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**SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
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Data over Transport – Generic aspects – Transport
network control aspects

**SERIES Y: GLOBAL INFORMATION
INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS
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Internet protocol aspects – Operation, administration and
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Distributed call and connection management (DCM)

Recommendation ITU-T G.7713/Y.1704

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COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
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General	G.7000–G.7099
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PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
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Recommendation ITU-T G.7713/Y.1704

Distributed call and connection management (DCM)

Summary

Recommendation ITU-T G.7713/Y.1704 provides the requirements for the distributed call and connection management for both the user network interface (UNI) and the network node interface (NNI). The requirements in this Recommendation specify the communications across interfaces to effect automated call operations and connection operations. Items covered in this Recommendation include:

- attribute specifications;
- message specifications;
- signal flows;
- management of DCM.

This Recommendation does not cover any aspects related to routing or automatic discovery.

Revisions to this Recommendation include the following changes:

- Addition of interlayer signalling requirements following the ITU-T G.8080 interlayer architecture.

History

Edition	Recommendation	Approval	Study Group
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Keywords

ASON, automatically switched optical network, call control, connection management, connection operations, distributed call and connection management, external NNI, internal NNI, signalling, user network interface.

FOREWORD

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CONTENTS

Page

1	Scope	1
2	References.....	1
3	Terms and definitions	3
4	Abbreviations.....	4
5	Conventions	5
6	DCM requirements	7
6.1	Distributed call and connection management operations procedures	8
6.2	Signalling controller resilience.....	22
6.3	DCM signal flow – Exception handling.....	23
6.4	Restoration.....	35
7	DCM attributes list	37
7.1	UNI attributes list	41
7.2	I-NNI attributes list.....	44
7.3	E-NNI attributes list	46
7.4	Interlayer attributes list.....	49
8	DCM message sets.....	51
8.1	Call messages	52
8.2	Connection messages.....	57
9	Management of the call and connection controller function	62
9.1	Setting up a call and associated connections.....	66
9.2	Releasing a call and all associated connections	67
9.3	Modifying a call	68
	Appendix I – DCM state diagrams	70
I.1	Call state	71
I.2	Connection state	78

Introduction

This Recommendation forms part of a suite of Recommendations covering the full functionality of the automatically switched optical network (ASON).

Recommendation ITU-T G.7713/Y.1704

Distributed call and connection management (DCM)

1 Scope

This Recommendation covers the areas associated with the signalling aspects of the automatically switched optical network (ASON). Specifically, it provides the signalling requirements for the communications of call controller, connection controller and link resource manager. This Recommendation currently specifies support for multiple connections per call, call modification and calls across multiple layers. Areas covered include:

- attribute specifications;
- message specifications;
- signal flows;
- management of DCM.

Other areas of ASON such as routing mechanisms, parameters associated with routing mechanisms, discovery, and naming and addressing are outside the scope of this Recommendation. This Recommendation provides the attribute and message specification, and signalling exchange that allows support for hierarchical, source and step-by-step routing.

This Recommendation uses the architecture and functional requirements as outlined in [ITU-T G.8080] as the basis for the specification. This Recommendation aims to provide a protocol-neutral approach to describe the capability sets of the DCM. Capabilities specified in this Recommendation include support for soft permanent connections and switched connections.

In order to allow for interworking between multiple specific protocol implementations, an interworking function may need to be specified. This is currently for further study.

Transport of the DCM message sets is via a data communication network (DCN). One possible option for a DCN is described in [ITU-T G.7712].

In order to provide an automated DCM mechanism, *a priori* knowledge of the network resources is needed. These resources may be manually provisioned or automatically discovered. Automatic discovery of the topology and the resources may be performed as per [ITU-T G.7714].

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 G.707] Recommendation ITU-T G.707/Y.1322 (2003), *Network node interface for the synchronous digital hierarchy (SDH)*.
- [ITU-T G.709] Recommendation ITU-T G.709/Y.1331 (2009), *Interfaces for the Optical Transport Network*.
- [ITU-T G.783] Recommendation ITU-T G.783 (2006), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*.

