CS 725/825 & IT 725
Lecture 24
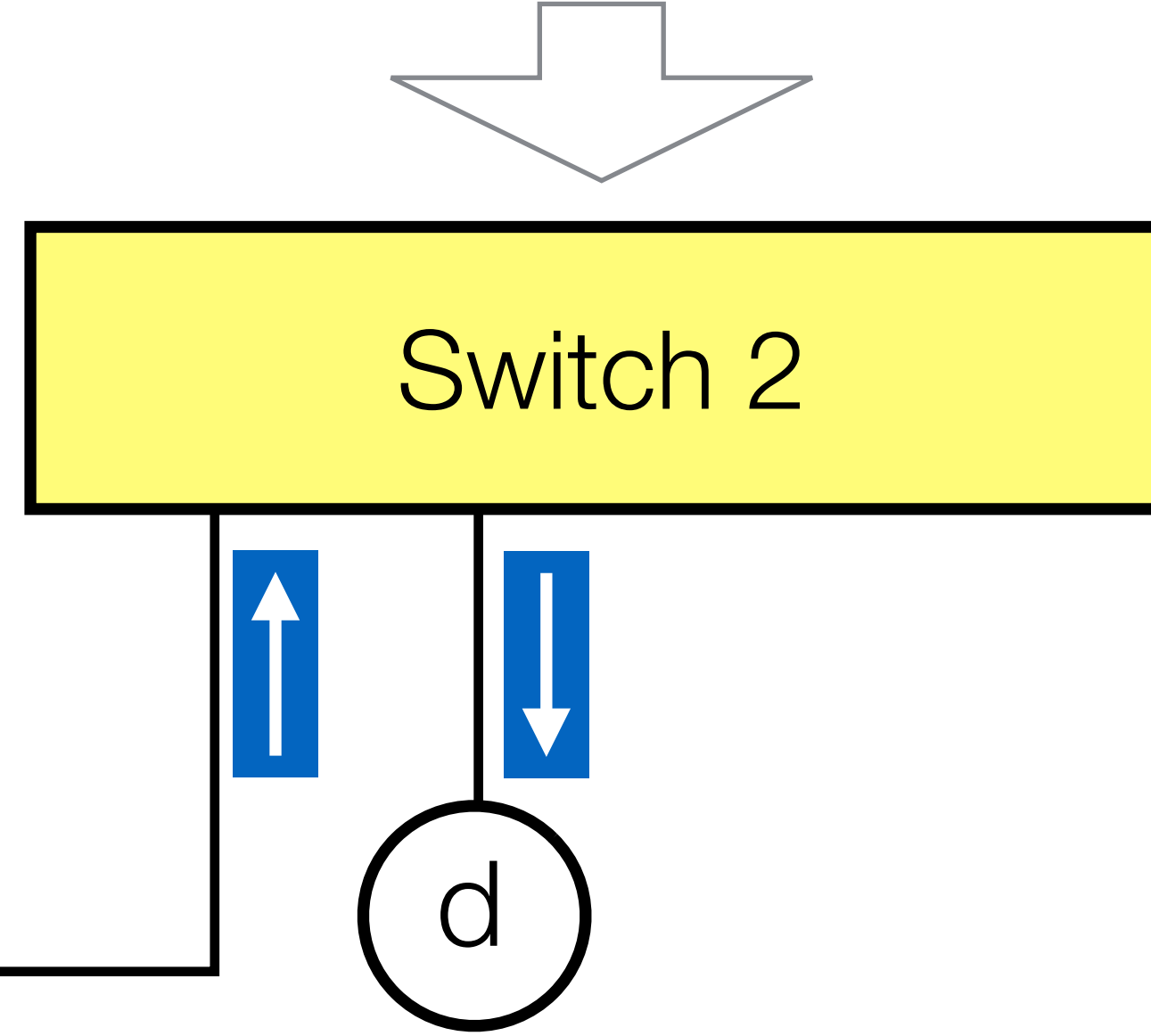