INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

I.322
(02/99)

SERIES I: INTEGRATED SERVICES DIGITAL NETWORK

Overall network aspects and functions – Reference models

Generic protocol reference model for telecommunication networks

ITU-T Recommendation I.322

(Previously CCITT Recommendation)

ITU-T I-SERIES RECOMMENDATIONS

INTEGRATED SERVICES DIGITAL NETWORK

GENERAL STRUCTURE	
Terminology	I.110–I.119
Description of ISDNs	I.120–I.129
General modelling methods	I.130–I.139
Telecommunication network and service attributes	I.140–I.149
General description of asynchronous transfer mode	I.150–I.199
SERVICE CAPABILITIES	
Scope	I.200–I.209
General aspects of services in ISDN	I.210–I.219
Common aspects of services in the ISDN	I.220–I.229
Bearer services supported by an ISDN	I.230–I.239
Teleservices supported by an ISDN	I.240–I.249
Supplementary services in ISDN	I.250–I.299
OVERALL NETWORK ASPECTS AND FUNCTIONS	
Network functional principles	I.310–I.319
Reference models	**I.320–I.329**
Numbering, addressing and routing	I.330–I.339
Connection types	I.340–I.349
Performance objectives	I.350–I.359
Protocol layer requirements	I.360–I.369
General network requirements and functions	I.370–I.399
ISDN USER-NETWORK INTERFACES	
Application of I-series Recommendations to ISDN user-network interfaces	I.420–I.429
Layer 1 Recommendations	I.430–I.439
Layer 2 Recommendations	I.440–I.449
Layer 3 Recommendations	I.450–I.459
Multiplexing, rate adaption and support of existing interfaces	I.460–I.469
Aspects of ISDN affecting terminal requirements	I.470–I.499
INTERNETWORK INTERFACES	I.500–I.599
MAINTENANCE PRINCIPLES	I.600–I.699
B-ISDN EQUIPMENT ASPECTS	
ATM equipment	I.730–I.739
Transport functions	I.740–I.749
Management of ATM equipment	I.750–I.799

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

ITU-T RECOMMENDATION I.322

GENERIC PROTOCOL REFERENCE MODEL FOR TELECOMMUNICATION NETWORKS

Summary

This Recommendation defines a Generic Protocol Reference Model (GPRM) used to describe heterogeneous transport networks based on the deployment of overlaid switching and transmission techniques. GPRM models the interconnection and exchange of information, including information pertaining to the user, control and management functions.

Source

ITU-T Recommendation I.322 was prepared by ITU-T Study Group 13 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 15th of February 1999.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

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

NOTE

In this Recommendation the term *recognized operating agency (ROA)* includes any individual, company, corporation or governmental organization that operates a public correspondence service. The terms *Administration, ROA* and *public correspondence* are defined in the *Constitution of the ITU (Geneva, 1992)*.

INTELLECTUAL PROPERTY RIGHTS

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

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

CONTENTS

Recommendation I.322

GENERIC PROTOCOL REFERENCE MODEL FOR TELECOMMUNICATION NETWORKS

(Geneva, 1999)

1 Scope

The objective of this Recommendation is the definition of a Generic Protocol Reference Model (GPRM) able to describe heterogeneous transport networks based on the deployment of overlaid switching and transmission techniques.

The scope of the Generic Protocol Reference Model is not associated with any particular network type or any particular service. The GPRM models the interconnection and exchange of information including user, control and management information through a Global Transport Network (GTN). The GTN is a generic network that provides a Global Transfer Service ensuring a global connectivity with standardized classes of services.

The Generic Protocol Reference Model is developed by using the modelling principles of stratification, partitioning, functional modelling and layering.

The concepts of the Generic Protocol Reference Model are then applied to specific networks (ISDN and B-ISDN) based on specific techniques.

The Recommendation is structured into two parts:

A general part covering the modelling principles and describing the Generic Protocol Reference Model.

A second part, which remains for further study, will show the application of the concepts of the Generic Protocol Reference Model to the specific cases of N-ISDN, B-ISDN, IP-based networks, and networks based on the SDH. Recommendations I.320 and I.321 remain valid protocol reference models for N-ISDN and B-ISDN respectively.

The Generic Protocol Reference Model also describes the interworking issues that arise from the coexistence of different transmission and switching techniques in the GTN.

2 References

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

– ITU-T Recommendation G.803 (1997), *Architecture of transport networks based on the synchronous digital hierarchy (SDH).*

– ITU-T Recommendation G.805 (1995), *Generic functional architecture of transport networks.*

– ITU-T Recommendation G.872 (1999), *Architecture of the optical transport networks.*

– ITU-T Recommendation I.320 (1993), *ISDN protocol reference model.*

- CCITT Recommendation I.321 (1991), *B-ISDN protocol reference model and its application.*
- ITU-T Recommendation I.326 (1995), *Functional architecture of the transport networks based on ATM.*
- ITU-T Recommendation X.200 (1994), *Information technology – Open Systems Interconnection – Basic reference model: The basic model.*
- ITU-T Recommendation X.213 (1995), *Information technology – Open Systems Interconnection – Network service definition.*
- ITU-T Recommendation Y.110 (1998), *Global Information Infrastructure principles and framework architecture.*
- ITU-T Recommendation Y.120 (1998), *Global Information Infrastructure scenario methodology*.

3 Relationship with existing standards

The intent of this Recommendation is to cover the full range of telecommunication networks and services and to be consistent with the concepts of the GII described in the Y.100-series of Recommendations. In order to illustrate this universal applicability, the way in which the GPRM is applied to ISDN, B-ISDN, Internet, and networks based on SDH is included in this Recommendation.

Recommendations have been produced, in the past, describing protocol reference models for different networks. The ISDN Protocol Reference Model (Recommendation I.320) and the B-ISDN Protocol Reference Model (Recommendation I.321) formalize the information flows to provide ISDN and B-ISDN telecommunication services. While these Recommendations define many important concepts for the networks they describe, they have proved hard to extrapolate to a more generic case. This Recommendation validates the important concepts while removing aspects of the description that prevent extrapolation to the generic case.

In a similar way, the OSI reference model described in Recommendation X.200 contains many important concepts, however, it is oriented towards message-based, non-real time networking and so is equally hard to extrapolate. The relationship of this Recommendation to Recommendation X.200 is covered in 4.4.

4 Modelling principles

This clause describes a number of general principles relevant to the definition of the Generic Protocol Reference Model. The concepts of stratification, functional modelling, layering, reference configuration and partitioning are discussed and combined together.

4.1 Service and functional model

User applications generate requirements for telecommunications services as shown in Figure 1. These requirements can be for real time and non-real time transfer of information between geographically separated components of the application, some or all of which may include people. The way in which this arises is described in Recommendation Y.110.

In addition to the user information, the application must pass control and management information to the global transport network in order to allow it to transfer the information in accordance with the requirements of the user application. This is also shown in Figure 1.

