VLAN

Mario Baldi
Politecnico di Torino
http://staff.polito.it/mario.baldi

Pietro Nicoletti
Studio Reti
http://www.studioreti.it

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M. Baldi, P. Nicoletti, "Switched LAN", McGraw-Hill, 2002, ISBN 88-386-3426-2

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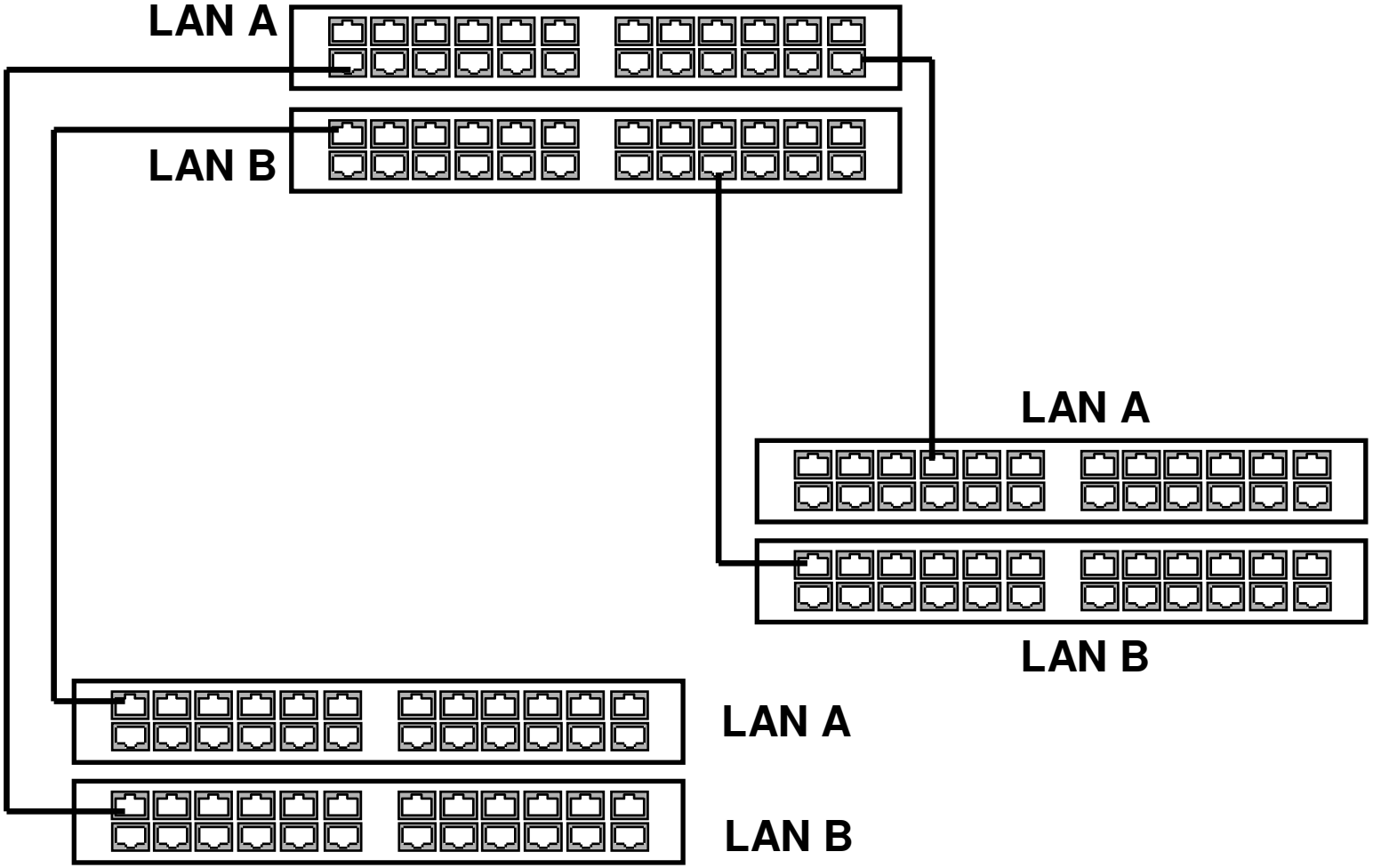
Parallel Independent Networks

- Need for separate networks within a building or campus
  - Privacy
  - Security
- Consequences
  - nNets = n x (links + net_devices)
  - Waste of resources
  - Full separation
    - Traffic segregation

Parallel Network Example



Virtual LAN (VLAN)

- Extended (bridged) LANs, when too large, are affected by several issues
  - High levels of multicast/broadcast traffic
  - Multiple Logical IP Subnets (LISs)
    - Routing among them
  - Security and privacy
- With Virtual LANs
  - Eliminate the need for parallel (physical) networks
  - Only one physical infrastructure
  - Multiple (*virtually*) separate logical (*virtual*) networks can be setup
- A virtual LAN can span
  - A single switch
  - A whole extended LAN, i.e., multiple switches

Virtual LAN (VLAN)

- Ethernet frames do not move between different VLANs
  - Full separation
- Communication between different VLANs is provided by means of higher layer packets
  - E.g., IP: IP Routers route IP packets between VLANs
    - Possibly Layer 3 switches

VLAN Deployment Advantages

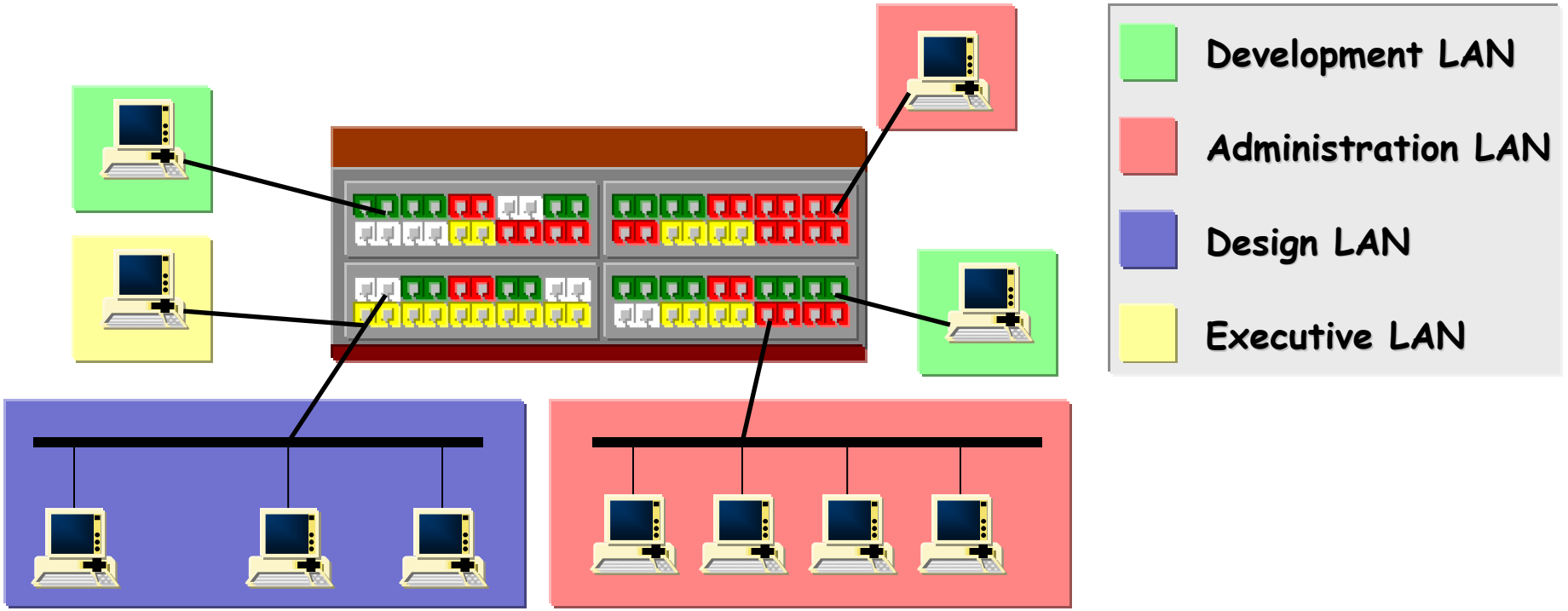
- Security
  - No direct, i.e. at the Ethernet frame level, communication between hosts in different VLANs
  - Communication can be granted (at a higher protocol layer) by routers with filtering functionalities
    - Layer 3 Switches
    - Firewalls
- Solve competence conflicts among different units/departments/functions of large organizations
  - Independent management/operation of VLANs
- Limit the scope of broadcast traffic

Intra-Switch and Inter-Switch VLANs

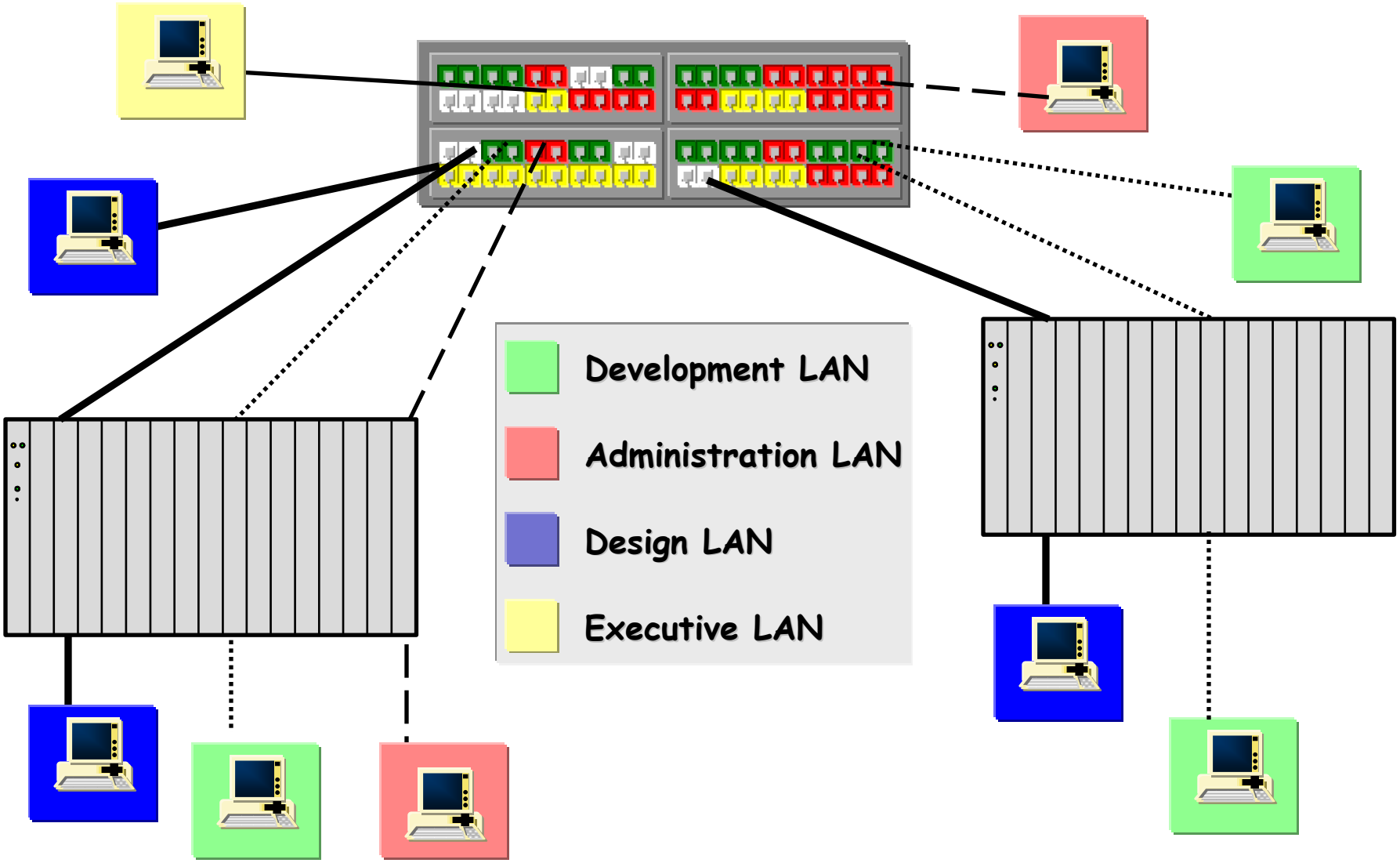
- First VLAN solutions were intra-switch
  - Simple
  - Only star topology networks with one switch at the core with hubs connected to it
  - Switch ports were grouped into a single broadcast domain
- Current products offer Inter-Switch VLAN solutions that can be deployed with both Full-Switching and Segment-Switching

