

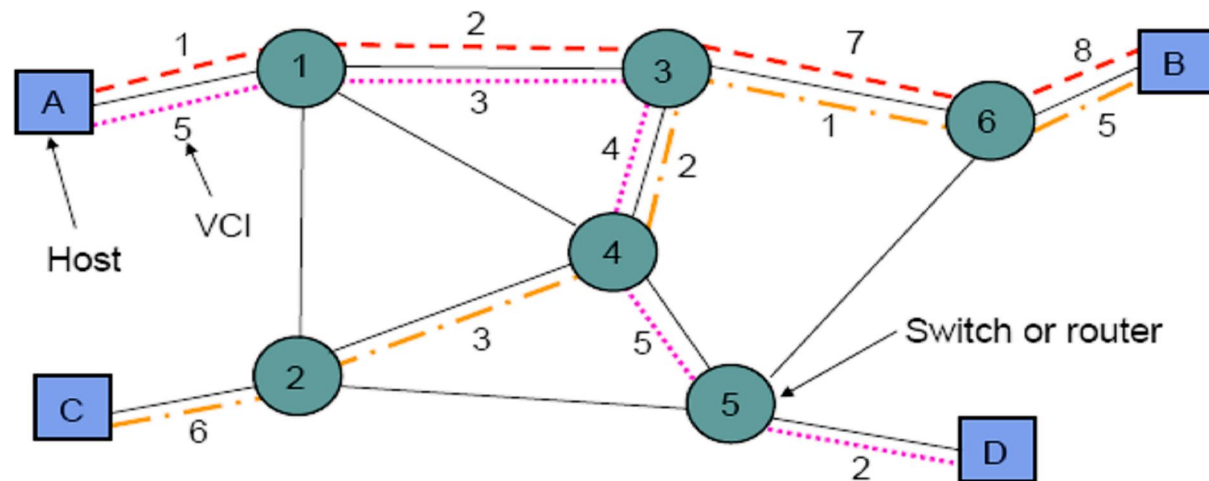
A decorative graphic consisting of a vertical black line and a horizontal grey line intersecting at a point.

EECS 122: Introduction to Communication Networks

Unit 21: ATM

Reminder: Virtual Circuits

(Garcia, Ch7)



Node 1				Node 3				Node 6			
Incoming		Outgoing		Incoming		Outgoing		Incoming		Outgoing	
Node	VCI	Node	VCI	Node	VCI	Node	VCI	Node	VCI	Node	VCI
A	1	3	2	1	2	6	7	3	7	B	8
A	5	3	3	1	3	4	4	3	1	B	5
3	2	A	1	4	2	6	1	B	5	3	1
3	3	A	5	6	7	1	2	B	8	3	7
				4	4	1	3				

Node 2				Node 4				Node 5			
Incoming		Outgoing		Incoming		Outgoing		Incoming		Outgoing	
Node	VCI	Node	VCI	Node	VCI	Node	VCI	Node	VCI	Node	VCI
C	6	4	3	2	3	3	2	4	5	D	2
4	3	C	6	3	4	5	5	D	2	4	5
				3	2	2	3				
				5	5	3	4				

Virtual circuit issues

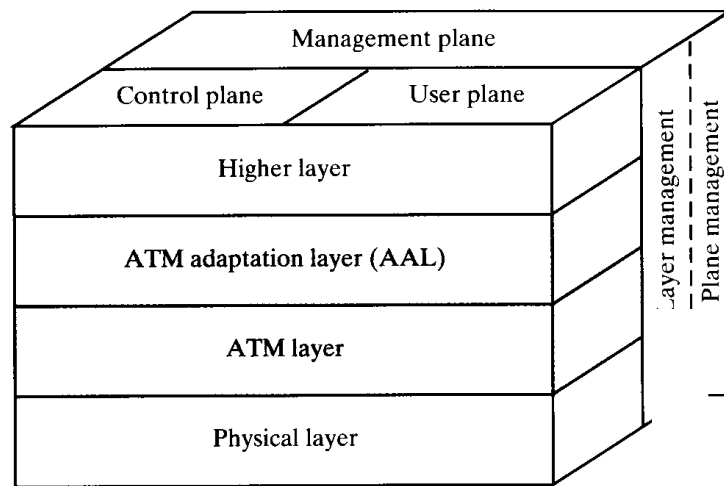
- Good: easy to associate resources with flows
 - can guarantee buffering and delay, which makes “quality of service” guarantees (QoS) easy to provide
 - Also good: VCI small, making per-pkt overhead small.
- Bad: not good in the face of crashes
 - doesn’t handle host crashes well: each connection has state strewn throughout network. to close connection, host must explicitly issue a “tear down.”
 - In general, to survive failure, want to make stuff as “stateless” as possible, trivially eliminating any storage management problems.
 - Doesn’t handle switch crashes well: have to teardown and reinitiate a new circuit

