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Telecommunications management network

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# Principles for a Telecommunications management network

ITU-T Recommendation M.3010



(Previously "CCITT Recommendation")

# Superseded by a more recent version

## FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The ITU-T 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 World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

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NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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## SUMMARY

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.

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

A functional reference model of layering is provided and considerations necessary to support the TMN architectures.

## KEYWORDS

architecture, interfaces, management principles, reference model, Telecommunications Management Network (TMN).

**Recommendation M.3010**

# PRINCIPLES FOR A TELECOMMUNICATIONS MANAGEMENT NETWORK

*(Melbourne 1988 approved as Recommendation M.30,*
*revised and renumbered in 1992, revised in 1996)*

## 1 Scope

The Telecommunications Management Network (TMN) supports management activities associated with telecommunication networks. This Recommendation introduces the TMN concept, defines interfaces and reference points and blocks which describes the functional, information and physical architecture. It also provides a functional reference model and identifies concepts and consideration necessary to support the TMN architecture.

### 1.1 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 ROAs, 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, services and other TMNs. 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.

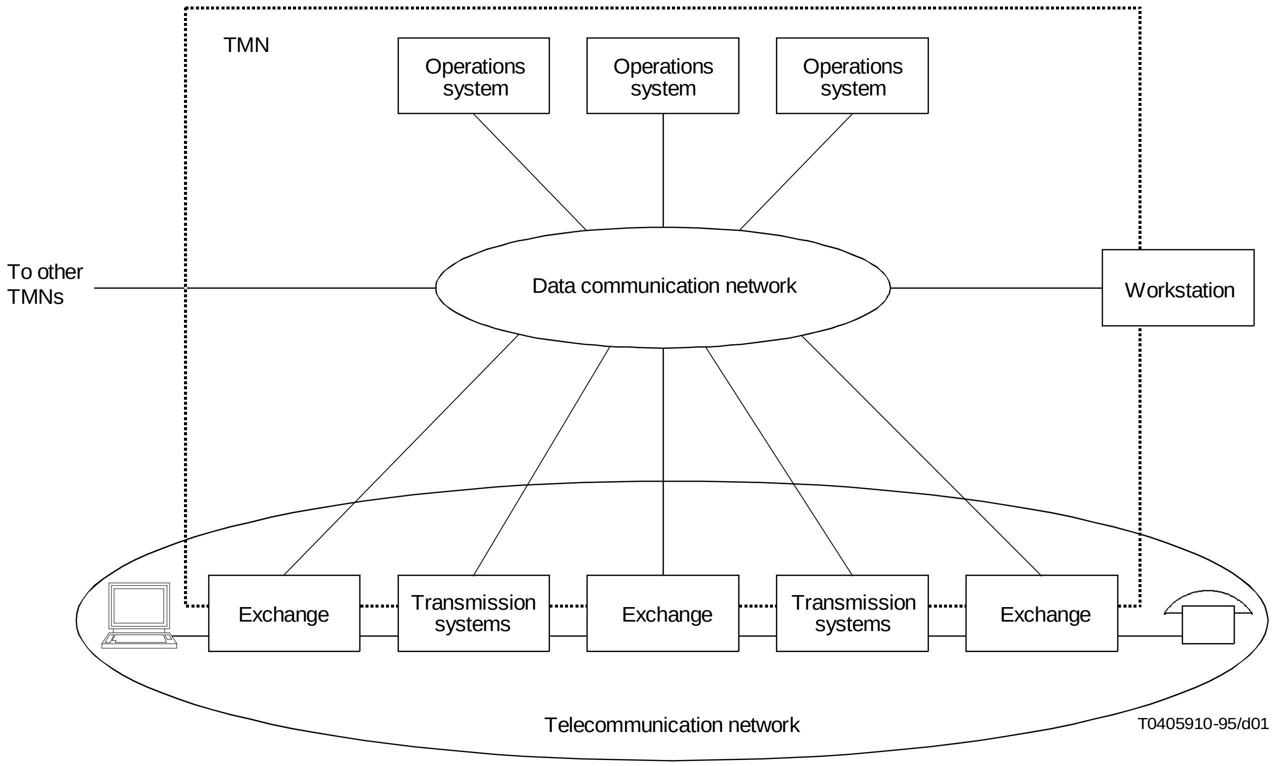
Provision is also made for access to, and display of, management information contained within the TMN to users. This Recommendation will provide both Administrations and manufacturers with a set of guidelines to use when developing equipment, and when designing infrastructure for the management of telecommunications networks and services.

### 1.2 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 TMN may also provide management functions and offer communications to another TMN or TMN-like[1] entities in order to fully support the management of international and national telecommunications networks. A telecommunications network consists of many types of analogue and digital telecommunications equipment and associated support equipment, such as transmission systems, switching systems, multiplexers, signalling terminals, front-end processors, mainframes, cluster controllers, file servers, etc. When managed, such equipment is generically referred to as Network Elements (NEs).

Figure 1 shows the general relationship between a TMN and a telecommunications network which it manages. A TMN is conceptually a separate network that interfaces a telecommunications network at several different points to send/receive information to/from it and to control its operations. A TMN may use parts of the telecommunications network to provide its communications. 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**

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[1] A TMN-like management network is one that is not based on TMN concept but can interwork with a TMN. The way this is done (e.g. via some form of gateway) is an implementation matter.

### 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 (including ATM), 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 databases;
- bearer services and teleservices;
- PBXs, PBX accesses and user (customer) terminals;
- ISDN user terminals;
- software provided by or associated with telecommunications services, e.g. switching software, directories, message databases, etc.;
- software applications running within mainframes, etc. (including applications supporting TMN);
- associated support systems (test modules, power systems, air conditioning units, building alarms systems, etc.).
- ...

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

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

### 1.4 Basic objectives for a 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 make use of OSI-based application services where appropriate.

The object-oriented approach 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. Distributed telecommunications management environments may require the use of emerging object-oriented distributed processing techniques such as Open Distributed Processing (ODP) [33].

### 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 ITU-T 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.

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 exchange management information across the boundary between TMN environments;
- 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.

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 TMN management services (Recommendation M.3200 [13]) to identify (possibly reusable) TMN management functions and TMN management function sets leading to TMN management services (Recommendation M.3400 [14]) which will in turn use one or more managed objects (Recommendations M.3100 [15] and M.3180 [16]).

### 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 an appropriate degree of reliability in the support of management functions;
- provide appropriate security functionality 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;
- support location transparency and association resolution;
- provide mechanisms for maintaining the information required for intersystem communication.

### 1.7 Aspects of TMN architectures

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 clause 2).

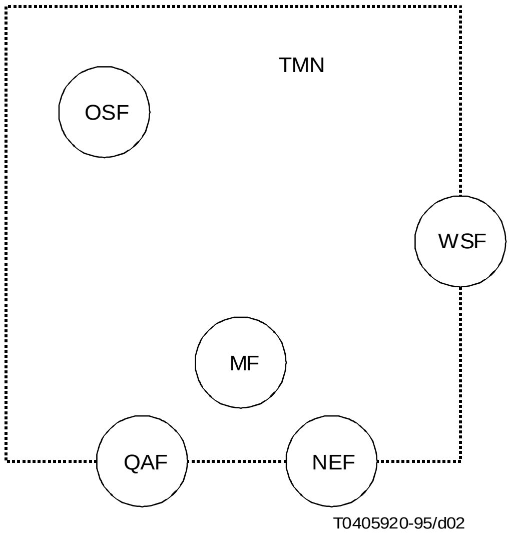
The information architecture, based on an object-oriented approach, gives the rationale for the application of Open Systems Interconnection (OSI) systems management principles to the TMN principles. The OSI systems management and X.500 Directory principles are mapped onto the TMN principles and are expanded to fit the TMN environment where necessary (see clause 3).

The physical architecture describes realizable interfaces and examples of physical components that make up the TMN (see clause 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 with functions which enable it to perform the TMN management functions. A Data Communication 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 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 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 Operations Systems function
MF Mediation Function
WSF Workstation Function
NEF Network Element Function
QAF Q Adaptor Function
........ The TMN functional boundary

FIGURE 2/M.3010

**TMN function blocks**

### 2.1 TMN function blocks

The TMN function blocks are listed below and shown in Figure 2. Each function block is itself composed of functional components. The functional components are collected and defined in 2.2.

Functional components permitted in each function block are defined in Table 2. Additional descriptions and details for each of the function blocks are given in clause 6.

**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 human user, and vice versa.

The responsibility of the WSF is to translate between a TMN reference point and a non-TMN reference point and hence a portion of this function block 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 a portion of this function block is shown outside the TMN boundary.

## 2.2 Functional components

A number of functional components have been identified as the elementary building blocks of the TMN function blocks and are defined in this subclause. Table 2 shows how these functional components are combined into various function blocks, and Table 3 shows the relationship of functional components to function blocks.

Functional components are identified, but are not presently subject to standardization within the TMN area.

**2.2.1 Management Application Function (MAF)**: An MAF represents part of the functionality of one or more TMN management services as defined in Recommendation M.3020 [12] and summarized in Recommendation M.3200 [13]. MAFs may be characterized by the type of function block in which they are contained, e.g. MF-MAF, OSF-MAF, NEF-MAF and QAF-MAF.

To conduct TMN management services, interactions take place between MAFs in different function blocks, with the help of other functional components. Each interaction, known as a TMN management function, involves one or more pairs of cooperating MAFs. Related TMN management functions are grouped into TMN management function sets and are described in Recommendation M.3400 [14]. A TMN management function set may be composed of all of the TMN management functions that are supported by a particular MAF.

An MAF includes a logical representation of the management information exchanged with other MAFs.

**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 Information Conversion Function (ICF)**: The ICF is used in intermediate systems to provide translation mechanisms between the information models at both interfaces. These information models may or may not be object oriented.

The ICF affects the transformation of the messages. The translation can be done at a syntactical level and/or at a semantical level.

The ICF is the component which characterizes the MF and the QAF function blocks and is therefore mandatory for them.

- When differences exist between the information models of both interfaces a number of features should be present in the ICF. A list of considerations for conversion between models may be found in Appendix IV.
- In other cases, the information model changes required in the MF may be null, and thus, the ICF may only provide simple application layer relay functionality.

**2.2.3 Workstation Support Function (WSSF)**: The WSSF provides support for the WorkStation Function block (WSF), including data access and manipulation, invocation and confirmation of actions, transmittal of notifications, and hiding the existence of NEFs and other OSFs (or MFs) from the WSF user communicating with a particular OSF (or MF). The WSSF can also provide administrative support for the WSF and access for administering the OSF.

**2.2.4 User Interface Support Function (UISF)**: The UISF translates the information held in the TMN information model to a displayable format for the human-machine interface, and translates user input to the TMN information model. The UISF is responsible for integrating information from one or more sessions with one or more OSFs or MFs, such that the information is presented in a correct and consistent form at the user interface. Functions similar to MAF and ICF may be provided by the UISF.

**2.2.5 Message Communication Function (MCF)**: The MCF is associated with all function blocks having a physical interface. It is used for, and limited to, exchanging management information contained in messages with its 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.

**2.2.6 Directory System Function (DSF)**: The Directory System Function (DSF) functional component represents a locally or globally available distributed Directory system. Each DSF stores directory information as a set of hierarchically ordered Directory Objects (DOs). As an implementation option it could be built by one or more Directory System Agents (DSAs) as described in the X.500-Series of Recommendations, and summarized in Appendix V.

**2.2.7 Directory Access Function (DAF)**: The Directory Access Function (DAF) functional component is associated with all function blocks which need to access the Directory (mainly required for OSF, but possibly also useful for WSF, MD, QAF, NEF). It is used to get access to and/or maintain (read, list, search, add, modify, delete) TMN related information represented in the Directory Information Base (DIB).

**2.2.8 Security Function (SF)**: Security functional component provides security service that is necessary for function blocks to satisfy the security policy and/or user requirements.

All the security service that function block includes can be classified into five basic services: authentication, access control, data confidentiality, data integrity, and non-repudiation, defined in Recommendation X.800 [24].

Since the detailed security service of each function block can differ from each other, security function is distinguished and named by the function block involved, e.g. WSF-SF, OSF-SF, MF-SF, NEF-SF, QAF-SF.

## 2.3 TMN 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. For a given pair of function blocks, the information passing between them may be characterized by listing the interactions (TMN management functions of Recommendation M.3400) that are appropriate for the pair of function blocks.

### 2.3.1 Classes of reference points

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

- q Class between OSF, QAF, MF and NEF.
- f Class between OSF or MF and 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.

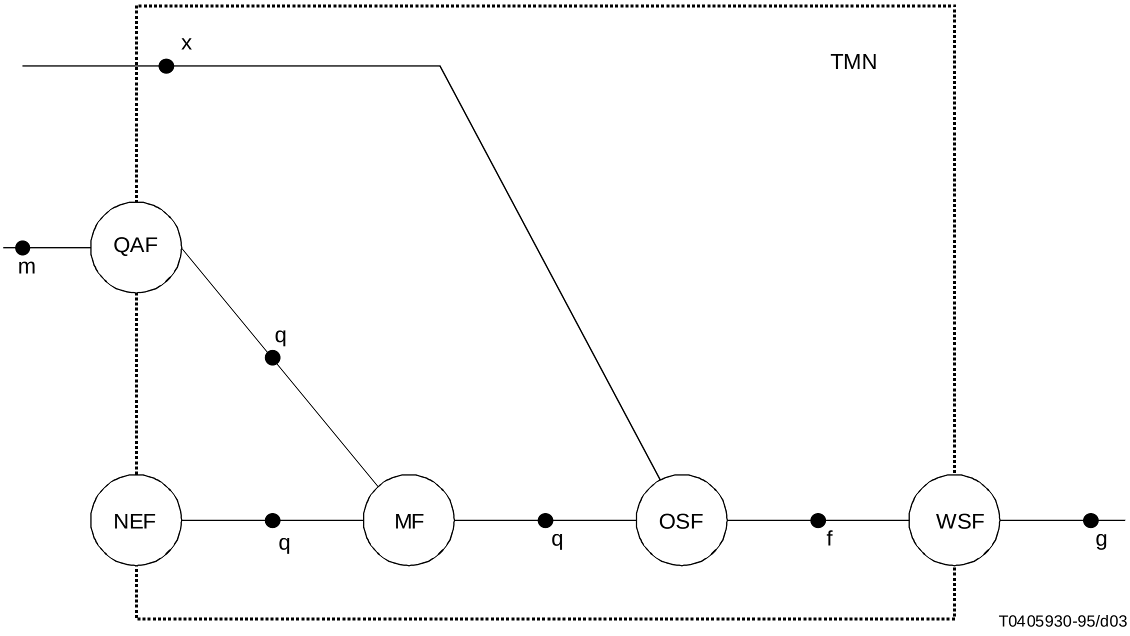
The interfaces corresponding to implementations of reference points are described in 4.3.

Figure 3 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.

### 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.




NOTE – This figure is illustrative and is not exhaustive

FIGURE 3/M.3010

**Classes of reference points in the TMN**

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.

**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.

#### 2.3.2.6 Relationship of reference points to function blocks

Table 1 defines the relationships between logical function blocks expressed as reference points. This table is intended as a concise definition of all possible pairings within the context of TMN.

Figure 6 illustrates an example of possible reference points between function blocks.

Figure 13 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.

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 |
| $QAF_{q_x}$ | | | $q_x$ | | | | m |
| WSF | | f | f | | | | g[b)] |
| non-TMN | | | | m | m | g[b)] | |

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

b) 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.

## 2.4 Data communication function of TMN

The Data Communication 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.

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 (MCFs) are associated with every point of attachment to the DCF as depicted in Figure 4.

Additional details on the DCF are given in 4.5.2.

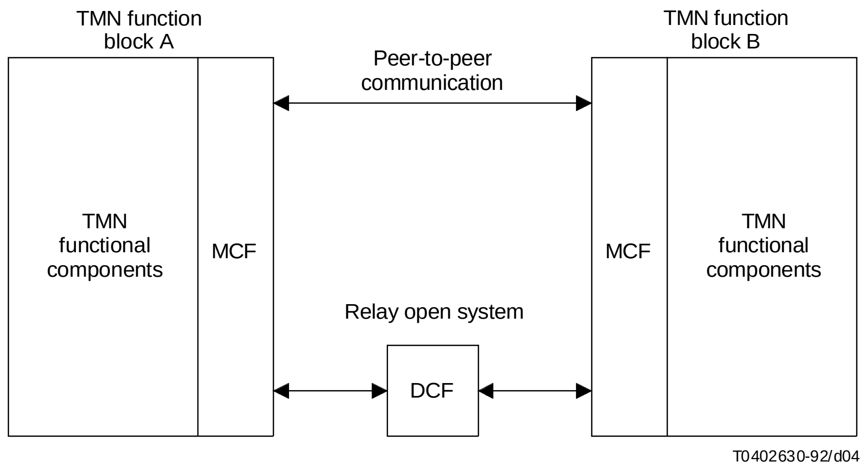



FIGURE 4/M.3010

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

Figure 5 illustrates Table 2 and gives an example, which TMN Functional Blocks could contain which TMN Functional Components. It should be noted that depending on the implementation not all of the TMN Functional Components mentioned in the figure must be present in the TMN Functional Blocks (e.g. the DSF and the DAF).

Figure 6 summarizes the TMN functional reference model by illustrating an example of each pair of functions that can be associated by a reference point. Figure 6 also illustrates the typical flow of information between function blocks in a hierarchical arrangement.

Figure 7 depicts the use of implicit and explicit DCF. It must be noted that a DCF is not present when a reference point is not realized as an interface, and that MF blocks may be cascaded.

TABLE 2/M.3010

**Relationship of function blocks to functional components**

| Function block | Functional components | Associated message communication functions |
|---|---|---|
| OSF[d)] | OSF-MAF (A/M), WSSF, ICF, DSF, DAF, SF | $MCF_x$, $MCF_{q_3}$, $MCF_f$ |
| WSF | UISF, DAF, SF | $MCF_f$ |
| $NEF_{q_3}$[a)] | NEF-MAF (A), DSF, DAF, SF | $MCF_{q_3}$ |
| $NEF_{q_x}$[a)] | NEF-MAF (A), DSF, DAF, SF | $MCF_{q_x}$ |
| MF[d)] | MF-MAF (A/M), ICF, WSSF, DSF, DAF, SF | $MCF_{q_3}$, $MCF_{q_x}$, $MCF_f$ |
| $QAF_{q_3}$[b), d)] | QAF-MAF (A/M), ICF, DSF, DAF, SF | $MCF_{q_3}$, $MCF_m$ |
| $QAF_{q_x}$[c)] | QAF-MAF (A/M), ICF, DSF, DAF, SF | $MCF_{q_x}$, $MCF_m$ |

A/M Agent/Manager
DAF Directory Access Function
DSF Directory System Function
ICF Information Conversion Function
MCF Message Communication Function
MAF Management Application Function
SF Security Function
UISF User Interface Support Function
WSSF WorkStation Support Function

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

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

c) The use of $QAF_{q_x}$ in the manager role is for further study.

