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DYNAMIC CHANNEL & BANDWIDTH MANAGEMENT IN ATM NETWORKS

GRADUATION PROJECT COM – 400

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ABSTRACT

Asynchronous Transfer Mode (ATM) is an extremely high speed, low delay, multiplexing and switching technology that can support any type of user traffic including voice, data, and video applications. ATM is ideally suited to applications that cannot tolerate time delay, as well as for transforming frame delay and IP traffic that are chracterized as busty.

As we enter the 21st century a competitive environment meets us where high-speed virtual networking is the upcoming field of interest. The question, why is taht we choose ATM networks . To answer that we can only say that, ATM networks are not only the highest speed networking in the 1990s. The fact that before ATM, separate networks were required to carry voice, data and video information is alone enough to support its importance. The unique profiles of these traffic types make significantly different demands on network speeds and resources.

Data traffic can tolerate delay, but voice and video cannot. With ATM, however, all of these traffic types can be transmitted or transported across one network (from megabit to gigabit speeds), because ATM can adapt the transmission of cells to the information generated.

ATM works by breaking information into fixed lenght 53-byte data cells. The cells are transported over traditional wire or fiber optic networks at extremely high speeds.

ATM is a connection-oriented protocol; this means that ATM must establish a logical connection to a defined endpoint before this connection can transport data. Calls on each port are assigned a path and a channel identifier that indicates the path or channel over which the cell is to be routed. The connections are called virtual paths or virtual channels.

ATM was designed for user and network provides who require guaranteed real-time transmission of voice, data, and images while also requiring efficient, high performance transport of busty packet data. Hospitals are using ATM to share real-time video and images for long distance consultation during diagnosis and operations. Schools are using ATM to bring students and instructors together, regardless of their locat.

LIST OF ABBREVIATIONS

AAL–1	ATM adaption Layer 1
AAL–2	ATM adaption Layer 2
AAL–3	ATM adaption Layer 3
AAL–4	ATM adaption Layer 4
AAL–5	ATM adaption Layer 5
ABR	available bit rate
ATM	asynchronous transfer mode
ATM UNI	ATM user network interface
BT	burst tolerance
CAC	connection admission control
CBR	constant bit rate
CCITT	Comite Consultif Internationale de Telegraphique et Telephonique
CDV	cell delay variation
CLR	cell loss ratio
CTD	cell transfer delay
IEEE	Institute of Electrical and Electronic Engineers
ITU–T	International Telecommunications Union–Telecommunications Standards Sector
LAN	local-area network
LANE	ATM LAN emulation
LES	LAN emulation server
LUNI	LAN emulation user-network interface
MPOA	multiple protocol over ATM
P-NNI	public network-to-network interface
PCR	peak cell rate
PVC	permanent virtual circuit
RM	resource management
SAD	speech activity detection
SCR	sustained cell rate
SDH/SONET	synchronous digital hierarchy/synchronous optical network
SVC	switched virtual circuit

TCP/IP	transmission control protocol/Internet protocol
UBR	unspecified bit rate
VBR–NRT	variable bit rate–nonreal time
VCC	virtual-channel connections
VPC	virtual-path connections

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INTRODUCTION

End-users and service, information and programme providers, as well as network operators, expect telecommunication facilities to keep pace with their changing needs. They ask for demand-oriented and cost-effective solutions: as in more applications, bandwidth, mobility, intelligence, flexibility, reliability and economy. In office and factory environments the primary motives for new telecom usages are enhanced productivity, cost reduction and improved customer relationships. In homes the important stimuli for the acceptance of new telecom services or products include variety, convenience and personal self-realization.

Recent developments in information processing technology are leading to innovative applications for computers and telecommunications in many businesses (e.g. the publishing sector, health care, travel agencies, real estate agencies and public administrations) and to new services to be provided for entertainment at home. Still-image archiving systems and reference databases, high performance video servers, high-speed transmission of color documents to printing facilities, and multiple access to distributed information banks or remote service centers are typical elements that are assembled into innovative applications.

At the same time advanced co-operative working methods, such as joint processing of common documents by remote users or remote expert consultation by video-conferencing, are being introduced into business. New multimedia applications call for an integration of data, text, graphics, image, video and audio and are gaining importance with increasing demand and with the advent of powerful personal computers and workstations for end-users.

Broadband and multimedia communication applications are typical examples of the growing qualitative and quantitative requirements placed on telecom networks and services (see fig. 1).

Different traffic flow characteristics, such as continuous traffic with constant or variable bit rates or bursty traffic, must be handled in the network. Point-to point and multipoint communication configurations as well as distribution of radio and TV

programmes are necessary. ATM networks offer several advantages because of their underlying principle.

They are

1) Effective usage of network capacity through bandwidth on demand and shared bandwidth between parallel applications.
2) Low transfer delay and support of both non-real-time and real-time applications through the provision of large peak bandwidth of up to 155 Mbit/s to the Telecommunications end-user

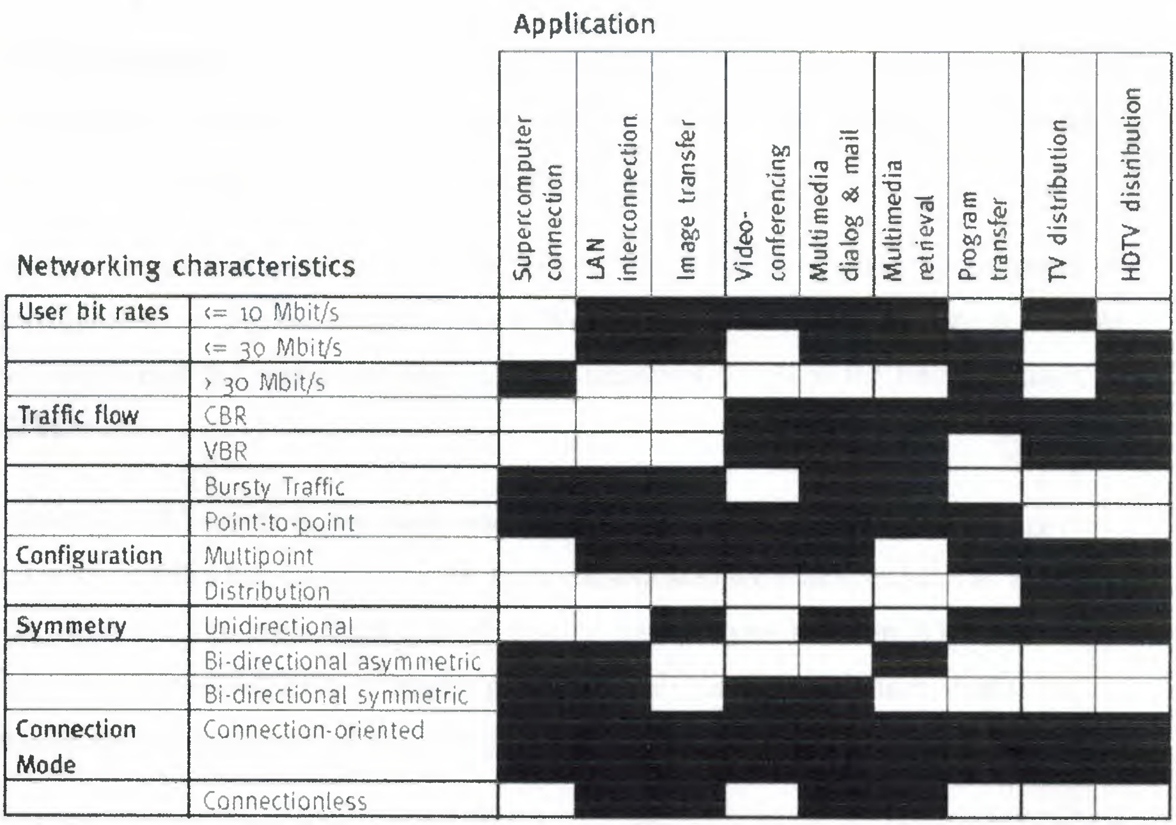

Figure 1 ATM enables breadband and multimedia applications. The highlighted boxews show where ATM adds value.

3) Support of multimedia applications and mixed traffic through VPs and VCs

4) An easy to manage network infrastructure.

The operational advantages offered by ATM technology fully meet the needs of advanced applications. User acceptance of the applications in any business sector will increase dramatically if ATM networks are used to connect computers and other end systems in local sites, as well as between remote sites.

ATM products are based on the international standards of ITU-TS and on the international agreements of The ATM Forum.

Interoperability between the ATM equipment of different manufacturers and gateways to existing LAN/WAN standards mean maximum investment protection to users. ATM equipment costs and network tariffs will take into consideration the huge number of potential users across Europe and will significantly support the introduction and acceptance of the new ATM technology, offering a good relation between price and performance.

ATM technology is the flexible and powerful common platform for Local Area Networks (LAN) and Wide Area Networks (WAN) to increase productivity, to reduce costs and to implement new applications and services.

Today it is clear that ATM products and services will be coming in a stream of developments during the next few years. We can expect continuous progress, but we can also expect that some customers may be impatient for all of the future features of ATM.

Currently ATM standards are stable enough to bring the user very low technology risks in legacy LAN when compared with more consolidated technologies such as FDDI or Fast Ethernet. The economics derived from a cost analysis between ATM and other technologies showed only a slight gap. The only issue still under evaluation is interoperability between multi-vendor devices.

Network *availability* is concerned with the cost-effective planning and maintenance of network resources so that to maximize user connection admissions. The planning aspect is not covered by this paper but the project has described suitable VP layer design algorithms needed to originally configure the ATM layer (given a physical network) so as to meet the traffic predictions. These algorithms include the configuration of the necessary protection resources required by the protection switching mechanism.

For the purposes of this paper we can consider that network operation is generally decomposed into two distinct operational phases. During the *initialization* phase, the network is prepared for service provisioning at a certain service level. During the *normal* phase, the network delivers services, and sees to the active management of its resources

so as to guarantee its service levels under deviations of offered traffic at its edges. This paper is concerned with the dynamic management of bandwidth during the normal phase according to network designs created during the initialization phase.

The initialization phase results in the definition of a suitable network of working VPCs (for carrying user traffic) and admissible routes based on them per source-destination and Class of Service1 (CoS) so that to preserve the performance characteristics of each CoS. Furthermore, for the network to cope gracefully (without affecting the integrity of existing services and its availability to future services) with fault conditions, protection VPCs need also to be planned and the appropriate restoration bandwidth need to be allocated. The initialization activities are undertaken within a single functional component, called *VPC Layer Design (VPC_LD).*

Since user behavior changes dynamically there is a chance that the network may become unbalanced when the bandwidth allocated to VPCs on the existing admissible routes are not in accordance with the quantity of the traffic that it is actually offered to be routed over them.

There are basically two levels at which adaptively to traffic variations should be provided, one at a level of (structural) traffic prediction changes and one at the level of actual traffic fluctuations around the predictions. Therefore, it is reasonable to consider that VPC and routing management is achieved through a two level hierarchy (Figure 2)

The higher level of the hierarchy undertaken by the VPC_LD component, which reconfigures the VPC and routes per class of service whenever the traffic predictions change significantly The level of reconstruction obviously depends on the significance of the changes.

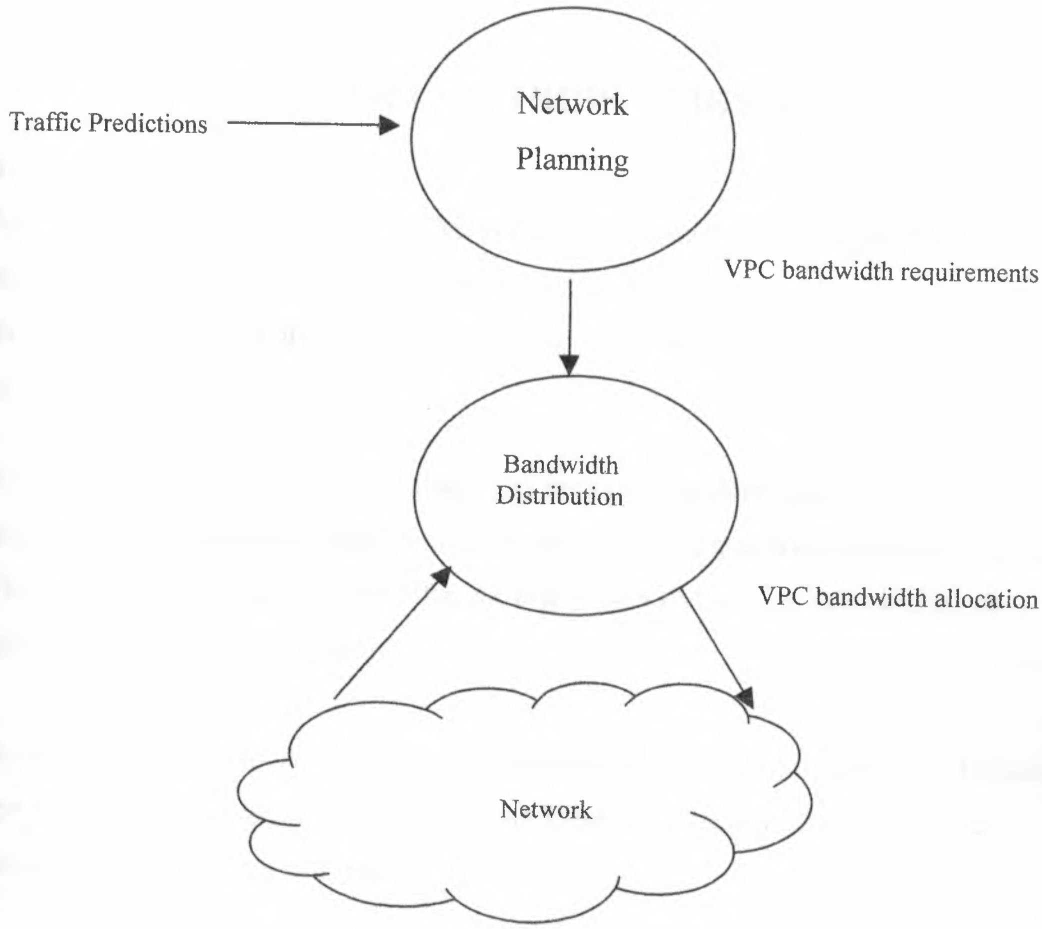

Figure 2 Hierarchical approach to bandwidth management

The lower level in the hierarchy is introduced to compensate for inaccuracies in the traffic predictions and short-term fluctuations in actual load around the predictions. The lower level functionality operates on the set of existing routes and redefines the working VPC bandwidth and route selection parameters.

The above discussion indicates that two further functional components need to play part in the resource and routing management hierarchy: *Bandwidth Distribution* (for updating working VPC bandwidth) and *Load Balancing* (for updating route selection parameters). This paper discusses the objectives, design constraints and proposes an algorithm for the first of these two components: Bandwidth Distribution.

CHAPTER I : INTRODUCTION TO ATM

1.1 ATM Technology

Asynchronous Transfer Mode (ATM) is the world's most widely deployed backbone technology. This standards-based transport medium is widely used within the core--at the access and in the edge of telecommunications systems to send data, video and voice at ultra high,speeds.

ATM is best known for its easy integration with other technologies and for its sophisticated management features that allow carriers to guarantee quality of service. These features are built into the different layers of ATM, giving the protocol an inherently robust set of controls.

Sometimes referred to as cell relay, ATM uses short, fixed-length packets called cells for transport. Information is divided among these cells, transmitted and then re-assembled at their final destination.

1.2 Historical Background of ATM

Everyday the world seems to be moving at a faster and faster pace with new technological advances occurring constantly. In order to deliver new services such as video conferencing and video on demand, as well as provide more bandwidth for the increasing volume of traditional data, the communications industry introduced a technology that provided a common format for services with different bandwidth requirements. This technology is **Asynchronous Transfer Mode (ATM)**. As ATM developed, it became a crucial step in how companies deliver, manage and maintain their goods and services.

ATM was developed because of developing trends in the networking field. The most important parameter is the emergence of a large number of communication services with different, sometimes yet unknown requirements. In this information age, customers are requesting an ever increasing number of new services. The most famous communication services to appear in the future are HDTV(High Definition TV), video conferencing, high speed data transfer, videophony, video library, home education and video on demand.

This large span of requirements introduces the need for one universal network which is flexible enough to provide all of these services in the same way. Two other parameters are the fast evolution of the semi - conductor and optical technology and the evolution in system concept ideas - the shift of superfluous transport functions to the edge of the network.

Both the need for a flexible network and the progress in technology and system concepts led to the definition of the Asynchronous Transfer Mode (ATM) principle. Before there were computers that needed to be linked together to share resources and communicate, telephone companies built an international network to carry telephone calls. These wide area networks (WAN) were optimized to carry multiple telephone calls from one person to another, primarily using copper cable. As time passed, the bandwidth limitations of copper cable became apparent, and these WAN carriers began looking into upgrading their copper cable to fiber cable.

Because of its potential for almost unlimited bandwidth, carriers saw fibers as an essential part of their future. However, other limitations of the voice network still existed. Even though WAN carriers were upgrading to fiber, there were still no agreed upon standards that allowed equipment from different vendors' fiber-based equipment to be integrated together. The short-term solution to this problem was to upgrade to fiber; however, this was costly and time consuming. In addition, the lack of sophisticated network management in these WANs made them difficult to maintain.

Around the same time, computers were becoming more prevalent in the office. Networking these computers together was desirable and beneficial. When linking these computers over a long distance, the existing voice-optimized WANs were used. Because computers send data instead of voice, and data has different characteristics, these WANs did not send computer data very efficiently. Therefore, separate WANs were sometimes built specifically to carry data traffic. Also, a network that could carry voice, data and video had been envisioned -something needed to be done.

To address these concerns, ITU-T (formerly CCITT) and other standards groups started work in the 1980s to establish a series of recommendations for the transmission, switching, signaling and control techniques required to implement an intelligent fiber-based network that could solve current limitations and would allow networks to be able

to efficiently carry services of the future. This network was termed Broadband Integrated Services Digital Network (B-ISDN). By 1990, decisions had been made to base B-ISDN on SONET/SDH (Synchronous Optical Network/Synchronous Digital Hierarchy) and ATM.

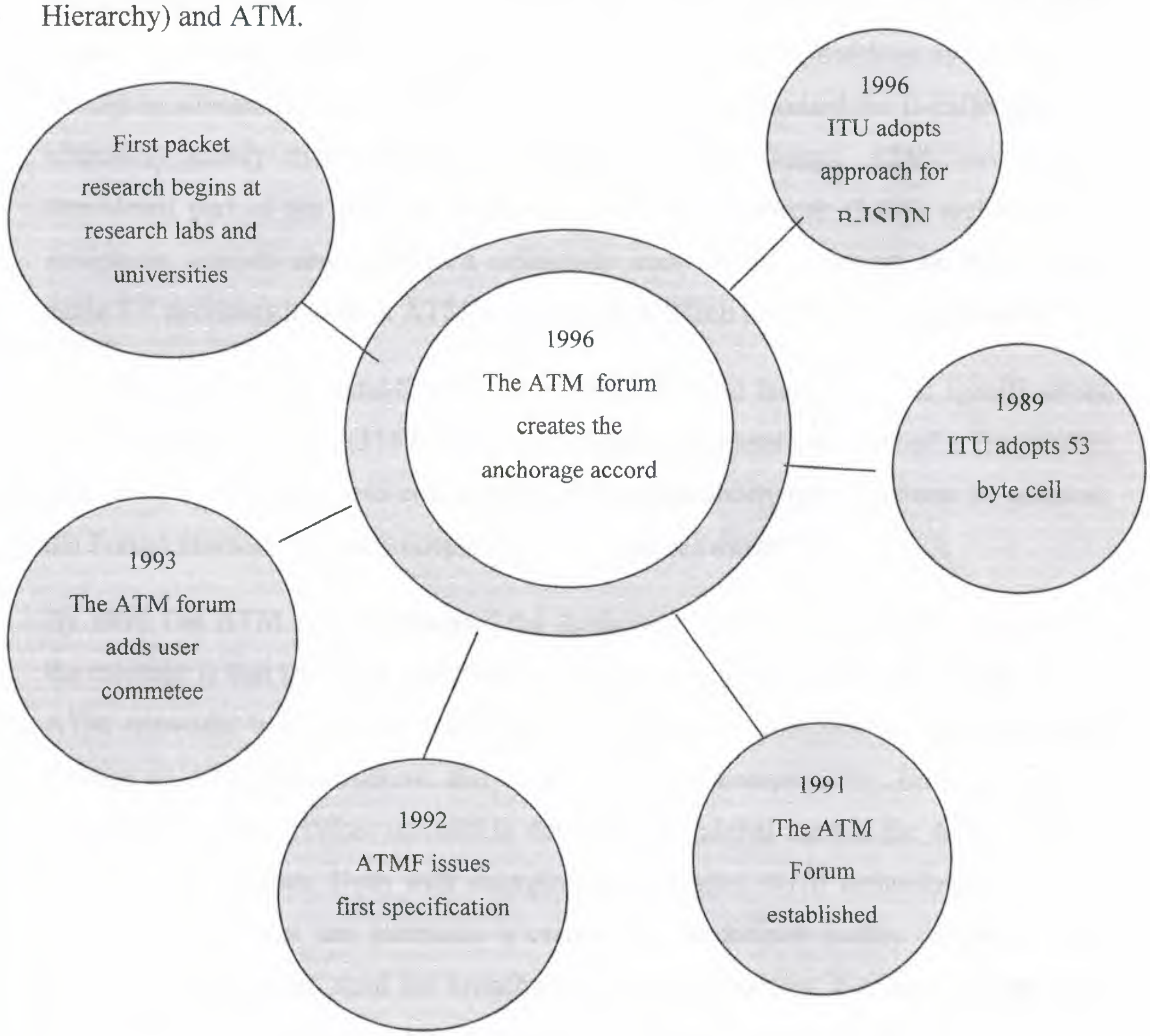

Figure 1.1 Historical Development of ATM

SONET describes the optical standards for transmission of data. SONET/SDH standards specify how information can be packaged, multi-plexed and transmitted over the optical network. An essential element of SONET/SDH is to ensure that optical equipment and services from different vendors/service providers are interoperable and manageable. ITU-T now needed as switching standard to complement SONET in the B-ISDN model. Because SONET only describes the transmission and multiplexing of information, without knowing what type of data or switching is being used, it can operate with nearly

all emerging switching technologies. For B-ISDN, two types of switching were considered by the ITU-T: Synchronous and Asynchronous. An intelligent switching fabric with the ability to switch all forms of traffic at extremely high speeds, while maximizing the use of bandwidth, was needed to optimize the potential of B-ISDN. Ideally, maximum bandwidth should be accessible to all applications and users, and should be allocated on demand. ATM was chosen as the standard for B-ISDN that will ultimately satisfy these stringent requirements. Even though ATM was initially considered part of the solution for WANs, local area network (LAN) architects and equipment vendors saw ATM as a solution to many of their network limitations, and cable TV operators looked at ATM as a possible addition to their existing networks.

The ATM Forum was established in October, 1991 and issued its first specifications eight months later. The ATM Forum was formed to accelerate the user of ATM product and services through a rapid convergence of interoperability specifications. In addition, the Forum promotes industry cooperation and market awareness.

By 1996 The ATM Forum presented the Anchorage Accord objective. Fundamentally, the message is that the set of specifications needed for the development of multi-service ATM networks is available. These specifications were complete to implement and manage an ATM infrastructure, and ensure backward compatibility. Entering the new millennium, ATM services are still in demand. The global market for ATM is in the billions of US dollars. Even with emerging technologies, ATM technology is still the only technology that can guarantee a certain and predefined quality of service. The growth of the Internet, need for broadband access and content, e-commerce and more are spurring the need for a reliable, efficient transport system - ATM Technology. For voice, video, data and images together, the next generation network depends on ATM.

1.3 ATM Standars

Asynchronous Transfer Mode, or ATM is a network transfer technique capable of supporting a wide variety of multimedia application with diverse service and performance requirements. It supports traffic bandwiths ranging from a few kilobites per second to several hundred megabits per second. And traffic types ranging from continuous, fixed-rate traffic to highly bursty traffic. ATM was designated by the telecommunication standardization sector of the International Telecommunication Union (ITU-T)

ATM is a form of packet-switching technology. That is, ATM networks transmit their information in small, fixed-length packets called "cells", each of which contains 48 octets (or bytes) of data and 5 octets of header information. The small, fixed cell size was chosen to facilitate the rapid processing of packets in hardware And to minimize the amount of the time required to fill a single packet. This is particularly important for real-time applications such as voice and video that require short packetization delays

ATM is also connection-oriented. In other words, a virtual connection must be established before a "call" can take place , where a call is defined as the transfer of information between two or more end points.

Another important characteristic of ATM is that its network functions are typically implemented in hardware. With the introduction of high speed fiber optic transmission lines, the communication bottleneck has shifted from the communication links to the processing at switching nodes and at terminal equipment. Hardware implementation is necessary to overcome this bottleneck, because it minimizes the cell processing overhead, thereby allowing the network to match link rates on the order of Gbit/s

Finally , as its name indicates , ATM is asynchronous. Time is slotted into cell-sized intervals, and slots are assigned to calls in an asynchronous, demand-based manner. Because slots are allocated to calls on demand ATM can easily accommodate traffic whose bit rate fluctuates over time . Moreover, in ATM also gains bandwidth efficiency by being able to statistically multiplex bursty traffic sources.
Since bursty traffic does not require continuous allocation of the bandwidth at its peak rate, statistical multiplexing allows a large number of bursty sources to share the network's bandwidth.

Since its birth in the mid-1980s, ATM has been fortified bt a number of robust standards and realized by a significant number of network equipment manufacturers.

International standards-making bodies such as the ITU and independent consortia like the ATM forum have developed a significant body of standards and implementation agrements for ATM

The telecommunication standardization sector of the ITU, the international standards agency commissioned by the United Nations for the global standardization of telecommunication, has developed standards for ATM networks. Other standards bodies and consortia have also contributed to the development of ATM.

1.3.1 Protocol Reference Model

The purpose of the protocol reference model is to clarify the funtions that ATM networks perform by grouping them into a set of interrelated, function-specific layers and planes. The reference model consist of a user plane, a control plane and a management plane. within the user and control planes is a hierarchical set of layers.

The user plane defines a set of functions for the transfer of user information between communication end-points; The conrol plane defines the control functions such as call establishment, call maintanance, and call release; and the management plane defines the operations necessary to control information flow between planes and layers, and to maintain accurate and fault –tolerant network operation.

Within the user and control planes, there are three layers: the physical layer, the ATM layer, and the ATM adaptation layer (ALL).

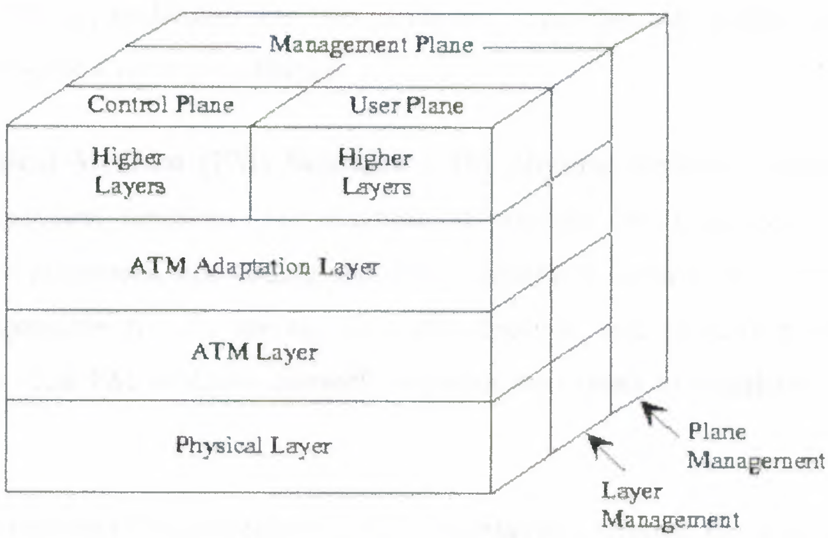

Figure 1.2 Protocol reference model for ATM

Within the user and control planes, there are three layer, the physical layer, the ATM layer,and the ATM adaptation layer (ALL). Table 1.2.2.1 summarizas the functions of

each layer . The physical layer performs primarily bit level functions, the ATM layer is primarily responsible for the switching of ATM cells, and the ATM adaptation layer is responsible for the conversion of higher layer protocol frames into ATM cells. The functions that the physical, ATM, and adaptation layers perform are described in more detail in the following.

Table 1.1 Functions of each layer in the protocol reference model

<table>
<tr><td rowspan="6">Layer Management</td><td>Higher Layer Functions</td><td colspan="2">Higher Layers</td></tr>
<tr><td>Convergence</td><td>CS</td><td rowspan="2">ALL</td></tr>
<tr><td>Segmentation and Reassembly</td><td>SAR</td></tr>
<tr><td>Generic Flow Control
Cell Header Generation/Extraction
Cell VPI/VCI Translation
Cell Multiplex and Demultiplex</td><td colspan="2">ATM</td></tr>
<tr><td>Cell Rate Decoupling
Header Error Control (HEC)
Cell Delineation
Transmission Frame Adaptation
Transmission Frame Generation / Recovery</td><td>TC</td><td rowspan="2">Physical Layer</td></tr>
<tr><td>Bit Timing
Physical Medium</td><td>PM</td></tr>
</table>

1.4 Physical layer

The physical layer is divided into two sublayers: The Physical Medium sublayer and The Transmission Converge sublayer

1.4.1 Physical Medium (PM) Sublayer : The physical medium sublayer performs medium-dependent functions. For example, it provides bit transmission capabilities including bit alignment, line coding and electrical/optical conversion. The PM sublayer is also responsible for bit timing, i.e.., the insertion and extraction of bit timing information. The PM sublayer currently supports two types of interface : optical and electrical

1.4.2 Transmission Convergence (TC) Sublayer : Above the physical medium sublayer is the transmission converge sublayer, which is primarily responsible for the framing of data transported over the physical medium. The ITU_T recomendation specifies two options for TC sublayer transmission frame structure cell-based and Synchronous Digital Hierarchy (SDH). In the cell-based case, cells are transported

continuously without any regular frame structure. Under SDH, cells are carried in a special frame structure based on the north American SONET (Synchronous Optical Network) protocol.

Regardless of which transmission frame structure is used, the TC sublayer is responsible for the following four funtions: Cell rate decoupling, header error control, cell delineation, and transmission frame adaptation. Cell rate decoupling is the insertion of idle cells at the sending side to adapt the ATM cell stream's rate to the rate of the transmission path .

Header error control is the insertion of an 8-bit CRC polynomial in the ATM cell header to protect the contents of the ATM cell header. Cell delineation is the detection of cell boundaries. Transmission frame adaptation is the encapsulation of departing cells into an appropriate framing structure

1.5 ATM Layer

The ATM layer lies a top the physical layer and specifies the functions required for the switching and flow control of ATM cells,There are two interfaces in an ATM network: The user network interface (UNI) between the ATM end point and the ATM switch, and the network-network interface (NNI) between two ATM switches.

