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Dynamic synchronous Transfer Mode (DTM);
Part 1: System description

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Foreword

This ETSI Standard (ES) has been produced by ETSI Technical Committee Services and Protocols for Advanced Networks (SPAN).

The present document is part 1 of a multi-part deliverable covering Dynamic synchronous Transfer Mode (DTM), as identified below:

Part 1: "System description";

Part 2: "System characteristics";

Part 3: "Physical Protocol";

Part 4: "Mapping of DTM frames into SDH/SONET containers";

Part 5: "Mapping of PDH over DTM";

Part 6: "Mapping of SDH/SONET over DTM";

Part 7: "Mapping of Ethernet over DTM";

Part 8: "Mapping of Frame relay over DTM";

Part 9: "Mapping of ATM over DTM";

Part 10: "Routeing and switching of IP flows over DTM";

Part 11: "Mapping of video streams over DTM";

Part 12: "Mapping of MPLS over DTM";

Part 13: "Network management".

NOTE: Parts 4, 5 and 6 will be produced by ETSI Technical Committee Transmission and Multiplexing (TM) and part 13 by ETSI Technical Committee Telecommunications Management Network (TMN).

Introduction

Dynamic synchronous Transfer Mode (DTM) is a time division multiplex and a circuit-switched network technique that combines switching and transport.

The present document describes the general properties of DTM and the DTM service over a unidirectional data channel. The overall system architecture is described and fundamental functions are identified.

Part 2 includes system aspects that are mandatory or optional for nodes from different vendors to interoperate. The interworking granularity should be at node level, such that nodes from different vendors can interoperate with regard to well-defined functions.

Part 3 specifies the physical layer for physical links based on 8b10b encoding.

Part 4 describes how DTM frames are mapped onto SDH/SONET containers.

The transport of various tributary signals is specified for PDH (part 5), SDH/SONET (part 6), Ethernet (part 7), Frame Relay (part 8), ATM (part 9), IP (part 10), video streaming (part 11), MPLS (part 12).

Finally, management aspects are standardized in part 13.

1 Scope

The present document contains:

1) the necessary terminology and definitions to constitute a conceptual base for Dynamic synchronous Transfer Mode (DTM);

2) a reference configuration and definition of the DTM service;

3) a layered protocol and function model for putting the DTM functional groups, protocols and relevant interfaces in a context.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[1] ATM Forum af-cs-0107.000: "Addressing Addendum for UNI Signalling 4.0".

[2] ITU-T Recommendation G.703: "Physical/electrical characteristics of hierarchical digital interfaces".

[3] ITU-T Recommendation G.704: "Synchronous frame structures used at 1 544, 6 312, 2 048, 8 488 and 44 736 kbit/s hierarchical levels".

[4] ITU-T Recommendation G.707: "Network node interface for the synchronous digital hierarchy (SDH)".

[5] ITU-R Recommendation BT.601-5: "Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios".

[6] RFC 791: "Internet Protocol".

[7] IEEE 802.3 (2000): "Information technology - Local and metropolitan area networks - Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications".

[8] ITU-T Recommendation G.708 (1999): "Sub STM-0 network node interface for the synchronous digital hierarchy (SDH)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

access node: node that supports an external network interface, contains an interworking function for an external network and uses the DTM service

bypass switching: space switching of slots from the receiver to transmitter on the same port on a per slot basis. Bypass switching does not include time reordering

channel: set of slots allocated from one source Access node to one or more destination Access nodes in a network.

NOTE: The source and destination Access nodes can be the same, i.e. the channel is internal to the node

control channel: channel used for control signalling

data channel: channel used for transport of user data

data link: set of physical links connected in any topology such that bidirectional communication between all nodes in the data link can be established using only bypass switching

domain: full or part of a DTM network that is managed by a particular commercial or administrative entity (carrier/operator)

DTM network: set of interconnected DTM nodes

NOTE: A DTM network may be single-domain, or multi-domain.