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

## 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

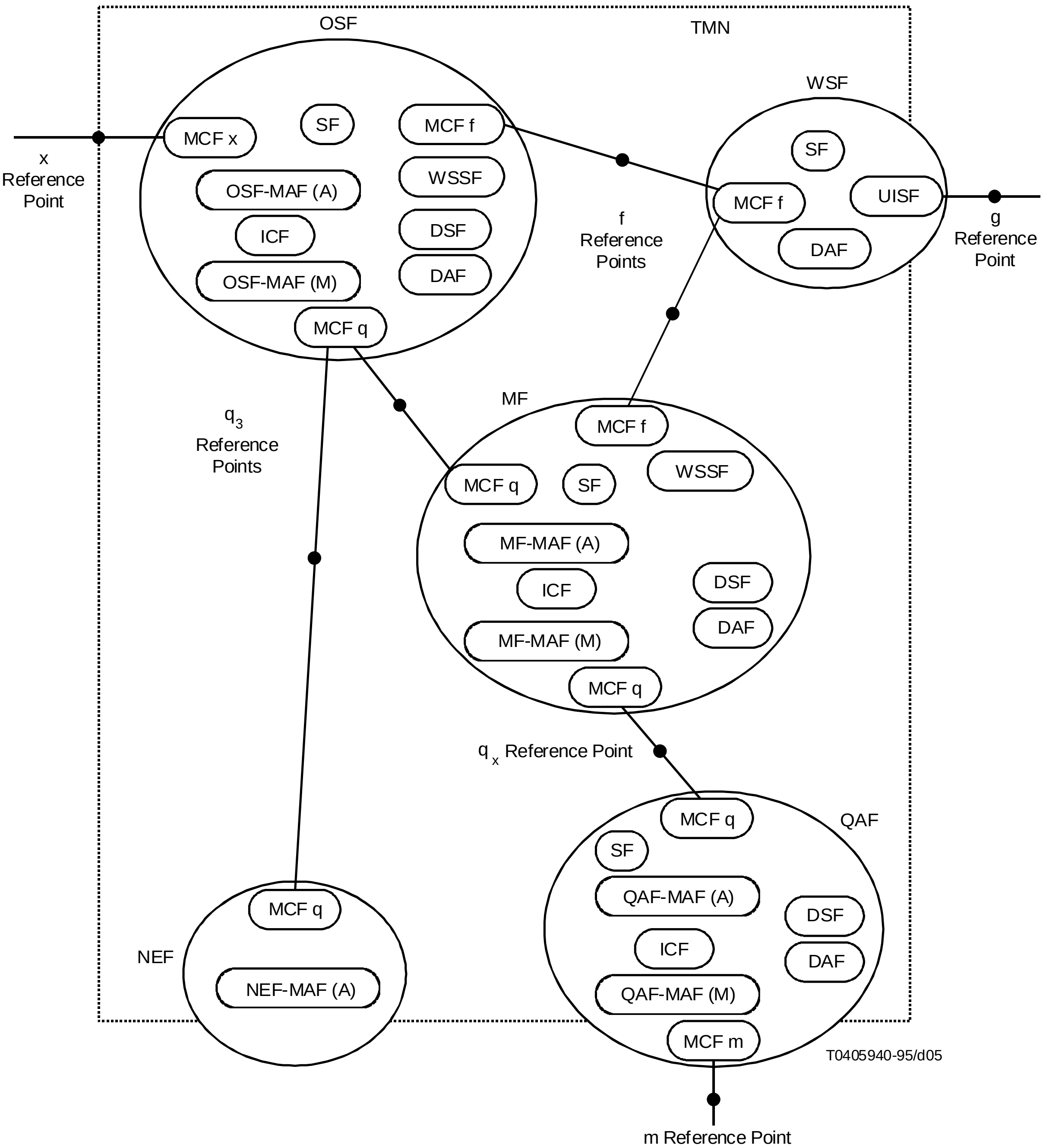
TMNs need to cooperate in order to provide the overall (end-to-end) service as seen by the network user. This often involves providing information and some degree of control to another TMN.

### 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 feedback on their use of the network.

An example of user access is described as Customer Network Management (CNM, see Recommendation X.160 [25]), which enables the user to access management services offered by the service providers. CNM is a set of services to the customers allowing them to access certain TMN functionalities. This service can be seen as a management interaction between users and TMN or between TMNs. The x reference point is used to realise CNM.

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.




*TMN Functional Blocks*

| | |
|---|---|
| OSF | Operations Systems Function |
| MF | Mediation Function |
| WSF | WorkStation Function |
| NEF | Network Element Function |
| QAF | Q Adaptor Function |

*TMN Functional Components*

| | |
|---|---|
| MAF | Management Application Function (M – Manager, A – Agent) |
| WSSF | WorkStation Support Function |
| UISF | User Interface Support Function |
| MCF | Message Communication Function |
| ICF | Information Conversion Function |
| SF | Security Function |
| DSF | Directory System Function |
| DAF | Directory Access Function |

FIGURE 5/M.3010

**Example of typical Functional Blocks containing Functional Components**

TABLE 3/M.3010

**Functional component options for function blocks**

| Function block | Functional components | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | MAF (Note 1) | ICF | WSSF | UISF | DSF | DAF | SF |
| OSF | | M | O | O | – | O | O | O |
| | | | | | | | | |
| WSF | | (Note 2) | (Note 2) | – | M | – | O | O |
| $NEF_{q_3}$ | | M | – | – | – | O | O | O |
| $NEF_{q_x}$ | | O | – | – | – | O | O | O |
| MF | | O | M | O | – | O | O | O |
| $QAF_{q_3}$ | | O | M | – | – | O | O | O |
| $QAF_{q_x}$ | | O | M | – | – | O | O | O |

M Mandatory
O Optional
– Not allowed
DAF Directory Access Function
DSF Directory System Function
ICF Information Conversion Function
MCF Message Communication Function
MAF Management Application Function
SF Security Function
UISF User Interface Support Function
WSSF WorkStation Support Function

NOTES

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

2 These functions (or equivalent) may be considered to be as part of the UISF.

### 2.6.3 Supporting external access to TMN functions

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

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

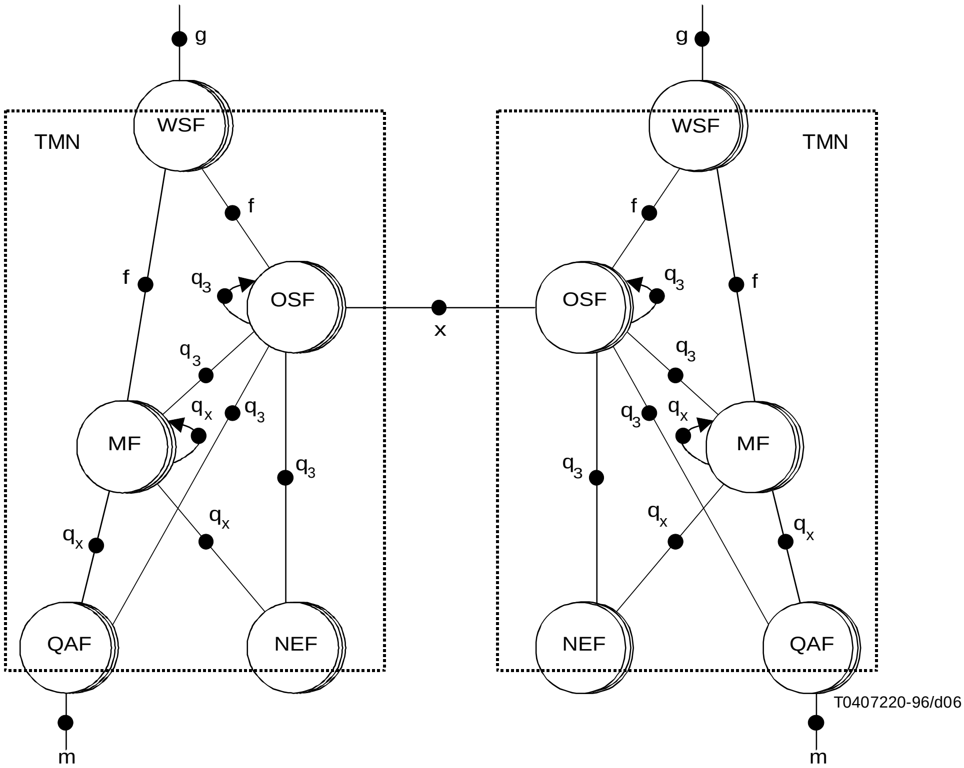



FIGURE 6/M.3010

**Illustration of reference points between management function blocks**

### 2.7 Directory access

TMN function blocks may optionally use Directory functional components to implement the required Directory functionality. This is modelled in the TMN functional architecture as TMN functional components which may be contained in specific TMN function blocks requiring Directory functionality. Figure 8 depicts the Integration of Directory and TMN.

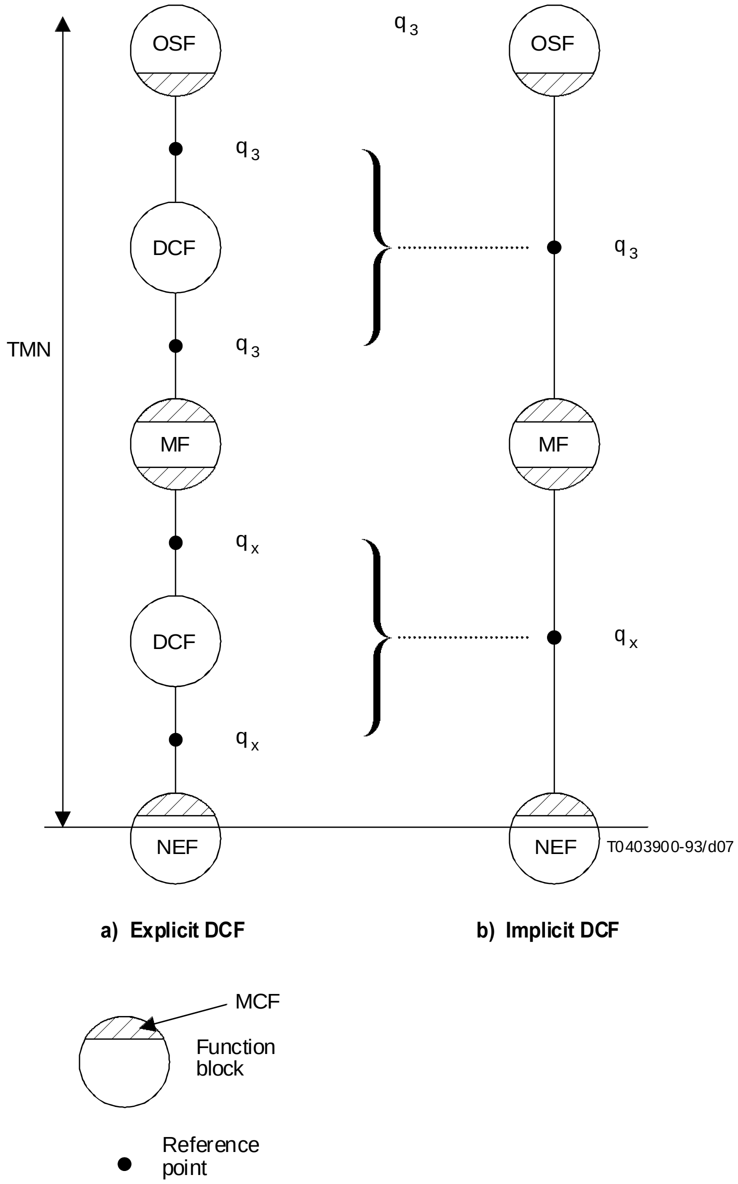
In each TMN function block a Directory Access Function (DAF) may be integrated to allow access and maintenance of TMN-related information in the Directory. In specific TMN function blocks, or TMN-like function blocks outside one specific TMN, a Directory System Function (DSF) may be contained to represent TMN-related directory information.

Associations between DAFs and DSF functional components may be established between TMN function blocks within one TMN for local Directory support (access via q or f reference point); they may be established between functional blocks in remote TMNs (access via x reference point) or they may exist in non-TMN Directories (access via x reference point to an OSF-like function block outside specific TMN environments).

The information exchange between function blocks containing DSFs is carried out via the q reference point in the case of TMN-internal DSF-DSF associations and via the x reference point in the case of associations to DSFs in remote TMNs or OSF-like function blocks.

## 3 TMN information architecture

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




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

FIGURE 7/M.3010

**Implicit and explicit DCF**

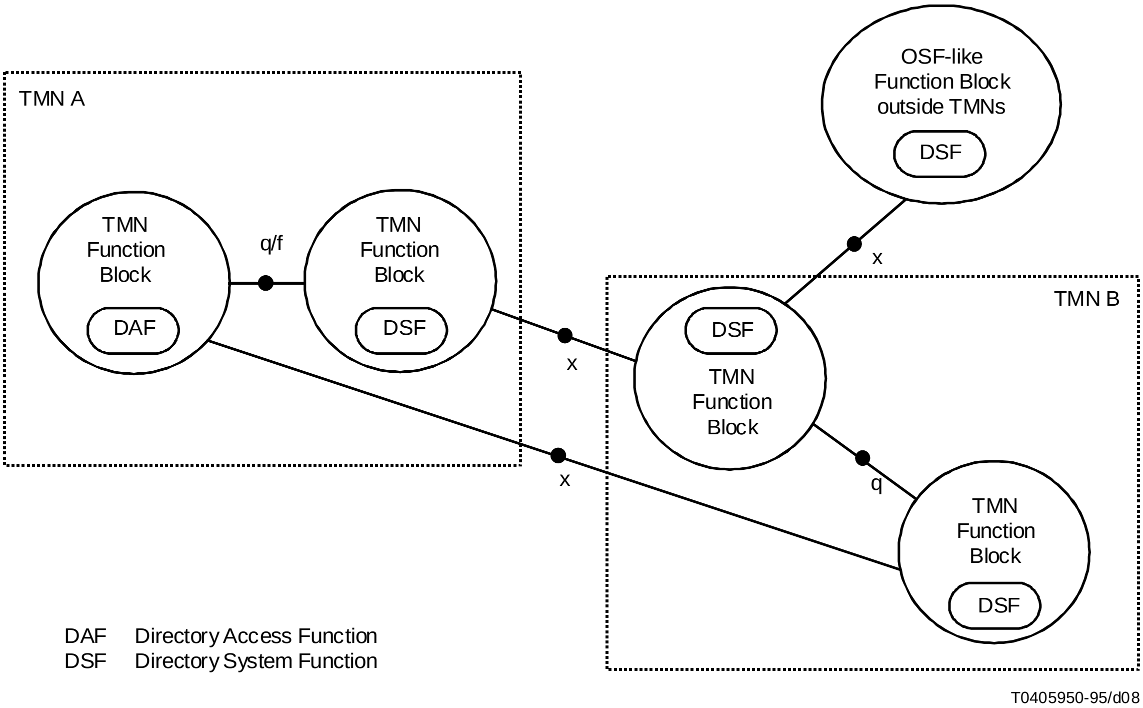



FIGURE 8/M.3010

**Integration of directory and TMN: the TMN point of view**

The information exchange described here should in general be realized through the use of the Common Management Information Services (CMISs) and Protocol (CMIP) Recommendations X.710 [19] and X.711 [4]. But the use of other ASEs (such as FTAM for example) and their associated PDUs should also be possible (see 6.4/X.701 [3]) if they are more convenient to a specified management operation.

Other concepts supportive of distributed applications in the TMN are being considered for TMN. Such concepts are intended to support and enhance, rather than replace, other aspects of the TMN, such as the Generic Information Model. Their full impact remains to be determined.

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.

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.

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 either internal (e.g. threshold crossing) or external (e.g. interaction with other objects);
- the notifications emitted by it.

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. Note that these objects might be coupled in their behaviour through physical or logical relationship;
- managed objects may exist which represent logical resources of the TMN rather than resources of the telecommunications network;
- 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 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 concept

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).

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 9 shows the interaction between Manager, Agent and objects.

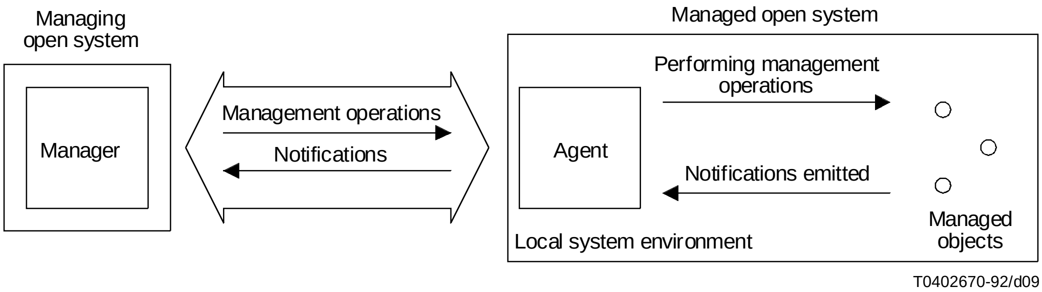



FIGURE 9/M.3010

**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:

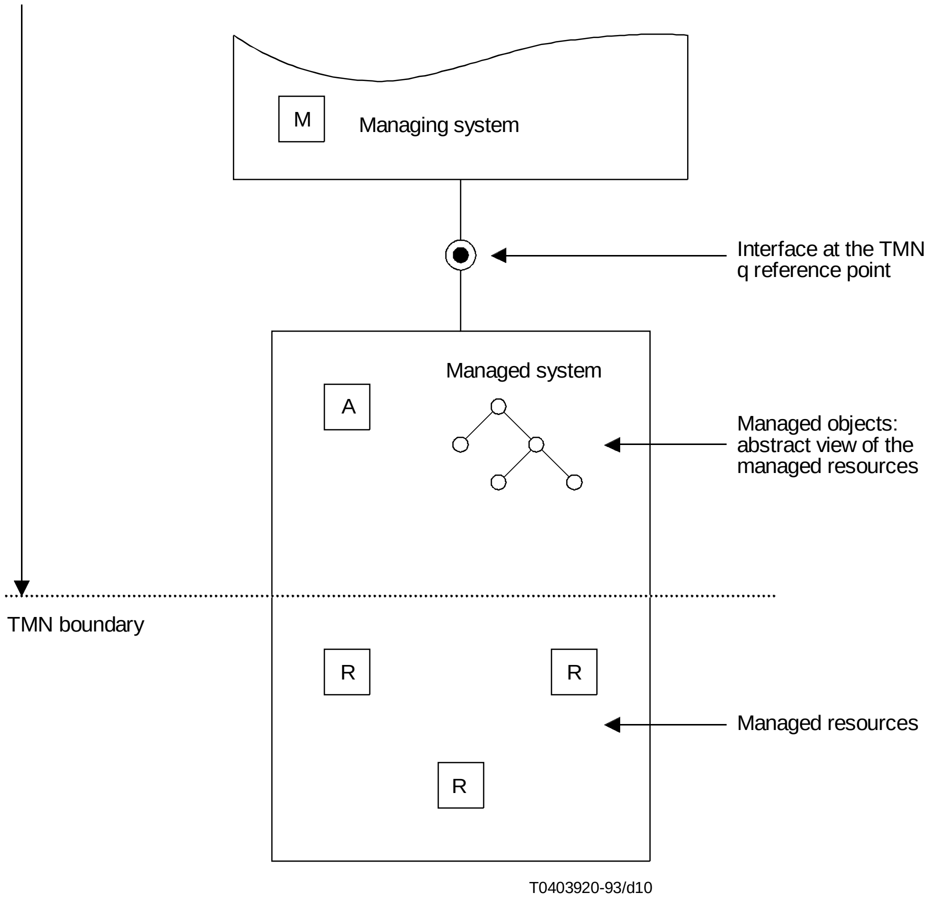
- one Manager may be involved in an information exchange with several Agents. In this case it will contain several manager roles interacting with their associated agent roles. In this scenario, the issue of synchronization of directives may exist. The synchronization issues require further study (see 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.

The information, which may be transferred or affected through use of OSI management protocols is a set of managed object, identified together as the Management Information Base (MIB) (see Framework for system management Recommendation X.700 [1]).

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 realized through the use of the Common Management Information Services (CMISs) [19] and Protocol (CMIP) [4].

An example of the relationships between objects and managed resources for the case of an NE are given in Figure 10.




