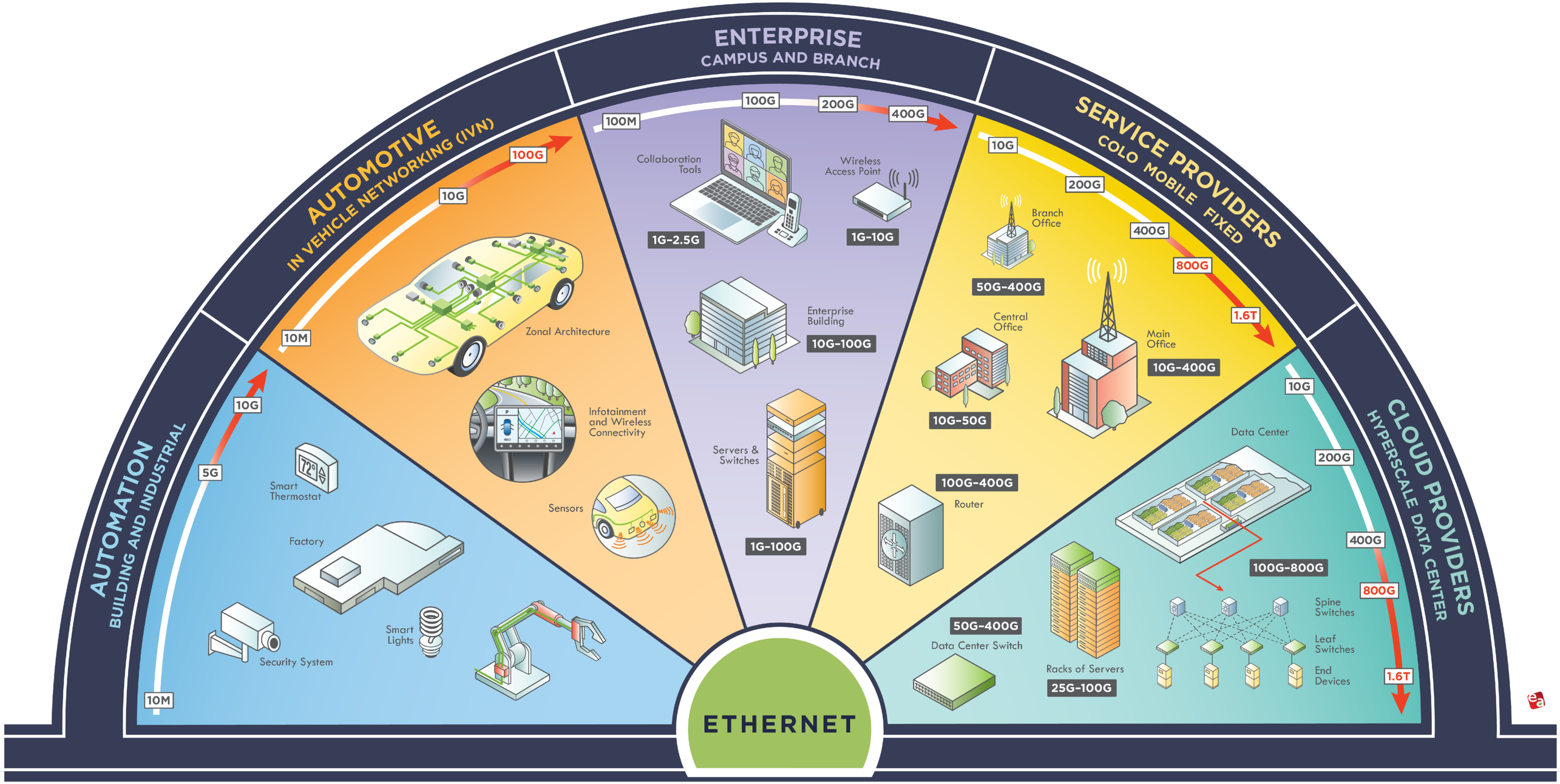
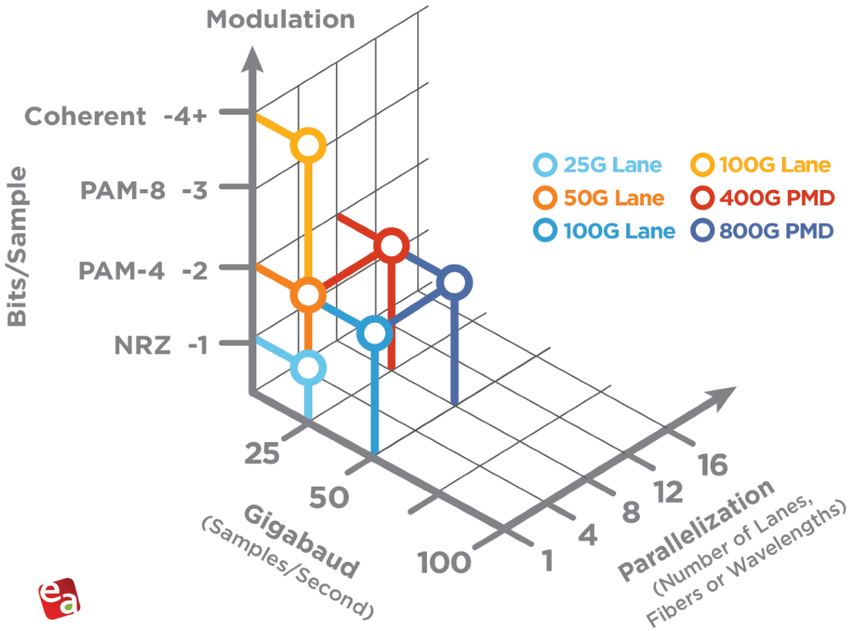
CS 725/825 & IT 725
Lecture 24
Link Layer

