Network Technology 2 –

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Accessing the WAN

- Last course in the CCNA curriculum
- Covers:
  - WAN protocols (HDLC, PPP, Frame Relay)
  - Security (Securing the routers, Access Control Lists)
  - Teleworker Services (VPN)
  - IP addressing Services (DHCP, NAT, IPv6)
  - Troubleshooting (Network documentation, troubleshooting methods)

Examination

- Final Exam
- Practical Exam
  - Lab will not be published beforehand.
  - 3 hours.
  - 7 minutes of discussion. Two topics from CCNA4 will be discussed.

Introduction to WAN

WAN

Background

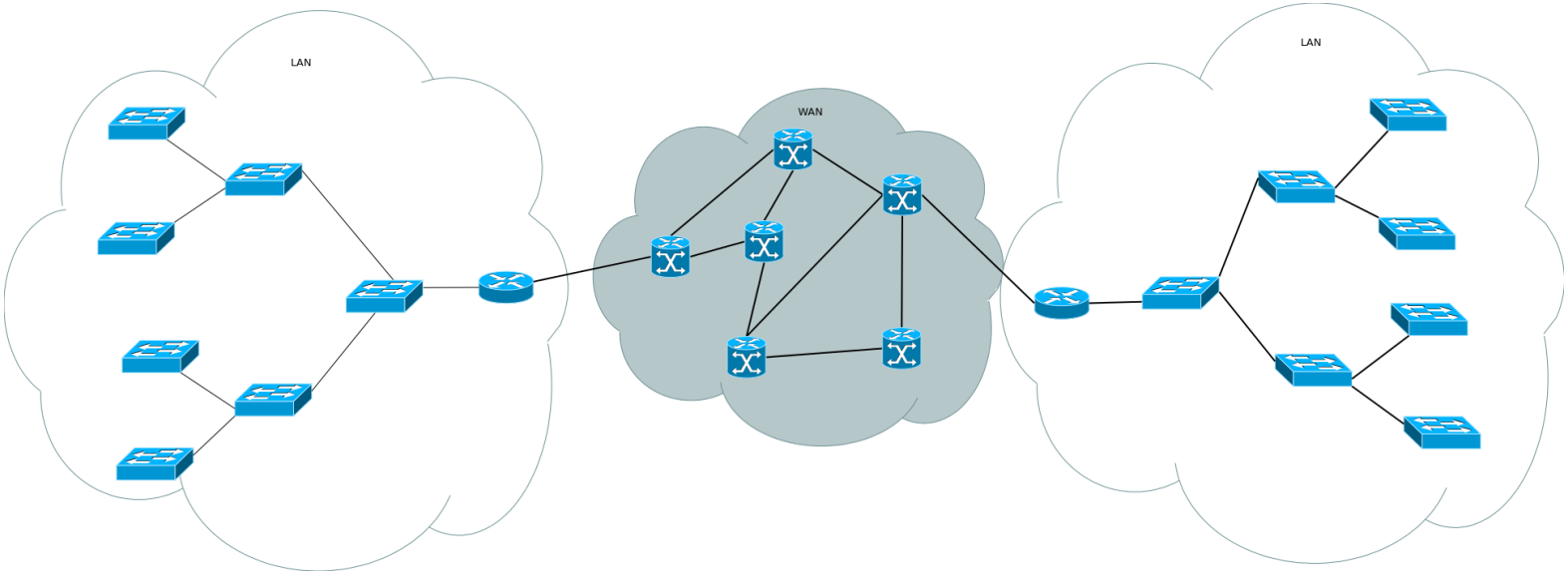


Figure 1 : Purpose of a WAN

WAN Switching Concepts

Types of WAN Switching

- Circuit Switched,
- Packet Switched,
  - Connectionless
  - Connection-oriented
    - Virtual Circuit Switched.

Circuit Switched

- Public Switched Telephone Network (PSTN)
- Invented by an undertaker named Almon Strowger in Missouri, due to a biased phone operator.
- A reserved circuit is established *before* any data can be sent.
- Only propagation delay, seldom congestion.
- No frames will arrive out of order.
- No addressing on each frame required.
- Congestion can occur during setup.
- Guaranteed service, but wasting resources.
- Not as fault tolerant as packet switched.

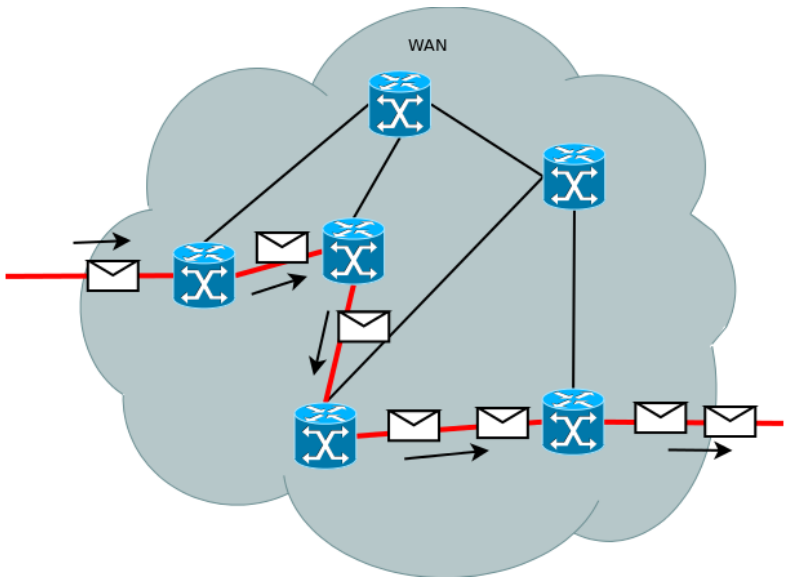


Figure 2 : Circuit-switched network.

Packet Switched

Connectionless:

- Data is divided into individual packets.
- Routed over a *shared* network.
- Each switch evaluates where to send the packet based on address.
- Tight limit on packet sizes to ensure that not one host can monopolize the link.
- No bandwidth is dedicated, allows for queueing delay and congestion.
- No guaranteed service, but no (less) waste of resources either.
- More fault tolerant than circuit switching.

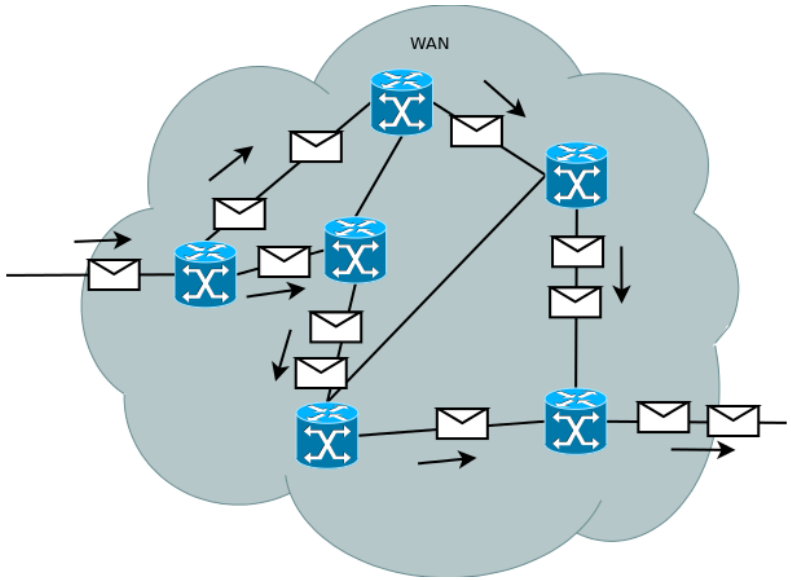


Figure 3 : Packet-switched connectionless network.

Packet Switched

Connection-oriented:

- Data is divided into individual packets.
- Routed over a shared network.
- A virtual circuit is pre-established through the network, and all packets are sent along that circuit.
- Each packet is marked with a Connection Identifier.

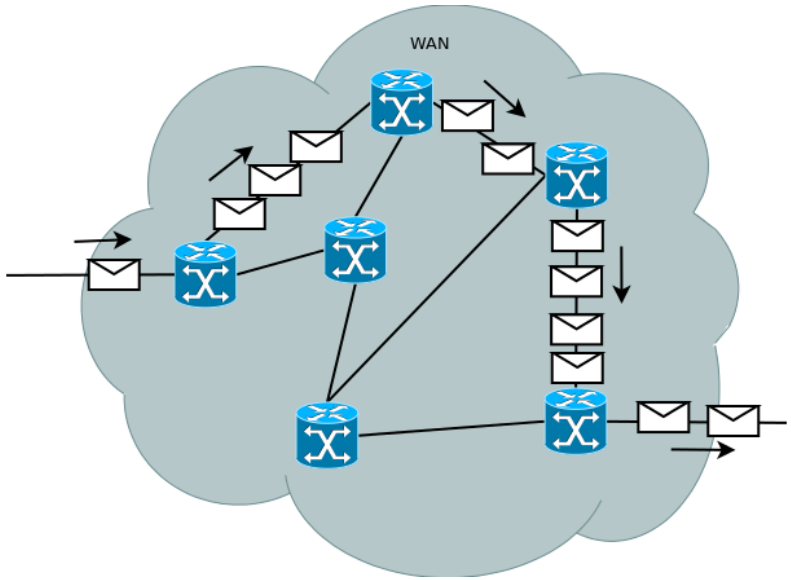


Figure 4 : Packet-switched Connection-oriented network.