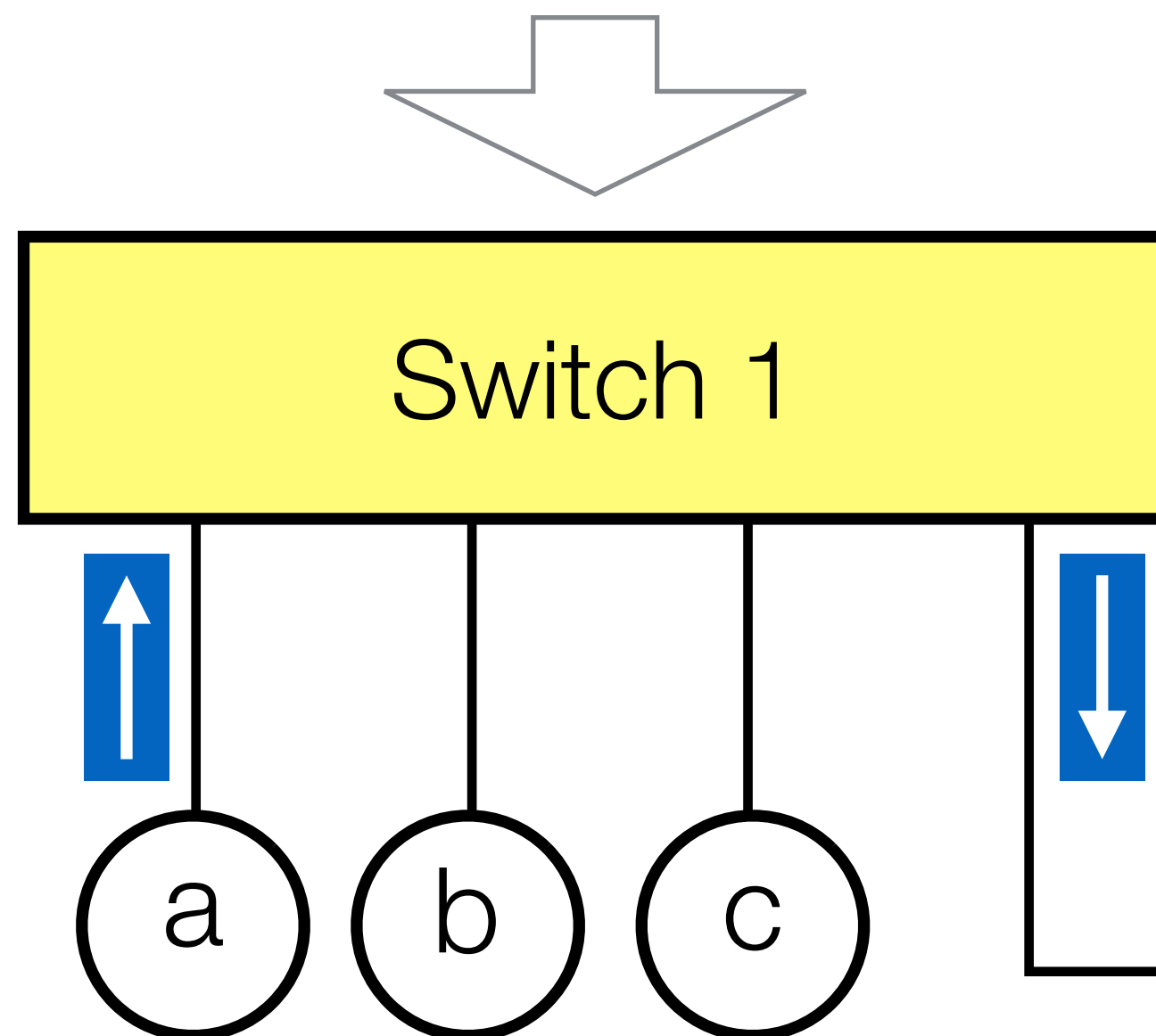# Link Layer

