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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital networks – General aspects

Functional architecture of connectionless layer networks

ITU-T Recommendation G.809

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ITU-T Recommendation G.809

Functional architecture of connectionless layer networks

Summary

This Recommendation describes the functional architecture of a connectionless transport network from the viewpoint of its information transfer capability. The functional and structural architecture of these networks is described independently of networking technology. As such, the Recommendation should be taken as the basis for technology-specific descriptions of connectionless transport networks.

Source

ITU-T Recommendation G.809 was prepared by ITU-T Study Group 13 (2001-2004) and approved under the WTSA Resolution 1 procedure on 22 March 2003.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. 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 Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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

NOTE

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

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. 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, 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.

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Functional architecture of connectionless layer networks

1 Scope

This Recommendation describes the functional architecture of connectionless layer networks using the methodology described in ITU-T Rec. G.805. The concept of the connection is central to the functional architecture described in ITU-T Rec. G.805 and in order to provide a common framework between the connection-oriented layer networks and a connectionless layer network, it is necessary to introduce new concepts that describe connectionless behaviour. The connectionless transport network functionality is described from a network level viewpoint, taking into account layer network structure, networking topology, client characteristic information, client/server layer associations and mapping between connectionless and connection-oriented layer networks.

This Recommendation describes the functional architecture of connectionless transport networks in a technology independent way. As such, it forms the basis for a set of Recommendations for management, performance analysis and equipment specifications related to specific connectionless technologies. The extension of the methodology defined in ITU-T Rec. G.805 for connectionless layer networks allows for the description of equipment containing both connection-oriented and connectionless technologies in a common way.

If this Recommendation is used as the basis for developing a technology-specific Recommendation to describe and model networks that use existing protocols (such as IP, Ethernet, Token Ring, etc.) it shall be used in a manner that is fully consistent with existing specifications as approved by the relevant standards organizations. The use of this Recommendation is not intended to provide a means by which existing protocols and architectures are modified.

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; 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. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

– ITU-T Recommendation G.803 (2000), *Architecture of transport networks based on the synchronous digital hierarchy (SDH)*.

– ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

– ITU-T Recommendation G.8080/Y.1304 (2001), *Architecture for the automatically switched optical networks (ASON)*.

– ITU-T Recommendation I.326 (2003), *Functional architecture of transport networks based on ATM*.

– ITU-T Recommendation X.200 (1994) | ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The basic model*.

3 Definitions

NOTE 1 – Where a definition contains a term which is itself defined, that term is given in quotation marks.

NOTE 2 – The terms can be further qualified by reference to a specific layer network by adding the appropriate layer network qualifier.

NOTE 3 – All architectural components are unidirectional.

NOTE 4 – The definitions only apply to connectionless layer networks. Definitions for connection-oriented networks are as described in ITU-T Rec. G.805.

This Recommendation defines the following terms:

3.1 access group: A group of colocated "flow termination" functions that are attached to the same "flow domain" or " flow point pool link".

3.2 access point: A "reference point" that represents the binding between the flow termination and adaptation functions.

3.3 adaptation: A "transport processing function". There are two types of adaptation, an adaptation sink and an adaptation source.

3.4 adaptation sink: A "transport processing function" which presents the client layer network characteristic information at its output by processing the information presented at its input by the server layer network trail.

3.5 adaptation source: A "transport processing function" which accepts client layer network characteristic information at its input and processes it to allow transfer over a trail (in the server layer network).

3.6 adapted information: A signal which is transferred on "trails" or "connectionless trails". The specific formats will be defined in the technology specific recommendations.

3.7 architectural component: Any item used in this Recommendation to generically describe transport network functionality.

3.8 binding: A direct relationship between a "transport processing function" or "transport entity" and another "transport processing function" or "transport entity" which represents static associations that cannot be directly modified by management action.

3.9 characteristic information: A signal with a specific format, which is transferred on "flows". The specific formats will be defined in the technology specific Recommendations.

3.10 client/server relationship: The association between layer networks that is performed by an "adaptation" function to allow the "flow" in the client layer network to be supported by a trail in the server layer.

3.11 connectionless trail: A "transport entity" responsible for the transfer of information from the input of a flow termination source to the output of a flow termination sink. The integrity of the information transfer may be monitored.

3.12 flow: An aggregation of one or more traffic units with an element of common routing.

3.13 flow domain: A topological component used to effect forwarding of a specific characteristic information.

3.14 flow domain flow: A "transport entity" that transfers information across a flow domain, it is formed by the association of "ports" on the boundary of the flow domain.

3.15 flow point: A "reference point" that represents a point of transfer for traffic units between topological components.

3.16 flow point pool: A group of colocated flow points that have a common routing.

3.17 flow point pool link: A "topological component" which describes a fixed relationship between a "flow domain" or "access group" and another "flow domain" or "access group".

3.18 flow termination: A "transport processing function". There are two types of flow termination, a flow termination sink and a flow termination source.

3.19 flow termination sink: A "transport processing function" which accepts the "characteristic information" of the layer network at its input, recovers the information related to "connectionless trail" monitoring and presents the remaining information at its output.

3.20 flow termination source: A "transport processing function" which accepts adapted "characteristic information" from a client layer network at its input, adds information to allow the "connectionless trail" to be monitored and presents the characteristic information of the layer network at its output(s).

3.21 layer network: A "topological component" that represents the complete set of access groups of the same type which may be associated for the purpose of transferring information.

3.22 link flow: A "transport entity" that transfers information between "ports" across a flow point pool link.

3.23 matrix: It represents the limit to the recursive partitioning of a flow domain.

3.24 matrix flow: A "transport entity" that transfers information across a matrix, it is formed by the association of ports on the boundary of the matrix.

3.25 network: All of the entities (such as equipment, plant, facilities) which together provide communication services.

3.26 network flow: A transport entity formed by a series of contiguous "flows" between "termination flow points".

3.27 port: It represents the output of a flow termination source or flow domain or the input to a flow termination sink or flow domain.

3.28 reference point: An architectural component, which is formed by the binding between inputs and outputs of transport processing functions and/or transport entities.

3.29 topological component: An architectural component, used to describe the transport network in terms of the topological relationships between sets of points within the same layer network.

3.30 traffic unit: An instance of characteristic information and a unit of usage.

3.31 transport: The functional process of transferring information between different locations.

3.32 transport entity: An architectural component which transfers information between its inputs and outputs within a layer network.

3.33 transport network: The functional resources of the network which conveys user information between locations.

3.34 transport processing function: An architectural component defined by the information processing which is performed between its inputs and its outputs. Either the input or the output must be inside a layer network.

3.35 termination flow point: A reference point that represents the binding of a flow termination to a flow.

4 Abbreviations

This Recommendation uses the following abbreviations:

AP	Access Point
CLPS	Connectionless packet switched
CO-CS	Connection-oriented circuit switched
CO-PS	Connection-oriented packet switched
CP	Connection Point
FP	Flow Point
FPP	Flow Point Pool
FPP link	Flow Point Pool link
TCP	Termination Connection Point
TFP	Termination Flow Point

5 Conventions

The diagrammatic convention for connection-oriented layer networks described in this Recommendation is that of ITU-T Rec. G.805.

6 Functional Architecture of connectionless layer networks

6.1 Introduction

The various functions that constitute a telecommunications network can be classified into two broad functional groups. One is the transport functional group that transfers any telecommunications information from one point to another point(s). The other is the control functional group that realises various ancillary services and operations and maintenance functions.

A connectionless transport network transfers user information from one location to another location in a unidirectional manner. A transport network can also transfer various kinds of network control information such as routing protocols and operations and maintenance information for the control functional group.

