ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

A MANAGEMENT FRAMEWORK FOR PRIVATE TELECOMMUNICATION NETWORKS

ECMA TR/54

December 1990

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Brief History

The trend for ever more sophistication and features in Private Networks has heightened the need for network management. The magnitude of the problem of managing a Private Telecommunication Network indicates that it would not be satisfactory to rely solely upon proprietary solutions.

CCITT, ETSI and ISO have been active in the area of management communications for some time. ISO has developed its Systems Management for OSI systems whilst CCITT and ETSI have developed a Telecommunications Management Network (TMN) concept to apply management to telecommunications networks.

The work of these organizations is unlikely to involve detailed considerations of the management of Private Telecommunication Networks. Indeed, some of their work is unavoidably biased towards public networks due to the nature of their members. Although similar in most of its management requirements, a private network differs in scale, certain features and some user requirements for management from those of public networks. In addition there are areas of management for which a detailed knowledge of private networking is required. Inevitably there are also areas where inter-working between public and private, or private and private networks is involved.

This has lead to the need to extend the work on management with a view to meeting the requirements of private networks. The objective of this activity has been not only to harmonise it with the current CCITT, ETSI and ISO work on management but also to simplify this work where there are less requirements for private network than for public networks, and extend it where private networks have additional requirements.

This ECMA Technical Report analyses the structure which management could take for private networks and identifies the interfaces involved.

The work done on this report is extensively based on personal experience of the work within both CCITT and ETSI, and within ISO . It has also drawn from concepts developed by the OSI/Network Management Forum to compliment the ISO experience.

The viewpoint taken in developing this report has been a pragmatic one. This has resulted in a management architecture which is capable of supporting management from a 'centralised' source. None the less, allowance has been made for what has been seen as a future trend towards distributing management functionality. It was the intention in this report that the two should not be mutually exclusive, but instead that it should provide a migration path for the evolution of network management.

A further step towards the future has been in providing for management 'building blocks' by employing a layered approach to the management architecture. It was felt that this should give a lot more freedom to how the management interfaces are deployed when actually implementing a structure based upon the standards to follow this Technical Report.

Adopted as Technical Report TR/54 by the General Assembly of 14th December 1990.

Table of Contents

1. SCOPE

The scope of this Technical Report is

- Network Management of a PTN environment including the communication components of PTN terminals,
- interworking of Network Management of a PTN with the management of public telecommunication (switching and transmission) networks, and with the management of other PTNs.

The definition of the management user interface is beyond the scope of this Technical Report.

1.1 Objectives

This Technical Report will provide

- an architectural model identifying Reference Points,
- a set of requirements for the management of PTNs,
- a methodology for defining management application services, concepts and
- objects in a PTN environment.

1.2 Applicability

This Technical Report can be used as the basis for

- the specification of Network Management functions and of the assignment of these functions to the network and the components of management,
- the definition of Network Management interfaces between Network Elements (see ISO/IEC 9545) and the components of management, and between the components of management,
- the identification of Managed Objects included in the Network Elements and the components of management.

1.3 Standardization

Based on this Technical Report, the following standards may be produced

- definition of a generic information model,
- definition of a PTN Managed Object Classes library,
- definition of naming and addressing schemas for Managed Object instances,
- definition of communication services, protocols and information models per interface,
- definition of interworking mechanisms between Management Domains.

1.4 Relationship with Technical Report ECMA TR/45

Technical Report ECMA TR/45 describes the principles for the exchange of information related to the maintenance of the communication aspects of ISDN S interfaces connecting a PTN with Data Processing Equipment, e.g. an ISDN terminal.

It is intended to produce a standard for the M1 interface which combines the requirements of this Technical Report for the M1 interface and the requirements for the maintenance of PTN Terminals as defined in Technical Report ECMA TR/34. This standard will supersede Technical Report ECMA TR/45.

2. FIELD OF APPLICATION

This Technical Report applies to PTNs consisting of ISPBXs and the related transmission equipment. If ISPBX functions reside in ISCTXs (Integrated Services CENTREXes) then management of these functions shall be available to the PTN Management .

The following are examples of major types of equipment for which PTN Management is responsible:

- switching units (circuit and packet),
- transmission systems,
- terminals, servers, processors.

The architecture and the physical components involved in PTNs are normally different from that of public networks. This results in the following:

- the management information is conveyed by a Data Communication Function (DCF) which may be implemented in the PTN. Therefore it is not necessary to define a dedicated Data Communication Network.
- PTN Management is mainly in the charge of one user or private operating agency. It may be centralized in one overall Manager and/or may be distributed through several Managers.

3. REFERENCES

ECMA 133	Reference Configurations for Calls through Exchanges of Private Telecommunication Networks *Also published as ENV 41004*
ECMA-135	Scenarios for Interconnections between Exchanges of Private Telecommunication Networks *Also published as ENV 41006*
ECMA TR/34	Maintenance at the Interface between Data Processing Equipment and Private Switching Network
ECMA TR/45	Information Interchange for Remote Maintenance at the DPE-to-PSN Interface
ECMA TR/49	Support Environment for Open Distributed Processing
ECMA TR/NTW	Networking in Private Telecommunication Networks *(in preparation)*
ISO/IEC 7498-4	OSI Basic Reference Model - Management Framework *Also published as CCITT Rec. X.700*
ISO/IEC 9545	OSI - Application layer structure (ALS)
ISO/IEC 9595	OSI - Common management information service definition (CMIS) *Also published as CCITT Rec. X.710*
ISO/IEC 9596	OSI - Common management information protocol specification *Also published as CCITT Rec. X.711*
ISO/IEC/JTC1/ SC21 N 3196	Draft for Reference Model for ODP - Modelling techniques and their use in ODP
CCITT Rec. G.771	Q Interfaces and Associated Protocols for Transmission Equipment in the Telecommunication Management Network (TMN)

CCITT Rec. M.20	Maintenance Philosophy for Telecommunications Networks
CCITT Rec. M.30	Principles for a Telecommunications Management Network (TMN)
CCITT Rec. M.36	Principles for the Maintenance of ISDNs
CCITT Rec. M.60	Maintenance Terminology and Definitions
CCITT Rec. Q.513	Connections, Signalling, Control, Call Handling and Ancillary
CCITT Rec. Q.940	ISDN User-Network Interface Protocol for Management - General Aspects
CCITT Rec. X.500 Series	The Directory
CCITT Rec. X.701	OSI Systems Management Overview
	Also processed as ISO/IEC DIS 10040
CCITT Rec. X.720	OSI Structure of Management Information
	Also processed as ISO/IEC DIS 10165-1
CCITT Rec. X.721	OSI Structure of Management Information
	Also processed as ISO/IEC DIS 10165-2
CCITT Rec. X.722	OSI Structure of Management Information
	Also processed as ISO/IEC DIS 10165-4
CCITT Rec. X.730	OSI Systems Management, Part 1: Object Management Function
	Also processed as ISO/IEC DIS 10164-1
CCITT Rec. X.731	OSI Systems Management, Part 2: State Management Function
	Also processed as SIO/IEC DIS 10164-2
CCITT Rec. X.732	OSI Systems Management, Part 3: Attributes for Representing Relationships
	Also processed as ISO/IEC DIS 10164-3
CCITT Rec. X.733	OSI Systems Management, Part 4: Alarm Reporting Function
	Also processed as ISO/IEC DIS 10164-4
CCITT Rec. X.734	OSI Systems Management, Part 5: Event Report Management Function
	Also processed as ISO/IEC DIS 10164-5
CCITT Rec. X.735	OSI Systems Management, Part 6: Log Control Function
	Also processed as ISO/IEC DIS 10164-6
CCITT Rec. X.736	OSI Systems Management, Part 7: Security Alarm Reporting Function
	Also processed as ISO/IEC DIS 10164-7

4. DEFINITIONS

For the purpose of this Technical Report the following definitions apply.

4.1 Agent (A)

An Agent performs the management function upon receipt of an instruction from a Manager specifying management operations on Managed Objects. Agents may also forward notifications to Managers to convey information generated by Managed Objects.

4.2 Function Block (Fig. 1)

A logical partition of functions. Different criteria are used for the partition, e.g. flexibility, performance, cost. Depending on the criteria different partitions are possible.

4.3 Information Model (Fig. 1)

Between two communicating entities there needs to exist a common understanding of the information about which communication can take place. This is abstracted in an Information Model as objects, their behaviour, characteristics and relationships. The objects only portray real resources insofar as it is necessary for management purposes.

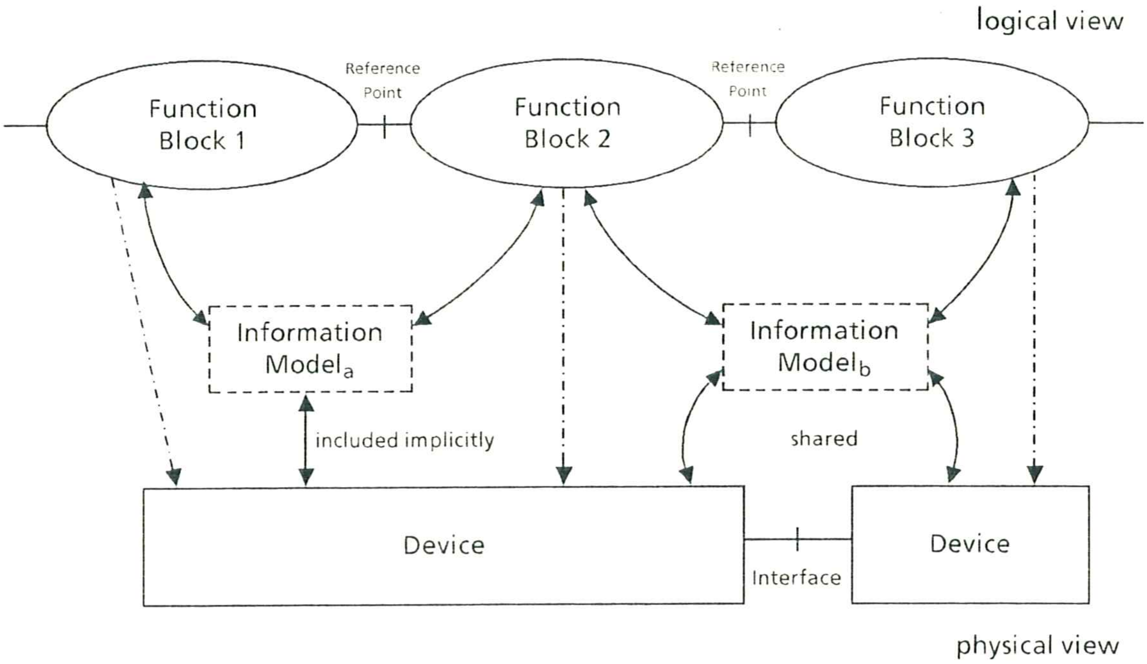


Figure 1 - Pictorial Representation of the Logical to Physical Mapping for Interfaces

4.4 Interface (Fig. 1)

The physical realisation of a Reference Point and as such a physical point of communication between devices which completely defines the communication between them. It requires a transmission medium with an appropriate protocol to control the flow of information between the devices. Between management functions the information is packaged as messages which are passed via the protocol. Interfaces may differ in the details of the protocol used, the messages employed or the information being communicated. Several interfaces may share the same transmission medium.

4.5 Managed Object (MO)

The destination of management operations, and the source of management notifications. A Managed Object may portray a physical item of equipment, a logical component, some abstract collection of information, a combination of any of these, a part of any of these, or a combination of such parts.

In some instances the object is directly accessible, in other cases the object is a virtual one and represents resources that are not directly accessible.

4.6 Managed Object Attributes

Properties of Managed Objects. A Managed Object has at least one attribute, its name, and it may (but not necessarily) have additional attributes. An attribute has associated values which may have a simple or complex structure.

An attribute is an item of information that represents the finest subdivision of information that can be operated on or reported. An attribute must, at least, have one management operation defined to act upon it via the Managed Object to which it belongs.

4.7 Managed Object Class

Instances of Managed Objects that share the same management operations, attributes and notifications are said to be in the same Managed Object Class (see CCITT Rec. X.720).

4.8 Management /Managed Domain

A Management Application Process (or management system) and all the Managed Objects which are under its control. The collection of Managed Objects is called the Managed Domain.

4.9 Management Application Process (MAP)

The processes comprising the management application are, by their very nature, distributed in that they occur in various parts of the physical architecture. The interactions which take place between the Management Application Processes are abstracted in terms of directives issued by one process to another.

4.10 Management Process (MP)

A specific type of Management Application Process that contains an Agent and a Manager and may contain a Mediation Function.

4.11 Manager

That part of a management application process that is responsible for manipulating and monitoring an associated set of Managed Objects. A Manager interacts with an Agent to carry out the management activities for which it is responsible.

A Manager requires a certain knowledge of the objects it is managing. This includes a view of their behaviour, characteristics and relationship with other objects. While this view may not fully model the resource(s) represented by the objects it is sufficient for management purposes. The information related to all the objects a Manager is managing is described as a Management Information Model.

4.12 Mediation Function (MF)

The concept of a Mediation Function (see CCITT Rec. M.20) is used to provide those Agent functions on the information path between Management Processes and Network Elements which the Network Elements are not able to provide themselves. As such they are a pragmatic bridge between the logical and physical view of the architecture. It is possible that such functions are physically implemented as separate physical devices which may then be called Mediation Devices.

4.13 Network Element (NE)

The physical implementation of a PTE.

4.14 Overall Management Process (OMP)

The process that represents the top of the hierarchy when the Management Application Processes are cascaded in a hierarchical arrangement. It also provides a conceptual point for the cooperation between differently administered networks.

4.15 Private Telecommunications Entity (PTE)

The entity that provides the functions necessary to support the PTN telecommunication services. It also provides management access to the PTN telecommunication services.

4.16 PTE 1

A PTE that is able to directly connect to a Management Process.

4.17 PTE 2

A PTE that can only be attached to a Management Process via an external Mediation Function.

4.18 PTN Management Application Function (Fig. 2)

The smallest part of the application service as perceived by the user of the service. In reality it will generally consist of one or a sequence of operations on a defined Managed Object or groups of Managed Objects.

4.19 PTN Management Application Service (Fig. 2)

An area of management activity which provides support for an aspect of operations, administration, and maintenance of the network being managed (e.g., management of transmission paths). It is always described from the user perception of the network management requirements.

4.20 PTN Management Application Service Component (Fig. 2)

The constituent parts of an application service stating the requirements for operations to be performed on the managed network.

Examples: change user service details, perform traffic measurements etc.

4.21 Reference Points (Fig. 1)

The conceptual points at the conjunction of two non- overlapping management function blocks (CCITT Rec. I.112).

4.22 Shared Management Information Knowledge

An instance of the Information Model at an interface and thus it is a feature determined at implementation time.

4.23 User

That which requires the PTN Management application services in the support of its activities. It may be a human user applying for the use of services via some man-machine communication or it may be some higher level organisational system requiring the capabilities of the PTN Management.

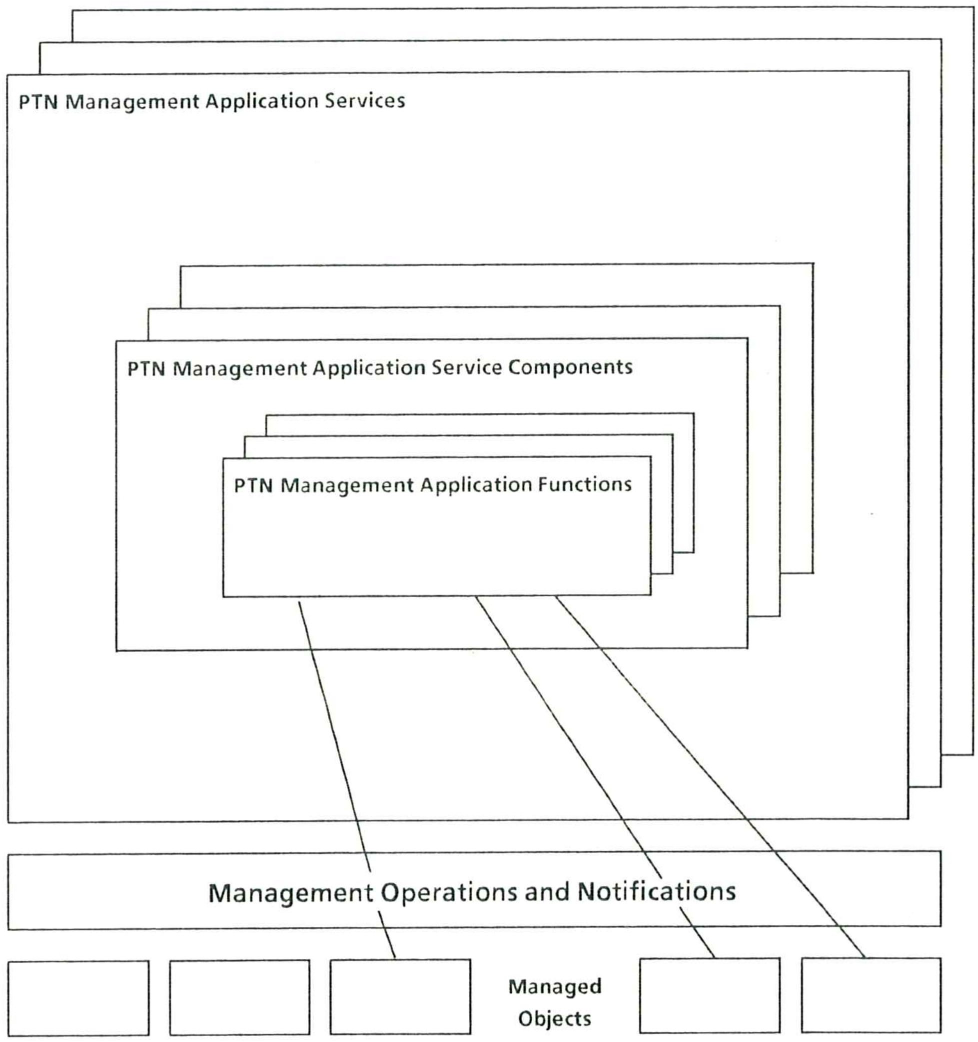


Figure 2 - General Relationship of PTN-Management Terminology

5. SPECIFICATION METHODOLOGY

In order to comply with the aims of this TR, when producing standards to implement its requirements, it is necessary to follow a methodology for the specification of the management architecture and of the management interface profiles based on common tools and techniques. The following principles are recommended for this methodology:

- top down functional design starting from the users (operators) point of view,
- object oriented methodology for the Shared Management Information Model and for the definition of the Information Models up to the protocol data units (messages) using the entity-relationship (E/R) method,
- step by step approach with the possibility of iterative back steps to provide specifications in more detail,
- documentation of the outcome of each step (task) in a task information base.

Fig. 2 illustrates the way in which the specification methodology is used to break down the application services to derive the Managed Objects which make up the Information Model.

The tasks and their outcomes as defined in TMN, and the PTN Management relevance are listed in Table 1.

