1. INTRODUCTION

Nowadays, most us are surrounded by powerful computer systems with graphics oriented input and output.

These computers include the entire spectrum of PCs, through professional workstations upto super-computers. As the performance of computers has increased, so too has the demand for communication between all systems for exchanging data, or between central servers and the associated host computer system.

The replacement of copper with fiber and the advancement sin digital communication and encoding are at the heart of several developments that will change the communication infrastructure. The former development has provided us with huge amount of transmission bandwidth. While the latter has made the transmission of all information including voice and video through a packet switched network possible.

With continuously work sharing over large distances, including international communication, the systems must be interconnected via wide area networks with increasing demands for higher bit rates.

For the first time, a single communications technology meets LAN and WAN requirements and handles a wide variety of current and emerging applications. ATM is the first technology to provide a common format for bursts of high speed data and the ebb and flow of the typical voice phone call. Seamless ATM networks provide desktop-to-desktop multimedia networking over single technology, high bandwidth, low latency network, removing the boundary between LAN WAN.

ATM is simply a Data Link Layer protocol. It is asynchronous in the sense that the recurrence of the cells containing information from an individual user is not necessarily periodic. It is the technology of choice for evolving B-ISDN (Board Integrated Services Digital Network), for next generation LANs and WANs. ATM supports transmission speeds of 155Mbits / sec. In the future. Photonic approaches have made the advent of ATM switches feasible, and an evolution towards an all packetized, unified, broadband telecommunications and data communication world based on ATM is taking place.

2. EVOLUTION TO ATM

Several transfer modes have been considered for B-ISDN. Synchronous Transfer Mode (STM) was the first technique to be considered due to its compatibility with most existing systems and the desire to preserve the investment in existing equipment while evolving to a more flexible network.

ATM has been proposed to overcome the limitations of STM and the large delay incurred by conventional packet switching. ATM is one of the general classes of digital packet technologies that relay and route traffic by means of an address contained within the packet. What makes packet technologies attractive for data traffic is that they exploit communication channels much more efficiently than the STM technologies common used to transmit digitized voice.

Comparison between ATM and STM is shown in table 1.1 and comparison of conventional and fast switching is shown in table 1.2.

In STM, data is routed over dedicated physical paths established either when a dialed call is setup or when a private is installed.

ATM	STM
Packet Switching	Circuit Switching
Statistical Multiplexing	Time Division Multiplexing
Allocation of Bandwidth on demand	Static Bandwidth allocation
Multi-service capability	Suitable for fixed rate continuous service
Distance and time sensitive Pricing	Pricing based on number of pricing packets
Efficient utilization of network resources	Less efficient utilization
Overhead information required	No overhead information is required

Table 1.1 Comparison between STM and ATM

Parameter	Conventional Packet switching	Fast Packet Switching	Result
Bottle neck	Channel transmission speed	Processing speed at switching nodes	Used of optical fiber and need for fast switching
Packet length	Variable	Fixed and Short (53 bytes)	Less delay, less jitter & less buffer management complexity
Switching	In software	In hardware	Higher speeds
Error and flow control	Link to link basis	End to end basis	Less Processing over head at switching at switching nodes

Table: 1.2 Comparison of conventional and fast packet switching

Voice traffic would suffer if the words arrived in bunches with irregular gaps in between. So, service provides ensure regular delivery by transferring the information synchronously.

Time division multiplexing is adopted here. Each frame of data is divided equally into as many time slots as there are voice channels. So instead of addresses, STM technologies identify data by its position within a frame. Therefore, time slots within an ATM frame cannot be shared among calls. Even when a talker is silent, another user cannot grab his time slot.

Being able to grab extra time slots would not improve voice communication very much, but for data transmission it could be very useful. Since data does not require periodic transfer like voice, a data circuit could utilize unused time slots whenever they appeared.

Packet and cell technologies gain efficiently for data transfer, by giving users access to the entire communication channel when they need it, for as long as they need it. If the channel is in use a new user may have to wait to gain access. But for data, this delay is not a problem; it is compensated for by the fact when the user does access the channel there is maximum bandwidth available.