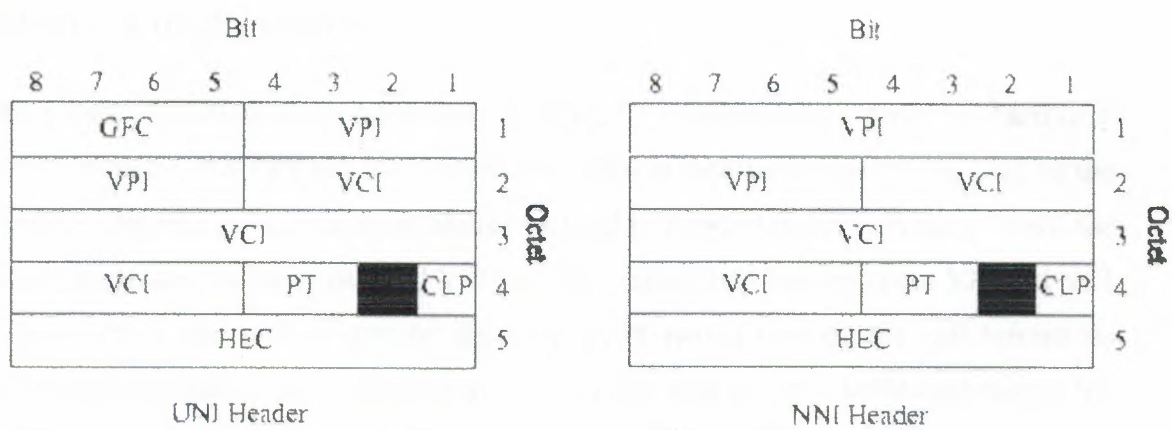

Figure 1.3 ATM cell header structure

Although a 48-octet cell payload is used at both interfaces, the 5 octet cell header differs slightly at these interfaces. Figure 2 shows the cell header structures used at the UNI and NNI At the UNI , the header contains a 4- bit generic flow control (GFC) field, a 24-bit label field containing Virtual Path Identifier (VPI) and Virtual Channel Identifier

(VCI) subfields (8 bits for the VPI and 16 bits for the VCI), a 2-bit payload type (PT) field, a 1-bit priority (PR) field, and an 8-bit header error check (HEC) field. The cell Header for an NNI cell is identical to that for the UNI cell, except that it lacks the GFC field; these four bits are used for an additional 4 VPI bits in the NNI cell header.

The VCI and VPI fields are identifier values for virtual channel (VC) and virtual path (VP), respectively. A virtual channel connects two ATM communication end-points. A virtual path connects two ATM devices, which can be switches or end-points, and several virtual channels may be multiplexed onto the same virtual path.

The 2-bit PT field identifies whether the cell payload contains data or control information. The CLP bit is used by the user for explicit indication of cell loss priority. If the value of the CLP is 1 the the cell is subjected to discarding in case of congestion. The HEC field is an 8 bit CRC polynomial that protects the contents of the cell header.

The GFC field, which appears only at the UNI, is used to assist the customer premises network in controlling the traffic flow for different qualities of service .
At the time of writing the exact procedures for use of this field have not been agreed upon .

1.6 ATM Layer Functions

The primary function of the ATM layer is VPI/VCI translation. As ATM cells arrive at ATM switches, the VPI and VCI values contained in their headers are examined by the switch to determine which outport should be used to forward the cell. In the process, the switch translates the cell's original VPI and VCI values into new outgoing VPI and VCI values, which are used in turn by the next ATM switch to send the cell toward its intended destination. The table used to perform this translation is initialized during the establishment of the call. An ATM switch may either be a VP switch, in which case it only translates the VPI values contained in cell headers, or it may be a VP/VC switch, in which case it translates the incoming VCI value into an outgoing VPI/VCI pair.

Since VPI and VCI values do not represent a unique end-to-end virtual connection. They can be reused at different switches through the network. This is important,

because the VPI and VCI fields are limited in lenght and would be quickly exhausted if they were used simply as destination addresses.

The ATM layer supports two types of virtual connections : switched virtual connection (SVC) and permanent, or semipermanent, virtual connections (PVC). Switched virtual connections are established and torn down dynamically by an ATM signaling procedure. That is they only exist for the duration of a single call.

Permanent virtual connections, on the other hand, are established by networkadministrators and continue to exist as long as the administrator leavesthem up, even if they are not used to transmit data. Other important functions of the ATM layer include cell multiplexing and demultiplexing, cell header creation and extraction, and genericflow control.

Cell multiplexing is the merging of cells from several calls onto a single transmission path , cell header creation is the attachment of a 5- octet cell header to each 48 octet block of user payload, and generic flow control is used at the UNI to orevent short-term overload conditions from occurring within the network

1.7 ATM Layer Service Categories

The ATM Forum and ITU-T have defined several distinct service categories at ATM layer. The categories defined by the ATM forum include constant bit rate (CBR), real-time variable bit rate (VBR-rt), non real-time variable bit rate (VBR-nrt), available bit rate (ABR), and unsipecific bit rate (UBR). ITU-T defines four service categories, namely, deterministic bit rate(DBR), statistical bit rate (SBR), avalable bit rate (ABR) and ATM block transfer(ABT). The first of the three ITU-T service categories correspond roughly to the ATM Forum's CBR,VBR and ABR classifications, respectively .

The fourth service category, ABT, is solely defined by ITU-T ans is intended for bursty data application. The UBR category defined bt the ATM Forum is for calls that request no quality of service guarantees at all. The constant bit rate CBR (or deterministic bit rate DBR) service category provides a very strict QoS guararentee. It is targeted at real-time applications, such as voice and raw video, which mandate severe restrictions on delay, delay variance(jitter) and cell loss rate.

The only traffic description required by the CBR service are the peak cell rate and the cell delay variation tolerance. A fixed amount of bandwidth, determined primarily by the call's peak cell rate, is reservedfor each CBR connection. The real-time variable bit rate VBR-rt (or statistical bit rate SBR) service category is intended for real time bursty application, which also require strict QoS guarantees.

The primary difference CBR and VBR-rt is in the traffic descriptions they use. The VBR-rt service requires the specification of the sustained cell rate and bursty tolerance in addition to the peak cell rate and the cell delay variation tolerance. The ATM Forum also defines a non-real-time VBR-nrt service category, in which cell delay variance is not guaranteed.The available bit rate (ABR) service category is defined to exploit the network's unutilized bandwidth. It is intended for non-real time data application in which the source is amenableto enforced adjustment of its transmission rate.

A minimum cell rate is reserved for the ABR connection and therefore guaranteed by the network. When the network has unutilized bandwidth, ABR sources are allowed to increase their cell rates up to an allowed cell rate (ACR), a value which is periodically updated by the ABR flow control mechanism. The value of ACR always falls between the minimum and the peak cell rate for the connection and is determined by the network

The ATM forum defines another service category for non-real-time application called the unspecified bit rate (UBR) service caregory. UBR service is entirelybest efford; the call is provided with no QoS guarantees. .The ITU-T also defines an additional sewrvice category for non-real-time data applications. The ATM block transfer (ABT) service category is intended for the transmission option (ABT/IT), the block of data is sent at the same time as the reservation request.

If bandwidth is not available for transporting block, then it is simply discarded; and the source must retransmit it. In the ABT service with delayed transmission (ABT/DT); the source waits for a confirmation from the network that enough bandwitdh is available before transmitting the block of tha data. In both cases, the network temprorarily resource reserves bandwitdh according to the peak. Cell rate for each block.Imediately after transporting the block, the network releases the reserved bandwidh.

Table 1.2 ATM layer service categories

ITU-T Service Categories →	DBR	SBR	ABT	ABR	
ATM Forum Service Categories →	CBR	VBR-rt	VBR-nrt	ABR	UBR
Cell Loss Rate	specified				unspecified
Cell Transfer Delay	specified			unspecified	
Cell Delay Variation	specified		unspecified		
Traffic Descriptors (Contract)	PCR/CDVT	PCR/CDVT SCR/BT		PCR/CDVT MCR/ACR	PCR/CDVT

PCR = Peak Cell Rate
CDVT = Cell Delay Variation Tolerance
MCR = Minimum Cell Rate
SCR = Sustained Cell Rate
BT = Burst Tolerance
ACR = Allowed Cell Rate

1.8 ATM Adaptation Layer

The ATM adaptation layer (AAL), which resides a top ATM layer, is responsible for mapping the requirements of higher layer protocols onto the ATM network. It operates in ATM devices at the edge of the ATM network and is totally up sent in ATM switches. The adaptation layer is divided into two sublayers: The convergence sublayer (CS), which performs error detection and handling, timing and clock recovery and the segmentation and reassembly (SAR) sublayer, which performs segmentation of convergence sublayer protocol data units (PDUs) into ATM cell-sized SAR sublayer service data units data units (SDUs) and vice versa In order to support different service requirements, the ITU-T proposed for AAL-specific services classes.

Note that while these ALL service classes are similar in many ways to the ATM layer service catagories defined in the perivious section, they are not the same; each exists at a different layer of the protocol reference model, and each requires a different set of functions. ALL service class A corresponds to constant bit rate (CBR), services with a timing the relation required between source and destination. The connection mode is connection – oriented . CBR audio and video blong to this class. Class B corresponds to variable bit rate (VBR) services. This class also requires timin between sources and destination , and its mode is connection-oriented. VBR audio and video are examples of class B services. Class C also corresponds to VBR connection –oriented services but the timing between source and destination needs not be related. Class C includes connection-oriented data transfer such as X.25, signaling and future high speed data

services. Class D corresponds to connectionless services. Connectionless data services such as those supported by LANs and WANs are examples of class D services .

Four AAL types , each with a unique SAR supplier and CS sublayer, are defined to support the four service classes. ALL type 1 supports constant bit rate services (Class A), and AAL type 2 supports available bit rate services with a timing relation between source and destination (Class B). ALL type 3 /4 was orginally specified as two different AAL type (Type 3 and Type 4), but due to their inherient similarities, they were eventually merget to support both Class C and Class D services. AAL Type 5 also supports class C and Class D services

Table 1.3 Service Classification for AAL

	Class A	**Class B**	**Class C**	**Class D**
Timing Relation between source and destionation	Required		Not Required	
Bit rate	Constant	Variable		
Connection Mode	Connnection Oriented			Connectionless

1.8.1 ALL Type5

Currently the most widely used adaptation layer is AAL type 5. AAL type 5 supports connection-oriented and connectionless services in which there is no timing relation between source and destination(class C and class D). Its functionality was intentionaly made simple in order to support high speed data transfer. AAL type 5 assumes that the layers above the ATM adaptation layer can perform error recovery. Retransmition and sequence numbering when require and those it does not provide this functions. Therefore, only none assured operation is provided; lost or corrupted AAL type 5 packet will not be corrected by retransmition.

The SAR supplier of AAL type 5 performs segmentation of CS-PDU into a size suitable for the SAR-SDU pay load. Unlike other AAL types, Type 5 devotes the entire 48-octet payload of the ATM cell to the SAR-SDU ; there is no overhead. An AAL specific flag in the ATM Payload Type (PT) Field of the cell header is set when the last cell of a

CS-PDU is sent . the assembly of the CS-PDU frames at the destionation is controlled by using this flag.

it conteins the user data payload, along with any recessary padding bits (PAD) and a CS-PDU trailer, which are added by the CS supplier when it recveives the uder information from the higher layer. the CS–PDU is padded using 0 + 47 bytes of PAD field to make the land of the CS-PDU and integral muliple of 48 bytes (the size of the SAR -SDU) at the receiving end, reassembled PDU is passed to the CS sublayer from the SAR sublayer, CRC values are then calculared and compared.

If there is no error, the PAD field is removed by using the value of lenght field (LF) in the CS-PDU trailer, and user data is passed to the higher layer. If an error is detected, the erroneous information is either deliverded to the use or discarded according to user 's choice .

1.9 ATM Signalling

ATM follows the principle of out-of-band signaling that was establihed for N-ISDN. in other words, signaling and data channels are separate. The main purposes of signaling are:

1) To establish ,maintain and release ATM virtual connections.
2) To negotiate the traffic parameters of new connections.

The ATM signaling standards support the creation of point to point as well as multicast connections. Typically certain VCI and VPI values are reserved by ATM networks for signaling messages. If additional signaling VCs are required, they may be establish through the process of meta-signaling.

CHAPTER II: DEVELOPMENT OF ATM

2.1 ATM in the Telecommunications Infrastructure

A telecommunications network is designed in a series of layers. A typical configuration may have utilized a mix of time division multiplexing, Frame Relay, ATM and/or IP. Within a network, carriers often extend the characteristic strengths of ATM by blending it other technologies, such as ATM over SONET/SDH or DSL over ATM. By doing so, they extend the management features of ATM to other platforms in a very cost-effective manner.

ATM itself consists of a series of layers. The first layer - known as the adaptation layer - holds the bulk of the transmission. This 48-byte payload divides the data into different types. The ATM layer contains five bytes of additional information, referred to as overhead. This section directs the transmission. Lastly, the physical layer attaches the electrical elements and network interfaces.

2.2 ATM as the backbone for other networks

The vast majority (roughly 80 percent) of the world's carriers use ATM in the core of their networks. ATM has been widely adopted because of its unmatched flexibility in supporting the broadest array of technologies, including DSL, IP Ethernet, Frame Relay, SONET/SDH and wireless platforms. It also acts a unique bridge between legacy equipment and the new generation of operating systems and platforms. ATM freely and easily communicates with both, allowing carriers to maximize their infrastructure investment.

2.2.1 ATM in the LAN (Local Area Network)

The LAN environment of a campus or building appears sheltered from the headaches associated with high-volumes of traffic that deluge larger networks. But the changes of LAN interconnection and performance are no less critical. The ATM/LAN relationship recently took a giant step forward when a prominent U.S. vendor announced a patent for its approach to extending ATM's quality of service to the LAN. The filing signals another

birth in a long lineage of applications that prove the staying power and adaptability of ATM.

2.2.2 ATM in the WAN (Wide Area Network)

A blend of ATM, IP and Ethernet options abound in the wide area network. But no other technology can replicate ATM's mix of universal support and enviable management features. Carriers inevitably turn to ATM when they need high-speed transport in the core coupled with the security of a guaranteed level of quality of service. When those same carriers expand to the WAN, the vast majority does so with an ATM layer.

Distance can be a problem for some high-speed platforms. Not so with ATM. The integrity of the transport signal is maintained even when different kinds of traffic are traversing the same network. And because of its ability to scale up to OC-48, different services can be offered at varying speeds and at a range of performance levels.

2.2.3 ATM in the MAN (Metropolitan Area Network)

The MAN is one of the hottest growing areas in data and telecommunications. Traffic may not travel more than a few miles within a MAN, but it's generally doing so over leading edge technologies and at faster-than-lightening speeds.

The typical MAN configuration is a point of convergence for many different types of traffic that are generated by many different sources. The beauty of ATM in the MAN is that it easily accommodates these divergent transmissions, often times bridging legacy equipment with ultra high-speed networks. Today, ATM scales form T-1 to OC-48 at speeds that average 2.5 Gb/s in operation, 10 Gb/s in limited use and spanning up to 40 Gb/s in trials

2.3 Bandwidth Distribution

The Bandwidth Distribution (BD) component is responsible for the management of the bandwidth allocated to working VPCs according to actual traffic conditions. That is, it adjusts the bandwidth allocated to the working VPCs to their actual usage to avoid situations where in the same links some VPCs tend to become over-utilized while other VPCs remain underutilized.

The dynamic management of the working VPC allocated bandwidth is achieved by distributing portions (viewed as a common pool) of the link working bandwidth (link capacity minus restoration bandwidth) among the working VPCs. Specifically, the management of the VPC allocated bandwidth is done within specific (upper and lower) bounds on the VPC bandwidth as originally estimated by VPC_LD (VPC required bandwidth).

The activities of BD are required to compensate for inaccuracies in traffic predictions and in the VPC bandwidth as estimated by VPC_LD as well as to withstand (short to medium) actual traffic variations. This is so, since it cannot be taken for granted that the traffic predictions will be accurate and furthermore even if they are accurate, they are accurate within statistical range. In this respect i.e. considering the random nature of the arriving traffic, the bandwidth that needs to be allocated to VPC, so that certain objectives (regarding connection admission) to be met, is a stochastic variable, depending on the connection arriving pattern. The VPC_LD component estimates originally the bandwidth that needs to be allocated to the VPCs (required bandwidth) so that satisfy traffic predictions. This is viewedas the mean value of the (stochastic in nature) bandwidth that needs to be allocated to the VPCs. It is the task then of the BD component, to manage the allocated bandwidth of VPCs, around the (mean) required bandwidth, according to actual traffic conditions.

By monitoring the usage on working VPCs, the BD component also emits warnings to VPC_LD indicating insufficient usage of the planned network resources. The warnings are issued in cases where some VPCs remain under-utilized (with respect to their required bandwidth as specified by VPC_LD) for a significant period of time. This implies that these resources cannot be utilized in the routes by the Load Balancing component and therefore such cases are interpreted as indicating overestimation of network resources.

ATM is a proven technology that is now in its fourth generation of switches. Its maturity alone is not its greatest asset. Its strength is in its ability to anticipate the market and quickly respond, doing so with the full confidence of the industry behind it.

The proposed algorithm for bandwidth redistribution assumes that there is a common pool of bandwidth per link to be redistributed to the VPCs when necessary. The algorithm assumes that this common pool of bandwidth per link is the links' unallocated bandwidth.

Note, that by its definition, this pool of bandwidth is not totally allocated to the VPCs at any instant; but it is there to be allocated to the VPCs that go highly utilized only when such conditions occur. Each VPC grabs or returns portions of its allocated bandwidth to the common pool of bandwidth according to its congestion level. We assume here that the modification of the bandwidth of a VPC does not impact on the traffic parameters (QoS) of the VCs using this VPC or other VPCs sharing the same links or nodes.

2.4 THE SITUATION IN THE TELECOMMUNICATION WORLD BEFORE ATM

Today's telecommunication networks are characterized by specialization. This means that for every individual telecommunication service at least one network exists that transports this service.

Each of these networks was specially designed for that specific service and is often not at all applicable to transporting another service. When designing the network of the future, one must take into account all possible existing and future services. The networks of today are very specialized and suffer from a large number of disadvantages.

1) **Service Dependence**

Each network is only capable of transporting one specific service .

2) **Inflexibility**

Advances in audio, video and speech coding and compression algorithms and progress in VLSI technology influence the bit rate generated by a certain service and thus change the service requirements for the network. In the future new services with unknown requirements will appear. A specialized network has great difficulties in adapting to new services requirements.

The basic idea behind the concept changes is the fact that functions must not be repeated in the network several times if the required service can still be guaranteed when these functions are only implemented at the boundary of the network.Progress In Technology In recent years large progress has occurred both in field of electronics and in the field of optics.

Broadband communication systems can be developed based on different technologies, the most promising being CMOS. (Complementary Metal Oxide Semiconductor) Cmos allows high complexity and reasonably high speed (up to 200 to 300 Mbits/s). The low power dissipation of Cmos is particularly important, and allows the realization of high complexity, high speed systems on a very small chip surface.

With the increased complexity per chip, the system cost can easily be reduced since the large integration will continuously allow the volume of the system to shrink or to increase the functionality at a constant cost. Optical technology is also evolving quite rapidly.Optical fiber has been installed for transmission services for several years.

2.6 Performance Requirements from ATM

In the future broadband network a large number of services have to be supported. These services are :

1) low speed like telemetry, low speed data ,telefax
2) medium speed like hifi sounds, video telephony, high speed data
3) very high speed like high quality video, video library .

A single typical service description does not exist. All services have different characteristics both for their average bit rate and burstiness. To anticipate future unknown services we must try to characterize as general a service as possible.

The optimal transfer mode should support the communication of various types of information via an integrated access. Ideally the transfer mode must provide the capability to transport information, whatever type of information is given at the network, very much like the electricity network, which provides power to it's customers without regarding the way the customer uses his electricity. Two other important factors are:

1) Semantic transparency - determines the possibility of network to transport the information error free.

The number of end to end errors introduced by the network is acceptable for the service No system is perfect. Most of the imperfections of telecommunication systems are caused by noise. Other factors contribute to a reduced quality: limited resources causing blocking; any system errors. One of the most important parameters used to characterize imperfections is the BER (bit error rate) - the ratio between erroneous bits and transmitted bits.

2) Time transparency - determines the capability of the network to transport the information through the network from source to destination in a minimal time acceptable for the service.

Time transparency can be defined as the absence of delay and delay jitter(different part of the information arrive at the destination with different delay). The value of end to end delay is an important parameter for real time services, such as voice and video. If the delay becomes too large echo problems may arise in a voice connection.

Table 2.1 The value of end to end delay is an important parameter for real time services

SERVICE	BER	DELAY
Telephony	10^{-7}	25 - 500 ms
Data Transmission	10^{-7}	1000 ms
Broadcast Video	10^{-6}	1000 ms
Hifi Sound	10^{-5}	1000 ms

2.7 ATM Benefits

1. One Network

ATM will provide a single network for all traffic types - voice, data, video. ATM allows for the integration of networks improving efficency and manageability.

2. Enables new applications

Due to its high speed and the integration of traffic types, ATM will enable the creation and expansion of new applications such as multimedia to the desktop.

3. Compatibility

ATM has been designed to be independent to the transmission medium. Because ATM is not based on a specific type of physical transport, it is compatible with currently deployed physical networks. ATM can be transported over twisted pair, coax and fiber optics.

4. Incremental Migration

Efforts within the standards organizations and the ATM Forum continue to assure that embedded networks will be able to gain the benefits of ATM incrementally-upgrading portions of the network based on new application requirements and business needs.

5. Simplified Network Management

ATM is evolving into a standard technology for local, campus/backbone, public and private wide area services. This uniformity is intended to simplify network management by using the same technology for all levels of the network.

6. Long Architectural Lifetime

The information systems and telecomunications industries are focusing and standardizing on ATM. ATM has been designed from the beginning to be scaleable and flexible in: Geographic distance, number of users, access and trunk bandwidths. This scalability and flexibility assures that ATM will be around for a long time.

7. Scaleability

The ATM network can be expanded to accomodate new users without the bandwith available to the existing users being restricted as a result. It is simply a matter of adding more connection modules to the ATM switch serving the user.

2.8 New ATM Service Categories

The introduction of new ATM service categories will increase the benefits of ATM, making the technology suitable for a virtually unlimited range of applications. An ATM network can provide Virtual Path (VP) or Virtual Channel (VC) Connections with different levels of service. The concept of negotiating, for each connection, the behavior expected from the ATM-layer, in terms of traffic and performance, allows users to betteize the application requirements versus the network capabilities.

The first ATM implementations have offered limited options. A typical network behavior, common to most of the first generation ATM networks, is to reserve a fixed amount of bandwidth for each connection for the duration of the call, on the basis of the maximum emission rate of the source (i.e. the "peak cell rate", PCR), and to provide a single level of quality of service. The ATM Service Categories represent new service building-blocks and introduce the possibility for the user to select specific combinations of traffic and performance parameters.

ATM is a multi-service technology. Actually, most of the requirements that are specific to a given application may be resolved at the edges of an ATM network by choosing an 0appropriate ATM Adaptation Layer (AAL). However, by definition, the ATM-layer behaviour should not rely on the AAL protocols, since these are service specific (and are in many cases supported by the user terminal, i.e., outside the core network visibility), nor on higher layer protocols which are application specific. Given the presence of a heterogeneous traffic mix, and the need to adequately control the allocation of network resources for each traffic component, a much greater degree of flexibility, fairness and utilization of the network can be achieved by providing a selectable set of capabilities within the ATM-layer itself. The Service Categories have been defined with this goal in mind. Both users and network operators can benefit from the availability of a selectable set of ATM-layer services. These services are, in effect, the tools, which will allow the promise of ATM to be fully realized.

2.8.1 Customer Perspective

ATM customers (e.g. end user, IT and telecommunications managers) aim at saving on network usage costs, provided that their substantial efficiency and quality requirements are matched. Requirements are variable in nature depending on what application (e.g. data, voice, video, multimedia) is running. As a matter of fact, users that produce variable traffic patterns would like to be able to get bandwidth just when actually needed and, in case of elastic sources, to have fast access to as much available bandwidth as possible, achieving a satisfactory compromise between performance and cost.

2.8.2 Network and Service Operators Perspective

All types of operators that are investing in ATM infrastructures and services aim to achieve maximum utilization of the deployed resources, avoid congestion while being able to share network resources among a large number of customers and fulfill the differing user needs in a cost-effective way. This allows for appropriate tariffing strategies to be deployed. The ability to offer a range of network services, with selectable cost/performance levels, is a key issue for network operators, particularly in a competitive market.

2.9 Service Categories Description

2.9.1 Constant Bit Rate (CBR)

The CBR service category is used by connections that request a fixed (static) amount of bandwidth, characterized by a Peak Cell Rate (PCR) value that is continuously available during the connection lifetime. The source may emit cells at or below the PCR at any time, and for any duration (or may be silent).

This category is intended for real-time applications, i.e., those requiring tightly constrained Cell Transfer Delay (CTD) and Cell Delay Variation (CDV), but is not restricted to these applications. It would be appropriate for voice and video applications, as well as for Circuit Emulation Services (CES).

The basic commitment made by the network is that once the connection is established, the negotiated QoS is assured to all cells conforming to the relevant conformance tests. It is assumed that cells, which are delayed beyond the value specified by Cell Transfer

Delay (CTD), may be of significantly less value to the application.

2.9.2 Real-Time Variable Bit Rate (rt-VBR)

The real-time VBR service category is intended for time-sensitive applications, (i.e., those requiring tightly constrained delay and delay variation), as would be appropriate for voice and video applications. Sources are expected to transmit at a rate which varies with time. Equivalently, the source can be described as "bursty".

Traffic parameters are Peak Cell Rate (PCR), Sustainable Cell Rate (SCR) and Maximum Burst Size (MBS). Cells which are delayed beyond the value specified by CTD are assumed to be of significantly less value to the application. Real-time VBR service may support statistical multiplexing of real-time sources.

2.9.3 Non-Real-Time (nrt-VBR)

The non-real time VBR service category is intended for applications which have bursty traffic characteristics and do not have tight constraints ay and delay variation. As for rt-VBR, traffic parameters are PCR, SCR and MBS. For those cells which are transferred within the traffic contract, the application expects a low Cell Loss Ratio (CLR). For all cells, it expects a bound on the Cell Transfer Delay (CTD). Non-real time VBR service may support statistical multiplexing of connections.

2.9.4 Available Bit Rate (ABR)

The Available Bit Rate (ABR) is a service category intended for sources having the ability to reduce or increase their information rate if the network requires them to do so. This allows them to exploit the changes in the ATM layer transfer characteristics (i.e., bandwidth availability) subsequent to connection establishment.

It is recognized that there are many applications having vague requirements for throughput: they can be expressed as ranges of acceptable values, e.g., a maximum and a minimum, rather than as an average value (that is typical for the VBR category). To meet this requirement on the establishment of an ABR connection, the end-system shall specify a maximum required bandwidth and a minimum usable bandwidth. These are designated as the Peak Cell Rate (PCR) and the Minimum Cell Rate (MCR),

respectively. The MCR may be specified as zero. The bandwidth made available from the network may vary, as it is the sum of an MCR, and a variable cell rate which results from sharing the available capacity among all the active ABR connections via a defined and fair policy. A flow control mechanism is specified which supports several types of feedback to control the source rate. In particular a closed-loop feedback control protocol using Resource Management (RM) cells has been specified in a rate-based framework.

Although no specific QoS parameter is negotiated with the ABR, it is expected that an end-system that adapts its traffic in accordance with the feedback will experience a low Cell Loss Ratio (CLR) and obtain a fair share of the available bandwidth according to a network specific allocation policy. Cell Delay Variation (CDV) is not controlled in this service, although admitted cells are not delayed unnecessarily. ABR service is not (as specified at present) intended to support real-time applications.

A source, destination and network switch behavior is specified by The ATM Forum along with details of the rate-based flow control mechanism.

2.9.5 Unspecified Bit Rate (UBR)

The Unspecified Bit Rate (UBR) service category is a "best effort" service intended for non-critical applications, which do not require tightly constrained delay and delay variation, nor a specified quality of service. UBR sources are expected to transmit non-continuous bursts of cells. UBR service supports a high degree of statistical multiplexing among sources.

UBR service does not specify traffic related service guarantees. Specifically, UBR does not include the notion of a per-connection negotiated bandwidth. There may not be any numerical commitments made as to the cell loss ratio experienced by a UBR connection, or as to the cell transfer delay experienced by cells on the connection.

Table 2.2 Service Category Attributes and Guarantees

Service Category	Traffic Description	Guarantees			Use of Feedback Control
		Min Loss (CLR)	Delay/Variance	Bandwidth	
CBR	PCR	X	X	X	NO
rt-VBR	PCR, SCR, MBS	X	X	X	NO
nrt-VBR	PRC, SCR, MBS	X	NO	X	NO
ABR	PCR, MCR+ behavior parameters	X	NO	X	X
UBR	(PCR)	NO	NO	NO	

CHAPTER III : ATM APPLICATION AREAS

3.1 ATM co-operative multimedia user business cases

This section describes ATM user business cases conducted in a joint effort between network operators, manufacturers of telecommunication and information technology equipment, software companies and end users from different industry sectors. The results are related to multimedia applications in the aircraft and banking industries. Common to both case studies is the concept of computer supported collaborative work (CSCW). Experiences are taken as a basis for deriving functional and technical requirements for supporting ATM networks. The focus lies on the future support of CSCW by teleservices and ATM bearer services in the network. The projects were partially funded by the European Union.

The BANK project (Banking applications using an image and broadband communications network) addresses possible multimedia enhancements of current banking services,

3.1.1 Multimedia banking

The banking and insurance industries are heavy users of information technology and telecommunication services, with almost every business transaction leading immediately to a computer-assisted process. Major banks operating world-wide would be unable to conduct business without efficient telecommunication networks. Banks also increasingly use information technology to serve their customers. An international consortium looked at how self-service banking and advisory support applications for up-to-the-minute analyses of bank products can be used to better serve customers in the future.

The integration of telecommunication and information processing, as well as recent progress in the field of audio and video presentation on computer workstations, is opening up new horizons for marketing and distribution applications. Multimedia product Information consisting of still and moving images, sound or voice sequences, charts, and text can help customers obtain information on the services offered by a bank.

In addition to product presentation, networked multimedia provides an innovative opportunity to hold small video-conferences regardless of distance. High-performance broadband networks are required to provide a high-quality connection; interest here is focused on ATM-based networks, with their capacity for flexible use of bandwidths. Broadband networks are being discussed as an important national infrastructure for the country's economy.

Almost everywhere in Europe, broadband networks are set up and are already interconnected or will be in future. An international consortium has investigated multimedia technology in the banking sector, establishing the BANK (Banking applications using image and broadband communications network) application project.

The high level of customer acceptance of self-service facilities and the increasing efficiency of modern information technology are the driving forces behind an extension of customer self-service, both quantitatively and qualitatively. In the future self-service machines will not only assist in processing transactions, but they will also increasingly serve as a marketing tool, supplying information on more complex products, such as loans, mortgages and investment and portfolio management.

The common feature of these products is that the customer has a number of options regarding the product structure and is therefore often reliant upon advice. In order to preserve the close customer-bank relationship the customer must always have access to the advice of his personal advisor at the bank. Thus the outstanding features of future self-service terminals must be simple operating instructions, high-quality presentation of product information and the opportunity, if required, to obtain advice from bank personnel.

There is a noticeable trend in the banking industry toward differentiation within the sales network. However, the cost of employing a specialist in every branch for each product in the growing product range would be prohibitive, so experts from larger branches offer specialized support to personnel in smaller branches.

Such an improvement would also enable customers at smaller branches to base their investment decisions on expert knowledge available only at the bank's larger branches.