Introduction to ATM (1)

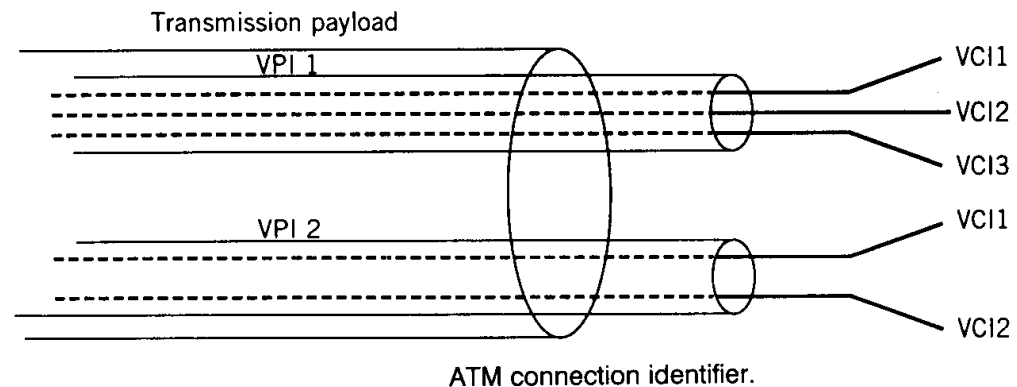
- ATM follows the principle of virtual circuit packet switched networks
- ATM is based on some important concepts:
 - virtual circuits
 - fixed-size packets (called cells!)
 - small cell size
 - statistical multiplexing
 - integrated services
- The usage of small and fixed sized packets simplifies the processing inside a switch and thus enables high data rates
- Two protocol layer relate to ATM functions: the ATM layer for all services that provide fixed-size packet transfer capabilities and the ATM adaptation layer (AAL) that is service dependent (multiple service classes).
- The protocol reference model has three separate planes:
 - user plane (for user information transfer and control),
 - control plane (call and connection control)
 - management plane (management functions for the whole system, resources and protocol entities)

Introduction to ATM (2)

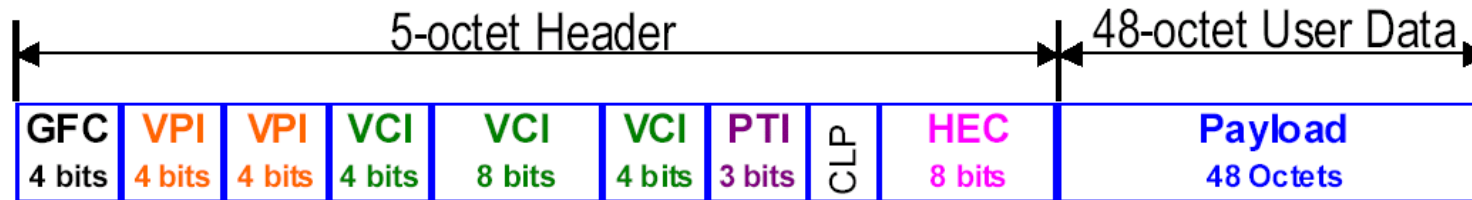
- Virtual circuits are referred to as virtual channel connections (VCC)
- A second sublayer has been introduced: the concept of virtual path connections (VPC); a VPC is a bundle of VCC that have the same endpoint; this concept is used to decrease the control costs (esp. in high speed networks like ATM) for connections that share common paths



ATM protocol reference model.