December 2, 2024

Unicast packet from a to d
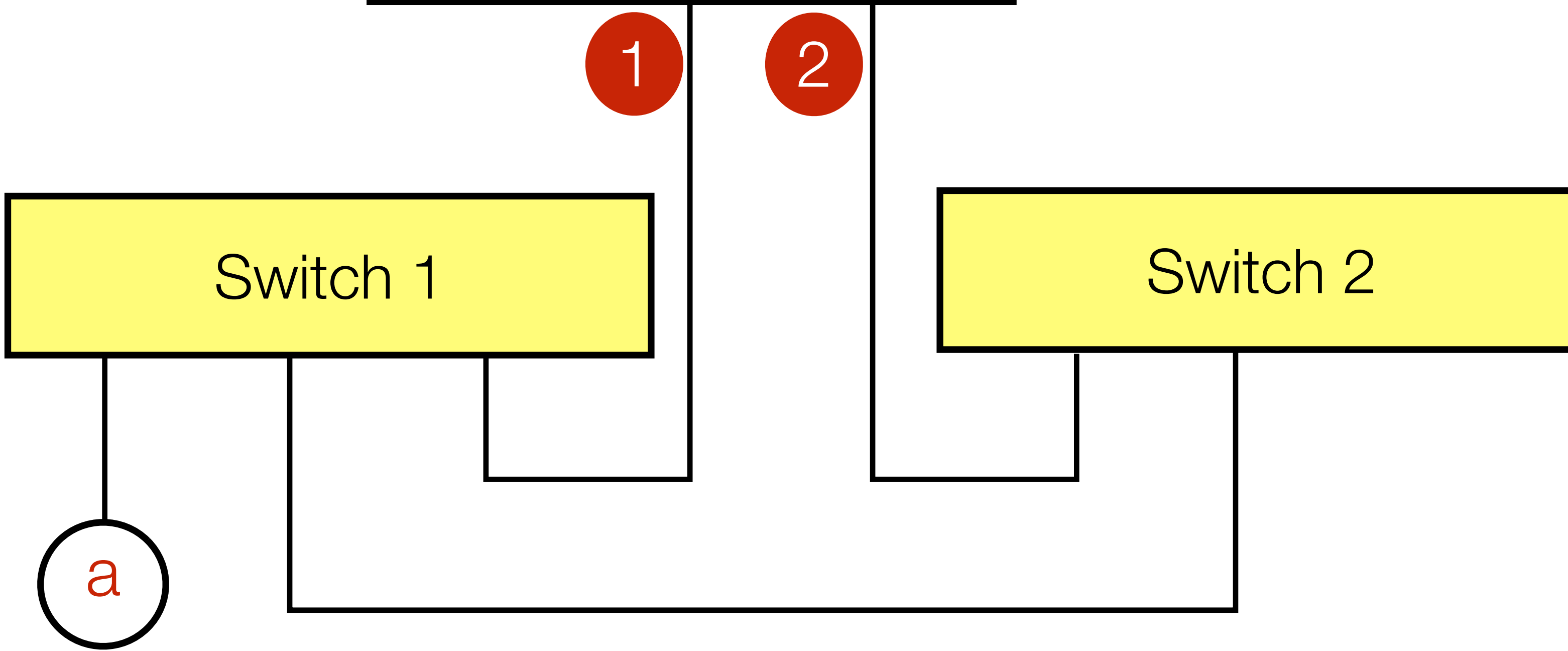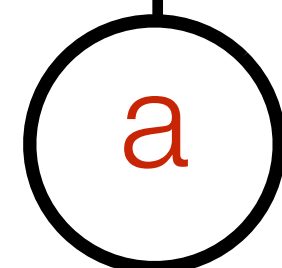
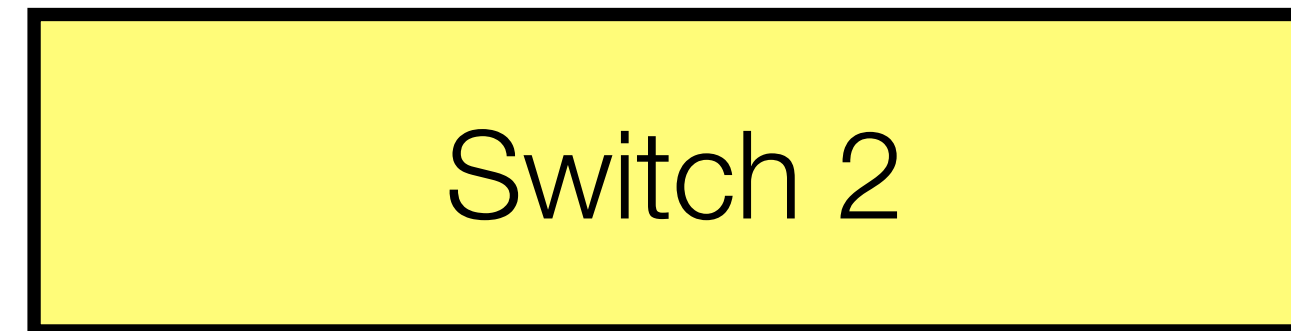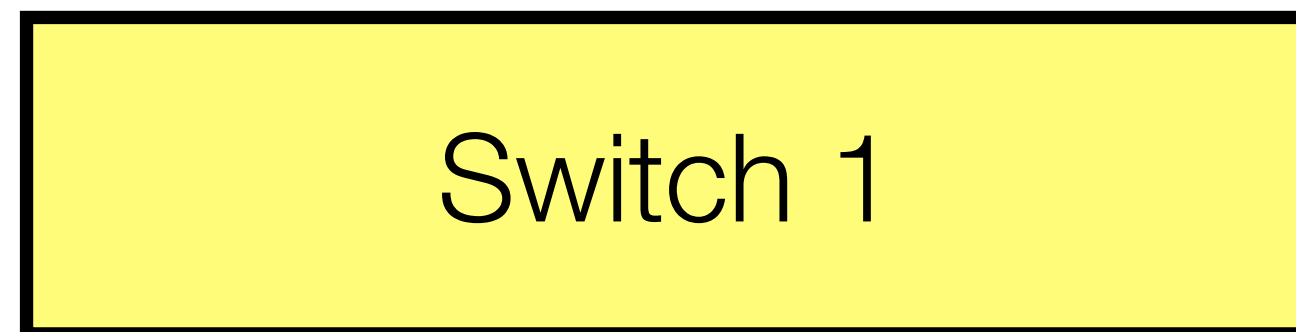| MAC	Interface
a	1
b	2
c	3
d	4

