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SERIES M: GENERAL MAINTENANCE PRINCIPLES

Maintenance of international transmission systems and telephone circuits – Introduction

PRINCIPLES FOR A TELECOMMUNICATIONS MANAGEMENT NETWORK

Reedition of CCITT Recommendation M.30 published in the Blue Book, Fascicle IV.1 (1988)

NOTES

1 CCITT Recommendation M.30 was published in Fascicle IV.1 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation M.30

PRINCIPLES FOR A TELECOMMUNICATIONS MANAGEMENT NETWORK

1 General

This Recommendation presents the general principles for planning, operating and maintaining a Telecommunications Management Network (TMN). The purpose of a TMN is to support Administrations in management of its telecommunications network. A TMN provides a host of management functions to the telecommunication network and offers communications between itself and the telecommunication network. In this context a telecommunications network is assumed to consist of both digital and analogue telecommunications equipment and associated support equipment.

The basic concept behind a TMN, therefore, is to provide an organized network structure to achieve the interconnection of the various types of Operations Systems (OSs) and telecommunications equipment using an agreed upon architecture with standardized protocols and interfaces. This will provide the telecommunication network Administrations and telecommunication equipment manufacturers a set of standards to use when developing equipment for and designing a management network for modern telecommunication networks [including their Integrated Services Digital Networks (ISDNs)].

1.1 *Relationships of a TMN to a telecommunication network*

A TMN can vary in size from a very simple connection between an OS and a single piece of telecommunication equipment to a massive network interconnecting many different types of OSs and telecommunication equipment. It may provide a host of management functions and offers communications both between the OSs and between OSs and the various parts of the telecommunication network which consists of many types of digital and analogue telecommunication equipment and associated support equipment, such as transmission systems, switching systems, multiplexers, signalling terminals. Such equipment is referred to generically as network elements (NEs).

Figure 1/M.30 shows the general relationship between a TMN and a telecommunications network which it manages. Note that a TMN is conceptually a separate network that interfaces a telecommunications network at several different points to receive information from it and to control its operations. However, a TMN may often use parts of the telecommunication network to provide its communications.

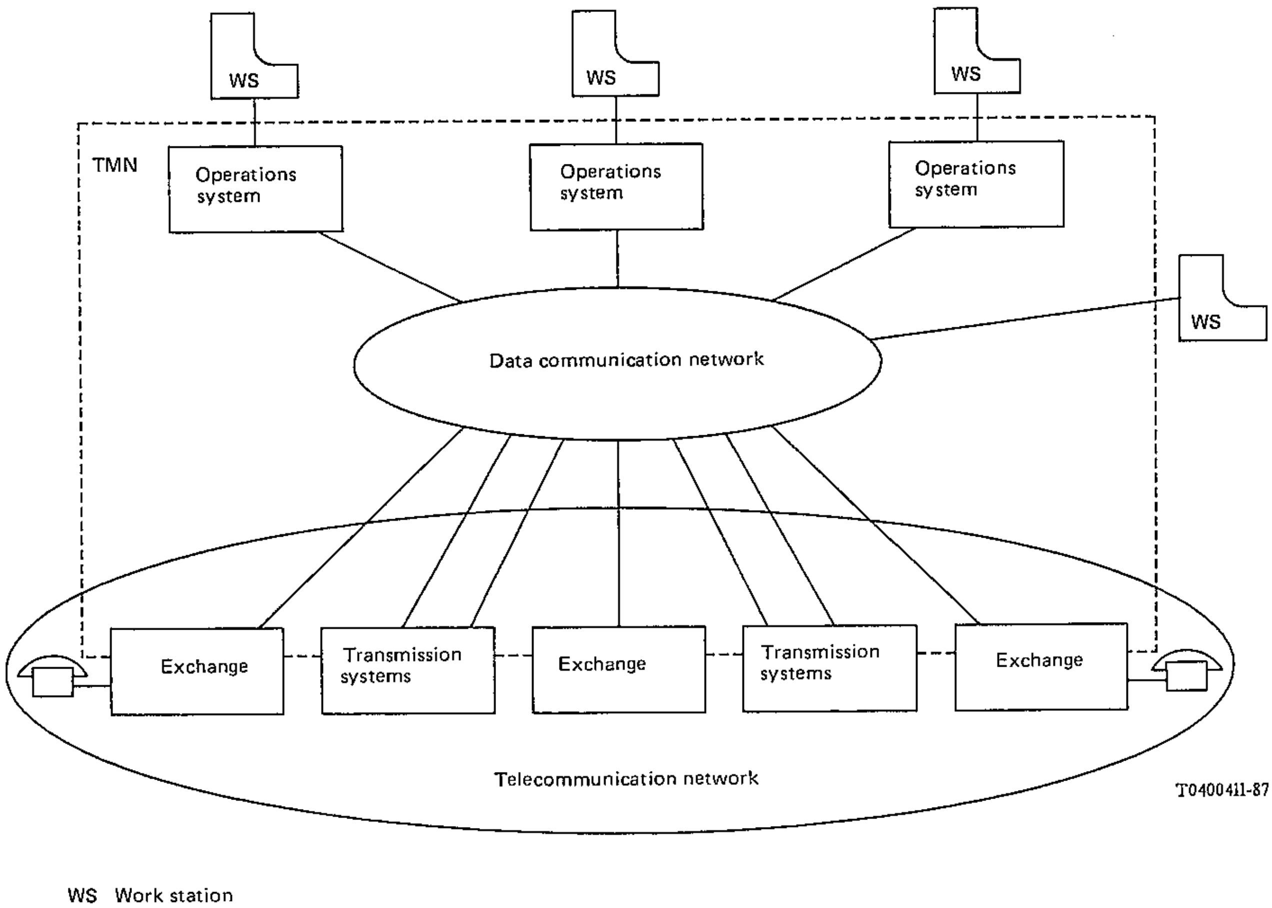


FIGURE 1/M.30
General relationship of a TMN to a telecommunication network

1.2 *Field of application*

The following are examples of the networks and major types of equipment that may be managed over the TMN:

- public and private networks, including ISDNs;
- transmission terminals (multiplexers, cross connects, channel translation equipment, etc.);
- digital and analogue transmission systems (cable, fibre, radio, satellite, etc.);
- restoration systems;
- digital and analogue exchanges;
- circuit and packet switched networks;
- signalling terminal and systems including signal transfer points (STP) and real time data bases;
- PBXs and customer terminals;
- ISDN user terminals;
- associated support systems (test modules, power systems, air conditioning units, building alarms systems, etc.).

In addition, by the monitoring, testing or control of these equipments, a TMN may be used to manage distributed entities such as circuits.

2 TMN architecture and definitions

The following definitions for the TMN architecture are conceptual in nature and are thus intended to be working definitions that cover the most common and general cases. It should be recognized that, because of the exceedingly complex nature of some telecommunications equipment and because of the ability, using microprocessors, to distribute functionality within various network parts, these definitions may not rigidly cover every possible physical configuration that may be encountered. However, even these exceptions are expected to fit within the general TMN concept and to be covered by its principles.

2.1 *TMN functional architecture*

A TMN functionally provides the means to transport and process information related to the management of telecommunication networks. As shown in Figure 2/M.30, it is made up of operations system functions (OSFs), mediation functions (MFs) and data communications functions (DCFs). The function blocks provide the TMN general functions which enable a TMN to perform the TMN application functions. A TMN is also connected to network element functions (NEFs) and workstation functions (WSFs).

Figure 2/M.30 shows the function blocks of a TMN. As shown, all like reference points (q to q, f to f, and x to x) are connected through the facility of the DCF. The WSF may also be directly connected to the NEF through a connection external to the TMN.

2.1.1 *Definition of function blocks*

2.1.1.1 **operations system function (OSF) block**

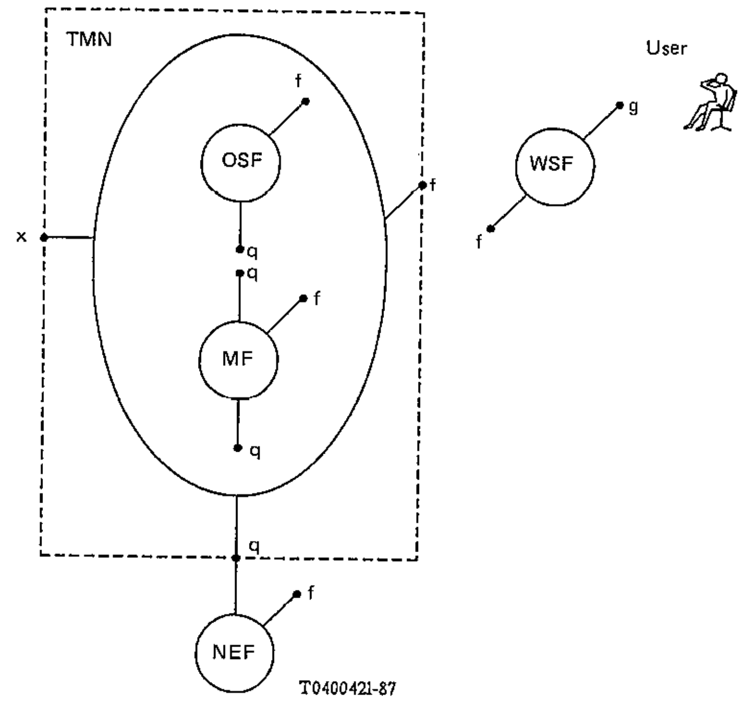
The OSF block processes information related to telecommunication management to support and/or control the realization of various telecommunication management functions. Details of the OSF are given in § 5.2.

2.1.1.2 **mediation function (MF) block**

The MF block acts on information passing between NEFs and OSFs to achieve smooth and efficient communication. Major MFs include communication control, protocol conversion and data handling, communication of primitive functions, processes involving decision making, and data storage. Details of the MF are given in § 5.4.

2.1.1.3 **data communications function (DCF) block**

The DCF block provides the means for data communication to transport information related to telecommunications management between function blocks. Details of the CDF are given in § 5.3.



Reference points:

q Class of reference points between OS, MF and NE functions

f Class of workstation reference points

g Class of workstation to user reference points

x Class of reference points to other networks, including other TMNs

Function blocks:

WSF Workstation function
OSF Operations system function
MF Mediation function
NEF Network element function
DCF Data communications function

FIGURE 2/M.31

A generalized functional architecture for a TMN

2.1.1.4 **network element function (NEF) block**

The NEF block communicates with a TMN for the purpose of being monitored and/or controlled. Details of the NEF are given in § 5.5.

2.1.1.5 **work station function (WSF) block**

The WSF block provides means for communications among function blocks (OSF, MF, DCF, NEF) and the user. Details of the WSF are given in § 5.6.

2.1.2 *Definitions of reference points*

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

2.1.2.1 **q reference points**

The q reference points connect the function blocks NEF to MF, MF to MF, MF to OSF and OSF to OSF either directly or via the DCF. Within the class of q reference points the following distinctions are made:

q_1: the q_1 reference points connect NEF to MF either directly or via the DCF;

q_2: the q_2 reference points connect MF to MF either directly or via the DCF;

q_3: the q_3 reference points connect MF to OSF and OSF to OSF either directly or via the DCF.

2.1.2.2 **f reference points**

The f reference points connect function blocks OSF, MF, NEF, DCF to the WSF.

2.1.2.3 **g reference points**

The g reference points are points between the WSF and the user.

2.1.2.4 **x reference points**

The x reference points connect a TMN to other management type networks including other TMNs.

2.2 *TMN physical architecture*

Figure 3/M.30 shows a generalized physical architecture for the TMN.

2.2.1 *Definitions of the physical architecture*

TMN functions can be implemented in a variety of physical configurations. The following are the definitions for consideration of implementation schemes.

2.2.1.1 **operations system (OS)**

The OS is the stand alone system which performs OSFs.

2.2.1.2 **mediation device (MD)**

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

2.2.1.3 **data communications network**

The DCN is a communication network within a TMN which supports the DCF at the reference point q_3.

2.2.1.4 **local communication network (LCN)**

The LCN is a communication network within a TMN which supports the DCF normally at the reference points q_1 and q_2.

2.2.1.5 **network element (NE)**

The NE is comprised of telecommunication equipment (or groups/parts of telecommunication equipment) and support equipment that performs NEFs and has one or more standard Q-type interfaces.

2.2.1.6 **workstation (WS)**

The WS is the stand alone system which performs WSFs.

