DEFINITION AND OVERVIEW

Definition

Dynamic synchronous transfer mode (DTM) is an exciting networking technology. The idea behind it is to provide high-speed networking with top-quality transmissions and the ability to adapt the bandwidth to traffic variations quickly. DTM is designed to be used in integrated service networks for both distribution and one-to-one communication. It can be used directly for application-to-application communication or as a carrier for higher-layer protocols such as Internet protocol (IP).

DTM, Dynamic synchronous Transfer Mode, is a broadband network architecture based on circuit switching augmented with dynamic reallocation of time slots. DTM provides a service based on multicast, multirate channels with short set-up delay. DTM supports applications with real-time QoS requirements as well as applications characterized by bursty, asynchronous traffic

Overview

This tutorial explores the development of DTM in light of the demand for network-transfer capacity. DTM combines the two basic technologies used to build high-capacity networks—circuit and packet switching—and therefore offers many advantages. It also provides several service-access solutions to city networks, enterprises, residential and small offices, content providers, video production networks, and mobile network operators.

WHY DTM?

Over the last few years, the demand for network-transfer capacity has increased at an exponential rate. The impact of the Internet; the introduction of network services such as video and multimedia that require real-time support and multicast; and the globalization of network traffic enhance the need for cost-efficient networking solutions with support for real-time traffic and for the transmission of integrated data, both audio and video. At the same time, the transmission capacity of optical fibers is today growing significantly faster than the processing capacity of computers. Traditionally, the transmission capacity of the network links has been the main bottleneck in communication systems. Most existing network techniques are therefore designed to use available link capacity as efficiently as possible with the support of large network buffers and elaborate data processing at switch points and interfaces. However, with the large amount of data-transfer capacity offered today by fiber networks, a new bottleneck problem is caused by processing and buffering at switch and access points on the network. This problem has created a need for networking protocols that are not based on computer and storage capacity at the nodes but that instead limit complex operations to minimize processing on the nodes and maximize transmission capacity.

Against this background, the DTM protocol was developed. DTM is designed to increase the use of fiber's transmission capacity and to provide support for real-time broadband traffic and multicasting. It is also designed to change the distribution of resources to the network nodes dynamically, based on changes in transfer-capacity demand.

DTM BASICS

CIRCUIT SWITCHING vs. PACKET SWITCHING

In principle, two basic technologies are used for building high-capacity networks: circuit switching and packet switching. In circuit-switched networks, network resources are reserved all the way from sender to receiver before the start of the transfer, thereby creating a circuit. The resources are dedicated to the circuit during the whole transfer. Control signaling and payload data transfers are separated in circuit-switched networks. Processing of control information and control signaling such as routing is performed mainly at circuit setup and termination. Consequently, the transfer of payload data within the circuit does not contain any overhead in the form of headers or the like. Traditional voice telephone service is an example of circuit switching.

Circuit-Switched Networks

An advantage of circuit-switched networks is that they allow for large amounts of data to be transferred with guaranteed transmission capacity, thus providing support for real-time traffic. A disadvantage of circuit switching, however, is that if connections are short-lived—when transferring short messages, for example—the setup delay may represent a large part of the total connection time, thus reducing the network's capacity. Moreover, reserved resources cannot be used by any other users even if the circuit is inactive, which may further reduce link utilization.

Packet-Switched Networks

Packet switching was developed to cope more effectively with the data-transmission limitations of the circuit-switched networks during bursts of random traffic. In packet switching, a data stream is divided into standardized packets. Each contains address, size, sequence, and error-checking information, in addition to the payload data. The packets are then sent through the network, where specific packet switches or routers sort and direct each single packet.

