

# **COMP 3721**

# **Introduction to Data Communications**

**09b - Week 9 - Part 2**

# Learning Outcomes

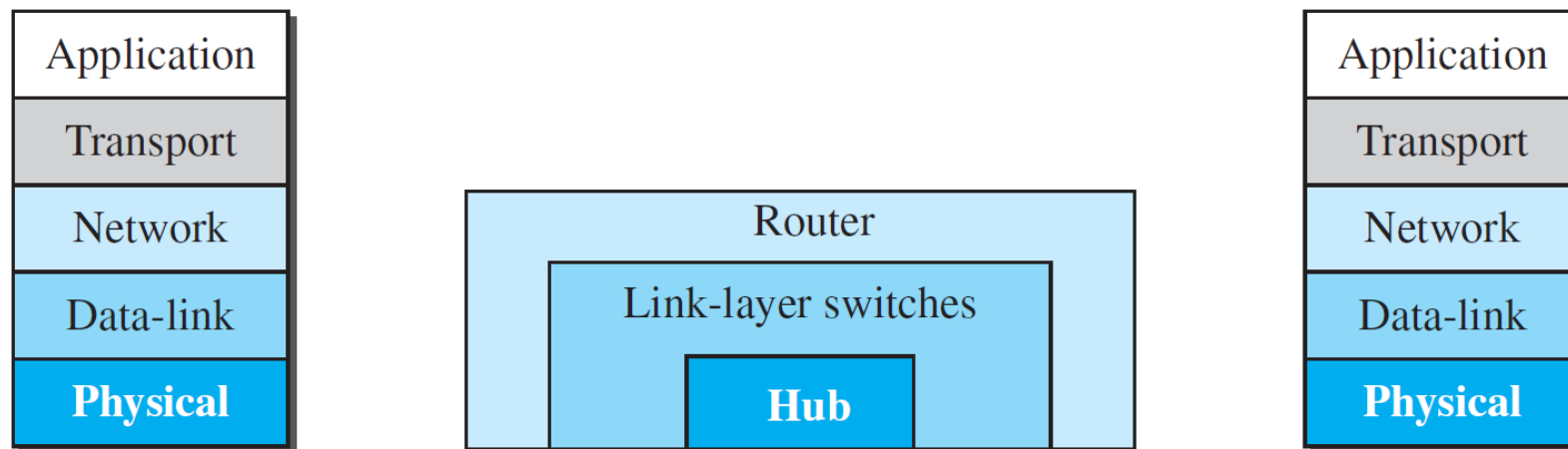
- By the end of this lecture, you will be able to
  - Explain what are VLANs and what is the benefit of using them.

# TCP/IP Protocol Suite Review

- **Physical layer** and **data-link layer** typically implemented in a **NIC** (Network Interface Card) and they handle **communication over a specific link**.
- **Hosts (end systems)** implement all 5 layers of the TCP/IP protocol stack.
- A link-layer address is also called MAC address, or hardware address, or physical address.
- **48-bit MAC address** (for most LANs) burned in NIC.
  - e.g., 1A-2F-BB-76-09-AD
- Each interface in a LAN, has a **unique MAC address**.
- Switches are called **link-layer devices**.

# Connecting Devices

- We use **connecting devices** to connect hosts together to make a network or to connect networks together to make an **internet**.
- We discussed three kinds of connecting devices:
  - Hubs
  - Link-layer switches
  - Routers



# Link-layer Switches

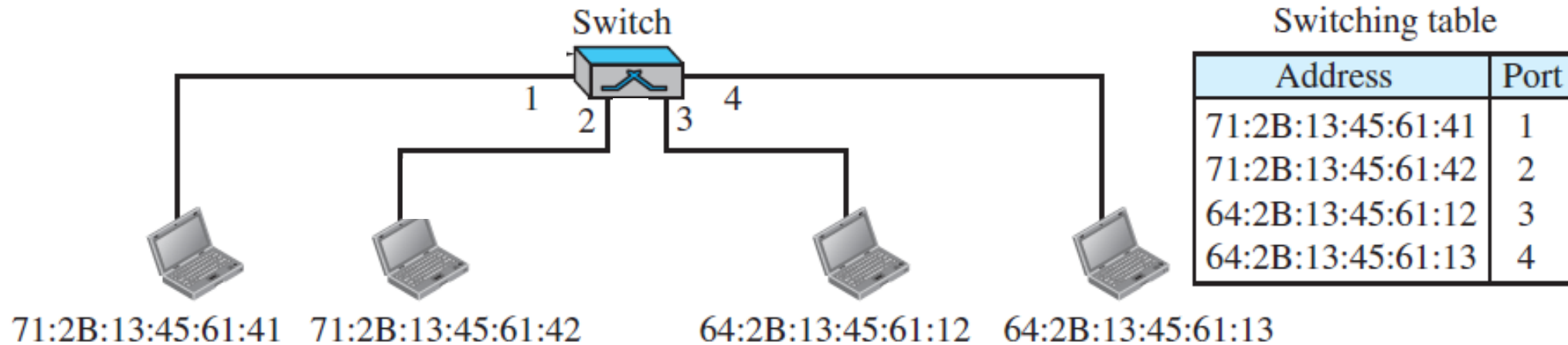
- A **link-layer switch** receives incoming link-layer **frames** and forwards them onto outgoing links (forwards frames based on **destination MAC address**).
- **Transparent**: hosts unaware of presence of switches.
- **Plug-and-play (Self-learning)**
  - Switches do not need to be configured.
  - Switch learns which hosts can be reached through which interfaces.
- **Filtering**: whether to forward a frame to an interface or drop it.
- **Forwarding**: determines the interface to which the frame should be directed and moves the frame to that interface.

# Link-layer Switches

- In a switch-based Ethernet LAN there are no collisions and, therefore, there is **no need for CSMA/CD protocol**! (A switch never forwards more than one frame onto the same interface at any time).