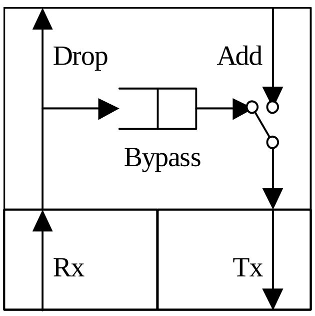
frame: set of slots forming an entity that is transmitted on a physical medium repeatedly every 125 µs (nominally), i.e. 8 000 frames/second

node: network element that contains DTM functions

node address: network layer address of a node

physical link: unidirectional connection between the transmitter of one port and the receiver of another port

port: receiver and transmitter pair on the same node being grouped such that bypass switching is possible



Each port is identified by a globally unique identifier (IEEE MAC address for the data link layer)

slot: time slot containing 64 bits of control or user data. The slot may also hold a special code for idle data, error slot and end of packet marker

switching: process of moving the data of a slot in both time and space, i.e. switching between different ports and changing slot numbers, while maintaining the bandwidth and avoiding slot reordering within each channel

switch node: node that contains a switching function

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

API	Application Protocol Interface
ATM	Asynchronous Transfer Mode
DLL	DTM data Link Layer
DNL	DTM Network Layer
DPL	DTM Physical Layer
DTM	Dynamic synchronous Transfer Mode
FR	Frame Relay
IP	Internet Protocol
MIB	Management Information Base
OSI	Open System Interconnection
PDH	Plesiochronous Digital Hierarchy
Rx	Receiver
SDH	Synchronous Digital Hierarchy
SNMP	Simple Network Management Protocol
SONET	Synchronous Optical NETwork
Tx	Transmitter
VC	Virtual Channel

4 System overview

This clause defines the concept of a *DTM system* (see figure 1)as a set of *nodes* interconnected by *physical links*. Communication between nodes takes place over *channels*, which are abstractions of communication resources between sending node and receiving node (or nodes). A node can be connected to nodes in external networks using technologies such as SDH, Ethernet, IP and Video, as well as other nodes in the DTM system.

