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Foreword

This ETR introduces the Telecommunications Management Network (TMN) concept, defines its scope, describes the functional and information architecture and gives examples of physical architectures. It also provides a functional reference model and identifies concepts necessary to support the TMN architecture.

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Introduction

This ETSI Technical Report (ETR) presents the general architectural requirements for a Telecommunications Management Network (TMN) to support the management requirements of administrations to plan, provision, install, maintain, operate and administer telecommunications networks and services.

Within the context of the TMN, management refers to a set of capabilities to allow for the exchange and processing of management information to assist administrations in conducting their businesses efficiently. ISO systems management services and protocols represent a subset of the management capabilities that can be provided by the TMN and that may be required by an administration.

The term administrations used in this document includes Registered Private Operating Agencies (RPOAs), public and private (customer and third party) administrations and/or other organisations that operate or use a TMN.

A TMN provides management functions for telecommunications networks and services and offers communications between itself and the telecommunications networks and services. In this context a telecommunications network is assumed to consist of both digital and analogue telecommunications equipment and associated support equipment. A telecommunications service in this context consists of a range of capabilities provided to customers.

The basic concept behind a TMN is to provide an organised architecture to achieve the interconnection between various types of Operations Systems (OSs) and/or telecommunications equipment for the exchange of management information using an agreed architecture with standardised protocols and interfaces. In defining the concept it is recognised that many administrations have a large infrastructure of OSs, networks and telecommunications equipment already in place, and which must be accommodated within the architecture. It is also recognised that provision must be made for access to and display of management information contained within the TMN. Within the architecture there is no presumption that the management information user will necessarily be a human or that the mechanism by which the management information will be displayed is necessarily a workstation.

The external interface could also be to other interfaces such as an alarm display or bell, and the ultimate user of the management information could be an expert system.

This ETR will provide both administrations and manufacturers with a set of standards to use when developing equipment, and when designing infrastructure for the management of telecommunications networks and services.

Relationships of a TMN to a telecommunications network:

- a TMN can vary in size from a very simple connection between an OS and a single piece of telecommunications equipment to a complex network interconnecting many different types of OSs and telecommunications equipment;

- a TMN may provide management functions and offer communications both between the OSs as such, and between OSs and the various parts of the telecommunications network. A telecommunications network consists of many types of analogue and digital telecommunications equipment and associated support equipment, such as transmission systems, switching systems, multiplexers, signalling terminals, front-end processors, mainframes, cluster controllers, file servers, etc. When managed, such equipment is generically referred to as Network Elements (NEs);

- figure 1 shows the general relationship between a TMN and a telecommunications network which it manages. A TMN is conceptually a separate network that interfaces a telecommunications network at several different points to send/receive information to/from it and to control its operations. A TMN may use parts of the telecommunications network to provide its communications. This will be a requirement for the management by the TMN of the TMN network.

1 Scope

This ETR identifies functionality, as function blocks, in so far as they potentially delineate the interfaces, which are the subject of standardisation. Functional components are introduced to aid the understanding of how function blocks support the interfaces. These functional components are informally defined and are not subject to standardisation.

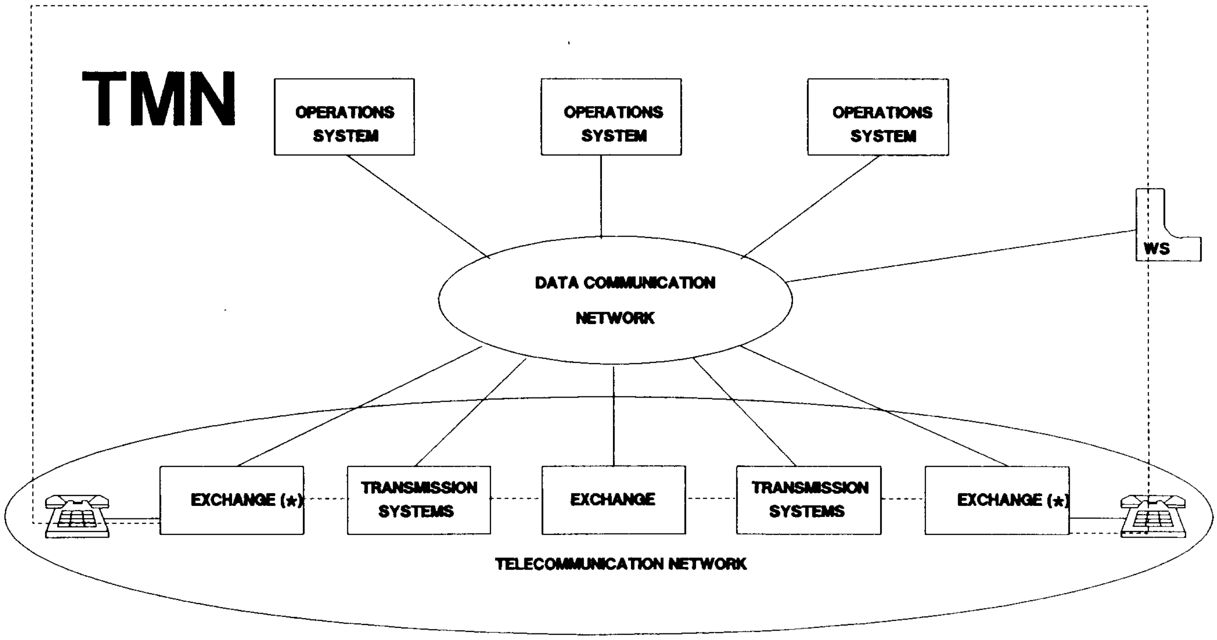
1.1 Field of application

The following are examples of the networks, telecommunications services and major types of equipment that may be managed by the TMN:

- public and private networks, including ISDNs, mobile networks, private voice networks, VPNs and INs;
- TMN itself;
- transmission terminals (multiplexers, cross connects, channel translation equipment, Synchronous Digital Hierarchy (SDH), etc.);
- digital and analogue transmission systems (cable, fibre, radio, satellite, etc.);
- restoration systems;
- operations systems and their peripherals;
- mainframes, front-end processors, cluster controllers, file servers, etc.;
- digital and analogue exchanges;
- area networks (WAN, MAN, LAN);
- circuit and packet switched networks;
- signalling terminals and systems including signal transfer points (STP) and real time data bases;
- bearer services and teleservices;
- PBXs, PBX accesses and user (customer) terminals;
- ISDN user terminals in accordance with relevant maintenance procedures in M.36 and I.602 for public networks;
- software provided by or associated with telecommunications services, e.g. switching software, directories, message databases, etc.;
- software applications running within mainframes, etc. (including applications supporting TMN);
- associated support systems (test modules, power systems, air conditioning units, building alarms systems, etc.).

In addition, a TMN may be used to manage distributed entities and services offered by grouping of the items in the above list.

All the equipment, applications software and networks or any grouping of equipment, applications software and networks described above, as well as any services derivable from any combination of the above examples, will from now on be referred to as belonging to the telecommunications environment.



WS = Work station

(*) More complex network terminals like PABXs are not excluded from the TMN field of application

Figure 1: General relationship of a TMN to a telecommunications network

1.2 Basic objectives for the TMN

The objective for the work on the TMN specifications is to provide a framework for planning the development of communications means for telecommunications management.

By introducing the concept of generic network models for management, it is possible to perform general management of diverse equipment using generic communications interfaces.

The principle of keeping the TMN logically distinct from the networks and services being managed introduces the prospect of distributing the TMN functionality for centralised or de-centralised management implementations. This means that from a number of management nodes operators can perform management of a wide range of distributed equipment, networks and services.

Security and distributed data integrity are recognised as fundamental requirements for the definition of a generic architecture. A TMN may allow access and control from sources considered outside the TMN (e.g. inter-TMN co-operation and network user access). Security mechanisms may be needed at various levels (managing systems, communications functions, etc.).

The TMN recommendations will endeavour to make use of OSI-based application services where appropriate.

The object oriented approach, which is a prerequisite in OSI management, is used to represent the TMN environment in terms of resource view and activity of management function blocks performed on it.

1.3 Functions associated with a TMN

A TMN is intended to support a wide variety of management areas which cover the planning, installation, operations, administration, maintenance and provisioning of telecommunications networks and services.

The specification and development of the required range and functionality of applications to support the above management areas is a local matter and is not considered within these recommendations. Some guidance, however, is provided by CCITT who have categorised management into five broad management functional areas (CCITT Recommendation X.700). These areas can provide a framework from within which appropriate applications to support the needs of the Administrations business can be determined. Five management functional areas identified to date are as follows:

- performance management;
- fault management;
- configuration management;
- accounting management;
- security management.

Some of the information exchanged over the TMN may be used in support of more than one management category. The TMN methodology is starting from a limited number of Management Services (MS) to identify elementary (possibly reusable) functional components. MS and their components, Management Service Components (MC) and Management Application Functions (MAF), are those aspects of the OS functions that are visible to the end user i.e. they define the end user service for the OS management capability. The OS management capability may in addition provide non-visible aspects like, for example, automatic management functions. MS may contain one or more MC which again may contain one or more MAF. MAF will in turn be mapped on to a set of managed objects and object operations.

The classification of the information exchange within the TMN is independent of the use that will be made of the information.

The term AFs will be used in the remainder of this ETR to represent an assembly of logic and data organised to achieve a certain management objective.

These Application Functions may be part of, or supported by, typical functions of the supporting systems such as:

- transport which provides for the movement of information among TMN elements;

- storage which provides for holding information over controlled amounts of time;

- security mechanisms which provides control for access to information;

- retrieval which provides access to information;

- processing which provides for analysis and information manipulation;

- user terminal support which provides for external interaction.

1.4 Architectural requirements

The TMN needs to be aware of telecommunications networks and services as being collections of co-operating systems. The architecture is concerned with orchestrating the management of individual systems so as to have a co-ordinated effect upon the network (see Annex D). Introduction of TMNs gives administrations the possibility to achieve a range of management objectives including the ability to:

- minimize management reaction times to network events;
- minimize load caused by management traffic where the telecommunications network 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;
- improve service assistance and interaction with customers.

To take into account at least the above objectives the TMN architecture should:

- make various implementation strategies and degree of distribution of management functional possible;
- allow for management of heterogeneous networks, equipment and services within telecommunications environment;
- allow for compartmented structure, where management functions may operate autonomously within the compartment;
- allow for technological and functional changes;
- include migration capabilities (to enhance early implementation and allow future refinement);
- provide a certain degree of reliability and security in the support of management functions;
- make it possible for customers, value added service providers and other administrations to access management functions;
- make it possible to have different or the same application service at different locations, even if it accesses the same NE;
- address the requirements of small and large numbers of managed objects;
- make the interworking between separately managed networks possible, so that inter-network services can be provided between administrations;
- provide for management of hybrid networks consisting of mixed network equipment;
- provide for a flexible degree of trade-off in terms of reliability/cost in all the network management components.

Within the general TMN architecture there are three basic aspects of the architecture which can be considered separately when planning and designing a TMN. These three aspects are the:

- functional architecture;
- information architecture;
- physical architecture.

The functional architecture describes the appropriate distribution of functionality within the TMN to allow for the creation of building blocks from which a TMN of any complexity can be implemented. The definition of building blocks gives guidance as to the range of functionality that suppliers and administrators are responsible for implementing (see Clause 2).

The information architecture describes the nature of the information that needs to be exchanged between the functional building blocks, and also describes the understandings that each building block must have about the information held in other building blocks (see Clause 3).

The physical architecture describes realisable interfaces and examples of physical components that make up the TMN (see Clause 4).

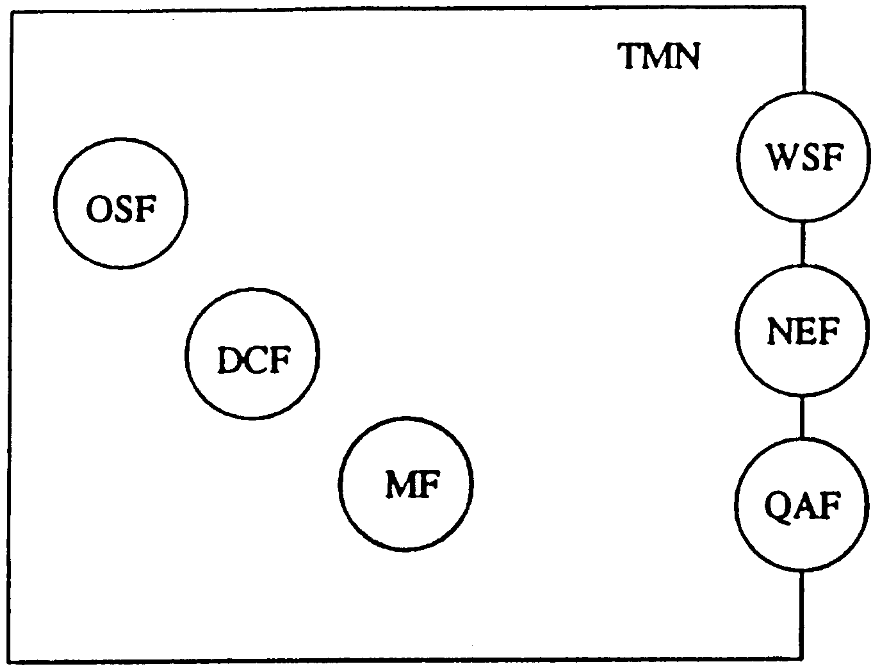
2 The TMN functional architecture

A TMN provides the means to transport and process information related to the management of telecommunications networks. The TMN functional architecture is based on a number of function blocks. The function blocks provide the TMN general functions which enable a TMN to perform the TMN application functions. The TMN functional model will be composed of principle function blocks such as the Operations Systems Functions (OSF) which allows management of the NEF and the WSF which allow the management information user to interact with the OSF.

Other complementary functions and function blocks are identified that allow interworking in various scenarios. These are the Data Communications Function (DCF) used for the transfer of information between function blocks, the Mediation Functions (MF) and the Q Adaptor Functions (QAF) that allow interworking between function blocks.

Figure 2 illustrates the function blocks and indicates that only those functions which are directly involved in management are part of the TMN.

NOTE: For reasons that are discussed in subclause 2.1, some of the function blocks are partly in and partly out of the TMN. This ETR is only concerned with the range of functionality which such function blocks provide to the TMN. It does not deal with functionality provided outside the TMN or the internal organisation of the functional blocks.



OSF: Operations Systems Functions
DCF: Data Communications Function
MF: Mediation Function
WSF: Work Station Function
NEF: Network Element Function
QAF: Q Adaptor Function

Figure 2: TMN function blocks

2.1 Function blocks

This subclause defines various function blocks and functional components and shows how they are related to each other, and the definition of the reference points used for developing the TMN architecture are presented.

The function blocks are listed in subclauses 2.1.1 to 2.1.5. Each function block is itself composed of functional components. The functional components are collected and refined in subclause 2.2.

2.1.1 Operations Systems Function block (OSF)

The OSF processes information relating to telecommunications management for the purpose of monitoring/co-ordinating and/or controlling telecommunications and support functions including management functions (i.e. the TMN itself).

Functional components of an OSF are defined in table 2. Details of the OSF functions are given in Clause 5.

2.1.2 Network Element Function block (NEF)

The NEF is a functional block which communicates with the TMN for the purpose of being monitored and/or controlled. The NEF provides the telecommunications and support functions which are required by the telecommunications network being managed.

The NEF includes the telecommunications functions which are the subject of management. These functions are not part of the TMN but are represented to the TMN by the NEF. The part of the NEF that provides this representation in support of the TMN is part of the TMN arena, whilst the telecommunications functions themselves are outside.

Functional components of an NEF are defined in table 2. Details of the NEF are given in section 5.

2.1.3 Workstation Function block (WSF)

The WSF provides the means to convert between the end user reference point and the OSF reference point. The purpose of the function is to give data independence between particular user interfaces (exploiting particular presentation features of the their workstation) and a generic OSF reference point.

The WSF includes support for interfacing to a human user. Such aspects of support are not considered to be part of the TMN and thus this part of the WSF is shown outside the TMN arena.

The WSF contains as a functional component a Presentation Function (PF) that provides human readable displays and human data entry (e.g. user terminal, personal computer, etc).

Functional components of the WSF are defined in table 2.2. Further details of the WSF are given in section 5.

2.1.4 Mediation Function block (MF)

The MF acts on information from NEFs, and in some cases QAFs, to adapt, filter and condense it as required by the OSFs. The MFs can be partitioned into the following functional components:

- Information Conversion Function (ICF) which effects the transformation of the messages (e.g converting object representations). This function characterises systems which have a mediation function and must always be present;

- Mediation Function - Management Application Function (MF-MAF). These application level functions may or may not be present. Examples of such functions include temporary storage, filtering, thresholding, concentration, security, testing, etc.;

- Higher Layer Protocol Interworking (HLPI). When the interworking at lower layer is not sufficient, higher layer protocol conversions are done in the MF. Lower layer protocol conversion functions may or may not be present.

The functional components of an MF are defined in table 2. Details of the MF are given in Clause 5. Examples of such functions can be found in subclause 5.4.2.

2.1.5 Q Adaptor Function block (QAF)

The QAF is used to connect to the TMN those NEFs which do not support standard TMN interfaces. The responsibility of the QAF is to translate between a TMN interface and a non-TMN (e.g. proprietary) interface and hence this latter activity is shown outside of the TMN, in figure 2.

The functional components of a QAF are defined in table 2. Details of the QAF are given in Clause 5.

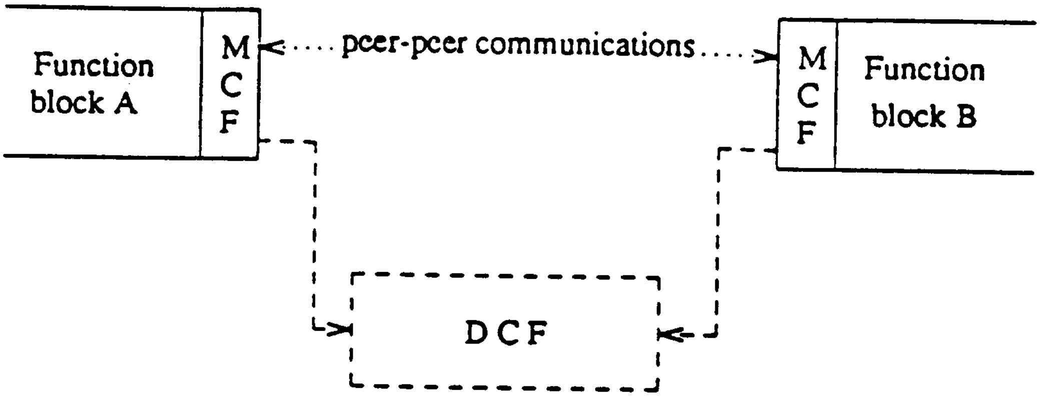


Figure 3: Relative roles of Message Communications Function (MCF) and DCF

2.2 Functional components

A number of functional components have been identified previously as the elementary building blocks of the TMN architecture. All these functional components are depicted in figure 5 which represents a generalised model for TMN function blocks. Table 2 shows how these functional components are combined into various function blocks. These are further defined in this subclause.

2.2.1 Management Application Function (MAF)

The MAFs will actually implement the management functions. Depending on their invocation they will act in the role of manager or agent (see subclause 3.2). Depending on the function block in which they are contained, they may be named by the function block involved e.g., MF-MAF.

2.2.2 Management Information Base (MIB)

The MIB is the conceptual repository for information within a TMN that can be exchanged or affected through the use of TMN protocols. The MIB is the set of managed objects within the TMN. The managed objects are the management view of the resources within a TMN to be managed (see Systems Management Overview, CCITT Recommendation X.701).

The structure and implementation of the MIB are not a subject for standardisation within the TMN.

2.2.3 Information Conversion Function (ICF)

The ICF is used in intermediate systems to translate the information model at one reference point into the information model at the other reference point.

The translation can be done at a syntactical level (e.g. object oriented to or from non-object oriented) and/or at a semantical level depending of the location of the ICF.

The implementation of the ICF is not a subject for standardisation within the TMN.

2.2.4 Human Machine Adaptation (HMA)

The HMA performs the conversion from the q_3 reference point to the f reference point (it masks some data, it adds information, and reorganizes the whole), and vice-versa. In addition, it supports the authentication and authorisation of the user.

The location and the contents of the HMA is presently not in line with the current CCITT SG X Unified Reference Model encompassing the f and the g reference points. These reference points should be brought in line in the future.

2.2.5 Presentation Function (PF)

The PF performs the general operations to translate the information held in the TMN information model to a displayable format for the human-machine interface, and vice- versa. The PF performs all the functions needed to provide user friendly facilities to enter, display, and modify details about objects.

2.2.6 Mediation Function - Management Application Function (MF-MAF)

Appropriate text is for further study. See also subclause 2.2.1.