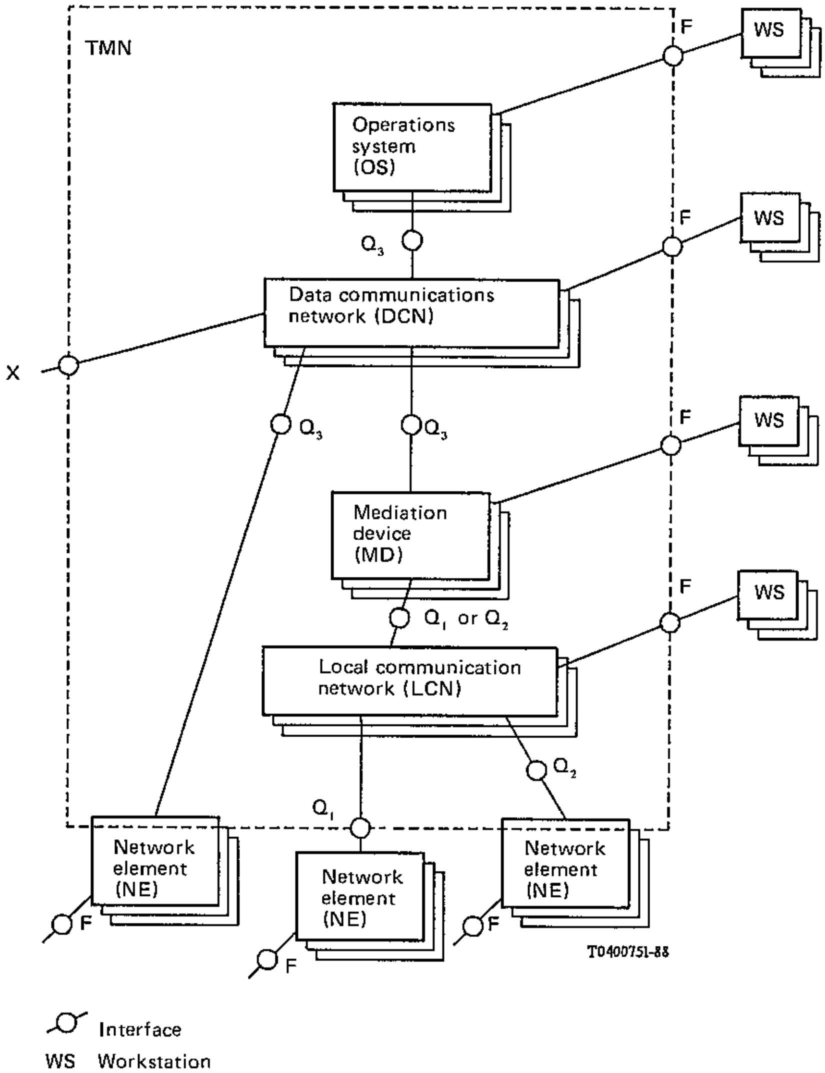


FIGURE 3/M.30

A generalized physical architecture for a telecommunications management network (TMN)

2.2.2 *Definitions of the standard interfaces*

Standard interfaces are defined corresponding to the reference points.

2.2.2.1 **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 three subclasses:

– interface Q_1, intended to connect NEs containing no MF to MDs or to NEs containing MF via an LCN

– interface Q_2, intended to connect MDs to MDs, NEs containing MF to MDs or to other NEs containing MF via an LCN

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

Note 1 – Applications different from primary applications are not excluded when different functions are combined for implementation.

Note 2 – A higher numbered interface will generally use a more sophisticated protocol than a lower numbered interface.

2.2.2.2 **F interface**

The F interface is applied at f reference points.

2.2.2.3 **G interface**

The G interface is applied at the g reference point.

2.2.2.4 **X interface**

The X interface is applied at the x reference point.

2.3 *TMN protocol families*

The Q interfaces as present on the DCN and the LCN determine protocol families PQDCN and PQLCN.

2.3.1 *Definitions of the TMN protocol families*

2.3.1.1 **PQDCN**

A family of protocol suites for use with the DCN applied to the Q_3 interface.

2.3.1.2 **PQLCN**

A family of protocol suites for use with the LCN, applied to the Q_1 and Q_2 interfaces.

2.4 *Consideration of reference and physical configurations*

2.4.1 *q-class considerations*

2.4.1.1 *q-class reference configuration*

Figure 4/M.30 shows the q-class reference configuration illustrating the q_1, q_2 and q_3 reference points and the types of functional blocks that can be connected to the reference points. Figure 4a/M.30 shows the case with explicit DCF (with data communication functions indicated). Since the DCF process preserves the information content, the same reference point appears on both sides of a DCF in the figure.

2.4.1.2 *Physical realization of the reference configuration*

Figure 5/M.30 shows examples of the relationship of the physical configurations to the reference configuration with DCFs not explicitly shown (implicit DCF case). It illustrates combinations of physical interfaces at the reference points q_1, q_2 and q_3. At reference points where a physical interface appears, this is denoted with a capital Q.

Figure 5/M.30, case a), shows an NE physically connected via a Q_1 interface to an MD, two MDs interconnected with a Q_2 interface and the top MD connected with OS via the Q_3 interface.

Figure 5/M.30, case b), shows an NE physically connected to an MD via a Q_1 interface. The MFs are merged into one MD which interfaces to the OS via a Q_3 interface, (see also Note 1).

Figure 5/M.30, case c), shows an NE with an internal MF which is interconnected to an MD via a Q_2 interface. The MD is connected to the OS via a Q_3 interface.

Figure 5/M.30, case d), shows an NE with MFs directly connected to the OS via a Q_3 interface.

Note 1 – Where a reference point is shown in Figure 5/M.30 this means that the point is inside a physical box. The designer is free to apply any implementation. It is not necessary that this point is physically present inside the equipment.

Note 2 – Any other equipment may be present between two adjacent boxes, which is necessary for the connection of these boxes. This equipment represents the DCF of Figure 2/M.30. Such equipments perform OSI network functions and are not shown in Figure 5/M.30, e.g., the Q_3 interface normally connects to the DCN which provides the data communication to the OS.

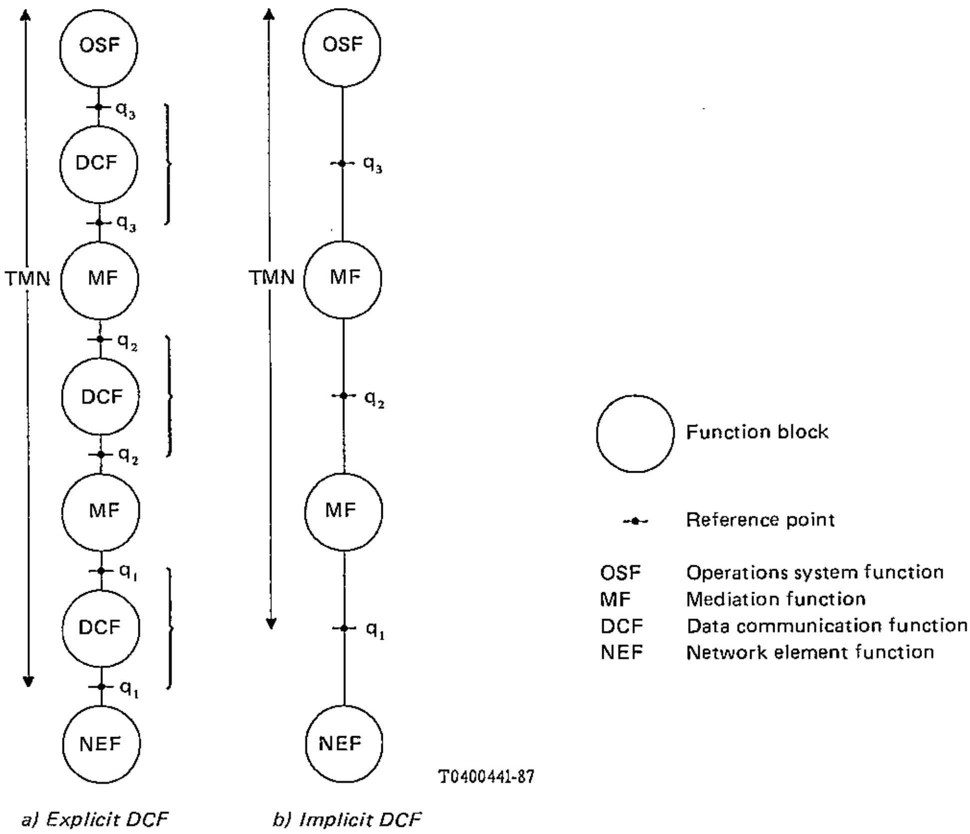
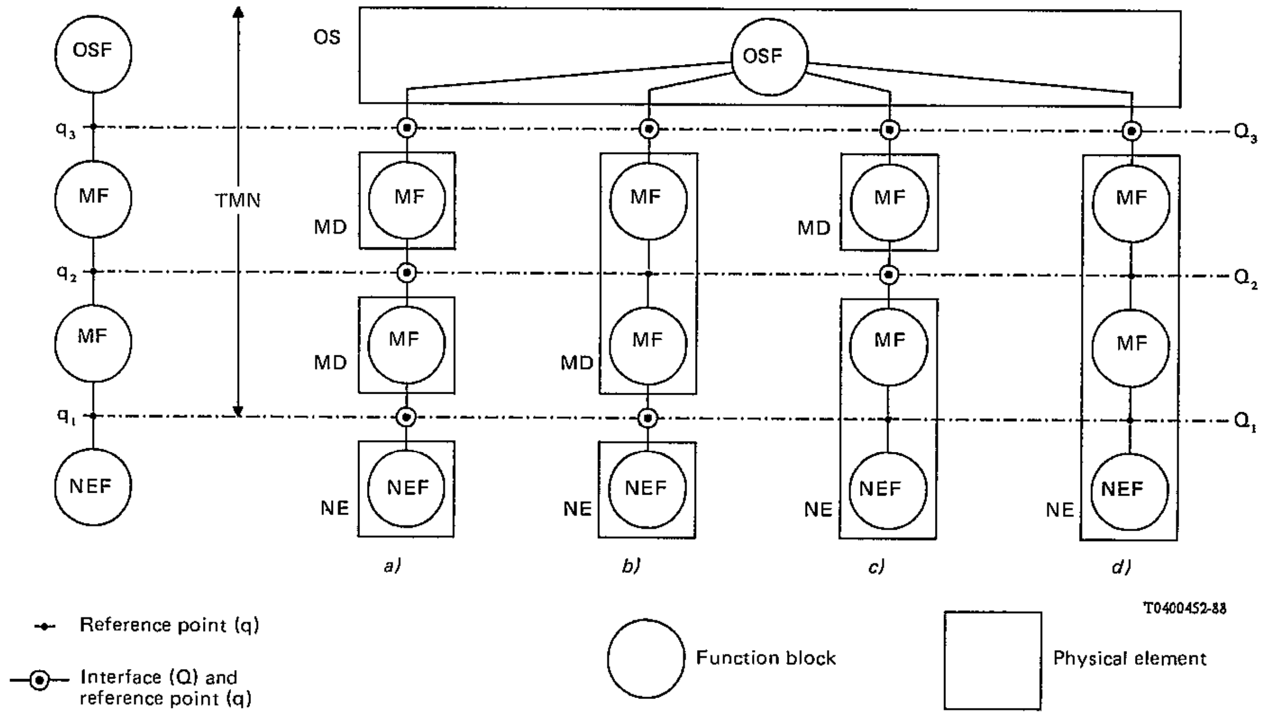


FIGURE 4/M.30
The q-class reference configuration

Figure 6/M.30 shows the same examples of the relationship of the physical configuration to the reference configuration as those given in Figure 5/M.30, but with the DCFs explicitly shown (explicit DCF case). It also shows different possible configurations that may be used for an LCN (e.g. star, bus or ring).