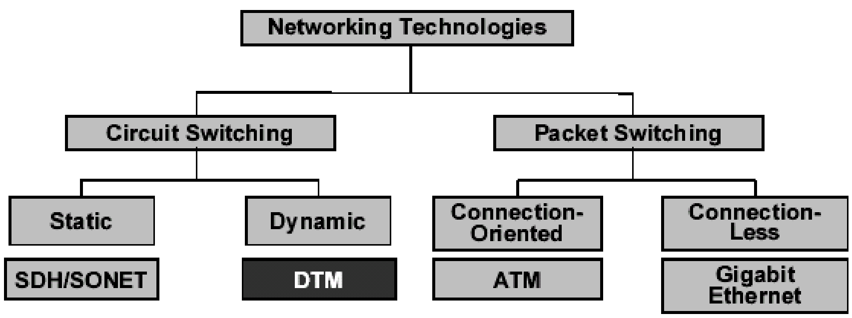

Figure1: Technology Overview

Packet-switched networks are based either on connectionless or connection-oriented technology. In connectionless technology, such as IP, packets are treated independently of each other inside the network, because complete information concerning the packet destination is contained in each packet. This means that packet order is not always preserved, because packets destined for the same receiver may take different paths through the network. In connection-oriented technology such as asynchronous transfer mode (ATM), a path through the network—often referred to as a logical channel or virtual circuit—is established when data transfer begins. Each packet header then contains a channel identifier that is used at the nodes to guide each packet to the correct destination. In many aspects, a packet-switched network is a network of queues. Each network node contains queues where incoming packets are queued before they are sent out on an outgoing link. If the rate at which packets arrive at a switch point exceeds the rate at which packets can be transmitted, the queues grow. This happens, for example, if packets from several incoming links have the same destination link. The queuing causes delay, and if the queues overflow, packets are lost, which is called congestion. Loss of data generally causes retransmissions that may either add to the congestion or result in less-effective utilization of the network. The ability to support real-time traffic in packet-switched networks thus calls for advanced control mechanisms for buffer handling and direction. As a result, the complexity and necessary ability to process information, and therefore the need for computer power, increases sharply when striving for high transmission capacity.

THE DTM ADVANTAGE: COMBINING SYNCHRONOUS AND ASYNCHRONOUS MEDIA ACCESS SCHEMES

In view of the above, DTM was developed in an effort to combine the simple, nonblocking, real-time traffic-supporting properties of circuit-switching technology with the dynamic resource-handling properties of packet-switching technology. Combining the advantages of synchronous and asynchronous media-access schemes, DTM forms a transport-network architecture that enables high transfer capacity with dynamic allocation of resources.

As will be shown in the following sections, DTM is fundamentally a circuit-switched, time division multiplexing (TDM) scheme, and, like other such schemes, it guarantees each host a certain bandwidth and uses a large fraction of available bandwidth for effective payload data transfer. In common with asynchronous schemes such as ATM, DTM supports dynamic reallocation of bandwidth between hosts. This means that the network can adapt to variations in the traffic and divide its bandwidth between nodes according to demand.

DTM, like existing transport networks, uses a similar kind of framing structure—synchronous digital hierarchy (SDH)/synchronous optical network (SONET) (i.e., 8-kHz frame repetition frequency)—and is extended with dynamic reallocation of resources. DTM operates at layers one to three in the open systems interconnection (OSI) model and includes switching, control signal for setup, routing, and support functions for easy management. In contrast to SDH/SONET, multirate channels or circuits can be established on demand in DTM, and the capacity of a channel can be changed according to traffic characteristics during operation. Because the distribution of resources among nodes on a ring or bus can be changed, free resources are allocated to nodes with the highest demands, providing an autonomous and efficient dynamic infrastructure. Also, an important aspect of DTM is that it provides a multichannel interface similar to the one provided by ATM.

PRINCIPLES OF DTM: FRAMES SLOTS AND CHANNELS

DTM is designed for a unidirectional medium with multiple access—for example, a medium with capacity shared by all connected nodes. It can be built on several different local topologies such as ring, double ring, point to point, or dual bus.

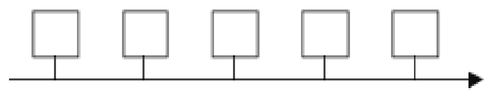

Figure2: DTM Multiplexing Medium with Multiple Access

DTM is based on TDM, whereby the transmission capacity of a fiber link is divided into small time units. The total link capacity is divided into fixed-size frames of 125 microseconds. The frames are further divided into a number of 64-bit time slots. The number of time slots per frame is dependent on the bit rate. Using a bit rate of 2 Gbps, the number of time slots within each frame totals approximately 3900. The selected use of a frame length of 125 microseconds and 64 bits per time slot enables simple adaptation to digital voice and plesiochronous digital hierarchy (PDH) transport(PDH is the conventional multiplexing technology for network transmission systems where transmitted signals have the same nominal digital rate but are synchronized on different clocks)

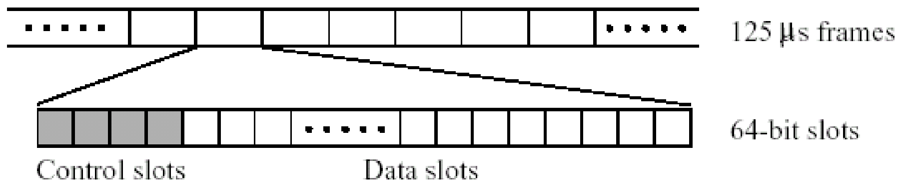

Figure3: DTM Multiplexing Format

The time slots within each frame are separated into data slots and control slots. At any point in time, a slot is either a data slot or a control slot. However, if needed, data slots may be converted into control slots and vice versa.