2.2.7 Higher Layer Protocol Interworking (HLPI)

Appropriate text is for further study.

2.3 TMN Reference points

In order to delineate management function blocks, the concept of **reference points** is introduced. Reference points define service boundaries between two management function blocks. The purpose of reference points is to identify the information passing between function blocks.

2.3.1 Classes of reference points

Three classes of TMN reference points are defined, these are:

- q: class between OSF, QAF, MF and NEF;
- f: class for attachment of workstations;
- x: class between OSFs of two TMNs or between the OSF of a TMN and the equivalent functionality of another network.

The interfaces corresponding to implementations of reference points are described in subclause 4.2.

Figure 4 illustrates the 3 classes of TMN reference points. In addition there are 2 further classes of non-TMN reference points shown which are relevant to consider:

- g: class between WSF and users;
- m: class between a QAF and non-TMN managed entity functions.

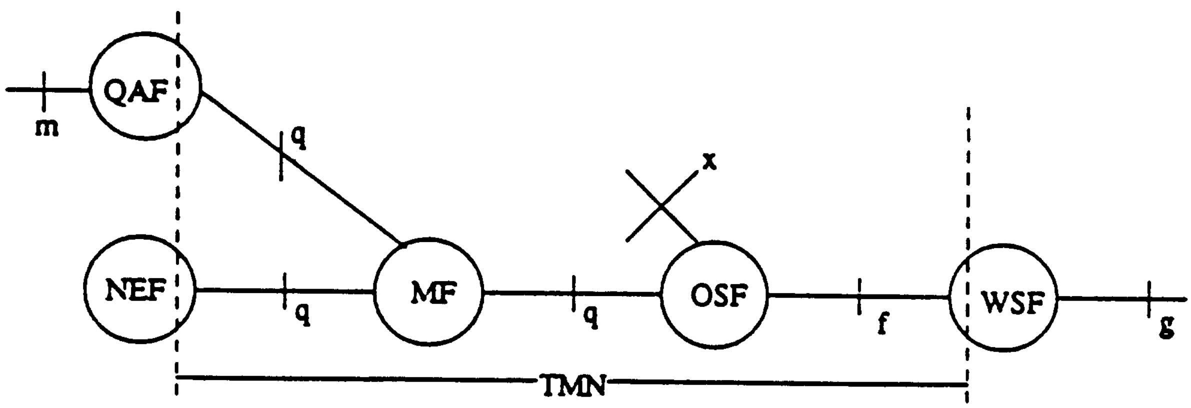


Figure 4: Classes of reference points.

NOTE: This figure is illustrative and is not exhaustive.

2.3.2 Definitions of reference points

As defined in subclause 2.3.1, reference points are conceptual points of information exchange between non-overlapping management function blocks. The classes of reference points are refined as follows.

2.3.2.1 The q reference points

The q reference points are located between the function blocks NEF and MF, MF and MF, QAF and MF, MF and OSF, QAF and OSF, and OSF and OSF either directly or via the DCF. Within the class of q reference points:

q_x: the q_x reference points are between NEF and MF, QAF and MF and between MF and MF.

q_3: the q_3 reference points are between NEFs and OSFs, QAF and OSFs, MFs and OSFs, and OSFs and OSFs.

2.3.2.2 The f reference points

The f reference points are located between the function blocks WSF and the OSF and the WSF and the MF via the DCF.

2.3.2.3 The x reference points

The x reference points are located between the OSF function blocks in different TMNs or the equivalent function in a non-TMN environment.

2.3.2.4 The g reference points

The g reference point are located outside the TMN between the human users and workstations. It is not considered to be part of the TMN even though it conveys TMN information. The detailed definition of this reference point is outside the scope of this ETR.

2.3.2.5 The m reference points

The m reference points are located outside the TMN between the QAF and non-TMN managed entity functions and managed entities that do not conform to TMN recommendations. The term is identified here because it is used in this document.

2.3.2.6 Relationship of reference points to function blocks

Table 1 defines the reference points which exist between functions and function blocks. This table is intended as a concise definition of all possible pairings within the context of TMN.

Table 1: Relationships between logical function blocks expressed as reference points

	NEF	OSF	MF	$QAFq_3$	$QAFq_x$	WSF	Non-TMN
NEF		q_3	q_x				
OSF	q_3	X (NOTE 1) q_3	q_3	q_3		f	
MF	q_x	q_3	q_x		q_x	f	
$QAFq_3$		q_3					m
$QAFq_x$			q_x				m
WSF		f	f				g (NOTE 2)
Non-TMN				m	m	g (NOTE 2)	

m, g = Non-TMN reference point (see NOTE 3).

NOTE 1: x reference point only applies when each OSF is in a different TMN.

NOTE 2: The g reference point lies between the WSF and the human user.

NOTE 3: Any function may communicate at a non-TMN reference point. These are not discussed here, but may include such things as communication with hand-held terminals. These may be standardised by other groups/organisations for particular purposes.

2.4 Communications Functions of the TMN

2.4.1 Data Communication Function (DCF)

The DCF will be used by the other management function blocks for exchanging information.

The prime role of the CF is to provide information transport mechanisms, including routing and relaying functions. The DCF may therefore be supported by the bearer capability of different types of sub-networks. These may include CCITT Recommendation X.25, LANs, Signalling System No. 7 (SS7) or the Embedded Communications Channel (ECC) of Synchronous Digital Hierarchy (SDH).

When DCFs have to be inserted at a given reference point, the MCFs are implemented at every point of attachment to the DCF as depicted in figure 4.

The DCF provides the means to transport information related to telecommunications management between management function blocks. The DCF provides layers 1 to 3 of the OSI reference model or their equivalent.

When different technologies are interconnected i.e. when different subnetworks need to interwork (e.g. LAN, WAN), the lower layer interworking functions, when required, will be part of the DCF.

Additional details on the DCF are given in subclause 4.4.

2.4.2 Message Communication Function (MCF)

The MCF is associated with all functional blocks and is used to exchange information. It is limited to the exchange of management information contained in messages with their peers. The MCF is composed of a protocol stack that allows connection of function blocks to data communication functions. Depending on the protocol stack supported at the reference point, different MCF types will exist. These will be differentiated by subscripts (e.g. $MCFq_3$ applies at a q_3 reference point).

When a function block is connected at two types of interfaces, the use of two types of MCFs will provide protocol conversion (see however the exception mentioned in subclause 2.1.4). Further clarification can be found in subclause 2.4 where the MCF is depicted in figure 3.

2.5 The TMN reference model

The functional components of each TMN function block are shown in table 2.

Table 2: Functional components of TMN function blocks

Function Block	Functional Components (NOTE 1)	Associated Management Communications Functions
OSF	MIB, OSF-MAF(A/M), HMA	MCF_x, $MCFq_3$, MCF_f
OSF Sub-ordinate (NOTE 2)	MIB, OSF-MAF(A/F), ICF, HMA	MCF_x, $MCFq_3$, MCF_f
WSF	MIB,PF	MCF_f
$NEFq_3$ (NOTE 3)	MIB, NEF-MAF(A)	$MCFq_3$
$NEFq_x$ (NOTE 3)	MIB, NEF-MAF(A)	$MCFq_x$
MF	MIB, MF-MAF(A/M), ICF, HLPI, HMA	$MCFq_3$, $MCFq_x$, MCF_m, MCF_f
$QAFq_3$	MIB, QAF-MAF(A/M), ICF, HLPI	$MCFq_3$, MCF_m
$QAFq_x$	MIB, QAF-MAF(A/M), ICF, HLPI	$MCFq_x$, MCF_m

KEY:
PF = Presentation Function.
MCF = Message Communications Function.
MIB = Management Information Base.
MAF = Management Application Function.
ICF = Information Conversion Function.
A/M = Agent/Manager.
HLPI = Higher Layer Protocol Interworking function.

NOTE 1: MAF (A/M) means management application function in Agent or Manager role.

NOTE 2: This is an OSF in the sub-ordinate layer of the logical layered architecture explained in subclause 3.5.

NOTE 3: The NEFs also include telecommunication and support resources that are outside of the TMN.

In table 2, the subscripts indicate at which reference point the functional component applies. Individual functional components may or may not appear, or may appear multiple times in a given instance of a functional block. An example of multiple occurrences is of several different MAFs in the same instance of a functional block.

Table 3 defines the set of functional components which each function block contains.

Table 3: Relationship of functional components to function blocks

	Functional Components					
	MIB	MAF (NOTE 3)	ICF	HLPI	HMA	PF
OSF	M	M	-	-	O	-
OSF_{sub}	M	M	M	(NOTE 1)	O	-
WSF	M	(NOTE 2)	(NOTE 2)	-	-	M
$NEFq_3$	M	M	-	-	-	-
$NEFq_x$	M	O	-	-	-	-
MF	M	O	M	O	O	-
$QAFq_3$	M	O	M	?	-	-
$QAFq_x$	M	O	M	?	-	-

Key:
M = Mandatory.
O = Optional.
? = Outside scope of TMN.
- = Not allowed.

NOTE 1: Only required if different variants of the communication protocol at q_3 apply.

NOTE 2: These functions are contained as part of the presentation function.

NOTE 3: MAF is considered to be additional to any agent or manager activities and may be in conflict with ISO definitions.

Figure 5 summarises the TMN functional reference model by illustrating an example of each pair of function blocks which can be associated by a reference point. Figure 5 also illustrates the typical flow of information between function blocks.

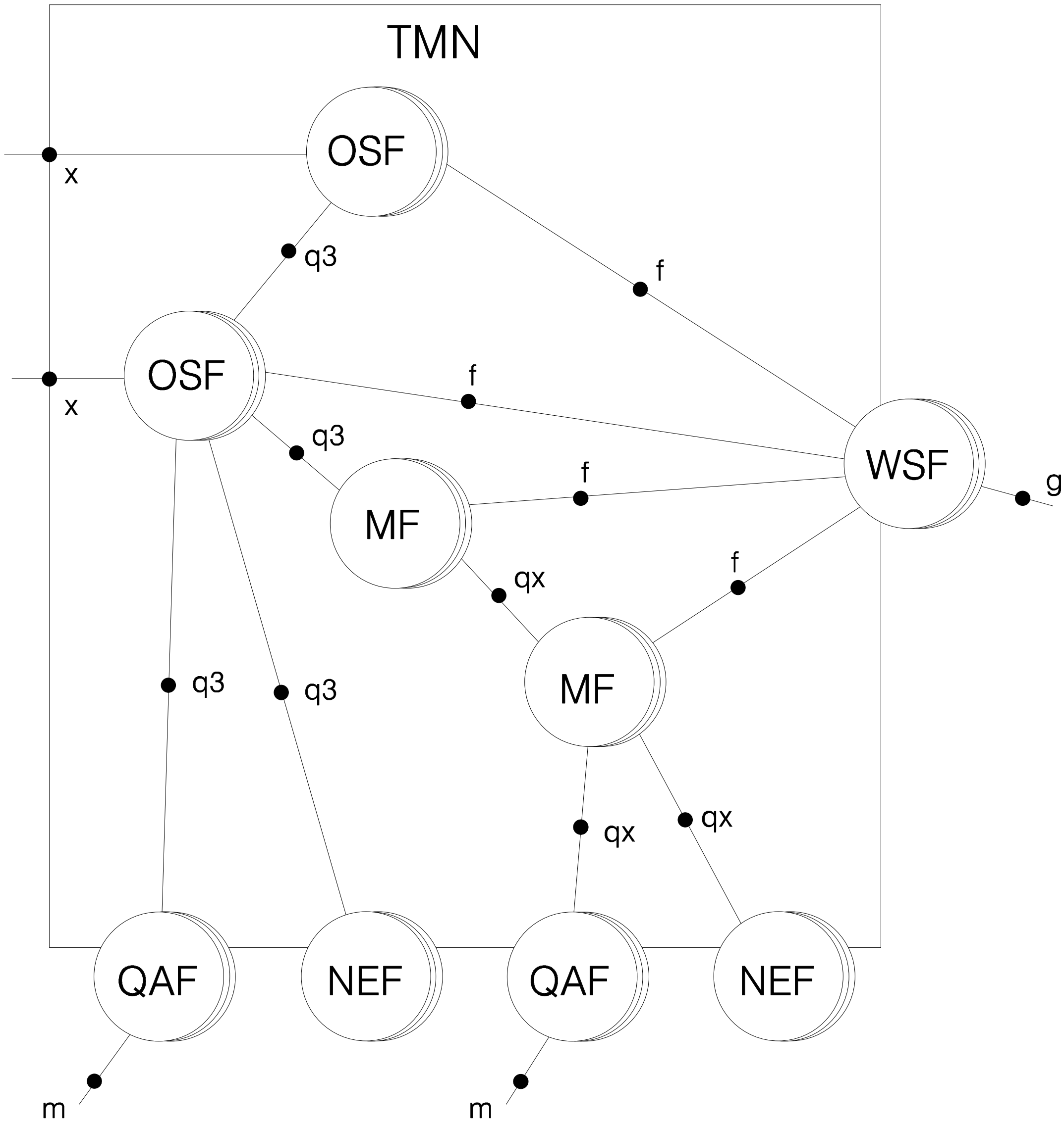
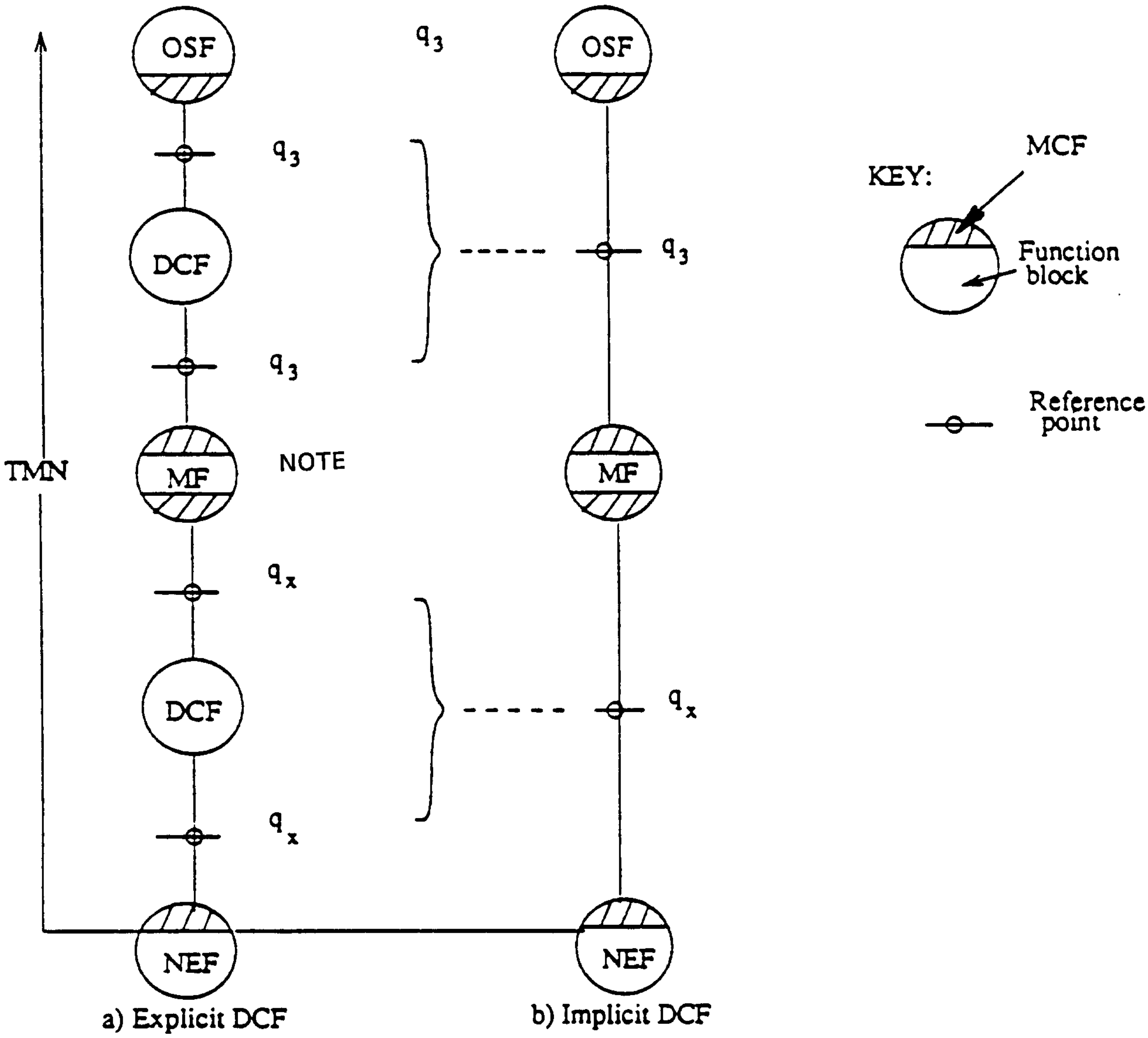


Figure 5: The TMN functional reference model

Figure 6 depicts the use of implicit and explicit DCF.

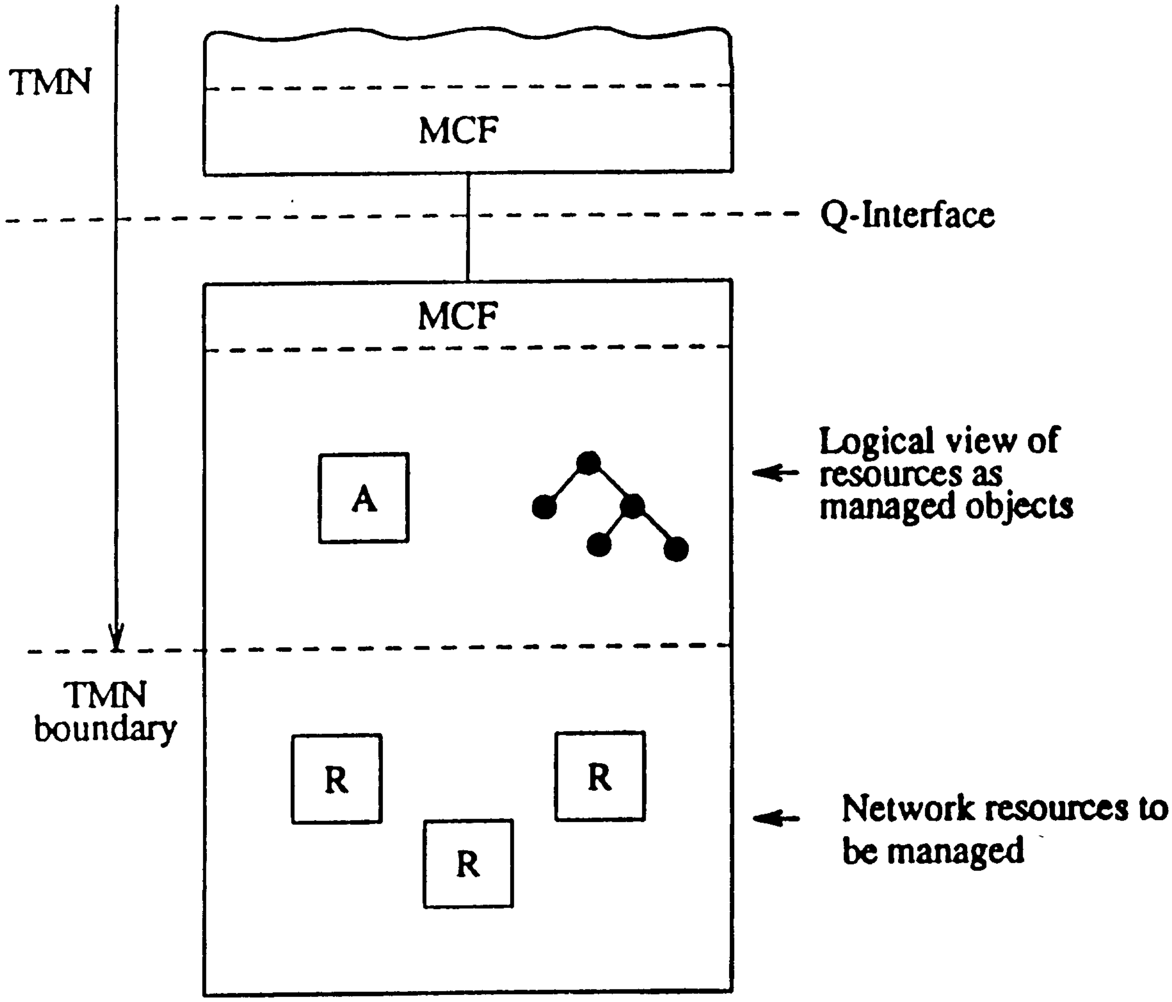


OSF	=	Operations Systems Function Blocks
MF	=	Mediation Function Blocks
DCF	=	Data Communication Function Block
NEF	=	Network Element Function Block
MCF	=	Message Communication Function

NOTE: A DCF block is not present when a reference point is not realised as an interface, and that MF blocks may be cascaded.