MAC	Interface
a	1
b	1
c	1
d	2

Switch 1

Switch 2

a b c

d

Loops?

MAC	Interface
a	1 or 2?
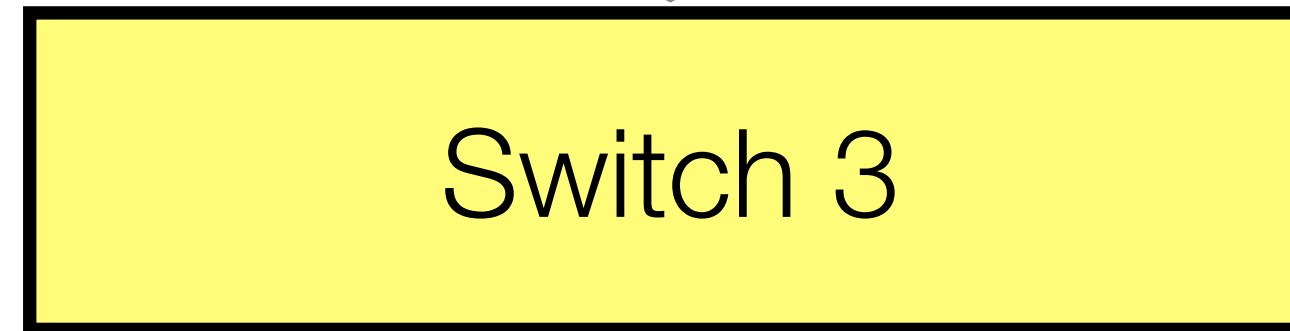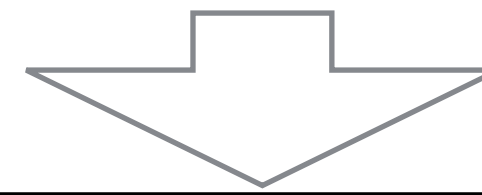
Spanning Tree Protocols