- Advantages of virtual paths:
 - Simplified network architecture
 - Increased network performance and reliability
 - Reduced processing and short connection setup time
 - Enhanced network services



- GFC - Generic Flow Control (4 bits)
 - Controls the flow of data across the UNI permitting multiple ATM devices to be attached to the same network interface
- VPI - Virtual Path Identifier (8 bits)
 - Contains the address of the Virtual Path for the end-to-end connection
- VCI - Virtual Channel Identifier (16 bits)
 - A pointer that identifies the virtual channel the system is using on a particular path
- PTI - Payload Type Identifier (3 bits)
 - Indicates the type of traffic contained in the cell (User Information or Control)
- CLP - Cell Loss Payload (1 bit)
 - Indicates droppability or non-droppability of a cell during congestion
 - 1 = droppable; 0 = not droppable
- HEC - Header Error Control (8 bits)
 - Provides error control for single-bit errors and error detection for multiple-bit errors in the cell error
- Payload - User Information

ATM Concepts: Fixed-size packets (RPI)

- Pros

- Simpler buffer hardware
 - packet arrival and departure requires us to manage fixed buffer sizes
- Simpler line scheduling
 - each cell takes a constant chunk of bandwidth to transmit
- Easier to build large parallel packet switches

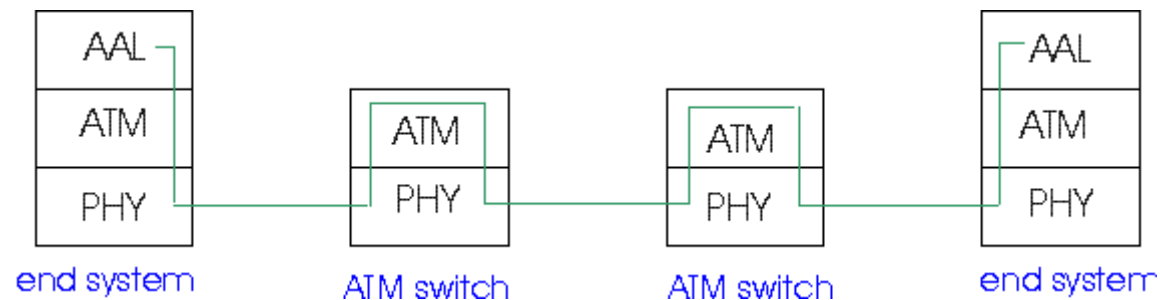
- Cons

- overhead for sending small amounts of data
- segmentation and reassembly cost
- last unfilled cell after segmentation wastes bandwidth

- At 8KHz, each byte is 125 microseconds
- The smaller the cell, the less an endpoint has to wait to fill it
 - *Low packetization delay*
- The smaller the packet, the larger the header overhead
- Standards body balanced the two to prescribe 48 bytes + 5 byte header = 53 bytes
 - => maximal efficiency of 90.57%

ATM Adaptation Layer (AAL)