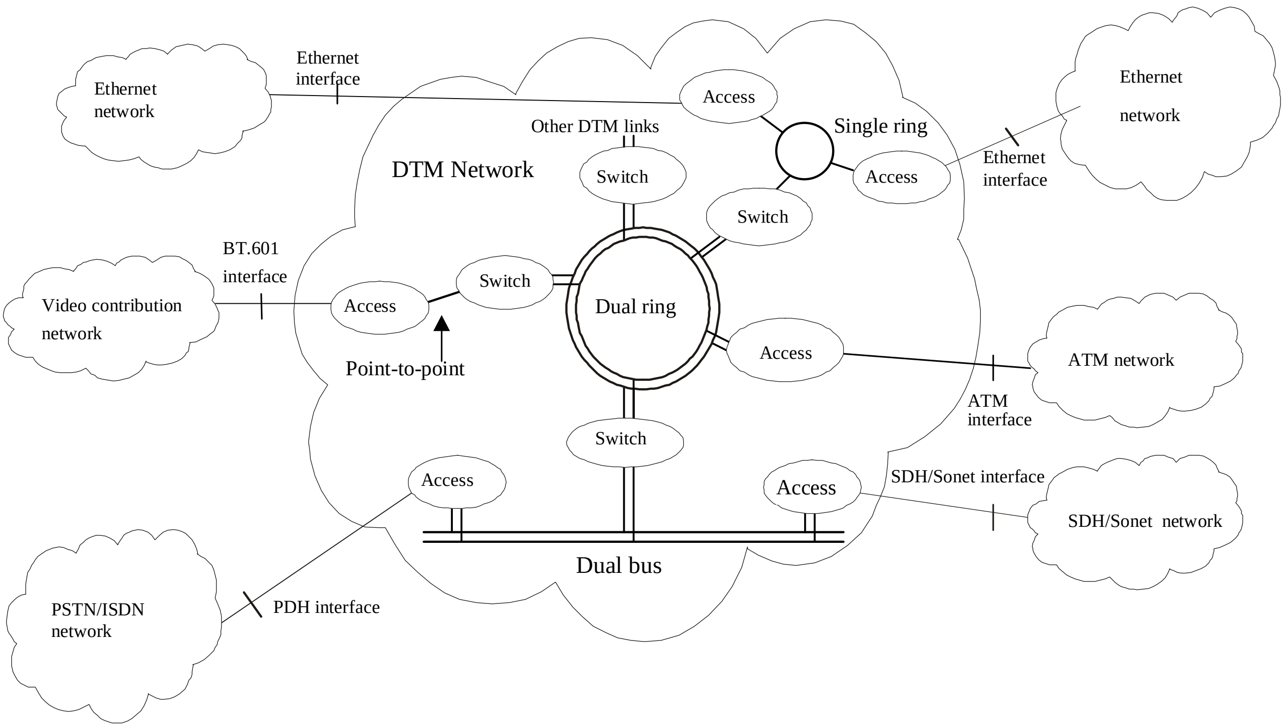


Figure 1: DTM system overview

4.1 Descriptions of Terms

4.1.1 Physical link

A physical link is a unidirectional communication medium connecting a pair of nodes. A signal can be transmitted on a physical link from a sending node to a receiving node. The physical protocols will define the properties of various forms of physical links.

4.1.2 Data link

A data link is a set of physical links and nodes, which are connected such that all involved nodes can communicate bidirectionally with all other nodes over bypass-switched paths only. The following fundamental data link topologies are supported: dual ring, dual bus and single ring (and its special case of a point-to-point connection). Combinations of these may be connected to form hybrid topologies, which may still be considered as one data link. The data link is monitored by a data link maintenance protocol, which among other things detects changes in the topology.

4.1.3 Frame and slot

A frame is a time-ordered set of bits. The frame is sent repeatedly at 8 000 times per second. The frame starts with a start-of-frame marker and then continues with a time slot structure. Each time slot transports 64 bits of data (thus giving a transfer rate of 512 kbit/s) and can also convey non-data codes.

The non-data codes are idle, End-of-Packet (EOP) and Error slot. The idle codeword is an end-to-end code that conveys the lack of data to send at the transmitter side. The EOP code is used for delimiting packets of channel adaptation protocols for asynchronous traffic. The Error slot is a special code that the network can generate whenever an unrecoverable error has occurred in the transmission. The Error slot can then help the receiver to distinguish intended traffic (data, idle or EOP) from broken traffic.

4.1.4 Channel

A channel is a unidirectional virtual transmission path formed by a set of slots over one or more data link(s). Channels spanning over several data links can use different number of slots as long as the number of slots downstream is at least the number of slots on the transmitter end, and the ordinal of the slots constituting the channel may vary between the different data links. Channels can be of unicast, multicast or broadcast types.

4.1.5 Network

A DTM network consists of one or more data links connected together in such a way that channels may be established between the interconnected nodes. The data link topologies may vary freely. The physical layer protocol may also vary between the connected data links.

4.1.6 Management

At least one Management station is connected to the network. The functions of the station are configuration and control of the network. The Management station will be SNMP based and MIBs will be standardized. Since there is a standardized interface for Management stations, a Management station can be connected to any DTM system node that supports the interface.

Management information can be sent using inband SNMP over IP. This facilitates remote management within the network scope and does not require a separate management network.

4.1.7 Synchronization

A Reference Clock node controls the frame rate and thereby also the slot rate.

There can be several reference clocks connected to the network to be able to handle faults of the master reference clock or if some part of the network looses connectivity with the master reference clock.

A standardized interface, using the standard ITU-T Recommendation G.703 [2], section 10 interface, between the DTM system and the Reference Clock node enables any suitable clock to be connected to the DTM system.

In DTM the bit rate and frame rate are not fixed integer multiples of each other.

DTM is a mesochronous technique instead of being synchronous or plesiochronous like SDH or PDH. DTM provides an isochronous service over its mesochronous physical links.

5 Service description

The DTM service provided to external user networks is illustrated in figure 2. These include PDH, SDH/SONET, Ethernet, Frame Relay, ATM, IP, MPLS and video. Each external protocol uses the relevant DTM interworking function in the DTM interworking layer.