▸ 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

Switch 3

1 2

Switch 1

Switch 2

a
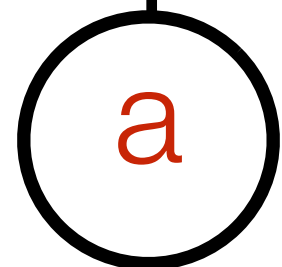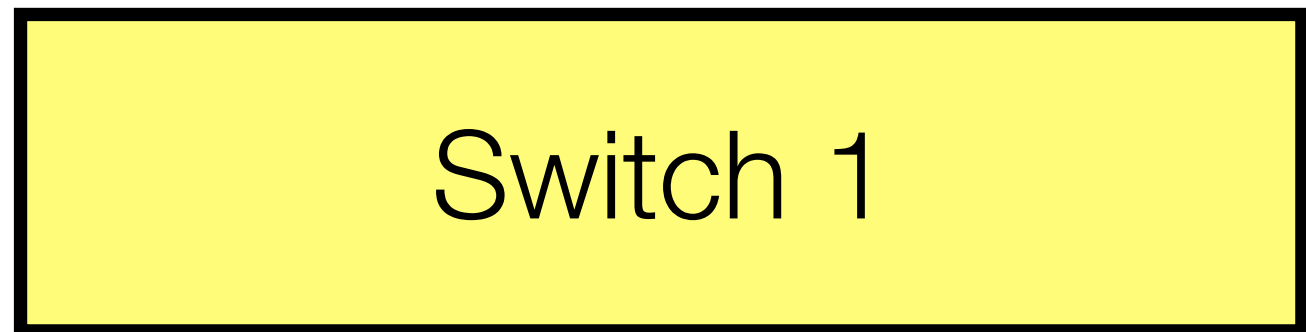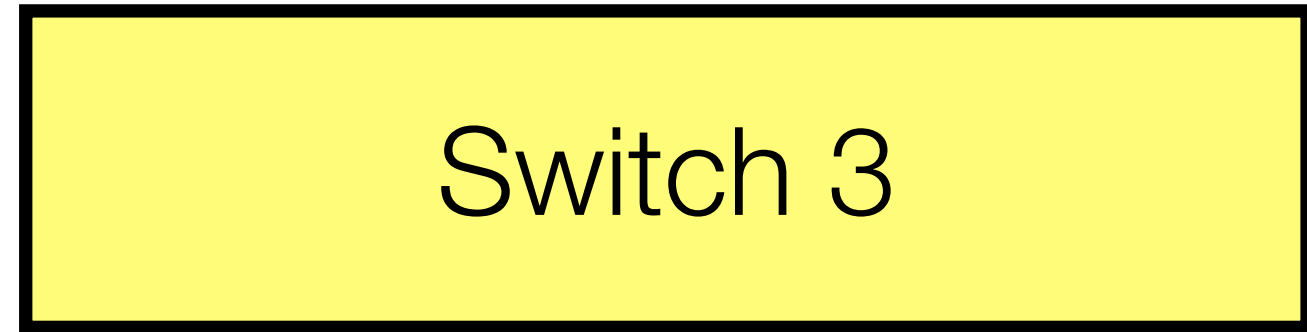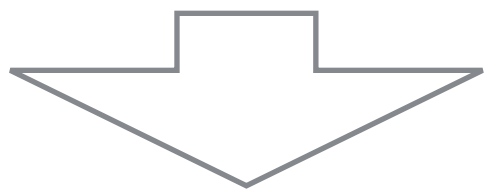
Link disabled

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

Preamble	SFD	Destination MAC	Source MAC	EtherType/Size	Payload	CRC / FCS	Inter Frame Gap
1 2 3 4 5 6 7	8	1 2 3 4 5 6	1 2 3 4 5 6	1 2	1 . . . n	1 2 3 4	1 2 3 4 5 6 7 8 9 10 11 12

n = 46-1500

Preamble	SFD	Destination MAC	Source MAC	802.1Q Header	EtherType/Size	Payload	CRC / FCS	Inter Frame Gap
1 2 3 4 5 6 7	8	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4	1 2	1 . . . n	1 2 3 4	1 2 3 4 5 6 7 8 9 10 11 12

