Chapter 18

Virtual-Circuit Networks: Frame Relay and ATM

18-1 FRAME RELAY

Frame Relay is a virtual-circuit wide-area network that was designed in response to demands for a new type of WAN in the late 1980s and early 1990s.

Topics discussed in this section:

Architecture
Frame Relay Layers
Extended Address
FRADs

18-1 FRAME RELAY

- ***Before Frame Relay, some organizations were using a virtual-circuit switching network called X.25. For e.g. Internet used X.25 but now is replaced by ATM and IP.***
- ***Drawbacks in X.25***
  - X.25 has a low **64-kbps** data rate. By 1990s, there was a need for higher data-rate WANs.
  - X.25 has **extensive flow and error control** at both the data link layer and the network layer. (because X.25 was designed in 1970s, the available transmission media were more prone to errors.) So **large overhead and slow transmissions (ack packets)**.

18-1 FRAME RELAY

Drawbacks in X.25

- ✓ Originally X.25 was designed for private line, not for the Internet.
- ✓ **X.25 has** its **own network layer**. The user's data are encapsulated in the network layer packets of X.25.
- ✓ The **Internet**, however, **has its own network layer**, which means if the Internet wants to use X.25, the Internet must deliver its network layer packet, called a datagram, to X.25 for **encapsulation** in the X.25 packet. This doubles the overhead.

18-1 FRAME RELAY

Drawbacks in X.25

- ✓ Disappointed with X.25, some organizations started their own private WAN by **leasing T-l** or **T-3 lines** from public service providers.
- ✓ If an organization has ***n*** branches spread over an area, it needs ***n*(*n* - 1)/2** **T-1** or T-3 **lines**. **If these lines are unused, waste/costly.**
- ✓ T-1 and T-3 lines assume that the **user has fixed-rate data** all the time. This service is **not suitable** for users that need to send **bursty data.**

18-1 FRAME RELAY

Design Goals:

- ✓ Frame Relay operates at a higher speed (**1.544 Mbps** and recently **44.376 Mbps**). Can replace the mesh of **leasing T-l** or **T-3 lines.**
- ✓ It operates only in **physical and data link layers**. This means it can be used as a backbone network to protocols that already have a network layer protocol, such as the Internet.
- ✓ It **allows bursty data (**refers to data that is sent in short, **high-volume bursts** followed by periods of **low or no data** transmission**).**
- ✓ Frame Relay allows a **frame size of 9000 bytes**, which can accommodate all local area network frame sizes

18-1 FRAME RELAY

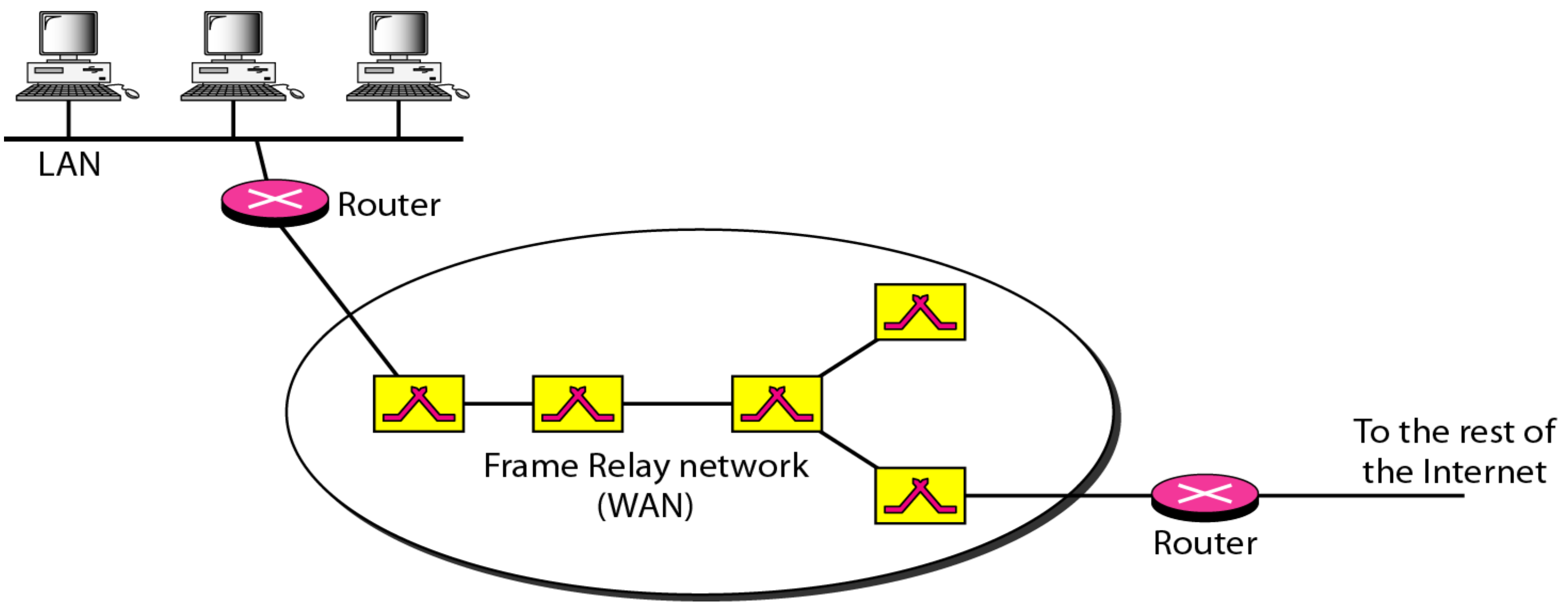
Design Goals:

- ✓ It is **less expensive** than other traditional WANs.
- ✓ It has **error detection at the data link layer only**. There is **no flow control or error control (**no retransmission policy if a frame is damaged; it is silently dropped**).**
- ✓ This way it provides fast transmission capability **for more reliable media** and for those protocols that have flow and error control at the higher layers.

18-1 Architecture

- ✓ Frame Relay provides **permanent virtual circuits** and **switched virtual circuits**.

Figure 18.1 ***Frame Relay network***



Note

Virtual circuit identifiers (VCIs) in Frame Relay are called data link connection identifiers (DLCIs).

18-1 Architecture

Permanent virtual circuit (PVC) and **Switched Virtual Circuits** (SVC)

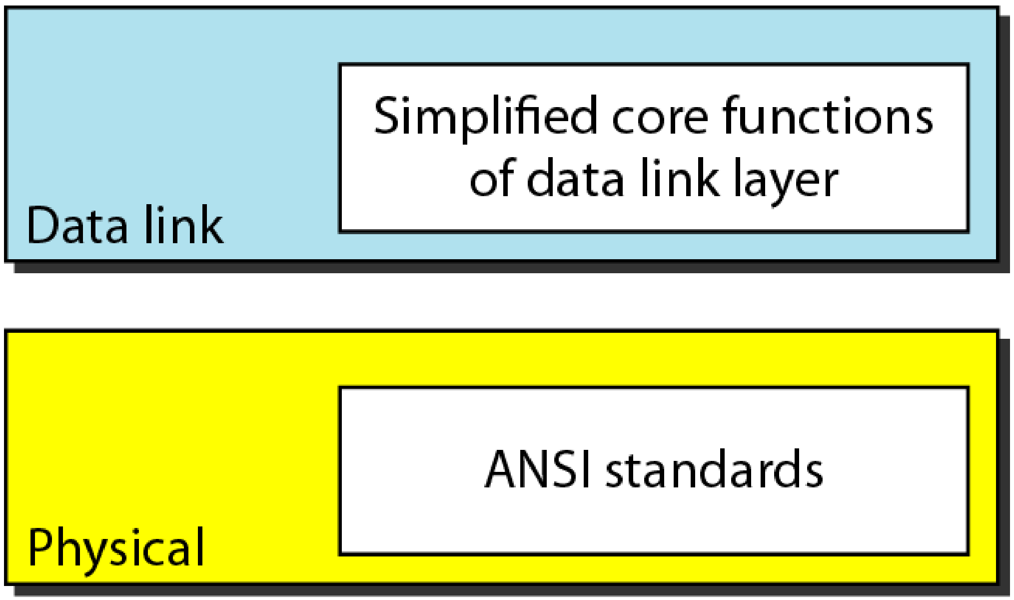
- ✓ A source and a destination may choose to have a permanent virtual circuit (PVC). In this case, the **connection setup is simple**.
- ✓ The corresponding **table entry is recorded for all switches by the administrator**.
- ✓ An outgoing DLCI is given to the source, and an incoming DLCI is given to the destination.