- [ITU-T G.784] Recommendation ITU-T G.784 (1999), *Synchronous digital hierarchy (SDH) management.*
- [ITU-T G.798] Recommendation ITU-T G.798 (2004), *Characteristics of optical transport network hierarchy equipment functional blocks.*
- [ITU-T G.800] Recommendation ITU-T G.800 (2007), *Unified functional architecture of transport networks.*
- [ITU-T G.803] Recommendation ITU-T G.803 (2000), *Architecture of transport networks based on the synchronous digital hierarchy (SDH).*
- [ITU-T G.805] Recommendation ITU-T G.805 (2000), *Generic functional architecture of transport networks.*
- [ITU-T G.806] Recommendation ITU-T G.806 (2006), *Characteristics of transport equipment – Description methodology and generic functionality.*
- [ITU-T G.851.1] Recommendation ITU-T G.851.1 (1996), *Management of the transport network – Application of the RM-ODP framework.*
- [ITU-T G.852.2] Recommendation ITU-T G.852.2 (1999), *Enterprise viewpoint description of transport network resource model.*
- [ITU-T G.853.1] Recommendation ITU-T G.853.1 (1999), *Common elements of the information viewpoint for the management of a transport network.*
- [ITU-T G.872] Recommendation ITU-T G.872 (2001), *Architecture of optical transport networks.*
- [ITU-T G.874] Recommendation ITU-T G.874 (2001), *Management aspects of the optical transport network element.*
- [ITU-T G.7712] Recommendation ITU-T G.7712/Y.1703 (2003), *Architecture and specification of data communication network.*
- [ITU-T G.7714] Recommendation ITU-T G.7714/Y.1705 (2005), *Generalized automatic discovery for transport entities.*
- [ITU-T G.7718] Recommendation ITU-T G.7718/Y.1709 (2005), *Framework for ASON management.*
- [ITU-T G.8080] Recommendation ITU-T G.8080/Y.1304 (2006), *Architecture of the automatically switched optical network (ASON).*
- [ITU-T G.8081] Recommendation ITU-T G.8081/Y.1353 (2008), *Terms and definitions for Automatically Switched Optical Networks (ASON).*
- [ITU-T M.3100] Recommendation ITU-T M.3100 (2005), *Generic network information model.*
- [ITU-T Q.1901] Recommendation ITU-T Q.1901 (2000), *Bearer Independent Call Control protocol.*
- [ITU-T Q.2931] Recommendation ITU-T Q.2931 (1995), *Digital Subscriber Signalling System No. 2 – User-Network Interface (UNI) layer 3 specification for basic call/connection control: plus amendments.*
- [ITU-T Q.2982] Recommendation ITU-T Q.2982 (1999), *Broadband integrated services digital network (B-ISDN) – Digital Subscriber Signalling System No. 2 (DSS2) – Recommendation Q.2931-based separated call control protocol.*

3 Terms and definitions

The following terms are defined in [ITU-T G.805]:

- administrative domain;
- layer network;
- link connection;
- management domain;
- subnetwork;
- subnetwork connection.

The following term is defined in [ITU-T G.806]:

- management information (MI) signal.

The following terms are defined in [ITU-T G.8081]:

- access group container;
- agent;
- component;
- control domain;
- call controller;
- call segment;
- connection controller;
- connection admission control;
- hard rerouting;
- routing controller;
- link resource manager;
- policy;
- protocol controller;
- rerouting domain;
- restoration;
- routing domain;
- signalling controller;
- soft rerouting;
- soft permanent connection;
- switched connection;
- subnetwork point;
- subnetwork point pool;
- transport domain;
- transport resource identifier.

The following term is defined in [ITU-T G.7712]:

- data communication network.

The following terms are defined in [ITU-T G.852.2] and [ITU-T G.853.1]:

- connection termination point (examples of connection termination points for technology specific instances may be found in [ITU-T G.784] (for SDH) and [ITU-T G.874] (for OTN));



- trail termination point (examples of trail termination points for technology specific instances may be found in [ITU-T G.784] (for SDH) and [ITU-T G.874] (for OTN));
- resource.

The following term is defined in [ITU-T G.783]:

- TPmode/PortMode.

4 Abbreviations

This Recommendation uses the following abbreviations:

ACC-n	A-end CC at domain n
AD	Administrative Domain
AGC	Access Group Container
AGC-a	A-end AGC
AGC-z	Z-end AGC
ARC	Alarm Reporting Control
ASC-n	A-end Signalling Controller in domain n
ASN-n	A-end SN in domain n
ASON	Automatically Switched Optical Network
CAC	Call Admission Control
CallC	Call Controller
CC	Connection Controller
CC-a	A-end Connection Controller
CC-z	Z-end Connection Controller
CCC	Calling/Called Party Call Controller
CCC-a	A-end CCC
CCC-z	Z-end CCC
CI	Characteristic Information
CO-PS	Connection Oriented Packet Switching
CoS	Class of Service
CP	Connection Point
CPS	Connection Point Status
CR-LDP	Constraint-based Routing Label Distribution Protocol
CTP	Connection Termination Point
DCM	Distributed Call and Connection Management
DCN	Data Communication Network
E-NNI	External NNI
GoS	Grade of Service
I-NNI	Internal NNI

