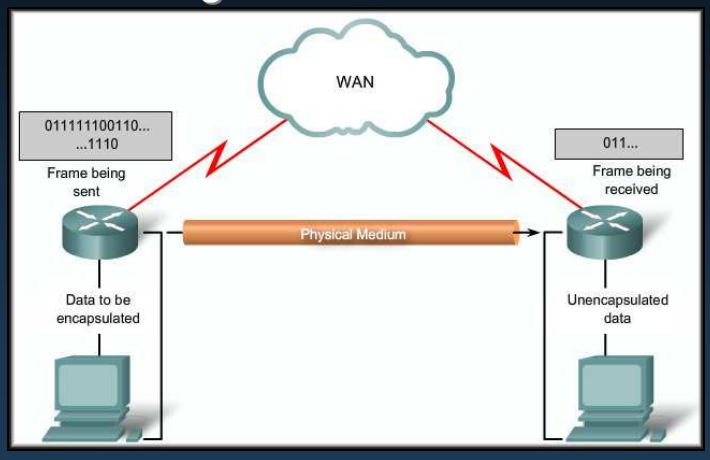
Chapter 2

Point-to-Point Protocol (PPP)

Part I

Point-to-Point Protocol (PPP)

Introducing Serial Communications

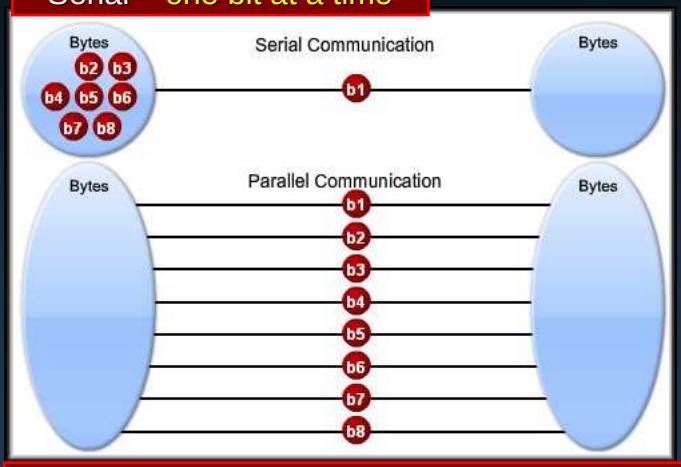


How Does Serial Communication Work?

- Most PCs have both serial and parallel ports.
  - Electricity can only move at one speed.
  - Data is compressed so that less bits are necessary and then require less time on the wire, or transmit the bits simultaneously.
  - Computers make use of relatively short parallel connections between interior components.
  - Use a serial bus to convert signals for most external communications.

How Does Serial Communication Work?

Serial – one bit at a time



Two wires to send and receive.

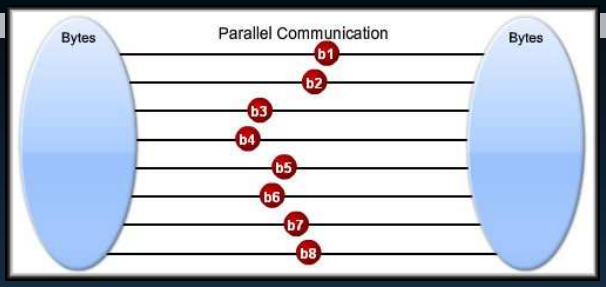
Eight wires to send and receive.

Parallel – bits over more wires simultaneously.

How Does Serial Communication Work?

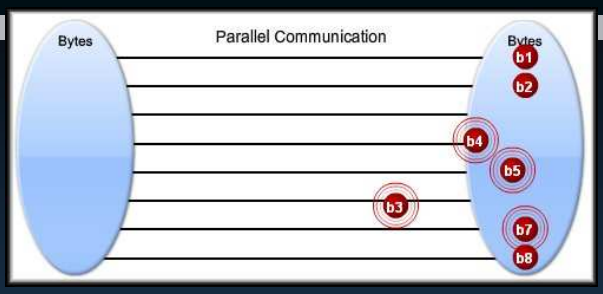
- In both cases, the remaining wires are used for control signals.
- The parallel link theoretically transfers data eight times faster than a serial connection.
- In reality, it is often the case that serial links can be clocked considerably faster than parallel links, and they achieve a higher data rate.
- Two factors affect parallel communications:
  - Clock Skew.
  - Crosstalk Interference.

