Introduction to TMN

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Introduction to TMN

The term TMN is introduced by the ITU-T (the former CCITT) as an abbreviation for 'Telecommunications Management Network'. The concept of a TMN is defined by [Recommendation M.3010](). TMN has a strong *relationship with OSI management*, and defines a number of concepts that have *relevance for Internet Management*.

According to M.3010, "a TMN is conceptually a separate network that interfaces a telecommunications network at several different points". The relationship between a TMN and the telecommunication network that is managed, is shown in Figure 1. According to this figure, the interface points between the TMN and the telecommunication network are formed by *Exchanges* and *Transmission systems*. For the purpose of management, these Exchanges and Transmission systems are connected via a *Data Communication Network* to one or more *Operations Systems*. The Operations Systems perform most of the management functions; these functions may be carried out by human operators but also automatically. It is possible that a single management function will be performed by multiple Operations Systems. In this case, the Data Communication Network is used to exchange management information between the Operation Systems. The Data Communication Network is also used to connect *Work Stations*, which allow operators to interpret management information. Work Stations have man-machine interfaces, the definition of such interfaces fall outside the scope of TMN (Work Stations are therefore drawn at the border of the TMN).

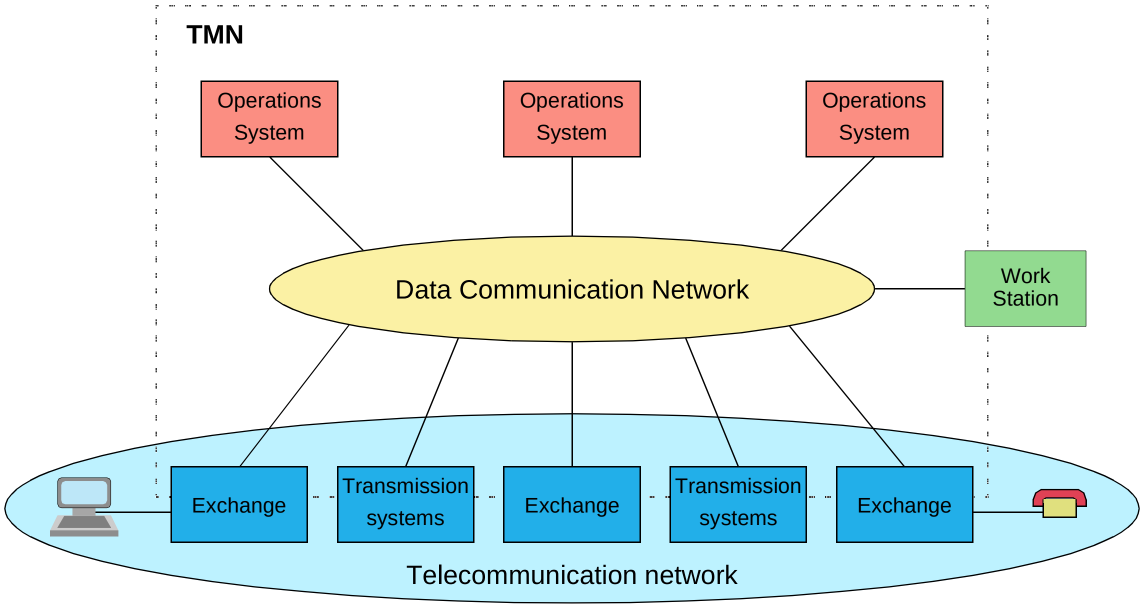

Figure 1: General relationship of a TMN to a telecommunication network

Recommendation M.3010 defines the general TMN management concepts and introduces several management architectures at different levels of abstraction:

- A *functional architecture*, which describes a number of management functions.
- A *physical architecture*, which defines how these management functions may be implemented into physical equipment.
- An *information architecture*, which describes concepts that have been adopted from OSI management.
- A *logical layered architecture* (LLA), which includes one of the best ideas of TMN: a model that shows how management can be structured according to different responsibilities.

1 TMN standardization

The TMN standardization started in 1985 by CCITT Study Group IV [1]. The first TMN recommendation was called M.30 [2] and was published in 1988 as part of the *blue books*. In 1992 a completely revised version appeared and the number of the recommendation was changed into M.3010. This version changed again in 1996 [4].
As compared to the 1988 version of M.30, the 1992 version of M.3010 removed the sections on 'Planning and Design' (which became an appendix) and on 'Functions associated with TMN'. The 1992 version added also a number of new sections, such as those on the 'TMN Information Architecture'. The most important changes of the 1996 version relate to 'TMN's Logical Layered Architecture'.

Since 1988 a number of related recommendations have been defined. These recommendations refine specific aspects of TMN and use M.3010 as the architectural basis (see Figure 2). In addition, a large number of TMN recommendations were defined for ISDN management.