LC	Link Connection
LRM	Link Resource Manager
MI	Management Information
MP	Management Plane
NCC	Network Call Controller
NCC-n	NCC in domain n
NE	Network Element
NNI	Network Node Interface
PC	Protocol Controller
PNNI	Private NNI
RC	Routing Controller
RSVP-TE	Resource Reservation Protocol-Traffic Engineering
SC	Switched Connection
SC-a	A-end user Signalling Controller
SC-z	Z-end user Signalling Controller
SN	SubNetwork
SNC	SubNetwork Connection
SNCr	SubNetwork Controller
SNP	SubNetwork Point
SNPP	SubNetwork Point Pool
SPC	Soft Permanent Connection
TCC-n	Transit CC in domain n
TCP	Termination Connection Point
TRI	Transport Resource Identifier
TSC-n	Transit Signalling Controller in domain n
TSN-n	Transit SN in domain n
TTP	Trail Termination Point
UNI	User Network Interface
ZCC-n	Z-end CC at domain n
ZSN-n	Z-end SN in domain n
ZSC-n	Z-end Signalling Controller at domain n

5 Conventions

Within the distributed connection management environment, certain roles are assigned to different agents based on their location with respect to the signalling flow. Figure 5-1 identifies these reference points.

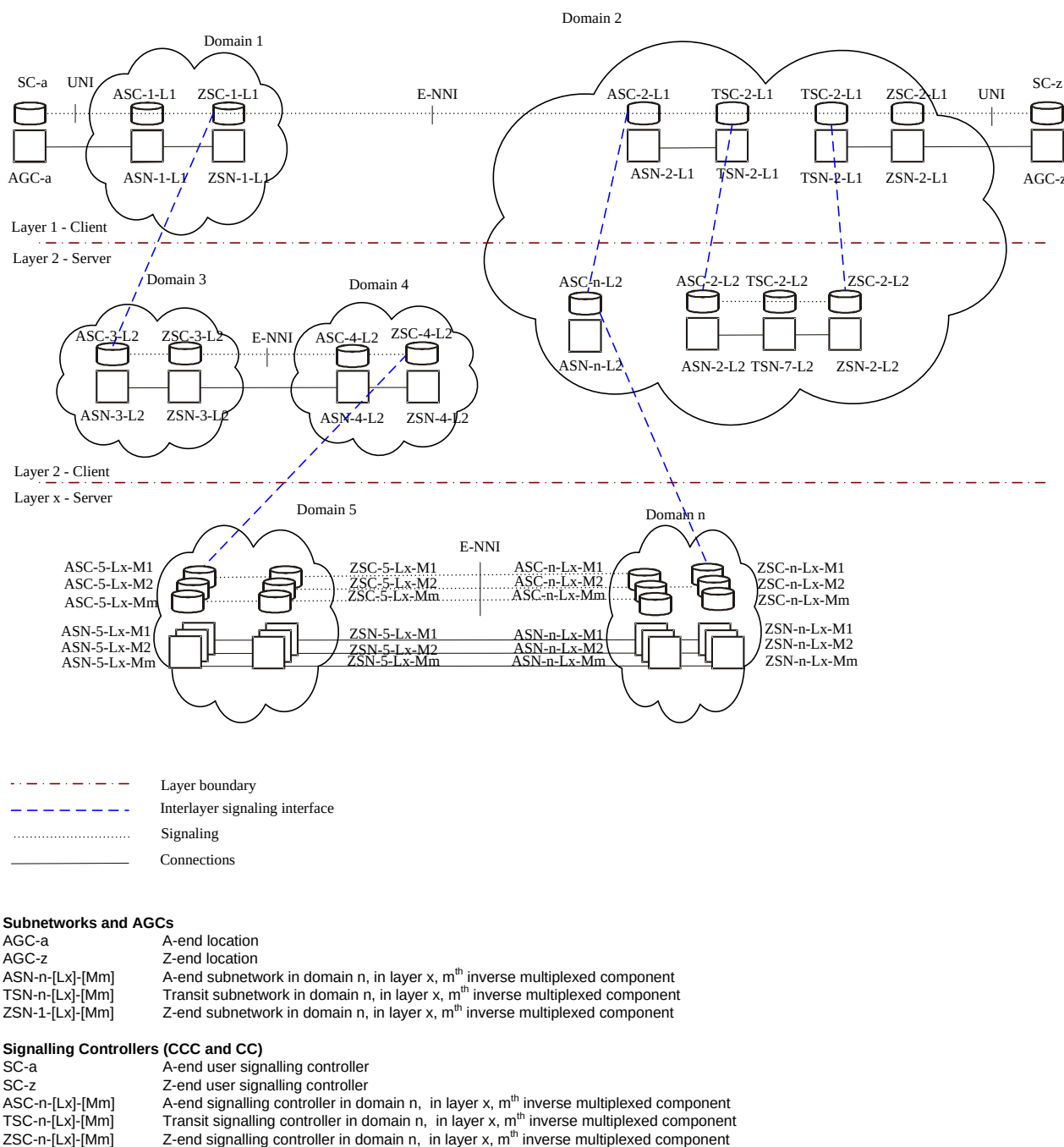


Figure 5-1 – Reference diagram for distributed connection management

Transport plane components in Figure 5-1 are the various subnetworks and access group containers (AGCs). These define the locality to which the control plane functions are associated. They are labelled in Figure 5-1 as AGC-a, ASN-n-[Lx]-[Mm], TSN-n-[Lx]-[Mm], ZSN-n-[Lx]-[Mm], and AGC-z.

When describing interlayer scenarios, a layer "Lx" may be added to the above abbreviations as follows, for an NCC in domain n at layer x, it is an "NCC-n-Lx". If inverse multiplexing is described, for the server layer providing m components that are multiplexed together to form the client layer, "Mm" may be added to the abbreviation. For example, the NCC for the mth component in the server layer is represented as "NCC-n-Lx-Mm".

Distributed call and connection management is also known as "signalling" and this Recommendation will also use this convention. Call-related functions at end users are known as

calling/called party call controllers, or CCCs. An originating CCC is a "CCC-a" and a destination CCC is a "CCC-z". Call controllers associated with a subnetwork are network call controllers (NCC) and for a particular domain n, is an "NCC-n".

Connection controllers for end users are identified as CC-a and CC-z. Within a domain n, the A-end, transit, and Z-end connection controllers are known as ACC-n, TCC-n, and ZCC-n.

A signalling controller contains the functions of connection control and/or call control. For end users, this is denoted as SC-a and SC-z. Within domain n, the A-end, transit, and Z-end signalling controllers are known as ASC-n, TSC-n, and ZSC-n. Note that TSCs usually do not have call control as shown in Figure 5-1.

