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Amendment 2
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SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

Digital networks – General aspects

Unified functional architecture of transport networks
Amendment 2

Recommendation ITU-T G.800 (2007) – Amendment 2

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Recommendation ITU-T G.800

Unified functional architecture of transport networks

Amendment 2

Summary

Amendment 2 to Recommendation ITU-T G.800 includes new clauses to describe communication, modifications to clause 8 on transparency, and a new clause for derived constructs for the routing viewpoint.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.800	2007-09-06	15
1.1	ITU-T G.800 (2007) Amend. 1	2009-03-09	15
1.2	ITU-T G.800 (2007) Amend. 2	2010-09-06	15

FOREWORD

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Unified functional architecture of transport networks

Amendment 2

1) Clause 3, Definitions

Add the following definitions:

server subnetwork: A topological component that consists of two or more link ports supported by a server layer network.

transitional link: A topological component that consists of the link port at the edge of one subnetwork and a corresponding link port at the edge of another subnetwork that operates on different instances of characteristic information or whose characteristic information is the same but with different layer information. A transitional link (topological component) is supported by or implemented by layer processors and/or adaptation/termination functions (transport processing functions). A transitional link can be partitioned into parallel transitional links, or a concatenation of transitional links. It can also be partitioned into a concatenation of transitional links and zero or more links.

2) Clause 6.4.2

Add the following to the end of clause 6.4.2 "**Resource Considerations**":

Transferring information between layers or sublayers also has an associated resource property. For this Recommendation, it is assumed that whenever this occurs, the adaptation/termination or layer processor functions have adequate resources for the link/subnetworks they source or sink.

3) Clause 6.5

Update clause 6.5 with the following:

6.5 Transport entities and their properties

Transport entities provide the means to transfer information across the network, between reference points, and are ~~derived from~~ configured within topological components ~~by the addition of a forwarding function which requires configuration~~. A transport entity is a generalized channel with a number of ports that transfers information from its input port(s) to its output port(s). The information transferred is characteristic of the layer network and specific resources are assigned to accomplish the information transfer. The information transfer relationship provided by a transport entity is distinct from that of other transport entities. The properties of a topological component are unchanged by the addition or configuration of a ~~forwarding function~~ transport entity. The ~~forwarding function~~transport entity can only further restrict any topological or resource constraints that are initially present.

A transport entity exists independently of the information/symbols it transfers. To create a transport entity, the set of forwarding points associated with the transport entity must be identified and a set of forwarding rules must be defined. At least one forwarding rule must be present to enable a transport entity to transfer information. For some transport entities, forwarding rules may be dynamically added or modified to further control the transfer of symbols, for example, to optimize the use of resources or to respond to faults in the network.

The following basic entities are described: forwarding relationship, subnetwork transport entity, server subnetwork transport entity, link connection, connection, differentiated connection, multipoint transport entities, and access transport entity~~and transfer association~~.

Modify clause 6.5.1 as below:

6.5.1 Forwarding relationship

The information transfer relationship provided by a transport entity is called ~~A~~a forwarding relationship~~ is the transport entity that is created by a forwarding function that has been configured in a subnetwork~~. The forwarding relationship is the net behaviour resulting from the forwarding rules associated with the transport entity's ingress forwarding points and egress forwarding points ~~of the forwarding relationship are identified together with~~ and any policy related to these points. The selection of the ingress and egress points to be used may be based on a policy that considers, for example, the condition of a link connected to the subnetwork for the purpose of protection switching. The creation of ~~the~~a transport entity and associated forwarding relationship in a subnetwork binds the forwarding ports on the subnetwork to the forwarding ports on ~~the~~a link, server subnetwork, or ~~termination~~access group. This binding creates the forwarding points (FwP). Two types of forwarding are possible:

Destination forwarding: Symbols presented at an ingress forwarding port are selectively forwarded to zero or more egress forwarding ports. The forwarding function requires control information to identify the output port(s) to which a ~~communication~~symbol is destined. This control information is carried by the symbol being forwarded (commonly in the form of a destination address). The resulting network behaviour is traditionally known as "connectionless."

Channel forwarding: All symbols on all ingress forwarding ports are forwarded to all egress forwarding ports. No additional control information is required with the symbol. When there is a single ingress forwarding port the forwarding relationship is equivalent to a subnetwork connection in [ITU-T G.805].

NOTE – A broadcast medium has a forwarding function associated with it that allows no further configuration of the forwarding relationship and is represented as a broadcast forwarding relationship.