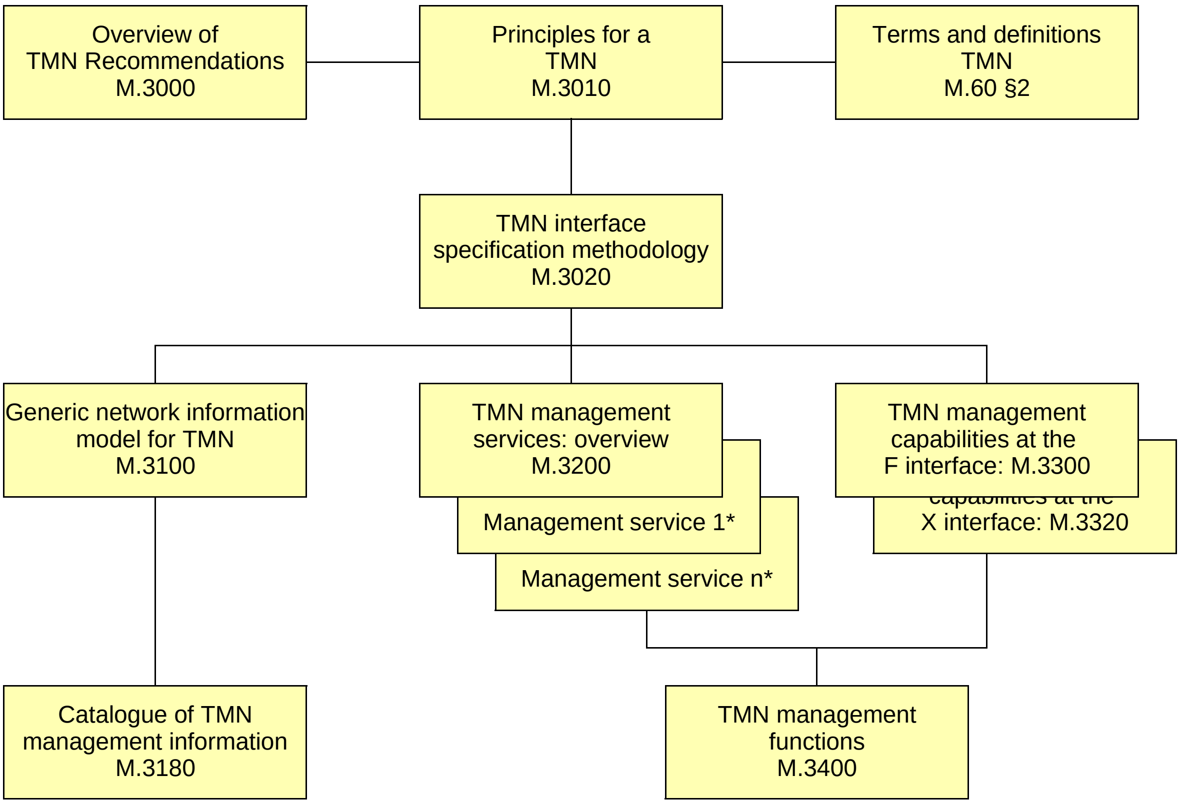

Figure 2: Relation between TMN recommendations

1.1 Basic TMN recommendations

Figure 3 shows the list of TMN recommendations, including the last modification date.

Title	NUMBER	DATE
Overview of TMN Recommendations	M.3000	10/94
Principles for a TMN	M.3010	05/96
TMN interface specification methodology	M.3020	07/95
Generic network information model	M.3100	07/95
Managed object conformance statements for the generic network inf. model	M.3101	07/95
Catalogue of TMN management information	M.3180	10/92
TMN Management Services: Overview	M.3200	10/92
TMN management Services: Maintenance aspects of B-ISDN management	M.3207.1	05/96
TMN management Services: Fault and performance mgt. of the ISDN access	M.3211.1	05/96
TMN management capabilities presented at the F interface	M.3300	10/92
Management requirements framework for the TMN X-interface	M.3320	04/97
TMN management functions	M.3400	04/97

Figure 3: TMN related recommendations

1.2 TMN recommendations for ISDN

Figure 4 shows the list of TMN recommendations for (broadband) ISDN, including the last modification date.

Title	NUMBER	DATE
Principles for the management of ISDNs	M.3600	10/92
Application of maintenance principles to ISDN subscriber installations	M.3602	10/92
Application of maintenance principles to ISDN basic rate access	M.3603	10/92
Application of maintenance principles to ISDN primary rate access	M.3604	10/92
Application of maintenance principles to static multiplexed basic rate access	M.3605	10/92
Principles for applying the TMN concept to the management of B-ISDN	M.3610	05/96
Test management of the B-ISDN ATM layer using the TMN	M.3611	04/97
Principles for the use of ISDN test calls, systems and responders	M.3620	10/92
Integrated management of the ISDN customer access	M.3621	07/95
Management of the D-channel - Data link layer and network layer	M.3640	10/92
Management information model for the management of the data link and network layer of the ISDN D channel	M.3641	10/94
Network performance measurements of ISDN calls	M.3650	04/97
ISDN interface management services	M.3660	10/92

Figure 4: TMN recommendations for ISDN

2 Functional Architecture

Five different types of *function blocks* are defined by TMN's functional architecture. It is not necessary that all of these types are present in each possible TMN configuration. On the other hand, most TMN configurations will support multiple function blocks of the same type.

Figure 5 has been copied from the TMN recommendations and shows all five types of function blocks[1]. In this figure, two types (OSF and MF) are completely drawn within the box labelled 'TMN'. This way of drawing indicates that these function blocks are completely specified by the TMN recommendations. The other three types (WSF, NEF and QAF) are drawn at the edge of the box to indicate that only parts of these function blocks are specified by TMN. Subsection 2.1 until Subsection 2.5 give short descriptions these five function blocks.

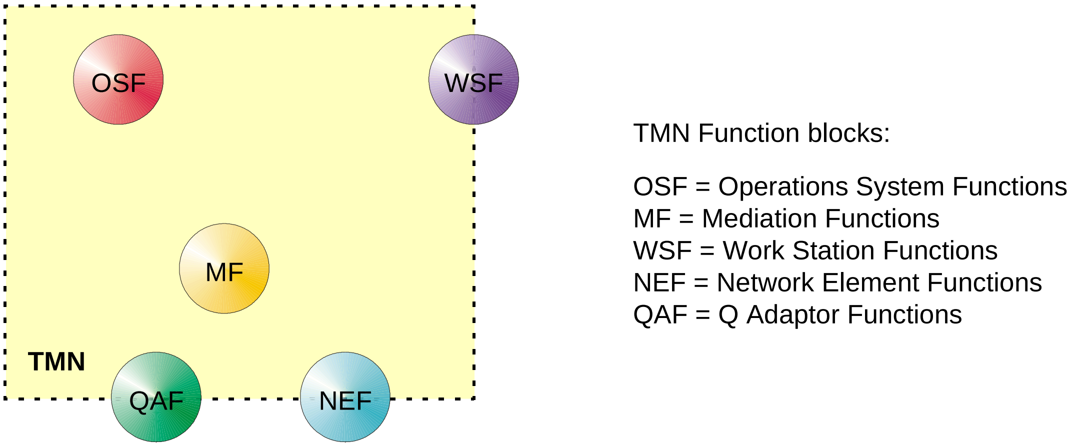

Figure 5: TMN Function blocks

The TMN functional architecture introduces the concept of reference point to delineate function blocks. Five different classes of *reference points* are identified. Three of them (q, f and x) are completely described by the TMN recommendations; the other classes (g and m) are located outside the TMN and only partially described.