Intra-Switch VLAN

Two or more switch ports can be grouped into a single broadcast domain



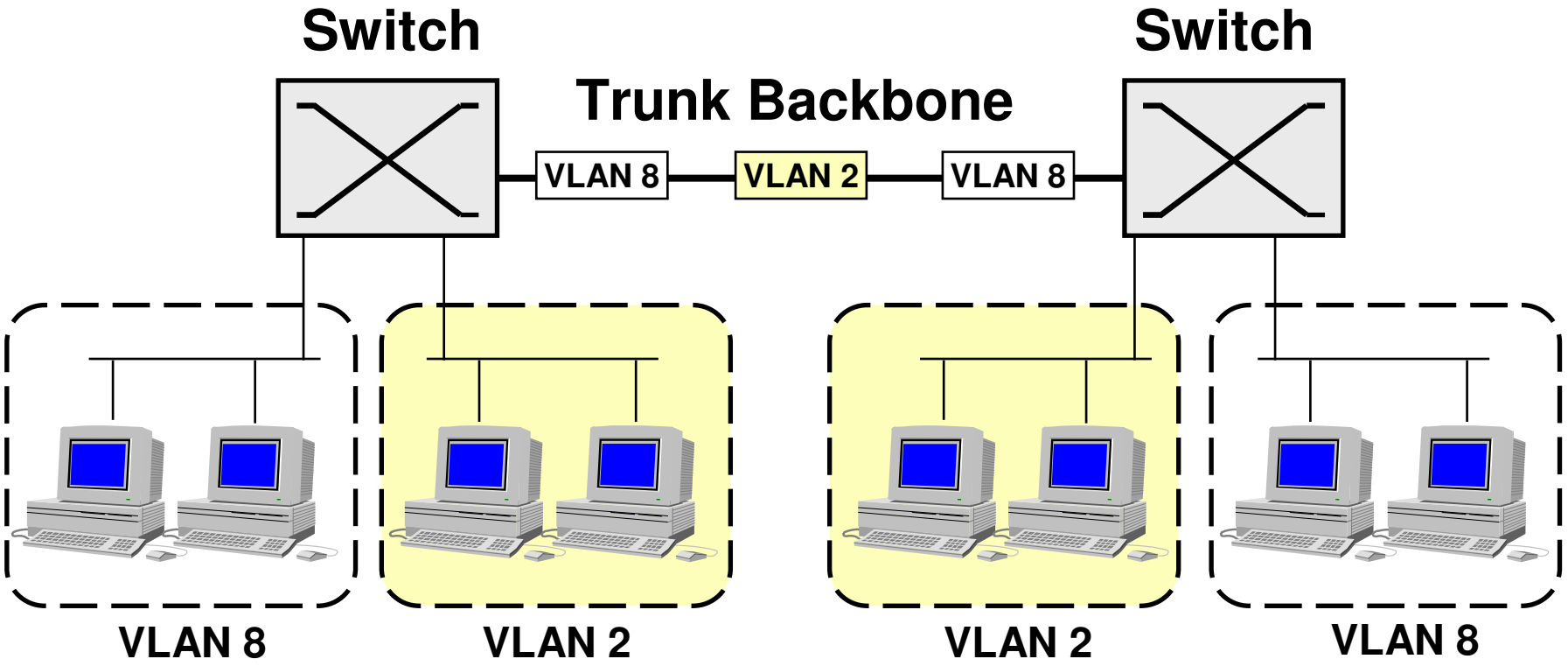
Intra-switch VLAN and Segmentable Hubs



Inter-Switch VLAN

One physical connection is deployed to build different LANs

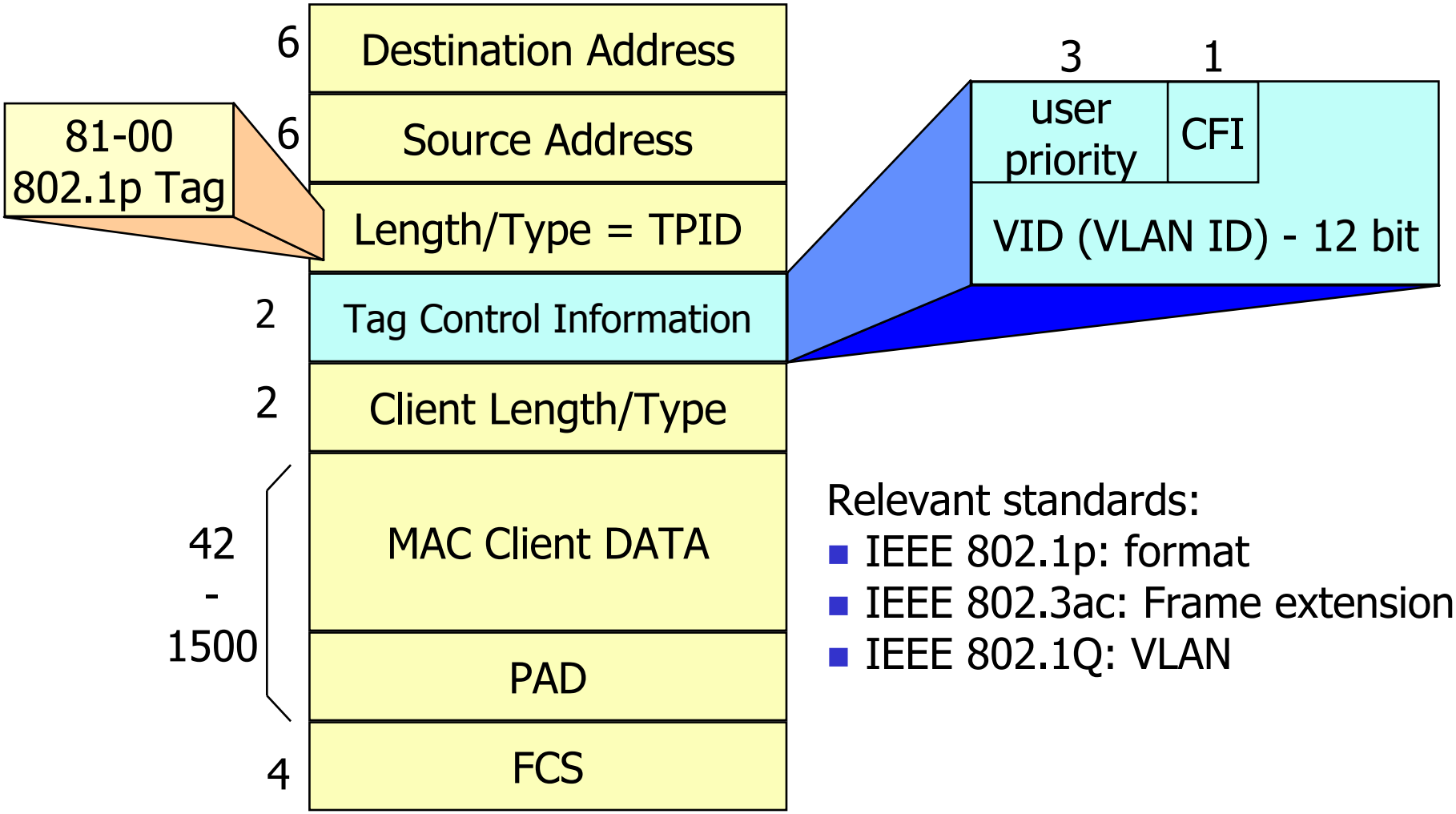
- It is necessary to identify the LAN each packet belongs to



Tagging

- Frame Tagging
  - Based on encapsulation
    - An Ethernet (Token Ring or FDDI) frame is encapsulated into another Ethernet frame
  - Proprietary solutions
    - E.g., ISL (Inter-Switch Link) by Cisco
- Packet Tagging
  - An additional header is added to the MAC header
  - Standardized by IEEE 802.1Q
    - VLAN-ID

IEEE 802.1Q Tag Encoding



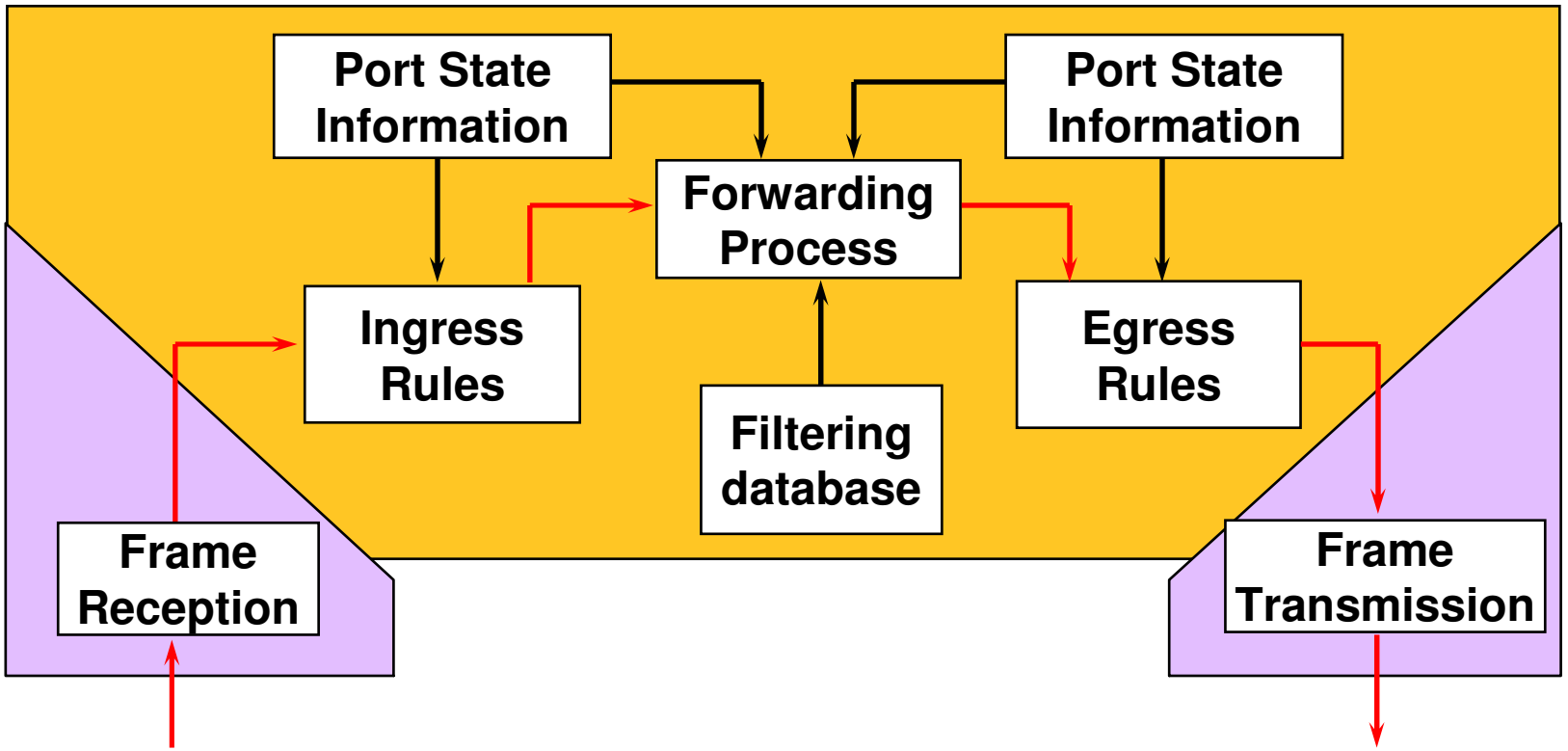
Relevant standards:

- IEEE 802.1p: format
- IEEE 802.3ac: Frame extension
- IEEE 802.1Q: VLAN

Relevant Standards

- IEEE 802.1Q defines VLAN functionalities and specifications
- IEEE 802.3ac defines a new Ethernet frame format to include the Tag header carrying the VLAN ID
- IEEE 802.1p defines:
  - Tag header format
    - Packet priority field, whose use is specified by IEEE 802.1p
    - VLAN ID field
  - GVRP for propagating VLAN related information among switches
    - Based on the more general GARP defined in IEEE 802.1p
    - GARP = Generic Attribute Registration Protocol
    - GVRP = GARP VLAN Registration Protocol