The right to write data slots and control slots is distributed among the nodes attached to the link. Consequently, each node attached to the link will typically have write-access to a set of data and control slots, and these time slots will occupy the same time-slot position within each frame of the link. Each node has write-access to at least one control slot that the node uses for sending control messages to the other nodes. Control messages can be sent upon request from a user served by the node, in response to control messages from other nodes, or spontaneously for network-management purposes. The control slots constitute only a small fraction of the total capacity, while the majority of the time slots are data slots carrying payload. The signaling overhead in DTM varies with the number of control slots but is typically low. For a ring with 20 attached nodes and a bit rate of 2 Gbps, the signaling overhead is typically less than one percent.

As stated, data slots are used for carrying payload data. Each node typically has write-access to a pool of free data slots, which will occupy the same time-slot positions within each frame of the link. When establishing communication channels, a node will allocate a portion of the data slots available in the node's pool of free data slots to the channel, as will be discussed further in the next section.

DTM channels are multicast in nature. This means that any channel at a given time can occupy one sender and any number of receivers. Over the network, any number of multicasting groups can be active simultaneously. The extreme case of multicasting is broadcasting, where one node is sending and all other nodes are receiving.

Slot Allocation

DTM uses a distributed algorithm for slot reallocation, where the pool of free slots is distributed among the nodes. At the reception of a user request, the node first checks its own time slots to see if it has slots enough to satisfy the request and, if so, immediately sends a channel establishment message to the next hop. Otherwise, the node first has to request more slots from the other nodes on the link. Each node maintains a status table that contains information about free slots in other nodes, and when more slots are needed the node consults its status table to decide which node to ask for slots. Every node regularly sends out status messages with information about its local pool of slots.

Channel Establishment

Each node has a network controller, which handles the node-to-node signaling. This signaling is done via the control slots and is used for channel management and time slots reservation.

When a DTM user wants to set up a channel, it sends a *create* primitive to the network control element which allocates the necessary bandwidth and sends an *announce* message to the receiving node. The network control element also sets up the channel tables in the DTM link layer and sends back an *indication* primitive, notifying the sending user that the requested capacity, i.e. the requested number of slots per frame, have been allocated. The user either waits for a confirmation from the receiving side (video, voice) or sends data directly after receiving the indication (datagram).

After a complete transfer, the user sends a remove message to the receiver notifying that the channel is to be closed and to de-allocate the reserved time slots. The actual data transfer is handled by the network without requiring any additional processing elements in the switches.

There is, however, a trade-off between throughput and access delay in DTM. The time delay to establish channels is depending of the availability of slots and the number of hops in the network. For small channels, the needed slots are more likely to be immediately available, while for large channels the node may have to ask other nodes for more slots.

It is reasonable to assume that a session that has very high demands on throughput and service quality, such as two-way video, can tolerate an access delay in the order of 10-20 milliseconds. On the other hand, for small IP-packet streams that arrive frequently enough, it can be justified to have the network permanently fully connected with a guaranteed minimum of 512 kbps.

It has been shown that the signaling delay associated with creation and deletion of communication channels determines much of the efficiency of fast circuit switching. DTM is therefore designed to create channels fast, within a fraction of a millisecond.

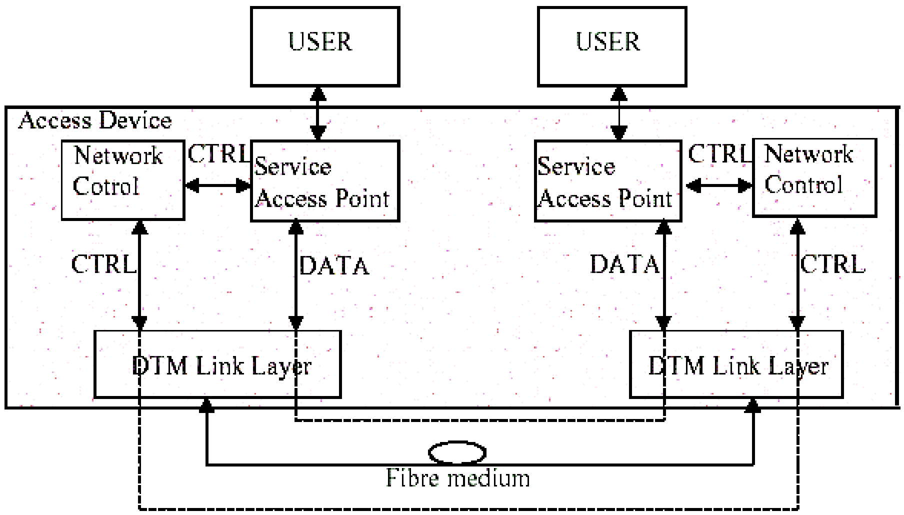

Figure4: Flow of data and control information

Time Slot Reservation

DTM uses a strict time slot reservation scheme. A new channel is admitted only if there are enough free slots, and a suitable route can be found. Once a route is established, the user of the route is guaranteed the reserved bandwidth until the channel is closed. Thus there can be no congestion in the network. Flow control is only needed at the access point. DTM may offer the user at least three types of reservation schemes.