18-1 Architecture

PVC and **SVC**

- PVC connections have two drawbacks.
  - First, they are costly because two parties pay for the **connection all the time even when it is not in use**.
  - Second, a connection is created from **one source to one single destination**. If a source needs connections with several destinations, it needs a PVC for each connection.
- An alternate approach is the switched virtual circuit (SVC).
- The **SVC creates a temporary**, **short connection** that exists only when data are being transferred between source and destination.
- An **SVC requires establishing and terminating** phases.

Figure 18.2 *Frame Relay layers*



Note

Frame Relay operates only at the physical and data link layers.

Frame Relay layers: Physical Layer

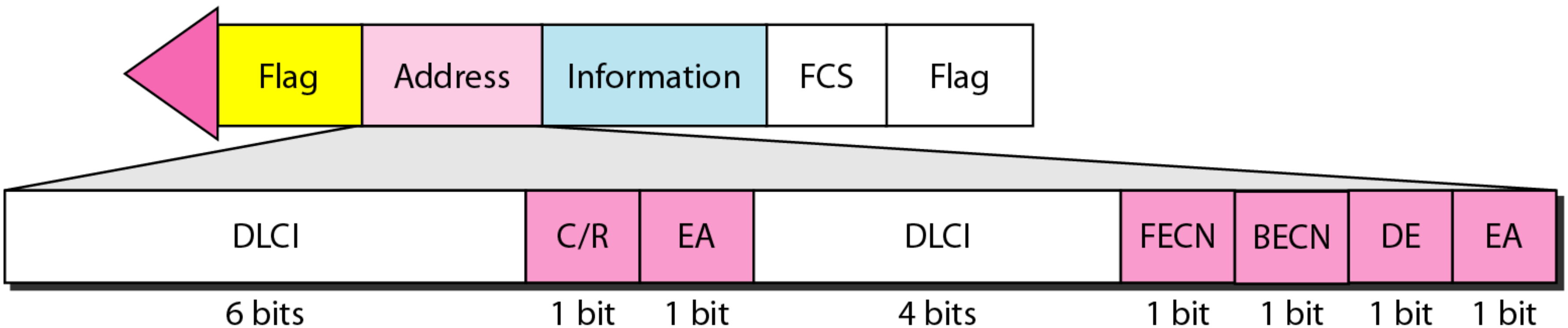
- ✓ No specific protocol is defined.
- ✓ Instead, it is **left to the implementer to use** whatever is available.
- ✓ Frame Relay supports any of the protocols recognized by American National Standards Institute (ANSI).

Frame Relay layers: Data Link Layer

- ✓ It uses a simple protocol that does not support flow or error control.
- ✓ It only has an error detection mechanism.
- ✓ It also provides control congestion

Figure 18.3 *Frame Relay frame*

C/R: Command/response
EA: Extended address
FECN: Forward explicit congestion notification
BECN: Backward explicit congestion notification
DE: Discard eligibility
DLCI: Data link connection identifier



Frame Relay layers: Data Link Layer

- **Address (DLCI) field (10-bit):**
  - The first 6 bits of the first byte makes up the first part of the DLCI.
  - The second part of the DLCI uses the first 4 bits of the second byte.

Frame Relay layers: Data Link Layer

Command/response (C/R):

- ✓ The command/response (C/R) **bit** is provided to allow upper layers to identify a frame as either a command or a response.

Frame Relay layers: Data Link Layer

Extended address (EA):

- ✓ The EA bit indicates whether the current byte is the final byte of the address.
  - ✓ An EA of 0 means that another address byte is to follow (extended addressing).
  - ✓ An EA of 1 means that the current byte is the final one

Frame Relay layers: Data Link Layer

Forward explicit congestion notification (FECN):

- ✓ The FECN bit can be set by any switch to indicate that traffic is congested.
- ✓ This bit informs the **destination** that congestion has occurred.
- ✓ In this way, the destination knows that it should expect delay or a loss of packets.

Frame Relay layers: Data Link Layer

Backward explicit congestion notification (BECN):

- ✓ The BECN bit is set (in frames that travel in the other direction) to **indicate a congestion problem in the network**.
- ✓ This bit informs the **sender** that congestion has occurred.
- ✓ In this way, the source knows it needs to slow down to prevent the loss of packets.

Frame Relay layers: Data Link Layer

Discard eligibility (DE):

- ✓ The DE bit indicates the **priority level** of the frame.
- ✓ In emergency situations, switches may have to discard frames to relieve bottlenecks and keep the network from collapsing due to overload.
- ✓ When set (DE 1), this bit tells the network to discard this frame if there is congestion.
- ✓ This bit can be set either by the sender of the frames (user) or by any switch in the network..

Note

Frame Relay does not provide flow or error control; they must be provided by the upper-layer protocols.

Figure 18.4 Extended Address: *Three address formats*

DLCI			C/R	EA = 0
DLCI	FECN	BECN	DE	EA = 1

a. Two-byte address (10-bit DLCI)

DLCI			C/R	EA = 0
DLCI	FECN	BECN	DE	EA = 0
DLCI			0	EA = 1

b. Three-byte address (16-bit DLCI)

DLCI			C/R	EA = 0
DLCI	FECN	BECN	DE	EA = 0
DLCI				EA = 0
DLCI			0	EA = 1

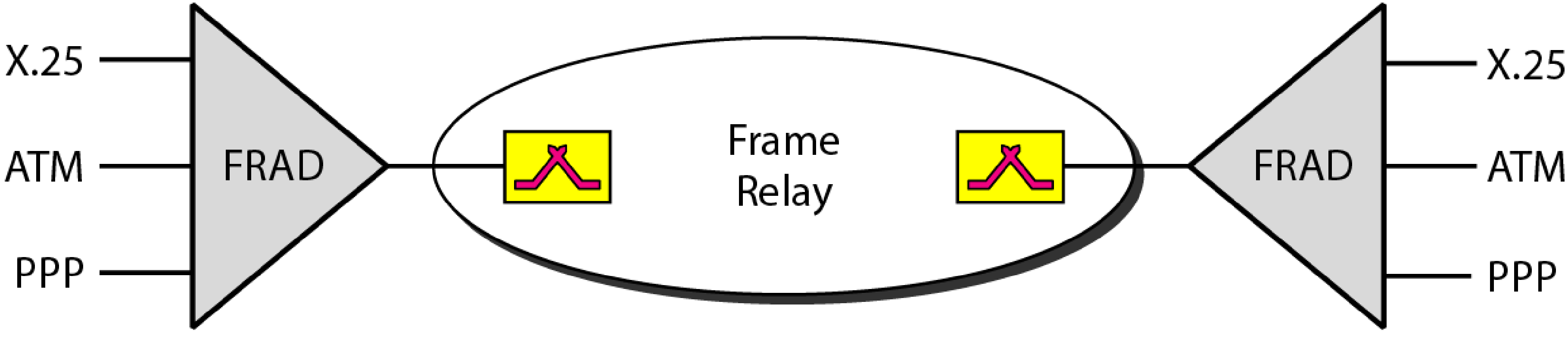
c. Four-byte address (23-bit DLCI)

- ✓ An EA of 0 means that another address byte is to follow
- ✓ An EA of 1 means that the current byte is the final one

FRADs

- ✓ To handle frames arriving from other protocols, Frame Relay uses a **device called a Frame Relay assembler/disassembler** (**FRAD**).
- ✓ A FRAD assembles and disassembles frames coming from other protocols to allow them to be carried by Frame Relay frames.
- ✓ A FRAD can be implemented as a separate device or as part of a switch.

Figure 18.5 *FRAD*



18-2 ATM

Asynchronous Transfer Mode (ATM) is the cell relay protocol designed by the ATM Forum and adopted by the ITU-T.