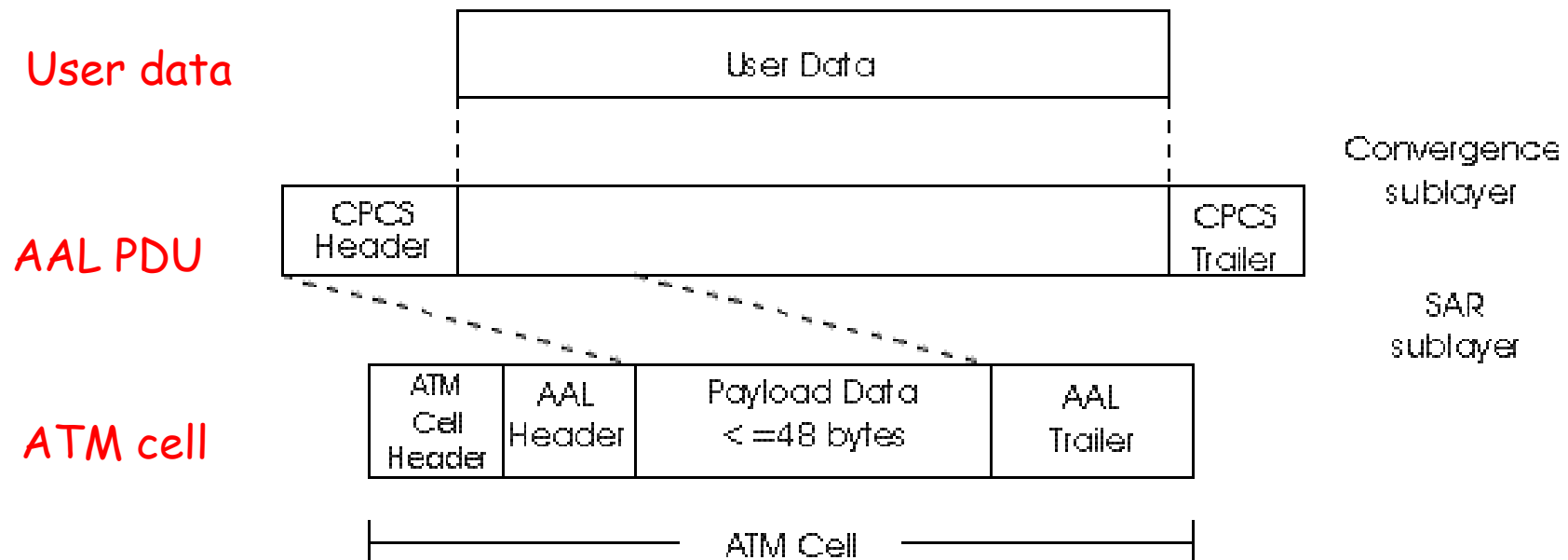
- ATM **Adaptation Layer** (AAL): “adapts” upper layers (IP or native ATM applications) to ATM layer below
- AAL present **only in end systems**, not in switches
- AAL layer segment (header/trailer fields, data) fragmented across multiple ATM cells
 - analogy: TCP segment in many IP packets



ATM Adaption Layer (AAL) [more]

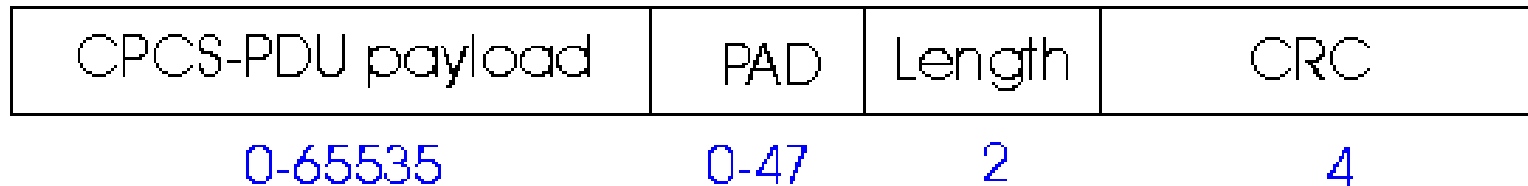
Different versions of AAL layers, depending on ATM service class:

- **AAL1**: for CBR (Constant Bit Rate) services, e.g. circuit emulation
- **AAL2**: for VBR (Variable Bit Rate) services, e.g., MPEG video
- **AAL5**: for data (eg, IP datagrams)