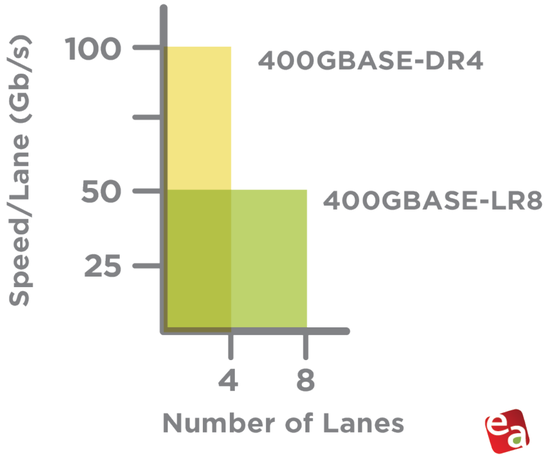
December 4, 2023

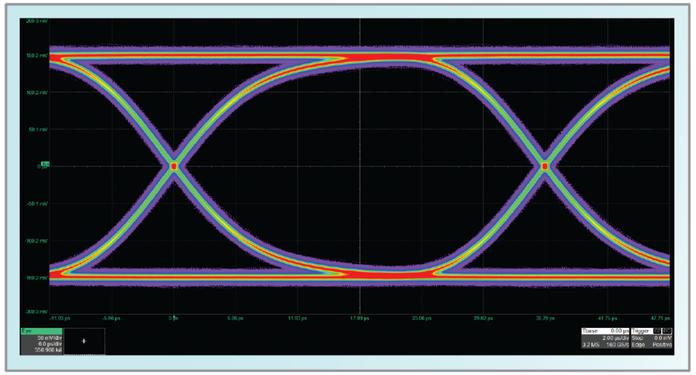


Source: Ethernet Alliance (www.ethernetalliance.org) 2023 Ethernet Roadmap

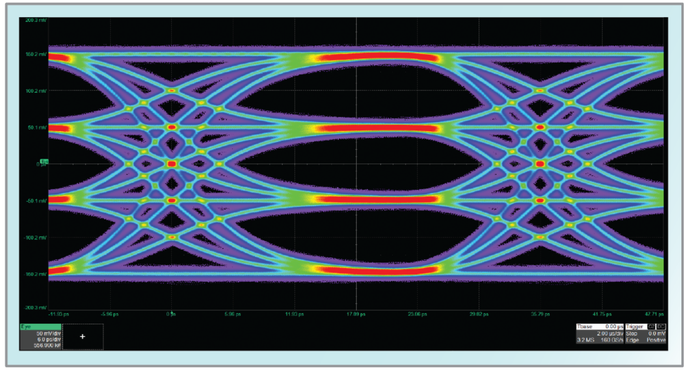
Fatter Pipes



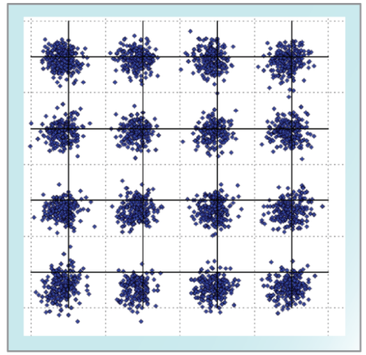




NRZ



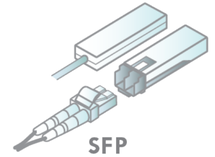
PAM-4

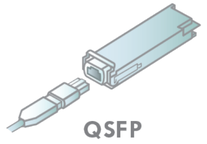


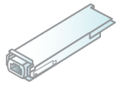
Coherent

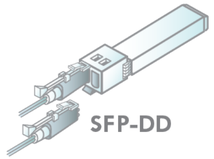
Source: Ethernet Alliance (www.ethernetalliance.org) 2023 Ethernet Roadmap

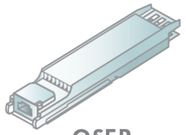
	Backplane	Twinax Cable	15-40m(OT) Single Twisted Pair	>100m (OT) Single Twisted Pair	100m (IT) Twisted Pair (2/4 Pair)	MMF	500m PSM4	2km SMF	10km SMF	20km SMF	40km SMF	80km SMF	Electrical Interface	Pluggable Module
10BASE–	T1S		T1S	T1L	T									
100BASE–			T1	T1L*	T									
1000BASE–			T1		T									
2.5GBASE–	KX		T1		T									
5GBASE–	KR		T1		T									
10GBASE–			T1		T				BIDI Access	BIDI Access	BIDI Access			
25GBASE–	KR1 KR	CR1 CR/CR-S	T1		T (30m)	SR			LR EPON BIDI Access	EPON BIDI Access	ER BIDI Access		25GAUI	SFP