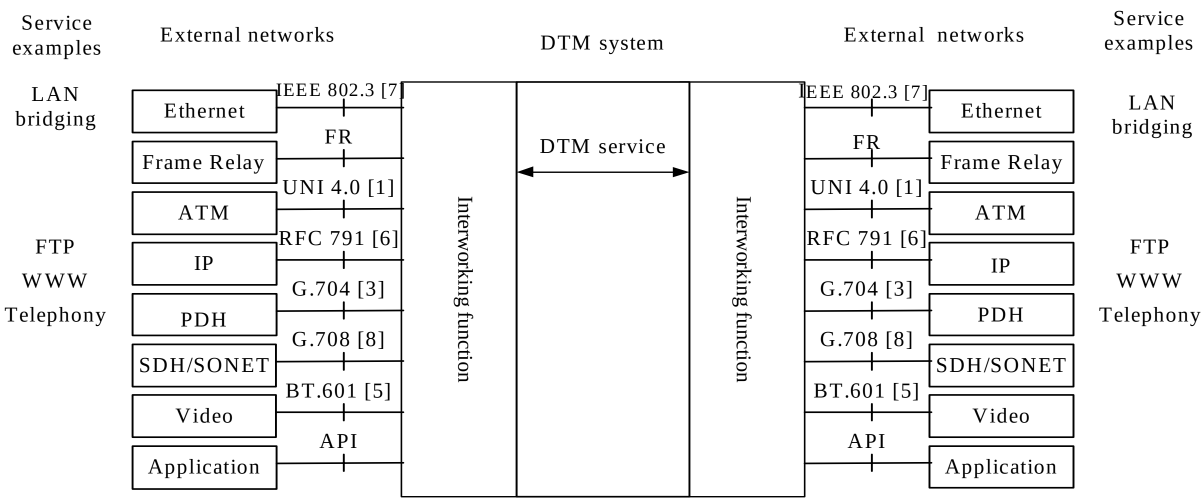


Figure 2: External network interfaces

5.1 Basic service over a channel

A channel is either a data channel or a control. The DTM service is defined for both types of channels. A data channel is a data transportation capability that is created and connected between nodes at the request of the user or the network operator. A control channel is a signalling channel that is connected between nodes using the same medium and physical protocols as the data channels.

5.1.1 Creation and removal

At channel creation time, the destination and source address, the bandwidth requirement, the channel adaptation and interworking function are required. During the data transmission phase of packet-oriented traffic, a protocol field in the encapsulation may be used to determine the disposition of the data.

The channel may be removed from either the source or destination end in normal operation. During abnormal situations (e.g. the channel is broken due to a failed link) the channel may be removed by the network management.

5.1.2 Bandwidth

The bandwidth is measured as the number of 64-bit slots at the frame rate of 8 000 Hz, which equals a bandwidth granularity of 512 kbit/s. The user must specify the bandwidth of the channel (in slots per second), using two parameters:

1) minimum bandwidth;

2) maximum bandwidth.

The network either returns an acknowledgement of the approved bandwidth - which can be any value between and including minimum and maximum - or rejects the request.

If the network chooses a value between and including minimum and maximum, the network has fulfilled the request and the channel is immediately acknowledged. When the user has received an acknowledgement from the network that the channel has been created, then the user will know:

- the amount of approved bandwidth;
- that the approved bandwidth is available all the way to the destination node(s);
- that it is guaranteed bandwidth such that other channels' traffic will not interfere with it in the transport part of the network.

A user of a channel may use a fraction or all of the bandwidth acknowledged but never more. A user may request to have the bandwidth changed during the channel lifetime. A request for reduction of bandwidth is always accepted. A request for increase of bandwidth may be rejected. The channel will not to lose data during the process of bandwidth change.

A channel may consist of zero or more slots, limited by the bandwidth of the underlying physical link capacity manifested in the Physical protocol. A channel can be reduced in terms of bandwidth down to zero slots. A zero slot channel is always prepared for activation, which saves the time required for setup, once data is ready for transmission.

5.1.3 Addresses

A channel can be set up to one or more destination nodes. The channel may address the destination nodes by either unicast or multicast node addresses. A unicast (point-to-point) channel has one destination address. A multicast (point-to-multipoint) channel has either one multicast destination address or zero or more unicast destination addresses. Unicast destination addresses may additionally be appended after the original channel creation.

5.1.4 Multicast

A multicast channel provides a point-to-multipoint channel:

- the source node can always change or terminate the channel;
- a destination node can detach itself from the multicast channel, terminating its leaf section, with no side effects on other destination nodes. If the destination is the only remaining destination node of a multicast channel, it can terminate a full channel just as it would in the unicast case;
- destination nodes may be added during the channel lifetime.