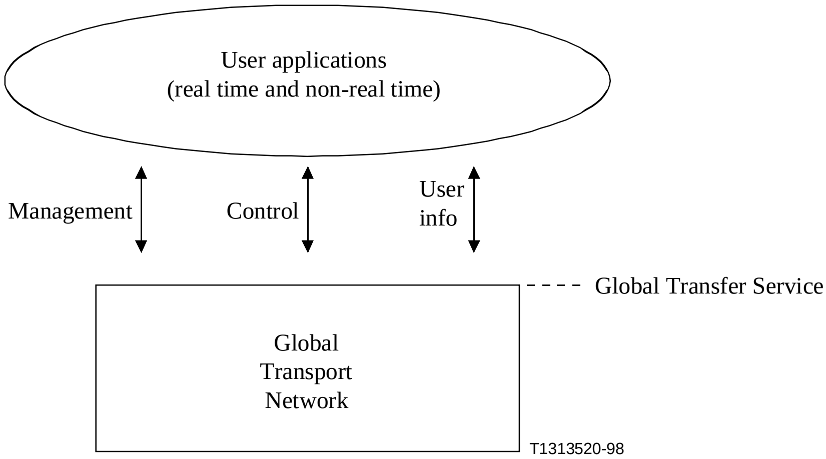


Figure 1/I.322 – The relationship between the users' applications and the global transport network

The Global Transfer Service is a service that offers a global connectivity with standardized classes of services, regardless of the addressing plans and the transport technologies used to transfer the information.

The network able to support the Global Transfer Service is called Global Transport Network. It should be noted that the Global Transport Network is typically a network based on the use of various transmission and switching techniques.

Three types of functional entities can be identified in the GTN. These functional entities are abstract objects that communicate between them by using input and output ports.

At the boundary between the GTN and the users' applications, which is normally at an API within terminal equipment, three sets of primitives exist which define the way in which this user information, the control information, and the management information are carried across the service interface. These three sets of primitives can also exist across similar interfaces within the GTN. This is illustrated in Figure 2.

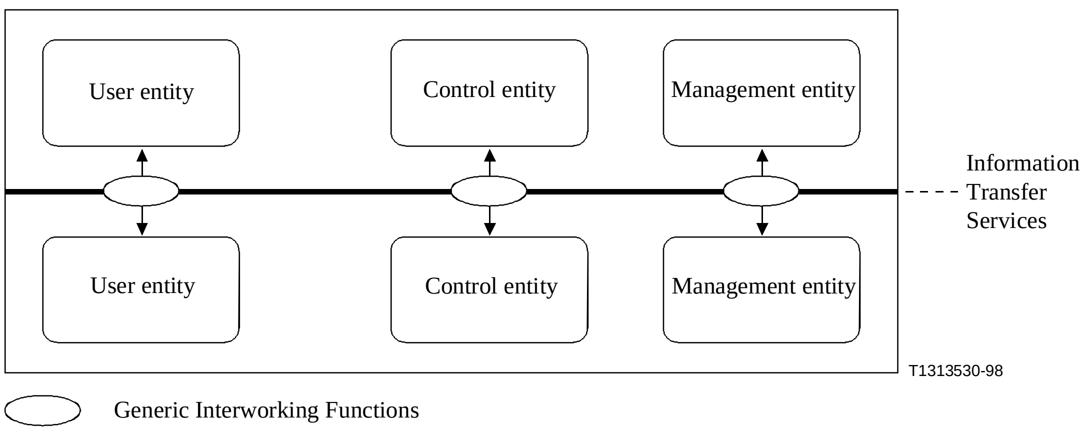


Figure 2/I.322 – Functional entities and interface primitives

In real networks the functional entities are implemented by a combination of hardware and software components.

– The user entities deal with the transport of the user information ensuring switching, multiplexing, flow control and data integrity functions.
– The control entities address aspects related to the control functions to establish, manage and release communications to transport information among user entities.
– The management entities address aspects related to the management functions to establish, manage and release communications to transport information among user entities.

All the user entities are collectively called the user plane, similarly all the control entities are called the control, and all the management entities are called the management plane.

The establishment of a communication is the result of cooperation of the control and management entities and the information transfer service provided may have different characteristics: e.g. connection-oriented, connectionless, on-demand, permanent, etc. If the information transfer service provided is a connectionless service the user and control entities collapse in a single user/control entity while if the service provided by is not on a demand service the control entity does not exist.

4.2 Layer networks and adaptation

The first decomposition of the GTN can be achieved by considering the user plane. User information is formatted in a number of different ways so that it can be carried across the GTN and each distinctive format is called a characteristic information. All the entities associated with a single characteristic information are called a layer network.

A layer network is often associated with a specific switching or transmission technique. In addition, it should be noted that a number of layer networks can also be identified within the same switching or transmission technique when the technique considered has different hierarchies of routing, resource management and resource control. For instance, considering a generic ATM network, two layer networks can be identified: ATM Virtual Channel layer network (ATM VC) and the ATM Virtual Path layer network (ATM VP).

The layer network provides at the least the following minimal set of functions:

– addressing;
– routing and relaying;
– network connection.

An essential feature of the GTN is that some networks will use the information transfer service of other layer networks. This can be to carry the aggregated traffic of many users demands present on a link of the network, or to transfer the control and management information of the layer network, or both. For example, the links of the ATM VP layer network can be carried by the information transfer service of the SDH VC4 layer network. Similarly, the management messages of SDH VC4 layer network could be carried by the information transfer service of the Internet Protocol (IP) layer network.

In order that the information of a "client" layer network can be carried by the information transfer service of a "server" layer network, it must be adapted to the characteristic information of that server layer network.

The adaptation provides at the least the following functions:

– multiplexing and information formatting;
– resource allocation.

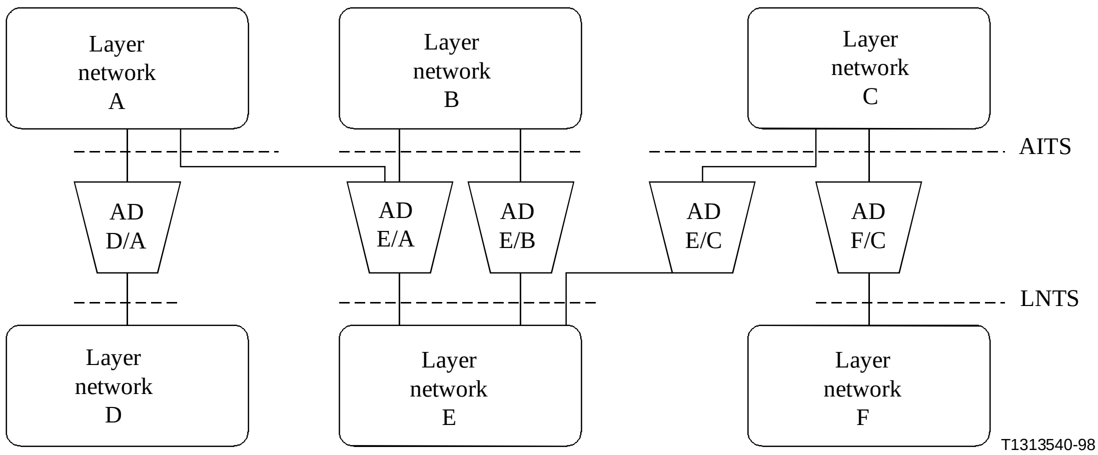
There can, therefore, exist client/server relationships between layer networks thus resulting in a many-to-many relationship between layer networks. One layer network can have many client layer networks and it can also use many server layer networks (notwithstanding that there are examples of client/server relationships which are designed to be one-to-one relationships, for example between the SDH MS and the SDH RS layer networks). The existence of a particular client/server relationship will depend on the capabilities of the technologies involved together with economic factors.