40GBASE–	KR4	CR4			T (30m)	SR4/eSR4	PSM4	FR	LR4				XLAUI XLPPI	QSFP
50GBASE–	KR2 KR	CR2 CR	T2			SR		FR	EPON BIDI Access LxR	EPON BIDI Access	BIDI Access ER		LAUI-2/50GAUI-2 50GAUI-1	SFP/QSFP
100GBASE–	KR4 KR2 KR1	CR10 CR4 CR2 CR1	T4			SR10 SR4 SR2 VR1 SR1	PSM4 DR	CWDM4 FR1	LR4 4WDM-10 LR1	4WDM-20	ER4 4WDM-40	ZR	CAUI-10 CPPI CAUI-4/100GAUI-4 100GAUI-2 100GAUI-1	SFP QSFP/QSFP-DD OSFP
200GBASE–	KR4 KR2	CR4 CR2 CR1*				SR4 VR2 SR2	DR4 1pair*	FR4 1 pair*	LR4		ER4		200GAUI-4 200GAUI-2 200GAUI-1*	QSFP/QSFP-DD SFP-DD
400GBASE–	KR4*	CR4 CR2*				SR16 SR8/SR4.2 VR4 SR4	DR4 2 pair*	FR8 FR4 400G-FR4	LR8 LR4-6 400G-LR4-10		ER8	ZR	400GAUI-16 400GAUI-8 400GAUI-4 400GAUI-2*	QSFP/QSFP-DD OSFP
800GBASE-	ETC-KR8 KR8*	ETC-KR8 CR8* CR4*				VR8* SR8*	8 pair* 4 pair*	8 pair* 4 pair* 4 lambda*	TBD*		TBD*		800GAUI-8* 800GAUI-4*	
1.6TBASE-		CR8*					8 pair*	8 pair*					1.6TAUI-16* 1.6TAUI-8*	QSFP/QSFP-DD OSFP/OSFP-XD











Gray Text = IEEE Standard Red Text = In Task Force Green Text = In Study Group

Blue Text = Non-IEEE standard but complies to IEEE electrical interfaces * Note: As of publication, subject to change

