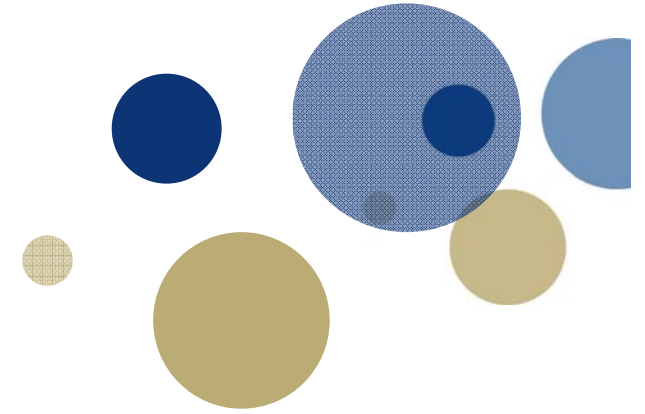




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# **IEC61850: Communication between substations**

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# Outline



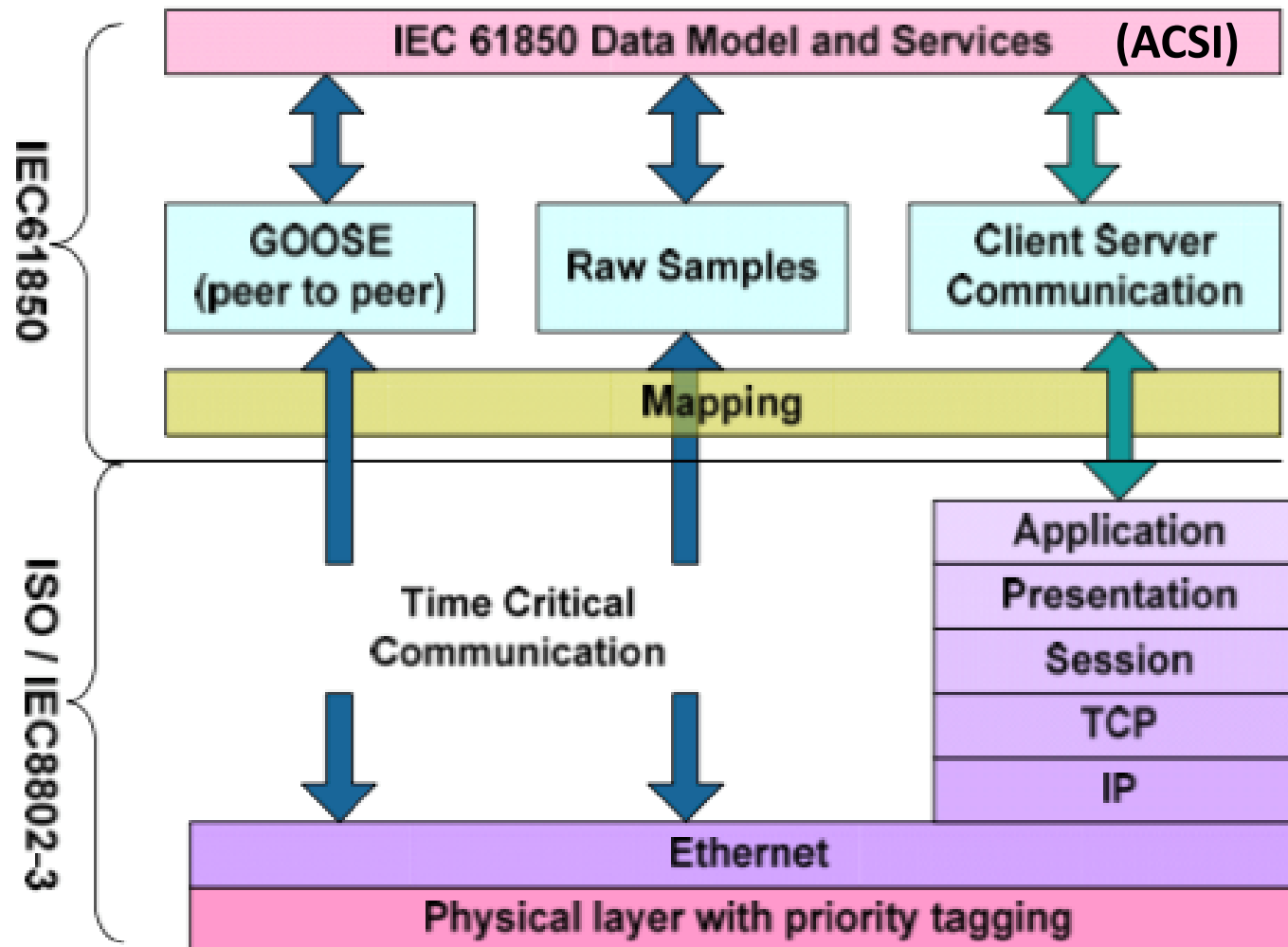
- **Introduction**
  - Motivation: Communication and protection
  - IEC61850 object model and OSI stack
  - Delay elements
- **SS-SS communication architecture: Tunnelling vs Gateway**
  - Tunnelling
  - Proxy gateway
- **Tunnelling Solutions**
  - VLAN
  - QinQ
  - MPLS