By giving user access to the whole channel at random intervals for random length of time, packet switched technologies give up the possibility of identifying data on the basis of its particular time slot within a fame. Hence the need for a header containing an address representing the destination of the message (label multiplexing arises. Apart from being bandwidth efficient and multi-service capable, advantages of ATM include scalability and flexibility.

Scalability

ATM is a scalable technology. Other digital communication technologies usually tie rates and formats together. The ATM standard described only the 53 byte cell format, without specifying rates, framing or physical bearers. The many different systems such as LANs and public networks can use the same format at rates convenient to them.

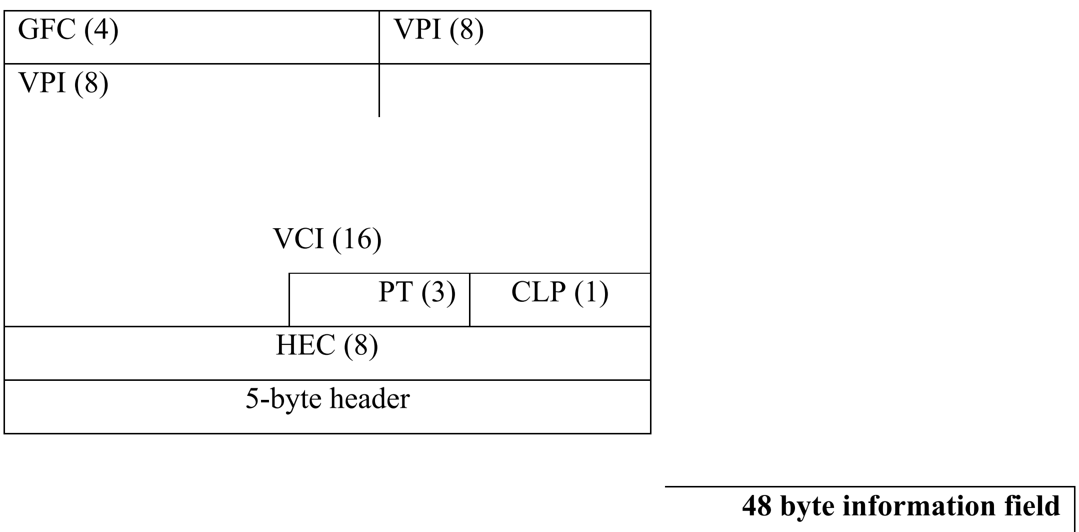
Flexibility

ATM is very flexibility in the way grants access to bandwidth. Its users are not obliged to but wide area bandwidth in network sized increments tied to the hierarchy or digital communication network. ATM users send bursts of as many few cells as necessary to transfer their data, they also pay only for the cells they sent, not for the speed of a dedicated system, they may use partially.

3. ATM CELL

Unlike the conventional packet switching technologies, ATM used very short fixed length packets called cells. ATM cells are 53 bytes long. They consist of a 5 byte header and a 48 byte information field. The header of an ATM cell contain al the information a network needs to relay the cell from one node to the next over the pre-established route. User data is contained in the remaining 48 bytes. The selection of the short fixed length cells reduces the delay and most significantly jitters for delay sensitive services. Fixed length cells also allow the switching functions to be moved from software into hardware with dramatic increase in switching speeds.

ATM is a connection-oriented technology. That is, every cell in an ATM transmission travels over the same route, which is specified either during call setup in the case of switched service or by provisioning the case of private line serve.



GFC	:	Generic Flow Control
VPI	:	Virtual Path Identifier
VCI	:	Virtual Channel Identifie
PT	:	Payload type
CLP	:	Cell Loss Priority
HEC	:	Header Error Control