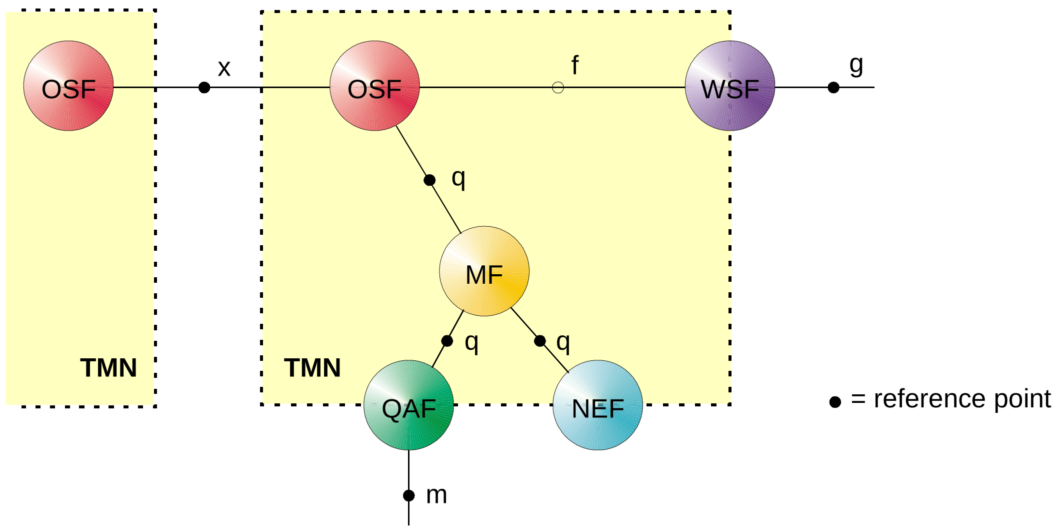

Figure 6: Example of reference points between function blocks

Figure 6 provides an example of reference points and function blocks. The picture shows for instance that the Mediation Function (MF) can be reached via *q* reference points and that the *m* reference point can be used to reach the Q Adaptor Function (QAF) from outside TMN.

1. To avoid adventitious interpretations, it was decided to copy as far as possible drawings from Recommendation M.3010.

2.1 Network Element Functions

A typical telecommunication network consists of *exchanges* and *transmission systems*. In TMN terminology, exchanges and transmission systems are examples of *network elements* (NEs). The functions that are performed by NEs are 'Network Element Functions' (NEFs). According to TMN, these functions include:

- Primary (or telecommunications) functions. These functions are the subject of management and support the exchange of data between the users of the telecommunication network.
- Management functions, which allow the NEF block to operate in an agent specific role.

As opposed to the second kind, the first kind of functions are not further defined by TMN. This explains why Figure 5 locates the NEF at the edge of the TMN.

2.2 Operations System Functions

The Operations System Functions (OSF) block initiates management operations and receives notifications. In terms of the manager-agent model, the OSF may be seen as the manager specific functions. An OSF communicates with the NEF over a q_3 reference point (Figure 7).

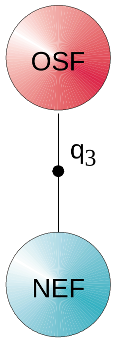

Figure 7: OSF and NEF

The initial 1988 version of M.30 defined three different q reference points: q_1, q_2 and q_3. The q_3 reference point is used whenever management information should be exchanged via an application layer management protocol, such as the Common Management Information Protocol (CMIP [6]) of OSI. The two other reference points were intended for cases in which management information should be exchanged via lower layer (e.g. data link) management protocols. After some time it appeared however that it was impossible to make a distinction between q_1 and q_2; these two reference points were therefore replaced by the generic q_x reference point.

Figure 8 shows the relation between OSF, NEF and q_3, expressed in terms of the OSI service and protocol concepts. The service provided at the q_3 reference point is generally the *Common Management Information Service* (CMIS [5]).

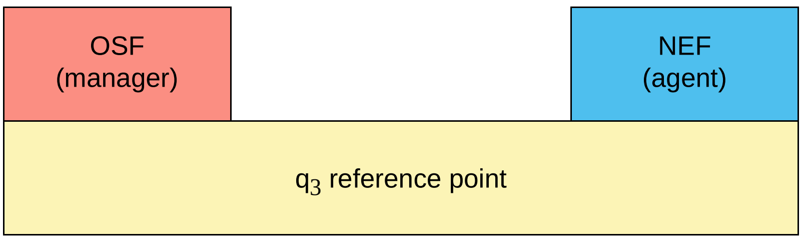

Figure 8: Relation between OSF, NEF and q_3, expressed in terms of OSI concepts

Within a single TMN (operated by a single administration) multiple OSFs may be defined. If necessary, these OSFs can communicate with each other over q_3 reference points. It is also possible that OSFs in different TMNs (operated by different administrations) communicate with each other; in this case communication takes place over a *x* reference points.

2.3 Work Station Functions

"The Work Station Function (WSF) block provides the means to interpret TMN information for the management information user. The WSF includes support for interfacing to a human user (at the g reference point). Such aspects of support are not considered to be part of the TMN". Figure 5 therefore locates the WSF at the edge, and the g reference point outside the TMN.

2.4 Q Adaptor Functions

The *Q Adaptor Function* (QAF) block is used to connect to the TMN those entities which do not support standard TMN reference points. An example is shown in Figure 9; in this figure a non-TMN OSF and a non-TMN NEF are connected to the TMN. The responsibility of both QAFs is to translate between *q* reference points (which are TMN reference points) and *m* reference points. Since the m reference point is a non-TMN (e.g. proprietary) reference point, Figure 5 showed the QAF at the edge of the TMN.

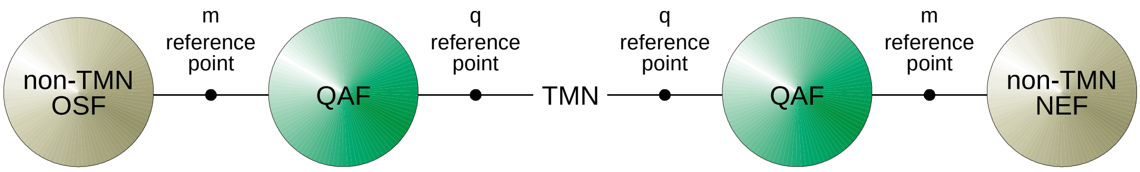

Figure 9: Q Adaptor Functions

2.5 Mediation Functions

The *Mediation Function* (MF) block is located within the TMN and acts on information passing between NEFs or QAFs, and OSFs. A MF block can be used to connect a single (Figure 10), as well as multiple NEFs and QAFs to an OSF. MF blocks can also be cascaded.