Types of Virtual Circuits

Permanent Virtual Circuit (PVC)

- A virtual circuit is permanently established.
- Less time and bandwidth spent on establishing circuits.
- Need to have the circuit constantly available.

Switched Virtual Circuit (SVC)

- Established dynamically when needed
- Terminated when the transmission has completed.
- Three phases involved:
  - Establish circuit.
  - Transfer data.
  - Terminate circuit.
- No need to maintain a constant virtual circuit.

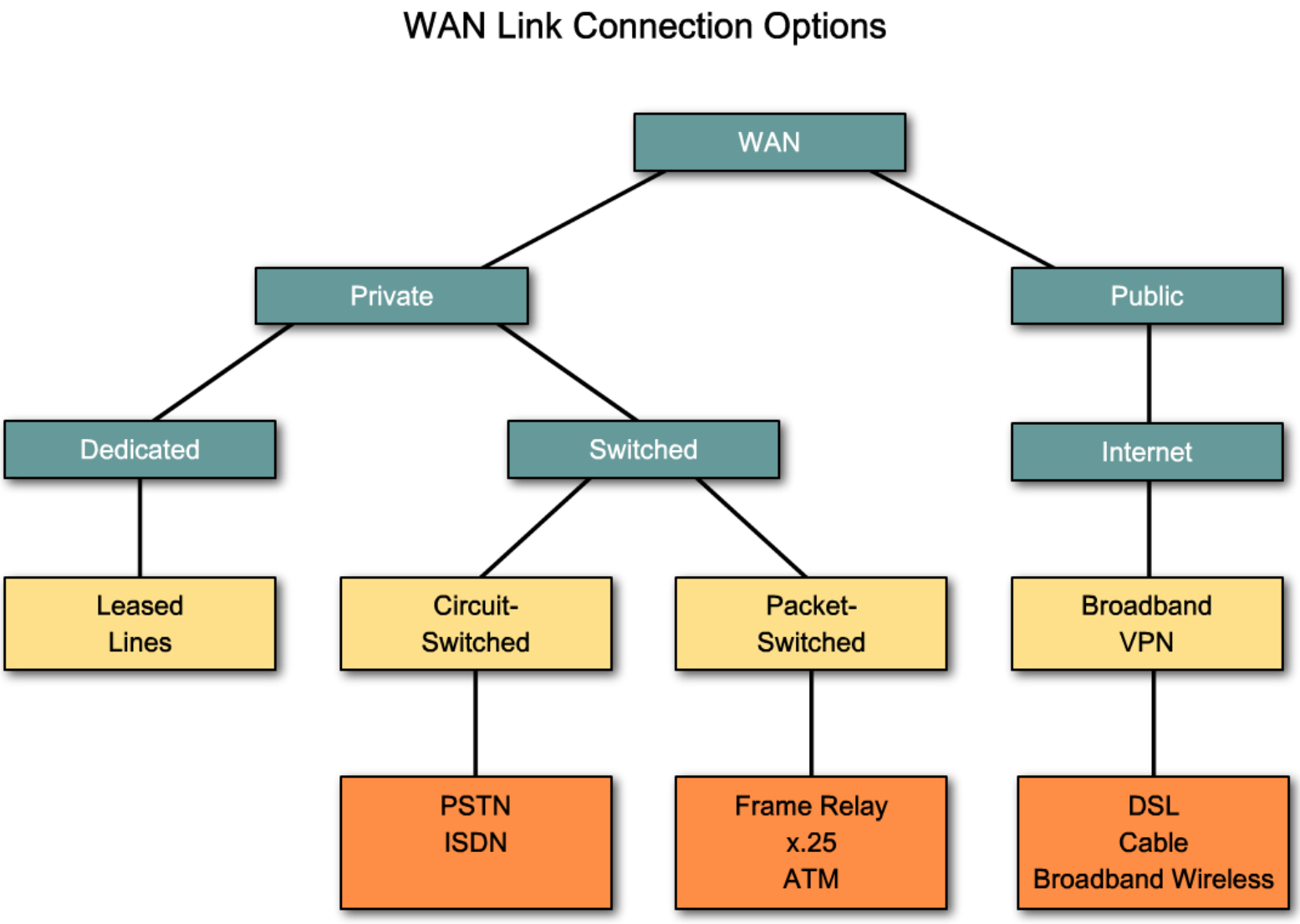

WAN Link Connection Options
WAN
Private
Public
Dedicated
Switched
Internet
Leased Lines
Circuit-Switched
Packet-Switched
Broadband VPN
PSTN ISDN
Frame Relay x.25 ATM
DSL Cable Broadband Wireless

Figure 5 : [3].

Transmission modes

Transmission modes

- Serial sends data using one wire.
- Parallel sends over multiple wires simultaneously.
- Problems with parallel transmission
  - Clock skew
  - Crosstalk
  - Cost.

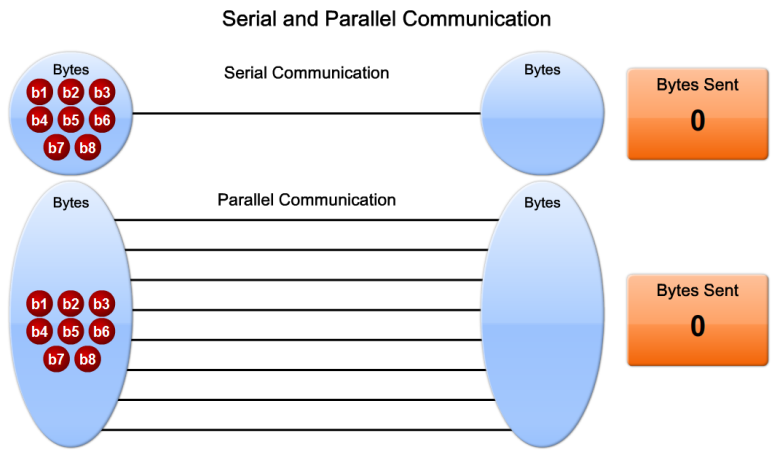


Figure 6 : Serial and Parallel transmissions [3].

Sharing a physical connection

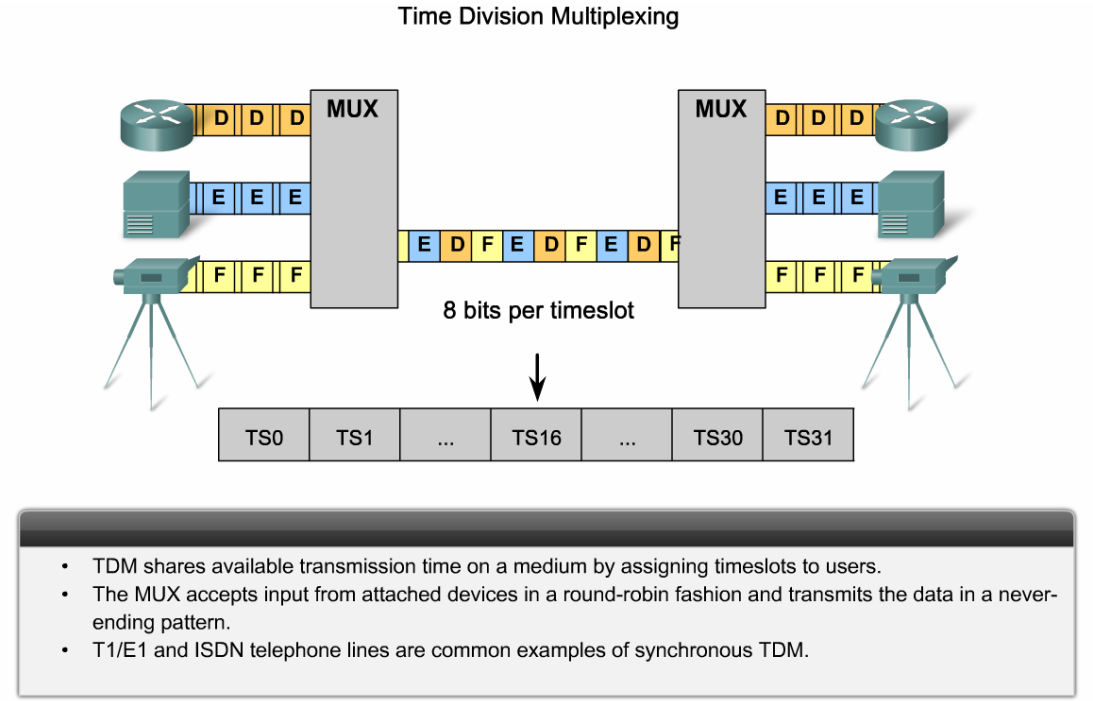


Figure 7 : Time-division Multiplexing [3].

