INTERNATIONAL TELECOMMUNICATION UNION

CCITT

M.3010

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

(10/92)

MAINTENANCE: TELECOMMUNICATIONS MANAGEMENT NETWORK

PRINCIPLES FOR A TELECOMMUNICATIONS MANAGEMENT NETWORK

Recommendation M.3010

FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation M.3010 was revised by Study Group IV and was approved under the Resolution No. 2 procedure on the 5th of October 1992.

CCITT NOTES

1) In this Recommendation, the expression "Administration" is used for conciseness to include telecommunication administrations, recognized private operating agencies, private (customer and third party) administrations and/or other organizations that operate or use a Telecommunications Management Network (TMN).

2) A list of abbreviations used in this Recommendation can be found in Annex A.

CONTENTS

Page

Recommendation M.3010

PRINCIPLES FOR A TELECOMMUNICATIONS MANAGEMENT NETWORK

(Melbourne 1988 approved as Rec. M.30, revised and renumbered in 1992)

Abstract

The Telecommunications Management Network (TMN) supports management activities associated with telecommunication networks. This Recommendation introduces the 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.

Keywords

– TMN;

– architecture;

– reference model;

– telecommunications management network;

– interfaces;

– management principles.

1 General

This Recommendation 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 business efficiently. OSI Systems Management (Recommendation X.700 [1]) 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 "Administration" used in this Recommendation includes RPOAs, public and private (customer and third party) administrations and/or other organizations that operate or use a TMN. Within this Recommendation there is a conceptual relationship between an Administration and a TMN. This Recommendation allows for multiple TMNs within an Administration or a single TMN across Administrations.

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

The basic concept behind a TMN is to provide an organized 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 standardized interfaces including protocols and messages. In defining the concept, it is recognized that many Administrations have a large infrastructure of OSs, networks and telecommunications equipment already in place, and which must be accommodated within the architecture. Provision is also made for access to, and display of, management information contained within the TMN via workstations.

Although not included within the TMN architecture, it is recognized that other external interfaces, such as an alarm display or audible alarm, may also be provided.

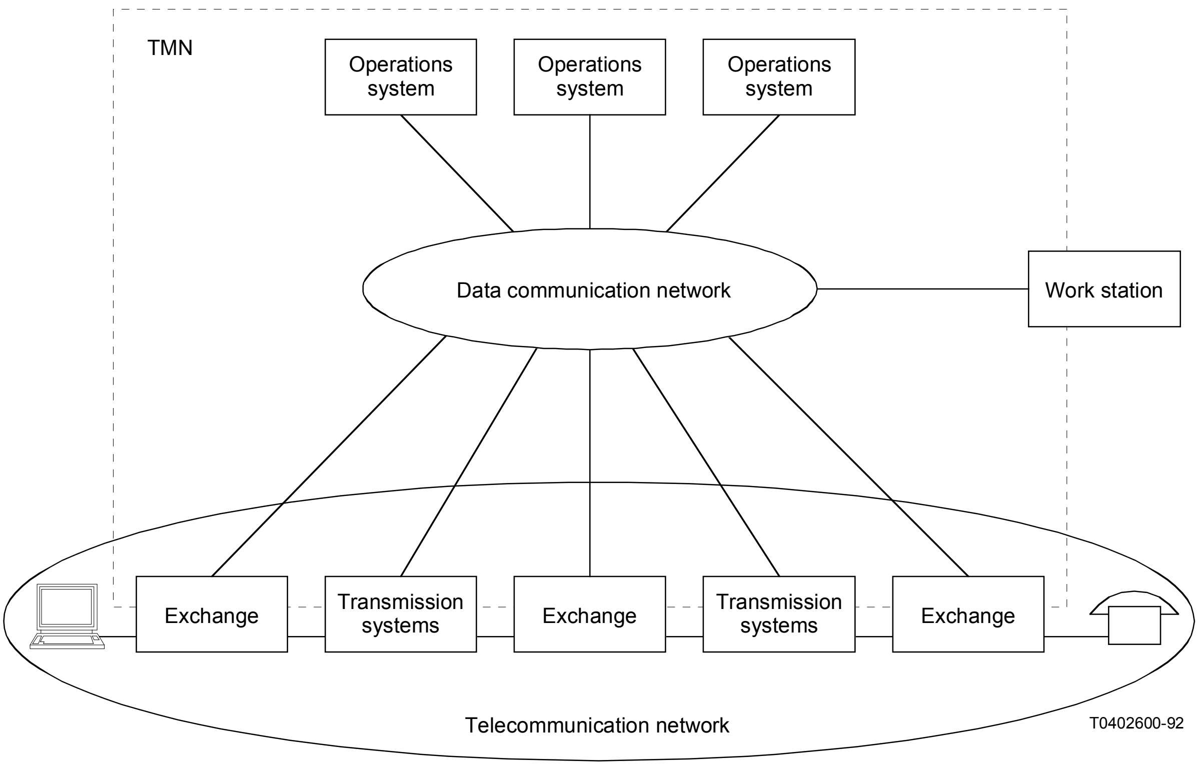
This Recommendation will provide both Administrations and manufacturers with a set of recommendations to use when developing equipment, and when designing infrastructure for the management of telecommunications networks and services.

1.1 *Relationship of a TMN to a telecommunications network*

A TMN can vary in complexity 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 themselves, 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/M.3010 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. Thus, there will be a requirement for the management by the TMN of the TMN network.



Note – The TMN boundary may extend to and manage customer/user services and equipment.

FIGURE 1/M.3010

General relationship of a TMN to a telecommunication network

1.2 *Scope*

This Recommendation describes the characteristics of the interfaces necessary to support a TMN and identifies the functionality, as function blocks, which the interfaces delineate. 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 standardization.

This Recommendation also describes and names the physical devices which comprise a TMN and identifies the interfaces which each device could potentially support.

1.3 *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 both narrow and broadband ISDNs, mobile networks, private voice networks, virtual private networks and intelligent networks;

– TMN itself;

– transmission terminals (multiplexers, cross connects, channel translation equipment, 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 Recommendations M.3600 [11] and M.3602 [2] for public networks;

– software provided by or associated with telecommunications services, e.g. switching software, directories, message data bases, 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.

1.4 *Basic objectives for the TMN*

The objective for the TMN specifications is to provide a framework 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 information models and standard 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 centralized or decentralized management implementations. This means that from a number of management systems, operators can perform management of a wide range of distributed equipment, networks and services.

Security and distributed data integrity are recognized 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 cooperation 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, that is a prerequisite in OSI management, is used to represent the TMN environment in terms of the resources making up that environment and the activity of management function blocks performed on such resources.

1.5 *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 which has categorized management into five broad management functional areas (Recommendation X.700 [1]). These areas provide a framework within which the appropriate applications can be determined so as to support the Administration's business needs. Five management functional areas identified to date are as follows:

– performance management;

– fault management;

– configuration management;

– accounting management;

– security management.

Some of the information which is exchanged within the TMN may be used in support of more than one management area. The TMN methodology (Recommendation M.3020 [12]) starts from a limited number of management services (Recommendation M.3200 [13]) to identify (possibly reusable) management services components leading to management services functions (Recommendation M.3400 [14]) which will in turn use one or more managed objects (Recommendations M.3100 [15] and M.3180 [16]).

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

The functionality of the TMN consists of the following:

– the ability to exchange management information across the boundary between the telecommunications environment and the TMN environment;

– the ability to convert management information from one format to another so that management information flowing within the TMN environment has a consistent nature;

– the ability to transfer management information between locations within the TMN environment;

– the ability to analyse and react appropriately to management information;

– the ability to manipulate management information into a form which is useful and/or meaningful to the management information user;

- the ability to deliver management information to the management information user and to present it with the appropriate representation;
- the ability to ensure secure access to management information by authorized management information users.

1.6 *Architectural requirements*

The TMN needs to be aware of telecommunications networks and services as collections of cooperating systems. The architecture is concerned with orchestrating the management of individual systems so as to have a coordinated effect upon the network. (See Appendix IV.) 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 functionality possible;
- allow for management of heterogeneous networks, equipment and services within a 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 a different or the same management 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;
- allow flexibility in the degree of reliability/cost trade-off in all 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:

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

The functional architecture describes the appropriate distribution of functionality within the TMN to allow for the creation of function blocks from which a TMN of any complexity can be implemented. The definition of function blocks and reference points between function blocks leads to the requirements for the TMN recommended interface specifications (see § 2).

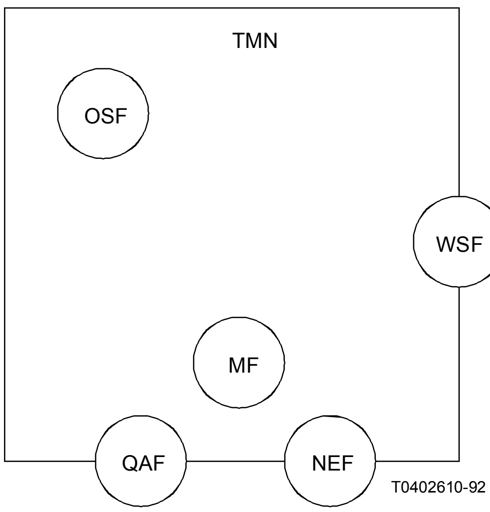
The information architecture, based on an object-oriented approach, gives the rationale for the application of Open System Interconnection (OSI) systems management principles to the TMN principles. The OSI systems management principles are mapped onto the TMN principles and are expanded to fit the TMN environment where necessary (see § 3).

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

2 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 TMN function blocks. The function blocks provide the TMN general functions which enable a TMN to perform the TMN management functions. A Data Communications Function (DCF) is used for this transfer of information between the TMN function blocks. Pairs of TMN functional blocks which exchange management information are separated by reference points. Table 1/M.3010 shows the relationships between the logical function blocks in terms of the reference points between them. Typically different functional blocks may have different degrees of restrictions in the scope of implementation of the same reference point. The functions provided by the TMN function blocks will be further described in terms of the functional components that comprise them.

Figure 2/M.3010 illustrates the function blocks and indicates that only these functions which are directly involved in management are part of the TMN. Note that for the reasons discussed in § 2.1, some of the function blocks are partly in and partly out of the TMN. This Recommendation is only concerned with the range of functionality which such function blocks provide to the TMN. It does not define the functionality provided outside the TMN or within the internal organization of the function blocks.



OSF Operation systems functions
MF Mediation function
WSF Work station function
NEF Network element function
QAF Q adaptor function

FIGURE 2/M.3010

TMN function blocks

2.1 *TMN function blocks*

The TMN function blocks are listed below. Each function block is itself composed of functional components. The functional components are collected and refined in § 2.2.

Functional components permitted in each function block are defined in Table 2/M.3010. Additional descriptions and details for each of the function blocks are given in § 5.

2.1.1 **Operations Systems Function (OSF) block**

The OSF processes information related to the telecommunications management for the purpose of monitoring/coordinating and/or controlling telecommunication functions including management functions (i.e. the TMN itself).

2.1.2 **Network Element Function (NEF) block**

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 itself, whilst the telecommunications functions themselves are outside.

2.1.3 **Workstation Function (WSF) block**

The WSF provides the means to interpret TMN information for the management information user.

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 boundary.

2.1.4 **Mediation Function (MF) block**

The MF block acts on information passing between an OSF and NEF (or QAF) to ensure that the information conforms to the expectations of the function blocks attached to the MF. This may be necessary as the scope of the information supported by different communicating function blocks at the same reference point can differ. Mediation function blocks may store, adapt, filter, threshold and condense information.

2.1.5 **Q Adaptor Function (QAF) block**

The QAF block is used to connect as part of the TMN those non-TMN entities which are NEF-like and OSF-like. The responsibility of the QAF is to translate between a TMN reference point and a non-TMN (e.g. proprietary) reference point and hence this latter activity is shown outside the TMN.

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/M.3010, and Table 2/M.3010 shows how these functional components are combined into various function blocks. These functional components are further defined in this subsection.

2.2.1 Management Application Function (MAF)

The MAF will actually implement TMN management services. TMN management services can be found in Recommendation M.3200 [13], and their supporting functions in Recommendation M.3400 [14]. Depending on their invocation, they will act in the role of Manager or Agent (see § 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, OSF-MAF, NEF-MAF and QAF-MAF.

MAFs are not subject for standardization within the TMN.

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

These management application functions are present in the MF in support of the Agent and Manager roles of the MF. These management application functions can optionally be part of the MF and are used to perform functions supportive to the application functions in the OSF. Examples of such functions include temporary storage, filtering, thresholding, concentration, security, testing, etc.

2.2.1.2 Operations Systems Function - Management Application Function (OSF-MAF)

These management application functions are the essential and underlying parts of OSFs. They may range from simple to more complex functions such as:

– support of Manager and Agent roles in access to managed object information;

– adding value to raw information, e.g. data concentration, alarm correlation, statistics and performance analysis, etc.;

– reaction to incoming information, e.g. automatic reconfiguration, trouble tracking, etc.;

– others (for further study).

2.2.1.3 Network Element Function - Management Application Function (NEF-MAF)

These management application functions are present in the NEF, primarily in support of its Agent role. Other aspects are for further study.

2.2.1.4 Q Adaptor Function - Management Application Function (QAF-MAF)

These management application functions are present in the QAF primarily in support of its Agent and Manager roles. Other aspects are for further study.

2.2.2 Management Information Base (MIB)

The MIB is the conceptual repository of management. It represents the set of Managed Objects within a managed system (see *Systems management overview*, Recommendation X.701 [3]).

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

2.2.3 Information Conversion Function (ICF)

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

The ICF affects the transformation of the messages (e.g. converting object representations). The translation can be done at a syntactical level and/or at a semantical level.

The ICF is the component which characterizes the MF block and is therefore mandatory for it. In certain cases, the information model changes required in the MF may be null, and thus, the ICF may only provide simple application layer relay functionality.

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

2.2.4 **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.

2.2.5 **Human Machine Adaptation (HMA)**

The HMA performs the conversion from the MAF information model to the information model presented by the TMN to the PF (it masks some data, it adds information, and reorganizes the whole), and vice versa. In addition, it supports the authentication and authorization of the user.

2.2.6 **Message Communication Function (MCF)**

The MCF is associated with all functional blocks having a physical interface. It is used for, and limited to, exchanging 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. The MCF may provide protocol convergence functions for interfaces where not all seven OSI layers are supported (e.g. a short stack). Depending on the protocol stack supported at the reference point, different MCF types will exist. These will be differentiated by subscripts (e.g. MCF_{q_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 if required. Further clarification can be found in § 2.4 where the MCF is depicted in Figure 4/M.3010.

2.3 *TMN reference points*

2.3.1 *Classes of reference points*

In order to delineate management function blocks, the concept of a reference point 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.

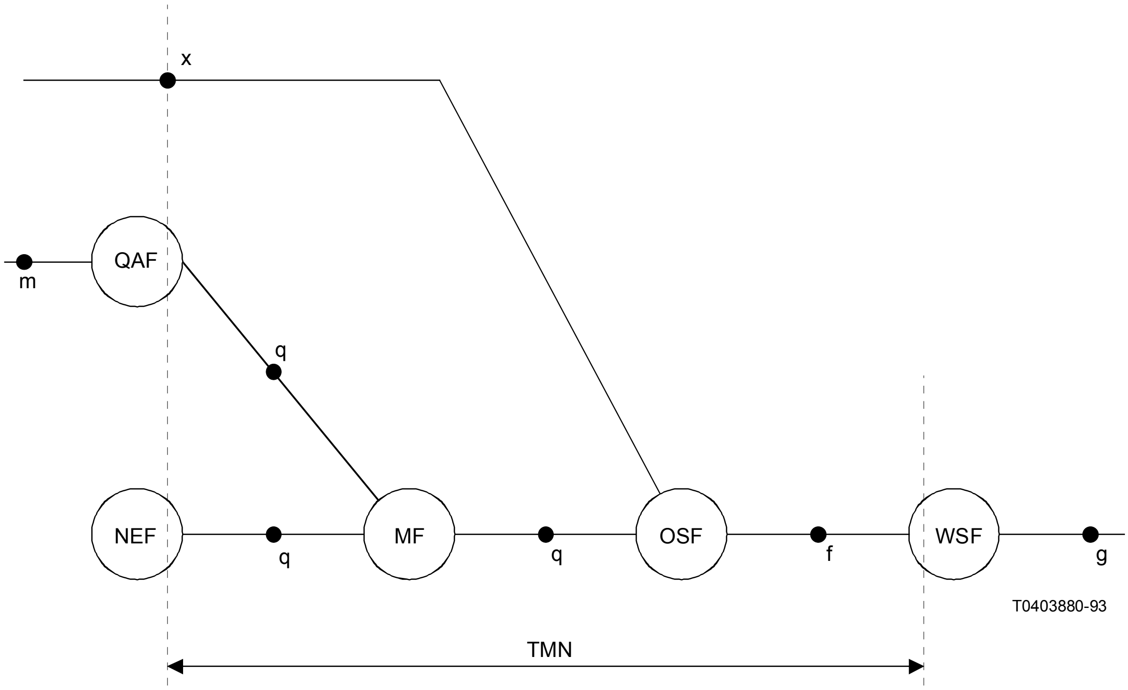
Three classes of TMN reference points are defined, these are

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

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

Figure 3/M.3010 illustrates the three classes of reference points. In addition there are two further classes of non-TMN reference points which are relevant to consider:

- g Class between a WSF and users;
- m Class between a QAF and non-TMN managed entities.



Note – This figure is illustrative and is not exhaustive.