# Motivation: Communication and protection

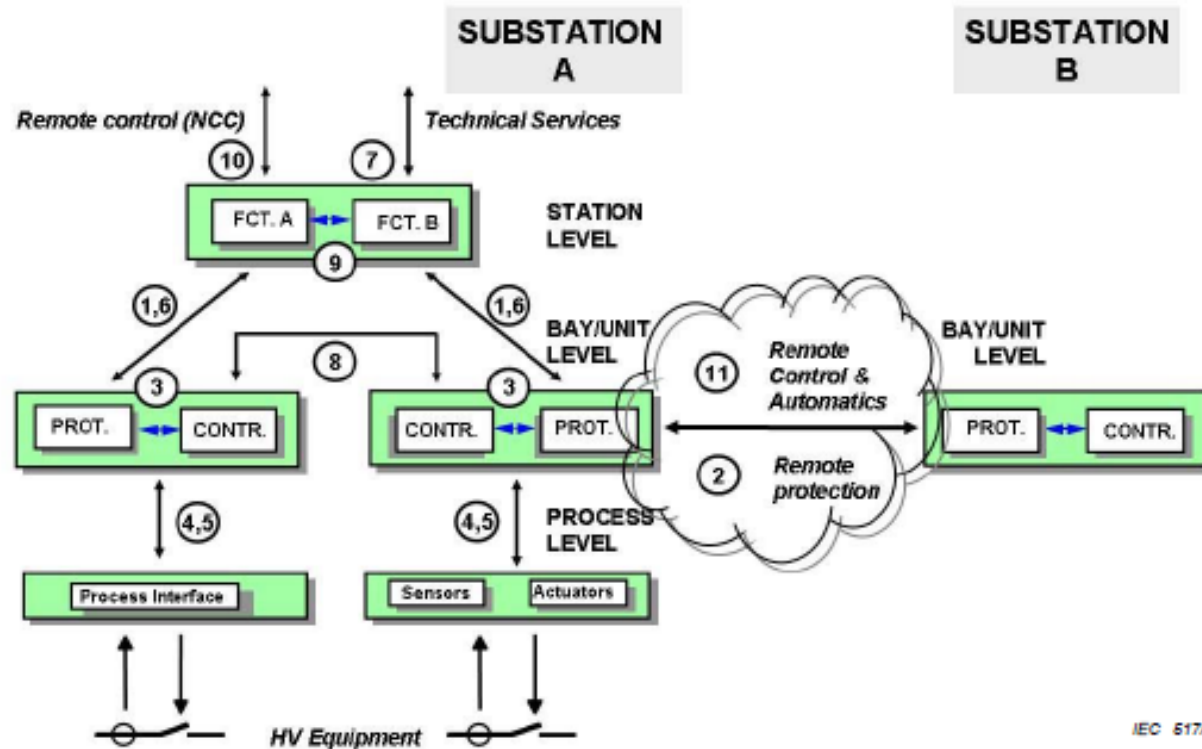


- Smart grid + modern relays (IEDs) = innovative communication-based protection schemes
- Communication Requirements
  - Latency, reliability, and dependability
- IEC61850
- Basic Values
  - Replace point-to-point copper wiring
  - Improved protection
  - Interoperable devices
- IEC 61850 Scope
  - Functional modelling of the power system
  - Self-description of information
  - Application-based transmission
    - Publish-subscribe for “high speed” data i.e. GOOSE/SV