Task No.	Task	Outcome in the TMN methodology	PTN Rele-vance
0	Generate Generic Network Information Model		yes
1	Describe PTN Management application services as perceived by the PTN operator (user)	PTN Management application services and components list	yes
2	Select PTN management application functions	Function list	yes
3	Define objects and their attributes, operations, and notifications	Object templates Object relationship diagrams	yes
4	Define management information schema	Management information schema	yes
5	Determine communication requirements	Requirements for communications	yes
6	Prepare documentation for protocol tasks	PTN management functional profiles	yes
7	Analyze message needs	Grouping of PTN management functional profiles	yes
8	Decide adequacy of existing protocols for each layer	Existing protocols and PTN management protocol suites	yes
9	Define new protocol requirements		yes
10	Define new layer services and protocols	Define Layer management services and protocols 1)	modi-fied 2)
11	Select layer services		yes
12	Select layer protocols and form protocol suites		yes

Table 1 - PTN Management Specification Methodology

NOTE 1

The definition of layer management functions (protocols and services) may be necessary for the M1-interface (see 10).

NOTE 2

Changes to the TMN approach.

5.1. Task 0: Generate Generic Network Information Model

Specify a Generic Network Information Model, including the object class hierarchy for that model. The model will be defined from analysis of telecommunication network architectures (CSDN, PSPDN etc.). The model (and class hierarchy) should contain those generic network object classes that are needed for further specialisation as well as support objects that are be used in the definition of interfaces.

5.2 Task 1: Describe PTN Management Application Services as perceived by PTN Operator (User)

Identify each area of management activity which is to be supported by the PTN Management in the form of a list of PTN Management application services. For each PTN Management application service, identify the PTN Management application components which are grouped under the service.

5.3 Task 2: Select PTN Management Application Functions

Expand each PTN Management application component into PTN Management application functions. Define the PTN Management functional requirements taking into account the OSI Management categories. Identify the CMISE services to be associated with each transaction-oriented function.

5.4 Task 3: Define objects and their attributes, operations, and notifications

Using the Generic Network Information Model including the object class hierarchy, identify existing and new object classes needed to support each PTN Management application function.

5.5 Task 4: Define management information schema (information model)

Determine the management information schema for each type of managed system as seen by a particular management application or system. Check the schema from the managed system point of view.

5.6 Task 5: Determine Communication Requirements

Create sets of communication requirements for the most likely communication scenarios. These may be requirements for simple transactions, file transactions, file transfer, file access or combinations of all types. Further there may also be requirements of throughput, reliability, transit delay or naming schemas which show the required features. The process can proceed in parallel with the other main parts of the methodology.

5.7 Task 6: Prepare Documentation for Protocol Tasks

The results of previous tasks should be examined to prepare the documentation to be used in accomplishing the protocol tasks.

5.8 Task 7: Analyze Message Needs

Analysis of the PTN Management functional profiles to determine the broad characteristics of the message needs. Messages between two systems may be defined as application layer protocols related to specific function subsets. It is not implied that functional profiles (see Note 3), e.g., for q Reference Points, always lead to a full seven layer OSI protocol suite and application layer structure. The analysis should determine if the functional profile leads to a minimal grouping of common messages.

NOTE 3

The PTN Management functional profiles provide all the information necessary to perform the tasks associated with selecting and defining the protocols for the PTN Management interfaces.

5.9 Task 8: Decide Adequacy of existing Protocols for each Layer

Evaluate appropriate protocols from existing standard protocols which meet the needs defined in task 7. For each layer that is successful (as is expected for layers 1 through 6), skip tasks 9 and 10.

5.10 Task 9: Define new Protocol Requirements

a) If a layer protocol in task 8 is not adequate in meeting the message needs defined task 7, the additional/amended layer protocol requirements are defined.

b) In the case of the application layer, application protocol requirements aimed at the specific message needs of task 7 are specified.

5.11 Task 10: Define new Layer Services and Protocols

Corresponding to task 9 (a) :appropriate new/amended layer (N-1) services to support layer N are defined. Appropriate protocol mechanisms are amended or defined. Corresponding to task 9 (b): application protocols aimed at the specific message needs chosen by task 7 are specified.

5.12 Task 11: Select Layer Services

Select the service requirement from layer (N-1) to N for N equal 1 through 6 (as appropriate) from output of tasks 8, 9, 10. In the case of the application layer, identify the application service elements (ASEs) necessary to support the specific management ASEs.

5.13 Task 12: Select Layer Protocols and form Protocol Suites

Select all layer protocols (1 to 7) from tasks 8 through 11 and define families of protocol suites including coding of information content, to support the specific management function(s). Ensure consistency of output from task 12 with that of task 6 and iterate through appropriate tasks as necessary. Identify the text to be included in the PTN Management protocol specification.

6. REQUIREMENTS

This clause lays out the broad requirements for PTN Management.

6.1 Recommended Conformance

The purpose of standardising PTN Management is to provide a communications platform suitable to support a wide range of network management applications. By adopting an object oriented approach it is expected that the mechanisms described in the standards, as developed from this TR, will be capable of adapting to future network management applications. Based on these requirements the following is recommended:

- Management systems designed from these guidelines should make use of OSI Management tools and in particular adopt CMIP as the interactive management protocol.
- The design of the management functions should be object-oriented and one good way to reach this objective is by adopting the methodology that is proposed in clause 5.

6.2 Functional Requirements

The directives (instructions from Manager to Agent) available to network management should be capable of selecting one or a range of Managed Objects to operate upon. The directives should also be capable of being delayed until selected events have occurred (e.g. time delay, completion of other commands, etc.).

Time is a fundamental dimension in network management . A number of activities will only make sense when associated to some time information.

Time constraints may affect management functions in an implicit or explicit way. The development of a good management architecture will have to encompass basic requirements such as:

- support of time stamping for events and alarms,
- control of the time dimension by the operators,
- synchronization of management activities,
- scheduling of management activities,
- management of time in distributed configurations.

Security is another fundamental aspect in network management . The possible damage caused by illegal penetration and exposure of sensitive information which is transmitted via PTNs or stored in PTNs, as well as by destruction or neutralization of PTN services is very large. Therefore, there is growing concern about providing adequate security arrangement.

Management of security has two facets:

- administration and control of security facilities which the network provides for users,
- security of PTN Management itself.

Security for users of Open Systems is provided on the basis of the OSI reference model security addendum. Different security services are applicable on different layers of the protocol stack.

PTN Management is extremely sensitive with regard to security. Security functions are necessary for the two forms of external accesses to a management system:

- all management user accesses,
- the communication interfaces to other management systems.

Security functions may also be necessary in all the components of management. The management data transfer requires security assurance as part of the communication function, even when the same communication function is used for user information transfer.

The following list constitutes a set of functional requirements which use communication functions. It does not represent the extent or limit of what an actual implementation should provide.

There is a requirement to provide generic mechanisms to allow manufacturer specific extensions to be added to PTN Management . The Information Model must provide for optional and vendor specific extensions. These features should also allow future standard's enhancement and extension for PTN Management .

Performance Management

- Performance Monitoring
  . collecting performance data (scheduled, on demand or on threshold),
  . selection of items to monitor,
  . control of monitoring operation at Network Elements (NE),
  . localized analysis/collation of performance data.
- Traffic and Automatic Management
  . collecting traffic data (on demand),
  . control of data collection operation at the NE,
  . localized analysis/collation of traffic data,
  . maintaining network clocking for synchronous connections,
  . localized error analysis,
  . collecting data on localized automatic management activities,
  . control over localized automatic management activities.
- Quality of Service
  . collecting QoS data (scheduled, on demand or on threshold),
  . control of data collection operation at the NE,
  . localized analysis/collation of QoS data,
  . QoS test calls (scheduled or on demand),
  . control of test call operations.

Fault Management

- Alarm Surveillance
  - collecting alarm reports (immediately, scheduled or on demand),
  - control over alarm detection operation at the NE,
  - routeing alarms to required recipients,
  - control over use of local/remote alarms by the NE.
- Failure Localization
  - localized diagnostic testing (scheduled, on demand or on threshold),
  - testing of a network path (e.g. loopback, loop insulation),
  - program traps/traces,
  - localized system validity auditing (scheduled, on demand or threshold),
  - component testing.
- Failure Correction
  - correction of software problems by download or patching,
  - invoking protection switching to backups.

Testing (components)

- Access and Control
  - passively measure monitored circuits (on demand or on test completion),
  - control transmission characteristics of a circuit under test,
  - actively test circuit by inserting test system,
  - report status of link carrying a specified circuit,
  - loopback testing,
  - control of test systems.
- Measurement
  - measure the electrical or optical status of a circuit (continuous or scheduled),
  - measure the AC & DC supervision operation of a circuit under test,
  - check signalling state of circuits.

Configuration Management

Provisioning

- Network Element (NE) Configuration
  - examination of selected configuration entities,
  - automatic configuration reports (immediate, scheduled or threshold),
  - insert/remove a configuration entity,
  - equip/unequip a configuration entity,
  - control of configuration entity states,
  - modification of configuration entity attributes,
  - provision of permanent call connections.
- Administrative
  - synchronising network time/date,
  - backing up the NE MIB memory areas (to local or remote store),
  - aborting management operations,
  - controlling routeing of management messages,
  - multiple destinations for NE management messages,
  - control over management functions availability.

- Data Base Management
  - recreate NE MIB areas either via NE backup or by download,
  - initialize a MIB to a predefined condition,
  - synchronize individual NE MIBs.
- Status and Control
  - supervision of automatic protection switching.
- Message Handling Systems
  - supervision of store & forward status.
- Leased Circuits
  - supervision of dynamic provision of leased circuits.
- Transmission Equipment
  - supervision of transmission protection switching operation.
- Installation

  under study

Accounting Management

- retrieval of meter and service utilization information.

Management of Security

- restriction control based upon access circuit/terminal,
- ringback connections for access from outside the network,
- password control on access to selected functions/entities,
- control of message encryption,
- supervision of encryption service,
- supervision of password service,
- allocation of passwords to telecommunications services.

Security of Management

- access restrictions
- ringback connections
- password control

6.3 Architectural Requirements

The proposed architecture should allow the management of heterogeneous networks, for example by supporting a hierarchical approach.

PTN Management needs to be aware of a network as a collection of cooperating systems. To manage such a collection requires services beyond those provided by system management (which is concerned with the management of only one system). Management of a PTN is concerned with orchestrating the management of individual systems so as to have a coordinated effect upon the network. (Fig. 3).

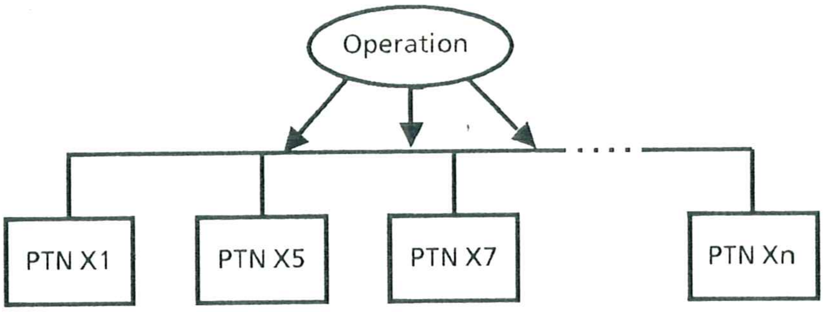


Figure 3 - Example of Management Operation effecting several PTN Exchanges (PTN Xs)

The architecture upon which the functionality is built needs the flexibility to support a spread of control so that the management functions may be controlled centrally (Fig. 4) or be distributed (Fig. 5). This mechanism should not be exclusive, it should assure flexibility in how PTN Management is implemented.

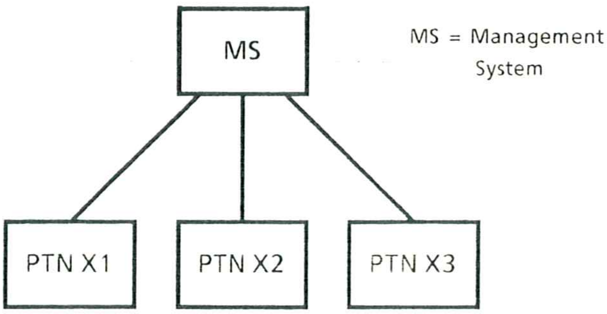


Figure 4 - Centralized Approach

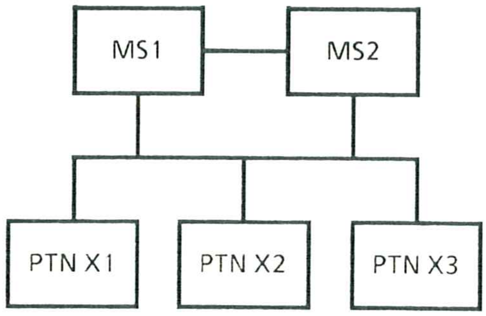


Figure 5 - Distributed Approach

Specific to PTNs is the need to provide flexible architectures in order to respond to customer requirements.

PTN Management needs to:

- minimize management reaction times to network events,
- minimize the load caused by management traffic where the PTN is used to carry it,
- allow for geographic dispersion of control over aspects of the network operation,
- provide isolation mechanisms to minimize security risks,
- provide isolation mechanisms to locate and contain network faults.

In order to take into account the above points the architecture should allow for a compartmented structure where management functions can operate autonomously within them. Such compartments lend themselves to a hierarchical layered approach.

The architecture model must address the requirements of small and large numbers of Managed Objects.

Provision must be made for the need to interwork between separately managed networks so that an inter-network service can be provided. In some instances the separate administrations in control of each network are rivals in other areas of their business. This leads to a major security issue on this interworking. A special case of interworking is with ISCTXs where the managed equipment is administered by both the public and private administrations. Hybrid networks consisting of mixed vendor equipment must be provided for.

To suit the range of functions for which a PTN can be used the degree of reliability cost trade-off shall be flexible in all the network management components.

6.4 Interactive Exchange of Management Information

In order to communicate harmoniously, two management components must share a Management Information Knowledge. This knowledge represents an Information Model that is used by each component and is contained in a Management Information Base (MIB). Communication between the components is based on the use of the Common Management Information Service Elements (CMISE) which cater for the exchange of management information messages.

CMISE, which is a part of the System Management Application Entity (Layer 7, see Fig. 28) and is defined in ISO 9595, shall provide:

- the Common Management Information Protocol (CMIP) for the exchange of management messages,
- the Common Management Information Service (CMIS).

A management interface is fully defined if the management Information Model and the communication protocol suit are specified. Since an object oriented approach is used, ISO CMIP is a suitable solution when the network component can provide a full 7 layer stack protocol. When the PTE is not able to handle an object-oriented management model or when only layer 1 to 3 functionality is provided by the PTE, the management information will be accessed via the layer management protocol or via a local mechanism. A Mediation Function is necessary to enable Management Information applying to such PTEs to be handled in a Management Process. This Process would use CMIP for management information exchange and is based on an object-oriented approach. This function is only relevant when more than just a protocol relay is involved.

7. ARCHITECTURES

The management of telecommunication networks can be envisaged from a number of perspectives depending on the size and interworking requirements of the network. This will impact the design of a network management architecture.

Since the environment being managed is physically distributed, the Management Application Processes are themselves distributed. These distributed management applications may be designed and organized in many ways.

Typically the following general aspects will have to be addressed:

- Hierarchical management ,
- Peer to peer management ,
- Distributed processing,
- Interworking between separately managed networks,
- Reliability (Redundancy).
- Performance considerations

The management architecture has a direct impact on the performance of PTN telecommunication services. It also has impacts on the performance of the management systems themselves and influences how they may be allocated within a particular network.

The various architectural requirements are reviewed in 6.3. This clause will further elaborate on these aspects and introduce the various parameters that may impact the design of an architecture for network management. Several aspects which are sometimes "orthogonal" (i.e. have an impact on or create a new dimension to the other ones) will be considered and integrated in a proposal that should lead to a flexible and non-constraining architecture.

This approach is developed within the OSI Management framework which is itself based on the Managed Objects paradigm.

7.1 OSI Management Concept

This Report will make use of the OSI Management concepts such as introduced in CCITT Rec. X.701 and ISO/IEC 9545 as well as of a number of CCITT TMN concepts derived from CCITT Rec. M.20. It will in particular make use of the terminology defined in clause 4. The goal is to generalize and adapt the OSI Management approach to the management of PTNs.

7.2 Management Domains

7.2.1 General

The definition of a domain has been briefly introduced in clause 4. This definition is actually derived from CCITT Rec. X.701. It suggests that a Management Domain is a collection of one or more distributed Managers (M) and their associated Managed Objects as depicted in Fig. 6.

In order to facilitate the discussion the concept of "Managed Domain" has been introduced that excludes the Manager. The Managed Domain will typically consists of a collection of Managed Object instances. This means that the concept of domain would be purely limited to the assignment of object instances whose classes have been defined as part of the network management Information Model.

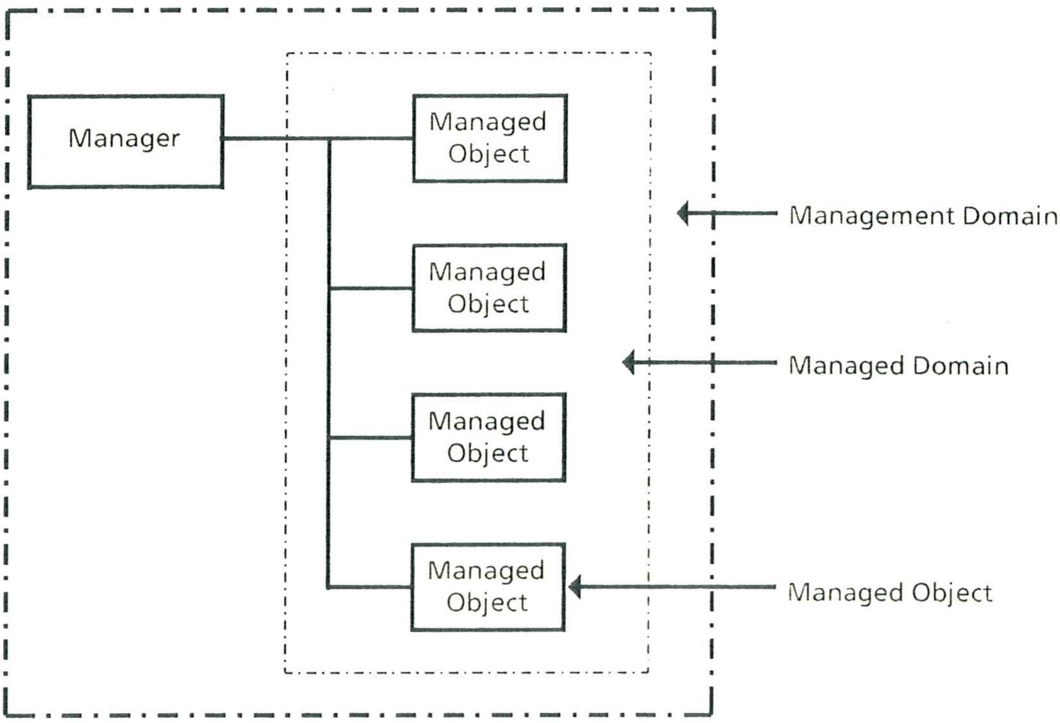


Figure 6 - Definition of Domain

Furthermore, CCITT Rec. X.701 qualifies the concept of Management Domains as being real Open Systems which may contain Managers, Agents, or both. To meet the organizational needs for flexibility, a real management environment can be functionally partitioned into a number of Management Domains. For example, Management Domains can be created in accordance with administrative boundaries.