Source: Ethernet Alliance (www.ethernetalliance.org) 2023 Ethernet Roadmap

Ethernet Frame

802.3 Ethernet frame structure

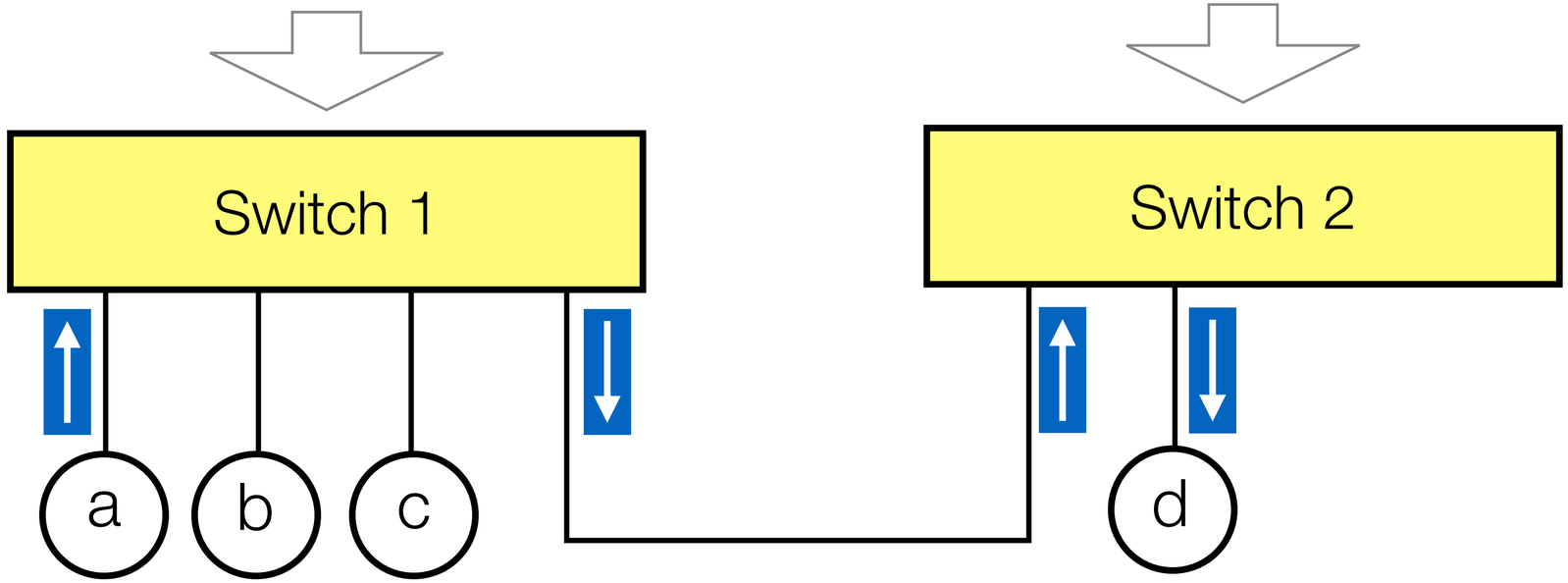
Preamble	Start of frame delimiter	MAC destination	MAC source	802.1Q tag (optional)	Ethertype (Ethernet II) or length (IEEE 802.3)	Payload	Frame check sequence (32-bit CRC)	Interframe gap
7 octets of 10101010	1 octet of 10101011	6 octets	6 octets	(4 octets)	2 octets	42[note 2]–1500 octets	4 octets	12 octets
		64–1522 octets						
72–1530 octets								
84–1542 octets								

Image source: Wikipedia article “Ethernet frame” (https://en.wikipedia.org/wiki/Ethernet_frame)

