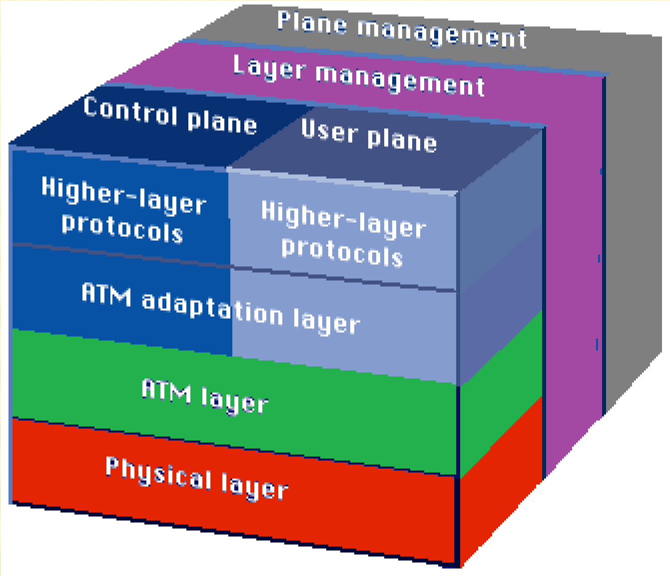
BROADBAND AND HIGH SPEED NETWORKS

6

Asynchronous Transfer Mode (ATM)

ATM LAYERS



The function and associated information of the planes is as follows:

Plane	Function	Information flow
User	Transfer of user application data	User application
Control	Call and connection control	Signalling related to calls and connections
Management (layer / plane management)	Network supervision	Network status and performance

- The ATM reference model is composed of the following *planes*:
  - Control Plane manages the call and connection.
  - User Plane manages the transfer of data, flow control, and error control.
  - Management Plane : This plane contains two components:
    - Layer management manages functions, such as the detection of failures and protocol problems.
    - Plane management manages and coordinates functions related to the complete system.

ATM LAYER FUNCTIONS

The higher layers

The user services are supported in these layers. Four classes of service have been identified:

- **Class A** connection oriented constant bit rate, e.g. speech
- **Class B** connection oriented with timing between the source and destination, e.g. video
- **Class C** connection oriented without timing, e.g. data
- **Class D** connectionless, e.g. data from LANs and MANs

The ATM adaption layer

The AAL converts application data into ATM data units in order to provide support for user applications. All AAL functions are performed at the edges of the network, and all AAL information is carried within the ATM cell information fields transparently by the ATM layer.