    - Client-server for trusted data to control centre e.g
  - XML for configuration

# IEC61850 object model and OSI stack



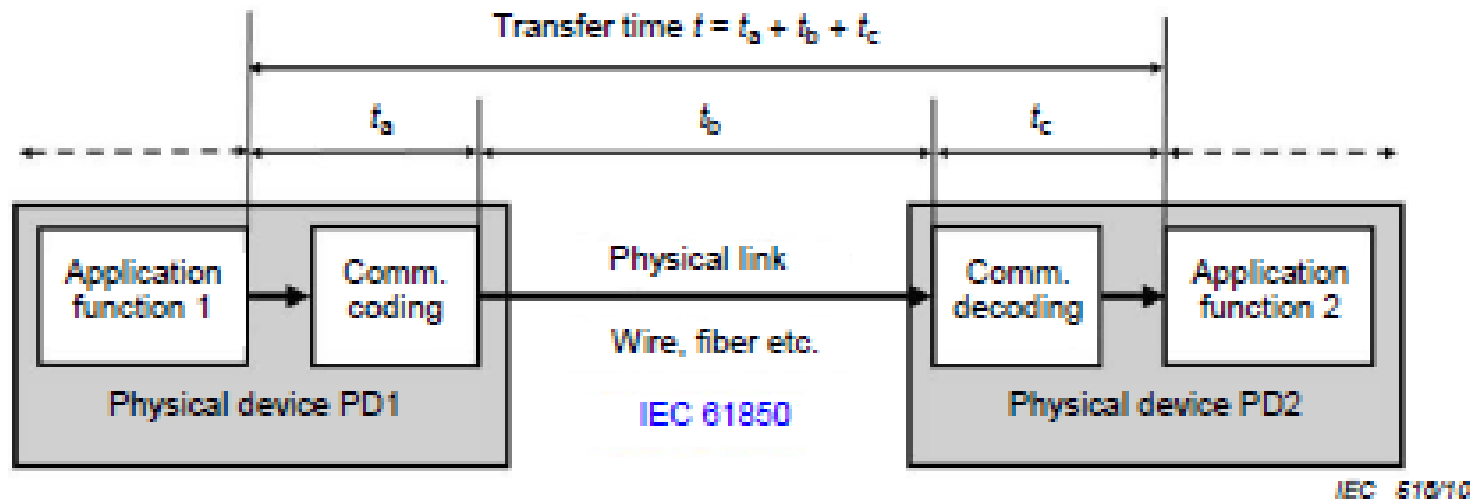
# SS-SS Communication: Logical allocation of functions and interfaces



IEC 61710

- Interface 2 and 11 as focus for SS-SS communication
  - I/F 2: Tele-protection interface, the protection related function between substations, Refers both to analogue data e.g. line differential protection and binary data e.g. line distance protection
  - I/F 11: Represents the control related functions between substations