A Agent
M Manager
R Resources
O Managed object

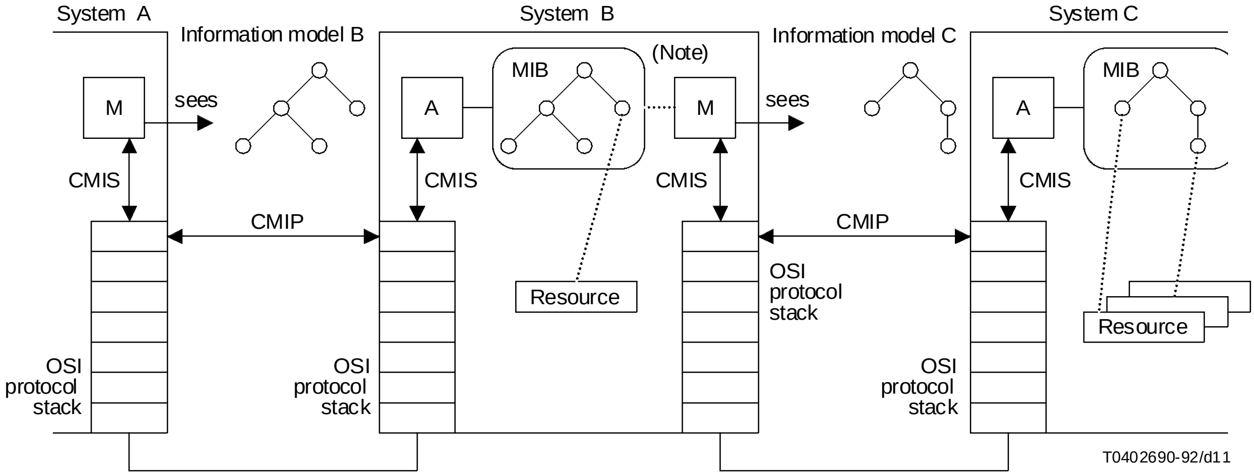
FIGURE 10/M.3010

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

### 3.2.2 Manager/Agent Interworking

The TMN uses 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 11, 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 11/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 may be required to establish this common understanding within each entity.

Figure 12 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 commonalties, in particular, at the system B level.

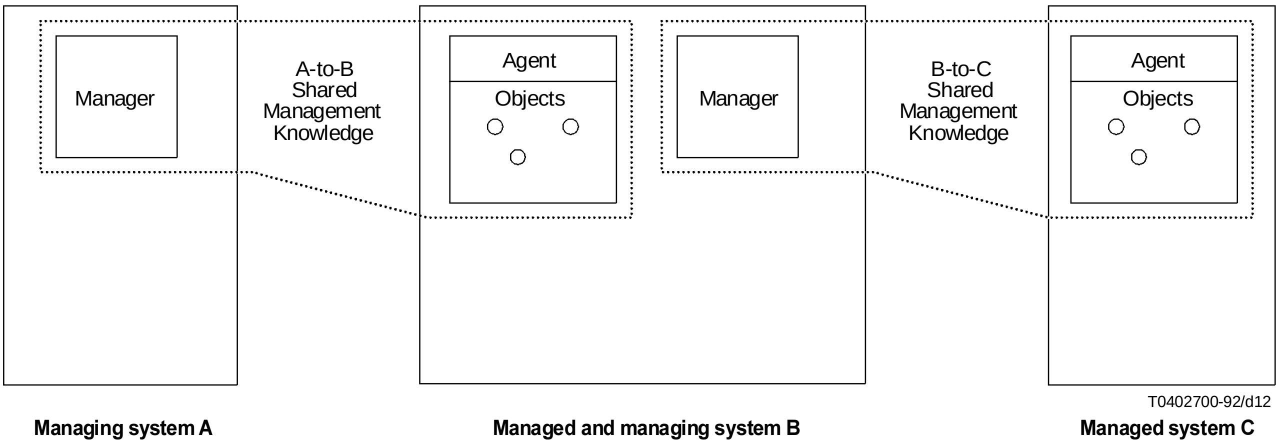



FIGURE 12/M.3010

**Sharing management knowledge between systems**

Figure 13 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 5.3).

Recommendation X.750 “Management Knowledge Management Function” [23] describes the concepts of how SMK (e.g. representation of SMAE presentation addresses) can be represented as Managed Objects (MOs) or as X.500 Directory Objects (DOs). The use of SMK in relation to Recommendations X.750 and X.500 is for further study.

### 3.4 TMN naming and addressing

For the successful introduction of TMNs (within an OSI environment) into Administrations, a logical, integrated naming and addressing scheme for identifying and locating the various communications objects within a TMN and between TMNs 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.

The X.500 Directory service can be used as one implementation option to support the naming and addressing requirements for TMN-interworking. A description of how TMN can be supported by the X.500 Directory system is described in Appendix V.

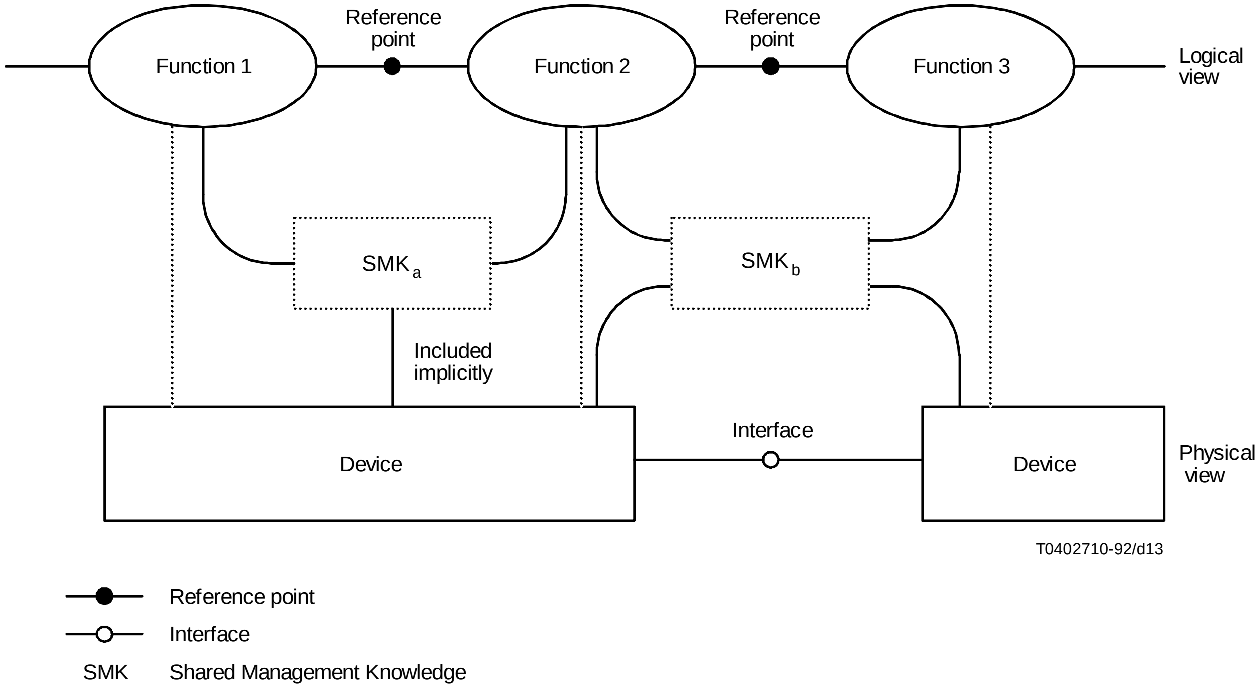



FIGURE 13/M.3010

**Independence of SMKs from the physical implementation**

## 4 TMN physical architecture

Figure 14 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. An additional example can be found in III.1.1.

### 4.1 TMN building blocks

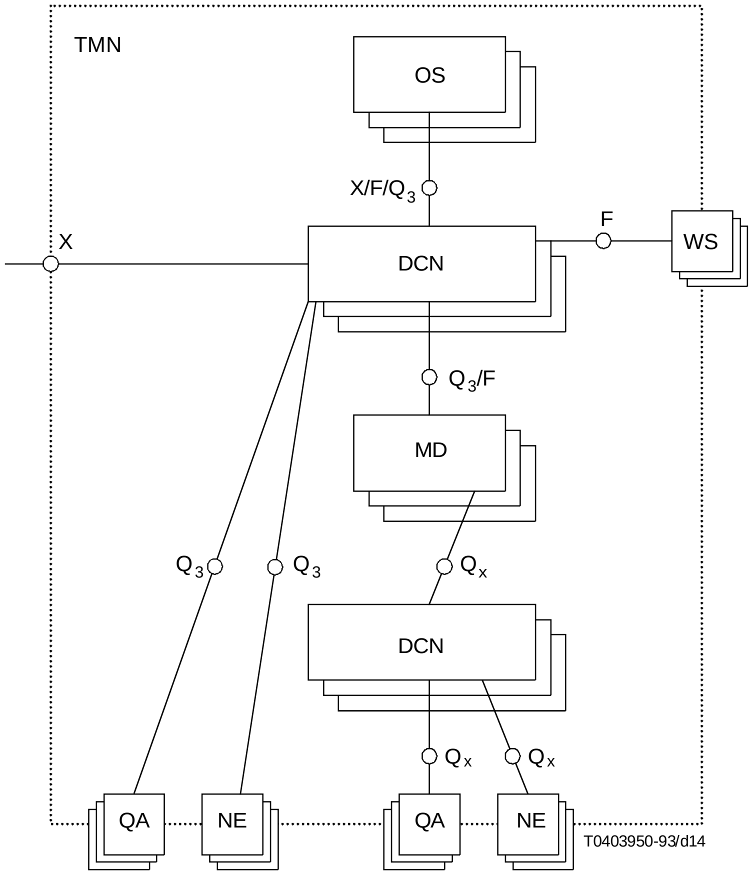
TMN functions can be implemented in a variety of physical configurations. The relationship of the functional blocks to physical equipment is shown in Table 4 which names the TMN building blocks according to the set of function blocks which each is allowed to contain. For each building block there is a function block which is characteristic of it and is mandatory for it to contain. There also exist other functions which are optional for the building blocks to contain. Table 4 does not imply any restriction of possible implementations, but defines those identified within this Recommendation.

The subclauses below give the definitions for consideration in implementation schemes.

**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.




Interfaces

| | |
|---|---|
| DCN | Data Communication Network |
| MD | Mediation Device |
| NE | Network Element |
| OS | Operations System |
| WS | Workstation |
| QA | Q Adaptor |

NOTES

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

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 14/M.3010

**An example of a simplified physical architecture for a TMN**

TABLE 4/M.3010

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

| (Notes 2 et 3) | NEF | MF | QAF | OSF | WSF |
|---|---|---|---|---|---|
| NE | M | O | O | O | O<br>(Note 3) |
| MD | | M | O | O | O |
| QA | | | M | | |
| OS | | O | O | M | O |
| WS | | | | | M |

M Mandatory

O Optional

NOTES

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.

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

3 For the WSF to be present either the MF or OSF must also be present. This means that the WSF must address an OSF or a MF. The local man-machine access is not considered part of the TMN.

**4.1.3 Q Adaptor (QA)**: The QA is a device which connects NE-like or OS-like 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 ITU-T (formerly 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 subnetwork(s) of differing types, interconnected together. For example, the DCN may have a backbone subnetwork(s) that provides TMN-wide connectivity between a variety of subnetwork(s) providing local access to the DCN. The various types of subnetworks may include technology specific subnetwork(s) such as the SDH DCC.

**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 and X interfaces.

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.

### 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 multivendor, multicapability 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 management operations types 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 14 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 13.

**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 $Q_3$ is applied at the $q_3$ reference point;
- the interface $Q_x$ is applied at the $q_x$ reference point.

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 $q_x$ 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 difference between $Q_x$ and $Q_3$ interfaces are for further study. The $Q_x$ interface is characterized by that portion of the information model that is shared between the MD and those NEs and QAs it supports.

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 TMN building blocks containing OSFs or MFs through a data communication network are included in this Recommendation. Connections of implementation specific, WS-like entities to OSs or NEs, are not 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 other network or systems 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.

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

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 rowspan="2">NE</td><td colspan="3">(Note 1)</td><td rowspan="2">O</td></tr>
<tr><td>O</td><td>O</td><td>O</td></tr>
<tr><td rowspan="2">OS</td><td colspan="3">(Note 1)</td><td rowspan="2">O</td></tr>
<tr><td>O</td><td>O</td><td>O</td></tr>
<tr><td rowspan="2">MD</td><td colspan="2">(Note 1)</td><td rowspan="2">O</td><td rowspan="2">O</td></tr>
<tr><td>O</td><td>O</td></tr>
<tr><td rowspan="2">QA</td><td colspan="2">(Note 1)</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>O</td><td>O</td></tr>
<tr><td>WS</td><td></td><td></td><td></td><td>(Note 2)<br>M</td></tr>
<tr><td colspan="5">M Mandatory<br>O Optional<br>NOTES<br>1 At least one of the interfaces inside the box must be present.<br>2 This mandatory relationship only to workstations as defined in 6.8.1.</td></tr>
</table>

#### 4.3.5 Characterization of TMN interfaces

Table 6 shows the identified differences which characterize the TMN interfaces. The contents of Table 6 may be enhanced as work continues at the X and F interface.

### 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.

TABLE 6/M.3010

**Differences between TMN interfaces**

| Differentiating factors | X interface | F interface | $Q_3$ interface |
|---|---|---|---|
| Function blocks | OSF- OSF | OSF – WSF<br>MF – WSF | OSF – NEF/<br>OSF – MF/<br>OSF – OSF/<br>OSF – QAF |
| Service type | interactive (object oriented)/store and forward file transfer/ | interactive (object oriented) | interactive (object oriented)/file transfer |
| Syntax | machine/machine<br>ASN.1 | machine/machine<br>human/machine<br>characters | machine/machine ASN.1 |
| Access control requirement on an activity basis | mandatory | optional | optional |
| Other security aspects (e.g. data integrity/ encryption) | yes | yes | For further study |
| NOTE – $Q_x$ interface is for further study. | | | |

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.811 [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 physical configurations

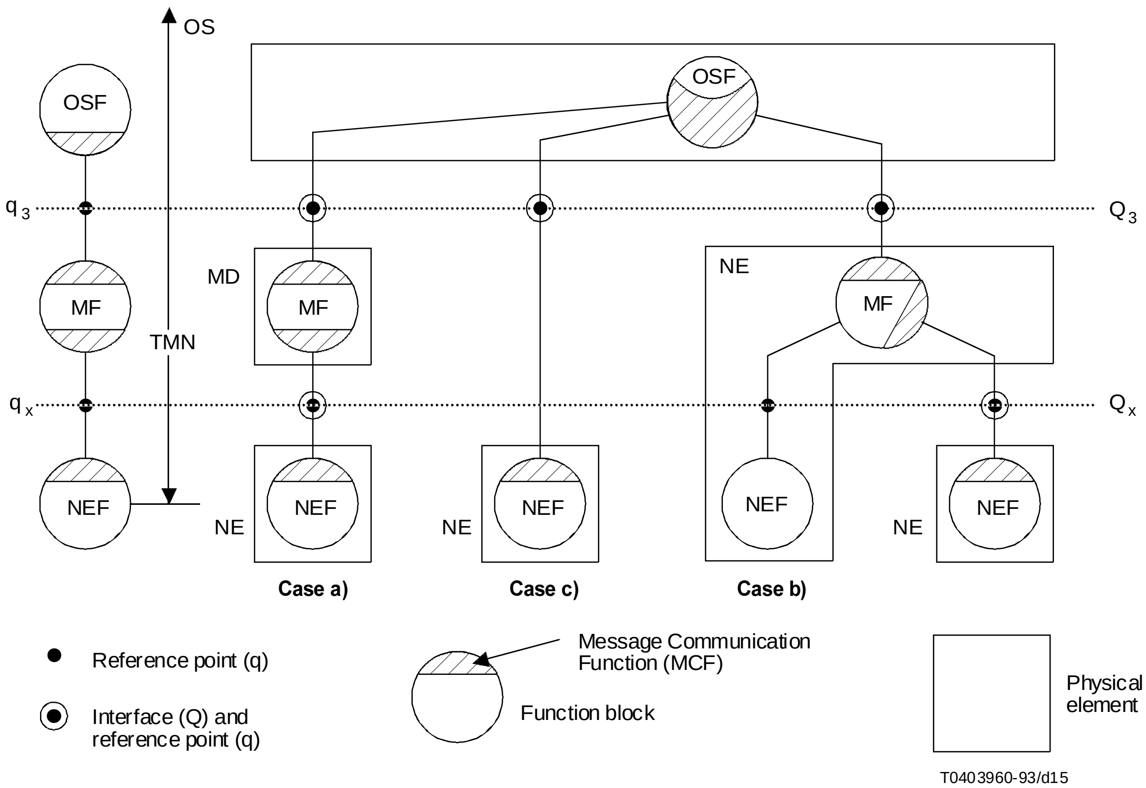
### 4.5.1 Physical realization of the q class reference configuration

Figure 15 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 15, 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 15, 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 15, case c), shows an NE physically connected to an OS via a $Q_3$ interface.




NOTES

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.

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. Such equipment performs OSI network functions, and are not shown in this figure, e.g. the Q interface normally connects to the DCN which provides the data communication to the OS.

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.

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

FIGURE 15/M.3010

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

### 4.5.2 DCN implementation examples

The Data Communication Function (defined in clause 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 16.

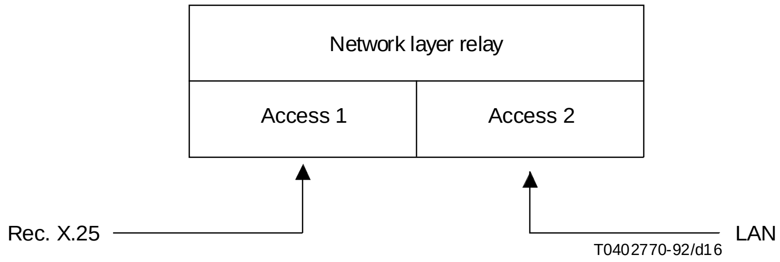



FIGURE 16/M.3010

**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 17, 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 Recommendations [20] and ISO / IEC 7498-1 [8]. Other OSI interworking schemes are not precluded and are for further study.

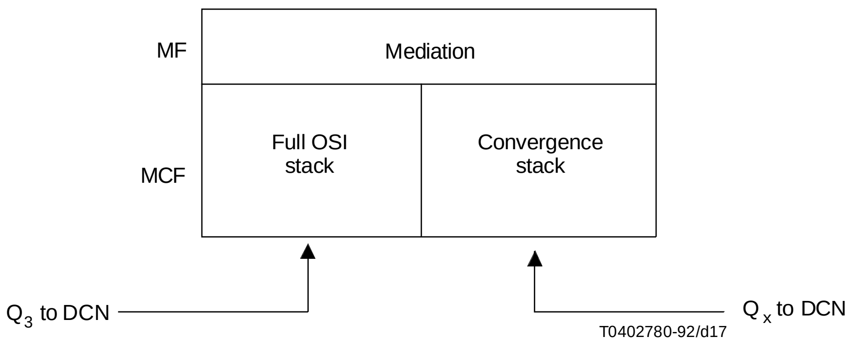



FIGURE 17/M.3010

**Example of higher layer interworking**

## 5 TMN Logical Layered Architecture

This clause describes the TMN Logical Layered Architecture (LLA), and provides examples of its uses.

To deal with the complexity of telecommunications management, the management functionality may be considered to be partitioned into logical layers. The LLA is a concept for the structuring of management functionality which organizes the functions into a grouping called "logical layers" and describes the relationship between layers. A logical layer reflects particular aspects of management and implies the clustering of management information supporting that aspect.