Figure 6: Implicit and explicit DCF

As an example, figure 7 introduces a functional breakdown of a NE in order to show how the various functions identified in the preceding sections are involved.



MCF = Message Communication Function
A = Agent
R = Resource

Figure 7: Depicting the A/M concepts in the case of an NE

2.6 TMN access from external sources

The needs of external access to TMN applications are divided into two groups:

- co-operation between peer TMNs;
- network/service user access to TMN;
- service provider access to TMN.

2.6.1 Access between TMNs

TMNs need to co-operate in order to provide the overall (end-to- end) service as seen by the network user. This often involves providing information and some degree of control to another TMN.

2.6.2 Access by network users

User access to a TMN is required in order to allow the users to exercise a limited amount of control and get feed-back on their use of the network. Such an access supposes management services being provided for the users by the network operators. Generally, the accessed TMN makes no assumptions about the user's needs and the information exchanged is purely related to TMN management functions.

2.6.3 Supporting external access to TMN functions

Both types of access identified above can be dealt with by a common approach.

Two kinds of information can be exchanged between the TMN and the external accessor:

1 management information related to a specific interface or a specific link (e.g. a loop request by the user);

2 management information which concerns events on the different links and services available to the accessor.

In the latter case, the management information will be exchanged in a centralised way at an x reference point supported at the connection between the two TMNs or TMN and network users.

It is necessary to provide the users with common access to management applications of one, or a set of, telecommunication services. The following functions are involved:

- security of access, - protocol conversion;
- translation between the objects known by the user and the service/network management functions;
- value added services.

Thus the Management Services Function (MSF) provides the access to various management services. It thus gives a common access to one or several TMNs. The MSF has no knowledge of the customer data or facilities. It manages its access to the TMN(s) with a particular emphasis being laid upon security (especially non-repudiation and authorisation). The MSF may provide support for the provision of value-added services, but will not provide the actual services itself.

NOTE: Further study is needed on the definition of MSF.

3 The TMN information architecture

In this Clause the manager/agent concepts, such as those developed for OSI management, are introduced.

The concepts necessary for the organisation and interworking of complex managed systems (e.g. networks) are also introduced under the headings of management domains and shared management knowledge.

The management information is considered from two perspectives:

a) the management information model that describes the management resources and the related management activities. This activity takes place at the application level and involves a variety of subfunctions such as storing, retrieving and processing information. The functions involved at this level are referred to as "TMN function blocks";

b) the management information exchange that involves DCFs such as a communication network and the MCFs that allow particular physical components to attach to the telecommunications network at a given interface. This level of activity only involves communication mechanisms such as protocol stacks.

3.1 Object oriented approach

In order to allow effective definition of a growing set of managed resources, the TMN methodology makes use of the OSI management principles and is based on an object oriented paradigm. These principles are those defined for OSI management. A brief presentation of the concept of objects is given below.

Management systems exchange information modeled in terms of managed objects. Managed objects are conceptual views of the resources that are being managed or may exist to support certain management functions (e.g. event forwarding or event logging).

Thus a managed object is the abstraction of such a resource that represents its properties as seen by (and for the purposes of) management.

A managed object may also represent a relationship between resources (e.g. a path) or a combination of resources (e.g. a network).

> NOTE: Object oriented principles apply to the information modelling i.e. to the interfaces over which communicating management systems interact and should not constrain the internal implementation of the telecommunications management system.

Additional consideration:

- there is not necessarily a one-to-one mapping between managed objects and real resources (which may be physical or logical);
- these resources can be network elements or other management components. Likewise, a resource may be represented by zero, one, or more objects;
- if a resource is not represented by a managed object, it cannot be managed across the management interface, i.e. it is not visible from the managing system;
- a managed object may provide an abstract view of resources that are represented by other managed objects;
- managed objects can be embedded, i.e. a managed object may represent larger resources that contain resources themselves modeled as subentities of the larger object.

The concepts defined above are depicted in figure 8.

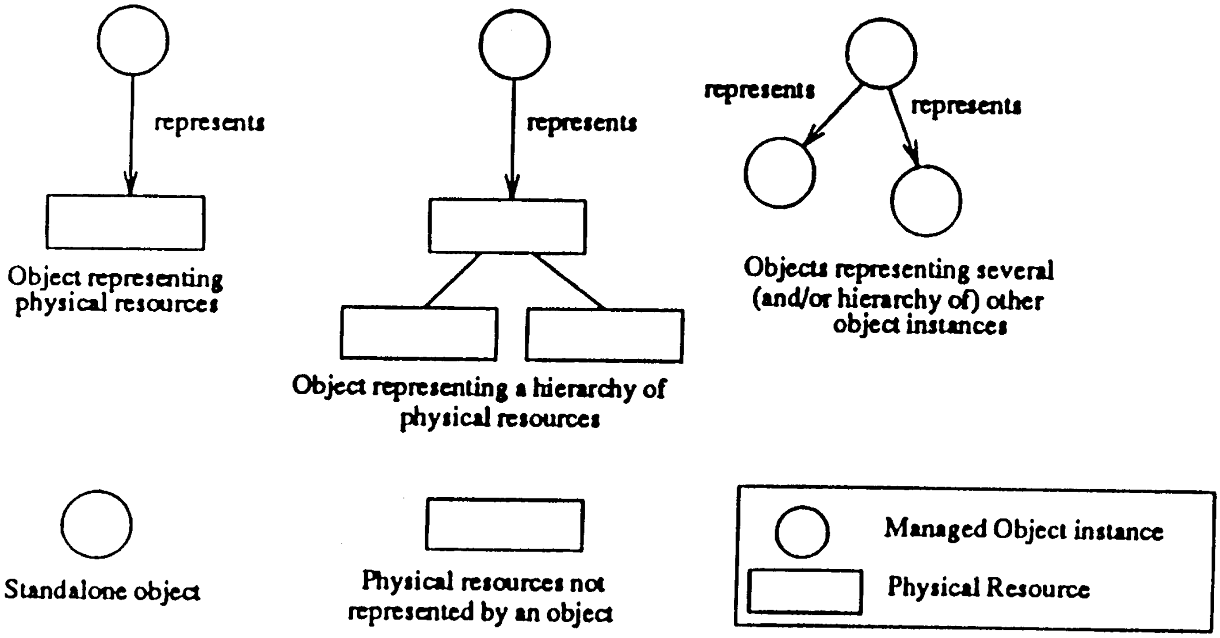


Figure 8: Managed objects and physical resources

A managed object is defined by:

- the attributes visible at its boundary;
- the management operations which may be applied to it;
- the behaviour exhibited by it in response to management operations or in reaction to other types of stimuli. These can be internal (e.g. threshold crossing) or external (e.g. interaction with other objects); and
- the notifications emitted by the object.

The use of the methodology defined in CCITT Recommendation M.3020 [5] has lead to the identification of a generic network model composed of a series of managed objects as defined in CCITT Recommendation M.3100 [6].

3.2 Manager/agent

Management of a telecommunications environment is an information processing application. Because the environment being managed is distributed, network management is a distributed application which involves the exchange of management information between management processes for the purpose of monitoring and controlling the various physical and logical networking resources.

For a specific management interaction the management processes will take on one of two possible roles. The initiator of an association requests one of three possible application contexts: manager application context, agent application context or manager-agent context. (For a definition of these see ISO OSI 10040). In the last case the roles played by the management processes may vary for each information exchange on the association depending on who is the invoker of the exchange irrespective of who is the initiator of the association.

- a **manager** role: the part of the distributed application that issues management operation requests and receives notifications; or

- an **agent** role: the part of the application process that manages the associated managed objects. The role of the agent will be to respond to directives issued by a manager on its behalf. It will also reflect to the manager the data view of these objects and emit notifications reflecting the behaviour of these objects.

A **manager** is the part of the distributed application which for a particular exchange of information has taken the manager role. Similarly, an **agent** is the part that has taken the agent role.

3.2.1 Manager/agent/objects relationships

The manager/agent roles are assigned to management processes within a given communications context (e.g. as part of an association).

Figure 9 shows the interaction between manager, agent and objects.

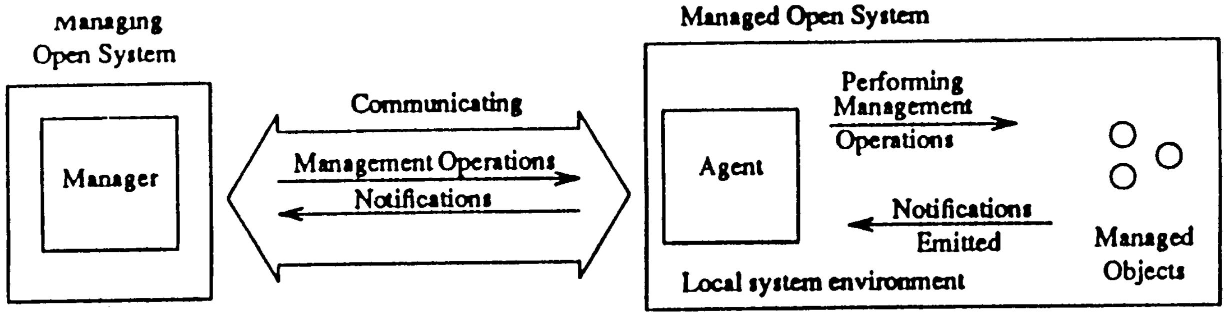


Figure 9: Interaction between manager, agent and objects

NOTE: A "many-to-many" relationship will typically exist between managers and agents in the sense that:

- one manager may be involved in an information exchange with several agents. In this case it will contain several manager roles interacting with their peer agent roles. In this scenario, the issue of synchronisation of requests may exist. The synchronisation issues require further study (see Annex D).

- one agent may be involved in an information exchange with their peer managers. In this case it will contain several agent roles interacting with several manager roles. In this scenario the issue of concurrent requests may exist. This requires further study.

An agent may deny a manager's request for several reasons e.g security, information model consistency, etc. A manager will therefore have to be prepared to handle negative responses from an agent.

A number of additional concepts related to the manager - agents - objects relationships are given in subclause 3.4.

All management exchanges between manager and agent are expressed in terms of a consistent set of management operations (invoked via a manager role) and notifications (filtered and forwarded by the agent role). The way agents interact with the resources they are in charge of is a local matter and not a subject for standardisation.

3.2.2 Interworking between TMN function blocks

These management function blocks use the M-A relationship described above to achieve management activities. The Manager (M) and Agent (A) are part of the management subfunctions and as such are part of the TMN.

Figure 10 shows how the concepts of manager, agent and managed objects are introduced in the management information flow at the reference points.

NOTE: The interaction between Agent (A) and Manager (M) in the middle box is the subject for further study and is discussed in subclause 3.5.

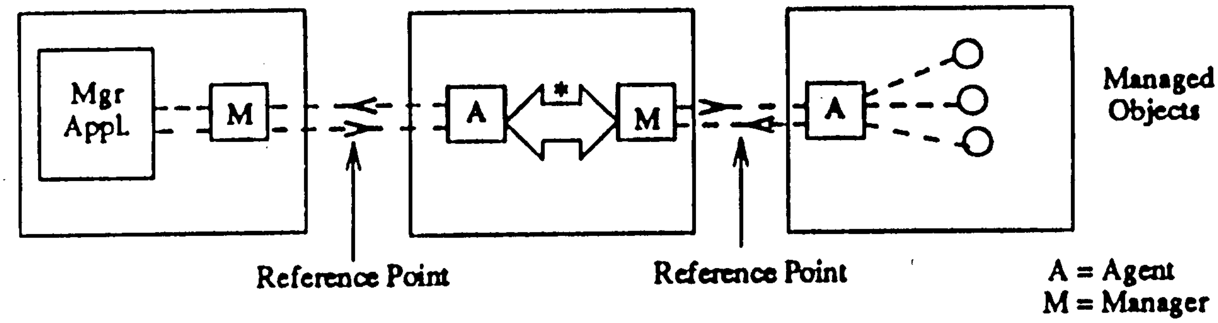


Figure 10: Example of manager/agent information flow

A possible physical example of this flow is shown in figures 21 and 22.

3.3 Shared management knowledge

In order to interwork, communicating management systems must share a common view or understanding of at least the following information:

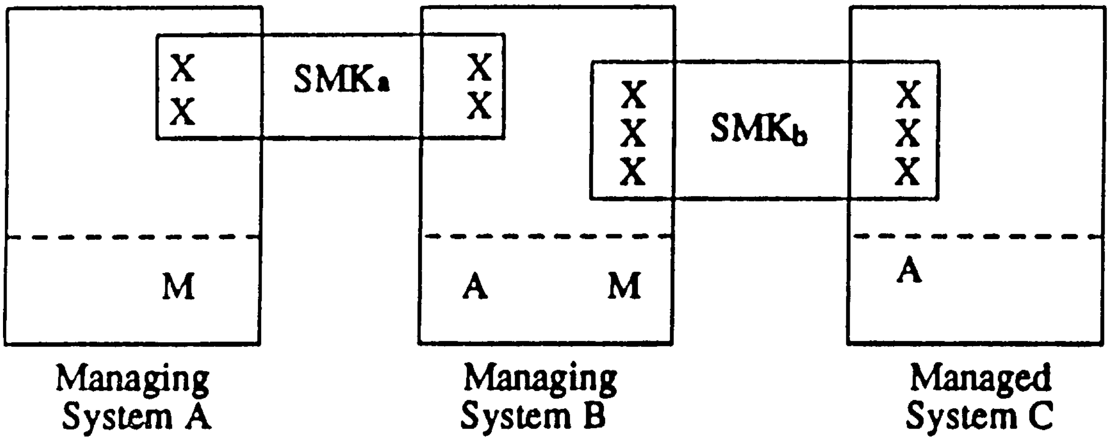
- supported protocol capabilities;
- supported management functions;
- supported managed object class;
- available managed object instances;
- authorised capabilities;
- containment relationships between objects (name bindings).

All the above information pieces are defined as the Shared Management Knowledge (SMK).

When two function blocks exchange management information, it is necessary for them to understand the SMK used within the context of this exchange. Some form of context negotiation may be required to establish this common understanding within each entity.

Figure 11 shows that the shared information is related to the communicating entities pair. In this picture the SMK between function 1 (system A) and function 2 (system B) is not the same as the SMK between function 2 (system B) and function 3 (system C). This does not preclude a number of commonalities in particular at system B level.

Figure 12 shows that the concept of SMK may exist independently of the actual existence of interfaces i.e. of the physical implementation. This is particularly the case for hierarchical management where a logical layered approach is retained (see subclause 3.5).



NOTE: The "Xs" stand for shared components of the management information.

Figure 11: Sharing the management knowledge

Understanding management functions (e.g. event management and state management) includes an understanding of what options and which roles (e.g. manager or agent) are supported for each function. While trial and error is one method of gaining this understanding the need for a more efficient mechanism is anticipated.

It is necessary to understand which managed object classes are supported by each management interface pairing. Since CMIP scoping is only capable of identifying instances of managed object classes, a more comprehensive mechanism is needed to understand the complete set of managed object classes supported, including those for which there is not presently an instance available. There may also be relationships (e.g. possible superior - subordinate pairs for naming) between managed object classes. If so, negotiation mechanism also needs to support the development of this understanding.

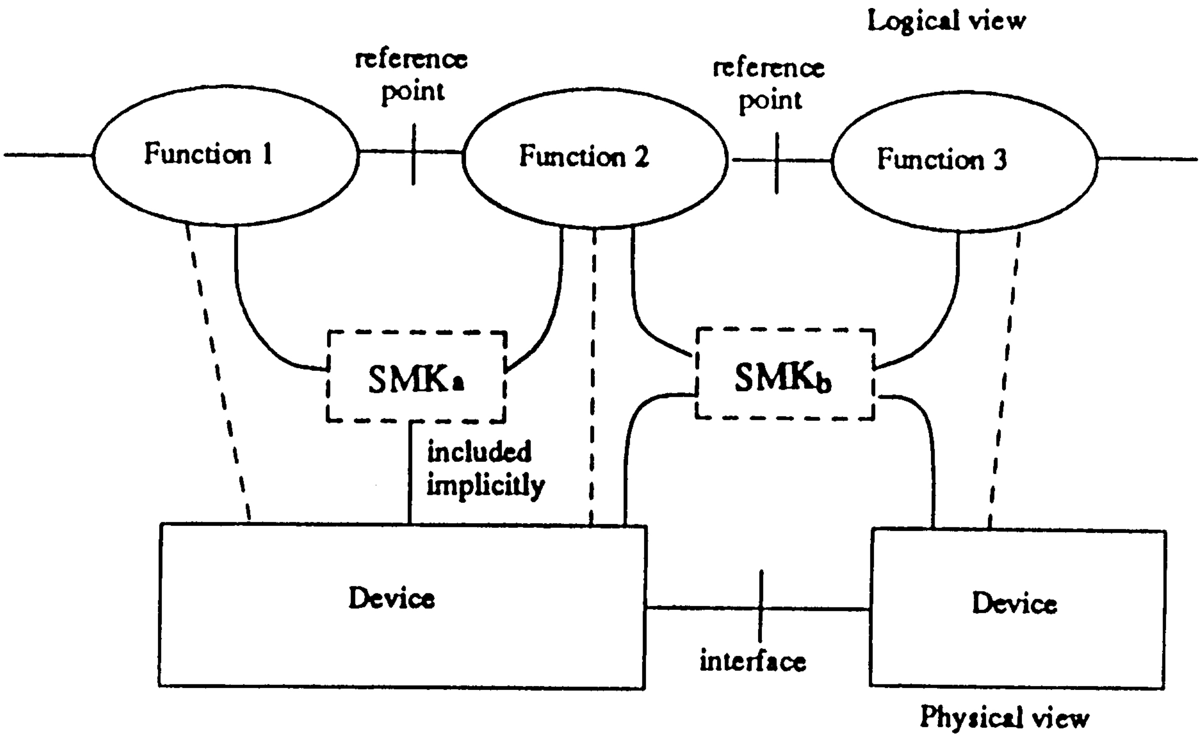


Figure 12: SMKs may be independent of the physical implementation.

The actual instances of managed object classes that are available in a management interface forms the most significant base of understanding needed by communicating management interfaces. CMIP scoping is a reasonable mechanism to provide most of this understanding. As with managed object classes, managed object instances may also be participating in relationships that need to be understood by a communicating management interface.

As well as understanding what functions and managed objects are supported, the SMK also includes an understanding of authorised management capabilities (e.g. permission to modify configurations, adjust tariffs, create or delete managed objects, etc.).

3.3.1 Context negotiation

The process that occurs between a pair of management interfaces for exchanging and understanding SMK is called context negotiation.

Depending on the requirements of management application, policy, etc. management interfaces can require different types of context negotiation. These can be classified as either static or dynamic negotiation processes.

3.3.1.1 Static context negotiation

In a static process the SMK exchange occurs only at a definite time and is binding for some contractual period. The static process can be carried out off line prior to the establishment of an association (communication dialogue) between the management interfaces. It can also be carried out on-line as part of the communication context (association) establishment process.

An off-line process of static context negotiation occurs as two equipment providers agree between themselves what the SMK will be. This agreement occurs prior to an association between the management interfaces being established. In this case the SMK can be identified by the application titles of the respective management interfaces.

The on-line process of static context negotiation occurs at the beginning of an association.

At association establishment time, information is exchanged which allows both of the management interfaces to come to a common understanding of what the SMK will be for this management association, thus completing the context negotiation process.

The negotiated SMK will remain in force for the duration of this association. The SMK information exchanged may reinforce an off-line context negotiation, or carry forward a context negotiation from a previous association.

In a dynamic process of context negotiation, SMK information is exchanged throughout the association by multiple interactions.

3.3.1.2 Dynamic context negotiation

Dynamic context negotiation is required if the set of capabilities (e.g. functions supported) or the resources (e.g. managed object classes or instances) that can be referenced in the information exchanges across the management interfaces can be changed during the association. One possible mechanism to support dynamic context negotiation would be to define a managed object class that supported a notification of any changes to the SMK.

These types of negotiation should not be mutually exclusive so that a management interface may elect to use multiple types (e.g. static and dynamic) of context negotiation.

3.4 Domains

The organisational requirements for managing a collection of managed objects include the following:

- to partition the management environment for a number of functional purposes (or policies), such as for security, accounting, fault management, etc. or to partition the management environment for each management purpose, such as according to geographical, technological, or organisational structure;

- to temporarily assign and possibly modify the roles of manager and agent for each of the purposes within each collection of managed objects;

- to exercise forms of control (e.g. security policy) in a consistent manner.

When managed objects are organised into sets to meet the above requirements, these sets are called management domains. This is further depicted in figure 13.