1. For applications requiring constant delay and guaranteed constant bit rate for their exclusive use through the network, a channel is set up with fixed capacity for the whole lifetime of the channel.
2. For applications requiring a minimal guaranteed bandwidth with options for additional bandwidth, a scheme is used where a guaranteed number of slots are always reserved, while more bandwidth can be given if time slots are available. The effect is a non-interrupted traffic that gracefully can be upgraded on demand.

3. For best-effort requirements, a channel is created for every burst. The sender has to wait until the channel is established, and there is no guarantee about bandwidth.

When the burst is over, the channel is closed. However, the recently allocated slots remain for a while with the nodes that used them. Thus, if a new burst occurs between the same nodes, it is very likely that there will be slots available.

DTM Channels

Channels in DTM have the following properties.

- Simplex: a channel is set up from sender to receivers. A duplex channel consists of two channels, one in each direction. The two channels can be of different capacity, thus facilitating asymmetrical communication patterns.
- Multirate: channels may consist of an arbitrary number of data slots, which means that channel capacity can be any multiple of 512 kbps, up to the entire data capacity of the link.
- Multicast: a channel can have several receivers.
- Renegotiated: the bandwidth allocated for a channel can be changed by adding slots to or removing slots from the channel. This can be done while still transmitting data on the channel.

A node creates a channel by allocating a set of data slots for the channel and by sending a channel establishment control message. The control message is addressed either to a single node or to a multicast group, and announces that the channel has been created and what slots it uses.

To create a channel, slots must be allocated at the sender and at each switch node along the channel's route. Thus, switch nodes allocate slots for a channel on behalf of the sender. The switch nodes then start switching the channel, by copying the channel's slots from the incoming to the outgoing link. An attempt to establish a multi-hop channel fails if any of the switch nodes involved cannot allocate the required amount of slots. In this case another route has to be tried. By using several physical links, load balancing and redundancy can be achieved.

Switching

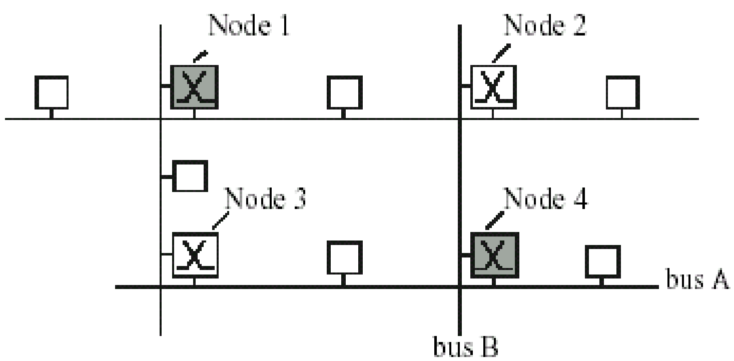

Figure5: Switch node interconnection

A DTM network can be expanded by interconnecting several links with switch nodes. DTM uses decentralized switching in the sense that any node connected to two or more links can switch data between them. One advantage with this is that the switching capacity can be increased gradually by adding more switch nodes. The switching is synchronous, which means that the switching delay is constant for a channel. This means that a multi-hop channel has roughly the same properties as a channel on a single link. The only difference is that a switched channel has slightly longer delay4.

Provided that a switch node can buffer one frame of data for each of its links, there cannot be any congestion or overflow in the node.

Multicast Channels

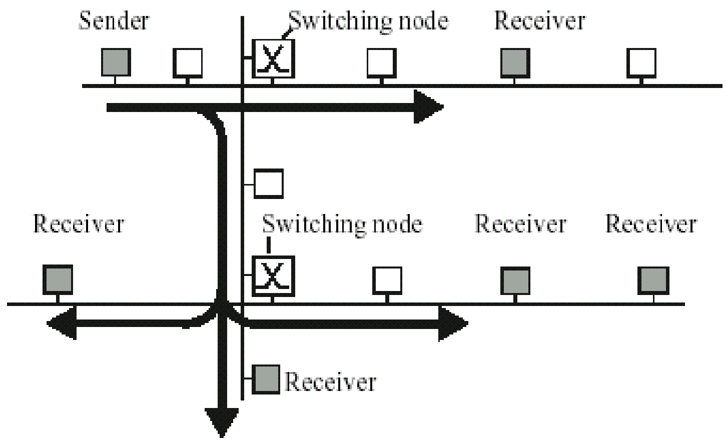

Figure6: A multicast group

A traditional circuit is a point-to-point channel between a sender and a receiver. DTM uses a shared medium that inherently supports multicast since a slot can be read by several nodes on a link. A multicast channel can easily be extended to span over several hops, since the switch operation is actually a multicast operation, in the sense that it duplicates data onto another link

DTM SERVICES

The DTM solution is designed to transport common communication protocols over optical fibers. DTM provides several simple and commonly used services in one integrated network. It results in better utilization of the fiber and of the node equipment and simple management and operation of the network.