# Delay components

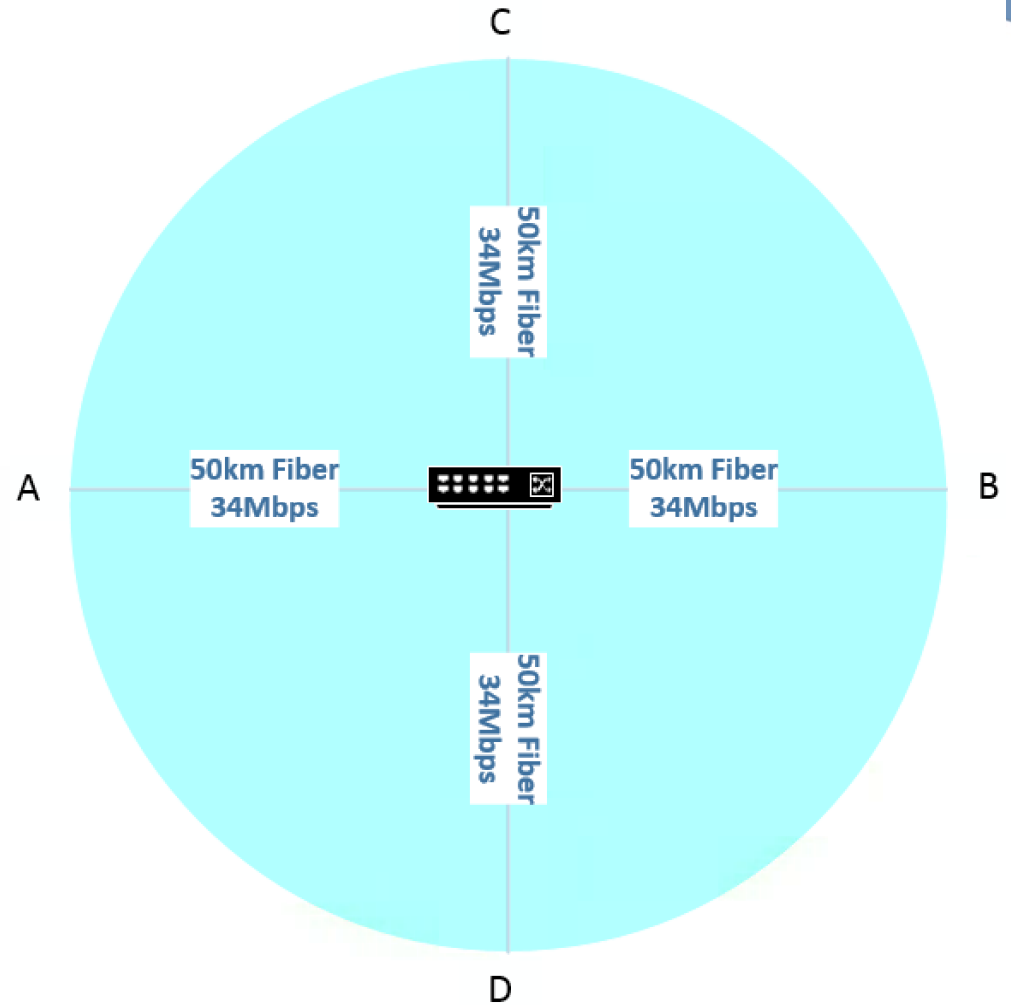


- **$t_a$  &  $t_c$  Coding and Decoding times;** varying processing times depending on the number of data objects in a dataset
- **$t_b$  Network transfer time**
  - Propagation time
  - Queuing time
  - Processing times of active components in the communication path such as switches, routers, repeaters