Fig: 2.1 ATM cell format

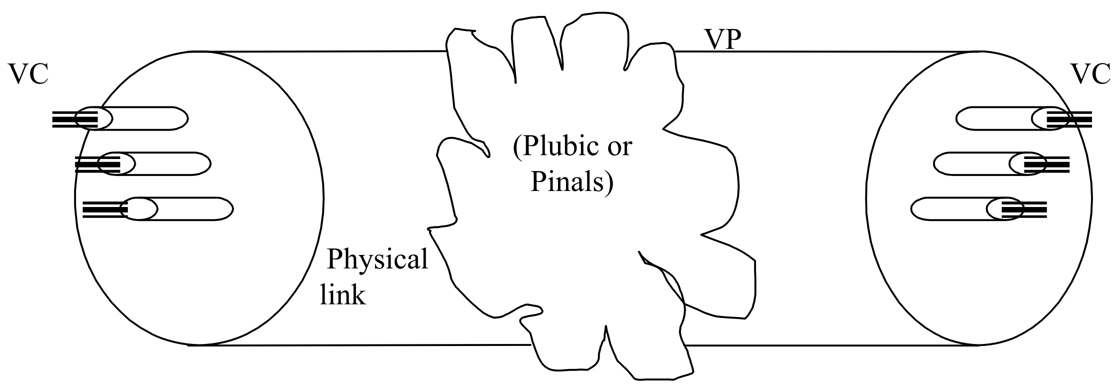
ATM Header

A header is protocol control information located at the beginning of a protocol data unit.

VPI and VCI

The ATM header comprises several fields with the address contained in the three bytes labeled VCI and VPI. The first byte of the address contains the Virtual Path Identifier (VPI) and the second two bytes make up the Virtual Channel Identifier (VCI).

In ATM, a virtual channel is used to described unidirectional transport of ATM cells associated by a common unique identifier value, VCI. Even though a channel is unidirectional the channel identifiers be assigned bidirectionally. The band width in the return direction may be assigned symmetrically or asymmetrically or it could be zero. A virtual path is used to describe unidirectional transport or ATM cells belonging to virtual channels that are associated by a common identifier value, called VPI.



This two part addressing allows the network to use a short hand notation for major trunks between locations while maintaining the identity of individual circuits within the trunk. A virtual path may consist of several virtual channels. Hence, the

VPI might represent a trunk between two cities and the VCRs might represent individual calls. Switching equipments along the way can route all the calls on the basis of just the first byte of the address until the trunk gets to the final location where the traffic is distributed. It is to be noted here that, these labels are only locally significant at a given interface. They may undergo remapping in the network, however, there is an end to end identification of the users stream so that data can flow reliably.

GFC (Generic Flow Control)

ATM headers consists of a four bit GFC field and has its functionality in multi-access network. The purpose of GFC is to provide an efficient and reliable mechanism for multiple B-ISDN terminals to be connected a shared medium local functions as the customer site (eg.: passive bus support) the field is ignored and may be overwritten by the public network.

PTI (Payload Type Indicator)

The three bit payload type is used for maintenance purpose. It helps the users to distinguish between cells that carry user information and those that carry service or network information, and optional service adaptation function information. In network information cells, the payload does not form part of the user's information transfer. Code points 000 to 0111 indicate user information, these PTI values identify two types of end user information and whether the cells has experienced congestion. Code points 100 to 111 identify different types of operation flows:

Table 2.1

PTI load point	Meaning
000	User data SDU Type 0, no congestion experienced
001	User data SDU Type 1, no congestion experienced
010	User data SDU Type 0, congestion experienced
011	User data SDU Type 1, congestion experienced
100	Segment OAM F4 flow cell
110	Reserved for future traffic control and resource management functions
111	Reserved for future use

The user can then generate a sub channel along the same path as the user information to check whether the quality of service promised by the network operator is in fact being delivered.

Foot note:-

Service Data Unit – A unit of interface information whose identify is preserved from one end of a layer connected to the other.

Operation and maintenance – A cell that contains ATM layer management information. It does not form part of the upper layer information transfer.

For VPs operation functions are supported via specially marked ATM cells which transmitted over VCs with specific VCI values (VCI = 4, for end to end operation and 3 for segment information) these are known as F4 flow. For VCs operation functions are supported via cells marked with an appropriate code point in the PTI field. These are known as Fr flows.

CLP (Cell Loss Priority)

The single bit CLP field determined the order in which the network discards cells in overload situations when buffer overflow is impending. The initial thinking was the if CLP is set to 1 by user, the cell is subjected to discard or erase depending on the network congestion conditions. If CLP is not set the cell has higher priority. But more recent thinking proposes not making use of this bit as the part of the user (i.e., it must always be set to 0 by the user).