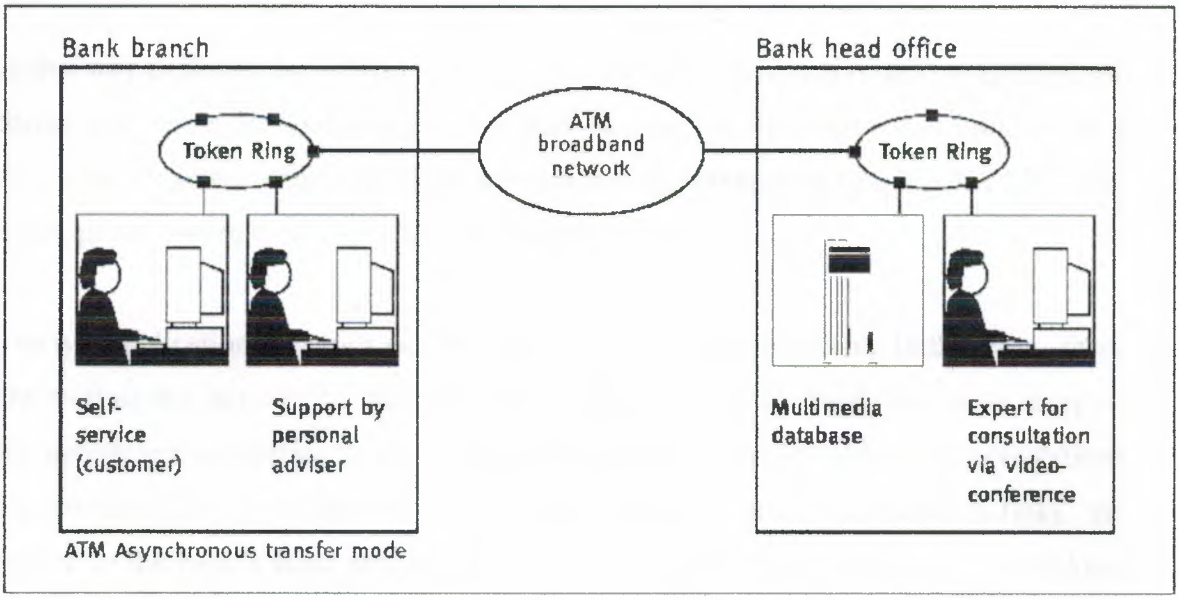

Figure 3.1 ATM network configuration for connections between bank branches and the head office.

In the BANK project, the two commercial scenarios outlined above were implemented on a prototype basis with specific applications.

In the first scenario a multimedia information terminal was created as a supplement to the automatic cash dispenser and statement printer. It consisted essentially of a workstation with a touch screen and equipment for audio and video recording and reproduction. The interest of a passing customer is attracted by a video film about the bank and its products.

By touching the screen the customer is given an overview of the institution's product spectrum and with the aid of the buttons shown on the screen he can select a subject area of interest. Information on the relevant subject is then conveyed by a varied multimedia product presentation, which contains videos, spoken explanations, texts, charts and still images.

Whatever the product, the customer is able to influence the course of the information sequence, for example by requesting more detailed information or carrying out illustrative calculations. If the customer needs more information than that which is

offered he can, at any time and directly from the self-service mode, enter into a video-conference with a customer adviser to discuss any outstanding questions.

In this way customer and adviser can also jointly prepare documents such as application forms and charts for evaluating a portfolio or perform illustrative calculations. In a future development phase, facilities for concluding agreements (e.g. card reader, PIN input, printer, scanner, fax) can also be integrated.

The two application scenarios can be installed in parallel at one bank. In this case there are multimedia self-service machines and workstations at the bank branch to support the investment consultant in his discussion with the customer; additional workstations are connected to a local network (token ring). An ATM broadband network links the branch to the bank's head office where there are experts who, by means of a desktop video-conference, can assist the customer with specialized advice. A multimedia database contains up-to-date information on new products, which can be accessed if required

Options were implemented for the interactive and non-interactive presentation of multimedia documents as well as shared working (joint pointing, joint viewing) for the purposes of a banking application. The functions of shared working were extended with an application-sharing mechanism for OS/2, DOS and Windows applications.

Thiscreates a flexible basis for enabling the applications available at the bank employee's placeof work also to be used in consultations via video-conference if required. Multimedia andbroadband technologies form the basis for innovative self-service equipment in the banking sector, offering new opportunities in the marketing of financial products and creating new sales channels for bank products.

In the BANK project a prototype multimedia system has been developed which can be used both as a self-service unit for bank products as well as an advisory support system for traditional customer service. Apart from pure product information, the system offers integrated desktop video-conference and the opportunity of processing documents jointly (application sharing). For data transfer between the workstations an ATM communications infrastructure was selected.

Multimedia documents with the option of video-conference and integrated application sharing can be used in other scenarios than those implemented. There are a number of other possible applications for such systems, e. g. in commercial education and in-service training. There are also potential applications in office support systems and co-ordination procedures within banks. These applications can overcome the restrictions of a particular location as well as providing enhanced communication with business partners. With sufficient availability of end-user equipment and inexpensive, suitable multimedia services within the public network a similar service can also be offered in the home banking sector.

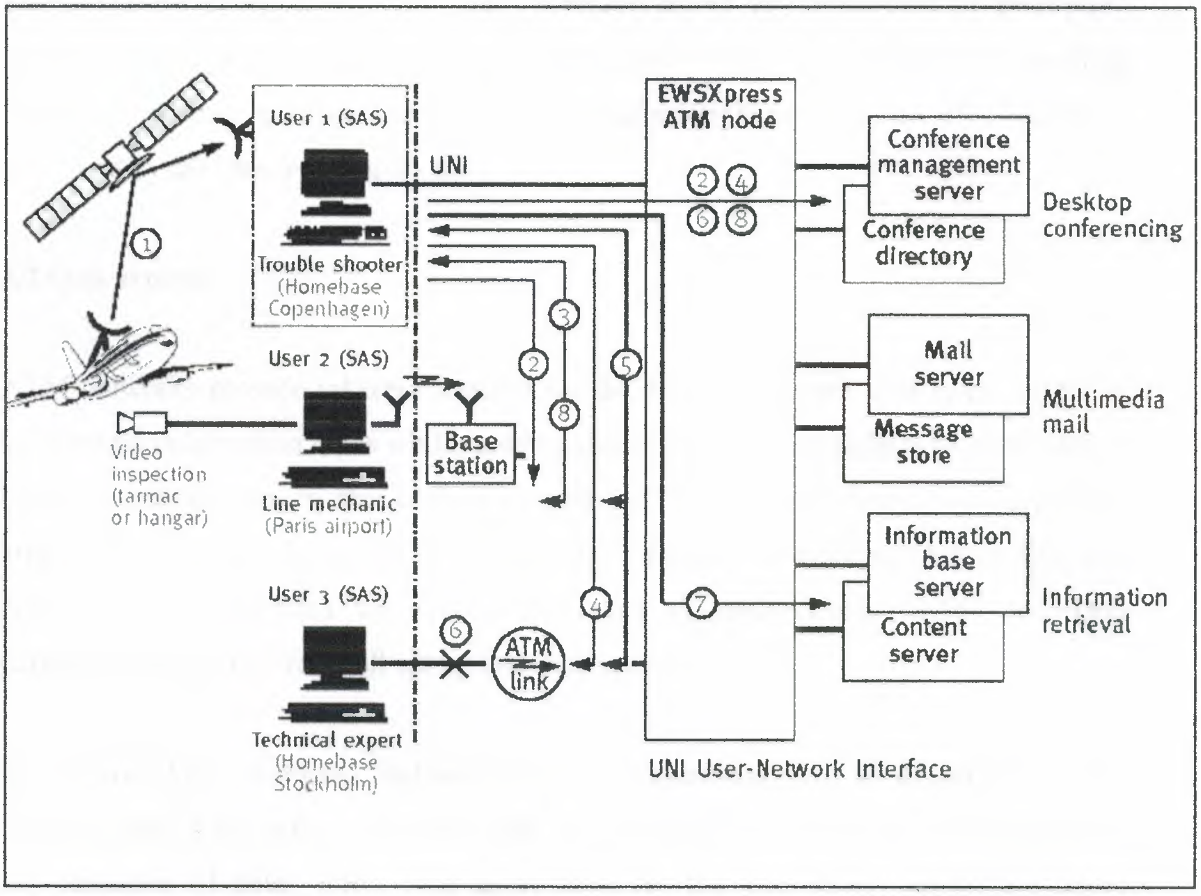

Figure 3.2 CSCW application case.

3.1.2 CSCW application support by future multimedia desktop conferencing Teleservices

The conference management server and the conference directory in Fig. 8.3 represent the essential functional groups, comprising some of the higher-layer teleservice functions such as association of partners, screening of access and distribution of output. Other advanced multimedia teleservices, such as multimedia mail, are also implemented in dedicated servers attached to network nodes. The lower-layer functions of the teleservice mainly refer to the user plane protocols of the ATM layer and AAL and the control plane signalling protocols up to Layer

The functions in the user plane deal with, for example, the support of multipoint communication configurations. The signaling protocols will enable the flexible handling of multiple parties, multiple information types and multiple connections, which are all perceived by the user as a single call.

3.2 QoS aspects

ATM networks provide inherent features for the efficient support of a large variety of multimedia information types while meeting considerably differing QoS requirements. Important capabilities in this context are: the ATM layer with two cell loss priority levels, cell delay priority levels per VC (Virtual Channel) connection, QoS profiles and AAL protocols adjusted to information types (Vcmultiplexed media) and QoS parameter renegotiation at call set-up and during a call.

In addition AAL protocols include recovery mechanisms such as detection of mis-inserted and lost cells, cell loss recovery, error correction on user data and compensation of delay jitter. Two approaches for the QoS class support are under discussion:

1. Delay and loss sensitive traffic (e.g. video phone) is mapped onto QoS-type-1 VC connections, handled with high priority and based on peak bit rate allocation at VC connection level. In contrast, more delay/loss tolerant bursty traffic (e.g. file transfer) is

mapped onto QoS-type-2 VC connections, allowing statistical multiplexing with high multiplex gain.

2. Further refinement of bandwidth allocation schemes, e.g. based on sustainable cell rate and burst tolerance, and respective traffic control protocols for QoS-type-1 VC connections. Split of QoS type 2 into several QoS types for improving statistical multiplexing.

Approach 1 represents a first refinement of the most basic approach of peak bit rate allocation for all traffic types. The basic idea is to provide an ATM transport mechanism with an excellent overall cell delay and loss performance capable of supporting any real-time traffic (QoS type 1). A promising solution that enables protection of the real-time traffic while allowing a statistical multiplexing of the bursty traffic with a multiplex gain of more than five.

Approach 2 can be considered as a development of approach 1. It follows the same line but refines the bandwidth allocation algorithm for the given QoS levels and introduces more QoS types for bursty traffic.

3.2.1 CSCW Application Support Through Bearer Services

Basic mono-medium ATM bearer services offer a single switched VC connection per call between the network access points (UNIs) of the CSCW conferees.

The characteristics of the connections involved are adjusted to the most demanding information types of the application under consideration. Most functional requirements such as the mapping of different information types onto network connections have to be implemented in end-systems. Switching according to ATM Forum UNI can support conferencing with a point-to-multipoint connection, which allows an automatic add/drop of leaf links via signalling.

User benefits of the CSCW support by mono-medium bearer services lie in the Flexibility offered by switching as well as the high performance (guaranteed

throughput, acceptable transfer delay for real-time traffic). For large user organizations with their own technical support this type of service may very well persist in future ATM networks. In a subsequent step, switched multimedia bearer services already provide all the lower layer functions for the support of CSCW applications such as handling of multiple connections per call and point-to-multipoint communication configurations. This will lead to additional user benefits: support of existing and new multimedia information types, conferencing with selective distribution of information to conferees (matching different terminal capabilities), support emerging ATM-based workstations at the public ATM UNI and support of conference servers in terms of reduced complexity and higher performance.

3.2.2 Standards Definitions

The specification of ATM-layer services is the result of a major effort of many traffic management experts. Traffic Management and Congestion Control issues have now reached stable definition within the international standardization organization ITU-T, and have been specified in detail by the ATM Forum, forming a base for industrial implementation agreements to facilitate interoperability in multivendor implementations.

Recent efforts made on traffic control issues are now resulting in new versions of ITU-T Recommendation I.371 and the ATM Forum Traffic Management Specification Both documents are technically ready and are presently undergoing formal approval.

A unified approach to the definition of ATM-layer services in the ATM Forum and in ITU-T is presented in Table I. Since different names are adopted to define concepts that are very similar in purpose, the differences are more apparent than real. The close relationships that have been established between the two bodies gives a further chance to harmonize the two documents in the course of their parallel development.

Table 3.1 An ATM Service Category (ATM Forum name) or ATM-layer

Correlation of ATM Forum and ITU-T ATM services		
ATM Forum TM4.0 "ATM Service Category"	ITU-T I.371 "ATM Transfer Capability"	Typical use
Constant Bit Rate (CBR)	Deterministic Bit Rate (DBR)	Real-time, QoS guarantees
Real-Time Variable Bit Rate (rt-VBR)	(for further study)	Statistical mux, real-time
Non-Real-Time Variable Bit Rate (nrt-VBR)	Statistical Bit Rate (SBR)	Statistical mux
Available Bit Rate (ABR)	Available Bit Rate (ABR)	Resource exploitation, feedback control
Unspecified Bit Rate (UBR)	(no equivalent)	Best effort, no guarantees
(no equivalent)	ATM Block Transfer (ABT)	Burst level feedback control

A first classification of these services/capabilities may be seen from a network resource allocation viewpoint. We can identify:

1) A category based on a constant (maximum) bandwidth allocation. This is called Constant Bit Rate (CBR) in the ATM Forum and Deterministic Bit Rate (DBR) in ITU-T;

2) A category based on a statistical (average) bandwidth allocation. This corresponds to the ATM Forum Variable Bit Rate (VBR) and ITU-T Statistical Bit Rate (SBR). The ATM Forum further divides VBR into real-time (rt-VBR) and non-real-time (nrt-VBR), depending on the QoS requirements. A further partitioning, commonly adopted, defines three VBR sub-classes depending on the conformance criteria adopted;

3) A category based on "elastic" bandwidth allocation, where the amount of reserved resources varies with time, depending on network availability. This is

the Available Bit Rate (ABR). The same name is used both in the ATM Forum and ITU-T;

4) A category considered only in the ATM Forum is the Unspecified Bit Rate (UBR). No explicit resource allocation is performed; neither bandwidth nor QoS objectives are specified;

5) A further category is considered in ITU-T only, and is based on block (or burst) allocation. This is called ATM Block Transfer (ABT). The feature of this class is the idea that network resources can be negotiated and allocated on a per block basis rather than on a per connection basis.

3. 3 The ATM Service Architecture

The ATM Service Architecture makes use of procedures and parameters for traffic control and congestion control whose primary role is to protect the network and the end-system in order to achieve network performance objectives. An additional role is to optimize the use of network resources. The design of these functions is also aimed at reducing network and end-system complexity while maximizing network utilization. To meet these objectives, the set of functions forming the framework for managing and controlling traffic and congestion can be used in appropriate combinations.

ATM Service Category (or Transfer Capability) relates quality requirements and traffic characteristics to network behavior (procedures and parameters). It is intended to specify a combination of Quality of and traffic parameters that is suitable for a given set of applications (user interpretation) and that allows for specific multiplexing schemes at the ATM layer (network interpretation).

A Service Category used on a given ATM connection, among those that are made available by the network, has to be implicitly or explicitly declared at connection set-up. All service categories apply to both Virtual Channel Connections (VCCs) and Virtual Path Connections (VPCs).

Functions such as Connection Admission Control (CAC), Usage Parameter Control (UPC), Feedback Controls, Resource Allocation, etc., are made available within the ATM node equipment and are, in general, structured differently for each Service Category. The CAC and UPC procedures implementation are network specific.

3.3.1 Generic Network Functions

Connection Admission Control (CAC) is defined as the set of actions taken by the network during the call (virtual connection) set-up phase, or during call re-negotiation phase, to determine whether a connection request can be accepted or rejected. Network resources (port bandwidth and buffer space) are reserved to the incoming connection at each switching element traversed, if so required, by the service category.

Usage Parameter Control (UPC) or Policing is defined as the set of actions taken by the network to monitor and control the traffic offered and the validity of the ATM connection at the User to Network Interface (UNI). It is an essential requirement for any network supporting multiple services. The main purpose of UPC is to protect network resources from malicious and unintentional misbehavior, which can affect the QoS of other already established connections. Procedures based on a Generic Cell Rate Algorithm (GCRA) may be applied to each cell arrival to assess conformance with respect to the traffic contract for the connection. Violations of negotiated parameters are detected and appropriate actions can be taken (eg. cell tagging, discard).

Feedback Controls are defined as the set of actions taken by the network and by the end-systems (possibly cooperating) to regulate the traffic submitted on ATM connections according to the state of network elements. Specific Feedback Control procedures may be associated with a service category.

3.3.2 Traffic Parameters

A source traffic parameter describes an inherent characteristic of a source. A set of these parameters constitute a Source Traffic Descriptor which, along with Cell Delay Variation Tolerance (CDVT) and a Conformance Definition, characterize an ATM Connection. The following parameters are considered for the purpose of defining the Service Categories :

Traffic Parameters

1) Peak Cell Rate(PCR)

2) Sustainable Cell Rate (SCR)

3) Maximum Burst Size (MBS)

4) Minimum Cell Rate (MCR)

5) QoS Parameters

The QoS parameters selected to correspond to a network performance objective may be negotiated between the end-systems and the network, e.g., via signaling procedures, or can be taken as default. One or more values of the QoS parameters may be offered on a per connection basis.

QoS Parameters

1) Cell Delay Variation (CDV)

2) Maximum Cell Transfer Delay (Max CTD)

3) Cell Loss Ratio (CLR)

A number of additional QoS parameters have been identified, but their negotiation is not foreseen, e.g., Cell Error Ratio (CER), Severely Errored Cell Block Ratio (SECBR), Cell Misinsertion Rate (CMR).

3.3.3 Traffic Contract and Negotiation

A traffic contract specifies the negotiated characteristics of a VP/VC connection at an ATM User Network Interface (either Private or Public UNI). The traffic contract at the Public UNI shall consist of a connection traffic descriptor and a set of QoS parameters for each direction of the ATM layer connection and shall include the definition of a compliant connection. The values of the traffic contract parameters can be specified either explicitly or implicitly. A parameter value is explicitly specified in the initial call establishment message. This can be accomplished via signalling for SVCs (Switched Virtual Connections) or via the Network Management System (NMS) for PVCs (Permanent Virtual Connections) or at subscription time. A parameter value is implicitly specified when its value is assigned by the network using default rules.

3.3.3.1. Some Typical Applications

This section identifies some sample applications, which can be seen as appropriate targets for one or more of the defined service categories. These applications are

provided to convey teh original intention and to focus on the possible use of service categories, which broadly relate application aspects to network functionality. However, an application is not constrained by this mappint, and may select any service category consistent with its needs, among those made available by a network.

3.3.3.2 Typical Applications for CBR

Any data/text/image transfer application which contains smooth enough traffic or for which the end-system's response time requirements justify occupying a fully reserved CBR channel. Examples are:

1) Videoconferencing

2) Interactive Audio (e.g., telephony)

3) Audio/Video Distribution (e.g., television, distance learning, pay-per-view)

4) Audio/Video Retrieval (e.g., video-on-demand, audio library)

For telephony and voiceband services over ATM, e.g., 64 kbit/s N-ISDN-compatible services, the access solution based on AAL1 requires CBR support for taking advantage of delay and variance bounds.

In the multimedia area, a near-term solution for residential services foresees VoD based on MPEG2 (Transport Stream, CBR mode) over AAL5, with transportation being provided by the ATM-layer with CBR service.

3.3.3.3 Typical Applications for VBR

VBR is suitable for any application for which the end-system can benefit from statistical multiplexing, by sending information at a variable rate, and can tolerate or recover from a potentially small random loss ratio. It is the case for any constant bit rate source, for which variable rate transmission allows more efficient use of network resources without a sensible performance impairment.

Real-time VBR, in particular, can be used by native ATM voice with bandwidth compression and silence suppression. For some classes of multimedia communications real-time VBR may be very appropriate.

Non-real time VBR can be used for data transfer, e.g., for response-time critical transaction processing applications (e.g., airline reservations, banking transactions, process monitoring) an frame relay interworking.

3.3.3.4 Typical Applications for ABR

Any non-time critical application running over an end-system capable of varying its emission rate can exploit the ABR service.

Examples include LAN interconnection/internetworking services, which are driving the business service market for ATM. These are typically run over router-based protocol stacks like TCP/IP, which can easily vary their emission rate as required by the ABR rate control policy. The support through ABR will likely result in an increased end-to-end performance (goodput). Another application environment suitable for ABR is LAN Emulation.

Other application examples are critical data transfer (e.g., defense information, banking services) super computer applications, and data communications, such as remote procedure call, distributed file services, and computer process swapping/paging.

3.3.3.5 Typical Applications for UBR

UBR can provide a suitable solution for less demanding applications. Most data applications, e.g., file transfer submitted in the background of a workstation with minimal service requirements, are very tolerant to delay and cell loss (store and forward networks are in fact widely used for these applications). Examples may include :

1) Text/Data/Image Transfer, Messaging, Distribution, Retrieval

2) Remote Terminal (e.g., telecommuting)

The above services can take advantage of any spare bandwidth and will profit from the resultant reduced tariffs ("cheap" services).

CONCLUSION

In developing computer networks only data transfer is not sufficient to the users both private and public sectors. Although today's computer are capable of supporting many useful applications, they are inadequate to support voice and audio applications. ATM was developed to support the multimedia applications. ATM delivers important advantages over existing LAN and WAN techologies, including the promise of scalable bandwidths at unprecedented price and performance points and Quality of Service (QoS) quaranties, which facilities new classes of applications such as multimedia. Some of the problems of ATM network are :

1.Achieving a desired quality of service

2.Network and switch complexity and

3.Bandwidth management and congestion control.

In this Project , a performance analysis of an ATM multiplexer is performed by a new congestion control mechanism. For this control mechanism we have analyzed two types of models. We have different sources that generate ATM cells. A High or Low priority is assigned for very generated ATM cell. These cells enter the ATM Multiplexer system with a finite number of identical sources and wait until they are served from the buffer of the multiplexer. In a time slot, only one cell can be transferred from the ATM multiplexer.The source alternates between geometrically distributed ON and OFF cycles. Cells generated in an ON cycle have a high or low priority. We derived equarions, which describe the steady-state behavior of the multiplexer. We also see The increased level of flexibility that is achievable through the introduction of the ATM Service Categories can be exploited in different ways and in a variety of combinations, in association with any VP or VC connection. With this choice of ATM services, the matching of real user needs may be approached in a totally new way. It is expected that the appropriate choice is influenced by a number of factors, such as:

Availability of a set of Service Categories offered by the network;

Actual attainable QoS in the network; this also depends on the resource management policy adopted, traffic engineering, number of nodes crossed and distance;

Capability of the application to cope with some degradation of the ATM-layer transfer characteristics;

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DYNAMIC CHANNEL & BANDWIDTH MANAGEMENT IN ATM NETWORKS

GRADUATION PROJECT
COM – 400

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ABSTRACT

Asynchronous Transfer Mode (ATM) is an extremely high speed, low delay, multiplexing and switching technology that can support any type of user traffic including voice, data, and video applications. ATM is ideally suited to applications that cannot tolerate time delay, as well as for transforming frame delay and IP traffic that are chracterized as busty.

As we enter the 21st century a competitive environment meets us where high-speed virtual networking is the upcoming field of interest. The question, why is taht we choose ATM networks . To answer that we can only say that, ATM networks are not only the highest speed networking in the 1990s. The fact that before ATM, separate networks were required to carry voice, data and video information is alone enough to support its importance. The unique profiles of these traffic types make significantly different demands on network speeds and resources.

Data traffic can tolerate delay, but voice and video cannot. With ATM, however, all of these traffic types can be transmitted or transported across one network (from megabit to gigabit speeds), because ATM can adapt the transmission of cells to the information generated.

ATM works by breaking information into fixed lenght 53-byte data cells. The cells are transported over traditional wire or fiber optic networks at extremely high speeds.

ATM is a connection-oriented protocol; this means that ATM must establish a logical connection to a defined endpoint before this connection can transport data. Calls on each port are assigned a path and a channel identifier that indicates the path or channel over which the cell is to be routed. The connections are called virtual paths or virtual channels.

ATM was designed for user and network provides who require guaranteed real-time transmission of voice, data, and images while also requiring efficient, high performance transport of busty packet data. Hospitals are using ATM to share real-time video and images for long distance consultation during diagnosis and operations. Schools are using ATM to bring students and instructors together, regardless of their locat.

LIST OF ABBREVIATIONS

AAL–1	ATM adaption Layer 1
AAL–2	ATM adaption Layer 2
AAL–3	ATM adaption Layer 3
AAL–4	ATM adaption Layer 4
AAL–5	ATM adaption Layer 5
ABR	available bit rate
ATM	asynchronous transfer mode
ATM UNI	ATM user network interface
BT	burst tolerance
CAC	connection admission control
CBR	constant bit rate
CCITT	Comite Consultif Internationale de Telegraphique et Telephonique
CDV	cell delay variation
CLR	cell loss ratio
CTD	cell transfer delay
IEEE	Institute of Electrical and Electronic Engineers
ITU–T	International Telecommunications Union–Telecommunications Standards Sector
LAN	local-area network
LANE	ATM LAN emulation
LES	LAN emulation server
LUNI	LAN emulation user-network interface
MPOA	multiple protocol over ATM
P-NNI	public network-to-network interface
PCR	peak cell rate
PVC	permanent virtual circuit
RM	resource management
SAD	speech activity detection
SCR	sustained cell rate
SDH/SONET	synchronous digital hierarchy/synchronous optical network
SVC	switched virtual circuit

TCP/IP	transmission control protocol/Internet protocol
UBR	unspecified bit rate
VBR–NRT	variable bit rate–nonreal time
VCC	virtual-channel connections
VPC	virtual-path connections

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INTRODUCTION

End-users and service, information and programme providers, as well as network operators, expect telecommunication facilities to keep pace with their changing needs. They ask for demand-oriented and cost-effective solutions: as in more applications, bandwidth, mobility, intelligence, flexibility, reliability and economy. In office and factory environments the primary motives for new telecom usages are enhanced productivity, cost reduction and improved customer relationships. In homes the important stimuli for the acceptance of new telecom services or products include variety, convenience and personal self-realization.

Recent developments in information processing technology are leading to innovative applications for computers and telecommunications in many businesses (e.g. the publishing sector, health care, travel agencies, real estate agencies and public administrations) and to new services to be provided for entertainment at home. Still-image archiving systems and reference databases, high performance video servers, high-speed transmission of color documents to printing facilities, and multiple access to distributed information banks or remote service centers are typical elements that are assembled into innovative applications.

At the same time advanced co-operative working methods, such as joint processing of common documents by remote users or remote expert consultation by video-conferencing, are being introduced into business. New multimedia applications call for an integration of data, text, graphics, image, video and audio and are gaining importance with increasing demand and with the advent of powerful personal computers and workstations for end-users.
Broadband and multimedia communication applications are typical examples of the growing qualitative and quantitative requirements placed on telecom networks and services (see fig. 1).

Different traffic flow characteristics, such as continuous traffic with constant or variable bit rates or bursty traffic, must be handled in the network. Point-to point and multipoint communication configurations as well as distribution of radio and TV

programmes are necessary. ATM networks offer several advantages because of their underlying principle.

They are

1) Effective usage of network capacity through bandwidth on demand and shared bandwidth between parallel applications.
2) Low transfer delay and support of both non-real-time and real-time applications through the provision of large peak bandwidth of up to 155 Mbit/s to the Telecommunications end-user

Networking characteristics		Supercomputer connection	LAN interconnection	Image transfer	Video-conferencing	Multimedia dialog & mail	Multimedia retrieval	Program transfer	TV distribution	HDTV distribution
User bit rates	<= 10 Mbit/s		■	■	■	■	■		■	
	<= 30 Mbit/s		■	■		■	■	■		■
	> 30 Mbit/s	■						■		■
Traffic flow	CBR				■	■	■	■	■	■
	VBR				■	■	■		■	■
	Bursty Traffic	■	■	■		■	■			
	Point-to-point	■	■	■	■	■	■	■		
Configuration	Multipoint		■	■	■	■		■	■	■
	Distribution								■	■
Symmetry	Unidirectional			■		■		■	■	■
	Bi-directional asymmetric	■	■				■			
	Bi-directional symmetric	■	■		■	■				
Connection Mode	Connection-oriented	■	■	■	■	■	■	■	■	■
	Connectionless		■	■		■	■			

Figure 1 ATM enables breadband and multimedia applications. The highlighted boxews show where ATM adds value.

3) Support of multimedia applications and mixed traffic through VPs and VCs
4) An easy to manage network infrastructure.

The operational advantages offered by ATM technology fully meet the needs of advanced applications. User acceptance of the applications in any business sector will increase dramatically if ATM networks are used to connect computers and other end systems in local sites, as well as between remote sites.

ATM products are based on the international standards of ITU-TS and on the international agreements of The ATM Forum.

Interoperability between the ATM equipment of different manufacturers and gateways to existing LAN/WAN standards mean maximum investment protection to users. ATM equipment costs and network tariffs will take into consideration the huge number of potential users across Europe and will significantly support the introduction and acceptance of the new ATM technology, offering a good relation between price and performance.

ATM technology is the flexible and powerful common platform for Local Area Networks (LAN) and Wide Area Networks (WAN) to increase productivity, to reduce costs and to implement new applications and services.

Today it is clear that ATM products and services will be coming in a stream of developments during the next few years. We can expect continuous progress, but we can also expect that some customers may be impatient for all of the future features of ATM.

Currently ATM standards are stable enough to bring the user very low technology risks in legacy LAN when compared with more consolidated technologies such as FDDI or Fast Ethernet. The economics derived from a cost analysis between ATM and other technologies showed only a slight gap. The only issue still under evaluation is interoperability between multi-vendor devices.

Network *availability* is concerned with the cost-effective planning and maintenance of network resources so that to maximize user connection admissions. The planning aspect is not covered by this paper but the project has described suitable VP layer design algorithms needed to originally configure the ATM layer (given a physical network) so as to meet the traffic predictions. These algorithms include the configuration of the necessary protection resources required by the protection switching mechanism.

For the purposes of this paper we can consider that network operation is generally decomposed into two distinct operational phases. During the *initialization* phase, the network is prepared for service provisioning at a certain service level. During the *normal* phase, the network delivers services, and sees to the active management of its resources

so as to guarantee its service levels under deviations of offered traffic at its edges. This paper is concerned with the dynamic management of bandwidth during the normal phase according to network designs created during the initialization phase.

The initialization phase results in the definition of a suitable network of working VPCs (for carrying user traffic) and admissible routes based on them per source-destination and Class of Service1 (CoS) so that to preserve the performance characteristics of each CoS. Furthermore, for the network to cope gracefully (without affecting the integrity of existing services and its availability to future services) with fault conditions, protection VPCs need also to be planned and the appropriate restoration bandwidth need to be allocated. The initialization activities are undertaken within a single functional component, called *VPC Layer Design (VPC_LD).*

Since user behavior changes dynamically there is a chance that the network may become unbalanced when the bandwidth allocated to VPCs on the existing admissible routes are not in accordance with the quantity of the traffic that it is actually offered to be routed over them.

There are basically two levels at which adaptively to traffic variations should be provided, one at a level of (structural) traffic prediction changes and one at the level of actual traffic fluctuations around the predictions. Therefore, it is reasonable to consider that VPC and routing management is achieved through a two level hierarchy (Figure 2)

The higher level of the hierarchy undertaken by the VPC_LD component, which reconfigures the VPC and routes per class of service whenever the traffic predictions change significantly The level of reconstruction obviously depends on the significance of the changes.