Since the transport network is a large, complex network with various components, an appropriate network model with well-defined functional entities is essential for its design and management. The connectionless transport can be described by defining the relationships between points in the network. In order to simplify the description, a transport network model, based on the concepts of layering and partitioning within each layer network is used in a manner that allows a high degree of recursion. It is recommended that this method is used for describing the transport network.

6.2 Relationship between connection-oriented and connectionless layer networks

Central to the description of connection-oriented networks is the concept of a connection. However, such a construct is inappropriate for the description of a connectionless network. Consequently, it is necessary to replace the concepts of a connection and a connection point as defined in ITU-T Rec. G.805 with new architectural components as defined in this Recommendation. A detailed description of the properties and differences between connection-oriented and connectionless layer networks can be found in Annexes A and B.

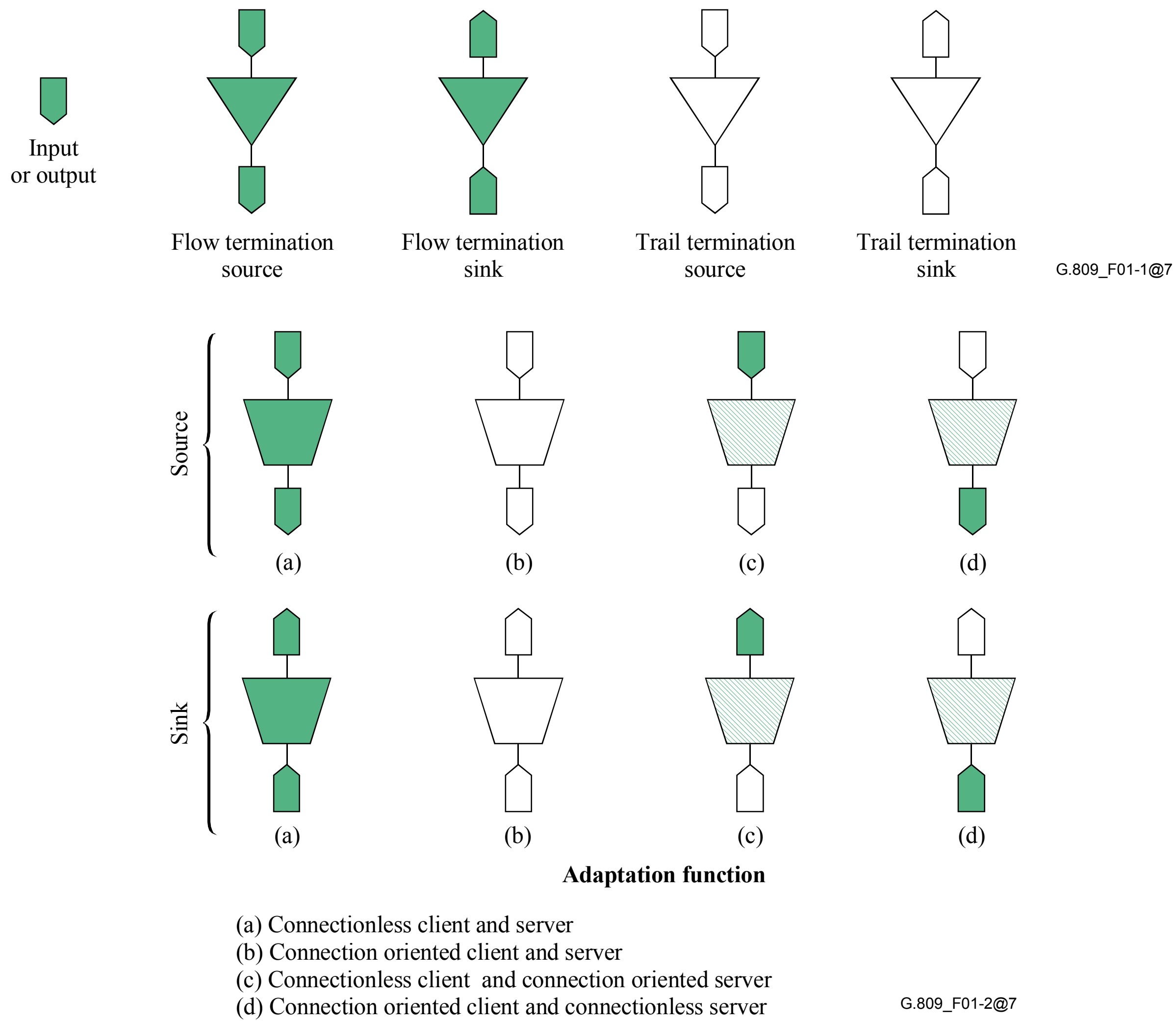
The description of connection-oriented layer networks in ITU-T Rec. G.805 assumes that the default for transmission is bidirectional whereas transfer in a connectionless layer network is always unidirectional. As such many of the definitions in ITU-T Rec. G.805 are not strictly appropriate for connectionless layer networks. This Recommendation therefore defines all of the architectural components related to the architecture of connectionless layer networks.

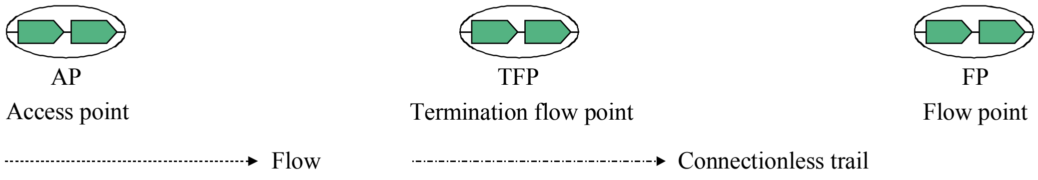
6.3 Architectural components

The connectionless transport network has been analysed to identify generic functionality that is independent of implementation technology. This has provided a means to describe network functionality in an abstract way in terms of a small number of architectural components. These are defined by the function they perform in information processing terms, or by the relationships they describe between other architectural components. In general, the functions described here act on information presented at one or more inputs and present processed information at one or more outputs. They are defined and characterized by the information process between their inputs and outputs. The architectural components are associated together in particular ways to form the network elements from which real networks are constructed. The reference points of the transport network architecture are the result of associations between the inputs and outputs of processing functions and transport entities.

Some diagrammatic conventions have been developed to support the descriptions that follow and these are illustrated in Figures 1 and 2 and summarized in Table 1.

Figure 1/G.809 – Diagrammatic conventions for processing functions *(start)*





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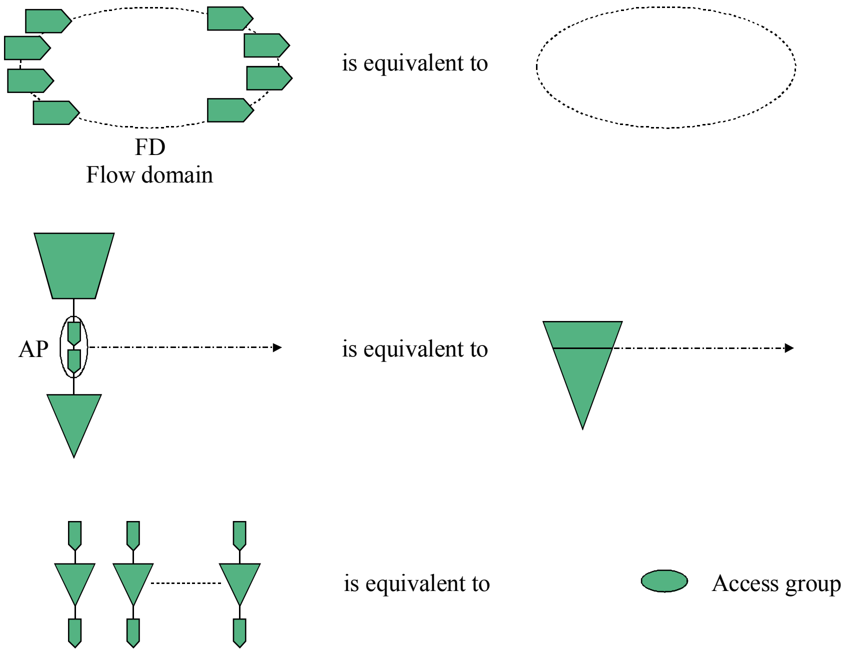