FIGURE 3/M.3010

Classes of reference points in the TMN

2.3.2 *Definition of reference points*

The TMN functional architecture, and the reference points it contains, gives a framework to the task of deriving the requirements for the specification of TMN interfaces. Each reference point requires different interface characteristics for the information exchange. However, a reference point does not itself determine the protocol suite. Protocol specification occurs as a latter task in the TMN interface specification methodology.

The protocol definition should seek to minimize the differences between the TMN interfaces and thus the requirements leading to protocol differences need to be clearly defined.

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

2.3.2.1 **q reference points**

The q reference points serve to delineate a logical part of the information exchange between function blocks as defined by the information model mutually supported by these functions. The scope of the information model for the q reference points involves aspects of Recommendation M.3100 [15] and optionally may also include technology specific aspects.

Function blocks communicating at the q reference points may not support the full scope of the information model. When there is a discrepancy between the scope of the information model supported at either side of the reference point then mediation must be used to compensate.

The q reference points are located between the function blocks NEF and OSF, 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 NEF and OSF, QAF and OSF, MF and OSF, and OSF and OSF.

The q_3 and q_x reference points may be distinguished by the knowledge required to communicate between the function blocks they connect. The distinction is for further study.

2.3.2.2 **f reference points**

The f reference points are located between the WSF and the OSF blocks and/or the WSF and MF blocks. (Attachment of the f reference point to the MF block is subject to further study.)

See Recommendation M.3300 [17] for additional information on the f reference point.

2.3.2.3 **x reference points**

The x reference points are located between the OSF function blocks in different TMNs. Entities located beyond the x reference point may be part of an actual TMN (OSF) or part of a non-TMN environment (OSF-like). This classification is not visible at x reference point.

2.3.2.4 **g reference points**

The g reference points are located outside the TMN between the human users and the WSF. 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 Recommendation and can be found in the Z.300-Series Recommendations [18].

2.3.2.5 **m reference points**

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

2.3.2.6 *Relationship of reference points to function blocks*

Table 1/M.3010 defines the reference points which exist between function blocks. This table is intended as a concise definition of all possible pairings within the context of TMN.

Figure 12/M.3010 below shows that each interface is an embodiment of a reference point but that some reference points may fall within equipment and are then not realized as interfaces. The information identified at a reference point, as being needed to be passed, is captured in an information model for an interface. However, the information that actually needs to be conveyed may be only a subset of the information possible at a reference point. The scope of the information at an interface is determined by the Shared Management Knowledge which is dealt with in § 3.3.

2.4 *Data communications function of the TMN*

The Data Communications Function (DCF) will be used by the TMN function blocks for exchanging information. The prime role of the DCF is to provide information transport mechanisms. The DCF may provide routing, relaying and interworking functions. 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.

TABLE 1/M.3010

Relationships between logical function blocks expressed as reference points

	NEF	OSF	MF	QAF_{q_3}	QAF_{q_x}	WSF	Non-TMN
NEF		q_3	q_x				
OSF	q_3	q_3, x[a)]	q_3	q_3		f	
MF	q_x	q_3	q_x		q_x	f	
QAF_{q_3}		q_3					m[b)]
QAF_{q_x}			q_x				m[b)]
WSF		f	f				g[b), c)]
Non-TMN				m[b)]	m[b)]	g[b), c)]	

a) x reference point only applies when each OSF is in a different TMN.

b) m and g are non-TMN reference points.

c) The g reference point lies between the WSF and the human user.

Note – Any function may communicate at a non-TMN reference point. These non-TMN reference points may be standardized by other groups/organizations for particular purposes.

The DCF may be supported by the bearer capability of different types of subnetworks. These may include packet switched networks (Recommendation X.25 [6]), MANs, WANs, LANs, SS No. 7 or the Embedded Communications Channel (ECC) of SDH. When different subnetworks are interconnected, the interworking functions when required, will be part of the DCF.

When DCFs are located between systems, the Message Communication Functions (MCF) are associated with every point of attachment to the DCF as depicted in Figure 4/M.3010.

Additional details on the DCF are given in § 4.5.2.

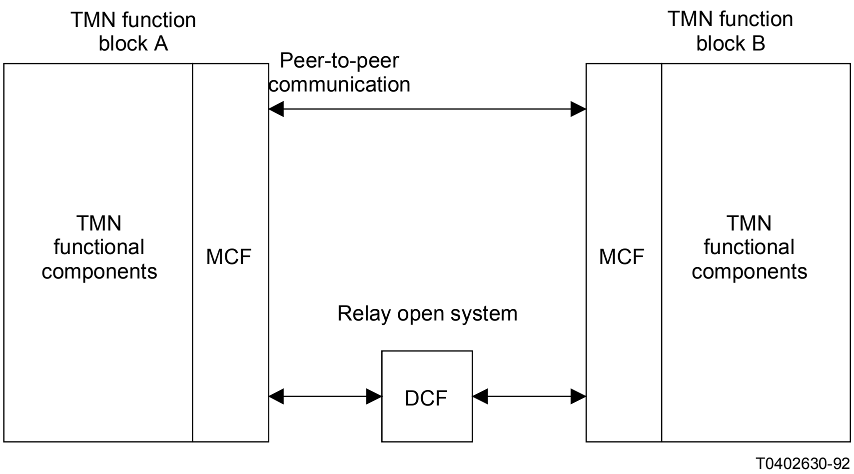


FIGURE 4/M.3010

Relative roles of MCF and DCF

2.5 *The TMN reference model*

The functional components of each TMN function block are shown in Table 2/M.3010. In this table the subscripts indicate at which reference point the functional component applies. Individual functional components 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 Management Application Functions (MAFs) in the same instance of a functional block.

TABLE 2/M.3010

Relationship of functional blocks to functional components

Function block	Functional components	Associated message communications functions
OSF	MIB, OSF-MAF (A/M), HMA	MCF_x, MCF_{q_3}, MCF_f
OSF subordinate[a)]	MIB, OSF-MAF (A/M), ICF, HMA	MCF_x, MCF_{q_3}, MCF_f
WSF	PF	MCF_f
NEF_{q_3}[b)]	MIB, NEF-MAF (A)	MCF_{q_3}
NEF_{q_x}[b)]	MIB, NEF-MAF (A)	MCF_{q_x}
MF	MIB, MF-MAF (A/M), ICF, HMA	MCF_{q_3}, MCF_{q_x}, MCF_f
QAF_{q_3}[c), d)]	MIB, QAF-MAF (A/M), ICF	MCF_{q_3}, MCF_m
QAF_{q_x}[d)]	MIB, QAF-MAF (A/M), ICF	MCF_{q_x}, MCF_m

a) This is an OSF in the subordinate layer of the logical layered architecture explained in § 3.6.

b) The NEFs also include telecommunications and support resources that are outside of the TMN.

c) When QAF_{q_3} is used in a manager role, the q_3 reference point lies between the QAF and an OSF.

d) The use of QAF in the manager role is for further study.

PF Presentation Function

MCF Message Communications Function

MIB Management Information Base

MAF Management Application Function

ICF Information Conversion Function

A/M Agent/Manager

HMA Human Machine Adaptation

Note – MAF (A/M) means Management Application Function in Agent or Manager role.

Table 3/M.3010 defines the set of functional components which each function block contains.

Figure 5/M.3010 summarizes the TMN functional reference model by illustrating an example of each pair of functions that can be associated by a reference point. Figure 5/M.3010 also illustrates the typical flow of information between function blocks in a hierarchical arrangement.

Figure 6/M.3010 depicts the use of implicit and explicit DCF. It must be noted that a DCF is not present when a reference point is not realised as an interface, and that MF blocks may be cascaded.

TABLE 3/M.3010

Relationship of functional components to function blocks

Function block	Functional components				
	MIB (Note 1)	MAF (Note 2)	ICF	HMA	PF
OSF	O)	M	–	O	–
OSF_{sub}	M	M	M	O	–
WSF	(Note 3)	(Note 3)	(Note 3)	–	M
NEF_{q_3}	M	M	–	–	–
NEF_{q_x}	M	O	–	–	–
MF	O	O	M	O	–
QAF_{q_3}	O	O	M	–	–
QAF_{q_x}	O	O	M	–	–

M Mandatory

O Optional

– Not allowed

sub Subordinate

Note1 – The MIB will only be provided when the function block supports an agent role.

Note 2 – MAF is considered to be additional to any Agent or Manager activities and may be in conflict with ISO definitions.

Note 3 – These functions (or equivalent) may be considered to be as part of the Presentation Function.

2.6 *TMN access from external sources*

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

– cooperation between peer TMNs;

– network user access to TMN functions.

2.6.1 *Access between TMNs*

TMNs need to cooperate 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 have feed-back on their use of the network. Such an access supposes management services being provided for the users by the service providers. Generally, the accessed TMN makes no assumptions about the user's needs or organization 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.

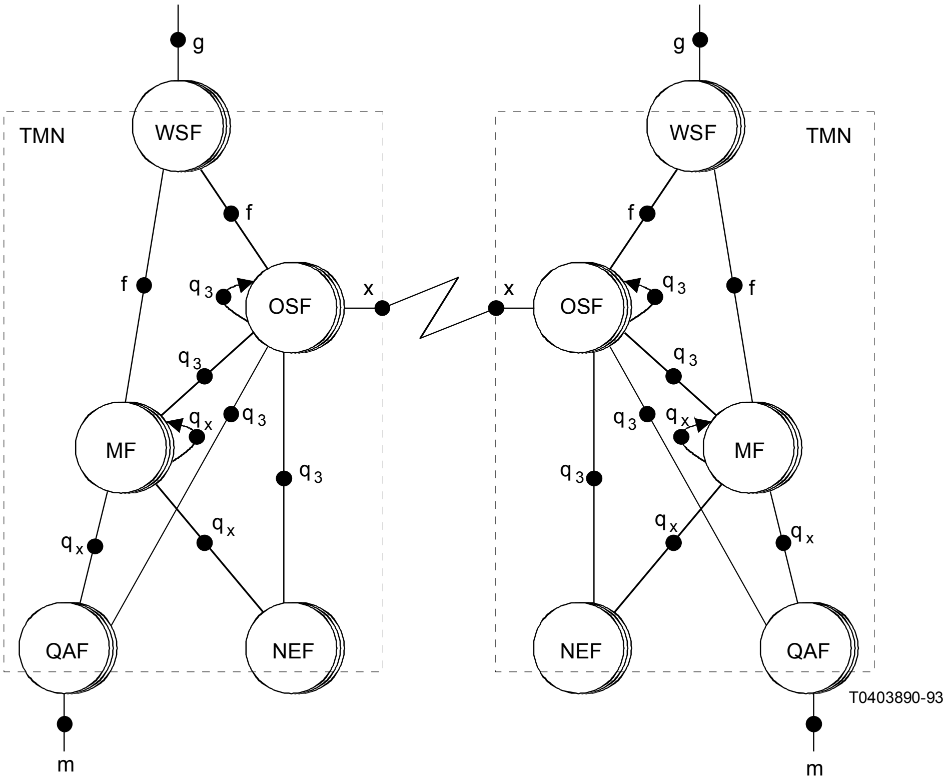


FIGURE 5/M.3010

Illustration of reference points between management function blocks

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

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

– management information which concerns events on the different links and services available to the accesser.

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

For this it is necessary to provide the users with common access to management applications of one, or a set of, telecommunication service(s) as follows:

– security of access;

– protocol conversion;

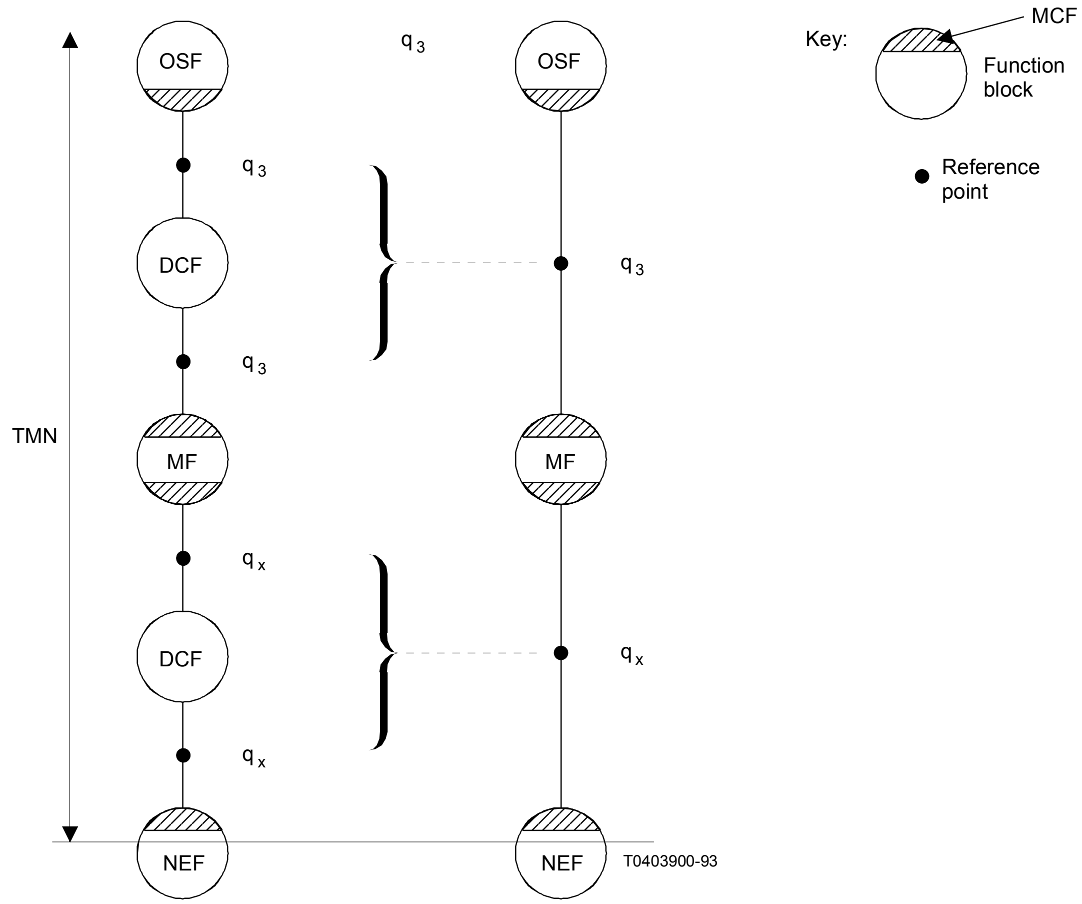
– translation between the objects known by the user and the service/network management functions;

– value added services.

3 TMN information architecture

This section describes an object-oriented approach for transaction-oriented information exchanges. Other additional approaches may be required for information exchanges and are for further study.

The Manager/Agent concepts, such as those developed for OSI systems management, are introduced. The concepts necessary for the organization and interworking of complex managed systems (e.g. networks) are also introduced under the headings of management domains and shared management knowledge.



a) Explicit DCF *b) Implicit DCF*

OSF Operations Systems Function blocks
MF Mediation Function blocks
DCF Data Communication Function
NEF Network Element Function block
MCF Message Communication Function

FIGURE 6/M.3010

Implicit and explicit DCF

The management information is considered from two perspectives:

a) *The management information model*

The management information model presents an abstraction of the management aspects of network resources and the related support management activities. The model determines the scope of the information that can be exchanged in a standardized manner. This activity to support the information model takes place at the application level and involves a variety of management application functions 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*

The management information exchange involves the 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 managed resources, the TMN methodology makes use of the OSI systems management principles and is based on an object-oriented paradigm. A brief presentation of the concept of objects is given below.

Management systems exchange information modelled 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 or a combination of resources (e.g. a network).

It must be noted that 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 considerations:

- there is not necessarily a one-to-one mapping between managed objects and real resources (which may be physical or logical);
- a resource may be represented by one or more objects. When a resource is represented by multiple managed objects, each object provides a different abstract view of the resource;
- managed objects may exist which represent logical resources of the TMN rather than resources of the telecommunications network. These are depicted as support objects in Figure 7/M.3010;
- if a resource is not represented by a managed object, it cannot be managed across the management interface. In other words 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 modelled as sub-entities of the larger object.

The concepts defined above are depicted in Figure 7/M.3010.

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);
- the notifications emitted by it.

The use of the methodology defined in Recommendation M.3020 [12] has led to the identification of a Generic Network Information Model composed of a set of managed objects as defined in Recommendation M.3100 [15]. This model encompasses the whole of the TMN and is generally applicable to all networks. However, additional extensions to this will be required to allow for the details of differing managed network equipment types to be conveyed by the TMN.

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. This involves the exchange of management information between management processes for the purpose of monitoring and controlling the various physical and logical networking resources (switching and transmission resources).