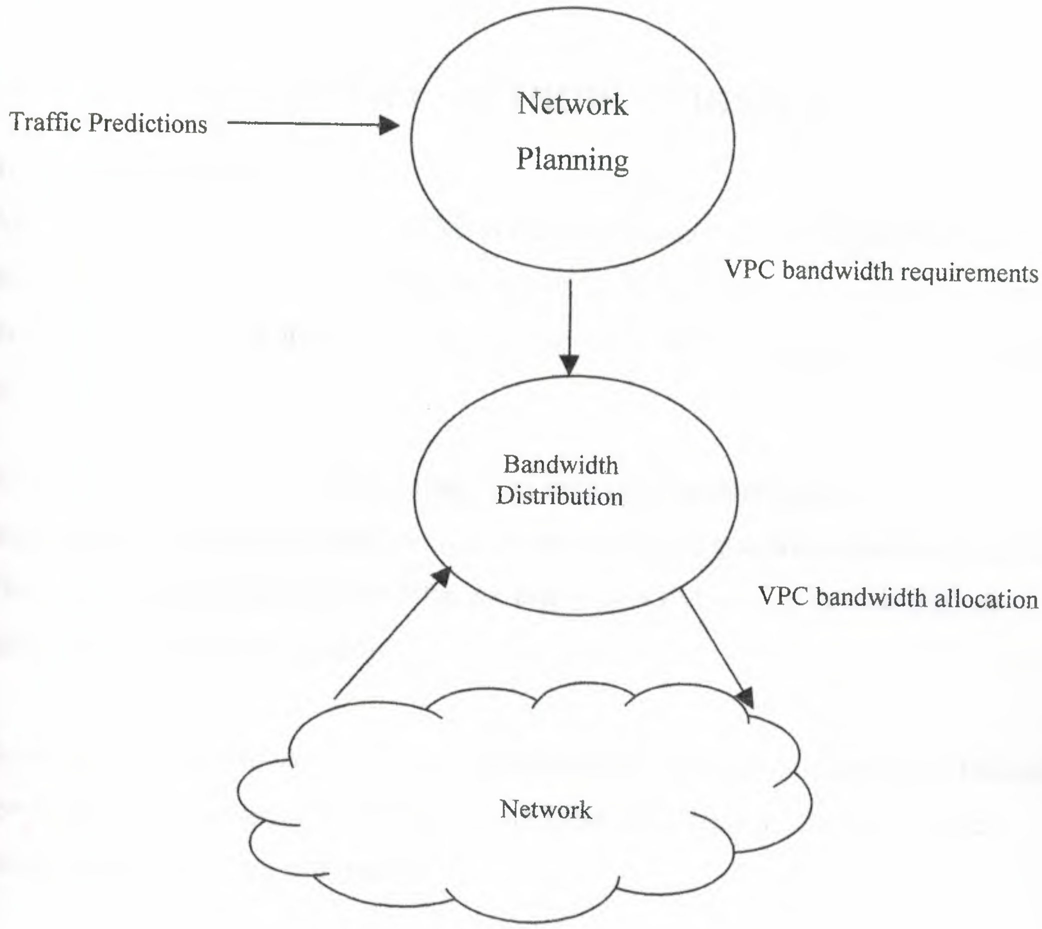

Figure 2 Hierarchical approach to bandwidth management

The lower level in the hierarchy is introduced to compensate for inaccuracies in the traffic predictions and short-term fluctuations in actual load around the predictions. The lower level functionality operates on the set of existing routes and redefines the working VPC bandwidth and route selection parameters.

The above discussion indicates that two further functional components need to play part in the resource and routing management hierarchy: *Bandwidth Distribution* (for updating working VPC bandwidth) and *Load Balancing* (for updating route selection parameters). This paper discusses the objectives, design constraints and proposes an algorithm for the first of these two components: Bandwidth Distribution.

CHAPTER I : INTRODUCTION TO ATM

1.1 ATM Technology

Asynchronous Transfer Mode (ATM) is the world's most widely deployed backbone technology. This standards-based transport medium is widely used within the core--at the access and in the edge of telecommunications systems to send data, video and voice at ultra high,speeds.

ATM is best known for its easy integration with other technologies and for its sophisticated management features that allow carriers to guarantee quality of service. These features are built into the different layers of ATM, giving the protocol an inherently robust set of controls.

Sometimes referred to as cell relay, ATM uses short, fixed-length packets called cells for transport. Information is divided among these cells, transmitted and then re-assembled at their final destination.

1.2 Historical Background of ATM

Everyday the world seems to be moving at a faster and faster pace with new technological advances occurring constantly. In order to deliver new services such as video conferencing and video on demand, as well as provide more bandwidth for the increasing volume of traditional data, the communications industry introduced a technology that provided a common format for services with different bandwidth requirements. This technology is **Asynchronous Transfer Mode (ATM)**. As ATM developed, it became a crucial step in how companies deliver, manage and maintain their goods and services.

ATM was developed because of developing trends in the networking field. The most important parameter is the emergence of a large number of communication services with different, sometimes yet unknown requirements. In this information age, customers are requesting an ever increasing number of new services. The most famous communication services to appear in the future are HDTV(High Definition TV), video conferencing, high speed data transfer, videophony, video library, home education and video on demand.

This large span of requirements introduces the need for one universal network which is flexible enough to provide all of these services in the same way. Two other parameters are the fast evolution of the semi - conductor and optical technology and the evolution in system concept ideas - the shift of superfluous transport functions to the edge of the network.

Both the need for a flexible network and the progress in technology and system concepts led to the definition of the Asynchronous Transfer Mode (ATM) principle. Before there were computers that needed to be linked together to share resources and communicate, telephone companies built an international network to carry telephone calls. These wide area networks (WAN) were optimized to carry multiple telephone calls from one person to another, primarily using copper cable. As time passed, the bandwidth limitations of copper cable became apparent, and these WAN carriers began looking into upgrading their copper cable to fiber cable.

Because of its potential for almost unlimited bandwidth, carriers saw fibers as an essential part of their future. However, other limitations of the voice network still existed. Even though WAN carriers were upgrading to fiber, there were still no agreed upon standards that allowed equipment from different vendors' fiber-based equipment to be integrated together. The short-term solution to this problem was to upgrade to fiber; however, this was costly and time consuming. In addition, the lack of sophisticated network management in these WANs made them difficult to maintain.

Around the same time, computers were becoming more prevalent in the office. Networking these computers together was desirable and beneficial. When linking these computers over a long distance, the existing voice-optimized WANs were used. Because computers send data instead of voice, and data has different characteristics, these WANs did not send computer data very efficiently. Therefore, separate WANs were sometimes built specifically to carry data traffic. Also, a network that could carry voice, data and video had been envisioned -something needed to be done.

To address these concerns, ITU-T (formerly CCITT) and other standards groups started work in the 1980s to establish a series of recommendations for the transmission, switching, signaling and control techniques required to implement an intelligent fiber-based network that could solve current limitations and would allow networks to be able

to efficiently carry services of the future. This network was termed Broadband Integrated Services Digital Network (B-ISDN). By 1990, decisions had been made to base B-ISDN on SONET/SDH (Synchronous Optical Network/Synchronous Digital Hierarchy) and ATM.

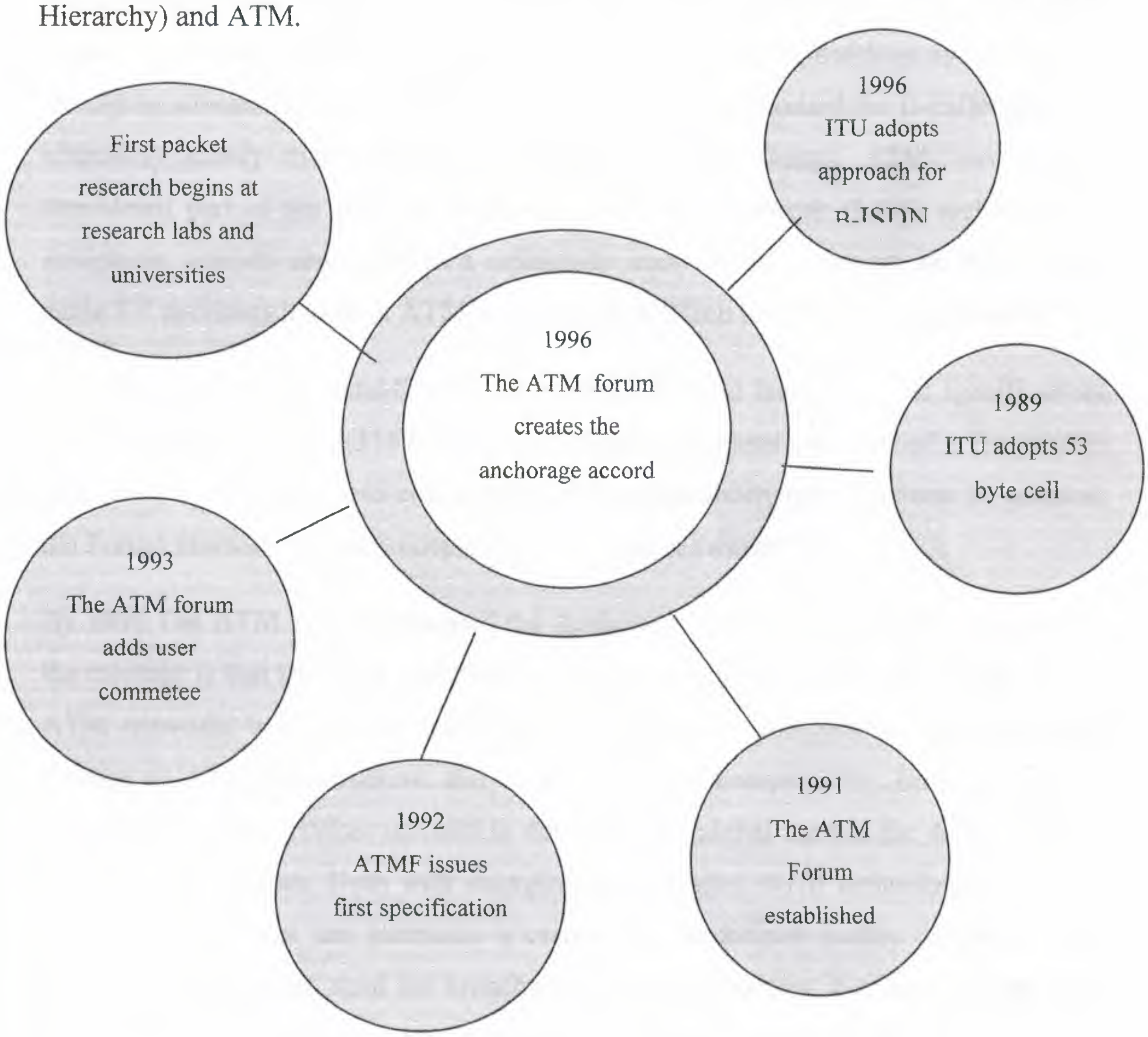

Figure 1.1 Historical Development of ATM

SONET describes the optical standards for transmission of data. SONET/SDH standards specify how information can be packaged, multi-plexed and transmitted over the optical network. An essential element of SONET/SDH is to ensure that optical equipment and services from different vendors/service providers are interoperable and manageable. ITU-T now needed as switching standard to complement SONET in the B-ISDN model. Because SONET only describes the transmission and multiplexing of information, without knowing what type of data or switching is being used, it can operate with nearly

all emerging switching technologies. For B-ISDN, two types of switching were considered by the ITU-T: Synchronous and Asynchronous. An intelligent switching fabric with the ability to switch all forms of traffic at extremely high speeds, while maximizing the use of bandwidth, was needed to optimize the potential of B-ISDN. Ideally, maximum bandwidth should be accessible to all applications and users, and should be allocated on demand. ATM was chosen as the standard for B-ISDN that will ultimately satisfy these stringent requirements. Even though ATM was initially considered part of the solution for WANs, local area network (LAN) architects and equipment vendors saw ATM as a solution to many of their network limitations, and cable TV operators looked at ATM as a possible addition to their existing networks.

The ATM Forum was established in October, 1991 and issued its first specifications eight months later. The ATM Forum was formed to accelerate the user of ATM product and services through a rapid convergence of interoperability specifications. In addition, the Forum promotes industry cooperation and market awareness.

By 1996 The ATM Forum presented the Anchorage Accord objective. Fundamentally, the message is that the set of specifications needed for the development of multi-service ATM networks is available. These specifications were complete to implement and manage an ATM infrastructure, and ensure backward compatibility. Entering the new millennium, ATM services are still in demand. The global market for ATM is in the billions of US dollars. Even with emerging technologies, ATM technology is still the only technology that can guarantee a certain and predefined quality of service. The growth of the Internet, need for broadband access and content, e-commerce and more are spurring the need for a reliable, efficient transport system - ATM Technology. For voice, video, data and images together, the next generation network depends on ATM.

1.3 ATM Standars

Asynchronous Transfer Mode, or ATM is a network transfer technique capable of supporting a wide variety of multimedia application with diverse service and performance requirements. It supports traffic bandwiths ranging from a few kilobites per second to several hundred megabits per second. And traffic types ranging from continuous, fixed-rate traffic to highly bursty traffic. ATM was designated by the telecommunication standardization sector of the International Telecommunication Union (ITU-T)

ATM is a form of packet-switching technology. That is, ATM networks transmit their information in small, fixed-length packets called "cells", each of which contains 48 octets (or bytes) of data and 5 octets of header information. The small, fixed cell size was chosen to facilitate the rapid processing of packets in hardware And to minimize the amount of the time required to fill a single packet. This is particularly important for real-time applications such as voice and video that require short packetization delays

ATM is also connection-oriented. In other words, a virtual connection must be established before a "call" can take place , where a call is defined as the transfer of information between two or more end points.

Another important characteristic of ATM is that its network functions are typically implemented in hardware. With the introduction of high speed fiber optic transmission lines, the communication bottleneck has shifted from the communication links to the processing at switching nodes and at terminal equipment. Hardware implementation is necessary to overcome this bottleneck, because it minimizes the cell processing overhead, thereby allowing the network to match link rates on the order of Gbit/s

Finally , as its name indicates , ATM is asynchronous. Time is slotted into cell-sized intervals, and slots are assigned to calls in an asynchronous, demand-based manner. Because slots are allocated to calls on demand ATM can easily accommodate traffic whose bit rate fluctuates over time . Moreover, in ATM also gains bandwidth efficiency by being able to statistically multiplex bursty traffic sources.
Since bursty traffic does not require continuous allocation of the bandwidth at its peak rate, statistical multiplexing allows a large number of bursty sources to share the network's bandwidth.

Since its birth in the mid-1980s, ATM has been fortified bt a number of robust standards and realized by a significant number of network equipment manufacturers.

International standards-making bodies such as the ITU and independent consortia like the ATM forum have developed a significant body of standards and implementation agrements for ATM

The telecommunication standardization sector of the ITU, the international standards agency commissioned by the United Nations for the global standardization of telecommunication, has developed standards for ATM networks. Other standards bodies and consortia have also contributed to the development of ATM.

1.3.1 Protocol Reference Model

The purpose of the protocol reference model is to clarify the funtions that ATM networks perform by grouping them into a set of interrelated, function-specific layers and planes. The reference model consist of a user plane, a control plane and a management plane. within the user and control planes is a hierarchical set of layers.

The user plane defines a set of functions for the transfer of user information between communication end-points; The conrol plane defines the control functions such as call establishment, call maintanance, and call release; and the management plane defines the operations necessary to control information flow between planes and layers, and to maintain accurate and fault –tolerant network operation.

Within the user and control planes, there are three layers: the physical layer, the ATM layer, and the ATM adaptation layer (ALL).

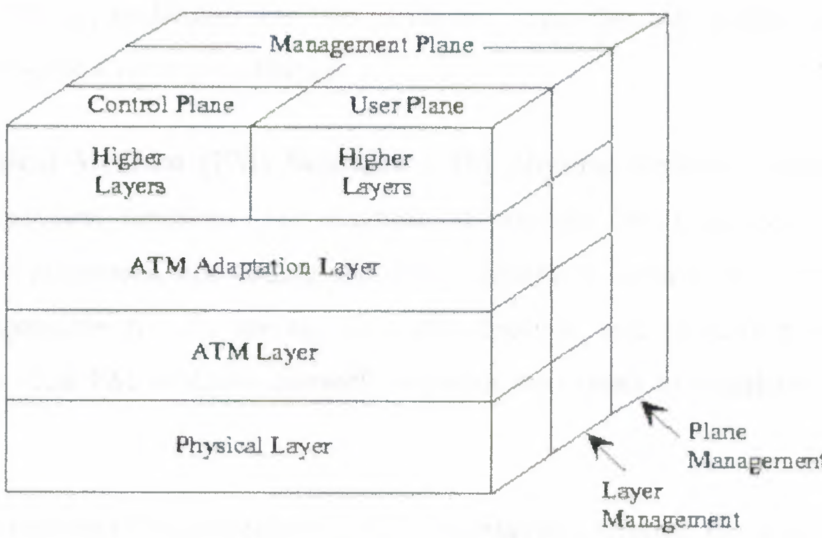

Figure 1.2 Protocol reference model for ATM

Within the user and control planes, there are three layer, the physical layer, the ATM layer,and the ATM adaptation layer (ALL). Table 1.2.2.1 summarizas the functions of

each layer . The physical layer performs primarily bit level functions, the ATM layer is primarily responsible for the switching of ATM cells, and the ATM adaptation layer is responsible for the conversion of higher layer protocol frames into ATM cells. The functions that the physical, ATM, and adaptation layers perform are described in more detail in the following.

Table 1.1 Functions of each layer in the protocol reference model

<table>
<tr><td rowspan="6">Layer Management</td><td>Higher Layer Functions</td><td colspan="2">Higher Layers</td></tr>
<tr><td>Convergence</td><td>CS</td><td rowspan="2">ALL</td></tr>
<tr><td>Segmentation and Reassembly</td><td>SAR</td></tr>
<tr><td>Generic Flow Control
Cell Header Generation/Extraction
Cell VPI/VCI Translation
Cell Multiplex and Demultiplex</td><td colspan="2">ATM</td></tr>
<tr><td>Cell Rate Decoupling
Header Error Control (HEC)
Cell Delineation
Transmission Frame Adaptation
Transmission Frame Generation / Recovery</td><td>TC</td><td rowspan="2">Physical Layer</td></tr>
<tr><td>Bit Timing
Physical Medium</td><td>PM</td></tr>
</table>

1.4 Physical layer

The physical layer is divided into two sublayers: The Physical Medium sublayer and The Transmission Converge sublayer

1.4.1 Physical Medium (PM) Sublayer : The physical medium sublayer performs medium-dependent functions. For example, it provides bit transmission capabilities including bit alignment, line coding and electrical/optical conversion. The PM sublayer is also responsible for bit timing, i.e.., the insertion and extraction of bit timing information. The PM sublayer currently supports two types of interface : optical and electrical

1.4.2 Transmission Convergence (TC) Sublayer : Above the physical medium sublayer is the transmission converge sublayer, which is primarily responsible for the framing of data transported over the physical medium. The ITU_T recomendation specifies two options for TC sublayer transmission frame structure cell-based and Synchronous Digital Hierarchy (SDH). In the cell-based case, cells are transported

continuously without any regular frame structure. Under SDH, cells are carried in a special frame structure based on the north American SONET (Synchronous Optical Network) protocol.

Regardless of which transmission frame structure is used, the TC sublayer is responsible for the following four funtions: Cell rate decoupling, header error control, cell delineation, and transmission frame adaptation. Cell rate decoupling is the insertion of idle cells at the sending side to adapt the ATM cell stream's rate to the rate of the transmission path .

Header error control is the insertion of an 8-bit CRC polynomial in the ATM cell header to protect the contents of the ATM cell header. Cell delineation is the detection of cell boundaries. Transmission frame adaptation is the encapsulation of departing cells into an appropriate framing structure

1.5 ATM Layer

The ATM layer lies a top the physical layer and specifies the functions required for the switching and flow control of ATM cells,There are two interfaces in an ATM network: The user network interface (UNI) between the ATM end point and the ATM switch, and the network-network interface (NNI) between two ATM switches.

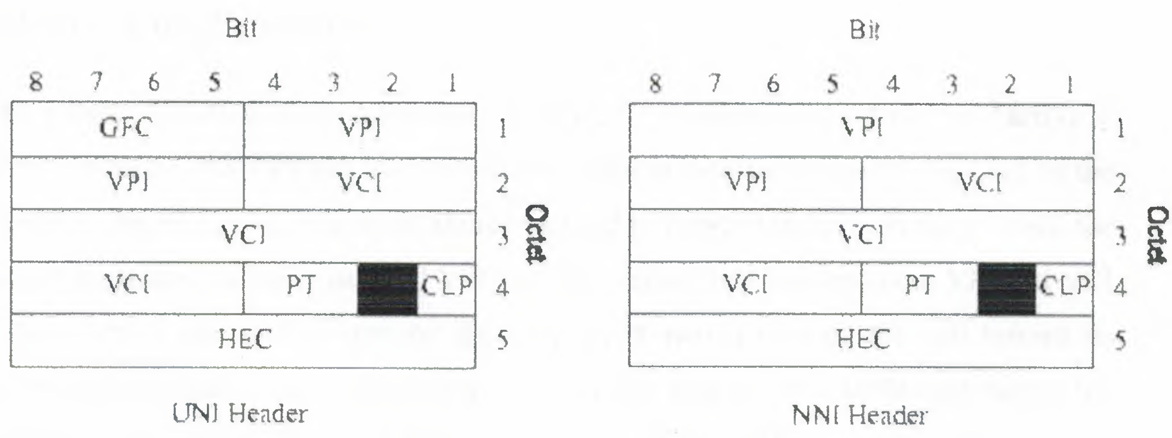

Figure 1.3 ATM cell header structure

Although a 48-octet cell payload is used at both interfaces, the 5 octet cell header differs slightly at these interfaces. Figure 2 shows the cell header structures used at the UNI and NNI At the UNI , the header contains a 4- bit generic flow control (GFC) field, a 24-bit label field containing Virtual Path Identifier (VPI) and Virtual Channel Identifier

(VCI) subfields (8 bits for the VPI and 16 bits for the VCI), a 2-bit payload type (PT) field, a 1-bit priority (PR) field, and an 8-bit header error check (HEC) field. The cell Header for an NNI cell is identical to that for the UNI cell, except that it lacks the GFC field; these four bits are used for an additional 4 VPI bits in the NNI cell header.

The VCI and VPI fields are identifier values for virtual channel (VC) and virtual path (VP), respectively. A virtual channel connects two ATM communication end-points. A virtual path connects two ATM devices, which can be switches or end-points, and several virtual channels may be multiplexed onto the same virtual path.

The 2-bit PT field identifies whether the cell payload contains data or control information. The CLP bit is used by the user for explicit indication of cell loss priority. If the value of the CLP is 1 the the cell is subjected to discarding in case of congestion. The HEC field is an 8 bit CRC polynomial that protects the contents of the cell header.

The GFC field, which appears only at the UNI, is used to assist the customer premises network in controlling the traffic flow for different qualities of service .
At the time of writing the exact procedures for use of this field have not been agreed upon .

1.6 ATM Layer Functions

The primary function of the ATM layer is VPI/VCI translation. As ATM cells arrive at ATM switches, the VPI and VCI values contained in their headers are examined by the switch to determine which outport should be used to forward the cell. In the process, the switch translates the cell's original VPI and VCI values into new outgoing VPI and VCI values, which are used in turn by the next ATM switch to send the cell toward its intended destination. The table used to perform this translation is initialized during the establishment of the call. An ATM switch may either be a VP switch, in which case it only translates the VPI values contained in cell headers, or it may be a VP/VC switch, in which case it translates the incoming VCI value into an outgoing VPI/VCI pair.

Since VPI and VCI values do not represent a unique end-to-end virtual connection. They can be reused at different switches through the network. This is important,

because the VPI and VCI fields are limited in lenght and would be quickly exhausted if they were used simply as destination addresses.

The ATM layer supports two types of virtual connections : switched virtual connection (SVC) and permanent, or semipermanent, virtual connections (PVC). Switched virtual connections are established and torn down dynamically by an ATM signaling procedure. That is they only exist for the duration of a single call.

Permanent virtual connections, on the other hand, are established by networkadministrators and continue to exist as long as the administrator leavesthem up, even if they are not used to transmit data. Other important functions of the ATM layer include cell multiplexing and demultiplexing, cell header creation and extraction, and genericflow control.

Cell multiplexing is the merging of cells from several calls onto a single transmission path , cell header creation is the attachment of a 5- octet cell header to each 48 octet block of user payload, and generic flow control is used at the UNI to orevent short-term overload conditions from occurring within the network

1.7 ATM Layer Service Categories

The ATM Forum and ITU-T have defined several distinct service categories at ATM layer. The categories defined by the ATM forum include constant bit rate (CBR), real-time variable bit rate (VBR-rt), non real-time variable bit rate (VBR-nrt), available bit rate (ABR), and unsipecific bit rate (UBR). ITU-T defines four service categories, namely, deterministic bit rate(DBR), statistical bit rate (SBR), avalable bit rate (ABR) and ATM block transfer(ABT). The first of the three ITU-T service categories correspond roughly to the ATM Forum's CBR,VBR and ABR classifications, respectively .

The fourth service category, ABT, is solely defined by ITU-T ans is intended for bursty data application. The UBR category defined bt the ATM Forum is for calls that request no quality of service guarantees at all. The constant bit rate CBR (or deterministic bit rate DBR) service category provides a very strict QoS guararentee. It is targeted at real-time applications, such as voice and raw video, which mandate severe restrictions on delay, delay variance(jitter) and cell loss rate.

The only traffic description required by the CBR service are the peak cell rate and the cell delay variation tolerance. A fixed amount of bandwidth, determined primarily by the call's peak cell rate, is reservedfor each CBR connection. The real-time variable bit rate VBR-rt (or statistical bit rate SBR) service category is intended for real time bursty application, which also require strict QoS guarantees.

The primary difference CBR and VBR-rt is in the traffic descriptions they use. The VBR-rt service requires the specification of the sustained cell rate and bursty tolerance in addition to the peak cell rate and the cell delay variation tolerance. The ATM Forum also defines a non-real-time VBR-nrt service category, in which cell delay variance is not guaranteed.The available bit rate (ABR) service category is defined to exploit the network's unutilized bandwidth. It is intended for non-real time data application in which the source is amenableto enforced adjustment of its transmission rate.

A minimum cell rate is reserved for the ABR connection and therefore guaranteed by the network. When the network has unutilized bandwidth, ABR sources are allowed to increase their cell rates up to an allowed cell rate (ACR), a value which is periodically updated by the ABR flow control mechanism. The value of ACR always falls between the minimum and the peak cell rate for the connection and is determined by the network

The ATM forum defines another service category for non-real-time application called the unspecified bit rate (UBR) service caregory. UBR service is entirelybest efford; the call is provided with no QoS guarantees. .The ITU-T also defines an additional sewrvice category for non-real-time data applications. The ATM block transfer (ABT) service category is intended for the transmission option (ABT/IT), the block of data is sent at the same time as the reservation request.

If bandwidth is not available for transporting block, then it is simply discarded; and the source must retransmit it. In the ABT service with delayed transmission (ABT/DT); the source waits for a confirmation from the network that enough bandwitdh is available before transmitting the block of tha data. In both cases, the network temprorarily resource reserves bandwitdh according to the peak. Cell rate for each block.Imediately after transporting the block, the network releases the reserved bandwidh.

Table 1.2 ATM layer service categories

ITU-T Service Categories	DBR	SBR	ABT	ABR	
ATM Forum Service Categories	CBR	VBR-rt	VBR-nrt	ABR	UBR
Cell Loss Rate	specified				unspecified
Cell Transfer Delay	specified			unspecified	
Cell Delay Variation	specified		unspecified		
Traffic Descriptors (Contract)	PCR/CDVT	PCR/CDVT SCR/BT		PCR/CDVT MCR/ACR	PCR/CDVT

PCR = Peak Cell Rate SCR = Sustained Cell Rate
CDVT = Cell Delay Variation Tolerance BT = Burst Tolerance
MCR = Minimum Cell Rate ACR = Allowed Cell Rate

1.8 ATM Adaptation Layer

The ATM adaptation layer (AAL), which resides a top ATM layer, is responsible for mapping the requirements of higher layer protocols onto the ATM network. It operates in ATM devices at the edge of the ATM network and is totally up sent in ATM switches. The adaptation layer is divided into two sublayers: The convergence sublayer (CS), which performs error detection and handling, timing and clock recovery and the segmentation and reassembly (SAR) sublayer, which performs segmentation of convergence sublayer protocol data units (PDUs) into ATM cell-sized SAR sublayer service data units data units (SDUs) and vice versa In order to support different service requirements, the ITU-T proposed for AAL-specific services classes.

Note that while these ALL service classes are similar in many ways to the ATM layer service catagories defined in the perivious section, they are not the same; each exists at a different layer of the protocol reference model, and each requires a different set of functions. ALL service class A corresponds to constant bit rate (CBR), services with a timing the relation required between source and destination. The connection mode is connection – oriented . CBR audio and video blong to this class. Class B corresponds to variable bit rate (VBR) services. This class also requires timin between sources and destination , and its mode is connection-oriented. VBR audio and video are examples of class B services. Class C also corresponds to VBR connection –oriented services but the timing between source and destination needs not be related. Class C includes connection-oriented data transfer such as X.25, signaling and future high speed data

services. Class D corresponds to connectionless services. Connectionless data services such as those supported by LANs and WANs are examples of class D services .

Four AAL types , each with a unique SAR supplier and CS sublayer, are defined to support the four service classes. ALL type 1 supports constant bit rate services (Class A), and AAL type 2 supports available bit rate services with a timing relation between source and destination (Class B). ALL type 3 /4 was orginally specified as two different AAL type (Type 3 and Type 4), but due to their inherient similarities, they were eventually merget to support both Class C and Class D services. AAL Type 5 also supports class C and Class D services

Table 1.3 Service Classification for AAL

	Class A	Class B	Class C	Class D
Timing Relation between source and destionation	Required		Not Required	
Bit rate	Constant	Variable		
Connection Mode	Connnection Oriented			Connectionless

1.8.1 ALL Type5

Currently the most widely used adaptation layer is AAL type 5. AAL type 5 supports connection-oriented and connectionless services in which there is no timing relation between source and destination(class C and class D). Its functionality was intentionaly made simple in order to support high speed data transfer. AAL type 5 assumes that the layers above the ATM adaptation layer can perform error recovery. Retransmition and sequence numbering when require and those it does not provide this functions. Therefore, only none assured operation is provided; lost or corrupted AAL type 5 packet will not be corrected by retransmition.

The SAR supplier of AAL type 5 performs segmentation of CS-PDU into a size suitable for the SAR-SDU pay load. Unlike other AAL types, Type 5 devotes the entire 48-octet payload of the ATM cell to the SAR-SDU ; there is no overhead. An AAL specific flag in the ATM Payload Type (PT) Field of the cell header is set when the last cell of a

CS-PDU is sent . the assembly of the CS-PDU frames at the destionation is controlled by using this flag.

it conteins the user data payload, along with any recessary padding bits (PAD) and a CS-PDU trailer, which are added by the CS supplier when it recveives the uder information from the higher layer. the CS–PDU is padded using 0 + 47 bytes of PAD field to make the land of the CS-PDU and integral muliple of 48 bytes (the size of the SAR -SDU) at the receiving end, reassembled PDU is passed to the CS sublayer from the SAR sublayer, CRC values are then calculared and compared.

If there is no error, the PAD field is removed by using the value of lenght field (LF) in the CS-PDU trailer, and user data is passed to the higher layer. If an error is detected, the erroneous information is either deliverded to the use or discarded according to user 's choice .

1.9 ATM Signalling

ATM follows the principle of out-of-band signaling that was establihed for N-ISDN. in other words, signaling and data channels are separate. The main purposes of signaling are:

1) To establish ,maintain and release ATM virtual connections.
2) To negotiate the traffic parameters of new connections.

The ATM signaling standards support the creation of point to point as well as multicast connections. Typically certain VCI and VPI values are reserved by ATM networks for signaling messages. If additional signaling VCs are required, they may be establish through the process of meta-signaling.

CHAPTER II: DEVELOPMENT OF ATM

2.1 ATM in the Telecommunications Infrastructure

A telecommunications network is designed in a series of layers. A typical configuration may have utilized a mix of time division multiplexing, Frame Relay, ATM and/or IP. Within a network, carriers often extend the characteristic strengths of ATM by blending it other technologies, such as ATM over SONET/SDH or DSL over ATM. By doing so, they extend the management features of ATM to other platforms in a very cost-effective manner.

ATM itself consists of a series of layers. The first layer - known as the adaptation layer - holds the bulk of the transmission. This 48-byte payload divides the data into different types. The ATM layer contains five bytes of additional information, referred to as overhead. This section directs the transmission. Lastly, the physical layer attaches the electrical elements and network interfaces.