According to this definition, a real Open System can be part of one or more Management Domains and a single Managed Object instance can participate in more than one Management Domain.

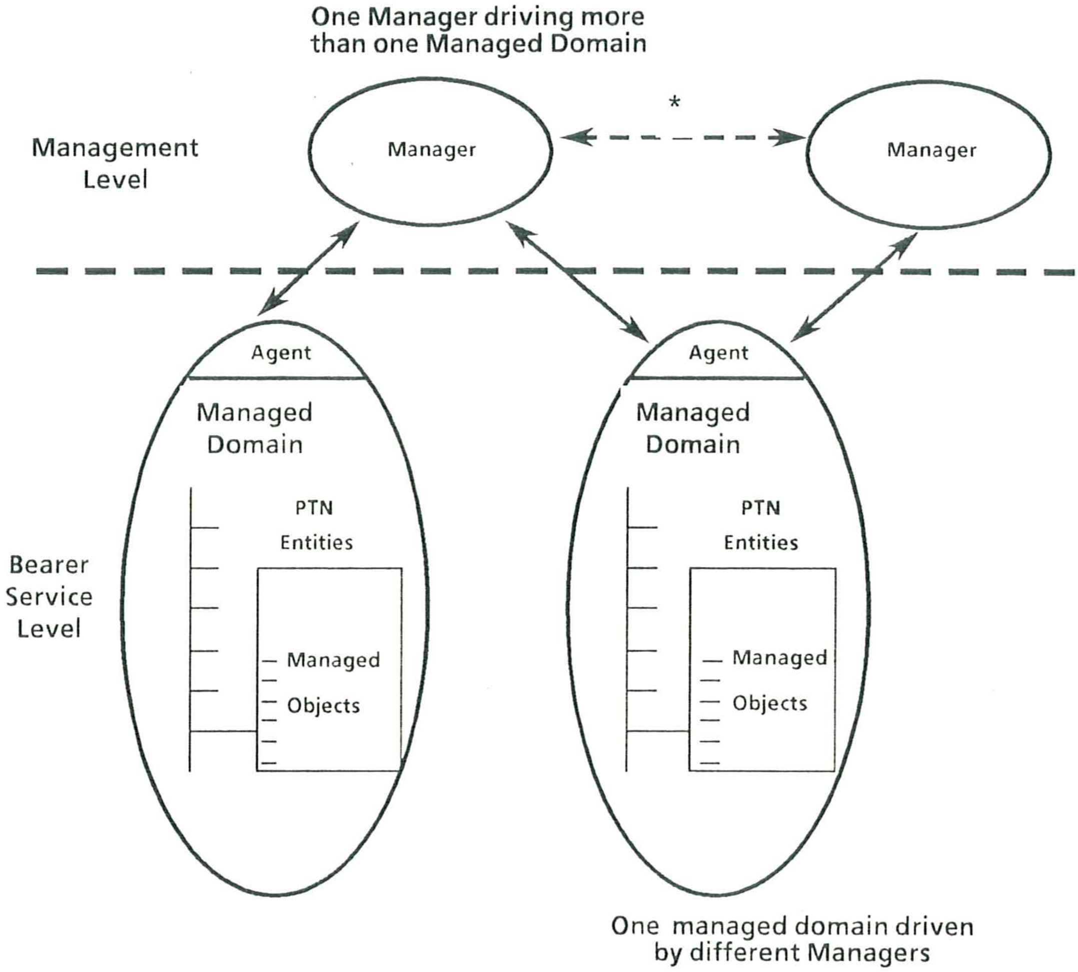
The definition of the Managed Domain as a collection of Managed Object instances is associated with the naming and enrollment of the Managed Object instances in a Management Information Base (MIB).

It must be noted that the question of defining "domains" and "subdomains" will impact the way the Managed Objects will be accessible from a Manager. This might in particular include the definition of the security mechanisms necessary to access and to control the elements which belong to this domain. This is further discussed in the following clauses.

A Manager has access to the Managed Objects via the Agent. When a Manager needs to access objects in a Manager Domain it will communicate with the Agent responsible for these objects in this domain. Optionally the information messages may be routed via the Manager in charge of this domain.

It should be noted that the Manager(s) responsible for the Managed Domain should be kept notified of any changes made to Managed Objects within that domain.

Fig. 7 shows that an Agent can actually communicate with several Managers as well as several Agents can communicate with one Manager. The first case typically takes place when different Managers are in charge of overlapping domains. This is further discussed in 7.2.3.



Distributed management communication, see 7.4.

Figure 7 - Manager-Agent Interaction

7.2.2 Definition and administration of Management and Managed Domains

The concept of a Management Domain may be used for various reasons when designing the management of a PTN. This can be:

- for administrative reasons,
- in order to identify certain functional groupings,
- based on security considerations (isolation of certain areas which are not under direct control of a Manager). Certain objects can be accessed only by the Manager whose domain they belong to,
- based on geographical or physical constraints,
- based on reliability considerations.

The concept of Managed Domain is easier to handle insofar as it represents a collection of Managed Objects. The objects of a Managed Domain will always be accessed via an Agent which will act on behalf of one or more Managers. When used alone the word domain will mean "Managed Domain" unless otherwise specified.

The extended TMN model presented in this report assumes the existence of "domains" and "subdomains". This is particularly the case for the PTN telecommunication service level where a number of functional groupings can be identified that may be mapped into subdomains, each of which being managed by a dedicated Manager.

The administration of a Management Domain implies creation, modification, and maintenance of:

- Managed Object instances belonging to this domain, and registered in the Management Information Base,
- relationships among Managers and Agents of distributed management applications,
- relationships among Agents and Managed Objects and Managers of the distributed management applications.

7.2.3 Overlapping Domains

Two domains will be defined as "overlapping" when each contains one or several common Managed Object instances.

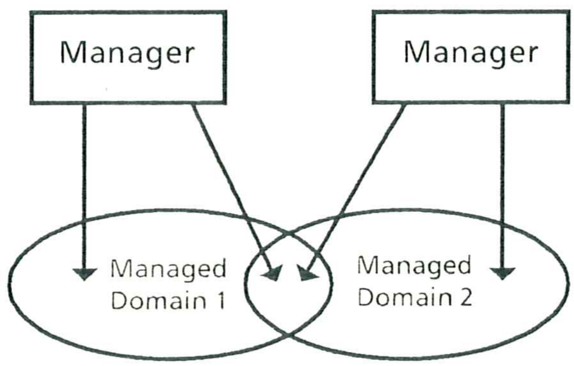


Figure 8 - Simple View of Overlapping Domains

In a multi-Manager environment several Managers may be in charge of the same Managed Domain (Fig. 7) or the domains may overlap (Fig. 8). This may happen in a number of scenarios such as:

- One object may belong to several functional groupings which are related internally to the physical component e.g. a telephone line unit belongs to one fault management domain as regards its maintenance and to an accounting domain as regards the billing aspects,
- one object may be shared/maintained by two networks in the case of hybrid or binational management ,
- one object may be accessed by distributed Managers for reliability reasons.

Fig. 9 depicts a scenario where a set of Managed Objects is actually involved in different Management Domains. Each subset of Managed Objects is a Managed Domain. Some subsets may contain common objects, these can be categorized as being in an 'overlapping domain'.

As far as the Managers are concerned, two main classes of solutions can be envisaged:

- All Managers share the same responsibilities and have equal access rights to all objects they can reach,

- one Manager has prime responsibility for a number of objects i.e. all objects are physically reachable by all Managers but accessible by only one at a time.

As far as the Managed Object instances are concerned, solutions are being defined (e.g. in CCITT Rec. X.732 and in ISO/IEC 9545) that consist in making use of relationship objects in lieu of "real objects" when these object instances happen to be duplicated in overlapping domains. In this case an object instance is recorded only once in a reference domain and pointers are used in the other domains.

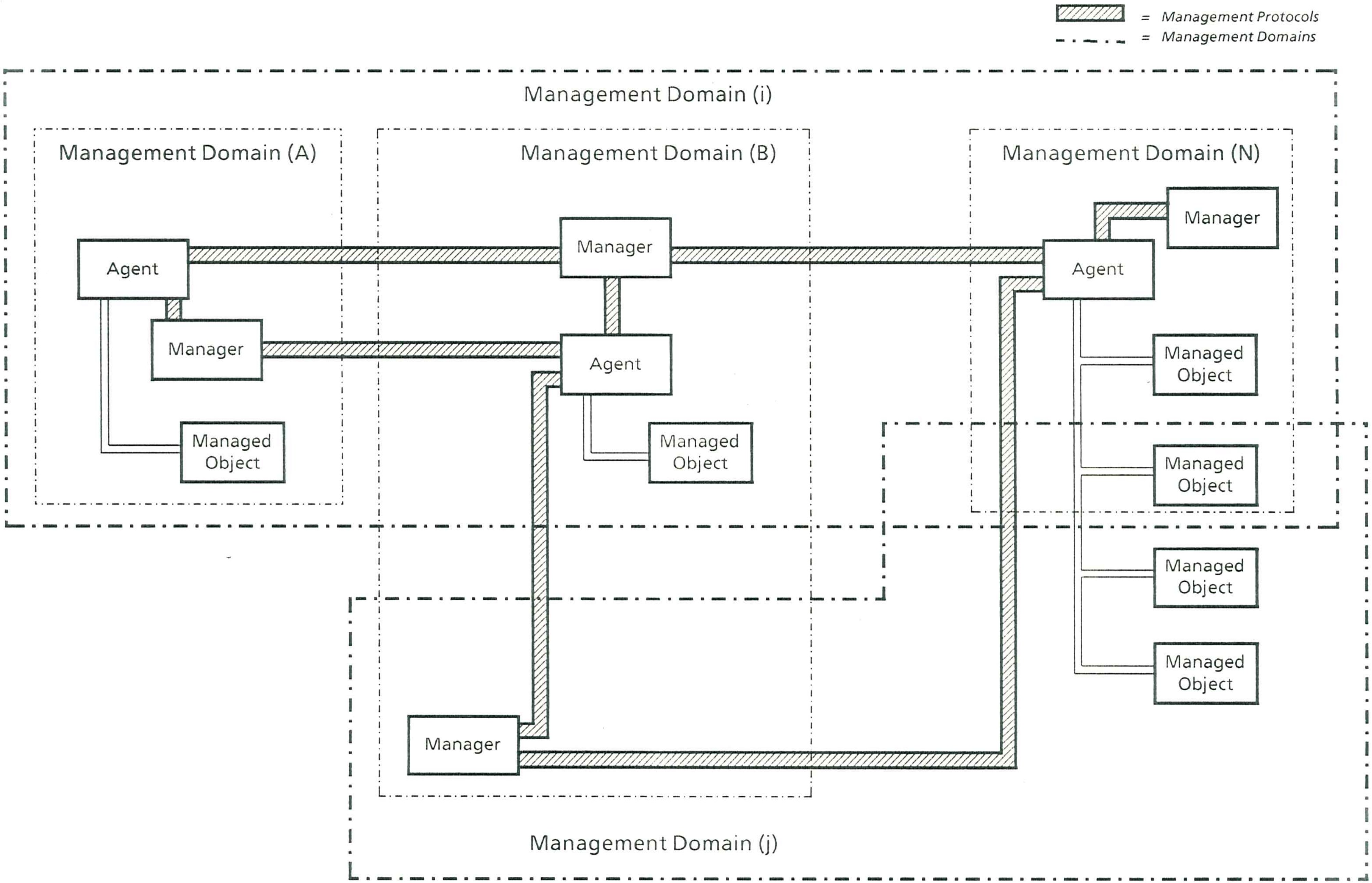


Figure 9 - Example of Overlapping Management Domains

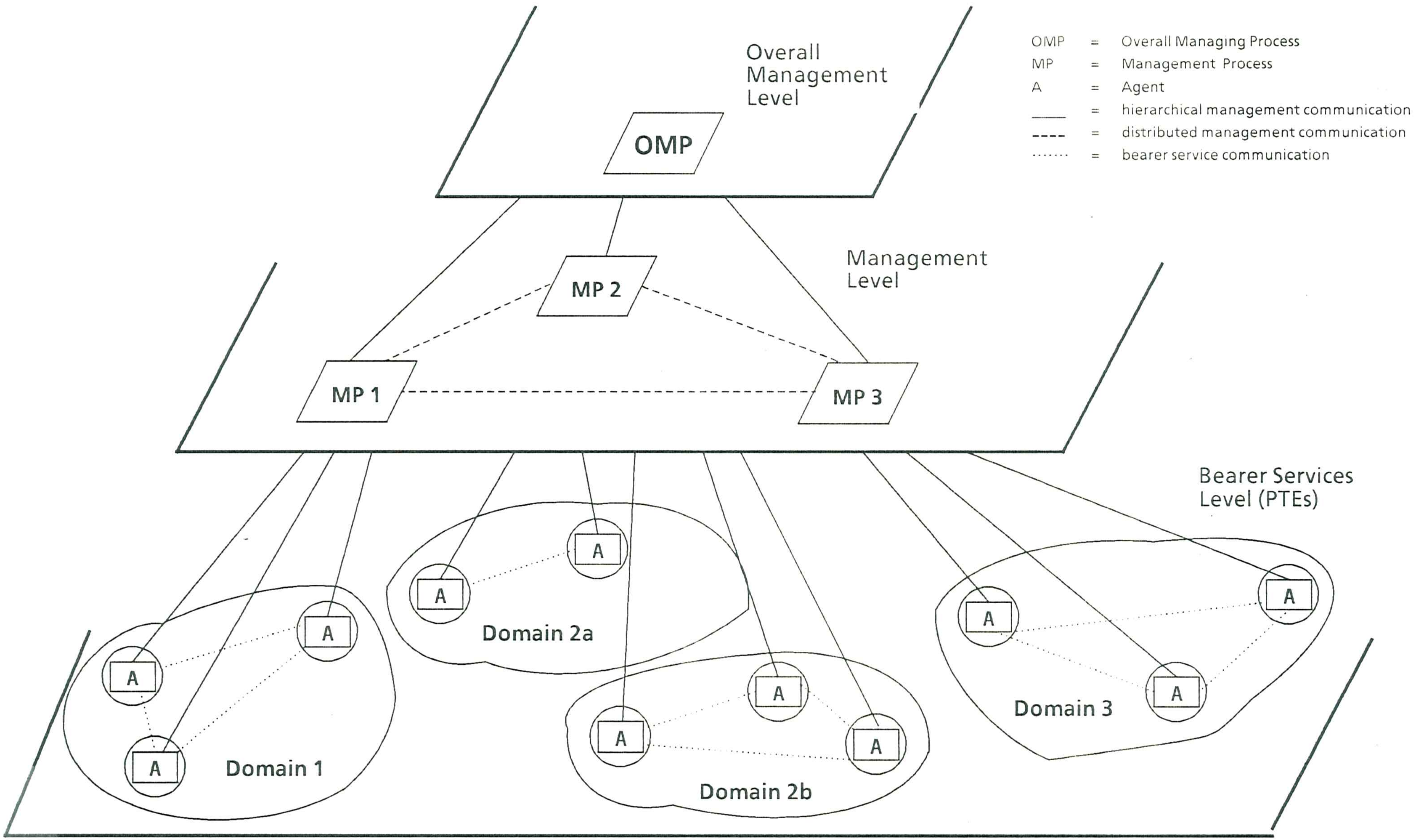


Figure 10 - An Example of a 3 Level Hierarchy for PTN Management

7.3 Hierarchical Management

7.3.1 Basic definition

Management will be defined in this report as being organized in a hierarchical manner when the Management Domains are composed of a set of embedded Management Domains and when each domain (and the Managed Objects it contains) is directly or indirectly under the control of the larger domain of which it is a component. Hierarchical management can also be modelled as a series of strata (levels), each of which is under the control of the next upper stratum.

A typical example can be found in the simplified CCITT TMN model (see CCITT Rec. M.20 and M.60) that identifies a number of hierarchical levels: Operation System Function (OSF), Mediation Function (MF) and Network Element Function (NEF).

This report extends the TMN model by adding one more level: the Overall Management Process (OMP) and by allowing a recursive use of the "intermediate" Management Processes. The model proposed is therefore more general than the TMN model. In practice, however, it is recognized that the management of most PTNs will be limited to a 3-level hierarchy as depicted by the example presented in Fig. 10. This figure makes use of some acronyms which will be further defined in the following sections.

Although the OMP will have most of the characteristics that are common to all the intermediate hierarchical levels, it is to be considered as a special element in the hierarchy.

In a more generalized approach the model can be extended to n strata and the principle of recursivity will be introduced in order to simplify the global approach.

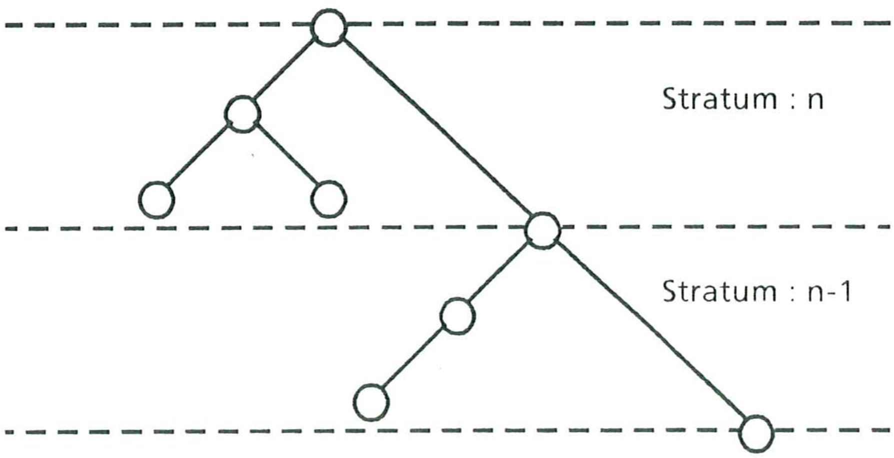


Figure 11 - A Stratified Model

A recursively stratified organization is a powerful one but introduces some questions and constraints that need to be recognized particularly in an OSI oriented context. One stratum may itself be organized in a tree arrangement (Fig. 11).

The stratified approach leads to some simplifications but also some constraints, for example as regards the synchronization of operations. Further considerations on the influence of time in management can be found in 7.5.

Whether the general recursive solution or the 3 strata solution is retained or not, it remains flexible enough so that the simplest scenario is encompassed. This case consists of a single Manager directly managing the Managed Objects.

The following clauses will further demonstrate how the concept of recursivity is used.

7.3.2 Recursivity

As described above, the generalization of a hierarchical approach together with a requirement for maximum simplicity leads to the definition and use of a recursive model. In such a model, the embedded domains are managed by their respective Managers (see 7.2) each participating in a typical Manager Agent relationship as suggested in CCITT Rec. X.701.

