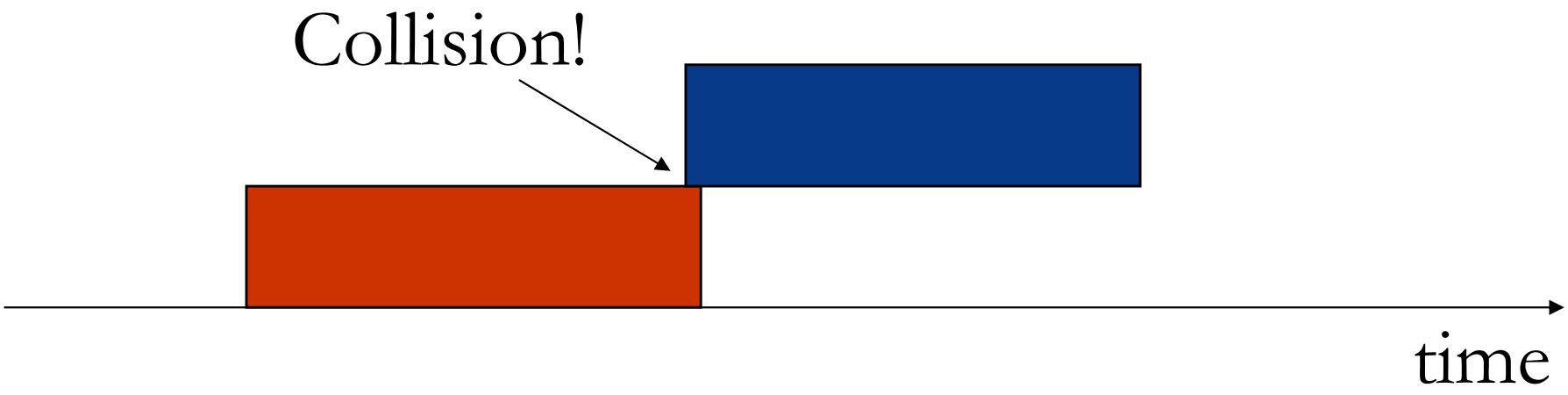
Blue=Common channel (to central node)

University of Hawaii (1971)

ALHOA access method

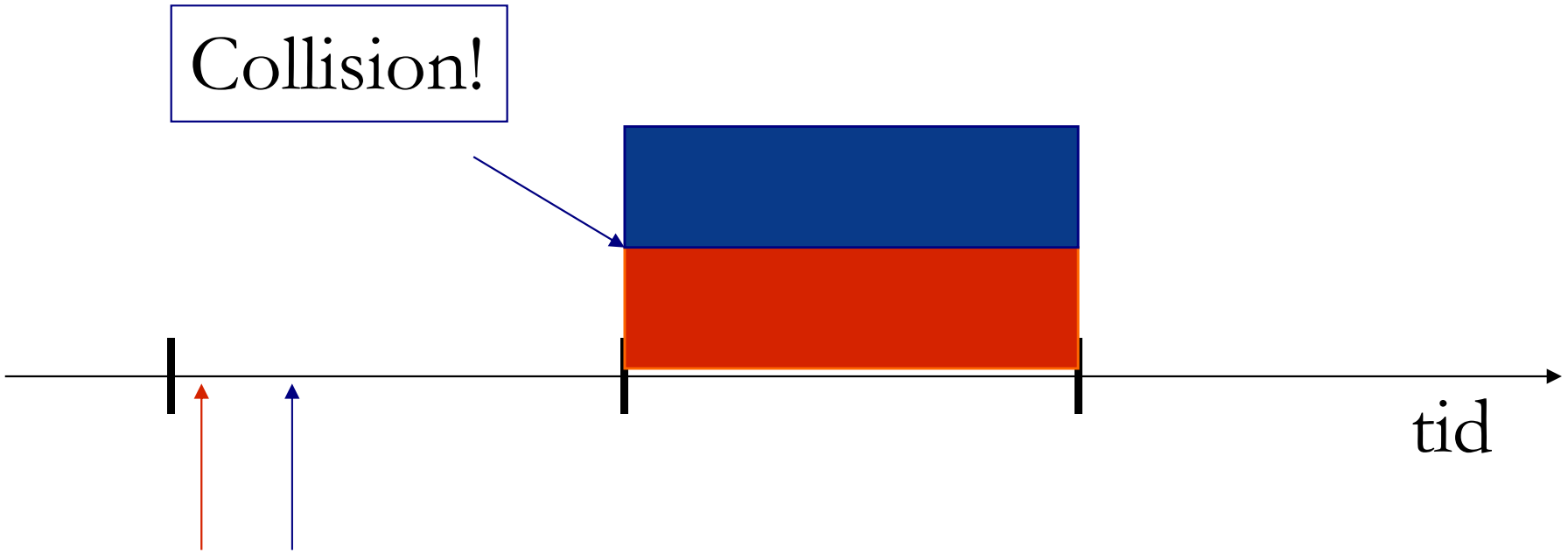
- Two channels
  - One from central node (simplex)
  - One from all remote nodes (half duplex)
- Any remote node can send at will
  - Await ACK.
  - If no ACK within time retransmit
- Collisions at central node!!!
  - Remote nodes cannot hear each other!!!