IEEE 802.1Q Bridge Relay Function

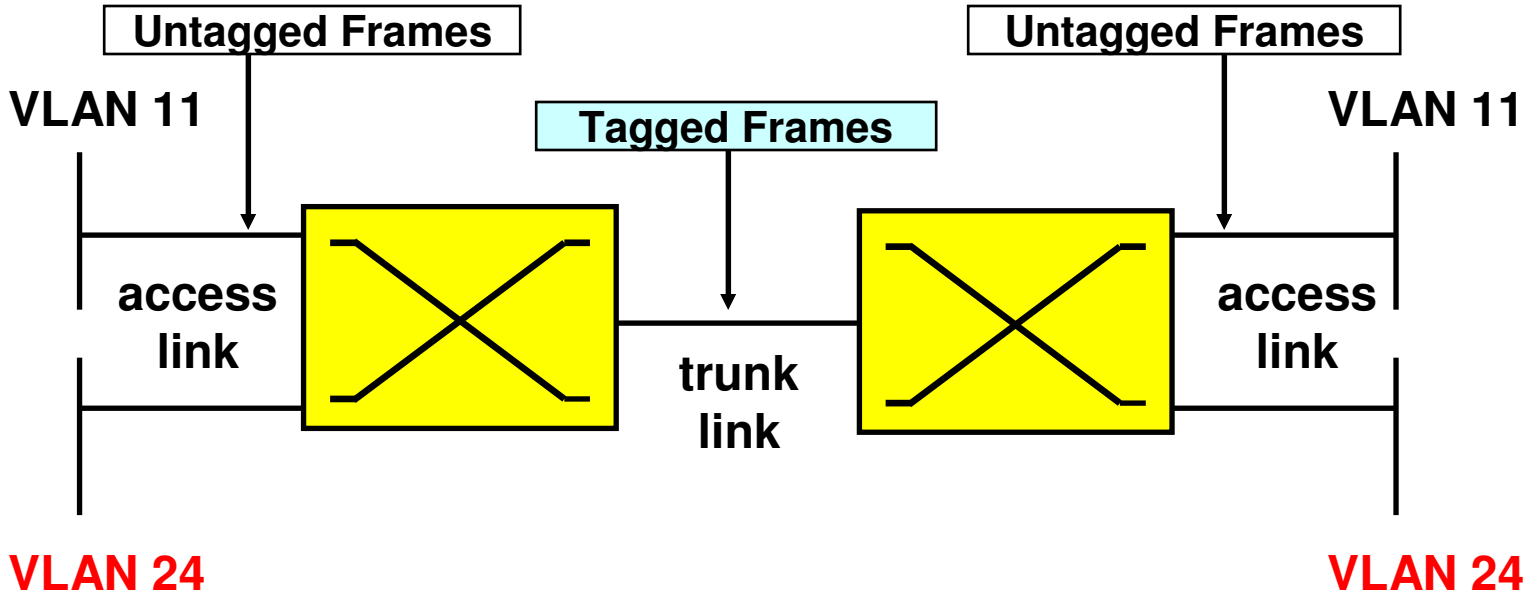


IEEE 802.1Q Specifics

- Per port based VLAN assignment
- Unique spanning tree
- Multiple filtering database identified by FID (Filtering Identifier)
  - Can exist only one entry per MAC address on filtering database
  - A MAC Address may be present in different filtering database

Port-based VLAN

- VLANs are setup on a per-port basis
- Each port can be configured as wither access port or trunk port



Device and Link Type

- Equipment:
  - VLAN-Aware manage tagged and untagged frames
  - VLAN-Unaware don’t manage tagged frames
- Access link:
  - Receive and transmit Untagged frames
  - default port configuration on the switch
- Trunk link:
  - Receive and transmit Tagged frames

VLAN Configuration on Switches

3 typical steps:

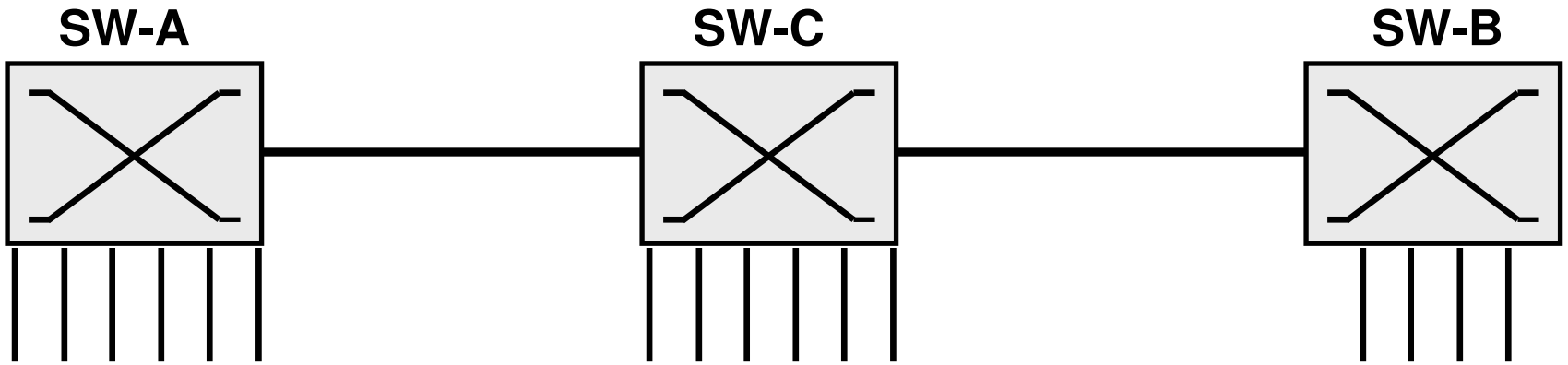
- VLAN creation on the switch;
- VLAN port association;
- Trunk ports definition

By default a port is considered of access type and associated to a default VLAN

- The switch has a VLAN-unaware behaviour.

VLAN Configuration Example

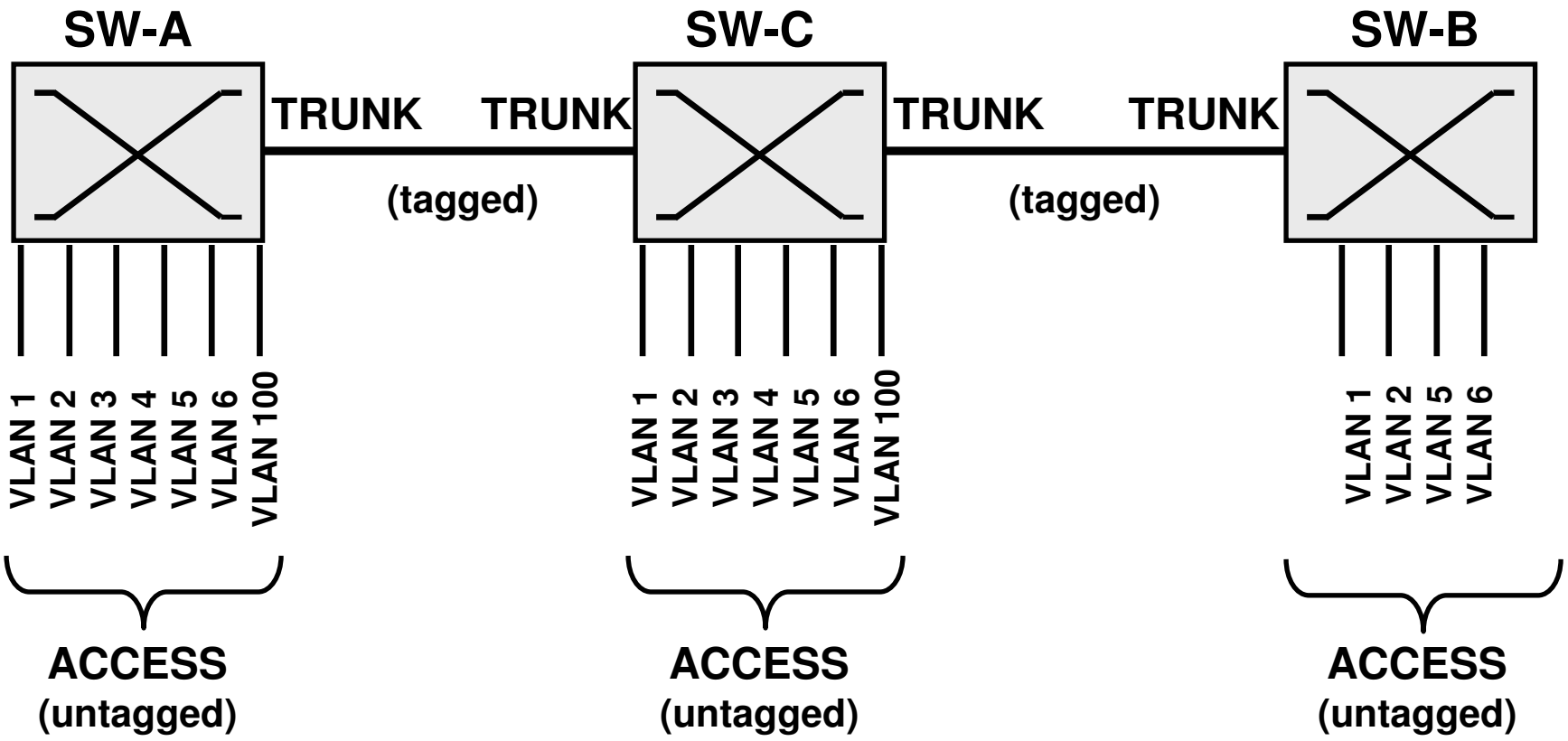
Network topology:



Port Information Before VLAN Configuration

```
SW-C#sho vlan brief
VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa0/1, Fa0/2, Fa0/3, Fa0/4,
                                                Fa0/5, Fa0/6, Fa0/7, Fa0/8,
                                                Fa0/9, Fa0/10, Fa0/11, Fa0/12,
                                                Fa0/13, Fa0/14, Fa0/15, Fa0/16,
                                                Fa0/17, Fa0/18, Fa0/19, Fa0/20,
                                                Fa0/21, Fa0/22, Fa0/23, Fa0/24,
                                                Fa0/25, Fa0/26, Fa0/27, Fa0/28,
                                                Fa0/29, Fa0/30, Fa0/31, Fa0/32,
                                                Fa0/33, Fa0/34, Fa0/35, Fa0/36,
                                                Fa0/37, Fa0/38, Fa0/39, Fa0/40,
                                                Fa0/41, Fa0/42, Fa0/43, Fa0/44,
                                                Fa0/45, Fa0/46, Fa0/47, Fa0/48,
                                                Gi0/1, Gi0/2
```

VLAN Scenario to be Realized



VLAN Creation


```
SW-C#vlan database
Switch(vlan)#vlan 2 name Administration
VLAN 2 added:
    Name: Amministrazione
Switch(vlan)#vlan 3 name Sales
VLAN 3 added:
    Name: Vendite
Switch(vlan)#vlan 4 name test-1
VLAN 4 added:
    Name: prova-1
Switch(vlan)#vlan 5 name test-2
VLAN 5 added:
    Name: prova-2
Switch(vlan)#vlan 6 name test-3
VLAN 6 added:
    Name: prova-3
Switch(vlan)#vlan 100 name Production
VLAN 100 added:
    Name: Produzione
SW-C(vlan)#exit
APPLY completed.
Exiting....
SW-C#
```

Port Association to VLAN


```
SW-C(config)#int fastEthernet 0/12
SW-C(config-if)#switchport access vlan 100
Switch(config-if)#exit
…….
SW-C(config)#int fastEthernet 0/16
SW-C(config-if)#switchport access vlan 2
SW-C(config-if)#exit
……..
SW-C(config)#int fastEthernet 0/20
SW-C(config-if)#switchport access vlan 3
SW-C(config-if)#exit
……..
SW-C(config)#int fastEthernet 0/24
SW-C(config-if)#switchport access vlan 4
SW-C(config-if)#exit
…….
SW-C(config)#int fastEthernet 0/28
SW-C(config-if)#switchport access vlan 5
SW-C(config-if)#exit
……..
SW-C(config)#int fastEthernet 0/32
SW-C(config-if)#switchport access vlan 6
SW-C(config-if)#exit
……..
```