How Does Serial Communication Work?



- Parallel Communications Clock Skew:
  - In a parallel connection, it is wrong to assume that the 8 bits leaving the sender at the same time arrive at the receiver at the same time.
  - In reality, some of the bits get there later than others.
  - Not trivial to overcome.
    - Read, wait, wait adds time.

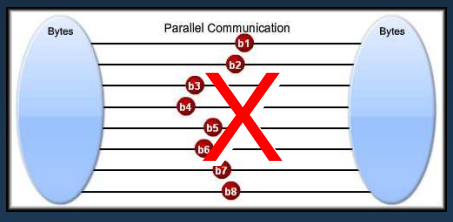
How Does Serial Communication Work?

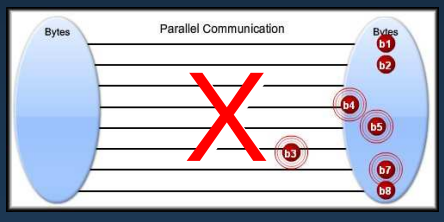


- Parallel Communications Crosstalk Interference:
  - In a parallel connection ,the wires are physically bundled in a parallel cable.
  - The possibility of crosstalk across the wires requires more processing.

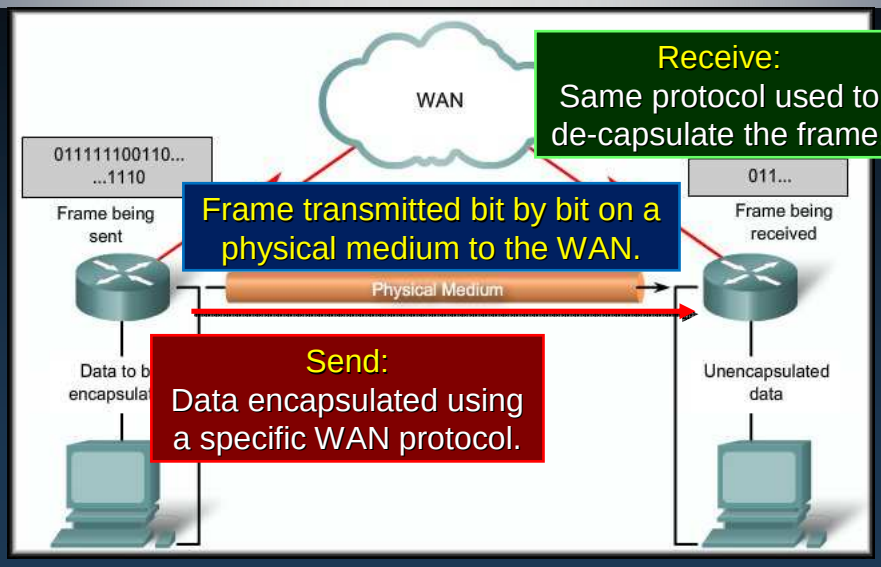
How Does Serial Communication Work?

- Serial Communication:
  - Clock skew is not a factor because most serial links do not need the same type of parallel clocking.
  - Crosstalk Interference is minimized since serial cables have fewer wires and network devices transmit serial communications at higher, more efficient frequencies.

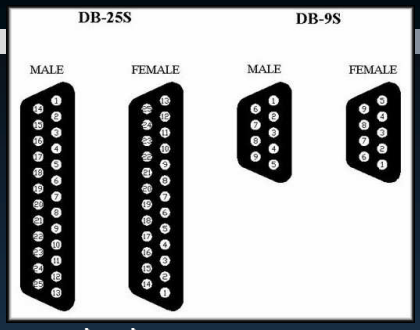




Serial Communication Standards



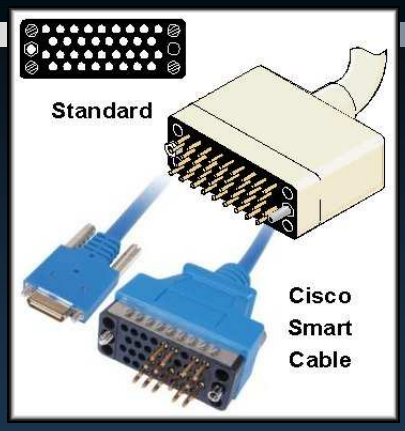
Serial Communication Standards



- Three key serial communication standards:
  - RS-232C or newer RS-422, RS-423:
    - Most serial ports on personal computers conform to the RS-232C standards.
    - Both 9-pin and 25-pin connectors are used.
    - A serial port is a general-purpose interface that can be used for almost any type of device, including modems, mice, and printers.