Sharing a physical connection

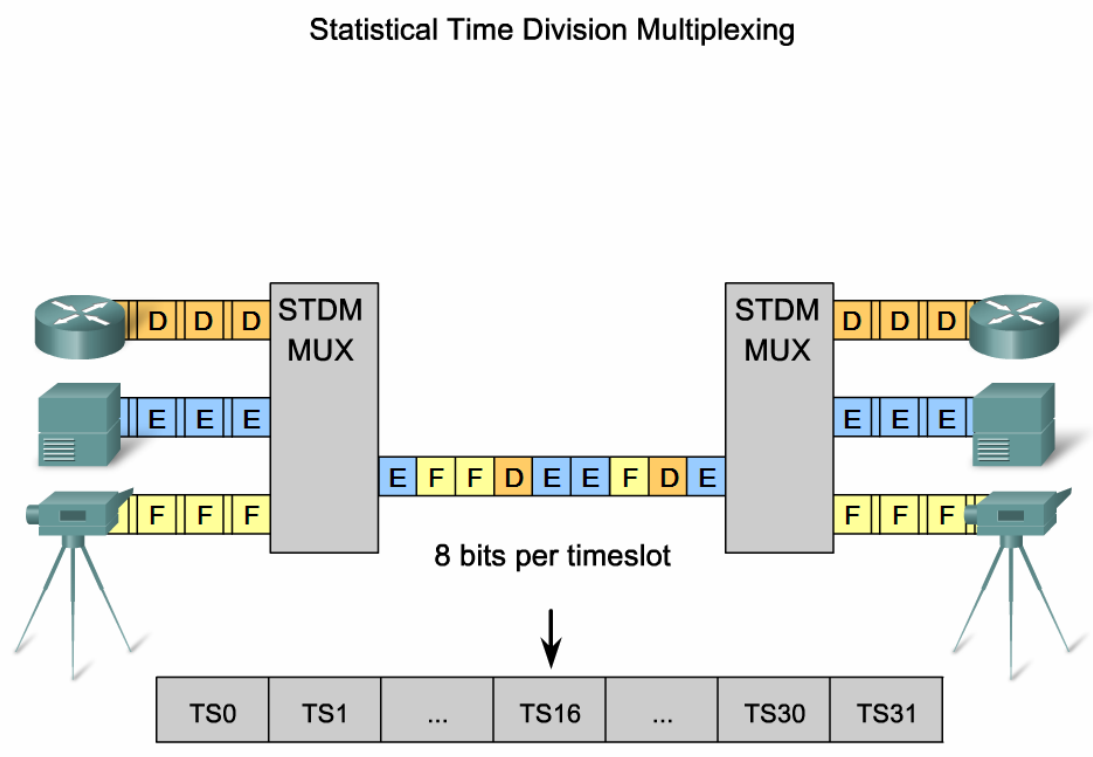


Figure 8 : Statistical Time-division Multiplexing [3].

Layer 2 encapsulation types

- Leased line – HDLC, PPP
- Circuit-Switched – HDLC, PPP
- Packet Switched – Frame Relay, ATM

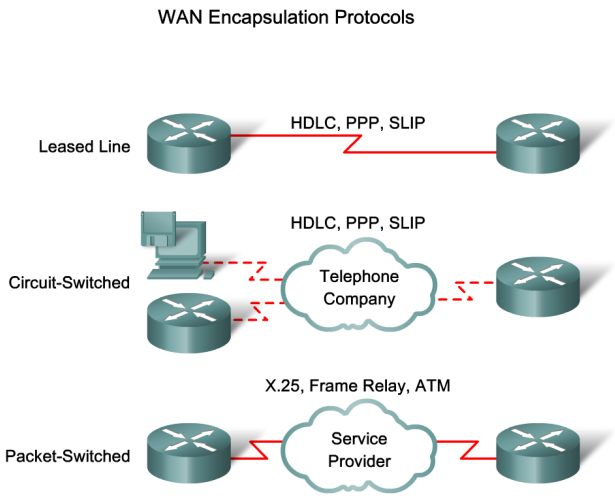


Figure 9 : Layer 2 encapsulation types [3].

Synchronous and Asynchronous serial communication

Synchronous

Needs an external clock signal to synchronize sender and receiver.

Asynchronous

No external clock is needed, usually timing is encoded within the symbols (Manchester encoding).

Bit- vs Byte-oriented protocols

Bit-oriented

"A communications protocol in which individual bits within a byte are used as control codes."[1]

Byte-oriented

"A communications protocol in which full bytes are used as control codes. Also known as character-oriented protocol."[1]

HDLC

High-level Data Link Control Procotol

High-level Data Link Control

HDLC

HDLC is the default layer two encapsulation type for point-to-point connections on a Cisco router.

Configuration

```
Router(config-if)#encapsulation hdlc
```

HDLC

- Bit-oriented
- Synchronous
- Flag – Initiates and terminates error checking.
  - Bit pattern: *01111110*.
  - Inserts a *0* after every fifth *1* (bit stuffing).

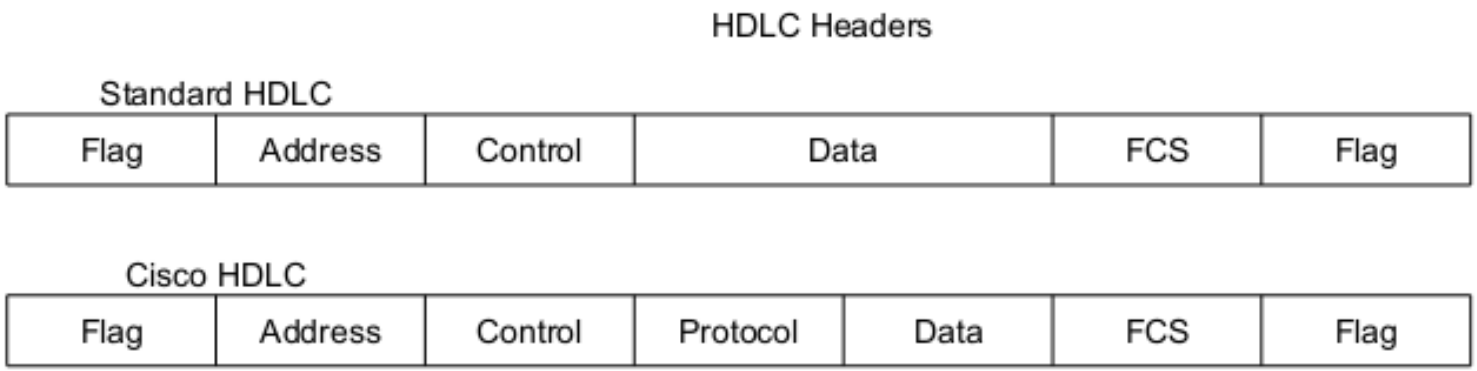


Figure 10 : HDLC Headers [3].

HDLC Frame types

- Control – Three types of HDLC frames
  - Information frames: Carry upper layer information, and used for flow control and error control (piggybacking).
  - Supervisory frames: Provides flow and error control (when we can't piggyback).
  - Unnumbered frames: Used for session management and control information between connected devices (e.g Establish and connection release)

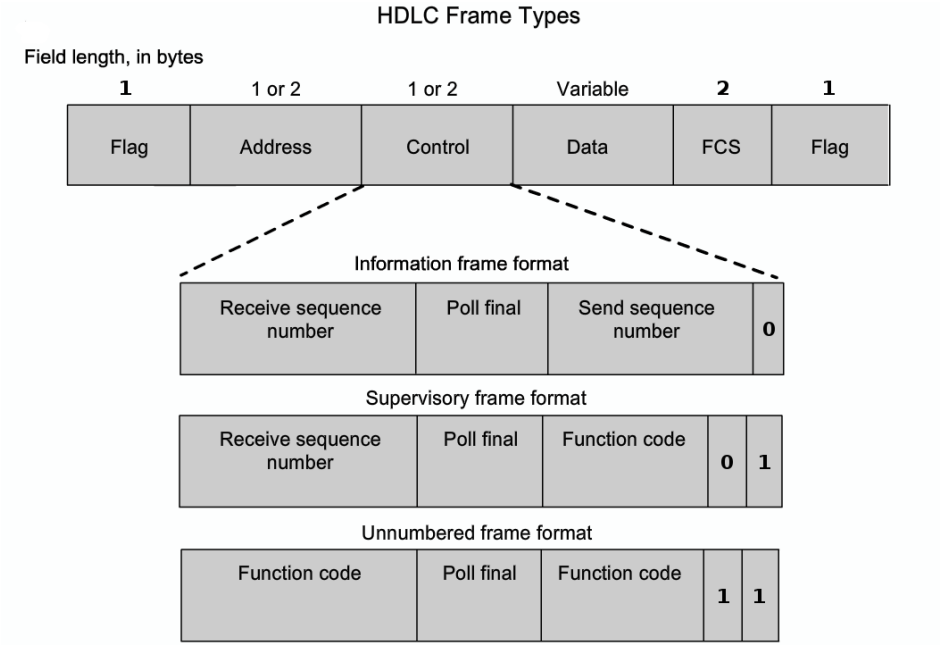


Figure 11 : HDLC Frame types [3].