Data communications—particularly IP traffic—are becoming the main traffic source in the networks. DTM has been specifically developed for efficient transport of this type of traffic. However, a large part of the network traffic is still PDH–based (PDH allows transmission of data streams that are nominally running at the same rate, but allowing some variation on the speed around a nominal rate), and, therefore, DTM products also transport PDH traffic.

There are a number of traffic types that can be integrated advantageously in a DTM network. Among such alternatives, the following traffic types will be implemented in the first stage:

- IP over DTM
- DTM local area network (LAN) emulation (DLE)
- PDH transport
- SDH/SONET tunneling
- Transport of 270–Mbps studio video

DTM today offers two different techniques for transmitting IP traffic: IP over DTM and DLE. IP over DTM is a technique that fully utilizes the DTM networks in transmitting IP traffic on a hop-by-hop basis via shortcuts. DLE is used to establish virtual LANs across the DTM network and makes it possible to attach IP nodes to the DTM network efficiently, for example.

DLE makes the attached nodes believe they are part of a widespread LAN (802.3 Ethernet). DLE is used to connect geographically distributed LANs by transferring Ethernet packets over DTM channels. Virtual private networks (VPNs) are effectively supported using DLE.

More than 90 percent of today's LANs are Ethernet-based, and the market-share is increasing. Because applications believe they are sending data onto an Ethernet LAN, no change to applications is necessary for using DLE. In addition, DLE is Layer-3 independent and therefore enables different Layer-3 protocols such as IP, NetBIOS, and IPX to be used.

E1/T1 is supported and the E3/T3 interface will be supported in the future. The E1/T1 transport can be used for interconnecting telephone switches or for leased-line services. DTM networks also support transparent PDH transport equivalent with PDH support in SDH/SONET networks. A DTM network differs from SDH/SONET in that the former has a distributed approach to the add-drop multiplexer functions. This feature provides flexible utilization of the fiber resources and a dynamic approach to protection switching.

DTM SOLUTION FOR ENTERPRISE ACCESS

How Is an Enterprise Connected?

With DTM, service providers are able to provide large enterprises with all their communication needs via one network-access point. DTM allows services to be integrated on a transport level and thus optimizes the utilization of network access. The solution for the large enterprise is a DTM access device that provides service access via several Ethernet ports and some E1/T1 ports on the same device. The upper link runs DTM directly on fiber from the access device toward the network. That gives the network provider a simple network structure with DTM as the only protocol needed in the aggregation loops for all services offered.

Bandwidth between 512 Kbps and Full Link Bandwidth

With the integration of services on the transport level, QoS is kept clean and simple without the use of any complex priority schemes. The high granularity (steps of 512 kbps) and bandwidth scalability (from 512 kbps to 850 Mbps) of DTM channels also allows for flexible price differentiation. When using the DTM access device, it is even possible to provide company control of its bandwidth resources and then bill upon resource (bandwidth) utilization. Typical services for enterprises that can be offered through the access device are voice VPN via private branch exchange (PBX) interconnection, corporate data network solutions, Internet access, and firewall solutions.

Private Data Networking

Corporate data networks can simply be built by interconnecting office LANs with DLE service. The DLE service provides a flexible high-speed LAN–to–LAN network, which is Level-3 independent and, hence, could be used for many kinds of protocols and applications supporting Ethernet. Supporting DTM short-cut establishment with channel isolation ensures high-quality communication with short delays that preserves communication security. The DLE service is therefore ideal for demanding applications such as videoconferences.

Because the DLE service supports Ethernet transparently, most office LAN architectures can be preserved, and interoperability, with all kinds of standard Ethernet equipment, is ensured. When using an access device at the customer premises, no additional equipment with gateway functions (such as a router) is actually needed for LAN interconnection, and thus much of the network management can be reduced.

For larger data networks it may, for manageability reasons, be desirable to build hierarchical networks using routers. The DLE service and any standard router with Ethernet support may be used for that purpose.