5.1.5 Delay and jitter

When a channel is acknowledged, the DTM service incurs a constant delay with a small jitter traceable to the sync distribution of the network. The delay is caused by transmission delay in the fibre as well as switching delay. The delay is unchanged during the session if the route is not changed due to protection-based rerouting. If the channel is changed due to necessary rerouting in the network the delay may change.

6 Functions and Protocols

In a circuit-switched system a channel must be set up prior to any flow of data traffic. This represents the establishment phase of that channel. After the establishment phase the channel enters the data transport phase. To terminate the channel after the transport phase the channel teardown phase is entered. The establishment and teardown of the channel requires control signalling, while the transport of data is a separate phase, which uses only the transport protocols and functions.

6.1 Control and Transmission model

In DTM the signalling is common channel with associated mode: it uses separate control channels but shares the same transport infrastructure as the data channels. This means that the physical protocols, channel adaptation functions and switching functions are common to the signalling and interworking layer (see figure 3). While the transport of data over an established channel is done only over a small stack of protocols, the setup and maintenance of that channel depends on the service provided by the signalling stack.

DTM Signalling	DTM Service
Channel Adaptation	
Data Link Layer	
Physical Layer	

Figure 3: Layered transport protocol model

The signalling protocols is defined using a layered model where the protocol for some function such as channel setup either uses channel adaptation over the physical layer transportation directly or the service provided by another protocols within the stack.

6.2 Protocol layers

The protocol layers are as shown in figure 4.

INTERWORKING LAYER					
Ethernet	ATM	SDH	Plesiochronous	IP	Etc.
DTM Network Layer					
Data Link Layer					
Physical Layer					

Figure 4: DTM protocol layers

These layers operate on a peer basis; this may be indicated as shown in figure 5, where peer layers in two nodes communicate with each other. This communication is carried out by passing messages from the layer that generated them down to the physical layer, and on the receiving side up to the peer of the originating layer. The net result is that the communication is as shown in the dotted lines, between peer layers.

Interworking layers	-------------------------------------	Interworking layers
DTM Network Layer	-------------------------------------	DTM Network Layer
Link Layer	-------------------------------------	Link Layer
Physical Layer	-------------------------------------	Physical Layer
Node A		**Node B**

Figure 5: Communication between peer layers across the DTM network

Communication between the peer layers is in the form of data PDUs (for user data), fields in the channel adaptation (for example, protocol type communicated between interworking layers), or control messages exchanged between the layer entities.

The functions of the layers are as follows:

6.2.1 DTM Physical Layer (DPL)

The DTM Physical Layer handles the transport of slots between nodes as well as bit encoding/decoding, slot synchronization and framing. The physical layer provides two or more physical links.

The functions and aspects are:

- bit clock recovery;
- demultiplexing of incoming and bypassed slots;
- framing;
- Idle encoding/decoding of the slot stream;
- line coding;
- link state information retrieval;
- multiplexing/demultiplexing of incoming and outgoing bit streams;
- multiplexing of outgoing and bypassed slots;
- physical connector;
- electrical/optical properties and associated signal conditioning.

The DTM Physical Protocol may offer several optional physical interfaces, depending on server (e.g. SDH/SONET) or port characteristics.

Currently there are two interfaces proposed:

- 8B10B code based physical protocol;
- SDH/SONET VC-4 container based physical protocol.

Others are for further study.

6.2.2 DTM data Link Layer (DLL)

The data link layer contains functions and protocols required to build, maintain and transport data over a data link.

6.2.2.1 Channel adaptation

The Channel adaptation function encapsulates the data transported on the channels. The channel adaptation function may also perform error detection on the transported data.

6.2.2.2 Add/drop function

The Add/Drop function provides the means to transmit and receive slots on a port.

6.2.2.3 Bypass function

The Bypass function provides the means for forwarding a received slot onto the transmitter of the same port in the case where the node does not use its add function on that slot. The slot number is maintained during the bypass switching (see port definition in clause 3.1).

6.2.2.4 Data link maintenance

The link maintenance function handles:

- discovery of the topology of data links;
- providing information concerning the interfaces and nodes connected to the data link;
- monitoring and surveillance of the data link, i.e., detection of physical link and node failures and reporting of them to the Management system, Routing function and Channel management function.