Port and VLAN Information After Switch Configuration

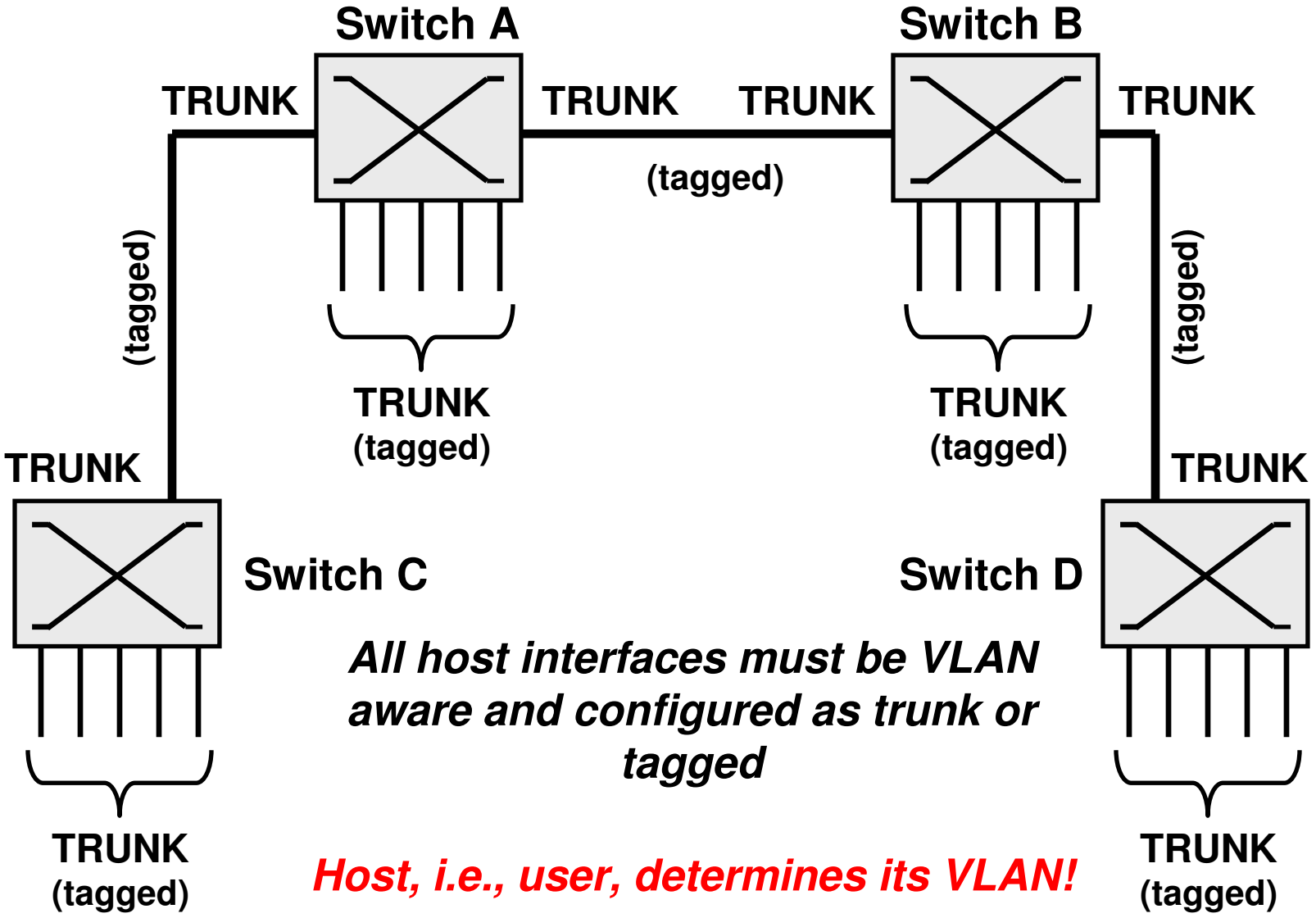

```
SW-C#show vlan brief
VLAN Name                         Status    Ports
---- -------------------- --------- -------------------------------
1    default                      active    Fa0/1, Fa0/2, Fa0/3, Fa0/4,
                                            Fa0/5, Fa0/6, Fa0/7, Fa0/8,
                                            Fa0/9, Fa0/10, Fa0/11, Fa0/36,
                                            Fa0/37, Fa0/38, Fa0/39, Fa0/40,
                                            Fa0/41, Fa0/42, Fa0/43, Fa0/44,
                                            Fa0/45, Fa0/46, Fa0/47, Fa0/48,
                                            Gi0/1, Gi0/2
2    Administration               active    Fa0/16, Fa0/17, Fa0/18, Fa0/19

3    Sales                        active    Fa0/20, Fa0/21, Fa0/22, Fa0/23

4    test-1                       active    Fa0/24, Fa0/25, Fa0/26, Fa0/27

5    test-2                       active    Fa0/28, Fa0/29, Fa0/30, Fa0/31

6    test-3                       active    Fa0/32, Fa0/33, Fa0/34, Fa0/35

100  Production                   active    Fa0/12, Fa0/13, Fa0/14, Fa0/15
```

Trunk Port Static Configuration

- Trunk port static configuration without implementation of GVRP protocol

```
SW-C(config)#interface GigabitEthernet 0/1
SW-C(config-if)#switchport mode trunk
SW-C(config-if)#switchport trunk allowed vlan add 1,2,5,6
SW-C(config-if)#exit
SW-C(config)#interface GigabitEthernet 0/2
SW-C(config-if)#switchport mode trunk
SW-C(config-if)#switchport trunk allowed vlan all
```

"Anarchic" VLAN on Switched LANs



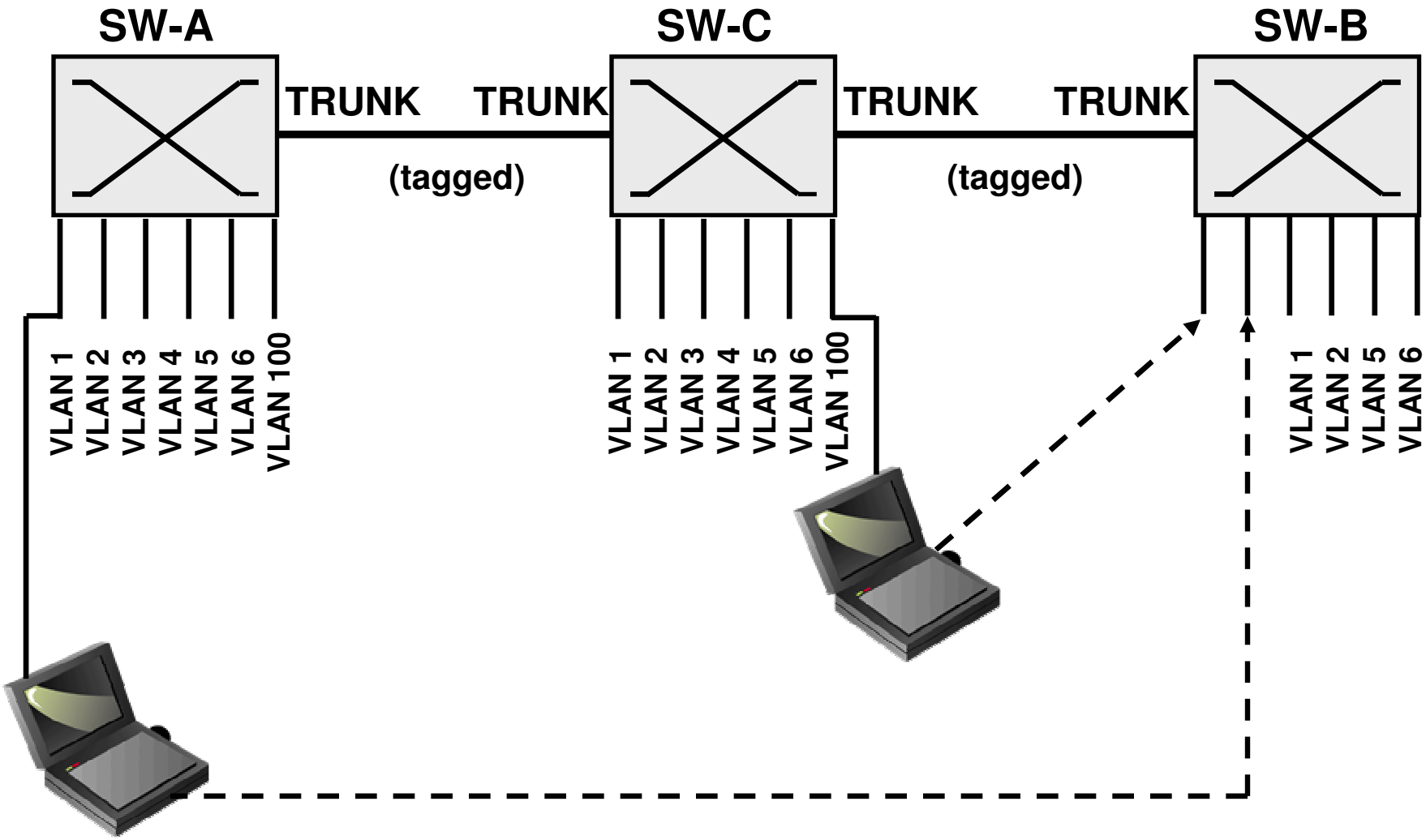
Mobility

Port-based VLAN assignment does not support mobility

- The VLAN a station belongs to depends on the port it is connected to
- If a host is moved to another port does not necessarily keep being assigned to the same VLAN
  - Proper configuration or network administrator intervention might be required