## 5.1 Functional OS configuration

The grouping of management functionality implies grouping OSFs into layers. A specialization of OSFs based upon different layers of abstraction is business, service, network and element and is depicted in Figure 18. As shown, some TMN implementations may include business OSFs that are concerned with a total enterprise (i.e. all services and networks) and carry out an overall business coordination. Service OSFs are concerned with services offered by one or more networks and will normally perform a customer interfacing role. Network OSFs are concerned with the management of networks, and Element OSFs with the management of individual elements.

Network OSFs cover the realization of network-based TMN application functions by interacting with Element OSFs. Thus the Element and Network OSFs provide the functionality to manage a network by coordinating activities across the network and support "Network" demands of service OSFs. Element OSFs and Network OSFs share the infrastructure aspects of a telecommunications network.

The NEFs comprising the Network Element Layer are managed by the OSFs of the management layer.

The layering of OSFs based in the reference model shown in Figure 18, although widely accepted, should not be regarded as the only possible solution. Additional or alternative layers may be used to specialize functionality.

The following subclause describes a typical allocation of functionality amongst the four management layers based in the reference model.

### 5.1.1 The management layers of the architecture

The reference model of an OS functional architecture with four management layers is illustrated in Figure 22 and described in the following subclauses.

### 5.1.2 Element management layer

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

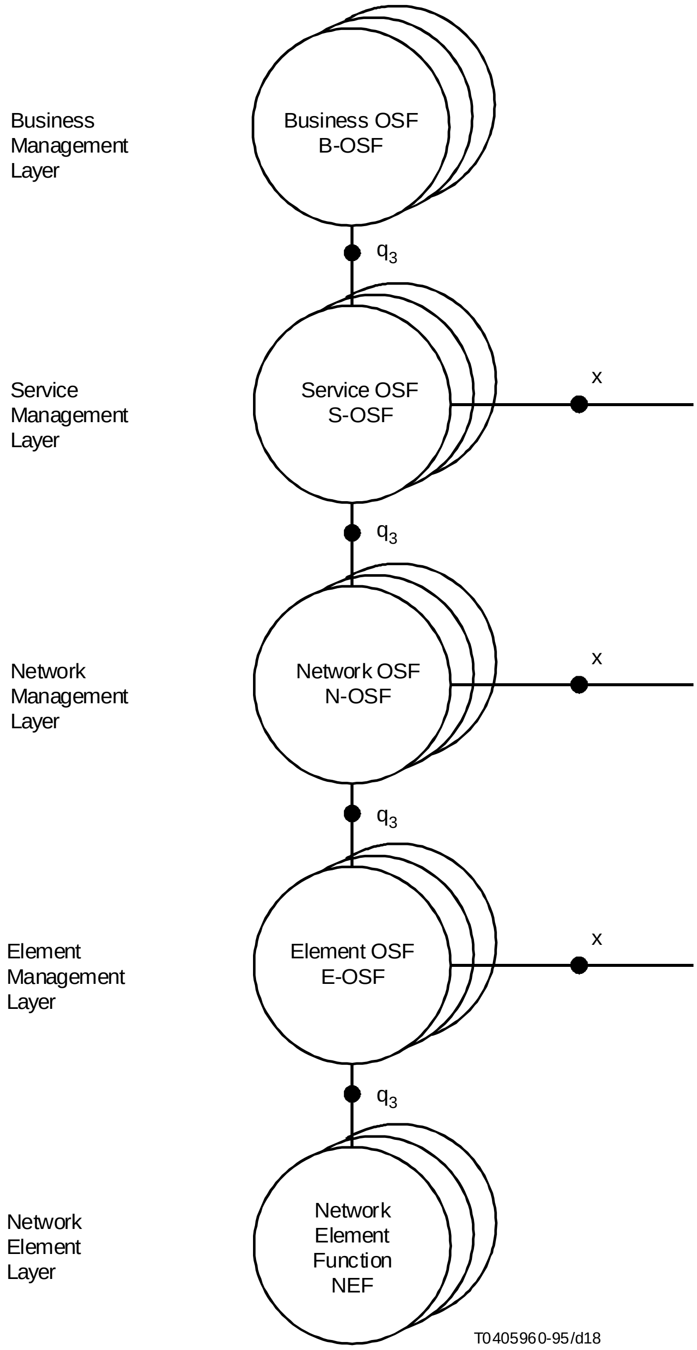
The element management layer has one or more element OSFs and/or MFs, that are individually responsible, on a devolved basis from the network management layer, for some subset of network element functions. As an objective, a vendor independent view will be provided to the network management layer.

The element management layer has the following three principle roles:

1) Control and coordination of a subset of network elements on an individual NEF basis. In this role, the element OSFs support interaction between the network management layer and the network element layer by processing the management information being exchanged between network OSFs and individual NEFs. Element OSFs should provide full access to NE functionality.

2) The element management layer may also control and coordinate a subset of network elements on collective basis. In this role, element OSFs may also provide a single entity view of a group of NEFs. In addition, these element OSFs may manage the relationships (e.g. connectivity) between NEFs.

3) Maintaining statistical, log and other data about elements within its scope of control.




NOTES

1 Additional or alternative layers are permitted.

2 Other interactions may also occur between non-adjacent layers.

FIGURE 18/M.3010

**Reference model of OS functional architecture**

OSFs in the element management layer interact with OSFs in the same or other layers within the same TMN through a $q_3$ reference point and in other TMNs through an x reference point.

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

### 5.1.3 Network management layer

The network management layer has the responsibility for the management of a network as supported by the element management layer.

At this layer, functions addressing the management of a wide geographical area are located. Complete visibility of the whole network is typical and, as an objective, a technology independent view will be provided to the service management layer.

The network management layer has the following four 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) The maintenance of network capabilities.
4) Maintaining statistical, log and other data about the network and interact with the service manager layer on performance, usage, availability, etc.

Thus, the network management layer provides the functionality to manage a network by coordinating activity across the network and supports the "network" demands made by the service management layer. It knows what resources are available in the network, how these are interrelated and geographically allocated and how the resources can be controlled. It has an overview of the network. Furthermore, this layer is responsible for the technical performance of the actual network and will control the available network capabilities and capacity to give the appropriate accessibility and quality of service.

OSFs in the network management layer interact with OSFs in the same or other layers within the same TMN through a $q_3$ reference point and in other TMNs through an x reference point.

### 5.1.4 Service management layer

Service management is concerned with, and responsible for, the contractual aspects of services that are being provided to customers or available to potential new customers. Some of the main functions of this layer are service order handling, complaint handling and invoicing.

The service management layer has the following four principle roles:

1) customer facing (Note) and interfacing with other administrations/ROAs;
2) interaction with service providers;
3) maintaining statistical data (e.g. QOS);
4) 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 service management layer interact with OSFs in the same or other layers within the same TMN through a $q_3$ reference point and in other TMNs through an x reference point.

The Service Management layer is responsible for all negotiations and resulting contractual agreements between a (potential) customer and the service(s) offered to this customer.

### 5.1.5 Business management layer

The business management layer has responsibility for the total enterprise.

The business management layer comprises proprietary functionality. To prevent access to its functionality, business OSFs do not normally support x reference points. Business OSFs access the information and functionality in the other management layers. The business management layer is included in the TMN architecture to facilitate the specification of capability that it requires of the other management layers.

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.

While the main functions of service and network management layers are the optimal utilization of existing telecommunications resources, those of the business management layer are for the optimal investment and use of new resources.

OSFs in the business management layer interact with OSFs in the same or other layers within the same TMN through a $q_3$ reference point.

The business management layer has the following four principle roles:

1) supporting the decision-making process for the optimal investment and use of new telecommunications resources;

2) supporting the management of AO&M related budget;

3) supporting the supply and demand of AO&M related manpower;

4) maintaining aggregate data about the total enterprise.

## 5.2 Information layering principles

For any logical layer, relations can be established between the OSF layer basic functionalities. Management information models are associated with layers and may be used for the exchange of information at the interlayer interfaces.

Figure 19 depicts the reference points of a given layer. The information model associated with the reference point to the upper layer $q_{3n+1,n}$ has to provide to that layer the management view of layer "n". The same considerations apply to the x interface. The reference points to OSFs in the same layer, $q_{3n,n}$ should have an information model relating to layer "n" functionality's. The reference point to the lower layer $q_{3n,n-1}$) for the same reason has to represent the view of the layer "n–1".

Any relationship between the management information models associated with different layers may be made visible at the interfaces between layers via explicit means such as described in the general relationship model (GRM, Recommendation X.725 [34]).

The general LLA model may be used under various conditions both for the creation of as many layers as desired/appropriate and to impose restriction in order to simplify the relationships between layers.

## 5.3 Relationship of LLA to the information architecture

Management activities can be clustered into layers and decoupled by introducing manager and agent roles.

The general case is that managers and agents can be placed without restrictions. An agent may be associated with a set of MOs from any layer. Managers can be placed in any layer and invoke operations associated with any other agent.

The general case may be restricted in order to simplify the relationship between layers as follows:

- certain agents can be associated with MOs that reside in one layer only;

- in a model where upper and lower layers are defined, it is possible to restrict the direction of control to one direction. For example, certain managers may invoke operations that are associated with agents in their own layers or certain management systems may be assigned solely a manager role or an agent role.

Figure 20 illustrates a case where the direction of line of control is down and where an agent is associated with MOs that reside in one layer only.

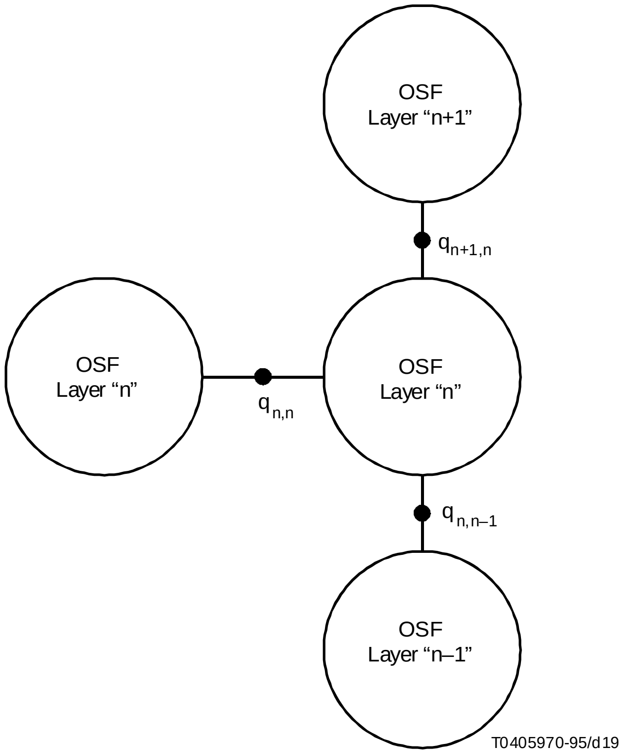



FIGURE 19/M.3010

**Reference points at a given functional OSF layer "n"**

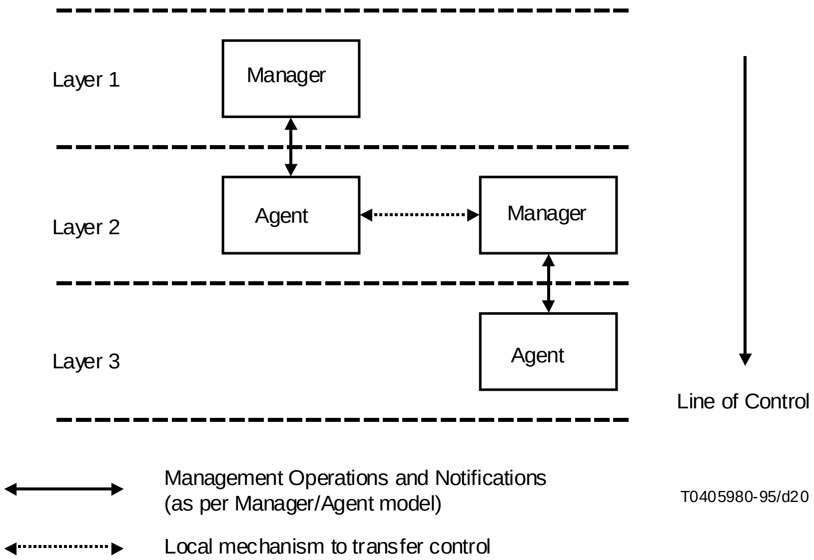



FIGURE 20/M.3010

**Illustration of a management operation that propagates down the LLA layers and where the agents are associated with MOs in one layer only**

NOTE – Management activities (operations and/or notifications) propagate through LLA layers as a series of consecutive activities of which some may be passed through activities.

Interactions between adjacent layers are invoked by a Manager in layer 1 and performed by an Agent in layer 2 which is associated with MOs in layer 2 only. This may in turn prompt a Manager in layer 2 to interact with an Agent in layer 3, and so on. In this way operations travel down the layered architecture.

As discussed in 3.2.2, the manager and/or agents involved at the inter-layers boundary must share information pertaining to both layers and do the appropriate information mapping. This information mapping should be transparent and is typically done via an ICF.

### 5.4 Interaction between management layers

While OSFs will typically interact with adjacent layers, due to operational and management considerations other interactions may also occur between non-adjacent layers. For example due to TMN traffic considerations the service management layer may wish to interact directly with the element management layer for the exchange of accounting data.

### 5.5 Layer synchronization

The adoption of this approach implies the possibility that two (or more) managers access the same agent (and MIB). Therefore, close attention must be paid in providing the necessary coordination and security mechanisms to avoid, for example, misuse and deletion of data.

### 5.6 Interaction between TMNs

TMN hierarchies may interact for many reasons including the following:

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

One example of TMN interactions at the service management layer between both external and internal organizations is shown in Figure 21. Here, the administrations TMN (TMN 1) can be seen to support interactions between OSFs within itself via a q reference point. However, when an OSF in either TMN 1, 2 or 3 interacts with an OSF in another TMN, this interaction is via an x reference point. Note that while all the interactions in this figure are shown between OSFs in the service management layer, interactions may occur via an x or q reference point at layers other than the service management layer.

Figure 22 shows another possible inter-TMN OSF connectivity example within the management hierarchy.

In Figure 22, TMN "C" is an example of a customer C TMN which is a customer of a provider P for some telecommunications services (e.g. a service provider C and a transport provider P). TMN "C" and TMN "P" may need to interact for the purpose of managing the telecommunications services.

In the general case of a customer TMN and a provider TMN interaction, the x reference points between the two TMN OSFs interconnect the provider's service management layer OSF and any management layer OSFs of the customer TMN according to the needs of the customer.

### 5.7 Layered OS building blocks

Four specializations of the OS building block are defined to support a physical realization of the logical layered function blocks. The four specialized OS building blocks are the Business (B-OS), the Service (S-OS), the Network (N-OS) and the Element (E-OS) Operations Systems. These building blocks are named according to the predominant function block they contain. Specifically, B-OS, S-OS, N-OS and E-OS predominately contain B-OSF, S-OSF, N-OSF, and E-OSF respectively. When building blocks contain more than one kind of specialized OS function block that provide substantial functionality to the building block, the building block is named according to the highest hierarchically layered function block. For example, a building block containing both N-OSF and E-OSF, providing substantial network functionality is called a N-OS.

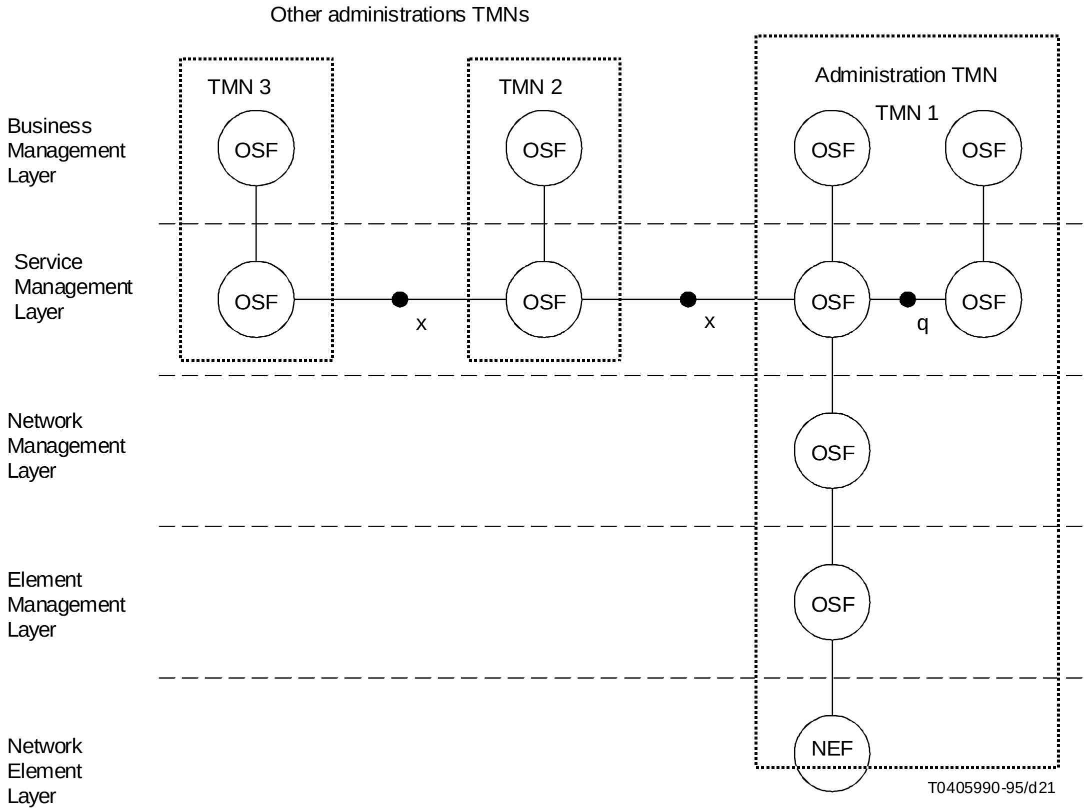



FIGURE 21/M.3010

**Examples of TMN interactions**

# 6 Detailed TMN architectural considerations

## 6.1 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.

### 6.1.1 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.

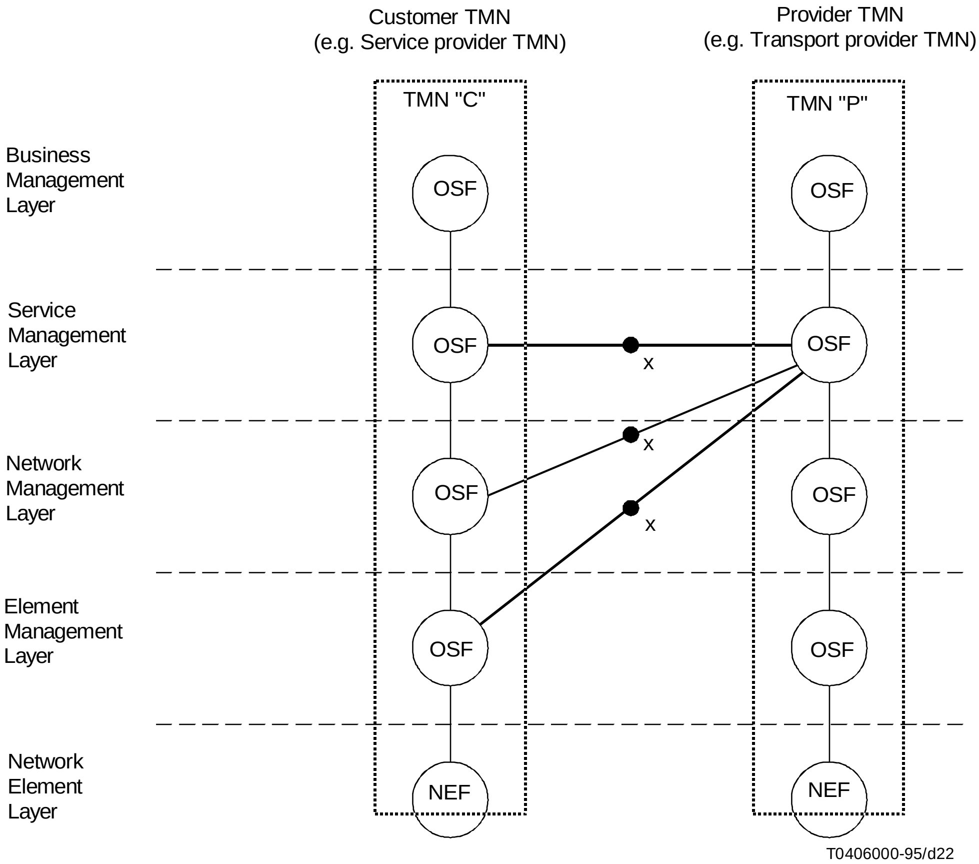



FIGURE 22/M.3010

**Examples of inter-TMN functional connectivity**

## 6.2 Network evolution considerations

The TMN functional, information and physical architectures must keep pace with the introduction of new technologies, services and evolving network infrastructures. New technologies such as ATM (Asynchronous Transfer Mode), new services such as UPT (Universal Personal Telecommunication) and evolving network infrastructure such as IN Intelligent Networks must be accommodated within the TMN. For example, the TMN must be able to test, deploy and support rapid service creation in IN.