# Switching Table

- **Switching table** includes entries for hosts and routers.
  - It is initially empty.
  - An entry in the table: **MAC address, port, other info**

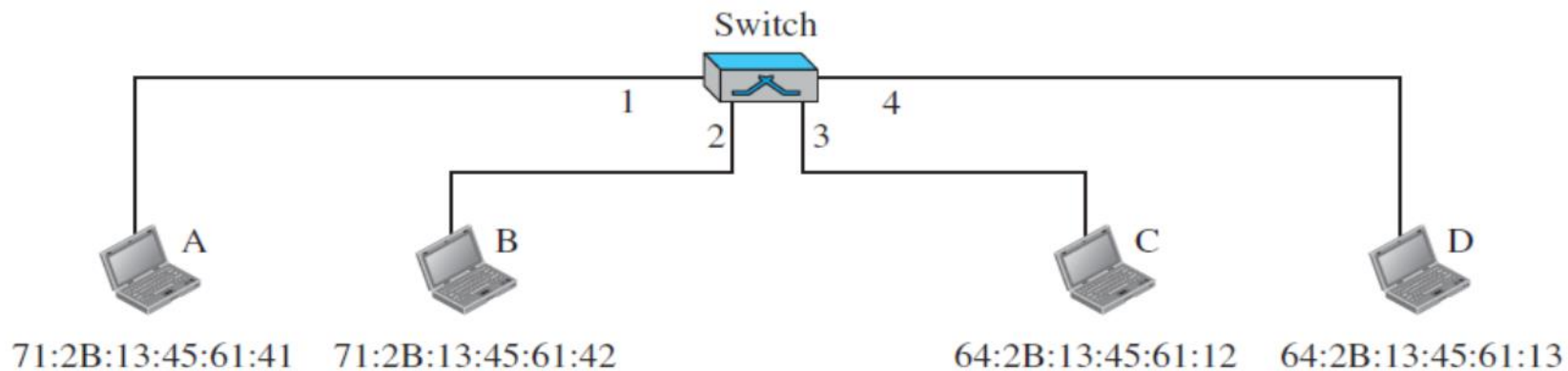


# Link-layer Switches Self-learning

Gradual building of table

Address	Port
---------	------

a. Original





# Link-layer Switches Self-learning

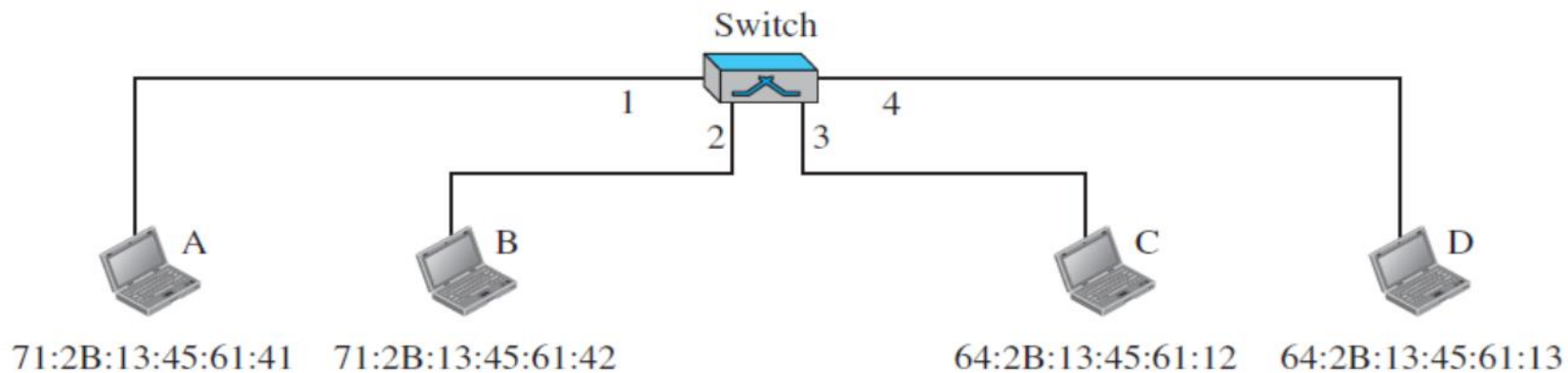
Gradual building of table

Address	Port
---------	------

a. Original

Address	Port
71:2B:13:45:61:41	1

b. After A sends a frame to D



# Link-layer Switches Self-learning

## Gradual building of table

Address	Port
---------	------

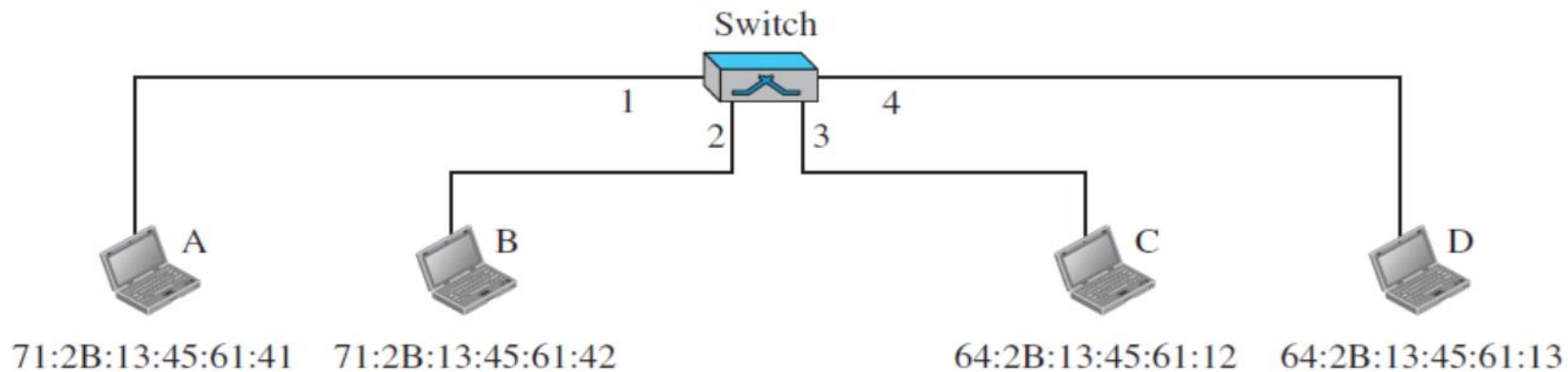
a. Original

Address	Port
71:2B:13:45:61:41	1

b. After A sends a frame to D

Address	Port
71:2B:13:45:61:41	1
64:2B:13:45:61:13	4

c. After D sends a frame to B



# Link-layer Switches Self-learning

## Gradual building of table

Address	Port
---------	------

a. Original

Address	Port
71:2B:13:45:61:41	1

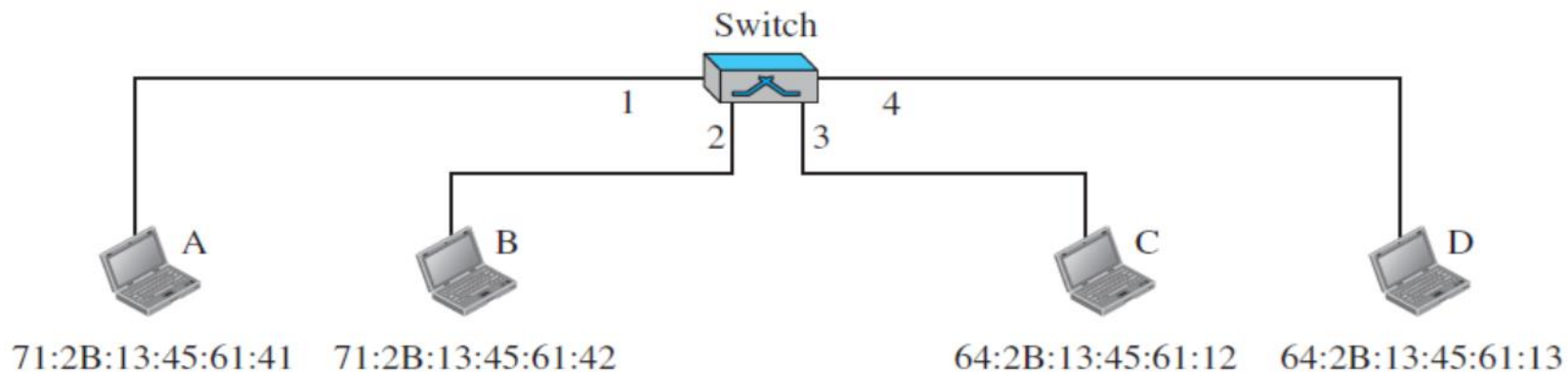
b. After A sends a frame to D

Address	Port
71:2B:13:45:61:41	1
64:2B:13:45:61:13	4

c. After D sends a frame to B

Address	Port
71:2B:13:45:61:41	1
64:2B:13:45:61:13	4
71:2B:13:45:61:42	2

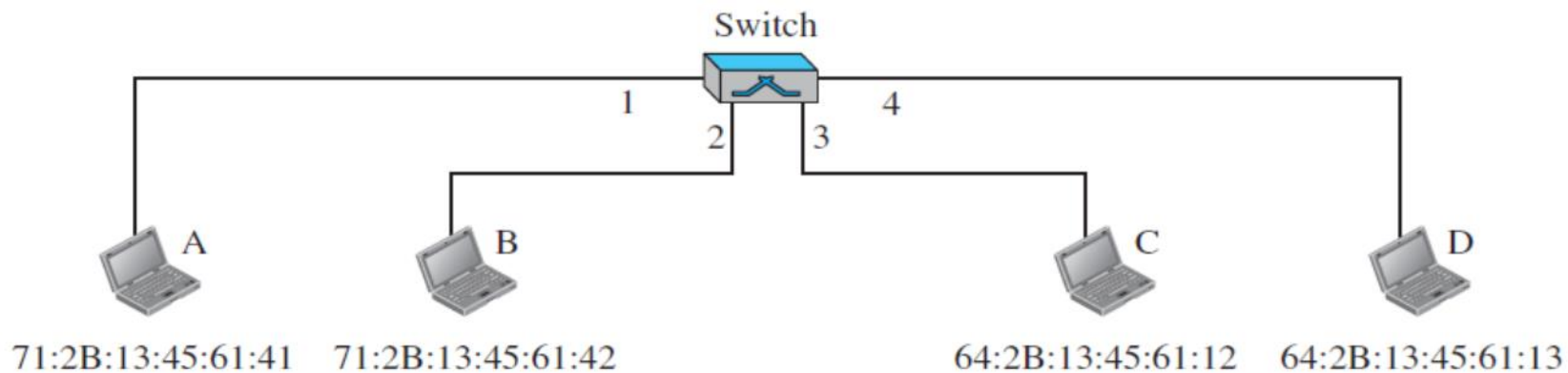
d. After B sends a frame to A