Management domains may themselves be modelled as managed objects but the content of these objects is not subject to standardisation as it is essentially of a dynamic nature.

NOTE: CCITT SG VII and ISO has a work item on the definition of "Management Domain". Resulting material should be used or referenced when available.

3.4.1 Relationships between domains

As domains are basically used to partition sets of objects based on policies, the following types of relationships may exist between domains:

- disjoint management domains;

- interacting management domains;

- contained management domains;

- overlapping management domains.

Overlapping management domains will exist when one or several objects belong simultaneously to several domains (see figure 14). In such a case a number of issues exist such as ownership, concurrency and access control that will require further study (see also subclause 3.2).

3.5 Logical layered architecture

Subclause 1.5 on architectural requirements identifies the requirements that the TMN architecture must comply with. In order to achieve this a Logical Layered Architecture (LLA) is required to allow the development of architectures specific to the network conditions.

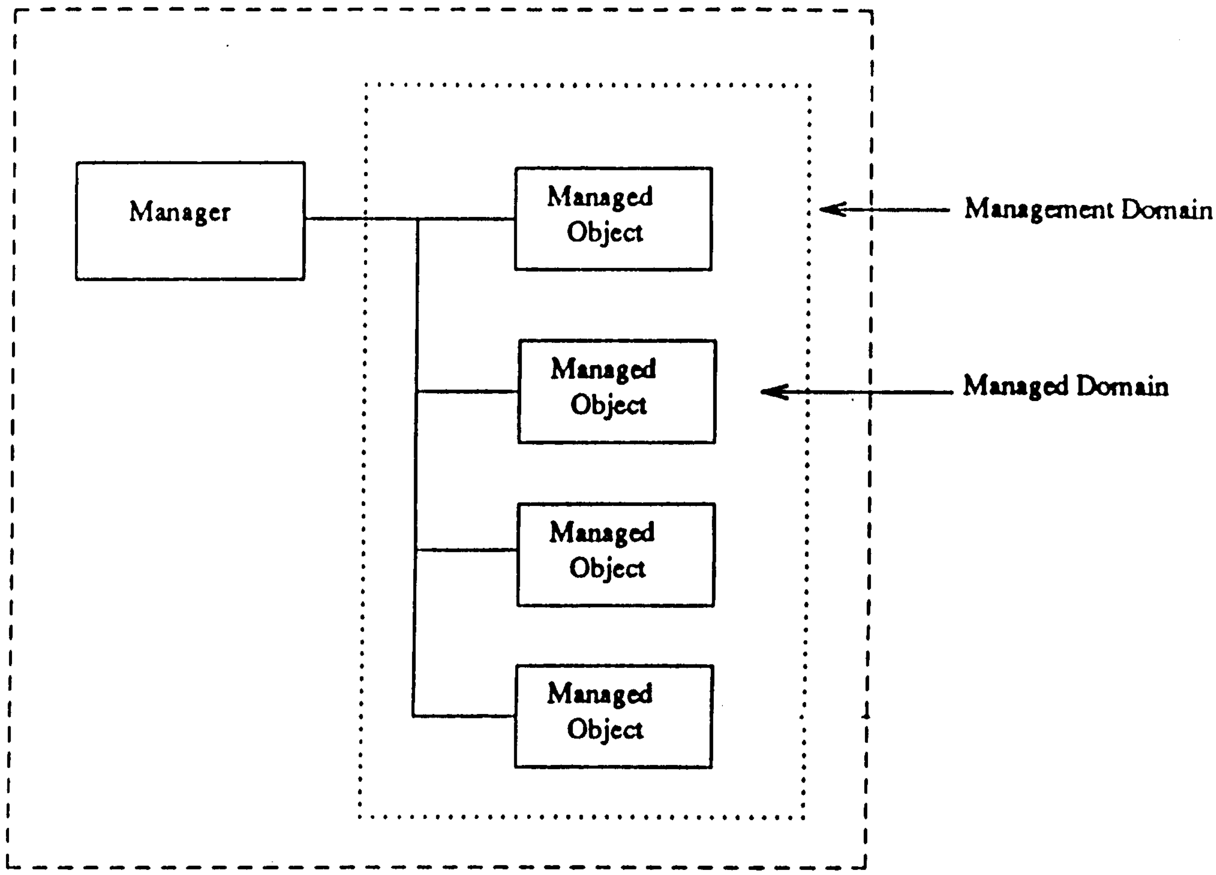


Figure 13: Examples of management domain sets

The LLA is a development concept based upon hierarchical principles in which the architecture can be thought of as being based on a series of layers. This is illustrated in figure 15.

Figure 15 represents two layers of a generalised layered model. The purpose of the model is to show the control authority between components of the management architecture (shown as circles in figure 15. Such components represent managed objects while the square on the notational boundary between layers (the dotted lines) represent the information model for the layer below it (this implies an ICF at this point).

The scope of each layer is broader than the layer below it, the upper layer directs the lower. In general it is expected that upper layers will be more generic while lower layers are more specific. Each layer encompasses relevant manageable objects. The LLA described below is based upon the layering principle but uses a single model to represent each layer via recursion.

The LLA architecture defines a TMN as being the overall management arena of an administration. The administration has business objectives and operational strategies. These then dictate the general composition of the administration and the services marketed, and thus lead to the management requirements.

The LLA provides a logical view of the management components and their control authority which can be put together to create the management solution (i.e. the set of functions and facilities making up a particular TMN). Another reason for a logical layered architecture is the partitioning of management components based on abstraction level (e.g. "service" as opposed to "supporting resources"). The LLA implies the clustering of management components in layers that will be themselves delineated by reference points. The actual implementation of these layers will map the reference points into interfaces. It is only when a specific instance of the LLA is defined that functions, or groups of functions, become processes and the reference points between the processes become interfaces.

All the points of connection within the LLA implicitly have a Manager (M) - Agent (A) relationship associated with them according to the control authority.

The LLA uses a recursive approach to decompose a particular management activity into a series of nested arenas. Each arena forms a management arena under the control of an OSF and thus each arena is called an OSF-arena.

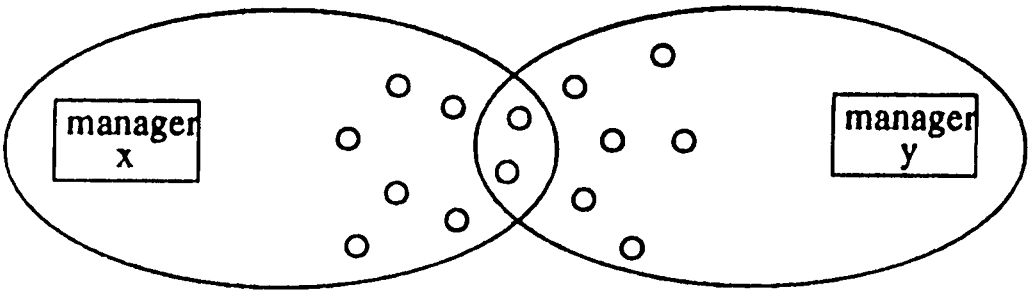
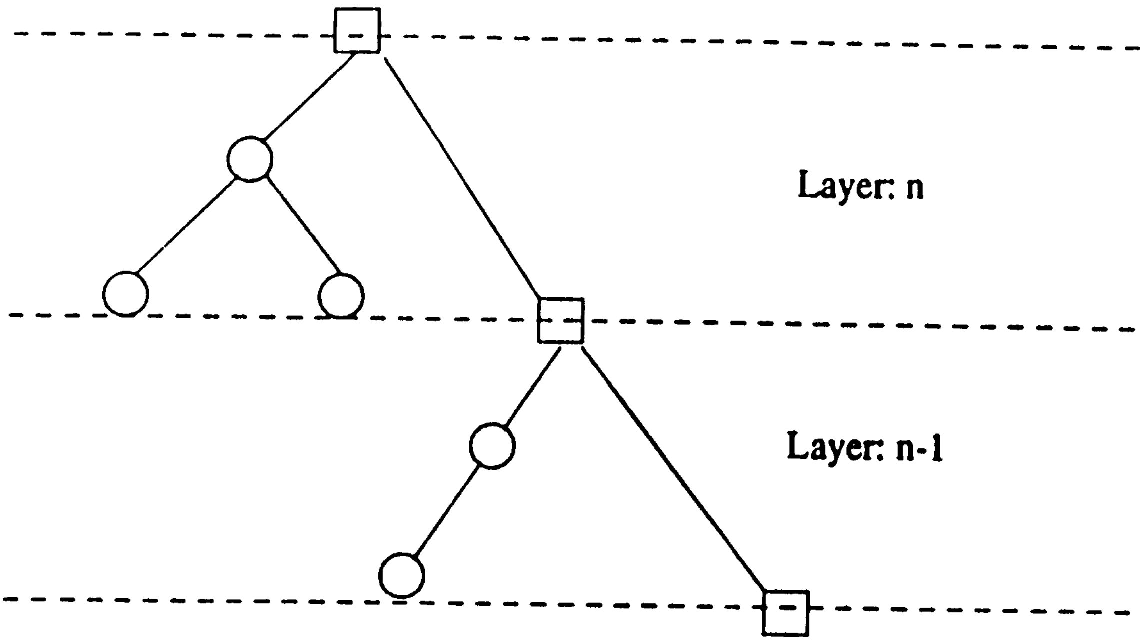


Figure 14: Overlapping management domains



NOTE: The OSF for the subordinate arena maps between the information model it shares with the upper level OSF into the information model of its own arena. This mapping is provided in a transparent manner by the subordinate OSF and actually hides (marks non-visible) the lower information models (objects) to the upper OSFs.

Figure 15: A layer model

The top arena encompassed all the arenas which are layered below it, the scope of the top level OSF-arena is the TMN. For each arena there is a model which the OSF uses to guide its management decisions. An arena may contain other OSF-arenas to allow further layering or it may represent resources as Managed Objects (MO) within that arena.

A managing OSF-arena makes use of an information model that describes all the objects that are visible to the OSF i.e. the objects under the OSF's direct control as well as the objects made visible to the OSF by the sub-ordinate arena of the next lower level of this hierarchical arrangement.

The OSF for the subordinate arena maps between the information model it shares with the upper level OSF into the information model of its own arena. This mapping is provided in a transparent manner by the subordinate OSF and actually hides (makes non- visible) the lower information models (objects) to the upper OSFs.

The OSF of the next arena down is also responsible for managing that arena. This recursive nature is depicted in figure 16. The ultimate objective is to manage the real resources which are represented by MOs. Thus each recursion path is terminated when the OSF of an arena is only managing MOs. MOs may also be present in arenas higher up the recursion path where they represent real, physical or logical, resources that are within the scope of the arena's model.

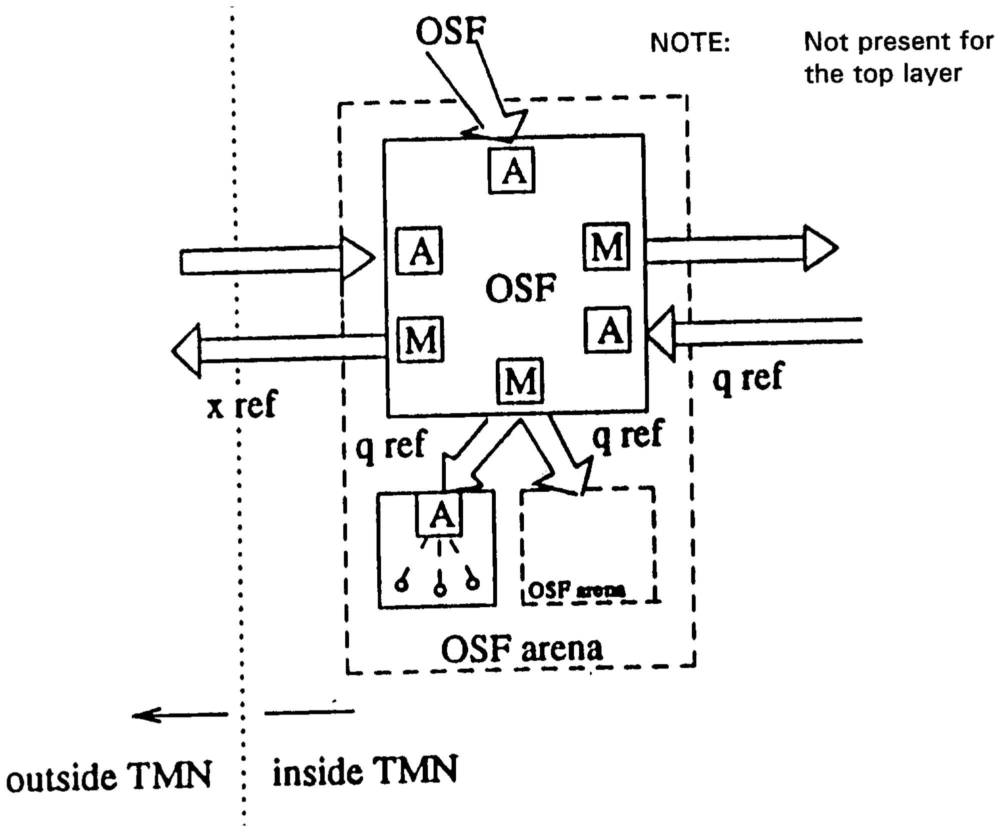


Figure 16: Logical layered architecture (showing control authority)

All interactions within an arena take place at generic "q" reference points. However interactions between peer arenas, i.e., crossing an OSF-arena boundary, can take place at a "q" or "x" reference point depending upon the business strategy applicable for those interactions. For the provision of network services it is common for management to cross the boundaries of an administration, hence provision is made for inter-TMN interactions. For security reasons this is restricted to the "x" reference point.

It is the flexibility of the layered architecture together with generic "q" reference points which gives the LLA the ability to be used as the basis for many different types of architecture. In all cases it is the scope of the model for each arena which dictates the layering and inter-arena interactions required.

Annex B contains an example architecture which is consistent with the LLA. Such example architectures are developed to cater for the needs of differing types of networks and would identify the interfaces required. Actual TMNs are implementations of these architectures.

It is not within the scope of this ETR to dictate the architecture to be used but rather to lay down the general principles for these architectures such that they might interwork, or even be nested. Such architectures will be presented in recommendations which are specific to the type of network being managed.

3.6 TMN naming and addressing

For the successful introduction of a TMN (within an OSI environment) into an administration, a logical, integrated naming and addressing scheme for identifying and locating the various communications objects within a TMN is critical. In order to locate TMN systems and identify various entities within each system, unambiguous naming and addressing methods are required. A more detailed overview of this subject is given in Annex A.

3.6.1 Principles for naming schemes

Some principles for the design of naming schemes contain properties such as:

- they are required to be unique or unambiguous;
- they are primarily for use by computers.

3.6.1.1 Unambiguous naming

When names are required to be unique or unambiguous (globally), a mechanism is required for co-ordinating naming activities among organisations (administrations). This is generally achieved at the global level by systematically dividing the set of all possible names into subsets.

3.6.1.2 Name structure

Structure is the assignment of meaning to sub-elements of a name. Reasons for incorporation of structure into names are:

- to identify naming authorities;
- for CCITT or ISO reasons;
- for purposes identified by naming authorities.

3.6.1.3 Application layer names

Administrations will need to consider:

- definition of an application process name (title);
- the derivation of other application layer identifiers from the basis of the application process naming scheme.

3.6.2 Addresses

The application entity maps to an OSI presentation address which maybe represented by the construction of network address and other OSI layer addressees.

4 The TMN physical architecture

Figure 17 shows a simplified physical architecture example for the TMN. This example is provided to assist in understanding the TMN building blocks described in subclause 4.1.

4.1 TMN building blocks

TMN functions can be implemented in a variety of physical configurations.

The following are the definitions for basic TMN building blocks containing mandatory TMN functions and function blocks.

4.1.1 Operations System (OS)

The OS is the system which performs OSFs.

4.1.2 Mediation Device (MD)

The MD is the device which performs MFs. MDs can be implemented as hierarchies of cascaded devices.

4.1.3 Q Interface Adaptor (QA)

The QA is a device which connects NEs with non TMN compatible interfaces (m reference points) to Q_x or Q_3 interfaces. QAs may contain MFs.

4.1.4 Data Communication Network (DCN)

The DCN is a communication network within a TMN which supports the DCF.

4.1.5 Network Element (NE)

The NE is comprised of telecommunication equipment (or groups/parts of telecommunication equipment) and support equipment or any item or groups of items considered belonging to the telecommunications environment that performs NEFs and has one or more standard Q-type interfaces.

Existing equipment that do not possess this standard interface will gain access to the TMN via a Q-adaptor, which will provide the necessary functionality to convert between a non-standard and standard management interface.

4.1.6 Work Station (WS)

The WS is the system which performs WSFs. The work station

functions translate information at the f reference point to a displayable format at the g reference point, and vice-versa.

4.1.7 Relationship of TMN building block names to TMN function blocks

Table 5 names the TMN building blocks according to the set of function blocks which each is allowed to contain. For each building block there is a function block which is characteristic of it and is mandatory for it to contain. There also exists a range of other functions which it is optional for the building blocks to contain. The examples in table 5 do not necessarily represent the final status of this ETR. Neither does table 5 restrict the range of the possible implementations. Table 5 is thus for further study.

Table 5: Relationship of TMN building block names to TMN function blocks

	NEF	MF	QAF	OSF	WSF
NE	M	O	O	O	O (NOTE 1)
MD		M	O	O	O
QA			M		
OS				M	O
WS					M

Key: M = Mandatory
O = Optional

NOTE 1: For the WSF to be present either the MF or OSF must also be present.

4.2 Interoperable interfaces

In order for two or more TMN elements to exchange management information they must be connected by a communication path and each element must support the same interface onto that communication path. It is useful to use the concept of an interoperable interface to simplify the communications problems arising from a multi-vendor, multi-capability network.

The connectivity of a TMN is confined by the message flow requirements.

The interoperable interface defines the protocol suite and the messages carried by the protocol. It is based upon an object oriented view of the communication and so all the messages carried deal with object manipulations. It is the formally- defined set of protocols, procedures, message formats and semantics used for the management of communications.

The message component of the interoperable interface provides a generalised mechanism for managing the objects defined for the information model. As part of the definition of each object there is a list of the type of management operations which are valid for the object. In addition, there are generic messages which are used identically for many classes of managed objects.

What distinguishes one interface in the architecture from another is the scope of the management activity which the communication at the interface must support. This common understanding of the scope of operation is termed SMK. SMK includes an understanding of the information model of the managed network (object classes supported, functions supported, etc.), management support objects, options, application context supported, etc. The SMK ensures that each end of the interface understands the exact meaning of a message sent by the other end.

4.3 Interfaces

Figure 17 allows the interconnection of the various TMN building blocks by a set of standard interoperable interfaces. The allowable interconnections of these standard interfaces within a given TMN may be controlled by both the actual interfaces provided and/or by security and routing restrictions provided within the various building block entities (e.g. passwords, log-ons, DCN routing assignments, etc.)

4.3.1 Definitions of the standard interoperable interfaces

Standard interfaces are defined corresponding to the reference points. They are applied at these reference points when external physical connections to them are required (see figure 12).