Appendix II illustrates how the TMN is expected to manage the IN and its associated services.

## 6.3 Physical OS considerations

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

- support application programs;
- database 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.

## 6.4 TMN data communication considerations

### 6.4.1 Data communication network considerations

A Data Communication Network (DCN) for a TMN should, wherever possible, follow the OSI reference model for ITU-T 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 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 SS 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 transfers 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 subnetwork configurations, e.g. point-to-point, star, bus or ring.

### 6.4.2 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*

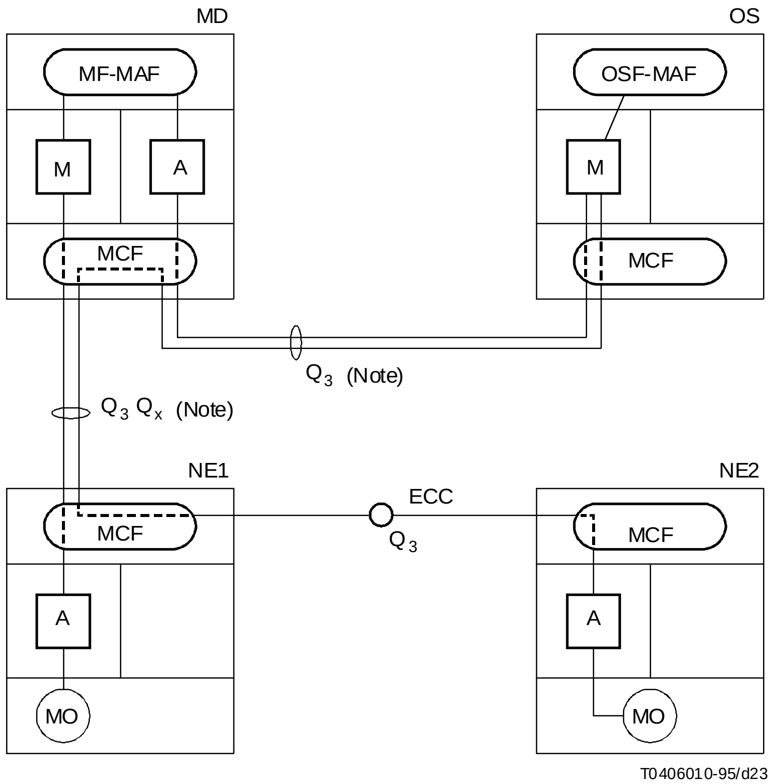
c) *communications of primitive functions*
   - command/response statement;
   - alarm statements;

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

### 6.4.3 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 MCFs within one device (e.g. MD, NE, OS or QA) may be necessary to allow protocol conversion.

Figures 23 and 24 show examples of how various MCFs are used in various physical devices to provide the DCF in an SDH environment.

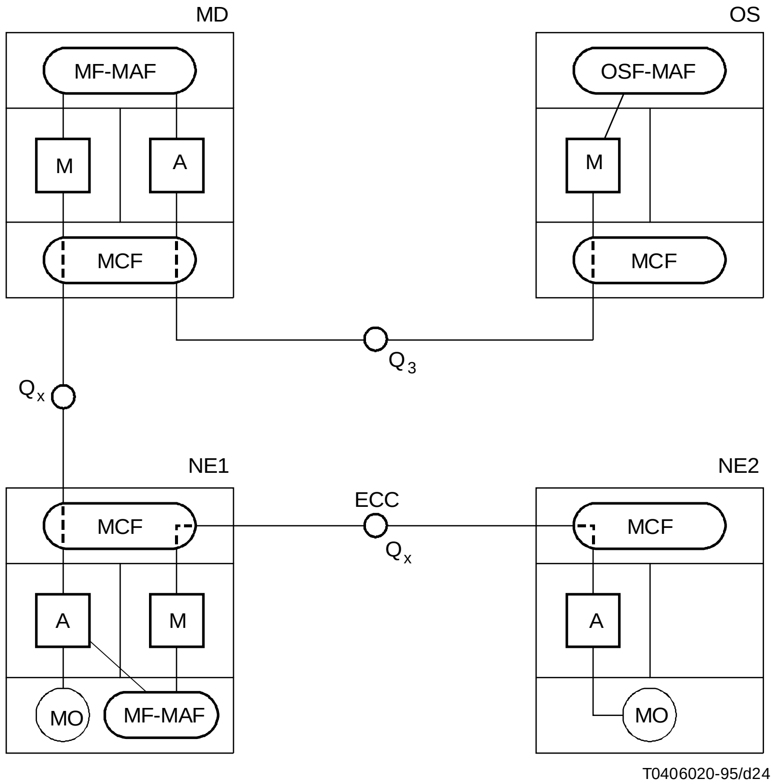



| | |
|---|---|
| OSF-MAF | OS Function-Management Application Function |
| MF-MAF | Mediation Function-Management Application Function |
| MCF | Message Communication Function |
| A | Agent |
| M | Manager |
| OS | Operations System |
| MD | Mediation Device |
| NE | Network Element |
| MO | Managed Object |
| ECC | Embedded Communications Channel |

NOTE – Indicates that both interfaces are in the same transport.

FIGURE 23/M.3010

**SDH management example (1)**




| | |
|---|---|
| OSF-MAF | OS Function-Management Application Function |
| MF-MAF | Mediation Function-Management Application Function |
| MCF | Message Communication Function |
| A | Agent |
| M | Manager |
| OS | Operations System |
| MD | Mediation Device |
| NE | Network Element |
| MO | Managed Object |
| ECC | Embedded Communications Channel |

FIGURE 24/M.3010

**SDH management example (2)**

## 6.5 Mediation

### 6.5.1 Mediation considerations

Mediation is a process within the TMN which acts on information passing between Network Element Functions (NEFs), or Q Adaptor Functions (QAFs), and Operations Systems Functions (OSFs) 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 25.

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 the one hand and MDs and NEs on the other hand provides for greater flexibility in the TMN. Some options are shown in Figure 26. 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.

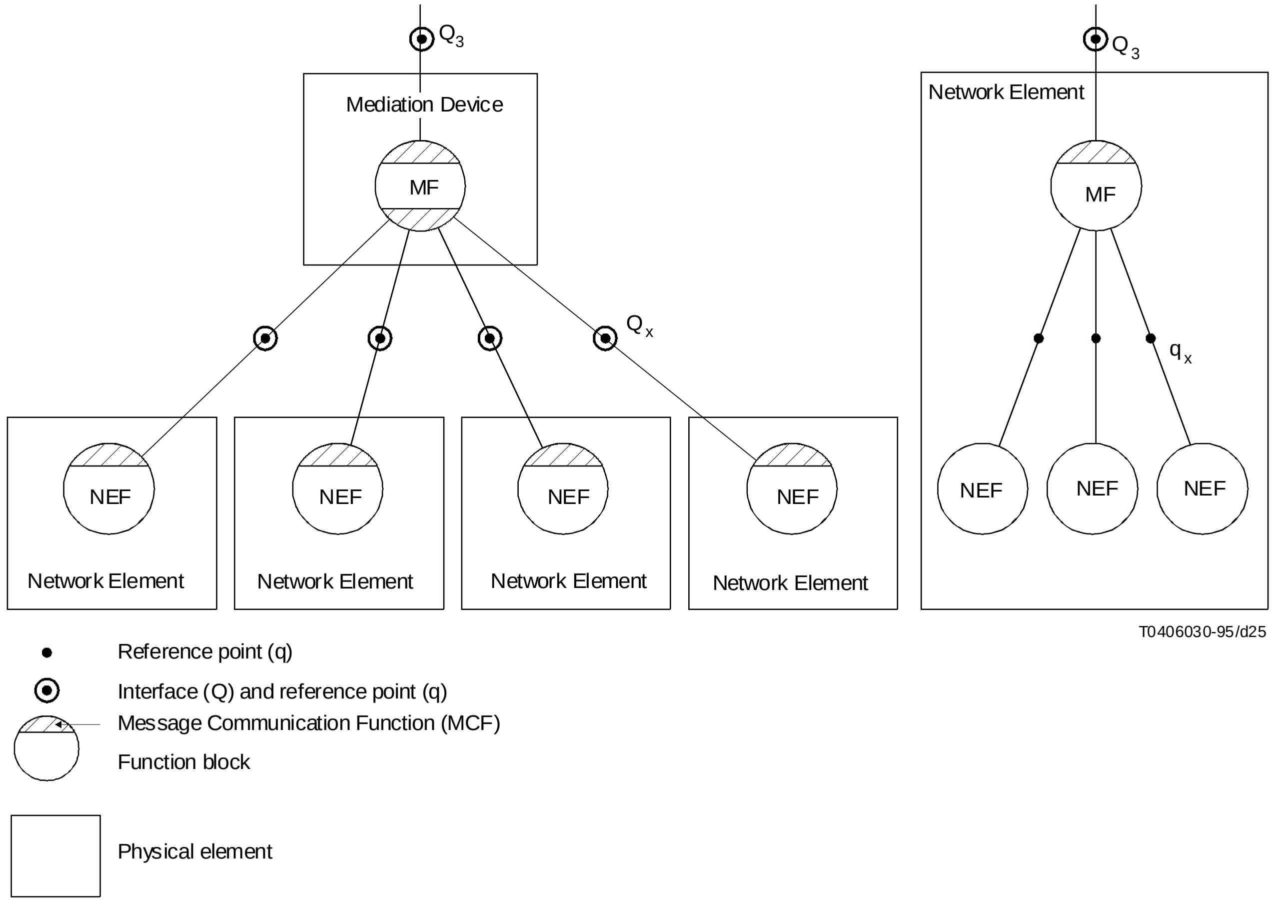
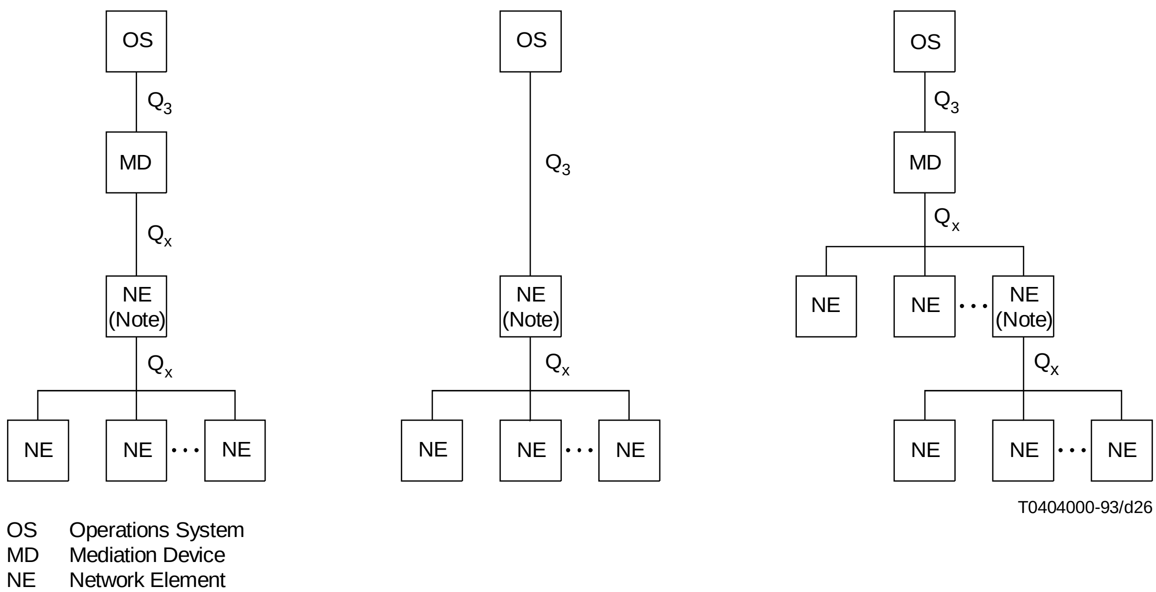



FIGURE 25/M.3010

**Example of the use of Mediation**




NOTE – These NEs contain MF.

FIGURE 26/M.3010

**Examples of cascaded Network Elements**

### 6.5.2 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 2.2.2):
   - 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.
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 backup;
   - 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*
   - database storage;
   - network configuration;
   - equipment identification;
   - memory backup.

Certain mediation processes may be carried out autonomously.

### 6.5.3 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.

## 6.6 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.

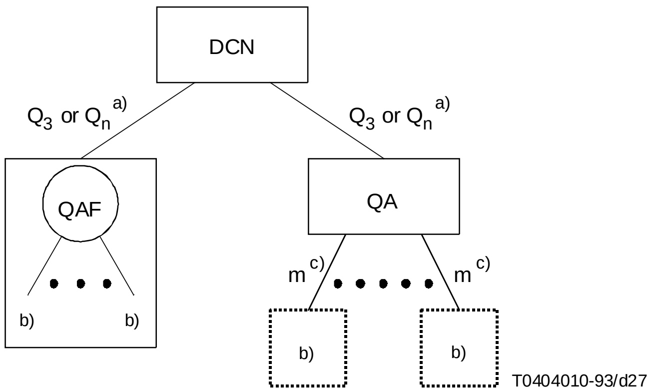
### 6.7 Q adaptor considerations

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 27 depicts an example of a QA connecting equipment both inside and outside the TMN.

A QA may also be the means to support external interfaces, such as simple sensors, indicators or visible/audible alarms.




NE Network Element
QA Q Adaptor
DCN Data Communication 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 27/M.3010

**QA configuration examples**

### 6.8 User interface considerations

#### 6.8.1 Workstations

In Figures 3 and 14 the workstation reference points and interfaces are shown. Workstations may access OSs and MDs across these interfaces. Although workstations vary in capabilities, for purposes of this Recommendation the workstation is considered to be a terminal connected via a data communication network to an operations system or a device with a mediation function. This terminal has sufficient data storage, data processing, and interface support, to translate the information between the g and f reference points. The terminal provides the user with the capability to manipulate objects in a TMN MIB, along with many other capabilities.

A workstation that can access TMN building blocks in more than one TMN is considered to be a part of the particular TMN during the time it is exchanging management information. This does not preclude a workstation from having simultaneous access to multiple TMNs.

For the purpose of this Recommendation, workstations do not include any OSF or MF, but functional components like MAF and ICF (or equivalent) may be considered to be as part of the UISF. If OSF (or MF) and WSF are combined in an implementation, that implementation is considered an OS (or MD). Therefore, a workstation must have an F interface.

Workstations can access NEs only when the NE supports OSF or MF as well as NEF. The only means that the WSF can access NEF is via an OSF or MF. Therefore, direct or “local” human-machine access to NEF is not considered part of TMN.

A workstation can access multiple OSs and an OS may serve several workstations.

### 6.8.2 The f reference point

The f reference point defines the boundary between WSF and OSF (or MF) functions. In a particular implementation the WSF and OSF (or MF) may or may not reside on the same piece of hardware.

To understand the placement of the f reference point, it is necessary to consider the different forms that the data can have when being transformed between their physical appearances on the human-machine interface and their internal representation in the OSF (or MF). Not all of these forms are present in all implementations. The first three items listed below pertain to the g reference point and provide a context for the last item, which pertains to the f reference point.

– *Layout form*

  The layout form defines the physical presentation of the data on the human-machine interface. The data may be presented in alphanumeric, graphic and other forms. The exact placement of symbols, styles (colour, fonts, highlighting) etc. are specified in the layout form. Existing windowing tools are example implementations of this level.

– *Contents form*

  The contents form defines the subset of the data to be viewed in a screen picture or report, using the end-user terminology and grammar. It does not include the information about exact presentations, such as fonts, lines, etc. The definition of the contents form includes the specification of the permissible operations (insert, delete, etc.) to this screen picture. The contents form is defined in the contents schemata of Recommendation Z.352 [35].

– *External terminology*

  The external terminology defines the full set of common end-user terminology and grammar for an application or application area, independently of this information being split into several screen pictures and reports. The external terminology is defined in the application schema of Recommendation Z.352 [35].

– *Internal representations*

  Internal representations define forms of the data used in the internal processing of the software system and/or for data communication between systems. Such data definition languages as GDMO/ASN.1 and IDL are examples of specification languages that facilitate implementations of the internal representation.

The data at the f reference point is at an internal representation level. Object-oriented techniques are used to define the information model to represent the data to be exchanged across the f reference point.

There is information specified in the information model at the f reference point which is not relevant at other reference points, but which needs to be communicated between the human user of the WSF and the OSF or MF and/or is needed by the WSF itself. For example, the OSF can produce information that was not available from an NEF or another OSF by synthesizing or correlating or by application of expert system rules. Along similar lines, information addressing work force management, job lists, and other data may not be available at other reference points. Information needed by the WSF itself includes, for example, the geographical characteristics that support a background map display, and the data type (such as “date”) that dictates different presentations.

The OSF or MF is responsible for transforming information between the internal representation and the representations used at other reference points. The WSF is responsible for transformations between the layout form and internal representation.

The WSF itself can be distributed, where different parts of the WSF can reside on different hardware. For example, detailed layout information can be sent to a terminal by a more powerful managing workstation. In this case, the managing workstation may be thought of as a "display client", issuing requests to update the display, and the terminal may be thought of as a "display server" that responds to these requests. Several example instantiations of distributed WSF are shown in Appendix III.

TMN data coming over the f reference point may be:

- all data needed for one screen picture (graphic and/or text);
- only parts of the data needed for one screen picture;
- data which may result in several screen pictures;
- data which only partly or indirectly appear in screen pictures.

The WSF receives such data and partitions as needed to support the resulting screen pictures.

Data may be communicated synchronously, for example, for On-Line Transaction Processing (OLTP), or asynchronously, for example, notifications.

The following are examples of data categories exchanged in either direction across the f reference point:

- security information;
- information pertinent to q3 managed object information (such as alarm indications);
- display support information (such as background maps);
- database queries and results;
- data describing function or command initiation:
  - application commands;
  - system commands (for example, backup);
  - request for command replay.
- data describing function or command responses:
  - command messages (information, warning, error);
  - data;
  - command histories.
- help text.

#### 6.8.3 Workstation function

The WSF translates the information available at the f reference point to a displayable format for the human at the g reference point. The WSF provides the user with input, output and edit facilities to enter, display and modify details about objects. This removes the need for an OSF or MF to be knowledgeable about the display capabilities of the user's terminal. The human-machine interface (g reference point), be it command line, menu driven, or window based, is supported by the WSF and is independent of the OSF/MF and therefore not visible at the f reference point. Details concerning the human-machine interface functions are contained in the Z-Series Recommendations. The integration within the WSF of non-TMN data with TMN-data is for further study.