# Link-layer Switches Self-learning

## Gradual building of table

<table><tr><th>Address</th><th>Port</th></tr><tr><td></td><td></td></tr></table> <p>a. Original</p>	Address	Port			<table><tr><th>Address</th><th>Port</th></tr><tr><td>71:2B:13:45:61:41</td><td>1</td></tr></table> <p>b. After A sends a frame to D</p>	Address	Port	71:2B:13:45:61:41	1						
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71:2B:13:45:61:42	2														
64:2B:13:45:61:12	3														



# Link-layer Switches Filtering/Forwarding and Self-Learning

- The table is empty at first.
- When frame received at switch:
  1. The switch records the source MAC address of the frame and the interface from which the frame arrived in the table (if not already in the table)
  2. **if** entry found for **destination MAC address**: /\*used as an index to access the table\*/
    - if** destination is on segment from which frame arrived (i.e., the associated port in the table is the same as the port from which the frame arrived)
      - drop frame** /\* discard the frame \*/
      - else**
        - forward frame** on interface indicated by entry
    - else:**
      - flood** /\* forward on all interfaces except arriving interface, i.e., broadcast the frame\*/

# Link-layer Switches Advantages

- **Collision elimination**

- The switches buffer frames and never transmit more than one frame on a segment at any one time.