Design Goals

- Allows high-speed interconnection
- Speed (eliminate as many software functions as possible, move to hardware)
- Provide interface with existing systems to provide wide-area interconnectivity without replacing existing systems.
- Must be available at Low cost to every user
- Must support existing telecommunications hierarchies (local loops/local providers/long-distance carriers, etc)
- Must be connection-oriented to ensure accurate and predictable delivery

18-2 ATM

Problems in

Frame Networks:

- Before ATM, communications at the data-link layer were based on frame switching and frame networks.
- Different protocols use varying fame sizes.
- Complex network require large header size (larger header smaller payload). One quick solution was to enlarge payload size. But large data field create waste when we have less data to transmit

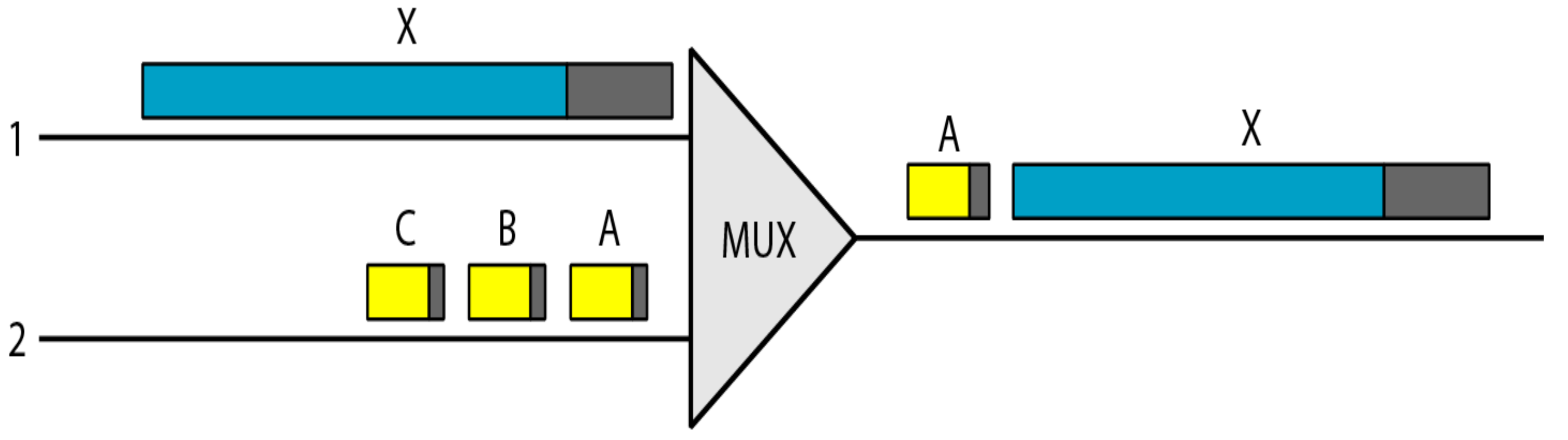
18-2 ATM

Problems in

Mixed Network Traffic:

- Variety of frame sizes make traffic unpredictable
- Switches, multiplexers, routers must incorporate complex software to manage. A great deal of header information require reading and evaluating, makes it slow and inefficient to use.
- Difficult to provide consistent data rate delivery due to varying frame size
- To make best use of broadband technology traffic must be time-division multiplexed

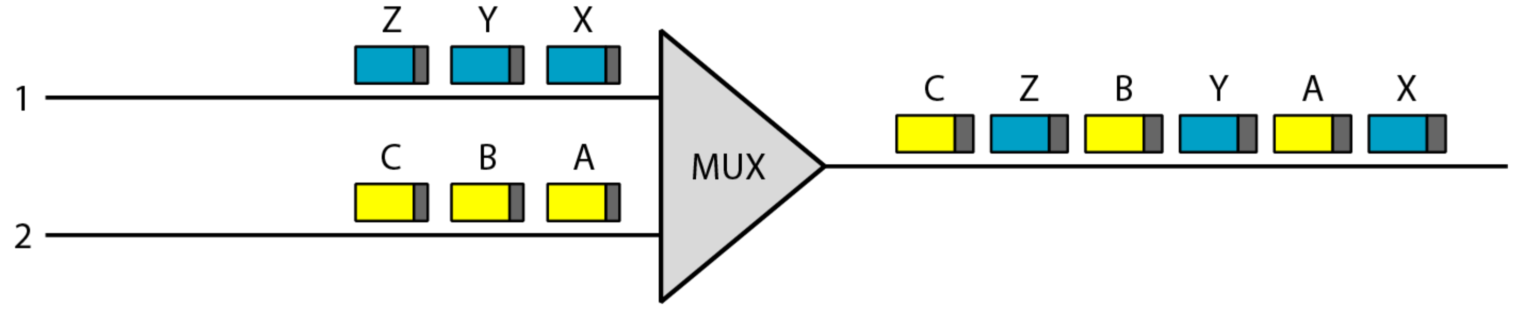
Figure 18.6 *Multiplexing using different frame sizes*



Note

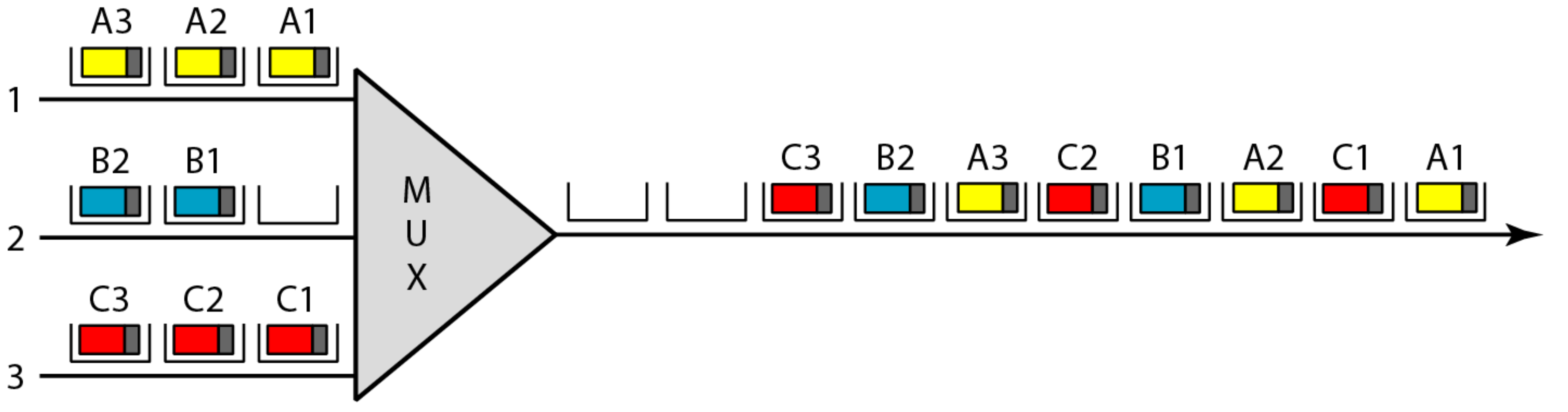
A cell network uses the cell as the basic unit of data exchange.
A cell is defined as a small, fixed-size block of information.

Figure 18.7 *Multiplexing using cells*



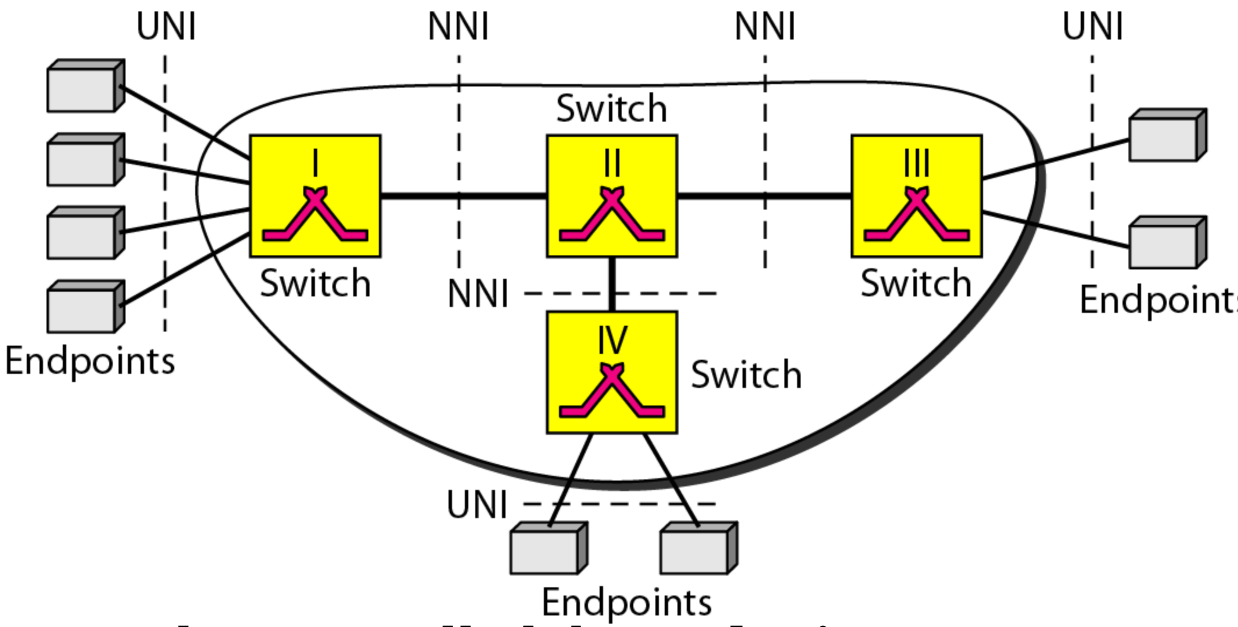
Delay issues due to variable frame sizes are resolved using fixed cells

