ATM Network
Types of Network

• Local area networks (LANs)
  – low latency, high speed, no routing, broadcast
  – Ethernet, FDDI, token ring, etc.

• Wide area networks (WANs)
  – hosts, packet switches (routing)
  – ISDN, B-ISDN, ATM

• Metropolitan area networks (MANs)
  – cable
Case Study: ATM Networks

Why ATM Networks?
• Combine the flexibility of the Internet with the per-user quality-of-service guarantees of the telephone network
• Create a unified infrastructure that carries voice, video and data

Two standardization bodies:
• ATM Forum
• International Telecommunications Union-Telecommunications Standardization Sector (ITU-T)
Growth of ATM

Customer base growth for public ATM services during 1998-1999
(Source:http://www.webtorials.com)
ATM Networks: Overview

• Connection-oriented service using virtual circuit
  – In sequence delivery along a virtual circuit
  – Unreliable: no acknowledgements
    • ATM is designed for using optical fibers, which are highly reliable
    • For real-time traffic, retransmission is worse than loss
  – Virtual circuit can be either permanent or switched

• Cell switching using fixed-size cells: 53 bytes
  Why fixed size?
  – Simpler buffer hardware in switches
  – Simpler line scheduling: easy to allocate different bandwidths to different virtual circuits
  – Easier to build large parallel packet switches
ATM Network: Overview

• Statistical multiplexing of cells of different VCs
• Provide QoS guarantees: when a VC is established, transport layer and the ATM network layer agree on a contract defining the service
  – The contract includes: traffic to be offered, the service agreed upon, compliance requirements
  – Load and service are formulated by QoS parameters
    • Specified by costumer: peak cell rate (PCR), sustained cell rate (SCR), minimum cell rate (MCR)
    • Negotiable: cell loss ratio (CLR), cell transfer delay (CTD), cell delay variation (CDV) or jitter
• Support five service categories
ATM

- **ATM** (Asynchronous Transfer Mode) is the switching and transport technology of the B-ISDN (Broadband ISDN) architecture (1980)
- Goals: **high speed** access to business and residential users (155Mbps to 622 Mbps); **integrated services** support (voice, data, video, image)
ATM VCs

• Focus on **bandwidth allocation** facilities (in contrast to IP best effort)
• ATM main role today: “**switched**” link layer for **IP-over-ATM**
• ATM is a **virtual circuit** transport: cells (53 bytes) are carried on VCs
• in IP over ATM: **Permanent VCs** (PVCs) between IP routers;
• scalability problem: \( N(N-1) \) VCs between all IP router pairs
ATM VCs

- **Switched VCs (SVCs)** used for short lived connections

- **Pros of ATM VC approach:**
  - Can guarantee QoS performance to a connection mapped to a VC (bandwidth, delay, delay jitter)

- **Cons of ATM VC approach:**
  - Inefficient support of **datagram** traffic; PVC solution (one PVC between each host pair) does **not scale**;
  - SVC introduces excessive **latency** on short lived connections
  - High **SVC processing Overhead**
## ATM Service Categories

<table>
<thead>
<tr>
<th>Class</th>
<th>Example</th>
<th>Bandwidth guarantee</th>
<th>No loss guarantee</th>
<th>Timing</th>
<th>Congestion indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBR</td>
<td>Real time audio and video streams</td>
<td>Guaranteed constant rate</td>
<td>Yes</td>
<td>Maintained</td>
<td>No congestion</td>
</tr>
<tr>
<td>RT-VBR</td>
<td>Video conferencing</td>
<td>Guaranteed rate</td>
<td>Yes</td>
<td>Maintained</td>
<td>No congestion</td>
</tr>
<tr>
<td>NRT-VBR</td>
<td>Multimedia Email</td>
<td>Guaranteed rate</td>
<td>Yes</td>
<td>Not maintained</td>
<td>No congestion</td>
</tr>
<tr>
<td>ABR</td>
<td>Web browsing</td>
<td>Guaranteed minimum</td>
<td>None</td>
<td>Not Maintained</td>
<td>Yes</td>
</tr>
<tr>
<td>UBR</td>
<td>File transfer</td>
<td>None</td>
<td>None</td>
<td>Not Maintained</td>
<td>None</td>
</tr>
</tbody>
</table>
# ATM Cell Format