The definition of a layer network is fully independent, in that, it does not depend on any other layer network and this independence is essential to enabling the many-to-many relationship.

When one or more client layer networks use the information transfer service of another layer network to transfer user plane information, the characteristic information of the client layer networks is mapped into a characteristic information of the server layer network by an adaptation function particular to that client/server relationship. This is illustrated in Figure 3.

The information transfer service offered by a server layer network does not equal the information transfer service requested by a client layer network and the service requirement is mapped to the service offered by the adaptation function. As a result, two types of information transfer service are identified:

- the layer network information transfer service offered directed by the server layer network;
- the adapted information transfer service offered to a client layer network.



AD Adaptation
ATIS Adapted Information Transfer Service
LNTS Layer Network Information Transfer Service

Figure 3/I.322 – Many-to-many relationship between layer networks

4.3 Partitioning

The partitioning concept is a division of a layer network that permits the identification of subnetworks. A subnetwork is a portion of layer network with similar characteristics from a technical or administrative point of view. In addition, by applying the partitioning process recursively, any subnetwork can be divided into a number of smaller subnetworks. Each subnetwork is formally described by a reference configuration with the respective functional groupings and reference points.

As a result of the fact partitioning takes place within a layer network, the characteristic information always remains unchanged by the process of partitioning.

As each subnetwork is conceived to perform a particular set of tasks, the description of a subnetwork at any level of detail, should be based on the functions necessary to perform such tasks. A powerful tool to provide the functional description of a subnetwork and the way it performs its tasks is the reference configuration. A reference configuration is made of blocks named functional groupings describing the locations of functions in the network and their logical relationships.

In principle, the reference configuration can either provide a high level description of the subnetwork structure or be closely related to the techniques used to implement the subnetwork.

In any case the reference configuration is independent of the actual physical structure, as the functional groupings can correspond to separate pieces of equipment or be implemented in the same equipment.

The partitioning process must be applied to each layer network independently. According to the different techniques in the different layer networks, the identification of homogenous portions of networks may lead to the definition of different subnetworks that are described by different reference configurations. For instance, the subnetworks that are derived from the Physical layer network and the respective reference configurations will probably be different from the subnetwork and reference configurations that are derived from an above layer network based on specific switching techniques, e.g. ATM, Frame relay.

Interworking requirements can exist between subnetworks. This interworking will not involve the user plane, as by definition, the characteristic information in the user plane remains unchanged between subnetworks. However, interworking may be required between the control and management planes of the two subnetworks. This is illustrated in Figure 4.

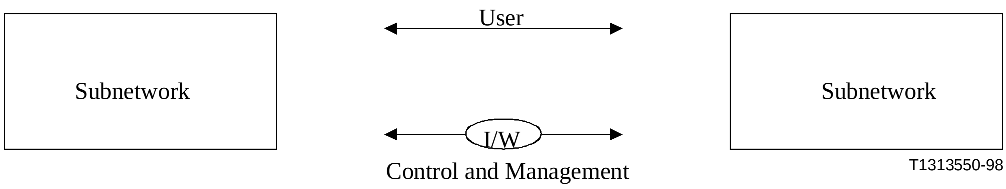


Figure 4/I.322 – Interworking between subnetworks

Generally, the interworking between the subnetworks produced by the layer network partitioning may require a number of interworking functions that could include:

– signalling protocol conversion;
– usage monitoring and billing;
– address/number translation;
– other functions.

A particularly powerful application of the partitioning concept is in the description of the topology of the layer network. Between some pairs of subnetworks, links will exist and these links become exposed as the layer network is partitioned to greater and greater detail. At any given depth of partitioning, the layer network will appear as a set of subnetworks with links between them. The arrangement of the subnetworks and the links is the topology of the layer network at that level of partitioning.

The links of the layer network are normally carried by the information transfer service of a server layer network. However, a different server layer network may be selected for each link as illustrated in Figure 5.

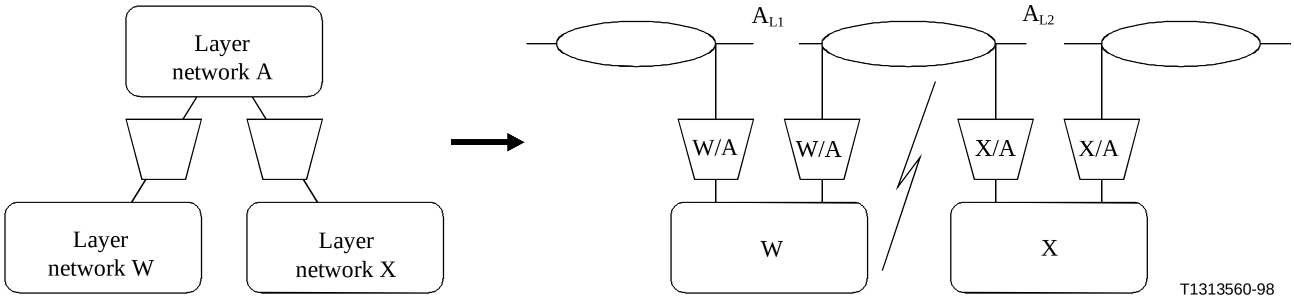


Figure 5/I.322 – Many-to-many relationships in partitioning a layer network

4.4 Stratification

Figure 3 illustrated the many possible non-contiguous client/server relationships that can exist between layer networks. It is often useful to consider a single line through this diagram in order to describe a single contiguous set of client/server relationships that may exist at some point in the GTN. When this is carried out, this can be represented as a set of strata where the characteristics of each stratum are similar and each stratum offers service to the stratum above.

Figure 6 shows the scope of the stratification. The Global Transfer Service represents the upper boundary from which other strata could be built down recursively. The stratification process terminated at the bottom with the identification of the physical layer.