Figure 18.8 *ATM multiplexing*



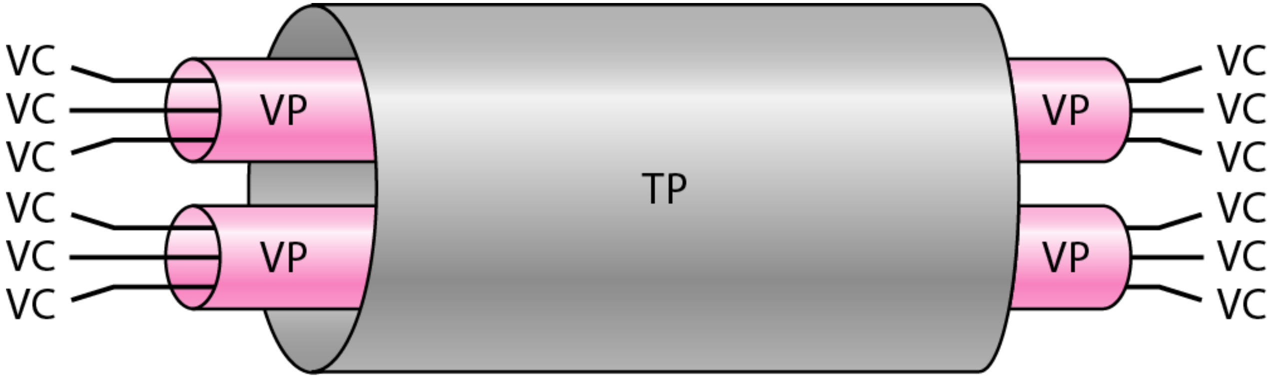
- ATM uses statistical (asynchronous) time-division multiplexing- that is why it is called Asynchronous Transfer Mode-to multiplex cells coming from different channels
- It uses fixed-size slots (size of a cell). Fill a slot with a cell from any input channel that has a cell

Figure 18.9 *Architecture of an ATM network*



- User access devices, called the **endpoints**, are connected through a **user-to-network interface (UNI)** to the **switches** inside the network.
- The **switches** are **connected** through **network-to-network interfaces (NNIs).**

Figure 18.10 *TP, VPs, and VCs*

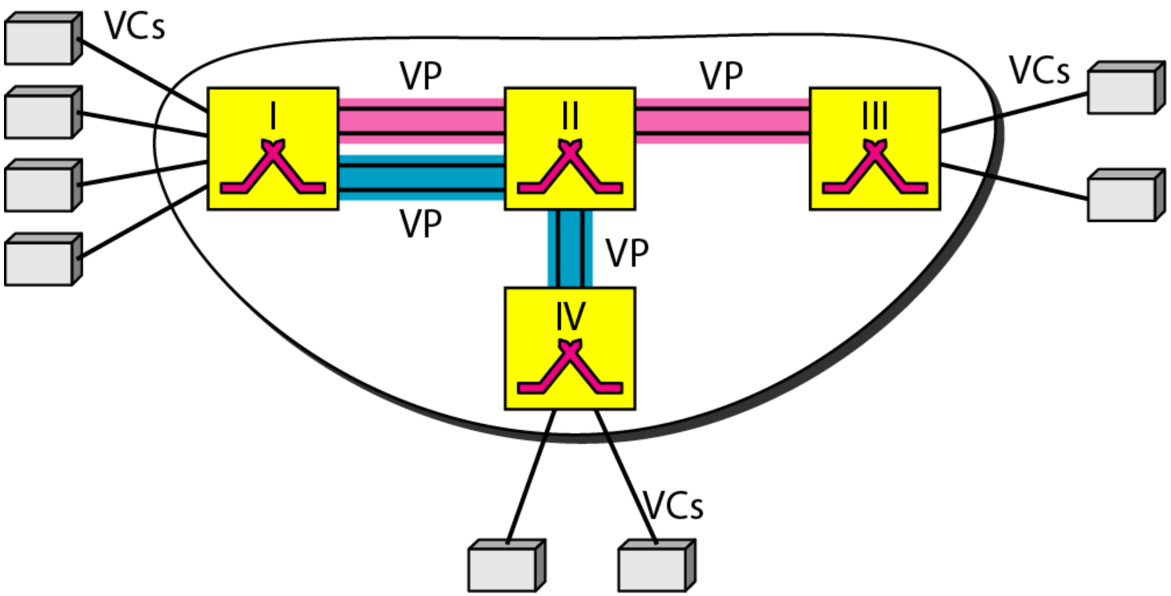


Connection between two endpoints** is accomplished through transmission paths (TP), virtual paths (VP), and virtual circuits (VC).

Figure 18.10 *TP, VPs, and VCs*

- Transmission paths (TP): is the physical connection (wire, cable, satellite, and so on) between an **endpoint** and a **switch or between two switches**
- Virtual paths (VP): A TP is divided into several virtual paths. A VP provides a connection or a **set of connections between two switche**s.
- Virtual circuits (VC): Cell networks are based on virtual circuits (VCs). **All cells belonging to a single message follow the same virtual circuit** and remain in their **original order until they reach their destination**

Figure 18.11 *Example of VPs and VCs*



Note

Note that a virtual connection is defined by a pair of numbers: the VPI and the VCI.

Figure 18.12 *Connection identifiers*

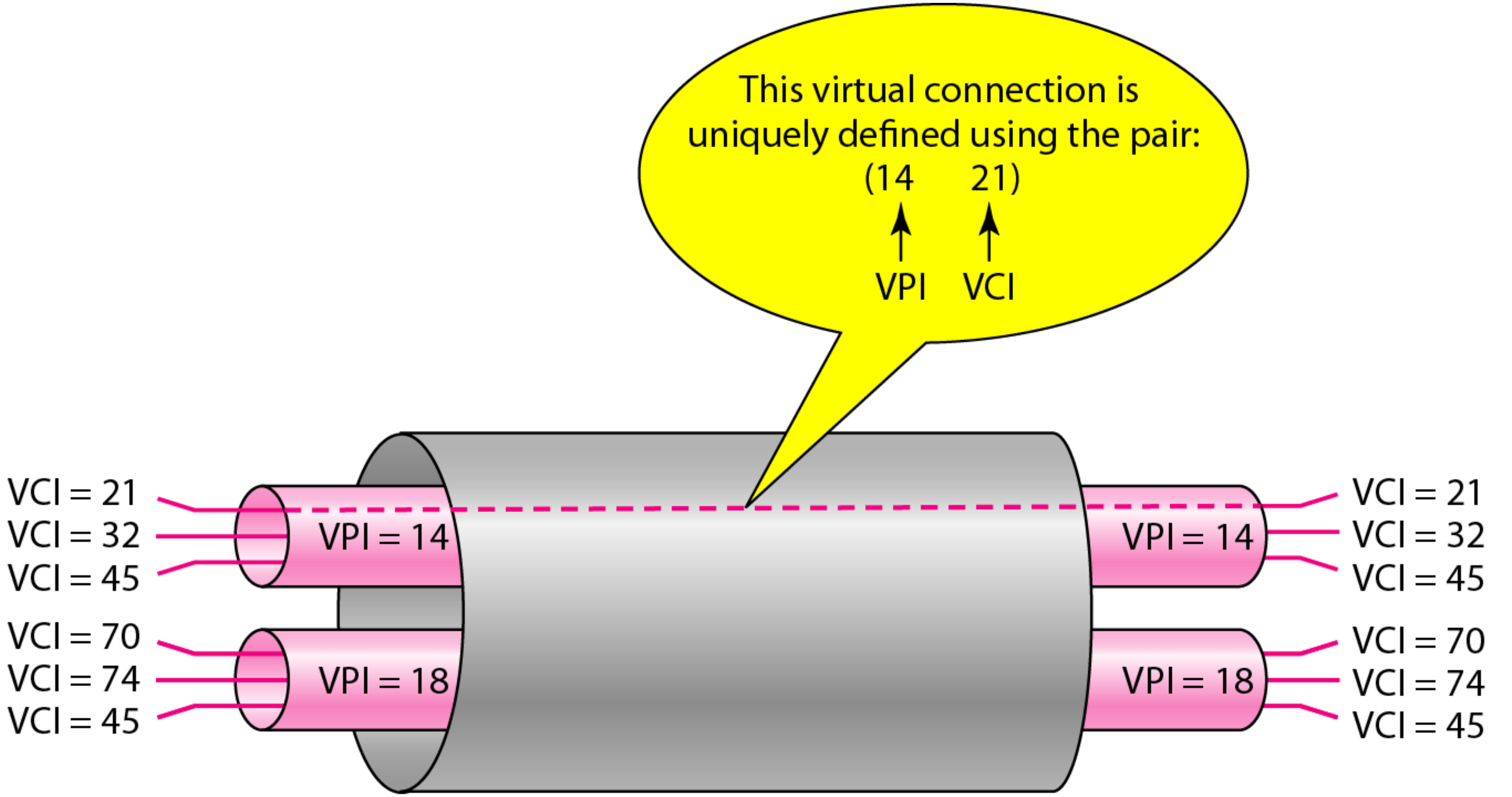
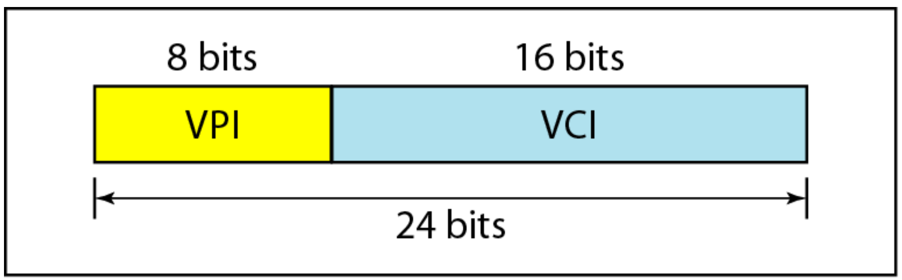
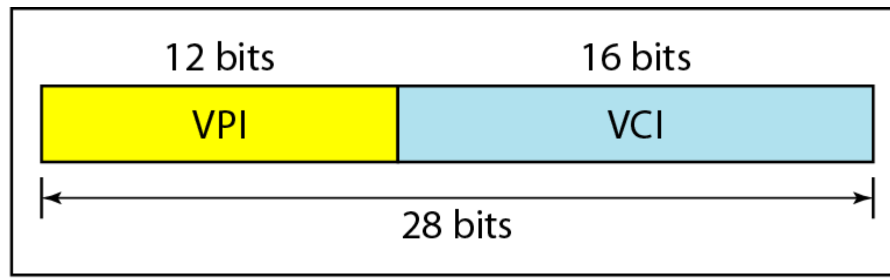