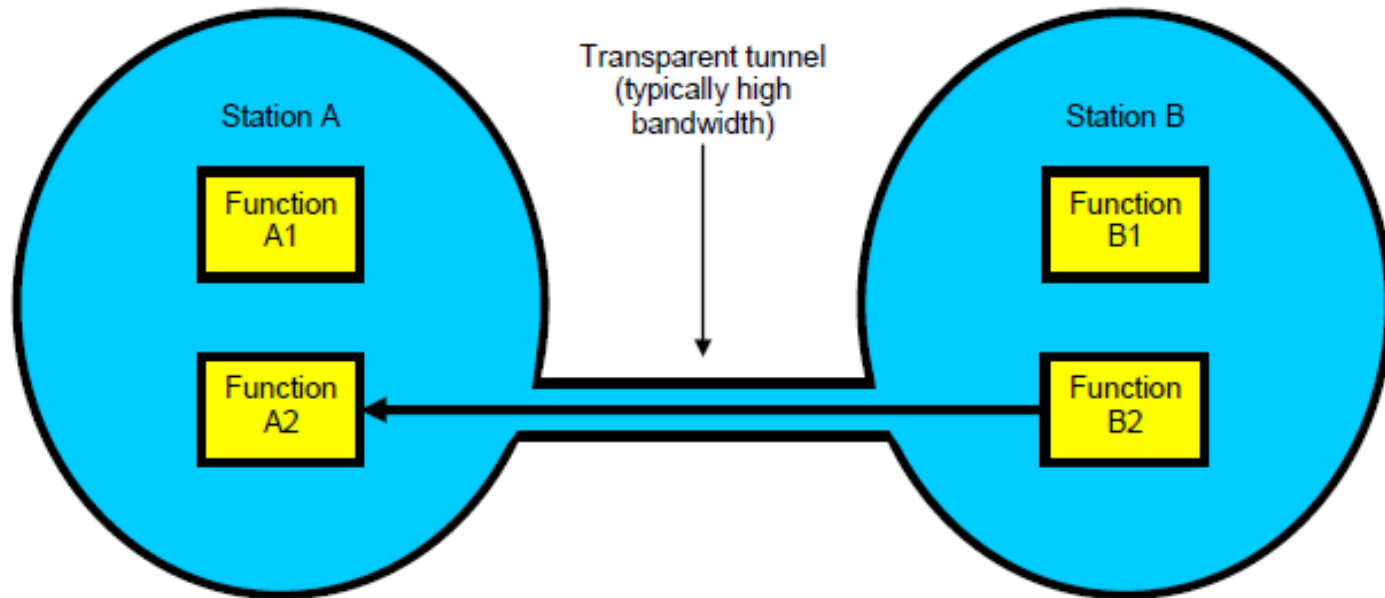
# Example delays



- Latency in a single mode fiber link approximated as  $5\mu s/km$  i.e.  $500\mu s/100km$
- High priority packet may have to wait for a maximum-length lower priority packet to egress;
- Also a high priority packet (GOOSE with 600 bytes) may have to wait for another high priority packet to egress;