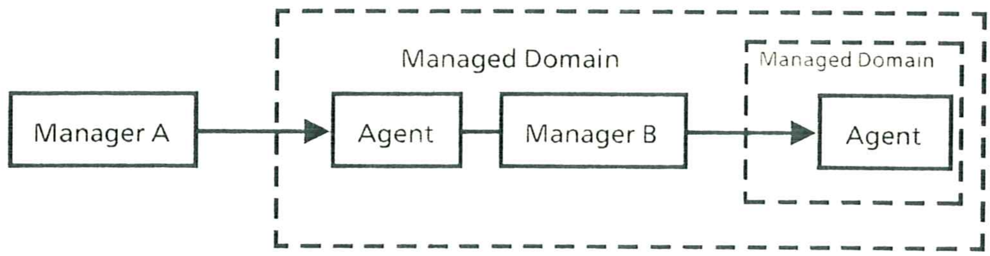


Figure 12 - Recursive Use of the Manager-Agent Model

Recursivity can be introduced in this organizational model by repeating the Manager Agent relationship as depicted in Fig. 12. More can be found on the Manager Agent type of an approach in Standard ECMA-135.

In brief, the model can be viewed as a chain of Manager Agent relationships. In the simpler case this chain is composed of one single link. The Manager and Agent would only need to be implemented when the Reference Point they are associated with becomes embodied as an interface.

7.3.3 Domain model and Reference Points

The PTN Management can be regarded as a domain (the PTN Management Domain) consisting of one or more embedded Management Domains. The PTN Management Domain is managed by one Overall Management Process (OMP) (Fig.13).

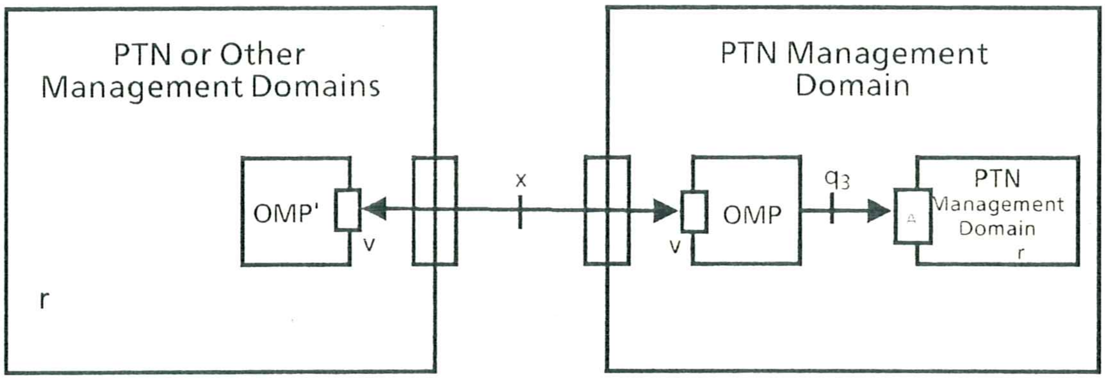
The embedded Management Domains are managed by their own Managers and are called here PTN Management Domains (Fig. 14).

The various domains will intercommunicate via ports which will in general be asymmetric due to the Manager Agent relationship.

It is worth noting, however, the specificity of the Manager which is at the top of the hierarchy (OMP). The OMP does not have an upward port. It might have instead a symmetrical port that will allow it to interwork with an equivalent function. This provides for interworking with a different Management Domain which is administered by an independent authority. The requirement for communication between peer OMPs has been identified in CCITT Rec. M.20. A typical example in telecommunication networks is the management of a connection (path) provided over several networks e.g. in the case of two national networks or in the case of private/public networks arrangements (some time referred to as hybrid networks).

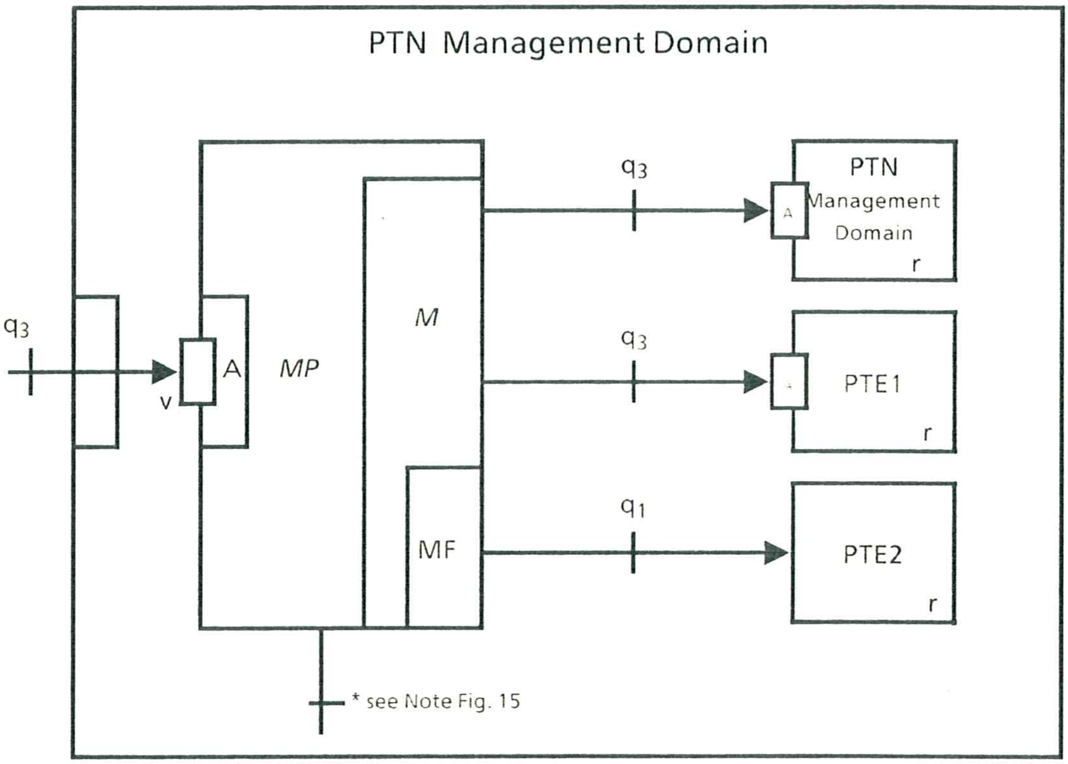
The interworking between OMPs will take place at the CCITT Rec. M.30 "x Reference Point" as depicted in Fig. 13.

In a generalized representation a PTN Management Domain consists of Managers managing other PTN Management Domains or PTEs. This allows the recursive definition of multiple strata of communicating Management Processes.



v	: visible port
r	: recurring object (object repeatable within the domain)
x	: inter-OMP Reference Point (TMN)
q3	: Management Reference Point (TMN)
A	: Agent
M	: Manager
OMP	: Overall Management Process
OMP'	: Equivalent Overall Management Process

Figure 13 - PTN Management Functional Model



v	: visible port
r	: recurring object (object repeatable within the domain)
q3	: Management Reference Point (TMN)
q1	: Management Reference Point
A	: Agent
M	: Manager
MF	: Mediation Function
MP	: Management Process
PTE1	: Private Telecommunication Entity Type 1
PTE2	: Private Telecommunication Entity Type 2

Figure 14 - PTN Management Domain Functional Model

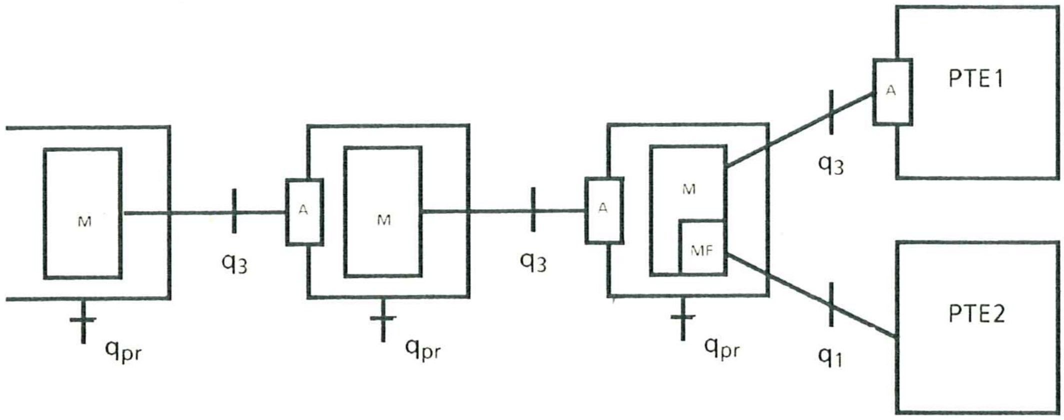
Every Management Process can be involved in a Manager Agent relationship with one or more Agents located in the next level of the hierarchy, i.e. in another PTN Management Domain or in a PTE. This communication should take place at the q3 Reference Point.

However when a PTE is not able to support the interface that will be necessary at q3, it will be attached via a Mediation Function at a q1 Reference Point.

A Mediation Function makes available those objects which the PTE is not able to represent directly. This occurs when the functionality of the PTE is restricted for reasons of implementation. To do this the Mediation Function acts as a remote Agent to support those PTEs which cannot fully provide an Agent directly. The Mediation Function constructs the objects in order to represent the resources a PTE contains which is attached to the q1 Reference Point. This implies that the PTE will provide sufficient information for the Mediation Function to support the management of these objects. In summary the Mediation Function provides all the Agent functions required for the q3 Reference Point but which are not available on the PTEs being managed.

The PTEs that can be connected to Managers via q3 Reference Point are called PTE type 1 (PTE1), those that can only support the q1 Reference Point are called PTE type 2 (PTE2). These concepts are illustrated in Fig. 14.

It is worth noting that while q3 Reference Points can be cascaded in a recursive arrangement, the q1 Reference Point will be used only once in such an arrangement. This is depicted in Fig. 15.



NOTE 4

Additional communication paths might be implemented between Management Processes as further described in 7.4

M : Manager

A : Agent

Figure 15 - q_1/q_3 Reference Points Arrangement

The proposed approach is more general than the CCITT TMN concept of Mediation Function but should be totally compatible with it.

7.3.4 Objects visibility

The visibility of an object can be described as the perception by a Manager of the characteristics and behaviour of this object. It is formally defined and represented by the Information Model that the Manager uses to manage the objects.

One of the main impacts of a hierarchical organization for network management can be summarized as an impact on visibility.

When a (n)th stratum (plane) of management is exchanging information with a (n-1)th stratum of management , it can do it in the OSI context if it has a certain view of the Managed Objects that belong to that stratum.

The (n)th stratum management system will communicate with an Agent in the (n-1)th stratum. This Agent will provide an OSI (object oriented) representation of the objects it has under its control even if these are not actually organized in an OSI fashion.

In some instances, the Agent in the (n-1)th stratum does not really interfere and acts as an information passing mechanism. In other cases it will provide a modified view of the objects it is itself in charge of. In this latter case, it will use a different Information Model for managing the objects which are in its own sphere of influence.

It must be noted that some objects may be conceptually known by a Manager but are kept outside of its domain of responsibility i.e. they should be inaccessible from this particular Manager. In other instances an object may belong to the Management Domain but cannot be directly reachable and needs the intervention of a Mediation Function.

Thus while an object which is not visible is not reachable, an object that is visible from a certain Manager is directly or indirectly reachable.

The various Information Models handled by the Managers therefore reflect the visibility of the Managed Objects. A (n)-management system will have to call on a (n-1)-management system via a certain protocol. In some cases and for particular uses, the protocol may be CMIP. This works when the "objects" modelled by the (n-1)-system provide an Information Model that conforms to the object oriented model. In this case, the (n)-system does not need to know whether the objects presented by the (n-1)-system are real or imaginary, since it only deals with the abstraction provided by the Information Model.The exact nature of the Information Model across an interface which does not support an object oriented approach is for further study, but the scope will be similar.

Further considerations on the way a "native object" (i.e. a PTE in the present context) can be perceived by and accessed from a Manager can be found in Technical Report ECMA TR/49. This document suggests that the way an intervening object modifies the visibility of the native objects is a distinctive characteristic of a distributed environment and is called transparency. One can conceive that different types of transparency can be achieved depending on the particular architecture.

The following types of transparencies are identified and defined in Technical Report ECMA TR/49: location transparency, failure transparency, distribution transparency, migration transparency, replication transparency and concurrency transparency.

In summary, several concepts have been introduced that will be used in the rest of this report to represent the various aspects (dimensions) of this architectural approach.

1. Accessibility

   An object is directly or indirectly accessible if it belongs to the relevant Management Domain. The accessibility may be subject to certain controls when the Management Domains need to interwork (hybrid networks ...).

2. Reachability

   An object is directly reachable or not depending on whether it needs an intervening Mediation Function.

3. Representability

   An object can be represented by a Mediation Function when it is accessible but not directly reachable from a nth stratum of management .

4. Visibility

   The nth stratum of management has a certain visibility of the objects that belong to its Management Domain that may not match with the reality of these objects particularly when these are located in the (n-1)th stratum.

5. Transparency

The degree of transparency of a distributed environment will depend on the particular architecture. It will have an impact on the visibility of the PTEs by the various Managers.

7.3.5 Some key questions

When defining and designing a PTN Management a certain number of questions may be raised, the answers to which may lead to implementation variants that should all fit within a single model.

In order to fully understand, study and define hierarchical management one must therefore discuss the following questions:

- Management functions

  What are the management functions and the Information Model that should exist at each level (stratum) of the hierarchy? One generally refers to this question as the definition of a Shared Management Information Knowledge for a given management stratum.

- Hierarchical stratum scope

  What is the scope (range of reachability) of a given management stratum? When one global Management Domain is defined, i.e. all its Managed Objects are identified, the question of clustering these objects into a number of sub-domains is posed. Should the objects in a subdomain be part of a global naming scheme or be defined within a local context? Should some gateways be installed to constrain the accessibility of certain objects? What is the value added by decoupling subdomains e.g. by creating hierarchical levels?

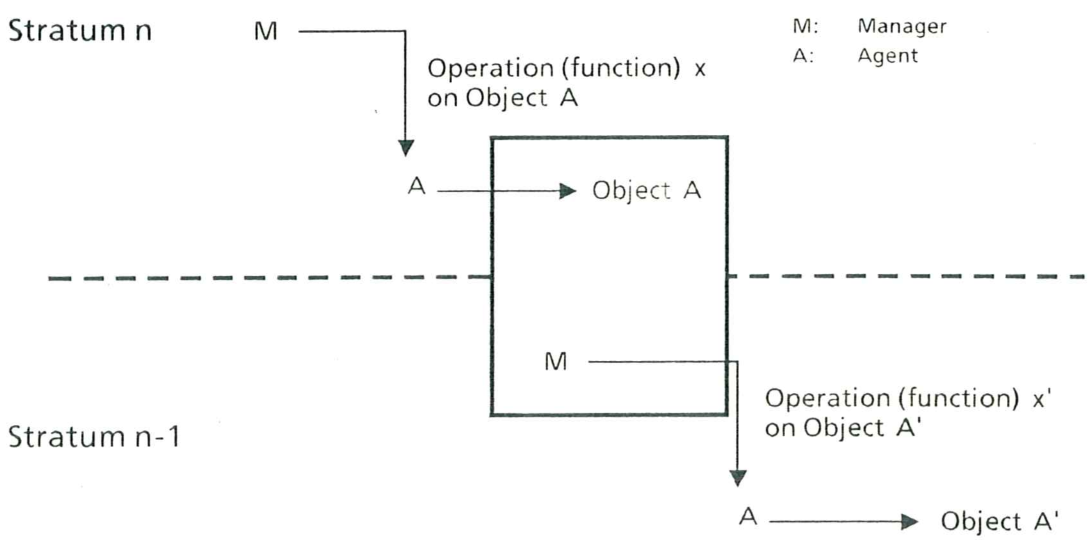


Figure 16 - Transparency and Visibility

- One or several Information Models:

  What is the visibility of any Managed Object that is accessible from any nth stratum of management ? When a Manager at the nth level wants to start an action on an object in a lower (non adjacent) level, does it need to know in a detailed fashion the object and its behaviour and reach it directly. Can it trigger an action on an-other object in its own domain of influence (of reachability) that will indirectly lead to the expected result. This question leads to the potential definition of different Information Models for each hierarchical stratum. In other words the granularity on the objects in a given stratum can be coarser than the granularity in the lower strata and some "rough" or "generic" objects in an upper stratum might be defined that act as a representation of some target objects in the lower strata as depicted in Fig. 16.

- Influence of time

  What is the influence of time on the various commands? Is the notion of time in one stratum of the same importance as in an other stratum? In general, the higher in the hierarchy the further away of real time, the concept of synchronization of actions in one stratum may be more constraining than in an other stratum. This question is further discussed in 7.5.

A number of conclusions are possible that should leave some freedom to implementers. But it must be noted that the type of communication protocols to be used between hierarchical strata will be largely influenced by the following issues:

- It is possible to define systems where the management levels are totally decoupled. Decoupling may be implemented in one of the following ways:

  . The Agents are real gateways that act at the inter-stratum boundary so that a Manager in the upper stratum will never be able to directly reach the Managed Objects in the lower strata.

  . The Information Model trees in each hierarchical stratum are independent. One schema is known and declared for each stratum. This could be exemplified by the fact that two definitions of a given Managed Object (characteristics and behaviours) can exist when this object is defined as the leaf of the Information Model in the upper stratum as well as the top of the information tree of the lower stratum (see Fig. 11).

  . The synchronization constraints (orchestration) might be restricted within a given stratum.

- The hierarchical approach can be designed as a fully distributed environment for which the Information Model is globally defined and in which the concepts of distributed processing such as discussed in CCITT Rec. X.701 can be put in place.

- Combinations of the above approaches may operate independently in the same implementation.

7.4 Distributed Management processing

This clause intends to highlight the difference between hierarchical management and distributed implementation of the Management Application Processes. It has been mentioned earlier that hierarchical management was by essence distributed in the sense that the various entities (Managers, Agents) are not necessarily supposed to be collocated (although they could be for a given implementation).

A new dimension is added when the Management Processes are implemented in a distributed manner.

A given Management Process belongs to a certain management level and may or may not coordinate its actions with other Management Processes of the same level in a distributed manner. The same considerations as those presented in 7.3.3 are applicable to this other form of distribution and most of the concepts and references identified in 7.3.3 (see Technical Report ECMA TR/49 and SC21 N 3196) are directly relevant.

Distributed management is where peer Management Processes, within the same management stratum, communicate together directly in order to implement management functions. This does not necessarily encompass "dispersed" management where the management functions are physically separated but each function is contained within only one physical component for the domain. Communication between Management Processes within the same hierarchical level may or may not exist as an implementation option. This optional communication will most probably fulfil different requirements than these applying at the q3 Reference Point. However the mechanism used for all communications shall be as similar as possible.

Until further study is made on this topic, the communication necessary for the distribution of Management Processes will be defined as taking place at the "qpr Reference Point" (Fig. 17).

Figure 17 - Illustration of q_{pr}

In this model the Management Process functionality is distributed across a number of Management Application Process instances.