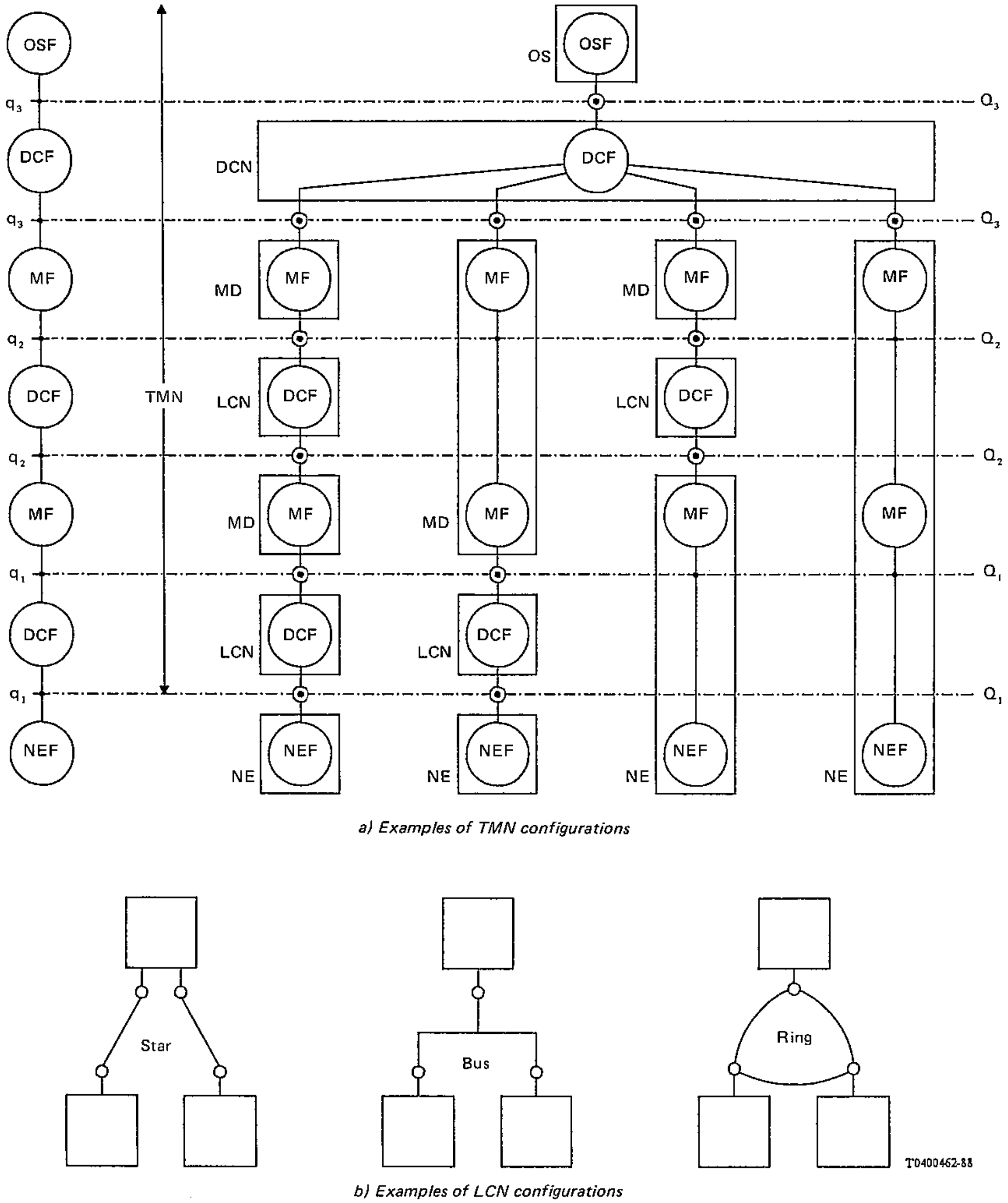


OSF Operations system fonction
MF Mediation function
NEF Network element function
NE Network element
MD Mediation device
OS Operations system
DCF Data communication function

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

FIGURE 5/M.30

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



Reference point (q)

Interface (Q)

Interface (Q) and reference point (q)

LCN Local communication network
DCN Data communication network
OSF Operations system function
DCF Data communication function
MF Mediation function
NEF Network element function
NE Network element
OS Operation system
MD Mediation device

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

FIGURE 6/M.30

Examples of the relationship of physical configuration to the reference configuration (with explicit DCF)

Figure 7/M.30 shows examples, with the DCFs not explicitly shown, of a special group of physical configurations in which NEs are cascaded to provide a single interface to the higher order TMN equipment. This is convenient for co-located NEs which generally contain different levels of MF, e.g., transmission equipment co-located with an exchange.

Figure 7/M.30 case a), shows how an NE without an internal MF is connected via a Q_1 interface to an NE with an internal MF which itself has a Q_2 interface to an MD.

Figure 7/M.30 case b), shows how an NE with an internal MF is connected via a Q_2 interface to an NE with higher level MF, which itself has a Q_3 interface to OS.

Figure 7/M.30 case c), shows another possibility where an NE without an internal MF has a Q_1 interface to an NE with an internal MF which itself has a Q3 interface to OS.

Figure 8/M.30 shows simplified examples of how NEs and MDs might be physically cascaded to serve multiple NEs. The examples show the connections to the OSs, but do not explicitly show the connections to the DCFs.

3 Functions associated with a TMN

The functions associated with a TMN can be split into two parts:

– TMN general functions provided by the function blocks defined in § 2.1; and

– TMN application functions listed in § 3.2;

3.1 *TMN general functions*

The TMN general functions provide support for the TMN application functions. Examples of TMN general functions are:

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

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

– security, which provides control over access for reading or changing information;

– retrieval, which provides access to information;

– processing, which provides for analysis and information manipulation;

– user terminal support which, provides for input/output of information.

3.2 *TMN applications functions*

A TMN is intended to support a wide variety of application functions which cover the operations, administration, maintenance and provisioning of a telecommunication network.

These four categories have a different meaning depending on the organization of an Administration. Moreover, some of the information which is exchanged over the TMN may be used in support of more than one management category. Therefore, the classification of the information exchange within the TMN is independent of the use that will be made of the information.

While it cannot claim to be complete, this section describes some of the most important application functions in terms of the OSI management categories, expanded to fit the need of a TMN.

The application functions have been classified in accordance with fields of use into major management categories:

a) performance management,

b) fault (or maintenance) management,

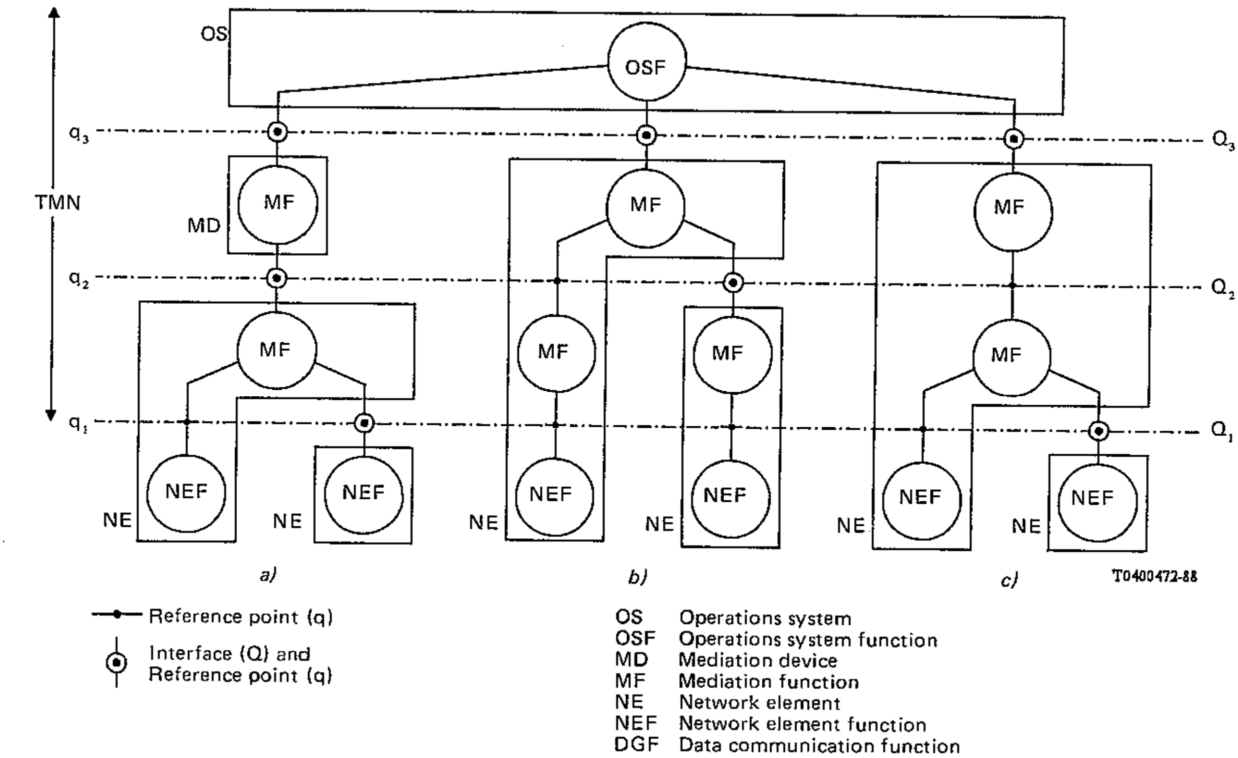
c) configuration management,

d) accounting management,

e) security management.

These allocations are provisional and subject to future review and rearrangement.

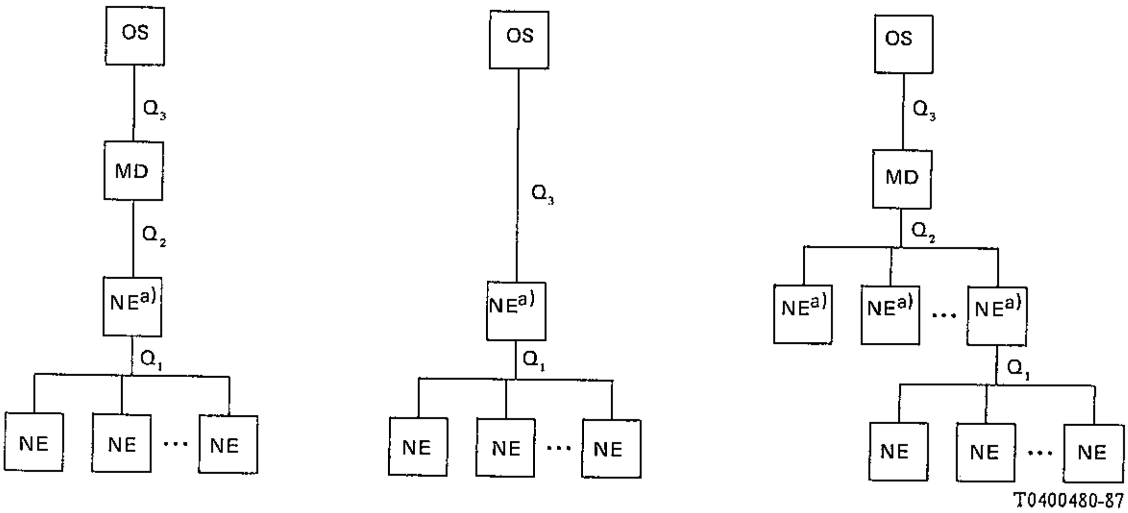
It should be noted that the functional configuration of the TMN will change depending on the phases in the life cycle and the momentary status of the related telecommunications equipment. Typical examples can be found in the development of installation functions and testing functions, notably when utilizing movable support equipment.



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

FIGURE 7/M.30

Examples of cascaded network elements (with implicit DCF)



OS Operations system
MD Mediation device
NE Network element

[a)] NE contains MF.

FIGURE 8/M.30

Examples of cascaded network elements (physical configuration)

3.2.1 *Performance management*

Performance management provides functions to evaluate and report upon the behaviour of telecom equipment and the effectiveness of the network or network element. Its role is to gather statistical data for the purpose of monitoring and correcting the behaviour and effectiveness of the network, network element or equipment and to aid in planning and analysis. As such, it is carrying out the performance measuring phase of Recommendation M.20.

The following functionalities have been defined:

3.2.1.1 *Performance monitoring functions*

Performance monitoring involves the continuous collection of data concerning the performance of the NE. While acute fault conditions will be detected by alarm surveillance methods, very low rate or intermittent error conditions in multiple equipment units may interact resulting in poor service quality. Performance monitoring is designed to measure the overall quality on the monitored parameters in order to detect such deterioration. It may also be designed to detect characteristic patterns before signal quality has dropped below an acceptable level.

3.2.1.2 *Traffic management and network management functions*

A TMN collects traffic data from NEs and sends commands to NEs to reconfigure the telecommunication network or modify its operation to adjust to extraordinary traffic.