# SS-SS communication architecture: Tunnelling vs Gateway



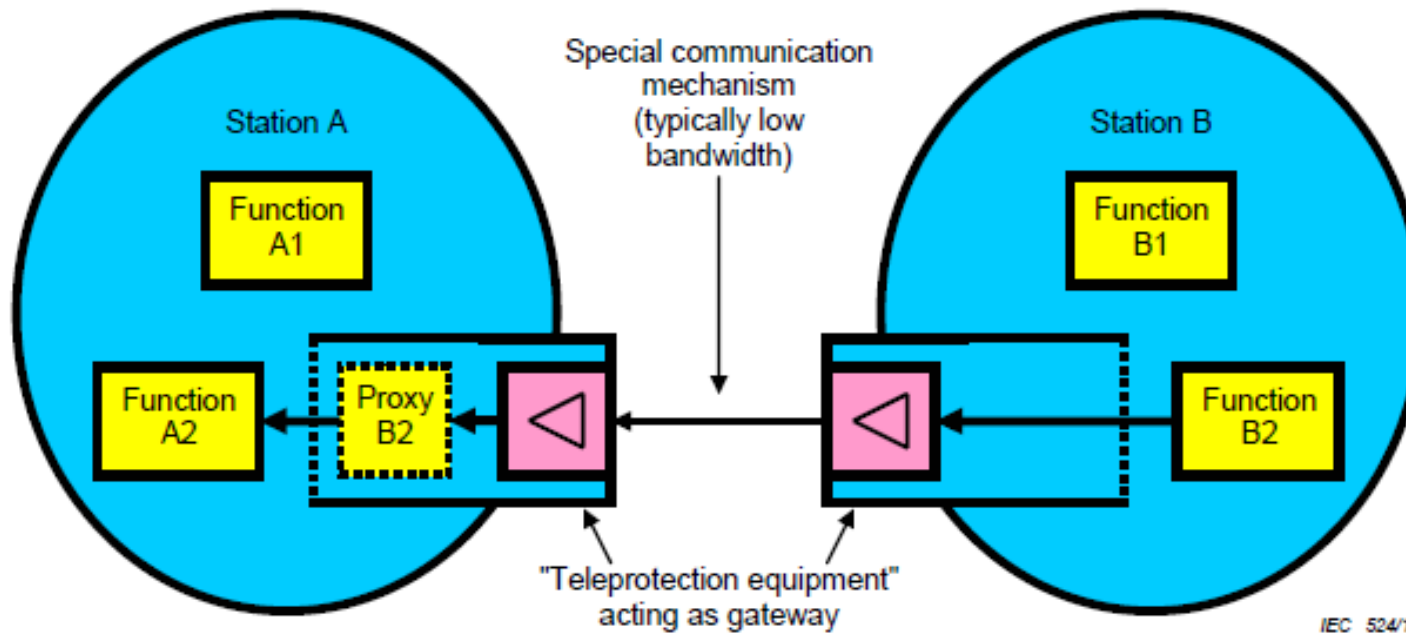
IEC 523/10

## Tunnelling

- Allows “direct” access
- Extended station network to include the remote station
- Broadcast domain extends into the remote station for GOOSE/SV



# SS-SS communication architecture: Tunnelling vs Gateway



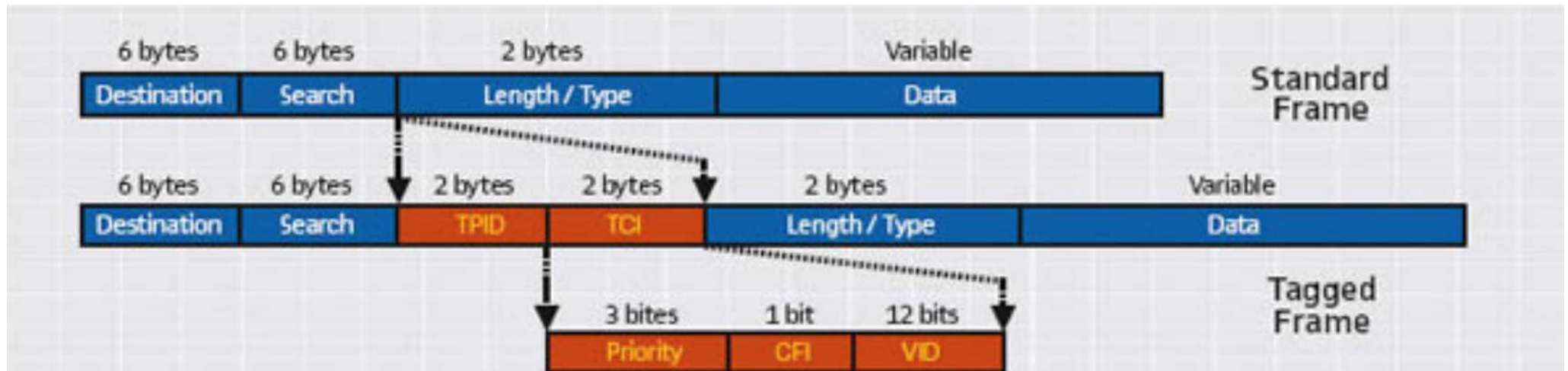
## Gateway

- Establishes “indirect access”
- Used if communication link does not support Ethernet communications e.g. PLC, radio, PDH
- Proxy gateways normally used

# Tunnelling Solutions:

## IEEE 802.1Q VLAN – Virtual Local Area Network

- Logically subdivide a network into virtual LANs
- GOOSE/SV support VLAN and priority tagging to create separate virtual network within the same physical network