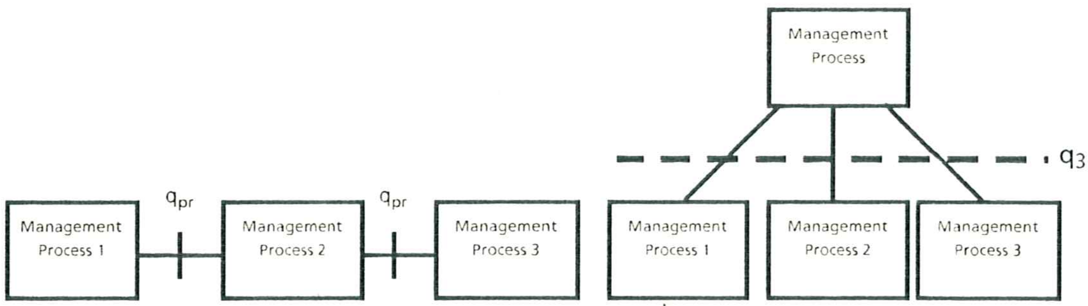


Figure 18 - Implementing Distribution in various Ways

Such an example of dual implementation for a given functionality exists for routeing management where two approaches are possible (Fig. 18):

- dynamic routeing where routeing tables are automatically updated by means of special protocol messages exchanged at the qpr Reference Point,
- static routeing where routeing tables are updating from a centralized Management Process via the q3 Reference Point.

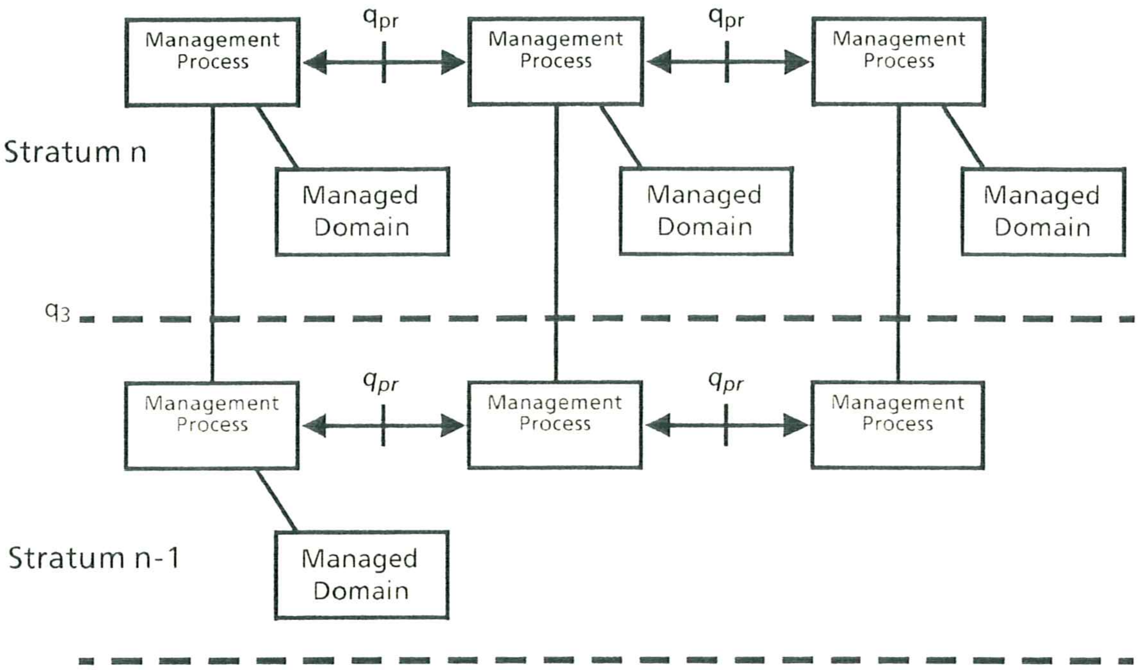


Figure 19 - Distributed and Hierarchical Aspects

From what has been said above, it is possible to define a more complete model that encompasses the requirements originating from hierarchical management and/or distributed implementation of Management Processes. The model depicted in Fig. 19 that introduces orthogonal communication paths actually covers the same scope as Fig. 10.

7.5 Influence of Time in Management

The information which is handled for management purposes can be modelled in a variety of ways. It has been mentioned previously (Clause 5) that a method to identify the required Managed Objects is to define an E/R model and hence deduce the management information tree (see 8.2). This method, however, does not take into account a fundamental dimension which is time. One trivial example is the case of billing applications where time plays a key role.

Time will also be essential in a number of other areas like activity orchestration and activity scheduling. The following are guidelines for the use of time in management :

- the inaccuracy that will inevitably result from a distributed environment (non homogeneous time) must be well understood if not fully mastered.
- time-stamping should be done as close as possible to the source of information.
- operators should be given the ability to define (or not) time in a variety of ways. When they won't use this ability, time will be implicitly defined by the semantics of the user interface. The time can be specified explicitly or it may default to a specification which is derived implicitly.
- the influence of international time zones should be carefully studied in large networks,
- the definition of management applications should take into consideration situations:
  - when resources might have to be used simultaneously
  - when concurrent use of resources should be avoided

- . when the ordinal aspect (sequence) of events is essential
- the use of interpolation or extrapolation methods to extract time information from a set of data should be done very carefully and only when a fair knowledge of the data behaviour with regard to time is available.

Layer 1 clock synchronization is outside the scope of PTN Management.

7.6 Physical Architectures and Communication Mechanism of the Interface

The work done for TMN in CCITT Rec. M.20 has lead to the definition of the two Reference Points q1 and q3 in this report.The communication mechanism at a given Reference Point is described by means of an interface definition.

PTN M interfaces provide for the connection of various devices with each other: The goal of an interface definition is to assure the connectivity of various devices in order to accomplish a given PTN Management function. The communication mechanisms as defined in clause 10 allow the exchange of messages related to the Information Model such as presented in clause 8.

The definition of an interface is complete when the Information Model and the communication mechanism that are to be implemented at the Reference Point are specified. As such there is a great number of possible interfaces that cover all combinations of groupings of Information Model and communication mechanism. However the purpose of standardization is to reduce the set of groupings to a minimum, i.e. by defining a generic Information Model and by specifying a reduced set of communication mechanisms.

The mapping of Reference Points into interfaces may be done in many ways: One Reference Point can be mapped into one or several interfaces, conversely one interface can support one or several Reference Points.

For each M interface one protocol stack (and an Information Model) will be needed for the exchange of management information.

The model proposed in Fig. 10 is a typical one and actually makes use of only 3 levels. It allows the identification of functional groupings that are expected to be commonly found in PTN Management .

Fig. 20 represents an example of a physical architecture obtained by applying the recursive model on a 3 level PTN example.

As a consequence of the reduction of the number of Reference Points, only 2 categories of physical interfaces are identified in this technical report as shown on Fig. 21. These interface families are named here M3 (applying at q3 Reference Point) and M1 (applying at q1 Reference Point).

The communication mechanism of the interfaces identified on Fig. 20 and Fig. 21 are further defined in Clause 10.

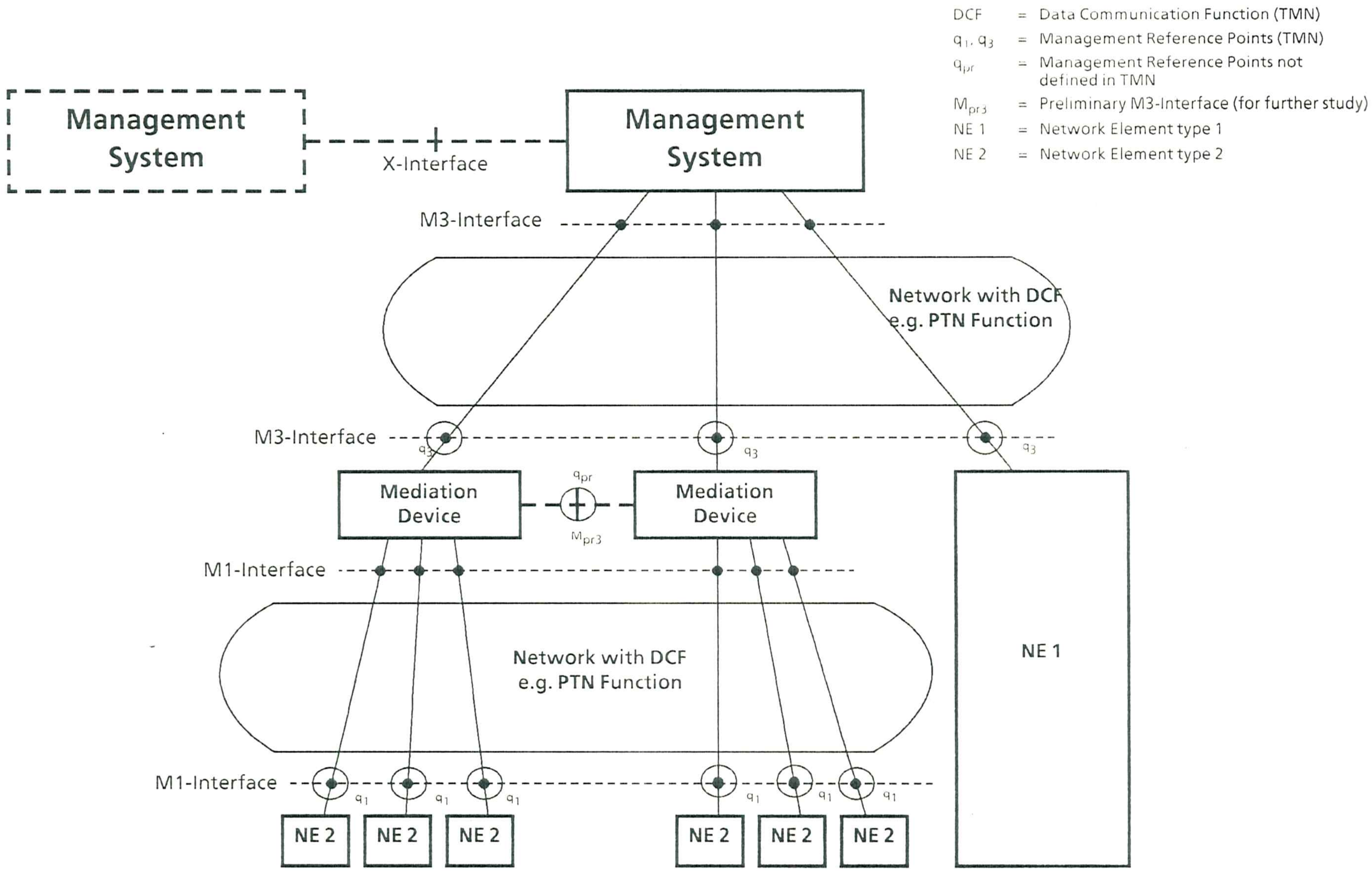


Figure 20 - Example of a PTN Management Physical Architecture

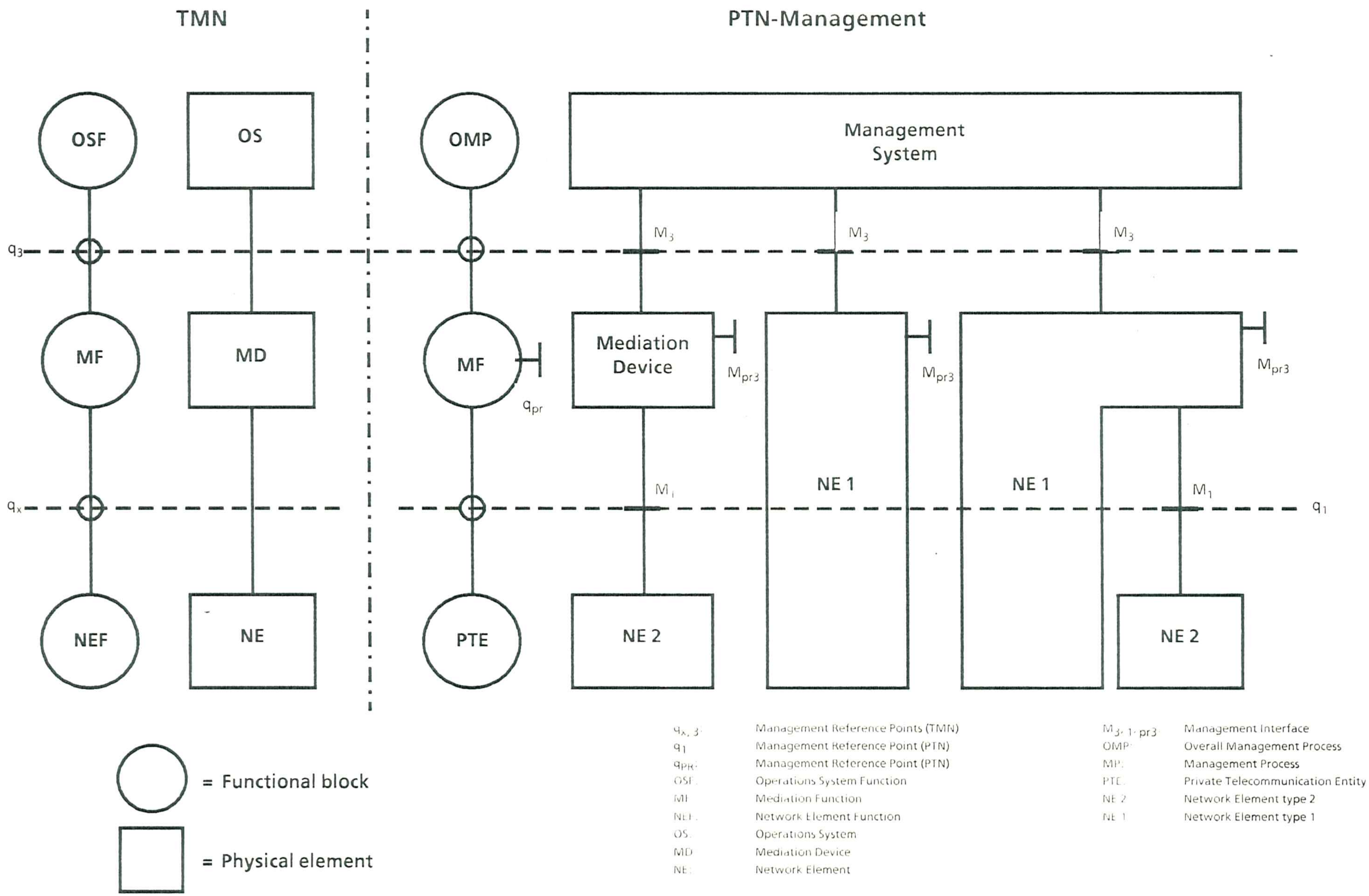


Figure 21 - Relationship of Physical Architecture to Model (Examples)

8. INFORMATION MODEL

8.1 Methodology for Managed Object Definitions

It is not within the scope of this report to describe the methodology for Managed Object definition at any length. We refer to CCITT Rec. X.722, which describes it in greater detail. That description gives the guidelines for the definition of Managed Objects (GDMO) for the OSI Management environment. The description is considered to be relevant but not binding for the modelling.

Managed Objects are defined as part of a generic Information Model. As such these represent "real world" resources but they may not be identical with real world resources. They may represent physical or logical resources as well as relationships between resources.

The Managed Objects should first to be classified as being members of an object class.

A tree structure for object classes can be constructed; and in this tree each class is a member of a superclass whose characteristics are all inherited by the underlying class (subclass), and may in that subclass be enhanced by other characteristics.

The structure and behaviour of a Managed Object class is primarily defined by means of the Managed Object Class template. This will allow a systematic approach to define, for each object class, the dynamic behaviour of the object, its key attributes (e.g. characteristics, states, counters) as well as the operations and notifications that the object supports.

8.2 Entity-Relationship Diagram

The entity relationship (E/R) approach is a valuable methodology during the initial design stages of a Management Information Model. The power of this graphical modelling technique is derived from its simplicity and clarity. The simplicity originates from the facility to depict properties of objects and relations between objects in comprehensive diagrams. It presents a clear view on interaction between separate objects.

Distinct object classes are entities within a conceptual framework. Each object instance (real object) belongs to at least one object class. Object instances can represent any part of the PTN: a physical or logical object, visible or invisible, real or on a meta-level. Entities are indicated by a noun and depicted by a box. Relations are indicated by a verb and depicted by a diamond (Fig. 22). The "is a" relation is mostly depicted only by an arrow.

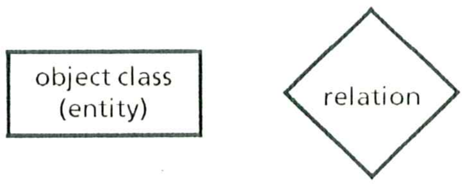


Figure 22 - Representation of Object Class and Relation

The E/R approach is non formal and broad. Therefore in the E/R diagram the attributes will not be shown. The exact definition of attributes is deferred until the mapping into a formal language (ASN.1).

An object class can be a subclass of only one other object class. In the object oriented approach this is represented by subclassing and by the "is a" relation. Subclassing deals with single inheritance: all properties of the parent are inherited by its children, each of which may add other and mutually different properties.

Relations can be defined between two or more object classes. Only relations between exactly two object classes may be used. Relations between more object classes can be decomposed into several double relationships. The number of objects (object instances) involved in the relation is described in the "cardinality". The cardinality of a relation is identified with two positive integers, denoting the number of objects on both sides of the relation (Fig. 23).

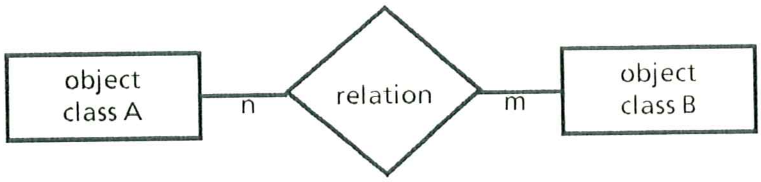


Figure 23 - Example of Relation with Cardinality

A relation binds objects to each other. A relation rule always has to contain a verb. Using the entity relationship approach to model networks delimits the range of usable relations to a set of standard relations, e.g. is a, contains, connects, terminates. Standard relations are unambiguously independent and in this way orthogonal. Therefore it is very important that these relations are well defined, and it must be clear to a user of this report which relation is to be used at which place.

For Managed Objects, which are defined in the OSI context, the diagram is derived from CCITT Rec. X.720 according to the OSI model. For the other Managed Objects in the PTN, e.g. transmission systems, switching systems, the network Information Model has to be constructed using the entity-relationship method.

For practical modelling of the whole of the PTN, the switching part and the transmission part have to be modelled separately. The proposed standard relations for the network are:

- Linking: a physical connection with known interface;
- Terminating: a logical connection between a physical and logical entity;
- Managing: a hierarchy of decision makers;
- Containing: physical or logical decomposition;
- Powering: a hierarchy of power supplies and power consumers.

The methodology to create an Information Model, whose definitive form is an ASN.1 description of the object, is as follows.

1. Draw an Entity Relationship diagram using the delimited range of standard relations; this helps in the necessary thought process and is invaluable for documenting the model once it is complete.

2. Make a class tree; this uses only 'is a' relations in the Entity-Relationship diagram. Different levels of classes will be defined. Basic object classes may be abstracted from identified object classes, or if any relations with one or more attributes of an object are present, they also become objects. New object

abstractions may be defined after re-examining the model. The class inheritance will be reflected in the 'subclass of' field in the ASN.1 class macro.