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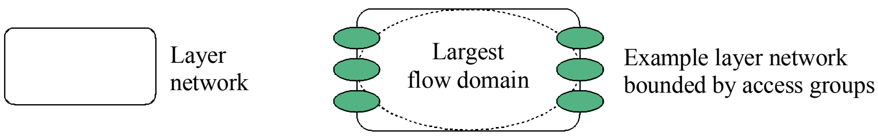

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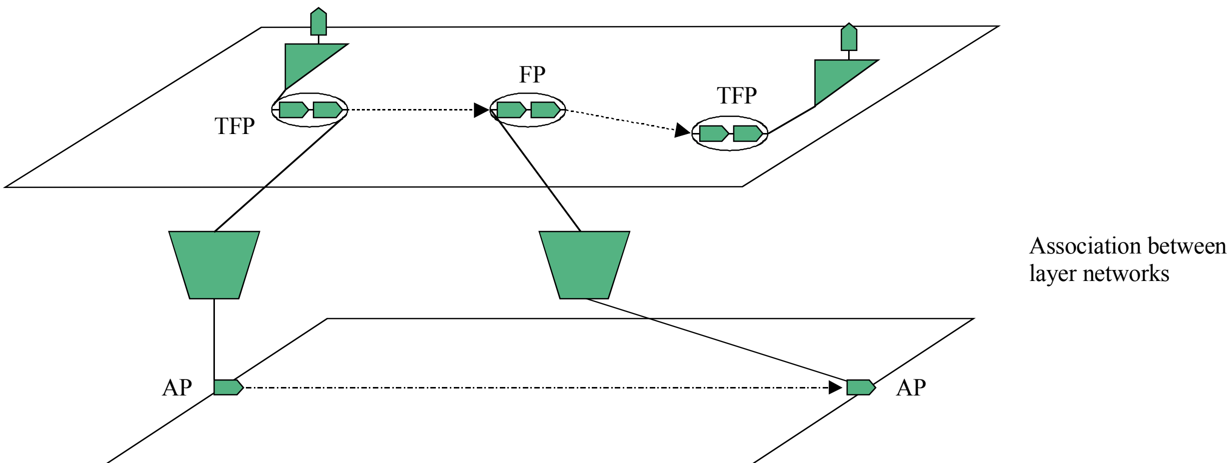

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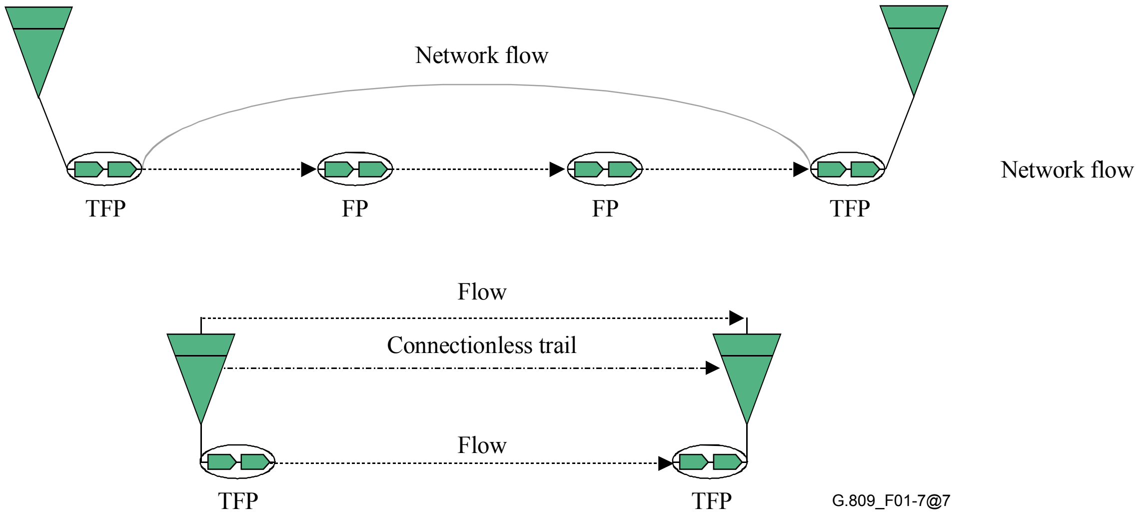


Figure 1/G.809 – Diagrammatic conventions for processing functions *(end)*

6.3.1 Topological components

The topological components provide the most abstract description of a network in terms of the topological relationships between sets of like reference points. Four topological components have been distinguished; these are the layer network, the flow domain, the flow point pool link and the access group. Using these components it is possible to completely describe the logical topology of a connectionless layer network.

6.3.1.1 Layer network

A layer network is defined by the complete set of access groups of the same type that may be associated for the purpose of transferring information. The information transferred is characteristic of the layer network and is termed characteristic information. The associations of the flow terminations (that form a connectionless trail) in a layer network are defined on a per traffic unit basis, which, in a connectionless layer network, is a datagram. A separate, logically distinct layer network exists for each flow termination type. The topology of a layer network is described by access groups, flow domains and the flow point pool links between them. The structures within and between layer networks are described by the components below.

6.3.1.2 Flow domain

A flow domain exists within a single layer network. It is defined by the set of flow points that are available for the purpose of transferring information. Datagram transfers across the flow domain that correspond to a particular association between ingress and egress flow points need not be present at all times. In general, flow domains may be partitioned into smaller flow domains interconnected by flow point pool links. The matrix is a special case of a flow domain that cannot be further partitioned.

6.3.1.3 Flow point pool link

A flow point pool link consists of a subset of the flow points at the edge of one flow domain or a subset of the access points of an access group that are associated with a corresponding subset of flow points or access points at the edge of another flow domain or access group for the purpose of transferring characteristic information. The flow point pool link (FPP link) represents the topological relationship and available capacity between a pair of flow domains, or a flow domain and an access group, or a pair of access groups.

Multiple flow point pool links may exist between any given flow domain and access group or pair of flow domains or access groups. Flow point pool links are established at the timescale of the server layer network.

6.3.1.4 Access group

An access group is a group of colocated flow termination functions that are connected to the same flow domain or flow point pool link.

6.3.2 Transport entities

The transport entities provide transparent information transfer between layer network reference points. There is no information change between input and output other than that resulting from degradation in the transfer process. Two basic entities are distinguished according to whether the information transferred is monitored for integrity. These are termed flows and trails. Flows may be decomposed in a number of ways including topologically, into network flows, flow domain flows and link flows.

6.3.2.1 Flow

A flow is an aggregation of one or more traffic units with an element of common routing. A flow has the following properties:

- it is a unidirectional entity;
- a flow can contain another flow. This is recursive until, for example, the limit of a single traffic unit is reached;
- flows can be multiplexed together in the same layer network;
- flows can be multiplexed together as part of adaptation to a server layer network;
- a flow can be associated with one or more topological entities;
- a flow can be defined in terms of a parameter such as its characteristic information, the address to which traffic units are directed or the address the traffic units have come from;
- the aggregation of traffic units may be spatial or temporal.