Among the types of MFs that can be recognized, are those that:

- Augment OSFs; examples are storage and filtering of management information.
- Augment NEFs; an example is the transformation from the local representation of management information into a standardized form.

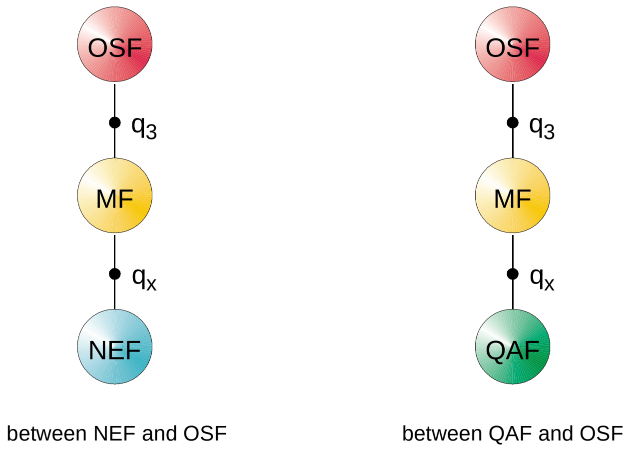

Figure 10: MF related to other function blocks

2.6 Relationship between function blocks

Now that an initial understanding of all function blocks and reference points exists, it is possible to discern all relationships between these function blocks and reference points. This relationship is given in Figure 11.

	NEF	OSF	MF	QAF_{q3}	QAF_{qx}	WSF	Non-TMN
NEF		q_3	q_x				
OSF	q_3	x*, q_3	q_3	q_3		f	
MF	q_x	q_3	q_x		q_x	f	
QAF_{q3}		q_3					m
QAF_{qx}			q_x				m
WSF		f	f				g**
Non-TMN				m	m	g**	

m, g = non TMN reference points

* = x reference point only applies when each OSF is in a different TMN
** = The g reference point lies between the WSF and the human user

Figure 11: Relation between function blocks

A function block at the top of a column may exchange management information with a function block at the left of a row over the reference point that is mentioned at the intersection of the column and row. In case an intersection is empty, the associated function blocks can not directly exchange management information between each other.

2.7 Further remarks

Besides the function blocks and reference points, the TMN functional architecture introduces some additional concepts. These concepts are:

- TMN's Data Communication Function
- TMN's functional components

According to recommendation M.3010, "TMN's Data Communication Function (DCF) will be used by the function blocks for exchanging information. The DCF provides layers 1 to 3 of the OSI RM".
The definition of the DCF concept has historical reasons: in initial drafts of TMN the DCF was modelled as a function block; it was therefore part of TMN's functional architecture. At present the DCF is no longer modelled as a function block; the text that describes the DCF remained, however.

Each of TMN's function blocks is itself composed of a number of *functional components*. The following functional components are defined:

- Management Application Function.
- Management Information Base.
- Information Conversion Function.
- Human Machine Adaptation.
- Presentation Function.
- Message Communication Function (MCF).

These functional components can be divided into two categories:

- The first five components belong to the first category. These components perform the actual management actions; they do not address problems related to the exchange of management information.
- The last component (MCF) belongs to the second category. This component is associated with all function blocks that require an underlying service for the exchange of their management information. "The MCF is composed of a protocol stack that allows connection of function blocks to DCFs". In many cases the MCF provides the end-to-end functions such as those found in OSI layers 4 to 7.

Recommendation M.3010 contains a picture (Figure 12) to illustrate the relation between function blocks, functional components, the MCF and the DCF.

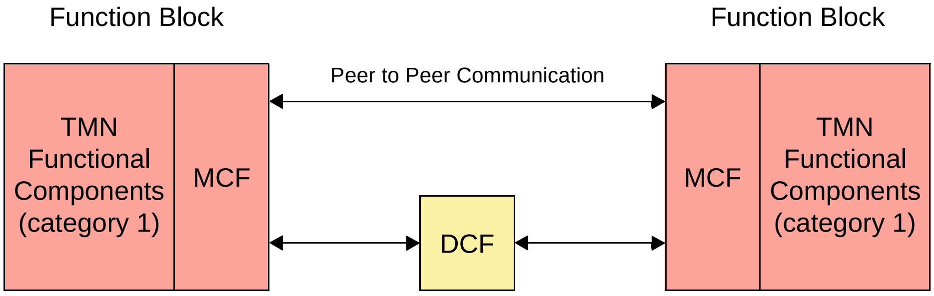

Figure 12: Function blocks, components, MCF and DCF

3 Physical Architecture

Next to a functional architecture, TMN also defines a physical architecture. The latter architecture shows how TMN's functions, which were defined by the functional architecture, can be implemented into physical equipment. TMN's physical architecture is thus defined at a lower abstraction level than TMN's functional architecture (Figure 13).

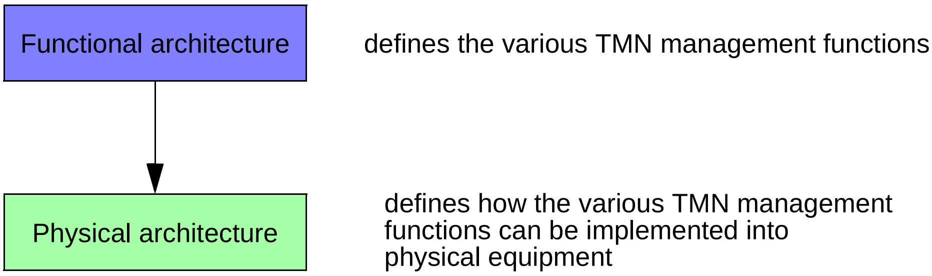

Figure 13: TMN has defined multiple, related architectures

The physical architecture shows how function blocks should be mapped upon *building blocks* (physical equipment) and reference points upon *interfaces*. In fact, the physical architecture defines how function blocks and reference points can be implemented (Figure 14). It should be noted however that one function block may contain multiple functional components and one building block may implement multiple function blocks.