A TMN may request traffic data reports to be sent from NEs, or such a report may be sent upon threshold triggering, or periodically, or on demand. At any time the TMN may modify the current set of thresholds and/or periods in the network.

Reports from the NE may consist of raw data which is processed in a TMN, or the NE may be capable of carrying out analysis of the data before the report is sent.

3.2.1.3 *Quality of Service (QOS) observation functions*

A TMN collects QOS data from NEs and supports the improvements in QOS. The TMN may request QOS data reports to be sent from the NE, or such a report may be sent automatically on a scheduled or threshold basis. At any time, the TMN may modify the current schedule and/or thresholds. Reports from the NE on QOS data may consist of raw data which is processed in a TMN, or the NE may be capable of carrying out analysis of the data before the report is sent.

Quality of Service includes monitoring and recording of parameters relating to;

– connection establishment (e.g. call set up delays, successful and failed call requests);
– connection retention;
– connection quality;
– billing integrity;
– keeping and examining of logs of system state histories;
– cooperation with fault (or maintenance) management to establish possible failure of a resource and with configuration management to change routing and load control parameters/limits for links etc.;
– initiation of test calls to monitor QOS parameters.

3.2.2 *Fault (or maintenance) management*

Fault (or maintenance) management is a set of functions which enables the detection, isolation and correction of abnormal operation of the telecommunication network and its environment. It provides facilities for the performance of the following maintenance phases from Recomendation M.20, § 5.

3.2.2.1 *Alarm surveillance functions*

A TMN provides the capability to monitor NE failures in near real time. When such a failure occurs, an indication is made available by the NE. Based on this, a TMN determines the nature and severity of the fault. For example, it may determine the effect of the fault on the services supported by the faulty equipment. This can be accomplished in either of two ways: a data base within a TMN may serve to interpret binary alarm indications from the NE, or if the NE has sufficient intelligence, it may transmit self-explanatory messages to a TMN. The first method requires little of the NE beyond a basic self-monitoring capability. The second method requires additionally that both the NE and a TMN support some type of message syntax which will allow adequate description of fault conditions.

3.2.2.2 *Fault localization functions*

Where the initial failure information is insufficient for fault localization it has to be augmented with information obtained by additional failure localization routines. The routines can employ internal or external test systems and can be controlled by a TMN (see Recommendation M.20).

3.2.2.3 *Testing functions (requested, on demand, or as a routine test)*

Testing can be carried out in one of two ways. In one case, a TMN directs a given NE to carry out analysis of circuit or equipment characteristics. Processing is executed entirely within the NE and the results are automatically reported to the TMN, either immediately or on a delayed basis.

Another method is where the analysis is carried out within the TMN. In this case, the TMN merely requests that the NE provide access to the circuit or equipment of interest and no other messages are exchanged with the NE.

3.2.3 *Configuration management*

Configuration management provides functions to exercise control over, identify, collect data from and provide data to NEs.

3.2.3.1 *Provisioning functions*

Provisioning consists of procedures which are necessary to bring an equipment into service, not including installation. Once the unit is ready for service, the supporting programmes are initialized via the TMN. The state of the unit, e.g., in service, out of service, stand-by, reserved, and selected parameters may also be controlled by provisioning functions.

Over the spectrum of network elements, the use of the provisioning functions can vary widely. For small transmission elements, these functions are used once and rarely again. Digital switching and cross-connect equipment may require frequent use of these functions as circuits are put up and dropped.

3.2.3.2 *Status and control functions*

The TMN provides the capability to monitor and control certain aspects of the NE on demand. Examples include checking or changing the service state of an NE or one of its sub-parts (in service, out of service, stand-by) and initiating diagnostics tests within the NE. Normally, a status check is provided in conjunction with each control function in order to verify that the resulting action has taken place. When associated with failure conditions, these functions are corrective in nature (e.g., service restoral).

Status and control functions can also be part of routine maintenance when executed automatically or on a scheduled periodic basis. An example is switching a channel out of service in order to perform routine diagnostic tests.

A TMN will enable the exclusion of faulty equipment from operation and as a result it may rearrange equipment or re-route traffic.

A TMN can enable the entry of a proposed configuration in order to automatically analyze the feasibility of that design before implementing it.

3.2.3.3 *Installation functions*

The TMN can support the installation of equipment which makes up the telecommunication network. It covers also the extension or reduction of a system. Some NEs call for the initial exchange of data between themselves and the TMN. An example of another function is the installation of programs into NEs from data base systems within the TMN. In addition, administrative data can be exchanged between NEs and the TMN.

Acceptance testing programmes can be done under control of, or supported by, the TMN.

A detailed list of installation functions for an SPC-exchange is provided in Recommendation Z.331, § 3.3 [1].

3.2.4 *Accounting management*

Accounting management provides a set of functions which enables the use of the network service to be measured and the costs for such use to be determined. It provides facilities to:

– collect accounting records,

– set billing parameters for the usage of services.

3.2.4.1 *Billing functions*

An OS within the TMN can collect data from NEs which is used to determine charges to customer accounts. This type of function may need extremely efficient and redundant data transport capabilities in order to maintain records of billing activity. Often the processing must be carried out in near real time for a large number of customers.

3.2.5 *Security management*

(For further study.)

4 Planning and design considerations

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

The interface requirements are measured in terms of function attributes that are required to provide the most efficient interface. The following is a listing of the function attributes. This list is incomplete and will be subject to further study.

4.1 *Functions attributes*

a) *Reliability*

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

b) *Frequency*

How often data is transferred across the interface boundary.

c) *Quantity*

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

d) *Priority*

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

e) *Availability*

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

f) *Delay*

Identifies the amount of buffering that may be tolerable between interfacing elements. This also impacts communications channel designs.

Annex C to this Recommendation provides a table of possible ranges for these function attributes and provides a definition for each range suggested.

4.2 *Functional characteristics*

Each major type of telecommunications equipment has functional characteristic needs that can be used to describe the complexity of the interface. There are, however, a basic group of TMN application functions that cross all major types of telecommunications equipment. However, there are also unique TMN application functions that are performed by specific categories of major telecommunications equipment. Alarm surveillance is an example of the former, whereas billing information collection is an example of the latter.

Functional characteristics of the elements within a TMN, e.g., OS, DCN, MD also describe the complexity of interfaces between these elements. Thus an identification of the functions performed by the elements within a TMN are also important considerations in determining the appropriate interfaces both within the TMN and to the NEs.

4.3 *Critical attributes*

Attribute values for a given function are generally consistent across the network elements. When considering a single Q interface it is important to identify the controlling attribute ranges for the design of the interface. If there are conflicting attribute values for different functions in a given network element, more than one interface may be needed.

Overall TMN attribute values for the interfacing of elements within the TMN depend on the type and number of functions performed within these elements. In this case the functions are not consistent across TMN elements, but are controlled by the individual TMN design of an Administration.

4.4 *Protocol selection*

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

The subject of protocol selection methodology will require further study in conjunction with other Study Groups.

4.5 *Communications considerations*

LCN and DCN architectures must be planned and designed to ensure that their implementation provides appropriate degrees of availability and network delay while minimizing cost. One must consider the selection of communications architectures, e.g., star, multipoint, loop, tree. The communications channels, e.g., dedicated lines, circuit switched networks and packet networks used in providing the communications paths, also play an important role.

5 Detailed TMN architectural considerations

5.1 *General*

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

The TMN must be carefully designed in order to prevent a single fault from making the transfer of critical management messages impossible. Congestion in the DCN or LCN should not cause blocking or excessive delay of network management messages that are intended to correct the congestion situation or restore a faulty system.

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

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

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

5.2 *Operations system*

5.2.1 *Functional OS configuration*

There are at least three functional types of OSFs, i.e. basic, network and service. Basic OSFs perform TMN application functions related to NEs located in specific regions. Network OSFs realize the network TMN application functions by performing the communication between basic OSFs. Service OSFs perform specific TMN application functions for managing an individual service. Basic OSFs and network OSFs share the same infrastructure of a telecommunication network. Service OSFs are concerned with service aspects of one or more telecommunication networks.

5.2.2 *Physical OS configuration*

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

a) support application programs;

b) data base functions;

c) user terminal support;

d) analysis programs;

e) data formatting and reporting.

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

The categorization of TMN function attributes as given in Tables C-1/M.30 to C-3/M.30 are also important factors in the OS physical architecture. For example, the choice of hardware depends strongly on whether an OS provides real time, near real time or non-real time service.

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

An OS which supports maintenance must provide for two types of data communication: spontaneous transmission of messages concerning problems from the NE to the OS, and two-way dialogue, when the OS obtains supporting information from the NE and sends commands to the NE. In addition, a maintenance OS is responsible for assuring the integrity of the maintenance data channels through a data communication network.

5.3 *TMN data communication considerations*

5.3.1 *Data communication networks considerations*

A DCN for a TMN should, wherever possible, follow the reference model for open systems interconnection for CCITT applications as specified in Recommendation X.200 [2].

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

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

A data communications network (DCN) connects NEs with internal mediation functions or mediation devices to the OSs and always interfaces at the standard Q_3 level. The use of standard Q_3 interfaces enables maximum flexibility in planning the necessary communications. In general, a DCN does not provide all the data communication functions for a TMN. Therefore, the communication between Q_1, Q_2 and Q_3 interfaces may require communication links, as part of an LCN.

A DCN can be implemented using point-to-point circuits, a switched network or a packet network. The facilities can be dedicated to a DCN or be a shared facility (e.g. using CCITT Signalling System No. 7 or an existing packet switched network).

5.3.2 *Local communications network considerations*

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

A local communication network (LCN) connects NEs to MDs or MDs to MDs and generally interfaces at two standard levels, Q_1 and Q_2, within a telecommunication center. However, for practical reasons, an LCN may connect remote NEs to local MDs. In some cases, NEs with internal mediation functions may be connected to a DCN through an LCN via a standard Q_3 interface.

5.4 *Mediation*

5.4.1 *Mediation considerations*

Mediation is a process within a TMN which acts on information passing between network elements (NE) and operations systems (OS) via a data communication network. Mediation devices use standard interfaces and can be shared by several NE(s) and/or OS(s).

Note – Mediation devices accommodate different designs of NEs when acting on information passing from these NEs to OSs by appropriate implementation of communication functions. The mediation function may be implemented in stand alone devices or combined with other unrelated functions (e.g. with a local processor or with a switching exchange). Mediation functions can be implemented as a hierarchy of cascaded devices using standard interfaces. Examples of the mediation function are concentration, protocol conversion, collection/control and processing. The mediation function may be absent in some implementations.

The cascading of mediation devices and various interconnection structures between MDs on one hand and MDs and NEs on the other hand provides for great flexibility in the TMN. Some options are shown in Figure 8/M.30. It enables cost effective implementations of the connection of NEs of different complexity (e.g. switching equipment and transmission multiplex equipment) to the same TMN. In addition, it gives the capability for future design of new equipment to support a greater level of processing within individual NEs, without the need to redesign an existing TMN.

It may be possible to recognize a mediation type process in some network elements similar to the one described above. For the purpose of this Recommendation, it is convenient to regard the function of mediation as being wholly contained within the TMN. However, this does not preclude practical realizations where some or all of the mediation functions are implemented within the network element, which must still interface to the TMN via a standardized Q interface. The choice of any interface which may be required for a network element is left to the discretion of the Administrations.

5.4.2 *Process of mediation*

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

1) communication control;
2) protocol conversion and data handling;
3) transfer of primitive functions;
4) decision making processes;
5) data storage.

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

a) communications control:
   – polling,
   – addressing,
   – communications networking,
   – ensuring integrity of data flows;
b) protocol conversion and data handling:
   – protocol conversion at either lower or upper OSI levels,
   – concentration of data,
   – compression or reduction of data,
   – collection of data,
   – data formatting,
   – data translation;
c) tranfer of primitive functions:
   – command/response statement,
   – alarm statements,
   – alarm forwarding,
   – test results/data,
   – operational measurement data,
   – upload of status report,
   – local alarming;
d) decision making processes:
   – work station access,
   – thresholding,
   – data communications back-up,
   – routing/re-routing of data,
   – security (e.g., log-in procedures),
   – fault sectionalization tests,
   – circuit selection and access for tests,

– circuit test analysis;

e) data storage:

– data-base storage,

– network configuration,

– equipment identification,

– memory back-up.

Certain mediation processes may be carried out autonomously.

