

ATM and SONET

- **Data requirements**
 - Voice, video, data
- **SONET and ATM**
- **ATM data “cells”**
- **ATM Private/public WANs and LANs**

Data Communications

- **Data communications**
 - **Transfer of of information from one computing element to another**
- **Three basic types**
 - **Voice**
 - **Video**
 - **Data files**

How Much Data Rate Required?

- **Information retrieval**
 - » 250 ms total response required
 - » Transmission time ~30% of total operation [75 ms]
 - 6200 byte text object \Rightarrow 0.7 Mb/s
 - 50 kB CAD/CAM object \Rightarrow 5.3 Mb/s
 - 144 kB scanned image \Rightarrow 15.4 Mb/s
 - 1 MB manufacturing image \Rightarrow 106 Mb/s
- **Computing applications**
 - Remote procedure calls
 - » Transmitted object: 200 bytes in transmission time of 0.1 ms \Rightarrow 16 Mb/s
 - » 10,000 byte file transmitted in 5 ms \Rightarrow 16 Mb/s
 - 80% of file transfers < 10,000 bytes
- **Video**
 - NTSC TV \Rightarrow 2-15 Mb/s (looks fine at 3 Mb/s to 4 Mb/s)
 - Video teleconferencing with 6 users \Rightarrow 25 Mb/s
 - High definition TV with MPEG++ compression \Rightarrow 18 Mb/s
 - X-ray image transmission \Rightarrow 45 Mb/s

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Voice

- **Originally carried in analog form**
 - Still is in local telephone loop
- **Now sampled and digitized**
 - Carried in packets with several voice samples per packet
 - Sample rate: 8 ksamples/s; digitized into 8 bits per sample
 - Typical rate per voice channel: 64 kb/s
 - » Can be compressed for lower data rate channels
 - Ex., transmission over radio channels
 - » Bandwidth seldom issue for single channel
- **Real-time connection required**
 - Delays (latency) > few 10s ms cause unacceptable conversation interruptions
 - » Can use echo-canceling circuits to help out

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Video

- **Generally carried as analog channel**
 - 6 MHz bandwidth per channel
- **In digital form:**
 - ~100 Mb/s without compression
 - ~1.5 - 6 Mb/s with compression
 - » Real-time compression available in direct satellite delivery;
 - » Usually recorded video is processed and transmitted
- **Either broadcast or coaxial cable**
- **Real-time connection required**
 - Interruptions of more than a few frames (1 frame = 1/30 s in US) not tolerated

Data Files

- **Wide variety**
 - **Computer programs**
 - **Data files**
 - **Graphics files**
 - **Stored video**
- **Bandwidth and latency requirements are application dependent**

Data Rate Variability Examples

1. High-resolution color display

- 1000 x 1000 pixels, 24-bit color \Rightarrow 24 Mb/frame
- Frame rate of 70 frames/s \Rightarrow 1.68 Gb/s
- ISDN operates at 64 kb/s \Rightarrow 6 minutes per frame
- FDDI operates at 100 Mb/s \Rightarrow \sim 1/4 sec (marginally acceptable)
 - » Note: on most networks only fraction of 100 Mb/s capacity available to any given station

2. Bank ATM transaction processing

- Relatively short bursts of data; long periods of quiet (i.e., “bursty” data)
- Screen updates of 2/s are acceptable

3. Large data file

- Usually not time critical
- Can be deconstructed in smaller groups (“frames” or “packets”), transmitted via most efficient means, and reassembled at receiver
 - » Frame “header” contains information about receiver, transmitter, packet contents, and reassembly info

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Protocols

- **Adding and removing communications protocols is modeled by OSI model**

Application - Provides service elements to process the data; e.g., resource sharing, file transfer, database management

Presentation - Services necessary to format exchange data and manage session

Session - Establishes and terminates connections; arbitrates rights to channel; synchronizes data exchanges

Transport - Provides functions for error-free delivery of messages, e.g., flow control, error recovery & acknowledgement

Network - Provides transparent routing of messages between two transport entities

Data link - Provides rules of transmission on physical link, e.g., packet formats, access rights, error detection and correction

Physical - Mechanical and electrical interconnection

SONET & ATM

- Offers ***seamless integration of digital data transmission over public WANs***
- Features
 - Scalable: Mb/s to multi Gb/s
 - Minimum overhead on packets
 - Point-point connection service
 - » Connection set up for duration of transmission
 - Sharable bandwidth
 - Allows mixture of synchronous traffic (e.g., voice, video, real-time imagery) and asynchronous data (e.g., email messages, Internet screens)

WANs vs. LANs

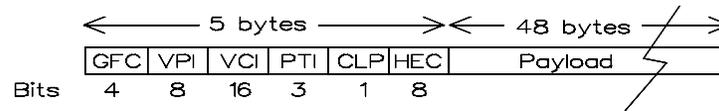
- **WANs**

- Large geographic areas
- Point-to-point dedicated connections (nodes)
- Switching used to add/drop signals
- High error rate (implies error correction at each node and message acknowledgment)
 - » Increased overhead
 - » Increased processing time at each node
 - » Increased node buffer requirements
- Example: X.25 link access protocol

- **LANs**

- Smaller geographic area
- Connectionless service (i.e., no dedicated connection; packets follow variable paths through network)
- Low error-rate (end-to-end error checking)