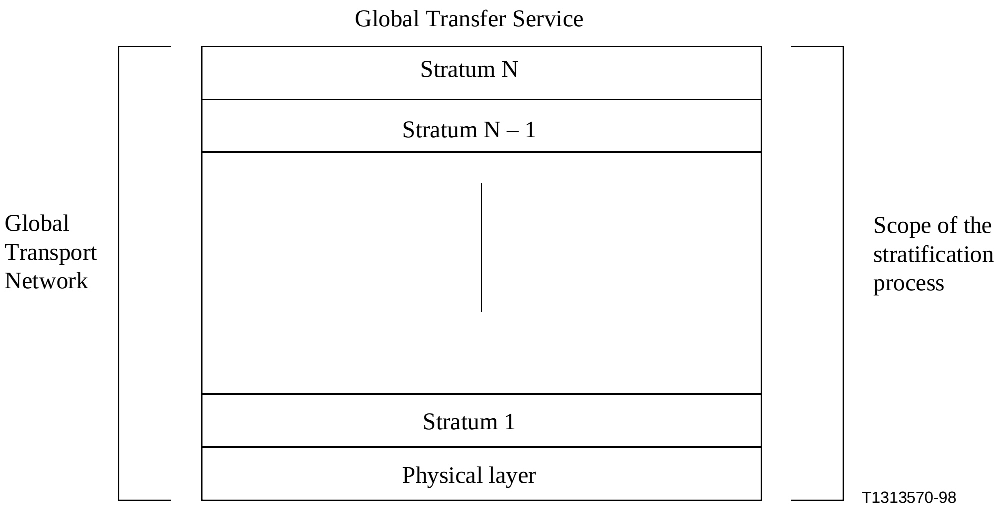


Figure 6/I.322 – Stratification process – General view

At any one point, only strata above a certain level may be of interest. In this case, all the strata below can be collected classes as the infrastructure supporting the strata of interest. This is illustrated in Figure 7.

The infrastructure can therefore be either the physical layer or when required for modelling, another stratum with its own layered structure on a top of an underlying infrastructure of a lower order. This recursion process can be applied as many times as needed up to the identification of a physical layer.

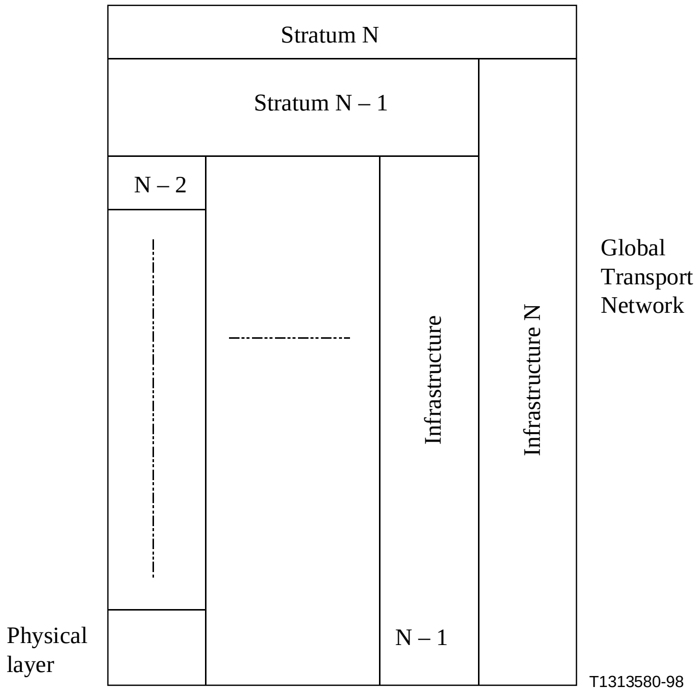


Figure 7/I.322 – Stratification process – Detailed view

From the definition of a stratum, all strata in the stratification process should be similar and offer the same type of service. However, as is illustrated in Figure 8, there are two possible ways of selecting strata. The adaptation function can be included either above the layer network or below the layer. Both of these views are possible, valid and important.

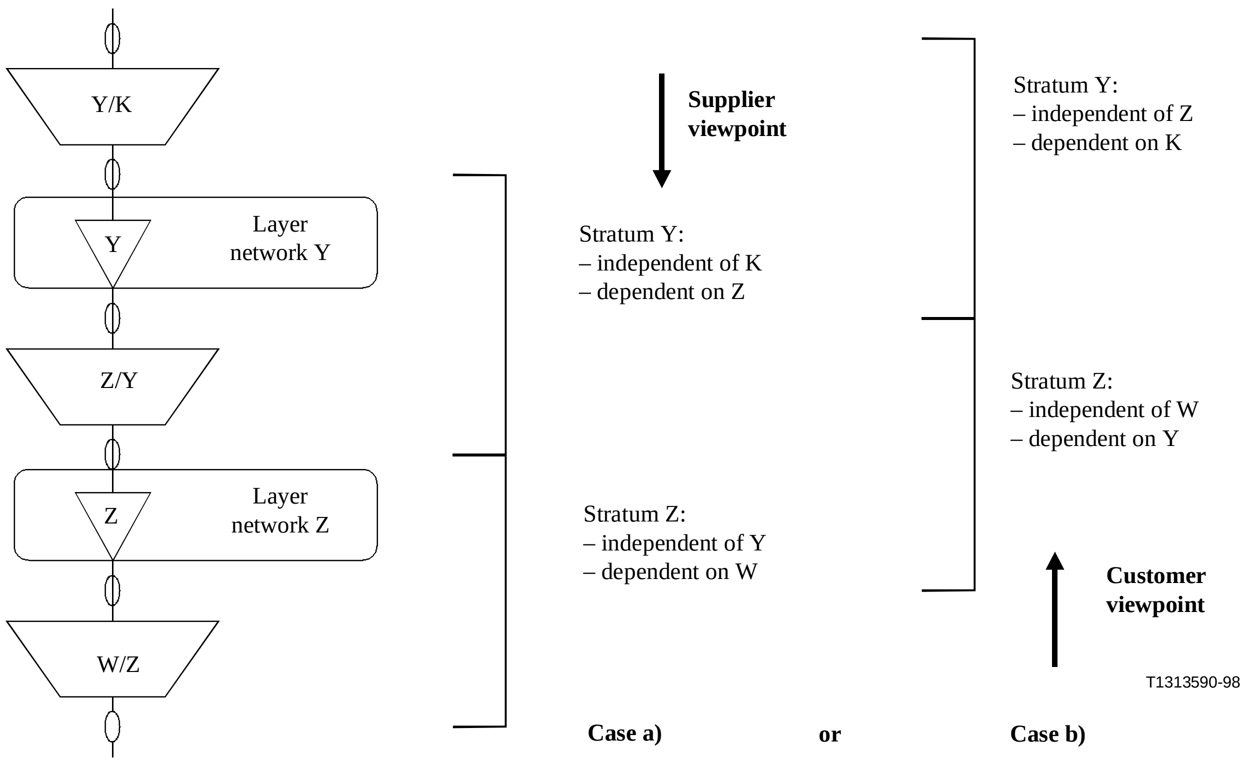


Figure 8/I.322 – The two cases of stratification

4.4.1 The supplier viewpoint

In the case where the adaptation is included below the layer network [case a)], the service offered by the stratum is the layer network information transfer service.