3. Make the management information tree (MIT); this uses the containment relations in the Entity-Relationship diagram. The MIT will be reflected in the 'possible superior' field of the ASN.1 class macro.

4. Make a complete informal definition of object classes, including their behaviour, attributes, actions, and events. All relations other than the subclass and the containment relations will cause the presence of suitable attributes in the objects which are subject to the relation to make these accessible to the Manager or Agent.

   NOTE 5

   The method for defining behaviour is a subject of current study.

5. Make a formal definition of object classes and attributes using ASN.1. Each attribute shall be assigned a value to be inserted upon creation of the entry for that attribute. The value assigned may be a default value specified as part of a standard, a value supplied by the creator of the object class or a value computed by means of a specific algorithm. The set of attribute values forms the attribute template which can be used for every object belonging to this object class. Beyond it optional attributes may be defined for specific object instances.

Examples of object classes definitions applicable across the functional areas of network management and of the transmission network information model are given in Appendix B.

8.3 Naming and Addressing of Managed Object Instances

The objectives of Managed Objects naming are the following.

1. To provide each Managed Object instance with a unique and unambiguous name within a given naming domain.

2. To allow the unambiguous identification of object instances made visible by one or several Managers.

3. To allow the definition of relationships that span over several Management Domains.

4. To allow the possibility of moving objects and making them visible from different Managers.

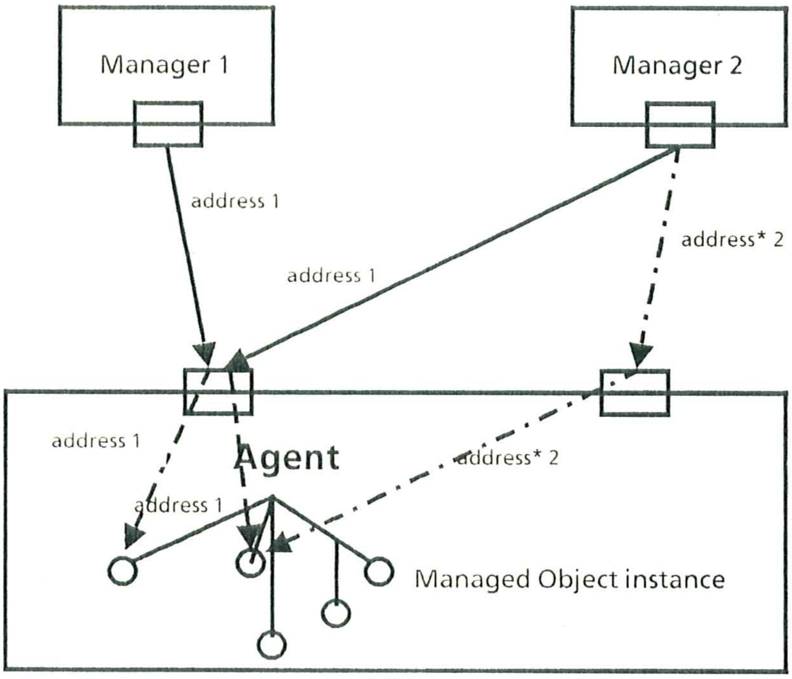
   Note, that such moves should not be considered as frequent i.e. not as a dynamic feature but rather as a semi-static aspect; for example as the result of a system reconfiguration. However this situation will have to be reviewed pending decisions on the integration of mobile techniques in the PTN.

5. To provide mechanisms that allow access to several objects within one class or within subclasses of a given class. This is defined by CMISE as"scoping".

6. To allow a generic object to be involved in various topologies and arrangements.

In addition a Manager requires an addressing scheme to get access to objects which are installed in various locations within an Open System and made visible by different Agents. Naming and addressing are therefore two different aspects. While naming must provide unambiguous mechanisms, addressing must provide mechanisms that will allow the routeing of management operations to the relevant Agent i.e. objects may share the same address or one object may even have multiple addresses when it can be accessed via different routes (Fig. 24). The addressing information is derived on the basis of the object names e.g. from a directory.

In order to be distinguishable, the name of a Managed Object instance is composed of two items: an object class name and the object instance identifier within that class. This is known as an Attribute Value Assertion (AVA) in the sense that it is composed of an attribute identifier of that object class and an attribute value (object instance identifier) asserted to it.



This alternative path is included for illustration and is not the exclusive province of Manager 2.

Figure 24 - Illustration of the Addressing Mechanism

The general mechanism of defining Managed Object Classes requires globally unique identifiers, known as Object Identifiers, that correspond to the various aspects of the object, such as the object class, attribute types etc. The ASN.1 standard specifies the structure of the Object Identifier and the values of the initial arcs (relations). Starting from the root (top), for which the value is defined as an ASN.1 printable string, the Object Identifier may be viewed as a sequence of integers that navigate through the registration tree from the root to the Managed Object Class. The E/R diagram allows the identification of object classes that will need to be assigned (see Appendix C).

The containment tree is used for naming of Managed Object instances. Any Managed Object instance may be contained in one other Managed Object instance, called its superior. The hierarchy of superior and subordinate Managed Object instances forms the containment tree. The attribute holding the information which uniquely identifies a Managed Object instance is used to build the Relative Distinguished Name (RDN) of that instance. The RDN is constructed from the Object Identifier associated with the attribute type and the value of the instance of the attribute. This name is relative to the Managed Object instance, in which it is contained. The concatenation of the RDN for an instance of an object class with all its superior object instances up to the root is called the Distinguished Name (DN) of the object and this is globally unique.

The concept of name binding is for further study.

An example of a name definition is given in Appendix C.

8.4. Shared Management Information Knowledge

The initialization of Shared Management Information Knowledge (6.4) across a management interface is considered outside the scope of this Technical Report.

9. INTERWORKING CONSIDERATIONS / REQUIREMENTS

9.1 Interworking between Domains within one PTN

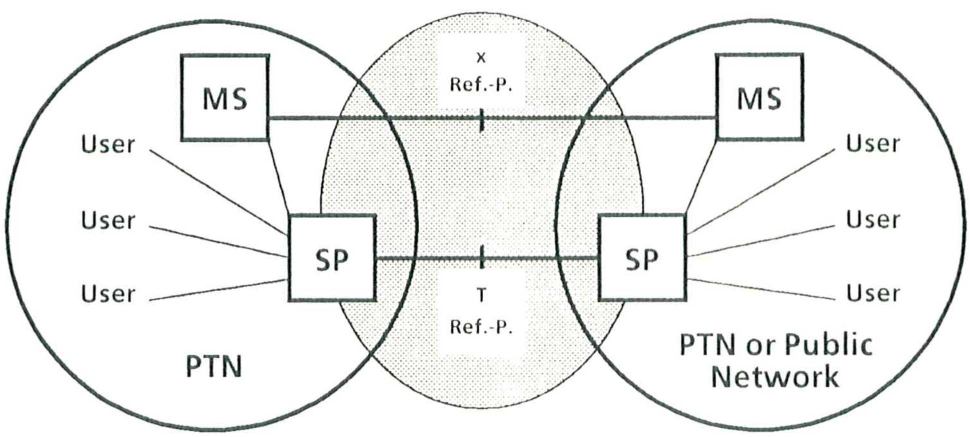
The PTN is defined in ECMA TR/NTW as a network comprising one or more interconnected Private Telecommunication Network Exchanges (PTNXs). A PTN may spread over more than one user premises. The inter-PTNX connections are considered part of the PTN. Depending on user decisions PTN Management may be centralized or may be provided by dividing the PTN into different Management Domains. Such a division can arise for several reasons (see 7.2.2) and is user defined.

9.2 Interworking between PTNs or between PTN and Public Network

At the boundary between a PTN and Public Network a number of factors have to be taken into account to ensure smooth interchange of management information.

Each Network contains Service Providers (SP) e.g. a collection of Network Elements (NEs) whose responsibility is to allow users to gain access to a number of Telecommunications Services (fig. 25). These are managed by Management Systems (MS). Service Providers interact at the T Reference Point (Standard ECMA-133) to provide internetwork telecommunication services.

In some instances it may be appropriate to allow the transfer of management information between a private and public network. The type of management information available across the boundary will depend upon agreements arrived at between those networks concerned. The subject of schema negotiation is dealt with in more detail in 9.2.3. Until standards for Public Networks become defined this Technical Report assumes that an a-priory mechanism is used.



MS: Management System

SP: Service Provider

Figure 25 - Interworking Conceptual Schema

Where a connection exists between a Public and Private Network the Service Provider of both networks will be involved in the provision of Basic Services (X.25, ISDN-Access etc.). The provision of Supplementary Services (SS) may be shared between both Service Providers. The degree of involvement may vary according to the type of Supplementary Services provided.

9.2.1 General approach for hybrid Management

One common requirement for the Managers of separate networks is that these should not need to be aware of the internal structure nor organisation of the other network.

The 'grey area' between the two networks is actually a typical example of what has been previously described as the intersect of overlapping domains.

Even if some elements are common to both networks (e.g. a cable). the set of these elements should be reduced to a minimum. Actually a number of issues exist:

1. there is not a guarantee that the two networks make use of the same Information Model,
2. the naming scheme is most probably different in each network,
3. a physical network element on one side may not map into a similar physical element at the other side (in an element belonging to the same object class).

It is therefore suggested that the communication between two Managers is based on the highest possible level of abstraction.

In order to ease this approach one must look at the type of relationship that exists between two networks. In other words, by applying the methodology defined in clause 5 one can immediately conclude that the interaction between two telecommunication networks is based on a service provisioning type of relationship.

The objects that will compose the Information Model shared by the OMPs will be essentially of an abstract nature and represent services.

These logical objects might be complemented by a minimum set of physical objects as described in the next section.

The definition of services as Managed Objects should not represent any particular difficulty since it is possible to define service characteristics, statuses and behaviours.

The implementation of these services by physical resources is a matter which is local to each network. The modelling will therefore have to be done separately by following the methodology described in clause 5.

The direction proposed above brings the following advantages:

- the overlap of physical resources is reduced as far as possible,
- the management of physical objects lying in the grey area is always done by one Manager only,
- the Management Information Model applying across the interface is raised to a level of abstraction that allows implementation independence,
- it conforms with the concepts of hierarchical management described in 7.3 in the sense that the service stratum is one hierarchical layer situated above the PTE stratum,
- it should not allow the collision of conflicting orders at the physical level.

9.2.2 Objects of the 'grey area'

As a consequence of the above statements it has to be considered what is common in the 'grey area' for the both networks with respect to

- the services,
- the NEs,
- the resources.

Aspects of the types of Management Information that may be available across this boundary are as follows:

- Fault Management
- Configuration Management
- Security Management
- Performance Management
- Accounting Management

A possible relationship between these management and telecommunications services is given in the entity relationship diagrams contained in Figs. 26 and 27.

Fig. 26 describes the relationship between entities contained within the shaded area of Fig. 25.

Fig. 27 gives a brief list of the Managed Object Classes available at these boundaries. This list is not exhaustive and is for further study.

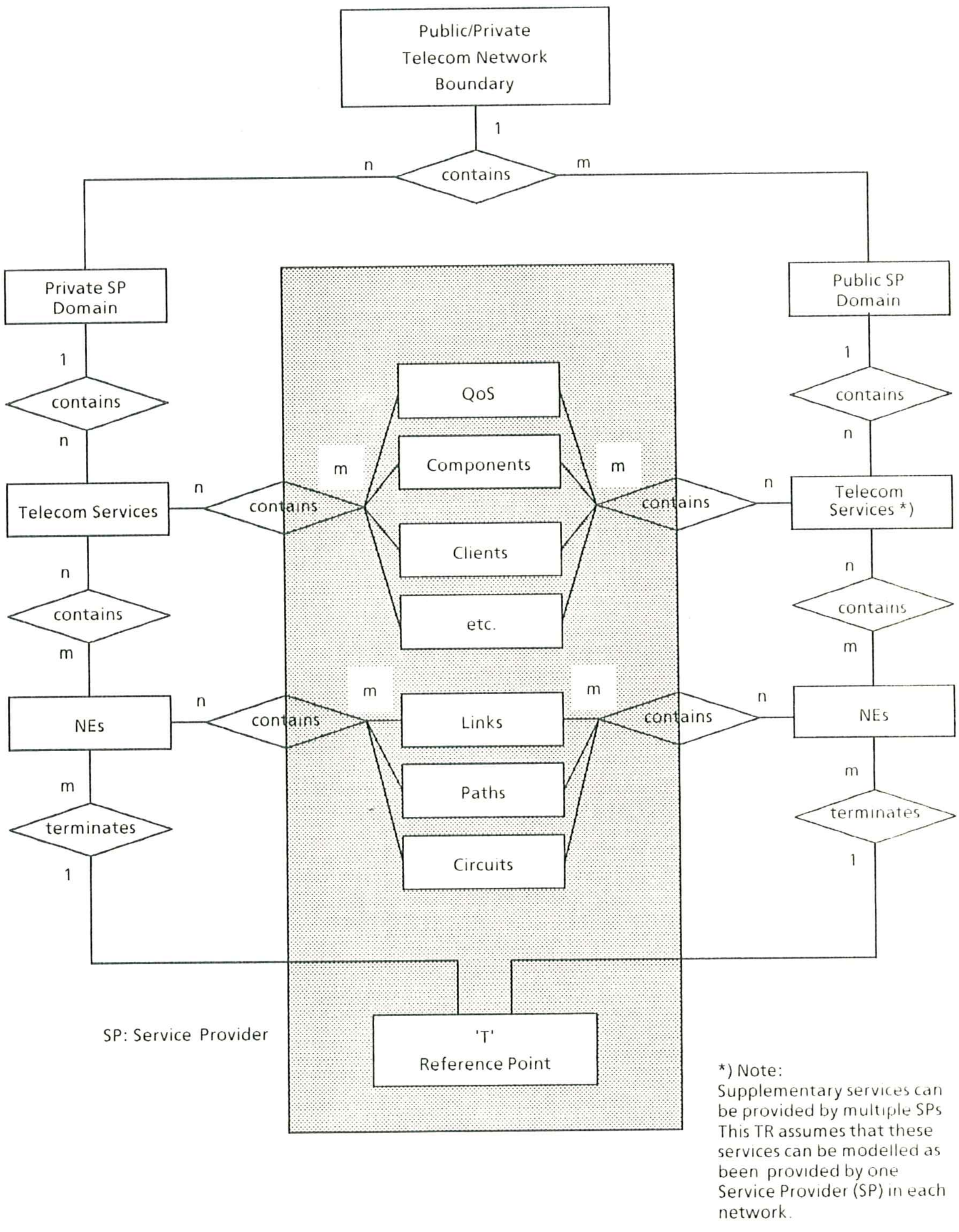


Figure 26 - Pictorial View of Inter-Domain Boundary

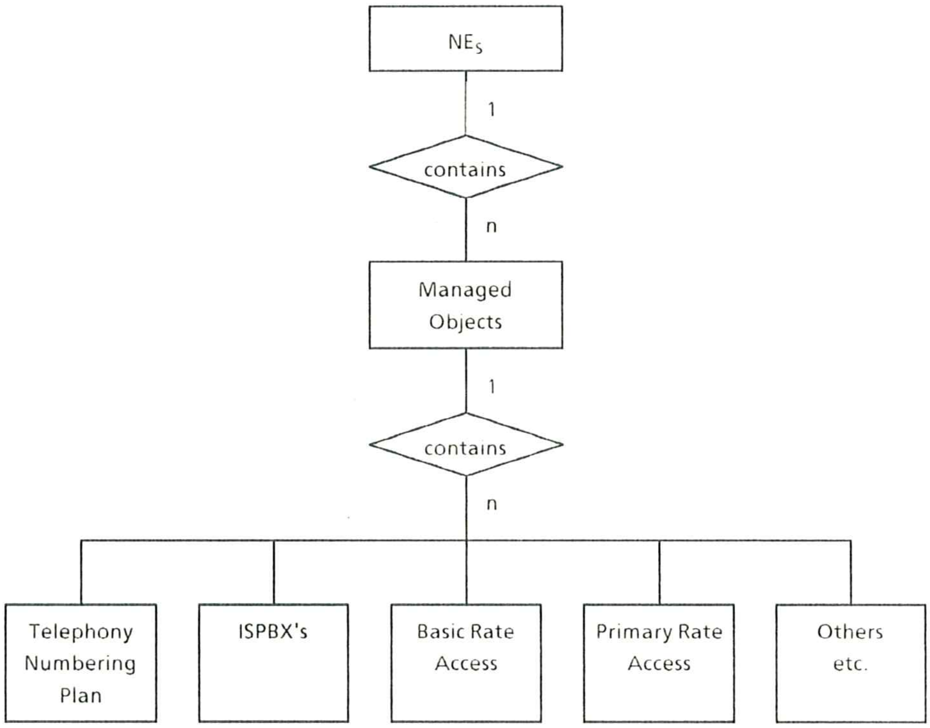


Figure 27 - Example of Network Element E/R Diagram (not exhaustive)

9.2.3 Schema negotiation

When the managing systems of interworking networks or domains exchange information for the purpose of management they need to share a certain Management Information Knowledge. This actually represents a common subset of the Management Information that each managing system is handling in its own Management Domain. It has been described earlier as the "grey area".

The shared information will be composed of abstract information such as, generic, object oriented, descriptions of the resources to be managed as well as specific data such as configuration data. This information can be defined a priori or in a dynamic way:

1. What information should be shared?

   - Supported Management Object Classes
   - Optional attributes or packages supported by Managed Objects
   - Managed Objects instances supported (i.e. configuration)
   - Supported name bindings
   - Supported access control mechanism, i.e. password
   - Management functions supported by an application context. This is under discussion at ISO and consists in defining functional groupings (or functional units) at application (SMASE) (see ISO/IEC 9545) level.
   - Management functions supported by objects. When objects are defined as sup-porting optional operations, there is a need to agree on which ones are supported in the interworking context.

2. When should this information be exchanged/negotiated?

- Before association establishment (business agreement).

  In this case the parties will sign one or several profiles that will unambiguously define the shared knowledge. Any enhancement (with the exception of configuration information or by agreed mechanism) will lead to the definition of a new agreement

- During association establishment (static). Here three possibilities exist:

  Negotiation of Application Entity-title (AE-title): However, this might lead to adding semantics to the AE-title and could lead to too many variant definitions.

  Negotiation of Application (AP)-context: In this approach the proposal is to associate the concept of functional units to the definition of AP-contexts. This is under discussion in a number of standardization ebodies but the concept of functional units (or functional groupings at application level) is not well defined yet.

  Business agreement complemented by exchange of user information in the Association Control Service Element (ACSE) user information field: The user information might be agreed between the partners on an ad hoc basis (e.g. it could contain password mechanisms, definition of options etc.).

- Any time after association establishment (dynamic). This scheme proposes the definition of schema support objects. These objects contain information about class features, behaviour, name bindings etc. These objects can be defined at or after association establishment and modified by attribute change requests.

These possible variants are listed here to identify issues for discussion between the parties implementing communicating managing systems. Possible directions are listed here and detailed solutions are considered to be beyond the scope of this TR. These are subject to further study in the context of detailed specifications.