### 6.9 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.

### 6.9.1 $Q_3$ interfaces

For the $Q_3$ family it is recommended that each set of TMN application functions with similar protocol needs to 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.811 [5] and Q.812 [9].

### 6.9.2 $Q_x$ 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 ITU-T (formerly 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.

One candidate protocol suite for the $Q_X$ interface is found in Recommendation G.773 [32].

### 6.9.3 The F interface

The F interface is applied at the f reference point. There may be protocols to support the F interface that are different than, or in addition to, those that support the $Q_3$ or X interface.

The F interface is one of the links in the chain that allow the human to retrieve and modify management information within a MAF.

### 6.9.4 The X interface

The TMN X interface specification must cater for TMNs interworking in support of both inter-administrative applications and commercial services.

Administratively, the X interface may vary depending upon geographical or jurisdictional boundaries as follows:

- intra-administrations;
- intra-national;
- inter-national.

There may be protocols and information models to support the X interface that are different from, or in addition to, those that support the Q or F interface.

Details of X family protocols are given in Recommendations Q.811 [5] and Q.812 [9].

The Security Functional component comprises five basic security services (as defined in 2.2.8). Authentication and access control services should be considered as mandatory for the X interface. The remaining security services (data integrity, confidentiality, non-repudiation) are considered to be optional. However, depending on the particular application, these optional security services could be required to be mandatory. As an example: for a TMN request to activate a Real-Time Restoration by another TMN, data integrity and non-repudiation could be considered as mandatory. For further information on the types of functionality that an Administration may utilize concerning security, see Recommendation M.3400 [14].

# Annex A

## Alphabetical list of abbreviations used in this Recommendation

(This annex forms an integral part of this Recommendation)

| | |
|---|---|
| A | Agent |
| A/M | Agent/manager |
| ASN.1 | Abstract Syntax Notation One |
| AE | Application Entity |
| AP | Application Process |
| ATM | Asynchronous Transfer Mode |
| BML | Business Management Layer |
| B-OSF | Business Management Layer-Operations Systems Function |
| CMIP | Common Management Information Protocol |
| CMIS | Common Management Information Service |
| CMISE | Common Management Information Service Element |
| CNM | Customer Network Management |
| DAF | Directory Access Function |
| DAP | Directory Access Protocol |
| DCF | Data Communication Function |
| DCN | Data Communication Network |
| DIB | Directory Information Base |
| DO | Directory Object |
| DSF | Directory System Function |
| DSP | Directory System Protocol |
| ECC | Embedded Communications Channel |
| EML | Element Management Layer |
| E-OSF | Element Management Layer-Operations Systems Function |
| GDMO | Guidelines for the Definition of Managed Objects |
| ITU-T | International Telecommunication Union – Telecommunication Standardization Sector |
| ITU-R | International Telecommunication Union – Radiocommunication Sector |
| ICF | Information Conversion Function |
| IN | Intelligent Network |
| ISO | International Organization for Standardization |
| ISDN | Integrated Services Digital Network |
| LAN | Local Area Network |
| LLA | Logical Layered Architecture |
| M | Mandatory |
| M | Manager |
| MAF | Management Application Function |
| MAN | Metropolitan Area Network |
| 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 |
| N-OSF | Network Management Layer-Operations System Function |
| NSAP | Network Service Access Point |
| O | Optional |
| OA&M | Operations, Administration and Maintenance |
| ODP | Open Distributed Processing |
| OID | Object Identifier |
| OLTP | On-line Transaction Processing |
| OS | Operations System |
| OSF | Operations Systems Function |
| OSF-MAF | Operations Systems Function-Management Application Function |
| OSI | Open Systems Interconnection |
| OSIE | Open Systems Interconnection Environment |
| PBX | Private Branch Exchange |
| PDU | Protocol Data Unit |
| QA | Q Adaptor |
| QAF | Q Adaptor Function |
| QAF-MAF | Q Adaptor Function-Management Application Function |
| QOS | Quality of Service |
| R | Resource |
| ROA | Recognized Operating Agency |
| RSE | Real System Environment |
| S-OSF | Service Management Layer-Operations Systems Function |
| SDH | Synchronous Digital Hierarchy |
| SF | Security Function |
| 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 |
| TP | Transaction Processing |
| UISF | User Interface Support Function |
| UPT | Universal Personal Telecommunication |
| VAS | Value Added Service |
| VASP | Value Added Service Provider |
| WSF | Workstation Function |
| WSSF | Workstation Support Function |

# Appendix I

## TMN planning and design considerations

(This appendix does not form an integral part of this Recommendation)

### 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 one 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 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 suggests a table of possible ranges for these function attributes.

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<br>Medium<br>Long | Objective of design and control (acceptable/unacceptable but available/unavailable) |
| | Reliability (accuracy) | High<br>Medium<br>Low | |
| | Availability | High<br>Medium<br>Low | |
| Characteristics of TMN traffic (C) | Quantity | Large<br>Medium<br>Small | Condition or parameter of design |
| | Frequency | Often continuous<br>Periodic<br>Sparse | |
| | Priority | High<br>Medium<br>Low | |

### 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.

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 subclause 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 (refer to Appendix V). 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.1.6.2 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

## Management of Intelligent Networks (INs)

(This appendix does not form an integral part of this Recommendation)

The TMN provides capabilities to manage telecommunications infrastructures including Services, Networks and Network Elements.

The goals of IN Management are to:

- provide effective management of the network infrastructure required to support IN based services;
- provide/support effective management of the IN service creation environment;
- ensure rapid and efficient service deployment;
- provide for the efficient management of IN based services.

The management of the IN infrastructure and service creation environment are not dealt with in the body of this appendix. The management of the IN infrastructure (Network Elements, Signalling Protocols, etc.) is considered to be performed as for other, non-IN, infrastructures (e.g. SDH, ISDN). The management of the service creation environment and its relation with the TMN are for further study.

The advantages of using the TMN for the management of IN are:

- a common management philosophy for the management of INs and other networks (e.g. SDH, ISDN) services and equipment;
- economies through the use of common techniques. These economies can arise from the reuse of software developed for one application in another;
- unification of management processes. The use of common management systems (e.g. common fault, accounting, performance and security systems).

## II.1 IN activities within the scope of TMN Management

The TMN can be involved with all of the steps identified below.

The TMN manages the communication of management information between the service creation environment and the telecommunications networks and management resources. The actual split between "off line" service creation and interaction with the TMN or the network via the TMN is for further study.

### II.1.1 Service creation

The creation of (new) services consists of several steps which are summarized in the service creation process. The different steps are:

- service specification;
- service development;
- service verification;
- service creation deployment;
- service creation management.

There is partitioning of functionality between the TMN and the Service Creation Environment.

### II.1.2 Service Management

**Service Deployment**

Service deployment deals with the installation of software and data (e.g. created by the SCEF), into the management systems associated with the service and the network on which the service is being deployed (e.g. the SCF/SDF).

Service Deployment Functions allocate information to the relevant parts of the network and manages that information. This information includes:

- Service Scripts;
- Service Generic Data;
- Signalling Routing data;
- Trigger data;
- Specialized Resource data;
- Service Testing;
- Service Provisioning.

Service provisioning collects service specific data and controls the installation and administration of this data in subscriber databases and contact databases.

#### II.1.2.1 Service operation control

Service operation control performs service maintenance and updates information (e.g. service generic, customer specific data, signalling routing, trigger data and specialized resource data) and security.

#### II.1.2.2 Billing

Billing functions include the management of the generation, collection and storage of call records and the introduction and modification of tariffs.

#### II.1.2.3 Service monitoring

Service Monitoring includes the measurement, analysis and reporting of service usage and performance.

## II.2 IN concepts

A key concept in IN is the IN conceptual Model which comprises four planes:

- The SERVICE PLANE (SP) represents an exclusively service oriented view (no implementation knowledge).
- The GLOBAL FUNCTIONAL PLANE (GFP) models network functionality from a network wide view. As such the IN structured network is viewed as a single entity.
- The DISTRIBUTED FUNCTIONAL PLANE (DFP) models a distributed view of an IN structured network.
- The PHYSICAL PLANE (PP) models the physical aspects of IN structured networks.

In addition, there are general aspects defined for the Intelligent Network Application Protocol (INAP).

## II.3 Relationship between TMN and IN concepts

One common aspect between TMN and IN is that both make physical/implementation specific aspects independent of the logical/functional aspects

Although the TMN has similar concepts as those contained in the Service Plane and Global Functional Plane (the TMN has Management Services and Function Sets) these concepts do not map directly into a TMN architecture.

However, the Distributed Functional Plane and Physical Plane of the IN can be mapped into the TMN Logical and Physical architectures.

Table II.1 is an attempt to relate the IN and TMN concepts. Please note that the relationships only indicate a rough correspondence.

TABLE II.1/M.3010

**Correspondence between IN and TMN concepts**

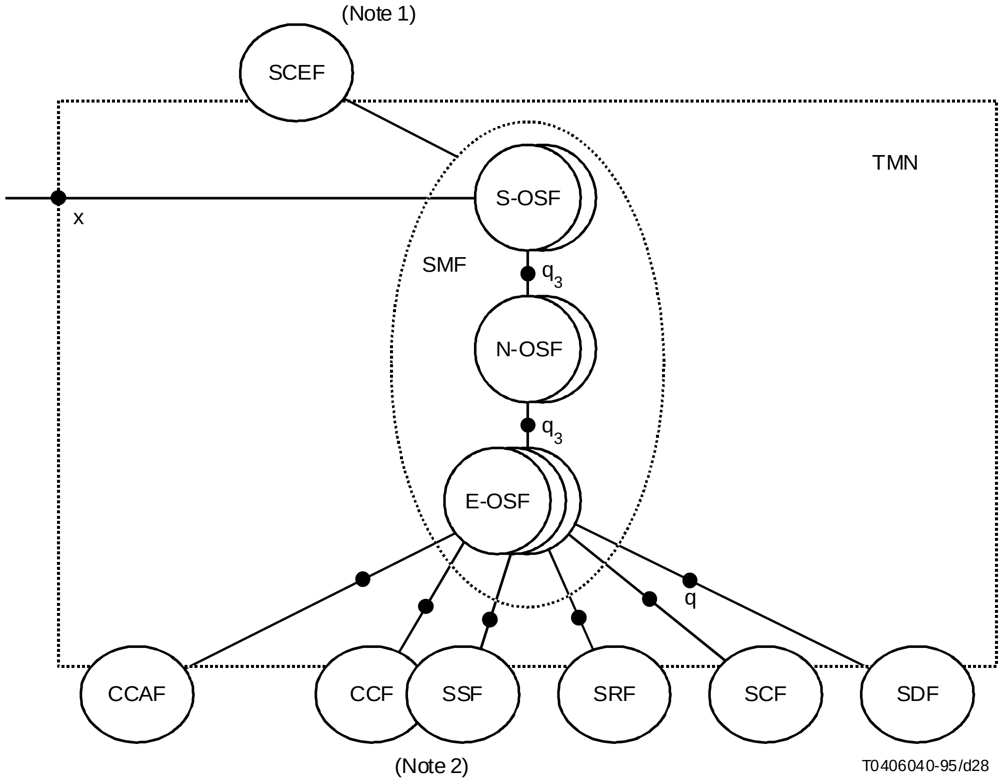
| | IN | Relationship | TMN |
|---|---|---|---|
| Service Plane | IN Service | corresponding level of abstraction | TMN Management Service |
| | IN Service Feature | corresponding level of abstraction | TMN Function Set |
| Global Functional Plane | SIB | corresponding level of abstraction | To be determined |
| Distributed Functional Plane | Functional Entity | allocated to | Function Block |
| | Functional Entity Action | corresponding level of abstraction | Management Application Functions (MAFs) |
| | Information Flow Element | corresponding level of abstraction | Managed Object(s) |
| | Information Flow Element | corresponding level of abstraction | Attribute/Operation/Notification |
| | Reference Point | equivalent to | Reference Point |
| Physical Plane | Physical Entity | corresponding level of abstraction | Resource |
| | Interface | corresponding level of abstraction | Interface |

It should be noted that the IN Planes and the TMN layers represent different concepts, it is not appropriate to try to show a direct relationship between them.

Superseded by a more recent version

## II.4 Mapping of IN Distributed Functional Plane to the TMN logical architecture

Figure II.1 shows how the FEs in the IN Distributed Functional Plane can be considered as TMN Function Blocks. CCAF, SSF, SCF, SDF, CCF and SRF are TMN Network Element Functions and SMF is equivalent to one or more TMN OSFs.




| | |
|---|---|
| CCAF | Call Control Access Function |
| CCF | Call Control Function |
| E-OSF | Element Management Layer – Operations Systems Function |
| N-OSF | Network Management Layer – Operations Systems Function |
| SCF | Service Control Function |
| SCEF | Service Creation Environment Function |
| SDF | Service Data Function |
| S-OSF | Service Management Layer – Operations Systems Function |
| SRF | Special Resource Function |
| SSF | Service Switching Function |

NOTES

1 SCEF location and reference points to OSFs are for further study.

2 The SSF and CCF functionality are assumed collocated in IN.

FIGURE II.1/M.3010

**A possible mapping of the IN Service processing Functional Entities onto a TMN Functional Architecture**

## II.5 Mapping of IN Physical Plane to the TMN physical architecture

When IN functionality is realized in physical systems, the reference point between functionality in one system and functionality in another system becomes an interface.

In the case of Management interfaces these can be translated into TMN interfaces.

Figure II.2 illustrates the relationship between IN Physical Entities to the TMN Managed Objects and Physical Architecture.

Figure II.3 illustrates the mapping of IN Physical Entities to the TMN Physical Architecture.

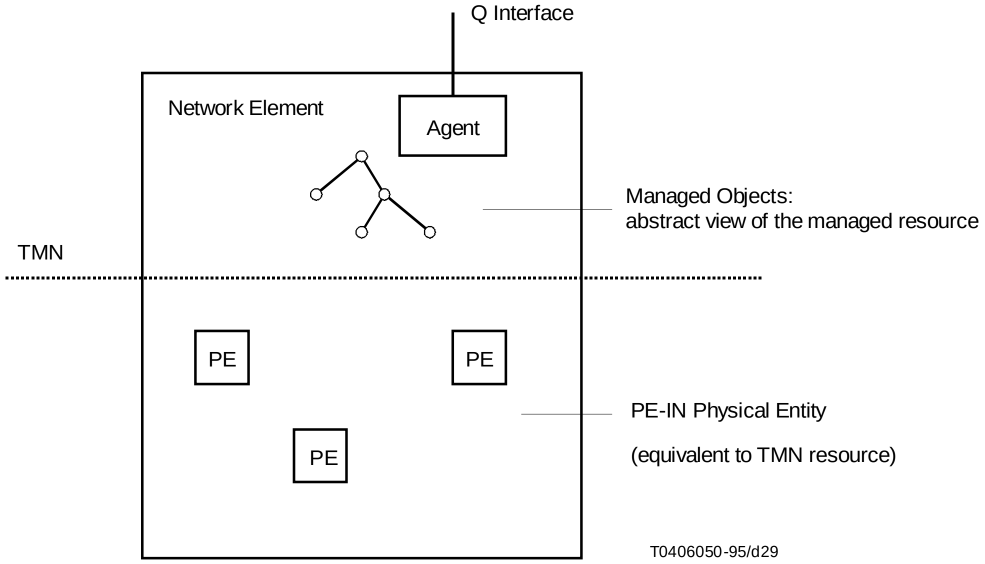
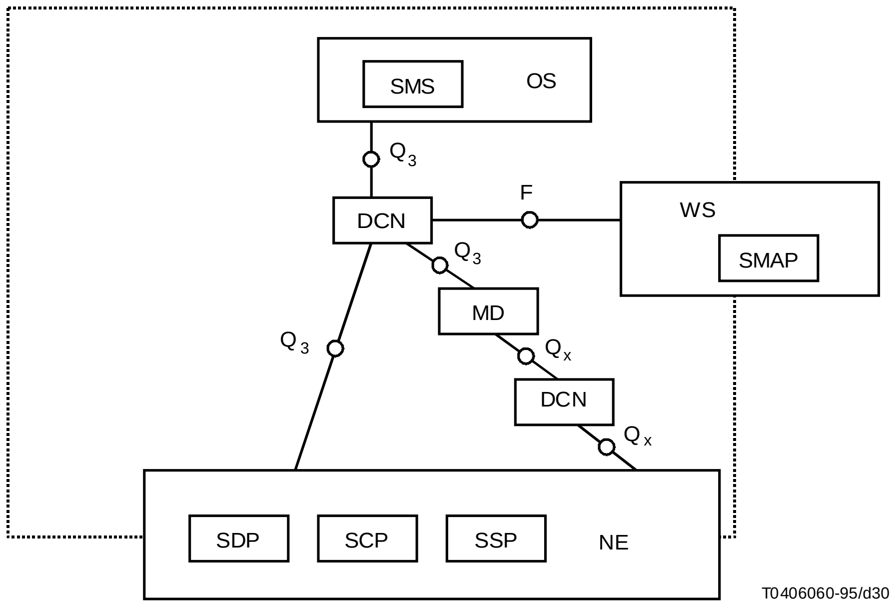



FIGURE II.2/M.3010

**Relationship of IN Physical Entities to the TMN**




DCN Data Communication Network
MD Mediation Device
SCP Service Control Point
SDP Service Data Point
SMAP Service Management Access Point
SMS Service Management System
SSP Service Switching Point

FIGURE II.3/M.3010

**Mapping of IN Physical Entities to the TMN Physical Architecture**

Table II.2 provides a possible mapping of the IN Physical and Functional Entities onto the TMN physical and Functional Architectures.

TABLE II.2/M.3010

**A possible mapping for the IN Physical Entities onto the TMN Function and Building Blocks**

| IN Physical Entity (PE) | IN Functional Entity (FE) | TMN Function Blocks | TMN Building Blocks |
|---|---|---|---|
| SDP (Service Data Point) | SDF (Service Data Function) | NEF | NE |
| SCP (Service Control Point) | SCF (Service Control Function) | NEF | NE |
| SSP (Service Switching Point) | CCAF (Call Control Access Function)<br>CCF (Call Control Function)<br>SSF (Service Switching Function)<br>SRF (Special Resource Function) | NEF | NE |
| SMS (Service Management System) | SMF (Service Management Function)<br>SMAF (Service Management Access Function)<br>SCEF (Service Creation Environment Function) | E-OSF, N-OSF, S-OSF<br>WSF<br>(Note) | OS<br>WS<br>(Note) |
| SMAP (Service Management Access Point) | SMAF (Service Management Access Function) | WSF | WS |
| SCEP (Service Creation Environment Point) | SCEF (Service Creation Environment Function) | (Note) | (Note) |
| NOTE – The relationship between SCEF and TMN Function Blocks is for further study. | | | |

# Appendix III

# Configuration examples

(This appendix does not form an integral part of this Recommendation)

## 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 shows additional example connections, to those shown in Figure 14. 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.