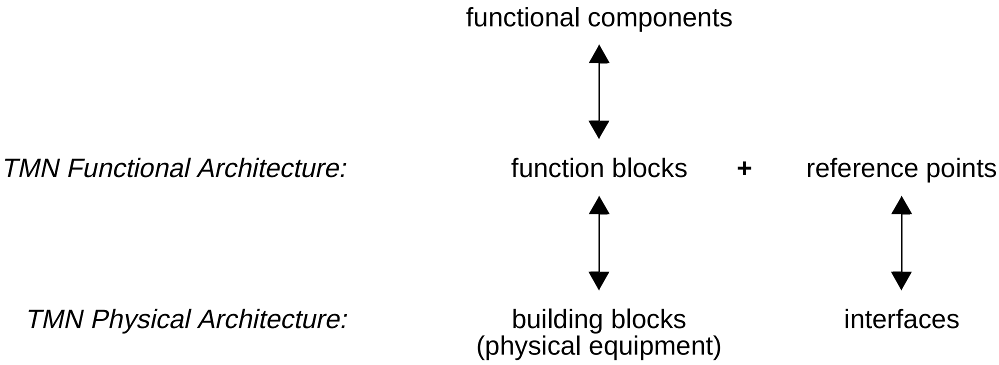

Figure 14: Relation between TMN Architectures

To avoid confusion between the functional and physical architecture, it is helpful to understand the following conventions. Names of reference points are written in lower case, names of interfaces in upper case (subscripts may be added). Reference points are drawn as small filled circles (bullets), interfaces as open circles. Function blocks are shown as big circles or ellipses, building blocks are drawn as boxes.

Figure 15: Drawing conventions

3.1 Building blocks

TMN's Physical Architecture defines the following building blocks:

- Network Element (NE).
- Mediation Device (MD).
- Q Adaptor (QA).
- Operations System (OS).
- Work Station (WS).
- Data Communication Network (DCN).

Building blocks always implement the function blocks of the same name (e.g. Network Elements perform Network Element Functions, Mediation Devices perform Mediation Functions etc.).

It is possible to implement multiple function blocks (of the same or of a different type) into a single building block. The Operations System, for example, may be used to implement multiple OSFs, but may also be used to implement an OSF, MF and a WSF. In the case a building block implements multiple function blocks of different types, "the choice on the building block's name is determined by the predominate usage of the block".
Figure 16 shows which function blocks may be implemented into which building blocks.

	NEF	MF	QAF	OSF	WSF
NE	M	O	O	O	O*
MD		M	O	O	O
QA			M		
OS		O	O	M	O
WS					M
DCN					

M = Mandatory
O = Optional
O* = may only be present if OSF or MF is also present

Figure 16: Relation between function blocks and building blocks

A special kind of building block is the Data Communication Network (DCN). As opposed to the others, this building block does not implement any TMN function block. In fact, the DCN is *used* by other building blocks for the exchange of management information; the DCN's task is to act as a transport network.

At first sight it seems strange that TMN defines a building block that does not implement any function block. The existence of the DCN can be understood however when we remember that previous TMN drafts (e.g. [8]) modelled the DCF as a function block. According to these drafts, the DCF had to be implemented by a DCN and, in that case, each building block implemented at least one function block. In 1990 it was decided however to model the DCF no longer as a function block [9]. After this decision was made, the standard was not rewritten in a consistent way and the DCN is therefore still modelled as a building block.

3.2 Interfaces

Interfaces may be regarded as the implementations of TMN reference points. Whereas reference points may generally be compared with underlying *services*, interfaces may be compared with the *protocol stacks* that implement these services.
In most cases reference points and interfaces have a one to one mapping. However, no interfaces exist for those reference points that:

- interconnect function blocks that are implemented within a single building block,
- lay outside TMN (g and m, see Figure 6). Implementation of these reference points is outside the scope of TMN.

The naming of interfaces is also straightforward: an interface gets the same name (this time written in upper case) as the related reference point. Figure 17 shows all possible mappings.

reference point	q_x	q_3	x	f	(g	m)
	↓	↓	↓	↓		
interface	Q_x	Q_3	X	F		

Figure 17: Mapping reference points upon interfaces

4 Information Architecture

TMN's information architecture uses an object oriented approach and is based on OSI's Management Information Model [7]. According to this model, the management view of a managed object is visible at the *managed object boundary*. At this boundary, the management view is described in terms of (Figure 18):

- Attributes, which are the properties or characteristics of the object.
- Operations, which are performed upon the object.
- Behaviour, which is exhibited in response to operations.
- Notifications, which are emitted by the object.

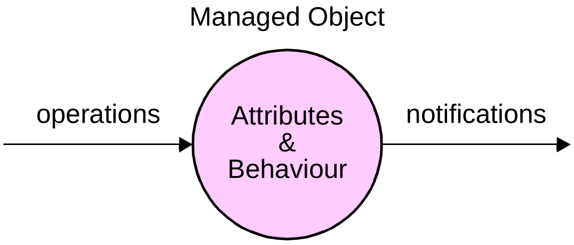

Figure 18: A managed object

The managed objects reside within managed systems, which include agent functions to communicate with the manager. TMN uses the same manager-agent concept as OSI.

Because TMN's information architecture is a copy from OSI's information architecture, this tutorial will not discus the information architecture any further.

5 Logical Layered Architecture

TMN recognizes that, corresponding to human society, a hierarchy of management responsibilities exist. Such hierarchies can be described in terms of management *layers*; the architecture that describes this layering is called the *Logical Layered Architecture*. Over time the concept of management layers has become the most important concept of TMN; it appeared as appendix in the 1992 version of M.3010 and moved into the main text of the 1996 version. The ideas behind this architecture were described first in 1989 by BT [10] as part of its Open Network Architecture (ONA). BT uses the name structural architecture for this model [11]; the name *responsibility model* is being used too.

To deal with the complexity of management, the management functionality with its associated information can be decomposed into a number of logical layers. The principle of such layering is shown in Figure 19. At the border between Layer 1 and 2 the management view of Layer 2 is presented to Layer 1; this view is presented in the form of management information that is contained within the agent at Layer 2. Note that the management view that is presented to layer 1 need not unveil all details of layer 2; the agent at layer 2 will only provide those pieces of management information that are necessary at layer 1. The principle of layering can be applied in a recursive fashion; the management view of Layer 3 can be presented to Layer 2 etc.