PPP

Point-to-Point Protocol

Point-to-Point Protocol

PPP

- PPP is a commonly used layer 2 protocol for connecting two (non-Cisco) routers together.
- Allows two devices to negotiate a link-establishment.
- Provides authentication.
- Provides link quality management features – Shuts down the link if too many errors are detected.
- Works in both the Physical Layer, Data Link Layer and Network Layer.
- Can be used for both point-to-point connections and multi-point connections.
- Byte-oriented.

Point-to-Point Protocol

PPP

- Does not provide flow-control.
- Very basic error-control, depends on higher layer protocol to address missing packets, out-of-order delivery et cetera.

PPP frame

- Flag - Starts and ends with a 1-byte flag *0x7E*
- Byte stuffing – An escape byte is inserted when a "flag-byte" appears in the payload, *0x7D*
- Address - *0xFF*, can be omitted.
- Control - Left for backwards compatibility (HDLC), *0xC0* can be omitted.

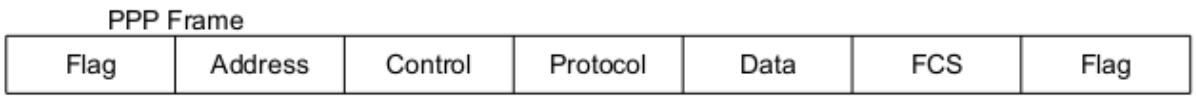


Figure 12 : PPP frame

PPP Layered Architecture

Layered architecture

- PPP uses a set of protocols to provide the necessary functions.
- Physical Layer.
- Link Control Protocol.
- Two Authentication protocols.
- Multiple Network Control Protocols.

Physical layer and PPP

- Requires a duplex circuit (in comparison to simplex).
- Operates in Synchronous or Asynchronous mode.
- Operates across more or less any media.

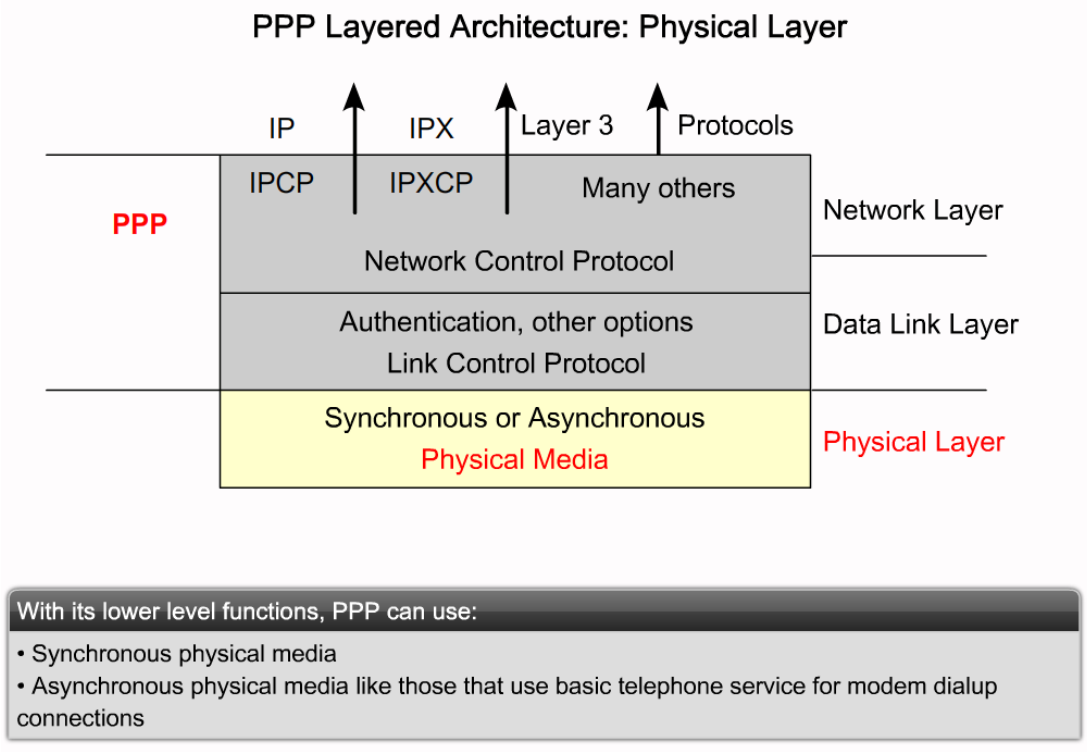
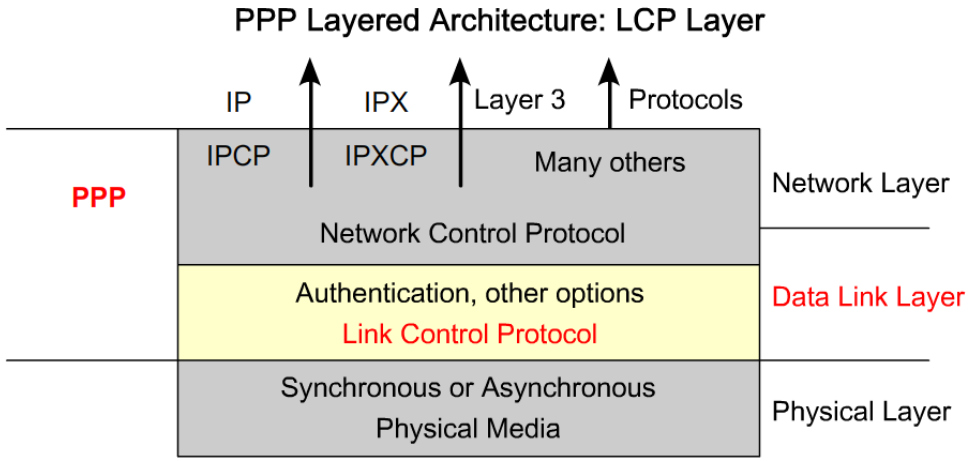


Figure 13 : Physical layer [3].

Data link Layer and PPP

- Negotiate, Establish, Authenticates and Maintains the connection between the devices.
- Can handle variably sized packets.
- Detects common misconfiguration errors, and if the link is working properly.
- Terminates the link.



PPP offers service options in LCP and is primarily used for negotiation and frame checking when implementing the point-to-point controls specified by an administrator.

Figure 14 : PPP – Logical Control Protocol [3].

LCP Packets

Table 1 : LCP packet types [2].

Code	Packet Type	Description
0x01	Configure-request	Contains a list of proposed options and their values
0x02	Configure-ack	Accepts all options proposed
0x03	Configure-nak	Announces that some options are not acceptable
0x04	Configure-reject	Announces that some options are not recognized
0x05	Terminate-request	Requests to shut down the line
0x06	Terminace-ack	Accept the shutdown request
0x07	Code-reject	Announces an unknown code
0x08	Protocol-reject	Announces an unknown protocol
0x09	Echo-request	A type of hello message to check if the other end is alive
0x0A	Echo-reply	The response to the echo-request message
0x0B	Discard-request	A request to discard the packet