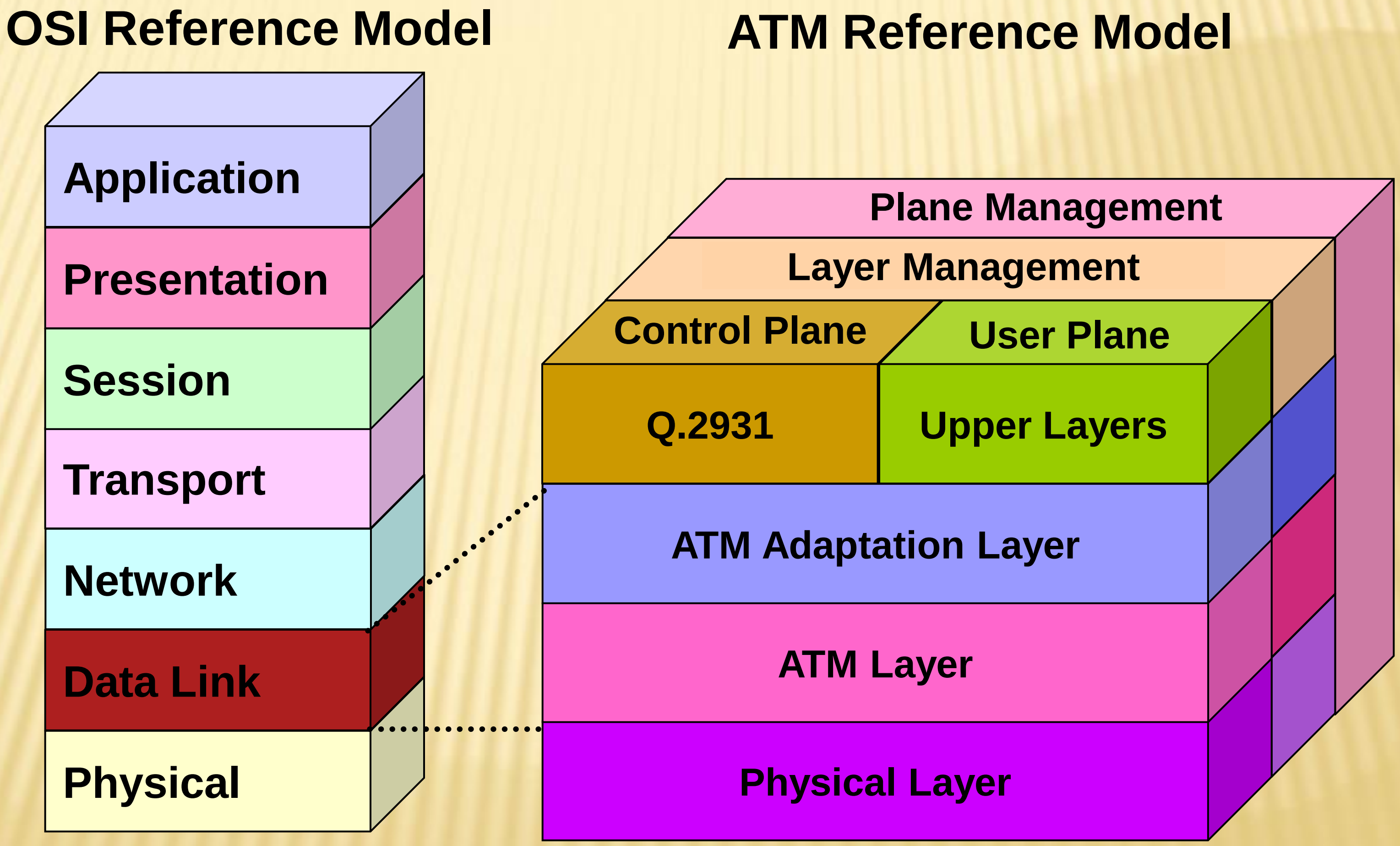
The ATM layer

This layer takes and returns data from the AAL and generates and interprets the cells respectively. The layer transports the data according to the protocol information in the cell headers transparently.