TPID=0x8100 PCP/DEI/VID

n = 42-1500
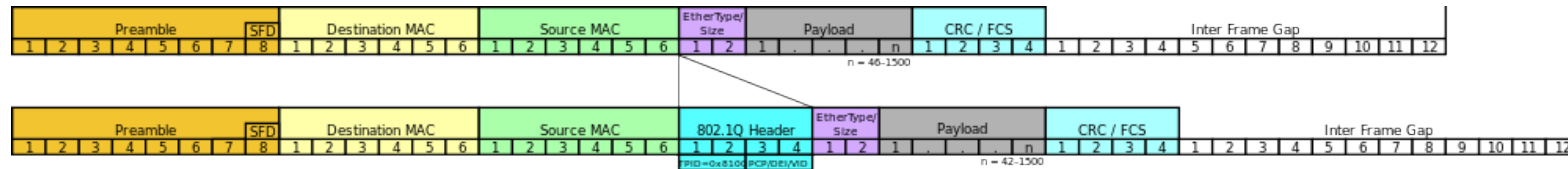
802.1Q header:

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)

Wireless Networks

▶ Radio Frequency (RF) transmission

– Omnidirectional (broadcast and select)

– Point to point (directional antennas)

▶ Organization

– WLAN

– Cellular networks (LTE, 5G, 6G …)

– Personal area networks / home automation / Internet of Things (Thread/Matter) …