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

5.4.3 *Implementation of mediation processes*

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

In the stand-alone case the interfaces towards both NEs and OSs are one or more of the standard operations interfaces (Q_1, Q_2 and Q_3). Where mediation is part of an NE only, the interfaces towards the OSs are specified as one or more of the standard operations interfaces (Q_2 and Q_3). Mediation that is part of an NE (e.g. as part of a switching exchange) may also act as mediation for other NEs. In this case standard operations interfaces (Q_1 and Q_2) to these other NEs are required.

Also, the mediation functions within an NE which carries out the mediation function for other NEs is regarded as being a part of the TMN.

5.5 *Network element considerations*

In the TMN reference model, a network element performs the network element function (NEF), and may in addition perform one or more MFs.

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

– The Maintenance entity function (MEF) is involved in the telecommunication process. Typical MEFs are switching and transmission. A maintenance entity (ME) can contain one or more MEFs.

– The support entity function (SEF) is not directly involved in the telecommunication process. Typical SEFs are fault localization, billing, protection switching. A support entity (SE) can contain one or more SEFs.

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

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

– an NE contains MEs or SEs or both MEs and SEs;

– an NE may or may not contain a QA.

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

Figure 9/M.30 shows the NE reference model outside the TMN with related physical implementations. The m-reference point separates the maintenance entity function (MEF), the support entity function (SEF), and the Q-adapter function (QAF).

Figure 10/M.30 shows different types of Q-adapters connected to MEs and SEs. The Q-adapters are not required if MEs or SEs are supplied with Q-interfaces. The M-interface can be of parallel, star or bus-type.

Examples of network elements are shown in Annex A.

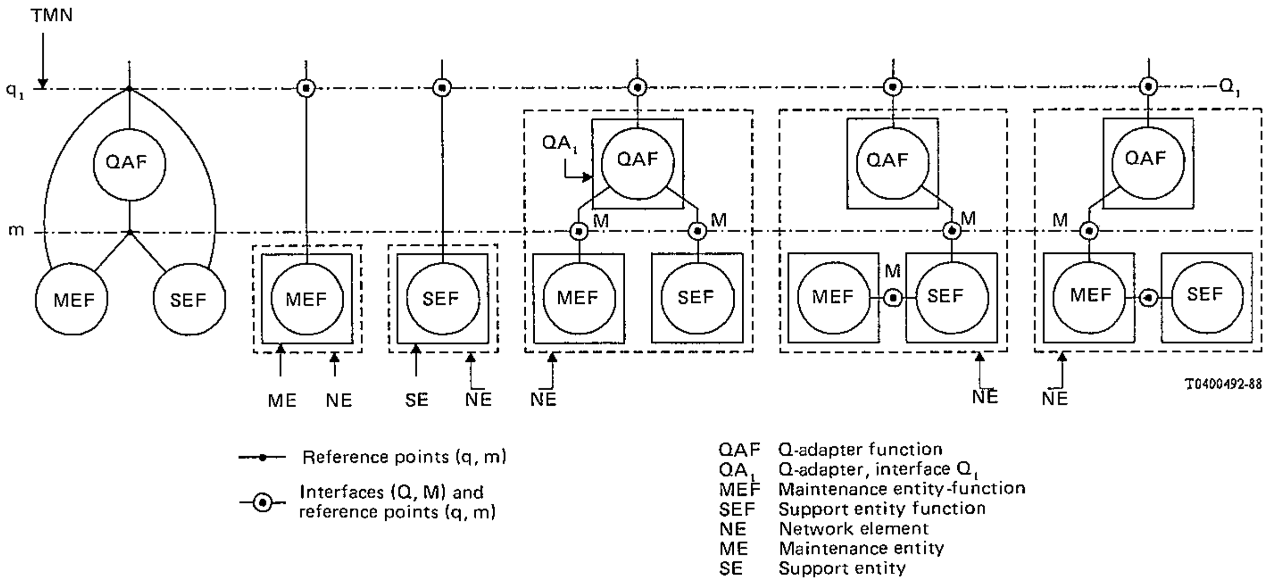


FIGURE 9/M.30

NE reference model and physical configuration outside the TMN

5.6 *Work stations*

In Figure 2/M.30 and 3/M.30, the work station reference points and interfaces are shown at a number of locations. An Administration may choose to implement a work station at only some of these locations.

The TMN work stations and their interfaces are subjects for further study.

5.7 *TMN standard interfaces*

TMN standard interfaces provide for the interconnection of NEs, OSs, MDs and WSs through the DCN or LCN. The purpose of an interface specification is to assure compatibility of devices interconnected to accomplish a given TMN application function, independent of the type of device or of the supplier. This requires compatible communication protocols and a compatible data representation method for the messages, including compatible generic message definitions for TMN application functions. A minimum set of protocol suites, to be applied to TMN standard interfaces, should be determined according to the protocol selection method described in § 4.4.

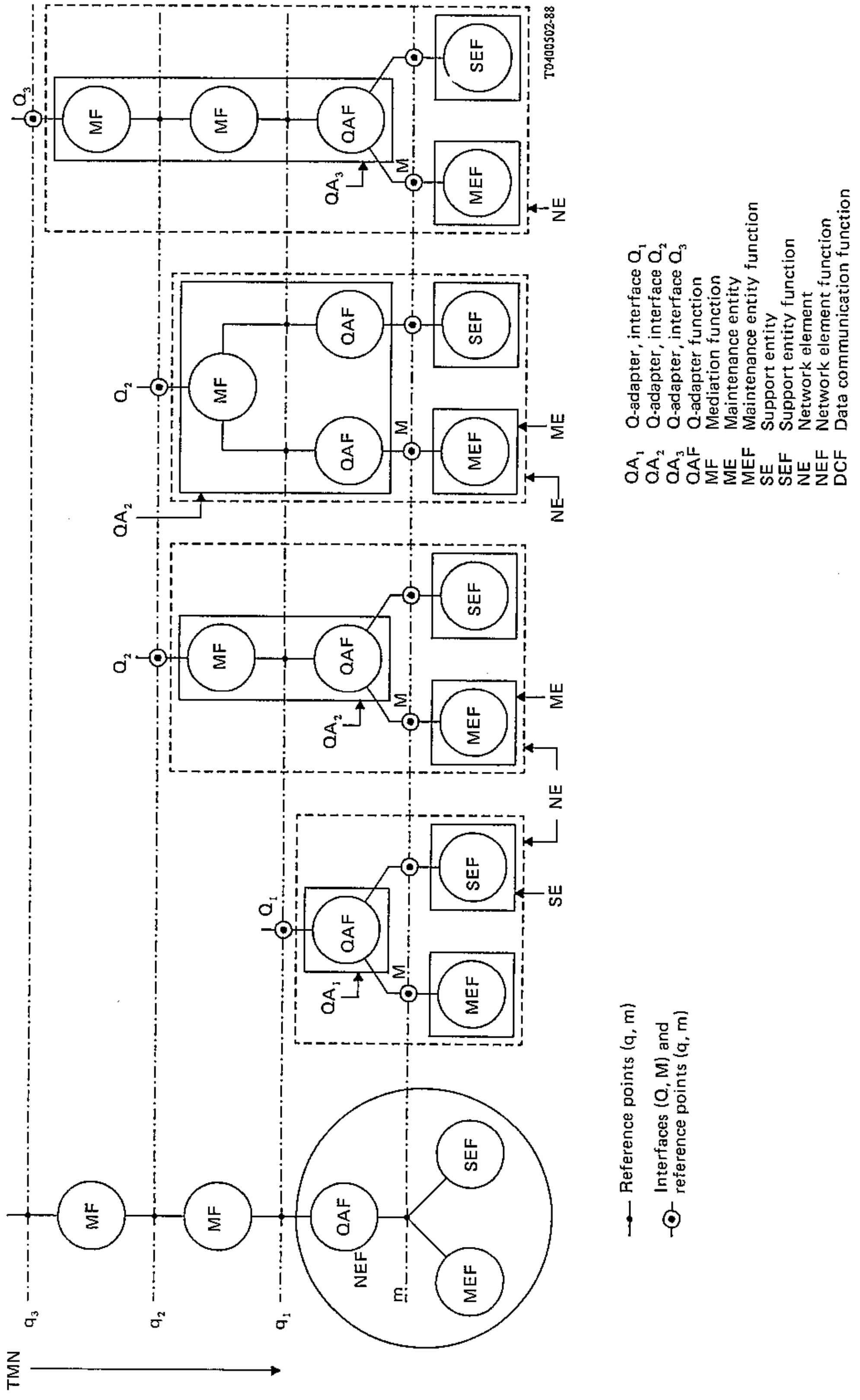


FIGURE 10/M.30

NE + TMN reference model and physical configuration (with implicit DCF)

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

It is recognized that NEs, OSs, DCNs, LCNs, MDs and WSs may have other interfaces in addition to the Q, F, G 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, G and X interfaces. These additional interfaces and related functionality are outside the TMN.

5.7.1 *Q_1 and Q_2 interfaces*

The PQLCN function attributes required at the Q_1/Q_2 interfaces are strongly dependent on the mediation functions needed, as well as the mediation function partitioning between cascaded MDs. Since the purpose of putting MDs between OSs and NEs is to make flexible implementation possible, mediation function partitioning should not be restricted to only one case. Therefore, one minimum set of protocol suites should be selected to be applied to both Q_1 and Q_2 interfaces instead of selecting a different set for each of them. The choice of individual protocol suites from the recommended PQLCN family should be left to the Administrations.

The protocol suites to be applied to the Q_1 and Q_2 interfaces need not implement all layers of the OSI model. Details of the Q_1 and Q_2 interface specification and the PQLCN family of protocol suites are given in Recommendation G.771 [3].

5.7.2 *Q_3 interface*

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

Details of the Q_3 interfaces and the PQDCN protocols are given in Recommendation Q.513 [4].

5.7.3 *F interface* (under study)

5.7.4 *X interface* (under study)

Interconnection to other TMNs.

6 User interface (under study)

This section will provide information and recommendations about the possible location and type of user work stations to be provided with a TMN. It will discuss work station back-up considerations when parts of the TMN have failed.

7 TMN maintenance considerations (under study)

This section will provide information and recommendations about the considerations associated with the maintenance of the TMN itself.

ANNEX A

(to Recommendation M.30)

Examples of network elements

A.1 A network element (NE) is the grouping of telecommunication and other equipment that can communicate operations and administrative messages via a telecommunication management network (TMN) over one or more standard interfaces for the purpose of being monitored and/or controlled.

Network elements are not part of a TMN if they contain only maintenance entities (ME) and/or support entities (SE), as defined in Recommendation M.20. Network elements with mediation functions are partly within a TMN, as described in § 5.5.

The various parts of NEs and their interfaces are shown in a) of Figure A-1/M.30 for ME, in b) of Figure A-1/M.30 for SE, and in c) of Figure A-1/M.30 for QA. Using these units, Figure A-2/M.30 shows an example of NE-configurations. As illustrated, one NE may contain a number of MEs and SEs connected to a Q-adapter.

The following interfaces are used:

a) T telecommunications interface, which carries the information flow to be managed by TMN;

b) Q Q1, Q2 and Q3 TMN-interfaces as described in this Recommendation;

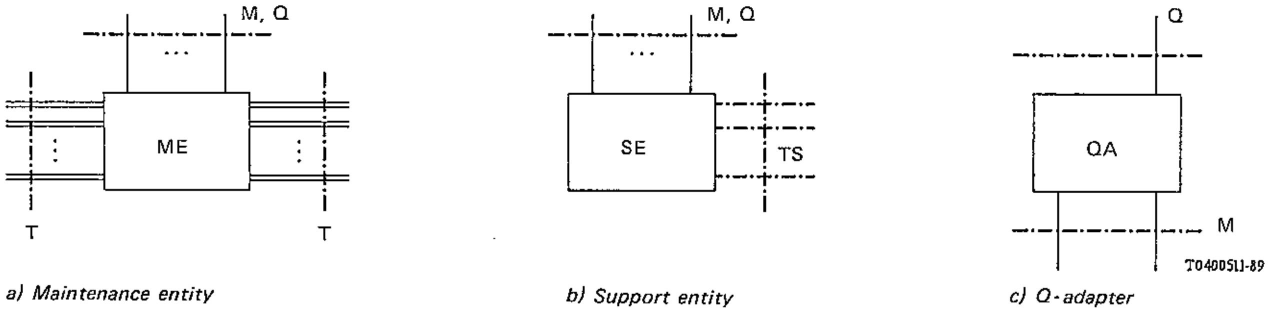
c) M non-standardized maintenance interface as described in this Recommendation;

d) TS telecommunication support interface, which is related to the function of the support element or used for connection of monitors/work stations.