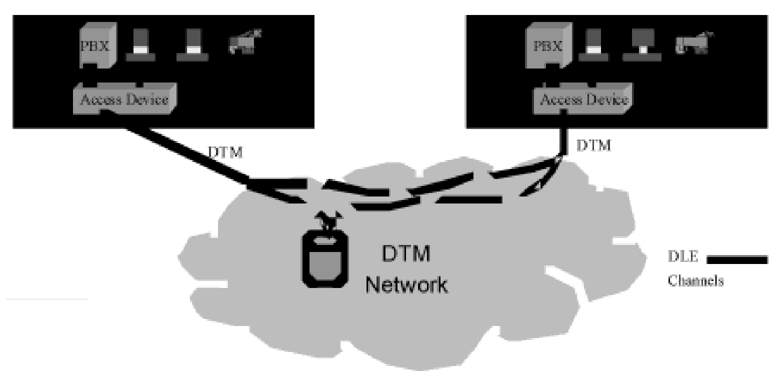

Figure7: Corporate Data Network using the DTM LAN Emulation (DLE) Service

By combining the DLE service with an IP–routing solution, the same Ethernet access may be used for both the corporate-data network and the company's Internet access. The IP–routing solution has a built-in firewall that permits the same access to be used. Because the DLE service isolates DTM channels for flows between different Ethernet segments, all Internet communication will be separated from corporate data, even though these are defined on the same DLE segment. It is thereby possible to separate the Internet from corporate-data traffic completely.

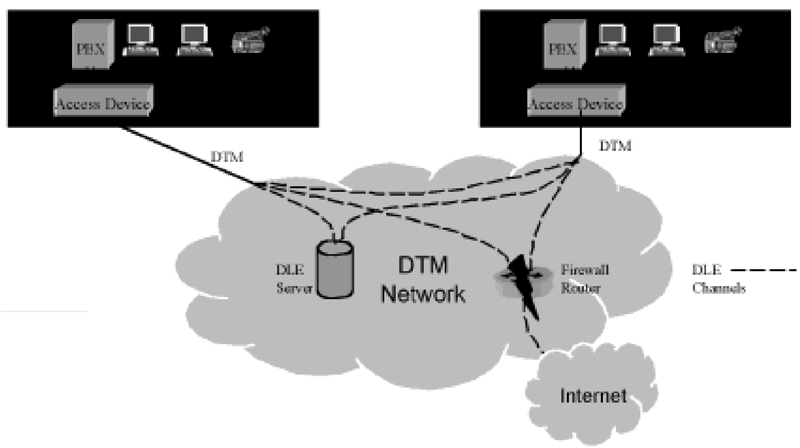

Figure8: Corporate Data Network Combined with an Internet Connection

Benefits of the access device as a service integration device include the following:

- One network layer exists between the user and the service access points.
- Synchronous circuit switching enables a guarantee for QoS to customers.
- High granularity and scalability in bandwidth allow for pricing differentiation.

- Customers can be guaranteed control of bandwidth and can be billed for it.
- Transparent support of PDH ensures voice quality and interoperability.
- Layer-3–independent data link escape (DLE) service ensures interoperability and preserves existing LAN architectures.
- DTM short-cut establishment ensures high-quality communication for special needs such as videoconferences.
- Internet traffic can be controlled so as not to interfere with the corporate-data network

DTM SOLUTION FOR RESIDENTIAL AND SMALL -OFFICE ACCESS

The DTM network solution has several features that make it suitable to handle aggregate traffic from emerging residential communications. The possibility for residents of modern society to use information technology (IT) in their daily life has increased during the last decade, mainly through the widespread use of the personal computer (PC), the expansion of the Internet, and the growth of services for the home market. With the fast development and deployment of new access technologies such as digital subscriber line (DSL), a high-speed communication infrastructure becomes a reality. The availability of high-speed access to the home will establish new requirements for the network that aggregate traffic up to the service-access points.

The future aggregation network must have the following qualities:

- Capable of handling large amounts of traffic
- Capable of handling different types of traffic streams such as synchronous video, bursty data, and synchronous voice
- Adaptable to traffic variations
- Scalable in connections as well as capacity
- Easy to manage

Digital subscriber line access multiplexers (DSLAMs) are often used to aggregate traffic from subscribers connected with DSL modems. Many of the DSLAMs are built with an ATM user network interface (UNI) on the uplink or an Ethernet interface. DTM can efficiently be used to transport heavy traffic introduced by DSL users from the DSLAMs to the service-access point, which is normally the Internet point of presence (PoP).