6.3.2.2 Link flow

A link flow is capable of transferring information (traffic units) transparently across an FPP link. It is delimited by flow points and represents the fixed relation between the ends of the link. A link flow represents a pair of adaptation functions and a trail in the server layer network.

The flow point at the input to the unidirectional link flow also represents the input to an adaptation source; the flow point at the output of the unidirectional link flow also represents the output of an adaptation sink.

6.3.2.3 Flow domain flow

A flow domain flow is a grouping of traffic units that are transferred transparently across a flow domain. It is delimited by the ports associated with flow points at the boundary of the flow domain and represents an association between these ports. In general, flow domain flows are constructed from a concatenation of flow domain flows and link flows. The matrix flow is a special case of the flow domain flow.

6.3.2.4 Network flow

A network flow is a grouping of traffic units that are transferred transparently across a layer network. It is delimited by the termination flow points (TFPs). In general, network flows are constructed from a concatenation of flow domain flows and link flows. The TFP is formed by binding the port of a flow termination to either a flow domain port or a port on an FPP link.

6.3.2.5 Connectionless trail

A connectionless trail represents the transfer of monitored adapted characteristic information of the client layer network between access points. It is delimited by two access points, one at each end of the connectionless trail. It represents the association between a source and destination on a per traffic unit or datagram basis. A connectionless trail is formed by associating flow terminations with a traffic unit or datagram.

6.3.3 Transport processing functions

Two generic processing functions of adaptation and flow termination are distinguished in describing the architecture of connectionless layer networks.

6.3.3.1 Adaptation function

Adaptation source: A transport processing function which adapts the client layer network characteristic information into a form suitable for transport over a trail (in a connection-oriented server layer network) or connectionless trail (in a connectionless server layer network) in the server layer network.

Adaptation sink: A transport processing function which converts the server layer network trail (in a connection-oriented server layer network) or connectionless trail (in a connectionless server layer network) information into the characteristic information of the client layer network.

The following are examples of processes that may occur singly or in combination in an adaptation function:

Labelling, scheduling, buffering, queuing, multiplexing, traffic dropping, segmentation and reassembly.

Adaptation function cardinality: The adaptation source function input to output relation is a many-to-one relationship or a one-to-many. In the first case, one or more client layer network inputs are adapted into a single adapted information stream suitable for transport over a trail (or connectionless trail) in the connection-oriented (or connectionless) server layer network and this relationship is commonly used to represent the multiplexing of several clients into a single server. In the second case, one composite stream is split over several outputs, and this is used to describe the common processing involved in inverse multiplexing. The converse relationships hold for the adaptation sink function between its single input and one or more outputs.

6.3.3.2 Flow termination function

Flow termination source: A transport processing function which accepts adapted characteristic information from a client layer network at its input, adds information to allow the connectionless trail to be monitored, and presents the characteristic information of the layer network at its output(s). The flow termination source can operate without an input from a client layer network.

NOTE – Whilst the general case is one where a flow termination function adds or extracts information to monitor a connectionless trail, it is also possible that no overhead is provided to monitor the connectionless trail.

Flow termination sink: A transport processing function which accepts the characteristic information of the layer network at its input, removes the information related to connectionless trail monitoring and presents the remaining information at its output.

Flow termination function cardinality: The flow termination source function input to output relation is a one-to-many relationship. The single adapted information input stream is distributed over one or more (connectionless) trails in the server layer. The flow termination source function is associated with a number of termination flow points. The termination flow point that is selected for a particular datagram is dependent on the destination address.

Note that, in a connection-oriented network, the default cardinality is such that a trail termination source has a single termination connection point associated with it.

The flow termination sink function input to output relation is a one-to-one relationship. The flow termination sink is bound to a single termination flow point.

6.3.4 Reference points

Reference points are formed by the binding between inputs and outputs of transport processing functions or represent the role of an unbound input or output of a transport processing function when associated with a topological component. The resultant bindings and specific types of reference point are shown in Table 1.

A dynamic binding exists between a flow point or a termination flow point and a connectionless datagram. This binding exists for the time period over which the datagram transits the flow point or termination flow point.

Table 1/G.809 – Allowable bindings and resulting reference points

Architectural components				**Reference point**	
Adaptation	Source output	Flow Termination	Source input	AP	unidirectional
	Sink input		Sink output		unidirectional
Flow domain	Input port	Flow termination	Source output	TFP	unidirectional
	Output port		Sink input		unidirectional
Flow domain	Output port	Adaptation	Source input	FP	unidirectional
	Input port		Sink output		unidirectional
Flow domain	Output port	Flow domain	Input port	FP	unidirectional
	Input port		Output port		unidirectional
Flow	Egress	Flow	Ingress	FP	unidirectional
	Ingress		Egress		
AP Access Point					
FP Flow Point					
TFP Termination Flow Point					

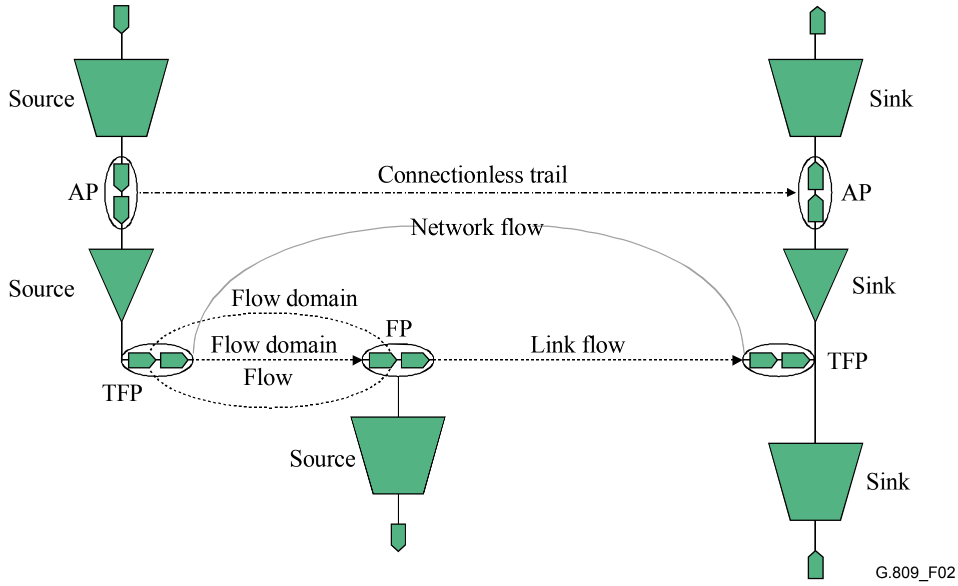


Figure 2/G.809 – Bindings and types of reference points

6.4 Partitioning and layering

6.4.1 Introduction

A transport network can be decomposed into a number of independent transport layer networks with a client/server association between adjacent layer networks. Each layer network can be separately partitioned in a way that reflects the internal structure of that layer network or the way that it will be managed. Thus the concepts of partitioning and layering are orthogonal as shown in Figure 3.