Link Control Protocol

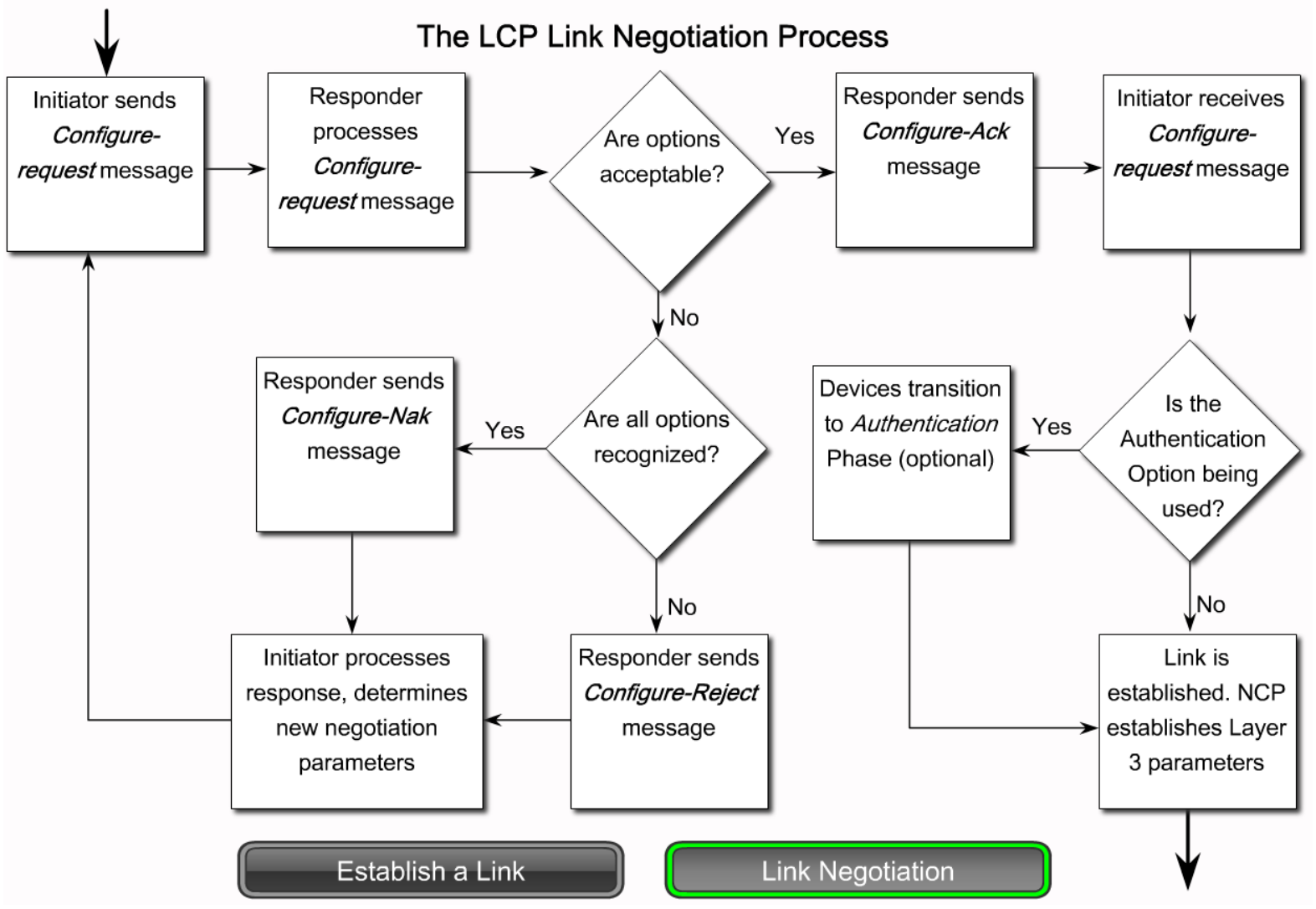


Figure 15 : LCP negotiation process [3].

PPP Authentication

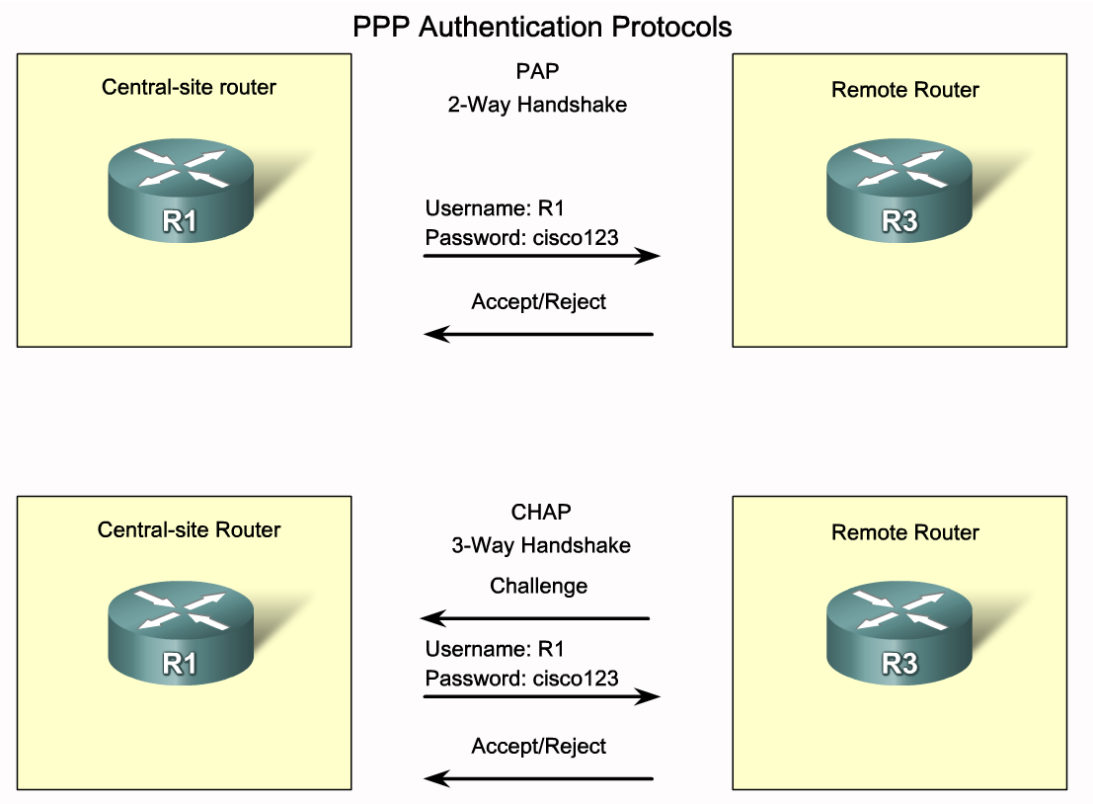


Figure 16 : PPP Authentication types [3]

PPP – Password Authentication Protocol

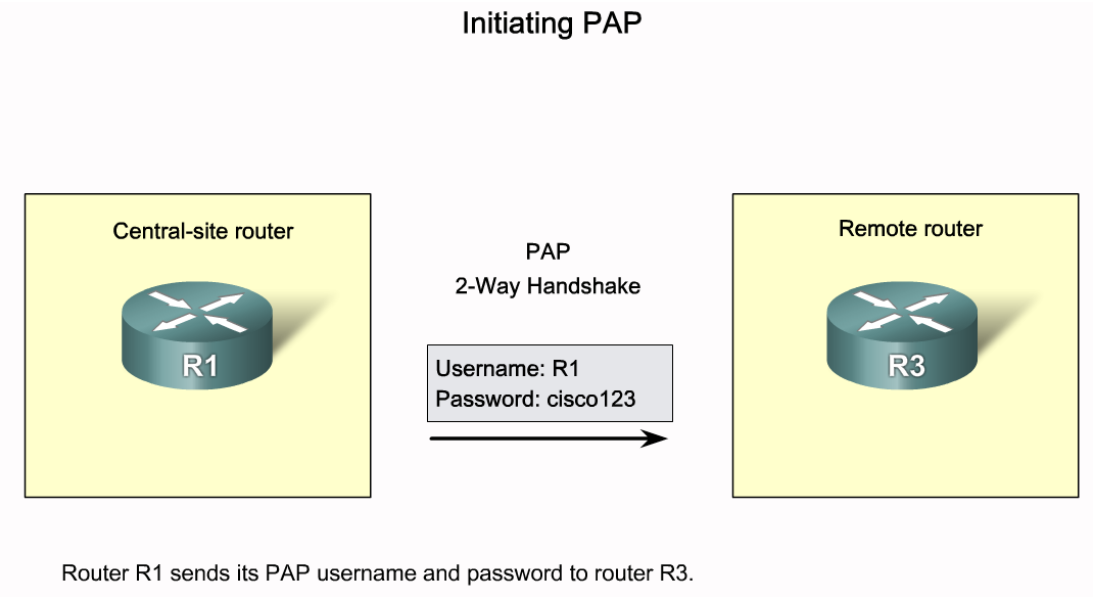


Figure 17 : PPP PAP [3]

PPP – Challenge Handshake Authentication Protocol

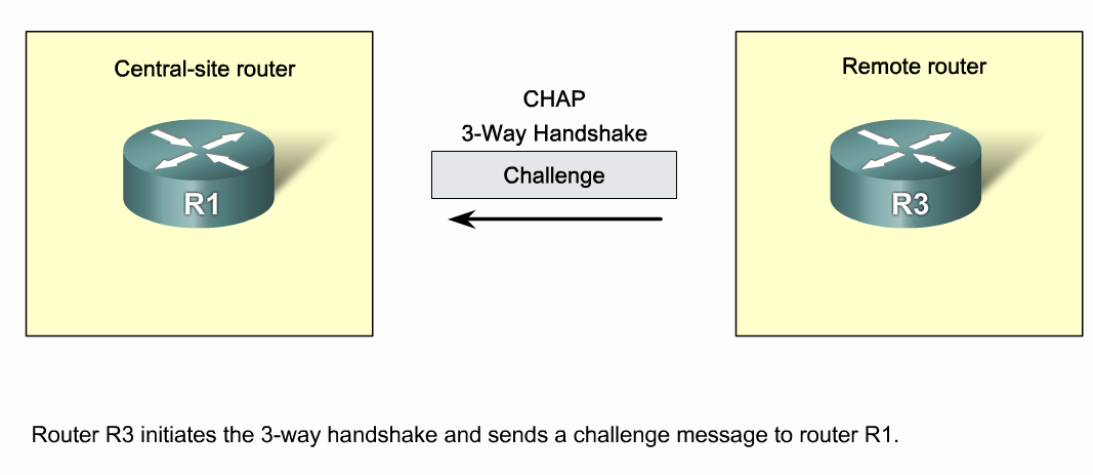


Figure 18 : PPP CHAP [3]