- **Heterogeneous links**

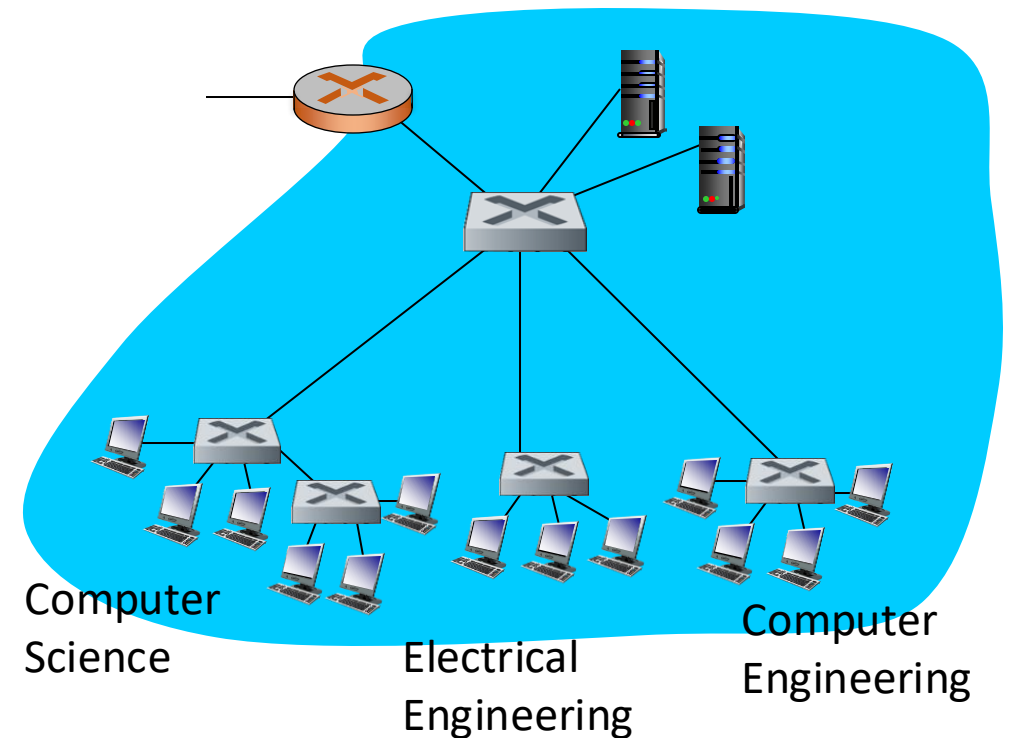
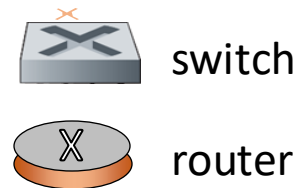
- Links with different speeds and running over different transmission medium

- **Ease of network management**

- Detecting and disconnecting malfunctioning adapters, etc.
- Statistics on bandwidth usage, traffic types, etc.

# Link-layer Switches Disadvantages

- Lack of traffic isolation/single broadcast domain
- Security/privacy/efficiency
- User management



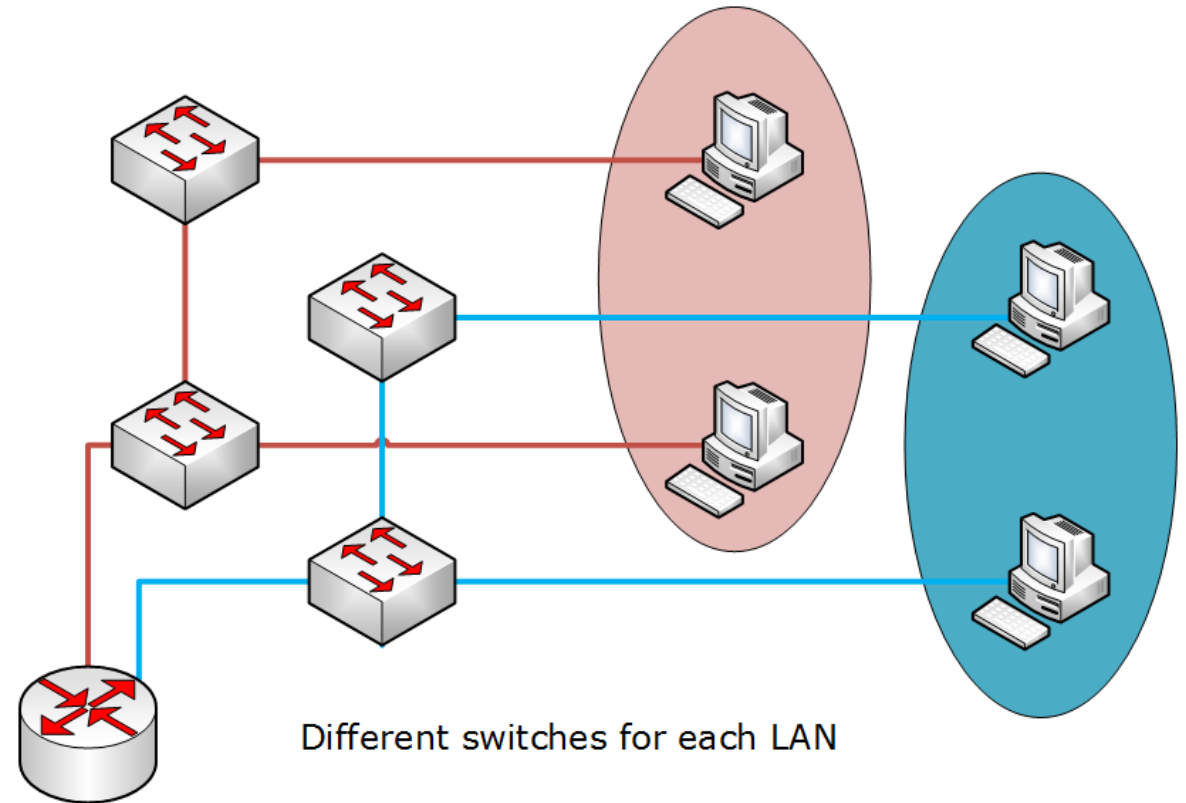
# Virtual LANs (VLANs)

- Before the advent of VLANs, if you wanted networks separated by department, function, or subnet, you needed hubs or switches that were separated by routers.
- VLANs allow different **logical networks** to share the same **physical hardware**.