<table>
<thead>
<tr>
<th>UNI ATM cell header</th>
<th>NNI ATM cell header</th>
</tr>
</thead>
<tbody>
<tr>
<td>GFC</td>
<td>VPI</td>
</tr>
<tr>
<td>4 bits</td>
<td>8 bits</td>
</tr>
</tbody>
</table>

- **UNI**: user-network interface
- **NNI**: network-network interface
- **GFC**: general flow control
- **VCI**: virtual channel identifier
- **VPI**: virtual path identifier
- **PT**: payload type
- **CLP**: cell loss priority
- **HEC**: header error check
ATM Physical Layer

- Two Physical sublayers:

- (a) Physical Medium Dependent (PMD) sublayer
  - (a.1) SONET/SDH: transmission frame structure (like a container carrying bits);
    - bit synchronization;
    - bandwidth partitions (TDM);
    - several speeds: OC1 = 51.84 Mbps; OC3 = 155.52 Mbps; OC12 = 622.08 Mbps
  - (a.2) TI/T3: transmission frame structure (old telephone hierarchy): 1.5 Mbps/ 45 Mbps
  - (a.3) unstructured: just cells (busy/idle)
ATM Physical Layer (more)

• Second physical sublayer

(b) Transmission Convergence Sublayer (TCS): it adapts PMD sublayer to ATM transport layer

• TCS Functions:
  – Header **checksum** generation: 8 bits CRC; it protects a 4-byte header; can correct all single errors.
  – Cell **delineation**
  – With “unstructured” PMD sublayer, transmission of **idle cells** when no data cells are available in the transmit queue
ATM Layer

- **ATM layer** in charge of transporting cells across the ATM network
- ATM layer protocol defines ATM cell **header format** (5 bytes);
- **payload** = 48 bytes; total cell length = 53 bytes
ATM Layer

- **VCI** (virtual channel ID): translated from link to link;
- **PT** (Payload type): indicates the type of payload (e.g., mngt cell)
- **CLP** (Cell Loss Priority) bit: CLP = 1 implies that the cell is low priority cell, can be discarded if router is congested
- **HEC** (Header Error Checksum) byte
ATM Adaptation Layer (AAL)

- ATM Adaptation Layer (AAL): “adapts” the ATM layer to the upper layers (IP or native ATM applications)
- AAL is present only in end systems, not in switches
- The AAL layer has its header/trailer fields, carried in the ATM cell
ATM Adaption Layer (AAL) [more]

- **Different versions** of AAL layers, depending on the service to be supported by the ATM transport:
  - **AAL1**: for CBR (Constant Bit Rate) services such as circuit emulation
  - **AAL2**: for VBR (Variable Bit Rate) services such as MPEG video
  - **AAL5**: for data (eg, IP datagrams)
ATM Adaption Layer (AAL) [more]

- Two sublayers in AAL:
  - (Common Part) Convergence Sublayer: encapsulates IP payload
  - Segmentation/Reassembly Sublayer: segments/reassembles the CPCS (often quite large, up to 65K bytes) into 48 byte ATM segments
AAL5 - Simple And Efficient AL (SEAL)

- **AAL5**: low overhead AAL used to carry IP datagrams
  - SAR header and trailer eliminated; CRC (4 bytes) moved to CPCS
  - PAD ensures payload multiple of 48 bytes (LENGTH = PAD bytes)
  - At destination, cells are **reassembled based on VCI number**;
    AAL indicate bit delineates the CPCS-PDU; if CRC fails, PDU is dropped, else, passed to Convergence Sublayer and then IP
Virtual Paths and VP Switch

• A group of VCs between a source and a destination can be grouped together into a virtual path
• All VCIs in a VP share path and resource reservation
• VP switch: routing based on VPI only, VCI is not translated
• Why use virtual paths (VPs)?
  – Saves table space in switches and faster lookup
  – Once a VP has been established, a source can just choose a VCI in the VP and avoid the need to perform call setup
  – Easy to reroute a group of VCs
  – May waste resources if no VCs are using the VP
• Virtual private network service
  – A company can set up permanent VPs among its offices
  – Allocate VCs in VPs on demand
Virtual Path Switching

• VPI: 8 or 12 bits, local to a link
• VPI of each VP must be unique on each link
• Incoming VPI to outgoing VPI translation
  – At each incoming link, switch does the translation using a table containing entries of the form [old VPI, new VPI, output port]