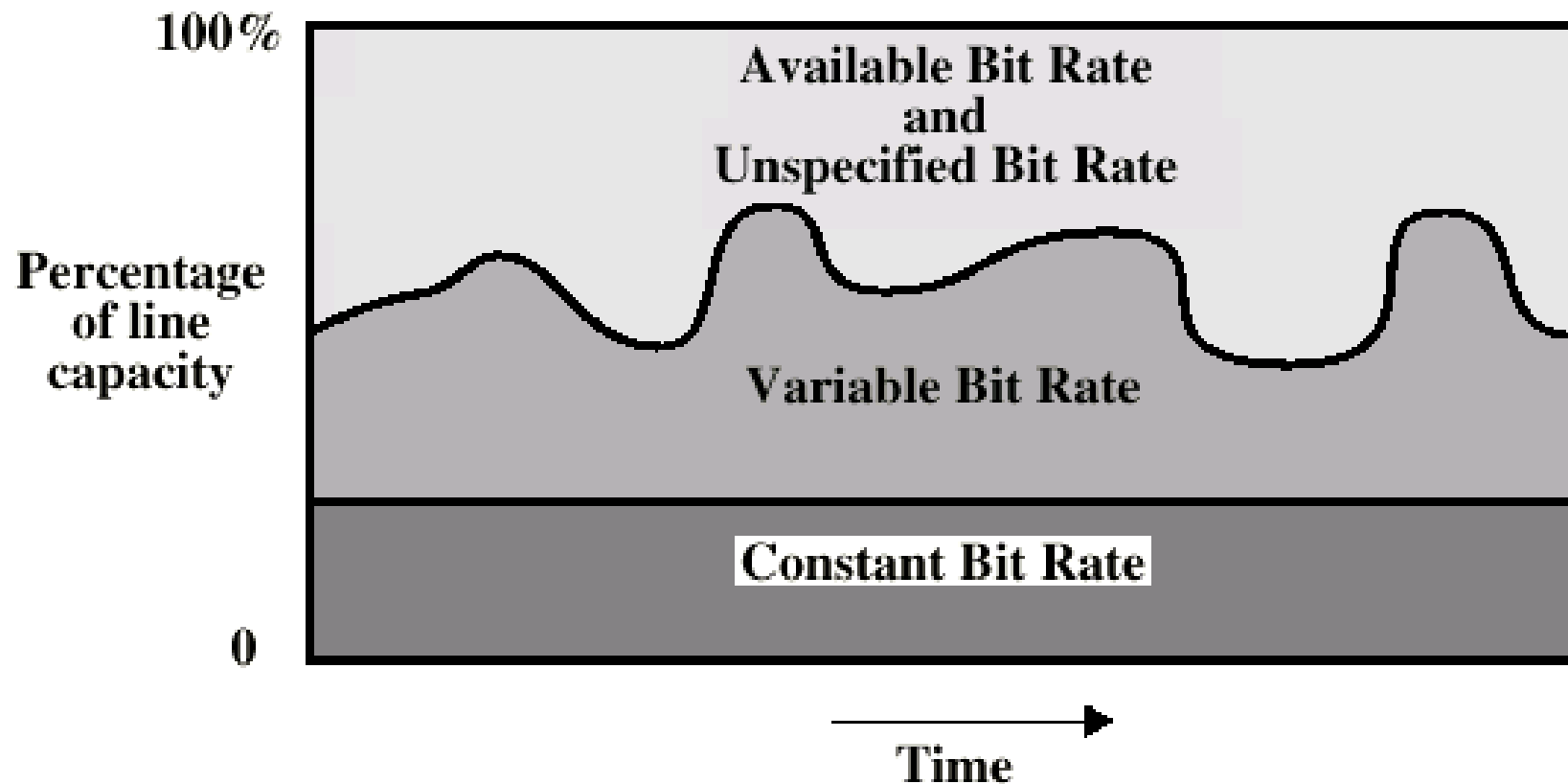
AAL5 - Simple And Efficient AL (SEAL)

- **AAL5: low overhead** AAL used to carry IP datagrams
 - 4 byte cyclic redundancy check
 - PAD ensures payload multiple of 48bytes
 - large AAL5 data unit to be fragmented into 48-byte ATM cells



- ABR (Available bit rate):
 - Source follows network feedback.
 - Max throughput with minimum loss.
- UBR (Unspecified bit rate):
 - User sends whenever it wants. No feedback. No guarantee. Cells may be dropped during congestion.
- CBR (Constant bit rate): User declares required rate.
 - Throughput, delay and delay variation guaranteed.
- VBR (Variable bit rate): Declare avg and max rate.
 - rt-VBR (Real-time): Conferencing.
 - Max delay guaranteed.
 - nrt-VBR (non-real time): Stored video.