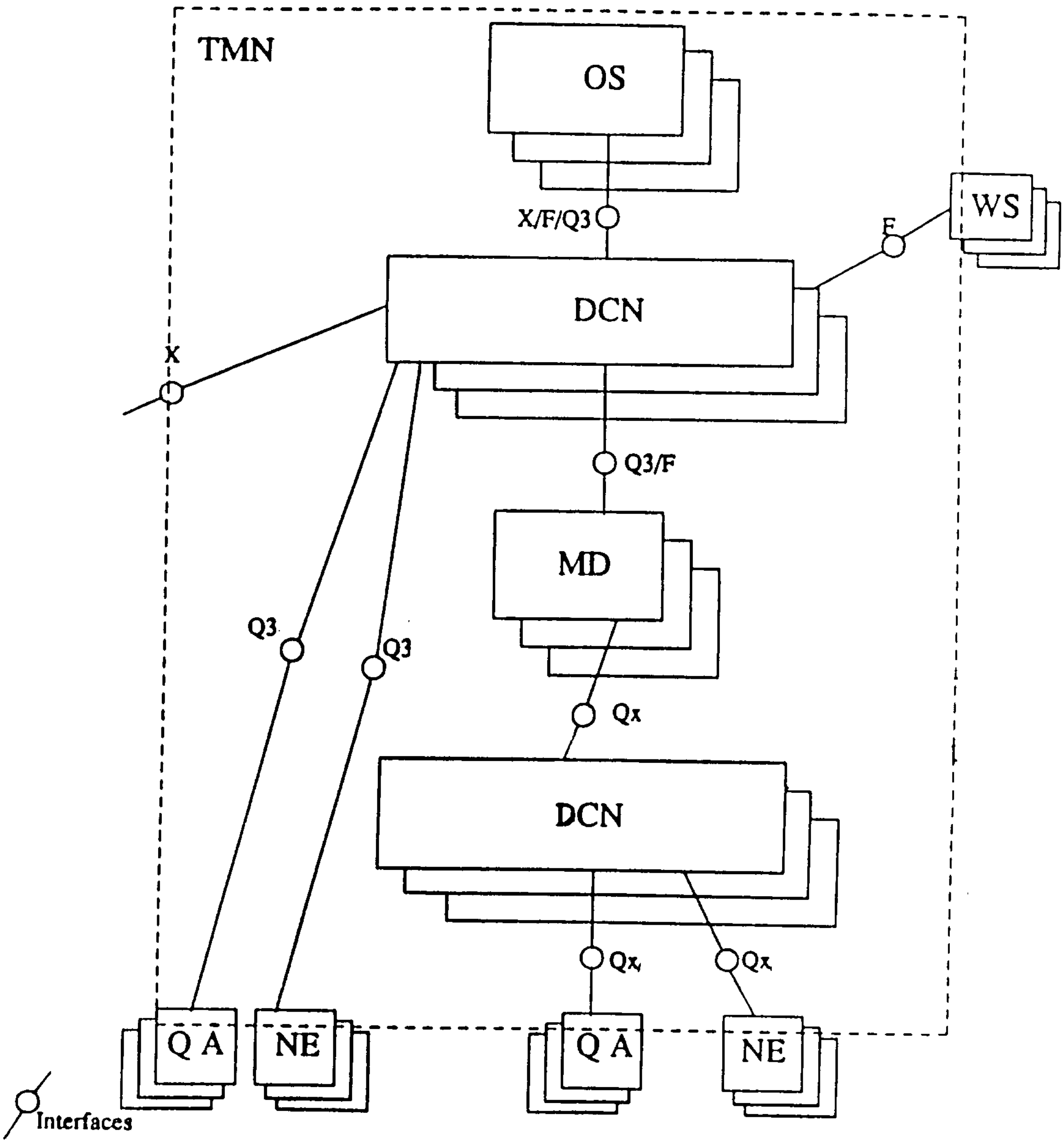
4.3.2 Q interface

The Q interface is applied at q reference points.

To provide flexibility of implementation, the class of Q interfaces is made up of the following subclasses:

- interface Q_x, intended to connect MDs to MDs, NEs to MDs, QAs to MDs, and NEs to NEs when one or both NEs contain a mediation function;

- interface Q_3, intended to connect MDs, QAs, NEs containing MF, and OSs to OSs via a DCN.



NOTE: Within this simplified example, the DCN is used to pair up like interfaces.

Figure 17: Simplified physical architecture example for a telecommunications management network

4.3.3 F interface

The F interface is applied at f reference points. The F interfaces connecting work stations remotely to the OSF or MF through a data communication network are included in this Technical Report. Direct connection of WSF to OSF or NEF is not the subject of this standardisation.

4.3.4 X interface

The X interface is applied at the x reference points. The purpose of an X interface is to interconnect two management systems or TMNs (see figure 17). It will be used to interconnect the TMNs of two separate administrations or an administration's TMN to an external service provider's TMN. As such this interface may require increased security over the level which is required by a Q type interface. It will therefore be necessary that aspects of security are addressed at the time of agreement between associations, i.e. passwords and access capabilities.

4.3.5 Relationship of TMN interfaces to TMN building blocks

Table 6 defines the possible interfaces which each named TMN building block can support. It is based upon the function blocks which table 5 associates with each building block and the reference points between function blocks, defined in table 2.

Table 6: Relationship of TMN interfaces to TMN building blocks

	Q_x	Q_3	X	F
NE	[0	0	0]	
MD	M (NOTE 1)	0	0	0
QA	[0	0]		
WS				M
OS		[0	0]	0

NOTE 1: A MD must always have a Q_x interface in order to be part of the TMN.

NOTE 2: At least one of the interfaces inside the box must be present.

4.4 TMN protocol families

There is a family of 4 protocols for each of the TMN interfaces; Q_3, Q_x, X and F.

The upper layers (layers 4 through 7) of each family are common and are the basis for ensuring interoperability. Some functionality of layer 7 may not always be required (e.g. file transfer).

The requirement of the lower layers is to carry the upper layers. Several network types have been identified as suitable for the transport of TMN messages such as those detailed in draft CCITT Recommendation Q.961. Any one or a mixture of sub-networks could be used so long as suitable interworking is made available.

For network equipment that does not have an interoperable interface there is a need to convert the protocols and messages into an interoperable interface format. This conversion is performed by MCFs and MFs which can reside in NEs or MDs.

4.5 Consideration of reference and physical configurations

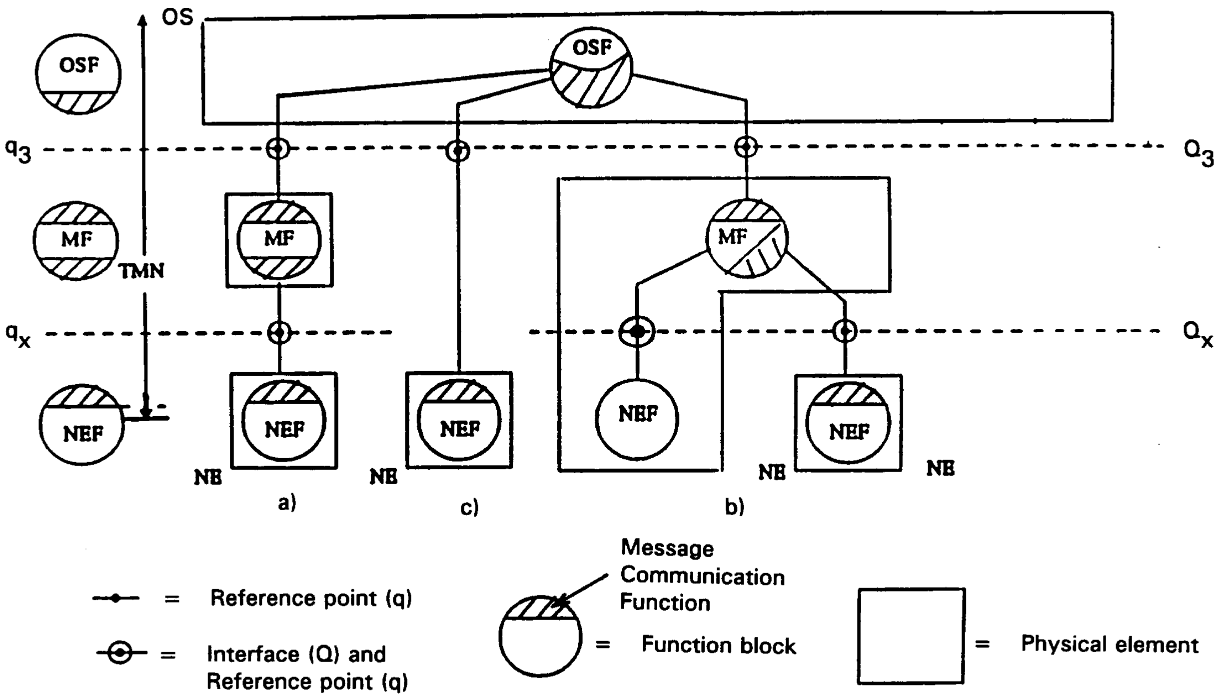
4.5.1 Physical realisation of the q class reference configuration

Figure 18 shows examples of the relationship of the physical configurations to the reference configuration with DCFs not explicitly shown. It illustrates combinations of physical interfaces at the reference points q_x and q_3. At reference points where a physical interface appears, this is denoted with a capital Q.

Figure 18, case a), shows an NE physically connected via a Q_x interface to an MD, an MD interconnected connected with OS via the Q_3 interface.

Figure 18, case b), shows an NE with an internal MF which is interconnected to an OSF via a Q_3 interface (also see NOTE 1). An external NE is also connected to this NE via a Q_x interface.

Figure 18, case c), shows an NE physically connected to an OS via a Q_3 interface.



NOTE 1: Where only a reference point is shown in the physical portion of figure 18, this means that the point is inside a physical box. The designer is free to apply any implementation. It is not necessary that this point is physically present inside the equipment.

NOTE 2: Any other equipment may be present between two adjacent boxes, which is necessary for the connection of these boxes.

NOTE 3: MCF is only provided in function blocks which communicate over a standard interface. As shown, communications between function blocks within a box is not supported by MCF.

Figure 18: Example of the relationship of the physical configuration to the reference configuration (with implicit DCF)

This equipment represents the DCF of figure 4. Such equipments perform OSI network functions, and are not shown in figure 18, e.g. the Q_3 interface normally connects to the DCN which provides the data communication to the OS.

Additional examples showing other physical configurations are given in Annex C.

4.5.2 Communication functions

4.5.2.1 DCN implementation examples

Section 2 has shown that the DCF is composed of:

a) the transmission and routing mechanism (networking role); and

b) the access mechanism allowing the management function blocks to attach to the transmission mechanism.

In the case where different technologies are involved in the provisioning of the DCN (e.g. CCITT Recommendation X.25 based functions are interconnected to LAN based functions), the DCN continuity is provided by a function known as a communication relay. Different types of communication relays exist and depending of their level of intervention in the protocol stacks they will be named bridges, routers or transport relays.

Such boxes are typically composed of a relay function associated with two access functions as depicted in the example of figure 19.

Additional considerations are required when DCN/DCN interworking is required at the higher layers. When, for example in figure 20, a complete stack is used on the Q_3 side of the MD and a stack with a convergence function is used on the Q_x side, the TMN model imposes that the DCN to DCN protocol interworking conversion at the higher layers is done by an MF (i.e. it would be typically implemented in an MD).

See the CCITT X. Series of Recommendations for additional details about these relay and interworking functions.

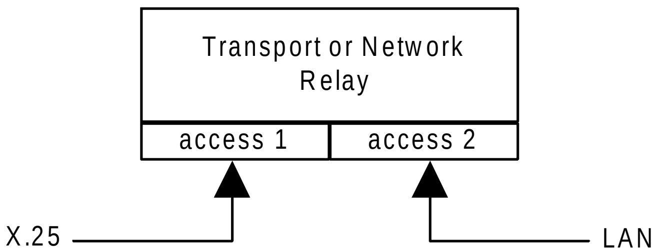


Figure 19: Communication relay implemented via two DCNs

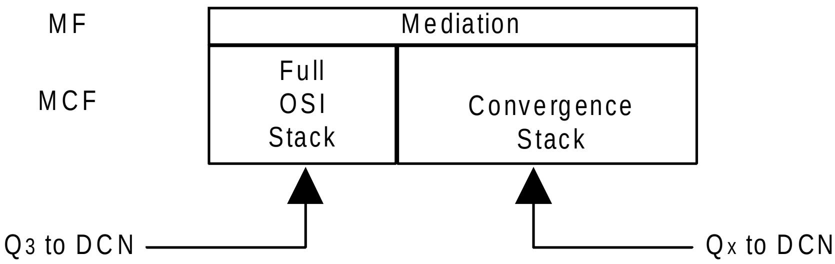


Figure 20: Example of higher layer interworking

4.5.2.2 MCF considerations

The MCF allows managers or agents to interwork across the DCN and provides the access mechanism allowing the management function blocks to attach to the transmission mechanism. When different technologies are used the use of two MCF within one device (e.g. MD or OS or QA) may allow protocol conversion.

The following figures, 21 and 22, show examples of how various MCFs are used in various physical devices to provide the DCF in an SDH environment.

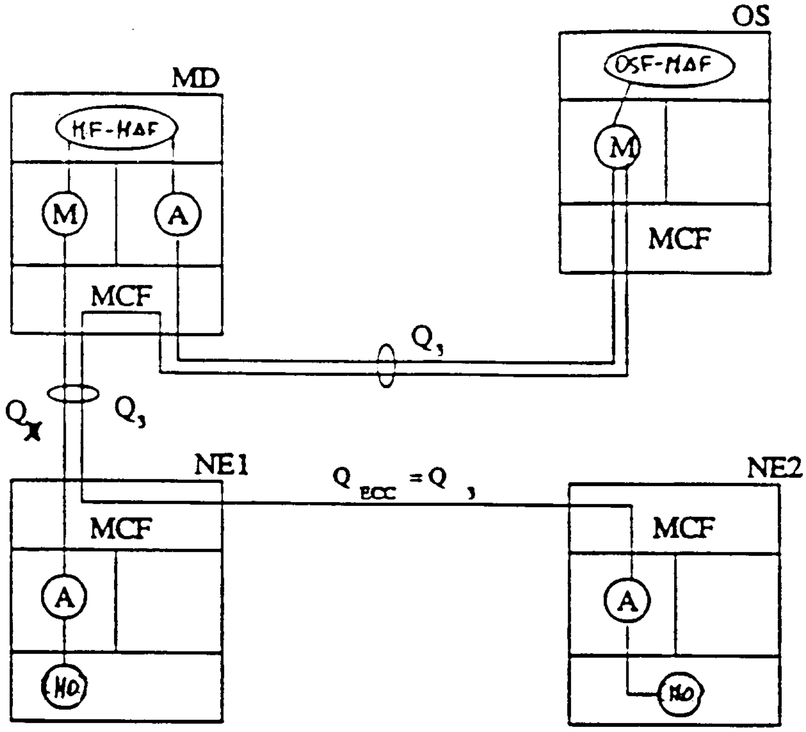
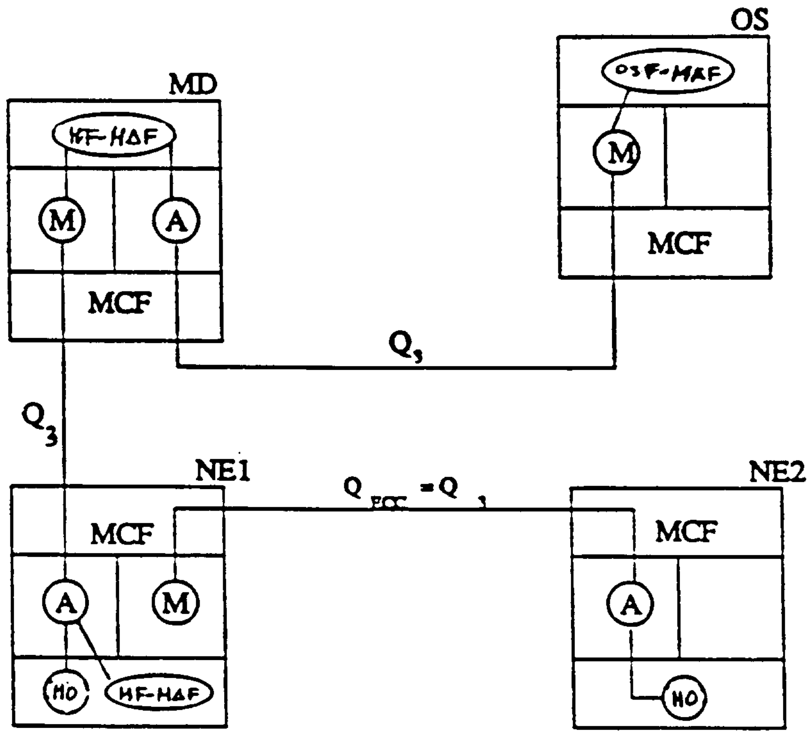


Figure 21: SDH Management example



OSF-HAF	=	OS Function Management Application Function
HF-HAF	=	Mediation Function Management Application Function
MCF	=	Management Communication Function
A	=	Agent
M	=	Manager
OS	=	Operation System
MD	=	Mediation Device
NE	=	Network Element
MO	=	Managed Object

Figure 22: SDH Management example

5 Detailed TMN architectural considerations

5.1 General

The TMN architecture must provide a high degree of flexibility to meet the various topological conditions of the network itself and the organisation of the Administrations. Examples of the topological conditions are the physical distribution of the NEs, the number of NEs and the communication volume of the NEs. Examples of the organisation are the degree of centralisation of personnel and the administrative practices. The TMN architecture will be such that the NEs will operate in the same way, independently of the OS architecture.

5.1.1 Messaging availability/reliability

The TMN must be designed to prevent a single fault from making the transfer of critical management messages impossible. It should also be taken into account that congestion in the DCN does not cause the blocking or excessive delay of network management messages that are intended to correct the congestion situation to restore a failed system.

As an example of the single fault situation, in a critical NE such as a local switch, a separate channel can be provided for emergency action. The emergency action function, when provided, requires an independent maintenance capability when the normal OS is inoperative or when the NE has degraded to the point where the normal surveillance functions cannot operate. For these reasons, the emergency action OS may be separate from the normal maintenance OS, although they are usually at the same location. OSs and NEs which provide the emergency action function may require at least two physical access channels to the DCN for redundancy.

Another example is a TMN which is used to determine charges to the customers. The OSs and the NEs which are associated with this function require at least two physical DCN communication channels in order to provide sufficient reliability in the process of OSs collecting charging messages from the NEs.

The nature of transmission line systems provides the possibility to transport a management message in two directions so that, assuming only one fault exists at a time, one of the two directions is available.

5.2 Operation systems

5.2.1 Functional OS configuration

This section builds on the concepts described in subclause 3.5 on the logical layered architecture.

There are many types of OSFs, dependent on the structure of the TMN. A categorisation of OSFs based upon ascending abstraction is: business, customer, service, network and basic.

Some TMN implementations may include business OSFs which are concerned with a total enterprise (i.e. all services and networks) and carries out an overall business co-ordination. Service OSFs are concerned with the service aspects of one or more networks and will normally perform a customer interfacing role.

Network OSFs cover the realisation of network based TMN application functions by communicating with basic OSFs. Thus the basic and network OSFs provide the functionality to manage a network by co-ordinating activity across the network and support "network" demands of service OSFs. Basic OSFs and network OSFs share infrastructure aspects of a telecommunications network. In smaller networks basic OSFs may not be present and network OSFs will communicate with NEFs and/or MFs directly.

Further description can be found in Annex B.

5.2.2 Physical OS configuration

OS physical architecture must provide the alternatives of either centralising or distributing the OS functions and data, which include:

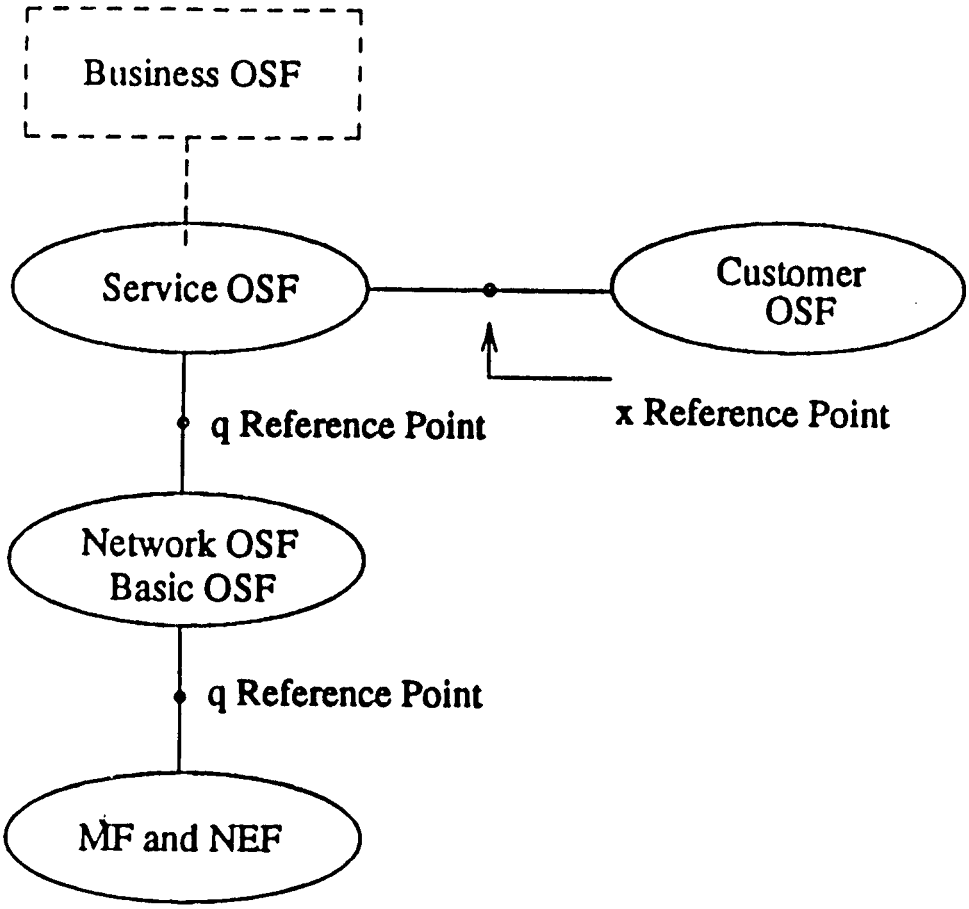
a) support application programs;

b) data base functions;

c) user terminal support;

d) analysis programs;

e) data formatting and reporting.