Possible solution: “anarchic” VLAN

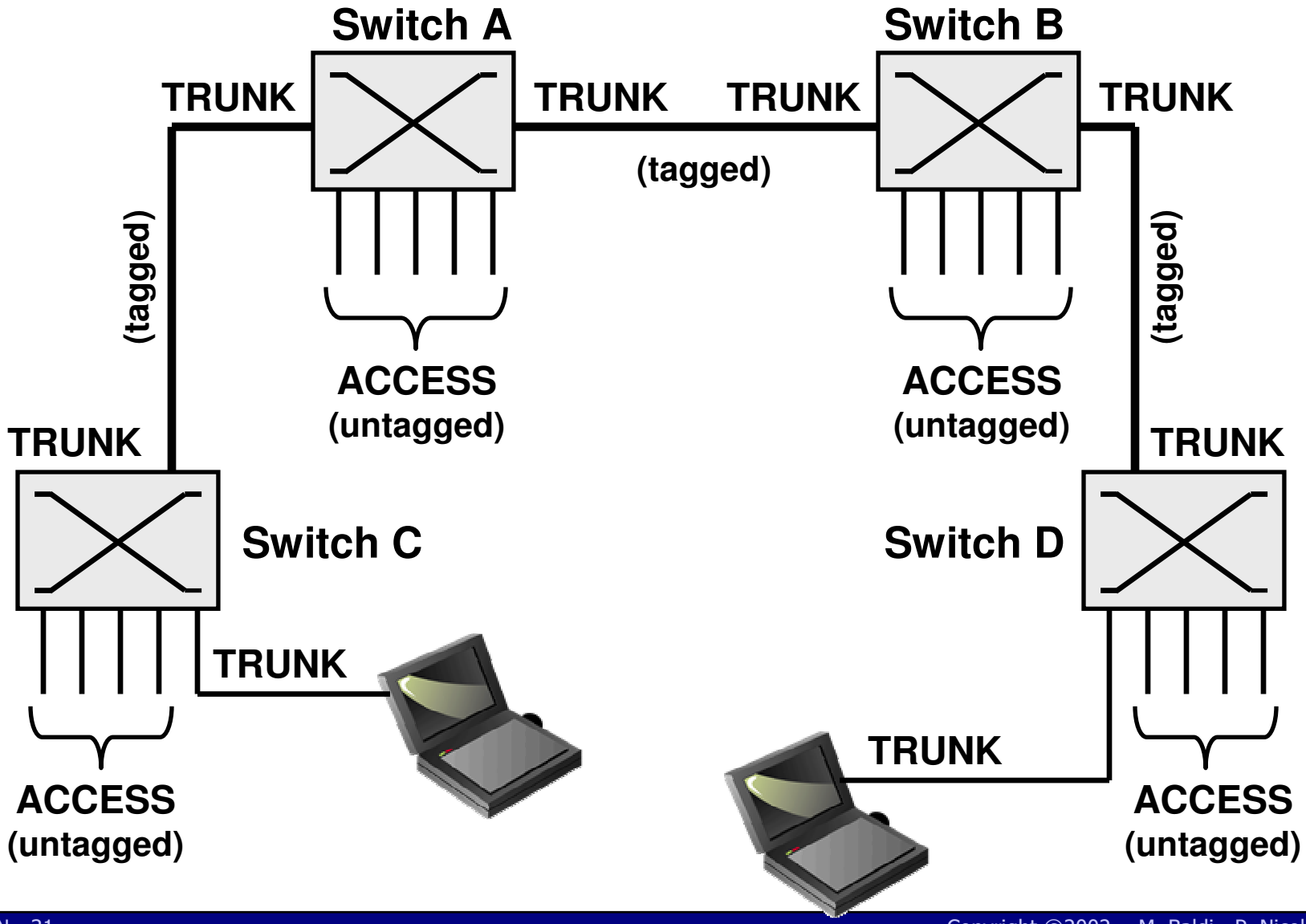
Mobility support example



Mobility Support

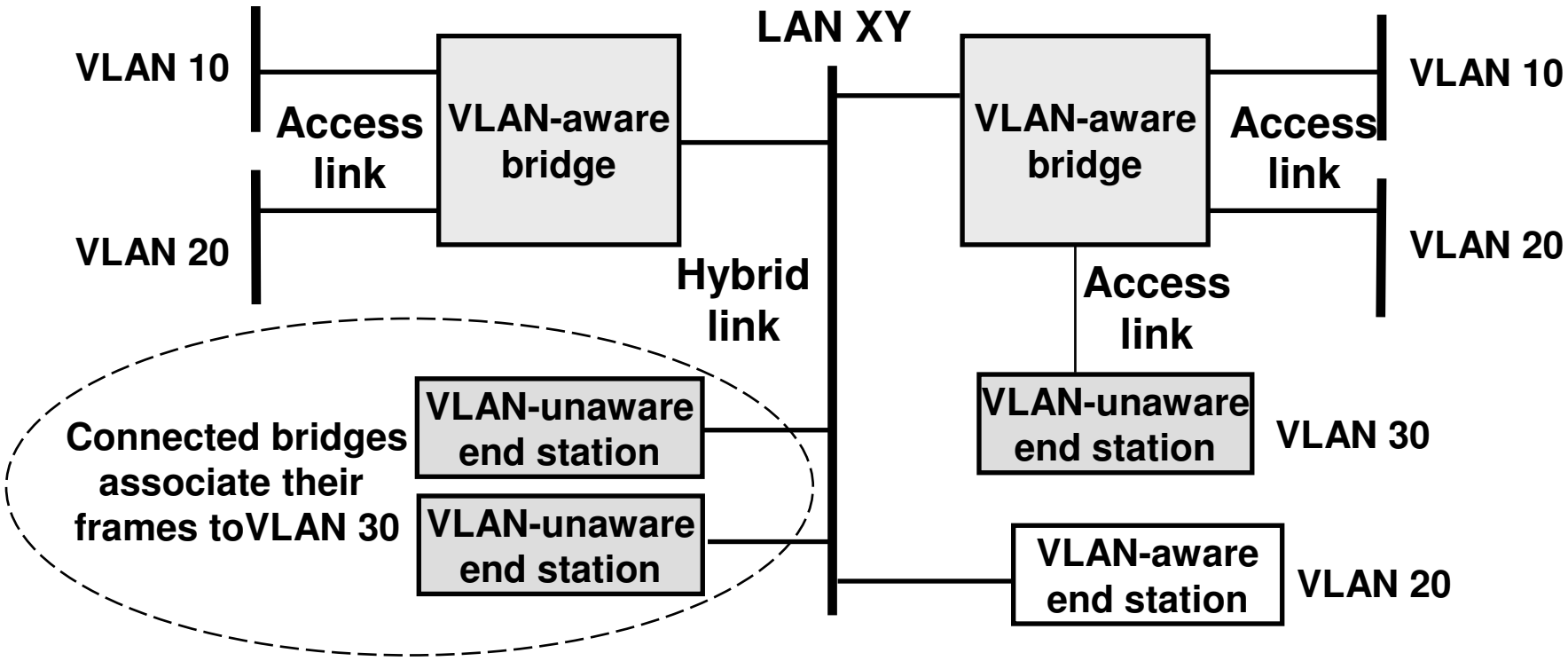
- Hosts with VLAN aware interfaces supporting IEEE 802.1Q tagging
- *Trunk* configuration of host interfaces
- Applicable to both shared (HUB-based) and switched LANs
- Hosts (users) determine the VLAN they belong to
- Hybrid solution:
  - (Large number of) Access ports for non-mobile hosts
  - (Small number of) Trunk ports for mobile hosts

Hybrid Solution with Access and Trunk Ports



Hybrid Link

Both tagged and untagged frames travel on a hybrid link and the switch ports connected to it



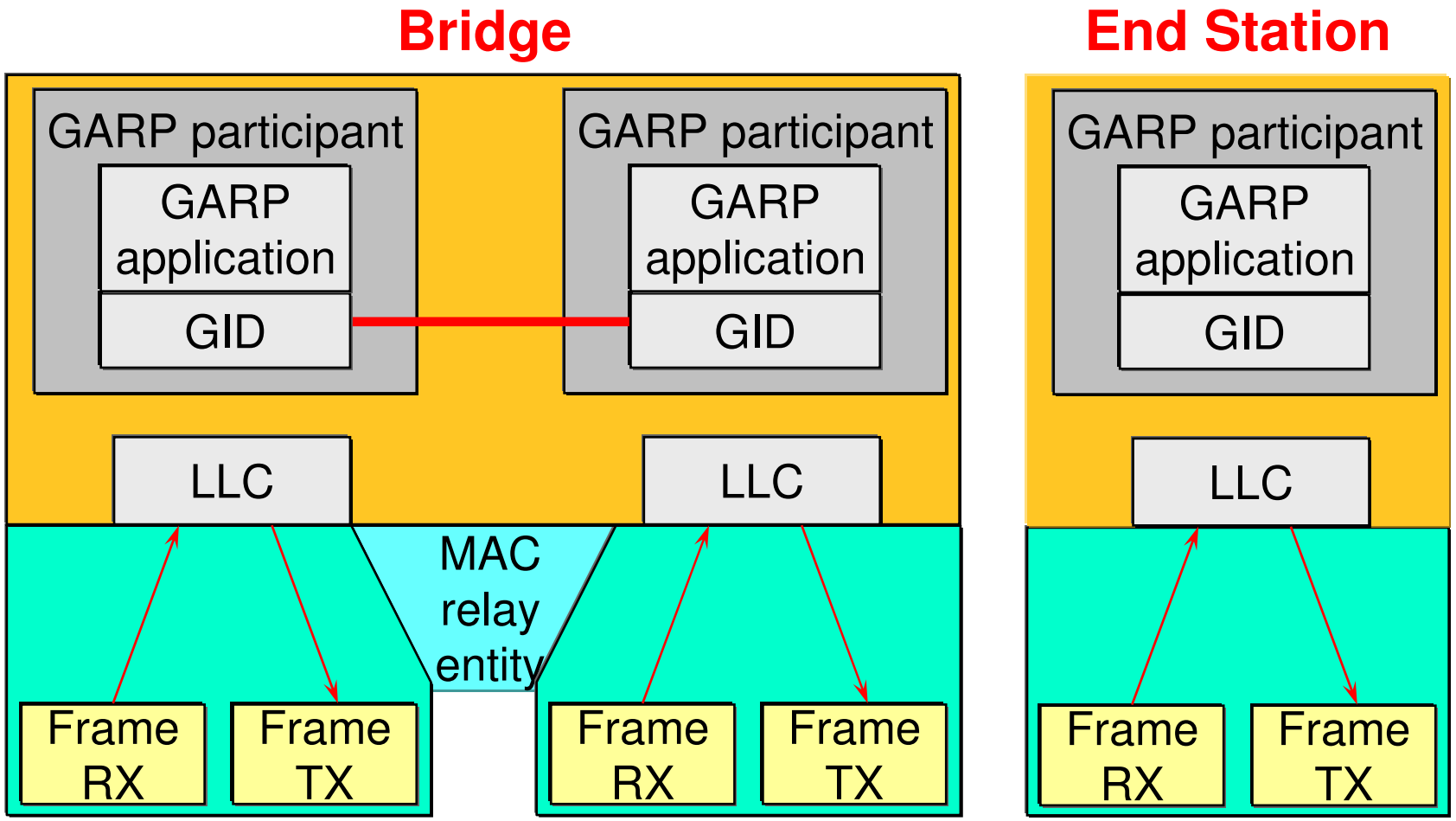
GVRP: GARP VLAN Registration Protocol

- A specialization of GARP: Generic Attribute Registration Protocol
- Used to register or unregister VLAN related attributes
  - A switch registers the VLANs it "knows" with the switch on the other side of a trunk link.
  - Remote switch learns the VLANs whose packets should be forwarded on the trunk link
- Alternative to static definition of VLANs to be forwarded on a *Trunk Link*
- Switch using GVRP are said GVRP-Aware
- GVRP operates on the STP active topology

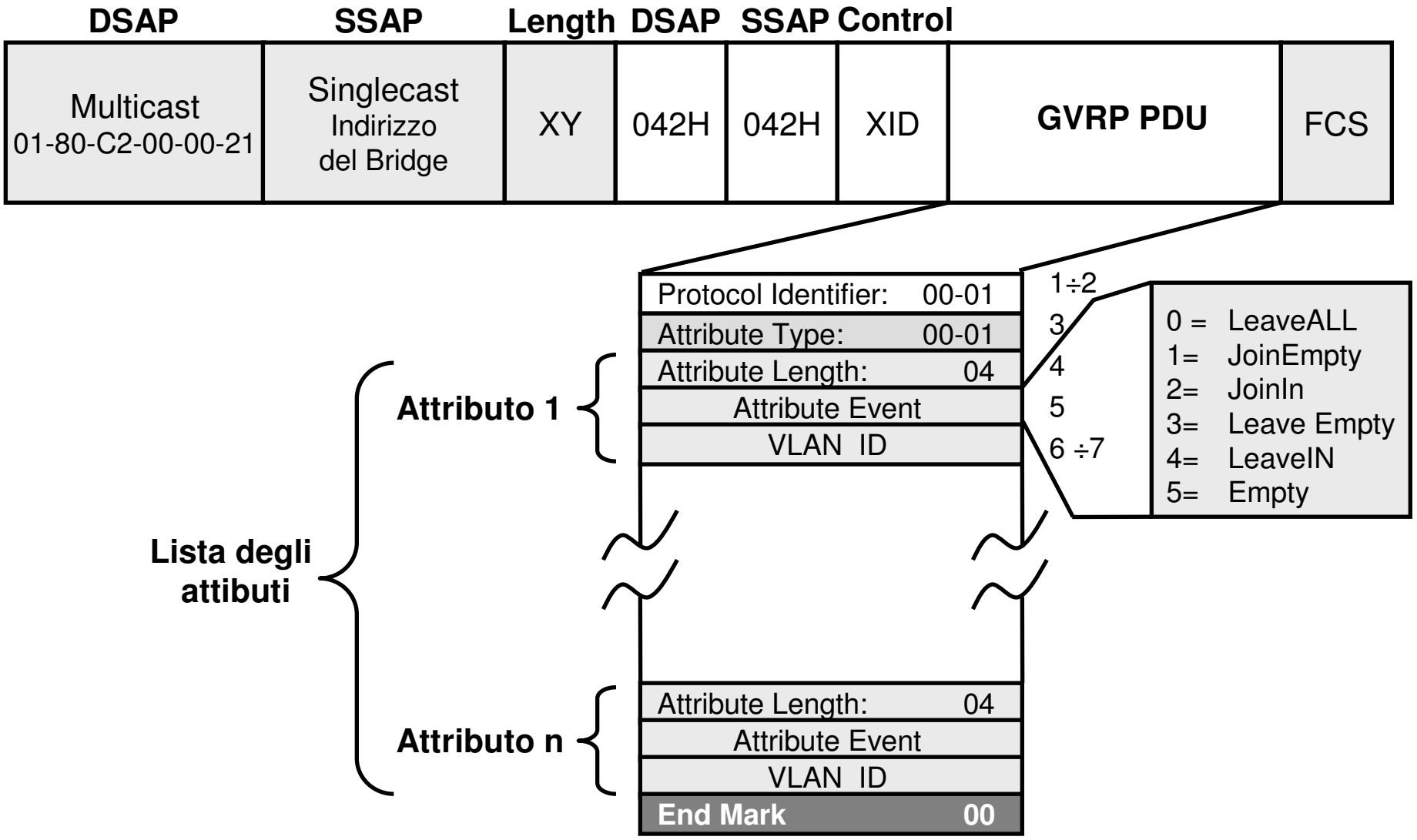
GARP: Generic Attribute Registration Protocol

- Registers or unregisters various types of attributes into an entity within a switch called GID
- GID (GARP Information Distribution)
  - Collection of state machines defining the current status of attribute registrations and declarations
- Attribute registration relates to a port receiving a GARP PDU with the corresponding declaration
    - Also a port set in Blocking state by STP
- GIP (GARP Information Propagation)
  - Entity in charge of propagating information among GARP Participants
    - Inside a single bridge
    - Among different bridges (based on LLC type 1)