PPP – Authentication process

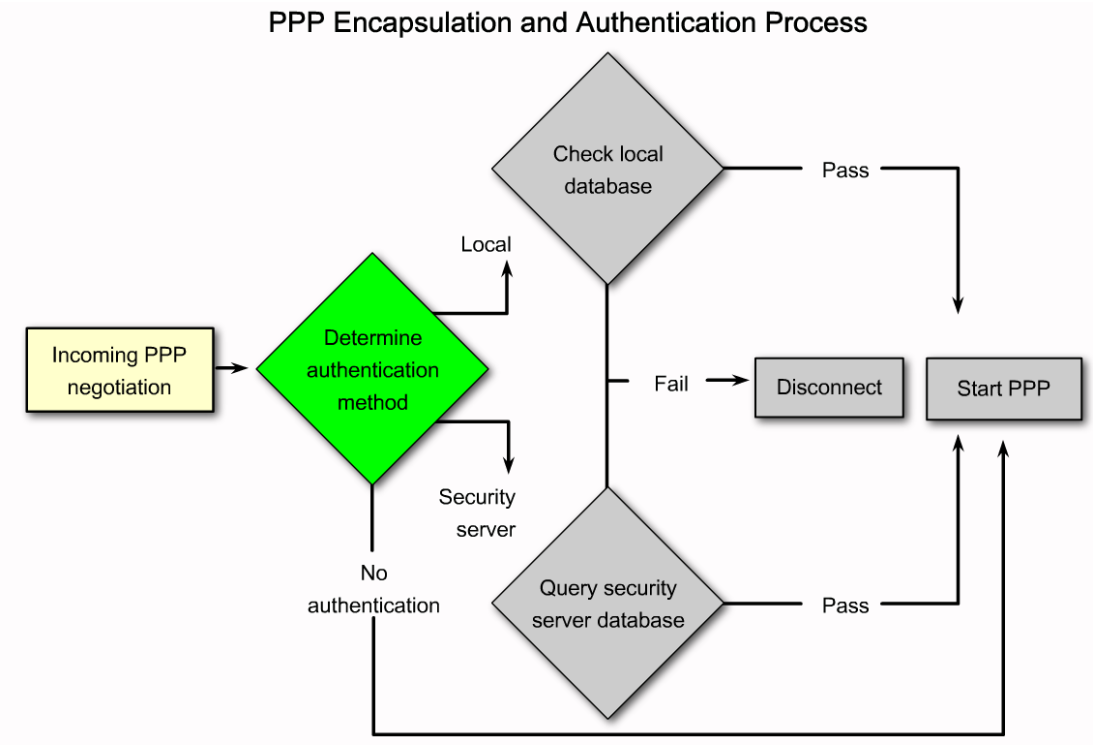


Figure 19 : PPP Authentication types [3]

- Supports multiple network layer protocols (IP, IPX, Apple Talk et cetera.)
- Uses Network Control Protocol to configure the link for carrying a specific type of network layer protocol.
- Configure and assigning addresses.
- Compression.

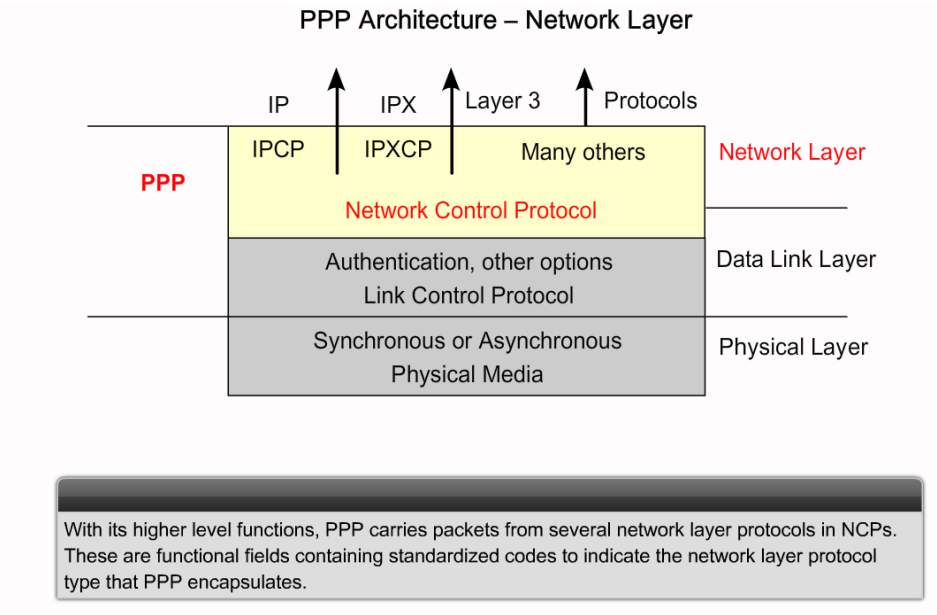


Figure 20 : PPP – Network Control Protocol [3].

PPP Network Control Protocol process

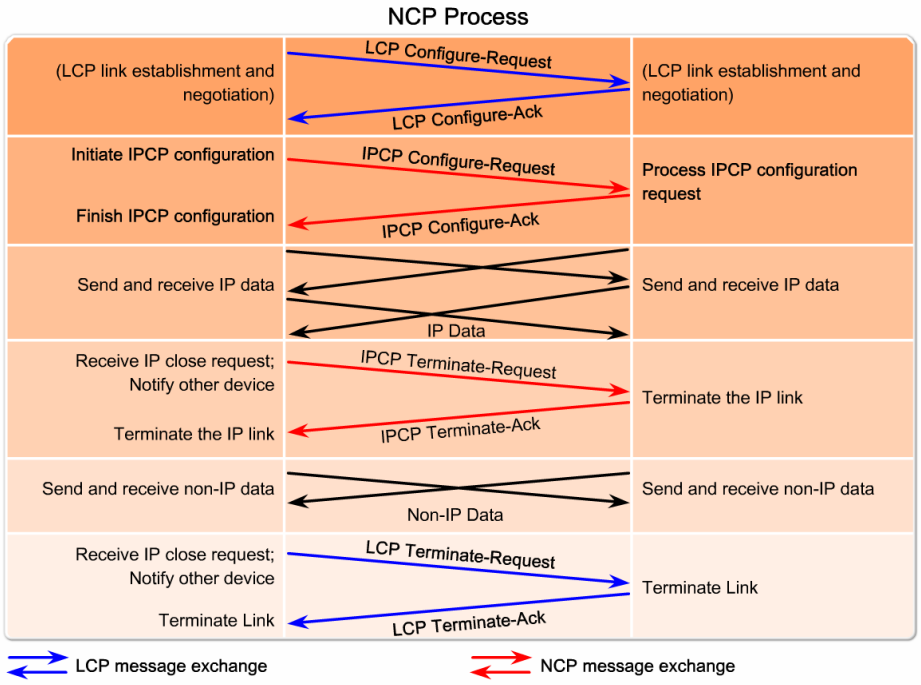


Figure 21 : NCP process [3].

PPP transition phases

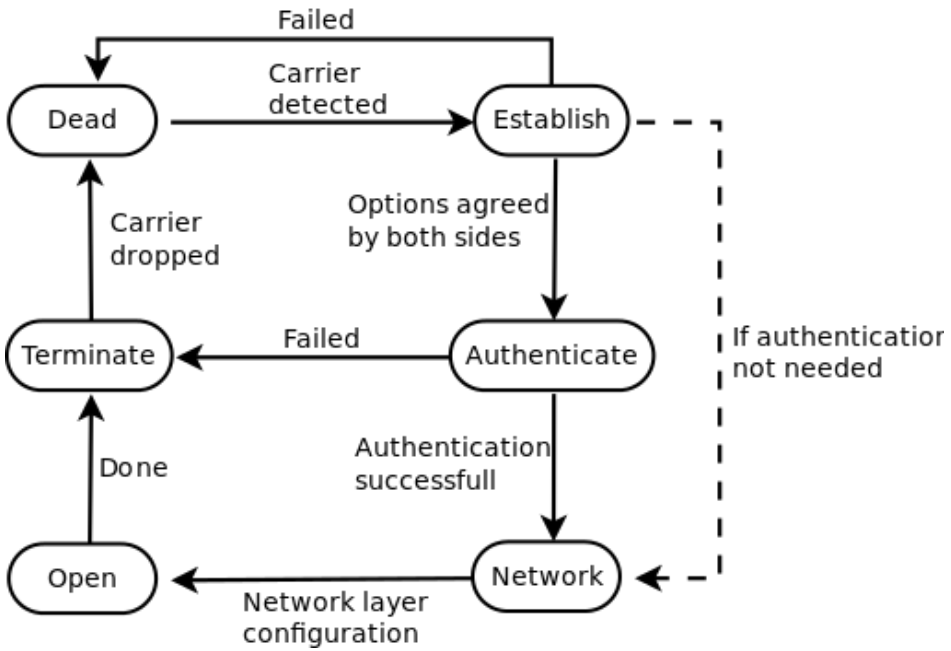


Figure 22 : Transition phases in PPP [2].