NOTE 1: Customer OSF is a peer of Service OSF.

NOTE 2: Splitting of Network OSF and Basic OSF is an item for further study.

Figure 23: Example of an OS functional architecture

A distributed OS architecture may be chosen for various reasons. More study is required on how communications between distributed OS functions may be accommodated under the TMN architecture.

The OS functional architecture may be realised on various numbers of OSs, depending on the network size.

The categorisation of TMN protocol selection attributes as given in tables A.A.1 to A.A.3 of Appendix A of Annex A are also important factors in the OS physical architecture. For example, the choice of hardware depends strongly on whether an OS provides real time, near real time or non-real time service.

Normally OS functions will be implemented in a set of OSs with a Q_3 interface connected to the DCN. However, this should not preclude a practical realisation whereby these functions are implemented in an NE or an MD.

5.3 TMN data communication considerations

5.3.1 Data communication network considerations

A DCN for a TMN should, wherever possible, follow the reference model for open systems interconnection for CCITT applications as specified in CCITT Recommendation X.200.

Within a TMN the necessary physical connection (e.g. circuit switched or packet switched) may be offered by communication paths constructed with all kinds of network components, e.g. dedicated lines, public switched data network, Integrated Services Digital Network (ISDN), common channel signalling network, Public Switched Telephone Network (PSTN), LANs, terminal controllers, etc. In the extreme case the communication path provides for full connectivity, i.e. each attached system can be physically connected to all others.

All connections not using a type Q, F or X interface are outside of a TMN.

A DCN connects NEs, QAs and MDs to the OSs at the standard Q_3 level. Data communication links will also be used to connect MDs with NEs and QAs using a Q_x interface. The use of standard Q type interfaces enables maximum flexibility in planning the necessary communications.

A DCN can be implemented using point-to-point circuits, a circuit switched network or a packet switched network. The facilities can be dedicated to a DCN or be a shared facility (e.g. using CCITT SS7 or an existing packet switched network).

An OS must provide for two types of data communication; the spontaneous transmission of messages concerning problems from the NE to the OS and the two-way dialogue as the OS obtains supporting information from the NE and sends commands to the NE or transfers messages to/from another OS. In addition, an OS is responsible for assuring the integrity of the data channels through a data communication network.

Within a TMN, the necessary physical connection may be locally offered by all kinds of sub-network configurations, e.g. point-to-point, star, bus, or ring.

5.3.3 Message communication considerations

Within a TMN the communications functions such as protocol conversion and communications relay functions are performed by MCF. The MCF interfaces all function blocks and consists of one or more of the following processes.

1) Communications control :

   - polling;

   - addressing;

   - communications networking;

   - ensuring integrity of data flows.

2) Protocol conversion:

3) Communications of primitive functions:

- command/response statement;
- alarm statements;
- alarm forwarding;
- test results/data;
- operational measurement data;
- upload of status report;
- local alarming.

5.4 Mediation

Mediation is a process within the TMN which acts on information passing between NEs and OSs and provides local management functionality to the NEs. Mediation uses standard interfaces and can be realised in a separate MD or be shared among NEs and/or OSs.

5.4.1 Mediation considerations

Typically, mediation will fulfil one of two roles. To provide management functionality to a number of similar network elements (e.g. modems or transmission equipment, etc.) or provide management functionality to one network element (e.g. digital switch) (see figure 24).

Mediation can be implemented as a hierarchy of cascaded devices using a standard interface.

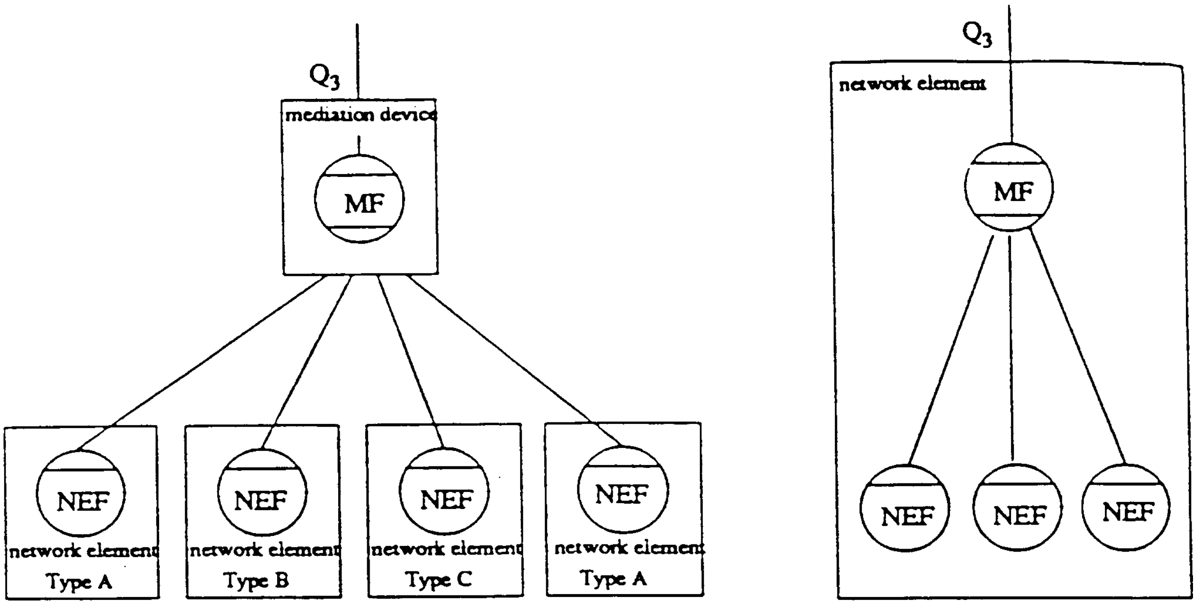


Figure 24: Example use of Mediation

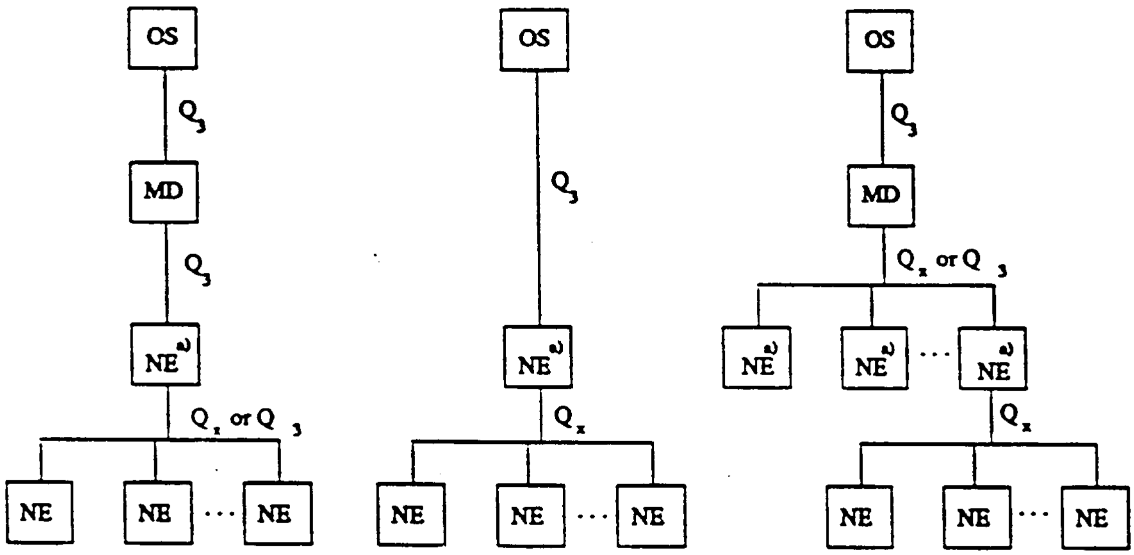
The cascading of mediation devices and various interconnection structures between MDs on one hand and MDs and NEs on the other hand provides for great flexibility in the TMN. Some options are shown in figure 25. It enables cost effective implementations of the connection of NEs of different complexity (e.g. switching equipment and transmission multiplex equipment) to the same OS. In addition, it gives the capability for future design of new equipment to support a greater level of processing within individual NEs, without the need to redesign an existing TMN.

It may be possible to recognize a process similar to the one above in some NEs. For the purpose of this ETR, it is convenient to regard the function of mediation as being wholly contained within the TMN.

However, this does not preclude practical realisations where some or all of the mediation function are implemented within the NE, which must still interface within the TMN via a standardised Q interface.

5.4.2 Processes of mediation

Mediation is a process that routes and/or acts on information passing between NEs, QAs and OSs. The processes that can form mediation can be classified into five general process categories.



OS = Operations System
MD = Mediation Device
NE = Network Element
a) = NE contains MF

Figure 25: Examples of cascaded network elements

A number of more specific processes can be identified within each of these general process categories, some examples of which are given below. Mediation may consist of one or more of these specific processes:

1. Processes involving information conversion between information models (refer to subclause 2.2.3):

    - translating between information models (e.g. object model);
    - translating multiple information models to a generic information model;
    - structuring non-object oriented data to an information model;
    - augment and enhance information in the translation process from a local MIB to be compliant with the generic information model.

2. Processes involving higher order protocol interworking:

    - connection establishment and connection negotiation;
    - maintaining the communication context.

3. Processes involving data handling:

    - concentration of data;
    - compression or reduction of data;
    - collection of data;
    - data formatting;
    - data translation.

4. Processes involving decision making:

   - work station access;
   - thresholding;
   - data communications back-up;
   - routing/re-routing of data;
   - security (e.g. log-on procedures);
   - fault sectionalisation tests;
   - circuit selection and access for tests;
   - circuit test analysis.

5. Processes involving data storage:

   - data-base storage;
   - network configuration;
   - equipment identification;
   - memory back-up.

Certain mediation processes may be carried out autonomously.

The mediation function of the TMN permits a flexible design of the NE to OS architecture. Different architectural designs for operations, administration and maintenance communications can be accommodated in the same TMN by appropriate implementation of the hierarchical configuration of mediation. By these means, NEs of different complexity (e.g. switching exchange or multiplex equipment) can connect into the same TMN.

5.4.3 Implementation of mediation processes

Mediation processes can be implemented as stand-alone equipment or as part of an NE or a QA. In either case the mediation function remains part of the TMN.

In the stand-alone case the interfaces towards the NEs, QAs and OSs are one or more of the standard operations interfaces (Q_x and Q_3). Where mediation is part of an NE only the interfaces towards the OSs are specified as one or more of the standard operations interfaces (Q_x and Q_3). Mediation that is part of an NE (e.g. as part of a switching exchange) may also act as mediation for other NEs. In this case standard operations interfaces (Q_x or Q_3) to these other NEs are required.

The mediation functions within an NE, which carry out mediation functions for other NEs, is considered a part of the TMN.

5.5 Network element considerations

In the functional reference model, figure 6, a NE performs the NEF and may in addition perform one or more MFs or QAFs.

The study of various application examples leads to the desirability to distinguish between the following functions contained in a NEF:

- The Maintenance Entity Function (MEF) is involved in the telecommunication process. Typical MEFs are switching and transmission. A Maintenance Entity (ME) can contain one or more MEFs;

- The Support Entity Function (SEF) is not directly involved in the telecommunication process. Typical SEFs are failure localisation, billing, protection switching. A Support Entity (SE) can contain one or more SEFs.

This approach to definition of the parts of an NE which perform operations functions implies the following relationships:

- A NE contains MEs or SEs or both MEs and SEs;

- A NE may or may not contain a QA.

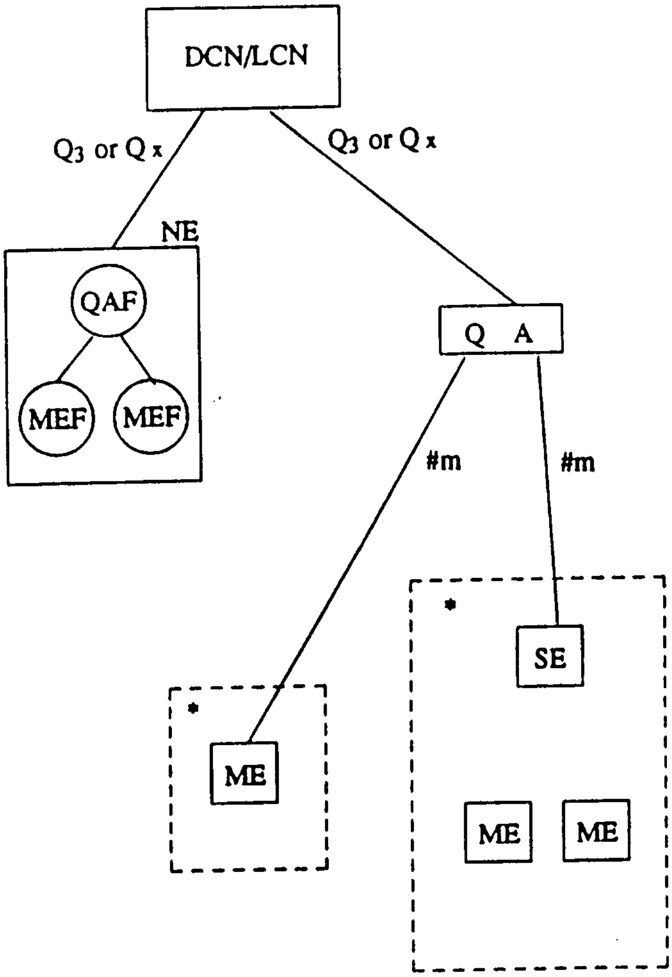
  NOTE: The various parts of an NE are not geographically constrained to one physical location. For example, the parts may be distributed along a transmission system.

5.6 Q-Adaptor considerations

The QAF is used to connect to the TMN those MEs and SEs which do not provide standard TMN interfaces. Typical QAFs are interface conversion functions. A Q-adaptor (QA) can contain one or more QAFs and may also contain MFs.

A Q-adaptor can support either a Q_3 or Q_x interface.

Figure 26 depicts an example of a QA connecting equipment outside TMN with the TMN.



NE = Network Element
ME = Maintenance Entity
SE = Support Entity
QA = Q-Interface Adaptor
DCN = Data Communications Network
LCN = Local Communications Network
QAF = Q-Interface Adaptor Function
MEF = Maintenance Entity Function

Any interface at the "m" reference point is not subject to standardisation
* Other equipment in the telecommunications environment

Figure 26: QA configuration examples

5.7 Work stations

In figures 3 and 17 the Work Station (WS) reference points and interfaces are shown. It is recognised that across these interfaces work stations may access any suitable TMN component, and that work stations vary in power and capabilities. Nevertheless, for the purpose of this ETR the work station is considered to be a terminal connected via a data communication network to an operations system or a device with mediation function. This terminal has sufficient data storage, data processing, and interface support, to provide functionality to translate the information held in the TMN information model, and available at the f reference point, to a displayable format for presentation to the user at the g reference point. The terminal also provides the user with data input and edit facilities to manage objects in the TMN.

For the purpose of this ETR workstations do not include any OSF. If OSF and WSF are combined in an implementation, that implementation is considered an OS. Therefore, a workstation must have an F interface.

5.7.1 Presentation function

The presentation function performs the general operations to translate the information held in the information model, and available at the f reference point, to a displayable format for the human at the g reference point, and vice-versa. The PF provides the user with physical input, output, and edit facilities to enter, display, and modify details about objects. This removes the need for OSF/MF to be involved in the management of the users terminal (apart from network security aspects). If the PF resides in a TMN component which also performs human machine adaptation, the f reference point is said to be within that component, consequently, in that case no F interface exists. The human machine interface (g reference point), whether it is command line, menu driven, or window based, is supported by the PF and is independent of the OSF/MF and therefore not evident at the F interface.

5.7.2 g functions

The g functions provide the user at the terminal with the general functions to handle input and output of data to the user's terminal. The functions are:

- security access, login, etc to the terminal;
- recognize and validate input;
- format and validate output;
- support the menus, screens, windows, scrolling, paging, etc.;
- access to OSs, with security if required;
- screen development tools to allow:

  development, modification of screen layouts;
  definition of fixed text;
  help information;
  field validation rules.

- maintain database of screens;
- user input edit facilities:

  backspace, rubout, undo, etc.;
  notepad;
  cut and paste;
  diary.

The g functions are listed here only for clarity. Details concerning g functions are contained in the Z series of CCITT Recommendations.

5.7.3 f functions

These provide the capability to manage the data flow across the f reference point and are arranged in directional lists, PF to HMA and from HMA to PF.

PF to HMA:

- access scope negotiation;
- request object details;
- request help information;
- handbooks;
- tutorials;
- request attribute verification rules;
- search and query database;
- operations to initiate functions;
- commands etc.

HMA to PF:

- access and authentification management;
- non-repudiation;
- audit trails;
- permissions;
- display object requests;
- alarms;
- performance data;
- helps;
- operator forums;
- display files.

5.8 TMN standard interfaces

TMN standard interfaces provide for the interconnection of NEs, QAs, OSs, MDs and WSs through the DCN. The goal of an interface specification is to assure compatibility of devices interconnected to accomplish a given TMN application function independent of the type of device or of the supplier. This requires compatible communication protocols and a compatible data representation method for the messages, including compatible generic message definitions for TMN application functions. A minimum set of protocol suites to be applied to TMN standard interfaces should be determined according to the recommendation included in M.3020 [5].

Consideration should be given to compatibility with the most efficient data transport facilities available to reach individual network elements (e.g. leased circuits, circuit switched connections, CCITT Recommendation X.25 packet switched connections, CCITT Signalling System No. 7, embedded operations channels and ISDN access network D and B channels).

It is recognised that NEs, QAs, OSs, DCNs, LCNs, MDs and WSs may have other interfaces in addition to the Q, F, and X interfaces defined in this ETR. It is also recognised that this equipment may have other functionality in addition to that associated with information sent or received via Q, F and X interfaces. These additional interfaces and related functionality are outside of the TMN.

5.8.1 Q_x interface

The function attributes required at the Q_x interface are strongly dependent on the mediation functions needed as well as the mediation function participating between cascaded MDs. Since the purpose of putting MDs between OSs and NEs is to give flexibility of the implementation, mediation function partitioning should not be restricted to only one case.

The choice of individual protocol suites from the recommended Q_x family should be left open to the administrations.

The protocol suites to be applied to the Q_x interfaces need not implement all layers of the OSI model. Details of the Q_x interface specification and the Q_x family of protocol suites are given in CCITT Recommendation G.773.

5.8.2 Q_3 interface

For the Q_3 family it is recommended that each set of TMN application functions with similar protocol needs are supported with unique protocol selections for layers 4 to 7 as defined by the OSI Reference Model (CCITT Recommendation X.200). The nulling of service options of individual layers above layer 3 and even entire layers above layer 3 may be necessary for justifiable economic reasons. Also, protocol options are likely to be required for the Q_3 family for layers 1, 2 and 3 in order to permit the use of the most efficient data transport.

Details of the Q_3 interfaces and the Q_3 family of protocols will be given in CCITT Recommendations Q.961 and Q.962.

Annex A

A.1 Planning and design considerations

A TMN should be designed such that it has the capability to interface with several types of communications paths to ensure that a framework is provided which is flexible enough to allow for the most efficient communications between the NE and the TMN, work stations and the TMN, between elements within the TMN, or between TMNs.

The basis for choosing the appropriate interfaces however, should be the functions performed by the elements between which the appropriate communications are performed.

The interface requirements are measured in terms of function attributes that are required to provide the most efficient interface.

The following is a listing of the function attributes.

This list is incomplete and will be subject to further study.

A.1.1 Functions attributes

a) Reliability.

The capability of the interface to ensure that data and control is transferred such that integrity and security are maintained.

b) Frequency.

How often data is transferred across the interface boundary.

c) Quantity.

The amount of data that is transferred across the interface during any transaction.

d) Priority.

Indicates precedence to be given to data in case of competition for network resources with other functions.

e) Availability.

Determines the use of redundancy in the design of the communications channels between interfacing elements.

f) Delay.

Identifies the amount of buffering that may be tolerable between interfacing elements.

This also impacts communications channel designs.

Appendix A to Annex A of this ETR provides a table of possible ranges for these function attributes and provides a definition for each range suggested.

A.1.2 Functional characteristics

Each major type of telecommunications equipment has functional characteristic needs that can be used to describe the complexity of the interface.

There are, however, a basic group of TMN application functions that cross all major types of telecommunications equipment.

However, there are also unique TMN application functions that are performed by specific categories of major telecommunications equipment.

Alarm surveillance is an example of the former, whereas billing information collection is an example of the latter.

Functional characteristics of the elements within a TMN, e.g. OS, DCN, MD also describe the complexity of interfaces between these elements.