GARP: Architecture and Entities



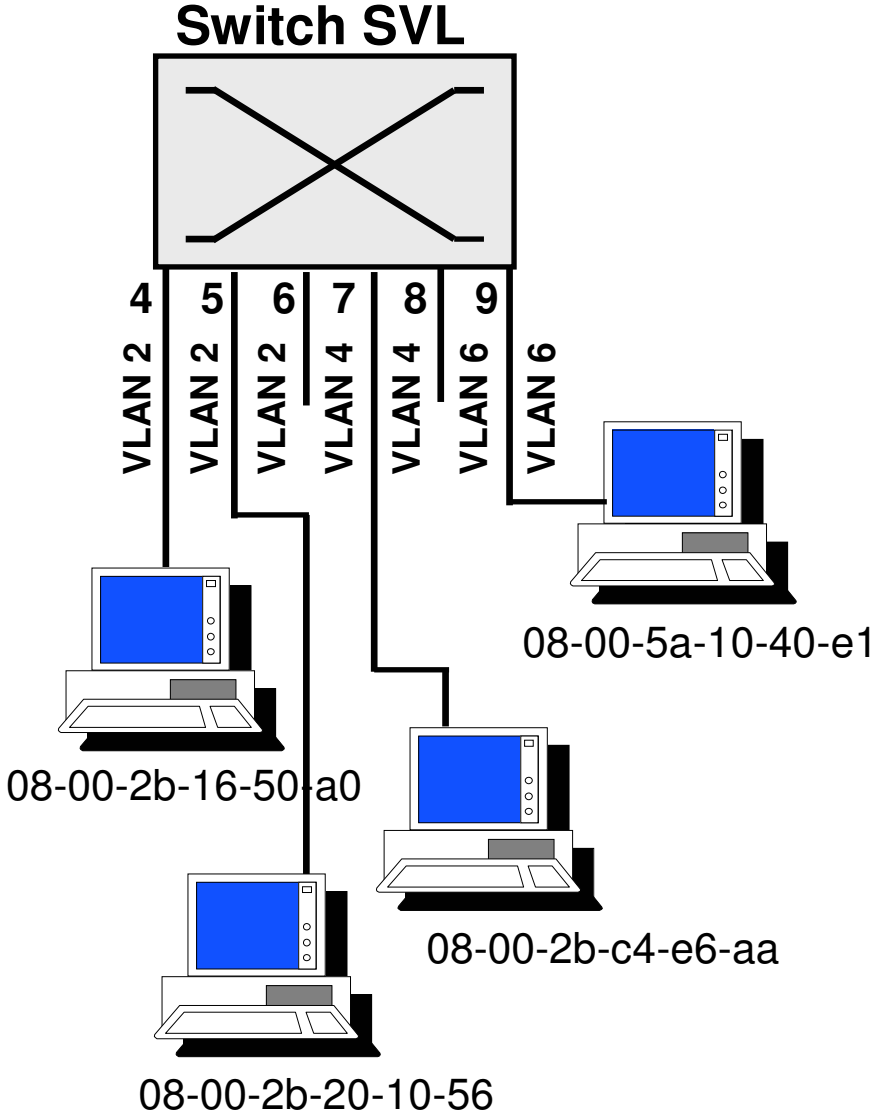
GVRP Packet Format



SVL and IVL Bridge/Switch

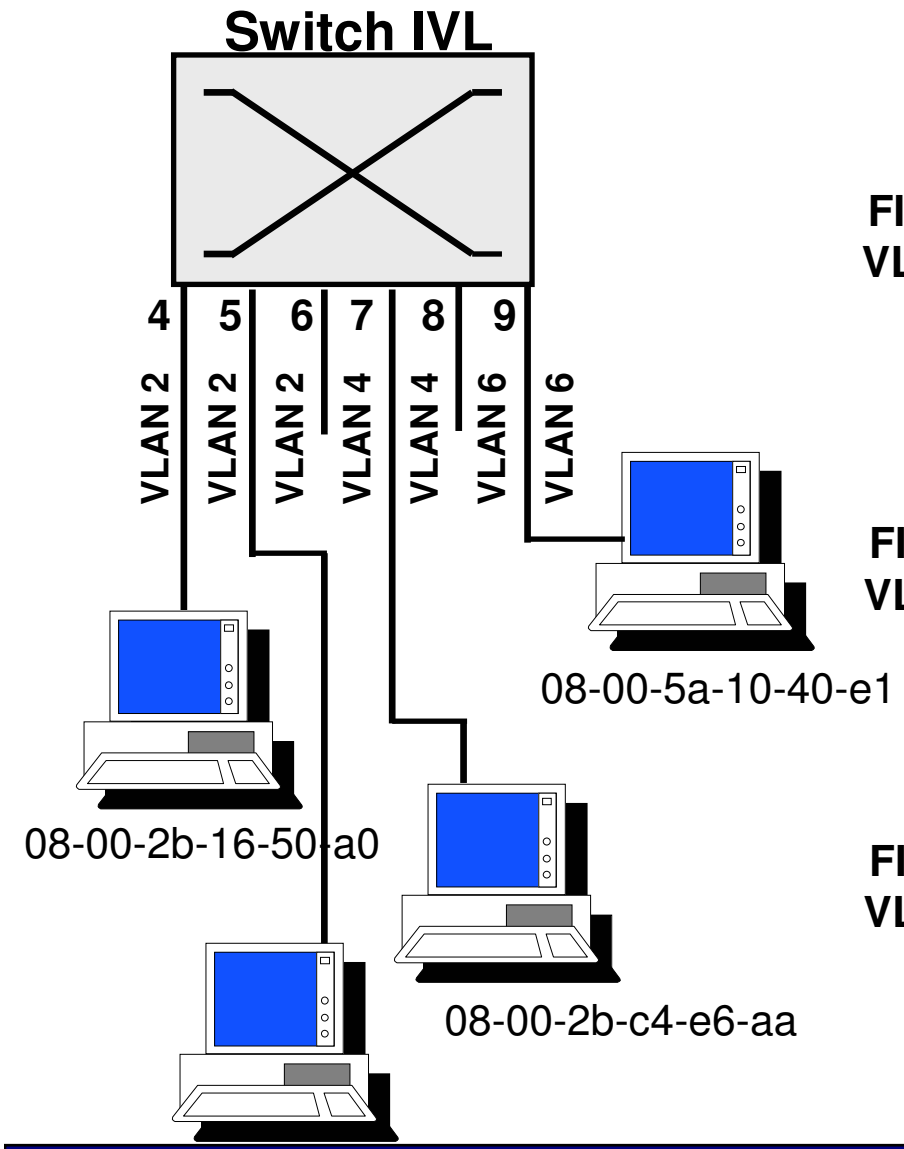
- SVL (*Shared VLAN*) Bridge
  - Single forwarding table (filtering database)
  - Shared by all VLANs
- IVL (*Indipendent VLAN*) Bridge
  - A forwarding table is maintained for each VLAN
  - Identified by a FID (Filtering Identifier)

SVL Bridge/Switch



Port	MAC adress	Ag. Time	VLAN
4	08-00-2b-16-50-a0	1	2
7	08-00-2b-c4-e6-aa	2	4
5	08-00-2b-20-10-56	7	2
2	08-00-5a-10-40-e1	12	6

IVL Bridge/Switch



FID # 1
VLAN 2

FID # 2
VLAN 4

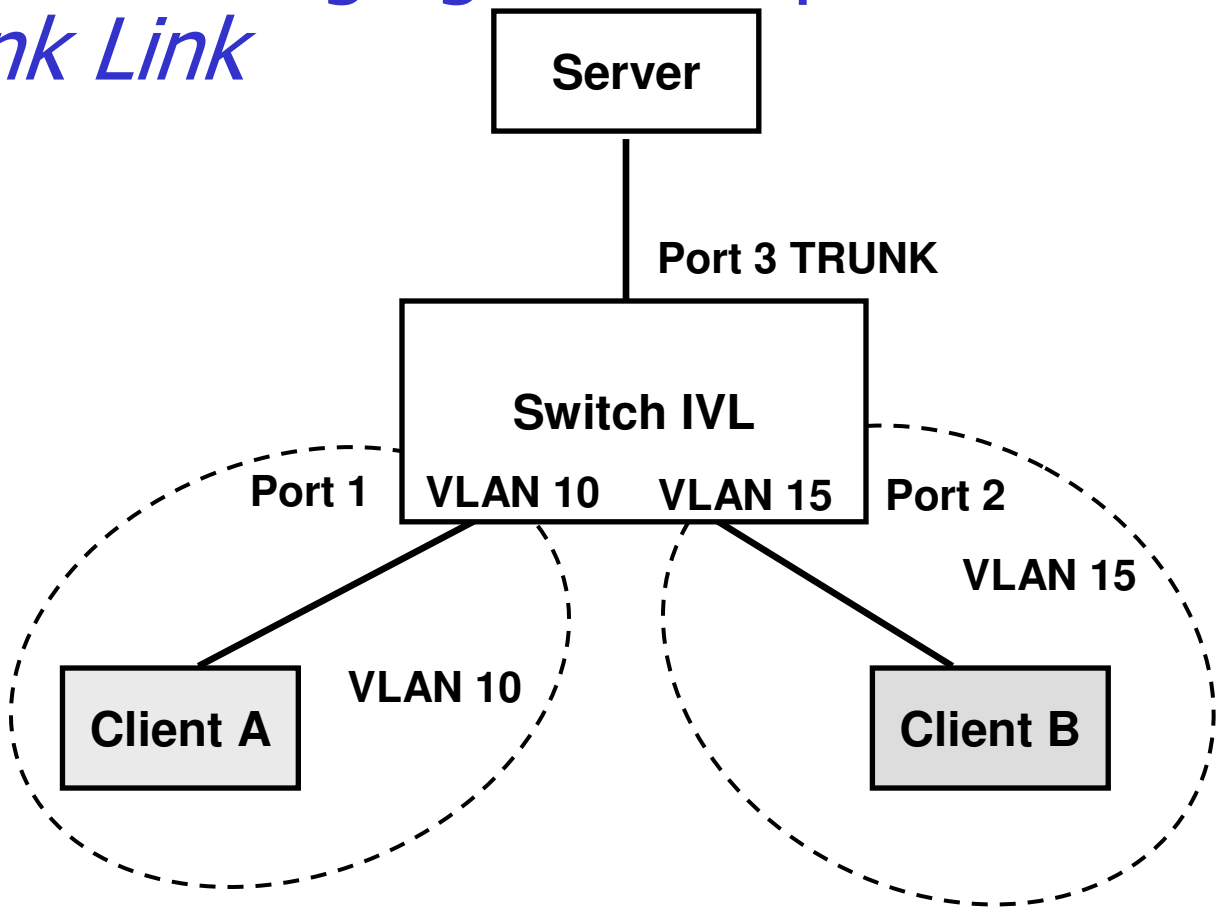
FID # 3
VLAN 6

Port	MAC adress	Ag. Time
4	08-00-2b-16-50-a0	1
5	08-00-2b-20-10-56	7
7	08-00-2b-c4-e6-aa	2
2	08-00-5a-10-40-e1	12

Host Belonging to Multiple VLANs

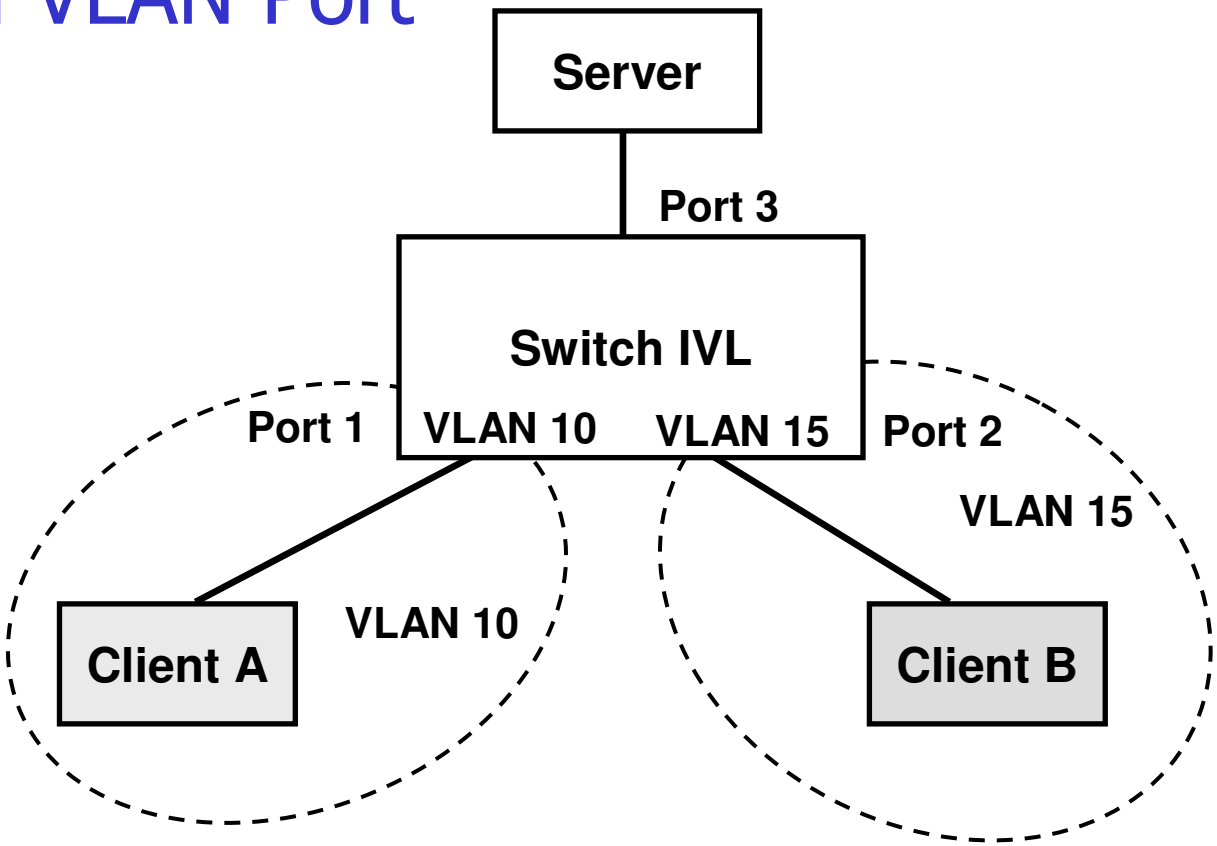
- IVL Switch
  - If host (e.g., a server) interface is VLAN-Aware (i.e., it supports IEEE 802.1q tagged frames), host and switch port are configured in *Trunk mode*
  - Some products (e.g., Cisco switches) support *Multi VLAN* access ports
- SVL Switch
  - Host is connected to Access port
  - Sophisticated VLAN configuration