Frame Relay

Frame Relay

Frame-Relay

- Packet-Switched connection-oriented or Virtual Circuit data link protocol.
- Invented by Stratacom 1986, that was later bought by Cisco in 1996.
- Meant to replace X.25 due to some drawbacks with this protocol.
  - Designed in the 1970s
  - Low data rate (64Kbps)
  - Extensive flow control due to error prone transmission media.
  - Operated in both Data Link and Network layer.
- Before Frame-Relay, only other option were dedicated lines.
  - Expensive, *n(n-1)/2 dedicated lines where needed*
  - Seldom the entire line was fully utilized.

Frame Relay

- Higher speed (up to 44 Mbps)
- Operates only in physical layer and data link layer (makes it compatible with IP).
- Less overhead, depends on upper layer protocols for flow and error control.

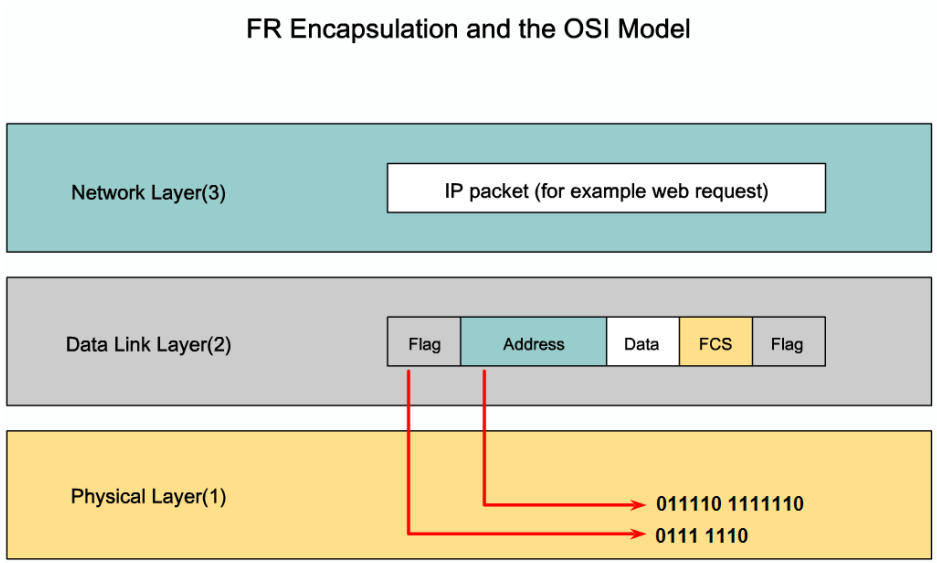


Figure 23 : Frame Relay Encapsulation [3]

Frame Relay architecture

- Provides connectivity between two DTE-devices.
- Frame Relay network is accessed using either:
  - Frame Relay Access Device (FRAD)
  - Frame Relay compatible Router, Switch or Bridge.

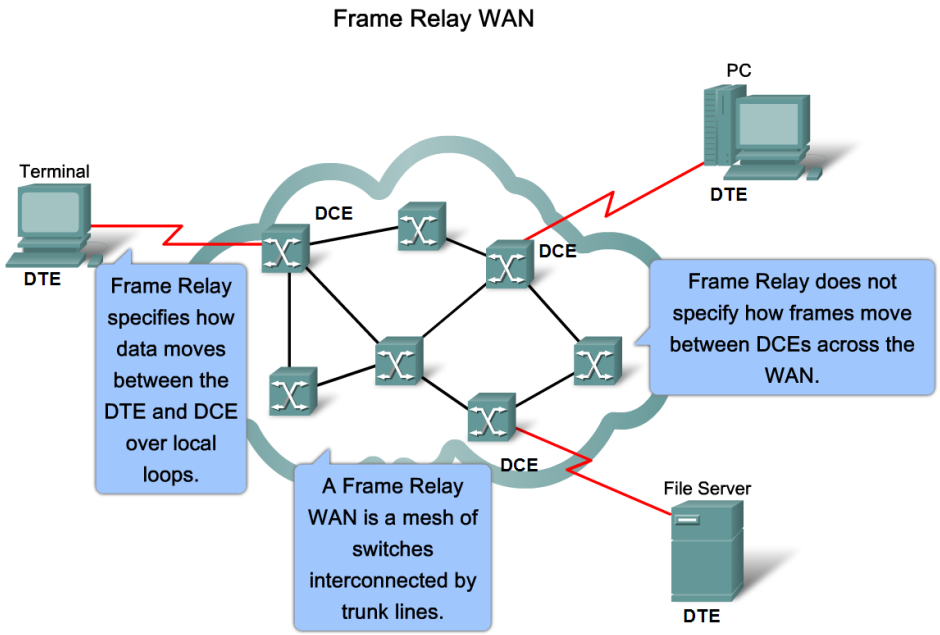


Figure 24 : Frame Relay Architecture [3]

Virtual Circuits

- Frame Relay supports both SVC and PVC.
- A Switched Virtual Circuit consists of four operational states
  - Call Setup
  - Data Transfer
  - Idle
  - Call Termination
- A Permanent Virtual Circuit operates in Data Transfer or Idle only.

DLCI – Data Link Connection Identifier

- DLCI are used to identify a virtual circuit.
- DLCI are only locally significant.
- Multiple DLCI on the same interface.
- When used togheter with IP, a mapping must be done between DLCI and the destination IP address.
- Mapping can be done by static or dynamic mapping.

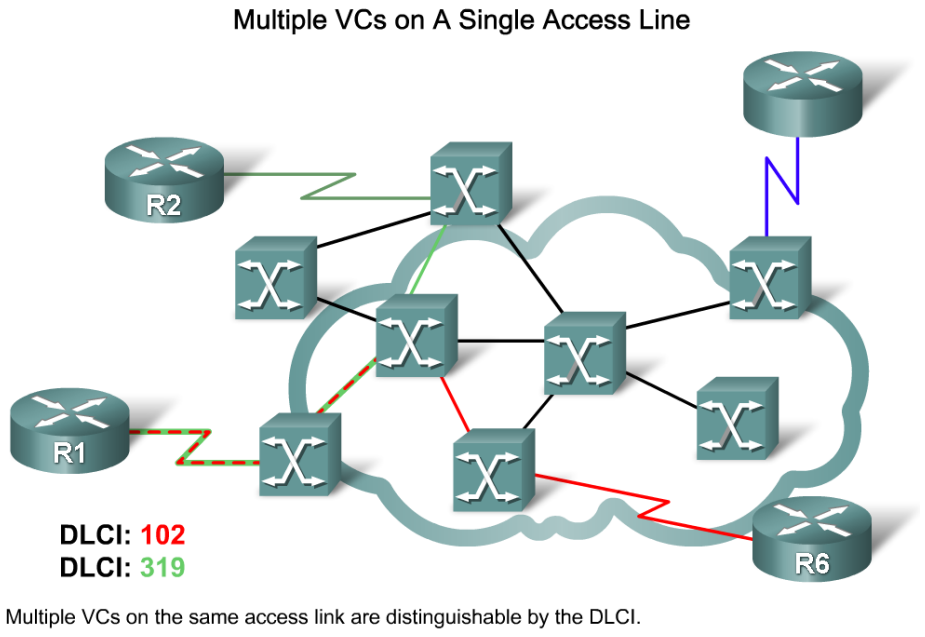


Figure 25 : DLCIs to locally identify a virtual circuit [3]

Static DLCI mapping

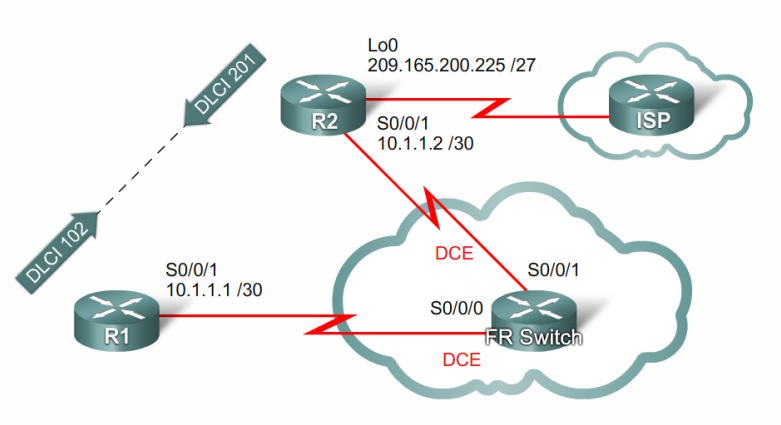


Figure 26 : Frame Relay Topology [3]

Configuration for R1

```
interface s0/0/1
ip address 10.1.1.1 255.255.255.252
encapsulation frame-relay
bandwidth 64
frame-relay map ip 10.1.1.2 102 broadcast
```

Figure 27 : Static DLCI mapping [3]

Dynamic DLCI mapping

Dynamic DLCI

- Dynamic DLCI mapping is done using *inverse ARP*
- Enabled by default.
- Works only on point-to-point connections.