A.2 Relations between NE, ME, SE and QA for maintenance are illustrated in Figures A-3/M.30 to A-10/M.30 using a number of examples.

The abbreviations used in the figures are:

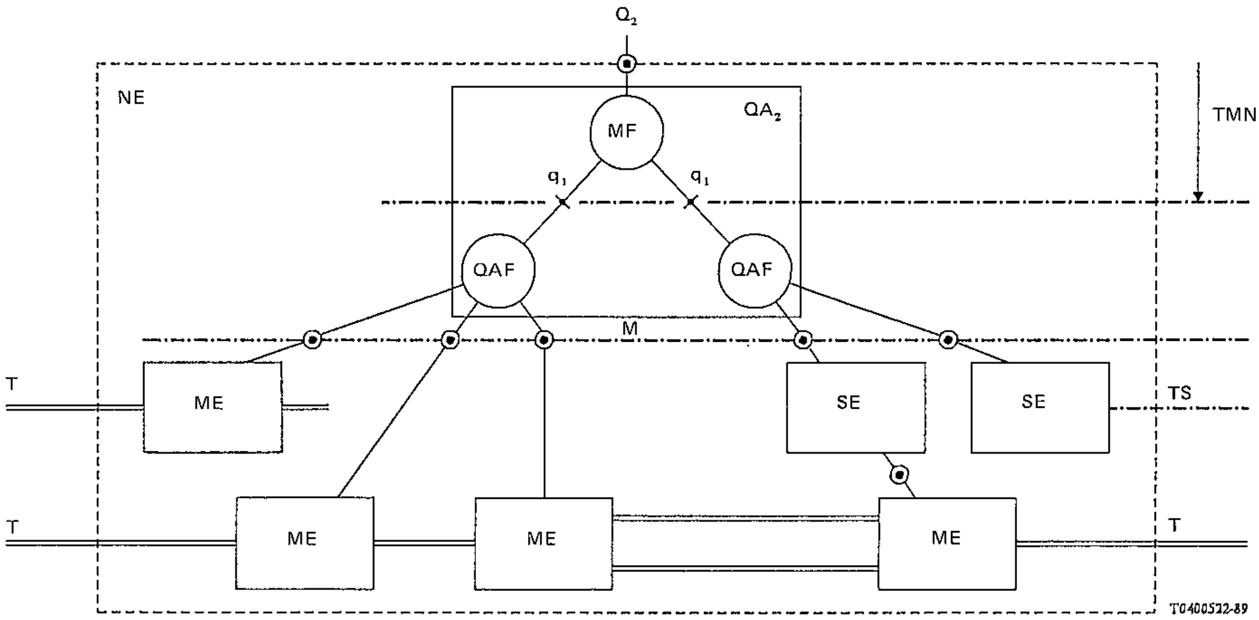
CFS	Common frequency supply
CTE	Channel translation equipment
DCC	Digital cross connect
DIG MUX	Digital multiplexer
GTE	Group translation equipment
LT	Line terminal
M	(non-standardized) Maintenance interface
ME	Maintenance entity
MTE	Mastergroup translation equipment
NE	Network element
Q	Q_1, Q_2, Q_3 interfaces
QA	Q-adapter
SE	Support entity
SMTE	Supermastergroup translation equipment
STE	Supergroup translation equipment
SUR	Supervision unit, dependent repeater
SUT	Supervision unit, line terminal
T	Telecommunications interface
TS	Telecommunications support interface



T = Telecommunications interface
Q = Q_1, Q_2, Q_3 interfaces
M = (Non-standardized) maintenance interface
TS = Telecommunications support interface

FIGURE A-1/M.30

Parts of network elements



Reference points (q, m)
Interface (Q, M) and reference points (q, m)

M	(Non-standardized) maintenance interface	QA	Q-adapter
ME	Maintenance entity	QAF	Q-adapter functional block
MF	Mediation functional block	SE	Support entity
NE	Network element	T	Telecommunications interface
Q	Q_1, Q_2, Q_3 interfaces	TS	Telecommunications support interface

FIGURE A-2/M.30

Example of network element configuration

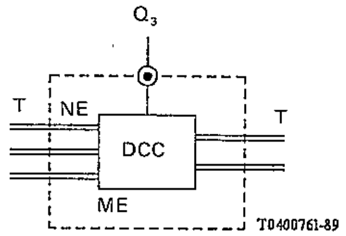


FIGURE A-3/M.30

Example: digital cross connect equipment with Q-interface;
NE contains one ME

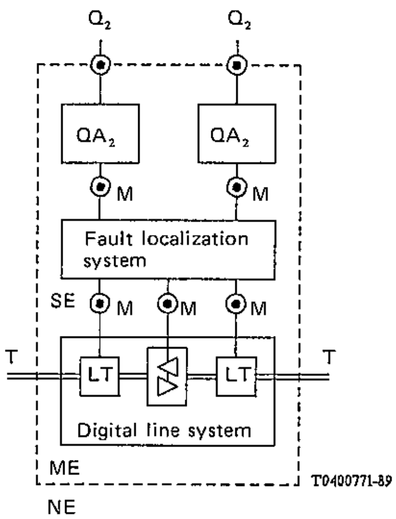


FIGURE A-4/M.30

Example: digital line system with NE-internal fault localization
and two Q_2-interfaces;
NE contains one ME (digital line system)
and one SE (fault localization system)
and two Q-adapters; the digital line system contains
line terminals LT and dependent repeaters

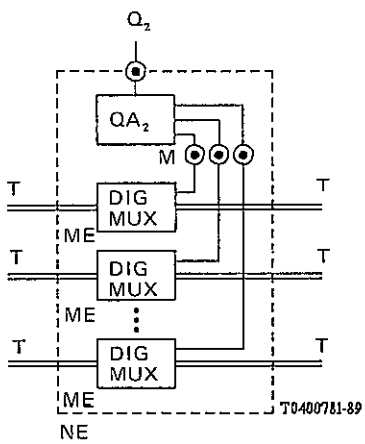


FIGURE A-5/M.30

Example: bay frame or shelf with digital multiplex equipment;
SE is used for interface conversion between n maintenance
interface and one Q_2-interface;
NE contains one SE and n × MEs

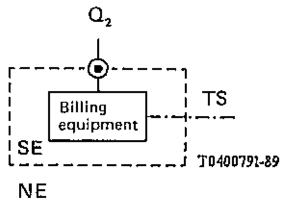


FIGURE A-6/M.30

Example: billing equipment (SE) with Q-interface;
NE contains one SE

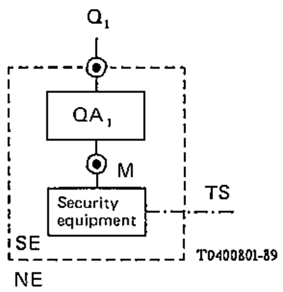
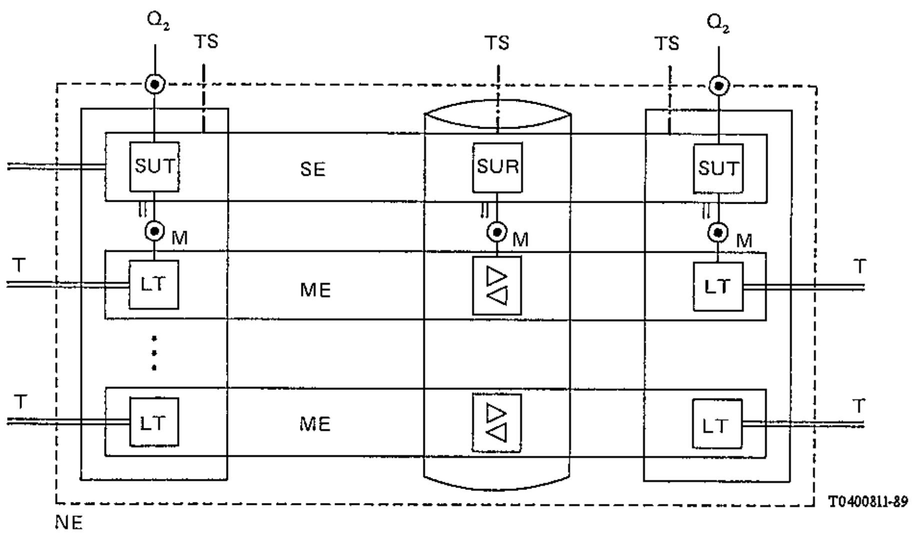


FIGURE A-7/M.30

Example: premises security equipment (SE);
a Q-adapter is used for interface conversion;
NE contains one SE and one QA_1



Note – Telecommunication support interfaces are shown which can be used for local maintenance, e.g. connection of portable monitors.

FIGURE A-8/M.30

Example: digital line systems with NE-internal fault localization and two Q_2-interfaces;
NE contains one SE and n × ME; SE contains embedded
transmission channels for communication
between the various parts of ME, e.g. for fault localization

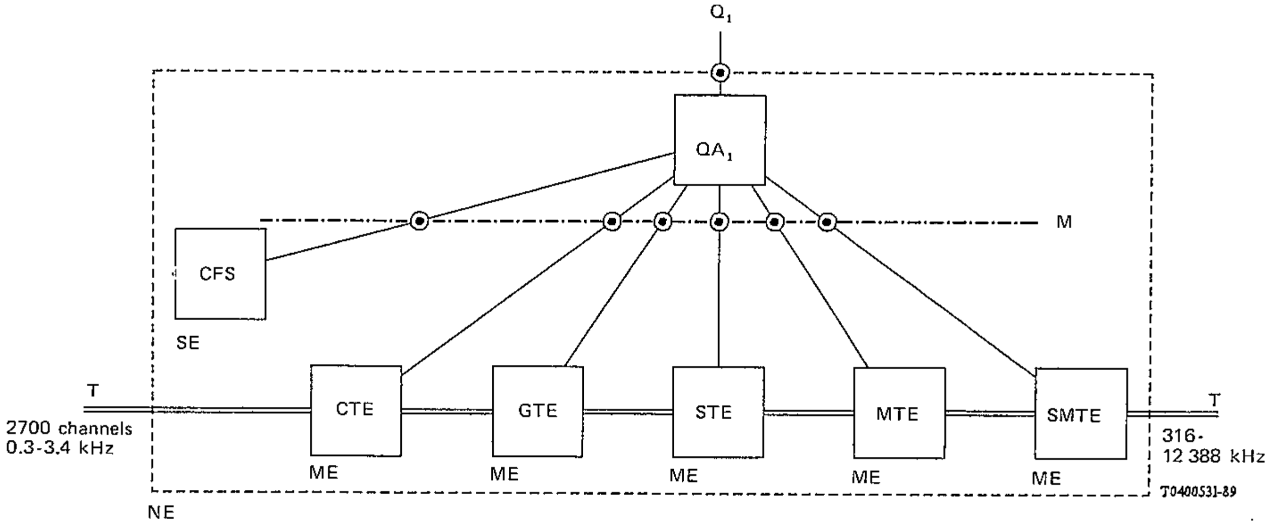


FIGURE A-9/M.30

Example: analogue terminal equipment converting 2,700 voice-frequency channels to the 12 MHz transmission band; NE contains 5 MEs and one SE

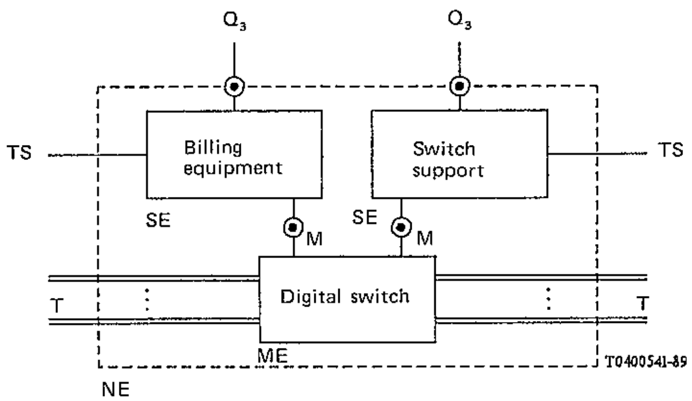


FIGURE A-10/M.30

Example: digital switch (ME) with billing equipment (SE) and switching support (SE)

ANNEX B

(to Recommendation M.30)

TMN application functions

B.1 *Introduction*

The TMN application functions are classified in the five categories specified in § 3.2.