ATM Bit Rate Services (stallings)



ATM Historic view

- Has been expected to become universal...
- Has had a lot of potential.
- High complexity.. scalability!
- Today – some areas
 - In Wide Area Networks
 - IN ADSLBut usually in highly static way...



PPP, ADSL

Where does PPP get used?

- Dial-up – PPP over async serial, over modem
- ADSL – PPP over ATM
- Backbone – Packet over SONET (POS)
- Why?
 - Framing (dialup, POS)
 - Efficiency (POS)
 - Authentication, address negotiation (PPPoE)

Point to Point Data Link Control

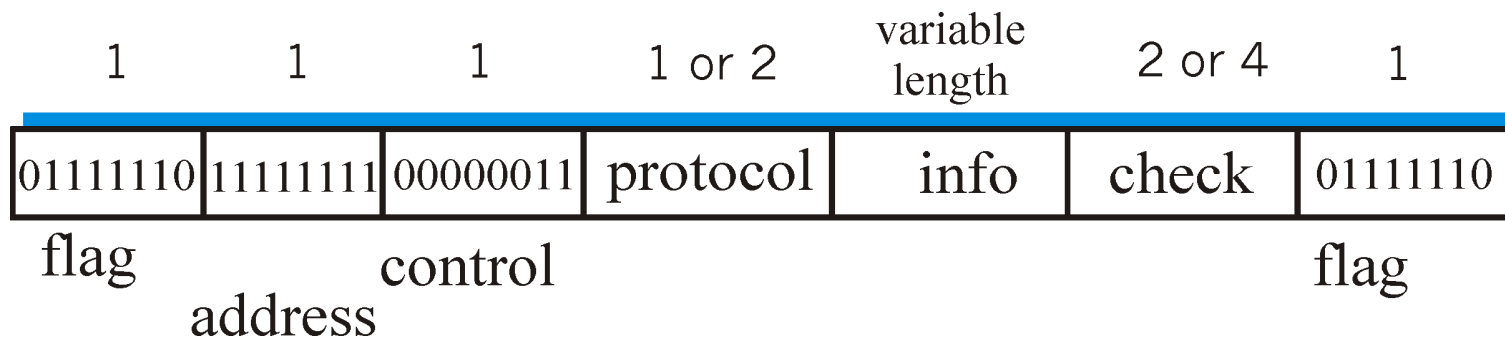
- One sender, one receiver, one link: easier than broadcast link:
 - No Media Access Control
 - No need for explicit MAC addressing
 - E.g., dialup link, ISDN line
- Popular point-to-point and high-level DLC protocols:
 - PPP (point-to-point protocol)
 - HDLC: High level data link control (Data link used to be considered “high layer” in protocol stack). HDLC is also used in multi-point links (one station many receivers)
- These protocols can often be run over other data link technologies providing best of both worlds
 - E.g., PPPoE, HDLC encapsulation by Ethernet

PPP Design Requirements [RFC 1557]