When the parties have defined business agreements that recognize several scenarios, one of the scenarios can be specified within the user information field as part of the schema negotiation.

10. MANAGEMENT INFORMATION COMMUNICATION MECHANISM

The concept of an interface has been defined earlier as consisting of the two aspects that need to be considered when implementing a Reference Point: communication mechanisms and Information Model. This clause focuses on the communication mechanisms only (Fig. 28 and 29).

10.1 M_3 Interface Communication Mechanism

These types of interfaces are characterized as supporting a full OSI stack as per the ISO OSI Management framework. The essential concept in this framework (and retained by CCITT Rec. M.20) is the decoupling of the application part from the communication part, identifying clearly an abstract management service boundary which is independent of the underlying stack.The Manager and Agent provide management application functions and communicate via OSI layer 7 communication protocols.

However the exact use of FTAM (e.g. in an interleaved way with CMIP, and the FTAM profiles to be used) will need to be further studied. It is expected that the first network management profile(s) would only include CMIP.

10.2 M_1 Interface Communication Mechanism

The M1 interface applies at the q1 Reference Point as defined in 7.6. Due to the limited capabilities of network element terminators, a M1 interface may be necessary to reduce the interface functionality by either:

- supporting only lower layers of OSI/CCITT (up to data link or network or transport)
- supporting short stacks (by a mapper function)
- supporting skinny stacks
- supporting proprietary protocols

The CMIP protocol need not be carried over these stacks, but if it is then the need for, and the definition of, convergence functions and protocols will need to be carefully studied.

10.3 M_{pr3} Interface Communication Mechanism

The M_{pr3} interface applies at the qpr Reference Point as defined in 7.4. The exact requirements that apply at this interface have not yet been defined and will need further study.

It is anticipated however that this will involve mechanisms such as those being studied and defined in the context of open distributed processing (ODP see SC21 N 3196). If so then they may be expected to use Remote Procedure Calls (RPC) and/or Transaction Processing type of mechanisms based on OSI stacks.

As the whole area is under study no explicit recommendation can be made in this TR.

10.4 Inter-Management Interface Communication Mechanism

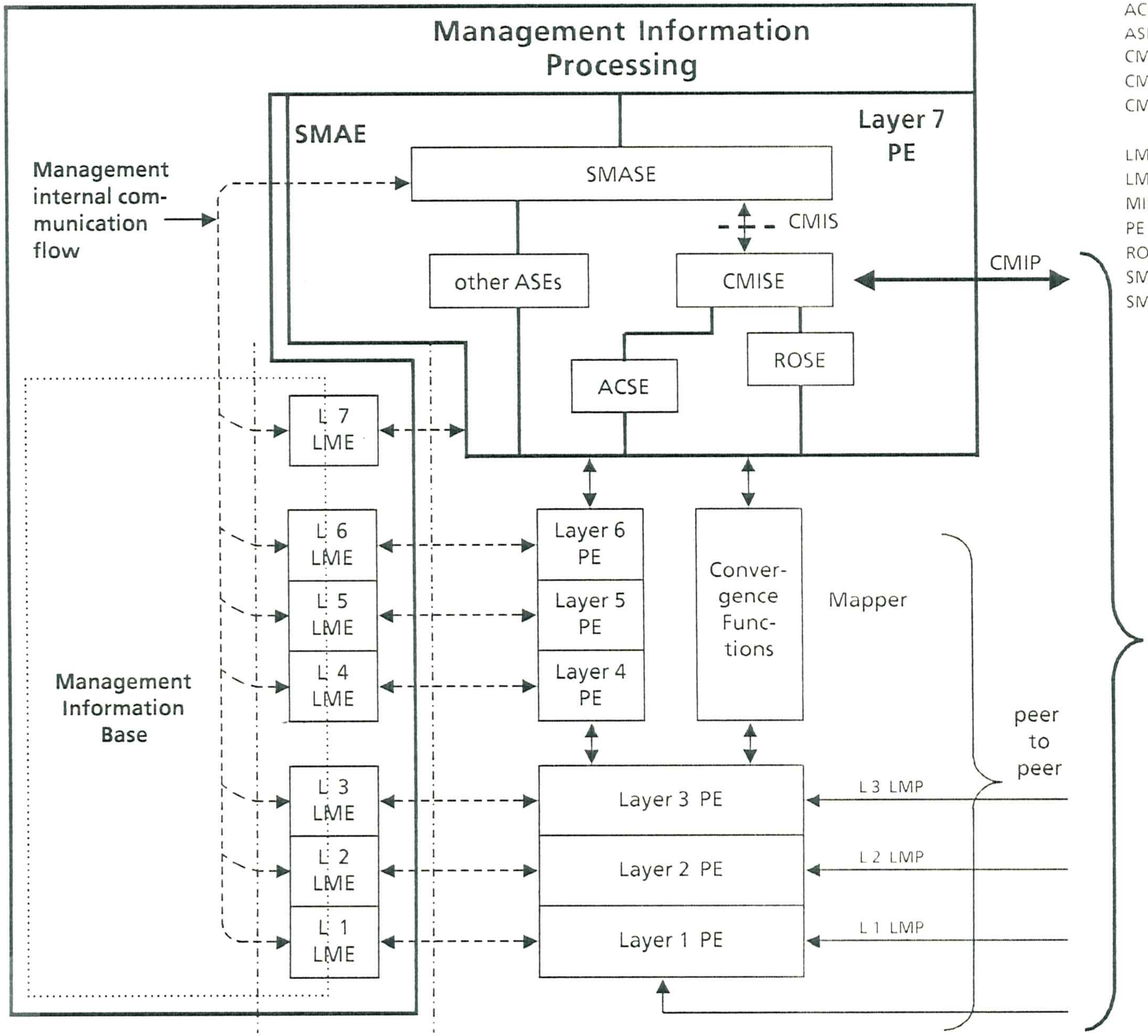
The X interface applies at the x Reference Point as defined in 7.3.3. The requirements for this interface are not fully defined and will be the subject of another technical report. As a consequence the definition of detailed mechanisms is beyond the scope of this TR.

However it is anticipated that the communication mechanisms used at this interface should be close to the ones used at M3 interface. In particular they will be based on an OSI stack and might involve CMISE for the interactive activities and FTAM for the bulk transfer activities.

10.5 User (Operator) Interface

The user interface is considered as proprietary and thus outside the scope of ECMA standardization. However, as a guide, the definitions could be based on existing standards (like CCITT MML Recommendations of the Z series) or emerging standards (windowing techniques defined by the OSF).

As they are local to the managing systems, they should not constrain the mechanisms defined at the other interfaces. They will however be affected by the object-oriented approach retained in the context of this Technical Report.



ACSE	=	Association Control Service Element
ASE	=	Application Service Element
CMIP	=	Common Management Information Protocol [19]
CMIS	=	Common Management Information Service [18]
CMISE	=	Common Management Information Service Element
LME	=	Layer Management Entity
LMP	=	Layer Management Protocol
MIB	=	Management Information Base
PE	=	Protocol Entity
ROSE	=	Remote Operations Service Element
SMAE	=	Systems Management Application Entity
SMASE	=	Systems Management Application Service Elements

Figure 28 - PTN Management: OSP-Management Model

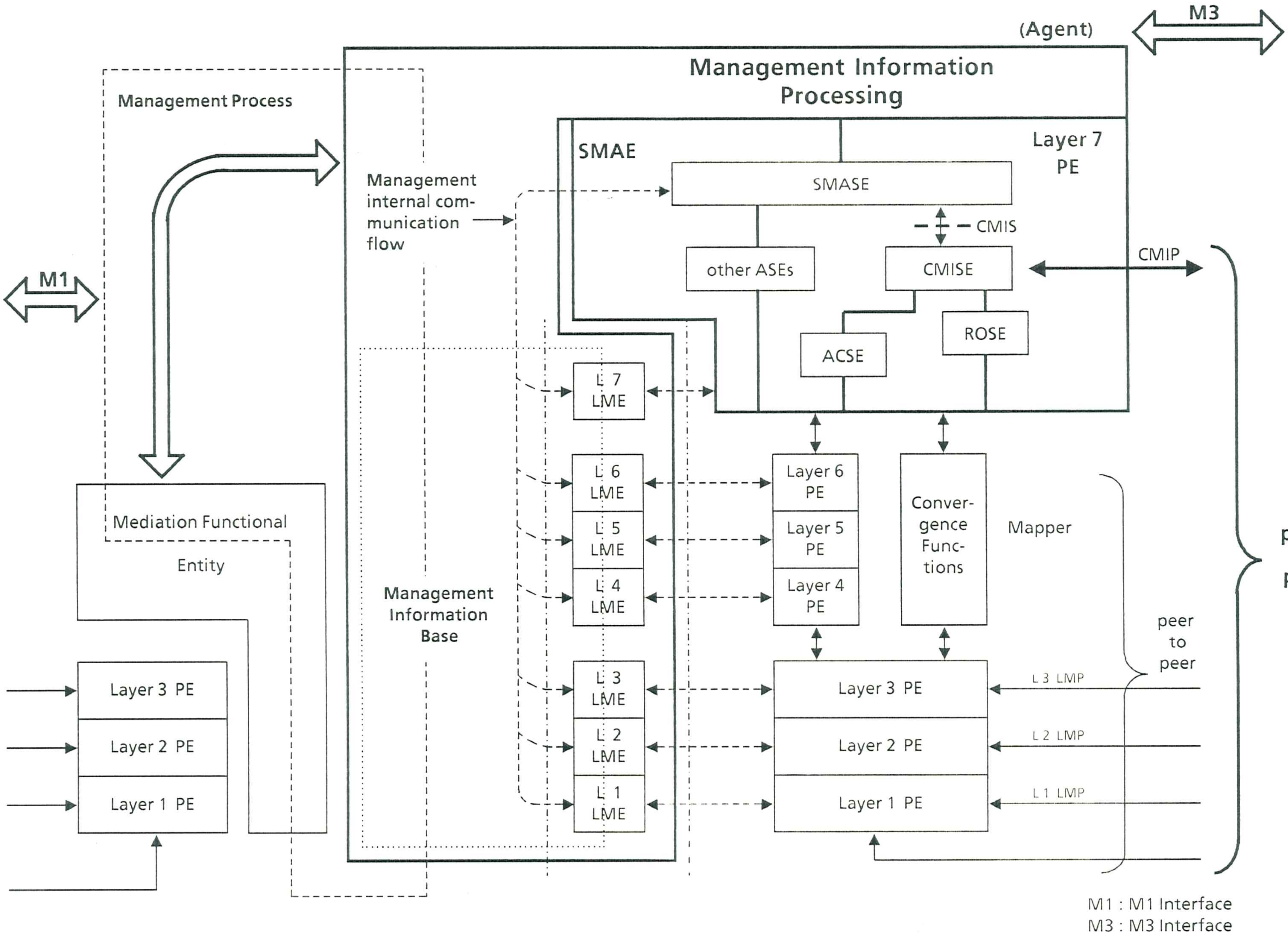


Figure 29 - Example Relationship of Mediation Function to Agent

APPENDIX A

Definition of q Reference Points

1. Extract of CCITT Rec. M.30 "Principles for a TMN"

The following Reference Points define conceptual points of information exchange between non overlapping function blocks. A Reference Point becomes an interface when the connected function blocks are embodied in separate pieces of equipment.

The q Reference Points connect the function blocks for NEF to MF, MF to MF, MF to OSF and OSF to OSF either directly or via the DCF. Within the class of q Reference Points:

q_1: the q_1 Reference Points connect NEF to MF either directly or via the DCF; *

q_2: the q_2 Reference Points connect MF to MF either directly or via the DCF; *

q_3: the q_3 Reference Points connect MF to OSF and OSF to OSF either directly or via the DCF.

* In a revised version of M30 q_1 and q_2 will be replaced by q_x.

NEF: Network element function
MF: Mediation function
OSF: Operating system function
DCF: Data communication function

2. PTN Management Definition

For the Generic Model and the Physical Architecture of PTN Management the following definitions apply:

The q Reference Points connect the function for:

- PTE2 to Mediation Function (q_1)
- PTE1 to Manager (q_3)
- Manager to Management Domain (q_3)
- Management Domain to OMP (q_3)

q_1 reference points connect the functions either directly or via the DCF (PTN).

q_3 reference points connect the functions via the DCF (PTN).

DCF: Data Communication Function
OMP: Overall Management Process
PTE1: Private Telecommunication Entity type 1
PTE2: Private Telecommunication Entity type 2

APPENDIX B

Object Class Definition (Example)

Fig. B-1 shows an example for the first step in the methodology to create an Information Model and define Managed Object classes. This example deals with a section of the transmission network.

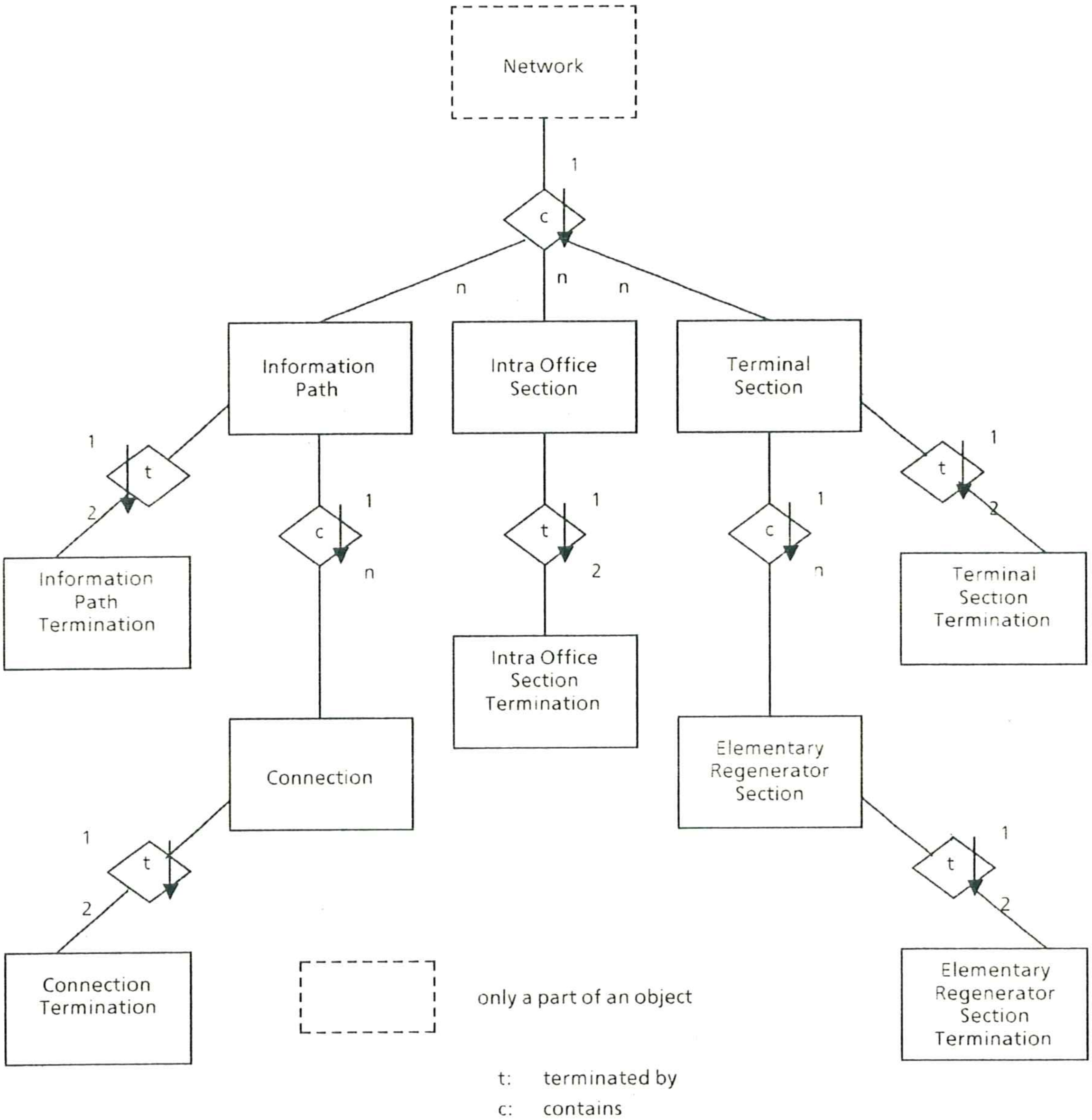


Figure B.1 - An Example for the Transmission Network Object Model

Table B.1 shows an example of object classes applicable across the functional areas of network management . They are defined in the text part.

No.	Object Class
1	Alarm Record
2	Alarm Report Control
3	Connection
4	Connection Termination
5	Cross-Connection
6	Current Alarm Summary Control
7	Discriminator
8	Elementary Regenerator Section
9	Elementary Regenerator Section Termination
10	Equipment
11	Event Reporting Sieve
12	Event Log
13	Event Record
14	Framed Path
15	Framed Path Termination
16	Hardware
17	Information Path
18	Information Path Termination
19	Intra Office Section
20	Intra Office Section Termination
21	Line
22	Line Termination
23	Management Operations Schedule
24	Network
25	Network Element
26	Path Group
27	Service
28	Software
29	Span
30	Span Termination
31	Terminal Section
32	Terminal Section Termination
33	Termination Point
34	Top

Table B.1 - Example of Object Classes

1) Alarm Record

The 'Alarm Record' object class is a class of support objects that contains information about alarms that have occurred. This object class is a subclass of the Event Record object class

2) Alarm Report Control

The 'Alarm Report Control' object class is a class of support objects that contain attribute types used to determine which alarms should be reported. Instances of this class are operated on in order to control the reporting of alarms on the basis of specific criteria for example, a value of the Alarm Severity attribute type. This object class is a subclass of the Discriminator object class.

3) Connection

The 'Connection' object class is a class of Managed Objects that represents portions of an information path. Instances of this class represent logical objects between two Connection Terminations including the terminations themselves. Several connections can be bundled into a higher rate information path. A sequence of one or more connections are linked together to form an information path. A terminal section carries one or more connections. A connection may be carried over one or more terminal sections. A connection may be either uni- or bi-directional.

4) Connection Termination

The 'Connection Termination' object class represents the class of terminations that terminate a connection, rather, a portion of an information path. This object class is a subclass of Termination Point.

5) Cross-Connection

The 'Cross-Connection' object class is a class of Managed Objects that indicates an assignment relationship between two Channel Terminations. Examples of devices that contain Cross-Connections include a digital cross-connect, an add-drop multiplexer, a circuit switch, and a multiplexer. Application of the Cross-Connection concept to a packet switch is for further study.

6) Current Alarm Summary Control

The 'Current Alarm Summary Control' object class is a class of support objects that provide the criteria for generation of current alarm summary reports. An object is included in a current alarm summary report if:

- the object is included in the Object List (if present), and
- the object has an Alarm State that is present in the Alarm State List (if present), and
- the object has an alarm (or potential alarm) with an Alarm Severity and Problem Type matching members of the Alarm Severity List (if present) and Problem Type List (if present), respectively.

If any of the above are absent, then the missing criteria are not used in selecting objects that will appear in the current alarm summary report.

A single object may appear in a report multiple times if it has multiple outstanding alarm conditions that match the Alarm Severity List and Problem Type List criteria.