Thus an identification of the functions performed by the elements within a TMN are also important considerations in determining the appropriate interfaces both within the TMN and to the NEs.

A.1.3 Critical attributes

Attribute values for a given function are generally consistent across the network elements.

When considering a single Q interface it is important to identify the controlling attribute ranges for the design of the interface.

If there are conflicting attribute values for different functions in a given network element, more than one interface may be needed.

Overall TMN attribute values for the interfacing of elements within the TMN depend on the type and number of functions performed within these elements.

In this case the functions are not consistent across TMN elements, but are controlled by the individual TMN design of an administration.

A.1.4 Protocol selection

In many cases more than one protocol suite will meet the requirements for the network element or TMN element under consideration.Care should be taken by the administration to select the protocol suite that optimises the relationship between the total cost to implement that protocol suite and the data communications channels that carry the information across the interface.

The subject of protocol selection methodology will require further study in conjunction with other ETSI Technical Committees.

A.1.5 Communications considerations

DCN architectures must be planned and designed to ensure that their implementation provides appropriate degrees of availability and network delay while minimising cost.

One must consider the selection of communications architectures, e.g. star, multipoint, loop, tree.

The communications channels, e.g. dedicated lines, circuit switched networks and packet networks used in providing the communications paths, also play an important role.

A.1.6 TMN naming and addressing

For the successful introduction of a TMN (within an OSIE) into an administration, a logical, integrated naming and addressing scheme for identifying and locating the various communications objects within a TMN is critical. In order to locate TMN systems and identify various entities within each system, unambiguous naming methods are required.

The following text provides information on the issues involved in creating and using naming and addressing schemes for use within the TMN environment.

This overview is incomplete and is the subject of further study.

A.1.6.1 Principles for naming schemes

This section presents some principles for the design of naming schemes:

Some properties of the names are:

- they are required to be unique or unambiguous;
- they are primarily for use by computers;
- mappings between various of the names (such as from AE-title to presentation; address) are expected to involve "directory" functions;
- The directories may be held locally and/or off-system.

A.1.6.1.1 Unambiguous naming

When names are required to be unique or unambiguous (globally), a mechanism is required for co-ordinating naming activities among organisations (administrations). This is generally achieved at the global level by systematically dividing the set of all possible names into subsets.

The relevant OSI names and addresses that should be unambiguous on a wide scale are:

- NSAP addresses;
- system titles (including application process titles and application entity titles).

The relevant OSI names and addresses that should be unambiguous within a particular system are:

- selectors;
- AE-qualifiers, AP-invocation-identifiers, AP-invocation-identifier.

A.1.6.1.2 Name structure

Structure is the assignment of meaning to sub-elements of a name. Reasons for incorporation of structure into names are:

- to identify naming authorities;
- for CCITT or ISO reasons;
- for purposes identified by naming authorities.

Many factors need to be taken into account, e.g.:

- impact of directories - implementations of directory systems;
- user-friendliness;
- incorporation of other names;
- location changes;
- mobile services.

A.1.6.1.3 Application layer names

Administrations will need to consider:

- definition of an Application Process (AP)-title;
- the derivation of other application layer identifiers from the basis of the AP-title scheme.

AP-titles have Object Identifier (OID) format. The OID tree is designed to facilitate unambiguous naming of OSI objects and functions by successive delegation of naming authority.

There are several aspects to consider for the AP-title scheme.

- determination of the co-ordinating authority and it's "location" in the OID tree;
- structuring the co-ordinating authority's sub-tree for the allocation of system-titles;
- structuring the sub-tree under each system-title node for derivation of AP-titles.

A.1.6.2 Addresses

An Application Entity (AE)-title maps to a presentation address which maybe represented by the tuple:

(P-selector,S-selector,T-selector, list of network addresses)

The selectors are identifiers that are local to a system, that is, they can be set independently in regard to other systems. However, a set of standardised values for selectors should be established for administrative reasons.

It is recommended that there should be few assigned selector values as possible. Further, the lengths should be small.

The NSAP should be based on CCITT Recommendation X.2xx.

Appendix A to Annex A:

A.A.1 Tables of function attribute ranges

The TMN should be designed such that it has the capability to interface with several types of communications paths, to ensure that a framework is provided which is flexible enough to allow for the most efficient communications between the NE and the TMN, workstations and the TMN, between elements within the TMN or between TMNs.

In this case the term efficiency relates to the cost, reliability and quantity of the data transported.

Costs are impacted by two aspects.

The first is the actual cost to transport data across the network between the TMN and the NE.

To minimize this cost various network architectures are considered, e.g., star, multipoint, loop, tree.

The communications required must also be considered, e.g. leased circuits, circuit switched or packet-switched networks.

In making this choice, network availability and cross-network delays must be evaluated as attributes to be used in the decision-making process.

The second aspect is the design of the interface including the selection of the appropriate communications protocol.

In this case there are several attributes associated with functions performed within the NE that would help to govern this choice.

These attributes include: reliability, frequency, quantity and the requirement for priority.

This Appendix to Annex A provides tables of ranges for each of the function attributes that should be taken into consideration when planning the design of the data communications channels and selecting the appropriate protocol to be used to interface between a TMN and NE, TMN and workstation, or between elements within a TMN.

Table A.A.1 shows the basic function attributes.

Table A.A.2 shows examples of TMN attributes to support the OSs requiring real-time operations.

Table A.A.3 shows examples of the same attributes for a non real-time OS.

Table A.A.1: Basic table of function attributes

	Attributes	Requirements		Nature of attributes
Performance, or grade of service (P)	Delay (speed)	Short Medium Long		Objective of design and control (acceptable/ unacceptable)
	Reliability (accuracy)	High Medium Low		
	Availability	High Medium Low		
Characteristics of TMN traffic (C)	Quantity	Large Medium Small		Condition or parameter of design and control
	Frequency	Non-periodic	Often Medium Seldom	
		Periodic	Often Medium Seldom	
	Priority	High Medium Low		

Table A.A.2: Example of function attributes for real-time operation (NOTES 1, 2)

	Attributes	Requirements		Attribute ranges
(P)	Delay (speed)	Short Medium Long		Network delay < 1 s Network delay ≤ 10 s Network delay > 10 s
	Reliability (accuracy)	High Medium Low		No errors (goal) Infrequent errors (not service affecting) Can tolerate errors
	Availability	High Medium Low		Network availability > 99.95% Network availability > 99.5% Network availability < 99.5%
(C)	Quantity	Large Medium Small		> 256 octets per transaction (10^6 to 10^7 octets per job) (NOTE 3) < 256 octets per transaction < 16 octets per transaction
	Frequency	Non-periodic	Often Medium Seldom	> 1 transaction per 10 ms > 1 transaction per 10 s < 1 transaction per 10 s (week, month) (NOTE 3)
		Periodic	Often Medium Seldom	> 1 transaction per 10 s > 1 transaction per minute < 1 transaction per minute (hour, day) (NOTE 4)
	Priority	High Medium Low		

NOTE 1: "Real-time" has a two fold meaning:

a) on-line activities consistently carried out from time-to-time, such as sampling of system status (type A);

b) activities that are not frequently done but require quick operation once they have been called for (type B).

NOTE 2: Attributes can be considered for:

a) each command, each enquiry, the responses to them, and each spontaneous report;

b) an operation which consists of the combination of the categories in a), e.g. a command and its response.

NOTE 3: For example, file loading, system recovery, etc. (type B).

NOTE 4: For example, system file saving, call data saving, etc.

Table A.A.3: Example of function attributes for non-real-time operation (NOTES 1, 2)

	Attributes	Requirements		Attribute ranges
(P)	Delay (speed)	Short Medium Long		Network delay < 30 s Network delay < 15 min Network delay ≥ 15 min
	Reliability (accuracy)	High Medium Low		No errors (goal) Infrequent errors (not service affecting) Can tolerate errors
	Availability	High Medium Low		Network availability > 99.95% Network availability > 99.5% Network availability < 99.5%
(C)	Quantity	Large Medium Small		> 4096 octets per transaction (10^6 to 10^7 octets per job) (NOTE 3) < 256 octets per transaction < 16 octets per transaction
	Frequency	Non-periodic	Often Medium Seldom	> 1 transaction per minute ≥ 1 transaction per hour < 1 transaction per hour (week, month) (NOTE 3)
		Periodic	Often Medium Seldom	> 1 transaction per minute ≥ 1 transaction per hour < 1 transaction per hour
	Priority	High Medium Low		

NOTE 1: Non-real-time operation can include both off-line and on-line operations.

NOTE 2: Attributes can be considered for:

a) each command, each enquiry, the response to them, and each spontaneous report;

b) an operation which consists of the combination of the categories in a), e.g. a command and its response.

NOTE 3: For example, file loading, system recovery, etc. (type B).

A.A.2 References

[1] CCITT Recommendation Z.331, Vol. X: "Introduction to the specifications of the man-machine interface".

[2] CCITT Recommendation X.200, Vol. VIII: "Reference model of open systems interconnection for CCITT applications".

[3] CCITT Recommendation G.771, Vol. III: "Q-interfaces and associated protocols for transmission equipment in the telecommunication management network (TMN)".

[4] CCITT Recommendation Q.513, Vol. VI: "Exchange interfaces for operations, administration and maintenance".

[5] CCITT Recommendation M.3020: "TMN Interface Specification Methodology".

[6] CCITT Recommendation M.3100: "Generic Network Information Model".

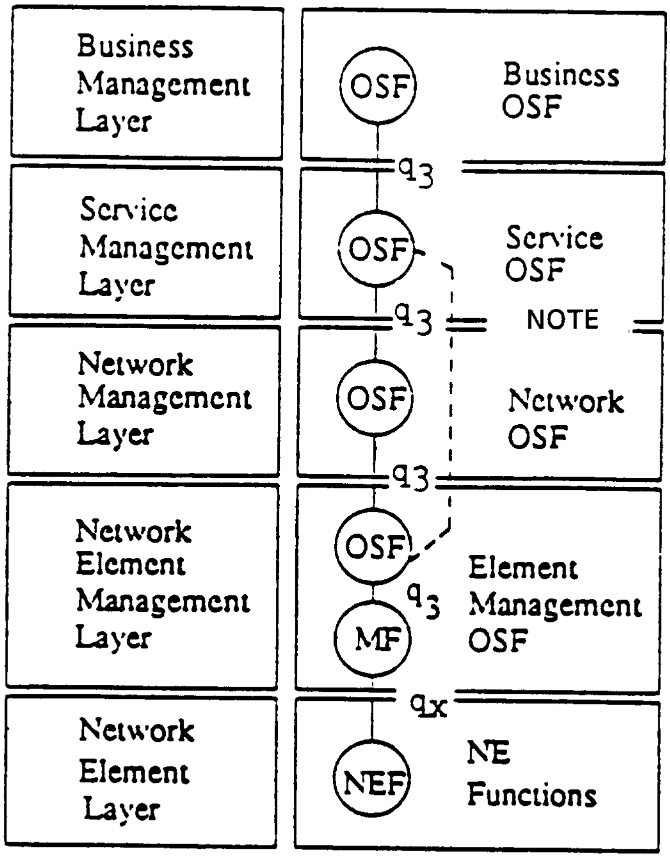
[7] CCITT Recommendation M.3010: "Principles for a Telecommunications Management Network".

Annex B: Examples of functional architectures

B.1 Functional TMN hierarchy

For operational purposes, the management functionality may be considered to be partitioned into layers. Each layer restricts management activity within the boundary of the layer to a clearly defined rank, that is concerned with some sub set of the total management activity.

NOTE: The architectures contained in this Annex are limited to the functional hierarchy of the TMN and therefore do not necessarily dictate the physical hierarchy of operation systems and mediation devices.



NOTE: In some instances it may be possible for administrations to bypass layers of communication within the functional hierarchy.

Figure B.1: Example of a TMN OS functional hierarchy

B.2 The management layers of the architecture

The management layers of the architecture are illustrated in figure B.1.

B.2.1 Element management layer

The element management layer manages each network element on an individual basis and supports an abstraction of the functions provided by the NE layer.

The element management layer has a set of element managers, that are individually responsible, on a devolved basis from the network management layer, for some subset of network elements.

Each element manager has the following 3 principal roles:

1) control and co-ordination of a subset of network elements;

2) providing a gateway (mediation) function to permit the network management layer to interact with network elements;

3) maintaining statistical, log and other data about elements.

The element management layer always interfaces with the network management layer through a q_3 reference point.

NOTE: All mediation functions, including those physically located elsewhere (e.g. in a network element) are logically located in the element management layer.

B.2.2 Network management layer

This layer which has a set of network managers has the responsibility for the management of all the network elements, as presented by the element management layer, both individually and as a set. It is not concerned with how a particular element provides services internally.

At this layer, functions addressing the management or a wide geographical area are located. Complete visibility of the whole network is typical and a vendor independent view will need to be maintained.

The network manager layer has 3 principle roles:

1) the control and co-ordination of the network view of all network elements within its scope or domain;

2) the provision, cessation or modification of network capabilities for the support of service to customers;

3) interact with the service manager layer on performance, usage, availability, etc.

Thus the network management layer provides the functionality to manage a network by co-ordinating activity across the network and supports the "network" demands made by the service management layer.

The network management layer always interfaces with the service management layer through a q_3 reference point.

B.2.3 Service management layer

Service management is concerned with, and responsible for, the contractual aspects of services that are being provided to customers or available to potential new customers. It has 5 principle roles:

1) customer facing (see NOTE) and interfacing with other administrations/RPOAs;

2) interaction with service providers;

3) interaction with the Network Management Layer;

4) maintaining statistical data, e.g. Quality Of Service (QOS);

5) interaction with the business management layer;

6) interaction between services.

NOTE: Customer facing provides the basic point of contact with customers for all service transactions including, provision/cessation of service, accounts, QoS, fault reporting, etc.

The service management layer always interfaces with the business management layer through a q_3 reference point.

Service management layers interface with other service management layers (e.g. basic service providers interface to value added service providers) through q_3 or x reference points. Basic and value added services are described in Clause B.3 of Annex B.

B.2.4 Business management layer

The business management layer has responsibility for the total enterprise and is the layer at which agreements between operators are made.

This layer normally carries out goal setting tasks rather than goal achievement but can become the focal point for action in cases where executive action is called for. This layer is part of the overall management of the enterprise and many interactions are necessary with other management systems.

B.3 Value added services

Value Added Services (VASs) may be supplied by network operators or Value Added Service Providers (VASPs) and are services provided in addition to the basic services available on a network.

It is not possible to permanently split services between basic and value added as value added services can, over a period of time, become basic.

However value added services may be identified as those services which can be provided by service providers other than the network operator. Provision of these services may be subject to local regulation.

Figure B.2 shows how service management capability would be provided to value added service providers from external and internal organisations.

Network operator's TMN can be seen to support his own Value Added Service Provider 1 (VASP1) via an OSF connected to the basic service management OSF via a q reference point.

The basic service and the VASP1 could be physically realised on the same OS or on separate OSs.

VASP2 can be provided with access to the basic service management capability via an x reference point.

VASP3 can provide an additional VAS over VASP2's service via an X interface.

NOTE: It may be possible in some specific implementations to interconnect between TMNs via an X interface at layers other than the service management layer.

B.4 Interaction between TMNs

TMN hierarchies may interact for many reasons including the following:

- to provide value added services;
- to manage a number of geographical/functional TMNs as a single TMN;
- to provide end to end circuit/service provision.

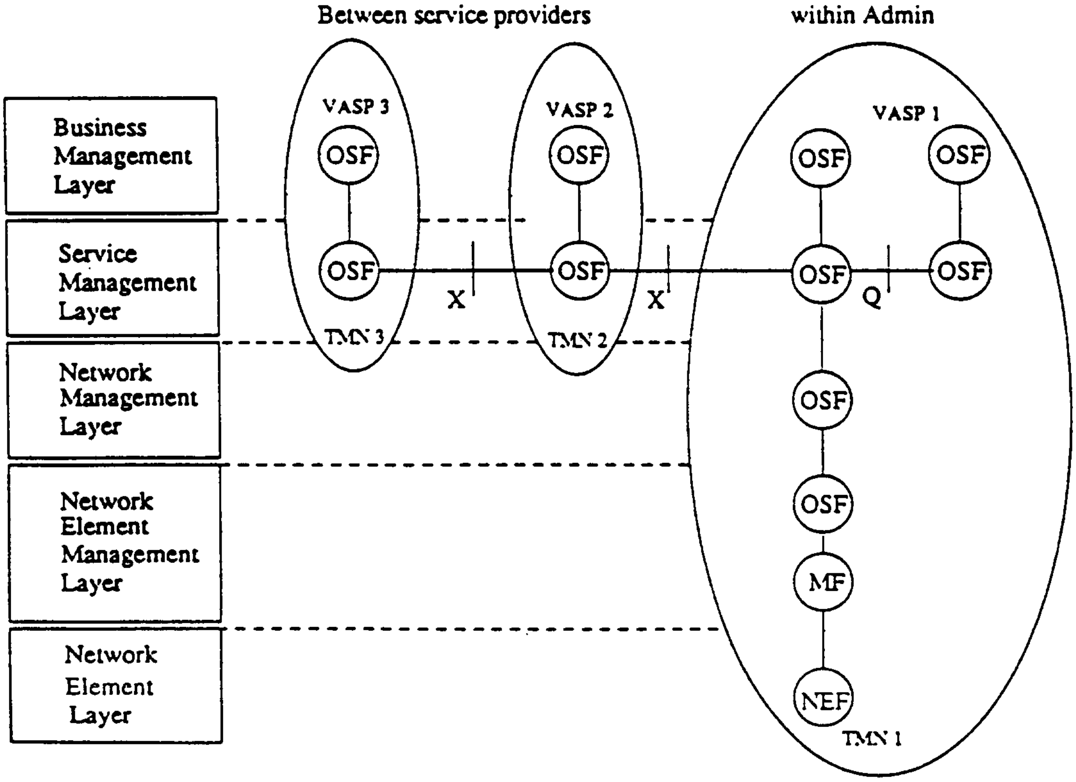
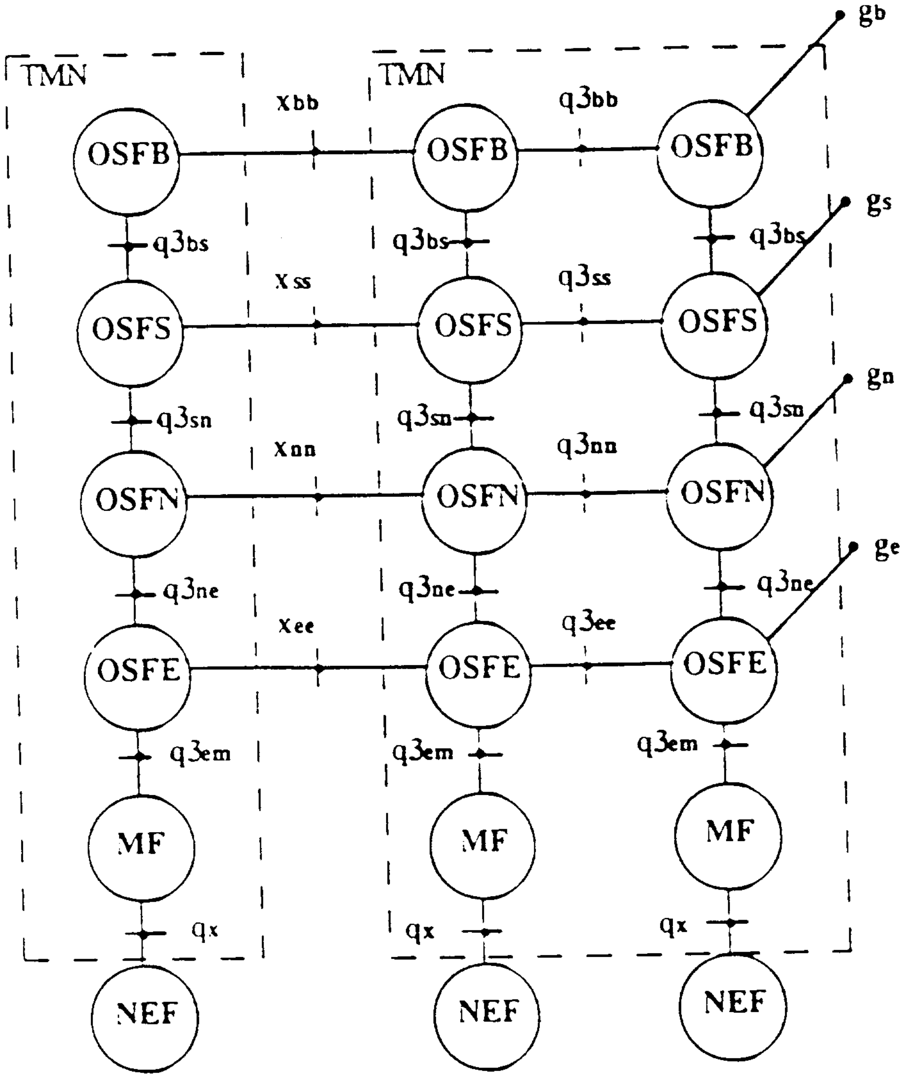


Figure B.2: Examples of value added services

Figure B.3 shows another possible inter-TMN OSF connectivity example within the management hierarchy.