This service offered by a stratum to the stratum above is independent of the stratum above. However, the service requested by a stratum of the stratum below is now dependent on the stratum below.

This case expresses a "suppliers" view as the service supplied is independent.

4.4.2 The customer viewpoint

In the case where the adaptation is included above the layer network [case b)], the service offered by the stratum is the adapted information transfer service.

The service requested by a stratum to the stratum below is independent of the stratum below. However, the service offered by a stratum to the stratum above is now dependent on the stratum above.

This case expresses a "customer" view as the service requested is independent.

4.4.3 The relationship between the supplier viewpoint stratification and Recommendation X.200

Some of the "layers" identified in Recommendation X.200 can be readily seen and identified in the supplier viewpoint. In the GTN user plane, a stratum and its associated infrastructure can be viewed as a set of layers 1, 2 and 3 as shown in Figure 9.

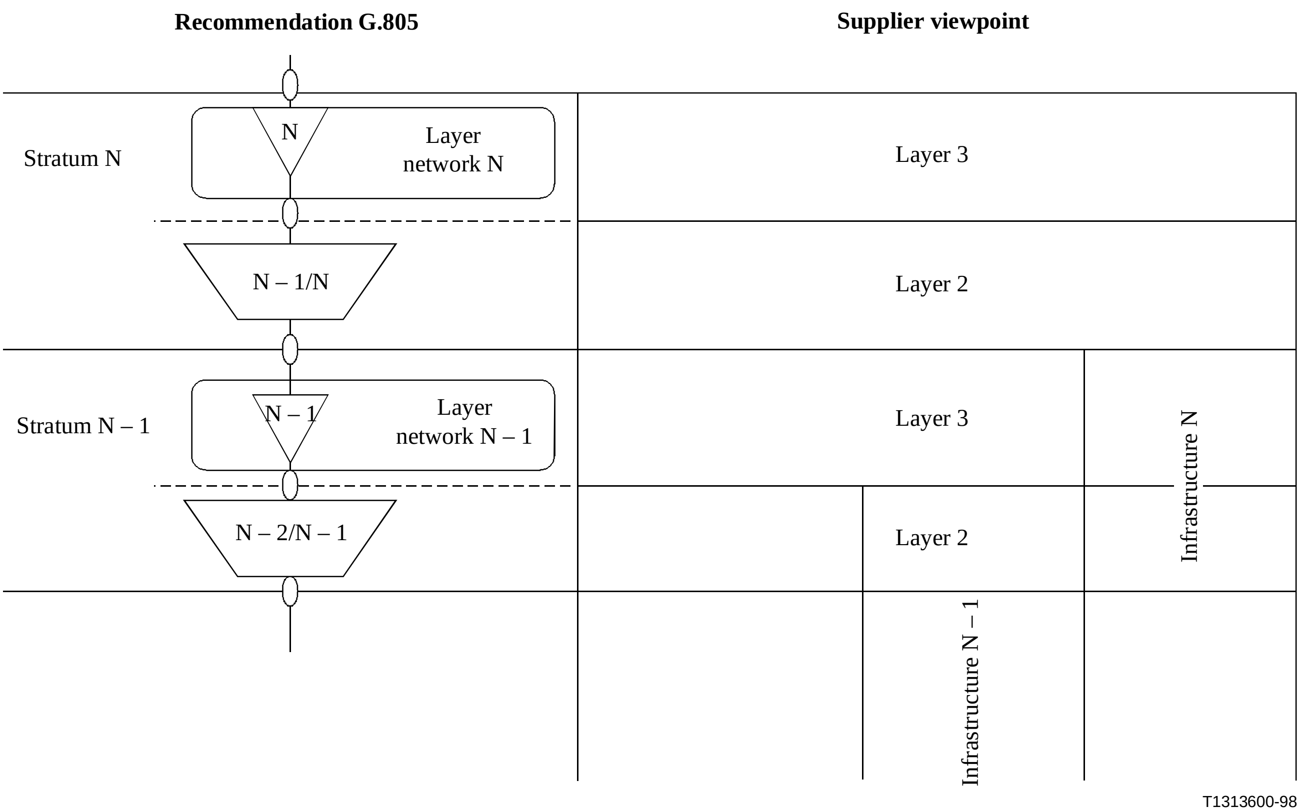


Figure 9/I.322 – Relationship of the supplier viewpoint stratification to Recommendation X.200

The layer network includes the functionality assumed by the OSI network layer (layer 3).

The adaptation, which is shown below the layer network in the supplier viewpoint can then be associated with the OSI link layer (layer 2). Finally, the infrastructure can be associated with the OSI physical layer.

The stratification process illustrates that the view of the OSI physical layer implied by Recommendation X.200 can be overly simplistic and that a great deal of network complexity can be encapsulated in the OSI physical. Moreover, often the great majority of the complexity is not physical but functional.

4.4.4 The relationship between the customer viewpoint stratification and Recommendation X.200

In this viewpoint, the adaptation is above the layer network. As with the supplier viewpoint, the layer network includes functionality assumed by the OSI network layer (layer 3). The infrastructure in this case includes both the OSI link layer (layer 2) and the OSI physical layer (layer 1). Again, the stratification process illustrates that there is often very much more complexity in describing these OSI layers that is apparent from a simple reading of the X.200-series of Recommendations.

The OSI model was developed with *message* transport in mind, in particular between two open computer systems, hence the name Open Systems Interconnect. It has been extensible to the transport of files (e.g. using FT AM), however, it was not developed with the transport of real-time streams (e.g. audio and video) in mind not the transport of the links of client layer networks. As a result, the OSI transport layer (layer 4), session layer (layer 5), and presentation layer (layer 6) tend to be directly associated with Recommendations X.214/X.224, X.215/X.225, and X.216/X.226 respectively. A more general concept of the functionality of an OSI transport layer, session layer, and presentation layer is not normal in any discussion of these OSI layers. It is therefore more difficult to extend the concepts of these layers more easily into the more general context of the GTN that includes real-time services, noting that one important real-time service is the transport of links of client layer networks.

One possible way of understanding X.200 in this context is to generalize the concepts of the OSI transport, session, and presentation layers to include real-time services.

The characteristic information of a layer network often includes a certain "overhead" which is used to verify the connectivity and/or the fidelity of the information transfer. This overhead, and the process present at the end point of the connectivity, is called the termination function (see Recommendation G.805), has, in part, a broad similarity with the OSI transport layer (layer 4). (The OSI transport layer also includes functionality associated with interworking of the control and management planes between subnetworks.)

The generalized OSI session and presentation layers are associated with the adaptation as the link transport has become the generalized OSI application (layer 7). The generalized OSI presentation layer is associated with the multiplexing and formatting aspects of the adaptation while the generalized OSI session layer, in part, is associated with resource allocation aspects of the adaptation.

A consequence of the supplier and customer viewpoints is that the same adaptation function, when viewed from both perspectives, appears to be different when related in an abstract way to the OSI layers.