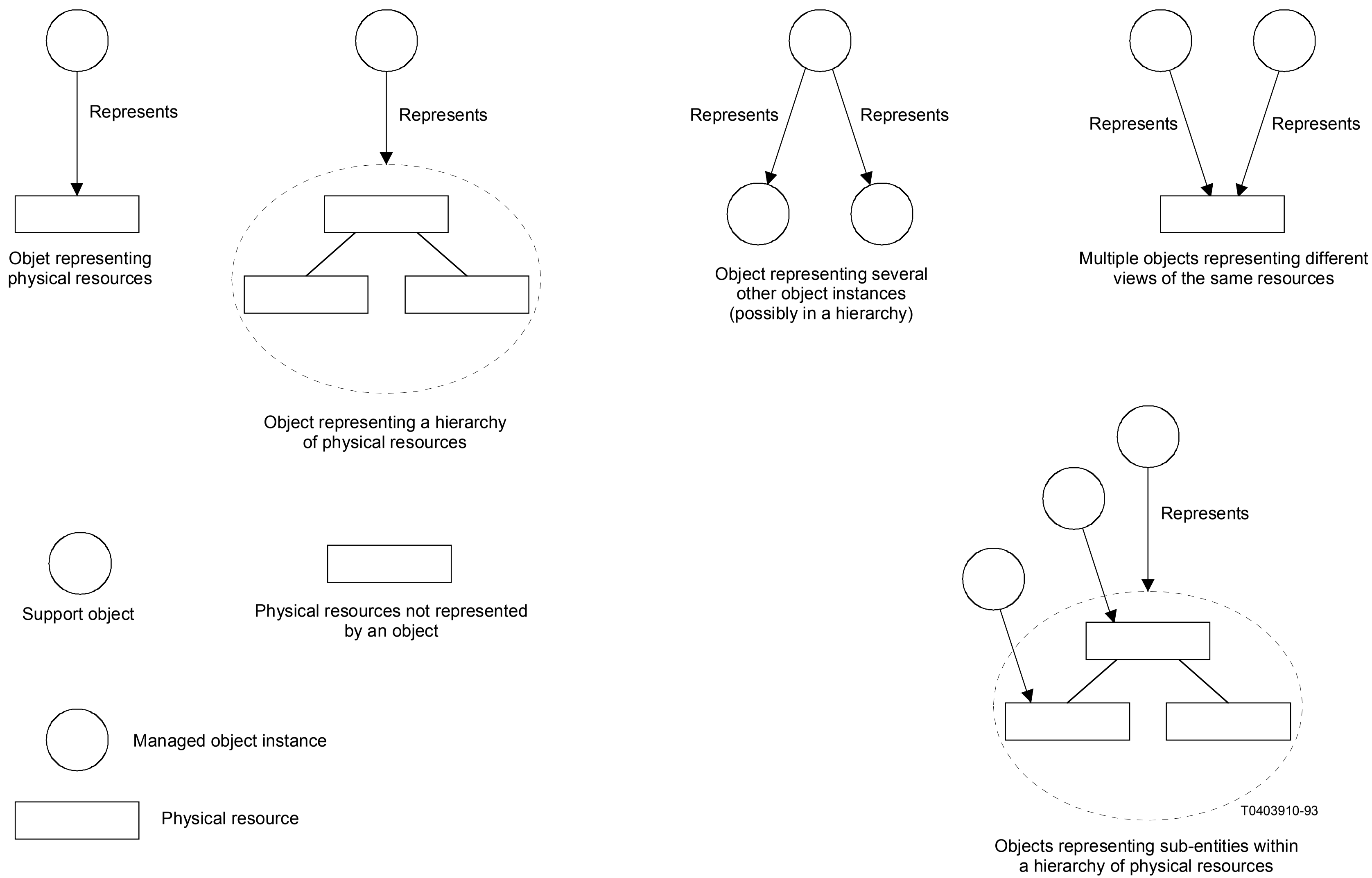


FIGURE 7/M.3010

Illustration of managed objects and physical resources

For a specific management association, the management processes will take on one of two possible roles. Note that the case where both roles can be taken during a single association requires further study. The description of the Manager/Agent concept given here is intended to reflect the definitions given in Recommendation X.701 [3].

– Manager role: the part of the distributed application that issues management operation directives and receives notifications, or

– 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. It will also reflect to the Manager a view of these objects and emit notifications reflecting the behaviour of these objects.

A Manager is the part of the distributed application for which 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 8/M.3010 shows the interaction between Manager, Agent and objects.

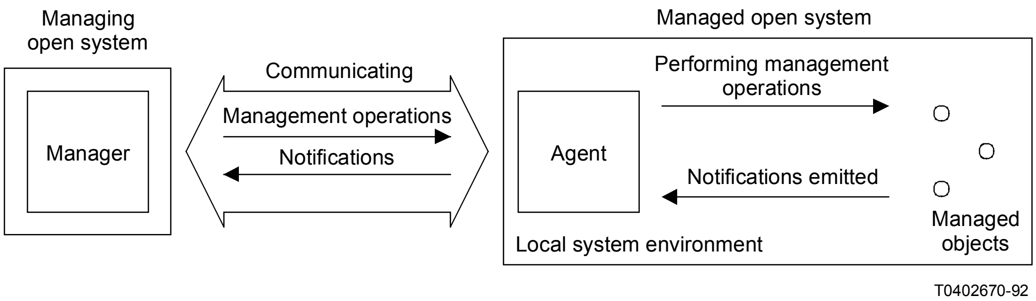


FIGURE 8/M.3010

Interaction between Manager, Agent and objects

It must be noted that 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 associated agent roles. In this scenario, the issue of synchronization of directives may exist. The synchronization issues require further study (see Appendix IV;

– one Agent may be involved in an information exchange with several Managers. In this case it will contain several agent roles interacting with their associated manager roles. In this scenario the issue of concurrent directives may exist. Concurrent requests received by an agent require further study.

An Agent may deny a Manager’s directive 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 captured in § 3.5 (Domains).

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). These operations are all realised through the use of the Common Management Information Services (CMIS) and Protocol (CMIP) Recommendations X.710 [19] and X.711 [4]. The manner in which Agents interact with the resources is a local matter and not a subject for standardization.

An example of the relationships between objects and managed resources for the case of an NE are given in Figure 9/M.3010.

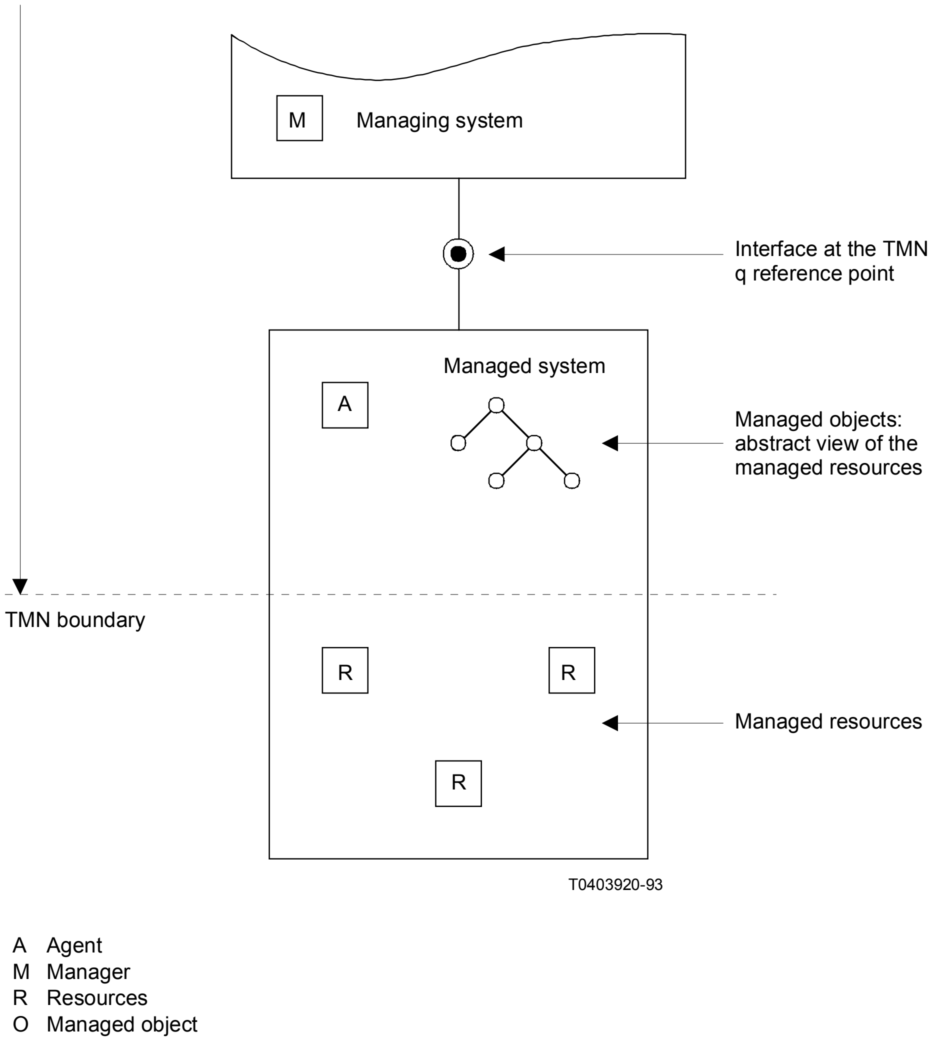


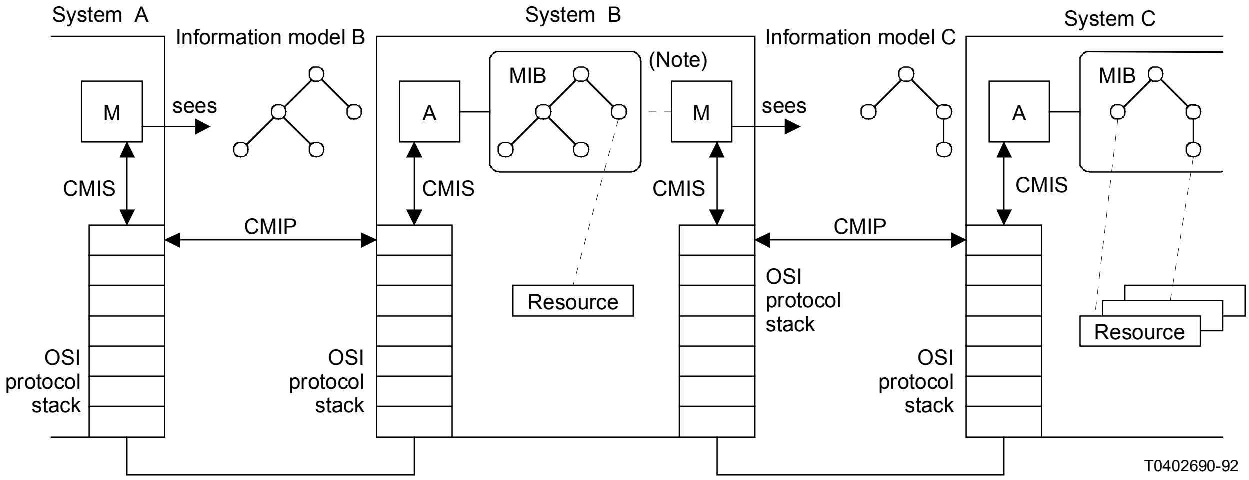
FIGURE 9/M.3010

Relationship between objects and managed resources for the case of an NE

3.2.2 *Interworking between TMN function blocks*

The TMN function blocks use the Manager/Agent relationship described above to achieve management activities. The Manager and Agent are part of the management application functions and as such are part of the TMN. In Figure 10/M.3010, system A manages system B which manages system C (cascading of systems). System A interacts with system B by reference to the information model supported by system B at its interface to system A. Similarly for system B to system C.

In the cascaded environment, system B provides (presents) the information model B to system A. To do this it uses information from information model C. System B processes the operations from system A on objects in the MIB of B. This may involve further operations on information model C. System B processes the notifications from system C, and this may involve further notifications to system A. In system B, the relationship between the Manager, Agent and the MIB is not subject to standardization and is an implementation issue.



CMIP Common management information protocol
CMIS Common management information system
MIB Management information base
M Manager
A Agent

Note – The interaction between a Manager and an MIB, between open systems, is performed via the Agent function. However, within a system, the interaction is not subject to standardization.

FIGURE 10/M.3010

Example of communication TMN systems

A system in the TMN may play the agent role to many systems, presenting as many different information models. A TMN system may also play the manager role to many systems, seeing as many different information models.

3.3 *Shared management knowledge (SMK)*

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 classes;

– available managed object instances;

– authorized capabilities;

– containment relationships between objects (name bindings).

All the above information pieces are defined as the Shared Management Knowledge (Recommendation X.701 [3]).

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 (see § 3.4) may be required to establish this common understanding within each entity.

Figure 11/M.3010 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 the system B level.

Figure 12/M.3010 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 § 3.6).

3.4 *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. See Appendix IV for more information on this subject.

3.5 *Domains*

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

– to partition the management environment for a number of functional areas, such as for security, accounting, fault management, etc., or to partition the management environment for each management purpose, such as according to geographical, technological, policy, or organizational 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.

Managed objects may be organized into sets to meet the above requirements. A managed set of objects, with its Manager, constitutes a management domain, as shown in Figure 13/M.3010.

The following types of relationships may exist between management 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/M.3010). In such a case a number of issues exist (e.g. ownership, concurrency, access control) that will require further study. On these issues see also § 3.2 (Manager/Agent).