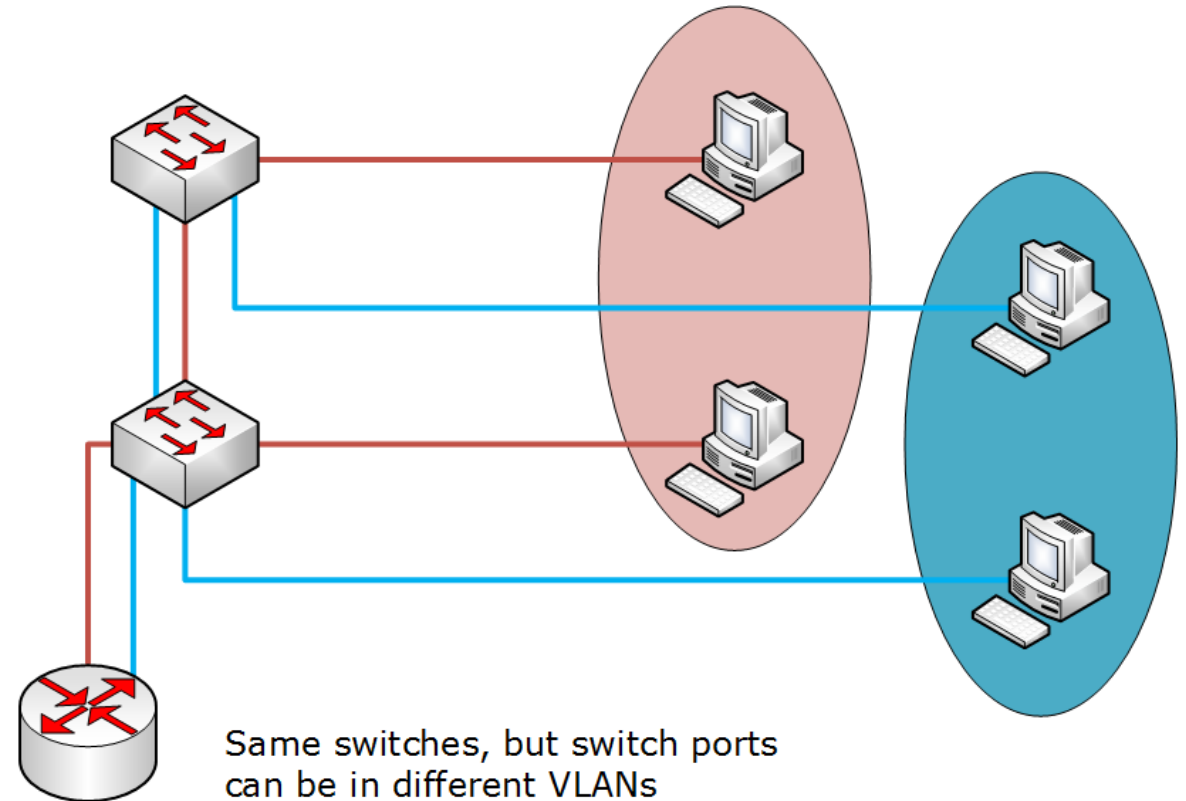
# Traditional LANs

- In this graphic, the red devices are isolated from the blue devices by the router, while there is a separated switch used for each device in different floor e.g.



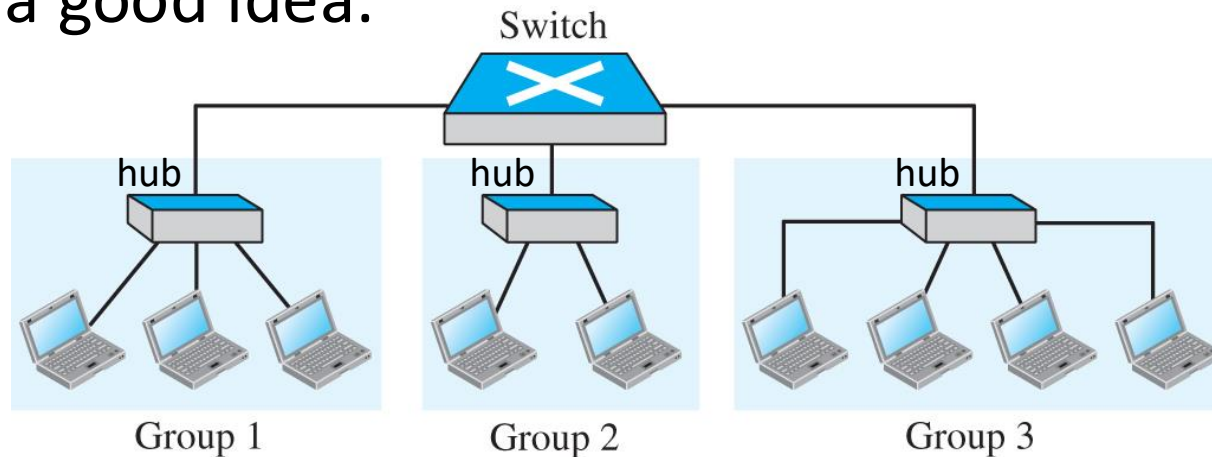
# Virtual LANs

- The red hosts are now connected to the **same switches** as the blue hosts, even though they are in different subnetworks. A **VLAN** port assignment can make this work.



# Example 1

- Three groups of engineers, each group is working on a project.
- Each group forms a LAN.
- Three LANs are connected by a switch.
- What if the manager wants to move two engineers from the first group to the third group to speed up the project? Rewiring for each change is not a good idea.