HEC (Header Error Control)

The last byte of the HEC is a checksum for the first four bytes. It is used for error management of the header. It allows multibit header errors to be detected and single bit error to be corrected. ATM cells that have errors will be discarded by the network.

4. ATM PROTOCOLS

Protocol is a set of rules and formats, semantic and systematic, that determines the communication behavior of layer entitles in the performance of the layer functions. It defines the way in which users communicate with the public network for the purpose of accessing the service provided by the network. Fig. 4.1 illustrates the ATM protocol stack.

CLCP layer	
AAL	CS ……………………… SAR
ATM layer	
Physical layer	

CLCP : Connectionless Convergence Protocol
AAL : ATM Adaptation Layer
CS : Convergence Sublayer
SAR : Segmentation and Reassembly

Fig. 4.1 ATM Protocol stack

ATM network can be considered as a number of layers providing different functions.

It has got three main layers:- the physical layer, ATM layer and the ATM adaptation layers. The protocol stack for the application of Connectionless service over an ATM network may also include a CLCP layer or a Connectionless convergence protocol. The CLCP includes such network layer information as addressing information carrier selection and quality of service selection.

The different functions of other layers are discussed in the following sections.

ATM Physical layers

The Physical layer provides access to the physical medium for the transport of ATM cells. It includes methods for mapping cells to the physical medium and methods dependent on the physical medium.

Thus the physical layer is made up of two sublease – the Transmission Convergence Sub layer and the Physical Medium Dependent Sub layer. The TC sub layer maps the cells stream to the underlying framing mechanism of the physical transmission facility and generate the required protocol control information for the physical layer. It also generate the HEC.

The PMD sub layer deals with the electrical or optical aspects of the physical interface.

Its function includes cell delineation, cell scrambling and descrambling timing recovery and line coding.

ATM Layer

The ATM layer provide for the transport of cells between end user location. It is implemented in user's equipment and in network equipment. ATM cells from end users are forwarded across virtual connections through the public network. These connections are provided at subscription time or in real time via signaling. The ATM layer also provides multiplexing functions to allow the establishment of multiple connections across a single user network interface (UNI). ATM cells delivered across the network in the same sequence they are received. The function of this layer includes cell multiplexing and de-multiplexing, VPI and VCI translation cell header generation / extraction etc.

ATM Adaptation Layers (AAL)

The AAL enhances the services provided by the ATM layer to support the function required by next higher layer. The AAL function are organized in two logical sub layers:- the Convergence Sub layer (CB) and the Segmentation and Reassembly sub layer (SAR).

The CS performs a set of service related functions. It maintains bit count integrity, generator timing information, recovers timing, generates and recovers data structure information etc. The SAR is responsible for the transport and bit error detection and correction.

AAL Definition	AAL	AAL2	AAL3/4	AAL5
Timing relation	Required		Not required	
Bit rate	constant	Variable		
Connection oriented	Yes			Both

Table 4.1 AAL Layers

The role of AAL is to be provide the mapping of particular type of traffic on to the under laying ATM cell layer. Traffic can split in four basic classes depending on the requirements for constant or variable bit require constant bit rate video and circuit emulation. Transfer of timing information over the call is the major function that AAL 1 has to be provide to ensure synchronization of data.

AAL2 provides support for variable bit rate video which requires maintenance of timing information across the call.

The merged AAL ¾ layers support for variable bit rate traffic which does not require timing information. This supports both connection – oriented and connectionless services.

AAL5 is designed to be simple AAL to support variable bit rate data traffic with no timing relationships. It does not offer enhanced services such as reliable network services, and is seen as the primary AAL used to provide LAN interconnection.

5. THIRD GENERATION LANs

ATM LAN

Local Area Networks are one of the most active application area for ATM, because the technology offers entirely new approach to LAN architecture, centralized switching and control, rather than distributed access, Traditional LANS depend on sharing of a physical medium. Software at each station controls access to the physical bearers in accordance with rules established as part of the LAN standard. These rules arbitrate among users trying to use the shared medium at the same time. Drawbacks of shared medium include one at a time access to the medium, the fact that all stations run at the same rate, regardless of need and loss of through put during heavy use.