Unicast packet from a to d

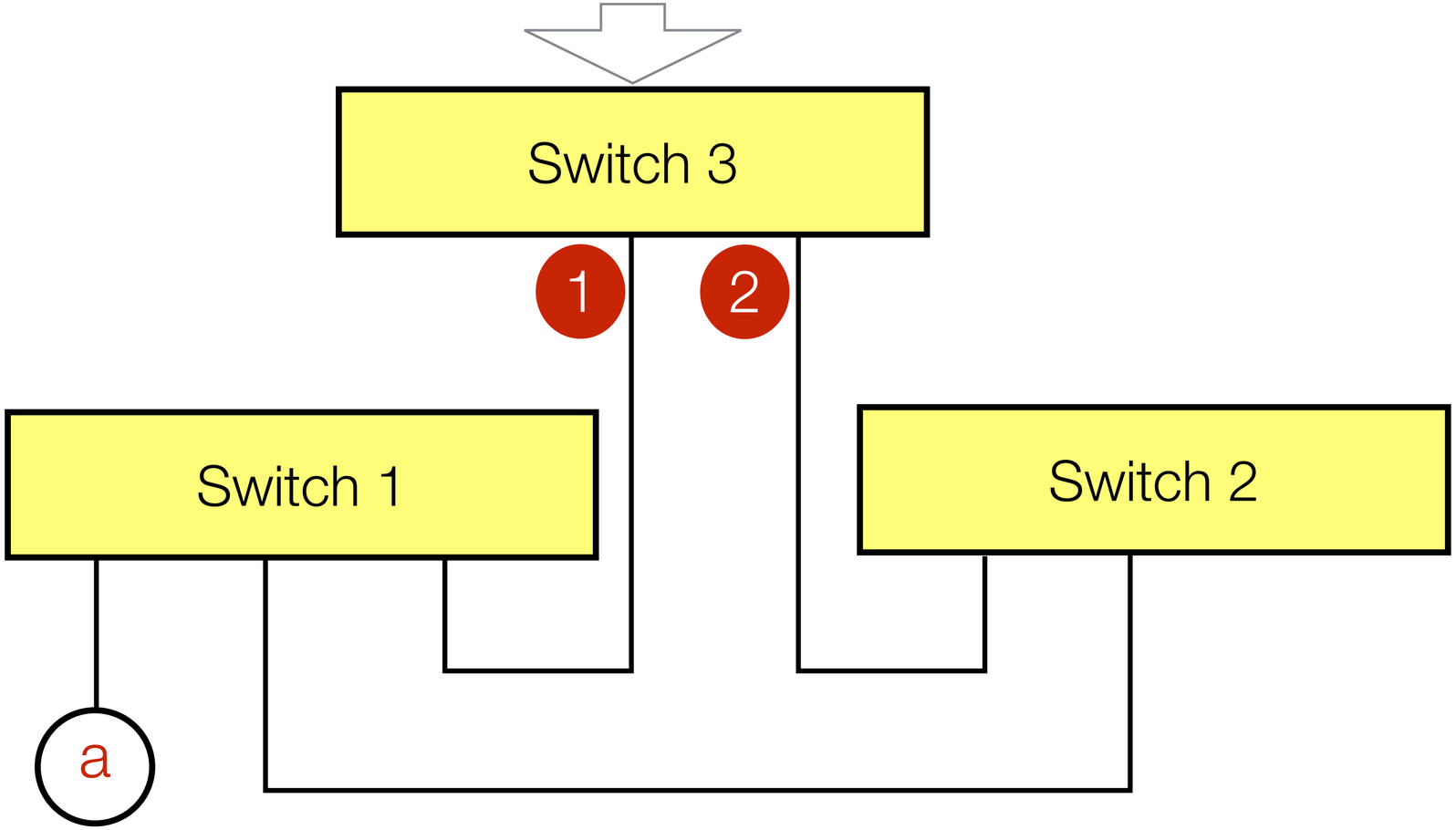
MAC	Interface
a	1
b	2
c	3
d	4

MAC	Interface
a	1
b	1
c	1
d	2



Loops?

MAC	Interface
a	1 or 2?