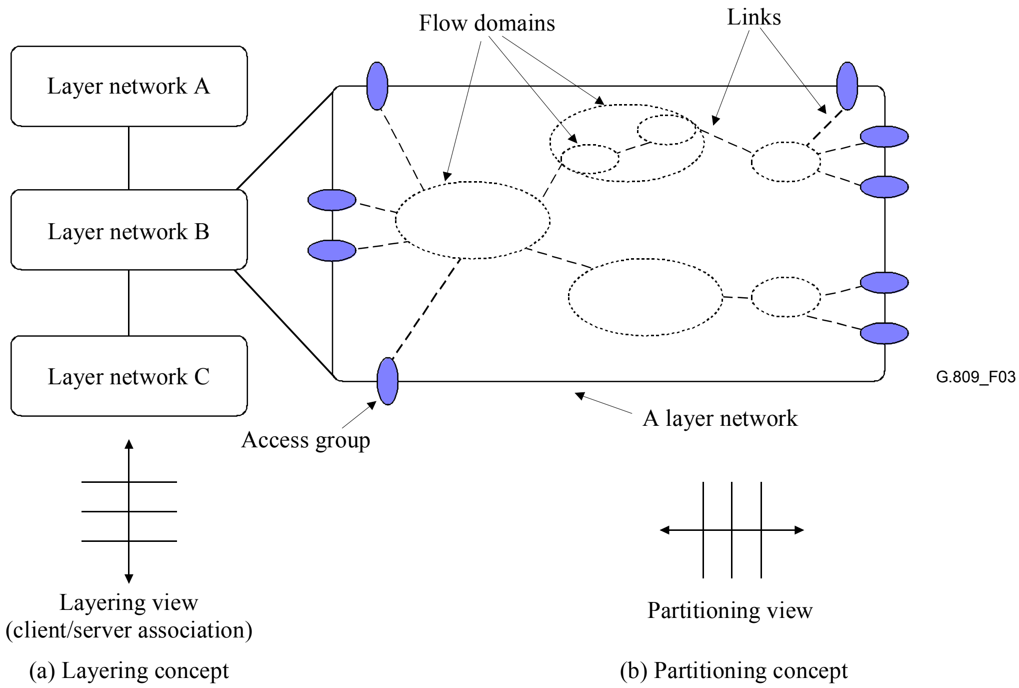


Figure 3/G.809 – Orthogonal views of layering and partitioning

6.4.1.1 Application of the partitioning concept

The partitioning concept is important as a framework for defining:

– the network structure within a layer network;
– administrative boundaries between network operators within a single layer network;
– routing domain boundaries within the layer network of a single operator;
– the part of a layer network or routing domain that is under the control of a third party for routing purposes (e.g., customer network management).

6.4.1.2 Application of the layering concept

The layering concept of the transport network allows:

– each layer network to be described using similar functions;
– the independent design and operation of each layer network;
– each layer network to have its own operations, diagnostic and automatic failure recovery capability;
– the possibility of adding or modifying a layer network without affecting other layer networks from the architectural viewpoint;
– simple modelling of networks that contain multiple transport technologies.

6.4.2 Partitioning concept

6.4.2.1 Flow domain partitioning

In general a flow domain is constructed by representing the physical implementation as FPP links and flow domains, starting from the matrix that is the smallest (indivisible) flow domain. A set of flow domains and FPP links may be abstracted as a higher (containing) flow domain. The way in which the contained flow domains are interconnected by FPP links describes the topology of the containing flow domain. The ports at the boundary of the containing flow domain and the interconnection capability must fully represent, but not extend, the connectivity supported by the contained flow domains and FPP links. Therefore, a higher level flow domain may be partitioned to show the level of detail required.

Thus, in general, any flow domain may be partitioned into a number of smaller (contained) flow domains interconnected by FPP links. The partitioning of a flow domain cannot extend or restrict its connectivity i.e.:

– The ports on the boundary of the containing flow domain and the interconnection capability must be represented by the contained flow domains and FPP links.
– The contained flow domains and FPP links cannot provide connectivity that is not available in the containing flow domain.

Examples of flow domains are the international portion and the national portions of a layer network which can be further divided into transit portions and access portions and so on, as shown in Figure 4. Another example of partitioning is the creation of virtual private network topologies.

A network flow or flow domain flow may be decomposed into a concatenation of other transport entities (link flow or flow domain flow) which reflects the partitioning of a flow domain.

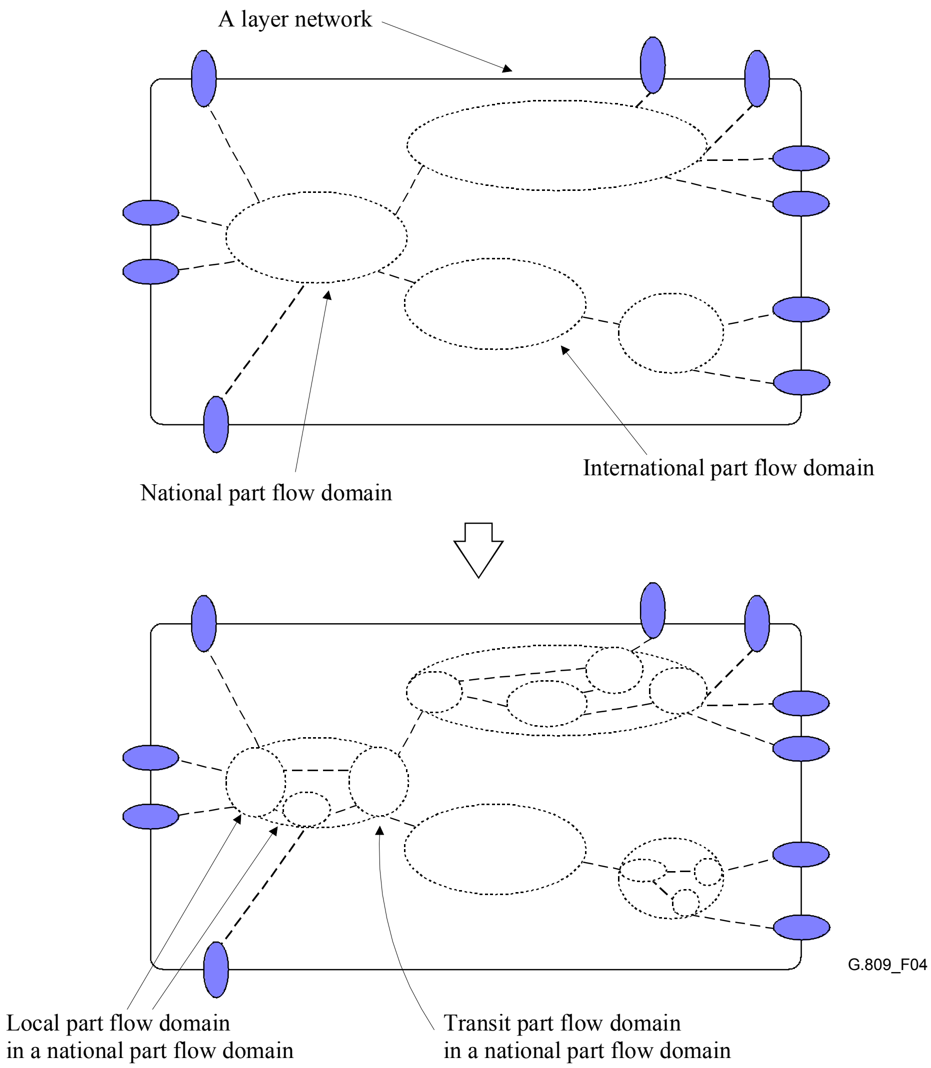


Figure 4/G.809 – Partitioning of layer networks and flow domains

6.4.2.2 Flow point pool link partitioning

In general, a flow point pool link is constructed by bundling a set of link flows (and assigning the associated flow points into flow point pools), that are equivalent for the purposes of routing. Flow point pool links may also be further bundled to provide for any desired capacity visibility.

6.4.3 Layering concept

The transport network can be decomposed into a number of independent layer networks with a client/server relationship between adjacent layer networks. A layer network describes the generation, transport and termination of a particular characteristic information.

The layer networks that have been identified in the transport network functional model should not be confused with the layers of the OSI Model (ITU-T Rec. X.200). An OSI layer offers a specific service using one protocol among different protocols. On the contrary, each layer network (in this Recommendation) offers the same service using a specific protocol (the characteristic information).