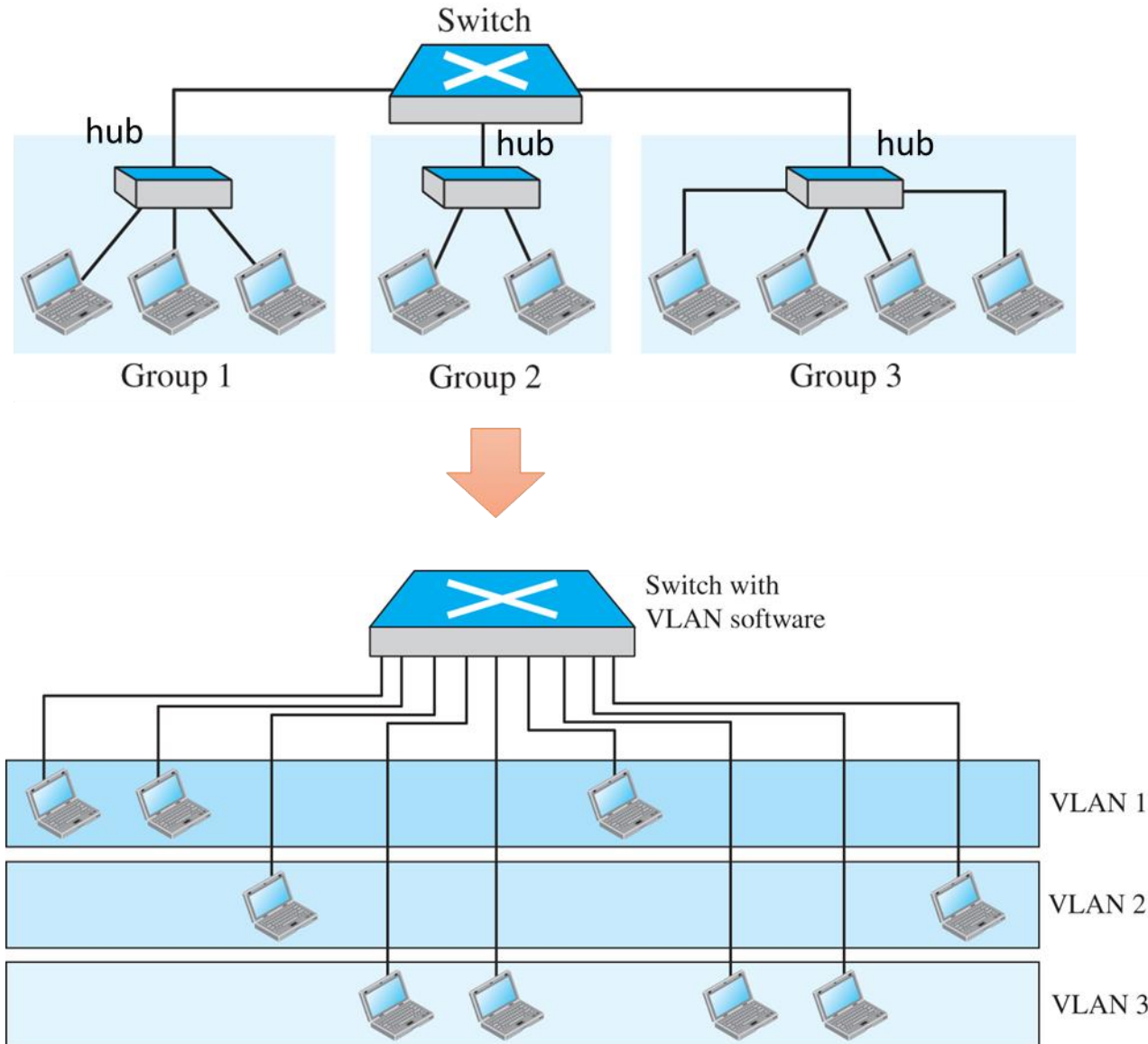


**Nine stations are grouped into three LANs that are connected by a switch.**

# Virtual LANs

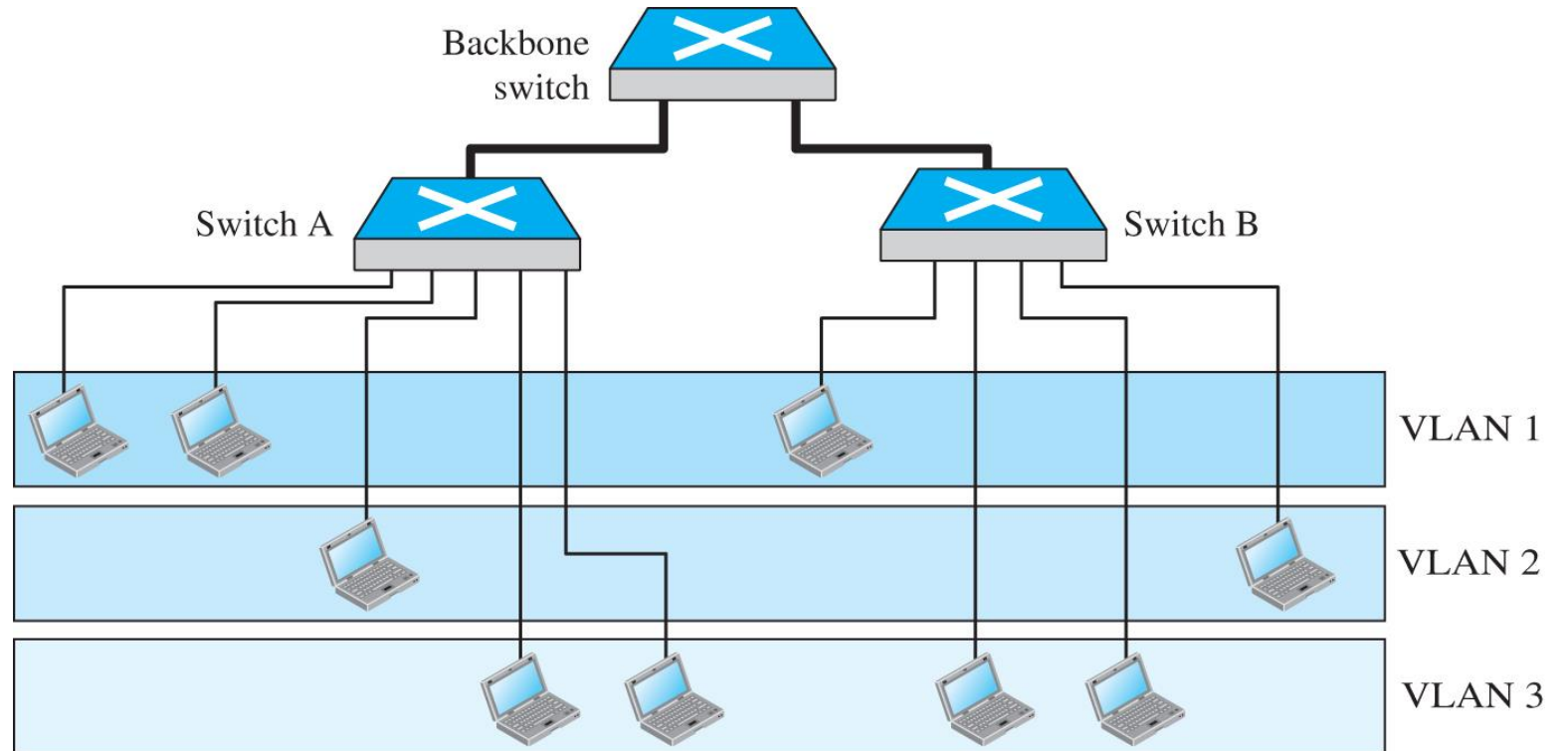
- What if we require a virtual connection between two stations belonging to two different physical LANs? Use a **VLAN (Virtual LAN)**.
- A **VLAN** is a LAN configured by **software**, not by physical wiring.
- **Main idea**: A LAN is divided into several **logical LANs**, called VLANs.
- VLANs define **broadcast domains**.
  - VLANs group stations belonging to one or more physical LANs into broadcast domains.
  - The stations in a VLAN communicate with one another as though they belonged to a physical segment.