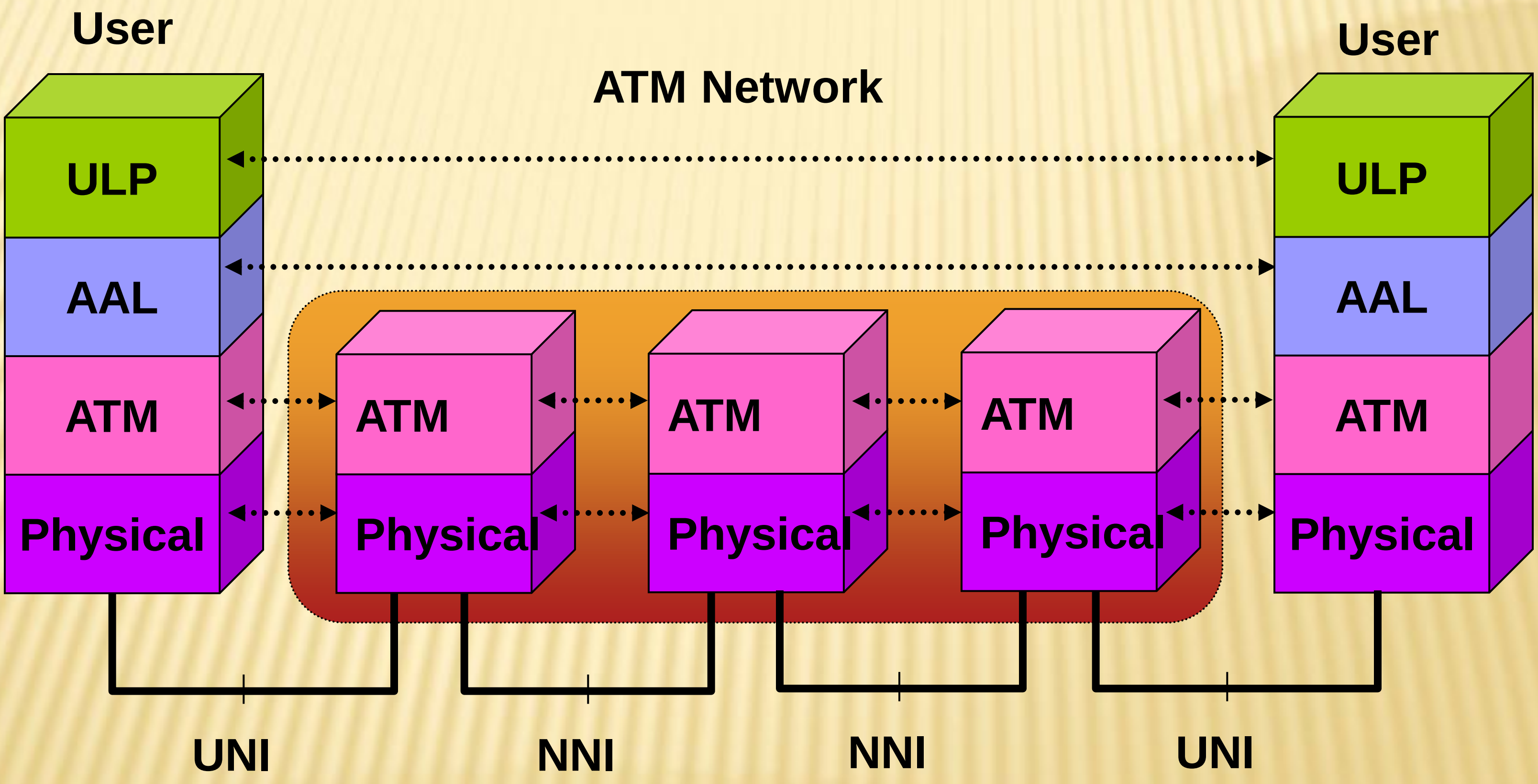
The physical layer

This is the lowest level layer, and it is responsible for the transmission of ATM cells as bit streams across a physical medium.