Insert new clauses 6.5.2 and 6.5.3 and renumber existing clauses:

6.5.2 Subnetwork transport entity

A subnetwork transport entity (SNTE) is a transport entity created in a subnetwork by the configuration of the forwarding function represented by that subnetwork. The SNTE may provide channel forwarding or destination forwarding behaviour according to the capabilities of the forwarding function represented by the subnetwork. If the SNTE provides destination forwarding behaviour, the symbols (CI) of the layer network must contain destination selection information (e.g., destination address). A network transport entity is bounded by FwEPs, i.e., it is an SNTE in the maximal subnetwork of a layer network.

6.5.3 Server subnetwork transport entity

A server subnetwork transport entity (SSNTE) is a transport entity created by the configuration of adaptation functions bounding a server layer access transport entity. The SSNTE may provide channel forwarding or destination forwarding behaviour. If the SSNTE provides destination forwarding behaviour, additional information to select destination server layer access port(s) must accompany symbols passed to the SSNTE.

Modify clauses as below. Note that these were original clauses 6.5.2 and 6.5.3:

6.5.4 Link connection

A link connection is ~~the~~a transport entity ~~that is~~ created by the configuration of two adaptation functions~~when a forwarding function is configured in a link~~. The link connection has exactly one ingress forwarding port and one egress forwarding port and provides channel forwarding behaviour. Any symbol presented at the ingress is delivered to the egress port unless it is discarded by a function in the link or server subnetwork such as policing, congestion control, or filtering. Resources are reserved for that link connection and there is no possibility of further reservation of capacity. When configured in a link, t~~T~~his is equivalent to a link connection in [ITU-T G.805]. A bidirectional link connection is a pair of link connections in opposite directions in the same bidirectional link or server subnetwork. The link connection can be created ~~in the link~~ either before the FwPt is bound to another FwPt or at the time the binding is created. Changing the binding can only create or delete a link connection; it cannot modify an existing link connection.

6.5.5 Connection

A connection is a ~~channel forwarding relationship~~transport entity with the added constraint that all the link connection resources have been reserved for a specific communication. A connection has only one ingress forwarding port and provides channel forwarding behaviour. Further, the user of a connection has complete control over the allocation of the capacity of the connection. The allocation ~~can be controlled by a local synchronous information system and~~ is only controlled locally, so the local allocation decisions can be instantaneous, deterministic, and flexible. A point-point bidirectional connection is a pair of unidirectional connections between the same bidirectional FwPs (in opposite directions). A unidirectional connection may have multiple egress forwarding ports (P-MP), each of which receives in principle the same communication. ~~The~~A network connection is a connection that has an FwEP at each end.

Add the following text as new clause 6.5.7:

6.5.7 Multipoint transport entities

A multipoint transport entity is a subnetwork transport entity or server subnetwork transport entity that provides destination forwarding behaviour. Two specific forms of multipoint transport entity are multipoint (MP-MP) and rooted multipoint (RMP). A MP-MP transport entity provides bidirectional transfer of symbols among a set of bidirectional forwarding ports. A RMP transport entity provides bidirectional transfer of symbols among a set of root forwarding points and leaf forwarding points, where a root can exchange symbols with any other root or leaf, and a leaf can exchange symbols with any root but not with another leaf.

Modify clause 6.5.8 as below. Note that this was original clause 6.5.4:

6.5.8 Access ~~relationship~~ transport entity

An ~~"~~access~~ relationship"~~ transport entity is ~~created when a forwarding function is configured in~~a transport entity provided between a set of access ports at the boundary of a layer network~~. The ingress access ports and egress access ports of the forwarding relationship are identified together with any policy related to these ports~~. An access ~~relationship~~transport entity cannot be partitioned. The access ~~relationship~~ transport entity may be established either before or after the termination is bound to an adaptation, i.e., it may be bounded by access ports or access points or a combination. Modifications to the bindings do not change the access ~~relationship~~ transport entity. The access ~~relationship~~transport entity is supported by a corresponding ~~forwarding relationship~~subnetwork transport entity in the largest subnetwork (i.e., a network transport entity).

In a network that uses channel forwarding, the access ~~relationship~~transport entity is supported by a network connection, i.e., it is equivalent to a trail in [ITU-T G.805]. The access ~~relationship~~ transport entities provided by such a network are channel based.