Serial Communication Standards

- Three key serial communication standards:
  - V.35:
    - V.35 is the interface standard used by most routers and DSUs that connect to T1 carriers.
    - V.35 cables are high-speed, serial assemblies designed to support higher data rates and connectivity between DTEs and DCEs over digital lines.

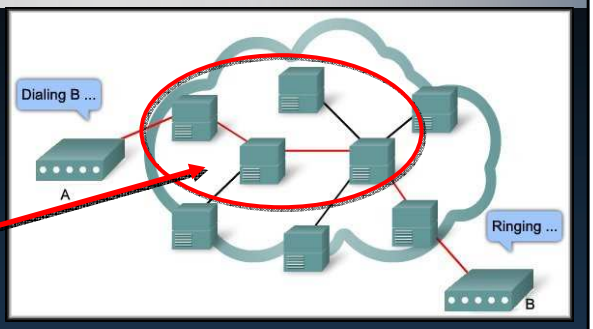


Serial Communication Standards

- Three key serial communication standards:
  - HSSI:
    - A High-Speed Serial Interface supports transmission rates up to 52 Mb/s.
    - Engineers use HSSI to connect routers on LANs with WANs over high-speed lines such as T3 lines.

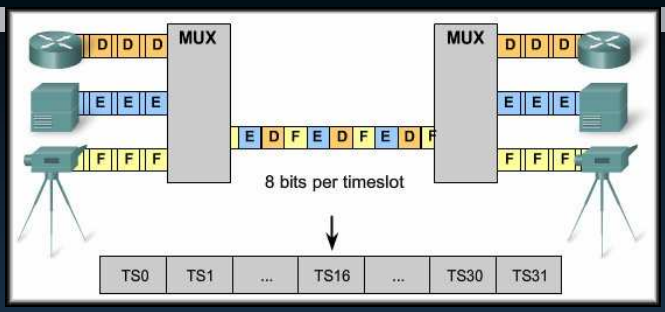
Time Division Multiplexing

- Remember that a WAN connection normally uses a provider's network.
- The internal path is shared by several conversations or WAN connections.



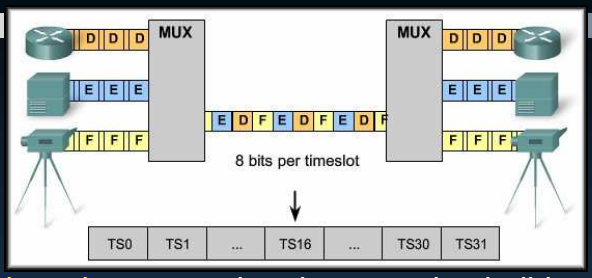
- Time Division Multiplexing (TDM) is used to give each conversation a share of the connection in turn.
  - TDM assures that a fixed capacity connection is made available to the subscriber.

Time Division Multiplexing



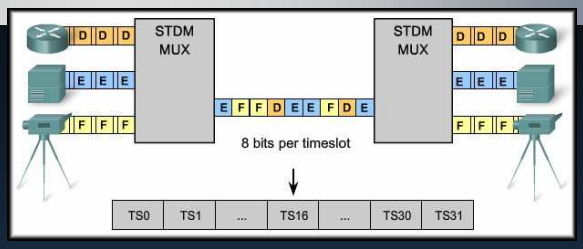
- Time-Division Multiplexing (TDM) is the transmission of several sources of information using one common channel, or signal, and then the reconstruction of the original streams at the remote end.
  - TDM is a physical layer concept.
  - It has no regard of the information that is being multiplexed.