TMN "X" illustrates an administration that is only a transport provider. TMN 1 through TMN "N" illustrate some number of services. No service management layer OSFs exist within the TMN 1, because it is not economical to develop/provide separate service management layer OSFs for each possible service that an external service provider may place upon the transport providers environment.

The X interface exists between different management layer OSFs depending on the problem domain being encountered within a service's lifestyle. The X interface is not exclusively required to exist from peer to peer management layer OSF.



NOTE: The possibility of allowing bypass of layer has not been excluded, but is for further study. This would appear to be a requirement in the current IN architecture.

Figure B.3

Annex C: Configuration examples

This Annex contains a number of TMN configuration examples. They are based on both an analysis of CCITT Recommendation M.3010 [7] and the expectations of probable implementations. They are presented here to help visualise the extent of the possibilities that a TMN can offer an administration.

NOTE: They are only collected here with some of the existing text which has not been edited.

Figure C.1 shows examples, with the DCFs not explicitly shown, of a special group of physical configurations in which NEs are cascaded to provide a single interface to the higher order TMN equipment.

This is convenient for co-located NEs which generally contain different levels of MF, e.g. transmission equipment co-located with an exchange.

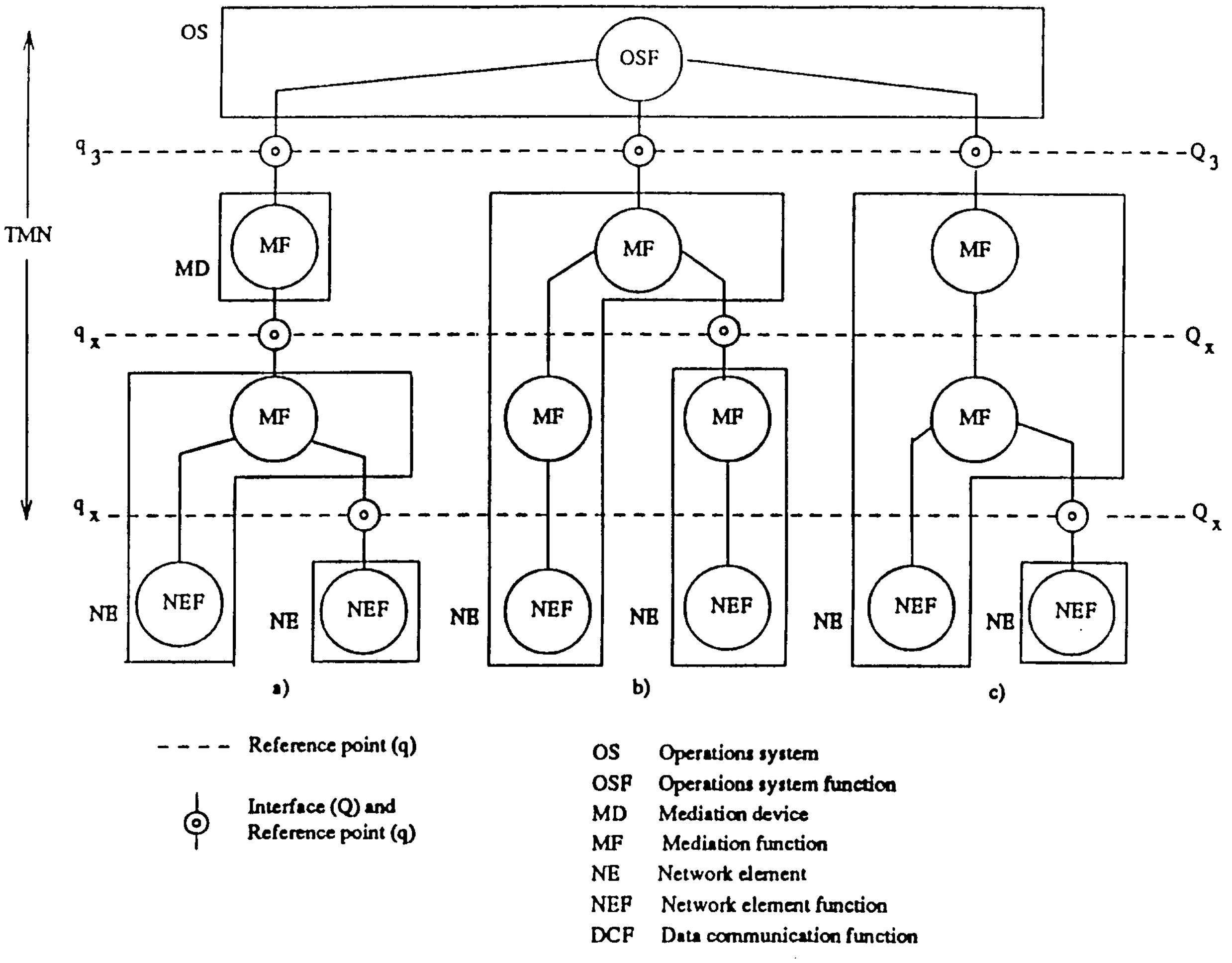
Figure C.1, case a), shows how an NE without an internal MF is connected via a Q_2 interface to an NE with an internal MF which itself has a Q_2 interface to an MD.

Figure C.1, case b), shows how an NE with an internal MF is connected via a Q_2 interface to an NE with higher level MF, which itself has a Q_3 interface to OS.

Figure C.1, case c), shows another possibility where an NE without an internal MF has a Q_2 interface to an NE with an internal MF which itself has a Q_3 interface to OS.

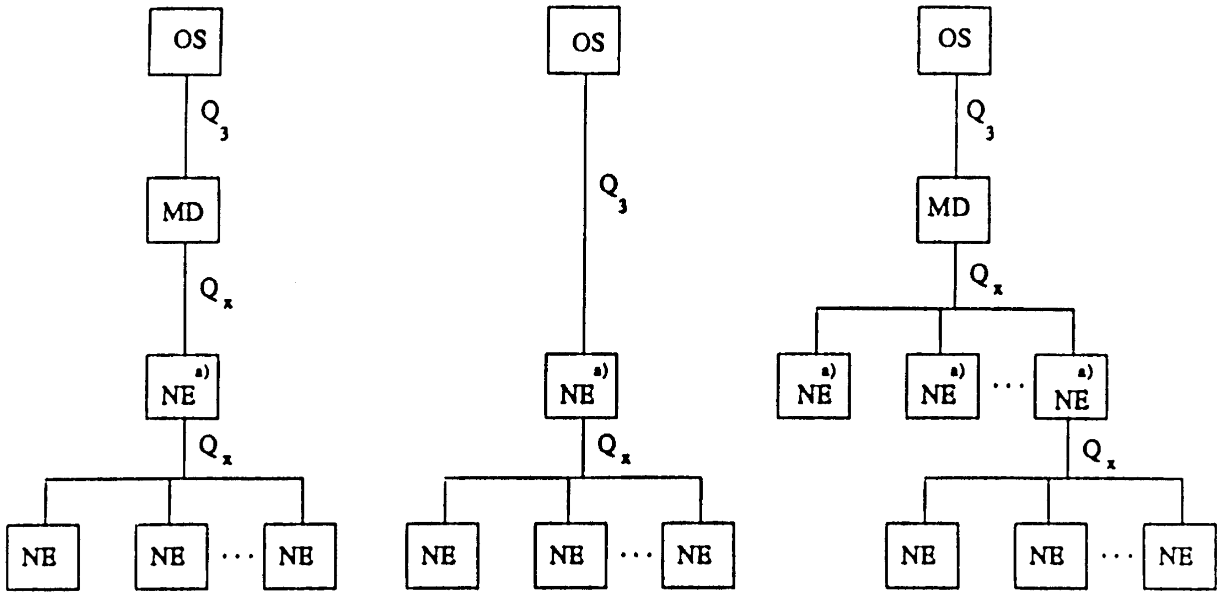
Figure C.2 shows simplified examples of how NEs and MDs might be physically cascaded to serve multiple NEs.

The examples show the connections to the OSs, but do not explicitly show the connections to the DCFs.



NOTE: The OSF shown on top of this figure can consist of a family of OSFs.

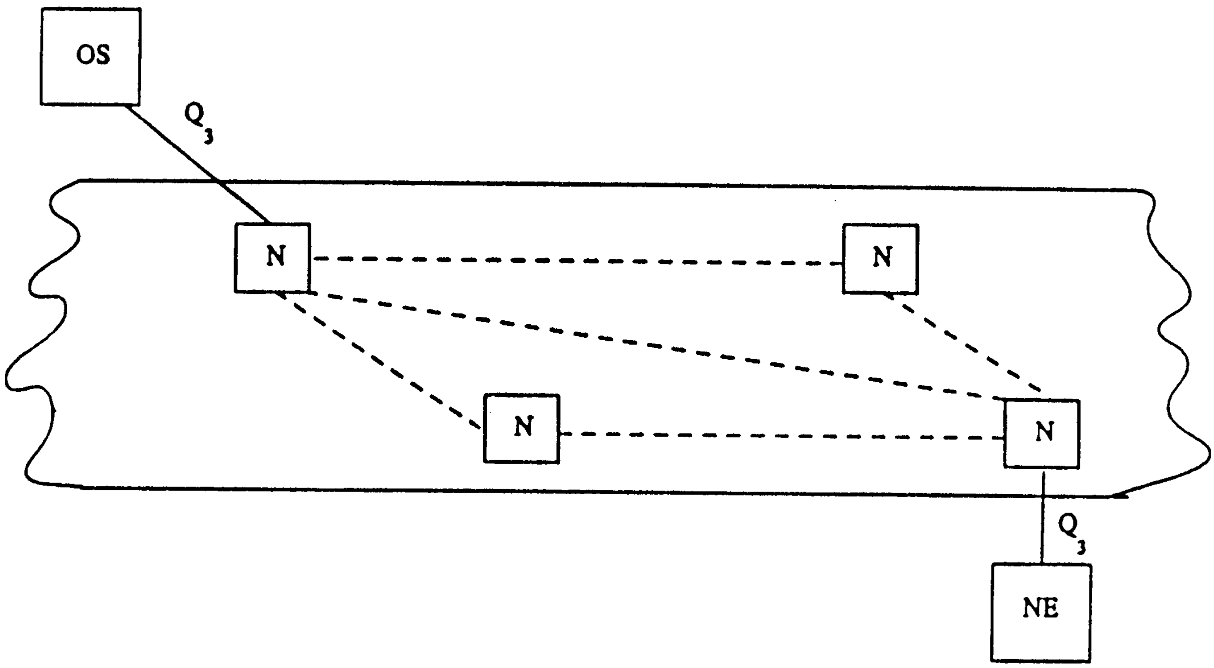
Figure C.1: Examples of cascaded network elements (with implicit DCF)



OS	=	Operations system
MD	=	Mediation Device
NE	=	Network Element
a)	=	NE contains MF

Figure C.2: Examples of cascaded network elements (physical configurations)

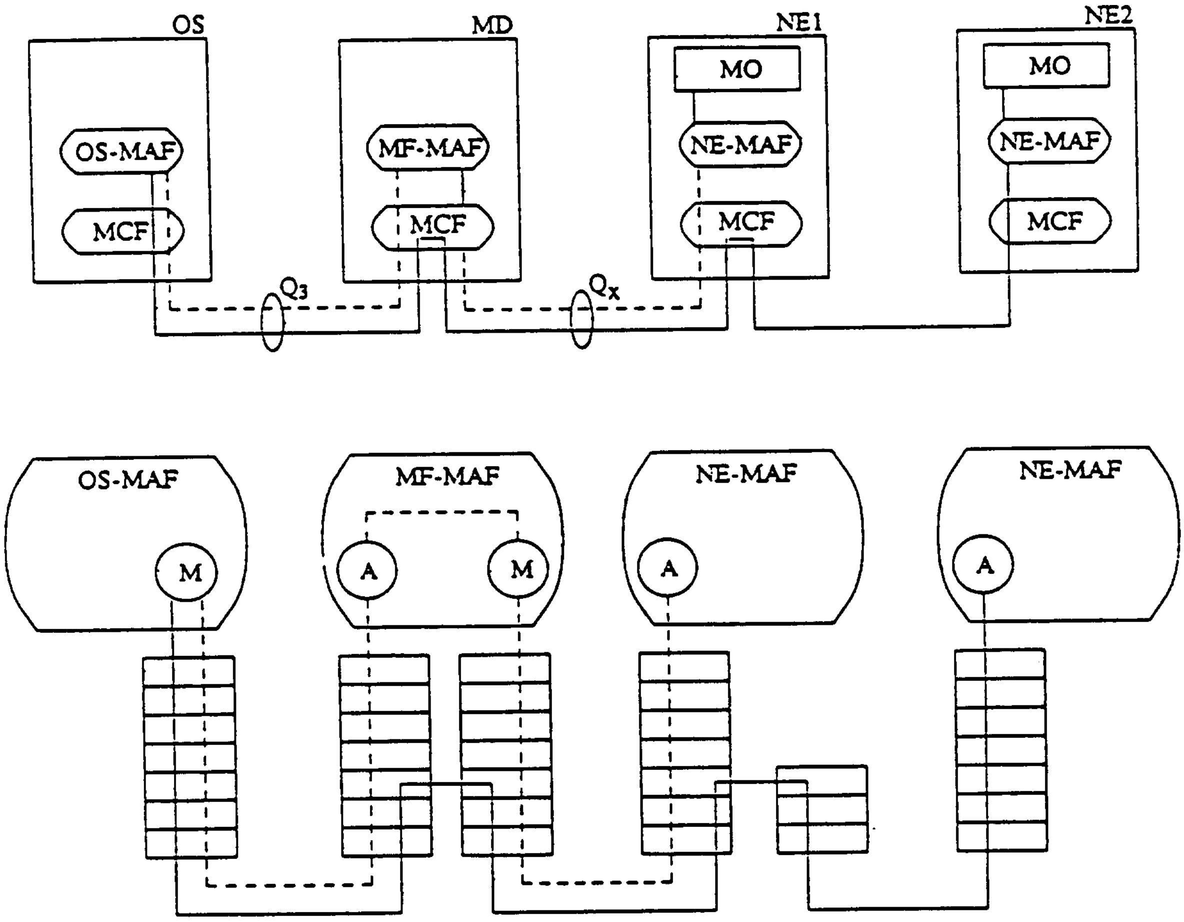
Figure C.3 shows a typical multi-mode CCITT Recommendation X.25 packet switched realisation for the DCN.



NOTE: A service call from the OS to the NE may take any of the possible paths between the DCN nodes (N) depending on the DCN traffic load at that moment.

Figure C.3: Example of DCN

In a cascaded arrangement some devices may, therefore, only serve as communication relays, while some others will include Mediation functions. For the same examples in figures 21 and 22, figure C.4 and C.5 are examples from the SDH environment showing how some devices may provide a routing and relaying function (via MCF) while in other cases they intervene at information model level, e.g. by providing information conversion or even additional functions.



MCF = Message Communication Function

OS-MAF = OS-Management Application Function

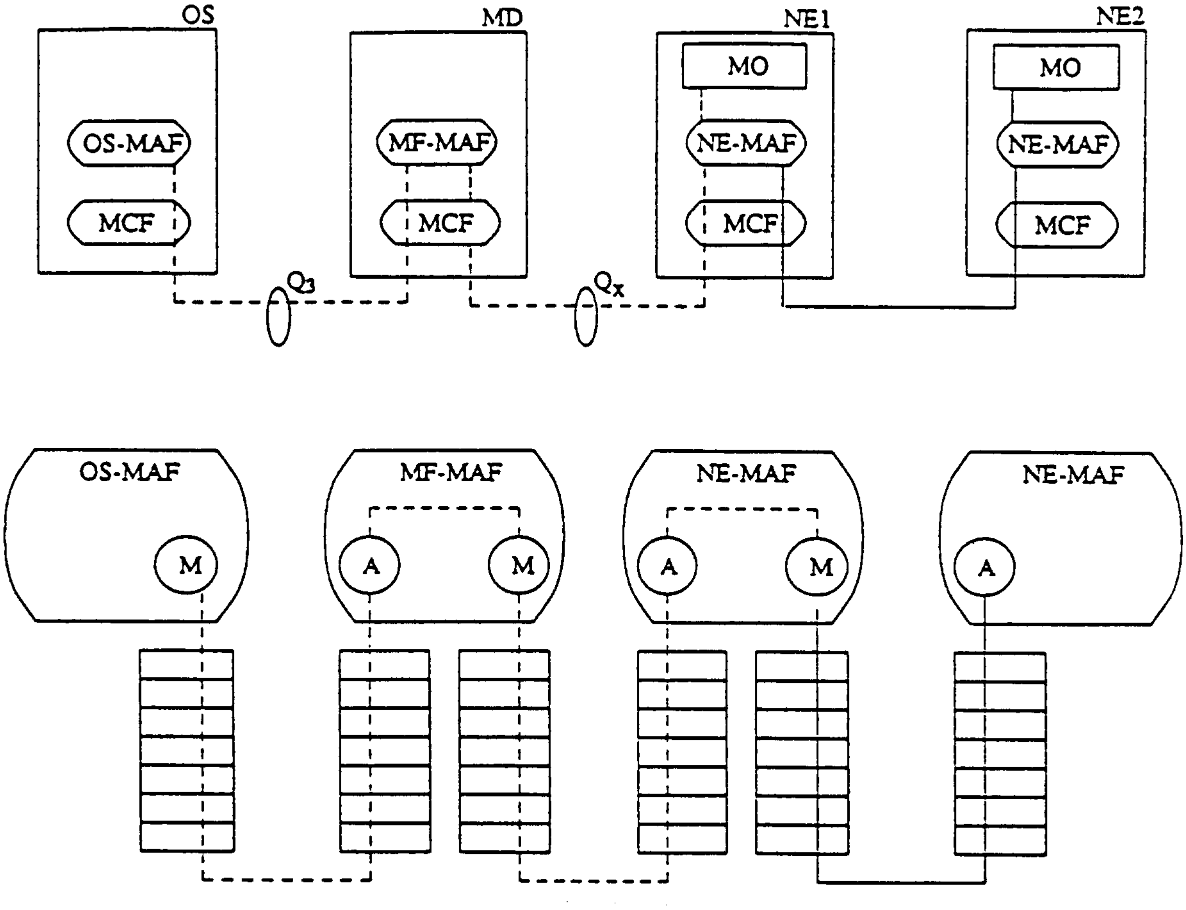
MF-MAF = MD-Management Application Function

M = Manager

A = Agent

MO = Managed Object

Figure C.4: Example of manager-agent processes



MCF = Message Communication Function

OS-MAF = OS-Management Application Function

MF-MAF = MD-Management Application Function

M = Manager

A = Agent

MO = Managed Object

Figure C.5: Example of manager-agent processes

Annex D: Considerations for managing networks

This Annex contains a brief description of issues which require further study and which fall into the general class of "orchestration of management activities". Orchestration applies where management activities for a single management "operation" have to be co-ordinated so as to achieve the overall desired effect. there are several different categorisations or problems possible:

1 Activity synchronisation is where the "operation" needs to influence several managed objects in a co-ordinated manner. The objects which are involved could be distributed across several separate managed elements. Synchronisation becomes critical when the state of the network is threatened by not making all the changes required for a single "operation" at the same time, and in practice within a statistically insignificant time period. Implicit in synchronisation is the ability to recover from failures of implemented management operations.

2 Maintenance of consistency is closely allied to synchronisation in that there may be many relationships between objects that have to be consistent for the total model to be valid. These relationships have to hold even though the objects are strictly distinct. This is rather more specific than suggested in item 1 above, because the manager may know that there are several related objects that have to be modified simultaneously.

3 Sequencing is allied to the above concepts and is where an operation is dependent upon several TMN nodes in a network being changed in a strict sequence.

4 Conflict occurs when several managers are trying to control the same, or closely related, objects at the same time.

5 Deadlocks occur when a manager has embarked upon a course of action which involves the control of several objects and not all the objects are immediately available as they are locked by another operation which cannot continue until objects locked by the first operation are released. Hence both operations are waiting for the other to do something.

NOTE: Multiple operations may be involved in a deadlock.

6 Reporting correlation is required on occasions when a single "event" will be detected by a number of distinct agents as separate events. This will require that the manager responsible is able to correlate these separate events so as to detect the underlying "event" which gave rise to them.

History

Document history	
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