Figure 18.13 *Virtual connection identifiers in UNIs and NNIs*



a. VPI and VCI in a UNI



b. VPI and VCI in an NNI

Figure 18.14 *An ATM cell*

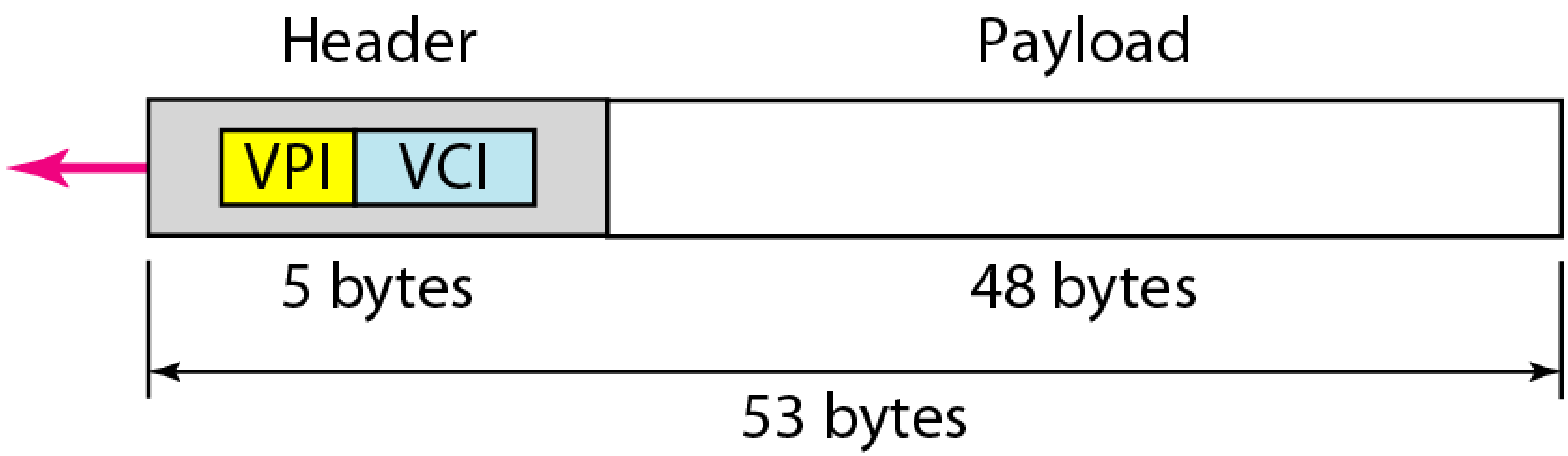


Figure 18.15 *Routing with a switch using the switching table*

Input			Output		
Interface	VPI	VCI	Interface	VPI	VCI
1	153	67	3	140	92
.....	.....	.....	.....	...	.....

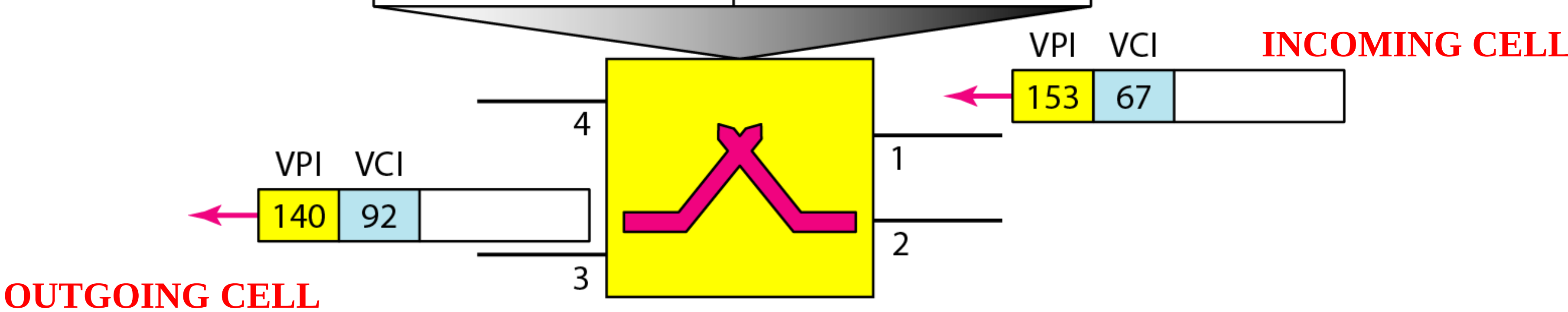
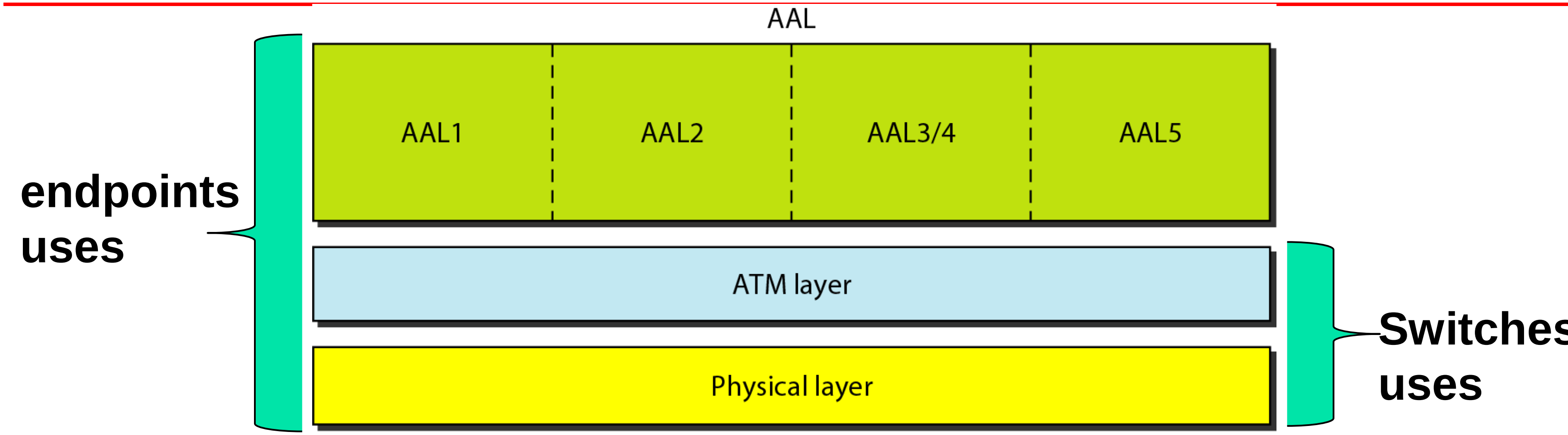