ATM REFERENCE MODEL

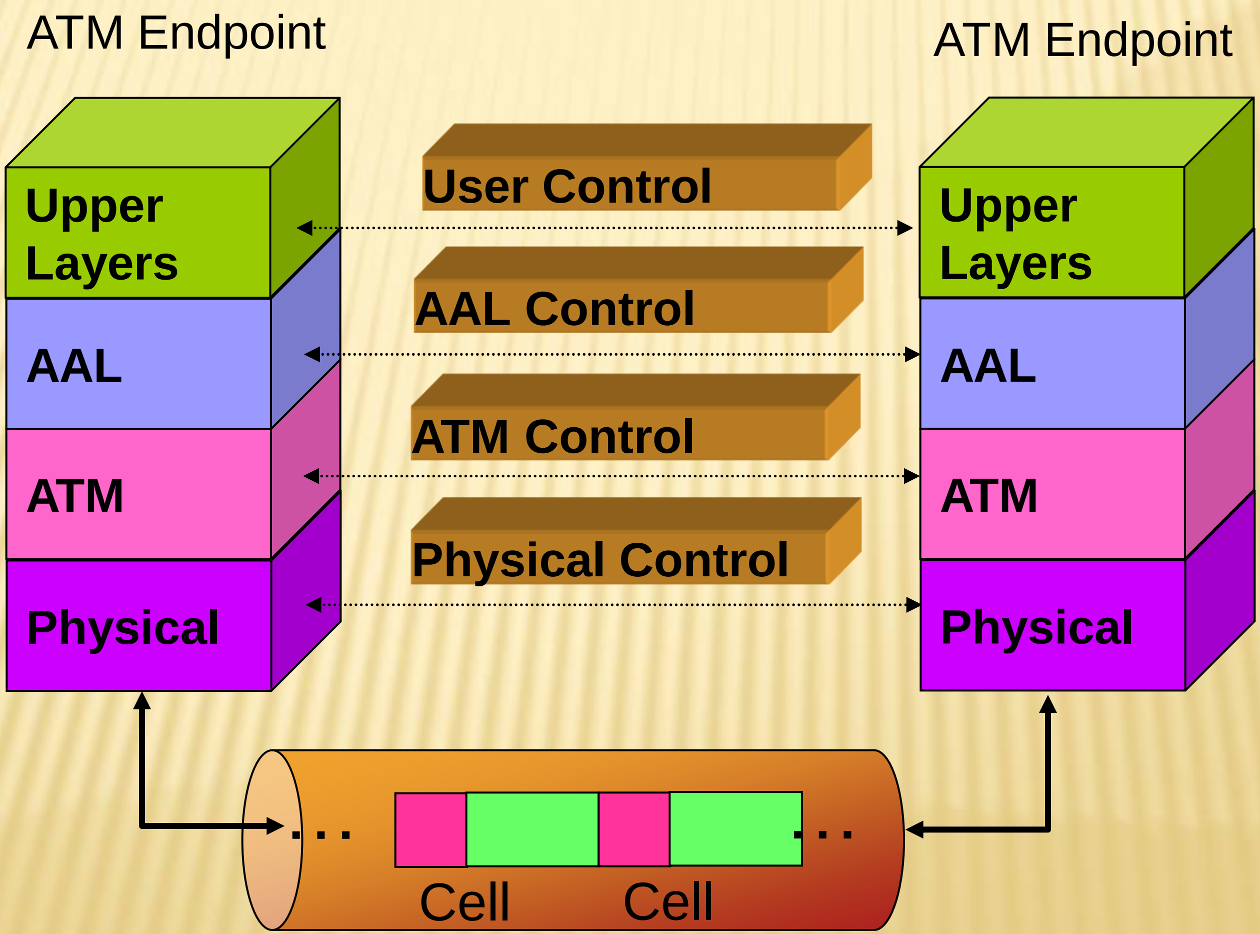


ATM REFERENCE MODEL



Transfer of User Payload