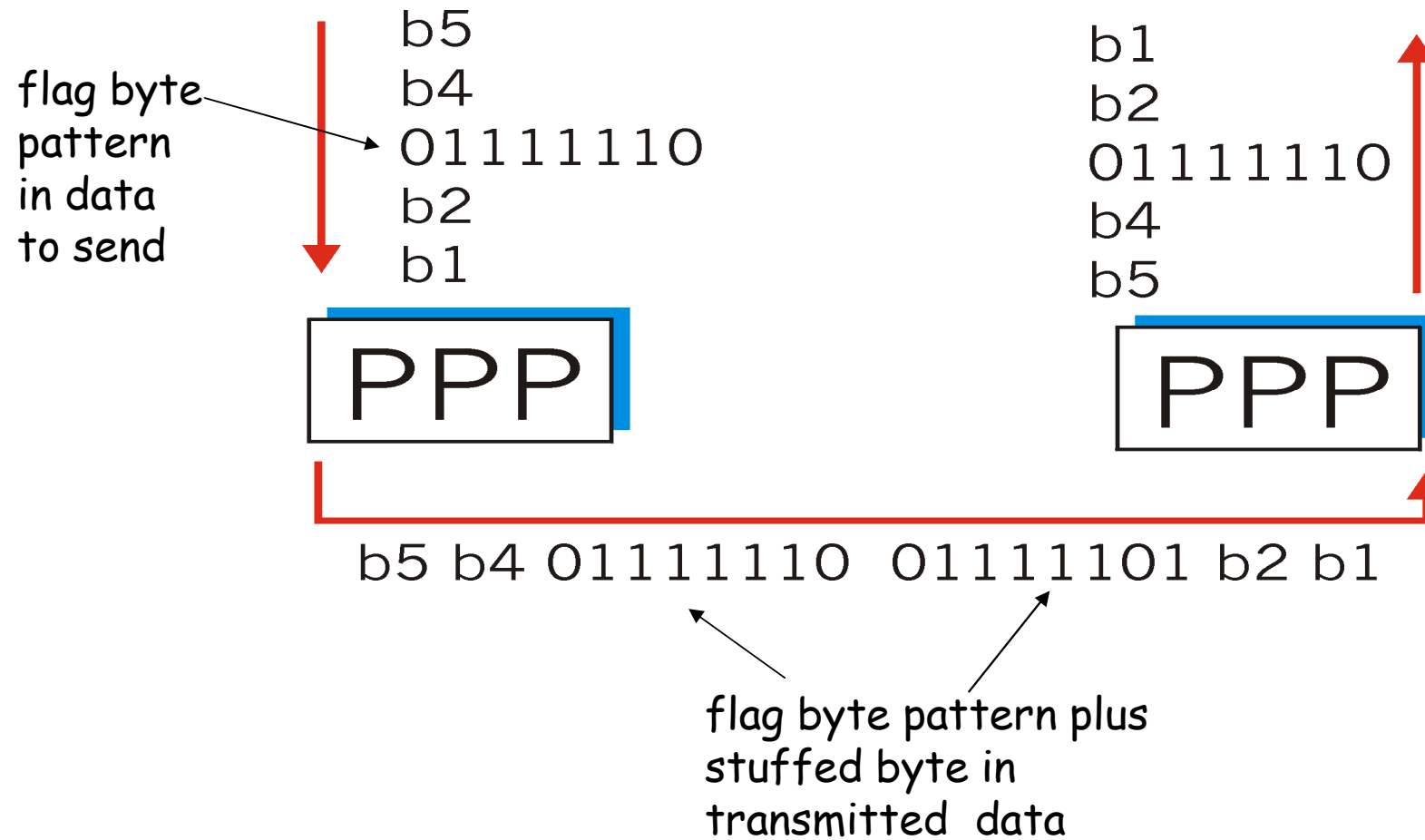
- Multi-protocol - carry network layer data of any network layer protocol (not just IP) *at same time* ability to demultiplex upwards
- Bit transparency - must carry any bit pattern in the data field (even if underlying channel can't)
- Packet framing - encapsulation of network-layer datagram in data link frame
- Error detection - not correction
- **Connection liveness:** detect, signal link failure to network layer
- **Network layer address negotiation:** endpoint can learn/configure each other's network address and other characteristics.
- **Authentication:** who are you (or at least whose account do I bill for your dial-in time?)
- **Management features:** loopback detection
- Note: No FLOW CONTROL _ responsibility of higher Layers

PPP Data Frame

- **Flag:** delimiter (framing)
- **Address:** ignored. (historical)
- **Control:** ignored. (historical)
- **Protocol:** upper layer protocol to which frame delivered (e.g., PPP-LCP, IP, IPCP, etc)