6.4.3.1 Client/server relationships between layer networks

Four forms of client/server relationships exist between connection-oriented and connectionless layer networks:

– A connection-oriented client layer supported by a connection-oriented server layer network. This relationship is described in ITU-T Rec. G.805.

– A connection-oriented client layer network supported by a connectionless server layer network. This relationship is illustrated in Figure 5. In this relationship, a client layer link connection (or a network connection containing no subnetwork connections) is supported by a server layer connectionless trail. The server layer source adaptation adapts the connection-oriented characteristic information of the client layer into connectionless adapted information in the server layer. The server layer sink adaptation function adapts server layer connectionless adapted information to client layer connection-oriented characteristic information.
– A connectionless client layer network supported by a connection-oriented server layer network. This relationship is illustrated in Figure 6. In this relationship, a client layer flow is supported by a server layer trail. The server layer source adaptation adapts the connectionless characteristic information of the client layer into connection-oriented adapted information in the server layer. The server layer sink adaptation function adapts server layer connection-oriented adapted information to client layer connectionless characteristic information.
– A connectionless client layer network supported by a connectionless server layer network. This relationship is illustrated in Figure 7. In this relationship, a client layer flow is supported by a server layer connectionless trail. The server layer source adaptation adapts the connectionless characteristic information of the client layer into connectionless adapted information in the server layer. The server layer sink adaptation function adapts server layer connectionless adapted information to client layer connectionless characteristic information.

The concept of adaptation is introduced to describe how the client layer network characteristic information is modified so that it can be transported over a trail, or connectionless trail, in the server layer network. From a transport network functional viewpoint, therefore, the adaptation function falls between the layer networks. All the reference points belonging to a single layer network can be visualized as lying on a single plane as illustrated in Figure 1. This is the reason why there is not the same concept of contiguous layer boundaries in the transport network model as in the OSI protocol reference model.

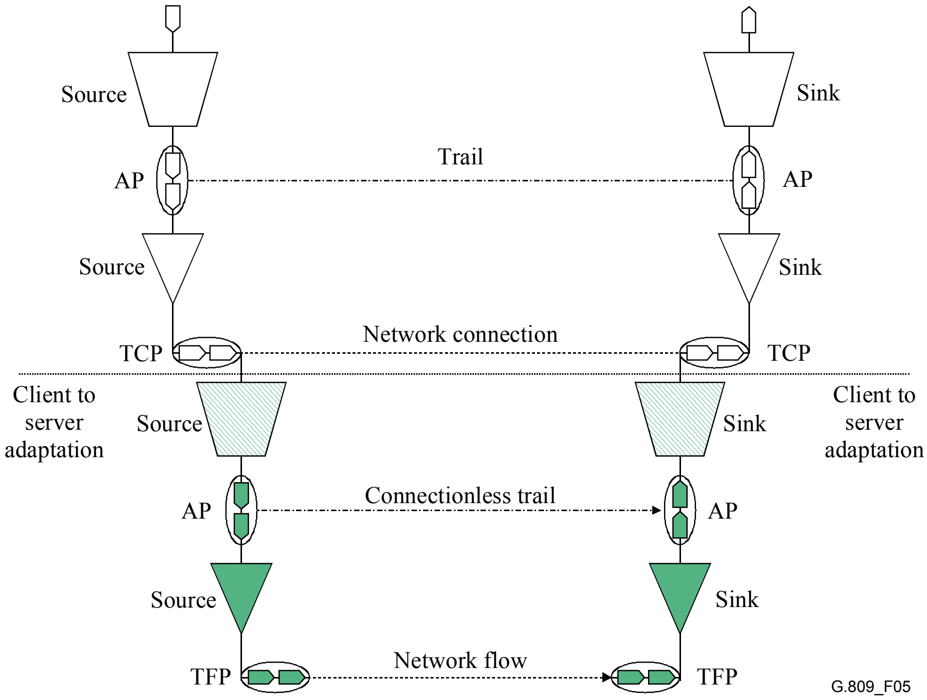


Figure 5/G.809 – Example client server/relationship between a connection-oriented client layer network and a connectionless server layer network

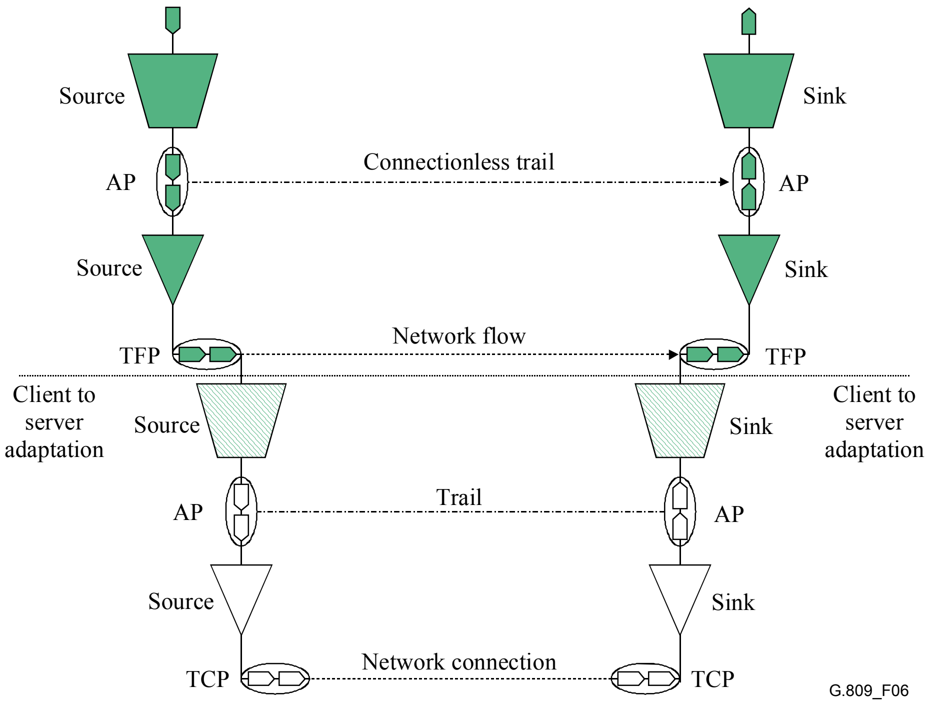


Figure 6/G.809 – Example client server/relationship between a connectionless client layer network and a connection-oriented server layer network

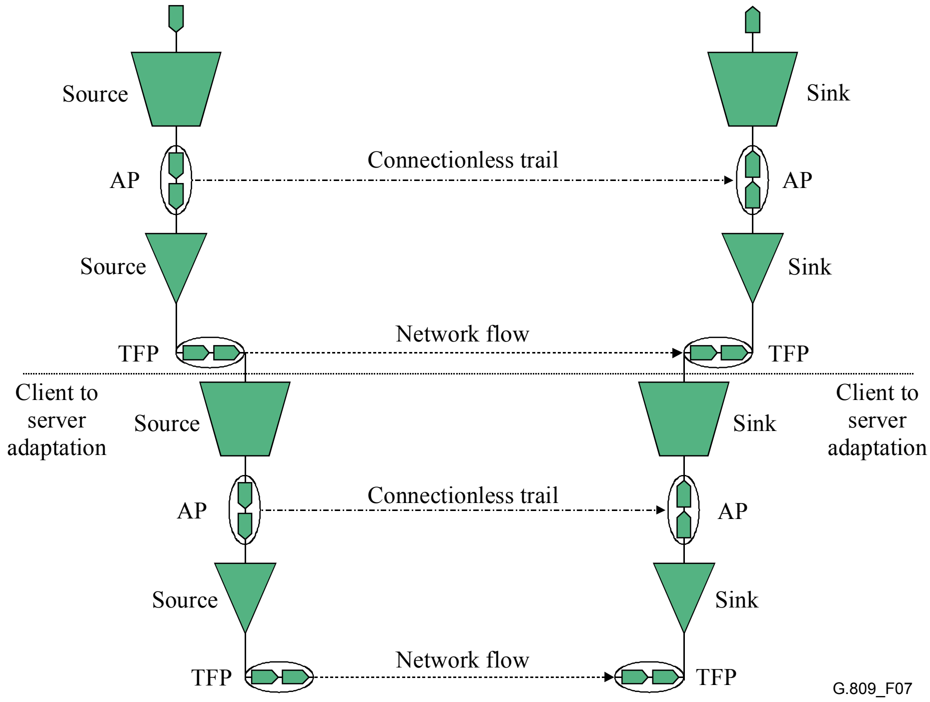


Figure 7/G.809 – Example client server/relationship between a connectionless client layer network and a connectionless server layer network

