INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

M.3010

(02/2000)

SERIES M: TMN AND NETWORK MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS, TELEPHONE CIRCUITS, TELEGRAPHY, FACSIMILE AND LEASED CIRCUITS

Telecommunications management network

Principles for a telecommunications management network

ITU-T Recommendation M.3010

(Formerly CCITT Recommendation)

ITU-T M-SERIES RECOMMENDATIONS

TMN AND NETWORK MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS, TELEPHONE CIRCUITS, TELEGRAPHY, FACSIMILE AND LEASED CIRCUITS

Introduction and general principles of maintenance and maintenance organization	M.10–M.299
International transmission systems	M.300–M.559
International telephone circuits	M.560–M.759
Common channel signalling systems	M.760–M.799
International telegraph systems and phototelegraph transmission	M.800–M.899
International leased group and supergroup links	M.900–M.999
International leased circuits	M.1000–M.1099
Mobile telecommunication systems and services	M.1100–M.1199
International public telephone network	M.1200–M.1299
International data transmission systems	M.1300–M.1399
Designations and information exchange	M.1400–M.1999
International transport network	M.2000–M.2999
Telecommunications management network	**M.3000–M.3599**
Integrated services digital networks	M.3600–M.3999
Common channel signalling systems	M.4000–M.4999

For further details, please refer to ITU-T List of Recommendations.

ITU-T RECOMMENDATION M.3010

PRINCIPLES FOR A TELECOMMUNICATIONS MANAGEMENT NETWORK

Summary

This Recommendation defines concepts of Telecommunications Management Network (TMN) architectures (TMN functional architecture, TMN information architecture, and TMN physical architectures) and their fundamental elements.

This Recommendation also describes the relationship among the three architectures and provides a framework to derive the requirements for the specification of TMN physical architectures from the TMN functional and information architectures. A logical reference model for partitioning of management functionality, the Logical Layered Architecture (LLA), is provided.

Source

ITU-T Recommendation M.3010 was revised by ITU-T Study Group 4 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on 4 February 2000.

Keywords

Architecture, conformance and compliance, interfaces, reference model, telecommunications management network (TMN).

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the 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.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

INTELLECTUAL PROPERTY RIGHTS

The ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. The ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

CONTENTS

		Page
1	Scope	1
2	References	1
3	Definitions	2
4	Abbreviations	4
5	Introduction	6
5.1	General	6
5.2	Relationship of a TMN to a telecommunications network	6
6	Field of application	7
7	Basic objectives for a TMN	8
8	General TNM requirements	9
9	TMN functional architecture	9
9.1	TMN function blocks	10
	9.1.1 Operations Systems Function (OSF) block	10
	9.1.2 Network Element Function (NEF) block	10
	9.1.3 Workstation Function (WSF) block	11
	9.1.4 Transformation Function (TF) block	11
9.2	TMN Functionality	11
	9.2.1 Management Application Functionality	11
	9.2.2 Support Functionality	11
9.3	TMN Management Function Sets and TMN Management Functions	12
9.4	TMN reference points	12
	9.4.1 Classes of reference points	13
	9.4.2 Reference point descriptions and usage	14
	9.4.3 Relationship of reference points to function blocks	15
9.5	TMN Logical Layered Architecture within the TMN functional architecture	15
	9.5.1 Management function layers of abstraction	16
	9.5.2 Information layering principles	19
	9.5.3 Functional interaction between management layers	20
10	TMN information architecture	20
10.1	Principles	20
10.2	Interaction model	20
10.3	TMN management information models	21
10.4	TMN management information elements	21
10.5	Information model of a reference point	21

Page

10.6 Reference points 22

10.7 TMN logical layered architecture within the TMN information architecture 22

11 TMN physical architecture 22

11.1 TMN physical blocks 23

11.1.1 Operations System (OS) 24

11.1.2 Transformation 24

11.1.3 Network Element (NE) 24

11.1.4 Workstation (WS) 25

11.2 Data Communication Network (DCN) 25

11.3 TMN logical layered architecture within the TMN physical architecture 25

11.4 Interoperable interface concept 25

11.5 TMN standard interfaces 26

11.5.1 Q interface 26

11.5.2 F interface 26

11.5.3 X interface 26

11.5.4 Relationship of TMN interfaces to TMN physical blocks 26

11.5.5 TMN standard interfaces 26

12 Relationships between TMN architectures 27

12.1 Relationship between the TMN architectures and a TMN implementation 27

12.2 Relationship between reference points in the functional and information architecture specifications and physical interfaces in an implementation of the physical architecture 29

12.3 Shared management knowledge (SMK) 32

13 TMN conformance and TMN compliance 32

13.1 Introduction 32

13.2 TMN conformance definitions 33

13.3 TMN interface protocol conformance 33

13.4 TMN interface information conformance 34

13.4.1 Level A interface information conformance 34

13.4.2 Level B interface information conformance 34

13.4.3 Level C interface information conformance 35

13.5 TMN compliance 35

Recommendation M.3010

PRINCIPLES FOR A TELECOMMUNICATIONS MANAGEMENT NETWORK

(Melbourne, 1988 approved as Recommendation M.30, revised and renumbered in 1992, revised 1996, revised 2000)

1 Scope

This Recommendation defines concepts of Telecommunications Management Network (TMN) architectures (TMN functional architecture, TMN information architecture, and TMN physical architectures) and their fundamental elements.

This Recommendation also describes the relationships among the three architectures and provides a framework to derive the requirements for the specification of TMN physical architectures from the TMN functional and information architectures. A logical reference model for partitioning of management functionality, the Logical Layered Architecture (LLA), is provided.

This Recommendation also defines how to demonstrate TMN conformance and compliance for the purpose of achieving interoperability.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] CCITT Recommendation X.700 (1992), *Management framework for Open Systems Interconnection (OSI) for CCITT applications*.

[2] ITU-T Recommendation X.701 (1997) | ISO/IEC 10040:1998, *Information technology – Open Systems Interconnection – Systems management overview*.

[3] ITU-T Recommendation X.703 (1997) | ISO/IEC 13244:1998, *Information technology – Open distributed management architecture*.

[4] ITU-T Recommendation X.724 (1996) | ISO/IEC 10165-6:1997, *Information technology – Open Systems Interconnection – Structure of management information: Requirements and guidelines for implementation conformance statement proformas associated with OSI management*.

[5] CCITT Recommendation X.720 (1992) | ISO/IEC 10165-1:1993, *Information technology – Open Systems Interconnection – Structure of management information: Management information model*.

[6] ITU-T Recommendation X.725 (1995) | ISO/IEC 10165-7:1996, *Information technology – Open Systems Interconnection – Structure of management information: General relationship model*.

[7] ITU-T Recommendation X.290 (1995), *OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications – General concepts*.

[8] ITU-T Recommendation M.3013 (2000), *Considerations for a telecommunications management network*.

[9] ITU-T Recommendation M.3020 (2000), *TMN interface specification methodology*.

[10] ITU-T Recommendation M.3200 (2000), *TMN management services and telecommunications managed areas: Overview*.

[11] ITU-T Recommendation M.3400 (2000), *TMN management functions*.

[12] ITU-T Recommendation Q.811 (1997), *Low layer protocol profiles for the Q3 and X interfaces*.

[13] ITU-T Recommendation Q.812 (1997), *Upper layer protocol profiles for the Q3 and X interfaces*.

[14] ITU-T Recommendation X.200 (1994) | ISO/IEC 7498-1:1994, *Information technology – Open systems interconnection – Basic reference model: The basic model*.

[15] ITU-T Recommendations M.31xx-series, *Generic network information model*.

[16] ITU-T Recommendations X.73x-series, *Management functions and ODMA functions*.

[17] ITU-T Recommendations G.85x-series, *Telecommunications management network*.

[18] ITU-T Recommendation Q.82x-series, *Specifications of Signalling System No. 7 – Q3 interface maintenance*.

[19] ITU-T Recommendations Z.300-series, *Man-machine language – Basic syntax and dialogue procedures*.

[20] ITU-T Recommendation M.3000 (2000), *Overview of TMN Recommendations*.

3 Definitions

This Recommendation defines the following terms:

3.1 business management layer: A management layer responsible for the total enterprise and not subject to standardization.

3.2 data communication network: A communication network within a TMN or between TMNs which supports the data communication function (DCF).

3.3 element management layer: A management layer which is responsible for management of network elements on an individual or collective basis.

3.4 F interface: An interface applied at f reference points.

3.5 f reference points: A reference point that is located between the workstation function block (WSF) and the operations systems function block (OSF).

3.6 function block: The smallest (deployable) unit of TMN management functionality that is subject to standardization.

3.7 g reference points: A reference point located outside the TMN between the human users and the workstation function block (WSF). It is not considered to be part of the TMN even though it conveys TMN information.

3.8 interface: An architectural concept that provides interconnection between physical blocks at reference points.

3.9 logical layered architecture: An architectural concept that organizes the management functions into a grouping of management layers and describes the relationship between the layers.

3.10 m reference points: A reference point located outside the TMN between a Q adapter function block (QAF) and managed entities that do not conform to TMN Recommendations.

3.11 managed resource: The abstraction of those aspects of a telecommunication resource (logical or physical) required for telecommunications management.

3.12 management application function: A function that represents (part of) the functionality of one or more management services.

3.13 management domain: A set of managed resources subject to a common management policy.

3.14 management function: The smallest part of a management service as perceived by the user of the service.

3.15 management function set: TMN management function set is a grouping of TMN management functions that contextually belong together, i.e. they are related to a specific management capability (e.g. alarm reporting functions, traffic management control). The TMN management function set is the smallest reusable item of functional specification. The TMN management function set must be considered as a whole. It is similar to the requirements part of the OSI SMF (system management function).

3.16 management layer: An architectural concept that reflects particular aspects of management and implies a clustering of management information supporting that aspect.