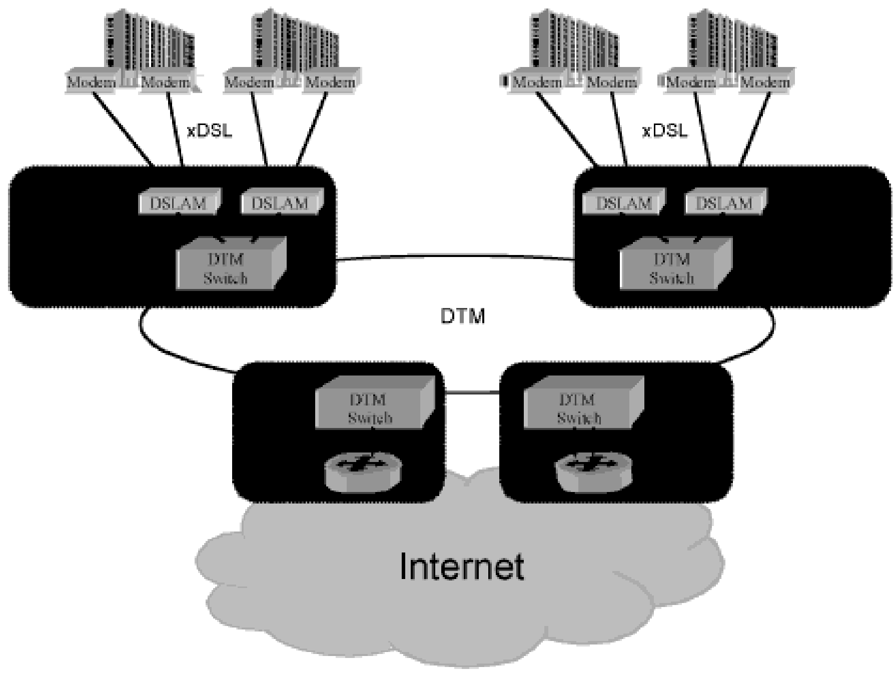

Figure9: DSLAM Aggregation Network for Internet Connections

Integrated access devices are used to offer homes and small offices voice services as well as data services over the same physical line.

The physical medium may be copper, radio link, or other media, but the concept is likely to be the same. A subscriber modem combines the telephone and data services over the media and connects to an integrated access multiplexer that separates voice traffic to E1s and data traffic to Ethernet. The DTM transports the divided traffic up to the service-access points—the voice switch and the Internet PoP—by supporting both Ethernet and E1s efficiently.

The benefits of using a DTM network for DSLAM and integrated-access–device aggregation include the following:

- DTM may dynamically adapt to traffic generated by the DSLAMs and thus eliminate the need for over-dimensioning.

- DTM may dynamically distribute bandwidth resources (time slots) between the DSLAMs, which allows for better over-time utilization.
- By using 10/100 Base-T interfaces and the DLE service, only one network layer is required between the DSLAMs or integrated-access devices and the Internet PoP.
- The transparent support of E1 ensures interoperability.
- New DSLAMs, integrated-access devices, and service-access points can be added easily to the DTM architecture

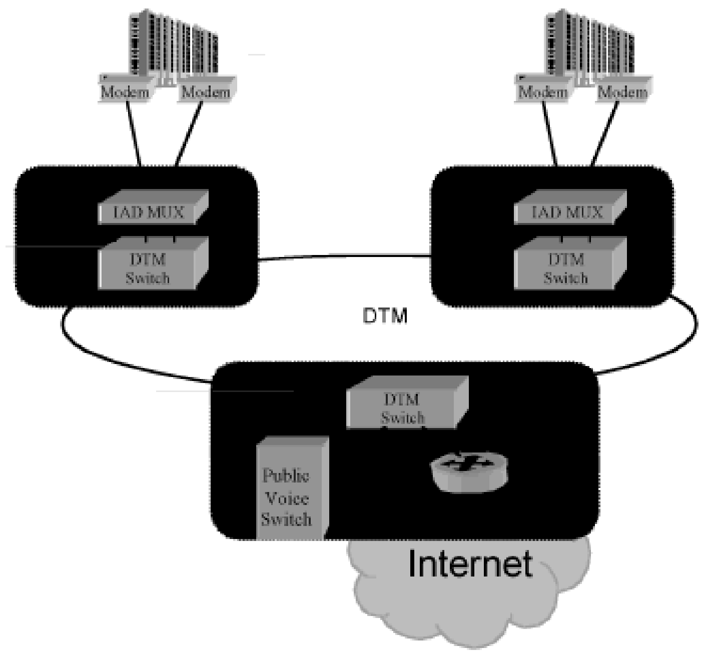

Figure10: DTM Network for Integrated-Access–Device Aggregation

DTM SOLUTION FOR CONTENT PROVIDERS

The high-capacity protocol control information (PCI) adapter card for DTM can be used to build highly efficient service networks for content server providers. Network and service providers searching for new business opportunities can use DTM to build high-capacity marketplaces for content providers with high-capacity and reliability requirements such as Web hotels, MPEG2 providers, and public databases.