7) Discriminator

The 'Discriminator' object class is a class of support objects that provide the specification of criteria relevant to the Alarm Report Control (or any other subclasses of the Discriminator object class to be specified in the future). These criteria must be satisfied before allowing the associated management service (e.g. generating an Alarm Report) to proceed. They are specified in terms of a Begin Time and End Time that defines a period during which the operation is valid, a Discriminator State that determines whether the Discriminator is currently active, and a Discriminator Construct that specifies comparison, arithmetic, and Boolean operations on the attribute values that may be combined by means of logical operators.

At least one Discriminator is defined for every management application entity (indicated by the management user Id) ,to which the reports satisfying the Discriminator Construct are to be sent. This object class is a basic class from which subclasses, such as Alarm Report Control, can inherit attribute types, events, and actions.

8) Elementary Regenerator Section

The 'Elementary Regenerator Section' object class is a class of Managed Objects characterized by a rate and way of modulating or coding a signal (analogue or digital) for transport over a physical medium to the next regenerator site. An Elementary Regenerator Section is terminated by Elementary Regenerator Section Terminations. An Elementary Regenerator Section may be either uni- or bi-directional.

9) Elementary Regenerator Section Termination

The 'Elementary Regenerator Section Termination' object class is class of Managed Objects that represent the physical connections where signal enters to a physical medium to the next regenerator site or exits from a regenerator equipment. An Elementary Regenerator Section Termination is a sub-class of Termination Point. Instances of this class terminate Elementary Regenerator Sections.

10) Equipment

The 'Equipment' object class is a class of Managed Objects that are contained within NEs and thus perform PTN Element Functions (NEFs). An instance of this object class is present in a single geographical location. Equipment may be nested within other Equipment, thereby creating a containment relationship.

11) Event Reporting Sieve

The 'Event Reporting Sieve' object class resides within a management entity. It determines whether the detection of an event should result in the forwarding of event data to an identified destination address. Event data are defined elements of event information. The event data is sent to the destination in the form of a CMIS Event Report.

The Event Reporting Sieve object class is created via the Initiate Event Reporting Service and deleted via the Terminate Event Reporting Service.

12) Event Log

The 'Event Log' object class is a class of support objects that consists of collections of 0 or more Event Records and/or any of the subclasses of Event Records (e.g. Alarm Records).

13) Event Record

The 'Event Record' object class is a class of support objects that contain information about events that have occurred. This object class is a basic class from which subclasses, such as Alarm Record, can inherit attribute types, events and actions.

14) Framed Path

The 'Framed Path' object class is a class of Managed Objects characterized by a specified rate and frame format that is independent of the physical means of carrying the signal. Instances of this class represent logical objects, called Framed Paths, that are connections between two Framed Path Terminations, including the Framed Path Terminations themselves. This object class is a subclass of the Information Path object class.

A Framed Path at a specified rate is carried over an ordered sequence of one or more Lines, see below. These Lines may be at the same or higher rate as the Framed Path. A Framed Path may be either uni- or bi-directional

15) Framed Path Termination

The 'Framed Path Termination' object class is a class of Managed Objects that represent Termination Points at which a frame format is assembled, disassembled, and/or modified. Instances of this class delimit Framed Paths. This object class is a subclass of the Termination Point object class.

16) Hardware

The 'Hardware' object class is a class of Managed Objects that represent physical components of Equipment, including replaceable components. Hardware may be nested within other Hardware, thereby creating a containment relationship.

17) Information Path

The 'Information Path' object class is a class of Managed Objects characterized by a specified information/data rate that is independent of the physical means of carrying the signal. Instances of this class carry information from point to point and preserve its content. This object class represents logical objects, called Information Paths, that are connections between two Information Path Terminations, including the Information Path Terminations themselves. This object class is a basic class from which subclasses, such as Framed Path, inherit attribute types, events, and actions.

An Information Path is carried over an ordered sequence of one or more Lines. These Lines may be at the same or higher rate than the Information Path. An Information Path may be uni- or bi-directional.

18) Information Path Termination

The 'Information Path Termination' object class is a class of Managed Objects that represent a Termination Point at which information content (payload) is originated or terminated. Instances of this class delimit Information Paths. This object class is a subclass of the Termination Point object class.

19) Intra Office Section

The 'Intra Office Section' object class is a class of Managed Objects characterized by a rate and way of modulating or coding a signal (analogue or digital) for transport to another site. An Intra Office Section is terminated by Intra Office Section Terminations. An Intra Office Section may be either uni- or bi-directional.

20) Intra Office Section Termination

The 'Intra Office Section Termination' object class is a class of Managed Objects representing the physical connections where a signal enters or exits equipment in a site. An Intra Office Section Termination object class is a sub-class of Termination Point. Instances of this class terminate Intra Office Sections.

21) Line

The 'Line' object class is a class of Managed Objects that represent a physical transmission medium and associated Equipment (intermediate Equipment and Line Terminations) required to provide the means of transporting information between two consecutive Line Terminations. A Line may be uni- or bi-directional. A Line consists of an ordered sequence of one or more Spans or pairs of Spans and intermediate Equipment, including the Line Terminations. A Line operates at a specific rate.

22) Line Termination

The 'Line Termination' object class is a class of Managed Objects that represent points at which the digital/analog signal is originated and/or terminated. Instances of this class delimit Lines. This object class is a subclass of the Termination Point object class.

23) Management Operations Schedule

The 'Management Operations Schedule' object class is a class of support objects that provide the ability to schedule a management service to occur periodically. The period is specified by an interval, with the first occurrence of the service (coinciding with the start of the first interval) specified as the Begin Time. The end of the time span during which the service can occur is defined by the End Time.

24) Network

The 'Network' object class is a class of Managed Objects that are collections of interconnected telecommunications and management objects (logical or physical) capable of exchanging information. These objects have one or more common characteristics, for example, they may be owned by a single provider, or associated with a specific service. A Network may be nested within another (larger) Network, thereby forming a containment relationship.

25) Network Element

The 'Network Element' object class is a class of Managed Objects that represent telecommunications equipment (either groups or parts) within the PTN that performs PTEs, i.e., provide support and/or service to the user. A Network Element communicates with the management system over one or more standard interfaces for the purpose of being monitored and/or controlled.

A network contains equipment that may or may not be geographically distributed. The various Equipment that comprise a geographically distributed Network Element may themselves be interconnected using other Network Elements.

26) Path Group

The 'Path Group' object class is a class of Managed Objects that consist of sets of Paths of the same category between two Equipments.

27) Service

The 'Service' object class is a class of Managed Objects that represent offerings from a provider that supply specific network functionality to one or more users. Services may be nested, thereby creating a containment relationship.

28) Software

The 'Software' object class is a class of Managed Objects that represent logical information stored in Equipment, including programs and data tables. Software may be nested within other Software, thereby creating a containment relationship.

29) Span

The 'Span' object class is a class of Managed Objects that represent continuous sections of a physical transmission medium, usually between repeaters/ regenerators. Instances of this class are connections between two Span Terminations, including the Span Terminations themselves. A Span is uni-directional; therefore a sequence of one or more pairs is required to construct a bi-directional line.

30) Span Termination

The 'Span Termination' object class is a class of Managed Objects that represent the physical connections where a signal enters or exists Equipment. Instances of this object class may provide functions such as reshaping, regeneration, optical-electrical conversion and alarm performance monitoring on the Span. Span Terminations delimit Spans. This object class is a subclass of the Termination Point object class.

31) Terminal Section

The 'Terminal Section' object class is a class of Managed Objects characterized by a rate and way of modulating or coding a signal (analogue or digital) for physical transport over a line system to another site. A Terminal Section is terminated by Terminal Section Terminations. Instances of this class use an ordered sequence of one or more Elementary Regenerator Sections. A Terminal Section may be either uni- or bi-directional.

32) Terminal Section Termination

The 'Terminal Section Termination' object class is a class of Managed Objects representing the physical connections where a line signal enters or exits Equipment. A Terminal Section Termination is a sub-class of Termination Point. Instances of this class terminate Terminal Sections.

33) Termination Point

The 'Termination Point' object class is a class of Managed Objects that delimit transport entities such as Information/Framed Paths, Lines or Spans. This object class is a basic object class from which subclasses, such as Information Path Termination, Framed Path Termination, Line Termination and Span Termination inherit attribute types, events, and actions.

34) Top

The 'Top' object class is the special object class of which every other class is a subclass.

APPENDIX C

Naming and addressing of Managed Object Instances

1. Containment Relationships used for Naming

Managed Object instances are named (unambiguously identified) through the use of a chosen set of containment relationships. From the naming standpoint, contained Managed Objects are known as subordinates, and the containing Managed Object is called the superior of its subordinate Managed Objects. These containment relationships form a hierarchy (as with any other containment relationships), but they must also satisfy two other properties.

- existence dependency - A Managed Object instance can only exist if its superior Managed Object exists (and therefore has been created and has not been deleted).
- tree structure - Each Managed Object instance is contained in only one other Managed Object. (However, a Managed Object may contain many other Managed Objects).

Note C.1

The second property is not required if aliases are allowed.

Any set of containment relationships satisfying these properties may be used for naming. In particular, the containment relationships used for naming do not necessarily reflect physical containment.

2. Naming Tree and other Trees

The hierarchy of superior and subordinate Managed Object instances forms what is called the naming tree. The base level of the naming tree is referred to as "Root". The naming tree consists of all the Managed Objects.

The naming tree does not have to use the same kind of containment relationship for different levels of the tree, or even for different Managed Object instances at the same level. That is, in different parts of the naming tree, different containment relationships can be used for naming.

Note that the same attribute value can be used with different attributes for different Managed Object instances, and the same RDN can be used for different Managed Objects under different superiors.

Note C.2

The inheritance tree is completely independent of the naming tree. The inheritance tree shows superclass-subclass relationships between Managed Object classes, while the naming tree shows containment relationships between Managed Object instances. A particular class appears once in the inheritance tree, while there may be many instances of a class at various places in the naming tree. The toplevel of the naming tree is called root while the ultimate superclass of the inheritance tree is called top. Also, the registration tree is independent of these two trees.

The registration tree (being developed by the OSI/NM FORUM) depicts the general mechanism for producing globally unique identifiers, e.g. the Object Identifiers which correspond to object classes, attributes etc. and whose structure is specified by the ASN.1 standard.

The exact procedures for performing registration are under study.

3. Managed Object Names

The name of a Managed Object instance is based on the naming tree. A Managed Object is named by the combination of:

- the name of its superior (that is, containing) Managed Object instance, and
- information uniquely identifying this Managed Object instance within the scope of its superior Managed Object.

Note C.3

As this concept is recursive it also applies to the Managed Object superiors etc.

The second part of this name is called a Relative Distinguished Name (RDN), since it is relative to the containing Managed Object. It consists of one (or possibly more than one) assertion that a particular attribute in the subordinate Managed Object has a particular value. This assertion is known as an Attribute Value Assertion (AVA).

Note C.4

The subject of Managed Object instances that have RDNs with multiple AVAs requires further study.

From this definition, we see that the name of a Managed Object instance consists of a sequence of the Relative Distinguished Names of its superiors in the naming tree, starting at the root, and working to the Managed Object to be identified. This sequence is known as the Distinguished Name (DN) of the Managed Objects. (The Distinguished Name of the root is defined to be the empty sequence.) Since every Managed Object has only one superior, there is one and only one Distinguished Name for every existing Managed Object. A naming example is shown in Figure C.1 and Table C.1.

Note C.5

The subject of aliases requires further study.

For a particular Managed Object instance only one attribute serves to name it. However, different Managed Object instances (even different instances of the same class) may each use a different attribute in its RDN. For a given Managed Object class, there may be several attributes which are suitable to name instances of that class, but only one of those attributes can be used to name a particular instance. Attributes that can be used to form an RDN are called distinguishing attributes.

Note C.6

The subject of Managed Object classes with more than one distinguishing attribute requires further study.

It is the entire AVA (attribute identifier plus attribute value) which must be unique within the containing Managed Object instance, not just the attribute value (i.e. two AVAs with equal attribute values but different attribute identifiers are different, see attribute value "B" in Fig. C-1). However, the class of the contained Managed Object is not a part of the RDN, so it does not distinguish subordinates of a common superior.

For example, consider an instance of the circuit Managed Object class and an instance of the facility Managed Object class, each instance contained in the same network Managed Object instance. The values of the circuit and facility distinguishing attributes could be the same, provided they have different distinguishing attributes.

4. Rules for Naming

It is possible to define rules which govern the containment relationships used for naming. One kind of naming rule is known as a name binding which is under study.

Note C.7

The need for other kinds of naming rules requires further study.

5. Addressing of Managed Object Instances

While naming must be unambiguous for a Managed Object instance, addressing must provide mechanisms that will allow to root management operations to and from various Managers to a Managed Object instance.

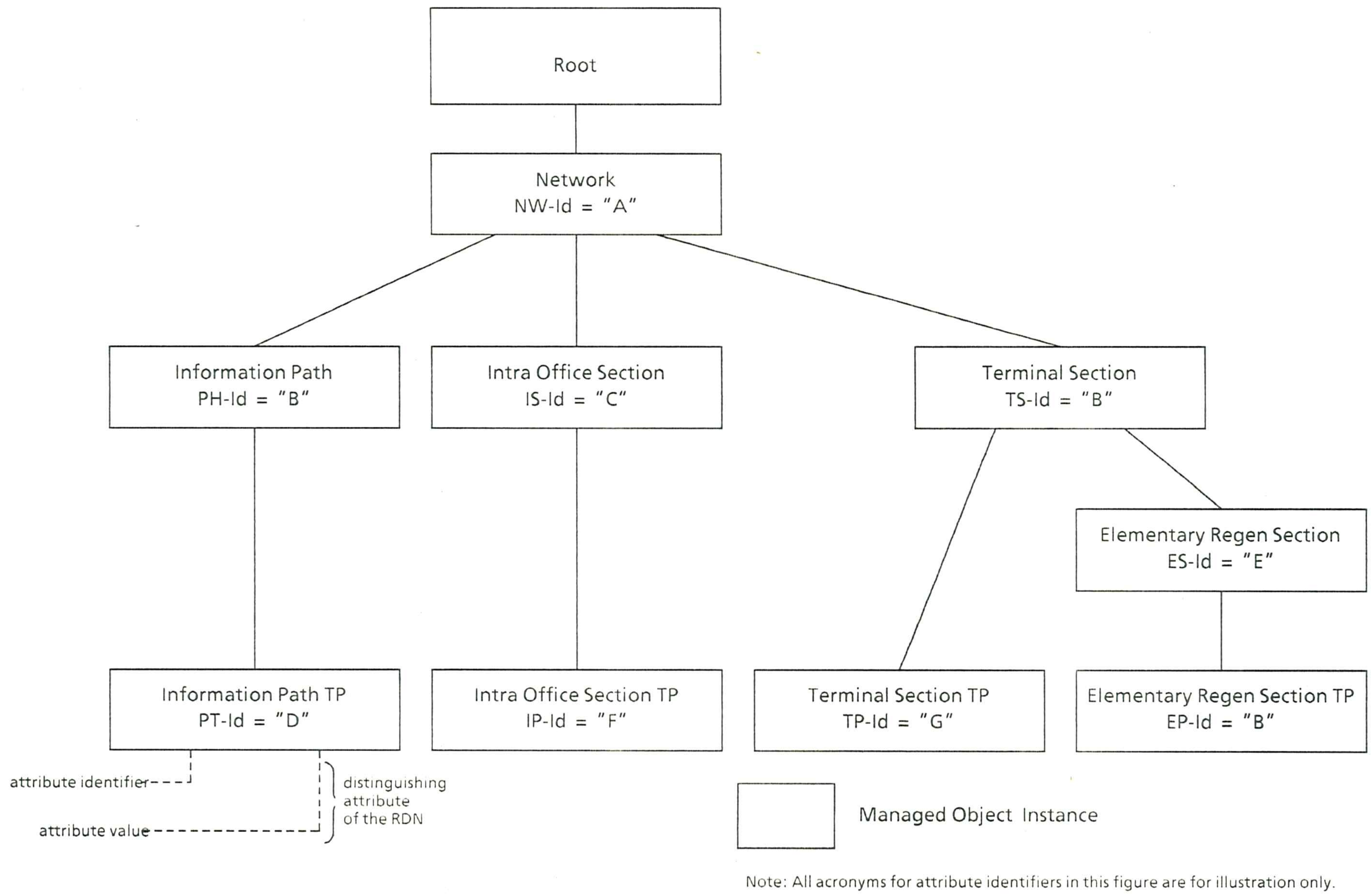


Figure C.1 - Managed Object Naming Tree

RDN = Relative Distinguished Name	DN = Dinstinguished Name
NW-Id = "A"	NW-Id = "A"
IS-Id = "C"	NW-Id = "A", IS-Id = "C"
IP-Id = "F"	NW-Id = "A", IS-Id = "C", IP-Id = "F"

Table C.1 - RDN- and DN-Examples of Managed Object Instances

APPENDIX D

List of Acronyms

A:	Agent
AC:	Alternating Current
ACSE:	Association Control Service Element
AE-title:	Application Entity-title
AP-context:	Application-context
ASE:	Application Service Element
ASN.1:	Abstract Syntax Notation Number 1
AVA:	Attribute Value Assertion
CCITT:	Comité Consultatif International Télégraphique et Téléphonique
CSDN:	Circuit Switched Public Data Network
CMIP:	Common Management Information Protocol
CMIS:	Common Management Information Service
CMISE:	Common Management Information Service Element
DC:	Direct Current
DCF:	Data Communication Function
DN:	Distinguished Name
DPE:	Data Processing Equipment
E/R:	Entity/Relationship relation
Fig.:	Figure
FTAM:	File Transfer Access and Management
GDMO:	Guidelines for the Definition of Managed Objects
Id:	Identification
ISCTX:	Integrated Services CENTREX
ISDN:	Integrated Service Digital Network
ISO:	International Organization for Standardization
ISPBX:	ISDN Private Branch Exchange
LME:	Layer Management Entity
LMP:	Layer Management Protocol
LPE:	Layer Protocol Entity
M:	Manager
MAP:	Management Application Process
MD:	Mediation Device
MF:	Mediation Function
MIB:	Management Information Base
MIT:	Management Information Tree
MML:	Man Machine Language
MP:	Management Process
MS:	Management System
NE:	Network Element
NEF:	Network Element Function
NM:	Network Management
ODP:	Open Distributed Processing
OMP:	Overall Management Process
OS:	Operation System
OSF:	Operation System Function
OSI:	Open Systems Interconnection
PE:	Protocol Entity
PSPDN:	Packed Switched Public Data Network

PTE:	Private Telecommunication Entity
PTN:	Private Telecommunication Network
PTNX:	Private Telecommunication Network Exchange
QoS:	Quality of Service
RDN:	Relative Distinguished Name
ROSE:	Remote Operation Services Element
RPC:	Remote Procedure Call
SMAE:	Systems Management Application Entity
SMASE:	Systems Management Application Service Element
SP:	Service Provider
SS:	Supplementary Service
TMN:	Telecommunication Management Network
TP:	Termination Point
TR:	Technical Report
TR/NTW:	Technical Report/Networking