The functional list has been classified according to the OSI management categories as an aid in selecting the protocol and the application language for the TMN interfaces.

The list of functions, its terminology and classification is preliminary and is expected to be refined as the study proceeds.

The application functions are not intended as requirements for any NE or TMN. Each function in the list is included because it may be necessary for some implementation of a related application. Some functions will be appropriate for a certain implementation of an interface application, but unnecessary or inconvenient for others.

B.2 *Index of list of application functions described in § B.3*

B.3 *List of application functions*

B.3.1 *Performance management*

B.3.1.1 *Performance monitoring (PM)*

1) *Request PM data* – TMN requests the NE to send current PM data;

2) *PM data report* – NE sends performance data to the TMN. It may be generated routinely by the NE, sent upon demand by the TMN or by exception when a parameter threshold has been exceeded;

3) *Schedule PM data report* – TMN directs NE to establish a schedule for the reporting of PM data;

4) *Request PM data report schedule* – TMN directs NE to send the current PM data reporting schedule. NE responds with the schedule;

5) *Start/stop PM data* – TMN directs the NE to start or stop the collection of PM data;

6) *Initialize PM data* – TMN directs NE to reset storage registers for PM data;

7) *Set PM attributes* – TMN directs NE to assign designated values to PM attributes;

8) *Request PM attributes* – TMN requests NE to send current PM attributes;

9) *PM attributes report* – NE sends the currently assigned PM attributes to TMN;

10) *Request protocol conversion data* – TMN requests NE to transmit the data concerning the protocol conversion performance, such as the types and their number of protocol conversions;

11) *Protocol conversion data report* – NE sends data concerning protocol conversion performance.

B.3.1.2 *Traffic management and network management (NM)*

1) *Set traffic data attributes* – TMN directs NE to set parameters to collect traffic data;

2) *Request traffic data attributes* – TMN requests NE to report the current traffic data attributes;

3) *Request traffic data* – TMN requests NE to transmit traffic data to TMN;

4) *Traffic data report* – NE sends specified traffic data to TMN;

5) *Request clock sync* – TMN requests NE to transmit its current clock time to TMN;

6) *Clock sync report* – NE sends the current clock time;

7) *Set error analysis* – TMN directs NE to assign designated values to error analyses parameters. These are used by NE to recognize that a given unit is faulty based on the detection of errors and intermittent troubles;

8) *Request error analysis data* – TMN requests NE to report the current error analysis parameters or resulting data;

9) *Error analyses report* – NE sends error analyses data to TMN;

10) *Set NM data attributes* – TMN directs NE to set parameters to generate required NM measurement data;

11) *Request NM data attributes* – TMN requests NE to report the current NM data attributes;

12) *Request NM data* – TMN requests NE to send the NM data to TMN. This includes periodic measurement data and status and alerting discrete information;

13) *NM data report* – NE sends required NM data to TMN;

14) *Sent NM control* – TMN directs the NE to perform specified real-time NM controls;

15) *Control report* – NE sends NM control status information to the TMN;

16) *Set NM thresholds* – TMN directs the NE to set or change the congestion thresholds used by the NE to perform automatic NM control;

17) *Request NM threshold* – TMN requests the NE to send the current congestion thresholds to the TMN;

18) *NM threshold report* – NE sends current congestion thresholds to TMN.

B.3.1.3 *Quality of service (QOS) observations*

1) *Schedule QOS data report* – TMN directs NE to establish a schedule for the report of QOS data;

2) *Request QOS data report schedule* – TMN directs NE to send the current QOS data reporting schedule;

3) *QOS report* – NE reports to TMN the value of an observed QOS parameter. It may be sent on demand by TMN or on a scheduled basis;

4) *Set QOS threshold* – TMN directs NE to set or change the QOS parameter threshold;

5) *Request QOS threshold* – TMN directs NE to send the current QOS threshold;

6) *Exceptional QOS report* – NE reports to TMN the value of an observed parameter when a parameter threshold has been exceeded;

7) *Initialize QOS data* – TMN directs NE to reset storage registers for QOS data;

8) *Start/stop QOS data* – TMN directs NE to start or stop the collection of QOS data;

9) *Schedule QOS test calls* – TMN directs NE to establish a schedule for the execution of QOS test calls;

10) *Request QOS test call schedule* – TMN directs NE to send the current QOS test call schedule;

11) *QOS test call report* – NE reports to TMN the result of QOS test calls. It may be sent on demand by TMN or on a scheduled basis;

12) *Set QOS test call attributes* – TMN directs NE to set or change the attributes of QOS test calls;

13) *Start/stop QOS test calls* – TMN directs NE to start or stop sending test calls;

14) *Initialize QOS test calls* – TMN directs NE to reset the storage registers for test calls;

15) *Request QOS test call attributes* – TMN directs NE to send the current QOS test call attributes;

16) *Schedule (semi) automatic observations* – TMN directs NE to establish a schedule for the execution of (semi) automatic observations;

17) *Request (semi) automatic observation schedule* – TMN directs NE to send the current (semi) automatic observation schedule;

18) *Automatic observation report* – NE reports to TMN the result of automatic observations. It may be sent on demand by TMN or on a scheduled basis;

19) *Set (semi) automatic observation attributes* – TMN directs NE to set or change the attributes of (semi) automatic observations;

20) *Start/stop (semi) automatic observations* – TMN directs NE to start or stop the (semi) automatic observations;

21) *Initialize automatic observations* – TMN directs NE to reset the storage registers for automatic observations;

22) *Request (semi) automatic observation attributes* – TMN directs the NE to send the current (semi) automatic observation attributes.

B.3.2 *Fault (or maintenance) management*

B.3.2.1 *Alarm surveillance*

1) *Request alarm information* – TMN requests NE to send current alarm information;

2) *Alarm information report* – NE notifies TMN of alarm information. It may be sent automatically on occurrence, or on demand by TMN;

3) *Schedule alarm report* – TMN directs NE to establish a schedule for the reporting of alarms;

4) *Request alarm report schedule* – TMN directs NE to send the current schedule for alarm reporting. NE responds with the schedule;

5) *Condition alarm* – TMN directs NE to assign alarm attributes, modes and thresholds;

6) *Request condition* – TMN requests NE to report the current assignment of alarm attributes, modes and thresholds; NE responds with the assignments;

7) *Route alarm* – TMN directs NE to send alarms to designated locations;

8) *Request alarm route* – TMN requests NE to send the current assignment of alarm routes for a specified set of alarms; NE responds with the routes;

9) *Allow/inhibit alarms* – TMN directs NE to allow/inhibit either local audible/visual alarms or remote alarms;

10) *Alarm cut-off* – TMN directs NE to reset designated audible alarms.

B.3.2.2 *Fault localization*

1) *Request diagnostic data* – TMN requests NE to send the results of a diagnostic sequence;

2) *Stop diagnostic in progress* – TMN directs the NE to stop a particular diagnostic procedure in progress;

3) *Diagnostic report* – NE reports the results of a diagnostic sequence to the TMN. It may be used in conjunction with the request and stop functions and has applications where it may be necessary or desirable to repeat diagnostic tests for a period of time to "catch" a failure;

4) *Schedule diagnostic* – TMN directs NE to establish a routine schedule for the initiation of a diagnostic;

5) *Request diagnostic schedule* – TMN requests NE to report the current schedule of diagnostics;

6) *Diagnostic schedule report* – NE sends the current schedule of diagnostics;

7) *Request exercise report* – TMN requests NE to send the results of a particular exercise;

8) *Exercise report* – NE sends the results of an exercise to TMN;

9) *Stop exercise* – TMN directs NE to stop a particular exercise in progress;

10) *Schedule exercise* – TMN directs NE to establish a routine schedule for the initiation of an exercise;

11) *Request exercise report schedule* – TMN directs NE to send the current schedule of an exercise. NE responds with the schedule;

12) *Operate/release loopback* – TMN directs NE to establish or release a specific loopback. It may be activated either remotely by TMN or locally by craft action;

13) *Test internal access path* – TMN directs NE to connect a termination on NE to another termination by a specified path within NE, then test the path;

14) *Hold network path* – TMN directs NE to hold a particular network path;

15) *Start/stop program traps* – TMN directs NE to start or stop a specific program trap;

16) *Program trap report* – NE automatically reports to TMN the occurrence of a program trap;

17) *Start/stop program trace* – TMN directs NE to start or stop a specific trace;

18) *Program trace report* – NE automatically reports to TMN the results of a trace;

19) *Start/stop audit* – TMN directs NE to start or stop an audit;

20) *Audit report* – NE automatically reports to TMN the results of an audit;

21) *Schedule audit* – TMN directs NE to establish a specified schedule for a given audit;

22) *Request audit schedule* – TMN requests NE to send the current audit schedule. NE responds with the test schedule;

23) *Start/stop loop insulation test* – TMN directs NE to start or stop a loop insulation test;

24) *Schedule loop insulation test* – TMN directs NE to schedule a loop insulation test;

25) *Request loop insulation test schedule* – TMN requests NE to send current loop insulation test schedule. NE responds with the schedule.

B.3.2.3 *Testing*

B.3.2.3.1 *Voiceband and voiceband data circuits test*

B.3.2.3.1.1 *Access and control*

1) *Connect test access* – TMN directs NE to provide a monitor connection to the transmission pairs of the accessed circuits;

2) *Disconnect test access* – TMN directs NE to drop access to the circuit under test and return the circuit to its normal state;

3) *Request test result* – TMN requests NE to report intermediate or final results from a measurement;

4) *Test result report* – NE sends the results of a test to TMN;

5) *Change terminate and leave (T&L)* – TMN directs NE to change T&L state of the circuit under test and report the resulting T&L state to TMN;

6) *Request to terminate and leave* – TMN directs NE to report the T&L status of the circuit under test;

7) *Terminate and leave report* – NE reports the T&L status of the circuit under test;

8) *Change pairs* – TMN directs NE to execute reversals of specified transmission pairs for 4- and 6-wire metallic circuits on either the equipment or facility side of the test port;

9) *Change leads* – TMN directs NE to execute reversal of tip and ring leads of metallic transmission pairs on the circuit under test;

10) *Change port restore* – TMN directs NE to clear all test conditions and restore the circuit to a monitor state;

11) *Request facility test status* – TMN directs NE to send the status of the facility carrying the circuit under test;

12) *Facility test status report* – NE sends the status of the facility carrying a specified circuit.

B.3.2.3.1.2 *Monitor and talk*

1) *Connect talk and split* – TMN directs NE to establish talk and listen paths between the circuit under test and the monitor/talk line;

2) *Connect monitor listen* – TMN listens selectively to the circuit under test and monitors any transmission pair in either direction;

3) *Change monitor level* – the TMN directs NE to change the level of the monitor connection;

4) *Change monitor filter* – TMN directs NE to remove or insert the single frequency notch filter placed in the monitor connection;

5) *Disconnect monitor* – TMN directs NE to remove any monitor or talk conditions established on the circuit under test.

B.3.2.3.1.3 *Measurement*

1) *Measure circuit characteristic* – TMN directs NE to measure a circuit characteristic including, but not restricted to, voltage, current, tip-ring-ground capacitance and resistance, noise, tone and outpulsing signals;
2) *Apply test signals* – TMN directs NE to send a test signal on the circuit. Examples are outpulsing and ringing signals;
3) *Remove test signal* – TMN directs NE to remove the test signal sent by the apply function;
4) *Stop measurement* – TMN directs NE to terminate continuous or repeating type measurements.

B.3.2.3.1.4 *Signalling and supervision*

1) *Change split and supervision* – TMN directs NE to set up metallic test access splitting of the circuit and supervise in both directions for both a.c. and d.c. supervision;
2) *Request supervision status* – TMN requests NE to send in an analysis of the current signalling state of the circuit under test;
3) *Supervision status report* – TMN reports the current signalling state of a circuit under test to TMN.