Figure 18.16 *ATM layers*



- **Application adaptation layer(AAL):** designed to accept any type of payload
    - A data frame (Internet)
    - Streams of bits (multimedia)
- It can accept continuous bit streams and break them into chunks to be encapsulated into cells

Figure 18.17 *ATM layers in endpoint devices and switches*

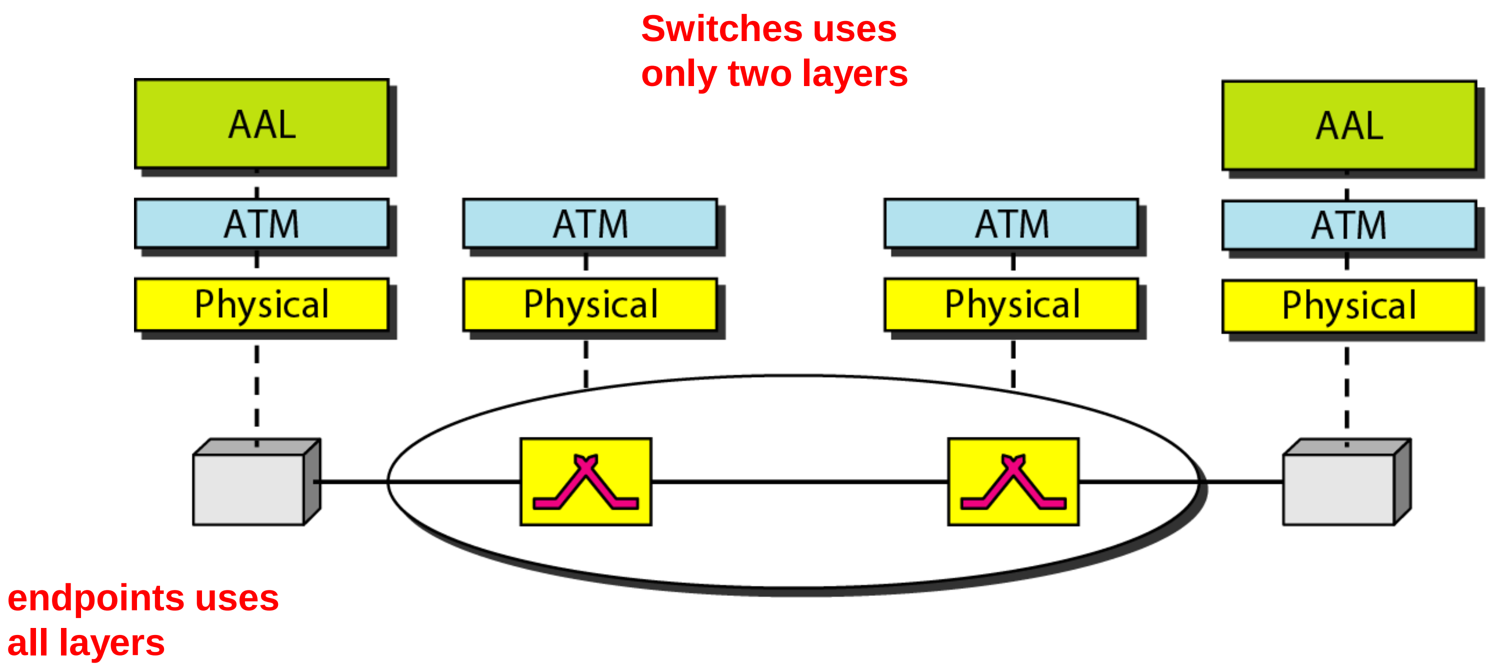