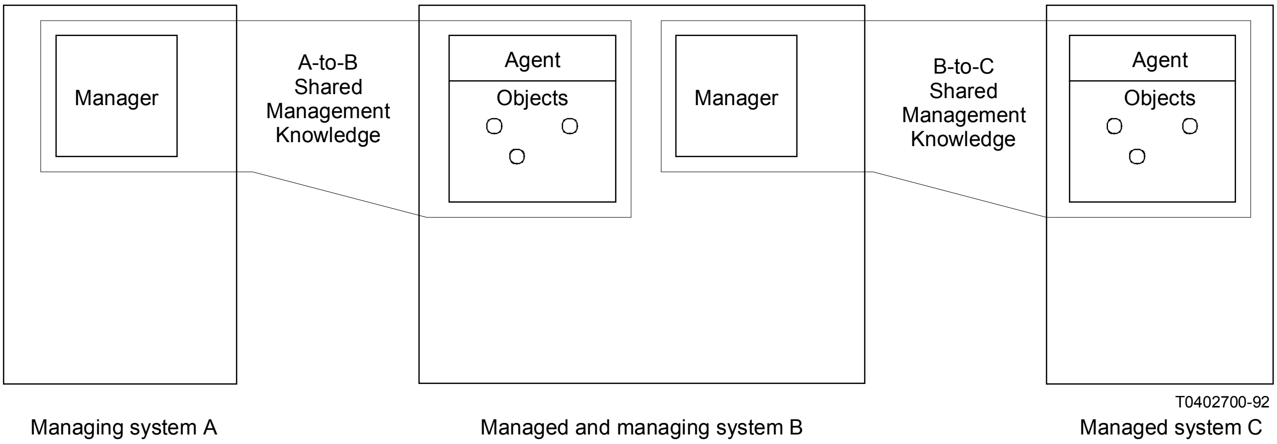


FIGURE 11/M.3010

Sharing management knowledge between systems

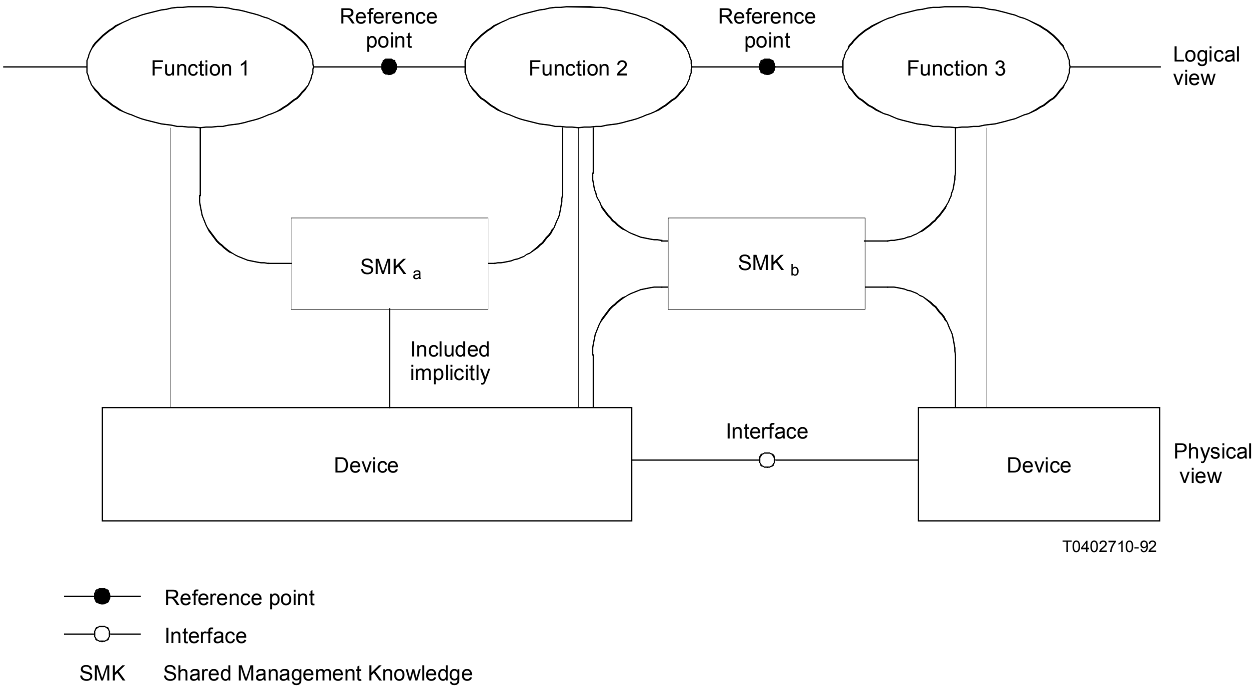


FIGURE 12/M.3010

Independance of SMKs from the physical implementation

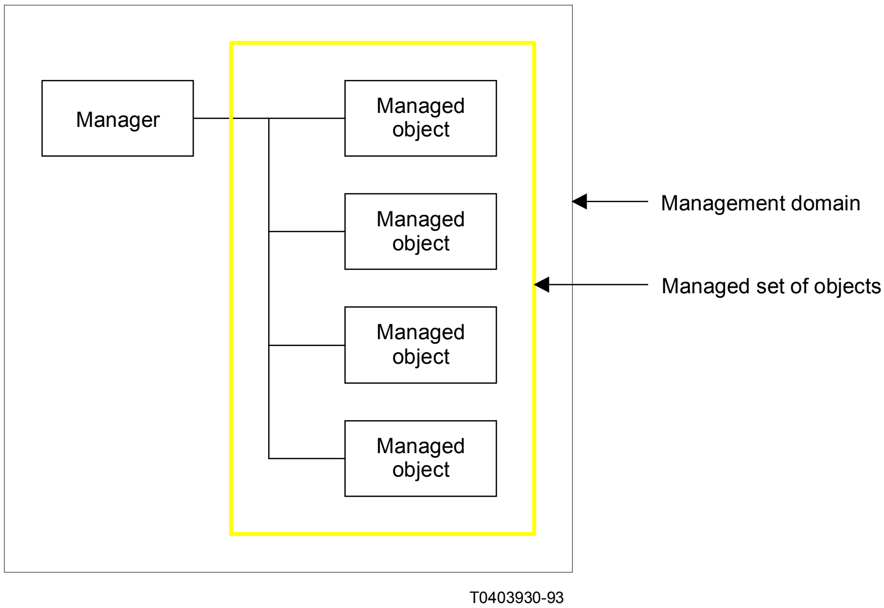


FIGURE 13/M.3010

Example of a managed set of objects in a management domain

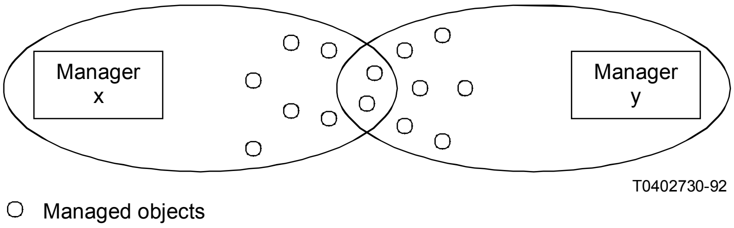


FIGURE 14/M.3010

Overlapping management domains

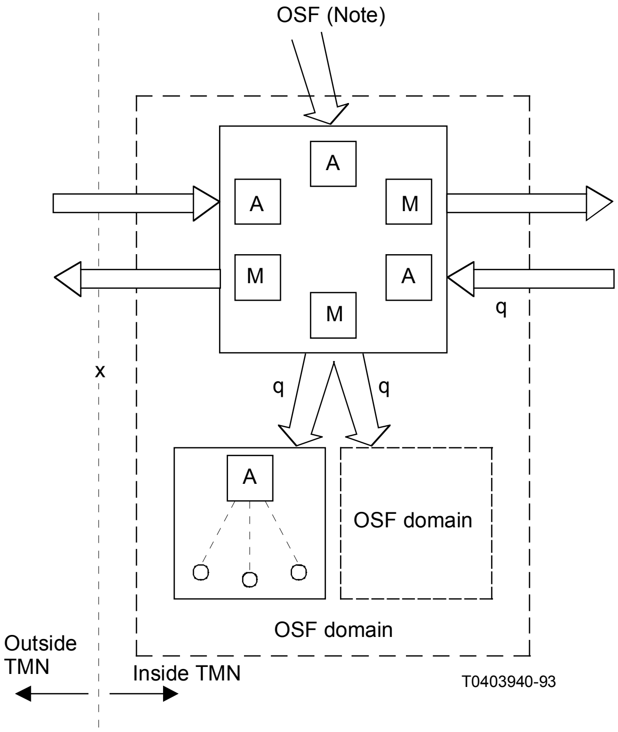
3.6 *Logical layered architecture (LLA)*

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. The scope of each layer is broader than the layer below it. In general, it is expected that upper layers will be more generic in functionality while lower layers are more specific.

The LLA implies the clustering of management functionality into layers. It is only when a specific LLA instance is defined that functions, or groups of functions, may become processes, and then the reference points between the processes may become interfaces.

The LLA uses a recursive approach to decompose a particular management activity into a series of nested functional domains. Each functional domain forms a management domain under the control of an operation system function (OSF) and thus each domain is called an OSF domain. A domain may contain other OSF domains to allow further layering and/or it may represent resources (logical or physical) as managed objects (MO) within that domain.

Figure 15/M.3010 presents the logical layered architecture. Due to its recursive nature only the details of one domain need be shown. The reference points depicted do not need to be present in every domain implementation.



Note – When the OSF domain is at the top of the layered architecture, then a superior OSF will not be present.

FIGURE 15/M.3010

Logical layered architecture (showing control authority)

All interactions within a domain take place at generic q reference points. However, interactions between peer domains, i.e. crossing an OSF domain boundary, can take place at a q or x reference point depending upon the business strategy applicable for that interaction. When providing network services it is common for management to cross the boundaries of an Administration, hence arrangements are 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 domain which dictates the layering and inter-domain interactions required.

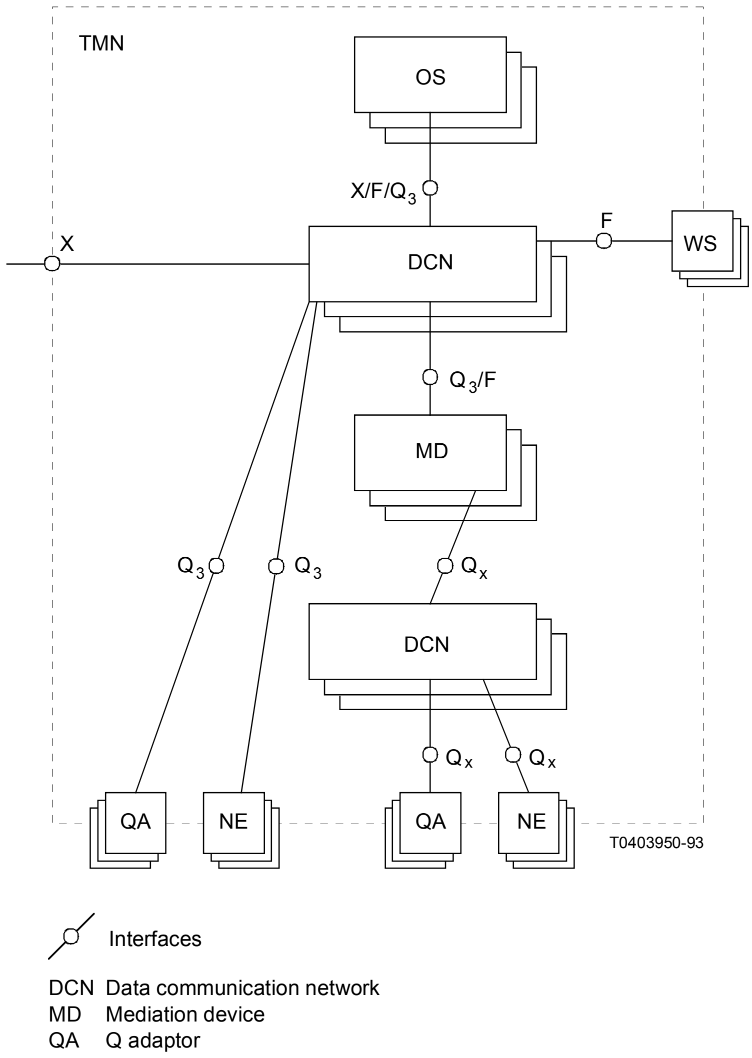
Further information on the layering concept and LLA can be found in Appendix V.

3.7 *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 Appendix I.

4 TMN physical architecture

Figure 16/M.3010 shows an example of a simplified physical architecture for a TMN. This example is provided to assist in understanding the TMN building blocks described below.



Note 1 – For this simplified example the building blocks are considered to contain only their mandatory functions (see Table 4/M.3010).

Note 2 – The interfaces shown on either side of the DCN are actually a single interface between end systems for Layers 4 and above. For Layers 1 through 3, they represent the physical link, and network interface between an end system and the DCN.

FIGURE 16/M.3010

An example of a simplified physical architecture for a TMN

4.1 *TMN building blocks*

TMN functions can be implemented in a variety of physical configurations. The relationship of the functional blocks to physical equipment is shown in Table 4/M.3010. The subsections below give the definitions for consideration in implementation schemes.

TABLE 4/M.3010

Relationship of TMN building block names to TMN function blocks (Notes 1, 2)

(Notes 2 and 3)	NEF	MF	QAF	OSF	WSF
NE	M	O	O	O	O (Note 3)
MD		M	O	O	O
QA			M		
OS		O	O	M	O
WS					M

M Mandatory

O Optional

Note 1 – Within this table, where more than one name is possible, the choice on the building block name is determined by the predominant usage of the block.

Note 2 – TMN building blocks may contain additional functionality which allows them to be managed.

Remarque 3 – For the WSF to be present either the MF or OSF must also be present.

4.1.1 **Operations System (OS)**

The OS is the system which performs OSFs. The OS may optionally provide MFs, QAFs and WSFs.

4.1.2 **Mediation Device (MD)**

The MD is the device which performs MFs. The MD may also optionally provide OSFs, QAFs and WSFs.

MDs can be implemented as hierarchies of cascaded devices.

4.1.3 **Q Adaptor (QA)**

The QA is a device which connects NEs or OSs with non-TMN compatible interfaces (at m reference points) to Q_x or Q_3 interfaces.

4.1.4 **Data Communication Network (DCN)**

The DCN is a communication network within a TMN which supports the DCF. The DCN represents an implementation of the OSI layers 1 to 3, which include any relevant CCITT or ISO standards for layers 1 to 3. The DCN provides no functionality at layers 4 to 7.

The DCN may consist of a number of individual sub-network(s) of differing types, interconnected together. For example, the DCN may have a backbone sub-network(s) that provides TMN-wide connectivity between a variety of sub-network(s) providing local access to the DCN. The various types of sub-networks may include both technology specific sub-network(s) such as the SDH DCC and other generic intra-office networks.

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. The NE may optionally contain any of the other TMN function blocks according to its implementation requirements. The NE has one or more standard Q-type interfaces and may optionally have F interfaces. The NE, as an exception, may have an X interface when an NE contains OSF functionally.

Existing NE-like equipment that does not possess a TMN standard interface will gain access to the TMN via a Q Adaptor Function, which will provide the necessary functionality to convert between a non-standard and standard management interface.

4.1.6 **Workstation (WS)**

The WS is the system which performs WSFs. The workstation functions translate information at the f reference point to a displayable format at the g reference point, and vice versa.

If equipment incorporates other TMN functionality as well as the WSF, then it is named by one of the other names in Table 4/M.3010.

4.1.7 *Relationship of TMN building block names to TMN function blocks*

Table 4/M.3010 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 is optional for the building blocks to contain. This table does not restrict the range of possible implementations, but defines those identified within this Recommendation.

4.2 *Interoperable interface concept*

In order for two or more TMN building blocks to exchange management information they must be connected by a communications path and each element must support the same interface onto that communications 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 interoperable interface defines the protocol suite and the messages carried by the protocol. Transaction-oriented interoperable interfaces are based upon an object-oriented view of the communication and therefore, 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 communications.

The message component of the interoperable interface provides a generalized 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.

In the architecture, what predominantly distinguishes one interface 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 Shared Management Knowledge. Shared Management Knowledge 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 Shared Management Knowledge ensures that each end of the interface understands the exact meaning of a message sent by the other end.

4.3 *TMN standard interfaces*

Figure 16/M.3010 shows 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 assignment, etc.).

TMN 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 11/M.3010.

4.3.1 *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:

– the interface Q_x is applied at the q_x reference point;

– the interface Q_3 is applied at the q_3 reference point.

The q_x reference point represents the requirements derived from the interaction between MF-MAF and other applicable MAFs. The difference in these requirements from those which a q_3 reference point represents will be clarified using TMN management functions (as defined in Recommendation M.3400 [14]) as well as some definite interface characteristics. The Q_3 and Q_x interfaces are distinguished primarily by the information they carry. The Q_x interface is characterized by that portion of the information model that is shared between the MD and those NEs it supports. The Q_3 interface is characterized by that portion of the information model shared between the OS and those TMN elements to which it directly interfaces. The information models for both types of interfaces can potentially be the same but it can normally be expected that the less functionality there is, that the protocol supports, the less generic the information model will be. Hence, the MF is needed to provide conversion between the information models.

4.3.2 *F interface*

The F interface is applied at f reference points. The F interfaces connecting workstations to the OSF or MF through a data communication network are included in this Recommendation. Connections of implementation specific, WS-like entities to OSs or NEs are not the subject of this Recommendation.

4.3.3 *X interface*

The X interface is applied at the x reference point. It will be used to interconnect two TMNs or to interconnect a TMN with another management network which accommodates a TMN-like interface. 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, e.g. passwords and access capabilities. For further information on the types of functionality that an Administration may utilize concerning security, see § 6 in Recommendation M.3400 [14].

The information model at the X interface will set the limits on the access available from outside the TMN. The set of capabilities made available at the X interface for access to the TMN will be referred to as TMN Access.

Additional protocol requirements may be required to introduce the level of security, non-repudiation, etc. which is required.

4.3.4 *Relationship of TMN interfaces to TMN building blocks*

Table 5/M.3010 defines the possible interfaces which each named TMN building block can support. It is based upon the function blocks which Table 4/M.3010 associates with each building block and the reference points between function blocks, defined in Table 1/M.3010.

TABLE 5/M.3010

Relationship of TMN interfaces to TMN building blocks

<table>
<tr><th></th><th>Q_x</th><th>Q_3</th><th>X</th><th>F</th></tr>
<tr><td>NE</td><td colspan="3">(Note 1)
O O O</td><td>O</td></tr>
<tr><td>OS</td><td colspan="3">(Note 1)
O O O</td><td>O</td></tr>
<tr><td>MD</td><td colspan="2">(Note 1)
O O</td><td>O</td><td>O</td></tr>
<tr><td>QA</td><td colspan="2">(Note 1)
O O</td><td>O</td><td>O</td></tr>
<tr><td>WS</td><td></td><td></td><td></td><td>(Note 2)
M</td></tr>
</table>

M Mandatory

O Optional

Note 1 – At least one of the interfaces inside the box must be present.

Note 2 – This mandatory relationship only to workstations as defined in § 5.7.

4.4 *TMN protocol families*

There is a family of protocol suites for each of the TMN interfaces; Q_3, Q_x, X and F. The choice of the protocol is dependent on the implementation requirements of the physical configuration.

The application layer (layer 7) of each family is common, and is the basis for ensuring interoperability. Some functionality of layer 7 may not always be required (e.g. file transfer). In certain interfaces, some or all of the other layers may have reduced functionality.

The requirement of the lower layers is to support the upper layers. Several network types have been identified as suitable for the transport of TMN messages such as those detailed in Recommendation Q.961 [5]. Any one or a mixture of 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 Message Communications Functions plus Q Adaptor Functions which can reside in Q Adaptors, Network Elements, Mediation Devices or Operations Systems.

4.5 *Consideration of reference and physical configurations*

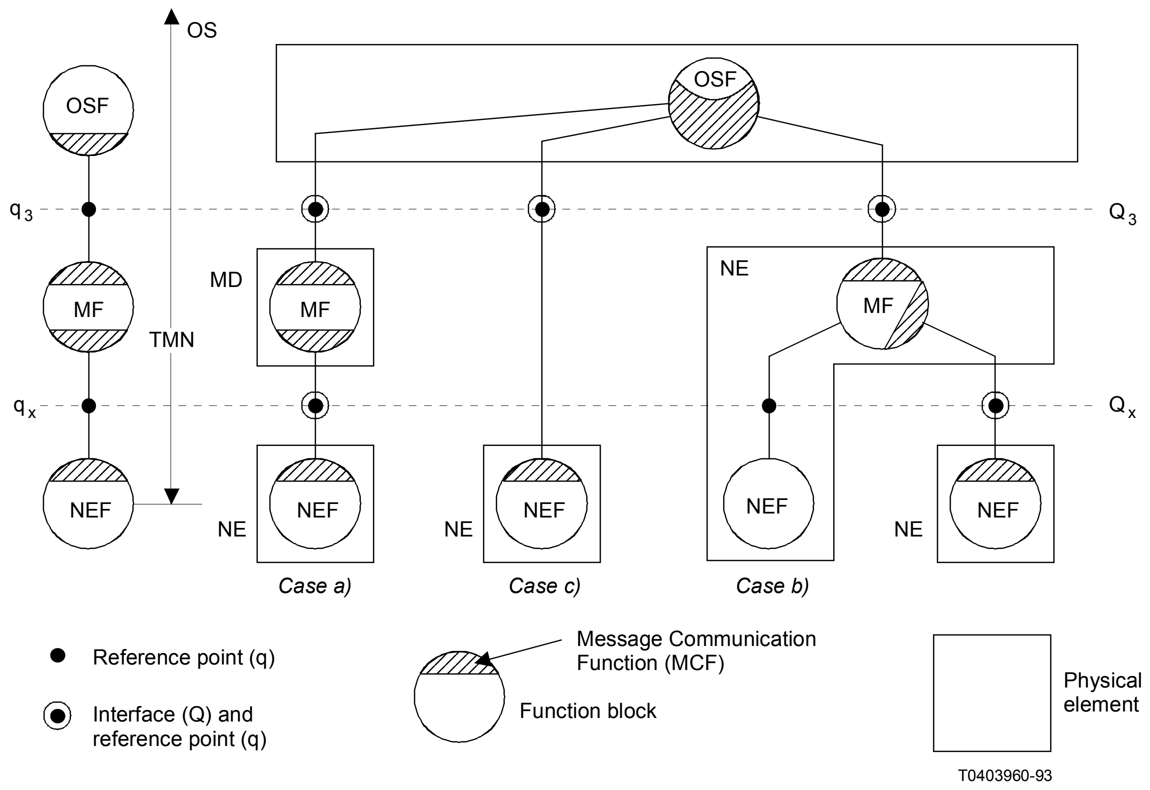
4.5.1 *Physical realization of the q class reference configuration*

Figure 17/M.3010 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, they are denoted with a capital Q.