Time Division Multiplexing



- TDM Operation:
  - Each device attached to the MUX is assigned a specific time slot.
  - 8 bits from each time slot are read and are used to build the frame.
  - If there is nothing to send from that time slot, it still takes up space in the frame (null characters).
  - At the receiving end, the frame is de-capsulated and time slot data is forwarded to the appropriate device.
  - A technique called bit interleaving keeps track of the sequence of the bits so that they can be efficiently reassembled into their original form.

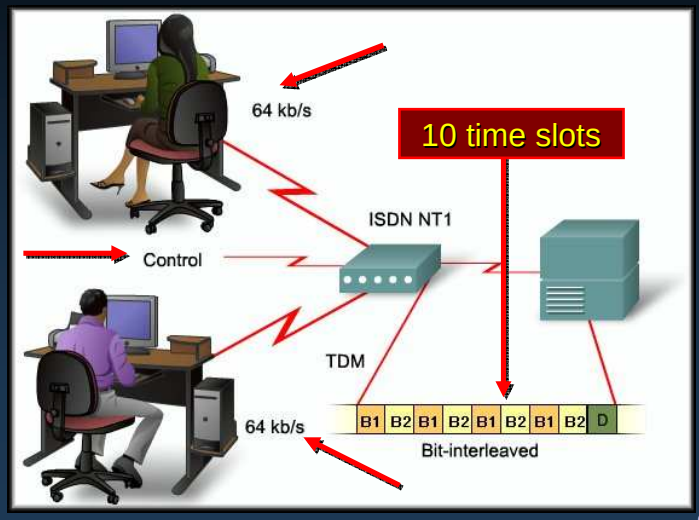
Statistical Time Division Multiplexing



- Remember that TDM will fill an empty time slot with null characters if there is no data.
- Inefficient.
  - Statistical Time Division Multiplexing (STDM) was developed to overcome this inefficiency.
    - It uses a variable time slot length allowing channels to compete for any free slot space.
    - It employs buffer memory to temporarily store the data and requires each transmission to carry identification information (a channel identifier).

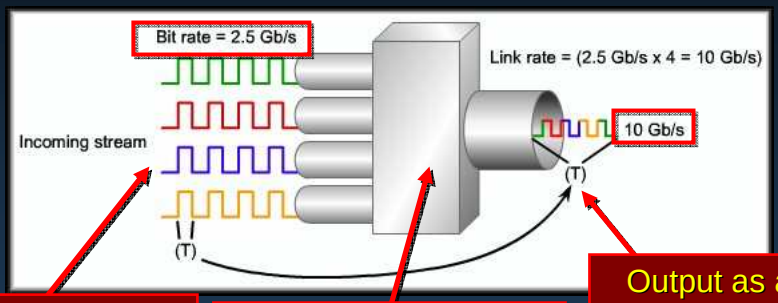
TDM and STDM Examples

- Integrated Services Digital Network (ISDN).....TDM



TDM and STDM Examples

- Synchronous Optical Networking (SONET).....STDM
- Synchronous Digital Hierarchy (SDH):



Multiple (n) input channels.

Optically multiplexed and modulated to 4 times the input bit rate.

Output as a single stream on fiber. Bit rate = 4 x n

TDM and STDM Examples

- T-carrier Hierarchy:
  - The original unit used in multiplexing telephone calls is 64 kb/s, which represents one phone call.
  - It is referred to as a DS-0 or DS0 (digital signal level zero).
  - T1:
    - In North America, 24 DS0 units are multiplexed using TDM into a higher bit-rate signal with an aggregate speed of 1.544 Mb/s for transmission over T1 lines.
  - E1:
    - Outside North America, 32 DS0 units are multiplexed for E1 transmission at 2.048 Mb/s.