An ATMLAN replaces the shared medium with a centralized switch that has a dedicated connection for each user. Controls of the network resides the switch which routes messages and controls access in the event of congestion. Each user in the ATM LAN has line to port on the switch that is shared with no one else. A user send a message to the switch which routes it to the destination by the address indicated in the header. Because each port is dedicated to one user to users do not have to contend for access to the connections. If a file is being transmitted it moves in one continuous burst at the full channel rate instead of being segmented into shorter frames as with other LANs.

In the IEEE 802 model (fig.5.1) the data link layer protocol is divided into 91) MAC which defined the mechanisms that are used to access, share and manage the communication medium & (2) LLC that defines a common interface for different network layer protocols to inter work with different MAC protocols.

Each host attached to a LAN has a globally unique MAC address which is 6 bytes in length. In order for host to sent data to another host, it is necessary for the source host to know the MAC address of the next hop router if they are different LANS, or the MAC address is done by an Address Resolution Protocol (APR). For example, if A wants to send data B and doesn't know its MAC address, it broadcasts an ARP query which its own IP and MAC address and 'B's IP address. B responds to the query by sending an ARP reply with its own MAC address obtained from the ARP cache. Subsequent data transfer from A to B done using B's MAC address obtained from the ARP cache.

Bridges are used to join different LAN segments to create a larger single LAN, Bridges are required to be able to learn to associate MAC address to specific bridge ports. For example, after listening to the various packets on the LAN in the Fig.5.1, bridge B can learn that the MAC address of A, B and C are associated with one of its ports while D, E, F, G, H and RI are associated with the other port. Bridges are transparent to the host. Thus when A sends an ARP query for F, it receives F's MAC address.