Figure 17/M.3010, case a), shows an NE connected via a Q_x interface to an external MD which supplies the MF necessary to convert this interface to the Q_3 interface required by the OS which manages the NE.

Figure 17/M.3010, case b), shows an NE with an internal MF which is interconnected to an OSF via a Q_3 interface (see also notes to the figure). An external NE is also connected to this NE via a Q_x interface.

Figure 17/M.3010, 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 this figure, the meaning is 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 – Other equipment, which is necessary for the connection, may be present between two adjacent boxes, which is necessary for the connection of these boxes. This equipment represents the DCF of Figure 4/M.3010. Such equipment performs OSI network functions, and are not shown in this Figure, e.g. the Q_3 interface normally connects to the DCN which provides the data communication to the OS.

Note 3 – MCF is only associated with function blocks which communicate over a standard interface. As shown in this Figure, communication between function blocks within a box is not supported by MCF.

Note 4 – Additional examples showing other physical configurations are given in Appendix III.

FIGURE 17/M.3010

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

4.5.2 *Communication functions*

4.5.2.1 *DCN implementation examples*

The Data Communication Function (defined in § 2) is composed of

– the transmission and routing mechanism (networking role);

– the access mechanism allowing the MCF to attach to the transmission mechanism.

In the case where different technologies are involved in the provisioning of the DCN (e.g. Recommendation X.25 [6] 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 on their level of intervention in the protocol stacks, they will be named bridges, routers or network relays.

Such equipment are typically composed of a relay function associated with two access functions as depicted in the example of Figure 18/M.3010.

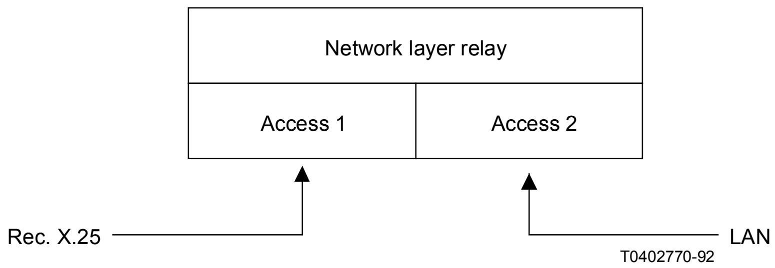


FIGURE 18/M.3010

Communication relay implemented via two DCNs

Additional considerations are required when DCN/DCN interworking is required at the higher layers. When for example in Figure 19/M.3010, 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).

For examples of these relay and interworking functions, see X.200-Series of CCITT Recommendations [20] and ISO | IEC 7498 [8]. Other OSI interworking schemes are not precluded and are for further study.

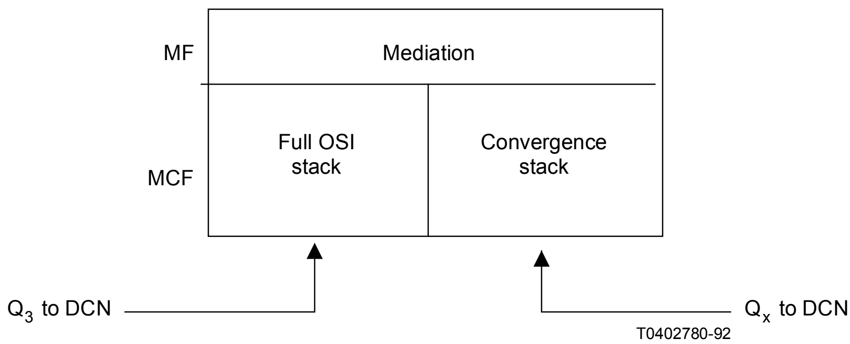


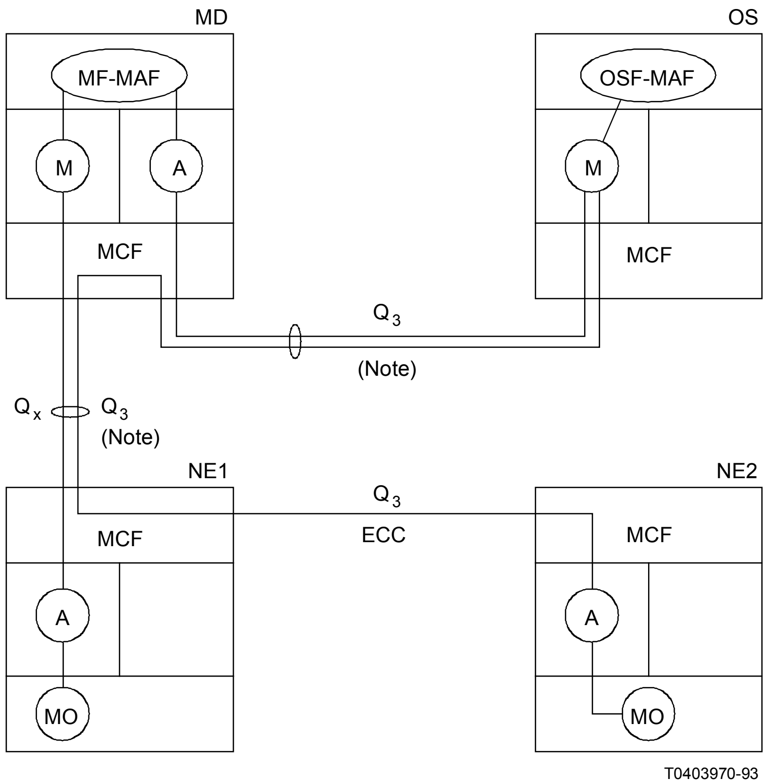
FIGURE 19/M.3010

Example of higher layer interworking

4.5.2.2 *MCF considerations*

The MCF allows Managers or Agents to interwork across the DCN. When there are instances of different types of DCNs, the use of two MCF within one device (e.g. MD, NE, OS or QA) may be necessary to allow protocol conversion.

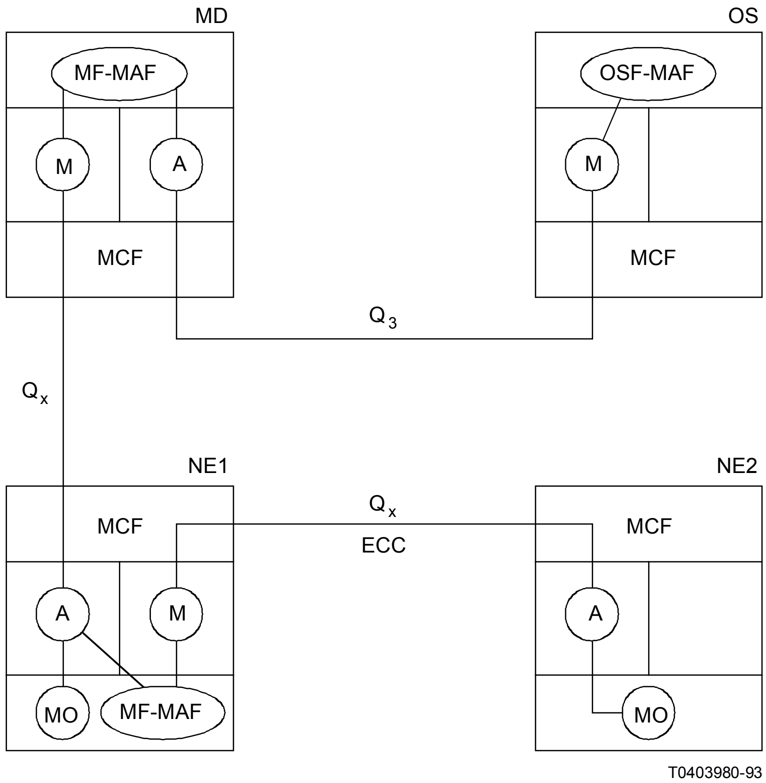
The following Figures 20/M.3010 and 21/M.3010 show examples of how various MCFs are used in various physical devices to provide the DCF in an SDH environment.



Note – Indicates both interfaces are in the same transport.

FIGURE 20/M.3010

SDH management example (1)



OSF-MAF	OS Function-Management Application Function	M	Manager
MF-MAF	Mediation Function-Management Application Function	OS	Operation System
MCF	Message Communication Function	MD	Mediation Device
A	Agent	NE	Network Element
		MO	Managed object
		ECC	Embedded Control Channel

FIGURE 21/M.3010

SDH management example (2)

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 organization 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 organization are the degree of centralization 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 should be designed to prevent a single fault from making the transfer of critical management messages impossible. It should also take measures to ensure 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 by restoring 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, an 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.

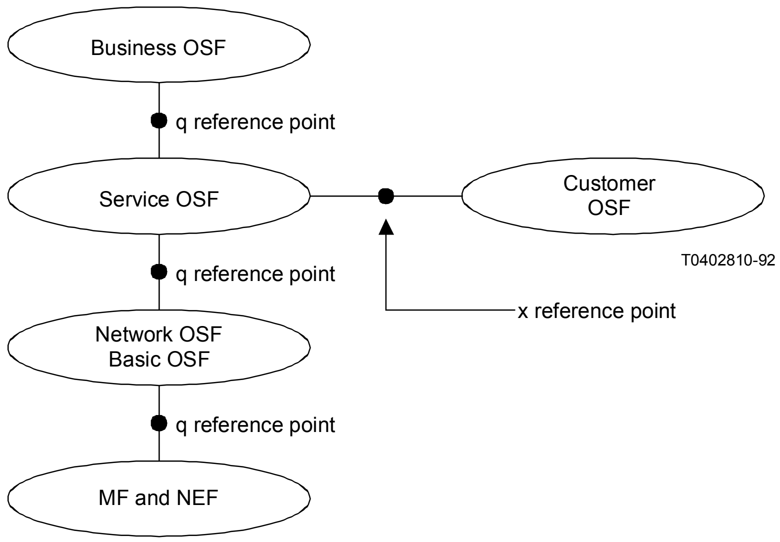
Another example is a TMN which is used to determine charges to the customers. The OSs and the NEs which may be associated with this function may require at least two physical DCN communication channels in order to provide sufficient reliability in the process of OSs collecting charging messages from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

5.2 *Operations Systems*

5.2.1 OS functional configuration

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

There are many types of OSFs with the types being dependent on the structure of the TMN. One possible categorization of OSFs based upon descending abstraction is – business, service, network and basic. An example is shown in Figure 22/M.3010. As shown, some TMN implementations may include business OSFs which are concerned with a total enterprise (i.e. all services and networks) and carry out an overall business coordination. Service OSFs are concerned with the service aspects of one or more networks and will normally perform a customer interfacing role.



Note 1 – Customer OSF is peer of Service OSF.
Note 2 – Splitting of Network OSF and Basic OSF is an item for further study.

FIGURE 22/M.3010

Example of an OS functional architecture

Network OSFs cover the realization 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 coordinating activity across the network and support "networking" demands of Service OSFs. Basic OSFs and Network OSFs share management of infrastructure aspects of a telecommunication network. In smaller networks' Basic OSFs may not be present and Network OSFs will communicate with NEFs and/or MFs directly.

Appendix II contains examples of architectures which are consistent with the LLA. Such example architectures are developed to cater to 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 Recommendation 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.

5.2.2 *Physical OS configuration*

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

- support application programs;
- data base functions;
- user terminal support;
- analysis programs;
- data formatting and reporting.

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 realized on various numbers of OSs (or MDs, NEs), depending on the network size, functionality required, reliability, etc.

The categorization of TMN protocol selection attributes 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 realization 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 Data Communications Network (DCN) for a TMN should, wherever possible, follow the OSI reference model for CCITT applications as specified in Recommendation X.200 [7].

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, packet switched data network, ISDN, common channel signalling network, public switched telephone network, local local area networks, 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. Additionally, the DCN will also be used to connect MDs to 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 CCSS No. 7 or an existing packet-switched network).

Equipment supporting an OSF must provide for two types of data communication: the spontaneous transmission of messages (e.g. for the NEF to the OSF) and a two-way dialogue (e.g. as the OSF obtains supporting information from the NEF and sends commands to the NEF or transfer messages to or from another OSF). In addition, an OSF 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.

5.3.2 *Message communication considerations*

Within a TMN, the communications functions such as protocol conversion and communications relay functions are performed by the Message Communication Function (MCF). The MCF interfaces all function blocks in different equipment and consists of one or more of the following processes:

a) *communications control*

- polling;
- addressing;
- communications networking;
- ensuring integrity of data flows.

b) *protocol conversion*

c) *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*

5.4.1 *Mediation considerations*

Mediation is a process within the TMN which acts on information passing between Network Elements Functions (NEF), or Q Adaptor Functions (QAF), and Operations Systems Functions (OSF) and provides local management functionality to the NE(s). Mediation uses standard interfaces and can be realized in a separate Mediation Device or be shared among NE(s).

Typically, mediation will fulfil one of two roles. To provide management functionality to groups of similar network elements (e.g. modems or transmission equipment, etc.) or provide management functionality to one network element (e.g. digital switch) as shown in Figure 23/M.3010.

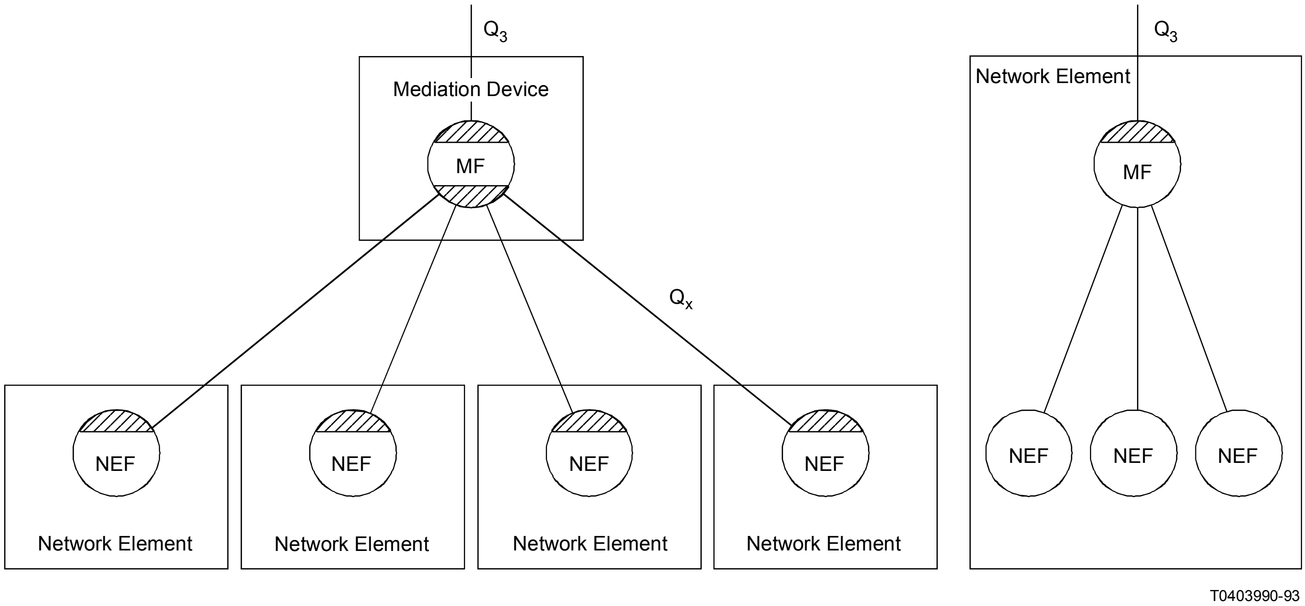


FIGURE 23/M.3010
Example of the use of Mediation

Mediation can be implemented as a hierarchy of cascaded devices using standard interfaces. The cascading of mediation devices and various interconnection structures between MDs on one hand and MDs and NEs on the other hand provides for greater flexibility in the TMN. Some options are shown in Figure 24/M.3010. 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.

5.4.2 *Processes of mediation*

The processes that can form mediation can be classified into five general process categories. A number of more specific processes can then 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* (see § 2.2.3):

   – translating between information models (e.g. object model);

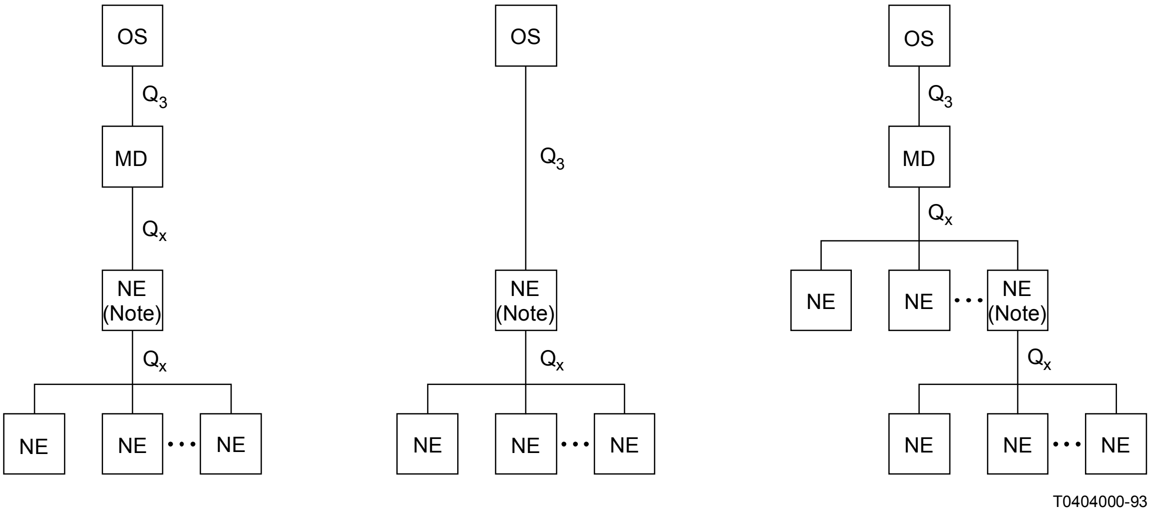
   – translating multiple information models to a generic information model;

   – augmenting and enhancing information in the translation process from a local Management Information Base (MIB) to be compliant with the generic information model.