In a network that uses destination-based forwarding, the access ~~relationship~~transport entity is supported by a corresponding destination forwarding ~~relationship in the largest subnetwork.~~ network transport entity. The access ~~relationships~~ transport entities provided by such a network may be channel or destination based.

Add the following text as new clause 6.5.9:

6.5.9 Transitional link connection

A transitional link connection is the transport entity that is created when a forwarding function is configured in a transitional link. The transitional link connection has exactly one ingress forwarding port and one egress forwarding port. Any symbol presented at the ingress is delivered to the egress port with a change in LI value due to layer processors. A bidirectional transitional link connection is a pair of transitional link connections in opposite directions in the same bidirectional transitional link.

Modify clauses 6.5.10 and 6.5.11 as below. Note that these were original clauses 6.5.5 and 6.5.6:

6.5.10 Partitioning of transport entities

A network transport entity (bounded by termination functions) may be partitioned into parts (smaller transport entities) controlled by different administrations and within an administrative domain into parts supported by different resources (links or matrices). Each transport entity has a topology defined by its forwarding points and the transport entities provided between these points. When additional functionality (e.g., tandem monitoring, subnetwork protection, etc.) is provided for a portion of a transport entity, this creates additional forwarding points, adding to the topology of the transport entity. In some cases, only a subset of the parts of a transport entity are used to transfer client traffic at any given time.

When a subnetwork that contains a ~~channel forwarding relationship~~connection is partitioned to reveal the internal structure of the connection, the subnetworks contain only ~~channel forwarding relationships~~ subnetwork connections and the links or server subnetworks contain link connections.

When a subnetwork that contains a destination forwarding ~~relationship~~SNTE is partitioned to reveal the internal structure of the SNTE, the subnetworks contain destination or channel forwarding ~~relationships~~SNTEs and the links or server subnetworks contain link connections or SSNTEs.

6.5.11 Reservation and allocation

In the network, resources are represented by links and matrices and these resources can be reserved for a particular ~~forwarding relationship~~transport entity, or a set of ~~forwarding relationships~~ transport entities, for supporting a particular communication ~~(a connection)~~ or set of communications. A portion of a resource is reserved for (or assigned to) a transport entity when the transport entity is created. A resource is allocated to a communication only when the communication is using the resource. Resources are limited by the installed capacity and allocations must be within this capacity.

In networks using packet switching, a resource is only allocated when a symbol is present. Therefore it is possible that the total of the reservations exceeds the capacity of the link. This overbooking may cause link congestion in which case some symbols may suffer increased delay and in extreme cases may be discarded. Note that policing functions are derived from contracts and are not part of resource reservation. However, they may be used to ensure that the resource allocated does not exceed the reservation. Communications transported by destination forwarding may be subjected to policies even when there is no explicit resource reservation in the network.

In networks using circuit switching, the resource allocation takes place at the time the reservation is made, i.e., when the ~~forwarding relationship~~transport entity is provisioned, and the allocated resource is used even in the absence of any meaningful communication.

4) New clause 6.11

Add the text below as new clauses:

6.11 Derived network constructs for topological viewpoints

This clause describes a number of constructs that can be used when providing a topological viewpoint for purposes such as routing.

One of two topology views may be used to show the relationship between a set of link points in a layer network (client layer) that are, or may be, related by transport provided by a server layer network.

1) The first view would include at least the set of link points of interest and indicate the set relationship among these points. If the server layer transport has been provisioned (and is presumed fixed) attributes related to the communication capacity and behaviour of the server layer transport may be indicated in addition to the set relationship. The simplest form of this view is as a single subnetwork (simple set relation).

   NOTE – If further partitioning of the topological relationship between the link points of interest is provided, any additional subnetworks or links provided in this (client layer) topology serve to represent attributes related to the communication capacity and behaviour of the server layer transport. They need not have any direct relation to the topology of the server layer network. Link points added in a further decomposed topology do not represent actual forwarding point sets in the client layer (as this partitioned topology is actually representing server layer transport).

2) The second view would include the set of link points of interest and indicate the topological relationship between these points by showing a transitional link from each client layer link point to a server layer link point at the boundary of a server layer topology. This server layer topology may be as simple as a single subnetwork or may be further partitioned (as may be done with any layer network topology).

6.11.1 Transitional link

A transitional link consists of the link port at the edge of one subnetwork and a corresponding link port at the edge of another subnetwork that operates on different instances of characteristic information or whose characteristic information is the same but with different layer information. A transitional link (topological component) is supported by or implemented by layer processors and/or adaptation/termination functions (transport processing functions). A transitional link can be partitioned into parallel transitional links, or a concatenation of transitional links. It can also be partitioned into a concatenation of transitional links and zero or more links.