Pure ALOHA



Collision possible 2 * transmission time

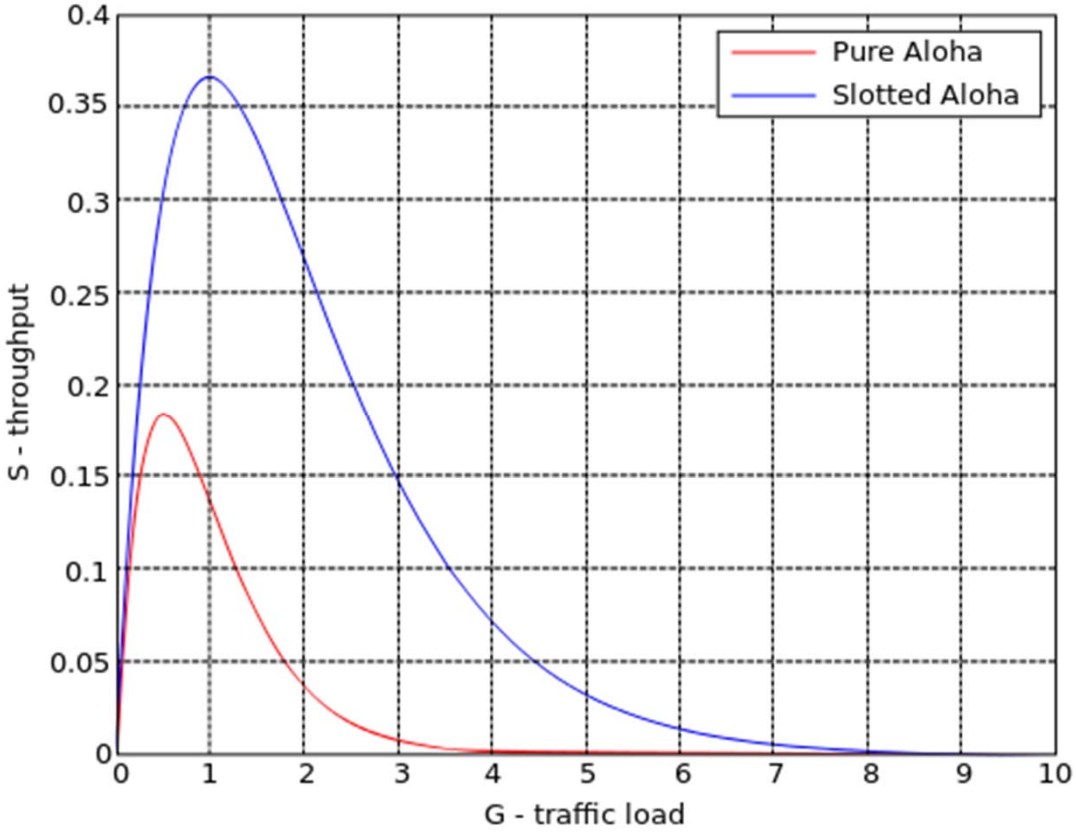
Slotted Aloha



Collision possible 1 * transmission time

ALOHA thruput

- Pure: approx 18%
- Slotted: approx 36%



Carrier Sense Multiple Access (CSMA)

CS: Listen before transmit

- If busy, wait and try again
- Requirement: All stations must hear each other

CSMA/CD

- CD: Collision Detection
- Listen for collision while transmitting
- Works only in wired environment

CSMA/CA

- CA: Collision avoidance
- Request channel before sending
- RTS/CTS (master/slave)