3.17 management service: A management service is an offering fulfilling specific telecommunications management needs.

3.18 network element: An architectural concept that represents telecommunication equipment (or groups/parts of telecommunication equipment) and supports equipments or any item or groups of items considered belonging to the telecommunications environment that performs network element functions (NEFs).

3.19 network element function: A function block which represents the telecommunication functions and communicates with the TMN OSF function block for the purpose of being monitored and/or controlled.

3.20 network management layer: A management layer responsible for the management, including coordination of activity, of a network view.

3.21 operations system: A physical block which performs operations systems functions (OSFs).

3.22 operations systems function: A function block that 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).

3.23 physical block: An architectural concept representing a realization of one or more function blocks.

3.24 Public Telecommunication Operator (PTO): Is used for conciseness to include telecommunication administrations, recognized operating agencies, private (customer and third party) administrations and/or other organizations that operate or use a Telecommunications Management Network (TMN).

3.25 Q adapter: A physical block that is characterized by a contained Q adapter function block and which connects NE-like or OS-like physical entities with non-TMN compatible interfaces (at m reference points) to Q interfaces.

3.26 Q interface: An interface applied at q reference points.

3.27 q reference points: A reference point located between NEF and OSF, between QAF and OSF, and between OSF and OSF.

3.28 reference point: An architectural concept used to delineate management function blocks and which defines a service boundary between two management function blocks.

3.29 service management layer: A management layer that is concerned with, and responsible for, the contractual aspects, including service order handling, complaint handling and invoicing, of services that are being provided to customers or available to potential new customers.

3.30 telecommunications management network: An architecture for management, including planning, provisioning, installation, maintenance, operation and administration of telecommunications equipment, networks and services.

3.31 transformation function: A function block which translates between a TMN reference point and a non-TMN (either proprietary or otherwise standardized) reference point. The non-TMN part of this function block is outside the TMN boundary.

3.32 workstation: A physical block which performs workstation functions (WSFs).

3.33 workstation function: A function block which interprets TMN information for the human user, and vice versa.

3.34 X interface: An interface applied at x reference points.

3.35 x reference points: A reference point located between OSF function blocks in different TMNs.

NOTE – 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 points.

3.36 user: A person or process applying management services for the purpose of fulfilling management operations.

4 Abbreviations

This Recommendation uses the following abbreviations:

A	Agent
A/M	Agent/manager
AE	Application entity
ASN.1	Abstract Syntax Notation number One
ATM	Asynchronous Transfer Mode
BML	Business management layer
B-OSF	Business Management Layer – Operations Systems Function
CMIP	Common management information protocol
DCF	Data communication function
DCN	Data communication network
EML	Element management layer
E-OSF	Element Management Layer – Operations Systems Function
GDMO	Guidelines for the Definition of Managed Objects
IN	Intelligent Network
ISDN	Integrated services digital network
ISO	International Organization for Standardization
ITU	International Telecommunication Union
LAN	Local area network

LLA	Logical Layered Architecture
M	Manager
M	Mandatory
MAF	Management application function
MAN	Metropolitan Area Network
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 Systems Function
O	Optional
OA&M	Operations, Administration and Maintenance
OID	Object Identifier
OS	Operations system
OSF	Operations systems function
OSF-MAF	Operations systems function – Management application function
OSI	Open systems interconnection
PBX	Private branch exchange
PTO	Public Telecommunication Operator
QA	Q adapter
QOS	Quality of Service
R	Resource
SDH	Synchronous Digital Hierarchy
SMK	Shared management knowledge
SML	Service management layer
S-OSF	Service management layer – Operations Systems Function
TF	Transformation Function
TF-MAF	Transformation Function – Management application function
TMN	Telecommunications management network
WSF	Workstation function
WSSF	Workstation Support function

5 Introduction

5.1 General

This Recommendation presents the general architectural requirements for a Telecommunications Management Network (TMN) to support the management requirements of PTOs (Public Telecommunication Operators) to plan, provision, install, maintain, operate and administer telecommunication networks and services.[1]

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 PTOs in conducting their business efficiently.

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 PTOs 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.

5.2 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.

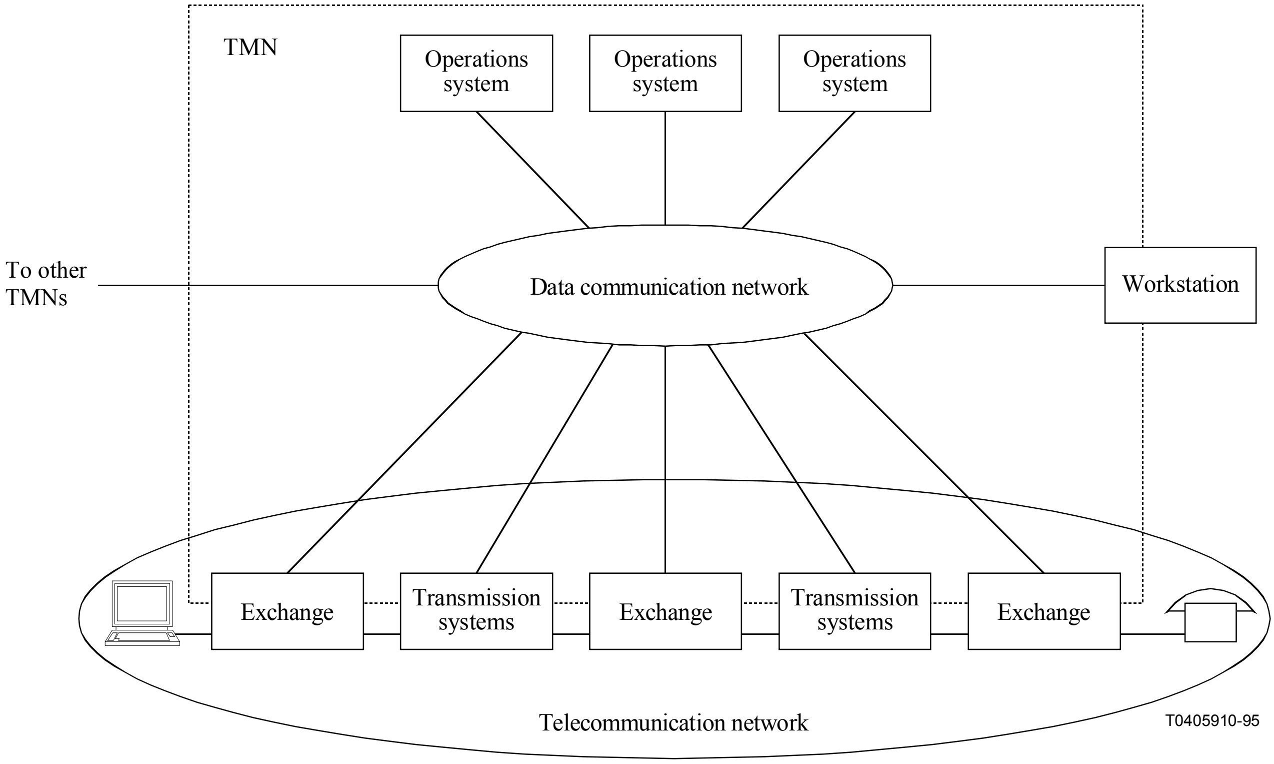
A TMN may provide management functions and offer communications both between the OSs themselves, and between OSs and the various parts of the telecommunications network. A TMN may also provide management functions and offer communications to another TMN or TMN-like[2] entities in order to support the 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, multiplexes, 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.

---

1 Some considerations for design, planning, installation and operating a TMN and examples of use are presented in Recommendation M.3013.

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



NOTE – The TMN boundary represented by the dotted line may extend to and manage customer/user services and equipment.

Figure 1/M.3010 – General relationship of a TMN to a telecommunication network

6 Field of application

The following are examples of telecommunications equipment, networks and services that may be managed by a 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.;
– TMN software applications;
– associated support systems (test modules, power systems, air conditioning units, building alarm 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;
– resources related to the processes that a PTO uses in the operation of equipment, networks and services. Examples of such managed resources are equipment repair service order, trouble tickets generated by customer complaints, customer contract for service provisioning, service level agreements, historical data, etc.

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.

7 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, network and services using generic information models and standard interfaces.

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. Recommendation M.3200 [10] describes the scope of management through the following two main concepts: Telecommunications Managed Areas and TMN Management Services. The former relates to the grouping of telecommunications resources being managed and the latter relates to the set of processes needed to achieve business objectives, namely TMN Management Goals.

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 functional areas support the management scope described by M.3020 [9]. They provide a framework through which the appropriate Management Services support the PTOs business processes. 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 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. Introduction of TMNs gives PTOs 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.

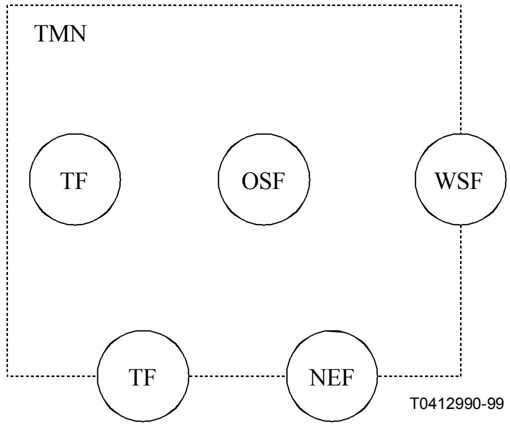
8 General TNM requirements

The requirements of the TMN consist 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;
- the ability to achieve technology independence based on requirements and to be extendable to include prominent and available management technologies in its implementations, as appropriate.

9 TMN functional architecture

The TMN functional architecture is a structural and generic framework of management functionality that is subject to standardization.