6.5 Decomposition of connectionless layer networks

It is possible to decompose a connectionless layer network by expanding either the flow terminations, or (termination) flow points of the layer network.

6.6 Application of concepts to network topologies and structures

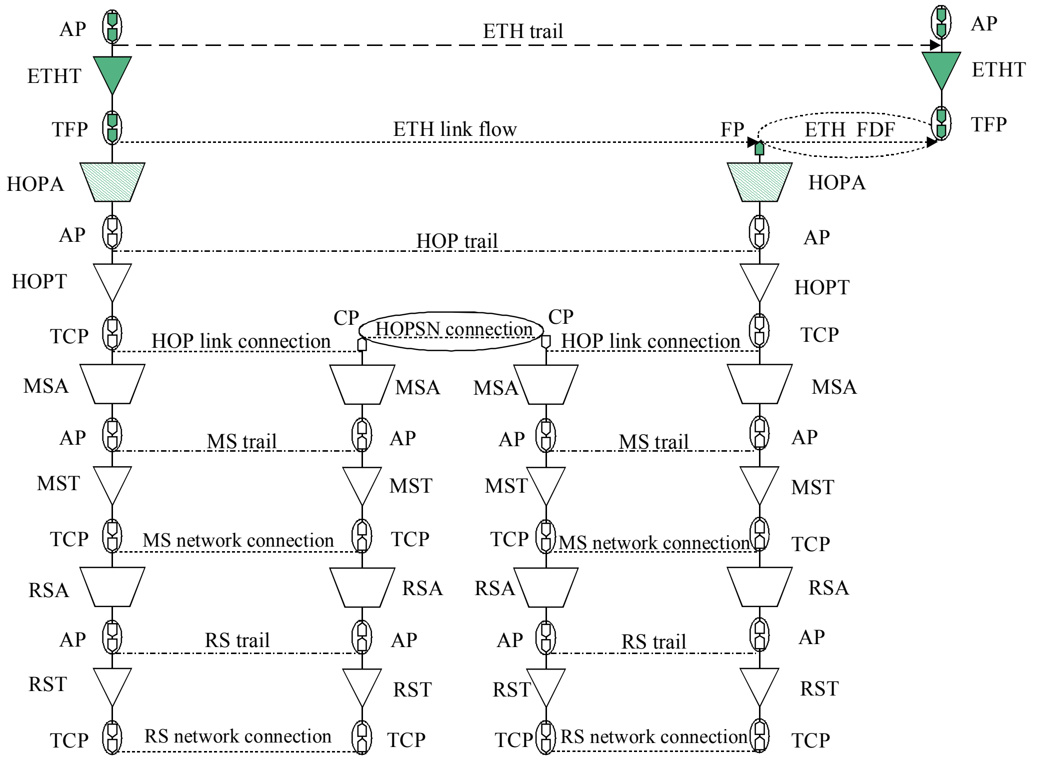
NOTE 1 – The naming schemes used in the examples may not correspond with the naming schemes used in any related equipment specifications.

NOTE 2 – The examples show only the basic network topologies and structures. Additional functionality, where appropriate, will be provided in the related equipment specifications.

6.6.1 Ethernet supported on SDH layer networks

Figure 8 shows an example of the case where Ethernet signals (ETH) are supported on SDH. Four layer networks are shown:

– Ethernet Media Access Control (ETH) layer network;
– SDH higher-order path (e.g., VC-4) layer network;
– SDH multiplex section layer network;
– SDH regenerator section layer network.



AP	Access point	MS	Multiplex section
CP	Connection point	MSA	Multiplex section adptation
ETH	Ethernet	MST	Multiplex section trail termination
ETHT	Ethernet termination	RS	Regenerator section
FDF	Flow domain flow	RSA	Regenerator section adaptation
FP	Flow point	RST	Regenerator section termination
HOPA	Higher order path adaptation	TCP	Termination connection point
HOPT	Higher order path trail termination	TFP	Termination flow point
HOPSN	Higher order path subnetwork		

G.809_F08

Figure 8/G.809 – Application of functional architecture to the case of Ethernet supported on SDH

Annex A

Characteristics of connectionless and connection-oriented layer networks

This annex compares and contrasts the properties of connection-oriented and connectionless layer networks.

Many existing transport networks provide a Connection-oriented circuit switched (CO-CS) infrastructure (e.g., SDH). The architecture of transport networks based on SDH is described in ITU-T Rec. G.803. A Connection-oriented packet switched (CO-PS) infrastructure (e.g., ATM) that uses the CO-CS infrastructure may also be provided. ITU-T Rec. I.326 describes the functional architecture for ATM networks. A Connectionless Packet Switched (CLPS) infrastructure may be provided directly over a CO-CS infrastructure, CO-PS infrastructure, another CLPS infrastructure or over none of the above (e.g., directly connected). Note that the CO-CS infrastructure supporting a CO-PS or CLPS infrastructure may have limited capability (e.g., flexibility).

These infrastructures have certain inherent characteristics that are used in the Operation and Administration of the network and the services that the network supports. A simplified description of, and an attempt to characterise, some of these networks is provided below:

A.1 Characteristics of a CO-CS network implemented with SDH, OTN or PDH

Before a user information flow is initiated across the network, the user source, user destination (applications) and the network must agree on the characteristics of the connection (e.g., bit rate, availability). In terms of the Automatic Switched Transport Network architecture described in ITU-T Rec. G.8080/Y.1304, a call represents the negotiation between the customer and the network, whilst the connection supports the information flow. Based on this agreement to communicate (the call), the end customer payload is explicitly assigned to network resources by a connection management process, e.g., an explicit time-slot is identified in each of a series of concatenated (server layer) trails to interconnect the end user terminals at the addresses identified in the call request. These trails may be shared by multiple end customer payloads. Contention for resources is resolved at the time the connection is requested, if resources are not available the connection request is rejected (and the call attempt fails). In this case, the timeslot represents both a networking identifier (for the purposes of cross-connection or switching) and an explicit resource reservation. In terms of the ITU-T Rec. G.805 model, it is the adaptation function at the input of a server layer trail that "stores" the client signal until the assigned timeslot arrives. The customer does not constrain the choice of timeslot within the network i.e., the network "owns" the multiplexing and switching identifier space. This networking identifier (timeslot) has only local significance; it is only valid in the context of a specific trail. Separation of customer signals is provided inherently by the timeslot assignment performed by the network. Since the network has performed the assignment process, it can also arrange to intercept and monitor the client signal (or the trail supporting it) at any convenient point in the network. Network failures invoke a specific process, either a protection switch or restoration. A protection switch process is not visible to a connection management system (i.e., the end points of the trail are unchanged) whilst restoration invokes a new connection setup. Monitoring of the client signal can be coordinated across these processes. In general, both the client signal and the trails used to carry it are monitored using network overhead.