ATM REFERENCE MODEL



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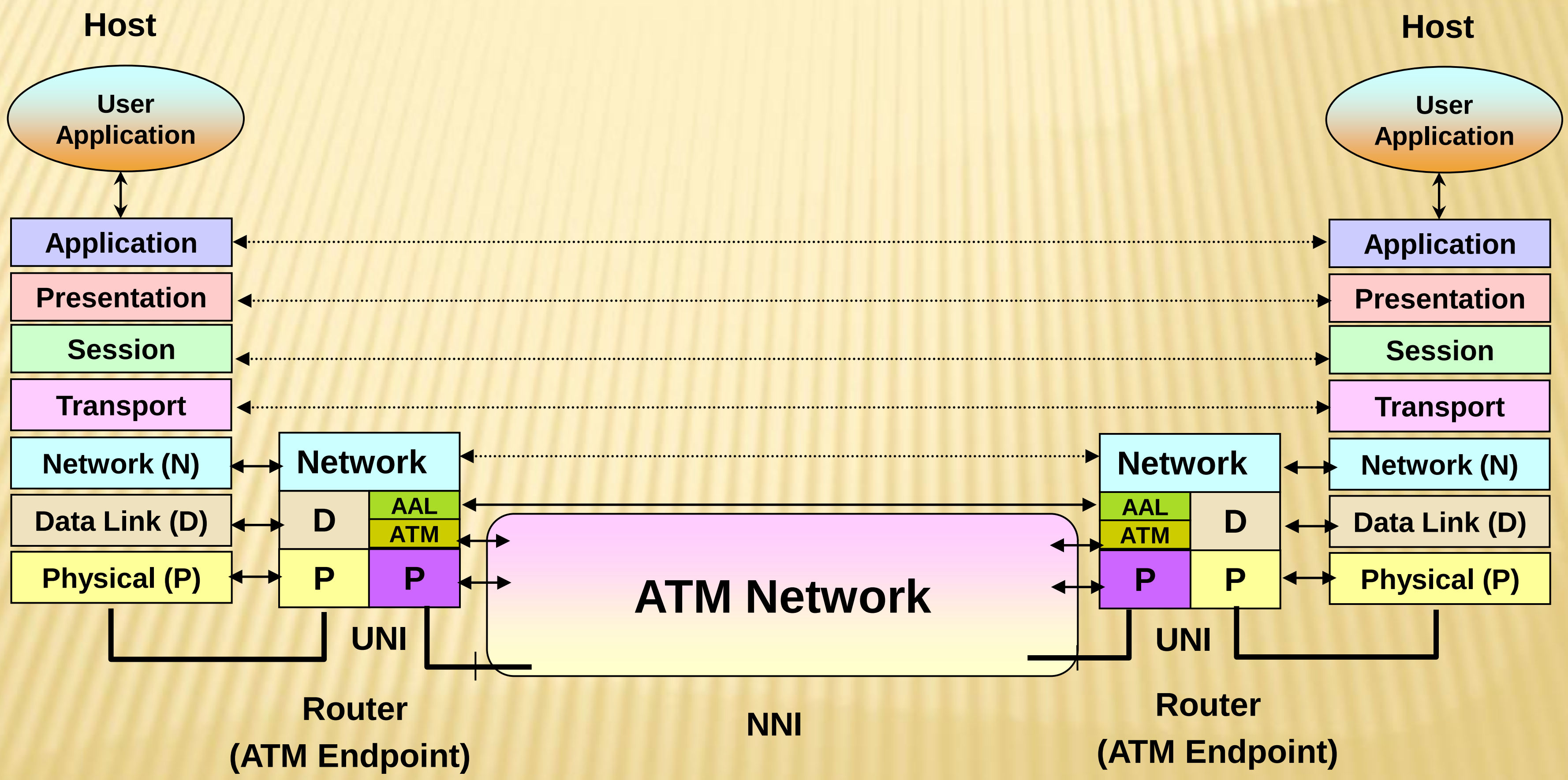