# VLAN Stacking/ QinQ / IEEE 802.1Q Tunneling



Original Ethernet Frame



802.1Q Frame from Customer



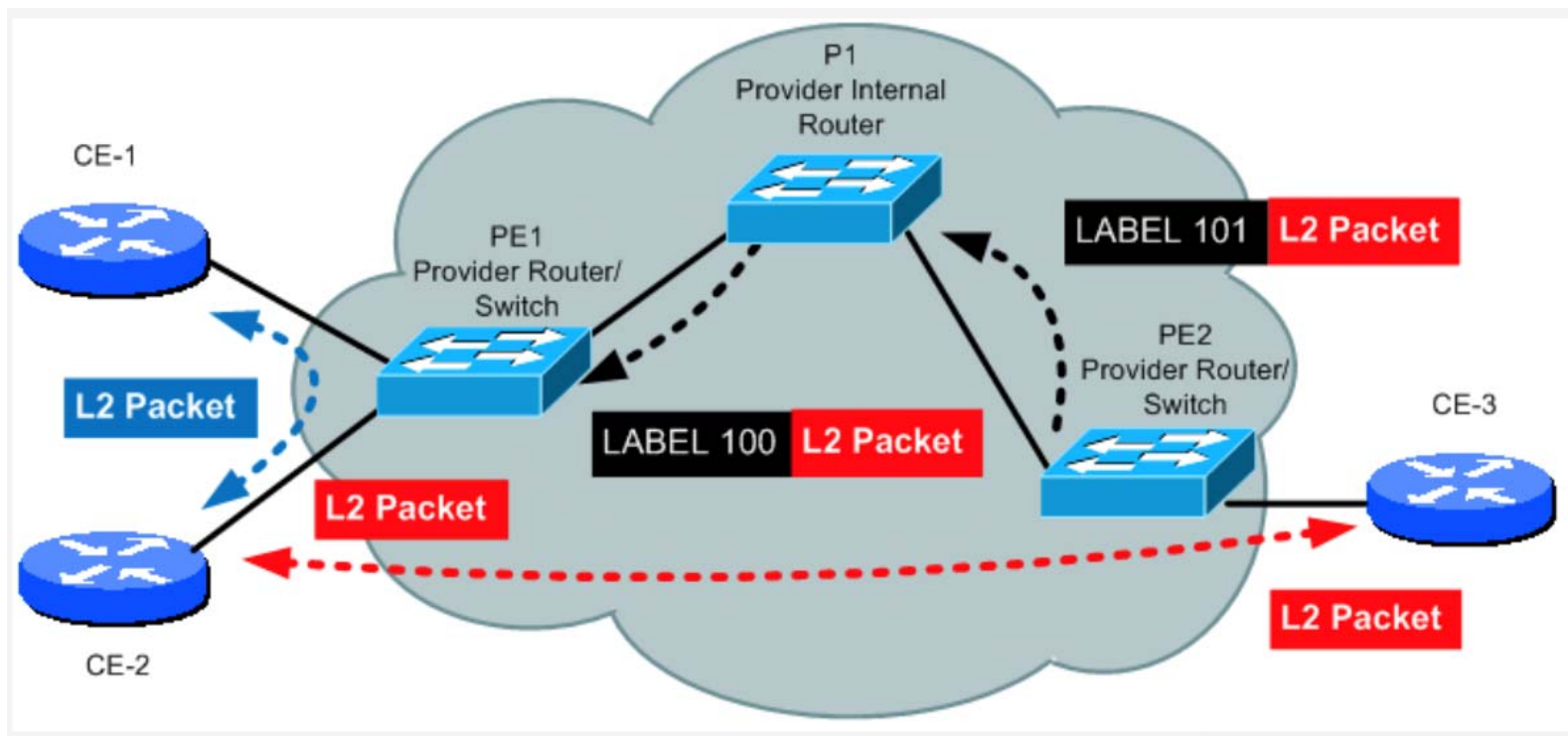
802.1Q Frame on Trunks between service provider Switches



- Placing one VLAN inside another (or on top of)
- Provides simple Layer 2 VLAN solution

# MPLS – Multiprotocol Label Switching: Ethernet over MPLS

- Provides a tunnelling mechanism for Ethernet traffic through an MPLS-enabled layer 3 core
- Encapsulates Ethernet PDUs inside MPLS packets
- Forward packets using label stacking, across the MPLS network





**Thanks for the attention**