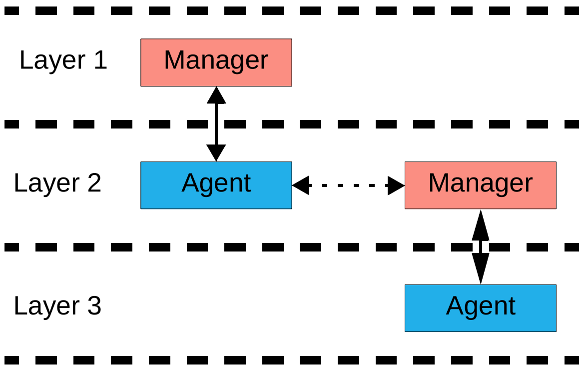

Figure 19: Decomposition of Management Functionality

A usual decomposition of management functionality leads to the following layers of abstraction:
- element management layer.
- network management layer.
- service management layer.
- business management layer.

These layers, including their function blocks and reference points, are shown in Figure 20.

5.1 Element Management layer

The functions of individual Network Elements are managed by Operations Systems Functions (OSF) in the *Element Management layer*. This layer deals with vendor specific management functions and hides these functions from the layer above, the Network Management layer.

Examples of functions performed at the Element Management layer are:
- detection of equipment errors,
- measuring power consumption,
- measuring the temperature of equipment,
- measuring the resources that are being used, like CPU-time, buffer space, queue length etc.,
- logging of statistical data,
- updating firmware.

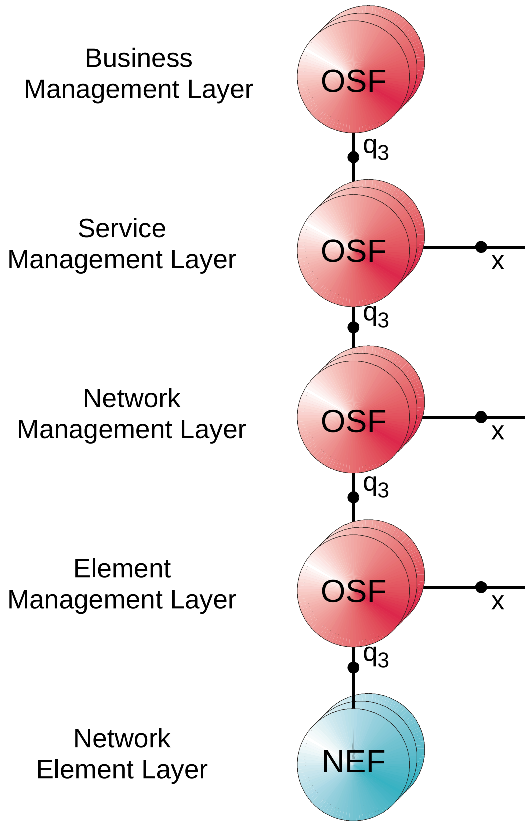

Figure 20: TMN-LLA Functional hierarchy

Note that an OSF in the Element Management Layer and a NEF may be implemented within the same piece of equipment, or in different pieces of equipment.

5.2 Network Management layer

Whereas the responsibility of the Element Management layer is to manage NEFs implemented within *single* pieces of equipment, the responsibility of the *Network Management layer* is to manage the functions related to the interaction between multiple pieces of equipment. At network management level the internal structure of the network elements is not visible; this implies that buffer space within routers, the temperature of switches etc. can not be directly managed at this level.

Examples of functions performed at this layer are:
- creation of the complete network view,
- creation of dedicated paths through the network to support the QoS demands of end users,
- modification of routing tables,
- monitoring of link utilization,
- optimizing network performance, and
- detection of faults.

The OSFs at the Network Management layer use the vendor independent management information that is provided by the OSFs in the Element Management layer. In this interaction the OSFs at the Network Management layer act in a manager role and the OSFs in the Element Management layer in an agent role.

5.3 Service Management layer

The *Service Management layer* is concerned with management of those aspects that may directly be observed by the users of the telecommunication network. These users may be end users (customers) but also other service providers (administrations). Service Management builds upon the management information that is provided by the Network Management layer, but does not 'see' the internal structure of the network. Routers, switches, links etc. can therefore not directly be managed at Service Management level.

Examples of functions performed at the Service Management layer are:

- Quality of Service management (delay, loss, etc.),
- Accounting,
- Addition and removal of users,
- Address assignment,
- Maintenance of group addresses.

The notion of Service Management can be regarded as the most valuable contribution of TMN and other management frameworks, most notably the Internet management framework, may take advantage of this idea and extend their management frameworks with this notion.

5.4 Examples of Service Management

Service Management may be useful in many cases.

A first case is the example in which two operators exchange management information to manage their interconnected networks (inter-operator management). For commercial and security reasons each of these operators will try to hide the internal structure of its network from the other operator; only those pieces of management information that are absolutely necessary will be exchanged. An example of such information may be Quality of Service figures.

A second case is the example where an operator who provides end-to-end transport services uses the network of another operator to connect its network elements. A typical example is an IP service provider, who uses ATM (or SDH or DWDM) links of other operators to connect its IP routers. This case is shown in Figure 21. In this figure there are three x-reference points from the IP service provider to the ATM service provider. At the side of the ATM service provider, all reference points are connected to the service management layer, since this service provider will not allow the IP service provider to monitor and modify the internals of its ATM network; only high level information like Quality of Service figures will be made available. For the IP service provider the ATM link can be seen as a single element in its IP network; this explains the reference point at the element management layer. In case the IP service provider has the option to choose alternative routes around the ATM link, there will also be a reference point at network management level. Finally the performance of the ATM link may impact the Quality of Service of the entire IP network; in this case there may be also be a reference point at service management level.

A third case is the example where an operator should exchange management information with customers (customer network management). Again the operator will try to hide the internal structure of its network from the customer, and allow the customer only access to high level information. Possible management interactions may be the provision of QoS figures by the operator or the modification of the members of a closed user group by the customer.