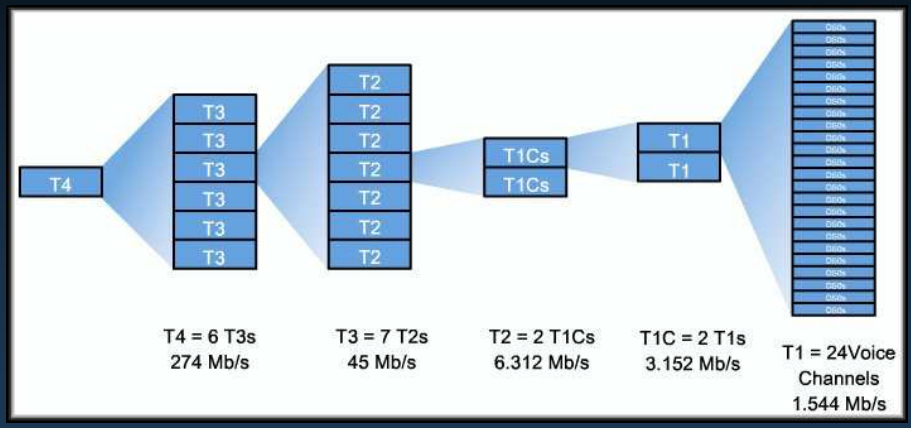
TDM and STDM Examples

- T-Carrier Hierarchy:
  - While it is common to refer to a 1.544 Mb/s transmission as a T1, it is more correct to refer to it as DS1.
  - T-carrier refers to the bundling of DS0s.

Signal	Bit Rate	Voice Slots
DS0	64 kb/s	1 DS0
DS1	1.544 Mb/s	24 DS0s
DS2	6.312 Mb/s	96 DS0s
DS3	44.736 Mb/s	672 DS0s or 28 DS1s

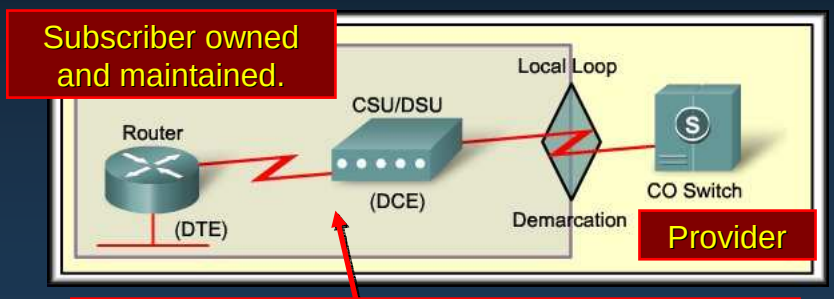
TDM and STDM Examples

- T-Carrier Hierarchy:



Demarcation Point (Demarc)

- Deregulation forced telephone companies to unbundle their local loop infrastructure to allow other suppliers to provide equipment and services.
- The demarcation point marks the point where your network interfaces with the network owned by another organization.



DTE and DCE

- DTE: Data Terminal Equipment
  - Router, Terminal, PC, Printer, Fax Machine
- DCE: Data Communications Equipment
  - CSU/DSU, Modem (Internal or External)

- A serial connection has a DTE device at one end of the connection and a DCE device at the other end.

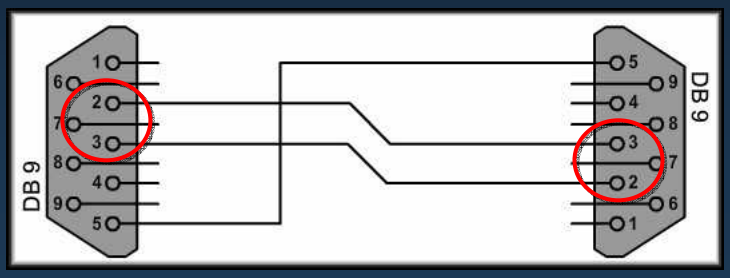
- The connection between the two DCE devices is the WAN service provider transmission network.

DTE and DCE

- DCE and DTE Cable Standards:
  - Originally, the concept of DCEs and DTEs was based on two types of equipment:
    - Terminal equipment that generated or received data.
    - Communication equipment that only relayed data.
  - While the reasons are no longer significant, we are left with two different types of cables:
    - One for connecting a DTE to a DCE.
    - Another for connecting two DTEs directly to each other.