NEF Network Element Function
OSF Operation Systems Function
TF Transformation Function
WSF Workstation Function
------------ The TMN functional boundary

Figure 2/M.3010 – TMN function blocks

The TMN functional architecture is structured from the following fundamental elements:

- function blocks;
- Management Application Functions (MAFs);
- TMN Management Function Sets and TMN Management Functions;
- reference points.

TMN management functionality to be implemented can then be described in terms of these fundamental elements.

9.1 TMN function blocks

Figure 2 illustrates the different types of TMN function blocks and indicates that only the functions that are directly involved in management are part of a TMN. Some of the function blocks are partly in and partly out of a TMN; these TMN function blocks also perform functions outside of the TMN functional boundaries as discussed and defined in the subclauses below.

The TMN function block is the smallest *deployable* unit of TMN management functionality. If the TMN function block contains a Management Application Function, it may only contain one Management Application Function.

9.1.1 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).

9.1.2 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.

9.1.3 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.

9.1.4 Transformation Function (TF) block

The Transformation Function block (TF) provides functionality to connect two functional entities with incompatible communication mechanisms. Such mechanisms may be protocols or information models (see 10.3) or both.

The TF may be used anywhere within a TMN or anywhere at the boundary of a TMN. When used within a TMN, the TF connects two function blocks, each of which supports a standardized, but different, communication mechanism.

When used at the boundary of a TMN, the TF may be used either as communication between two TMNs or between a TMN and a non-TMN environment.

When used at the boundary of two TMNs the TF connects two function blocks, one in each TMN, each of which supports a standardized, but different, communication mechanism.

When the TF is used between a TMN and a non-TMN environment, the TF connects a function block with a standardized communication mechanism in a TMN to a functional entity with a non-standardized communication mechanism in the non-TMN environment.

NOTE – The TF consolidates and extends the functionality and scope associated with the Mediation and Q Adaption function blocks in Recommendation M.3010 (05/96).

9.2 TMN Functionality

9.2.1 Management Application Functionality

The Management Application Functionality (MAF) represents (part of) the functionality of one or more TMN management services. ITU-T Recommendations M.32xx-series enumerates the MAFs with respect to the technologies and services supported by the TMN.

The management application functionality (MAF) may be identified with the type of TMN function block in which they are implemented. The following MAF may be identified:

– Operations Systems Functionality;
– Management Application Function (OSF-MAF);
– Network Element Functionality – Management Application Function (NEF-MAF);
– Transformation Functionality;
– Management Application Function (TF-MAF);
– Work Station Functionality – Management Application Function (WSF-MAF).

9.2.2 Support Functionality

Support functions may optionally be found in a TMN function block. The support functionality is potentially common to more than one TMN function block within an implemented TMN. Some support functionality assist the MAF within a TMN function block in its interactions with other function blocks.

Examples of such functionality include the following:

- data communication functionality (DCF);
- workstation support functionality;
- user interface functionality;
- directory system functionality;
- database functionality;
- security functionality;
- message communication functionality.

9.3 TMN Management Function Sets and TMN Management Functions

To perform TMN management services, interactions take place between MAFs in different TMN function blocks, with the help of the support functions. These interactions between cooperating MAFs are referred to as TMN Management Functions. TMN Management Functions, that collectively are all of the potential interactions that a single MAF will support, are grouped together and referred to as a TMN Management Function Set. The library of general TMN Management Function Sets and their TMN Management Functions members can be found in ITU-T Recommendation M.3400 [11].

9.4 TMN reference points

A TMN reference point delineates one of several external views of functionality of a function block; it defines that function block's service boundary. This external view of functionality is captured in the set of TMN Management functions that will have visibility from the function block.

Reference points have meaning in functional specifications leading to an implementation. A reference point can represent the interactions between a particular pair of function blocks. Table 1 shows the relationships between the function blocks in terms of the reference points between them. The reference point concept is important because it represents the aggregate of all of the abilities that a particular function block seeks from another particular function block, or equivalent function blocks. It also represents the aggregate of all of the operations and/or notifications (as defined in ITU-T Recommendation X.703 [3]) that a function block can provide to a requesting function block.

A TMN functionally specified reference point usually corresponds to a to-be-implemented physical interface, in the physical architecture, if and only if the function blocks are implemented in different physical blocks.

Table 1/M.3010 – Relationships between logical function blocks expressed as reference points

	NEF	OSF	TF	WSF	non-TMN
NEF		q	q		
OSF	q	q, x[a)]	q	f	
TF	q	q	q	f	m[c)]
WSF		f	f		g[b)]
non-TMN			m[c)]	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.

c) The m reference point lies between the TF and the telecommunication functionality.

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.

9.4.1 Classes of reference points

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

q Class between OSF, TF and NEF.

f Class between OSF and a WSF.

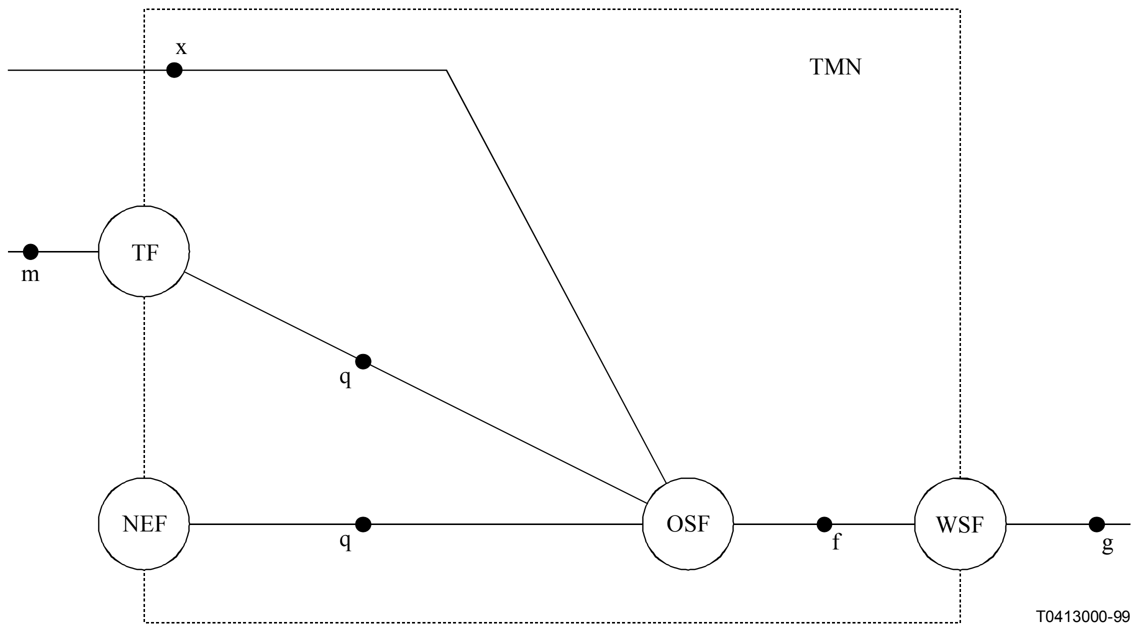
x Class between OSFs of two TMNs or between the OSF of a TMN and the equivalent OSF-like functionality of another network.

The interfaces corresponding to implementations of reference points are described in 9.4.

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.



NOTE – This figure is illustrative and is not exhaustive.

Figure 3/M.3010 – Classes of reference points in the TMN

9.4.2 Reference point descriptions and usage

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

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

9.4.2.1 q reference points[3]

The q reference points are located between the function blocks NEF and OSF, NEF and TF, TF and OSF, and OSF and OSF either directly or via the DCF.

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

9.4.2.2 f reference points

The f reference points are located between the WSF and the OSF blocks.

9.4.2.3 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 the x reference point.

[3] The q reference point includes the old q3 and qx reference points.

9.4.2.4 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 [19].

9.4.2.5 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.

9.4.3 Relationship of reference points to function blocks

Figure 4 illustrates an example of all of the possible pairs of TMN function blocks that can be associated via a reference point. Figure 4 also illustrates a typical flow of functionality between TMN function blocks in a hierarchical arrangement.

Figure 4 illustrates an example of possible reference points between function blocks.