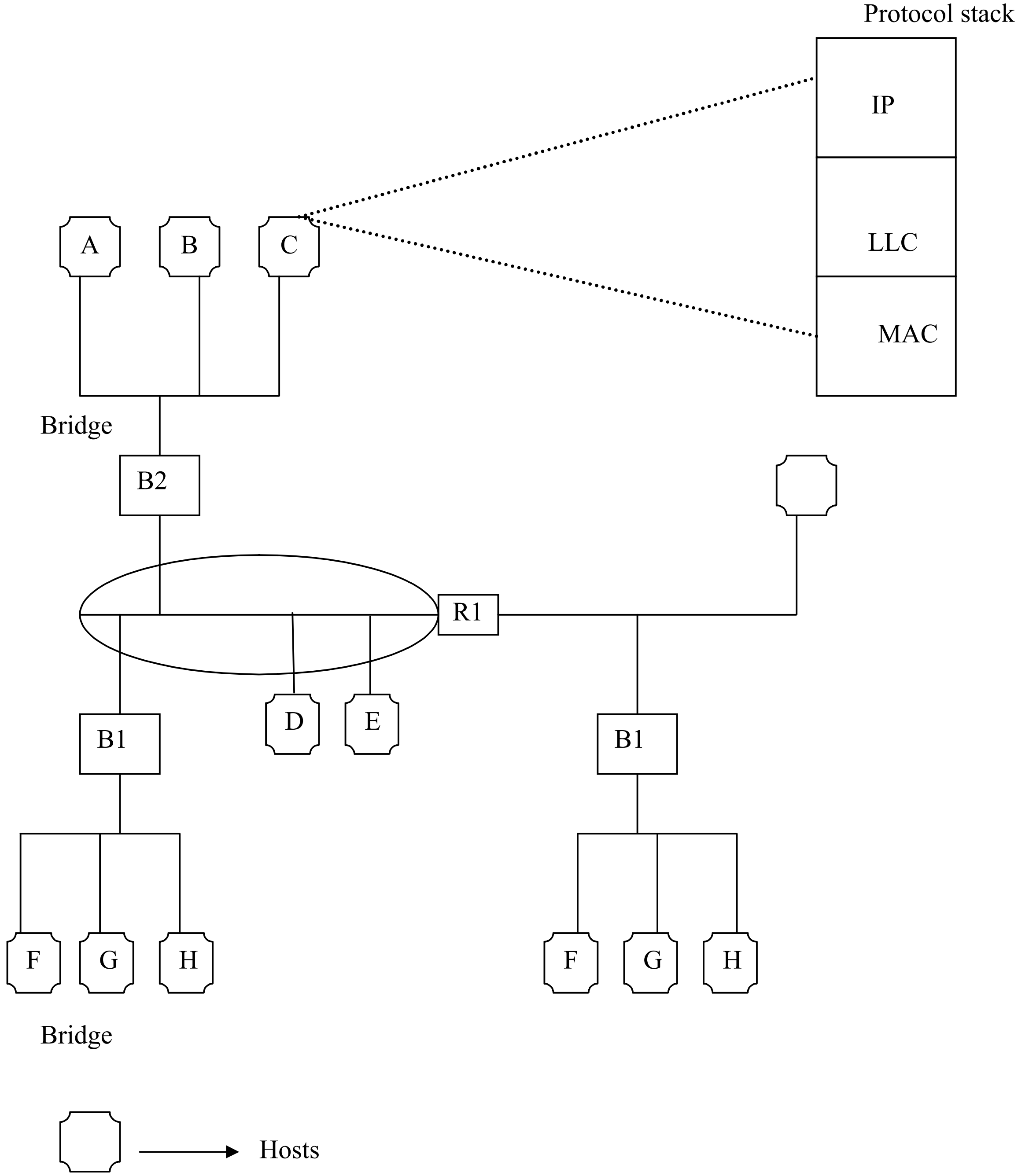


Fig 5.1 A Local Area Network

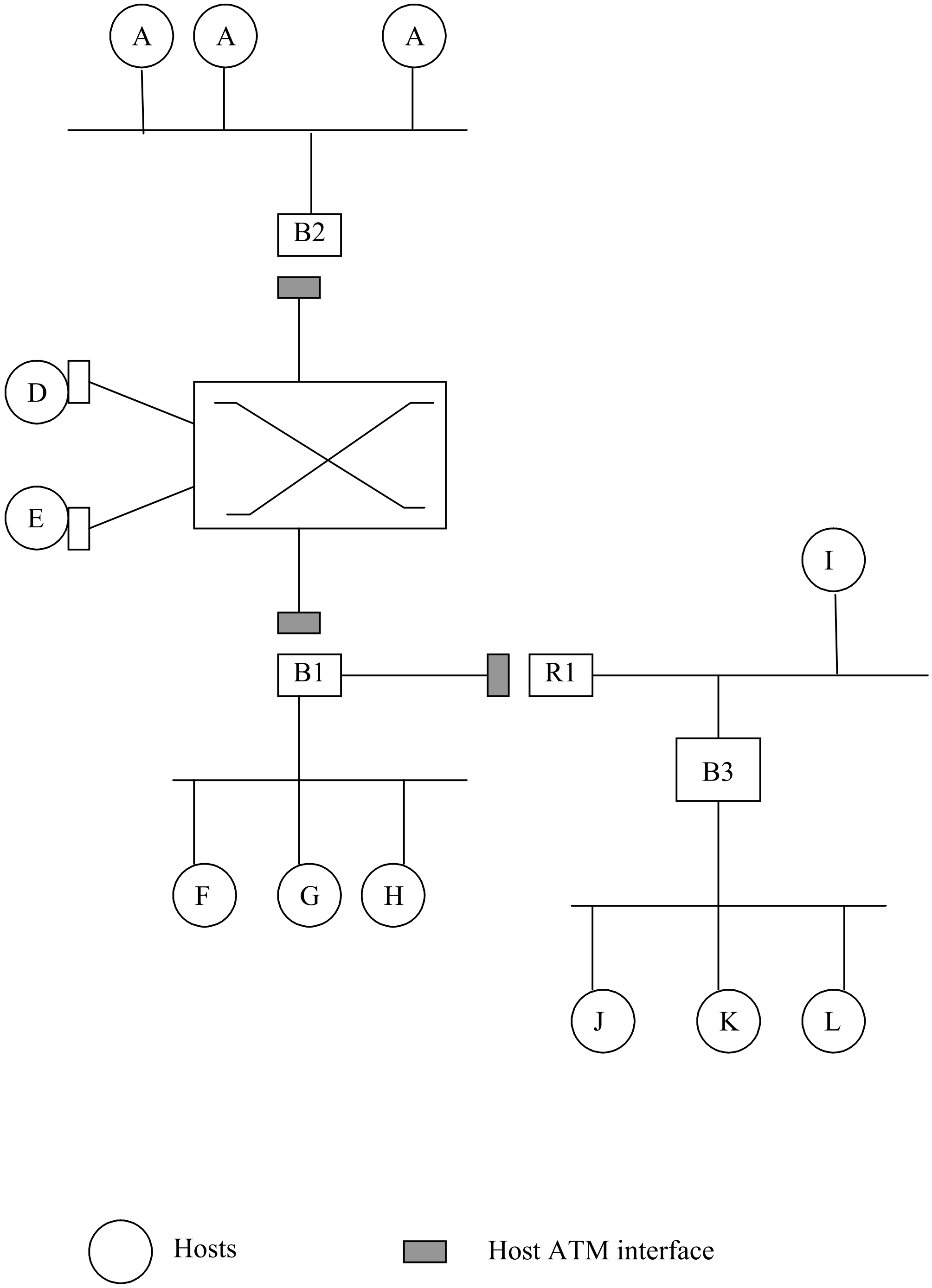


Fig 5.2 A Local ATM Network

Now, consider the LAN in Fig. 5.2 which is obtained by replacing an IEFE 802 LAN by an ATM switch routers bridges and dedicated leased lines into a private data network. The router connected to a LAN detects a message a addressed to a station off the local network and directs it down the appropriate leased line to another router. The process is repeated until the message reaches the determination LAN.

All these involves a lot of leased lines and on nation wide basis can be quite expensive. These charges are independent of usage and the companies need these dedicated lines only for a small part of time. ATM can fix this problem. It can substitute a shared public facility for dedicated lines one connection would be provided from user protocols to a public network ATM switch. Using a cell header address, the network switch would route the data traffic from switch over shared mode band carrier facilities until it has delivered to is destination.

Since the connection between the user and network switch replaces dedicated facilities used by bursty data traffic, its capacity can be less than the sum of capacities of the lines it replaces. The costs of provisioning service are thus lowered. ATM makes possible, billing on a per cell basis.

6. TRAFFIC MANAGEMENT FOR ATM LANS

There are two fundamental classes of traffic:- Capitalist traffic and Socialist traffic or rather guaranteed and best effort. Guaranteed traffic is one for which an explicit guarantee of service has been given by the network. Prior to connection setup, the source must describe its traffic characteristic and request a specific quality of service and the network must police the arriving ignored to ensure that it confirms to the traffic descriptor. Examples of traffic that may require a guaranteed service include real time traffic like voice and video.

The vast majority of existing data networking application are incapable of predicting their own bandwidth requirements. Since the traffic characteristics are own bandwidth requirements. Since the traffic characteristics are unknown, an explicit guarantee of service cannot be given. Rather data applications require a service that dynamically shares the available bandwidth between all active sources. This service is referred to as best effort service.

The switch hardware needs to ensure that at no time will the quality of service of the guaranteed traffic be adversely affected by the best effort traffic.

Traffic Management

Several traffic Management schemes are under consideration by the ATM form.