# Virtual LANs Configuration Example



# Virtual LANs Example 2

- A company with two separate buildings.
- People in the first building and people in the second building can be in the same work group although they are connected to different physical LANs.



# VLAN Membership

- How to group stations in a VLAN?
  - Interface numbers (ports)
  - MAC addresses
  - IP addresses
  - A combination of different characteristics

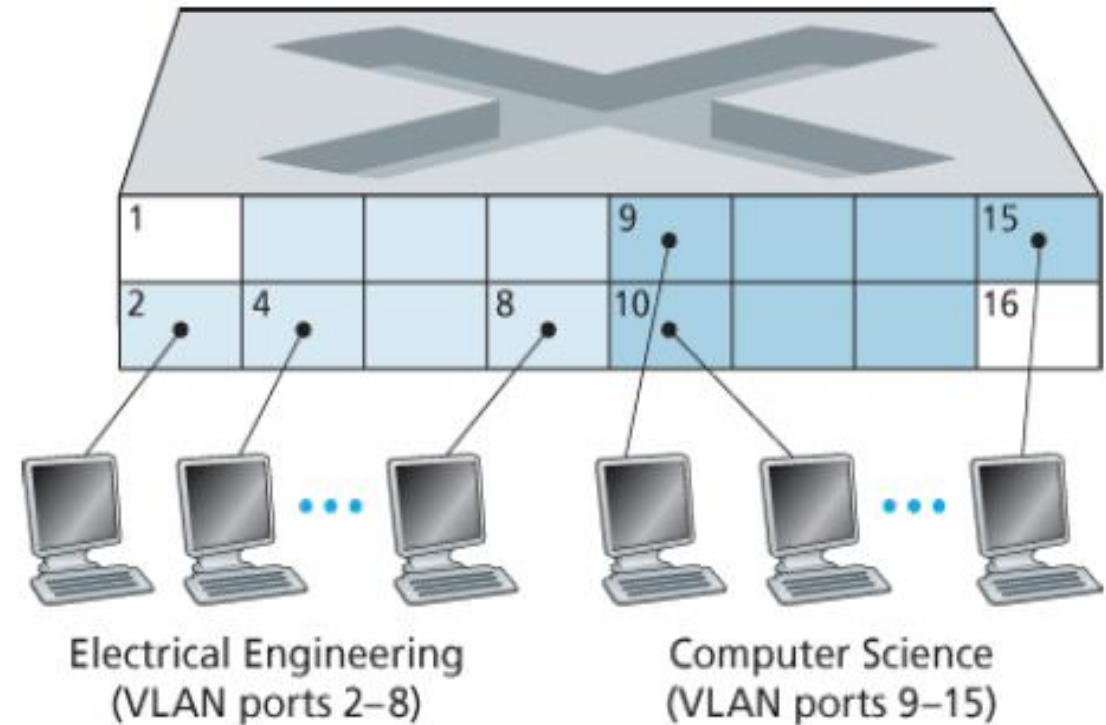
# VLAN Configuration

- It is a **logical configuration** and is performed using the **VLAN software**.
- Ways of configuration:
  1. Manual (during setup or migration)
  2. Automatic (criteria defined by the administrator)
  3. Semiautomatic (usually, manual setup and automatic migration)



# Example of Port-Based VLANs

- Broadcast traffic from one port can only reach other ports in the group (same VLAN).
- A table of port-to-VLAN mappings is maintained within the switch.
- Switch hardware only delivers frames between ports belonging to the same VLAN.