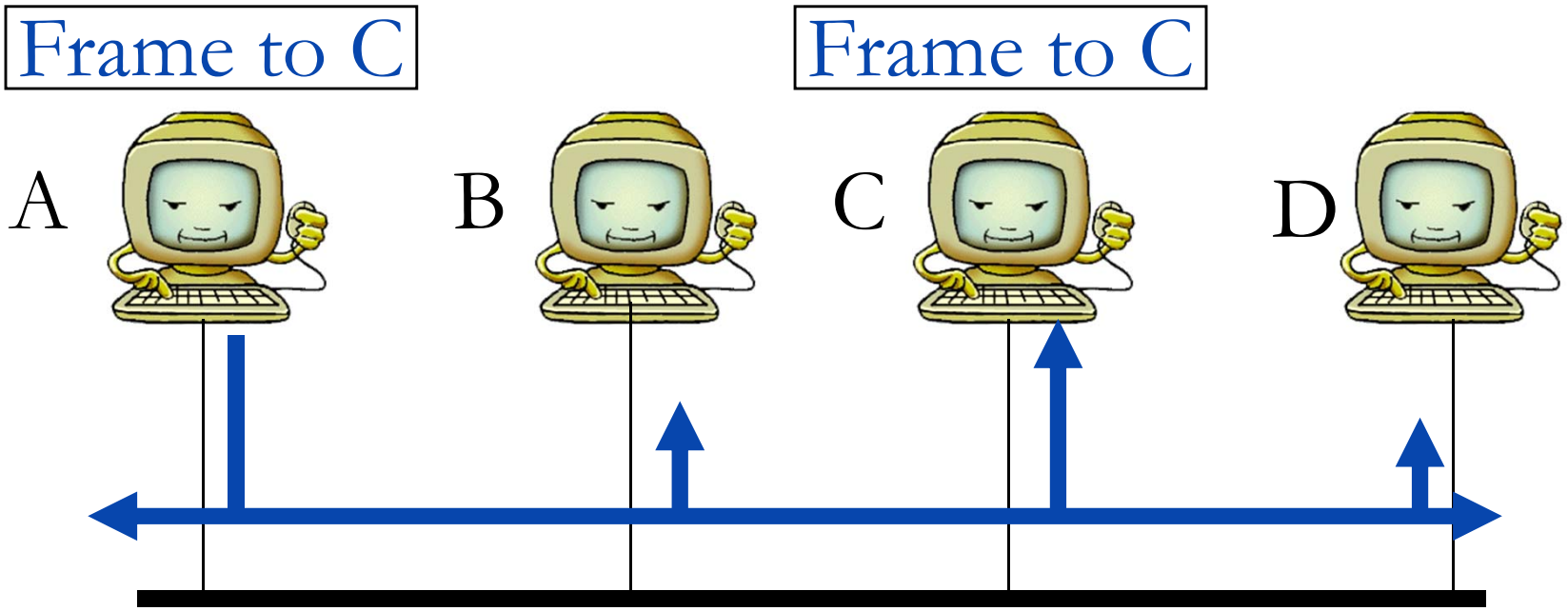
Token Ring

- Data transmitted in one direction in the circle
- Token (small frame) sent round the circle
- Station that has the token can send data

Orthogonal Frequency Division Multiple Access (OFDMA)

- The sub-carriers divided between stations
- Each station has a unique set of sub-carriers
- Base station can send to all remote stations in one OFDM symbol

The need for addresses

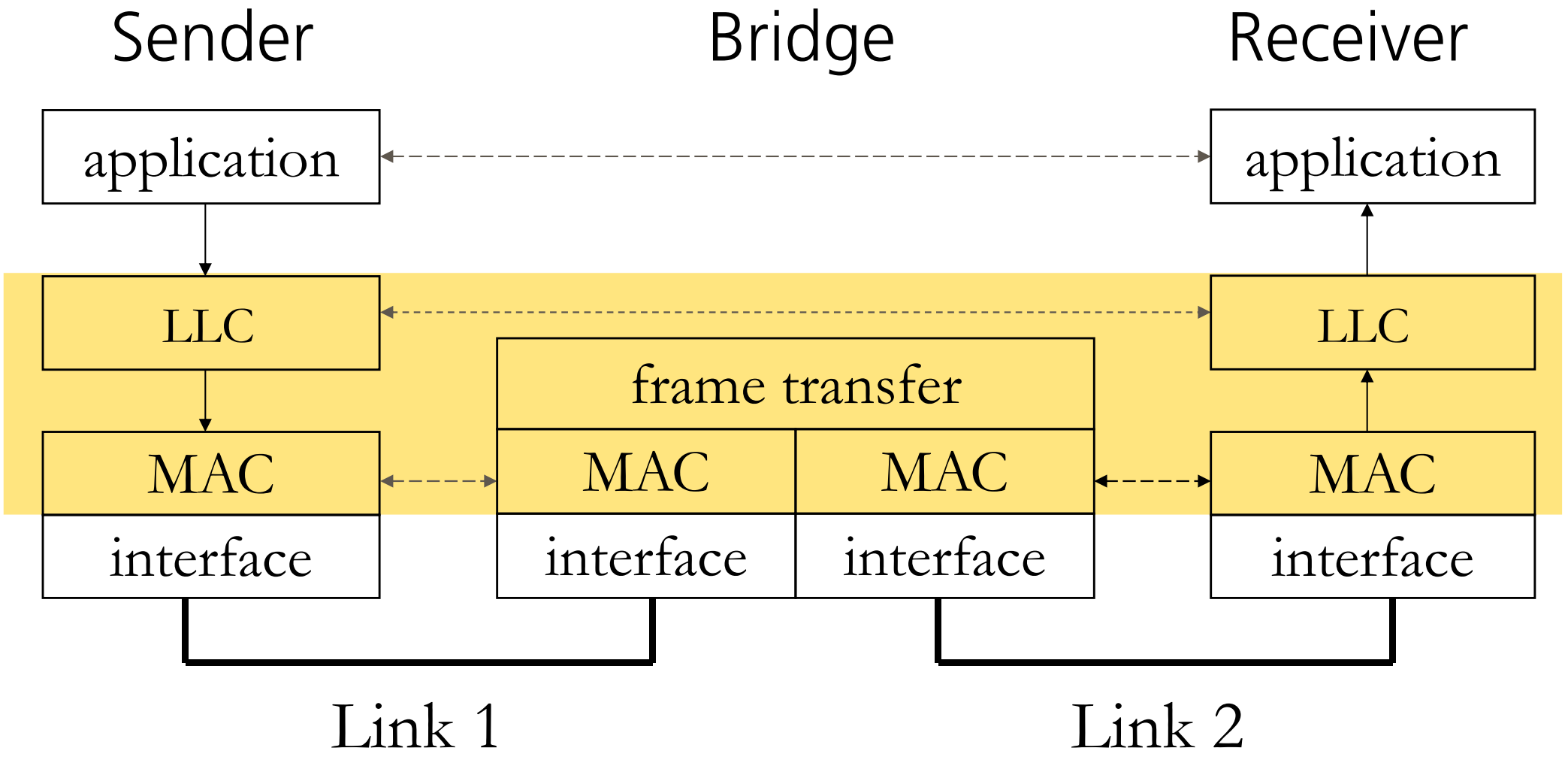


- All stations must have a unique address.
- All stations receives frame.
- Only addressed station handle the frame