– Access network

Wireless Networks

▸ Free Space Optical Networks

  – point to point laser links

  – HPC interconnects

▸ Acoustic Networks

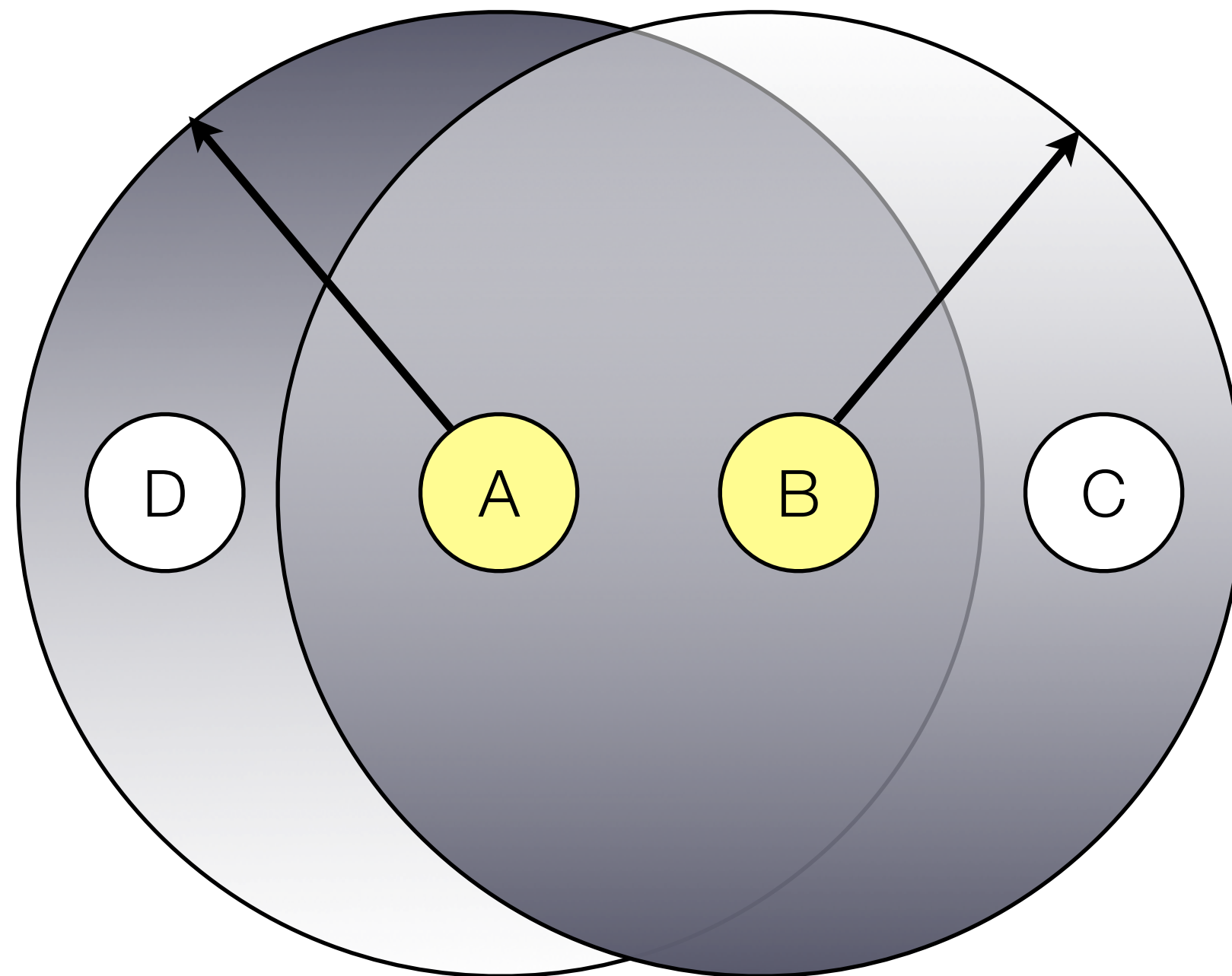 – underwater communication

Wireless Link Layer

▸ Hidden Terminal Problem
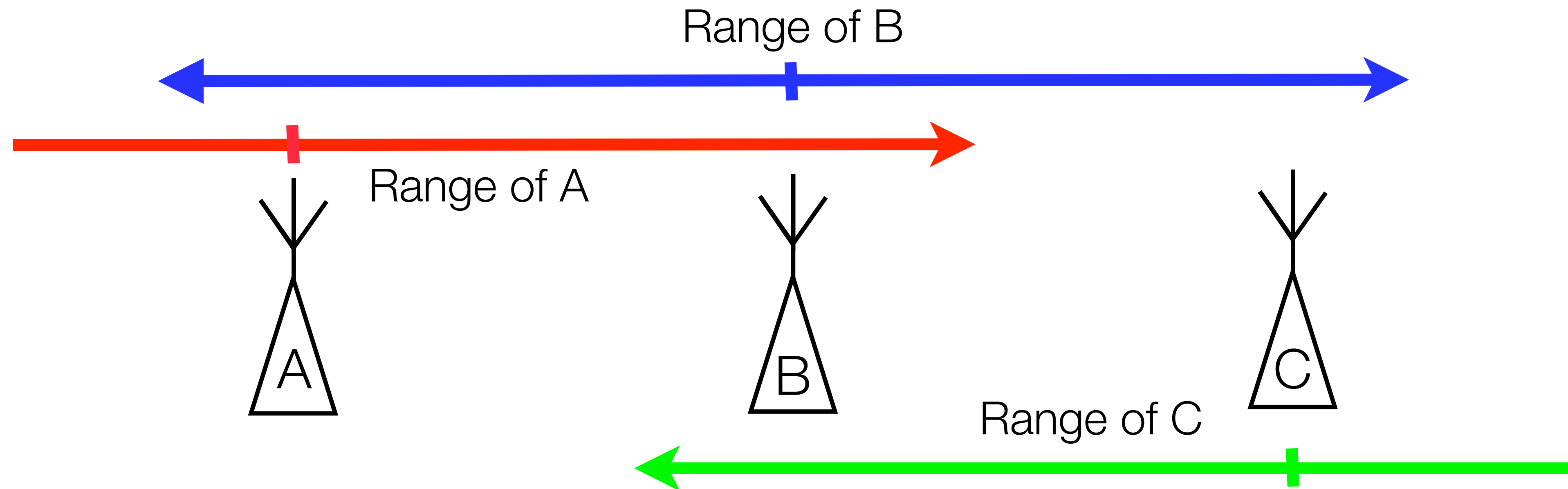
Solution: CSMA/CA

▸ **Collision Avoidance (CA)**

— make sure that the all nodes in the ranges of both source and destination are allowed to transmit

CSMA/CA

D   A (sender)   B (receiver)   C

RTS - request to send
CTS - clear to send
NAV - node cannot send

RTS   RTS

CTS   CTS

NAV   NAV   NAV

Data   Data

ACK