A fourth case is the example of Value Added Services (VAS). In this case one OSF may be responsible for management of the VAS and another OSF may be responsible for management of the telecommunications network that must be traversed to use the service. Both OSFs

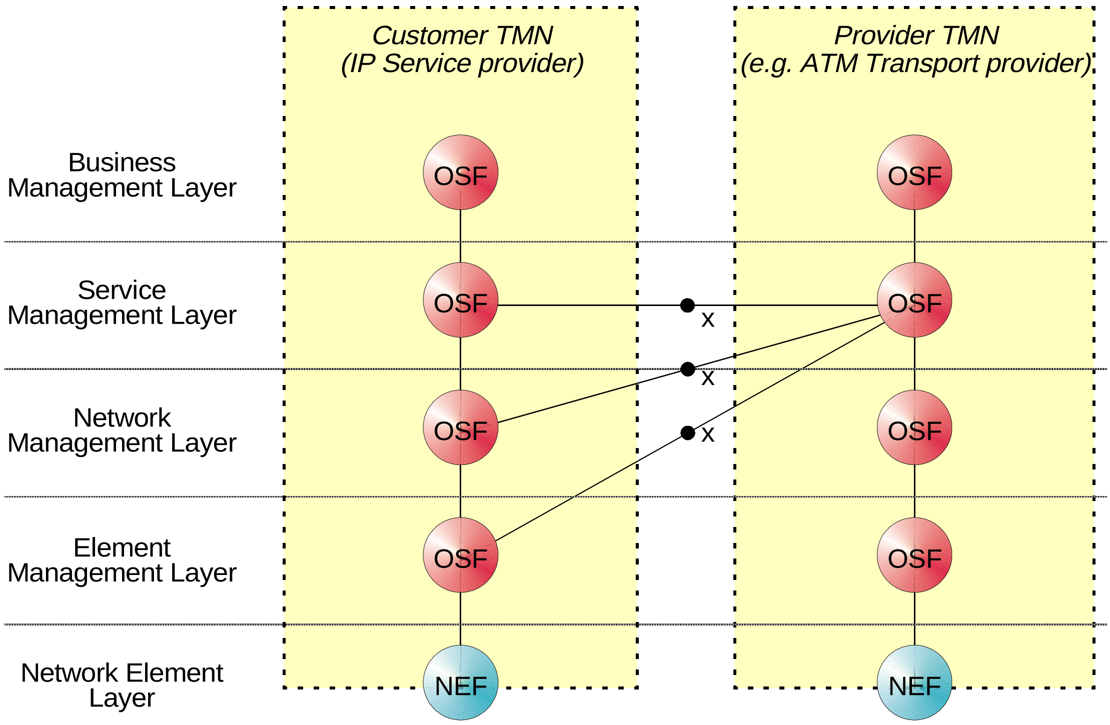

Figure 21: Example of IP service provider who uses ATM links

must be able to communicate with each other. If these OSFs belong to the same TMN (administration), communication is realized over a *q* reference point. If both OSFs belong to different TMNs, the *x* reference point will be used (Figure 22).

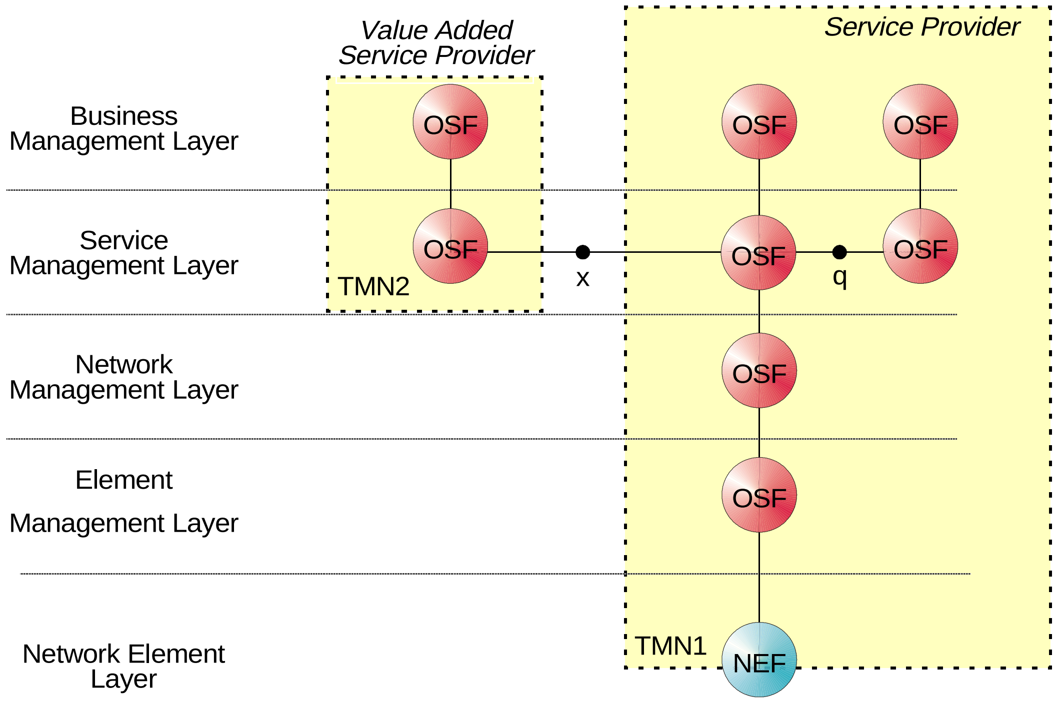

Figure 22: Example of Value Added Services

5.5 Business Management layer

The *Business Management* layer is responsible for the management of the whole enterprise. This layer has a broad scope; communications management is just a part of it. Business management can be seen as *goal setting*, rather than *goal achieving*. For this reason business Management can better be related to strategical and tactical management, instead of operational management, like the other management layers of TMN.

6 Relation with other management approaches

Although TMN recommendation M.3010 does not make any reference to the Internet nor to its management protocol SNMP, it is still possible to explain the relationship between TMN and SNMP. TMN also includes a number of concepts that may be relevant to the Internet management community.

There is a strong relationship between TMN and OSI management. TMN's functional architecture, which is defined in terms of *function blocks* and *reference points*, can for example be explained in terms of OSI concepts. Function blocks contain *functional components* (such as 'Presentation Functions' or MIBs) and are comparable to OSI protocol entities. Reference points are used to interconnect function blocks and are in OSI terminology comparable to underlying (management information) service providers (Figure 23).