The use of a transitional link implies a sequence of adaptations between layers, or a sequence of layer processors between sublayers. Any directed ingress transformations must be reversed by corresponding egress transformations.

An example is illustrated in Figure AM2.1 below.

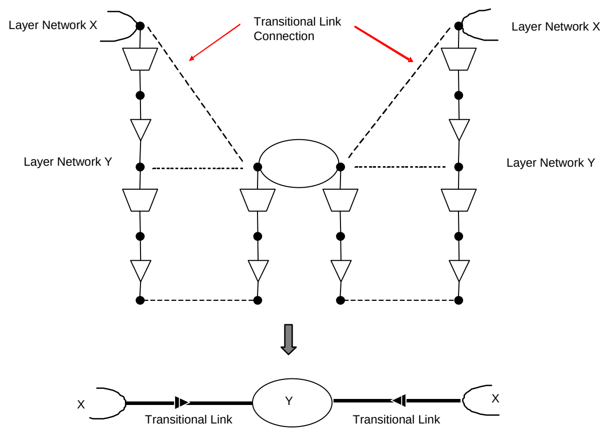

Figure AM2.1 – Transitional link between layer networks X and Y

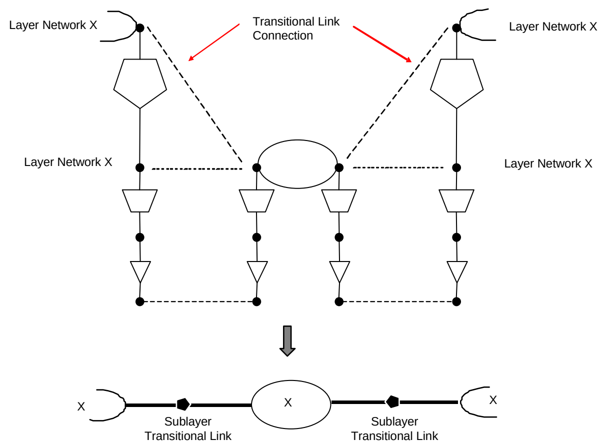

Figure AM2.2 – Transitional link between sublayers

Figure AM2.1 shows a transitional link pair between layer X and layer Y. That the X and Y subnetworks are remote from each other is shown by the Y layer server trail. Note that the ingress Y/X adaptation is undone by the egress Y/X adaptation. Figure AM2.2 shows the same situation but within the same layer. In this case, the X and Y subnetworks refer to sublayers.

6.11.1.1 Drawing conventions

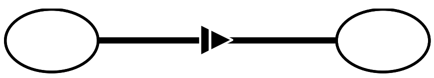

Figure AM2.3 – Symbol for layer transitional link

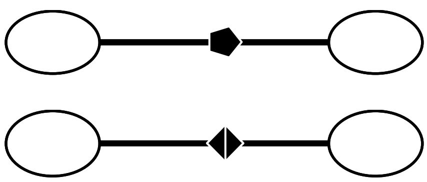

Figure AM2.4 – Symbols for sublayer transitional links

The upper diagram is used to depict a directed transformation, which needs to be undone within a trail. An example is inserting a sublayer OAM field. The lower diagram is used to depict a non-directed operation, such as setting a parameter value.

6.11.2 Server subnetwork

A server subnetwork is a topological component with two or more link ports supported by a server layer network. It represents an abstraction of the server layer topology in the client layer. This is illustrated in Figure AM2.5a.

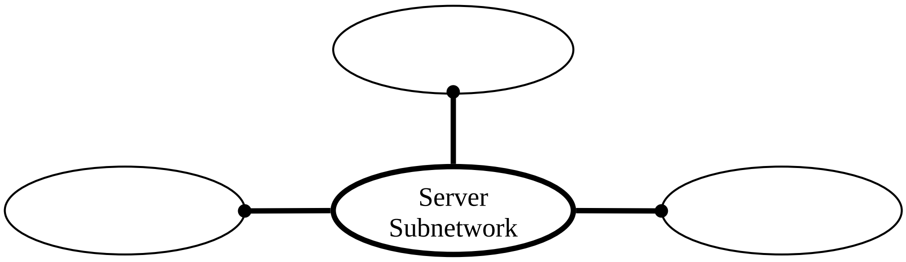

Figure AM2.5a – Client layer view

The server subnetwork provides one or more server subnetwork transport entities (SSNTEs) between forwarding points in the link points in the client layer. These SSNTEs are able to transfer CI of the client layer network between their forwarding points. It can support one or more SSNTEs.