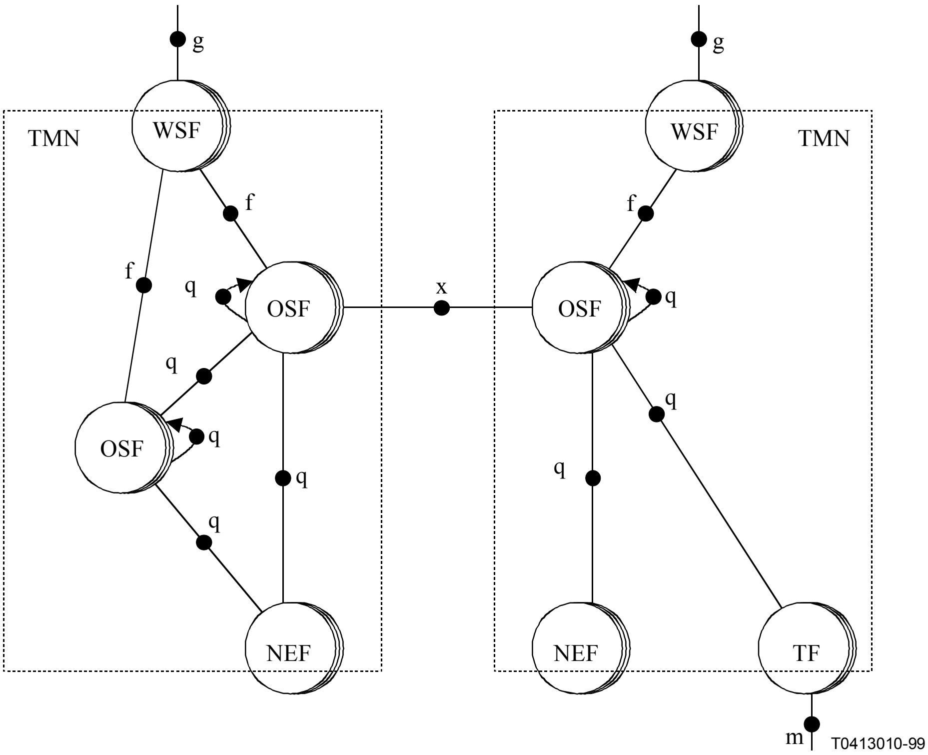
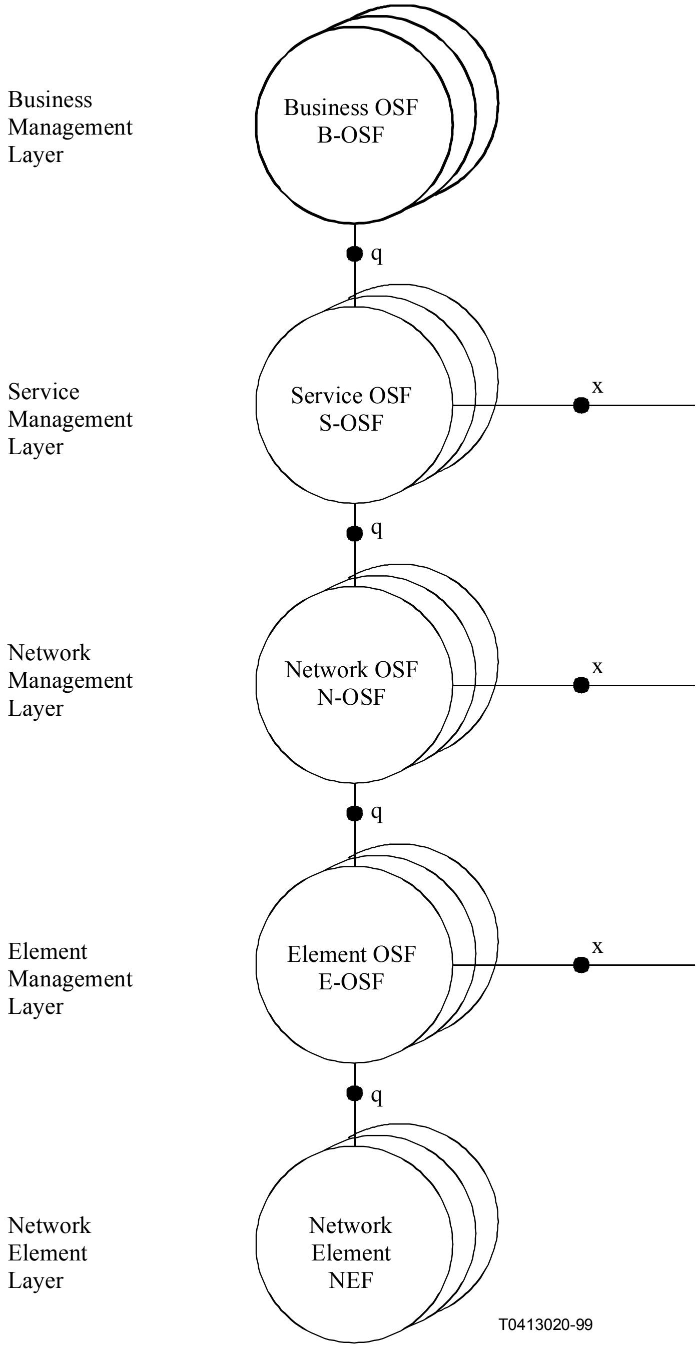


Figure 4/M.3010 – Illustration of reference points between management function blocks

9.5 TMN Logical Layered Architecture within the TMN functional architecture

To deal with the complexity of telecommunications management, management functionality may be considered to be partitioned into logical layers. The Logical Layered Architecture (LLA) is a concept for the structuring of management functionality which organizes the functions into groupings called "logical layers" and describes the relationship between layers. A logical layer reflects particular aspects of management arranged by different levels of abstraction.



NOTE 1 – Additional or alternative layers are permitted.
NOTE 2 – Other interactions may also occur between non-adjacent layers.

Figure 5/M.3010 – Suggested model for layering of TMN management functions

9.5.1 Management function layers of abstraction

The grouping of management functionality implies grouping OSF function blocks into layers. A specialization of OSF function blocks based upon different layers of abstraction is:

- business;
- service;
- network;
- element.

These layers of abstraction are depicted in Figure 5.

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 network and element layers.

The layering of OSFs shown in Figure 5, although widely accepted, should not be regarded as the only possible solution. Additional or alternative layers may be used to specialize functionality.

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

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

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

9.5.1.2 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 five principal 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.

5) The network OSFs may manage the relationships (e.g. connectivity) between NEFs.

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 reference point and in other TMNs through an x reference point.

9.5.1.3 Service management layer

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

The service management layer has the following four principal roles:

1) customer facing (Note) and interfacing with other PTOs/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 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.

9.5.1.4 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 reference point.

The business management layer has the following four principal roles:

1) supporting the decision-making process for the optimal investment and use of new telecommunications resources;
2) supporting the management of OA&M related budget;
3) supporting the supply and demand of OA&M related manpower;
4) maintaining aggregate data about the total enterprise.

9.5.2 Information layering principles

Management information models are associated with layers and may be used for the exchange of information at the interlayer interfaces.

Figure 6 depicts the reference points of a given layer. The information model associated with the reference point to the upper layer $q_{n+1,n}$ 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, $q_{n,n}$ should have an information model relating to layer "n" functionality. The reference point to the lower layer $q_{n,n-1}$ for the same reason has to represent the view of the layer "n–1".

For any logical layer, relations can be established between the OSF layer basic functionalities. 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 [6]).

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.

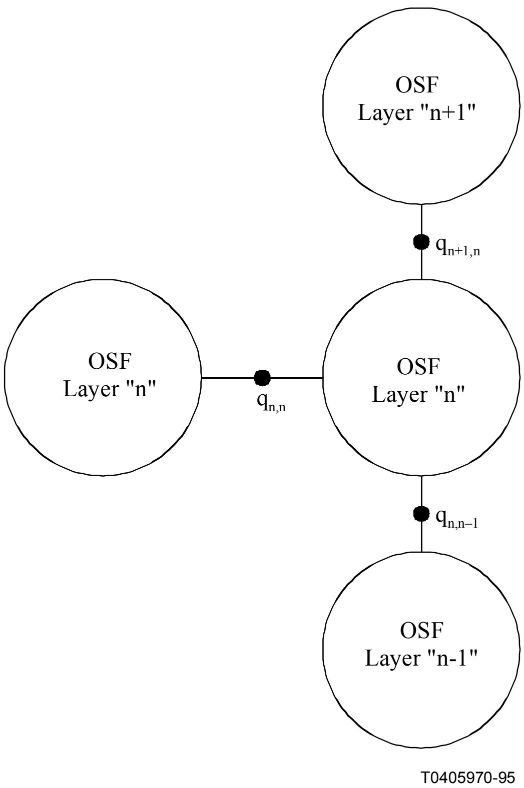


Figure 6/M.3010 – Reference points at a given functional OSF layer "n"

9.5.3 Functional interaction between management layers

While OSF will typically interact with TMN function blocks in logical adjacent management layers, operational and management considerations may support the need for interactions 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.

10 TMN information architecture

10.1 Principles

Management of a telecommunications environment is an information processing application. To effectively manage complex networks and support network operator/service provider business processes, it is necessary to exchange management information between management applications implemented in multiple managing and managed systems. Thus telecommunication management is a distributed application.

The TMN information architecture, in order to promote interoperability, is based on standardized open management paradigms that support the standardized modelling of the information to be communicated. TMN standardization activities will not develop a specific management paradigm but build upon industry recognized solutions, focusing primarily on object-oriented techniques. Specific management paradigms may be used in TMN standards when judged to be adequate.

TMN standardization favours the reusability of standardized information definitions to reduce the overall standardization effort. Object-oriented techniques such as encapsulation, inheritance, and specialization are preferred. Where information is expected to be utilized in conjunction with more than one management paradigm, the information should first be defined in a paradigm-neutral manner utilizing industry-recognized techniques after which it would then be mapped onto paradigm-specific formats.

It must be noted that the techniques, e.g. object-oriented, applied to define information to be exchanged should not constrain the internal implementation of the telecommunications management or managed systems.

As management information and actions play crucial roles for administrations, security techniques have to be applied in the TMN environment in order to assure the safety of the information exchanged over the interfaces and residing in the management application. Security principles and mechanisms are also related to the control of access rights of the TMN users to information associated with TMN applications.

Internal system implementations are outside the scope of TMN standardization.

TMN information architectural principles are applied to interface specifications using the methodology and techniques specified in Recommendation M.3020 [9].

The TMN information architecture is structured from the following fundamental elements: reference points, information models, information elements, information model of a reference point and interaction models. TMN management information exchange to be implemented can then be described in terms of these fundamental elements.

10.2 Interaction model

A TMN interaction model provides the rules and patterns that govern the flow of information between TMN function blocks at a reference point. Possible interaction models include manager/agent, client/server, invoker/responder, peer-to-peer, publisher/subscriber, and consumer/producer and are associated with a specific management paradigm.

For the exchange of management information, management processes will take on one of two possible roles:

- managed role: a process that manages the TMN information elements associated with managed resources. The process acting in this role responds to directives issued by the process acting in the managing role. It will also reflect to the process acting in the managing role a view of these information elements and provide information reflecting resource behaviour (e.g. information source);
- managing role: a process that issues management operation directives and receives information from the process acting in the managed role (e.g. information user).

It is the responsibility of the information user to be able to address the information source in a manner that the information source will respond properly. In addition, the information user is responsible for parsing what the information source provides.