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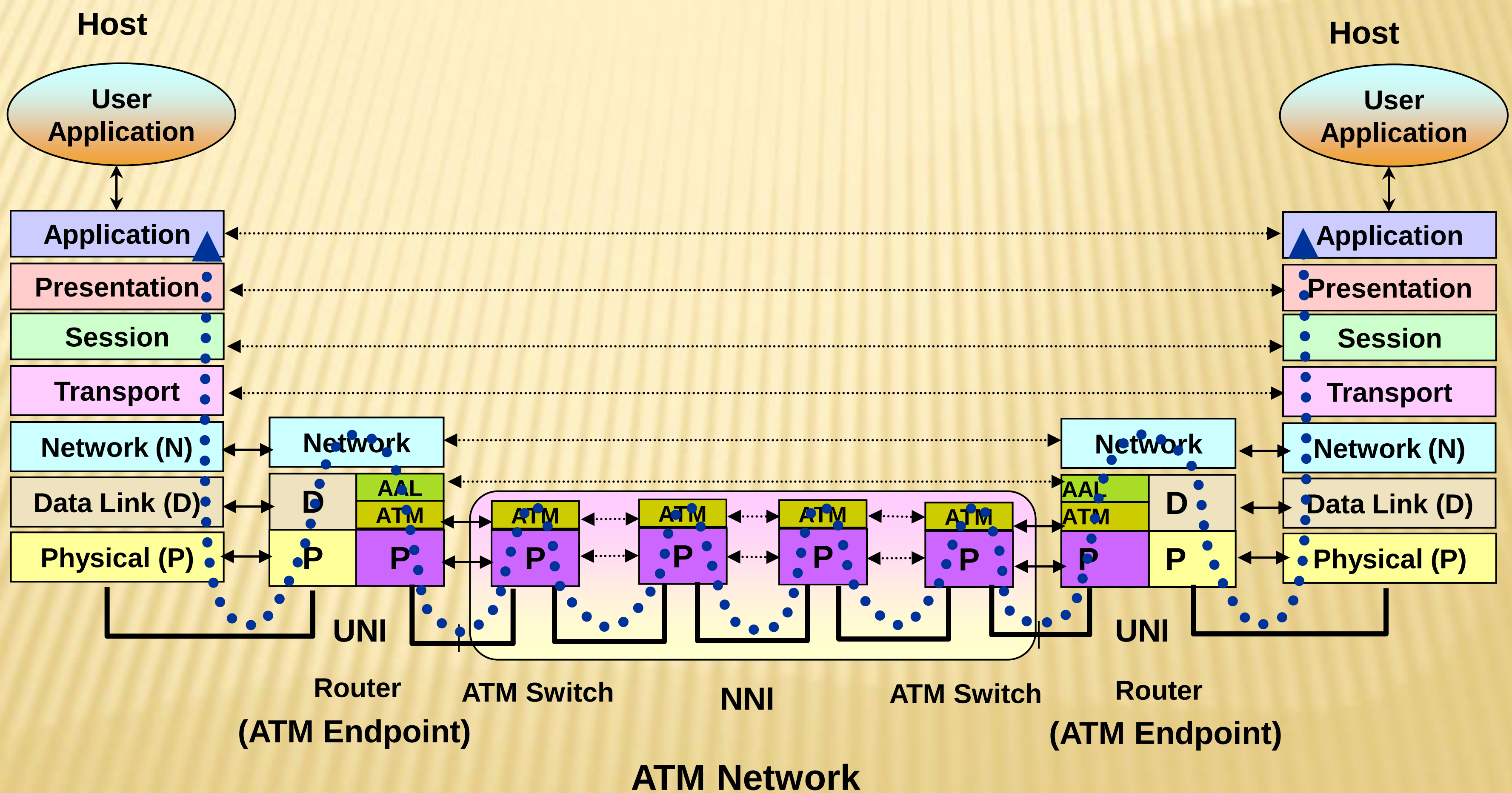

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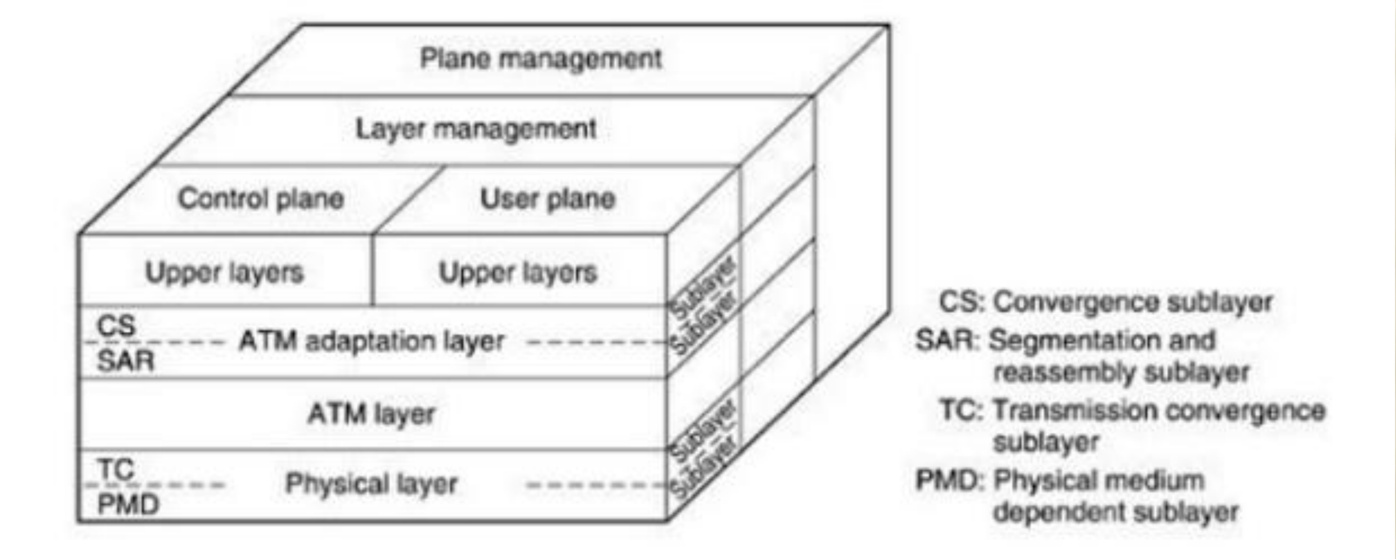