2) *Processes involving higher order protocol interworking:*

   – connection establishment and connection negotiation;

   – maintaining the communications context.



OS Operations System
MD Mediation Device
NE Network Element

Note – NE contains MF.

FIGURE 24/M.3010
Examples of cascaded Network Elements

3) *Processes involving data handling:*

   – concentration of data;

   – collection of data;

   – data formatting;

   – data translation.

4) *Processes involving decision making:*

   – workstation access;

   – thresholding;

   – data communications back up;

   – routing/re-routing of data;

   – security (e.g. access control, verification);

   – fault sectionalization 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.

5.4.3 *Implementation of mediation processes*

Mediation processes can be implemented as stand-alone equipment or as part of an NE. 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 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 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 interfaces (Q_x) to these other NEs are required.

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

5.5 *Network element considerations*

A network element performs the NEF and may in addition perform one or more OSFs, MFs or QAFs.

The study of various application examples leads to the desirability to distinguish between the following functions contained in a Network Element Function (NEF):

– Telecommunication functions which are involved in the telecommunication process. Typical functions are switching and transmission.

– Telecommunications support functions which are not directly involved in the telecommunication process. Examples are failure localization, billing, protection switching and air-conditioning.

Note that 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 Q Adaptor Function Block (QAF) is used to connect to the TMN those NE-like and OS-like entities which do not provide standard TMN interfaces. Typical QAFs are interface conversion functions. A Q Adaptor (QA) can contain one or more QAFs.

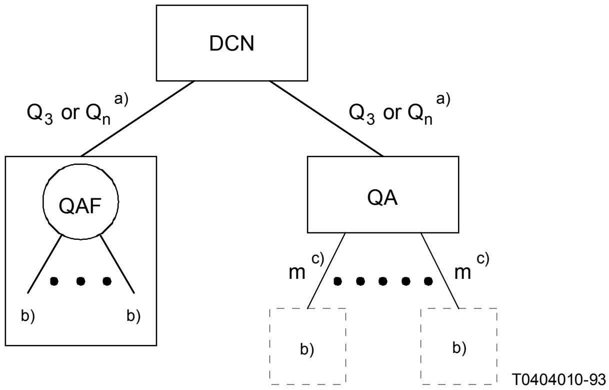
A QA can support either a Q_3 or Q_x interface.

Figure 25/M.3010 depicts an example of a QA connecting equipment both inside and outside the TMN.

5.7 *Workstations*

In Figures 3/M.3010 and 16/M.3010 the workstation reference points and interfaces are shown. It is recognized that across these communication links workstations may access any suitable TMN component, and that workstations vary in power and capabilities. Nevertheless, for the purpose of this Recommendation, the workstation is considered to be a terminal connected via a data communication network to an operation system or a device with a 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 Recommendation, 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.



NE Network Element
QA Q Adaptor
DCN Data Communications Network
QAF Q Adaptor Function

a) Q_x only if connected to an MD or an NE with MF via the DCN.
b) May include telecommunication functions and/or telecommunication support function.
c) Any interface at the m reference points is not subject to standardization.

FIGURE 25/M.3010
QA configuration examples

5.7.1 *Presentation Function (PF)*

The PF 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 an OSF or MF to be involved in the management of the user's terminal (apart from network security aspects). If the PF resides in a TMN component which also performs Human Machine Adaptation (HMA), the f reference point is said to be within that component, and consequently, in that case no F interface exists. The human machine interface (g reference point), be it 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. Details concerning G interface functions are contained in the Z-Series Recommendations.

5.7.2 *Workstation Functions (WSFs)*

The WSFs provide the user at the terminal with the general functions to handle input and output of data to/from the user's terminal. The typical workstation functions are:

- security access, log in, etc. to the terminal;
- recognize and validate input;
- format and validate output;
- support the menus, screens, windows, scrolling, paging, etc.;
- access to TMN;
- screen development tools to allow
  - development, modification of screen layouts;
  - definition of fixed text;
  - help information;
  - field validation rules;

- maintain data base of screens;
- user input edit facility:
  - backspace, rub out, undo, etc.;
  - note pad;
  - cut and paste;
  - diary.

5.7.3 *Functions across the f reference point*

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:

a) from PF to HMA:

- access scope negotiation;
- request object details;
- request help on TMN information;
- handbooks, e.g. management procedures;
- tutorials;
- request attribute verification rules;
- search and query data base;
- operations to initiate functions;
- commands;
- etc.

b) from HMA to PF:

- access and authentication 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 ensure compatibility of devices interconnected to accomplish a given TMN 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 management functions. A minimum set of protocol suites to be applied to TMN standard interfaces should be determined according to Recommendation M.3020 [12].

Consideration should be given to compatibility with the most efficient data transport facilities available to each individual network elements [e.g., leased circuits, circuit switched connections, packet-switched connections (Recommendation X.25 [6]), CCSS No. 7, Embedded Communications Channels of the SDH and ISDN access network D- and B-channels].

It is recognized that NEs, QAs, OSs, MDs and WSs may have other interfaces in addition to the Q, F and X interfaces defined in this Recommendation. It is also recognized 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_3 interfaces*

For the Q_3 family it is recommended that each set of TMN application functions with similar protocol needs be supported with unique protocol selections for layers 4 to 7 as defined by the OSI reference model (Recommendation X.200 [7]). Protocol options will likely 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 family of protocols are given in Recommendations Q.961 [5] and Q.962 [9].

5.8.2 *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 to 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 may be chosen from any of the CCITT recommended communication protocols. Details of one of the chosen Q_x interface specifications and a Q_x family of protocol suites will be found in network specific Recommendations.

5.9 *Relationship between a TMN function block and the OSI systems management model*

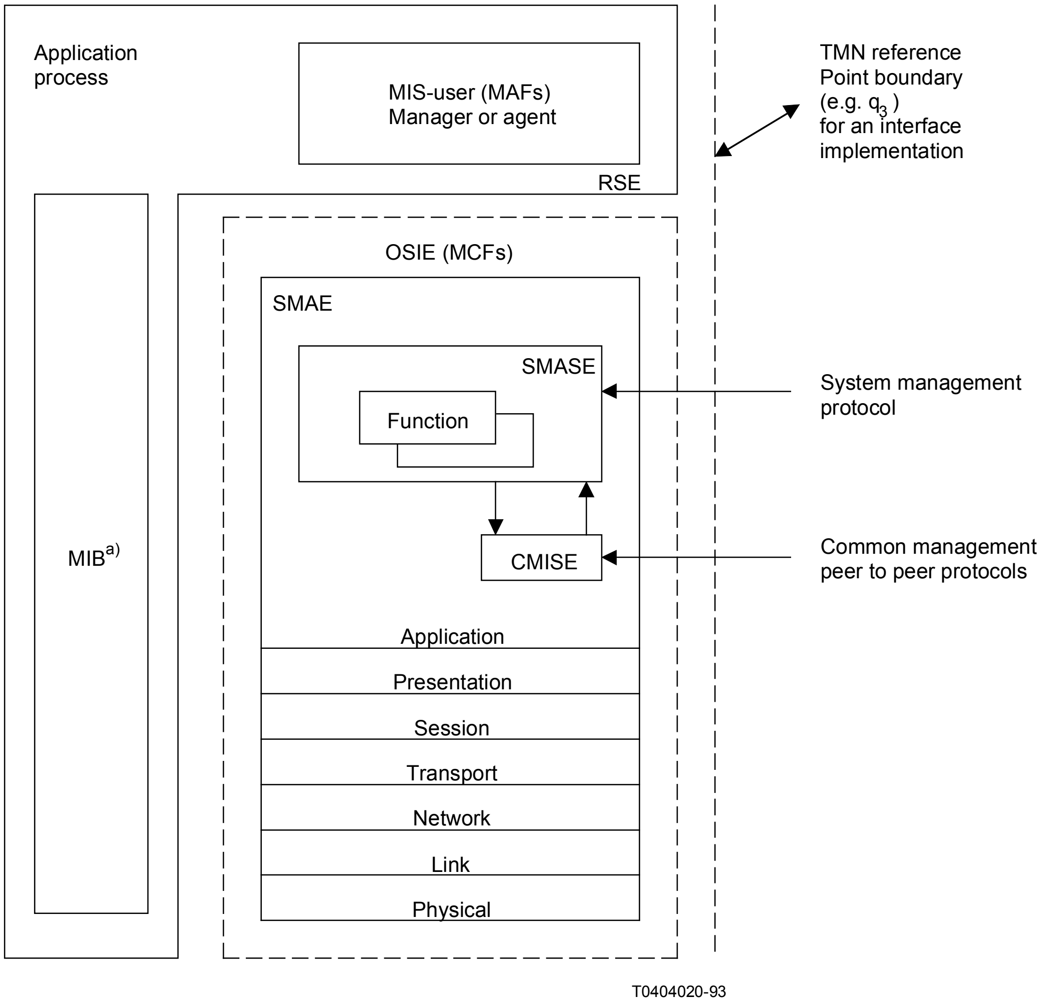
The TMN functional architecture provides a functional description of a network. The TMN is comprised of TMN function blocks. Each functional block which is part of the TMN might comply with the OSI systems management model which is defined in Recommendation X.701 [3]. This section shows the relationships between the TMN functional architecture and the system management model.

Figure 26/M.3010 illustrates a relationship between a TMN function block and the OSI systems management model. The model in Figure 26/M.3010 describes a TMN function block within the TMN, namely: OSF, MF, WSF, NEF and QAF.

Within each open system there is a set of application processes. The Management Information Service (MIS) user is an application making use of systems management service Recommendation X.701 [3]. The MIS-users are part of the Real System Environment (RSE).

Each MIS-user controls management operations. The MIS-user is associated with the MAFs which are defined in § 2. The functions that comprise a system management application service element (SMASE) are associated with management functions which are defined in Recommendation M.3400 [14]. The system management functions are a subset of the management functions which are defined in Recommendation M.3400 [14]. The OSI environment is associated with the MCFs which are defined in § 2.

The Management Information Base (MIB) is a conceptual repository of the management information. It contains OSI system managed objects and managed objects which represent resources of the TMN plus additional resources of the telecommunications network. The MIB is defined as a TMN functional component in § 2.



OSIE	OSI environment
SMAE	Systems management application entity
MCF	Message communication function
SMASE	Systems management application service element
CMISE	Common management information service element
MIB	Management information base
MIS	User-management information service user
MAF	Management application function
RSE	Real system environment

a) An MIB representing TMN managed objects is only provided when the MIS-user supports an agent role.

FIGURE 26/M.3010

Relationships between a TMN function block and the OSI systems management model

APPENDIX I

(to Recommendation M.3010)

TMN planning and design considerations

I.1 *General TMN 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 on NE and other elements within the TMN;

– between a WS and other elements within the TMN;

– between elements within the TMN;

– 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 specified in terms of function attributes needed to provide the most efficient interface.

This list is not complete and is subject to further study.

I.1.1 *Function attributes*

a) *Reliability* – The capability of the interface to ensure that data and control are 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.

Table I-1/M.3010 suggests a table of possible ranges for these function attributes.

I.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. 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 and MD also describe the complexity of interfaces between these elements.

I.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.

TABLE I-1/M.3010

Possible ranges for TMN 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 but available/unavailable)
	Reliability (accuracy)	High Medium Low	
	Availability	High Medium Low	
Characteristics of TMN traffic (C)	Quantity	Large Medium Small	Condition or parameter of design
	Frequency	Often Non-medium periodic Seldom periodic	
	Priority	High Medium Low	

If there are conflicting attribute values for different functions in a given network element, more than one instance of an 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.

I.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 optimizes 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 Study Groups.

I.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 minimizing 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.

I.1.6 *TMN naming and addressing*

For the successful introduction of a TMN [within an Open Systems Interconnection Environment (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.

I.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 automated equipment;
- mappings between various names (such as from Application Entity (AE) title to presentation address) are expected to involve "directory" functions;
- the directories may be held locally and/or off-system.

I.1.6.1.1 *Unambiguous naming*

When names are required to be unique or unambiguous (globally), a mechanism is required for coordinating naming activities among 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:

- Network Service Access Point (NSAP) addresses;
- system titles [including Application Process (AP) titles and Application Entity (AE) titles].

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

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

I.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 purposes;
- for purposes identified by naming authorities.

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

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

I.1.6.1.3 *Application layer names*

Administrations will need to consider:

- definition of an 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 the naming authority.

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

- determination of the registration authority and its "location" in the object identifier tree;
- structuring the registration authority's sub-tree for the allocation of system titles;
- structuring the sub-tree under each system title node for derivation of AP-titles.

I.1.6.2 *Addresses*

An AE-title maps to a presentation address which may be 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 with regard to other systems. However, a set of standardized values for selectors should be established for administrative reasons.

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

The NSAP should be based on Recommendation X.213 [10].

I.2 *DCN considerations*

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 the most efficient communications:

- between NE and other elements within the TMN;
- between WS and other elements within the TMN;
- between elements within the TMN;
- 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.

APPENDIX II

(to Recommendation M.3010)

Examples of functional architectures

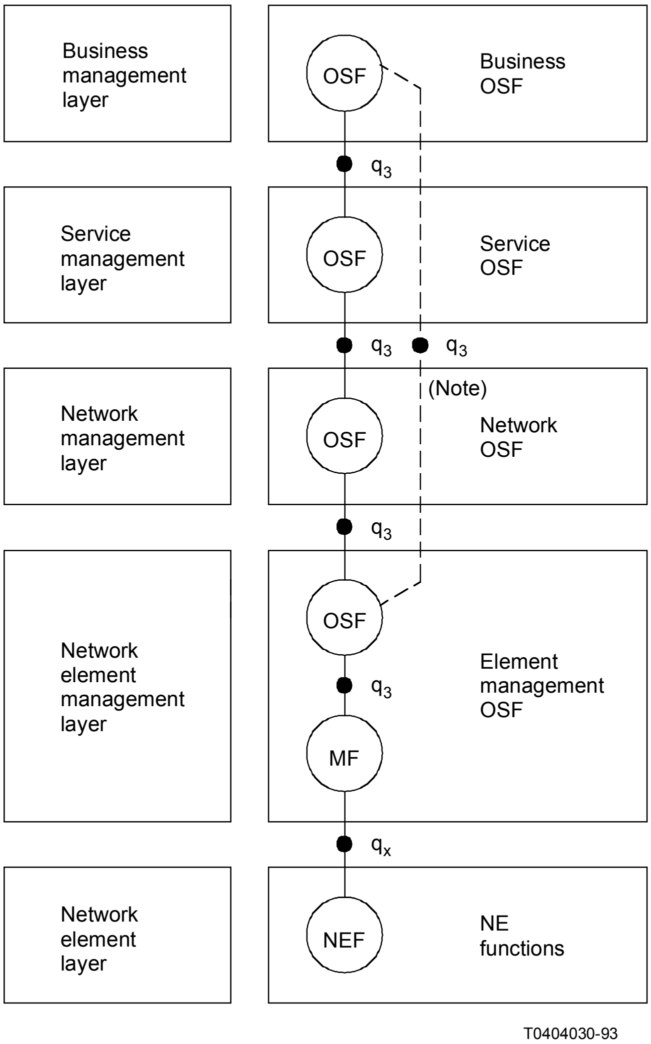
II.1 Functional architecture examples for the TMN hierarchy

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 subset of the total management activity.

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

II.2 *The management layers of the architecture*

The management layers of the architecture are illustrated in Figure II-1/M.3010.



Note – In some instances it may be possible for Administrations to bypass layers of communication within the functional hierarchy.

FIGURE II-1/M.3010

Example of a TMN OS functional hierarchy

II.2.1 *Element management layer (EML)*

The EML 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 three principle roles:

1) control and coordination 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.

OSFs in the element management layer always interface with OSFs in the network management layer through the q_3 reference point.

Note – All mediation functions, including those physically located elsewhere (e.g. in an NE) are logically located in the EML.

II.2.2 *Network management layer (NML)*

The NML has the responsibility for the management of all the NEs, as presented by the EML, both individually and as a set. It is not concerned with how a particular element provides services internally.

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

The network management layer has three principle roles:

1) the control and coordination 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 management layer on performance, usage, availability etc.

Thus, the NML provides the functionality to manage a network by coordinating activity across the network and supports the “networking” demands made by the service management layer.

OSFs in the NML always interface with OSFs in the service management layer through a q_3 reference point.

II.2.3 *Service management layer (SML)*

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 five principle roles:

1) customer facing (see Note) and interfacing with other Administrations/RPOAs;
2) interaction with service providers;
3) interaction with the NML;
4) maintaining statistical data (e.g. 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.

OSFs in the SML always interface with OSFs in the business management layer through a q_3 reference point.

OSFs in the SMLs interface with OSFs in other SMLs (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 § II.3.

II.2.4 *Business management layer (BML)*

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.