Domains

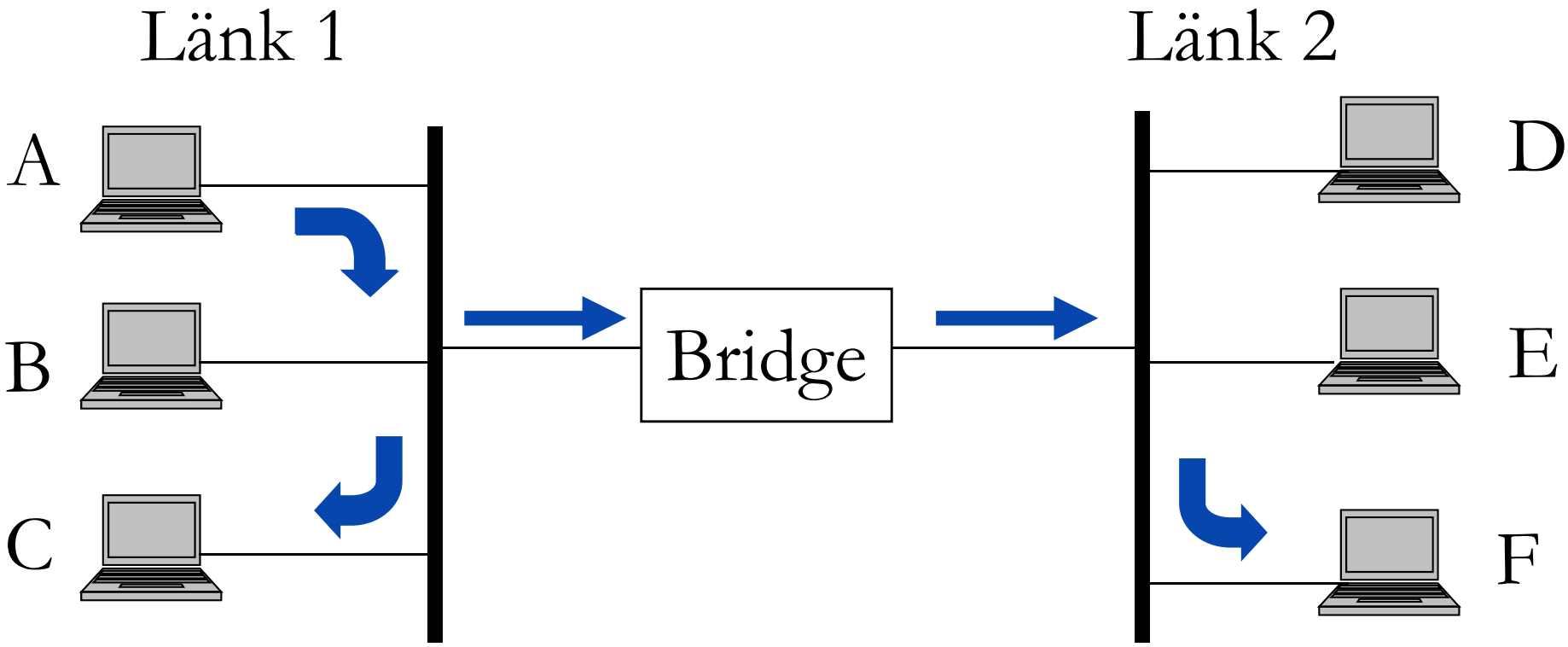
- Collision domain
  - Every station are effected by the same collision
  - Number of (busy) stations in a domain affects throughput
- Broadcast domain
  - Every station receives the same broadcast message
  - Alas: there exists a broadcast address!
  - Number of stations/broadcasts in a domain affects throughput

A Bridge breaks collision domain



A bridge recognises frames!