Server Belonging to Multiple VLANs with *Trunk Link*



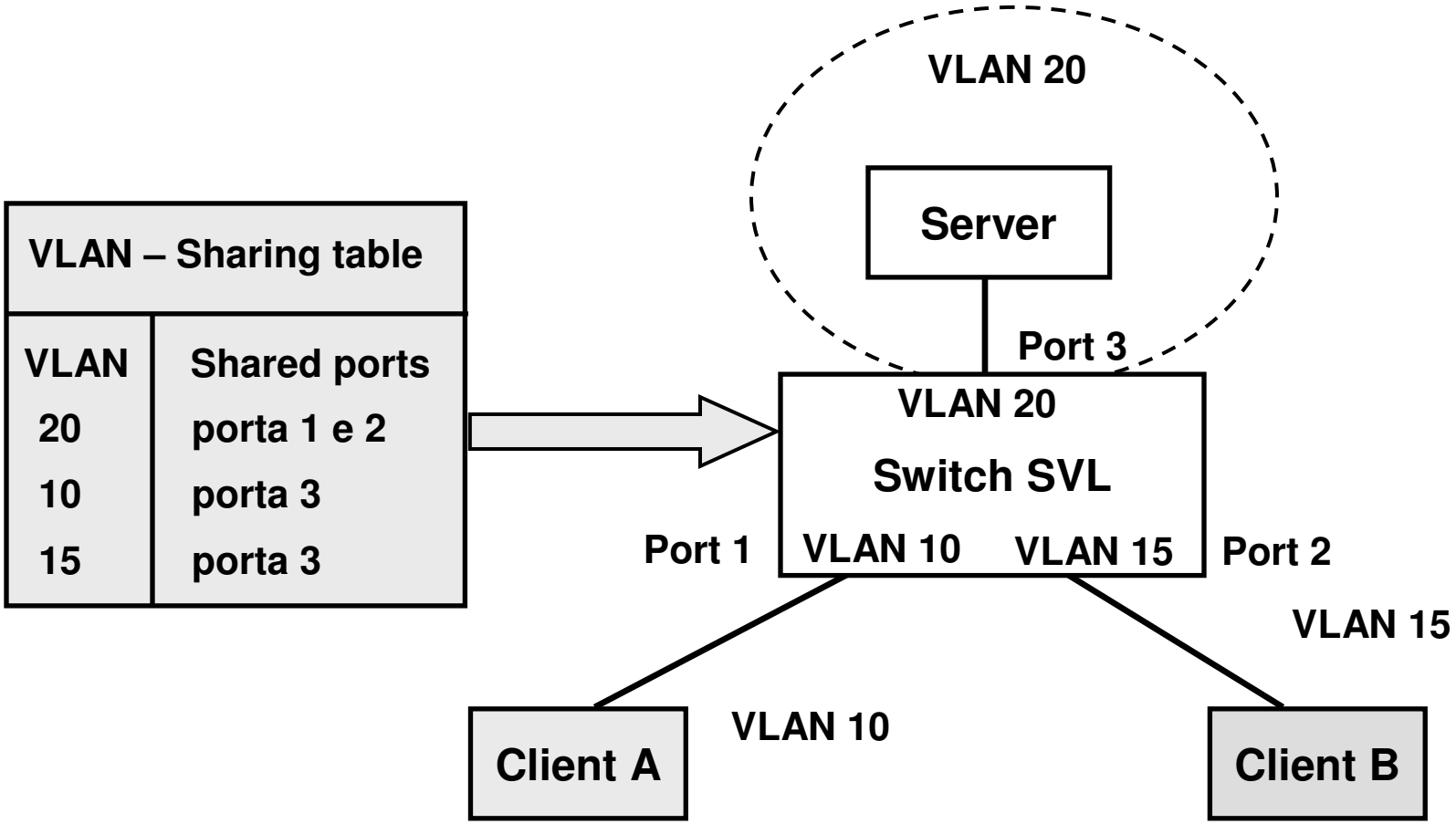

```
Switch(config)#int fastEthernet 0/3
Switch(config-if)#switchport mode trunk
Switch(config-if)#switchport trunk allowed vlan add 10,15
Switch(config-if)#end
```

Server Belonging to Multiple VLANs with Multi VLAN Port



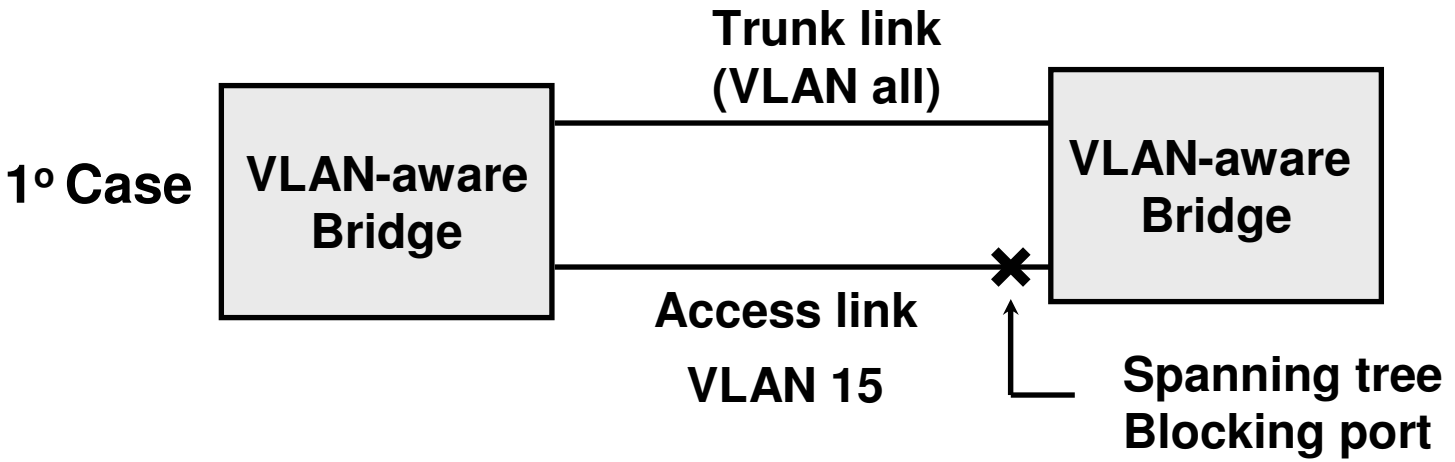

```
Switch(config)#int fastEthernet 0/3
Switch(config-if)#switchport mode multi
Switch(config-if)#switchport multi vlan add 10
Switch(config-if)#switchport multi vlan add 15
Switch(config-if)#end
```