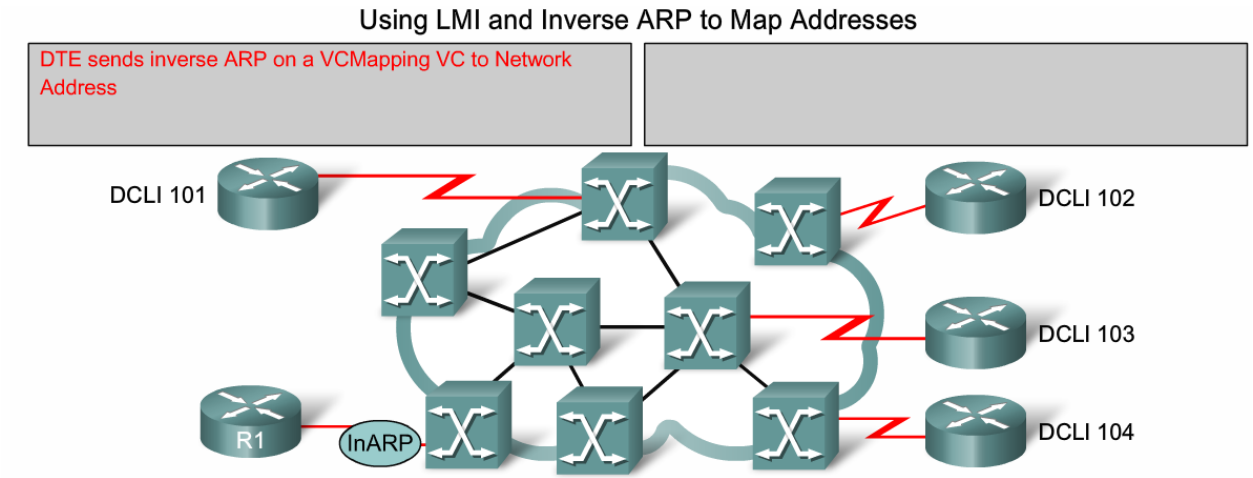


Figure 28 : Using Inverse ARP to map DCLI to L3 address [3]

Local Management Interface

- Frame Relay was developed to be as simple as possible.
- Omitted everything that could in some way introduce extra delay.
- LMI was introduced to extend Frame Relays capabilities.
- LMI provides:
  - Connection status, to ensure the connection is still working.
  - Multicasting
  - Global addresses.
  - Flow Control.

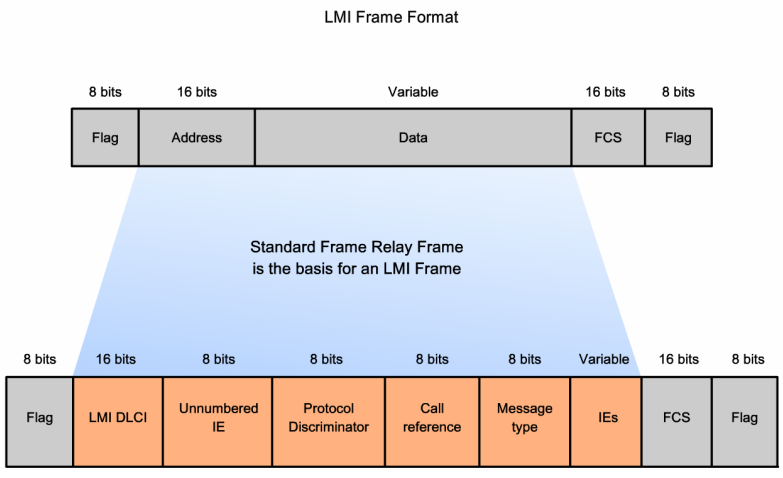


Figure 29 : LMI Format [3]

Traffic pattern

- Commited Information Rate (CIR)
- Commited Burst Information Rate (CBIR)
- Excess Burst Size (BE)
- Data that exceeds CBIR will be marked as *Discard Eligible (DE)*

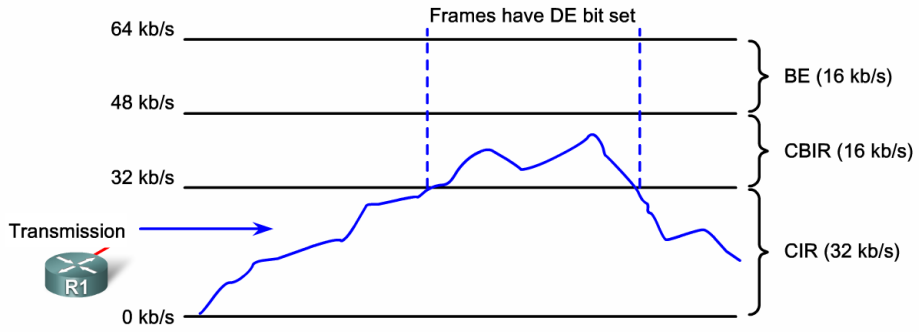


Figure 30 : Traffic bursts

Flow Control

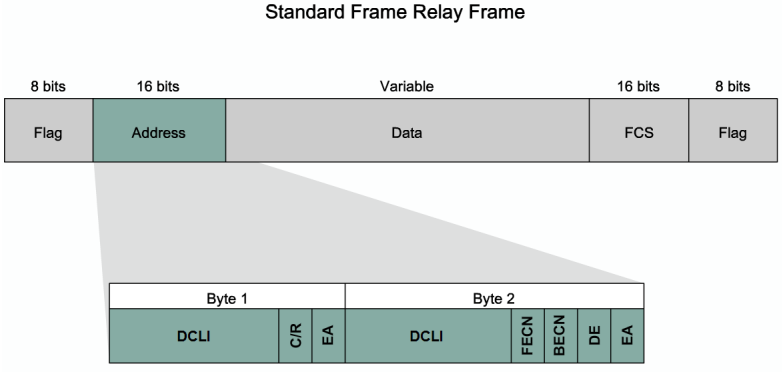


Figure 31 : Standard Frame Relay frame [3]

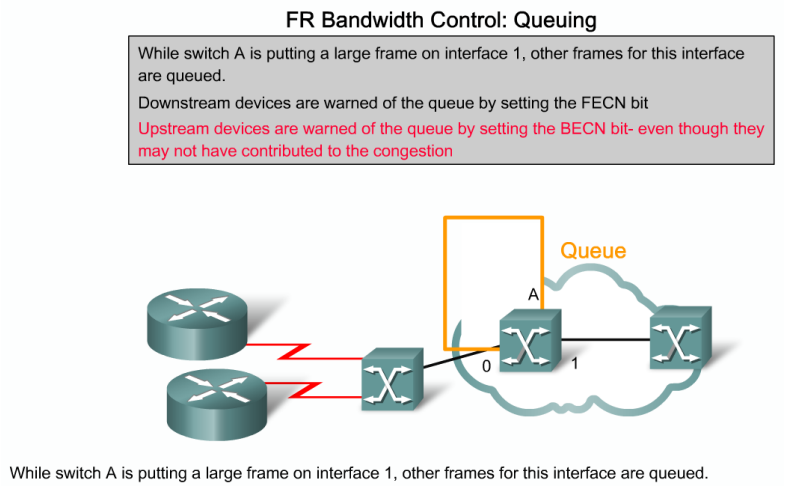


Figure 32 : Explicit Congestion Notification [3]

References

[1] Mcgraw-hill dictionary of scientific and technical terms. New York, 2003. ISBN 0-07-042313-X.

[2] Behrouz A. Forouzan and Sophia Chung Fegan. *Data communications and networking*. McGraw-Hill, Boston, 4. ed. edition, 2007. ISBN 0-07-125442-0 (International ed.).

[3] Bob Vachon and Rick Graziani. *Accessing the WAN : CCNA exploration companion guide*. Cisco Press, Indianapolis, Ind., 2008. ISBN 978-1-58713-205-6 (hardcover w/cd).