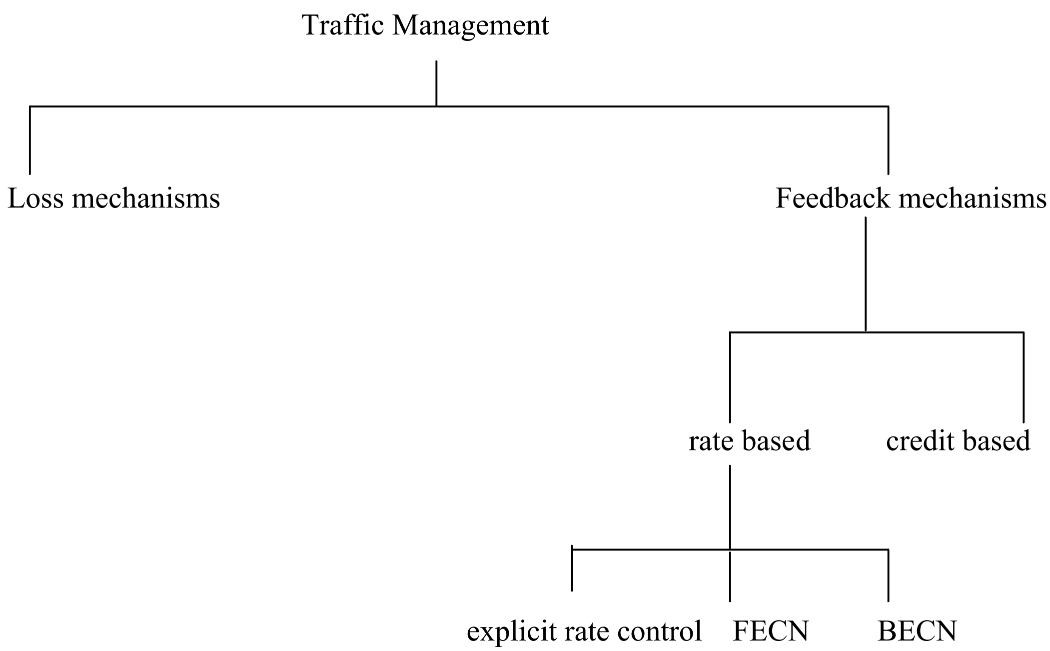


Figure 6.1 Different schemes adopted for traffic management

Loss mechanism simply discards arriving cells when the buffer is full by checking the CLP bit. Feedback scheme is a closed loop feedback control mechanism that allows the network to control the cell emission process at each source. Each virtual connection must have an independent control loop since each connection may follow a different path.

The credit-based approach is a link window flow control scheme. Each window in a network independently runs the flow control mechanism.

Rate based schemes use feedback information from the network to control the rate at which each source emits cells into the network on every virtual connection.

With explicit rate control, the network periodically determined a what rate ach source should be transmitting and sends a message to each source informing them of the new rate.

Foreward Explicit Congestion Notification (FECN)

It is an end-to-end scheme in which most of the control complexity resides in the end systems. When a path through a switch becomes congested the switch marks a bit in the header of all cell on that paths in the forward direction to indicate congestion. The destination end system monitors the congestion status of each active virtual connection and sends congestions notification cells in the reverse direction in each virtual connection to inform the source of the congestion status. The source uses this feedback to increase or decrease the cell transmission rate on each virtual connection.

Backward Explicit Congestion Notification (BECN)

In BECN congestion information is returned directly from the point of congestion back to the source for each virtual channel.

The source (S) generates packets represents the segmentation process for a particular virtual connection in the host's ATM network interface, (r) is a point of congestion somewhere in the network. There is transmission delay between transmitter transmitting a cell and the cell being received at (r). the transmission delay represents the combination of the propagation delay and the switching delay from the source to the point of congestion.

If the length of the congested queue (Q) exceeds a threshold, the filter (F) will send congestion notification (BECN) cells back on the virtual channel currently sending traffic through the congested queue. BECN cells are subjected to the same transmission delay in the return direction as cells in the forward direction. When a transmitter receives a BECN cell it reduces it cell transmission rate by half for the indicated virtual connection. If no BECN cells are received within recovery time period, the current transmission rate for the virtual connection is doubled once each recovery time period, until it reaches the peak rate.

The filter is required to prevent excess BECN cells being generated. There is no point sending another BECN cell back to each source until the previous feedback has had time to take effort. So, when the queue us congested, the filter should transmit no more than a single BECN previous BECN cell to take effect, the filter period should be of the same order of magnitude as the maximum propagation delay for which the system is designed. From the investigations done conducted so far it would seem that both the credit based and rate based schemed can be engineered to offer acceptable performance in the local area.

7. CONCLUSION

For those who experienced the ponderous deliberations and delays of ISDN, the ATM must seem like a tidal wave; a technology whose predicted implementation has continually advanced in time(while others have receded) and which is backed by a greater number of diverse players than the telecom sector has never seen before. Concurrently, ATM proponents are setting into accepting 1996 as serious time fame for installation of ATM stations. Anyway, there appears to be consensus that ATM will become the standard of late 90s.

The reference materials of this seminar are based on the recommendations that have been or will be amended to keep abreast of the progress of the recommendations.