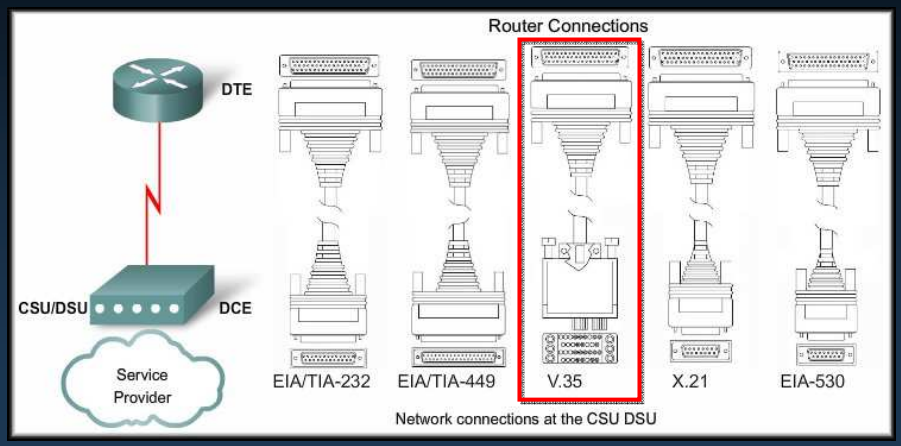
DTE and DCE

- DCE and DTE Cable Standards:
  - RS232 Standard:
    - The original RS-232 standard only defined the connection of DTEs with DCEs (modems).
    - If you want to connect two DTEs, such as two computers or two routers in the lab, a special cable called a null modem eliminates the need for a DCE.



DTE and DCE

- DCE and DTE Cable Standards:



DTE and DCE

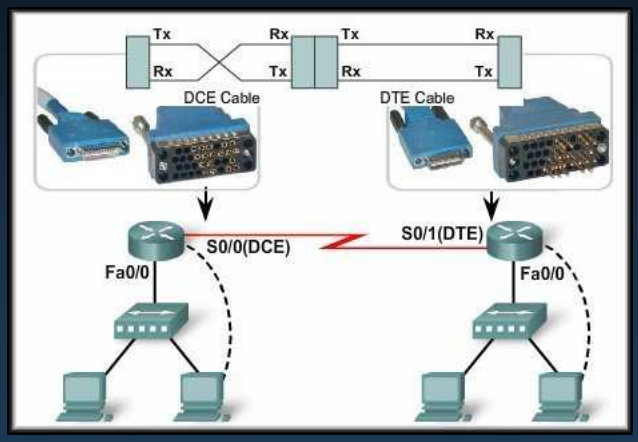
- DCE and DTE Cable Standards:

Router DB-60 Connection

Router Smart Serial

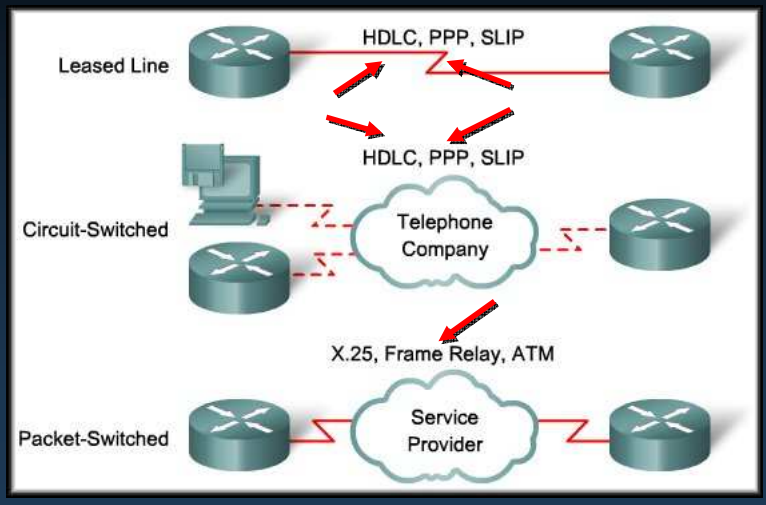
DTE and DCE

- DCE and DTE Cable Standards:
  - In the lab:



HDLC Encapsulation

- Layer 2 WAN Encapsulation Protocols:

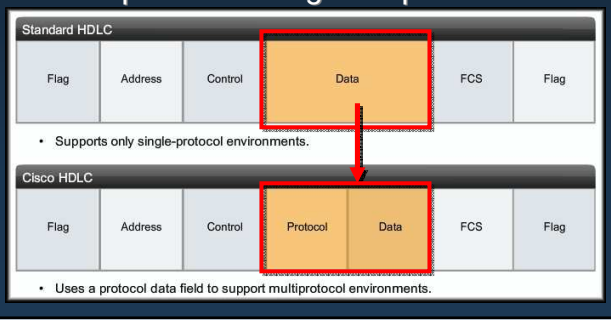


HDLC Encapsulation

- High-level Data Link Control (HDLC):
  - HDLC is a bit-oriented, synchronous, Data Link layer protocol developed by the International Organization for Standardization (ISO).
    - Developed from IBM's Synchronous Data Link Control (SDLC) standard proposed in the 1970s.
    - Provides both connection-oriented and connectionless service.
    - Defines a Layer 2 framing structure that allows for flow control and error control through the use of acknowledgments.
    - Uses a frame delimiter, or flag, to mark the beginning and the end of each frame.

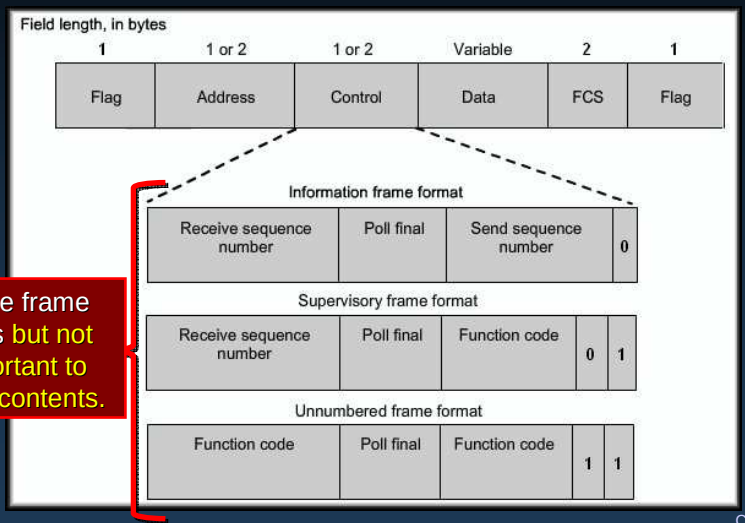
HDLC Encapsulation

- High-level Data Link Control (HDLC):
  - Cisco has developed an extension to the HLDC protocol to solve an inability to provide multiprotocol support.
    - Cisco HLDC is proprietary and is the default encapsulation on a Cisco device WAN port.
    - Cisco HDLC frames contain a field for identifying the network protocol being encapsulated.



HDLC Encapsulation

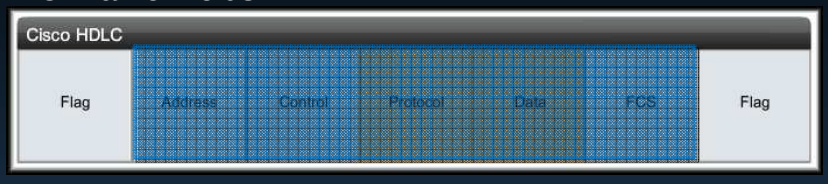
- Standard/Cisco HDLC Frame Types:



Three frame types but not important to know contents.

HDLC Encapsulation

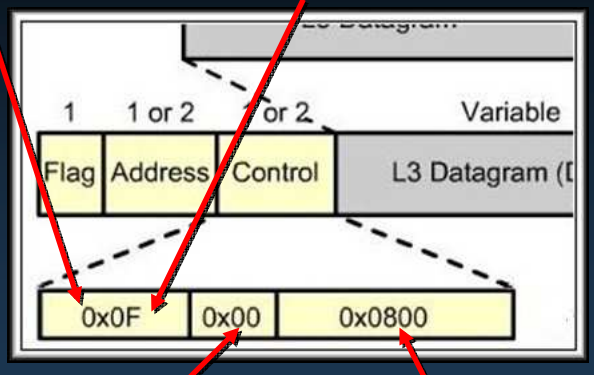
- **HDLC Frame Fields:**



- **Flag:**
  - The flag field initiates and terminates error checking.
  - The frame always starts and ends with an 8-bit flag field.
  - The bit pattern is **01111110**.
  - If the pattern occurs in the data after the flag, **zero-bit insertion** is used to ensure data integrity.
    - '0' bit is inserted after every occurrence of five '1' bits.
    - Sender inserts – receiver removes.