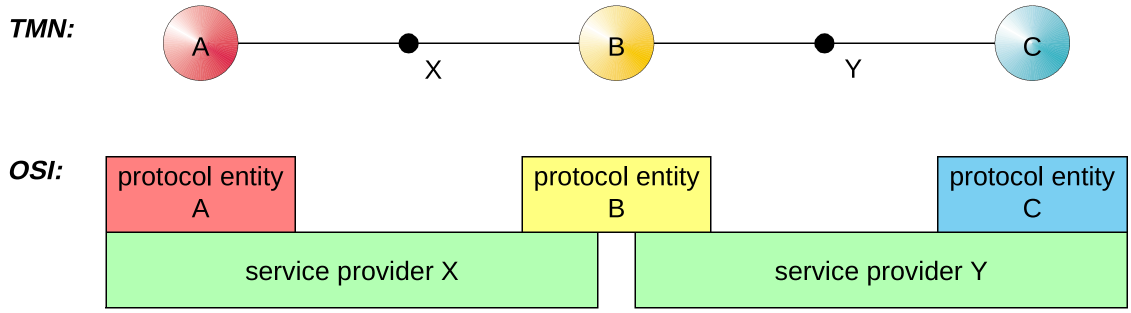

Figure 23: Relation between TMN concepts and OSI concepts

6.1 TMN and Internet management

An important difference between TMN and Internet management is that the first concentrates on the *specification of management architectures* and the second on the *implementation of management protocols*. As a result, there are only a limited number of TMN products on the market, whereas there are many commercial as well as public domain Internet management products. In fact, the Internet community did not bother about management architectures until they discovered that they could only obtain sufficient support for their new management protocol if they introduced a modular architecture for SNMPv3. As compared to the rich collection of architectural concepts defined by TMN, the SNMPv3 architecture remains relatively simple.

Integration between TMN and SNMP has been an important research topic and many research groups, in particular groups funded by the European RACE programme, addressed this topic. Integration is usually obtained via a Q Adaptor Function (QAF). The QAF translates between the q_3 reference point, which is implemented as an OSI management protocol stack (CMIP), and the m reference point, which is implemented as an Internet management (SNMP) protocol stack. The most critical task of the QAF is to translate between TMN's information model, which uses the OSI Guidelines for the Definition of Managed Objects (GDMO), and the Internet's Structure of Management Information (SMI).

As opposed to Internet management, the TMN specifications suggest a conceptual separation between the network that is managed (the telecommunication network) and the network that transfers the management information (the Data Communication Network, DCN). Members of the Internet management group took a different approach: they preferred to use the *same* components for the network that is managed and the network over which management information is transferred. The idea to introduce a separate network to transfer management information is comparable to the idea to introduce a separate network to exchange signalling information. In this sense TMN resembles the SS No. 7 network.

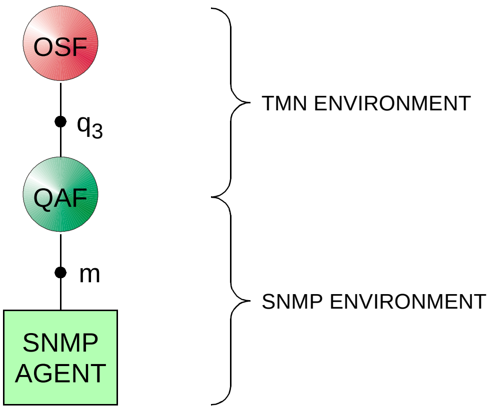

Figure 24: Integration between TMN and SNMP

Probably TMN's most valuable concept is the Logical Layered Architecture (LLA). This architecture distinguishes between element, network, service and business management. Internet management has traditionally focused on element and network management, but needs to extend in the direction of service management to allow the exchange of management information between different operators as well as between customers and operator. The question of how to extend the Internet management framework with service management is investigated by research groups within the *IRTF*.

6.2 TMN and OSI management

Initially there was little collaboration between the management groups of CCITT and ISO/IEC. As a result, the 1988 version of Recommendation M.30 had no ISO/IEC counterpart and ISO/IEC standards had little impact on TMN. After publication of M.30, the collaboration between CCITT and ISO/IEC improved, which resulted in the incorporation of many OSI management ideas into TMN. Nowadays work on TMN and OSI management is being performed within the *TeleManagement Forum* (TMF), which is the successor of the Network Management Forum (NMF).

The most important changes to TMN were:

- The 'manager-agent' concept, as originally developed by ISO/IEC, was adopted. The current TMN text contains for instance a statement saying that "The description of the manager/agent concept … is intended to reflect the definitions given in X.701" (the OSI Systems Management Overview).
- ISO/IEC's 'Object Oriented' approach was copied. The current TMN text says: "... the TMN methodology makes use of the OSI systems management principles and is based on an object oriented paradigm".
- The idea of 'Management Domains' was included. A number of TMN drafts that were developed during the 1988-1992 study period contained notes saying: "CCITT SG VII and ISO have a work item on the definition of Management Domains. Resulting material should be used or referenced when available".

Despite this cooperation between the ITU-T and OSI management groups, fundamental differences in philosophy still exist.

6.3 Differences between TMN and OSI management

A first difference between OSI and TMN management is that OSI has defined a *single* management architecture whereas TMN defined *multiple* architectures at different levels of abstraction. In general it may be a good idea to define multiple architectures. This is particularly true in case each architecture elaborates an additional, orthogonal issue. Care should be taken, however, that the relationship between the various architectures remains easy to understand. In the specific example of TMN's functional and physical architecture, this has been the case.

A second difference between TMN and OSI management is that TMN defines a structure for the multiple levels of management responsibility that exist in real networks; OSI management does not provide such structure. The TMN structure is known as the 'Logical Layered Architecture'. The advantage of having such a structure, is that understanding and distinguishing the various management responsibilities becomes easier.

A third difference between TMN and OSI management is that, as opposed to OSI, TMN suggests a *conceptual separation* between the network that is managed (the telecommunication network) and the network that transfers the management information (the Data Communication Network, DCN).

6.4 Separating the management from the telecommunication network

Separating the management network from the telecommunication network prevents potential problems with fault management: even in the case of a failure in the telecommunication network, management will still be able to access the failing components. TMN has thus better fault management capabilities than management approaches like OSI and SNMP. Unfortunately, the separate management network requires additional equipment and transmission systems. Costs are thus higher. However, failures can also take place in the management network and therefore it will be necessary to manage the management network too (meta management). This introduces additional costs.

There is also another reason to introduce a separate network for management. Telecommunication networks, like the one for telephony, provide an isochronous type of service. Such type of service does not correspond to the asynchronous (packet oriented) type of service that is required to transfer management information. A separate management network must thus be introduced to manage the telephone network. The better fault management capabilities of the separation are in such case only a secondary consideration.
As opposed to TMN, OSI and SNMP are particularly aimed at management of datacommunication networks. The type of service provided by such networks is usually the same as the type of service required for the exchange of management information. With datacommunication networks, and thus in case of OSI and SNMP, a serious consideration is needed whether the advantages of a DCN outweigh its costs.

7 References

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