The *physical* and *AAL* layers are divided into two sublayers, one at the *bottom* that does the work and a *convergence sublayer* on the *top* that provides the proper interface to the layer above it.

ATM REFERENCE MODEL

AAL	CS	Providing the standard interface
	SAR	Segmentation and reassembly
ATM	ATM	Flow control Cell header generation/extraction Virtual circuit/path management Cell multiplexing and demultiplexing
Physical	TC	Cell delineation Header checksum generation and verification Cell rate decoupling Packing/unpacking cells from the enclosing envelope
	PMD	Bit timing Physical medium

THE ATM PHYSICAL LAYER

- The ATM physical layer is divided into *two* parts:
  - *A. The physical medium-dependent (PMD) sublayer.*
  - *B. The transmission convergence (TC) sublayer.*

A. The PMD sublayer provides *two* key functions:

- It synchronizes transmission and reception by sending and receiving a continuous flow of bits with associated timing information.
- It provides the *physical medium specifications* used, including *connector types* and *cable*. Examples of physical medium standards for ATM include *Synchronous Digital Hierarchy/Synchronous Optical Network (SDH/SONET)*, *DS-3/E3*, 155Mbps over Multi-Mode Fiber (MMF), and over Shielded Twisted-Pair (STP) cabling.

B. The TC sublayer has four functions:

- **Cell delineation:** It maintains ATM cell boundaries, allowing devices to locate cells within a stream of bits.
- **Header error control (HEC) sequence generation and verification:** It generates and checks the header error control code.
- **Cell-rate decoupling:** To maintain synchronization, it inserts idle ATM cells at the sending end and extract them at the receiving end to *adapt* the rate of valid ATM cells to the *payload capacity* of the transmission system.
- **Transmission frame adaptation:** To package ATM cells into frames acceptable to the particular physical layer implementation.

HEADER CHECKSUMMING

- Each cell contains a 5-byte header consisting on 4 bytes followed by a 1-byte checksum (HEC).
- The contents of the header are *meaningless* to the TC sublayer.
- The checksum only covers the *first four header bytes*, not the payload field.
- It is up to the *higher layers* to checksum the payload field.
- The HEC scheme *corrects all single-bit errors* and *detects many multi-bit errors* as well.

CELL TRANSMISSION

- Once the HEC has been generated and inserted into the cell by the *TC sublayer*, the cell is ready for transmission.
- Transmission media comes in two categories: *asynchronous* and *synchronous*.
- When an *asynchronous medium* is used, a cell can be sent whenever it is ready to go. No timing restrictions exist.
- With a *synchronous medium*, cells must be transmitted according to a predefined timing pattern.
- If no data cell is available when needed, the *TC sublayer* adds *idle cells*.
- Another kind of non-data cell is *Operation and Maintenance (OAM)* cell which used by the ATM switches for exchanging control information for keeping the system running.
- The job of matching the ATM output rate to the rate of the underlying transmission system is a task of the *TC sublayer*.
- Finally, the TC sublayer generates the SONET/SDH framing and pack the ATM cells inside.

CELL RECEPTION

- On the receiver side, the TC sublayer:
  - Takes an incoming bit stream, locates the cell boundaries.
  - Verifies the headers (discarding cells with invalid headers).
  - Processes OAM cells.
  - Passes the data cells up to the ATM layer.
- With SDH/SONET, cells can be aligned with the *synchronous payload envelope (SPE)*, so the SPE pointer in the SONET/SDH header points to the start of the first full cell.