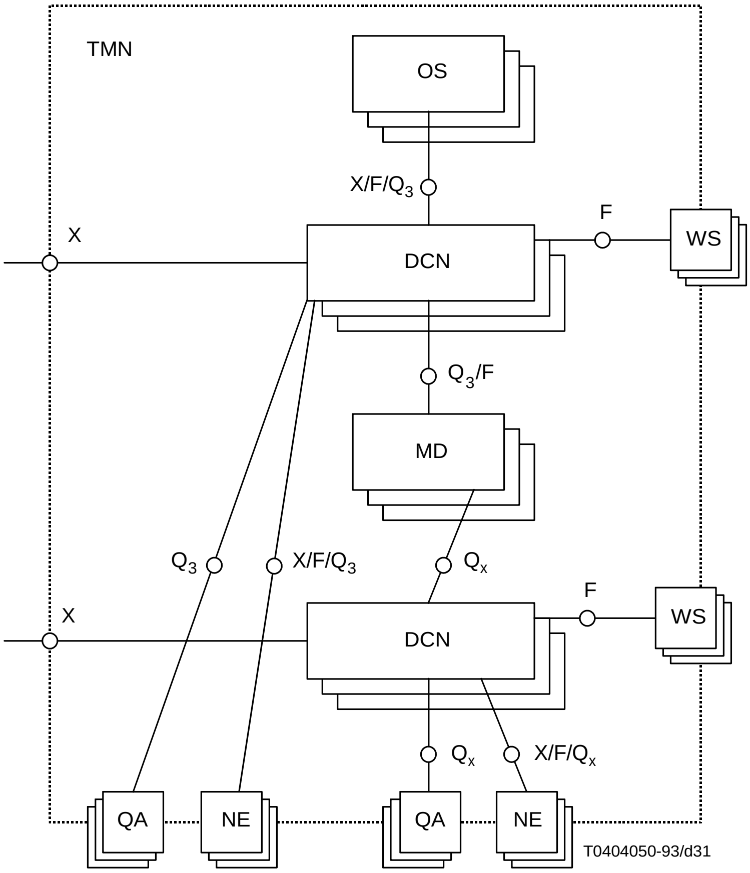



FIGURE III.1/M.3010

**Additional examples of interfaces for the TMN physical architecture**

Figure III.2 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

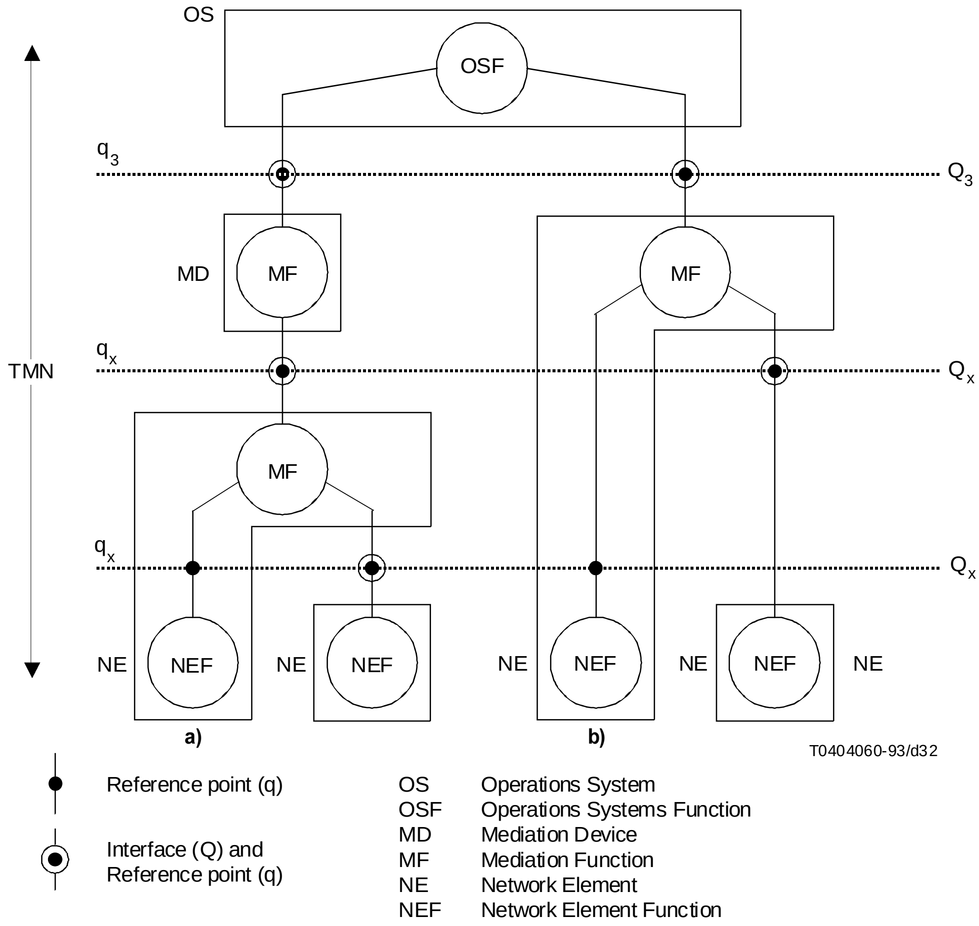
Figure III.3 shows an example of a multi-node X.25 packet-switched realization (Recommendation X.25 [6]) for the DCN.

### III.1.3 Distributed and non-distributed Workstation Function

In the TMN, functionality may be distributed in a variety of ways over physical components. Subclause 6.8.2 describes the concept of distributed WSF, where one workstation may perform some UISF processing and send the processed information to one or more other workstations for display (and user input). In this appendix, example configurations with distributed WSF are illustrated, along with non-distributed WSF for comparison.

A distributed functional configuration can support greater flexibility for Administrations in controlling their costs while maximizing productivity.

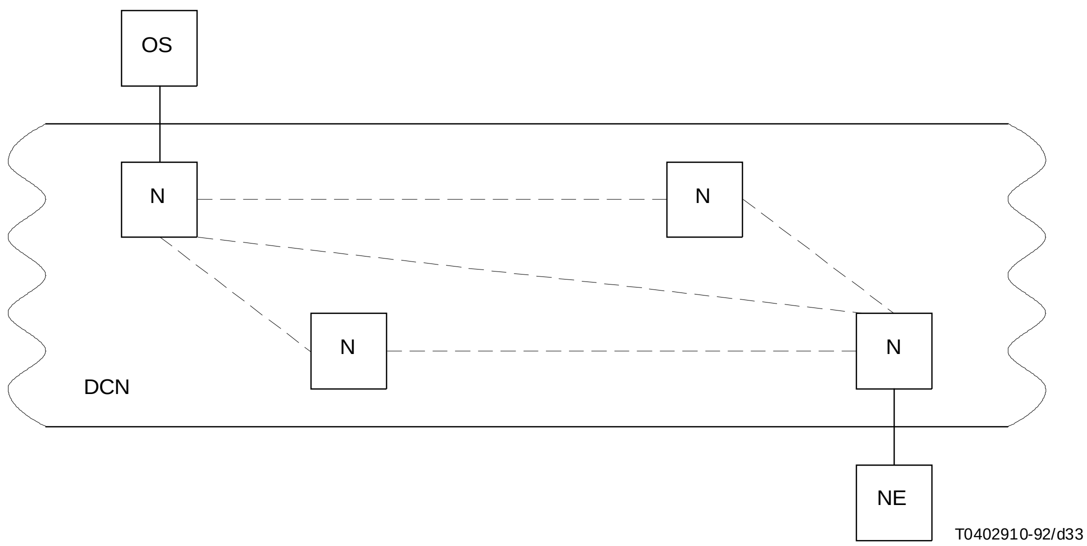
**Superseded by a more recent version**




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**

Figure III.4 illustrates the simplest case. The Workstation Function block (WSF) is not distributed, and it is co-located with OSF on a physical building block, the OS. The f reference point is internal. One piece of processing equipment with built-in graphical display supports the WSF and OSF. Only the OS aspect of the TMN is shown.

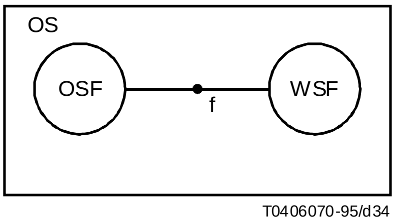



FIGURE III.4/M.3010

**Example WSF in an OS**

Figure III.5 shows another case where the WSF is not distributed. In this case, the OSF resides on one building block (the OS) and the WSF resides on another (the WS). The f reference point is between these building blocks and implemented over an F interface. Only the OS and WS portions of the architecture are shown.

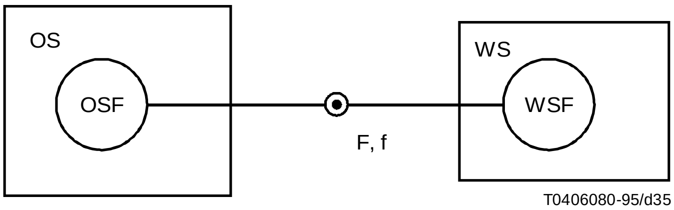



FIGURE III.5/M.3010

**Example WSF in a WS**

Figure III.6 provides an example of one way in which the WSF may be distributed. In this example, the f reference point is external and implemented over an F interface. Only the OS and WS parts of the architecture are shown.

The rightmost Workstations (WSs) may be "display servers", while the "display client" is shown interfacing to the OS (see 6.8.2).

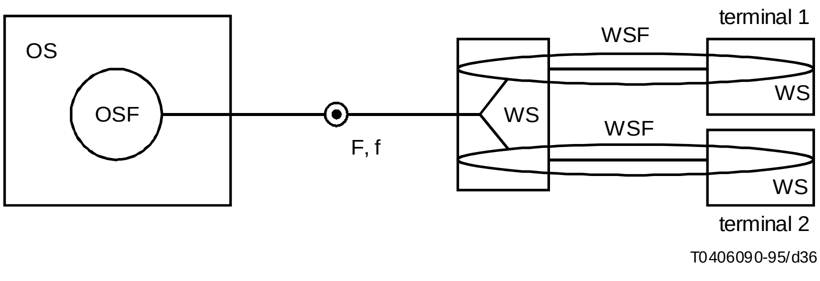



FIGURE III.6/M.3010

**Example of distributed WSF**

Figure III.7 shows another example of distributed WSF. In Figure III.7, the OSF and some WSF are co-located on the OS and the f reference point is internal. Some WSF is provided by the display server.

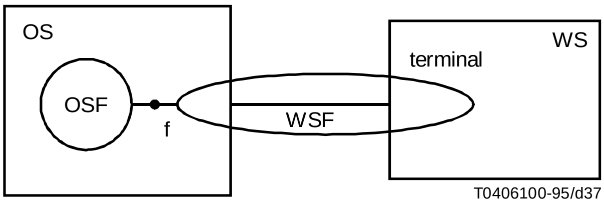



FIGURE III.7/M.3010

**Example of distributed WSF**

Many other configurations are possible.

### III.1.4 SDH communications examples

Figures III.8 and III.9 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.

### III.1.5 Interactions between multiple OS and multiple NE configurations

The configuration of interaction between multiple OS and multiple NE raises special considerations. One case is the notification aspect where a single NEF is expected to issue notifications to multiple OSFs, and another case is where multiple OSFs are controlling a single NEF. Figure III.10 illustrates a portion of the logical OS configuration. Within a single TMN interactions are allowed between each OSF and each NEF. However, between TMNs, as illustrated in Figure III.10, an OSF in TMN 2 can only communicate with NEF in TMN 1, using an x reference point via an OSF located in TMN 1. OSF normally resides in the OS, while OSF and NEF may reside in the same physical NE.

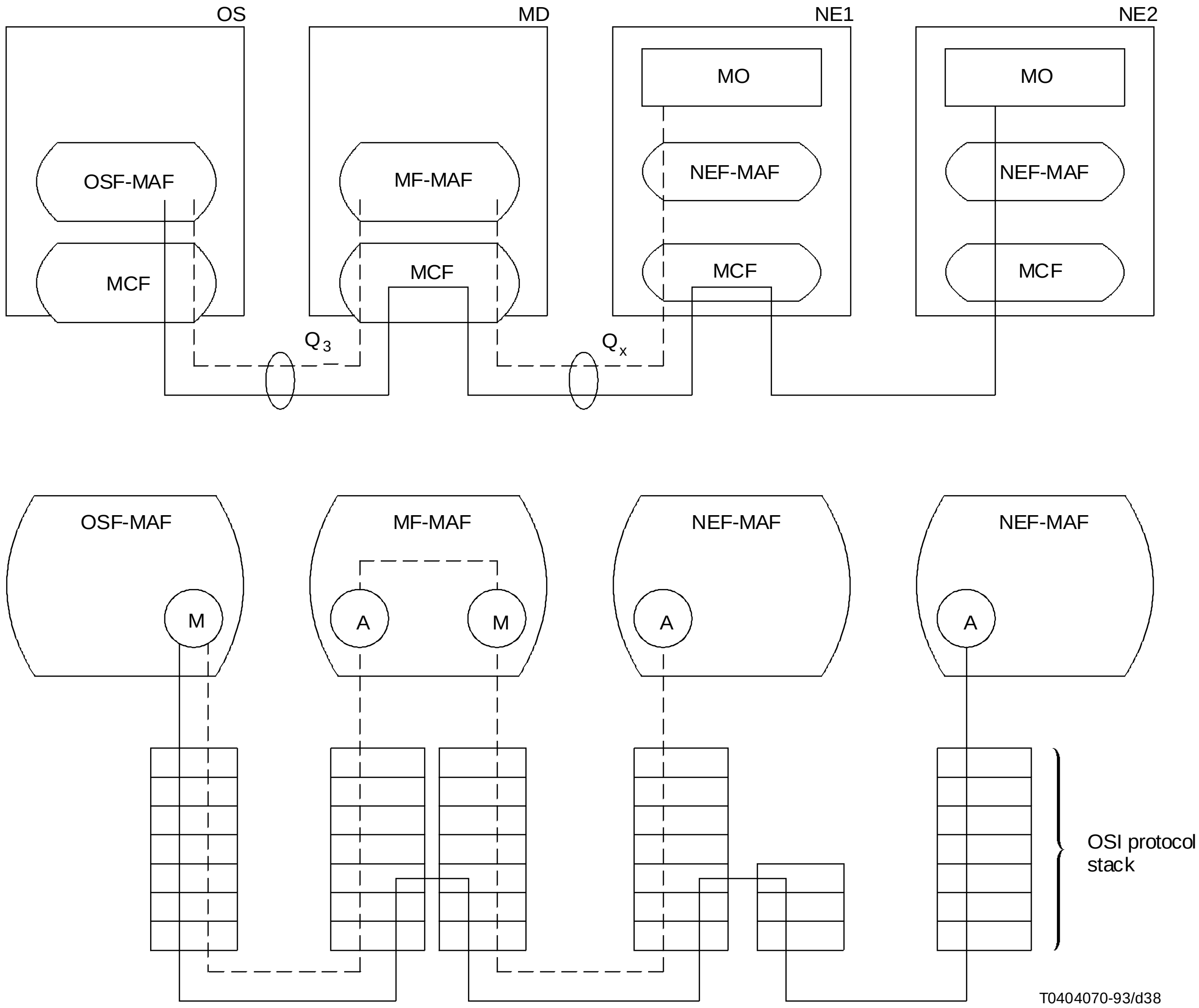
The TMN concept does not impose constraint on implementation regarding the flow of event-related information. A series of tools exists that allows one to design a solution based on specific requirements and constraints.

Whenever an operations conflict exists, resolution should be achieved by a well-defined conflict resolution schema (e.g. SMK, Access Control, Concurrency Control, etc.) that must be supported by all involved entities (OSF, NEF). When the NEF is not capable of resolving conflicts, it is up to the OSFs to coordinate and synchronize the activities on this NEF. Tools for this (OSF-OSF) have not been identified by TMN. Standard tools such as ODP and TP may exist elsewhere, but is for further study as part of the TMN repertoire.

### III.1.6 Examples of interconnection of user access services with TMNs

There are two basic ways to provide user access services. The first case is when the end-user of the service has its own TMN. In this case the end-user TMN and the administration TMN will be interconnected by an X interface.

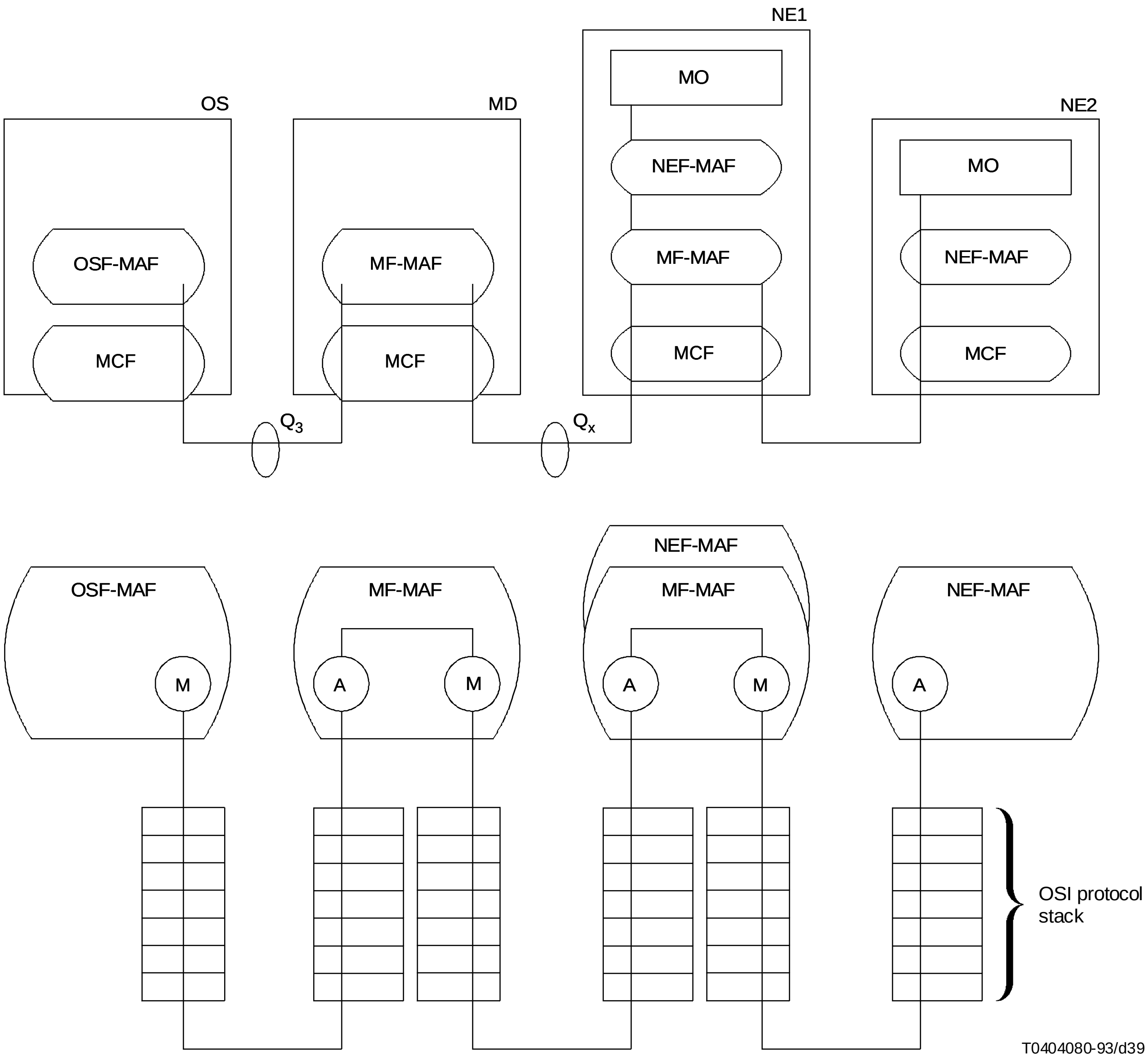
Figure III.11 shows an example of such a situation. The administration needs a TMN building block(s) with OSF(s) capable of providing user access services. The end-user TMN needs a TMN building block(s) with OSF(s) capable of supporting an X interface for user access CNM services.