FYI - Cisco Proprietary HDLC Frame - (cHDLC)

- **0x0F** for Unicast **0x8F** for Broadcast packets.



- The **Control field** is always set to zero.
- The **Protocol Code field** is used to specify the protocol type encapsulated within the HDLC frame.

Configuring HDLC Encapsulation

- Cisco HDLC is the default encapsulation method used by Cisco devices on synchronous serial lines.
  - *You use Cisco HDLC as a point-to-point protocol on leased lines between two Cisco devices.*
  - If you are connecting to a non-Cisco device, use synchronous PPP.

```
Router(config)#interface s0/2/0

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


FYI - Troubleshooting a Serial interface

- *For data to move across a serial link, both the interface (Layer 1) and the line protocol (Layer 2) must be in the "up" state.*
  - Layer 1:
    - The Layer 1 physical interface must be up before the logical Layer 2 protocol can come up.
    - When the provider's circuit becomes active, a clocking or carrier detect signal is sent to the CSU/DSU.
    - The CSU/DSU recognizes that the line is active and sends the same signal to the DTE device.
    - You will see this signal referenced as CD or DCD either on a LED (CSU/DSU or modem) or in a status display (DCD=up).

FYI - Troubleshooting a Serial interface

- *For data to move across a serial link, both the interface (Layer 1) and the line protocol (Layer 2) must be in the "up" state.*
  - Layer 2:
    - Once the physical link is active, the Layer 2 protocol can begin it's connection process.
    - The Layer 2 connect will depend upon the line protocol in use. (Frame Relay / PPP / X.25)
    - Additionally, keepalive packets are sent by the remote router on a regular basis (usually every 10 seconds) to ensure that the link is still usable.
    - Once the Layer 2 connection is made, the line protocol is up.

Troubleshooting A Serial Interface

- **`show interfaces serial`** command:
  - Will show the status of all serial links on the router.
  - The interface status line has six possible states:

```
serial x is up, line protocol is up
serial x is down, line protocol is down
serial x is up, line protocol is down
serial x is up, line protocol is up (looped)
serial x is up, line protocol is down (disabled)
serial x is administratively down,
               line protocol is down
```

Troubleshooting A Serial Interface

- **`serial x is up, line protocol is up`**
  - *Proper status for the link.*

Troubleshooting A Serial Interface

- **`serial x is down, line protocol is down`**
  - *The router is not sensing the carrier detect signal.*
  - Possible Causes:
    - Router cable is faulty or incorrect.
    - Router has a faulty router interface.
    - CSU/DSU hardware failure.
    - Provider's circuit is down or it is not connected to the CSU/DSU.

Troubleshooting A Serial Interface

- **`serial x is up, line protocol is down`**
  - *A local or remote router is not reachable.*
  - Possible Causes:
    - Router not receiving/sending *keepalive* packets.
    - Local router has a faulty router interface.
    - Local router cable is faulty.
    - Local CSU/DSU not providing the DCD signal.
    - Local CSU/DSU hardware failure.
    - Provider's circuit is down.
    - *One of the LOCAL conditions above exist at the remote end of the link.*

Troubleshooting A Serial Interface

- **`serial x is up, line protocol is up (looped)`**
  - *A loop exists in the circuit.*
    - The sequence number in the keepalive packet changes to a random number when a loop is detected. If the same number is returned, a loop exists.
  - Possible Causes:
    - Misconfigured loopback interface.
    - CSU/DSU manually set in loopback mode.
    - CSU/DSU remotely set in loopback mode by the provider.

Troubleshooting A Serial Interface

- **`serial x is up,`**
  `line protocol is down (disabled)`
  - *A high error rate exists.*
  - Possible Causes:
    - A high error rate exists on the provider's circuit due to a provider problem.
    - CSU/DSU hardware problem.
    - Router interface hardware problem.

Troubleshooting A Serial Interface

- **`serial x is administratively down,`**
  `line protocol is down`
  - *Router configuration problem.*
  - Possible Causes:
    - Duplicate IP Address exists.
    - The **`no shutdown`** command has not been entered for the serial interface.

P.S. I tried to get Cisco to change the message to

```
serial x is administratively down,
          line protocol is down, DUMBASS
```

but they said that while they agreed, they couldn't possibly make that change…..