ATM

Asynchronous Transfer Mode
Voice

Digital voice samples

A/D → s₁, s₂...

Video

Picture frames

Compressed frames

A/D → AAL → cells

Data

Bursty variable-length packets

AAL → cells

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Networks: ATM

Figure 9.3
Asynchronous Transfer Mode (ATM)
ATM

- ATM standard (defined by CCITT) is widely accepted by common carriers as mode of operation for communication – particularly BISDN.
- ATM is a form of cell switching using small fixed-sized packets.

![Basic ATM Cell Format](image-url)
Assumptions for ATM Conceptual Model

1. ATM network will be organized as a hierarchy.
   User’s equipment connects to networks via a UNI (User-Network Interface).
   Connections between provided networks are made through NNI (Network-Network Interface).

2. ATM will be connection-oriented.
   A connection (a channel) must be established before any cells are sent.
Assumptions for ATM Conceptual Model (cont.)

- two levels of ATM connections are defined:
  - virtual path connections
  - virtual channel connections
These are indicated by the two fields in the cell header:

- virtual path identifier \( \text{VPI} \)
- virtual channel identifier \( \text{VCI} \)
Figure 9.5 Leon-Garcia & Widjaja: Communication Networks

Networks: ATM
ATM Virtual Connections

Physical Link

Virtual Paths

Virtual Channels
Assumptions for ATM Conceptual Model (cont.)

3. Vast majority of ATM networks will run on optical fiber networks with extremely low error rates.

4. ATM supports low cost attachments
   • This decision lead to a significant decision – to prohibit cell reordering in ATM networks.
   ➔ ATM switch design is more difficult.
### UNI Cell Format

<table>
<thead>
<tr>
<th>GFC (4 bits)</th>
<th>VPI (4 bits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPI (4 bits)</td>
<td>VCI (4 bits)</td>
</tr>
<tr>
<td>VCI (8 bits)</td>
<td></td>
</tr>
<tr>
<td>VCI (4 bits)</td>
<td>PT (3 bits)</td>
</tr>
<tr>
<td>HEC (8 bits)</td>
<td></td>
</tr>
</tbody>
</table>

Payload
(48 bytes)
Figure 7.38

ATM Cell Switching

Switch

1

video 25

voice 32

2

video 67

voice 67

3

data 39

4

5

6

32

25

N

32

61

25

32

N

75

1

67

3

2

39

67

N

video 61

data 32

Materials: Voice, Video, Data

Networks: ATM

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Digital Cross Connect

Only switches virtual paths
ATM Protocol Architecture

• ATM Adaptation Layer (AAL) – the protocol for packaging data into cells is collectively referred to as AAL.

• Must efficiently package higher level data such as voice samples, video frames and datagram packets into a series of cells.

**Issue:** How many adaptation layers should there be?
Management plane

Control plane

User plane

Higher layers

ATM adaptation layer

ATM layer

Physical layer

Figure 9.2 - Leon-Garcia & Widjaja: Communication Networks

Networks: ATM

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Original ATM Architecture

- CCITT envisioned four classes of applications (A-D) requiring four distinct adaptation layers (1-4) which would be optimized for an application class:
  A. Constant bit-rate applications  CBR
  B. Variable bit-rate applications  VBR
  C. Connection-oriented data applications
  D. Connectionless data application
ATM Architecture

• The AAL is further divided into:
  – The Convergence Sublayer (CS) – to manage flow of data to and from SAR sublayer.
  – The Segmentation and Reassembly Sublayer (SAR) – responsible for breaking data into cells at the sender and reassembling cells into larger data units at the receiver.
Networks: ATM 20

Upper Layers

AAL SAPs

- handling lost / misdelivered cells
- timing recovery (class A, B)
- interleaving

AAL

SAR

- split frames / bit stream into cells
- reassemble frames / bit stream

ATH

- cell routing
- multiplexing / demultiplexing
- generic flow control

PL

TC

- cell header verification and cell delimitation
- rate decoupling
- transmission frame adaptation

PH

- bit timing
- physical medium

Abbreviations

AAL = ATM Adaptation Layer
SAR = Segmentation And Reassembly
CS = Convergence Sub-layer
PL = Physical Layer
TC = Transmission Convergence
PH = Physical Medium

SERVICE CLASSES for AAL

<table>
<thead>
<tr>
<th>class</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Constant Bit Rate</td>
</tr>
<tr>
<td>B</td>
<td>Variable Bit Rate</td>
</tr>
<tr>
<td>C</td>
<td>Connection Oriented Data</td>
</tr>
<tr>
<td>D</td>
<td>Connectionless Data</td>
</tr>
</tbody>
</table>