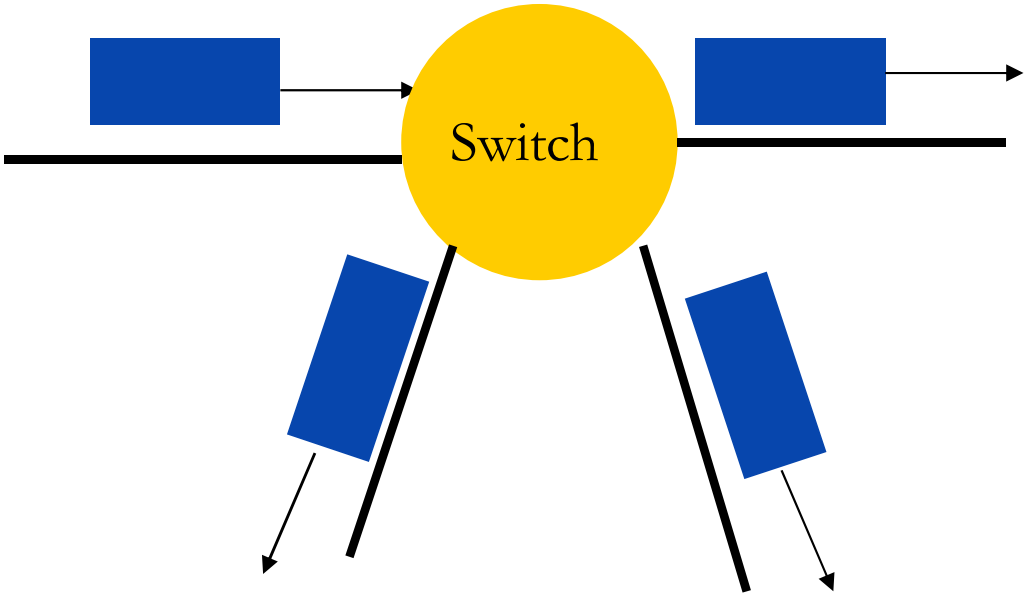
A simple switch: The Transparent Bridge



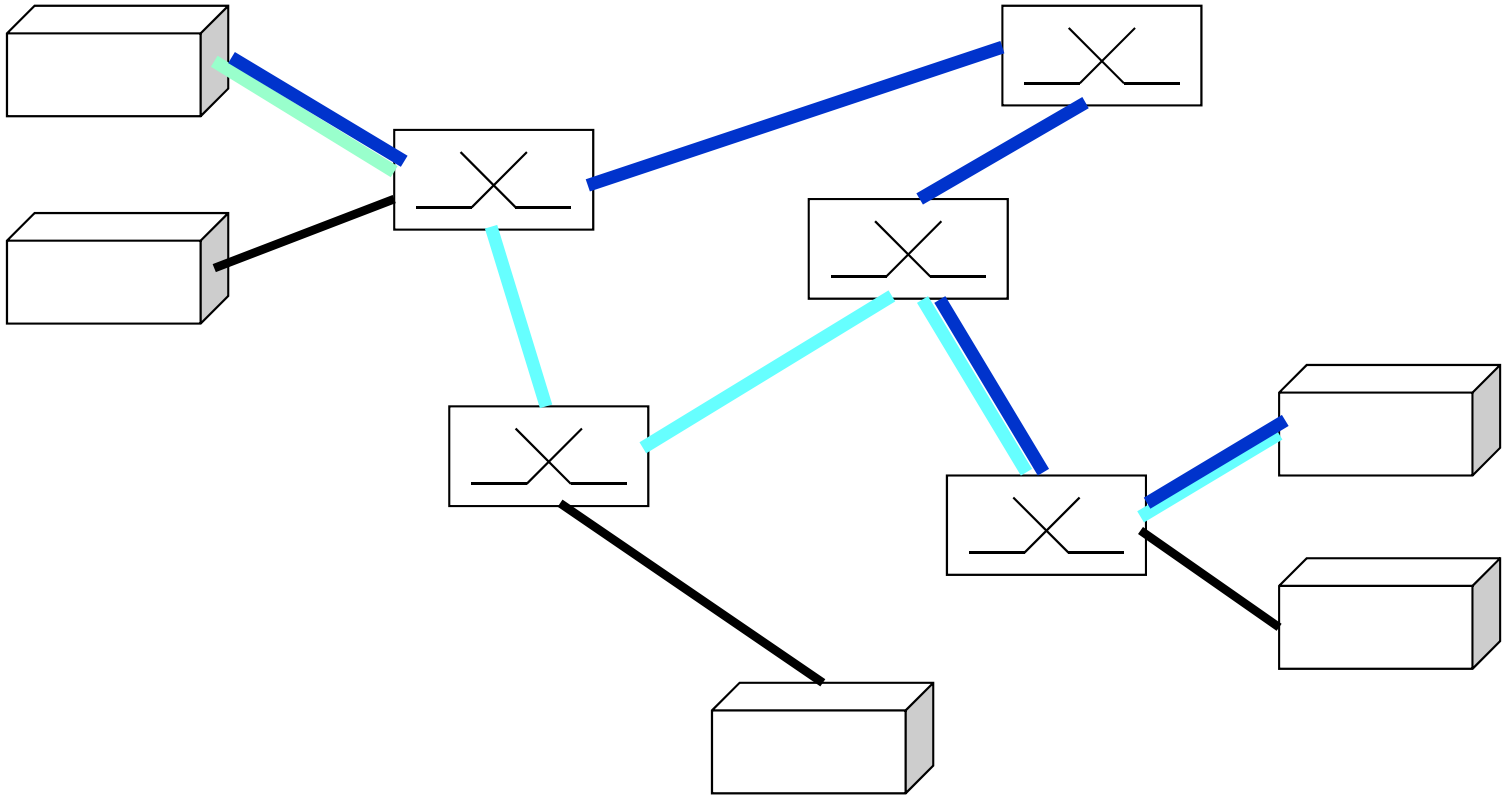
- Frames address to unknown receivers have to be flooded.
- Broadcast must be flooded!

Flooding

- Incoming frames are copied out on all other ports.
- To break loops: All frames must have a hop counter.