A TMN manager is defined to be a management process acting in the managing role, while a TMN agent is defined to be a process acting in a managed role. The interaction model relevant to a manager/agent pair is determined by the management paradigm selected.

10.3 TMN management information models

The TMN information architecture contains constructs called information models that are supported by function blocks' managed roles and shared management knowledge that is known by function blocks' managing roles. As examples, information models can be found in ITU-T series Recommendations: M.31xx [15], X.73x [16], G.85x [17], and Q.82x [18].

A TMN 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 exposed and exchanged in a standardized manner. This activity to support the information model takes place at the application level and involves a variety of management applications such as storing, retrieving and processing information.

Multiple information models are necessary to describe the full range of information to be exchanged for telecommunication management.

10.4 TMN management information elements

TMN management information models consist of TMN management information elements. Management systems exchange information modelled in terms of TMN information elements. TMN information elements may be conceptual views of the resource types that are being managed or may exist to support certain management functions (e.g. event forwarding or event logging). Thus, an information element is the abstraction of such a resource that represents its properties as seen by and for the purposes of management. In object-oriented paradigms, TMN information elements are modelled as objects.

10.5 Information model of a reference point

A subset of this exposed information, which can be considered the information model of a reference point, is mapped to each reference point, based on the functional interactions defined for the reference point. This information model of a reference point is the minimum cluster of exposed management information that may be specified on a TMN function block.

10.6 Reference points

This TMN information-specified reference point further defines the concept of reference point (beyond the TMN functional architecture definition); the reference point concept unifies the TMN functional and information architectures. TMN function blocks interact via TMN management functions over a reference point. Over the same reference point, the TMN function blocks communicate the appropriate management information in order to perform the specified TMN management functionality.

Reference points have meaning in functional and information-exchange specifications leading to an implementation. A reference point represents the functional interactions and information exchange between function blocks. The reference point concept is important because it represents the aggregate of all of the abilities with associated information exchange that a particular function block seeks from another particular function block, or equivalent function blocks. It also represents the aggregate of all of the operations and/or notifications (as defined in ITU-T Recommendation X.703 [3]) that a function block can provide to a requesting function block.

A TMN functionally-specified and information-specified reference point usually corresponds to a to-be-implemented physical interface, in the TMN physical architecture, if the function blocks are implemented in different physical blocks.

10.7 TMN logical layered architecture within the TMN information architecture

As introduced in clause 9, the Logical Layered Architecture (LLA) is a concept for the structuring of management functionality which organizes the functions into groupings called "logical layers" and describes the relationship between layers. A logical layer reflects particular aspects of management arranged by different levels of abstraction. Functional interactions between OSF function blocks within different logical layers are described by the reference point. Over the same reference point, the TMN function blocks communicate the appropriate management information in order to perform the specified TMN management functionality.

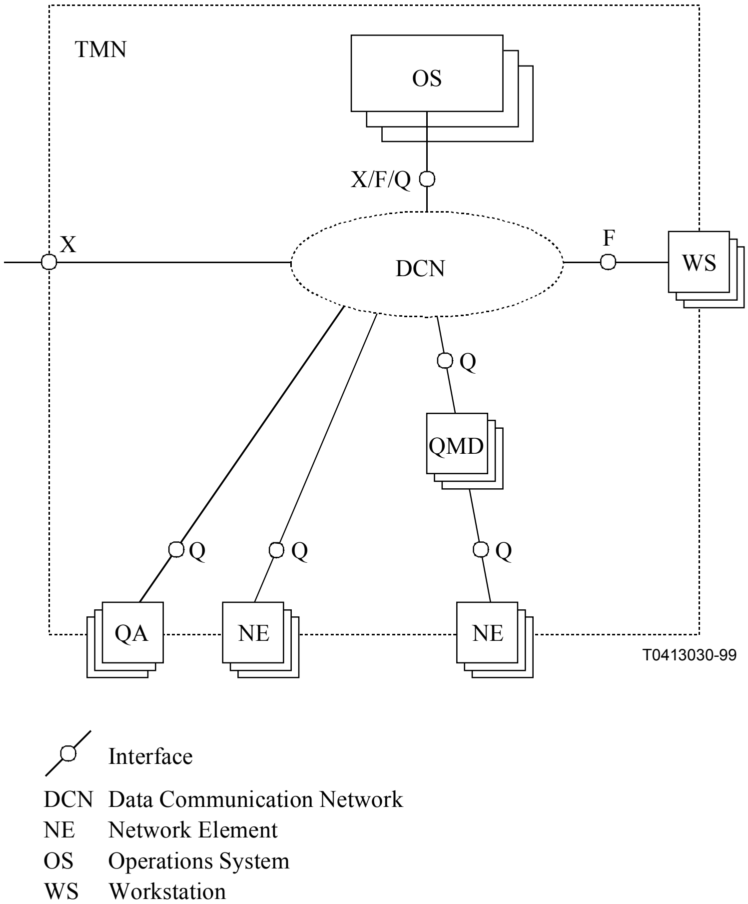
The relationship of the Logical Layered Architecture and the TMN Information Architecture can be described by projecting the TMN Information Architecture through a series of views. Each view represents the information elements from the information models that may be exposed or exchanged at reference points between function blocks in layers of the LLA. The view encompasses the necessary level of abstraction necessary for the exchange of management information at the level of abstraction captured in the layer.

The exchange of management information between logical layers employs the managing roles and managed roles of the TMN interaction model. This allows management activities to be clustered into layers and to be decoupled. The managed roles will be associated with a set of information elements from information model(s) exposing a view at the layer's level of abstraction (e.g. equipment, element, network, service). Generally, managing and managed roles may be placed in logical layers without restriction. A managed role may be associated with a set of information elements from any layer. Managed roles may be placed in any layer and invoke operations associated with any other managed roles.

11 TMN physical architecture

The TMN physical architecture is structured from the following fundamental elements: physical blocks and physical interfaces.

Figure 7 shows an example of a simplified physical architecture for a TMN. This example is provided to assist in understanding the TMN physical blocks described below.



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

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

NOTE 3 – The existence of an m reference point may imply an M interface to the QA and the existence of a g reference point may imply a G interface to a WS. Since such interfaces are beyond the scope of this Recommendation, they are not explicitly defined.

Figure 7/M.3010 – An example of a simplified physical architecture for a TMN

11.1 TMN physical 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 2 which names the TMN physical blocks according to the set of function blocks which each is allowed to contain. For each physical 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 physical blocks to contain. Table 2 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.

Table 2/M.3010 – Relationship of TMN physical block names to TMN function blocks (Notes 1, 2)

(Notes 2 and 3)	NEF	TF	OSF	WSF
NE	M	O	O	O (Note 3)
QA, XA, QM, XM		M		
OS		O	M	O
WS				M

M Mandatory
O Optional

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

NOTE 2 – TMN physical blocks may contain additional functionality which allows them to be managed.

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

11.1.1 Operations System (OS)

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

11.1.2 Transformation

Transformation provides conversion between different protocols and data formats for information interchange between physical blocks. There are two types of transformation: adaptation and mediation that can apply at q or x reference points.

11.1.2.1 Adaptation device

An adaptation device (AD), or adapter, provides transformation between a non-TMN physical entity to a NE to OS within a TMN. A Q-adapter (QA) is a physical block used to connect NE-like or OS-like physical blocks with non-TMN compatible interfaces (at m reference points) to Q interfaces. An X-adapter (XA) is a physical block used to connect non-TMN physical entities having a non-TMN communication mechanism in a non-TMN environment to an OS at the edge of a TMN.

11.1.2.2 Mediation device

A mediation device (MD) provides transformation between TMN physical blocks that incorporate incompatible communication mechanisms. A Q-mediation device (QMD) is a physical block that supports connections within one TMN. An X-mediation device (XMD) is a physical block that supports connections of OSs in different TMNs.

11.1.3 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 Adapter Function, which will provide the necessary functionality to convert between a non-standard and standard management interface.

11.1.4 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 2.

11.2 Data Communication Network (DCN)

The DCN is a support service that provides paths for information flow between physical blocks in a TMN environment. It provides functionality within the transport service of the lower four layers of the OSI Reference Model defined in Recommendation X.200. Refer to Recommendations Q.811 [12] and Q.812 [13] for specific interface protocols for information transfer through a DCN.

The DCN may consist of a number of individual subnetworks of different types, interconnected together. The DCN may be a local path or a wide-area connection among distributed physical blocks. The DCN is technology independent and may employ any single or combination of transmission technologies.

11.3 TMN logical layered architecture within the TMN physical architecture

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

11.4 Interoperable interface concept

In order for two or more TMN physical 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 that 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 that 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.

11.5 TMN standard interfaces

Figures 8a, 8b and 8c shows the interconnection of the various TMN physical 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 physical 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 7.

11.5.1 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 is applied at the q reference point;

– the Q interface is characterized by that portion of the information model shared between the OS and those TMN elements to which it directly interfaces.

11.5.2 F interface

The F interface is applied at f reference points. The F interfaces connecting workstations to the TMN physical 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 the subject of this Recommendation.

11.5.3 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 networks or systems which accommodate 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.

11.5.4 Relationship of TMN interfaces to TMN physical blocks

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

11.5.5 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 [9].

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.

12 Relationships between TMN architectures

12.1 Relationship between the TMN architectures and a TMN implementation

The TMN is realized from three different, but interrelated architectures. These are the functional, information and physical architectures.

Two of these architectures (functional and information) provide a framework that allows requirements to be documented about *what* a TMN implementation should do.

The functional architecture framework permits the specification of what functions have to be achieved in the TMN implementation. The information architecture permits the specification of what information (i.e. data) has to be stored so that the functions defined in the functional architecture can be achieved in the TMN implementation. The functional specification based on the functional architecture framework, and the information specification based on the information architecture framework should be developed to express business needs to be met by the TMN implementation. The TMN implementation, that meets the requirements of the TMN functional and information specifications, may vary greatly from one TMN solution to another. TMN implementations are not currently a subject for standardization.