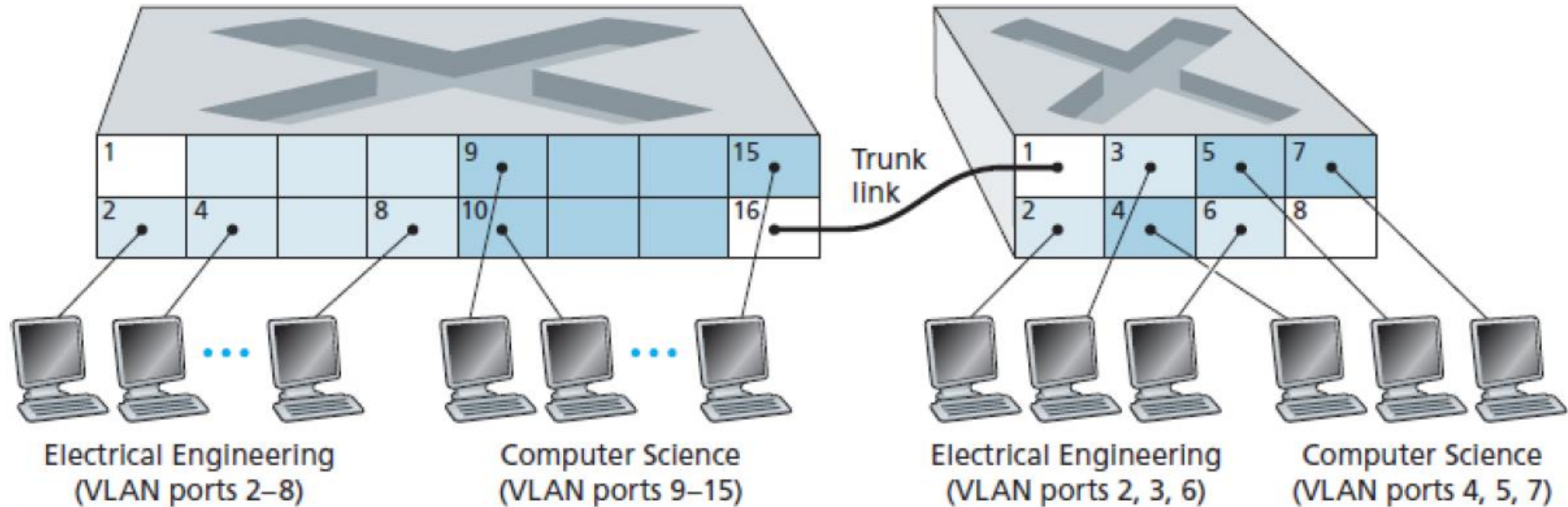


Two VLANs: EE VLAN, CS VLAN

# Communication Among Switches

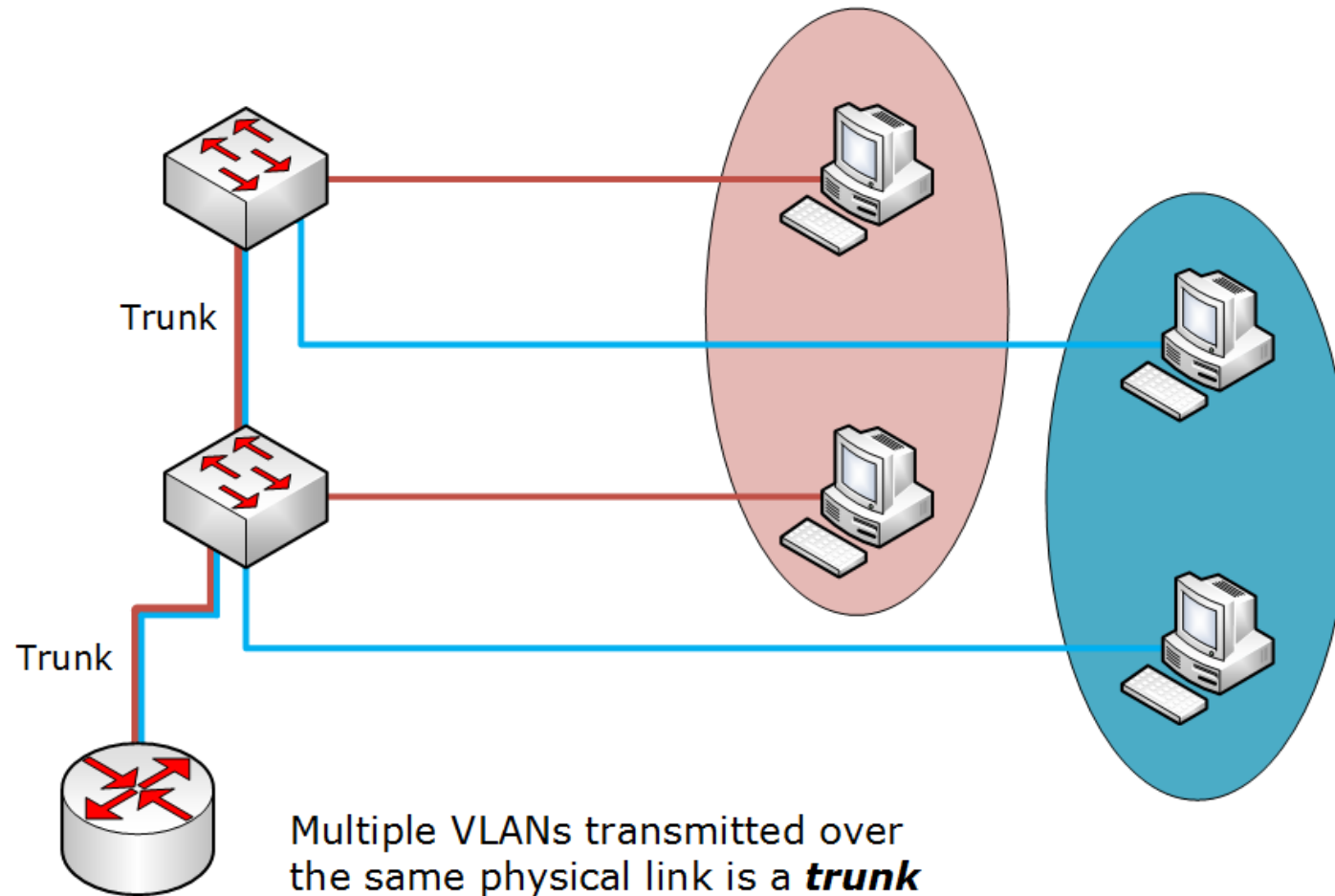
- A switch must know:
  - Membership of stations to VLANs (not only for its connected stations)
- **Frame tagging** and **VLAN trunking**
  - A special port (**trunk port**) on each switch is configured as the trunk port to provide connection to other VLAN switches.
  - An extra header is added to the MAC frame to define the destination VLAN.
  - Receiving switches use the **frame tag** (**VLAN tag**) to indicate the VLANs that should receive the broadcast message.
  - **IEEE standard 802.1Q**

# Interconnecting VLAN Switches – VLAN Trunking



Two VLANs: EE VLAN, CS VLAN

# Interconnecting VLAN Switches – VLAN Trunking



# VLANs – Advantages

- **Cost and time reduction**
  - Decreasing migration cost (physical reconfiguration is time-consuming and costly).
- **Creating virtual work groups**
  - Easier collaboration and user management.
- **Security (traffic isolation)**
  - Users in other groups (VLANs) will not receive the messages.

# Summary

- By using VLANs we can **logically group different stations in a LAN** based of characteristics such as switch port numbers, MAC addresses, etc.
- VLANs provide **easy and low-cost migration** among different virtual groups.
- **VLAN trunking** and **frame tagging** is used to interconnect the VLAN switches.

# References

- [1] Behrouz A. Forouzan, Data Communications & Networking with TCP/IP Protocol Suite, 6th Ed, 2022, McGraw-Hill companies.
- [2] J.F. Kurose, K.W. Ross, Computer Networking: A Top-Down Approach, 7th Ed, 2017, Pearson Education, Inc.

# Reading

- Chapter 6 of the textbook, sections 6.1 and 6.2.
- Chapter 6 of the textbook, section 6.4 (Practice Test)