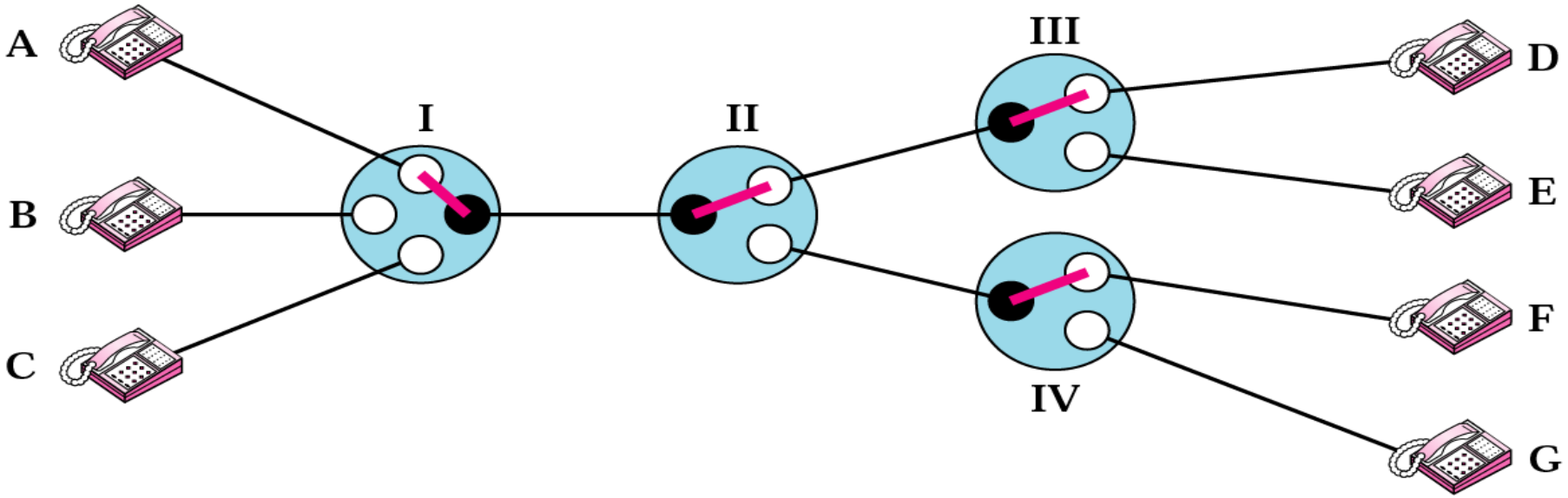


Switches selects routes?

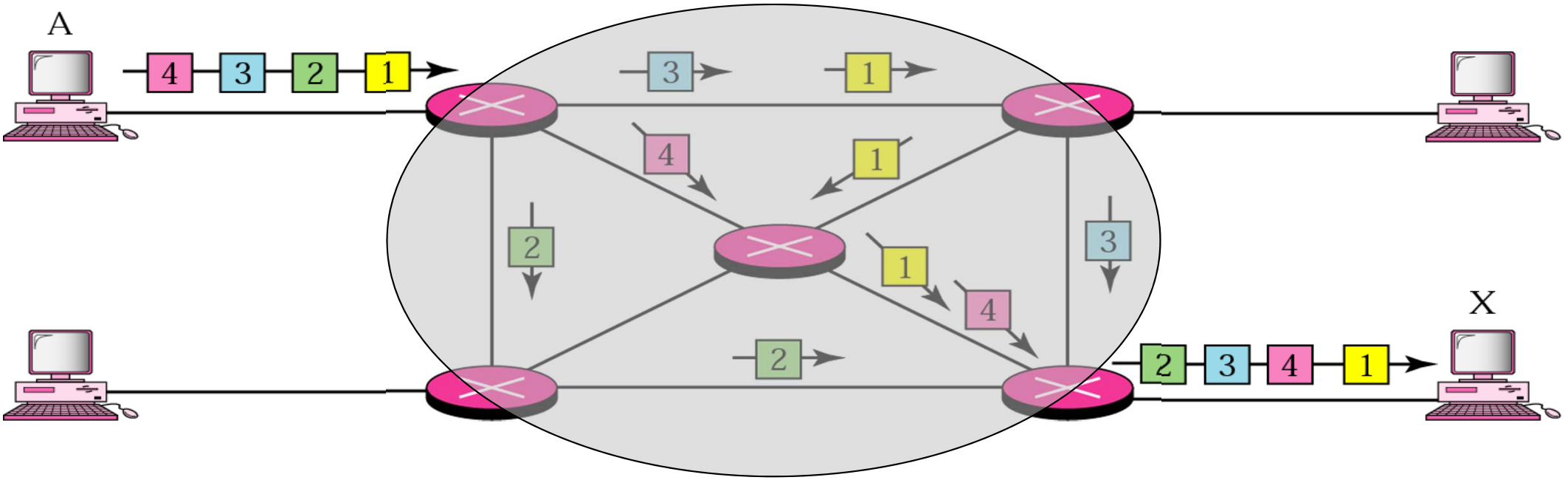


- In networks there might (preferable) exist mutliple paths.
- Switches must keep track of all stations!