1. Protocol Reference Model in the User Plane. See Section 4.1 for AAL SAP classes (A to D) and values (1 to 4).
Networks: ATM

Transmission convergence sublayer

Physical medium dependent sublayer

ATM layer

Physical layer
ATM Architecture {original}

- The AAL interface was initially defined as classes A-D with SAP (service access points) for AAL1-4.
- AAL3 and AAL4 were so similar that they were merged into AAL3/4.
- The data communications community concluded that AAL3/4 was not suitable for data communications applications and they pushed for standardization of AAL5 (also referred to as SEAL – the Simple and Efficient Adaptation Layer).
- AAL2 was not deployed.
(a) Network types:

<table>
<thead>
<tr>
<th>Service type</th>
<th>AAL 1</th>
<th>AAL 2</th>
<th>AAL 3/4</th>
<th>AAL 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timing rel.</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bit rate</td>
<td>Constant</td>
<td>Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mode</td>
<td>Connection-oriented</td>
<td>Connectionless</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) AAL layers:

- CS protocols
- SAR sublayer protocols

SAP 1, SAP 2, SAP 3/4, SAP 5

- Timing and cell loss recovery (AAL 1/2)
- Cell loss detection (AAL 3/4/5)

Segmentation and reassembly

- Processes cell pay
- Satisfies interface requirements

ATM

Physical

CS = Convergence sublayer
SAR = Segmentation and reassembly
# ATM Service Categories \{revised\}

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBR</td>
<td>Constant Bit Rate</td>
<td>T1 circuit</td>
</tr>
<tr>
<td>RT-VBR</td>
<td>Real Time Variable Bit Rate</td>
<td>Real-time videoconferencing</td>
</tr>
<tr>
<td>NRT-VBR</td>
<td>Non-real-time Variable Bit Rate</td>
<td>Multimedia email</td>
</tr>
<tr>
<td>ABR</td>
<td>Available Bit Rate</td>
<td>Browsing the Web</td>
</tr>
<tr>
<td>UBR</td>
<td>Unspecified Bit Rate</td>
<td>Background file transfer</td>
</tr>
</tbody>
</table>
QoS, PVC, and SVC

• Quality of Service requirements are handled at connection time and is viewed as part of signaling.

• ATM provides permanent virtual connections and switched virtual connections.
  – Permanent Virtual Connections (PVC)
    permanent connections set up *manually* by network manager
  – Switched Virtual Connections (SVC)
    set up and released *on demand* by the end user via signaling procedures.
(b) CS PDU with pointer in structured data transfer

AAL 1 Payload

1 Byte
47 Bytes
46 Bytes
optional

(a) SAR PDU header

<table>
<thead>
<tr>
<th>CSI</th>
<th>Seq. Count</th>
<th>SNP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 bit</td>
<td>3 bits</td>
<td>4 bits</td>
</tr>
</tbody>
</table>
Higher layer \[ \begin{array}{ccc} b_1 & b_2 & b_3 & \ldots \end{array} \]

Convergence sublayer

SAR sublayer

ATM layer

User data stream

CS PDUs

SAR PDUs

ATM Cells

Figure 9.10
AAL 3/4
CS and SAR PDUs

(a) CPCS-PDU format

<table>
<thead>
<tr>
<th>CPI</th>
<th>Btag</th>
<th>BASize</th>
<th>CPCS - PDU Payload</th>
<th>Pad</th>
<th>AL</th>
<th>Etag</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1 - 65,535</td>
<td>0-3</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>(bytes)</td>
<td>(bytes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) SAR PDU format

<table>
<thead>
<tr>
<th>ST</th>
<th>SN</th>
<th>MID</th>
<th>SAR - PDU Payload</th>
<th>LI</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4</td>
<td>10</td>
<td>44</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>(bits)</td>
<td>(bytes)</td>
<td>(bits)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Each SAR-PDU consists of 2-byte header, 2-byte trailer, and 44-byte payload.

Pad message to multiple of 4 bytes. Add header and trailer.

Assume null

User message

Figure 9.15
## AAL 5

### Convergent Sublayer Format

<table>
<thead>
<tr>
<th>Information</th>
<th>Pad</th>
<th>UU</th>
<th>CPI</th>
<th>Length</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 65,535</td>
<td>0-47</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>(bytes)</td>
<td>(bytes)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SAR Format

- 48 bytes of Data

- 1-bit end-of-datagram field (PTI)
Figure 9.18

AAL 5

Higher layer

Service specific convergence sublayer

Common part convergence sublayer

SAR sublayer

ATM layer

Information

Information

PTI = 0

PTI = 0

PTI = 1

48 (0)

48 (0)

48 (1)

PAD T

Assume null

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