ATM Cells

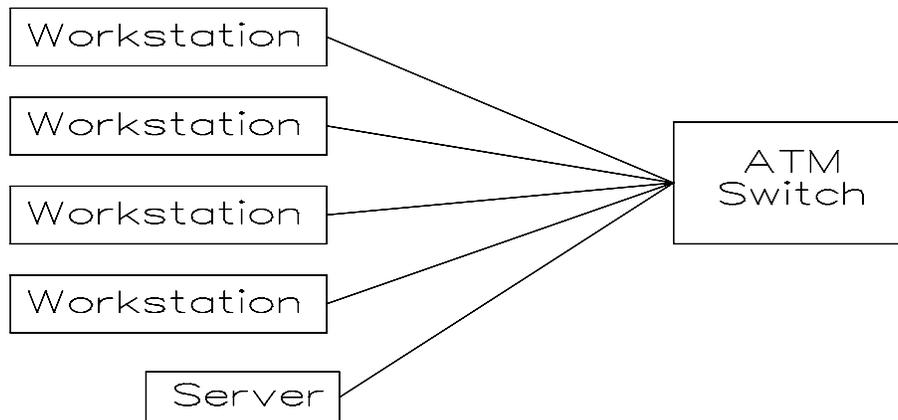


- **Packet-based transmission**
- **Cell features**
 - **53 bytes** (fixed cell length)
 - **5-byte header**
 - » **4-bit generic flow control (GFC)**
 - » **8-bit virtual path identifier (VPI)**
 - » **16-bit virtual channel identifier (VCI)**
 - » **3-bit payload type identifier (PTI)**
 - » **1-bit cell loss priority indicator (CLI)**
 - » **8-bit header control (HEC) field**
 - **48 bytes of data**
- **Network-frame layer breaks data down into ATM cells (ATM adaptation layer 5)**
- **Cells flow through connection**
- **Cells reassembled by network-frame layer at receiver**

ATM-11

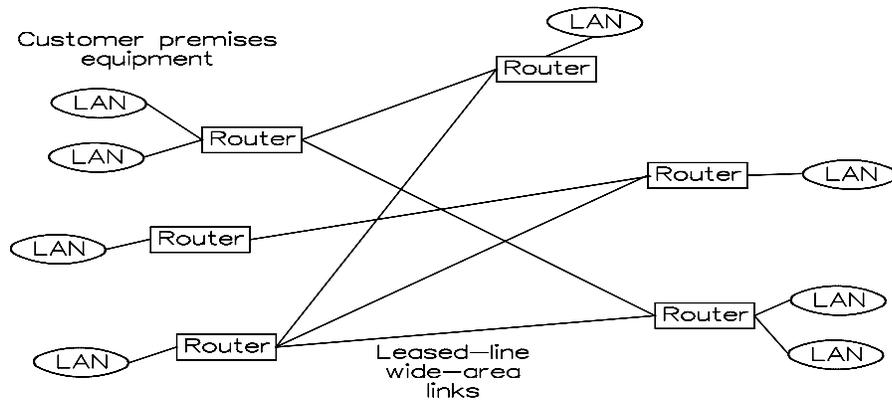
ATM LAN

- **ATM cards assemble data into cells**
- **Connections to switch are at appropriate data rate**
- **ATM switch multiplexes data from users and delivers data**



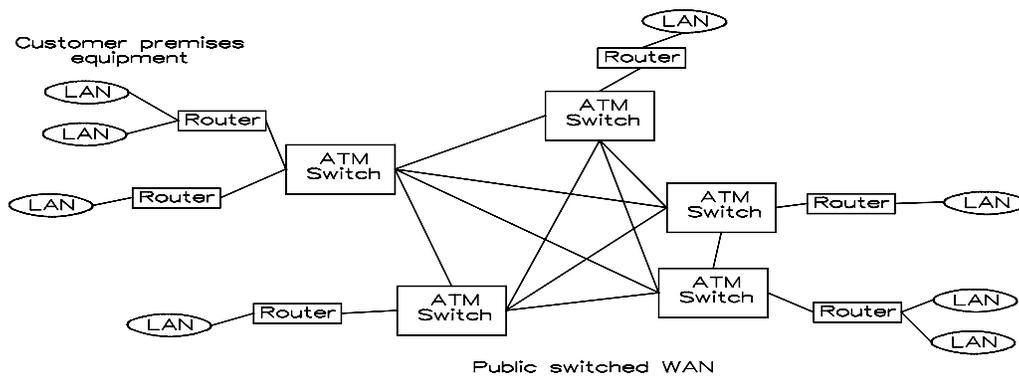
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Private LANs



- Leased dedicated lines
- Pay for full bandwidth 24x7

Public ATM WAN



- Costs of WAN are distributed among users
- Users pay only for bandwidth and time

ATM & SONET

- **ATM cells fit seamlessly into SONET STS payload**
- **Major feature of ATM**
 - **Allows seamless integration of local networks into the worldwide network**
- **Operation at SONET OC-3 (155 Mb/s), OC-12 (622 Mb/s), OC-48 (2.5 Mb/s), and higher**

ATM Future

- **ATM LANs are available today**
- **ATM WANs are under development**

Networks:Summary

- **Fiber optics used in data networks**
- **As long-haul applications have become saturated**
- **Data networks offer opportunities for fiber-optic systems**
- **Star and linear data bus popular configurations**
 - **Star configuration has advantages over linear bus**
- **FDDI and SONET standards**
 - **Efforts to establish standards using fibers**
 - **Optical transmission only part of breakthroughs represented by standards**
 - **Novel architectures offer revolutionary concepts**
- **ATM/SONET**
 - **Offers vision of seamless integration of LANs into WANs**
 - **Optimized for mixing synchronous and asynchronous traffic**