2.2 ATM as the backbone for other networks

The vast majority (roughly 80 percent) of the world's carriers use ATM in the core of their networks. ATM has been widely adopted because of its unmatched flexibility in supporting the broadest array of technologies, including DSL, IP Ethernet, Frame Relay, SONET/SDH and wireless platforms. It also acts a unique bridge between legacy equipment and the new generation of operating systems and platforms. ATM freely and easily communicates with both, allowing carriers to maximize their infrastructure investment.

2.2.1 ATM in the LAN (Local Area Network)

The LAN environment of a campus or building appears sheltered from the headaches associated with high-volumes of traffic that deluge larger networks. But the changes of LAN interconnection and performance are no less critical. The ATM/LAN relationship recently took a giant step forward when a prominent U.S. vendor announced a patent for its approach to extending ATM's quality of service to the LAN. The filing signals another

birth in a long lineage of applications that prove the staying power and adaptability of ATM.

2.2.2 ATM in the WAN (Wide Area Network)

A blend of ATM, IP and Ethernet options abound in the wide area network. But no other technology can replicate ATM's mix of universal support and enviable management features. Carriers inevitably turn to ATM when they need high-speed transport in the core coupled with the security of a guaranteed level of quality of service. When those same carriers expand to the WAN, the vast majority does so with an ATM layer.

Distance can be a problem for some high-speed platforms. Not so with ATM. The integrity of the transport signal is maintained even when different kinds of traffic are traversing the same network. And because of its ability to scale up to OC-48, different services can be offered at varying speeds and at a range of performance levels.

2.2.3 ATM in the MAN (Metropolitan Area Network)

The MAN is one of the hottest growing areas in data and telecommunications. Traffic may not travel more than a few miles within a MAN, but it's generally doing so over leading edge technologies and at faster-than-lightening speeds.

The typical MAN configuration is a point of convergence for many different types of traffic that are generated by many different sources. The beauty of ATM in the MAN is that it easily accommodates these divergent transmissions, often times bridging legacy equipment with ultra high-speed networks. Today, ATM scales form T-1 to OC-48 at speeds that average 2.5 Gb/s in operation, 10 Gb/s in limited use and spanning up to 40 Gb/s in trials

2.3 Bandwidth Distribution

The Bandwidth Distribution (BD) component is responsible for the management of the bandwidth allocated to working VPCs according to actual traffic conditions. That is, it adjusts the bandwidth allocated to the working VPCs to their actual usage to avoid situations where in the same links some VPCs tend to become over-utilized while other VPCs remain underutilized.

The dynamic management of the working VPC allocated bandwidth is achieved by distributing portions (viewed as a common pool) of the link working bandwidth (link capacity minus restoration bandwidth) among the working VPCs. Specifically, the management of the VPC allocated bandwidth is done within specific (upper and lower) bounds on the VPC bandwidth as originally estimated by VPC_LD (VPC required bandwidth).

The activities of BD are required to compensate for inaccuracies in traffic predictions and in the VPC bandwidth as estimated by VPC_LD as well as to withstand (short to medium) actual traffic variations. This is so, since it cannot be taken for granted that the traffic predictions will be accurate and furthermore even if they are accurate, they are accurate within statistical range. In this respect i.e. considering the random nature of the arriving traffic, the bandwidth that needs to be allocated to VPC, so that certain objectives (regarding connection admission) to be met, is a stochastic variable, depending on the connection arriving pattern. The VPC_LD component estimates originally the bandwidth that needs to be allocated to the VPCs (required bandwidth) so that satisfy traffic predictions. This is viewedas the mean value of the (stochastic in nature) bandwidth that needs to be allocated to the VPCs. It is the task then of the BD component, to manage the allocated bandwidth of VPCs, around the (mean) required bandwidth, according to actual traffic conditions.

By monitoring the usage on working VPCs, the BD component also emits warnings to VPC_LD indicating insufficient usage of the planned network resources. The warnings are issued in cases where some VPCs remain under-utilized (with respect to their required bandwidth as specified by VPC_LD) for a significant period of time. This implies that these resources cannot be utilized in the routes by the Load Balancing component and therefore such cases are interpreted as indicating overestimation of network resources.

ATM is a proven technology that is now in its fourth generation of switches. Its maturity alone is not its greatest asset. Its strength is in its ability to anticipate the market and quickly respond, doing so with the full confidence of the industry behind it.

The proposed algorithm for bandwidth redistribution assumes that there is a common pool of bandwidth per link to be redistributed to the VPCs when necessary. The algorithm assumes that this common pool of bandwidth per link is the links' unallocated bandwidth.

Note, that by its definition, this pool of bandwidth is not totally allocated to the VPCs at any instant; but it is there to be allocated to the VPCs that go highly utilized only when such conditions occur. Each VPC grabs or returns portions of its allocated bandwidth to the common pool of bandwidth according to its congestion level. We assume here that the modification of the bandwidth of a VPC does not impact on the traffic parameters (QoS) of the VCs using this VPC or other VPCs sharing the same links or nodes.

2.4 THE SITUATION IN THE TELECOMMUNICATION WORLD BEFORE ATM

Today's telecommunication networks are characterized by specialization. This means that for every individual telecommunication service at least one network exists that transports this service.

Each of these networks was specially designed for that specific service and is often not at all applicable to transporting another service. When designing the network of the future, one must take into account all possible existing and future services. The networks of today are very specialized and suffer from a large number of disadvantages.

1) **Service Dependence**

Each network is only capable of transporting one specific service .

2) **Inflexibility**

Advances in audio, video and speech coding and compression algorithms and progress in VLSI technology influence the bit rate generated by a certain service and thus change the service requirements for the network. In the future new services with unknown requirements will appear. A specialized network has great difficulties in adapting to new services requirements.

The basic idea behind the concept changes is the fact that functions must not be repeated in the network several times if the required service can still be guaranteed when these functions are only implemented at the boundary of the network.Progress In Technology In recent years large progress has occurred both in field of electronics and in the field of optics.

Broadband communication systems can be developed based on different technologies, the most promising being CMOS. (Complementary Metal Oxide Semiconductor)
Cmos allows high complexity and reasonably high speed (up to 200 to 300 Mbits/s). The low power dissipation of Cmos is particularly important, and allows the realization of high complexity, high speed systems on a very small chip surface.

With the increased complexity per chip, the system cost can easily be reduced since the large integration will continuously allow the volume of the system to shrink or to increase the functionality at a constant cost. Optical technology is also evolving quite rapidly.Optical fiber has been installed for transmission services for several years.

2.6 Performance Requirements from ATM

In the future broadband network a large number of services have to be supported. These services are :

1) low speed like telemetry, low speed data ,telefax
2) medium speed like hifi sounds, video telephony, high speed data
3) very high speed like high quality video, video library .

A single typical service description does not exist. All services have different characteristics both for their average bit rate and burstiness. To anticipate future unknown services we must try to characterize as general a service as possible.

The optimal transfer mode should support the communication of various types of information via an integrated access. Ideally the transfer mode must provide the capability to transport information, whatever type of information is given at the network, very much like the electricity network, which provides power to it's customers without regarding the way the customer uses his electricity. Two other important factors are:

1) Semantic transparency - determines the possibility of network to transport the information error free.

The number of end to end errors introduced by the network is acceptable for the service No system is perfect. Most of the imperfections of telecommunication systems are caused by noise. Other factors contribute to a reduced quality: limited resources causing blocking; any system errors. One of the most important parameters used to characterize imperfections is the BER (bit error rate) - the ratio between erroneous bits and transmitted bits.

2) Time transparency - determines the capability of the network to transport the information through the network from source to destination in a minimal time acceptable for the service.

Time transparency can be defined as the absence of delay and delay jitter(different part of the information arrive at the destination with different delay). The value of end to end delay is an important parameter for real time services, such as voice and video. If the delay becomes too large echo problems may arise in a voice connection.

Table 2.1 The value of end to end delay is an important parameter for real time services

SERVICE	BER	DELAY
Telephony	10^(–7)	25 - 500 ms
Data Transmission	10^(–7)	1000 ms
Broadcast Video	10^(–6)	1000 ms
Hifi Sound	10^(–5)	1000 ms

2.7 ATM Benefits

1. One Network

ATM will provide a single network for all traffic types - voice, data, video. ATM allows for the integration of networks improving efficency and manageability.

2. Enables new applications

Due to its high speed and the integration of traffic types, ATM will enable the creation and expansion of new applications such as multimedia to the desktop.

3. Compatibility

ATM has been designed to be independent to the transmission medium. Because ATM is not based on a specific type of physical transport, it is compatible with currently deployed physical networks. ATM can be transported over twisted pair, coax and fiber optics.

4. Incremental Migration

Efforts within the standards organizations and the ATM Forum continue to assure that embedded networks will be able to gain the benefits of ATM incrementally-upgrading portions of the network based on new application requirements and business needs.

5. Simplified Network Management

ATM is evolving into a standard technology for local, campus/backbone, public and private wide area services. This uniformity is intended to simplify network management by using the same technology for all levels of the network.

6. Long Architectural Lifetime

The information systems and telecomunications industries are focusing and standardizing on ATM. ATM has been designed from the beginning to be scaleable and flexible in: Geographic distance, number of users, access and trunk bandwidths. This scalability and flexibility assures that ATM will be around for a long time.

7. Scaleability

The ATM network can be expanded to accomodate new users without the bandwith available to the existing users being restricted as a result. It is simply a matter of adding more connection modules to the ATM switch serving the user.

2.8 New ATM Service Categories

The introduction of new ATM service categories will increase the benefits of ATM, making the technology suitable for a virtually unlimited range of applications. An ATM network can provide Virtual Path (VP) or Virtual Channel (VC) Connections with different levels of service. The concept of negotiating, for each connection, the behavior expected from the ATM-layer, in terms of traffic and performance, allows users to betteize the application requirements versus the network capabilities.

The first ATM implementations have offered limited options. A typical network behavior, common to most of the first generation ATM networks, is to reserve a fixed amount of bandwidth for each connection for the duration of the call, on the basis of the maximum emission rate of the source (i.e. the "peak cell rate", PCR), and to provide a single level of quality of service. The ATM Service Categories represent new service building-blocks and introduce the possibility for the user to select specific combinations of traffic and performance parameters.

ATM is a multi-service technology. Actually, most of the requirements that are specific to a given application may be resolved at the edges of an ATM network by choosing an 0appropriate ATM Adaptation Layer (AAL). However, by definition, the ATM-layer behaviour should not rely on the AAL protocols, since these are service specific (and are in many cases supported by the user terminal, i.e., outside the core network visibility), nor on higher layer protocols which are application specific. Given the presence of a heterogeneous traffic mix, and the need to adequately control the allocation of network resources for each traffic component, a much greater degree of flexibility, fairness and utilization of the network can be achieved by providing a selectable set of capabilities within the ATM-layer itself. The Service Categories have been defined with this goal in mind. Both users and network operators can benefit from the availability of a selectable set of ATM-layer services. These services are, in effect, the tools, which will allow the promise of ATM to be fully realized.

2.8.1 Customer Perspective

ATM customers (e.g. end user, IT and telecommunications managers) aim at saving on network usage costs, provided that their substantial efficiency and quality requirements are matched. Requirements are variable in nature depending on what application (e.g. data, voice, video, multimedia) is running. As a matter of fact, users that produce variable traffic patterns would like to be able to get bandwidth just when actually needed and, in case of elastic sources, to have fast access to as much available bandwidth as possible, achieving a satisfactory compromise between performance and cost.

2.8.2 Network and Service Operators Perspective

All types of operators that are investing in ATM infrastructures and services aim to achieve maximum utilization of the deployed resources, avoid congestion while being able to share network resources among a large number of customers and fulfill the differing user needs in a cost-effective way. This allows for appropriate tariffing strategies to be deployed. The ability to offer a range of network services, with selectable cost/performance levels, is a key issue for network operators, particularly in a competitive market.

2.9 Service Categories Description

2.9.1 Constant Bit Rate (CBR)

The CBR service category is used by connections that request a fixed (static) amount of bandwidth, characterized by a Peak Cell Rate (PCR) value that is continuously available during the connection lifetime. The source may emit cells at or below the PCR at any time, and for any duration (or may be silent).

This category is intended for real-time applications, i.e., those requiring tightly constrained Cell Transfer Delay (CTD) and Cell Delay Variation (CDV), but is not restricted to these applications. It would be appropriate for voice and video applications, as well as for Circuit Emulation Services (CES).

The basic commitment made by the network is that once the connection is established, the negotiated QoS is assured to all cells conforming to the relevant conformance tests. It is assumed that cells, which are delayed beyond the value specified by Cell Transfer

Delay (CTD), may be of significantly less value to the application.

2.9.2 Real-Time Variable Bit Rate (rt-VBR)

The real-time VBR service category is intended for time-sensitive applications, (i.e., those requiring tightly constrained delay and delay variation), as would be appropriate for voice and video applications. Sources are expected to transmit at a rate which varies with time. Equivalently, the source can be described as "bursty".

Traffic parameters are Peak Cell Rate (PCR), Sustainable Cell Rate (SCR) and Maximum Burst Size (MBS). Cells which are delayed beyond the value specified by CTD are assumed to be of significantly less value to the application. Real-time VBR service may support statistical multiplexing of real-time sources.

2.9.3 Non-Real-Time (nrt-VBR)

The non-real time VBR service category is intended for applications which have bursty traffic characteristics and do not have tight constraints ay and delay variation. As for rt-VBR, traffic parameters are PCR, SCR and MBS. For those cells which are transferred within the traffic contract, the application expects a low Cell Loss Ratio (CLR). For all cells, it expects a bound on the Cell Transfer Delay (CTD). Non-real time VBR service may support statistical multiplexing of connections.

2.9.4 Available Bit Rate (ABR)

The Available Bit Rate (ABR) is a service category intended for sources having the ability to reduce or increase their information rate if the network requires them to do so. This allows them to exploit the changes in the ATM layer transfer characteristics (i.e., bandwidth availability) subsequent to connection establishment.

It is recognized that there are many applications having vague requirements for throughput: they can be expressed as ranges of acceptable values, e.g., a maximum and a minimum, rather than as an average value (that is typical for the VBR category). To meet this requirement on the establishment of an ABR connection, the end-system shall specify a maximum required bandwidth and a minimum usable bandwidth. These are designated as the Peak Cell Rate (PCR) and the Minimum Cell Rate (MCR),

respectively. The MCR may be specified as zero. The bandwidth made available from the network may vary, as it is the sum of an MCR, and a variable cell rate which results from sharing the available capacity among all the active ABR connections via a defined and fair policy. A flow control mechanism is specified which supports several types of feedback to control the source rate. In particular a closed-loop feedback control protocol using Resource Management (RM) cells has been specified in a rate-based framework.

Although no specific QoS parameter is negotiated with the ABR, it is expected that an end-system that adapts its traffic in accordance with the feedback will experience a low Cell Loss Ratio (CLR) and obtain a fair share of the available bandwidth according to a network specific allocation policy. Cell Delay Variation (CDV) is not controlled in this service, although admitted cells are not delayed unnecessarily. ABR service is not (as specified at present) intended to support real-time applications.

A source, destination and network switch behavior is specified by The ATM Forum along with details of the rate-based flow control mechanism.

2.9.5 Unspecified Bit Rate (UBR)

The Unspecified Bit Rate (UBR) service category is a "best effort" service intended for non-critical applications, which do not require tightly constrained delay and delay variation, nor a specified quality of service. UBR sources are expected to transmit non-continuous bursts of cells. UBR service supports a high degree of statistical multiplexing among sources.

UBR service does not specify traffic related service guarantees. Specifically, UBR does not include the notion of a per-connection negotiated bandwidth. There may not be any numerical commitments made as to the cell loss ratio experienced by a UBR connection, or as to the cell transfer delay experienced by cells on the connection.

Table 2.2 Service Category Attributes and Guarantees

Service Category	Traffic Description	Guarantees			Use of Feedback Control
		Min Loss (CLR)	Delay/Variance	Bandwidth	
CBR	PCR	X	X	X	NO
rt-VBR	PCR, SCR, MBS	X	X	X	NO
nrt-VBR	PRC, SCR, MBS	X	NO	X	NO
ABR	PCR, MCR+ behavior parameters	X	NO	X	X
UBR	(PCR)	NO	NO	NO	

CHAPTER III : ATM APPLICATION AREAS

3.1 ATM co-operative multimedia user business cases

This section describes ATM user business cases conducted in a joint effort between network operators, manufacturers of telecommunication and information technology equipment, software companies and end users from different industry sectors. The results are related to multimedia applications in the aircraft and banking industries. Common to both case studies is the concept of computer supported collaborative work (CSCW). Experiences are taken as a basis for deriving functional and technical requirements for supporting ATM networks. The focus lies on the future support of CSCW by teleservices and ATM bearer services in the network. The projects were partially funded by the European Union.

The BANK project (Banking applications using an image and broadband communications network) addresses possible multimedia enhancements of current banking services,

3.1.1 Multimedia banking

The banking and insurance industries are heavy users of information technology and telecommunication services, with almost every business transaction leading immediately to a computer-assisted process. Major banks operating world-wide would be unable to conduct business without efficient telecommunication networks. Banks also increasingly use information technology to serve their customers. An international consortium looked at how self-service banking and advisory support applications for up-to-the-minute analyses of bank products can be used to better serve customers in the future.

The integration of telecommunication and information processing, as well as recent progress in the field of audio and video presentation on computer workstations, is opening up new horizons for marketing and distribution applications. Multimedia product Information consisting of still and moving images, sound or voice sequences, charts, and text can help customers obtain information on the services offered by a bank.

In addition to product presentation, networked multimedia provides an innovative opportunity to hold small video-conferences regardless of distance. High-performance broadband networks are required to provide a high-quality connection; interest here is focused on ATM-based networks, with their capacity for flexible use of bandwidths. Broadband networks are being discussed as an important national infrastructure for the country's economy.

Almost everywhere in Europe, broadband networks are set up and are already interconnected or will be in future. An international consortium has investigated multimedia technology in the banking sector, establishing the BANK (Banking applications using image and broadband communications network) application project.

The high level of customer acceptance of self-service facilities and the increasing efficiency of modern information technology are the driving forces behind an extension of customer self-service, both quantitatively and qualitatively. In the future self-service machines will not only assist in processing transactions, but they will also increasingly serve as a marketing tool, supplying information on more complex products, such as loans, mortgages and investment and portfolio management.

The common feature of these products is that the customer has a number of options regarding the product structure and is therefore often reliant upon advice. In order to preserve the close customer-bank relationship the customer must always have access to the advice of his personal advisor at the bank. Thus the outstanding features of future self-service terminals must be simple operating instructions, high-quality presentation of product information and the opportunity, if required, to obtain advice from bank personnel.

There is a noticeable trend in the banking industry toward differentiation within the sales network. However, the cost of employing a specialist in every branch for each product in the growing product range would be prohibitive, so experts from larger branches offer specialized support to personnel in smaller branches.

Such an improvement would also enable customers at smaller branches to base their investment decisions on expert knowledge available only at the bank's larger branches.

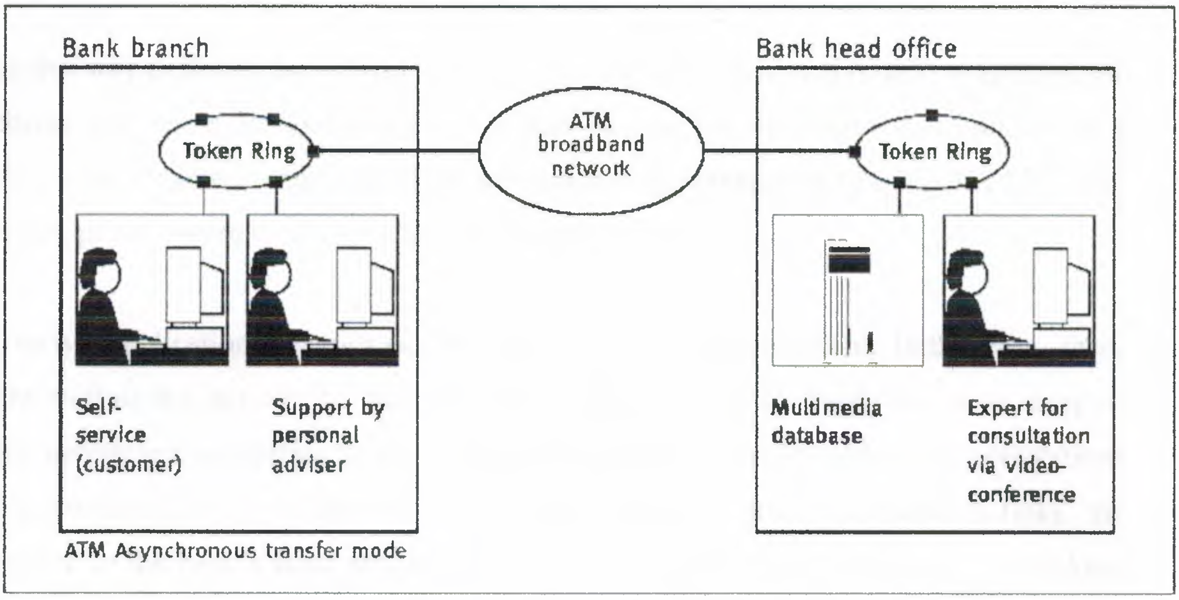

Figure 3.1 ATM network configuration for connections between bank branches and the head office.

In the BANK project, the two commercial scenarios outlined above were implemented on a prototype basis with specific applications.

In the first scenario a multimedia information terminal was created as a supplement to the automatic cash dispenser and statement printer. It consisted essentially of a workstation with a touch screen and equipment for audio and video recording and reproduction. The interest of a passing customer is attracted by a video film about the bank and its products.

By touching the screen the customer is given an overview of the institution's product spectrum and with the aid of the buttons shown on the screen he can select a subject area of interest. Information on the relevant subject is then conveyed by a varied multimedia product presentation, which contains videos, spoken explanations, texts, charts and still images.

Whatever the product, the customer is able to influence the course of the information sequence, for example by requesting more detailed information or carrying out illustrative calculations. If the customer needs more information than that which is

offered he can, at any time and directly from the self-service mode, enter into a video-conference with a customer adviser to discuss any outstanding questions.

In this way customer and adviser can also jointly prepare documents such as application forms and charts for evaluating a portfolio or perform illustrative calculations. In a future development phase, facilities for concluding agreements (e.g. card reader, PIN input, printer, scanner, fax) can also be integrated.

The two application scenarios can be installed in parallel at one bank. In this case there are multimedia self-service machines and workstations at the bank branch to support the investment consultant in his discussion with the customer; additional workstations are connected to a local network (token ring). An ATM broadband network links the branch to the bank's head office where there are experts who, by means of a desktop video-conference, can assist the customer with specialized advice. A multimedia database contains up-to-date information on new products, which can be accessed if required

Options were implemented for the interactive and non-interactive presentation of multimedia documents as well as shared working (joint pointing, joint viewing) for the purposes of a banking application. The functions of shared working were extended with an application-sharing mechanism for OS/2, DOS and Windows applications.

Thiscreates a flexible basis for enabling the applications available at the bank employee's placeof work also to be used in consultations via video-conference if required. Multimedia andbroadband technologies form the basis for innovative self-service equipment in the banking sector, offering new opportunities in the marketing of financial products and creating new sales channels for bank products.

In the BANK project a prototype multimedia system has been developed which can be used both as a self-service unit for bank products as well as an advisory support system for traditional customer service. Apart from pure product information, the system offers integrated desktop video-conference and the opportunity of processing documents jointly (application sharing). For data transfer between the workstations an ATM communications infrastructure was selected.

Multimedia documents with the option of video-conference and integrated application sharing can be used in other scenarios than those implemented. There are a number of other possible applications for such systems, e. g. in commercial education and in-service training. There are also potential applications in office support systems and co-ordination procedures within banks. These applications can overcome the restrictions of a particular location as well as providing enhanced communication with business partners. With sufficient availability of end-user equipment and inexpensive, suitable multimedia services within the public network a similar service can also be offered in the home banking sector.

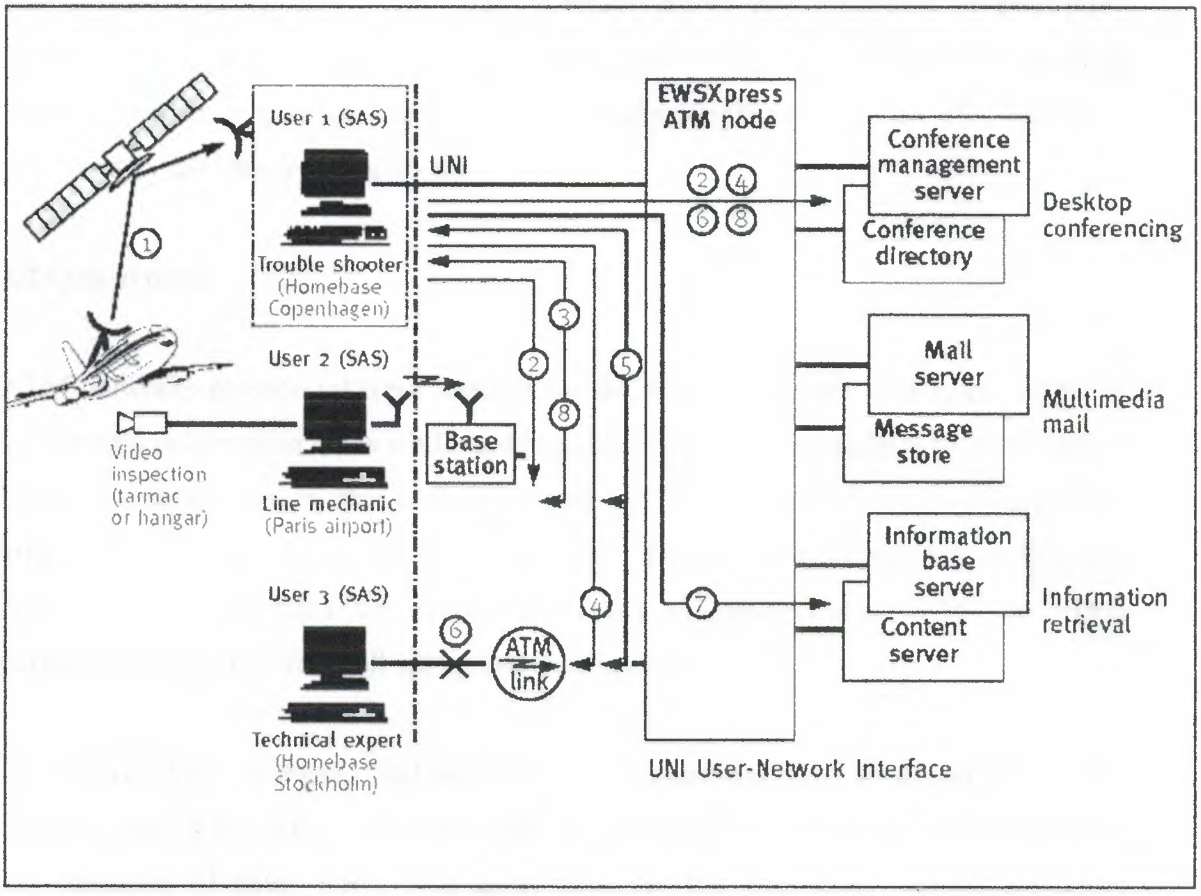

Figure 3.2 CSCW application case.

3.1.2 CSCW application support by future multimedia desktop conferencing Teleservices

The conference management server and the conference directory in Fig. 8.3 represent the essential functional groups, comprising some of the higher-layer teleservice functions such as association of partners, screening of access and distribution of output. Other advanced multimedia teleservices, such as multimedia mail, are also implemented in dedicated servers attached to network nodes. The lower-layer functions of the teleservice mainly refer to the user plane protocols of the ATM layer and AAL and the control plane signalling protocols up to Layer

The functions in the user plane deal with, for example, the support of multipoint communication configurations. The signaling protocols will enable the flexible handling of multiple parties, multiple information types and multiple connections, which are all perceived by the user as a single call.

3.2 QoS aspects

ATM networks provide inherent features for the efficient support of a large variety of multimedia information types while meeting considerably differing QoS requirements. Important capabilities in this context are: the ATM layer with two cell loss priority levels, cell delay priority levels per VC (Virtual Channel) connection, QoS profiles and AAL protocols adjusted to information types (Vcmultiplexed media) and QoS parameter renegotiation at call set-up and during a call.

In addition AAL protocols include recovery mechanisms such as detection of mis-inserted and lost cells, cell loss recovery, error correction on user data and compensation of delay jitter. Two approaches for the QoS class support are under discussion:

1. Delay and loss sensitive traffic (e.g. video phone) is mapped onto QoS-type-1 VC connections, handled with high priority and based on peak bit rate allocation at VC connection level. In contrast, more delay/loss tolerant bursty traffic (e.g. file transfer) is

mapped onto QoS-type-2 VC connections, allowing statistical multiplexing with high multiplex gain.

2. Further refinement of bandwidth allocation schemes, e.g. based on sustainable cell rate and burst tolerance, and respective traffic control protocols for QoS-type-1 VC connections. Split of QoS type 2 into several QoS types for improving statistical multiplexing.

Approach 1 represents a first refinement of the most basic approach of peak bit rate allocation for all traffic types. The basic idea is to provide an ATM transport mechanism with an excellent overall cell delay and loss performance capable of supporting any real-time traffic (QoS type 1). A promising solution that enables protection of the real-time traffic while allowing a statistical multiplexing of the bursty traffic with a multiplex gain of more than five.

Approach 2 can be considered as a development of approach 1. It follows the same line but refines the bandwidth allocation algorithm for the given QoS levels and introduces more QoS types for bursty traffic.

3.2.1 CSCW Application Support Through Bearer Services

Basic mono-medium ATM bearer services offer a single switched VC connection per call between the network access points (UNIs) of the CSCW conferees.

The characteristics of the connections involved are adjusted to the most demanding information types of the application under consideration. Most functional requirements such as the mapping of different information types onto network connections have to be implemented in end-systems. Switching according to ATM Forum UNI can support conferencing with a point-to-multipoint connection, which allows an automatic add/drop of leaf links via signalling.

User benefits of the CSCW support by mono-medium bearer services lie in the Flexibility offered by switching as well as the high performance (guaranteed

throughput, acceptable transfer delay for real-time traffic). For large user organizations with their own technical support this type of service may very well persist in future ATM networks. In a subsequent step, switched multimedia bearer services already provide all the lower layer functions for the support of CSCW applications such as handling of multiple connections per call and point-to-multipoint communication configurations. This will lead to additional user benefits: support of existing and new multimedia information types, conferencing with selective distribution of information to conferees (matching different terminal capabilities), support emerging ATM-based workstations at the public ATM UNI and support of conference servers in terms of reduced complexity and higher performance.

3.2.2 Standards Definitions

The specification of ATM-layer services is the result of a major effort of many traffic management experts. Traffic Management and Congestion Control issues have now reached stable definition within the international standardization organization ITU-T, and have been specified in detail by the ATM Forum, forming a base for industrial implementation agreements to facilitate interoperability in multivendor implementations.

Recent efforts made on traffic control issues are now resulting in new versions of ITU-T Recommendation I.371 and the ATM Forum Traffic Management Specification Both documents are technically ready and are presently undergoing formal approval.

A unified approach to the definition of ATM-layer services in the ATM Forum and in ITU-T is presented in Table I. Since different names are adopted to define concepts that are very similar in purpose, the differences are more apparent than real. The close relationships that have been established between the two bodies gives a further chance to harmonize the two documents in the course of their parallel development.