An address for signalling control is assigned to the signalling controller and is used by the protocol controller to exchange information between call controllers or between connection controllers. The signalling controller address is a control address, and the signalling channel will be identified by two adjacent signalling controller names. The signalling channel is provided by DCN communication.

This Recommendation also uses the following terms:

- LC Establish: establishing a link connection refers to obtaining (or choosing) an existing link connection for usage to satisfy a connection request, i.e., removing it from a list of available link connections.
- LC Free: freeing a link connection refers to returning the link connection to the list of available link connections.
- SNC Created: creating a subnetwork connection refers to creating a connection in a connection function between two SNPs within a subnetwork.
- SNC Released: releasing a subnetwork connection refers to releasing a connection in a connection function between two SNPs within a subnetwork.
- Allocate: allocate refers to either establishing an LC or creating an SNC.
- De-allocate: de-allocate refers to either freeing an LC or releasing an SNC.
- Downstream: depending on the routing model used, downstream may refer to either the component that is the subordinate (hierarchical model) or the component that is the next hop (source-based or step-by-step model).
- Upstream: depending on the routing model used, upstream may refer to either the component that is the parent (hierarchical model) or the component that is the previous hop (source-based or step-by-step model).

6 DCM requirements

Prior to any calls being established, contracts between the requester and the provider need to be set up. This contract may specify things such as:

- contract ID;
- service level agreement and service level specification;
- information required to allow policy control of a request. For example, this may include information that may be used to provide authentication and integrity.

Characteristics that impact the signalling performance may include:

- capacity of the data communication network used for transporting the signalling messages;
- size of the switched transport network (in terms of nodes and links);
- total number of call requests per time period, which may include new calls, protection events, and restoration events;

- average size of messages;
- mix of connection types;
- time to complete a call request;
- percentage of requests received by the network that will be retried if the requested operation is unsuccessful;
- additional bandwidth requirements to realize a robust messaging mechanism (e.g., time-out and retransmit);
- synchronous versus asynchronous message transport.