TMN implementations have to blend and balance a number of divergent constraints such as cost, performance, and legacy deployments, as well as new functionality being delivered. Since every TMN implementation will have different sets of these constraints to cope with, reality dictates that there will be many physical architecture implementations. These implementation architectures are the result of different distributions of the fundamental elements.

The fundamental elements are expressed in the functional and information architectures, their distribution being architected into an implementation. There are many possible and different distributions. Each implementation has to satisfy the needs identified and expressed in both the TMN functional architecture and the TMN information architecture specifications.

This is illustrated in Figure 8a.

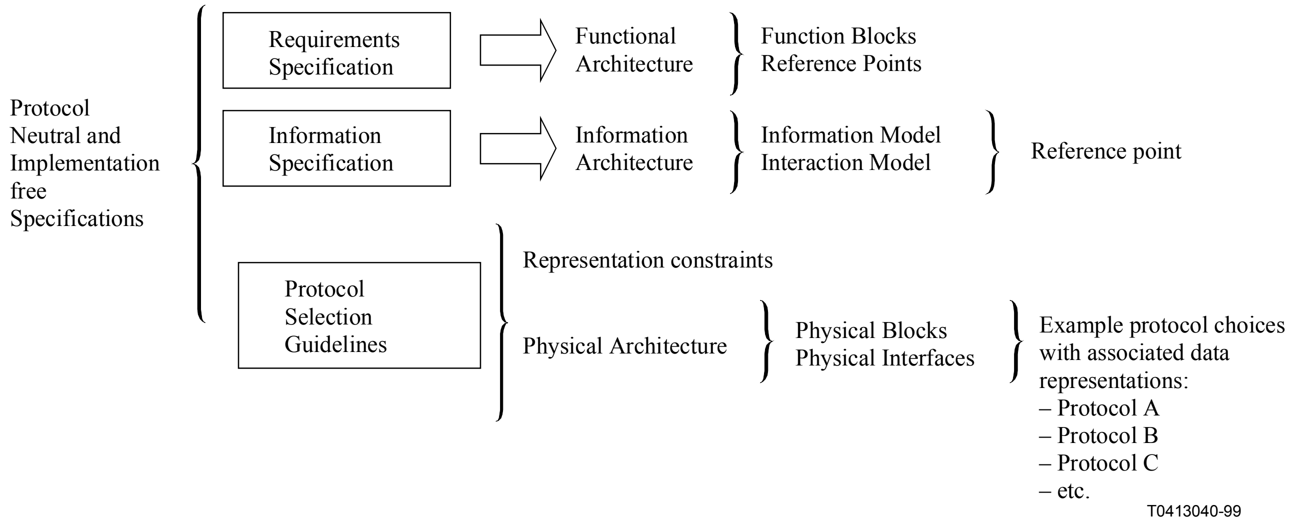


Figure 8a/M.3010 – Relationship between the TMN architectures

Figure 8b shows the complementary functional and information architecture specifications with the considerations that will influence the derivation of a particular physical architecture implementation during the development phase of an implementation.

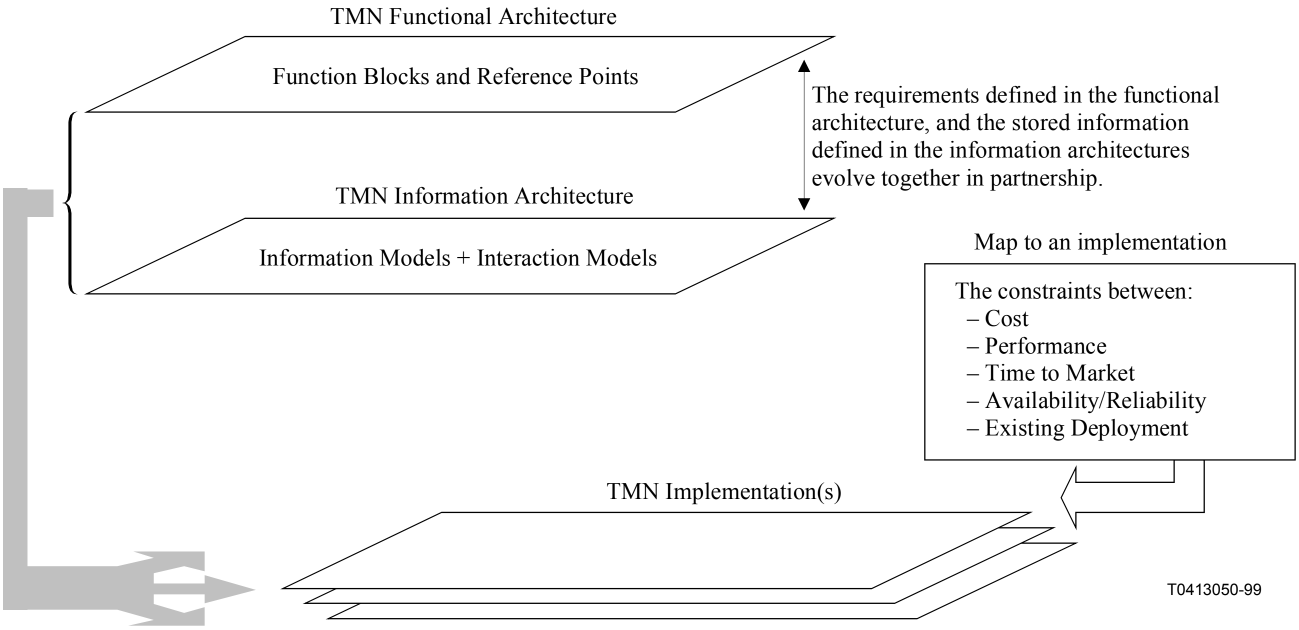
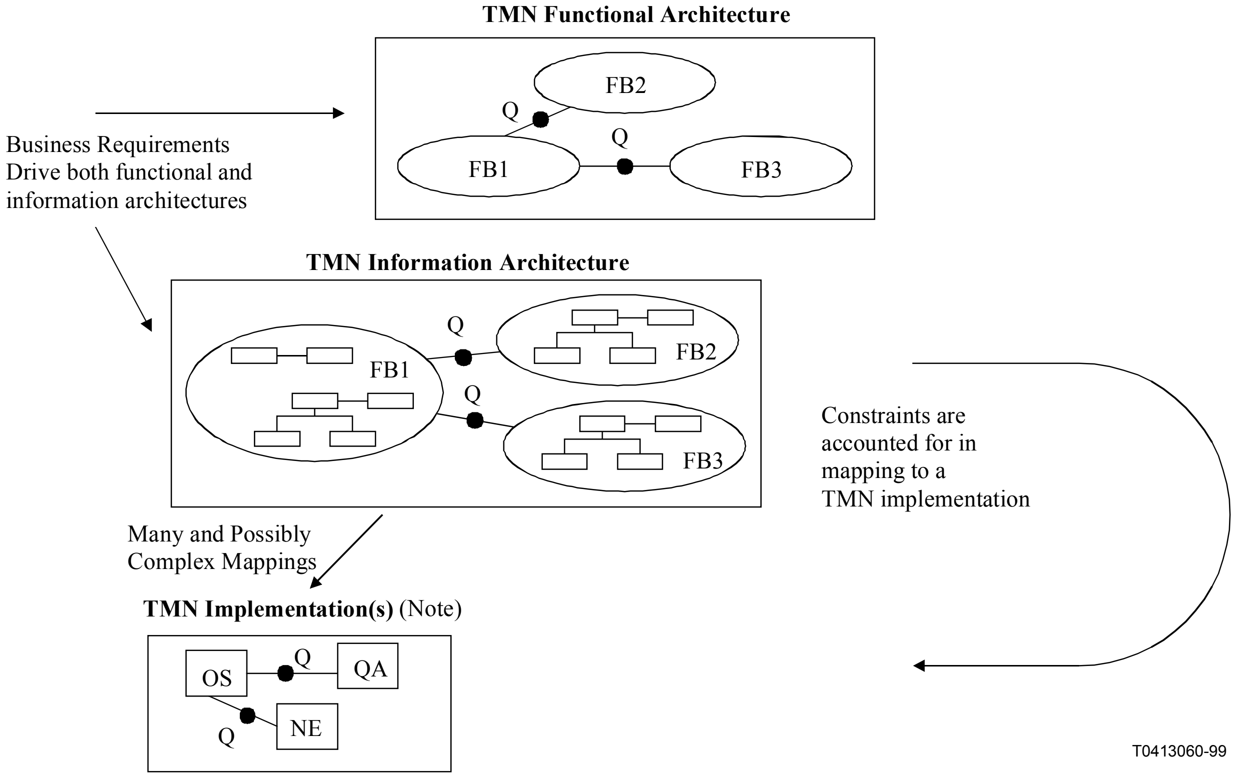


Figure 8b/M.3010 – Relationship between the TMN architectures and physical architecture implementations

Figure 8c shows how each fundamental element in the functional architecture specification has a corresponding set of information requirements expressed in the information architecture specification. Some entities and attributes expressed in the information architecture specification will be exchanged over reference points in the functional and information architecture specifications, that relate to a physical interface using a particular protocol within a particular physical implementation.

The information architecture specification also specifies the desired interaction behaviour, i.e. the interface's client side behaviour, and corresponding server side behaviour.

Figure 8c shows how all of these architectures and concepts are brought together for specification, and realization of physical NEs, OSs, etc. with physical interfaces to create TMN implementations.



NOTE – Implementation defined using the physical architecture framework.

Figure 8c/M.3010 – Relationship between the TMN functional and information architecture to physical architectures

The following subclause provides additional information on exposing information defined in the functional and information architecture specifications (via reference points) to implement interfaces using particular protocols for a particular TMN compliant system implementation.