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

FIGURE III.8/M.3010

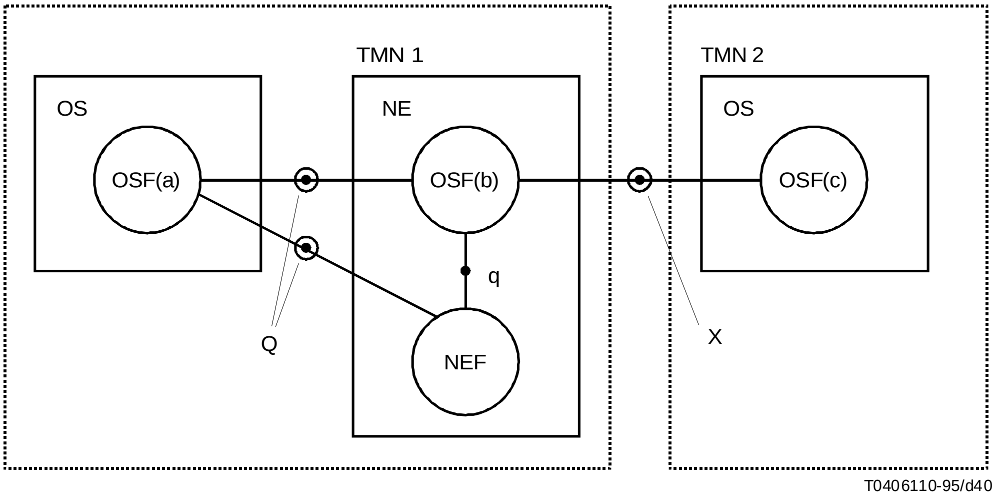
**ASH functional configuration examples**




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

FIGURE III.9/M.3010

**SDH functional configuration examples**




NOTES

1 Direct interaction between OSF(c) and NEF is prohibited. The interaction between OSF(c) and NEF is realized by an x reference point through OSF(b).

2 Both direct and indirect interaction between OSF(a) and NEF are allowed, where indirect interaction means using a q reference point through OSF(b). It results in a number of conflicts resolution difficulties in NEF.

3 OSF(b) and NEF may reside in the same NE. Physical configurations, OS and NE, are just an example.

FIGURE III.10/M.3010

**Example of multiple OSF Interaction with a single set of NEF resources**

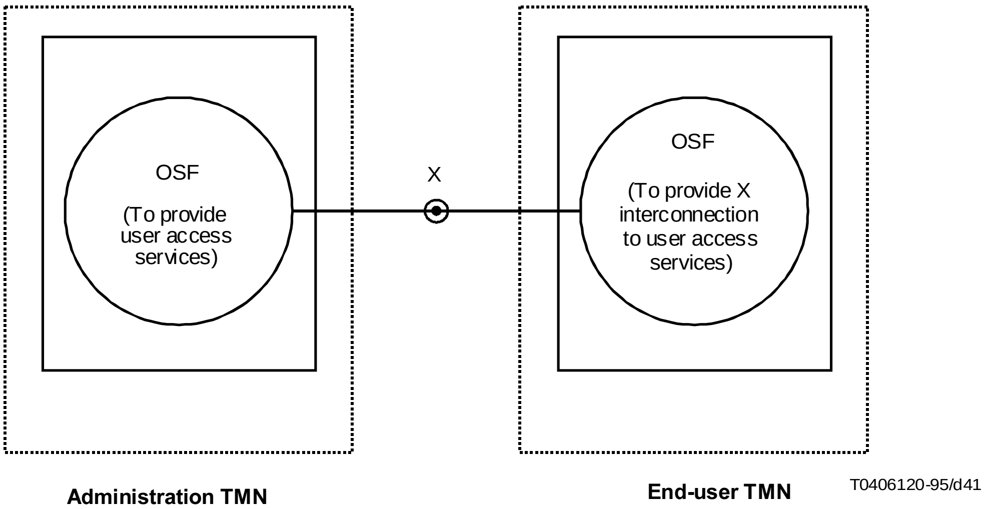
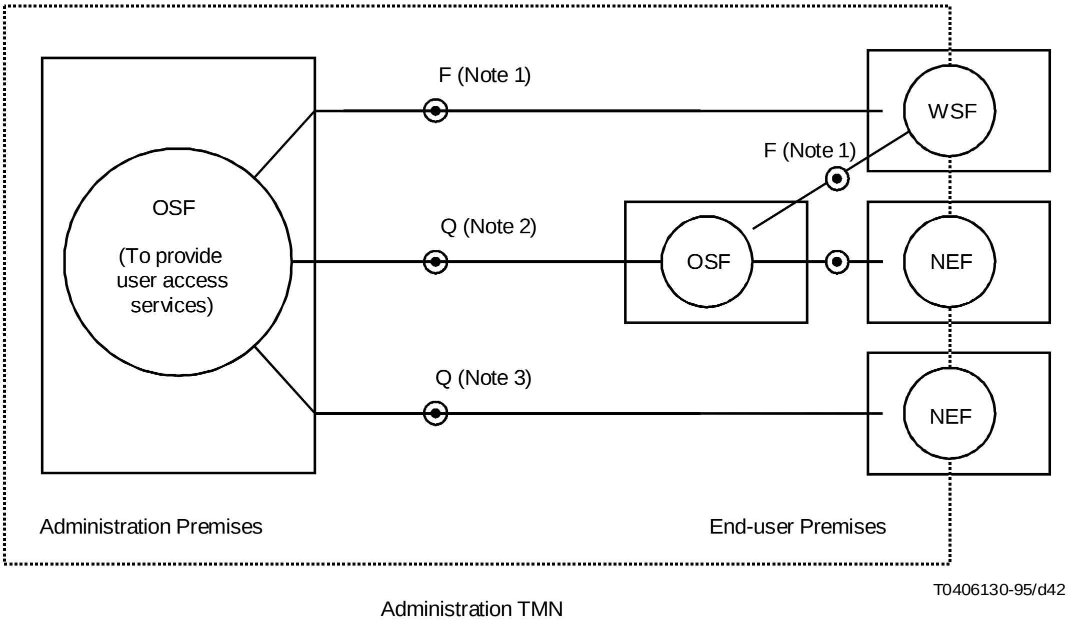



FIGURE III.11/M.3010

The second case is when the end-user is using the administration TMN. In this case the end-user will access the management services via an F interface. In order to manage network elements at end-user premises, Q interfaces may also be needed. Figure III.12 shows an example of this situation.




NOTES

1 In a given implementation there may exist both or just one of those F interfaces.

2 This Q interface will only exist in the case of an OS belonging to the administration TMN being installed at end-user premises.

3 This Q interface will only exist in the case of a NE at end-user premises being managed by the administration TMN.

FIGURE III.12/M.3010

## Appendix IV

## Considerations for managing networks

(This appendix does not form an integral part of this Recommendation)

### 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) Data/information synchronization is required to provide consistency between the NEs and the OSs. This is needed when the state of a managed element is changed (by the NE itself, OS or a source external to TMN), and the change is not updated within all the appropriate OSs.

3) 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.

4) 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.

5) Conflict occurs when several Managers are trying to control the same, or closely related, objects at the same time.

6) 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.)

7) 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.

8) Accuracy of every time stamp is a subject that may be maintained locally. Nevertheless some management capabilities might be impacted, if information is inconsistent as a result of inaccuracy of timing sources.

### 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, a negotiation mechanism need 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 Information conversion between two interfaces

Information conversion is required when the information received at one interface on a TMN building block must be transformed or modified before it is forwarded over a second interface. Thus, for the cases of MDs and QAs, an interface conversion function is necessary. This interface conversion capability is implemented via the Information Conversion Function component (ICF), see Table 2.

The ICF has to convert one standardized object-oriented information model into another information model and vice versa. This other interface may use a different paradigm.

The ICF needs to address differences in the functions supported by the protocols, differences in the identification of the information itself, and differences in how the information is modelled for exchanges across the interfaces.

The following is a non-exhaustive list of considerations that should be addressed when designing a QA, MD or other TMN building block which contains an ICF functional component that must convert between different information models associated with its interfaces.

These considerations are described in terms of ICF modelling considerations.

In the following text we shall identify the first interface as the "$Q_3$" interface and the second interface as the "other" interface. This other interface can be object-oriented ($Q_3$, $Q_x$) or not (e.g. proprietary).

1) *Unsupported information and functional capabilities at the other interface*

   - If the OSF attempts to invoke an operation, function, or access an object at the $Q_3$ interface that has no equivalent at the "other" interface, the relevant error message may be generated.

2) *Multiple representation of managed resources*

   - The ICF should be able to handle references to managed resources from the $Q_3$ interface specified in more than one way.

3) *Coordination*

   - An operation request on a single managed object at the $Q_3$ interface may result in multiple operation requests on multiple other interfaces. When this occurs these operations at the other interfaces must be coordinated in such a way that the operation request at the $Q_3$ is treated as a single activity.

4) *Naming*

   - ICF needs to have access to whatever information is necessary to do name mappings between both interfaces (naming schemes and naming trees, etc.).

   - The ICF may have to maintain additional information to map the distinguished names and the local distinguished names at the $Q_3$ interface for all operations to the names used on the other interface. Names may occur not only as the name of objects instances but also in other attributes.

5) *Single Request to perform multiple operations*

   - When a request at the $Q_3$ interface requests performing operations on multiple managed objects, the ICF may need to transform the single $Q_3$ request into multiple requests at the other interface.

   - If the request at the $Q_3$ interface specifies a criteria for performing the operations, the ICF may have to either implement the selection criteria or issue an appropriate error to the $Q_3$ interface.

6) *Capabilities at the other interface not supported at the $Q_3$*

   - When the other interface supports additional information or functional capabilities that have no correspondence at the $Q_3$ interface, this information and these functional capabilities may not be visible or accessible from the $Q_3$ interface.

# Appendix V

# Use of X.500 Directory to support distributed TMNs and TMN-Interworking

(This appendix does not form an integral part of this Recommendation)

## V.1 Scope of TMN/Directory Interworking

The architectural requirements described in this Recommendation cover some requirements to support distributed TMNs and TMN-Interworking (or inter-domain management). The TMN architecture should:

- allow for geographic dispersion of a control over an aspect of the network operation;
- improve service assistance and interaction with a customer;
- provide a certain degree of reliability and security in the support of management functions;
- make it possible for a customer, value added service provider and other Administrations to access management functions;
- make it possible to have different or the same management services at different locations, even if it accesses the same NE;
- make the interworking between separately managed networks possible, so that internetwork service can be provided between Administrations.

Additionally, in this Recommendation a lot of inter-TMN management-related aspects have already been described (basically) but many related problems are left for further studies.

The Directory usage will solve several problems of TMN interworking. It may also be used to support information handling requirements for distributed TMNs in one administrative domain. As described in the main part of the Directory Access and System Functions have been added to allow access to the Directory from each TMN function block. The X.500 Directory should be seen as one implementation option, although it seems to be today's best standards based choice.

The X.500 Directory can be used to support TMN systems with the following features:

1) General Information Service for TMN-related Information (Yellow Pages Services).
2) Global naming of Managed Objects (see also Recommendation X.750 [23]).
3) Name/Address Resolution (e.g. for SMAE).
4) Representation of Shared Management Knowledge (SMK) (for details see Recommendation X.750 [23]: the management knowledge management function).

## V.2 Requirements on X.500 Directory Support

Open systems which are participating in the TMN for the purpose of management require specific knowledge in order to determinate the peer system with which to associate, to enable association, and to fulfil their management functions. In addition, human users of the TMN need certain information to perform their functions. Some of this knowledge which is required to support distributed TMNs and TMN interworking is available from a Directory Service.

The following subclauses describe specific requirements which may be satisfied by the Directory Service defined in the X.500 Recommendations [22].

### V.2.1 General requirements

#### V.2.1.1 TMN-interworking

In the envisaged distributed TMN environment, the exchange of management information will take place between the following organizations and their TMNs across "X"-type interfaces:

- between network operator's TMNs and value added service provider's TMNs;
- between different network operator's TMNs; and
- between different service provider's TMNs.

In addition, service users and subscribers, in particular business subscribers, will require:

- customer management services which provide access to information of service and network provider TMNs.

### V.2.1.2 Distributed TMNs

Within one administrative domain there may exist several closely related TMNs or TMN function blocks of different management layers of the TMN functional hierarchy (Network Element, Network, Service, Business layer) which also needs some Directory support.

TMN building blocks of network operators and value added service providers as well as customers, require an efficient and effective information service which provides details about services, operators, networks, network elements, customer contracts, etc. TMN systems may make use of the already standardized information services offered by the X.500 Directory.

The following subclauses provide a list of specific requirements which could be supported by the use of X.500 Directory.

#### V.2.1.2.1 Association Resolution

There is the necessity to determine:

a) the TMN element involved in the management subsystem;

b) the AE-titles of the entity with which management associations may be established;

c) the presentation address of those entities;

d) given a managed object and optionally the name of the desired management capability, the identity of one or more management agents capable of providing the management functions.

#### V.2.1.2.2 Management knowledge

There is the necessity to determine:

a) the supported application contexts of management application entity;

b) the supported functional units of management applications entity;

c) the supported management profile of management applications entity;

d) the list of managed objects and managed object classes in a management applications entity;

e) the grouping of managed systems and management systems into management domains.

#### V.2.1.2.3 Security support

There is the necessity to determine:

a) password for management entities to support simple authentication during management association establishment;

b) access control information to support access directory.

#### V.2.1.2.4 Administrative usage

There is the necessity to allow:

a) a human administrator to search, modify, add, and delete entries and sub-tree structure (within access right) for the purposes of administering the Directory;

b) an application to search, modify, add, and delete entries and sub-tree structure (within access right) for the purposes of administering the Directory.

#### V.2.1.2.5 Messaging and use by persons

In order to support inter-personal messaging, there is a need to determine:

a) the X.400 addresses of roles and persons involved in TMN management;

b) other contact information (telephone numbers, facsimile, postal, etc.) of organizations, roles and persons involved in TMN management.

## V.3 The integrated Information Architecture

Figure V.1 depicts the relationships between the Directory Objects (DOs) in the Directory Information Base (DIB) and the Managed Objects (MO) in the Management Information Bases (MIBs). The DOs are associated to one globally unique root for providing unambiguous distinguished object names in the global environment. The MO are associated to its local root providing only unique naming in the local MIB environment. If managed objects (MOs) need to be made visible in the global context, for example: for inter-domain management or TMN interworking, a globally unique name will be required for these MOs. This can be archived by associating the local MIBs to the global DIT. A name binding between specific DOs and the MIB's root MO (system MO class (Recommendation X.721 [30]) or network MO class (Recommendation M.3100)) has been defined in Recommendations X.701 [3] and X.750 [23].

DOs may represent information types defined in Recomendation X.520: Selected Attribute Types [28], Recommendation X.521: Selected Object Classes [29] as well as information types already defined (or to be defined) by application specific Directory schema extensions in the X.700-Series (e.g. X.750 Management Knowledge Management Function [23]), M.3000-Series and other Recommendations (e.g. in the X.400-Series [36]). Some of the already defined information types (see Recommendations X.520 [28], X.521 [29]) may also be used to represent TMN-related management information.

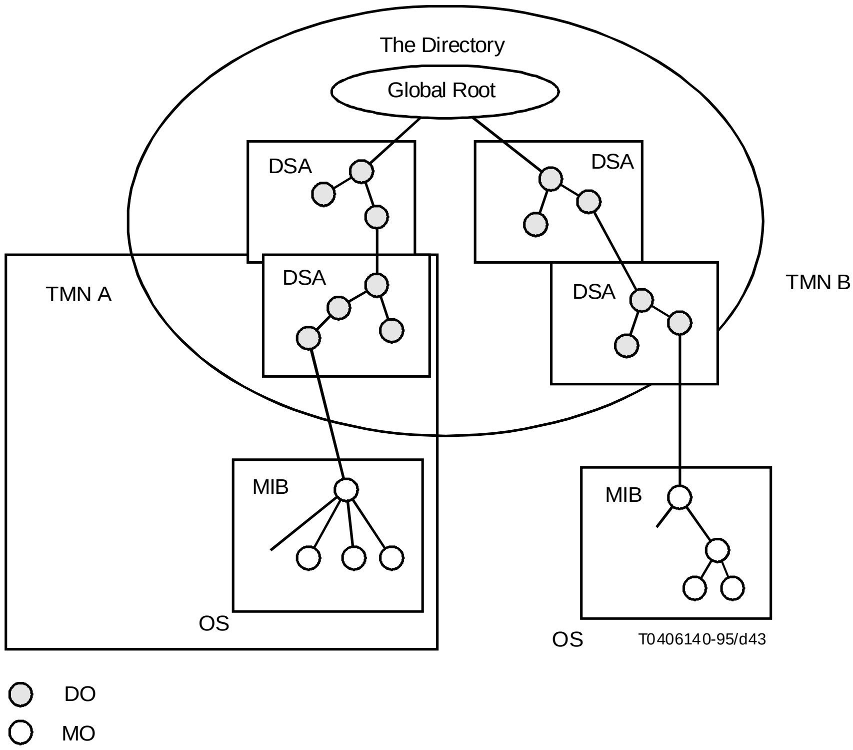



FIGURE V.1/M.3010

**Integrated Directory and TMN Information Architecture**

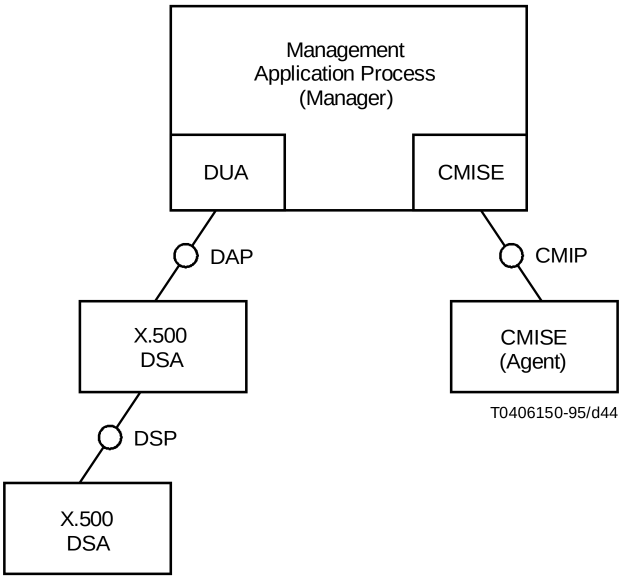
## V.4 Implementation considerations

The X.500 Directory System can be used as one implementation option to represent TMN-related information in the DIB. This type of information should be accessible globally by each authorized TMN management function or by responsible persons.

# Superseded by a more recent version

The Directory System is described as two communicating application processes: The Directory User Agent (DUA) and the Directory System Agent (DSA). They communicate using the Directory Access Protocol (DAP). The subject of their communication is the Directory Information Base (DIB) representing Directory Objects (DOs) or Directory entries. The Directory is a distributed application representing fragments of the whole DIT in several DSAs. DSAs are communicating via the Directory System Protocol (DSP) to get access on specific DOs represented in specific DSAs.

In the case of implementing the Directory functionality by Recommendation X.500, the DAF is implemented as a DUA, the DSF is implemented as a DSA and the Information exchange is executed via the Directory Access Protocol (DAP) or Directory System Protocol (DSP) defined in the X.500-Series of Recommendations (see Figure V.2). A common OSI communication protocol stack can be used for DUA, DSAs and CMIS Entities.




| | |
|---|---|
| DUA | Directory User Agent |
| DSP | Directory System Protocol |
| DAP | Directory Access Protocol |
| DSA | Directory System Agent |

FIGURE V.2/M.3010

**Joint use of Directory (DAP) and CMISE (CMIP)**

FIGURE V.3/M.3010

**Example of commmunicating TMN systems covering the Directory Access Function**

For further study.

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