6.2.2.5 Data link resource management

The data link resource management function provides the Channel Management function with resources (slots) for channels. The data link resource management entity in one node can allocate slots from other nodes connected to the same data link. It also supervises the slots on the data link and resolves inconsistent slot allocations. The data link resource management function should have access to the topology information in order to route the channel over the data link.

6.2.3 DTM Network Layer (DNL)

This layer supervises the set-up, modification and removal of channels operating across multiple data links, invoking data link-layer functions to do so at each data link. The switching function operates at the DTM network layer, as configured by the channel management function. This layer also performs the necessary distribution of synchronization information in the network. The network path determination function provides input to the channel management function.

NOTE: A complex set of DTM data links may be referred to as a DTM network without the implication that it necessarily resides at Layer 3 of the Reference Model.

6.2.3.1 Channel management

The Channel management function handles the set up, modification of capacity, and removal of channels throughout the network. This function includes signalling to other nodes along the path of the channel, indicating the slots associated with the channel and setting up the switching function of the node. Also, the Channel management function facilitates restoration of channels in case of data link failure.

6.2.3.2 Network Path determination

The path determination function provides information to the channel management function. An instance in one node may interact with instances in other nodes to acquire information in order to determine the best path through the network, spanning several links and switches.

Alternatively, DTM switches may operate at the OSI network layer as well as at the lower layers. In this case network-layer mechanisms such as IP routing may be invoked to assist in finding a route across multiple interconnected links.

6.2.3.3 Switching

The switching function moves contents of slots from incoming frames to outgoing frames on different ports. The switching function must switch a set of slots of the incoming channel into another set of slots of the outgoing channel without data loss, data reordering or data corruption. Further, the switch function must be able to perform lossless bandwidth changes on a channel carrying traffic. The switch function must also support multicast and the addition or removal of a multicast branch must be performed without impacting traffic destined for the other branches.

6.2.3.4 Synchronization

The synchronization function should determine which interface (DTM or Clock function interface) to retrieve the sync signal from, that is, from which node the sync reference should be retrieved. The function may interact with synchronization functions in other nodes in order to make the decision.

An Access node needs only to forward the incoming sync signal to downstream nodes on the data link.

6.2.4 Interworking layer

The DTM Interworking Layer handles the association between channel control and data. Furthermore, this layer provides an interface to higher layer protocols.

Several functions are defined for this layer:

- connection between signalling and data transfers;
- mapping of service requirements on DTM, i.e. how many channels, how large channels, and for how long they should last;
- address resolution (where applicable).

Each interworking function accepts user data formatted for a particular external network technology and adapts it to DTM format. It performs segmentation and re-assembly operations if necessary, signalling specific for the supported external network technology, as well as delivery of data across the relevant external network interfaces.

There is an interworking function for each supported external network technology, e.g. an Ethernet service function and a PDH service function.

7 Control, Transmission and Management planes

The functions found in the layer model can be viewed as being part of Control signalling, Transmission and Management planes.

7.1 Control plane

In the Control phase signalling directly relating to channel establishment occurs. The control plane includes:

- channel establishment protocol;
- interworking function (control phase);
- resource management (for the borrowing of slots).

7.2 Transmission plane

In the Transmission plane the protocols directly relating to transmission of user data are involved. The transmission plane includes:

- add/drop function;
- bypass function;
- channel Adaptation function;
- interworking function (transmission phase);
- physical protocol;
- switching function.

7.3 Management plane

The signalling required for the system as a whole takes place in the Management plane. The management plane includes:

- interworking function (management phase);
- link management (link state protocol);
- management protocol (SNMP);
- node management;
- resource management (fault handling and strategic maintenance);
- routing protocol;
- Synchronization routing.

7.3.1 Network management

The Network management functions are provided using DTM specific MIBs in the SNMP framework.

7.3.2 Node management

The Node management function handles configuration, fault, performance, node management and alarm handling.

8 Interfaces

Between the nodes in a DTM system an interface is defined by a set of protocols. Between nodes within the same operator's network the interface has a basic form. An extended form of the interface exists between nodes operated by two different operators. The extended interface is required only if the operators agree that it is necessary for their interoperation.

History

Document history		
V1.1.1	January 2001	Membership Approval Procedure MV 20010316: 2001-01-16 to 2001-03-16
V1.1.1	March 2001	Publication