Circuit switching



Packet Switching

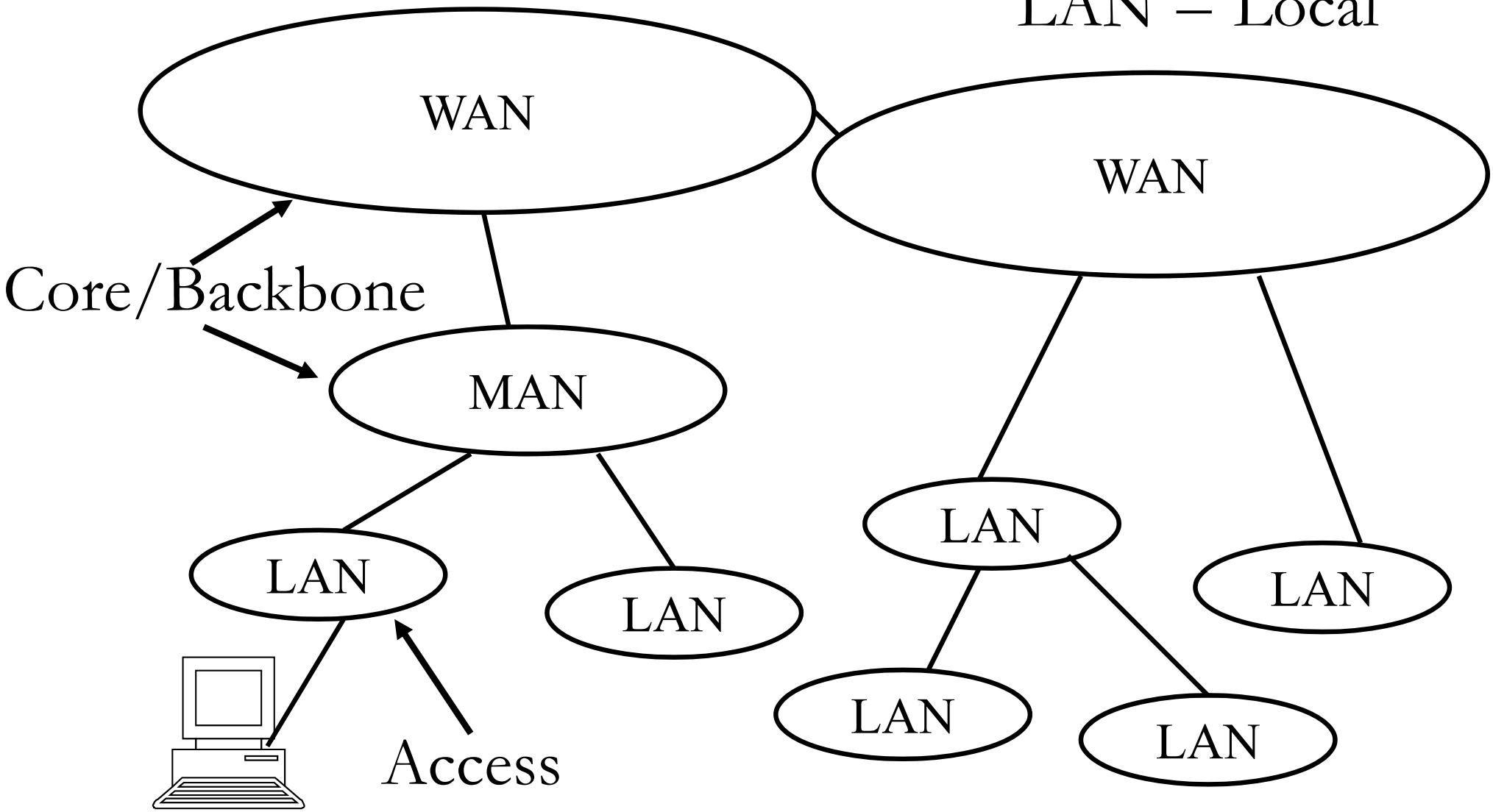


Network structures

WAN = Wide

MAN = Metropolitan

LAN = Local



Network structures (cont …)

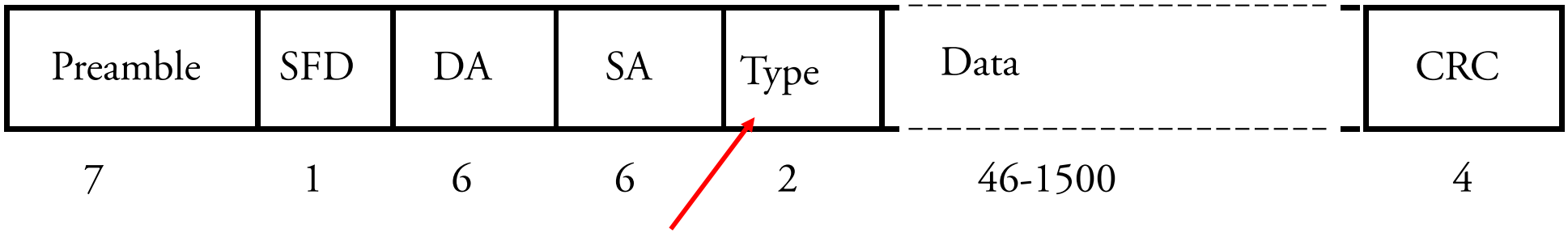
- Not very well defined …
- A local backbone can be seen as core in another context
- The ISP's access network stops at the CPE. This is were your own access netwwork terminates. (CPE = Customer Premises Equipment)