A server subnetwork cannot be further partitioned within the client layer network and it is not a matrix. Server subnetworks are partitioned into transitional links between the link ports in the client layer and link ports in the server layer. This is illustrated in Figure AM2.5b. The server layer topology may be further partitioned as described in clause 6.4.1.

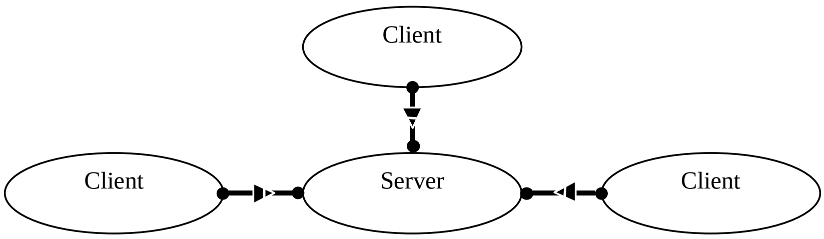

Figure AM2.5b – Multi-layer view

5) Clause 8

Replace the following text in clause 8:

– symbol value degeneration;

– symbol order degeneration (deviation from original order);

– symbol timing degeneration (deviation from original time position);

with:

– symbol value degeneration (e.g., bit errors);

– symbol order degeneration (deviation from original order);

– symbol timing degeneration (deviation from original time position);

Modify the following sentence above the final set of bullet points in clause 8 as follows:

Besides degeneration of the symbols, ~~the forwarding relationship~~an access, network, subnetwork, matrix, server-subnetwork or link transport entity may experience unintended modifications:

Modify the last sentence of clause 8 as follows:

The techniques applied to the detection and mitigation of some or all of these impairments are described in technology-specific Recommendations and are based on deployment of additional, well-known OAM information symbols, which complement the adapted client symbols within the monitored transport entity. Mitigation of those impairments is provided via repair actions of such impaired transport entities.

The adaptation function or a function in the server layer may encode the symbols to allow mitigation of impairments incurred during the transfer of the symbols.

Add the following subclause at the end of clause 8:

8.1 Inter-layer information dependency

In a strict sense, there should be no information dependency between layer networks. Where there is, this may be decomposed into several different aspects:

a) Visibility and use of client information at the access point (i.e., in the adaptation function). The adaptation function reads the client "control" information and presents this as parameters across the access point. The termination function encodes these parameters into the syntax of the server layer[1]. This maximizes independence between the client and server symbol sets. The syntactic and semantic information dependency is resolved at the access point. In order to preserve the fidelity of transfer, the appropriate server layer encoding must be chosen.

b) Use of encoded client information between the forwarding end points. Within the server layer, some of the client information that has been encoded into the syntax of the server layer is used. Three general cases in which client control information may be used in a server layer network are:

- Symbol destination(s) for a destination forwarding server layer network transport entity;

  NOTE 1 – Transport entity destination information is resolved for a channel forwarding layer network when the transport entity is set up.

- Symbol urgency (e.g., queuing priority) for a packet transport network transport entity;

  NOTE 2 – This is resolved for a circuit network when the transport entity is set up.

- Symbol importance (e.g., drop precedence) for a packet transport network transport entity;

  NOTE 3 – This is resolved for a circuit network when the transport entity is set up, e.g., protection mode, and may be resolved similarly in a packet network as well.

[1] The encoded syntax of the parameters used by the adaptation function may match the syntax used by the server layer, in this case, the encoding in the termination is a null function.

However, if channel-based forwarding is used, this may result in impairment of the fidelity of transfer. For example, in a packet network where a transport entity utilizing channel-based forwarding has multiple client priorities, each mapped into different server priorities, then the order of symbols with different (client) priorities will not be preserved. Such impairment may not be significant if the client does not expect that the order of symbols with different priorities is preserved during transfer.

c) Visibility and use of the information contained in client symbols between forwarding end points. Functions in "this layer" read and interpret the syntax and semantics of the client "control" information that was passed across the access point as adapted information (AI). In this case, "this layer" is not transparent within the ITU-T G.800 definition since "this layer" assumes the presence of some information element that is provided directly by the client.