Table 3.1 An ATM Service Category (ATM Forum name) or ATM-layer

Correlation of ATM Forum and ITU-T ATM services		
ATM Forum TM4.0 "ATM Service Category"	ITU-T I.371 "ATM Transfer Capability"	Typical use
Constant Bit Rate (CBR)	Deterministic Bit Rate (DBR)	Real-time, QoS guarantees
Real-Time Variable Bit Rate (rt-VBR)	(for further study)	Statistical mux, real-time
Non-Real-Time Variable Bit Rate (nrt-VBR)	Statistical Bit Rate (SBR)	Statistical mux
Available Bit Rate (ABR)	Available Bit Rate (ABR)	Resource exploitation, feedback control
Unspecified Bit Rate (UBR)	(no equivalent)	Best effort, no guarantees
(no equivalent)	ATM Block Transfer (ABT)	Burst level feedback control

A first classification of these services/capabilities may be seen from a network resource allocation viewpoint. We can identify:

1) A category based on a constant (maximum) bandwidth allocation. This is called Constant Bit Rate (CBR) in the ATM Forum and Deterministic Bit Rate (DBR) in ITU-T;

2) A category based on a statistical (average) bandwidth allocation. This corresponds to the ATM Forum Variable Bit Rate (VBR) and ITU-T Statistical Bit Rate (SBR). The ATM Forum further divides VBR into real-time (rt-VBR) and non-real-time (nrt-VBR), depending on the QoS requirements. A further partitioning, commonly adopted, defines three VBR sub-classes depending on the conformance criteria adopted;

3) A category based on "elastic" bandwidth allocation, where the amount of reserved resources varies with time, depending on network availability. This is

the Available Bit Rate (ABR). The same name is used both in the ATM Forum and ITU-T;

4) A category considered only in the ATM Forum is the Unspecified Bit Rate (UBR). No explicit resource allocation is performed; neither bandwidth nor QoS objectives are specified;

5) A further category is considered in ITU-T only, and is based on block (or burst) allocation. This is called ATM Block Transfer (ABT). The feature of this class is the idea that network resources can be negotiated and allocated on a per block basis rather than on a per connection basis.

3. 3 The ATM Service Architecture

The ATM Service Architecture makes use of procedures and parameters for traffic control and congestion control whose primary role is to protect the network and the end-system in order to achieve network performance objectives. An additional role is to optimize the use of network resources. The design of these functions is also aimed at reducing network and end-system complexity while maximizing network utilization. To meet these objectives, the set of functions forming the framework for managing and controlling traffic and congestion can be used in appropriate combinations.

ATM Service Category (or Transfer Capability) relates quality requirements and traffic characteristics to network behavior (procedures and parameters). It is intended to specify a combination of Quality of and traffic parameters that is suitable for a given set of applications (user interpretation) and that allows for specific multiplexing schemes at the ATM layer (network interpretation).

A Service Category used on a given ATM connection, among those that are made available by the network, has to be implicitly or explicitly declared at connection set-up. All service categories apply to both Virtual Channel Connections (VCCs) and Virtual Path Connections (VPCs).

Functions such as Connection Admission Control (CAC), Usage Parameter Control (UPC), Feedback Controls, Resource Allocation, etc., are made available within the ATM node equipment and are, in general, structured differently for each Service Category. The CAC and UPC procedures implementation are network specific.

3.3.1 Generic Network Functions

Connection Admission Control (CAC) is defined as the set of actions taken by the network during the call (virtual connection) set-up phase, or during call re-negotiation phase, to determine whether a connection request can be accepted or rejected. Network resources (port bandwidth and buffer space) are reserved to the incoming connection at each switching element traversed, if so required, by the service category.

Usage Parameter Control (UPC) or Policing is defined as the set of actions taken by the network to monitor and control the traffic offered and the validity of the ATM connection at the User to Network Interface (UNI). It is an essential requirement for any network supporting multiple services. The main purpose of UPC is to protect network resources from malicious and unintentional misbehavior, which can affect the QoS of other already established connections. Procedures based on a Generic Cell Rate Algorithm (GCRA) may be applied to each cell arrival to assess conformance with respect to the traffic contract for the connection. Violations of negotiated parameters are detected and appropriate actions can be taken (eg. cell tagging, discard).

Feedback Controls are defined as the set of actions taken by the network and by the end-systems (possibly cooperating) to regulate the traffic submitted on ATM connections according to the state of network elements. Specific Feedback Control procedures may be associated with a service category.

3.3.2 Traffic Parameters

A source traffic parameter describes an inherent characteristic of a source. A set of these parameters constitute a Source Traffic Descriptor which, along with Cell Delay Variation Tolerance (CDVT) and a Conformance Definition, characterize an ATM Connection. The following parameters are considered for the purpose of defining the Service Categories :

Traffic Parameters

1) Peak Cell Rate(PCR)

2) Sustainable Cell Rate (SCR)

3) Maximum Burst Size (MBS)

4) Minimum Cell Rate (MCR)

5) QoS Parameters

The QoS parameters selected to correspond to a network performance objective may be negotiated between the end-systems and the network, e.g., via signaling procedures, or can be taken as default. One or more values of the QoS parameters may be offered on a per connection basis.

QoS Parameters

1) Cell Delay Variation (CDV)

2) Maximum Cell Transfer Delay (Max CTD)

3) Cell Loss Ratio (CLR)

A number of additional QoS parameters have been identified, but their negotiation is not foreseen, e.g., Cell Error Ratio (CER), Severely Errored Cell Block Ratio (SECBR), Cell Misinsertion Rate (CMR).

3.3.3 Traffic Contract and Negotiation

A traffic contract specifies the negotiated characteristics of a VP/VC connection at an ATM User Network Interface (either Private or Public UNI). The traffic contract at the Public UNI shall consist of a connection traffic descriptor and a set of QoS parameters for each direction of the ATM layer connection and shall include the definition of a compliant connection. The values of the traffic contract parameters can be specified either explicitly or implicitly. A parameter value is explicitly specified in the initial call establishment message. This can be accomplished via signalling for SVCs (Switched Virtual Connections) or via the Network Management System (NMS) for PVCs (Permanent Virtual Connections) or at subscription time. A parameter value is implicitly specified when its value is assigned by the network using default rules.

3.3.3.1. Some Typical Applications

This section identifies some sample applications, which can be seen as appropriate targets for one or more of the defined service categories. These applications are

provided to convey teh original intention and to focus on the possible use of service categories, which broadly relate application aspects to network functionality. However, an application is not constrained by this mappint, and may select any service category consistent with its needs, among those made available by a network.

3.3.3.2 Typical Applications for CBR

Any data/text/image transfer application which contains smooth enough traffic or for which the end-system's response time requirements justify occupying a fully reserved CBR channel. Examples are:

1) Videoconferencing

2) Interactive Audio (e.g., telephony)

3) Audio/Video Distribution (e.g., television, distance learning, pay-per-view)

4) Audio/Video Retrieval (e.g., video-on-demand, audio library)

For telephony and voiceband services over ATM, e.g., 64 kbit/s N-ISDN-compatible services, the access solution based on AAL1 requires CBR support for taking advantage of delay and variance bounds.

In the multimedia area, a near-term solution for residential services foresees VoD based on MPEG2 (Transport Stream, CBR mode) over AAL5, with transportation being provided by the ATM-layer with CBR service.

3.3.3.3 Typical Applications for VBR

VBR is suitable for any application for which the end-system can benefit from statistical multiplexing, by sending information at a variable rate, and can tolerate or recover from a potentially small random loss ratio. It is the case for any constant bit rate source, for which variable rate transmission allows more efficient use of network resources without a sensible performance impairment.

Real-time VBR, in particular, can be used by native ATM voice with bandwidth compression and silence suppression. For some classes of multimedia communications real-time VBR may be very appropriate.

Non-real time VBR can be used for data transfer, e.g., for response-time critical transaction processing applications (e.g., airline reservations, banking transactions, process monitoring) an frame relay interworking.

3.3.3.4 Typical Applications for ABR

Any non-time critical application running over an end-system capable of varying its emission rate can exploit the ABR service.

Examples include LAN interconnection/internetworking services, which are driving the business service market for ATM. These are typically run over router-based protocol stacks like TCP/IP, which can easily vary their emission rate as required by the ABR rate control policy. The support through ABR will likely result in an increased end-to-end performance (goodput). Another application environment suitable for ABR is LAN Emulation.

Other application examples are critical data transfer (e.g., defense information, banking services) super computer applications, and data communications, such as remote procedure call, distributed file services, and computer process swapping/paging.

3.3.3.5 Typical Applications for UBR

UBR can provide a suitable solution for less demanding applications. Most data applications, e.g., file transfer submitted in the background of a workstation with minimal service requirements, are very tolerant to delay and cell loss (store and forward networks are in fact widely used for these applications). Examples may include :

1) Text/Data/Image Transfer, Messaging, Distribution, Retrieval
2) Remote Terminal (e.g., telecommuting)

The above services can take advantage of any spare bandwidth and will profit from the resultant reduced tariffs ("cheap" services).

CONCLUSION

In developing computer networks only data transfer is not sufficient to the users both private and public sectors. Although today's computer are capable of supporting many useful applications, they are inadequate to support voice and audio applications. ATM was developed to support the multimedia applications. ATM delivers important advantages over existing LAN and WAN techologies, including the promise of scalable bandwidths at unprecedented price and performance points and Quality of Service (QoS) quaranties, which facilities new classes of applications such as multimedia. Some of the problems of ATM network are :

1.Achieving a desired quality of service

2.Network and switch complexity and

3.Bandwidth management and congestion control.

In this Project , a performance analysis of an ATM multiplexer is performed by a new congestion control mechanism. For this control mechanism we have analyzed two types of models. We have different sources that generate ATM cells. A High or Low priority is assigned for very generated ATM cell. These cells enter the ATM Multiplexer system with a finite number of identical sources and wait until they are served from the buffer of the multiplexer. In a time slot, only one cell can be transferred from the ATM multiplexer.The source alternates between geometrically distributed ON and OFF cycles. Cells generated in an ON cycle have a high or low priority. We derived equarions, which describe the steady-state behavior of the multiplexer. We also see The increased level of flexibility that is achievable through the introduction of the ATM Service Categories can be exploited in different ways and in a variety of combinations, in association with any VP or VC connection. With this choice of ATM services, the matching of real user needs may be approached in a totally new way. It is expected that the appropriate choice is influenced by a number of factors, such as:

Availability of a set of Service Categories offered by the network;

Actual attainable QoS in the network; this also depends on the resource management policy adopted, traffic engineering, number of nodes crossed and distance;

Capability of the application to cope with some degradation of the ATM-layer transfer characteristics;

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NEAR EAST UNIVERSITY

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DYNAMIC CHANNEL & BANDWIDTH MANAGEMENT IN ATM NETWORKS

GRADUATION PROJECT
COM – 400

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ABSTRACT

Asynchronous Transfer Mode (ATM) is an extremely high speed, low delay, multiplexing and switching technology that can support any type of user traffic including voice, data, and video applications. ATM is ideally suited to applications that cannot tolerate time delay, as well as for transforming frame delay and IP traffic that are chracterized as busty.

As we enter the 21st century a competitive environment meets us where high-speed virtual networking is the upcoming field of interest. The question, why is taht we choose ATM networks . To answer that we can only say that, ATM networks are not only the highest speed networking in the 1990s. The fact that before ATM, separate networks were required to carry voice, data and video information is alone enough to support its importance. The unique profiles of these traffic types make significantly different demands on network speeds and resources.

Data traffic can tolerate delay, but voice and video cannot. With ATM, however, all of these traffic types can be transmitted or transported across one network (from megabit to gigabit speeds), because ATM can adapt the transmission of cells to the information generated.

ATM works by breaking information into fixed lenght 53-byte data cells. The cells are transported over traditional wire or fiber optic networks at extremely high speeds.

ATM is a connection-oriented protocol; this means that ATM must establish a logical connection to a defined endpoint before this connection can transport data. Calls on each port are assigned a path and a channel identifier that indicates the path or channel over which the cell is to be routed. The connections are called virtual paths or virtual channels.

ATM was designed for user and network provides who require guaranteed real-time transmission of voice, data, and images while also requiring efficient, high performance transport of busty packet data. Hospitals are using ATM to share real-time video and images for long distance consultation during diagnosis and operations. Schools are using ATM to bring students and instructors together, regardless of their locat.

LIST OF ABBREVIATIONS

AAL–1	ATM adaption Layer 1
AAL–2	ATM adaption Layer 2
AAL–3	ATM adaption Layer 3
AAL–4	ATM adaption Layer 4
AAL–5	ATM adaption Layer 5
ABR	available bit rate
ATM	asynchronous transfer mode
ATM UNI	ATM user network interface
BT	burst tolerance
CAC	connection admission control
CBR	constant bit rate
CCITT	Comite Consultif Internationale de Telegraphique et Telephonique
CDV	cell delay variation
CLR	cell loss ratio
CTD	cell transfer delay
IEEE	Institute of Electrical and Electronic Engineers
ITU–T	International Telecommunications Union–Telecommunications Standards Sector
LAN	local-area network
LANE	ATM LAN emulation
LES	LAN emulation server
LUNI	LAN emulation user-network interface
MPOA	multiple protocol over ATM
P-NNI	public network-to-network interface
PCR	peak cell rate
PVC	permanent virtual circuit
RM	resource management
SAD	speech activity detection
SCR	sustained cell rate
SDH/SONET	synchronous digital hierarchy/synchronous optical network
SVC	switched virtual circuit

TCP/IP transmission control protocol/Internet protocol

UBR unspecified bit rate

VBR–NRT variable bit rate–nonreal time

VCC virtual-channel connections

VPC virtual-path connections

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INTRODUCTION

End-users and service, information and programme providers, as well as network operators, expect telecommunication facilities to keep pace with their changing needs. They ask for demand-oriented and cost-effective solutions: as in more applications, bandwidth, mobility, intelligence, flexibility, reliability and economy. In office and factory environments the primary motives for new telecom usages are enhanced productivity, cost reduction and improved customer relationships. In homes the important stimuli for the acceptance of new telecom services or products include variety, convenience and personal self-realization.

Recent developments in information processing technology are leading to innovative applications for computers and telecommunications in many businesses (e.g. the publishing sector, health care, travel agencies, real estate agencies and public administrations) and to new services to be provided for entertainment at home. Still-image archiving systems and reference databases, high performance video servers, high-speed transmission of color documents to printing facilities, and multiple access to distributed information banks or remote service centers are typical elements that are assembled into innovative applications.

At the same time advanced co-operative working methods, such as joint processing of common documents by remote users or remote expert consultation by video-conferencing, are being introduced into business. New multimedia applications call for an integration of data, text, graphics, image, video and audio and are gaining importance with increasing demand and with the advent of powerful personal computers and workstations for end-users.
Broadband and multimedia communication applications are typical examples of the growing qualitative and quantitative requirements placed on telecom networks and services (see fig. 1).

Different traffic flow characteristics, such as continuous traffic with constant or variable bit rates or bursty traffic, must be handled in the network. Point-to point and multipoint communication configurations as well as distribution of radio and TV

programmes are necessary. ATM networks offer several advantages because of their underlying principle.

They are

1) Effective usage of network capacity through bandwidth on demand and shared bandwidth between parallel applications.
2) Low transfer delay and support of both non-real-time and real-time applications through the provision of large peak bandwidth of up to 155 Mbit/s to the Telecommunications end-user

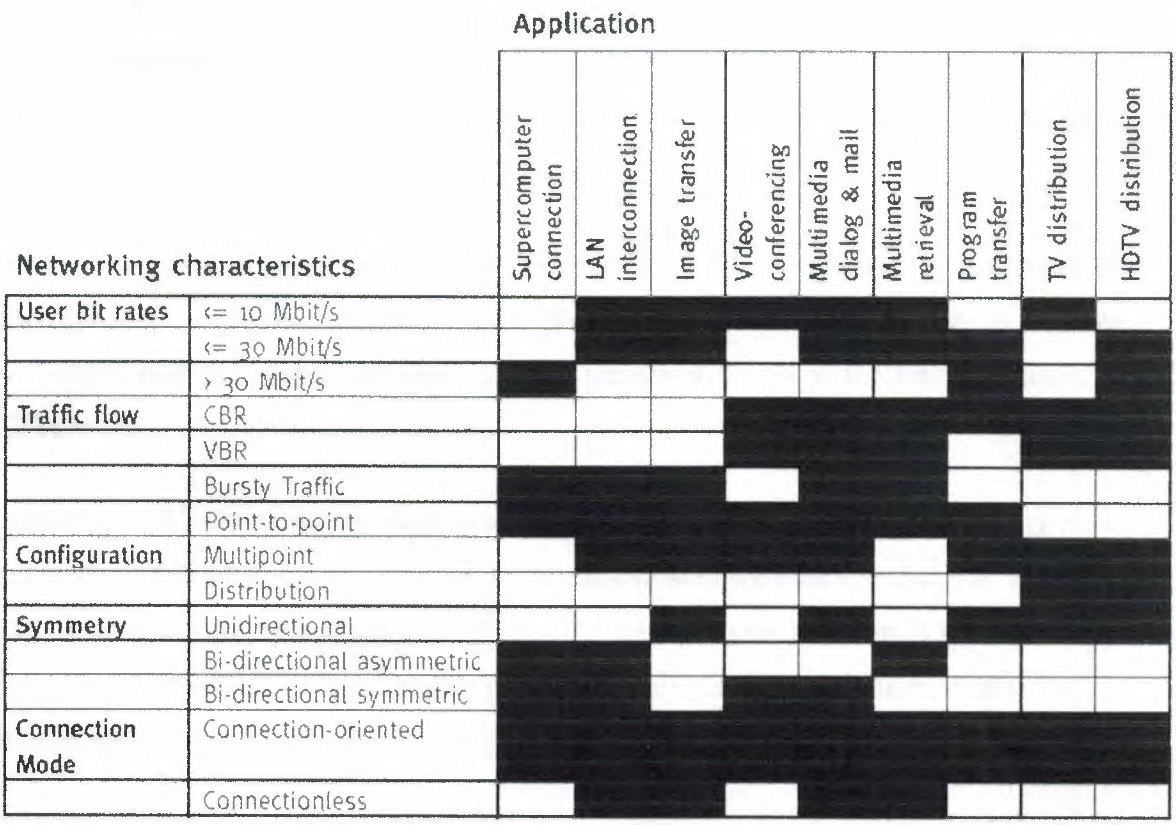

Figure 1 ATM enables breadband and multimedia applications. The highlighted boxews show where ATM adds value.

3) Support of multimedia applications and mixed traffic through VPs and VCs

4) An easy to manage network infrastructure.

The operational advantages offered by ATM technology fully meet the needs of advanced applications. User acceptance of the applications in any business sector will increase dramatically if ATM networks are used to connect computers and other end systems in local sites, as well as between remote sites.

ATM products are based on the international standards of ITU-TS and on the international agreements of The ATM Forum.

Interoperability between the ATM equipment of different manufacturers and gateways to existing LAN/WAN standards mean maximum investment protection to users. ATM equipment costs and network tariffs will take into consideration the huge number of potential users across Europe and will significantly support the introduction and acceptance of the new ATM technology, offering a good relation between price and performance.

ATM technology is the flexible and powerful common platform for Local Area Networks (LAN) and Wide Area Networks (WAN) to increase productivity, to reduce costs and to implement new applications and services.

Today it is clear that ATM products and services will be coming in a stream of developments during the next few years. We can expect continuous progress, but we can also expect that some customers may be impatient for all of the future features of ATM.

Currently ATM standards are stable enough to bring the user very low technology risks in legacy LAN when compared with more consolidated technologies such as FDDI or Fast Ethernet. The economics derived from a cost analysis between ATM and other technologies showed only a slight gap. The only issue still under evaluation is interoperability between multi-vendor devices.

Network *availability* is concerned with the cost-effective planning and maintenance of network resources so that to maximize user connection admissions. The planning aspect is not covered by this paper but the project has described suitable VP layer design algorithms needed to originally configure the ATM layer (given a physical network) so as to meet the traffic predictions. These algorithms include the configuration of the necessary protection resources required by the protection switching mechanism.

For the purposes of this paper we can consider that network operation is generally decomposed into two distinct operational phases. During the *initialization* phase, the network is prepared for service provisioning at a certain service level. During the *normal* phase, the network delivers services, and sees to the active management of its resources

so as to guarantee its service levels under deviations of offered traffic at its edges. This paper is concerned with the dynamic management of bandwidth during the normal phase according to network designs created during the initialization phase.

The initialization phase results in the definition of a suitable network of working VPCs (for carrying user traffic) and admissible routes based on them per source-destination and Class of Service1 (CoS) so that to preserve the performance characteristics of each CoS. Furthermore, for the network to cope gracefully (without affecting the integrity of existing services and its availability to future services) with fault conditions, protection VPCs need also to be planned and the appropriate restoration bandwidth need to be allocated. The initialization activities are undertaken within a single functional component, called *VPC Layer Design (VPC_LD).*

Since user behavior changes dynamically there is a chance that the network may become unbalanced when the bandwidth allocated to VPCs on the existing admissible routes are not in accordance with the quantity of the traffic that it is actually offered to be routed over them.

There are basically two levels at which adaptively to traffic variations should be provided, one at a level of (structural) traffic prediction changes and one at the level of actual traffic fluctuations around the predictions. Therefore, it is reasonable to consider that VPC and routing management is achieved through a two level hierarchy (Figure 2)

The higher level of the hierarchy undertaken by the VPC_LD component, which reconfigures the VPC and routes per class of service whenever the traffic predictions change significantly The level of reconstruction obviously depends on the significance of the changes.

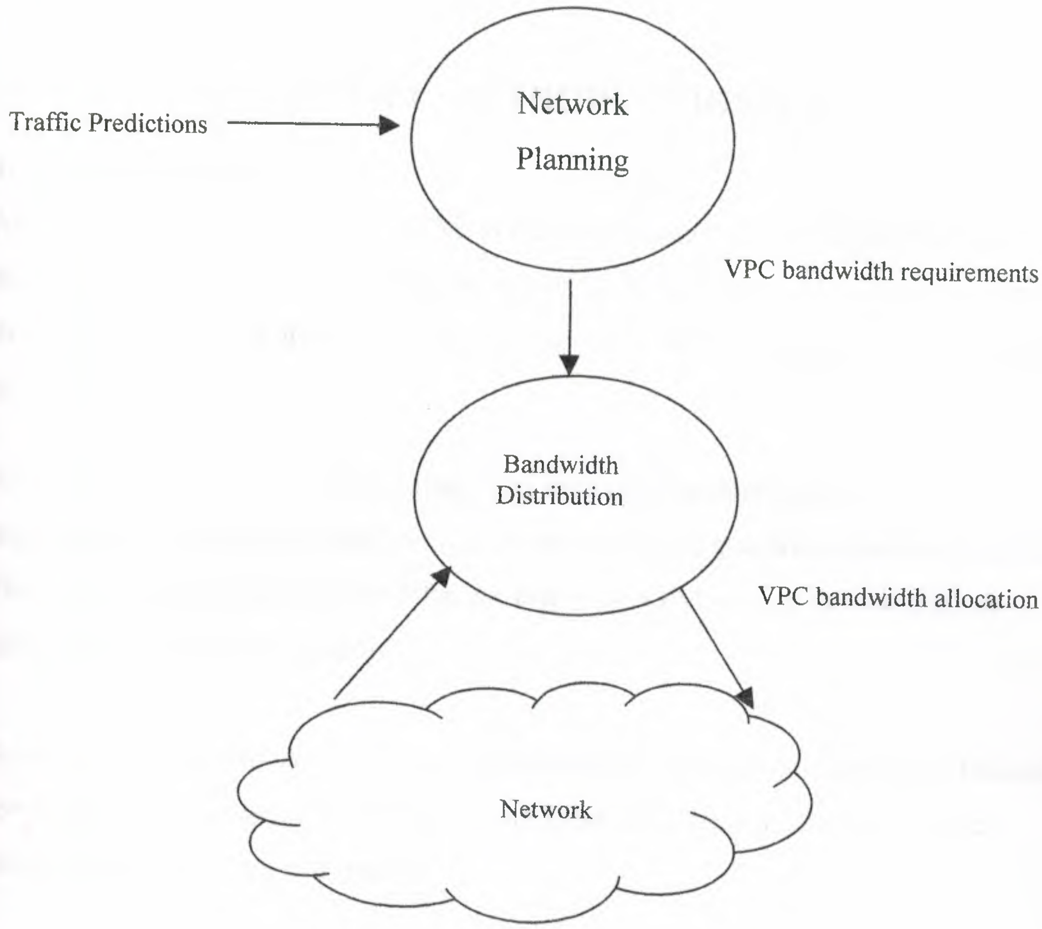

Figure 2 Hierarchical approach to bandwidth management

The lower level in the hierarchy is introduced to compensate for inaccuracies in the traffic predictions and short-term fluctuations in actual load around the predictions. The lower level functionality operates on the set of existing routes and redefines the working VPC bandwidth and route selection parameters.

The above discussion indicates that two further functional components need to play part in the resource and routing management hierarchy: *Bandwidth Distribution* (for updating working VPC bandwidth) and *Load Balancing* (for updating route selection parameters). This paper discusses the objectives, design constraints and proposes an algorithm for the first of these two components: Bandwidth Distribution.

CHAPTER I : INTRODUCTION TO ATM

1.1 ATM Technology

Asynchronous Transfer Mode (ATM) is the world's most widely deployed backbone technology. This standards-based transport medium is widely used within the core--at the access and in the edge of telecommunications systems to send data, video and voice at ultra high,speeds.

ATM is best known for its easy integration with other technologies and for its sophisticated management features that allow carriers to guarantee quality of service. These features are built into the different layers of ATM, giving the protocol an inherently robust set of controls.

Sometimes referred to as cell relay, ATM uses short, fixed-length packets called cells for transport. Information is divided among these cells, transmitted and then re-assembled at their final destination.

1.2 Historical Background of ATM

Everyday the world seems to be moving at a faster and faster pace with new technological advances occurring constantly. In order to deliver new services such as video conferencing and video on demand, as well as provide more bandwidth for the increasing volume of traditional data, the communications industry introduced a technology that provided a common format for services with different bandwidth requirements. This technology is **Asynchronous Transfer Mode (ATM)**. As ATM developed, it became a crucial step in how companies deliver, manage and maintain their goods and services.

ATM was developed because of developing trends in the networking field. The most important parameter is the emergence of a large number of communication services with different, sometimes yet unknown requirements. In this information age, customers are requesting an ever increasing number of new services. The most famous communication services to appear in the future are HDTV(High Definition TV), video conferencing, high speed data transfer, videophony, video library, home education and video on demand.

This large span of requirements introduces the need for one universal network which is flexible enough to provide all of these services in the same way. Two other parameters are the fast evolution of the semi - conductor and optical technology and the evolution in system concept ideas - the shift of superfluous transport functions to the edge of the network.

Both the need for a flexible network and the progress in technology and system concepts led to the definition of the Asynchronous Transfer Mode (ATM) principle. Before there were computers that needed to be linked together to share resources and communicate, telephone companies built an international network to carry telephone calls. These wide area networks (WAN) were optimized to carry multiple telephone calls from one person to another, primarily using copper cable. As time passed, the bandwidth limitations of copper cable became apparent, and these WAN carriers began looking into upgrading their copper cable to fiber cable.

Because of its potential for almost unlimited bandwidth, carriers saw fibers as an essential part of their future. However, other limitations of the voice network still existed. Even though WAN carriers were upgrading to fiber, there were still no agreed upon standards that allowed equipment from different vendors' fiber-based equipment to be integrated together. The short-term solution to this problem was to upgrade to fiber; however, this was costly and time consuming. In addition, the lack of sophisticated network management in these WANs made them difficult to maintain.

Around the same time, computers were becoming more prevalent in the office. Networking these computers together was desirable and beneficial. When linking these computers over a long distance, the existing voice-optimized WANs were used. Because computers send data instead of voice, and data has different characteristics, these WANs did not send computer data very efficiently. Therefore, separate WANs were sometimes built specifically to carry data traffic. Also, a network that could carry voice, data and video had been envisioned -something needed to be done.

To address these concerns, ITU-T (formerly CCITT) and other standards groups started work in the 1980s to establish a series of recommendations for the transmission, switching, signaling and control techniques required to implement an intelligent fiber-based network that could solve current limitations and would allow networks to be able

to efficiently carry services of the future. This network was termed Broadband Integrated Services Digital Network (B-ISDN). By 1990, decisions had been made to base B-ISDN on SONET/SDH (Synchronous Optical Network/Synchronous Digital Hierarchy) and ATM.

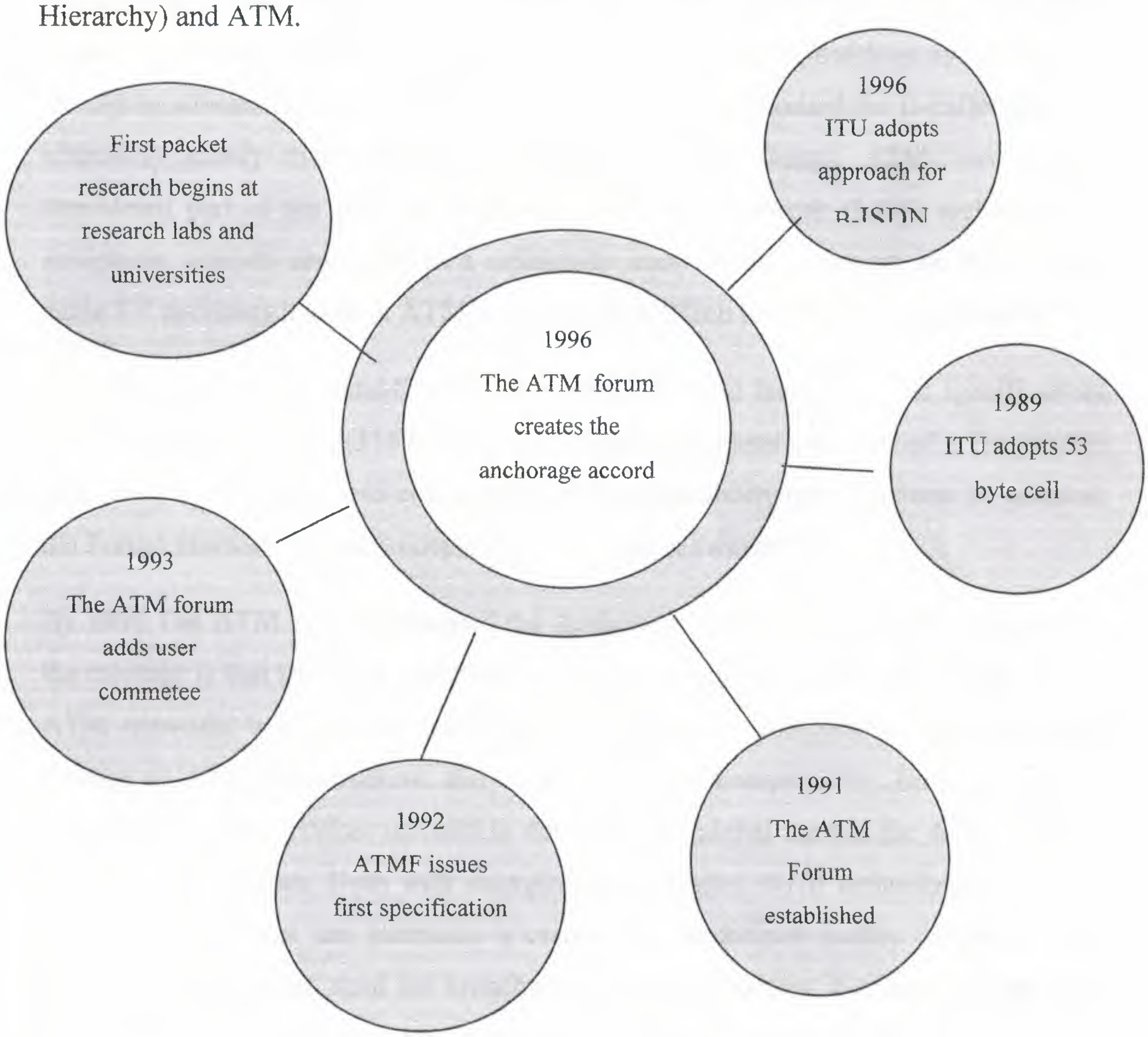

Figure 1.1 Historical Development of ATM

SONET describes the optical standards for transmission of data. SONET/SDH standards specify how information can be packaged, multi-plexed and transmitted over the optical network. An essential element of SONET/SDH is to ensure that optical equipment and services from different vendors/service providers are interoperable and manageable. ITU-T now needed as switching standard to complement SONET in the B-ISDN model. Because SONET only describes the transmission and multiplexing of information, without knowing what type of data or switching is being used, it can operate with nearly

all emerging switching technologies. For B-ISDN, two types of switching were considered by the ITU-T: Synchronous and Asynchronous. An intelligent switching fabric with the ability to switch all forms of traffic at extremely high speeds, while maximizing the use of bandwidth, was needed to optimize the potential of B-ISDN. Ideally, maximum bandwidth should be accessible to all applications and users, and should be allocated on demand. ATM was chosen as the standard for B-ISDN that will ultimately satisfy these stringent requirements. Even though ATM was initially considered part of the solution for WANs, local area network (LAN) architects and equipment vendors saw ATM as a solution to many of their network limitations, and cable TV operators looked at ATM as a possible addition to their existing networks.