II.3 *Value added services (VASs)*

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 VASs can, over a period of time, become basic.

However, VASs 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 II-2/M.3010 shows how service management capability would be provided to value added service providers from external and internal organizations.

A network operator's TMN can be seen to support his own VASP 1 via an OSF connected to the basic service management OSF via a q reference point.

The basic service and the VASP 1 could be physically realized on the same OS or on separate OSs.

VASP 2 can be provided access to the basic service management capability via an x reference point.

VASP 3 can provide an additional VAS over VASP 2's service via an x reference point.

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.

II.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/services provisioning.

Figure II-3/M.3010 shows another possible inter-TMN OSF connectivity example within the management hierarchy.

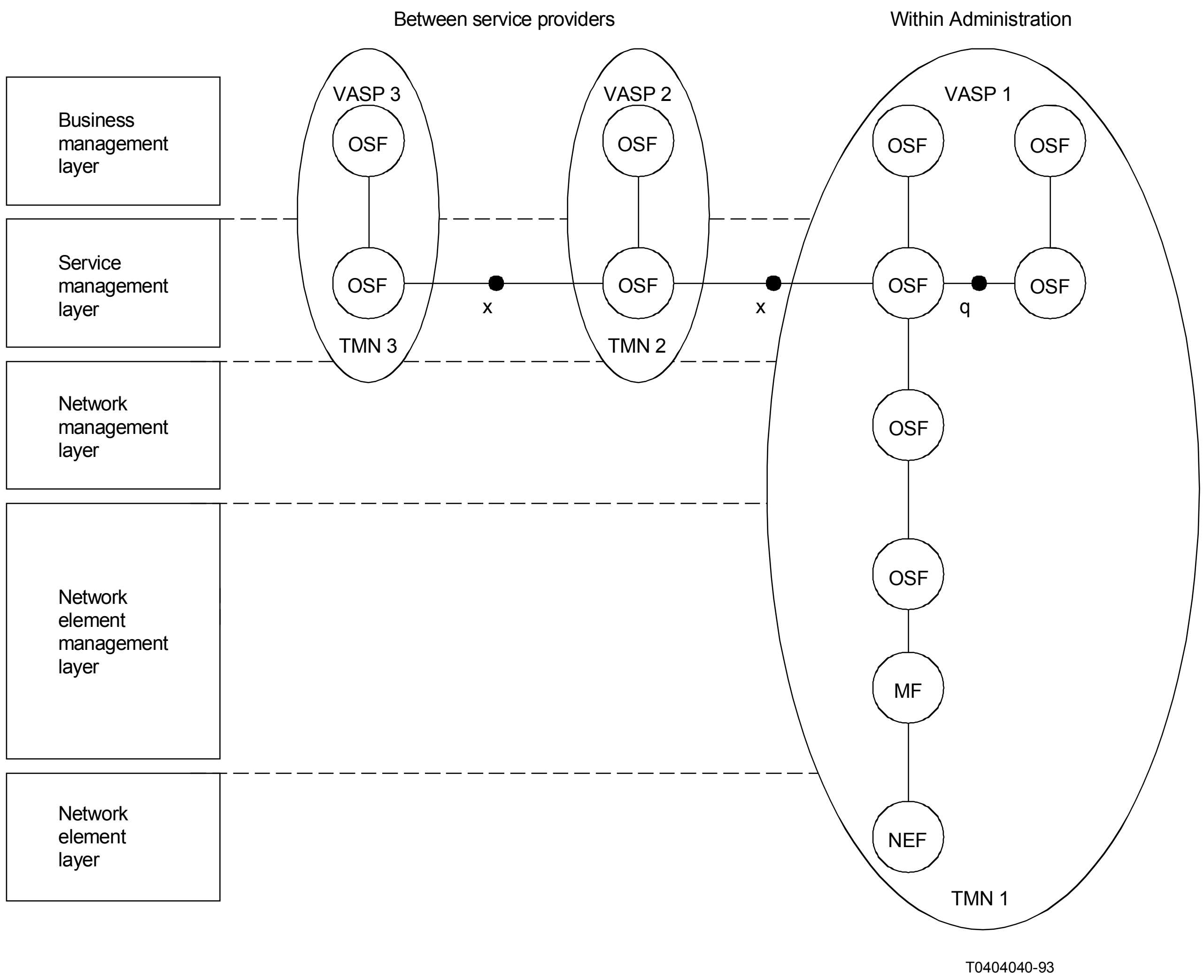


FIGURE II-2/M.3010

Examples of value added services

TMN Z illustrates an Administration that is only a transport provider. TMN 1 through TMN N illustrates some number of services. No service management layer OSFs exist within the TMN Z, 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 provider's environment.

The x reference point exists between different management layer OSFs depending on the problem domain being encountered within a service's lifecycle. The x reference point is not required to be exclusive to OSFs in peer-to-peer management layers.

Note – In Figure II-3/M.3010, the implementation of such an architecture may require very strong access control mechanisms.

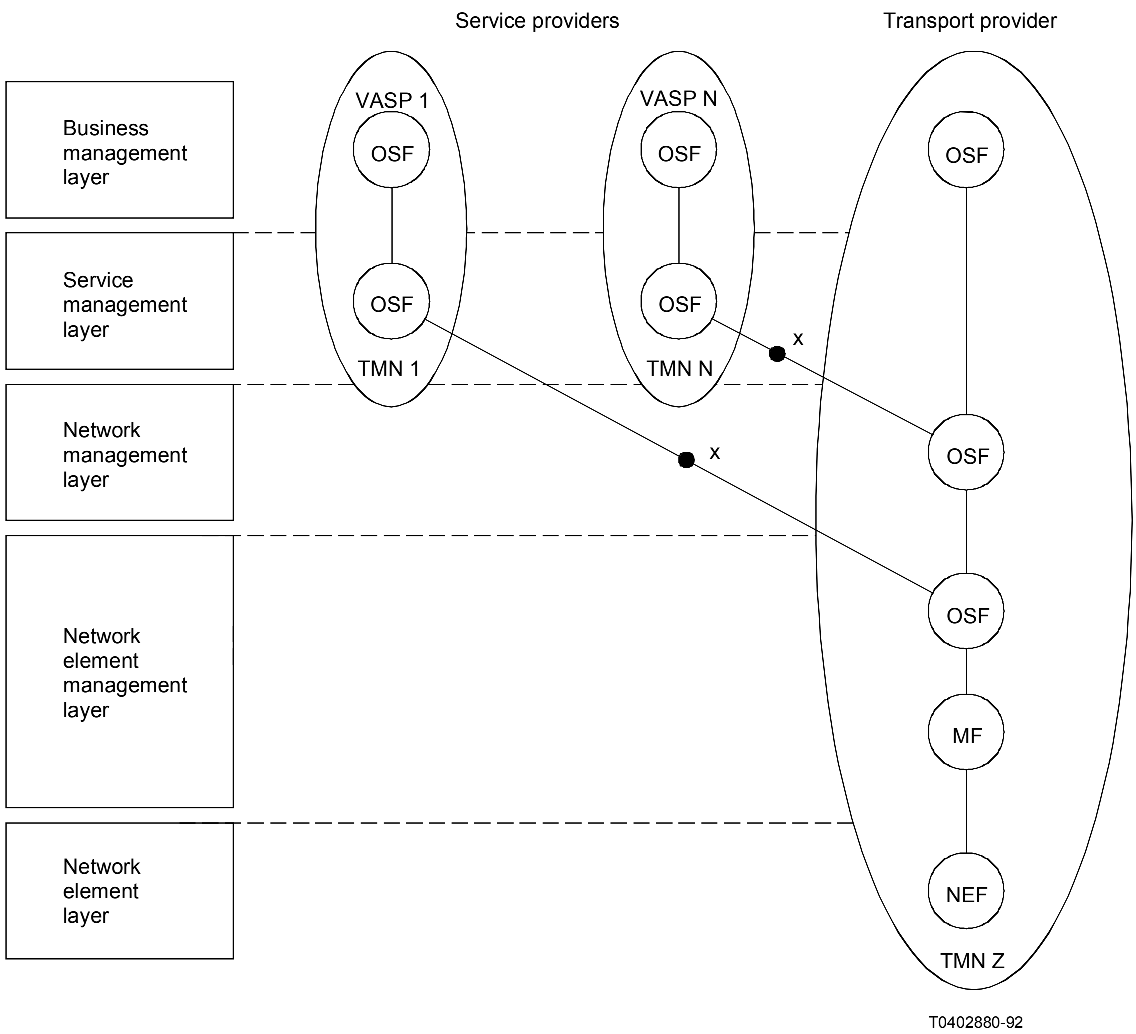


FIGURE II-3/M.3010

Examples of inter-TMN OS functional connectivity

APPENDIX III

(to Recommendation M.3010)

Configuration examples

III.1 *Configuration examples*

This appendix contains a number of TMN configuration examples. They are based on both an analysis of this Recommendation and the expectations of probable implementations. They are presented here to help visualize the extent of the possibilities that a TMN can offer an Administration.

III.1.1 *Physical architecture examples*

Figure III-1/M.3010 shows additional example connections, to those shown in Figure 16/M.3010. This figure illustrates how a number of interfaces might share communication paths within a given TMN physical architecture. These possibilities are based upon Table 5/M.3010.

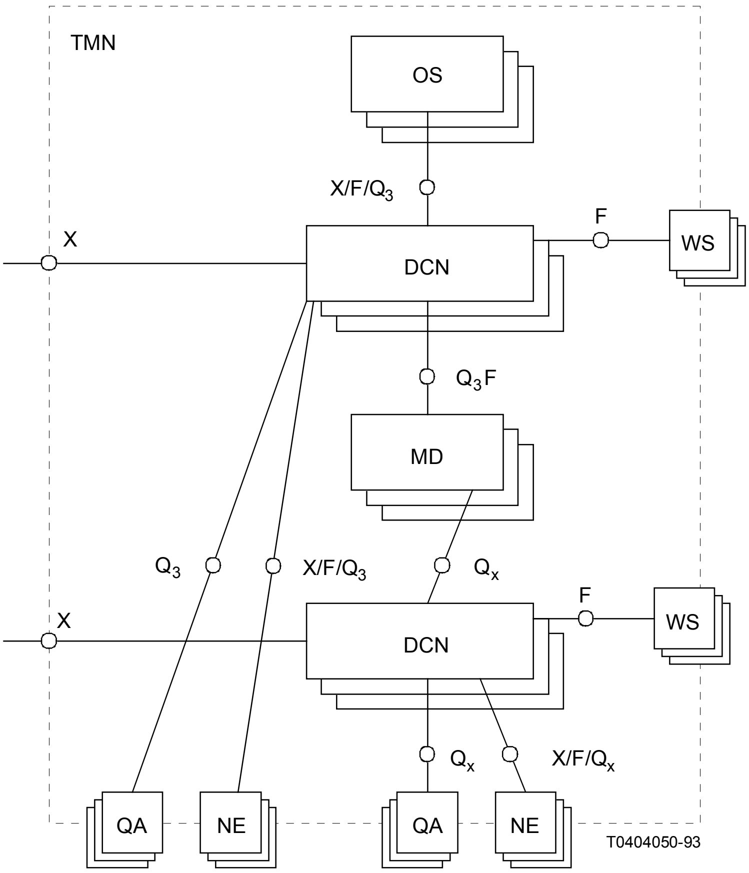


FIGURE III-1/M.3010
Additional examples of interfaces for the TMN physical architecture

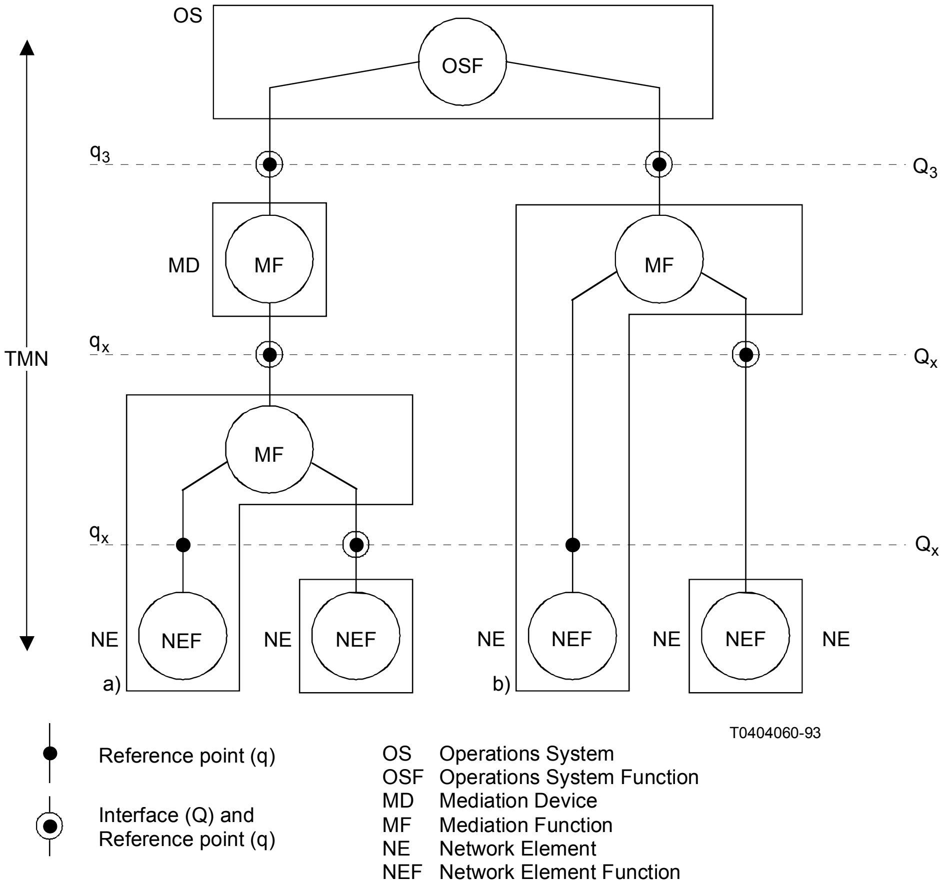
Figure III-2/M.3010 shows examples, with the DCFs not explicitly shown, of a special group of physical configurations in which NEs are cascaded to provide a single interface to the higher order TMN equipment.

Case a) shows how an NE without an internal MF is connected via a Q_x interface to an NE with an internal MF which itself has a Q_x interface to an MD.

Case b) shows another possibility where an NE without an internal MF has a Q_x interface to an NE with an internal MF which itself has a Q_3 interface to the OS.

III.1.2 *DCN examples*

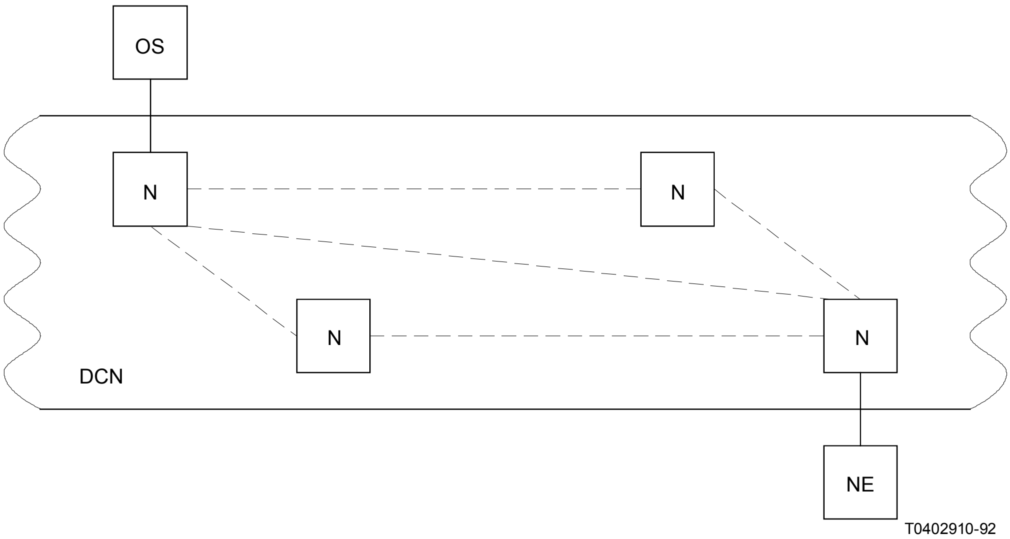
Figure III-3/M.3010 shows an example of a multi-node X.25 packet-switched realization (Recommendation X.25 [6]) for the DCN.



Note – The OSF shown on the top of this figure can consist of a family of OSFs.

FIGURE III-2/M.3010

Examples of cascaded Network Elements (physical configurations)



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 III-3/M.3010

Example of a DCN

III.1.3 *SDH communications examples*

Figures III-4 and III-5/M.3010 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. In a cascaded arrangement some devices may, therefore, only serve as communication relays, while some others will include mediation functions.