Figure 18.18 *ATM layer*

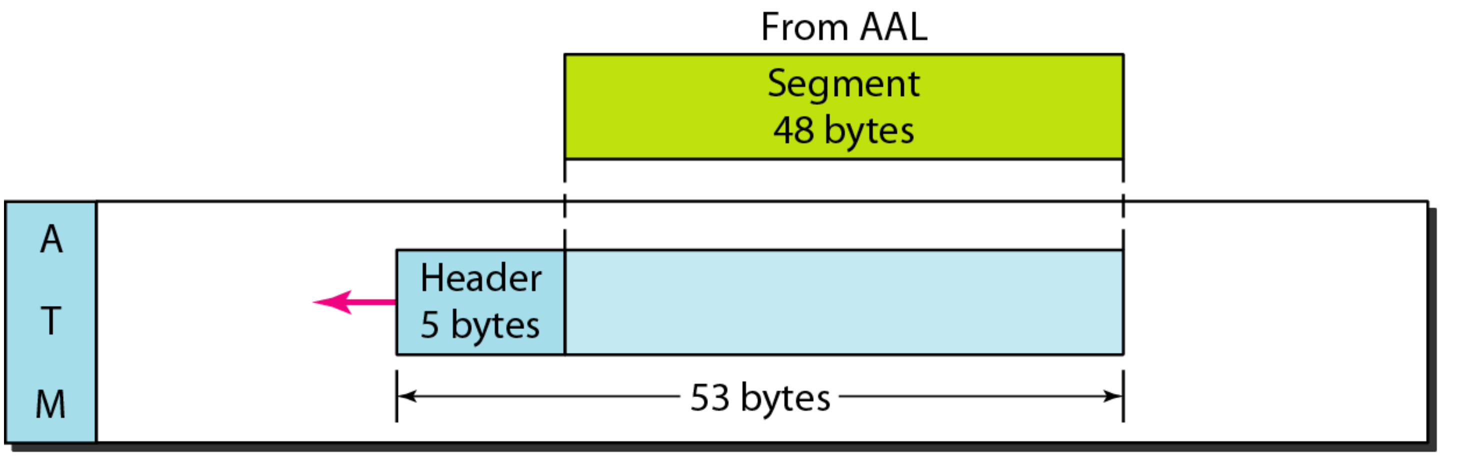


Figure 18.19 *ATM headers*

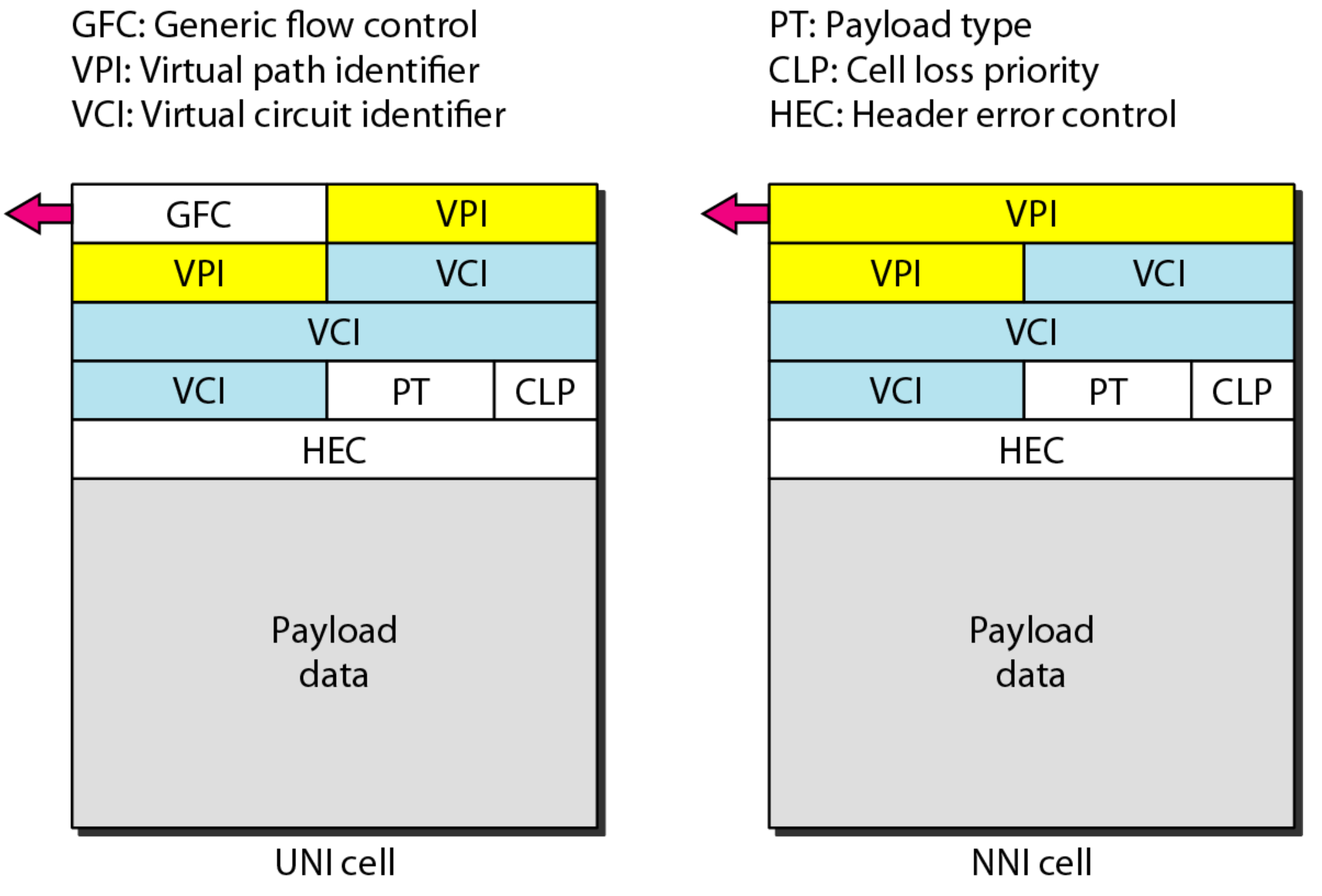


Figure 18.20 Versions of AAL: *AAL1*

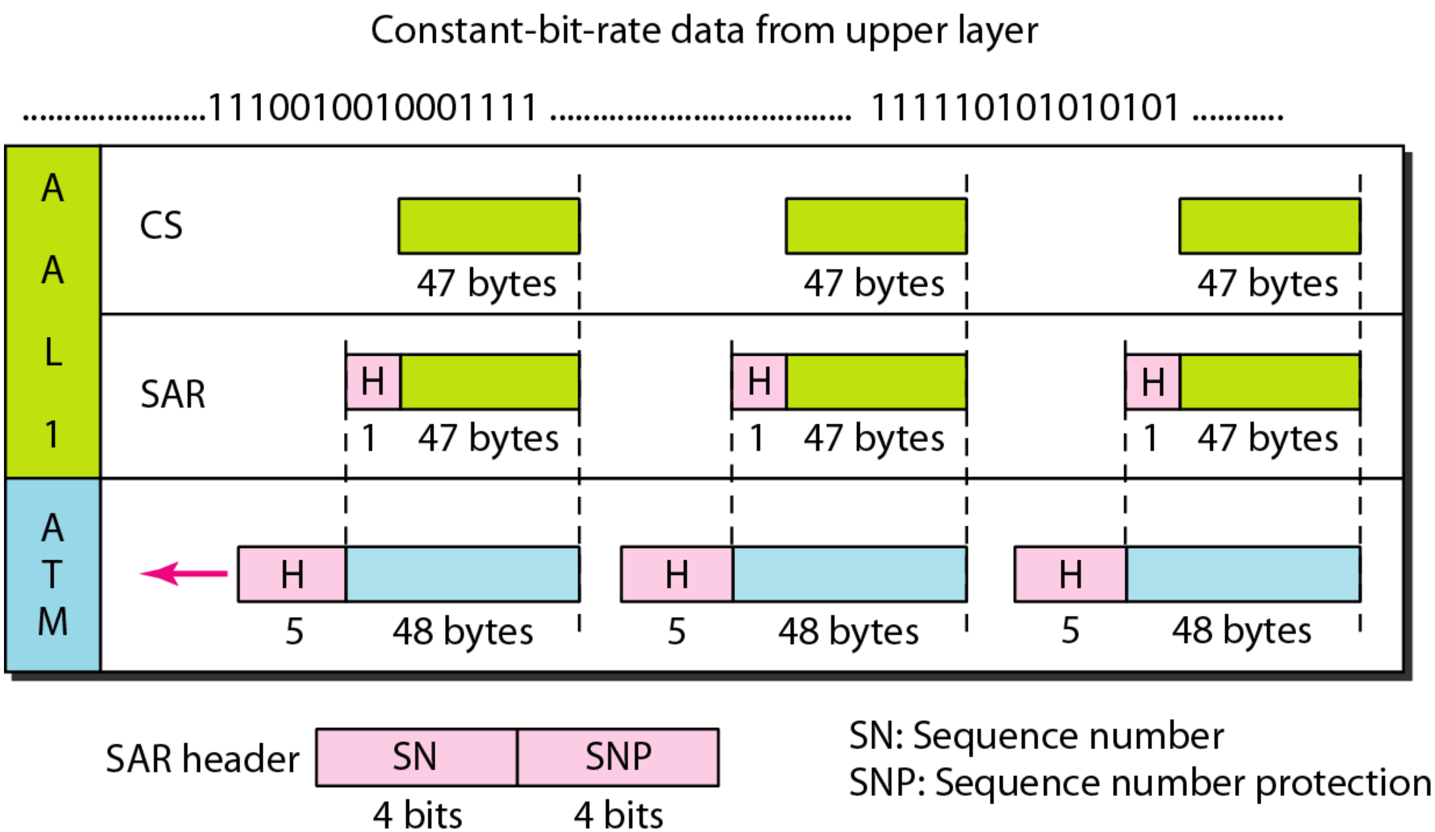


Figure 18.21 Versions of AAL: *AAL2*

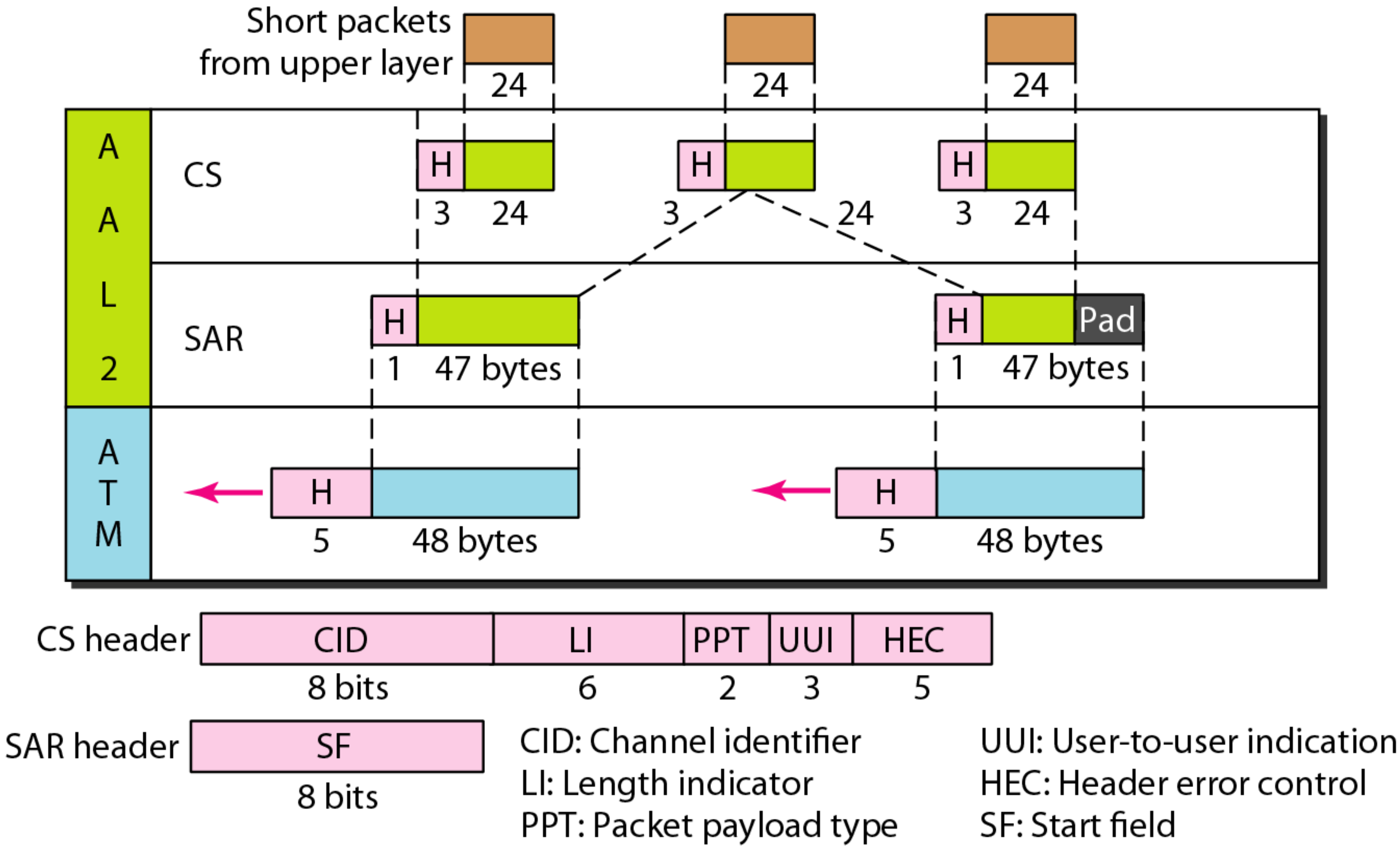


Figure 18.22 Versions of AAL: *AAL3/4*

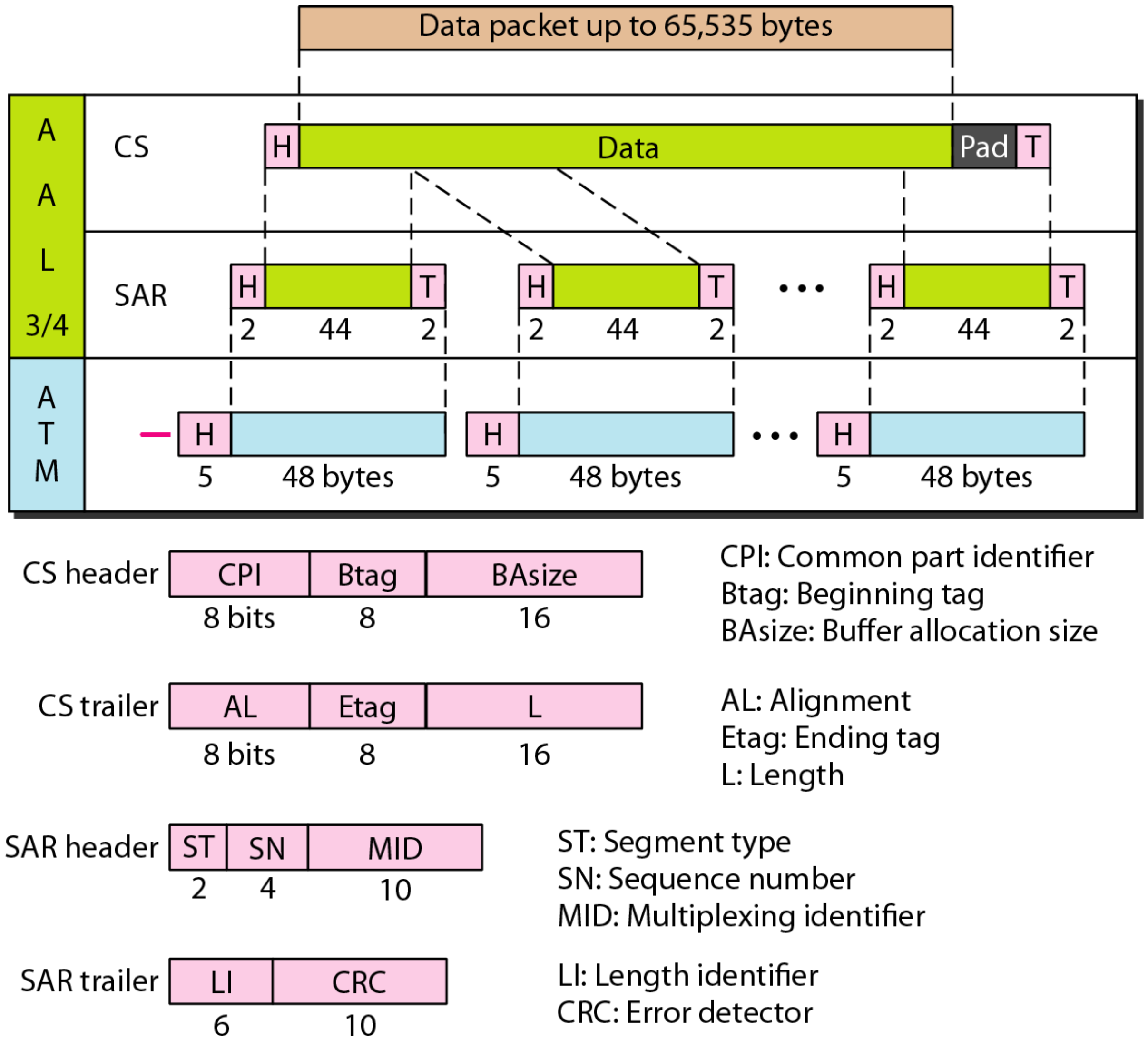