THE ATM LAYER

- It defines the *layout of a cell* and tells what the header fields mean.
- It also deals with Virtual circuit/path management.
- *Flow control* is also handled by this layer.
- The ATM layer is responsible for the simultaneous sharing of virtual circuits over a physical link (*cell multiplexing*) and passing cells through the ATM network (*cell relay*) by using the VCI/VPI information in the header of each ATM cell.

THE ATM ADAPTATION LAYER (AAL)

- **ATM adaptation layer (AAL)** Combined with the ATM layer, the AAL is roughly *similar to the data link layer* of the OSI model. The AAL is responsible for *isolating* higher-layer protocols from the details of the ATM processes. The adaptation layer prepares user data for *conversion into cells* and segments the data into 48-byte cell payloads, and reassembles them at the other end
- Finally, the *higher layers* residing above the AAL accept user data, arrange it into packets, and hand it to the AAL.

- **The AAL layer is split into :**
  - *A segmentation and Reassembly sublayer* (*SAR*): It breaks packets up into cells on the transmission side and put them back together again at the destination.
  - *A Convergence Sublayer (CS):* It makes it possible to have ATM systems offer different kinds of services to different applications (e.g., *file transfer* and *video on demand* have different requirements concerning error handling timing, etc.).

PRINCIPLE TASKS OF THE AAL

- The AAL is designed to support different types of applications and different types of traffic, such as voice, video, and data.
- Once the analog signals have been converted to digital, all transmissions can be treated as data bits.
- However, if we examine the transmission requirements of voice and data, they are quite different.
  - Voice and lower-quality video transmissions exhibits a *high tolerance for errors*. In contrast, data transmissions have *no tolerance* for errors.
  - Packets may be *discarded* in the event of congestion in the network.
  - The *network delay* for the voice and video cells must be constant and must be low. In contrast, specific data applications exhibit different delay requirements. For example, LAN-to-LAN traffic is more delay sensitive than E-mail traffic.
  - Voice and video transmissions require a short *queue length* at the network nodes in order to reduce delay. However, data packets require the queue length to be longer to prevent packet loss.

CONGESTION CONTROL

- Several strategies are used in ATM networks for Congestion Control:
  - *Admission Control.*
  - *Resource Reservation.*
  - *Rate-Based Congestion Control.*

ADMISSION CONTROL

- The major tool for preventing congestion is *admission control*.
- When a host wants a *new virtual circuit*, it must describe the *traffic to be offered* and the *service expected*.
- The network can then check if it is possible to handle this connection without affecting the existing connections.
- Multiple potential routes may have to be examined to find one which can do the job. If *no route* can be located, the call is *rejected*.
- A small number of high-bandwidth users can severely affect many low-bandwidth users. To prevent this users should b divided into classes based on usage.

RESOURCE RESERVATION

- The second technique is to *reserve resources* during call setup time.
- The network has the possibility of reserving enough bandwidth along the path to handle that rate.
- If the SETUP message hits a line that is full, it must *backtrack* and look for an *alternative path*.
- With *CBR* and *VBR* traffic, it is generally not possible for the sender to slow down, even in the event of congestion.
- With *UBR*, the cells are just dropped.
- With *ABR* traffic, it is possible for the network to signal one or more senders and ask them to slow down temporarily until the network can recover. It is an interest of the sender to comply, because the network can punish the sender by throwing out the excess cells.

- **There are two solutions:** *Credit-Based Solution & Rate-Based Solution*
  - The *credit-based solution* requires each switch to maintain, per virtual circuit, a *credit* — a number of buffers reserved for that circuit. As long as each transmitted cell has a buffer waiting for it, congestion could never arise. The switch vendors are against of this solution because of the large overhead.
  - The *rate-based solution* congestion control scheme was adopted. It works like this:
    - After every *k* data cells, each sender transmits a special **Resource Management (RM) cell.** This cell travels along the same path as the data cells, but it is treated specially by the switches along the way. When it gets to the destination, it is examined, updated, and sent back to the sender.
    - In addition, overloaded switches generate **RM** cells and ship them back to the sender.