In the supplier viewpoint, the adaptation appears to be associated with the OSI link layer. The customer viewpoint, the *same* adaptation appears to be associated with the generalized OSI session and presentation layers. This sets up a basic equity based on the two viewpoints. The OSI link layer from one viewpoint is the same as the generalized OSI session and presentation layers from the other viewpoint. This is illustrated in Figure 10.

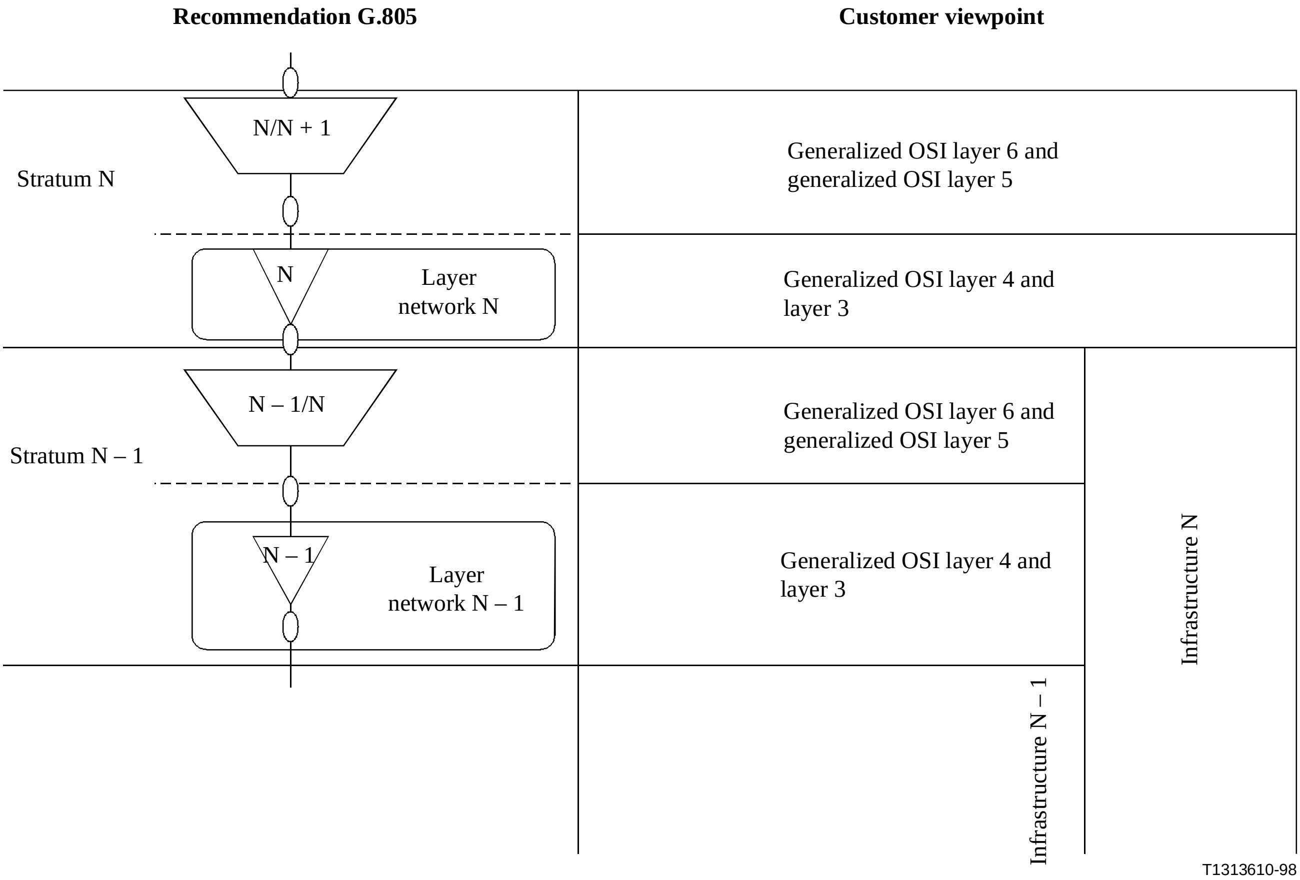


Figure 10/I.322 – Relationship of the customer viewpoint stratification to Recommendation X.200

5 Generic protocol reference model

Figure 11 shows the Generic Reference Protocol Model defined by applying the stratification principles to all planes (user, control, and management) of the GTN. The standardized transport service provided by the GTN is called Global Transfer Service. The Global Transfer Service is the service offered to the user application.

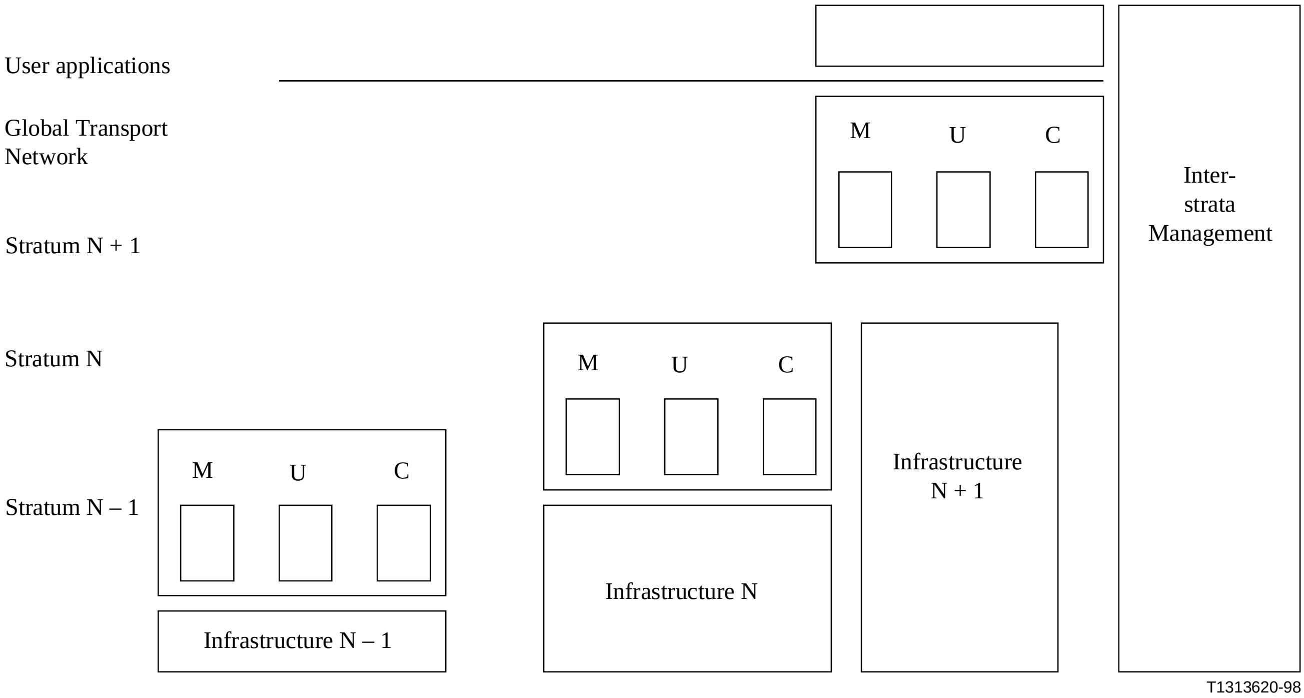


Figure 11/I.322 – Generic protocol network model

The protocols implementing the control and management entities in a generic stratum may need functionalities that for the provision of user plane information transfer service are traditionally located outside the GTN (typically these functionalities are present in the service network).