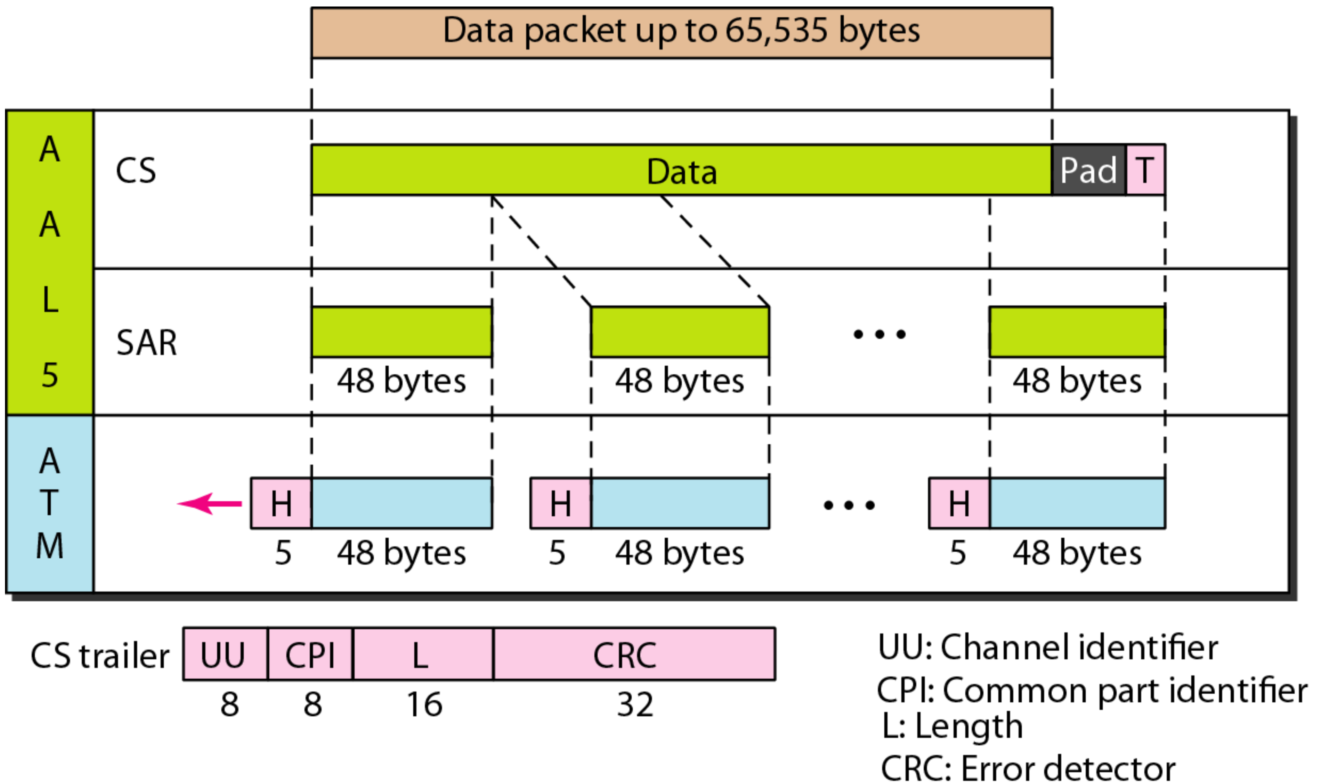


Figure 18.23 Versions of AAL: *AAL5*



18-3 ATM LANs

ATM is mainly a wide-area network (WAN ATM); however, the technology can be adapted to local-area networks (ATM LANs). The high data rate of the technology has attracted the attention of designers who are looking for greater and greater speeds in LANs.