The ATM Forum was established in October, 1991 and issued its first specifications eight months later. The ATM Forum was formed to accelerate the user of ATM product and services through a rapid convergence of interoperability specifications. In addition, the Forum promotes industry cooperation and market awareness.

By 1996 The ATM Forum presented the Anchorage Accord objective. Fundamentally, the message is that the set of specifications needed for the development of multi-service ATM networks is available. These specifications were complete to implement and manage an ATM infrastructure, and ensure backward compatibility. Entering the new millennium, ATM services are still in demand. The global market for ATM is in the billions of US dollars. Even with emerging technologies, ATM technology is still the only technology that can guarantee a certain and predefined quality of service. The growth of the Internet, need for broadband access and content, e-commerce and more are spurring the need for a reliable, efficient transport system - ATM Technology. For voice, video, data and images together, the next generation network depends on ATM.

1.3 ATM Standars

Asynchronous Transfer Mode, or ATM is a network transfer technique capable of supporting a wide variety of multimedia application with diverse service and performance requirements. It supports traffic bandwiths ranging from a few kilobites per second to several hundred megabits per second. And traffic types ranging from continuous, fixed-rate traffic to highly bursty traffic. ATM was designated by the telecommunication standardization sector of the International Telecommunication Union (ITU-T)

ATM is a form of packet-switching technology. That is, ATM networks transmit their information in small, fixed-length packets called "cells", each of which contains 48 octets (or bytes) of data and 5 octets of header information. The small, fixed cell size was chosen to facilitate the rapid processing of packets in hardware And to minimize the amount of the time required to fill a single packet. This is particularly important for real-time applications such as voice and video that require short packetization delays

ATM is also connection-oriented. In other words, a virtual connection must be established before a "call" can take place , where a call is defined as the transfer of information between two or more end points.

Another important characteristic of ATM is that its network functions are typically implemented in hardware. With the introduction of high speed fiber optic transmission lines, the communication bottleneck has shifted from the communication links to the processing at switching nodes and at terminal equipment. Hardware implementation is necessary to overcome this bottleneck, because it minimizes the cell processing overhead, thereby allowing the network to match link rates on the order of Gbit/s

Finally , as its name indicates , ATM is asynchronous. Time is slotted into cell-sized intervals, and slots are assigned to calls in an asynchronous, demand-based manner. Because slots are allocated to calls on demand ATM can easily accommodate traffic whose bit rate fluctuates over time . Moreover, in ATM also gains bandwidth efficiency by being able to statistically multiplex bursty traffic sources.
Since bursty traffic does not require continuous allocation of the bandwidth at its peak rate, statistical multiplexing allows a large number of bursty sources to share the network's bandwidth.

Since its birth in the mid-1980s, ATM has been fortified bt a number of robust standards and realized by a significant number of network equipment manufacturers.

International standards-making bodies such as the ITU and independent consortia like the ATM forum have developed a significant body of standards and implementation agrements for ATM

The telecommunication standardization sector of the ITU, the international standards agency commissioned by the United Nations for the global standardization of telecommunication, has developed standards for ATM networks. Other standards bodies and consortia have also contributed to the development of ATM.

1.3.1 Protocol Reference Model

The purpose of the protocol reference model is to clarify the funtions that ATM networks perform by grouping them into a set of interrelated, function-specific layers and planes. The reference model consist of a user plane, a control plane and a management plane. within the user and control planes is a hierarchical set of layers.

The user plane defines a set of functions for the transfer of user information between communication end-points; The conrol plane defines the control functions such as call establishment, call maintanance, and call release; and the management plane defines the operations necessary to control information flow between planes and layers, and to maintain accurate and fault –tolerant network operation.

Within the user and control planes, there are three layers: the physical layer, the ATM layer, and the ATM adaptation layer (ALL).

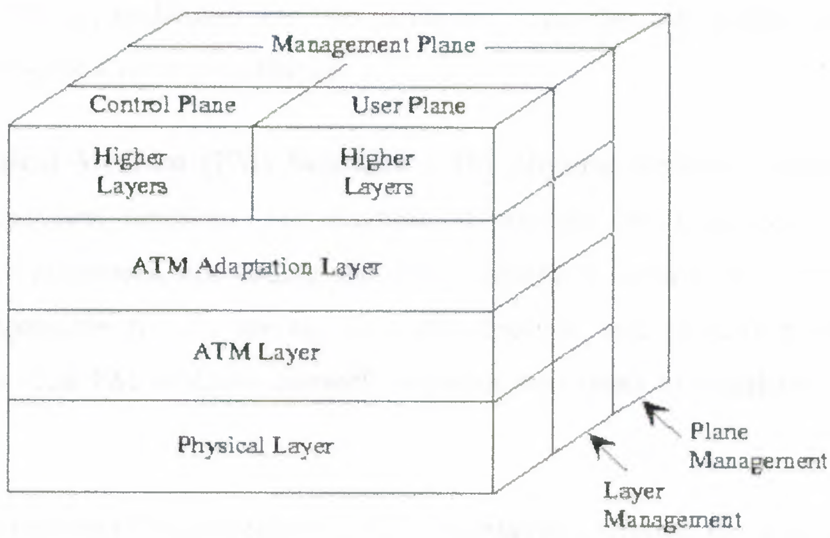

Figure 1.2 Protocol reference model for ATM

Within the user and control planes, there are three layer, the physical layer, the ATM layer,and the ATM adaptation layer (ALL). Table 1.2.2.1 summarizas the functions of

each layer . The physical layer performs primarily bit level functions, the ATM layer is primarily responsible for the switching of ATM cells, and the ATM adaptation layer is responsible for the conversion of higher layer protocol frames into ATM cells. The functions that the physical, ATM, and adaptation layers perform are described in more detail in the following.

Table 1.1 Functions of each layer in the protocol reference model

<table>
<tr><td rowspan="6">Layer Management</td><td>Higher Layer Functions</td><td colspan="2">Higher Layers</td></tr>
<tr><td>Convergence</td><td>CS</td><td rowspan="2">ALL</td></tr>
<tr><td>Segmentation and Reassembly</td><td>SAR</td></tr>
<tr><td>Generic Flow Control
Cell Header Generation/Extraction
Cell VPI/VCI Translation
Cell Multiplex and Demultiplex</td><td colspan="2">ATM</td></tr>
<tr><td>Cell Rate Decoupling
Header Error Control (HEC)
Cell Delineation
Transmission Frame Adaptation
Transmission Frame Generation / Recovery</td><td>TC</td><td rowspan="2">Physical Layer</td></tr>
<tr><td>Bit Timing
Physical Medium</td><td>PM</td></tr>
</table>

1.4 Physical layer

The physical layer is divided into two sublayers: The Physical Medium sublayer and The Transmission Converge sublayer

1.4.1 Physical Medium (PM) Sublayer : The physical medium sublayer performs medium-dependent functions. For example, it provides bit transmission capabilities including bit alignment, line coding and electrical/optical conversion. The PM sublayer is also responsible for bit timing, i.e.., the insertion and extraction of bit timing information. The PM sublayer currently supports two types of interface : optical and electrical

1.4.2 Transmission Convergence (TC) Sublayer : Above the physical medium sublayer is the transmission converge sublayer, which is primarily responsible for the framing of data transported over the physical medium. The ITU_T recomendation specifies two options for TC sublayer transmission frame structure cell-based and Synchronous Digital Hierarchy (SDH). In the cell-based case, cells are transported

continuously without any regular frame structure. Under SDH, cells are carried in a special frame structure based on the north American SONET (Synchronous Optical Network) protocol.

Regardless of which transmission frame structure is used, the TC sublayer is responsible for the following four funtions: Cell rate decoupling, header error control, cell delineation, and transmission frame adaptation. Cell rate decoupling is the insertion of idle cells at the sending side to adapt the ATM cell stream's rate to the rate of the transmission path .

Header error control is the insertion of an 8-bit CRC polynomial in the ATM cell header to protect the contents of the ATM cell header. Cell delineation is the detection of cell boundaries. Transmission frame adaptation is the encapsulation of departing cells into an appropriate framing structure

1.5 ATM Layer

The ATM layer lies a top the physical layer and specifies the functions required for the switching and flow control of ATM cells,There are two interfaces in an ATM network: The user network interface (UNI) between the ATM end point and the ATM switch, and the network-network interface (NNI) between two ATM switches.

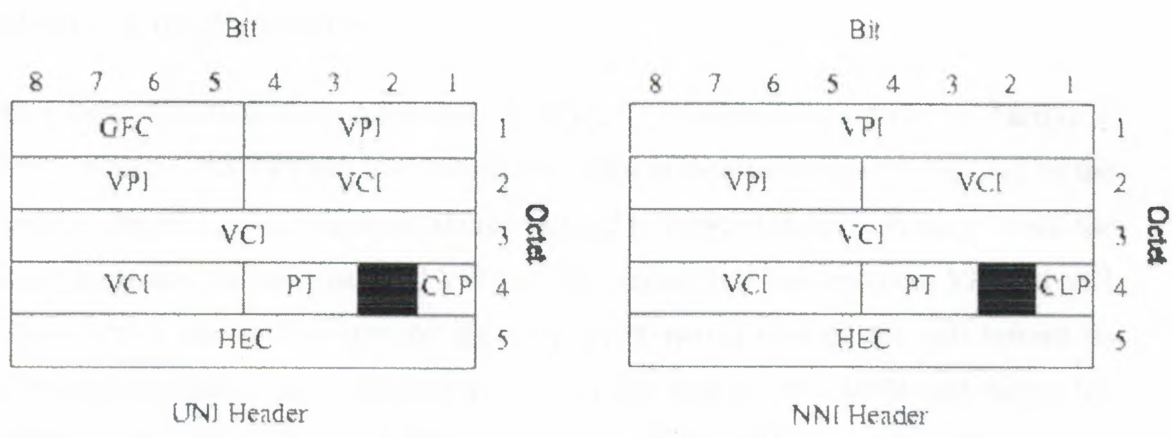

Figure 1.3 ATM cell header structure

Although a 48-octet cell payload is used at both interfaces, the 5 octet cell header differs slightly at these interfaces. Figure 2 shows the cell header structures used at the UNI and NNI At the UNI , the header contains a 4- bit generic flow control (GFC) field, a 24-bit label field containing Virtual Path Identifier (VPI) and Virtual Channel Identifier

(VCI) subfields (8 bits for the VPI and 16 bits for the VCI), a 2-bit payload type (PT) field, a 1-bit priority (PR) field, and an 8-bit header error check (HEC) field. The cell Header for an NNI cell is identical to that for the UNI cell, except that it lacks the GFC field; these four bits are used for an additional 4 VPI bits in the NNI cell header.

The VCI and VPI fields are identifier values for virtual channel (VC) and virtual path (VP), respectively. A virtual channel connects two ATM communication end-points. A virtual path connects two ATM devices, which can be switches or end-points, and several virtual channels may be multiplexed onto the same virtual path.

The 2-bit PT field identifies whether the cell payload contains data or control information. The CLP bit is used by the user for explicit indication of cell loss priority. If the value of the CLP is 1 the the cell is subjected to discarding in case of congestion. The HEC field is an 8 bit CRC polynomial that protects the contents of the cell header.

The GFC field, which appears only at the UNI, is used to assist the customer premises network in controlling the traffic flow for different qualities of service .
At the time of writing the exact procedures for use of this field have not been agreed upon .

1.6 ATM Layer Functions

The primary function of the ATM layer is VPI/VCI translation. As ATM cells arrive at ATM switches, the VPI and VCI values contained in their headers are examined by the switch to determine which outport should be used to forward the cell. In the process, the switch translates the cell's original VPI and VCI values into new outgoing VPI and VCI values, which are used in turn by the next ATM switch to send the cell toward its intended destination. The table used to perform this translation is initialized during the establishment of the call. An ATM switch may either be a VP switch, in which case it only translates the VPI values contained in cell headers, or it may be a VP/VC switch, in which case it translates the incoming VCI value into an outgoing VPI/VCI pair.

Since VPI and VCI values do not represent a unique end-to-end virtual connection. They can be reused at different switches through the network. This is important,

because the VPI and VCI fields are limited in lenght and would be quickly exhausted if they were used simply as destination addresses.

The ATM layer supports two types of virtual connections : switched virtual connection (SVC) and permanent, or semipermanent, virtual connections (PVC). Switched virtual connections are established and torn down dynamically by an ATM signaling procedure. That is they only exist for the duration of a single call.

Permanent virtual connections, on the other hand, are established by networkadministrators and continue to exist as long as the administrator leavesthem up, even if they are not used to transmit data. Other important functions of the ATM layer include cell multiplexing and demultiplexing, cell header creation and extraction, and genericflow control.

Cell multiplexing is the merging of cells from several calls onto a single transmission path , cell header creation is the attachment of a 5- octet cell header to each 48 octet block of user payload, and generic flow control is used at the UNI to orevent short-term overload conditions from occurring within the network

1.7 ATM Layer Service Categories

The ATM Forum and ITU-T have defined several distinct service categories at ATM layer. The categories defined by the ATM forum include constant bit rate (CBR), real-time variable bit rate (VBR-rt), non real-time variable bit rate (VBR-nrt), available bit rate (ABR), and unsipecific bit rate (UBR). ITU-T defines four service categories, namely, deterministic bit rate(DBR), statistical bit rate (SBR), avalable bit rate (ABR) and ATM block transfer(ABT). The first of the three ITU-T service categories correspond roughly to the ATM Forum's CBR,VBR and ABR classifications, respectively .

The fourth service category, ABT, is solely defined by ITU-T ans is intended for bursty data application. The UBR category defined bt the ATM Forum is for calls that request no quality of service guarantees at all. The constant bit rate CBR (or deterministic bit rate DBR) service category provides a very strict QoS guararentee. It is targeted at real-time applications, such as voice and raw video, which mandate severe restrictions on delay, delay variance(jitter) and cell loss rate.

The only traffic description required by the CBR service are the peak cell rate and the cell delay variation tolerance. A fixed amount of bandwidth, determined primarily by the call's peak cell rate, is reservedfor each CBR connection. The real-time variable bit rate VBR-rt (or statistical bit rate SBR) service category is intended for real time bursty application, which also require strict QoS guarantees.

The primary difference CBR and VBR-rt is in the traffic descriptions they use. The VBR-rt service requires the specification of the sustained cell rate and bursty tolerance in addition to the peak cell rate and the cell delay variation tolerance. The ATM Forum also defines a non-real-time VBR-nrt service category, in which cell delay variance is not guaranteed.The available bit rate (ABR) service category is defined to exploit the network's unutilized bandwidth. It is intended for non-real time data application in which the source is amenableto enforced adjustment of its transmission rate.

A minimum cell rate is reserved for the ABR connection and therefore guaranteed by the network. When the network has unutilized bandwidth, ABR sources are allowed to increase their cell rates up to an allowed cell rate (ACR), a value which is periodically updated by the ABR flow control mechanism. The value of ACR always falls between the minimum and the peak cell rate for the connection and is determined by the network

The ATM forum defines another service category for non-real-time application called the unspecified bit rate (UBR) service caregory. UBR service is entirelybest efford; the call is provided with no QoS guarantees. .The ITU-T also defines an additional sewrvice category for non-real-time data applications. The ATM block transfer (ABT) service category is intended for the transmission option (ABT/IT), the block of data is sent at the same time as the reservation request.

If bandwidth is not available for transporting block, then it is simply discarded; and the source must retransmit it. In the ABT service with delayed transmission (ABT/DT); the source waits for a confirmation from the network that enough bandwitdh is available before transmitting the block of tha data. In both cases, the network temprorarily resource reserves bandwitdh according to the peak. Cell rate for each block.Imediately after transporting the block, the network releases the reserved bandwidh.

Table 1.2 ATM layer service categories

ITU-T Service Categories	DBR	SBR	ABT	ABR	
ATM Forum Service Categories	CBR	VBR-rt	VBR-nrt	ABR	UBR
Cell Loss Rate	specified				unspecified
Cell Transfer Delay	specified			unspecified	
Cell Delay Variation	specified		unspecified		
Traffic Descriptors (Contract)	PCR/CDVT	PCR/CDVT SCR/BT		PCR/CDVT MCR/ACR	PCR/CDVT

PCR = Peak Cell Rate
SCR = Sustained Cell Rate
CDVT = Cell Delay Variation Tolerance
BT = Burst Tolerance
MCR = Minimum Cell Rate
ACR = Allowed Cell Rate

1.8 ATM Adaptation Layer

The ATM adaptation layer (AAL), which resides a top ATM layer, is responsible for mapping the requirements of higher layer protocols onto the ATM network. It operates in ATM devices at the edge of the ATM network and is totally up sent in ATM switches. The adaptation layer is divided into two sublayers: The convergence sublayer (CS), which performs error detection and handling, timing and clock recovery and the segmentation and reassembly (SAR) sublayer, which performs segmentation of convergence sublayer protocol data units (PDUs) into ATM cell-sized SAR sublayer service data units data units (SDUs) and vice versa In order to support different service requirements, the ITU-T proposed for AAL-specific services classes.

Note that while these ALL service classes are similar in many ways to the ATM layer service catagories defined in the perivious section, they are not the same; each exists at a different layer of the protocol reference model, and each requires a different set of functions. ALL service class A corresponds to constant bit rate (CBR), services with a timing the relation required between source and destination. The connection mode is connection – oriented . CBR audio and video blong to this class. Class B corresponds to variable bit rate (VBR) services. This class also requires timin between sources and destination , and its mode is connection-oriented. VBR audio and video are examples of class B services. Class C also corresponds to VBR connection –oriented services but the timing between source and destination needs not be related. Class C includes connection-oriented data transfer such as X.25, signaling and future high speed data

services. Class D corresponds to connectionless services. Connectionless data services such as those supported by LANs and WANs are examples of class D services .

Four AAL types , each with a unique SAR supplier and CS sublayer, are defined to support the four service classes. ALL type 1 supports constant bit rate services (Class A), and AAL type 2 supports available bit rate services with a timing relation between source and destination (Class B). ALL type 3 /4 was orginally specified as two different AAL type (Type 3 and Type 4), but due to their inherient similarities, they were eventually merget to support both Class C and Class D services. AAL Type 5 also supports class C and Class D services

Table 1.3 Service Classification for AAL

	Class A	Class B	Class C	Class D
Timing Relation between source and destionation	Required		Not Required	
Bit rate	Constant	Variable		
Connection Mode	Connnection Oriented			Connectionless

1.8.1 ALL Type5

Currently the most widely used adaptation layer is AAL type 5. AAL type 5 supports connection-oriented and connectionless services in which there is no timing relation between source and destination(class C and class D). Its functionality was intentionaly made simple in order to support high speed data transfer. AAL type 5 assumes that the layers above the ATM adaptation layer can perform error recovery. Retransmition and sequence numbering when require and those it does not provide this functions. Therefore, only none assured operation is provided; lost or corrupted AAL type 5 packet will not be corrected by retransmition.

The SAR supplier of AAL type 5 performs segmentation of CS-PDU into a size suitable for the SAR-SDU pay load. Unlike other AAL types, Type 5 devotes the entire 48-octet payload of the ATM cell to the SAR-SDU ; there is no overhead. An AAL specific flag in the ATM Payload Type (PT) Field of the cell header is set when the last cell of a

CS-PDU is sent . the assembly of the CS-PDU frames at the destionation is controlled by using this flag.

it conteins the user data payload, along with any recessary padding bits (PAD) and a CS-PDU trailer, which are added by the CS supplier when it recveives the uder information from the higher layer. the CS–PDU is padded using 0 + 47 bytes of PAD field to make the land of the CS-PDU and integral muliple of 48 bytes (the size of the SAR -SDU) at the receiving end, reassembled PDU is passed to the CS sublayer from the SAR sublayer, CRC values are then calculared and compared.

If there is no error, the PAD field is removed by using the value of lenght field (LF) in the CS-PDU trailer, and user data is passed to the higher layer. If an error is detected, the erroneous information is either deliverded to the use or discarded according to user 's choice .

1.9 ATM Signalling

ATM follows the principle of out-of-band signaling that was establihed for N-ISDN. in other words, signaling and data channels are separate. The main purposes of signaling are:

1) To establish ,maintain and release ATM virtual connections.
2) To negotiate the traffic parameters of new connections.

The ATM signaling standards support the creation of point to point as well as multicast connections. Typically certain VCI and VPI values are reserved by ATM networks for signaling messages. If additional signaling VCs are required, they may be establish through the process of meta-signaling.

CHAPTER II: DEVELOPMENT OF ATM

2.1 ATM in the Telecommunications Infrastructure

A telecommunications network is designed in a series of layers. A typical configuration may have utilized a mix of time division multiplexing, Frame Relay, ATM and/or IP. Within a network, carriers often extend the characteristic strengths of ATM by blending it other technologies, such as ATM over SONET/SDH or DSL over ATM. By doing so, they extend the management features of ATM to other platforms in a very cost-effective manner.

ATM itself consists of a series of layers. The first layer - known as the adaptation layer - holds the bulk of the transmission. This 48-byte payload divides the data into different types. The ATM layer contains five bytes of additional information, referred to as overhead. This section directs the transmission. Lastly, the physical layer attaches the electrical elements and network interfaces.

2.2 ATM as the backbone for other networks

The vast majority (roughly 80 percent) of the world's carriers use ATM in the core of their networks. ATM has been widely adopted because of its unmatched flexibility in supporting the broadest array of technologies, including DSL, IP Ethernet, Frame Relay, SONET/SDH and wireless platforms. It also acts a unique bridge between legacy equipment and the new generation of operating systems and platforms. ATM freely and easily communicates with both, allowing carriers to maximize their infrastructure investment.

2.2.1 ATM in the LAN (Local Area Network)

The LAN environment of a campus or building appears sheltered from the headaches associated with high-volumes of traffic that deluge larger networks. But the changes of LAN interconnection and performance are no less critical. The ATM/LAN relationship recently took a giant step forward when a prominent U.S. vendor announced a patent for its approach to extending ATM's quality of service to the LAN. The filing signals another

birth in a long lineage of applications that prove the staying power and adaptability of ATM.

2.2.2 ATM in the WAN (Wide Area Network)

A blend of ATM, IP and Ethernet options abound in the wide area network. But no other technology can replicate ATM's mix of universal support and enviable management features. Carriers inevitably turn to ATM when they need high-speed transport in the core coupled with the security of a guaranteed level of quality of service. When those same carriers expand to the WAN, the vast majority does so with an ATM layer.

Distance can be a problem for some high-speed platforms. Not so with ATM. The integrity of the transport signal is maintained even when different kinds of traffic are traversing the same network. And because of its ability to scale up to OC-48, different services can be offered at varying speeds and at a range of performance levels.

2.2.3 ATM in the MAN (Metropolitan Area Network)

The MAN is one of the hottest growing areas in data and telecommunications. Traffic may not travel more than a few miles within a MAN, but it's generally doing so over leading edge technologies and at faster-than-lightening speeds.

The typical MAN configuration is a point of convergence for many different types of traffic that are generated by many different sources. The beauty of ATM in the MAN is that it easily accommodates these divergent transmissions, often times bridging legacy equipment with ultra high-speed networks. Today, ATM scales form T-1 to OC-48 at speeds that average 2.5 Gb/s in operation, 10 Gb/s in limited use and spanning up to 40 Gb/s in trials

2.3 Bandwidth Distribution

The Bandwidth Distribution (BD) component is responsible for the management of the bandwidth allocated to working VPCs according to actual traffic conditions. That is, it adjusts the bandwidth allocated to the working VPCs to their actual usage to avoid situations where in the same links some VPCs tend to become over-utilized while other VPCs remain underutilized.

The dynamic management of the working VPC allocated bandwidth is achieved by distributing portions (viewed as a common pool) of the link working bandwidth (link capacity minus restoration bandwidth) among the working VPCs. Specifically, the management of the VPC allocated bandwidth is done within specific (upper and lower) bounds on the VPC bandwidth as originally estimated by VPC_LD (VPC required bandwidth).

The activities of BD are required to compensate for inaccuracies in traffic predictions and in the VPC bandwidth as estimated by VPC_LD as well as to withstand (short to medium) actual traffic variations. This is so, since it cannot be taken for granted that the traffic predictions will be accurate and furthermore even if they are accurate, they are accurate within statistical range. In this respect i.e. considering the random nature of the arriving traffic, the bandwidth that needs to be allocated to VPC, so that certain objectives (regarding connection admission) to be met, is a stochastic variable, depending on the connection arriving pattern. The VPC_LD component estimates originally the bandwidth that needs to be allocated to the VPCs (required bandwidth) so that satisfy traffic predictions. This is viewedas the mean value of the (stochastic in nature) bandwidth that needs to be allocated to the VPCs. It is the task then of the BD component, to manage the allocated bandwidth of VPCs, around the (mean) required bandwidth, according to actual traffic conditions.

By monitoring the usage on working VPCs, the BD component also emits warnings to VPC_LD indicating insufficient usage of the planned network resources. The warnings are issued in cases where some VPCs remain under-utilized (with respect to their required bandwidth as specified by VPC_LD) for a significant period of time. This implies that these resources cannot be utilized in the routes by the Load Balancing component and therefore such cases are interpreted as indicating overestimation of network resources.

ATM is a proven technology that is now in its fourth generation of switches. Its maturity alone is not its greatest asset. Its strength is in its ability to anticipate the market and quickly respond, doing so with the full confidence of the industry behind it.

The proposed algorithm for bandwidth redistribution assumes that there is a common pool of bandwidth per link to be redistributed to the VPCs when necessary. The algorithm assumes that this common pool of bandwidth per link is the links' unallocated bandwidth.

Note, that by its definition, this pool of bandwidth is not totally allocated to the VPCs at any instant; but it is there to be allocated to the VPCs that go highly utilized only when such conditions occur. Each VPC grabs or returns portions of its allocated bandwidth to the common pool of bandwidth according to its congestion level. We assume here that the modification of the bandwidth of a VPC does not impact on the traffic parameters (QoS) of the VCs using this VPC or other VPCs sharing the same links or nodes.

2.4 THE SITUATION IN THE TELECOMMUNICATION WORLD BEFORE ATM

Today's telecommunication networks are characterized by specialization. This means that for every individual telecommunication service at least one network exists that transports this service.

Each of these networks was specially designed for that specific service and is often not at all applicable to transporting another service. When designing the network of the future, one must take into account all possible existing and future services. The networks of today are very specialized and suffer from a large number of disadvantages.

1) **Service Dependence**

Each network is only capable of transporting one specific service .

2) **Inflexibility**

Advances in audio, video and speech coding and compression algorithms and progress in VLSI technology influence the bit rate generated by a certain service and thus change the service requirements for the network. In the future new services with unknown requirements will appear. A specialized network has great difficulties in adapting to new services requirements.

The basic idea behind the concept changes is the fact that functions must not be repeated in the network several times if the required service can still be guaranteed when these functions are only implemented at the boundary of the network.Progress In Technology In recent years large progress has occurred both in field of electronics and in the field of optics.

Broadband communication systems can be developed based on different technologies, the most promising being CMOS. (Complementary Metal Oxide Semiconductor)
Cmos allows high complexity and reasonably high speed (up to 200 to 300 Mbits/s). The low power dissipation of Cmos is particularly important, and allows the realization of high complexity, high speed systems on a very small chip surface.

With the increased complexity per chip, the system cost can easily be reduced since the large integration will continuously allow the volume of the system to shrink or to increase the functionality at a constant cost. Optical technology is also evolving quite rapidly.Optical fiber has been installed for transmission services for several years.

2.6 Performance Requirements from ATM

In the future broadband network a large number of services have to be supported. These services are :

1) low speed like telemetry, low speed data ,telefax
2) medium speed like hifi sounds, video telephony, high speed data
3) very high speed like high quality video, video library .

A single typical service description does not exist. All services have different characteristics both for their average bit rate and burstiness. To anticipate future unknown services we must try to characterize as general a service as possible.

The optimal transfer mode should support the communication of various types of information via an integrated access. Ideally the transfer mode must provide the capability to transport information, whatever type of information is given at the network, very much like the electricity network, which provides power to it's customers without regarding the way the customer uses his electricity. Two other important factors are:

1) Semantic transparency - determines the possibility of network to transport the information error free.

The number of end to end errors introduced by the network is acceptable for the service No system is perfect. Most of the imperfections of telecommunication systems are caused by noise. Other factors contribute to a reduced quality: limited resources causing blocking; any system errors. One of the most important parameters used to characterize imperfections is the BER (bit error rate) - the ratio between erroneous bits and transmitted bits.

2) Time transparency - determines the capability of the network to transport the information through the network from source to destination in a minimal time acceptable for the service.

Time transparency can be defined as the absence of delay and delay jitter(different part of the information arrive at the destination with different delay). The value of end to end delay is an important parameter for real time services, such as voice and video. If the delay becomes too large echo problems may arise in a voice connection.

Table 2.1 The value of end to end delay is an important parameter for real time services

SERVICE	BER	DELAY
Telephony	10^(–7)	25 - 500 ms
Data Transmission	10^(–7)	1000 ms
Broadcast Video	10^(–6)	1000 ms
Hifi Sound	10^(–5)	1000 ms

2.7 ATM Benefits

1. One Network

ATM will provide a single network for all traffic types - voice, data, video. ATM allows for the integration of networks improving efficency and manageability.

2. Enables new applications

Due to its high speed and the integration of traffic types, ATM will enable the creation and expansion of new applications such as multimedia to the desktop.

3. Compatibility

ATM has been designed to be independent to the transmission medium. Because ATM is not based on a specific type of physical transport, it is compatible with currently deployed physical networks. ATM can be transported over twisted pair, coax and fiber optics.

4. Incremental Migration

Efforts within the standards organizations and the ATM Forum continue to assure that embedded networks will be able to gain the benefits of ATM incrementally-upgrading portions of the network based on new application requirements and business needs.

5. Simplified Network Management

ATM is evolving into a standard technology for local, campus/backbone, public and private wide area services. This uniformity is intended to simplify network management by using the same technology for all levels of the network.

6. Long Architectural Lifetime

The information systems and telecomunications industries are focusing and standardizing on ATM. ATM has been designed from the beginning to be scaleable and flexible in: Geographic distance, number of users, access and trunk bandwidths. This scalability and flexibility assures that ATM will be around for a long time.

7. Scaleability

The ATM network can be expanded to accomodate new users without the bandwith available to the existing users being restricted as a result. It is simply a matter of adding more connection modules to the ATM switch serving the user.

2.8 New ATM Service Categories

The introduction of new ATM service categories will increase the benefits of ATM, making the technology suitable for a virtually unlimited range of applications. An ATM network can provide Virtual Path (VP) or Virtual Channel (VC) Connections with different levels of service. The concept of negotiating, for each connection, the behavior expected from the ATM-layer, in terms of traffic and performance, allows users to betteize the application requirements versus the network capabilities.

The first ATM implementations have offered limited options. A typical network behavior, common to most of the first generation ATM networks, is to reserve a fixed amount of bandwidth for each connection for the duration of the call, on the basis of the maximum emission rate of the source (i.e. the "peak cell rate", PCR), and to provide a single level of quality of service. The ATM Service Categories represent new service building-blocks and introduce the possibility for the user to select specific combinations of traffic and performance parameters.