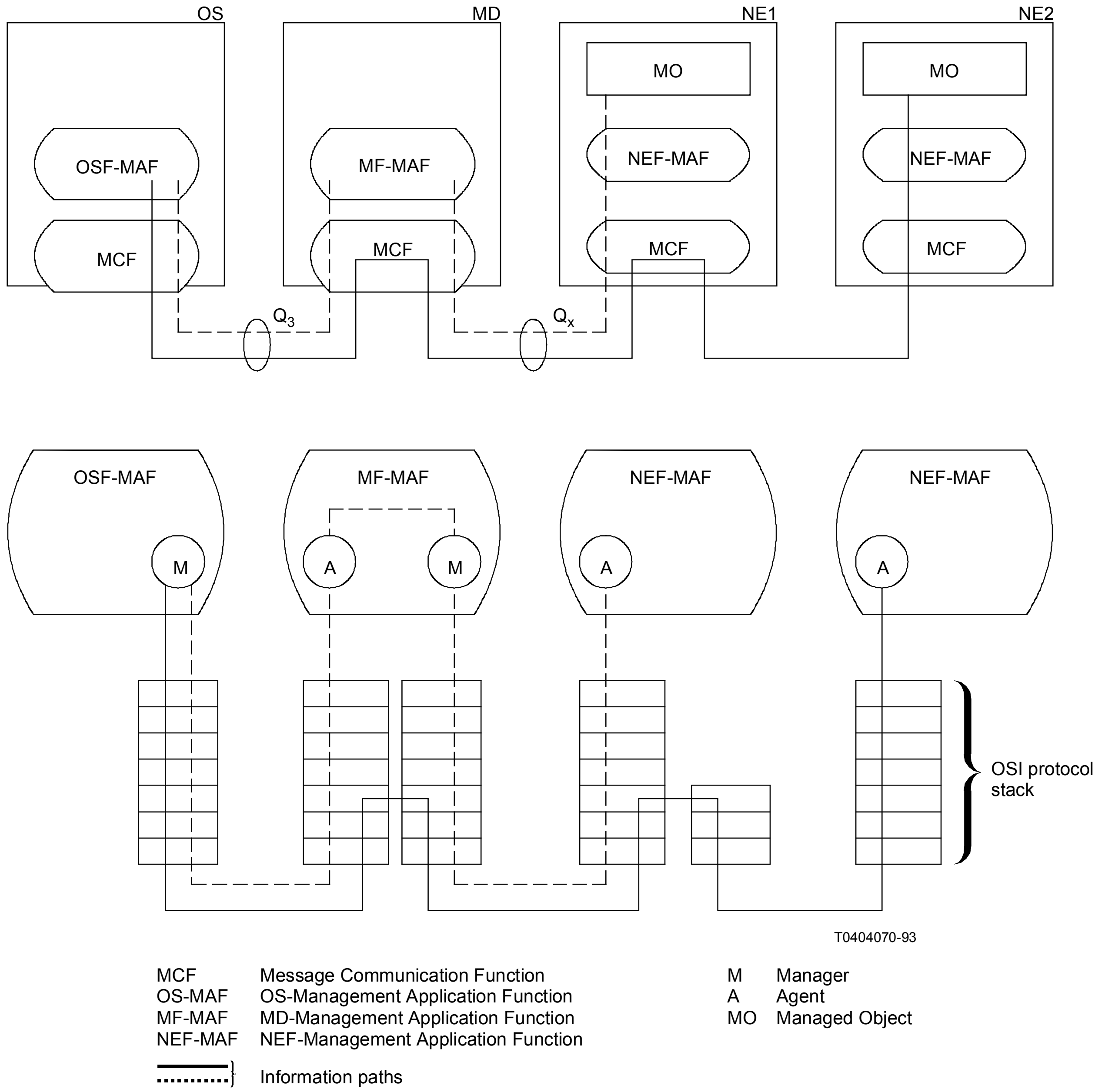
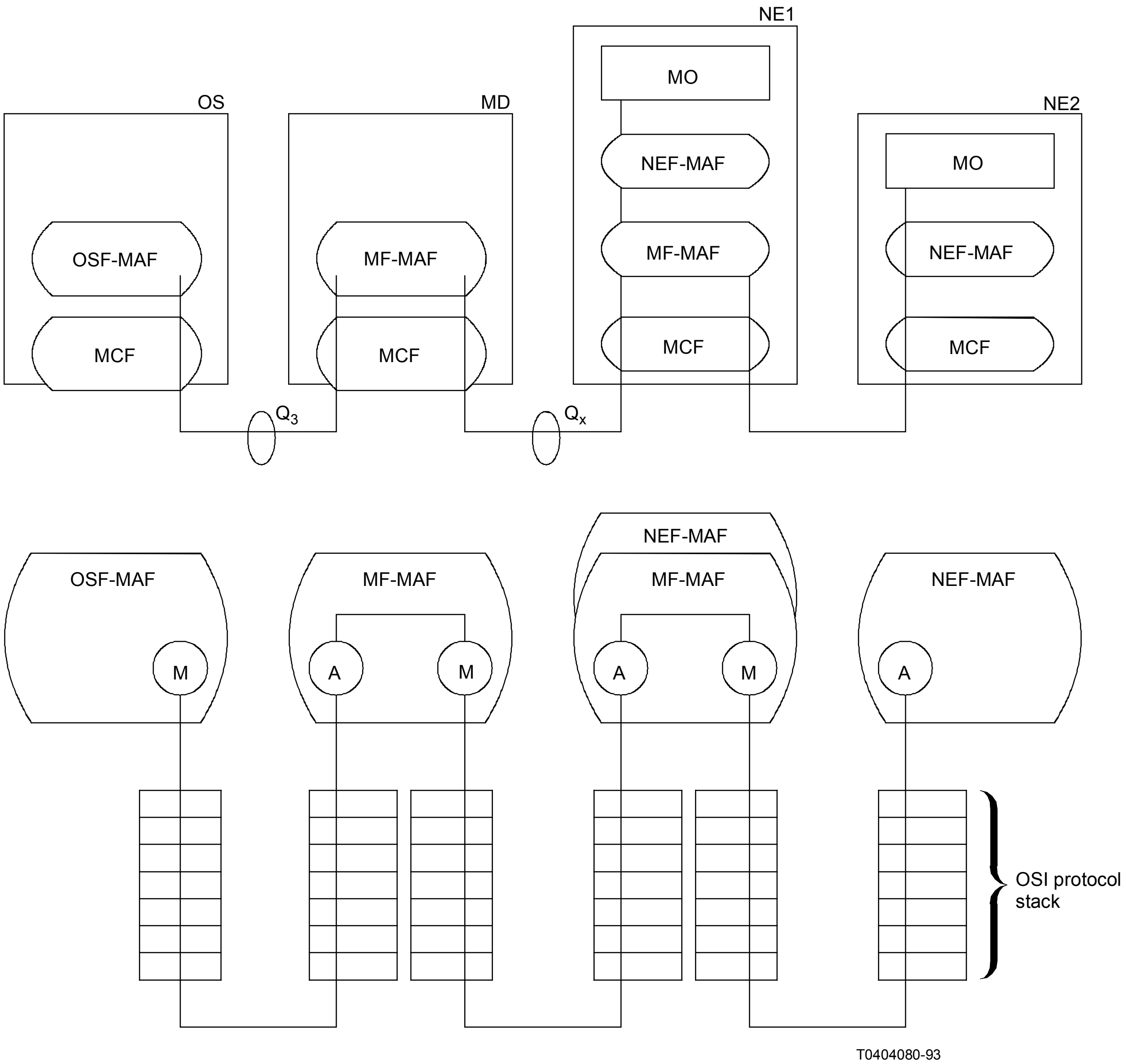


FIGURE III-4/M.3010

SDH functional configuration examples



NEF-MAF	NEF Management Application Function	M	Manager
MCF	Message Communication Function	A	Agent
OS-MAF	OS-Management Application Function	MO	Managed Object
MF-MAF	MD-Management Application Function		

——— Information paths

FIGURE III-5/M.3010
SDH functional configuration examples

APPENDIX IV

(to Recommendation M.3010)

Considerations for managing networks

IV.1 *General considerations for managing networks*

This appendix 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 coordinated so as to achieve the overall desired effect. There are several different categorizations or problems possible:

1) Activity synchronization is where the operation needs to influence several managed objects in a coordinated manner. The objects which are involved could be distributed across several separate managed elements. Synchronization 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 synchronization is the ability to recover from failures of implemented management operations.

2) Maintenance of consistency is closely related to synchronization 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 related to the above concepts. When an operation is dependent upon several TMN nodes in a network being changed in a strict sequence, this is called sequencing.

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. The course of action cannot continue until objects locked by the first operation are released. Both operations are waiting for the other to take action. (Note that 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.

IV.2 *Shared management knowledge (SMK)*

Management functions (e.g. event management and state management) include 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.

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.

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 needs to support the development of this understanding as well.

Besides understanding which functions and managed objects are supported, the shared management knowledge (SMK) also includes an understanding of authorized management capabilities (e.g. permission to modify configurations, adjust tariffs, create or delete managed objects, etc.).

IV.3 *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.

IV.3.1 *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 as to 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 management interfaces to come to a common understanding of what the SMK will be for this management association, thus completing the context negotiation process.

This 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.

IV.3.2 *Dynamic context negotiation*

Dynamic context negotiation is required if the capabilities (e.g. functions supported) or the management resources (e.g. managed object classes or instances) in the management interface are subject to change during the association. One possible mechanism to support dynamic context negotiation would be to define a managed object class that supports 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.

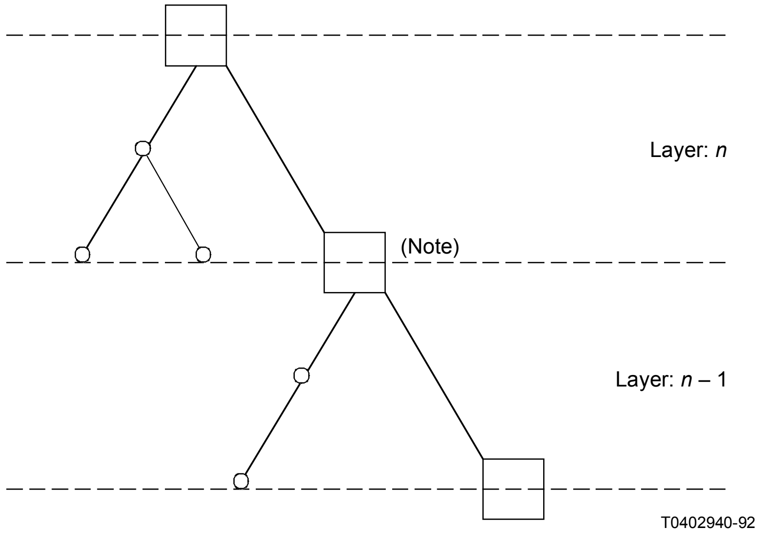
APPENDIX V

(to Recommendation M.3010)

Layered architecture considerations

V.1 *General layered architecture considerations*

Figure V-1/M.3010 represents two layers of a generalized layered model. The purpose of the model is to show the control authority between components of the management architecture (shown as circles in Figure V-1/M.3010). Such components represent managed objects while the square on the notional boundary between layers (the dotted lines) represent the information model for the layer below it [this implies an information conversion function (ICF) at this point].



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

FIGURE V-1/M.3010
A layer model

V.2 *Rationale for logical layered architecture (LLA)*

The LLA architecture defines a TMN as being the overall management domain of an Administration. The Administration has business objectives and operational strategies. These then dictate the organizational structure of the Administration and the services marketed, and therefore 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 an LLA is the partitioning of management components based on abstraction level (e.g. "service" as opposed to "supporting resources").

V.3 *Mapping between layers*

A managing OSF domain 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 subordinate domain of the next lower level. For each domain there is an information model which the OSF uses to guide its management decisions.

The OSF for the subordinate domain maps between the information model it shares with the upper level OSF into the information model of its own domain. 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. An example of this is described in § 3.2.2, a further example is depicted in Figure V-2/M.3010.

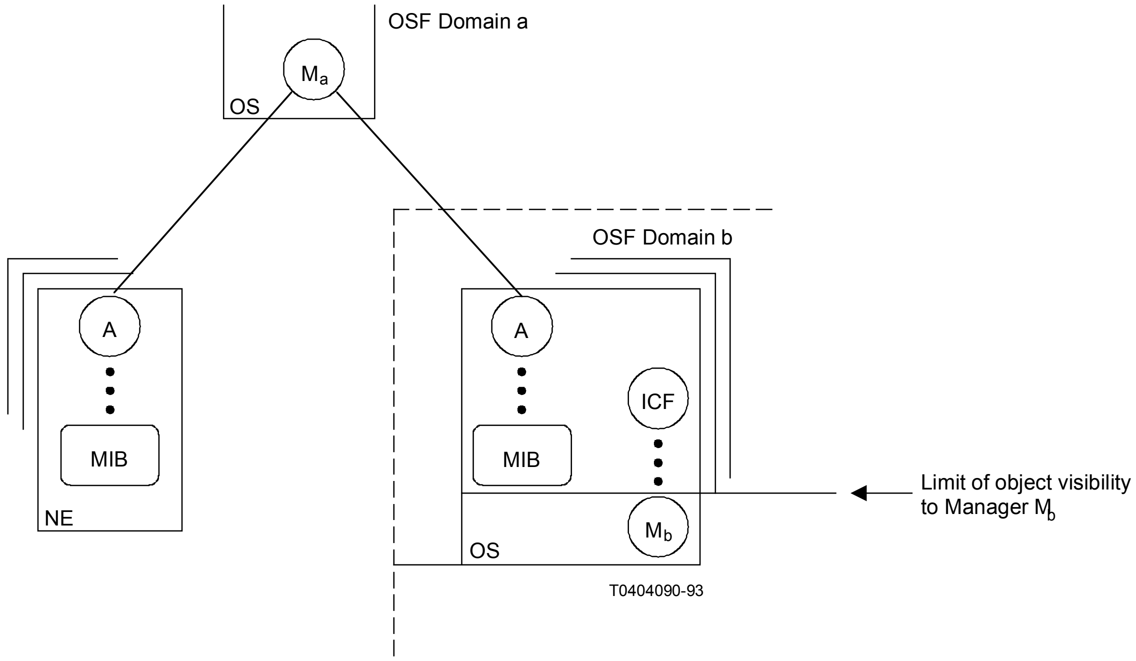


FIGURE V-2/M.3010
Physical interactions between LLA domains

The OSF of the next domain down is also responsible for managing that domain. This recursive nature is depicted in Figure V-2/M.3010. The ultimate objective is to manage the real resources which are represented by Managed Objects (MOs). Thus each recursion path is terminated when the OSF of a domain is only managing MOs. MOs may also be present in domains higher up the recursion path where they represent physical or logical resources that are within the scope of the domain's model.

Such mapping concepts are only explicitly required when the reference points between domains become embodied in interfaces. When this happens an arrangement such as depicted in Figure 10/M.3010 could occur.

References

[1] CCITT Recommendation X.700 *Management framework definition for open systems interconnection (OSI) for CCITT applications.*

[2] CCITT Recommendation M.3602 *Application of maintenance principles to ISDN subscriber installations.*

[3] CCITT Recommendation X.701 *System management overview.*

[4] CCITT Recommendation X.711 *Common management information protocol specification.*

[5] CCITT Recommendation Q.811 *Low layer protocol profiles for the Q3 interface.*

[6] CCITT Recommendation X.25 *Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit.*

[7] CCITT Recommendation X.200 *Reference model of open systems interconnection for CCITT applications.*

[8] ISO 7498 *Information processing system – Open system interconnection – Basic reference model* (Addendum 1-Series of Recommendations).

[9] CCITT Recommendation Q.812 *Upper layer protocol profiles for the Q3 interface.*

[10] CCITT Recommendation X.213 (Annex A) [ISO 8348] *Network layer addressing.*

[11] CCITT Recommendation M.3600 *Principles for the management of ISDNs.*

[12] CCITT Recommendation M.3020 *TMN interface specification methodology.*

[13] CCITT Recommendation M.3200 *TMN management services: overview.*

[14] CCITT Recommendation M.3400 *TMN management functions.*

[15] CCITT Recommendation M.3100 *Generic network information model.*

[16] CCITT Recommendation M.3180 *Catalogue of TMN management function.*

[17] CCITT Recommendation M.3300 *TMN management capabilities presented at the F-interface.*

[18] CCITT Recommendation Z.300-Series *Man-machine language (MML).*

[19] CCITT Recommendation X.710 *Common management information service definitions (version 2)*

[20] CCITT Recommendation X.200-Series *Open systems interconnection: model and notation, service definitions (Recommendations X.200 to X.219); Protocol specifications, conformance testing (Recommendations X.220 to X.290).*

ANNEX A

(to Recommendation M.3010)

Alphabetical list of abbreviations used in this Recommendation

A/M	Agent/manager
AE	Application entity
AP	Application process
BML	Business management layer
CMIP	Common management information protocol
CMIS	Common management information service
CMISE	Common management information service element
DCF	Data communication function
DCN	Data communication network
ECC	Embedded communications channel
EML	Element management layer
HMA	Human machine adaptation
ICF	Information Conversion Function
ISDN	Integrated services digital network

LAN	Local area network
LLA	Logical Layered Architecture
M	Mandatory
MAF	Management application function
MCF	Message communication function
MCF	Management communication function
MD	Mediation device
MF	Mediation function
MF-MAF	Mediation function-management application function
MIB	Management information base
MIS	Management information service
MO	Managed objects
NE	Network element
NEF	Network element function
NEF-MAF	Network element function-management application function
NML	Network management layer
NSAP	Network service access point
O	Optional
OID	Object Identifier
OS	Operations system
OSF	Operations systems function
OSF-MAF	Operations system function-management application function
OSI	Open system interconnection
OSIE	Open systems interconnection environment
PBX	Private branch exchange
PF	Presentation function
QA	Q adaptor
QAF	Q adaptor function
QAF-MAF	Q adaptor function-management application function
RPOA	Recognized private operating agency
RSE	Real system environment
SMAE	Systems management application entity

SMASE	System management application service element
SMK	Shared management knowledge
SML	Service management layer
SS No. 7	Signalling system No. 7
STP	Signal transfer point
TMN	Telecommunications management network
VAS	Value added service
VASP	Value added service provider
WSF	Workstation function

Printed in Switzerland
Geneva, 1993