12.2 Relationship between reference points in the functional and information architecture specifications and physical interfaces in an implementation of the physical architecture

A reference point in the functional and information architecture specifications is a delineation point of exposed functionality and the associated exposed information of a function block.

When function blocks are architected into physical blocks, for a particular physical architectural scheme, the functional and information architecture reference points are directly related to physical interfaces in the physical architecture. The physical interfaces are realizations of external presentations of data and capabilities for a particular (physical architectural) distribution of functionality.

The balance of existing hardware, computing systems, and the desired performance of the system leads to a choice of how the function blocks are distributed among systems, and the choice(s) of protocols for specific interfaces.

The functional distribution of a TMN implementation is not mandated, but is a choice of how a system integrator may choose to solve a particular integration problem. The choice may change as constraints change with time.

Figure 9 illustrates how the functional requirements, expressed in the functional architecture specification, combined with the information that has to be transferred to support the functional needs, may be combined to form the requirements for a reference point.

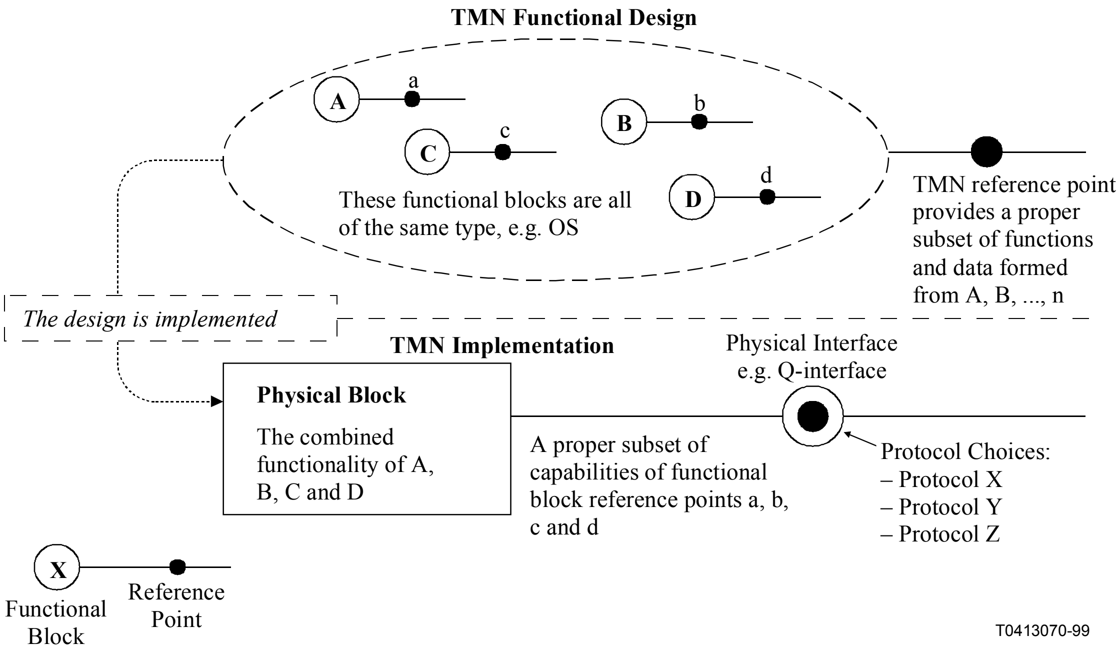


Figure 9/M.3010 – Design build-up of a functional architecture

When several physical blocks, with their reference points, are architected into an implementation, the selection of a particular protocol completes the specification of the physical interface.

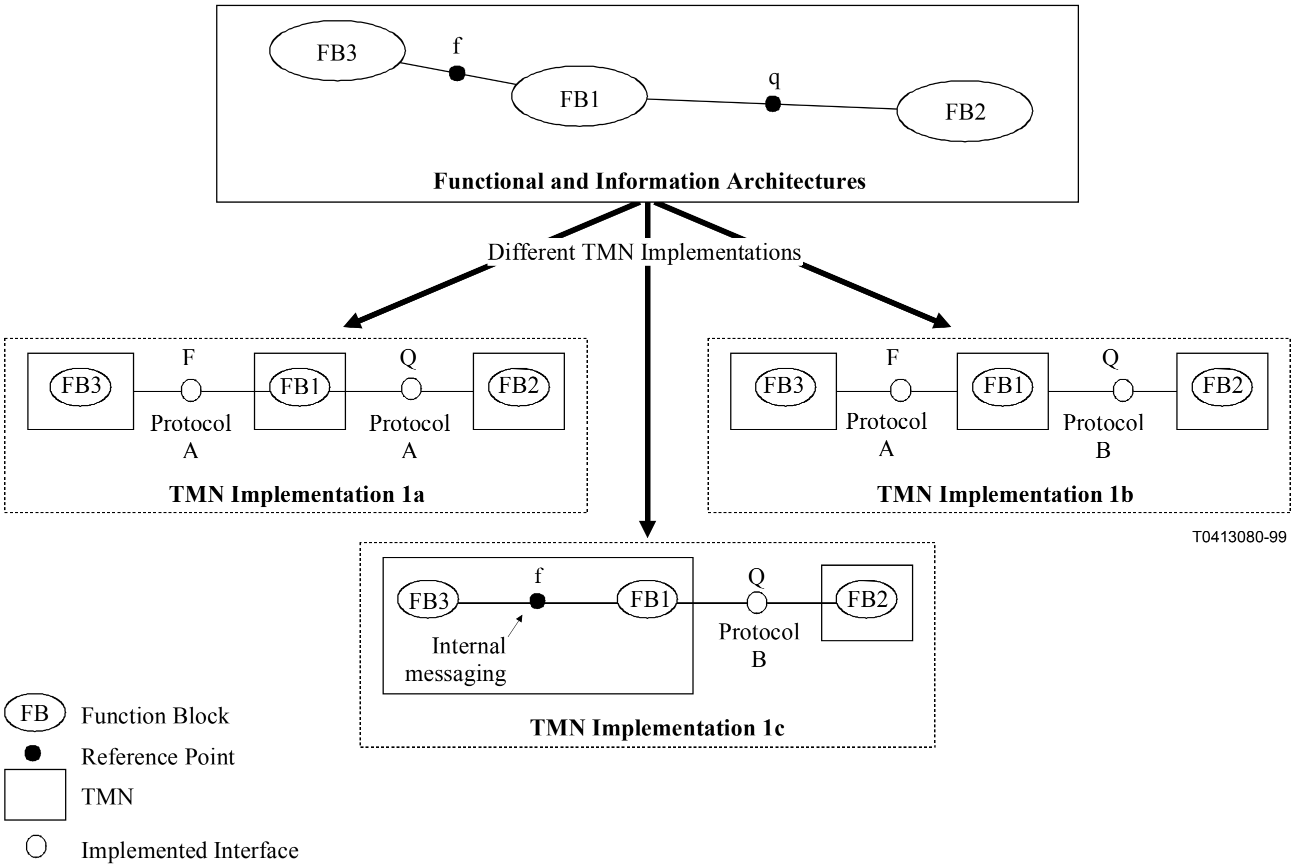


Figure 10/M.3010 – Function/information specification to implementation architecture example

Figure 10 shows an example functional architecture. This architecture is used to illustrate how different physical architectures may satisfy the functional architecture using different protocol choices, and different physical realizations.

Figure 10 illustrates how the functional architecture can be built into different implementations architectures.

TMN implementation 1a shows FB3 and FB1 in different physical blocks interacting using protocol A.

FB2 is architected into a physical block so that FB2 and FB1 interact using protocol A.

TMN implementation 1b shows the same architecture of FBs in the same implementation distribution arrangement, but a different choice of protocol has been made between FB1 and FB2.

TMN implementation 1c shows how FB1 and FB3 have been distributed into the same implementation system, and what in implementation architectures 1a and 1b is an externally exposed interface is now an internal reference point between FB1 and FB3, that may be implemented using an internal messaging system.

Figures 8a, 8b and 8c represent current known TMN solutions and integration needs, where the main concerns relate to integrating different physical processing machines from different vendors both within a TMN and between TMNs.

12.3 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;
– relationships between objects (name bindings).

All the above information pieces are based on the Shared Management Knowledge as defined in Recommendation X.701 [2].

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

Figure 11 shows that the 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.