Server Belonging to Multiple VLANs with SVL Switch

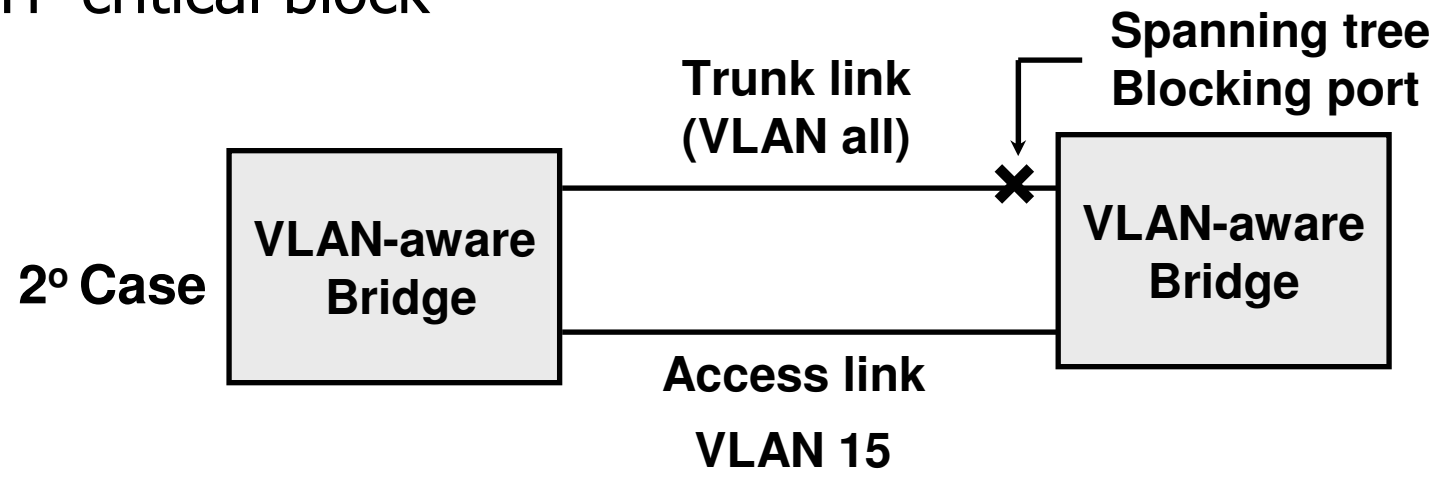


Spanning tree problem with 802.1Q

STP not critical block

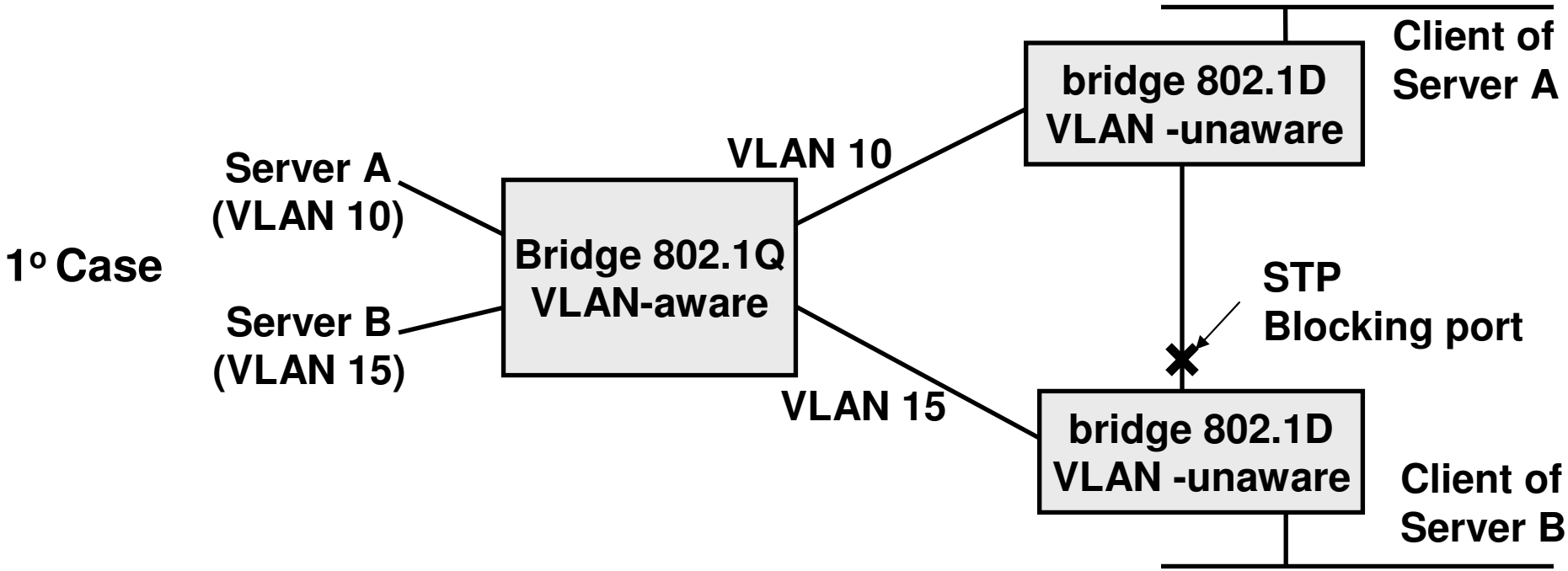


STP critical block



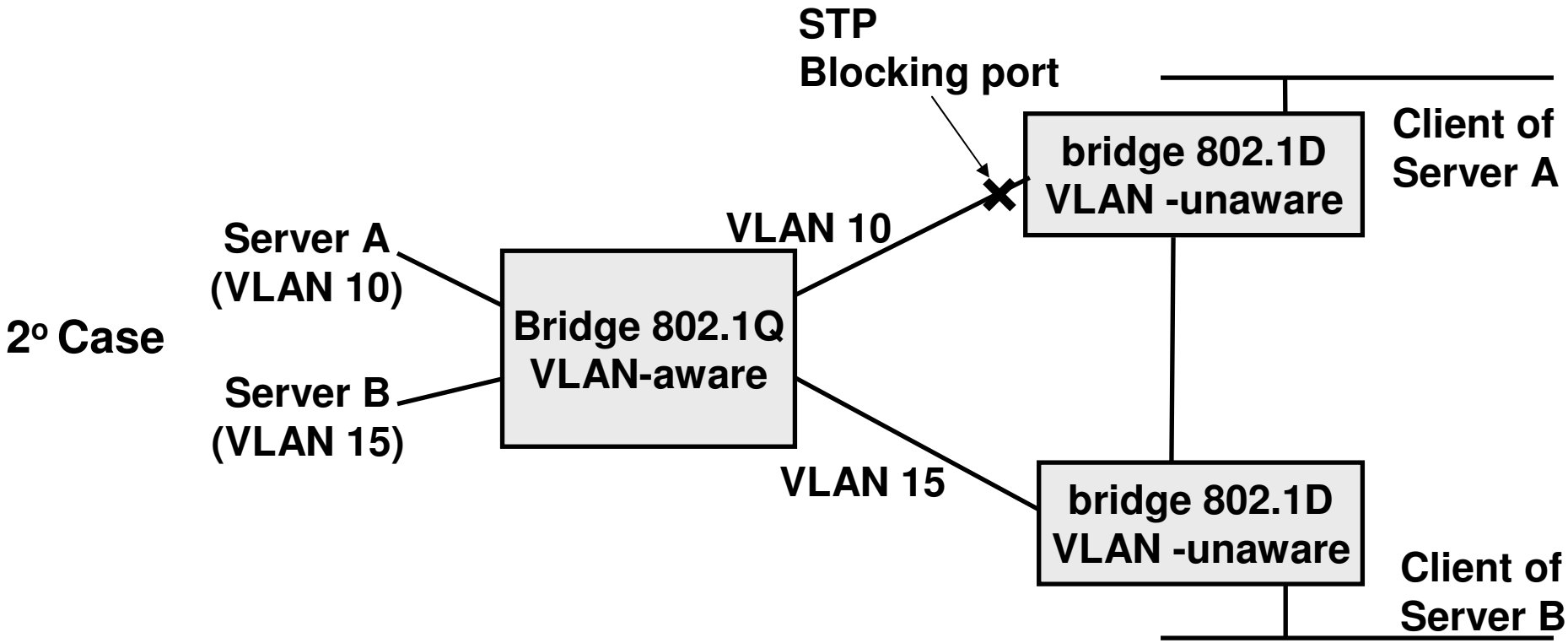
Problems between VLAN-Aware and VLAN-Unaware bridge

STP critical block



Problems between VLAN-Aware and VLAN-Unaware bridge

Block which does not allow the connection from clients A to server A



IEEE 802.1v STANDARD

- Per protocol based VLAN assignments
  - VLAN Port-and-Protocol-based classification
- Possible associations:
  - One VLAN an the switch port (per port VLAN)
  - More VLANs on the same port based on protocols classified (per protocol VLAN)
- Packets classification :
  - On a basis protocol if they transport one of the protocols a VLAN association was defined for
  - The other ones, not classified by protocol, assumes VLAN assigned to the port the (per port VLAN)

Protocol classification

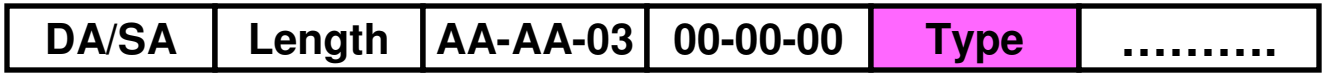
This fields according to the frame format are taken:

- Ethernet V 2.0
- IEEE 802.3 RFC 1042 compliant
- IEEE 802.3 IEEE 802.1H compliant
- IEEE 802.3 with Private SNAP
- All the other cases of IEEE 802.3 formats

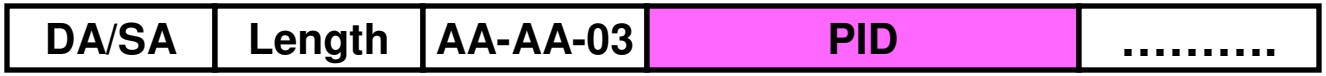
Classification fields

1 – Ethernet V 2.0

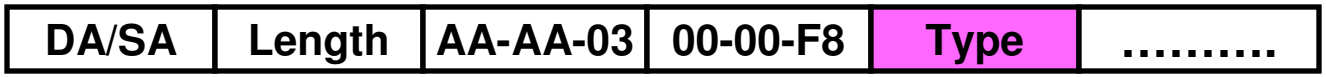
2 - 802.3 RFC 1042



3 - 802.3 Private SNAP



4 - 802.3 802.1H compliant

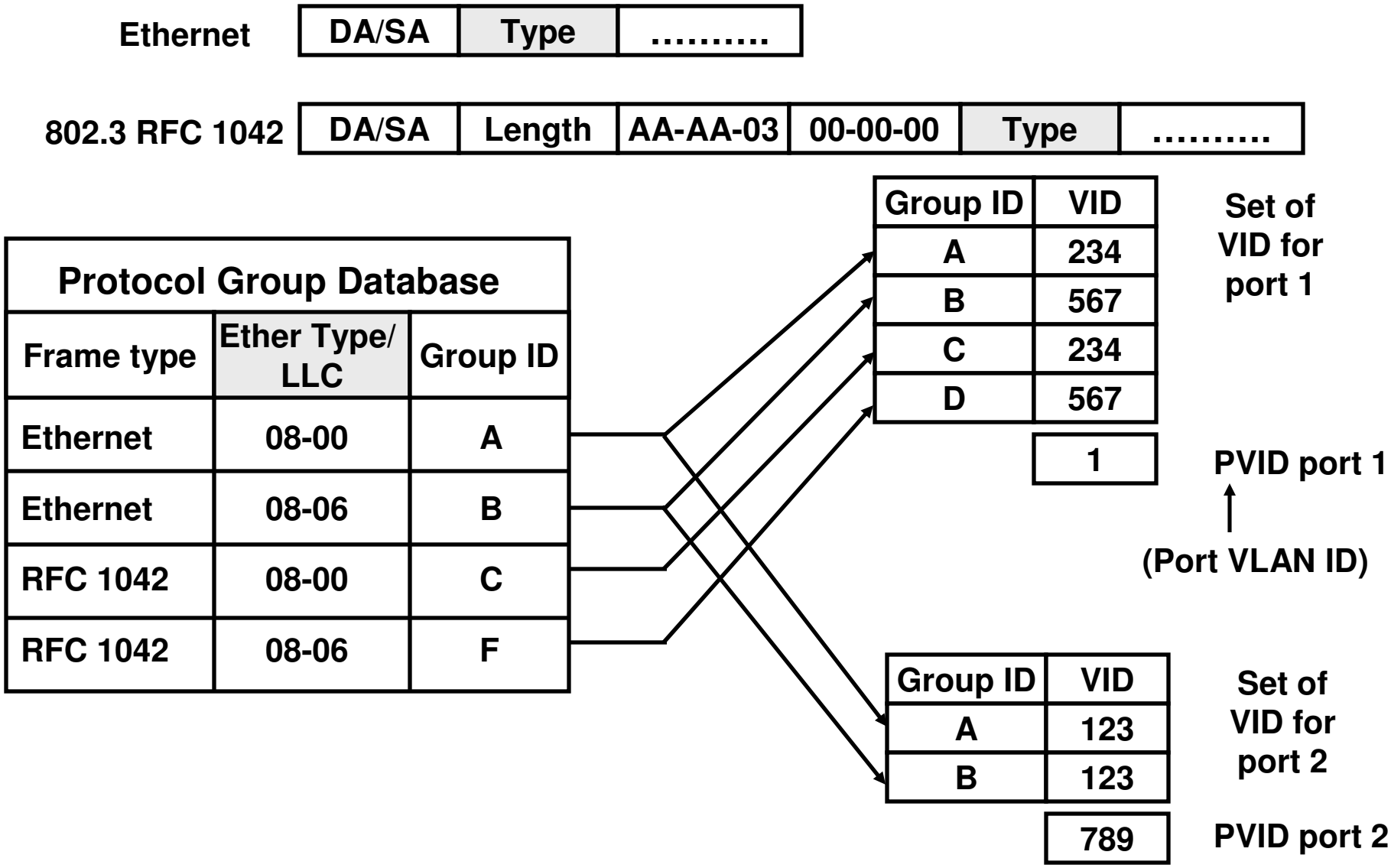


5 - 802.3 with LLC addresses

Rudiments on which 802.1v bases his functions

- Protocol Group Database
  - Code of the classifiable protocols
  - *Group ID* (identifier)
- Group ID are associated with VLAN in a flexible manner:
  - A VLAN for every Group ID
  - Several Group ID to the same VLAN
- Several VLAN ID (VID) for ports receiving untagged traffic
  - Port-and-Protocol-based classification

Multiple VID on the switch ports assignation example

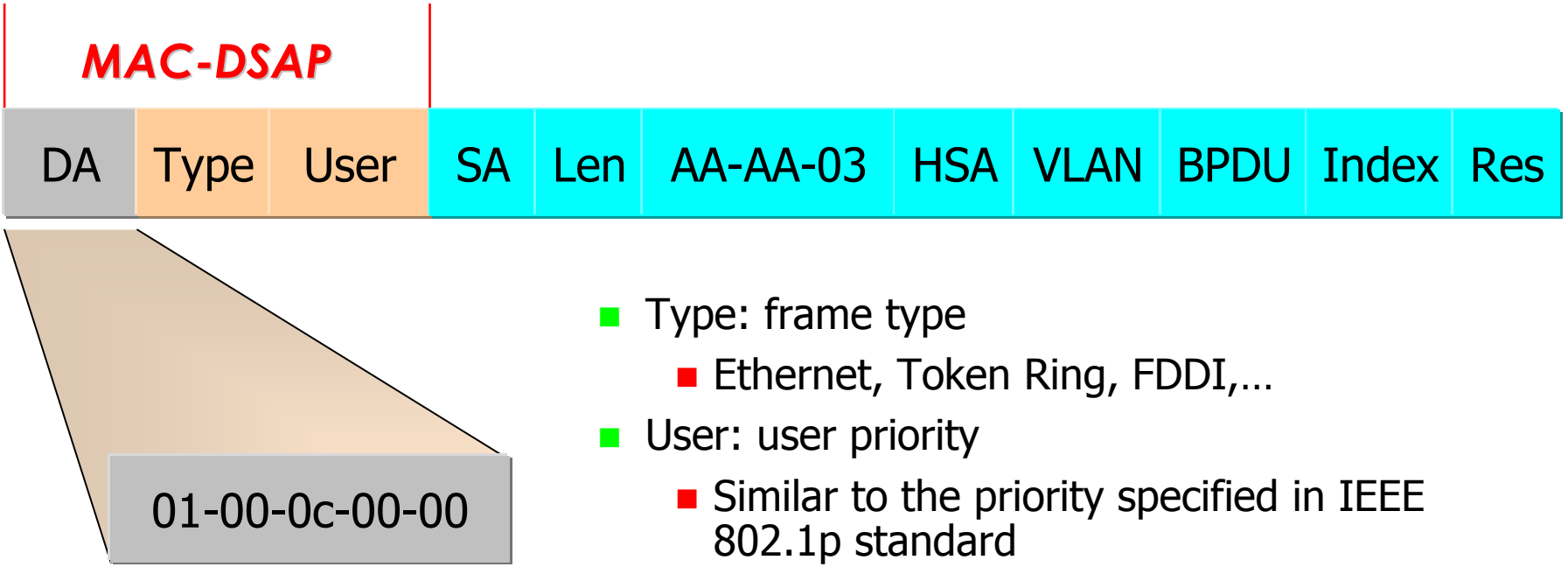


Cisco Inter Switch Link (ISL)

- The original frame is encapsulated within a ISL header and a new FCS
  - two level tagging method
- allows the support of 1024 VLAN
- Multiple Spanning Tree (one per VLAN)
- Realized in ASIC to ensure wire speed performances

ISL header format

- The 40 first bits of MAC DA identify a multicast destination address
- The other 8 bits are used as type and user field



- Type: frame type
  - Ethernet, Token Ring, FDDI,…
- User: user priority
  - Similar to the priority specified in IEEE 802.1p standard

ISL per VLAN Spanning tree