B.3.2.3.2 *Digital data circuit test*

B.3.2.3.2.1 *Test access*

1) *Connect test access digital* – TMN directs NE to provide test access to a digital data circuit;
2) *Monitor digital signals* – TMN establishes digital data monitor test access and determines the presence of network control codes or customer data;
3) *Change digital test access to split* – TMN directs NE to provide split test access to the digital circuit under test;
4) *Test digital loopback* – TMN directs NE to provide a loopback on the circuit under test and perform a loopback test;
5) *Change latching loopback* – TMN splits the circuit under test and changes the operate and release functions of digital network element latching loopback devices;
6) *Change multipoint junction unit functions* – TMN directs NE to perform various control functions such as block, select, unselect, and release, on the multipoint junction unit (MJU) in the circuit;
7) *Test* multipoint junction unit – TMN directs NE to split the circuit under test and performs primary and secondary channel tests on the multipoint junction unit (MJU);
8) *Test straightaway* – TMN directs NE to split the circuit under test and connect the required test modules to perform a straightaway test;
9) *Establish loop around access* – TMN directs NE to establish a test access to a metallic circuit by selecting a test access path (TAP) and providing a looparound on the selected TAP;
10) *Connect monitor state* – TMN directs NE to establish a monitor state without the need to re-access the circuit under test. This function will remove or reset any previous state or condition except the terminate and leave state;
11) *Change split metallic/digital* – TMN directs NE to split the specified pair or pairs at the metallic or digital access point of the circuit under test, and connect it to the TAP. Both the facility (F) and equipment (E) sides of the split circuit are connected to the TAP, in agreement with the lead-pair assignment and configuration code;
12) *Change terminate and leave metallic/digital* – TMN directs NE to change the terminate and leave state of the circuit under test;
13) *Silence repeater* – TMN directs NE to shut down a repeater;
14) *Request TAPs status* – TMN requests the status of all TAPs serving NE;
15) *TAPs status report* – NE reports the status of all TAPs to TMN;
16) *Reset TAPs* – TMN directs NE to release all existing test access connections in the NE. It also restores all TAPs involved to an idle state;

17) *Diagnose TAP* – TMN directs NE to carry out a looparound of the TAPs from the test system for purposes of diagnosis.

B.3.3 *Configuration management*

B.3.3.1 *Provisioning*

B.3.3.1.1 *NE configuration*

1) *Request configuration* – TMN requests that the NE report the current configuration of each entity;

2) *Configuration report* – For each entity, NE reports status, capacity of the entity, optional parameters, type of entity (in sufficient detail for TMN identification) and the version and revision of the version;

3) *Grow* – TMN notifies NE of the presence of a newly installed entity;

4) *Prune* – TMN notifies NE of the disconnection of an entity;

5) *Restore* – TMN notifies NE to begin monitoring the newly installed entity;

6) *Assign* – TMN notifies NE that a previously unequipped entity is now equipped;

7) *Delete* – TMN notifies NE that a previously unequipped entity is no longer equipped;

8) *Set service state* – TMN directs NE to place the specified entity in one of the following states: in service (available for use), out of service (unavailable for use), standby (not faulty but not performing normal function), reserved;

9) *Request assignments* – TMN requests that NE report the identity of each assigned entity. The request may be for a specified entity or for all equipped entities;

10) *Assignment reports* – NE reports the identity of each assigned channel for each equipped entity or for a specified entity;

11) *Set parameters* – TMN directs NE to set parameters associated with a specified entity;

12) *Set service thresholds* – TMN directs NE to set performance thresholds for the specified channel;

13) *Add/drop* – TMN directs NE to insert or remove a channel from the complement of through-channels;

14) *Cross-connect* – TMN directs NE to interconnect two specified channels operating at the same rate;

15) *Disconnect* – TMN directs NE to remove the interconnection between two specified channels;

16) *Start transmission test* – TMN directs NE to begin a transmission test on a given circuit;

17) *Balance* – TMN directs NE to perform a balance test/adjustment;

18) *Start transponder test* – TMN directs NE to look for a transponder signal on the given circuit;

19) *Set report periods* – The TMN directs NE to set or change report periods;

20) *Request report periods* – The TMN requests NE to send the current periods to the TMN.

B.3.3.1.2 *Administrative functions*

1) *Set clock* – TMN directs NE to set NE system clock to current calendar, date and time;

2) *Backup copy* – TMN directs NE to make a backup copy of the designated NE data base file for purposes of archiving for future restoral;

3) *Terminate procedure* – TMN directs the NE to terminate a process between a TMN and a NE;

4) *Route messages* – TMN directs NE to route automatic messages generated by NE to one or multiple communications channels;

5) *Set service controls* – TMN directs NE to assign user access and functional capability.

B.3.3.1.3 *Data base management*

1) *Initialize* – TMN configures a new data base which is related to an NE. This may or may not be downloaded to the NE. This may also include loading a new program related to the NE;

2) *Reinitialize* – TMN reconfigures the data base within an NE while it is in service;

3) *Update* – TMN adds, changes or deletes one or more records in the data base of an NE. This can be done in a delayed activation mode or upon command entry. It may also be able to enter data base updates on a test basis prior to permanent entry;

4) *Query* – TMN reads NE for all or part of its data base contents;

5) *Backup* – TMN keeps a copy of all or part of the data base of an NE. In case of memory failure in the NE, the TMN downloads the backup copy to the NE.

B.3.3.2 *Status and control*

1) *Request status* – TMN requests NE to send current status information;

2) *Status report* – NE reports to TMN the value of a monitored parameter. It may be sent on demand by TMN or on a scheduled basis;

3) *Schedule status report* – TMN directs NE to establish a schedule for the reporting of status information;

4) *Request status report schedule* – TMN directs NE to send the current schedule of status reporting. NE responds with the schedule;

5) *Allow/inhibit automatic restoration* – TMN directs NE to allow or inhibit automatic restoration in an M+N or duplex system;

6) *Operator/release automatic restoration* – TMN directs NE to switch a specified line or equipment to the redundant unit or release it from the redundant unit. For an M+N system, service is placed on the redundant unit and taken off of the working unit. For a duplex system the main unit becomes standby and the standby unit becomes the main unit.

B.3.3.2.1 *Message handling systems network*

1) *Request message storage status data* – TMN requests NE to transmit the message storage status data of store and forward communication to TMN;

2) *Message storage status data report* – NE sends the status data to TMN.

B.3.3.2.2 *Leased circuit network*

1) *Request status of dynamic provisioning of leased circuit network* – TMN requests NE to transmit the status of dynamic provisioning to TMN;

2) *Status report of dynamic provisioning of leased circuit networks* – NE sends the current status to TMN.

B.3.3.2.3 *Transmission network*

1) *Request status of automatic transmission restoration* – TMN requests NE to transmit the switching activities and current status of automatic transmission restoration;

2) *Status report of automatic transmission restoration* – NE sends the current status of the switching operations to TMN.

B.3.3.3 *Installation*

A detailed list of installation functions for an SPC-exchange is provided in Recommendation Z.331 [1], § 3.3.

B.3.4 *Accounting management*

This term and the subject is for further study.

B.3.5 *Security management*

1) *Change channel class* – TMN directs NE to change the security user class of an operations channel;

2) *Change terminal class* – TMN directs NE to change the security class of NE terminal;

3) *Dial capability* – TMN directs NE to initiate a secure dial-out/dial-back capability to TMN;

4) *Log in* – TMN sends the appropriate password and identification of an NE communications channel;

5) *Log off* – TMN directs NE to terminate communication on a channel;

6) *Change* – TMN directs NE to change the log-in code assigned to NE;

7) *Change dial number* – TMN directs NE to change the auto-dial-back number that NE uses to call back the calling party upon receipt of a dial-out call.

B.4 Glossary

B.4.1 **alarm**

An alerting indication to a condition that may have immediate or potential negative impact on the state of the monitored NE.

B.4.2 **alarm attribute**

A collective reference to delaying, stretching and severity of alarm indications.

B.4.3 **alarm route**

A path between an NE and a TMN for the transmission of alarm information.

B.4.4 **audit**

A test of the validity of data and/or generic programs in the NE.

B.4.5 **control**

A modifier of the state of an NE.

B.4.6 **delaying**

Withholding the report of alarm information until the condition has persisted for a predetermined amount of time.

B.4.7 **diagnostic**

A routine in the NE which performs detailed tests to isolate troubles.

B.4.8 **exercise**

Sequential operations which test the overall functioning of an NE or sub-system.

B.4.9 **initialization**

Setting a process to a specified state. This may be a restart state or intermediate levels.

B.4.10 **loopback**

A procedure used in fault location whereby a signal is returned to its source along the same path on which it was received.

B.4.11 **mode**

The alarm characteristic of being either continuous or self-retiring.

B.4.12 **performance monitoring (PM)**

The monitoring of various parameters of an NE on an in-service basis to measure the quality of performance.

B.4.13 **performance monitoring attributes**

Characteristics of PM parameters including thresholds and pattern recognition criteria.

B.4.14 **severity**

An alarm attribute indicating the magnitude of the related failure. Some measures of severity include major, minor, service affecting and non-service affecting.

B.4.15 **supervisory signal**

A signal indicating the state or change of state of a circuit.

B.4.16 **scheduling**

Can include the assignment of time intervals to the execution of one or more functions by the NE. It can also include inhibition or allowance of execution of the function without affecting prior scheduling.

B.4.17 **status**

Information on the current state of an NE.

B.4.18 **stretching**

Holding the indication of an alarm condition for a predetermined amount of time, even after the condition resolves to increase the chance that the TMN has scanned the indication.

B.4.19 **terminate and leave (T&L)**

Terminating one or both direction of transmission on an outgoing transmission path.

B.4.20 **test access point (TAP)**

A virtual or physical testing path between a test system and the circuit under test in the NE.

B.4.21 **thresholding**

Assignment of a specified value of a monitored parameter such that trouble indication is generated only when this value is exceeded.

B.4.22 **trace**

A report of the execution flow of a specified event.

B.4.23 **trap**

An automatic report of a specified event which would otherwise not be reported.

ANNEX C

(to Recommendation M.30)

Tables of function attribute ranges

The TMN should be designed such that it has the capability to interface with several types of communications paths, to ensure that a framework is provided which is flexible enough to allow for the most efficient communications between the NE and the TMN, workstations and the TMN, between elements within the TMN or between TMNs. In this case the term efficiency relates to the cost, reliability and quantity of the data transported.

Costs are impacted by two aspects. The first is the actual cost to transport data across the network between the TMN and the NE. To minimize this cost various network architectures are considered, e.g., star, multipoint, loop, tree. The communications required must also be considered, e.g. leased circuits, circuit switched or packet-switched networks. In making this choice, network availability and cross-network delays must be evaluated as attributes to be used in the decision-making process.

The second aspect is the design of the interface including the selection of the appropriate communications protocol. In this case there are several attributes associated with functions performed within the NE that would help to govern this choice. These attributes include: reliability, frequency, quantity and the requirement for priority.

This Annex provides tables of ranges for each of the function attributes that should be taken into consideration when planning the design of the data communications channels and selecting the appropriate protocol to be used to interface between a TMN and NE, TMN and workstation, or between elements within a TMN. Table C-1/M.30 shows the basic function attributes. Table C-2/M.30 shows examples of TMN attributes to support the OSs requiring real-time operations, and Table C-3/M.30 shows examples of the same attributes for a non real-time OS.

TABLE C-1/M.30

Basic table of function attributes

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

TABLE C-2/M.30

Example of function attributes for real-time operation [a), b)]

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

a) "Real-time" has a two-fold meaning:

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

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

b) Attributes can be considered for:

i) each command, each inquiry, the responses to them, and each spontaneous report,

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

c) For example, file loading, system recovery, etc. (type B).

d) For example, system file saving, call data saving, etc.

TABLE C-3/M.30

Example of function attributes for non-real-time operation [a), b)]

	Attributes	Requirements		Attribute ranges
(P)	Delay (speed)	Short Medium Long		Network delay < 30 s Network delay < 15 min Network delay ⩾ 15 min
	Reliability (accuracy)	High Medium Low		No errors (goal) Infrequent errors (not service affecting) Can tolerate errors
	Availability	High Medium Low		Network availability > 99.95 % Network availability > 95 % Network availability ⩽ 95 %
(C)	Quantity	Large Medium Small		> 4096 octets per transaction (10^6 to 10^7 octets per job) [c)] < 256 octets per transaction < 256 octets per transaction
	Frequency	Non-periodic	Often Medium Seldom	> 1 transaction per minute ⩾ 1 transaction per hour < 1 transaction per hour (week, month) [c)]
		Periodic	Often Medium Seldom	> 1 transaction per minute ⩾ 1 transaction per hour < 1 transaction per hour
	Priority	High Medium Low		

a) Non-real time operation can include both off-line and on-line operations.

b) Attributes can be considered for:

i) each command, each inquiry, the responses to them, and each spontaneous report,

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

c) For example, file transfer, large volume data transfer, etc.

References

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

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

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

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

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