One Link Protocol: IEEE 802

- IEEE 802.2 = Logical Link Control
- IEEE 802.3 = Wired Ethernet
  - Physical (CSMA/CD) and MAC (Ethernet frame) layers
  - 802.3i: 10 Mb/s, twisted pair, max 100m
  - 802.3ab: 1000Mb/s, twisted pair, max 100m
- IEEE 802.11 = Wireless Ethernet
  - a, b, g, n …
- IEEE 802.15.1 = Bluetooth
- IEEE 802.15.4 = ZigBee

Ethernet, wired

- Ethernet developed by Xerox, Intel and DEC 1976.
- IEEE 802.3 is based on Ethernet.
  - Ethernet version II is included in IEEE802.3
  - Differences in the frame format but can co-exist on same link as 802.3.



SFD=Start frame delimiter DA=Destination address SA=Source address

Ethernet frame, bit view

…… 10101010 10101010 10101010 10101010 10101010 10101010 10101011
11111111 11111111 11111111 11111111 11111111 11111111 00001000 01100000
01101110 01111010 10100110 10100100 00001000 00000000 01000101 00000000
00000000 01000100 00001110 01111001 00000000 00000000 10000000 00010001
10010001 00010001 10000010 11101011 11001001 01001000 10000010 11101011
11001011 11111111 11000101 10101010 00000111 10011011 00000000 00110000
10001110 00000001 01010000 01011010 00111000 01110000 01100001 01101101
01001000 00111000 01111010 01100101 01011010 01110100 01110100 01001111
01101111 01111010 01011000 01100101 00110110 01001110 01000010 01010010
01101011 01000100 01001100 01001001 01110011 01100101 01001001 01010010
01110101 01110111 01001100 01100100 01101011 00110110 01110011 01110101
00111000 01000001

Ethernet frame, hex view

```
… … … aa aa aa ab
ff ff ff ff ff ff 08 60  6e 7a a6 a4 08 00 45 00
00 44 0e 79 00 00 80 11  91 11 82 eb c9 48 82 eb
cb ff c5 aa 07 9b 00 30  8e 01 50 5a 38 70 61 6d
48 38 7a 65 5a 74 74 4f  6f 7a 58 65 36 4e 42 52
6b 44 4c 49 73 65 49 52  75 77 4c 64 6b 36 73 75
38 41
```

Ethernet Types

Note	Hex	
@	0000-05DC	IEEE802.3 Length Field (0.:1500.)
+	0101-01FF	Experimental
	0200	Xerox PUP (conflicts with 802.3 Length Field range) (see 0A00)
	0201	Xerox PUP Address Translation (conflicts ...) (see 0A01)
	0400	Nixdorf (conflicts with 802.3 Length Field)
+*	0600	Xerox NS IDP
	0601	XNS Address Translation (3Mb only)
+*	0800	DOD Internet Protocol (IP)
+	0801	X.75 Internet
+	0802	NBS Internet
+	0803	ECMA Internet
+	0804	CHAOSnet
+	0805	X.25 Level 3
+*	0806	Address Resolution Protocol (ARP) (for IP and for CHAOS)
	0807	XNS Compatibility
	081C	Symbolics Private
+	0888-088A	Xyplex
	0900	Ungermann-Bass network debugger
	0A00	Xerox IEEE802.3 PUP
	0A01	Xerox IEEE802.3 PUP Address Translation

Ethernet Vendor Codes

```
000001    SuperLAN-2U
000002    BBN (was internal usage only, no longer used)
000009    powerpipes?
00000C    Cisco
00000E    Fujitsu
00000F    NeXT
000010    Hughes LAN Systems (formerly Sytek)
000011    Tektronix
000015    Datapoint Corporation
000018    Webster Computer Corporation  Appletalk/Ethernet Gateway
00001A    AMD (?)
00001B    Novell (now Eagle Technology)
00001C    JDR Microdevices              generic, NE2000 drivers
00001D    Cabletron
00001F    Cryptall Communications Corp.
000020    DIAB (Data Intdustrier AB)
000021    SC&C (PAM Soft&Hardware also reported)
000022    Visual Technology
000023    ABB Automation AB, Dept. Q
000024    Olicom
000029    IMC
00002A    TRW
00002C    NRC - Network Resources Corporation - MultiGate Hub1+, Hub2, etc
000032    GPT Limited (reassigned from GEC Computers Ltd)
000037    Oxford Metrics Ltd
00003B    Hyundai/Axil                          Sun clones
```

Ethernet (cont…)

- Max payload 1500 bytes
  - Newer standards allows for jumbo frames (9000 bytes)
- Min payload 46 bytes
  - There is a good reason!
  - No ARQ defined for Ethernet
  - Sender has to detect collisions on the frame that is currently transmitted.

Ethernet, wireless

- First standard published 1997
- Two modes
  - Base station
  - Ad Hoc
- CSMA/CA
- Frame format extended compared with IEEE 802.3
  - Same address format

Ethernet thruput