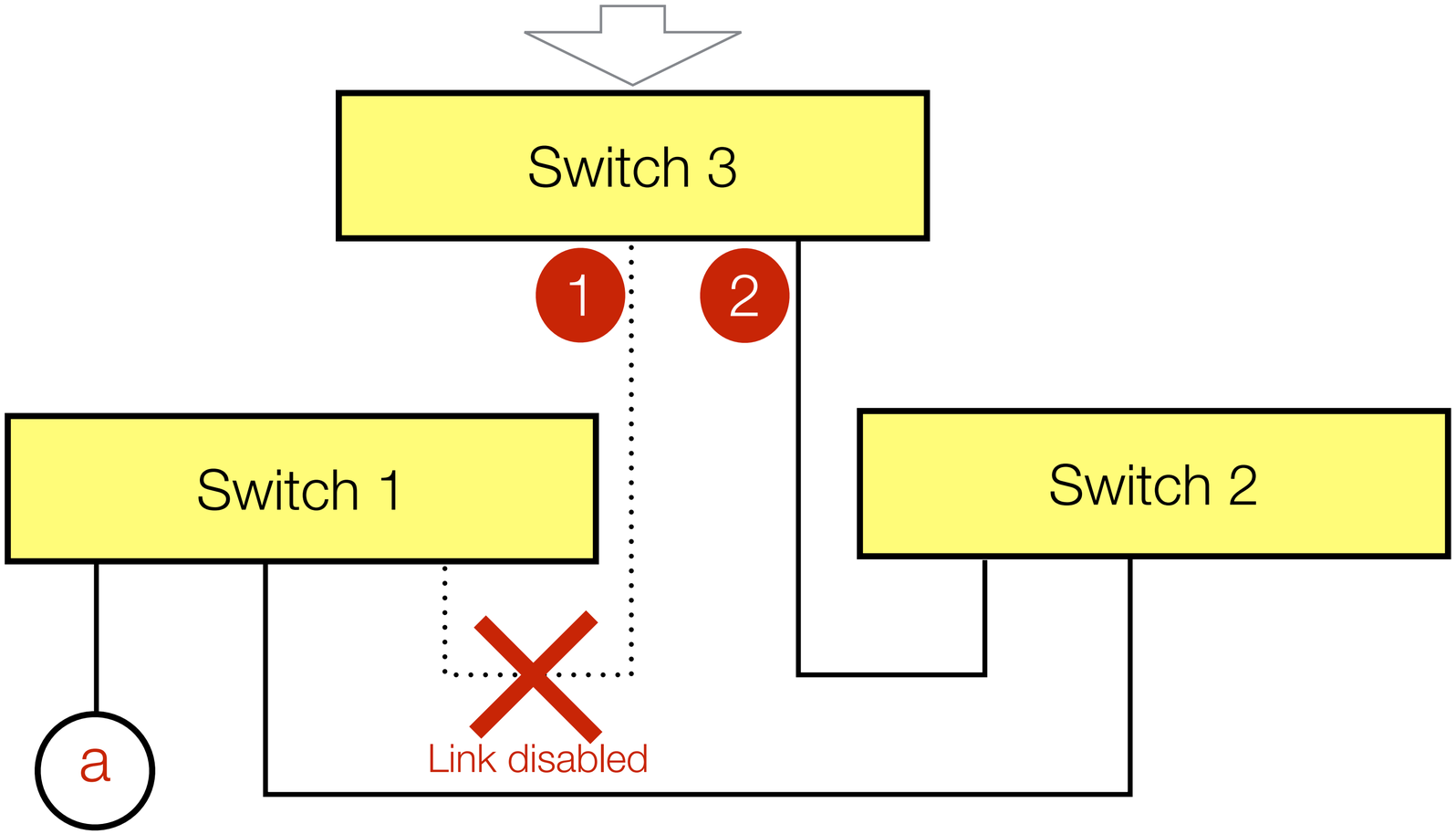


Spanning Tree Protocols

- Loops in the network topology help to increase resiliency of the network
  - but introduce problems when populating bridging tables
- Solution: Spanning Tree Protocols (STP)
  - temporarily disable links to break loops
  - monitor health of active links and re-enable links if network partitioning is detected
  - tradeoff: link health monitoring overhead vs repair latency

Spanning Tree Protocols

MAC	Interface
a	2

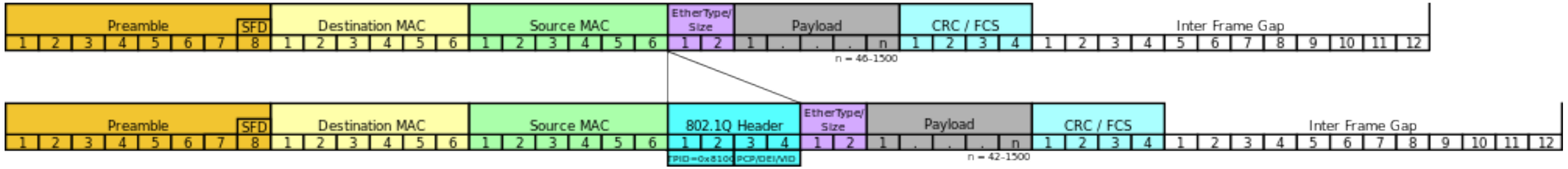


Virtual LANs (VLANs)

- Bridging/switching eliminates delivering unicast traffic that is not destined to the node
- Does not work for L2 broadcast traffic (still has to be delivered to all nodes)
- Solution: Virtual LANs (VLANs)
  - broad approach: decouple logical and physical topology: virtual networks, overlay networks, ...
  - specific approach: break broadcast domains into smaller ones
  - other benefits: QoS, security, control, ...

802.1Q Virtual LANs (VLANs)

- On VLAN capable links adds a 32-bit field to the standard Ethernet frame



802.1Q header:

TPID (16 bits) 0x8100

TCI - Tag Control Information (16 bits)

PCP - priority code point (3 bits)

DEI - drop eligible indication (1 bit)

VID - VLAN Identifier (12 bits)