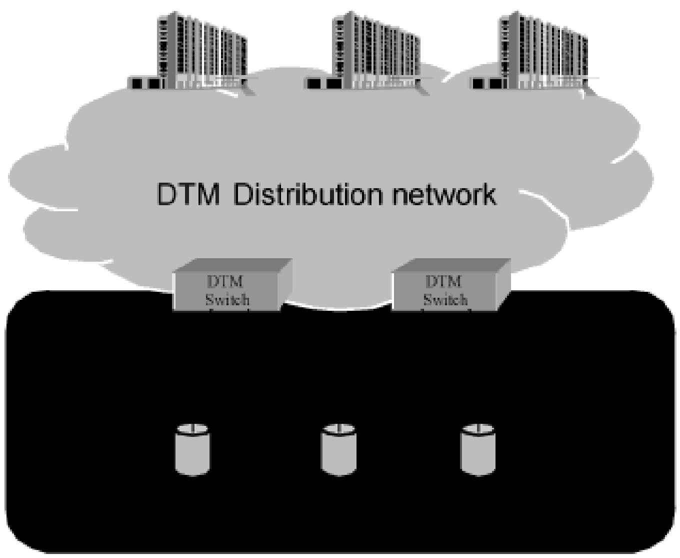

Figure11: Service Marketplace for High-Speed Content Servers

Benefits of using DTM as a content-server network include the following:

- DTM allows scalability in capacity from 512 kbps to transmission speeds close to the utilization of the fiber.
- DTM can use the fibers as shared medium, which allows for redundant topologies that are easy to expand.

- DTM provides isolated synchronous channels, which ensures service quality.
- DTM channels are unidirectional and resource usage is optimized for the traffic characteristics of content servers (asymmetric traffic load).
- Billing per usage of resources is possible.

CONCLUSION

DTM has been developed and tested since 1990 in a research environment. The basic principles are well tested, and the product development has been preceded by several generations of research pilots. The necessary protocols are well developed and ready for standardization. Working beta systems exist. Within ETSI the standardization of the Dynamic synchronous Transfer Mode (DTM) technology is underway. There are several patents and patent applications related DTM. These patents and applications are owned by Net Insight, Ericsson and Dynarc AB.

Network bandwidth is expected to increase by a factor of 10 each year over the next several years. Dense wavelength division multiplexing (DWDM) is becoming the dominant choice of transport for all fiber. Even though DWDM equipment today carries only a few wavelengths, 40 to 100 wavelengths carried on one single fiber will be possible in the near future. An integrating technology like DTM, having been developed for exactly this situation, is then needed for operators to be able to supply real-time video to the end user in an efficient way. As the bottlenecks of networks move from the transfer capacity of the network links to the processing capacity of the network nodes, DTM aims to reduce network complexity to provide full access to available bandwidth.

A community generates a great amount of information, but the information does not become true information until it is copied and provided to a receiver. The most efficient and easiest way to gain knowledge is through images. As we all know, children manage to attain a tremendous amount of knowledge by watching and listening.

The use of real-time video and audio for transferring knowledge is almost always more efficient than the use of textbooks.

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ABSTRACT

DTM, short for Dynamic synchronous transfer mode is a new transport network technology specifically designed for the foreseen explosion of real time media content within the Next Generation Networks (NGN).

DTM is designed to fully utilize the almost unlimited capacity of optical fiber by emphasizing simplicity and avoiding computation-intensive policing, queuing, buffering and control mechanisms. This is achieved through the technology's inherent characteristics, including low propagation delay, almost zero delay variation, dynamic allocation of bandwidth, full traffic isolation between channels and scalable, high-speed transmission. DTM simultaneously meets the transport demands of different traffic types such as Video, IP and PDH over a single, integrated network

This presentation covers the following topics concerning DTM

- Definition and overview of DTM
- The importance of DTM
- DTM basics
- DTM Advantages
- Principles of DTM
- Services
- DTM solution in different areas
- Final conclusion

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CONTENTS

MES COLLEGE OF ENGINEERING

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SEMINAR REPORT

ON

DYNAMIC Synchronous TRANSFER MODE (DTM)

Presented by

ANSON TIMOTHY

DEPARTMENT OF INFORMATION TECHNOLOGY

2002-2003

MES COLLEGE OF ENGINEERING

KUTTIPPURAM

DEPARTMENT OF INFORMATION TECHNOLOGY

CERTIFICATE

This is to certify that the Seminar titled DYNAMIC Synchronous TRANSFER MODE (DTM) was prepared and presented by ANSON TIMOTHY of the final semester of the Department of Information Technology, in partial fulfillment of the requirement for the award of Bachelor of Technology Degree of Information Technology under the University of Calicut during the academic year 2002 - 2003.

Staff in Charge | Head of the Department

Kuttippuram

Date:

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