A.2 Characteristics of a CO-PS network implemented with ATM

Before a user information flow is initiated across the network, the user source, user destination (applications) and the network must agree on the characteristics of the signal (e.g., peak and average bit rate). Based on this agreement, the end customer payload is explicitly assigned to network resources by a connection management system i.e., an explicit VPI/VCI is identified in each of a series of concatenated (server layer) trails to interconnect the end user terminals at the addresses identified in the call request. These trails may be shared by multiple end customer payloads. In this case, contention for the trail resources is not always fully resolved at the time the connection is requested, however, the network can assign (or not) customer connections to trails based on the traffic parameters of the connection request and the connections already assigned to the trail. In this case, the VCI/VPI represent networking identifiers for switching. In terms of the I.326 model, it is the adaptation function on the input to the server layer trail that buffers the ATM cell until a timeslot is available on the outgoing (CO-CS) trail. The customer does not constrain the choice of VPI/VCI within the network i.e., the network "owns" the multiplexing and switching identifier space. The VPI/VCI identifiers only have local significance; they are only valid in the context of a specific trail. Separation of customer signals is provided inherently by the VPI/VCI assignment performed by the network. Since the network has performed the assignment process, it can also arrange to intercept and monitor the client signal (or the trail supporting it) at any convenient point in the network. Note that, while network failures can cause the rearrangement of connections, this does not prevent monitoring as described above. In general, the integrity of the client signal is monitored using OAM cells. The trails in the network are monitored using network overhead.

A.3 Characteristics of a CLPS network implemented with IP using best effort, destination-based forwarding

An IP packet can be initiated by a user without prior negotiation with either the network or the destination user terminal: there is no reservation of end-to-end resources. The source and destination addresses (networking identifiers) are included in the IP header appended to each packet by the source terminal. Both addresses have global significance, and the destination address is used by each router to forward the packet towards the intended destination based on the routing table at each router. A new packet invokes the same process used for any previous packet i.e., the network does not maintain state. The transport network resources (e.g., the CO-CS trails between routers) are shared by arbitrary end customer packets based on the content of the routing tables (e.g., current network topology and congestion). Changes in network topology (e.g., failures) and traffic loading are accommodated by updating the routing tables (e.g., removal of a failed link from the topology). The IP network uses a routing protocol to keep the routing tables current. Since the network has no explicit knowledge of the existence or location of a specific packet between customer terminals, the network cannot monitor these packets for service assurance. In such a network, each packet is treated independently and each packet can be considered as being equivalent to a flow using the model described in this Recommendation. Higher granularity flows based upon aggregation of packets can also be defined.

A.4 Characteristics of a network implemented with ethernet

Similar to IP, as described above, a Media Access Control (MAC) frame can be initiated by a user, without prior negotiation, with either the network or the destination user terminal. The source and destination addresses (networking identifiers) are added to the header of each MAC frame by the source terminal. The addresses have global significance and the destination address is used by each switch to forward the information flow towards the intended destination based on the forwarding table at each switch.

When a switch receives a frame with a MAC address that is not in the forwarding table, it is broadcast and, based on the frames received in the reverse direction, a new entry is made in the forwarding table. The information in the forwarding table "ages" and after some period of inactivity (i.e., no frames) it is discarded. The transport network resources (e.g., the CO-CS trails between routers) are shared by arbitrary end customer information flows based on the content of the forwarding table. Network topology changes are accommodated by invoking the broadcast mechanism and spanning tree algorithm to refresh the forwarding table. Since the network has no explicit knowledge of the existence or location of a specific flow between customer terminals, the network cannot monitor these flows for service assurance. In common with IP used in best effort, destination-based forwarding mode, each MAC frame can be considered as a flow, where the flow is equivalent to a single frame. Higher granularity flows based on aggregation of frames can also be defined.

The characteristics of the networks identified above are summarized in Table A.1.

Table A.1/G.809 – Network characteristics of connection-oriented and connectionless layer networks

Network Characteristic	**CO-CS (e.g., SDH, OTN)**	**CO-PS (e.g., ATM)**	**CLPS (IP)** With best effort, destination-based forwarding	**CLPS (Ethernet)**
UNI demarcation	Yes	Yes	No	No
NNI demarcation	Yes	Yes	No	No
Control Plane/Bearer Plane separation	Yes	Yes	No	No
Networking identifier assigned by	Network	Network	Client	Client
Network identifier used for naming or addressing	No	No	Yes	Yes
Networking identifier	Local	Local	Global	Global
Networking identifier forwarding	Crossconnect	ATM Switch	router	switch
Source/destination address appended by	–	–	Client	Client
Source/destination address independent of networking identifier	Yes	Yes	No	No
Network visibility from client	No	No	Yes (e.g., Ping, Trace Route)	Yes (e.g., Ping)
Explicit connection request before flow initiation (Call/connection model)	Yes	Yes	No	No
Per flow (call) service assurance	Yes	Yes	No	No
Per flow (call) billing	Yes	Yes	No	No
Per flow (call) end-to-end resource allocation	Yes/Implicit	Yes	No	No
Flow (call) duration	Until explicitly terminated	Until explicitly terminated	Length of current packet	Length of current packet
Possibility of miss-sequencing of information between delivered to end user application	No – assuming communication is over a single flow	No – assuming communication is over a single flow	Yes – communication is segmented into packets each of which is routed independently	Yes – but not if packet flow is frequent enough to refresh the forwarding table

Annex B

Components of connection-oriented and connectionless layer networks

This annex compares the components of a connection-oriented architecture based on ITU-T Rec. G.805 with that of the connectionless architecture described in this Recommendation. This is described in Table B.1. Note that, whilst the terms "access group" and "access point" appear to be the same in both architectures their definitions are different depending upon the context of the layer network. In a connection-oriented layer network, the access point is the reference point between the adaptation and trail termination whilst, in a connectionless layer network, it is the reference point between the adaptation and flow termination. Furthermore, the access point of a connectionless layer network is associated with a connectionless trail, whilst the connection-oriented access point is associated with a trail. Similarly, the access group in a connectionless layer network is defined in terms of flow terminations, flow domains and flow point pool links whilst, in a connection-oriented layer network, it is defined in terms of terminations, links and subnetworks. This allows for a common description of a layer network for both connection-oriented and connectionless cases.

Note that bidirectional constructs described in ITU-T Rec. G.805 do not have a counterpart in a connectionless layer network.

Entities that are specific to a connectionless network are indicated in bold type.

Table B.1/G.809 – Components of connection-oriented and connectionless architectures

Connection-oriented component	Connectionless component
Access group	Access group
Access point	Access point
Adaptation	Adaptation
Adaptation sink	Adaptation sink
Adaptation source	Adaptation source
Adapted information	Adapted information
Architectural component	Architectural component
Characteristic information	Characteristic information
Client/server relationship	Client/server relationship
Unidirectional connection	**Flow**
Unidirectional connection point	**Flow point**
Layer network	Layer network
Link	**Flow point pool link**
Link connection	**Link flow**
Network connection	**Network flow**
Subnetwork	**Flow domain**
Subnetwork connection	**Flow domain flow**
Unidirectional termination connection point	**Termination flow point**
Topological component	Topological component
Trail	**Connectionless trail**
Trail termination	**Flow termination**
Trail termination sink	**Flow termination sink**
Trail termination source	**Flow termination source**
Transport	Transport
Transport entity	Transport entity
Transport network	Transport network
Transport processing function	Transport processing function

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