The control and management entities are themselves distributed applications which exist within the GTN. These generate an internal requirement for information transfer which is supported by one or more client layer networks.

In addition to the Management entities present in each Stratum, there is an entity of management called Inter-strata Management entity that performs management functions to the GTN as a whole and provides coordination among various Strata that built up the GTN. The inter-strata Management entity also provides management functions to the service network.

This management entity does not have a layered structure.

5.1 Relationship between protocol blocks of adjacent Strata

For the provision of a certain network connection service provided by a generic Stratum, the U-, C- and M-protocol blocks information will come together in an upper boundary, offered to the service user (the upper Stratum), and in a lower boundary, below which no more distinction can be made between the information flows. The upper and lower boundaries of the M-, C- and U-protocol blocks coincide with the boundaries of the Stratum within which these protocol blocks are defined.

A function is necessary to provide synchronization and coordination among the U-, C- and M-protocol blocks information.

The SCF provides similar functionally as the local system environment (LSE) in OSI. The exact relation between LSE and SCF is for further study.

In order to emphasize the purpose of SCF, it is essential to mention that when the M- or C-protocol block passes any user information, then no distinction can be made between the U- and M- or C-protocol blocks in their functionality.

For a given Stratum, the SCF forms the upper boundary of the M-, C and U-protocol blocks. The SCF is positioned as the service boundary in the OSI sense. The lower boundary of the M-, C- and U-protocol blocks will be perceived as the boundary below which M-, C- and U-information flows are seen as a single information flow and passed to a lower Stratum over a single service access point.

Figure 12 illustrates the model for the Synchronization and Coordination Function (SCF). The synchronization and coordination of the Management plane, Control plane and User plane is performed through the interaction between SCF and M-, C and U-protocol blocks via the use of service primitives. These primitive interactions involve that the related M-plane, C-plane and U-plane rely on the underlying service.

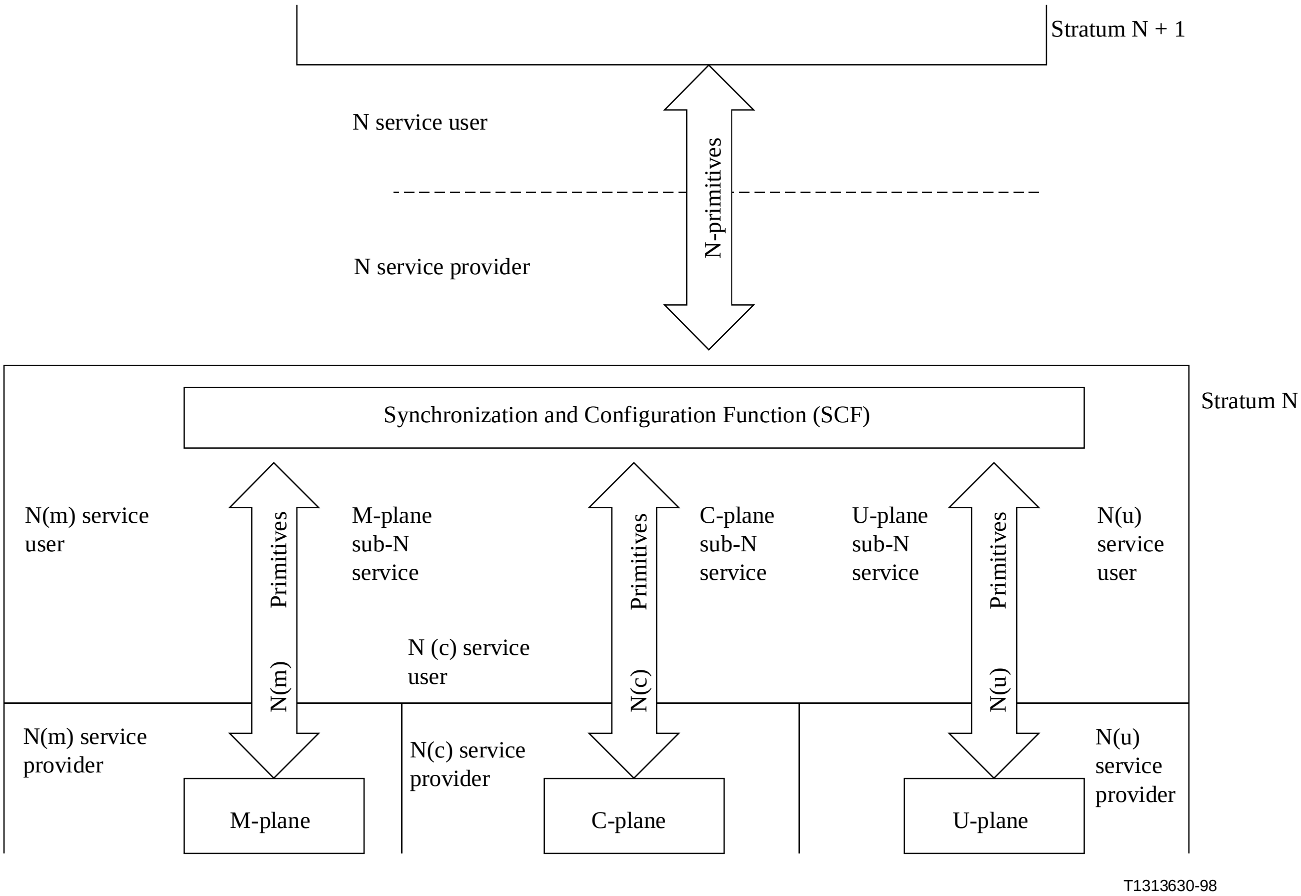


Figure 12/I.322 – Synchronization functions at the upper boundary of a Stratum

The model adopts a concept based on the definition of primitive procedures at four connection endpoints namely:

– Coordinate Connection NC;

– M-plane Connection N(m)C;

– C-plane Connection N(c)C;

– U-plane Connection N(u)C.

The SCF state machine acts as a coordination process of the four primitive procedures.

In the specific case that the given Stratum is the GTN, the model provides the framework to define the provision of the Network Service according to Recommendation X.213. In this specific case at the NC endpoint, the SCF provides a N(u)Service according to Recommendation X.213 while the primitive procedures ate the three other connection endpoints depend on the capabilities of the underlying protocol blocks.

The SCF state machine provides synchronization and coordination capabilities for different C-plane call control procedures and/or M-plane call/connection management and distinct U-plane N(u) Services, which may include confirmed N(u)C release.