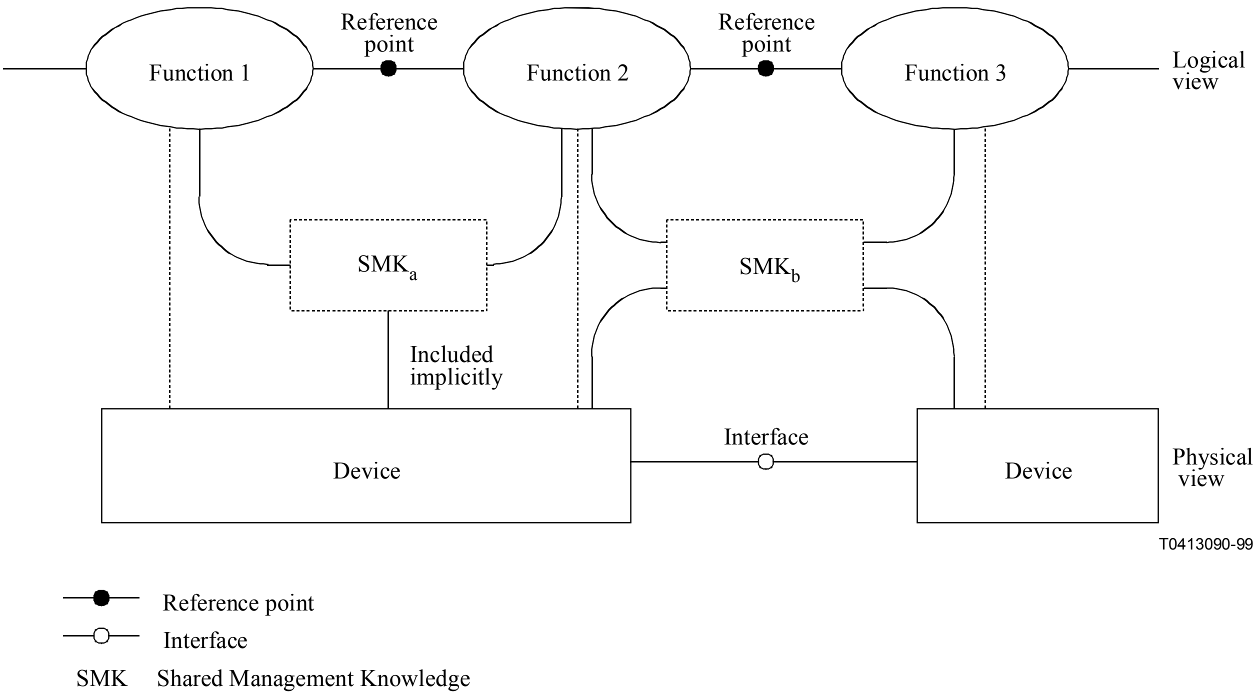


Figure 11/M.3010 – Independence of SMKs from the physical implementation

13 TMN conformance and TMN compliance

13.1 Introduction

This clause defines TMN conformance and TMN compliance. TMN conformance, which is testable, relates to the interfaces between TMN physical blocks. TMN compliance relates to the TMN architecture, principles and functions.

13.2 TMN conformance definitions

The goal of TMN conformance is to increase the probability that different systems within a TMN will be able to interoperate, that TMNs in different service/network providers' administrations will be able to interoperate as much as the administrations agree to do, and that a customer's system and a service provider's TMN will be able to interoperate as much as the two agree to interoperate.

The definitions can, in principle, be applied to Q, X or F interfaces. However, present requirements and standards for the F interface are in the formative stage. Therefore, the definitions in this clause apply to Q and X interfaces. However, this clause enumerates TMN conformance definitions which are testable.

TMN conformance is a condition for systems' interworking but is not sufficient to guarantee interoperability. It is always recommended that the purchaser/user of these systems perform some form of verification testing to determine that any two systems, claiming any type of TMN conformance, interoperate. Interoperability testing must include testing of the interface protocols, the shared/exposed information over those interfaces, and the interface functionality of the system.

Definitions associated with TMN interface conformance are provided as follows:

- TMN interface protocol conformance definition;
- levels of TMN interface information conformance.

The TMN interface specification must be documented, publicly available, and licensable at a reasonable price on a non-discriminatory basis.

13.3 TMN interface protocol conformance

An interface (Q, X) of a system is TMN interface protocol conformant if and only if all of the following are met:

1) The interface uses a communications protocol stack specified by ITU-T Recommendations for TMN. Currently, the communications protocol stack must conform to ITU-T Recommendation Q.811 [12] for lower layer protocols and ITU-T Recommendation Q.812 [13] for upper layer protocols. A valid and consistent selection of protocols must be chosen from the choices enumerated in ITU-T Recommendation Q.811 [12] and ITU-T Recommendation Q.812 [13].

2) The system interface documentation specifies the International Standardized Profiles (ISPs), where they exist, enumerated in ITU-T Recommendation Q.811 [12] and ITU-T Recommendation Q.812 [13] which are supported. Conformance with ITU-T Recommendation Q.811 [12] and ITU-T Recommendation Q.812 [13] is specified with respect to specific ISPs. Management Communications profiles are selected based on types of TMN Management Services that need to be provided over the interface as per the corresponding tables in ITU-T Recommendation Q.811 [12], ITU-T Recommendation Q.812 [13]. Standardized Implementation Conformance Statements in the form of Protocol Implementation Conformance Statements (PICS) (ITU-T Recommendation X.290 [7]), and Protocol Implementation Extra Information For Testing (PIXIT) (ITU-T Recommendation X.290 [7]) must be provided.

3) The system interface documentation specifies if the interface can be used as an X interface or a Q interface.

4) The system interface can act in the appropriate role(s) for the protocol over that interface (e.g. agent and/or manager for CMIP, initiator/responder for FTAM). The system interface documentation specifies the roles in which the system can act.

5) If the protocol stack selected in 1) requires information modelling, then a standardized information modelling technique must be used.

6) If GDMO-based information models are implemented, the system interface must meet one of the levels of TMN interface information conformance as documented in 13.4.

13.4 TMN interface information conformance

A system interface may make a claim, by level, of information conformance for each management functionality that the interface supports. It is expected that this management functionality will be by information model document.

13.4.1 Level A interface information conformance

An interface of a system is ***Level A*** interface information conformant, for this management functionality, if and only if all of the following are met:

1) The system interface is TMN interface protocol conformant i.e. meets the criteria in the definition in 13.3.
2) The managed-object classes the system interface supports are defined in the applicable information models specified in ITU-T Recommendations relevant to this management functionality. The system interface documentation shall list the Recommendations that define the specified information models with the inclusion of the version number and date. Standardized Implementation Conformance Statements in the form of Managed Objects Conformance Statements (MOCS), and Management Information Conformance Statements (MICS), and Managed Relationship Conformance Statement (MRCS), if applicable, must be provided (ITU-T Recommendation X.724 [4]).
3) If the system interface uses managed-object classes which have been subclassed from classes enumerated in 2) in this definition, for the sole purpose of providing for missing model functionality, then these managed-object classes must be defined following the strict inheritance rules as specified in ITU-T Recommendation X.720 [5].
4) Any additional object classes other than those enumerated in 2) in this definition, that are needed to extend the ITU-T information model due to missing model functionality, shall have accompanying documentation which fully specifies the information models with the inclusion of the version number and date. Separate standardized Implementation Conformance Statements in the form of Managed Objects Conformance Statements (MOCS), and Management Information Conformance Statements (MICS), and Managed Relationship Conformance Statement (MRCS), if applicable, must be provided (ITU-T Recommendation X.724 [4]) for these object classes.

13.4.2 Level B interface information conformance

An interface of a system is ***Level B*** interface information conformant, for this management functionality, if and only if all of the following are met:

1) The system interface is TMN interface protocol conformant i.e. meets the criteria in the definition in 13.3.
2) The managed-object classes the system interface supports are defined in the applicable information models specified in other *de jura* standards bodies (e.g. ETSI, T1, TTC) or *de facto* standards bodies (e.g. ATM Forum, NMF). The system interface documentation shall list the documents that define the specified information models with the inclusion of the version number and date. Standardized Implementation Conformance Statements in the form of Managed Objects Conformance Statements (MOCS), and Management Information Conformance Statements (MICS), and Managed Relationship Conformance Statement (MRCS), if applicable, must be provided (ITU-T Recommendation X.724 [4]).

3) If the system interface uses managed-object classes which have been subclassed from classes enumerated in 2) in this definition, for the sole purpose of providing for missing model functionality, then these managed-object classes must be defined following the strict inheritance rules as specified in ITU-T Recommendation X.720 [5].

4) Any additional object classes other than those enumerated in 2) in this definition, that are needed to extend the information model due to missing model functionality, shall have accompanying documentation which fully specifies the information models with the inclusion of the version number and date. Separate Standardized Implementation Conformance Statements in the form of Managed Objects Conformance Statements (MOCS), and Management Information Conformance Statements (MICS), and Managed Relationship Conformance Statement (MRCS), if applicable, must be provided (ITU-T Recommendation X.724 [4]) for these object classes.

13.4.3 Level C interface information conformance

An interface of a system is ***Level C*** interface information conformant, for this management functionality, if and only if all of the following are met:

1) The system interface is TMN interface protocol conformant i.e. meets the criteria in the definition in 13.3.

2) The managed-object classes the system interface supports are defined in a non-standard information model relevant to this management functionality. The system interface documentation shall fully document the information models with the inclusion of the version number and date. Standardized Implementation Conformance Statements in the form of Managed Objects Conformance Statements (MOCS), and Management Information Conformance Statements (MICS), and Managed Relationship Conformance Statement (MRCS), if applicable, must be provided (ITU-T Recommendation X.724 [4]).

3) If the system interface uses managed-object classes which have been subclassed from classes enumerated in 2) in this definition, for the sole purpose of providing for missing model functionality, then these managed-object classes must be defined following the strict inheritance rules as specified in ITU-T Recommendation X.720 [5].

13.5 TMN compliance

TMN compliance relates to the TMN architecture, principles and functions.

TMN compliance for an implementation may be claimed if the following criteria are met:

1) The implementation supports the TMN functional, informational and physical architecture.

2) The implementation's documentation should state what TMN logical layer(s) the implementation supports.

3) The implementation meets the definition of a TMN physical block (e.g. OS, NE, MD, QA).

4) The implementation's interfaces are documented and published.

5) The implementation interface documentation identifies the supported TMN Managed Areas and the associated TMN Management Services that are described in ITU-T Recommendation M.3200 [10]. The system interface documentation should also identify the applicable ITU-T M.32xx Recommendations, if available.

6) If the information requested in 5) is not available, e.g. the appropriate ITU-T Recommendation M.32xx document does not exist, the implementation interface documentation should itemize the TMN Management Function Sets and associated TMN Management Functions it supports (see ITU-T Recommendation M.3400 [11]).

ITU-T RECOMMENDATIONS SERIES

Series A	Organization of the work of the ITU-T
Series B	Means of expression: definitions, symbols, classification
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	**TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits**
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communications
Series Y	Global information infrastructure and Internet protocol aspects
Series Z	Languages and general software aspects for telecommunication systems

18328

Printed in Switzerland
Geneva, 2000