ATM is a multi-service technology. Actually, most of the requirements that are specific to a given application may be resolved at the edges of an ATM network by choosing an 0appropriate ATM Adaptation Layer (AAL). However, by definition, the ATM-layer behaviour should not rely on the AAL protocols, since these are service specific (and are in many cases supported by the user terminal, i.e., outside the core network visibility), nor on higher layer protocols which are application specific. Given the presence of a heterogeneous traffic mix, and the need to adequately control the allocation of network resources for each traffic component, a much greater degree of flexibility, fairness and utilization of the network can be achieved by providing a selectable set of capabilities within the ATM-layer itself. The Service Categories have been defined with this goal in mind. Both users and network operators can benefit from the availability of a selectable set of ATM-layer services. These services are, in effect, the tools, which will allow the promise of ATM to be fully realized.

2.8.1 Customer Perspective

ATM customers (e.g. end user, IT and telecommunications managers) aim at saving on network usage costs, provided that their substantial efficiency and quality requirements are matched. Requirements are variable in nature depending on what application (e.g. data, voice, video, multimedia) is running. As a matter of fact, users that produce variable traffic patterns would like to be able to get bandwidth just when actually needed and, in case of elastic sources, to have fast access to as much available bandwidth as possible, achieving a satisfactory compromise between performance and cost.

2.8.2 Network and Service Operators Perspective

All types of operators that are investing in ATM infrastructures and services aim to achieve maximum utilization of the deployed resources, avoid congestion while being able to share network resources among a large number of customers and fulfill the differing user needs in a cost-effective way. This allows for appropriate tariffing strategies to be deployed. The ability to offer a range of network services, with selectable cost/performance levels, is a key issue for network operators, particularly in a competitive market.

2.9 Service Categories Description

2.9.1 Constant Bit Rate (CBR)

The CBR service category is used by connections that request a fixed (static) amount of bandwidth, characterized by a Peak Cell Rate (PCR) value that is continuously available during the connection lifetime. The source may emit cells at or below the PCR at any time, and for any duration (or may be silent).

This category is intended for real-time applications, i.e., those requiring tightly constrained Cell Transfer Delay (CTD) and Cell Delay Variation (CDV), but is not restricted to these applications. It would be appropriate for voice and video applications, as well as for Circuit Emulation Services (CES).

The basic commitment made by the network is that once the connection is established, the negotiated QoS is assured to all cells conforming to the relevant conformance tests. It is assumed that cells, which are delayed beyond the value specified by Cell Transfer

Delay (CTD), may be of significantly less value to the application.

2.9.2 Real-Time Variable Bit Rate (rt-VBR)

The real-time VBR service category is intended for time-sensitive applications, (i.e., those requiring tightly constrained delay and delay variation), as would be appropriate for voice and video applications. Sources are expected to transmit at a rate which varies with time. Equivalently, the source can be described as "bursty".

Traffic parameters are Peak Cell Rate (PCR), Sustainable Cell Rate (SCR) and Maximum Burst Size (MBS). Cells which are delayed beyond the value specified by CTD are assumed to be of significantly less value to the application. Real-time VBR service may support statistical multiplexing of real-time sources.

2.9.3 Non-Real-Time (nrt-VBR)

The non-real time VBR service category is intended for applications which have bursty traffic characteristics and do not have tight constraints ay and delay variation. As for rt-VBR, traffic parameters are PCR, SCR and MBS. For those cells which are transferred within the traffic contract, the application expects a low Cell Loss Ratio (CLR). For all cells, it expects a bound on the Cell Transfer Delay (CTD). Non-real time VBR service may support statistical multiplexing of connections.

2.9.4 Available Bit Rate (ABR)

The Available Bit Rate (ABR) is a service category intended for sources having the ability to reduce or increase their information rate if the network requires them to do so. This allows them to exploit the changes in the ATM layer transfer characteristics (i.e., bandwidth availability) subsequent to connection establishment.

It is recognized that there are many applications having vague requirements for throughput: they can be expressed as ranges of acceptable values, e.g., a maximum and a minimum, rather than as an average value (that is typical for the VBR category). To meet this requirement on the establishment of an ABR connection, the end-system shall specify a maximum required bandwidth and a minimum usable bandwidth. These are designated as the Peak Cell Rate (PCR) and the Minimum Cell Rate (MCR),

respectively. The MCR may be specified as zero. The bandwidth made available from the network may vary, as it is the sum of an MCR, and a variable cell rate which results from sharing the available capacity among all the active ABR connections via a defined and fair policy. A flow control mechanism is specified which supports several types of feedback to control the source rate. In particular a closed-loop feedback control protocol using Resource Management (RM) cells has been specified in a rate-based framework.

Although no specific QoS parameter is negotiated with the ABR, it is expected that an end-system that adapts its traffic in accordance with the feedback will experience a low Cell Loss Ratio (CLR) and obtain a fair share of the available bandwidth according to a network specific allocation policy. Cell Delay Variation (CDV) is not controlled in this service, although admitted cells are not delayed unnecessarily. ABR service is not (as specified at present) intended to support real-time applications.

A source, destination and network switch behavior is specified by The ATM Forum along with details of the rate-based flow control mechanism.

2.9.5 Unspecified Bit Rate (UBR)

The Unspecified Bit Rate (UBR) service category is a "best effort" service intended for non-critical applications, which do not require tightly constrained delay and delay variation, nor a specified quality of service. UBR sources are expected to transmit non-continuous bursts of cells. UBR service supports a high degree of statistical multiplexing among sources.

UBR service does not specify traffic related service guarantees. Specifically, UBR does not include the notion of a per-connection negotiated bandwidth. There may not be any numerical commitments made as to the cell loss ratio experienced by a UBR connection, or as to the cell transfer delay experienced by cells on the connection.

Table 2.2 Service Category Attributes and Guarantees

Service Category	Traffic Description	Guarantees			Use of Feedback Control
		Min Loss (CLR)	Delay/Variance	Bandwidth	
CBR	PCR	X	X	X	NO
rt-VBR	PCR, SCR, MBS	X	X	X	NO
nrt-VBR	PRC, SCR, MBS	X	NO	X	NO
ABR	PCR, MCR+ behavior parameters	X	NO	X	X
UBR	(PCR)	NO	NO	NO	

CHAPTER III : ATM APPLICATION AREAS

3.1 ATM co-operative multimedia user business cases

This section describes ATM user business cases conducted in a joint effort between network operators, manufacturers of telecommunication and information technology equipment, software companies and end users from different industry sectors. The results are related to multimedia applications in the aircraft and banking industries. Common to both case studies is the concept of computer supported collaborative work (CSCW). Experiences are taken as a basis for deriving functional and technical requirements for supporting ATM networks. The focus lies on the future support of CSCW by teleservices and ATM bearer services in the network. The projects were partially funded by the European Union.

The BANK project (Banking applications using an image and broadband communications network) addresses possible multimedia enhancements of current banking services,

3.1.1 Multimedia banking

The banking and insurance industries are heavy users of information technology and telecommunication services, with almost every business transaction leading immediately to a computer-assisted process. Major banks operating world-wide would be unable to conduct business without efficient telecommunication networks. Banks also increasingly use information technology to serve their customers. An international consortium looked at how self-service banking and advisory support applications for up-to-the-minute analyses of bank products can be used to better serve customers in the future.

The integration of telecommunication and information processing, as well as recent progress in the field of audio and video presentation on computer workstations, is opening up new horizons for marketing and distribution applications. Multimedia product Information consisting of still and moving images, sound or voice sequences, charts, and text can help customers obtain information on the services offered by a bank.

In addition to product presentation, networked multimedia provides an innovative opportunity to hold small video-conferences regardless of distance. High-performance broadband networks are required to provide a high-quality connection; interest here is focused on ATM-based networks, with their capacity for flexible use of bandwidths. Broadband networks are being discussed as an important national infrastructure for the country's economy.

Almost everywhere in Europe, broadband networks are set up and are already interconnected or will be in future. An international consortium has investigated multimedia technology in the banking sector, establishing the BANK (Banking applications using image and broadband communications network) application project.

The high level of customer acceptance of self-service facilities and the increasing efficiency of modern information technology are the driving forces behind an extension of customer self-service, both quantitatively and qualitatively. In the future self-service machines will not only assist in processing transactions, but they will also increasingly serve as a marketing tool, supplying information on more complex products, such as loans, mortgages and investment and portfolio management.

The common feature of these products is that the customer has a number of options regarding the product structure and is therefore often reliant upon advice. In order to preserve the close customer-bank relationship the customer must always have access to the advice of his personal advisor at the bank. Thus the outstanding features of future self-service terminals must be simple operating instructions, high-quality presentation of product information and the opportunity, if required, to obtain advice from bank personnel.

There is a noticeable trend in the banking industry toward differentiation within the sales network. However, the cost of employing a specialist in every branch for each product in the growing product range would be prohibitive, so experts from larger branches offer specialized support to personnel in smaller branches.

Such an improvement would also enable customers at smaller branches to base their investment decisions on expert knowledge available only at the bank's larger branches.

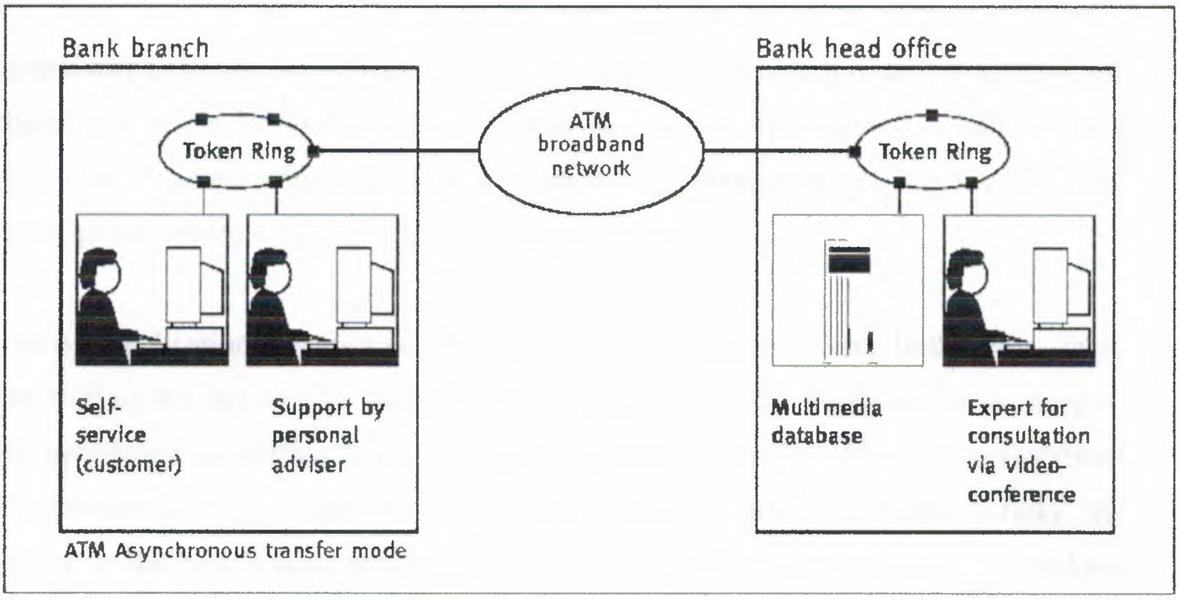

Figure 3.1 ATM network configuration for connections between bank branches and the head office.

In the BANK project, the two commercial scenarios outlined above were implemented on a prototype basis with specific applications.

In the first scenario a multimedia information terminal was created as a supplement to the automatic cash dispenser and statement printer. It consisted essentially of a workstation with a touch screen and equipment for audio and video recording and reproduction. The interest of a passing customer is attracted by a video film about the bank and its products.

By touching the screen the customer is given an overview of the institution's product spectrum and with the aid of the buttons shown on the screen he can select a subject area of interest. Information on the relevant subject is then conveyed by a varied multimedia product presentation, which contains videos, spoken explanations, texts, charts and still images.

Whatever the product, the customer is able to influence the course of the information sequence, for example by requesting more detailed information or carrying out illustrative calculations. If the customer needs more information than that which is

offered he can, at any time and directly from the self-service mode, enter into a video-conference with a customer adviser to discuss any outstanding questions.

In this way customer and adviser can also jointly prepare documents such as application forms and charts for evaluating a portfolio or perform illustrative calculations. In a future development phase, facilities for concluding agreements (e.g. card reader, PIN input, printer, scanner, fax) can also be integrated.

The two application scenarios can be installed in parallel at one bank. In this case there are multimedia self-service machines and workstations at the bank branch to support the investment consultant in his discussion with the customer; additional workstations are connected to a local network (token ring). An ATM broadband network links the branch to the bank's head office where there are experts who, by means of a desktop video-conference, can assist the customer with specialized advice. A multimedia database contains up-to-date information on new products, which can be accessed if required

Options were implemented for the interactive and non-interactive presentation of multimedia documents as well as shared working (joint pointing, joint viewing) for the purposes of a banking application. The functions of shared working were extended with an application-sharing mechanism for OS/2, DOS and Windows applications.

Thiscreates a flexible basis for enabling the applications available at the bank employee's placeof work also to be used in consultations via video-conference if required. Multimedia andbroadband technologies form the basis for innovative self-service equipment in the banking sector, offering new opportunities in the marketing of financial products and creating new sales channels for bank products.

In the BANK project a prototype multimedia system has been developed which can be used both as a self-service unit for bank products as well as an advisory support system for traditional customer service. Apart from pure product information, the system offers integrated desktop video-conference and the opportunity of processing documents jointly (application sharing). For data transfer between the workstations an ATM communications infrastructure was selected.

Multimedia documents with the option of video-conference and integrated application sharing can be used in other scenarios than those implemented. There are a number of other possible applications for such systems, e. g. in commercial education and in-service training. There are also potential applications in office support systems and co-ordination procedures within banks. These applications can overcome the restrictions of a particular location as well as providing enhanced communication with business partners. With sufficient availability of end-user equipment and inexpensive, suitable multimedia services within the public network a similar service can also be offered in the home banking sector.

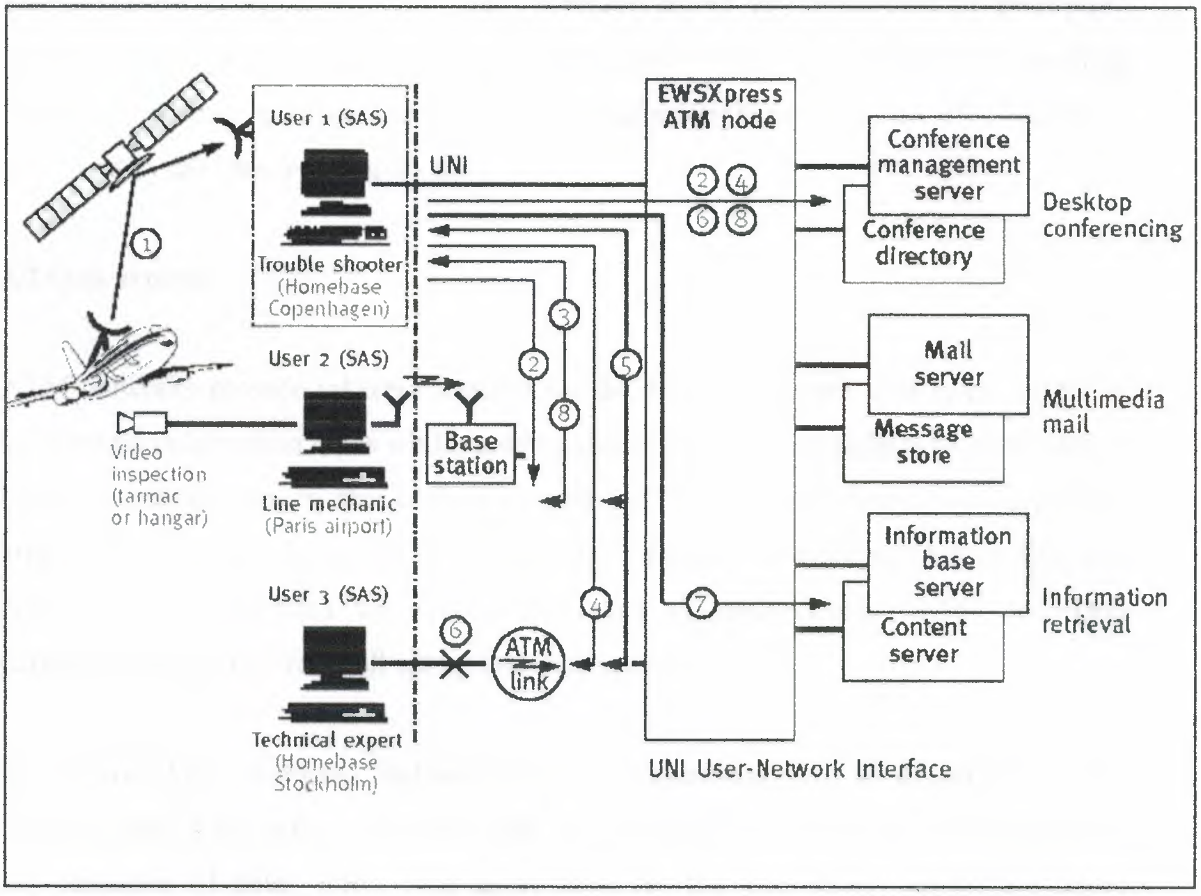

Figure 3.2 CSCW application case.

3.1.2 CSCW application support by future multimedia desktop conferencing Teleservices

The conference management server and the conference directory in Fig. 8.3 represent the essential functional groups, comprising some of the higher-layer teleservice functions such as association of partners, screening of access and distribution of output. Other advanced multimedia teleservices, such as multimedia mail, are also implemented in dedicated servers attached to network nodes. The lower-layer functions of the teleservice mainly refer to the user plane protocols of the ATM layer and AAL and the control plane signalling protocols up to Layer

The functions in the user plane deal with, for example, the support of multipoint communication configurations. The signaling protocols will enable the flexible handling of multiple parties, multiple information types and multiple connections, which are all perceived by the user as a single call.

3.2 QoS aspects

ATM networks provide inherent features for the efficient support of a large variety of multimedia information types while meeting considerably differing QoS requirements. Important capabilities in this context are: the ATM layer with two cell loss priority levels, cell delay priority levels per VC (Virtual Channel) connection, QoS profiles and AAL protocols adjusted to information types (Vcmultiplexed media) and QoS parameter renegotiation at call set-up and during a call.

In addition AAL protocols include recovery mechanisms such as detection of mis-inserted and lost cells, cell loss recovery, error correction on user data and compensation of delay jitter. Two approaches for the QoS class support are under discussion:

1. Delay and loss sensitive traffic (e.g. video phone) is mapped onto QoS-type-1 VC connections, handled with high priority and based on peak bit rate allocation at VC connection level. In contrast, more delay/loss tolerant bursty traffic (e.g. file transfer) is

mapped onto QoS-type-2 VC connections, allowing statistical multiplexing with high multiplex gain.

2. Further refinement of bandwidth allocation schemes, e.g. based on sustainable cell rate and burst tolerance, and respective traffic control protocols for QoS-type-1 VC connections. Split of QoS type 2 into several QoS types for improving statistical multiplexing.

Approach 1 represents a first refinement of the most basic approach of peak bit rate allocation for all traffic types. The basic idea is to provide an ATM transport mechanism with an excellent overall cell delay and loss performance capable of supporting any real-time traffic (QoS type 1). A promising solution that enables protection of the real-time traffic while allowing a statistical multiplexing of the bursty traffic with a multiplex gain of more than five.

Approach 2 can be considered as a development of approach 1. It follows the same line but refines the bandwidth allocation algorithm for the given QoS levels and introduces more QoS types for bursty traffic.

3.2.1 CSCW Application Support Through Bearer Services

Basic mono-medium ATM bearer services offer a single switched VC connection per call between the network access points (UNIs) of the CSCW conferees.

The characteristics of the connections involved are adjusted to the most demanding information types of the application under consideration. Most functional requirements such as the mapping of different information types onto network connections have to be implemented in end-systems. Switching according to ATM Forum UNI can support conferencing with a point-to-multipoint connection, which allows an automatic add/drop of leaf links via signalling.

User benefits of the CSCW support by mono-medium bearer services lie in the Flexibility offered by switching as well as the high performance (guaranteed

throughput, acceptable transfer delay for real-time traffic). For large user organizations with their own technical support this type of service may very well persist in future ATM networks. In a subsequent step, switched multimedia bearer services already provide all the lower layer functions for the support of CSCW applications such as handling of multiple connections per call and point-to-multipoint communication configurations. This will lead to additional user benefits: support of existing and new multimedia information types, conferencing with selective distribution of information to conferees (matching different terminal capabilities), support emerging ATM-based workstations at the public ATM UNI and support of conference servers in terms of reduced complexity and higher performance.

3.2.2 Standards Definitions

The specification of ATM-layer services is the result of a major effort of many traffic management experts. Traffic Management and Congestion Control issues have now reached stable definition within the international standardization organization ITU-T, and have been specified in detail by the ATM Forum, forming a base for industrial implementation agreements to facilitate interoperability in multivendor implementations.

Recent efforts made on traffic control issues are now resulting in new versions of ITU-T Recommendation I.371 and the ATM Forum Traffic Management Specification Both documents are technically ready and are presently undergoing formal approval.

A unified approach to the definition of ATM-layer services in the ATM Forum and in ITU-T is presented in Table I. Since different names are adopted to define concepts that are very similar in purpose, the differences are more apparent than real. The close relationships that have been established between the two bodies gives a further chance to harmonize the two documents in the course of their parallel development.

Table 3.1 An ATM Service Category (ATM Forum name) or ATM-layer

Correlation of ATM Forum and ITU-T ATM services		
ATM Forum TM4.0 "ATM Service Category"	ITU-T I.371 "ATM Transfer Capability"	Typical use
Constant Bit Rate (CBR)	Deterministic Bit Rate (DBR)	Real-time, QoS guarantees
Real-Time Variable Bit Rate (rt-VBR)	(for further study)	Statistical mux, real-time
Non-Real-Time Variable Bit Rate (nrt-VBR)	Statistical Bit Rate (SBR)	Statistical mux
Available Bit Rate (ABR)	Available Bit Rate (ABR)	Resource exploitation, feedback control
Unspecified Bit Rate (UBR)	(no equivalent)	Best effort, no guarantees
(no equivalent)	ATM Block Transfer (ABT)	Burst level feedback control

A first classification of these services/capabilities may be seen from a network resource allocation viewpoint. We can identify:

1) A category based on a constant (maximum) bandwidth allocation. This is called Constant Bit Rate (CBR) in the ATM Forum and Deterministic Bit Rate (DBR) in ITU-T;

2) A category based on a statistical (average) bandwidth allocation. This corresponds to the ATM Forum Variable Bit Rate (VBR) and ITU-T Statistical Bit Rate (SBR). The ATM Forum further divides VBR into real-time (rt-VBR) and non-real-time (nrt-VBR), depending on the QoS requirements. A further partitioning, commonly adopted, defines three VBR sub-classes depending on the conformance criteria adopted;

3) A category based on "elastic" bandwidth allocation, where the amount of reserved resources varies with time, depending on network availability. This is

the Available Bit Rate (ABR). The same name is used both in the ATM Forum and ITU-T;

4) A category considered only in the ATM Forum is the Unspecified Bit Rate (UBR). No explicit resource allocation is performed; neither bandwidth nor QoS objectives are specified;

5) A further category is considered in ITU-T only, and is based on block (or burst) allocation. This is called ATM Block Transfer (ABT). The feature of this class is the idea that network resources can be negotiated and allocated on a per block basis rather than on a per connection basis.

3. 3 The ATM Service Architecture

The ATM Service Architecture makes use of procedures and parameters for traffic control and congestion control whose primary role is to protect the network and the end-system in order to achieve network performance objectives. An additional role is to optimize the use of network resources. The design of these functions is also aimed at reducing network and end-system complexity while maximizing network utilization. To meet these objectives, the set of functions forming the framework for managing and controlling traffic and congestion can be used in appropriate combinations.

ATM Service Category (or Transfer Capability) relates quality requirements and traffic characteristics to network behavior (procedures and parameters). It is intended to specify a combination of Quality of and traffic parameters that is suitable for a given set of applications (user interpretation) and that allows for specific multiplexing schemes at the ATM layer (network interpretation).

A Service Category used on a given ATM connection, among those that are made available by the network, has to be implicitly or explicitly declared at connection set-up. All service categories apply to both Virtual Channel Connections (VCCs) and Virtual Path Connections (VPCs).

Functions such as Connection Admission Control (CAC), Usage Parameter Control (UPC), Feedback Controls, Resource Allocation, etc., are made available within the ATM node equipment and are, in general, structured differently for each Service Category. The CAC and UPC procedures implementation are network specific.

3.3.1 Generic Network Functions

Connection Admission Control (CAC) is defined as the set of actions taken by the network during the call (virtual connection) set-up phase, or during call re-negotiation phase, to determine whether a connection request can be accepted or rejected. Network resources (port bandwidth and buffer space) are reserved to the incoming connection at each switching element traversed, if so required, by the service category.

Usage Parameter Control (UPC) or Policing is defined as the set of actions taken by the network to monitor and control the traffic offered and the validity of the ATM connection at the User to Network Interface (UNI). It is an essential requirement for any network supporting multiple services. The main purpose of UPC is to protect network resources from malicious and unintentional misbehavior, which can affect the QoS of other already established connections. Procedures based on a Generic Cell Rate Algorithm (GCRA) may be applied to each cell arrival to assess conformance with respect to the traffic contract for the connection. Violations of negotiated parameters are detected and appropriate actions can be taken (eg. cell tagging, discard).

Feedback Controls are defined as the set of actions taken by the network and by the end-systems (possibly cooperating) to regulate the traffic submitted on ATM connections according to the state of network elements. Specific Feedback Control procedures may be associated with a service category.

3.3.2 Traffic Parameters

A source traffic parameter describes an inherent characteristic of a source. A set of these parameters constitute a Source Traffic Descriptor which, along with Cell Delay Variation Tolerance (CDVT) and a Conformance Definition, characterize an ATM Connection. The following parameters are considered for the purpose of defining the Service Categories :

Traffic Parameters

1) Peak Cell Rate(PCR)

2) Sustainable Cell Rate (SCR)

3) Maximum Burst Size (MBS)

4) Minimum Cell Rate (MCR)

5) QoS Parameters

The QoS parameters selected to correspond to a network performance objective may be negotiated between the end-systems and the network, e.g., via signaling procedures, or can be taken as default. One or more values of the QoS parameters may be offered on a per connection basis.

QoS Parameters

1) Cell Delay Variation (CDV)

2) Maximum Cell Transfer Delay (Max CTD)

3) Cell Loss Ratio (CLR)

A number of additional QoS parameters have been identified, but their negotiation is not foreseen, e.g., Cell Error Ratio (CER), Severely Errored Cell Block Ratio (SECBR), Cell Misinsertion Rate (CMR).

3.3.3 Traffic Contract and Negotiation

A traffic contract specifies the negotiated characteristics of a VP/VC connection at an ATM User Network Interface (either Private or Public UNI). The traffic contract at the Public UNI shall consist of a connection traffic descriptor and a set of QoS parameters for each direction of the ATM layer connection and shall include the definition of a compliant connection. The values of the traffic contract parameters can be specified either explicitly or implicitly. A parameter value is explicitly specified in the initial call establishment message. This can be accomplished via signalling for SVCs (Switched Virtual Connections) or via the Network Management System (NMS) for PVCs (Permanent Virtual Connections) or at subscription time. A parameter value is implicitly specified when its value is assigned by the network using default rules.

3.3.3.1. Some Typical Applications

This section identifies some sample applications, which can be seen as appropriate targets for one or more of the defined service categories. These applications are

provided to convey teh original intention and to focus on the possible use of service categories, which broadly relate application aspects to network functionality. However, an application is not constrained by this mappint, and may select any service category consistent with its needs, among those made available by a network.

3.3.3.2 Typical Applications for CBR

Any data/text/image transfer application which contains smooth enough traffic or for which the end-system's response time requirements justify occupying a fully reserved CBR channel. Examples are:

1) Videoconferencing

2) Interactive Audio (e.g., telephony)

3) Audio/Video Distribution (e.g., television, distance learning, pay-per-view)

4) Audio/Video Retrieval (e.g., video-on-demand, audio library)

For telephony and voiceband services over ATM, e.g., 64 kbit/s N-ISDN-compatible services, the access solution based on AAL1 requires CBR support for taking advantage of delay and variance bounds.

In the multimedia area, a near-term solution for residential services foresees VoD based on MPEG2 (Transport Stream, CBR mode) over AAL5, with transportation being provided by the ATM-layer with CBR service.

3.3.3.3 Typical Applications for VBR

VBR is suitable for any application for which the end-system can benefit from statistical multiplexing, by sending information at a variable rate, and can tolerate or recover from a potentially small random loss ratio. It is the case for any constant bit rate source, for which variable rate transmission allows more efficient use of network resources without a sensible performance impairment.

Real-time VBR, in particular, can be used by native ATM voice with bandwidth compression and silence suppression. For some classes of multimedia communications real-time VBR may be very appropriate.

Non-real time VBR can be used for data transfer, e.g., for response-time critical transaction processing applications (e.g., airline reservations, banking transactions, process monitoring) an frame relay interworking.

3.3.3.4 Typical Applications for ABR

Any non-time critical application running over an end-system capable of varying its emission rate can exploit the ABR service.

Examples include LAN interconnection/internetworking services, which are driving the business service market for ATM. These are typically run over router-based protocol stacks like TCP/IP, which can easily vary their emission rate as required by the ABR rate control policy. The support through ABR will likely result in an increased end-to-end performance (goodput). Another application environment suitable for ABR is LAN Emulation.

Other application examples are critical data transfer (e.g., defense information, banking services) super computer applications, and data communications, such as remote procedure call, distributed file services, and computer process swapping/paging.

3.3.3.5 Typical Applications for UBR

UBR can provide a suitable solution for less demanding applications. Most data applications, e.g., file transfer submitted in the background of a workstation with minimal service requirements, are very tolerant to delay and cell loss (store and forward networks are in fact widely used for these applications). Examples may include :

1) Text/Data/Image Transfer, Messaging, Distribution, Retrieval
2) Remote Terminal (e.g., telecommuting)

The above services can take advantage of any spare bandwidth and will profit from the resultant reduced tariffs ("cheap" services).

CONCLUSION

In developing computer networks only data transfer is not sufficient to the users both private and public sectors. Although today's computer are capable of supporting many useful applications, they are inadequate to support voice and audio applications. ATM was developed to support the multimedia applications. ATM delivers important advantages over existing LAN and WAN techologies, including the promise of scalable bandwidths at unprecedented price and performance points and Quality of Service (QoS) quaranties, which facilities new classes of applications such as multimedia. Some of the problems of ATM network are :

1.Achieving a desired quality of service

2.Network and switch complexity and

3.Bandwidth management and congestion control.

In this Project , a performance analysis of an ATM multiplexer is performed by a new congestion control mechanism. For this control mechanism we have analyzed two types of models. We have different sources that generate ATM cells. A High or Low priority is assigned for very generated ATM cell. These cells enter the ATM Multiplexer system with a finite number of identical sources and wait until they are served from the buffer of the multiplexer. In a time slot, only one cell can be transferred from the ATM multiplexer.The source alternates between geometrically distributed ON and OFF cycles. Cells generated in an ON cycle have a high or low priority. We derived equarions, which describe the steady-state behavior of the multiplexer. We also see The increased level of flexibility that is achievable through the introduction of the ATM Service Categories can be exploited in different ways and in a variety of combinations. in association with any VP or VC connection. With this choice of ATM services, the matching of real user needs may be approached in a totally new way. It is expected that the appropriate choice is influenced by a number of factors, such as:

Availability of a set of Service Categories offered by the network;

Actual attainable QoS in the network; this also depends on the resource management policy adopted, traffic engineering, number of nodes crossed and distance;

Capability of the application to cope with some degradation of the ATM-layer transfer characteristics;

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