6) New clause 11

Add new clause 11 and its associated subclauses as follows:

11 Communication

The purpose of a network is to deliver communications among a number of parties. From a service perspective, the necessary specification is the set of all senders and all destinations, together with all the set of relationships that those senders and receivers can use to unidirectionally exchange communications amongst themselves. This specification is called a communications matrix. Bi-directional communication is specified by means of additional sources and destinations.

A communications matrix may be written as:

$$C = \begin{bmatrix} c_{1,1} & c_{1,2} & \cdots & \cdots & c_{1,n} \\ c_{2,1} & \cdots & \cdots & \cdots & \vdots \\ \vdots & & \ddots & & \\ \vdots & & & \ddots & \\ c_{m,1} & \cdots & \cdots & \cdots & c_{m,n} \end{bmatrix}$$

where $c_{i,j}$ is the communication between source S_i and destination D_j. In the general case, m does not equal n. For a communication, $c_{i,j}$ equals one and for no communication equals zero.

Note that, in the matrix, all desired communications are explicitly specified with a directionality from a source, such that:

{S_1 communicates with D_1} and {S_1 communicates with D_2} specify individual communications and does *not* specify a multicast communication, which must be specified explicitly as {S_1 communicates with {D_1, D_2}}. Also note that a broadcast communication must be specified as {S_1 communicates with *all destinations*}. If a multicast or broadcast communication is to be supported, then it must be identified by an additional column in the communication matrix that identifies the set of destinations.

The communications relationship applies to points around a subnetwork and is the only property that can be stated about a service at the subnetwork level.

Each communication can be further specified by attributes (for example, delay, availability, bandwidth policy, etc.). These attributes can be attached to the communications relationship, and the meaning of such attachment is that the attribute applies to *all* communications. This indicates how attributes fit into the model.

It is also possible to attach relationship attributes such as "relationship name".

11.1 Service configuration

The configuration of service proceeds in steps.

The first step, usually associated with routing, chooses the links and inner subnetworks, which will be used to instantiate the service. This step also transforms the original communications matrix into appropriate individual sub-matrices, one for each inner subnetwork.

The second step, often associated with provisioning, applies each sub-matrix to its associated inner subnetwork and may reserve or allocate (link) resource to the service instance. Note that reservation information need not necessarily be kept on any network element.

This process continues recursively until configuration is complete. Note that communications attributes may affect how and when resources are reserved, and these attributes may affect the inner structure that is selected.

A transport entity is created when g, a communication matrix, is used to configure a forwarding function (in a subnetwork).

Diagrammatically, we have:

$$\{S{:}D\} \rightarrow \{\{S{:}D\}_1 , \{S{:}D\}_2 \text{........}, \{S{:}D\}_n\}$$

where {S:D} applies to the subnetwork and $\{S{:}D\}_n$ applies to the nth contained subnetwork.

Note that $\{S{:}D\}_1$ is transformed from {S:D} and the result of the transformation depends on the actual links and physical locations of the S_1..j. This transformation is not a decomposition, and cannot be reversed. That is, {S:D} cannot be derived from inspection of $\{S{:}D\}_1$ alone.

As more demands are put on the network, and each demand is transformed into an $\{S{:}D\}_n$ the transform matrices become combined, making it even less likely that is, {S:D} can be derived from inspection of $\{S{:}D\}_1$ alone.

The communications matrix defined is necessary to fully specify the service in terms of allowed communications; however, it is not sufficient to fully dimension the internal link resources. Additional parameters may be attached to each communication in order to specify additional properties, such as traffic profile and importance.

11.2 Forwarding modes of a transport entity

Channel-based forwarding supports 1:all communications, with 1:1 as a special case. Destination-based forwarding supports 1:n communications with 1:1 and 1:all as special cases.

	Destination forwarding	**Channel forwarding**
Point-to-point	As a special case of 1:n	Only for a single egress
Point-to-multipoint	Required at a minimum of one subnetwork	May or may not be present in network for supporting single egress
Multipoint-to-multipoint	Required at a minimum of one subnet	May or may not be present in network for supporting single egress
Full broadcast	As discussed in clause 6.5.1	

11.3 Monitoring of a transport entity

The transport entity, derived from a communications matrix, supports a set of senders and receivers that exchange information.

It may be possible to identify when a member sender or receiver leaves or a non-member sender or receiver joins the transport entity.

Individual pair wise communication $\{S_j \rightarrow D_k\}$ may be monitored.

If the communications matrix only specified a single sender and receiver, then the individual communication is the complete specification of the entire transport entity.

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