Byte Stuffing



PPP - IP encapsulation

- The frame format of PPP is similar to HDLC and the 802.2 LLC frame format:

flag	addr	ctrl	protocol	data	CRC	flag
7E	FF	03				7E
1	1	1	2	<= 1500	2	1

0021	IP datagram
------	-------------

C021	link control data
------	-------------------

8021	network control data
------	----------------------

- PPP assumes a duplex circuit
- Note: PPP does not use addresses
- Usual maximum frame size is 1500

Additional PPP functionality

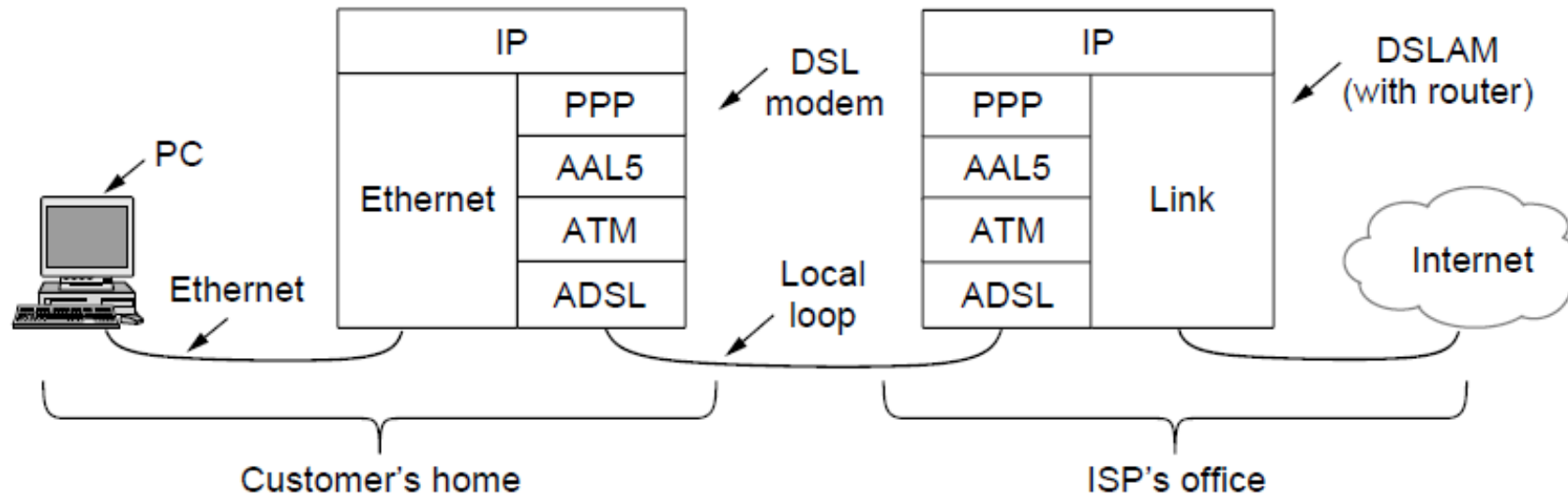
- In addition to encapsulation, PPP supports:
 - multiple network layer protocols (protocol multiplexing)
 - Link configuration
 - Link quality testing
 - Error detection
 - Option negotiation
 - Address notification
 - Authentication
- The above functions are supported by helper protocols:
 - LCP
 - PAP, CHAP
 - NCP

PPP Support protocols

- **Link management:** The link control protocol (LCP) is responsible for establishing, configuring, and negotiating a data-link connection. LCP also monitors the link quality and is used to terminate the link.
- **Authentication:** Authentication is optional. PPP supports two authentication protocols: Password Authentication Protocol (PAP) and Challenge Handshake Authentication Protocol (CHAP).
- **Network protocol configuration:** PPP has network control protocols (NCPs) for numerous network layer protocols. The IP control protocol (IPCP) negotiates IP address assignments and other parameters when IP is used as network layer.

ADSL (Asymmetric Digital Subscriber Loop)

ADSL protocol stacks.



AAL5 frame carrying PPP data