This model defines the provision of the network connection service by a generic Stratum in terms of the interrelationship between primitives at the upper and lower boundary of the SCF.

It should be noted that the information in different planes need not be carried by distinct physical/logical means in all cases. For example control and user information may use the same support, e.g. when inband signalling is used.

5.2 Interworking between adjacent Strata

The presence of specific U-, M- and C-protocol blocks in each Stratum raises interworking issues at the boundary of two adjacent Strata. For example the C-protocol block of the Stratum N ensuring the signalling capabilities in the portion of the network corresponding to the Stratum N must interwork with the C-protocol block of the Stratum N – 1. This interworking ensures the availability of switched connections in both the N and N – 1 Strata.

For interworking between C-Planes two solutions can be identified [see Figures 13 a) and 13 b)]:

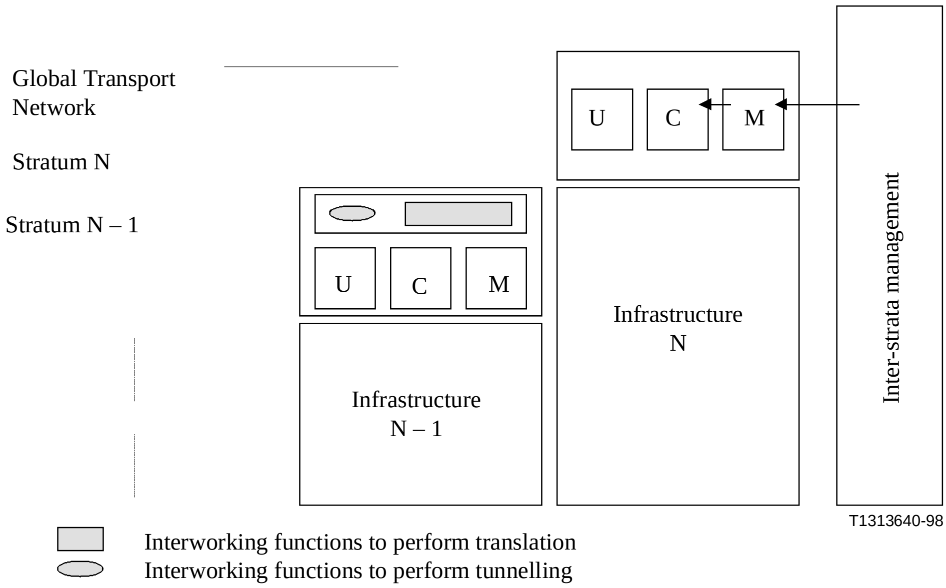


Figure 13 a)/I.322 – Interworking functions between adjacent strata

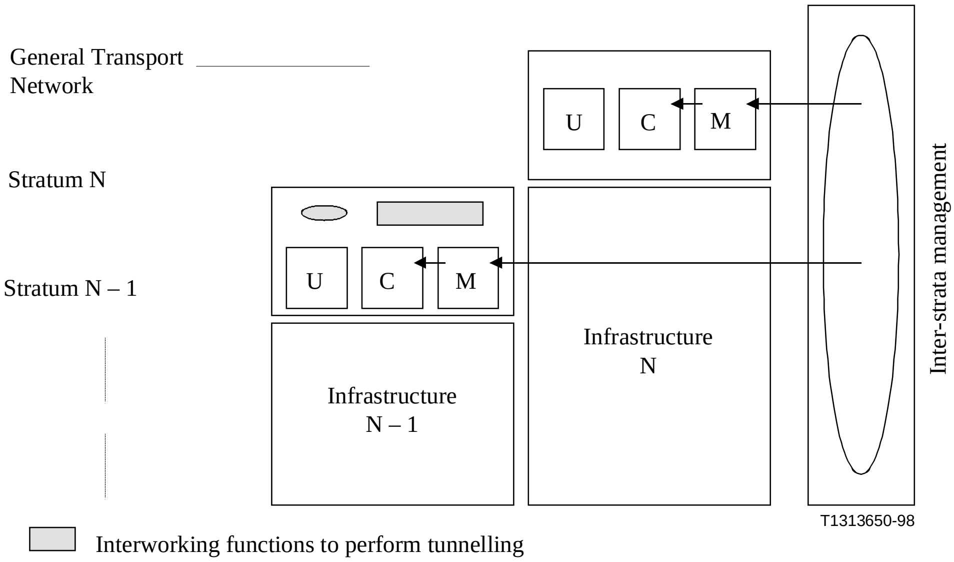


Figure 13 b)/I.322 – Interworking functions between adjacent strata

In the first solution the Inter-strata management through the M-protocol block of the Stratum N triggers only the signalling entity present in the higher layers of the Control protocol block of the Stratum N. The Control protocol block generates a set of signalling messages to negotiate the call at the level of Stratum N. At the upper boundary of Stratum N – 1 the signalling messages of N Stratum Control protocol block must be terminated and the signalling messages typical of the "translation" allow the generation of the adequate signalling messages to negotiate the call at the level of the Stratum N – 1.

After the translation the signalling messages of the N Stratum control protocol block are transparently transferred through the Stratum N – 1.

As depicted in Figure 13 b) this solution implies a presence of interworking functions between the C-protocol blocks belonging to different strata. These interworking functions translate N Stratum signalling flows in N – 1 Stratum signalling flows and transfer N Stratum signalling flows through the Stratum N – 1.

In the second solution the Inter-strata management plane triggers through the M-protocol blocks the signalling entities of the Control protocol blocks of each Stratum building up the transport network. At the upper boundary of Stratum N – 1 the signalling messages of N Stratum control protocol block must not be translated in signalling messages but only transported transparently (tunnelling). In the fact the signalling message related to Stratum N – 1 are already produced by the higher layers of the Control protocol block of the stratum itself triggered by the Management Plane.

These solutions, as shown in Figure 13 b), imply that the Inter-strata management plan triggers and coordinates the signalling entities present in each Stratum.

The Interworking between M-planes belonging to adjacent Strata requires the deployment of interworking functions at the boundaries of the Strata. As shown in Figure 13 a) the interworking functions must translate the management messages of the N Stratum management protocol block in appropriate management messages of the N – 1 Stratum management protocol block.

After the translation the N Stratum management messages are transparently transported through the N – 1 Stratum.

Another possibility is that the Inter-strata management provides direct interworking and mapping functions between the various Management protocol blocks. In this case as described in Figure 13 b) the interworking functions at the boundaries of adjacent Strata must only transparently transport N Stratum management flows through the Stratum N – 1.

The interworking functions to be deployed between User protocol blocks of adjacent strata must ensure tunnelling functions to transparently transport the user information of the Stratum N through the Stratum N – 1.

6 Application of the GPRM principles to ISDN case

For further study.

7 Application of the GPRM principles to B-ISDN case

For further study.

8 Application to IP based networks

For further study.

9 Application to SDH

For further study.

ITU-T RECOMMENDATIONS SERIES

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