In order to meet the requirements specified in [ITU-T G.8080], and to allow for future extensions to the capabilities, the DCM mechanism must provide the flexibility and extensibility to support multiple application requirements. These include support of basic DCM capabilities, as well as an extended set of capabilities (such as supplementary services). These basic capabilities provide the necessary mechanisms for set up and release of connections.

Call and connection management operations (i.e., signalling) occur within a control domain whose scope enables complete call and connection actions. The requirements in the subsequent clauses assume that call/connection operations are within one domain that may contain smaller domains within it. This reflects routing hierarchy which results in hierarchical routing domains. Signalling components at the edge of a routing domain use the routing components within that domain to provide routes through that domain.

Identifiers used for call and connection management must come from a different name space than the DCN identifiers to prevent changes in the DCN network from impacting call and connection management.

6.1 Distributed call and connection management operations procedures

The call controller (CallC), connection controller (CC) and link resource manager (LRM) functions provide the supervision and management of both call and connection requests, including the primitive operations for setting up a connection, modifying a connection, and releasing a connection. To complete an operation, the CallC, CC and LRM need to interact with other components as well as interact with each other. The CallC, CC and LRM interact with the following components to setup or release a connection:

- routing controller (RC): routing controller provides route information as queried by the CC;
- call admission control (CAC) function;
- call controller (CallC);
- connection controller (CC);
- link resource manager (LRM).

As described in [ITU-T G.8080], the calling party call controller interacts with a called party call controller by means of one or more intermediate network call controllers (NCC). The NCC function is provided at the network edge (i.e., UNI reference point) and may also be provided at gateways between domains (i.e., E-NNI reference points). The functions performed by NCCs at the network edge are defined by the policies associated by interactions between users and network, and the functions performed by NCCs at domain boundaries are defined by the policies associated by the interactions between the domains. As such, an end-to-end call is considered to consist of multiple call segments when the call traverses multiple domains. Each call segment could have one or more connections (LC or SNC) associated with it. This allows for flexibility in the choices of signalling, protection and recovery paradigms in different domains.

The number of connections associated with call segments may not be the same even in one end-to-end call. In Figure 6-1, the UNI call segment has one LC associated with it, the subnetwork

call segment for domain 1 has two associated SNCs. This allows the network to have different policies in their domain. All transport resources in Figure 6-1 are in a single overall domain that contains domains 1 and **n**. Routing in this overall domain provides the knowledge that domains 1 and **n** need to be traversed in order to support a call between the two clients in the figure.

Note that both calls and connections could be across intra-carrier E-NNI reference points. The concept of call segments and call/connection separation enables the following applications:

- Domain-based protection. The number of SNCs could be different between domains.
- Domain-based restoration. SNC failure may not cause an LC to go down, and a rerouting procedure could be provided by network to restore the failed SNC (refer to [ITU-T G.8080]).

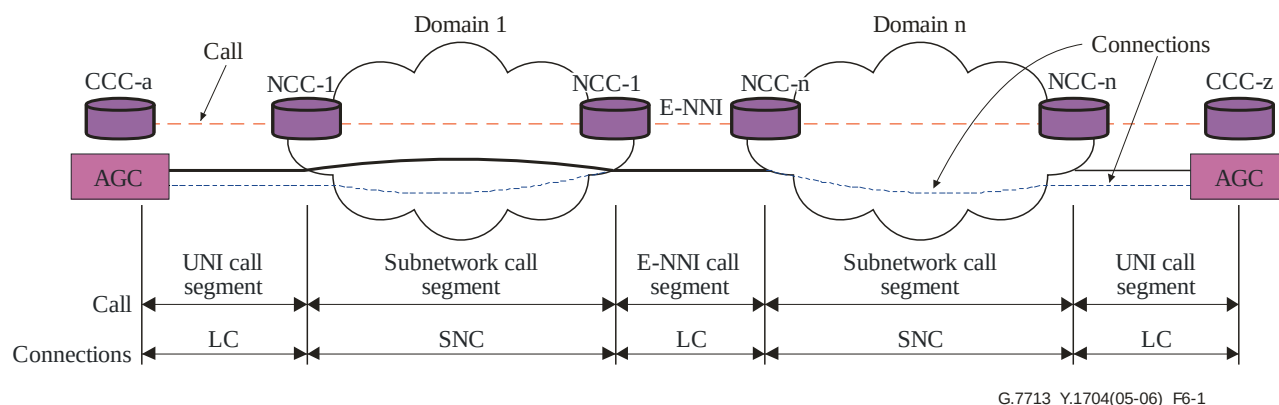


Figure 6-1 – Call segments and connections

The NCC at domain boundaries will also allow each domain to have independent functions, e.g., one domain could have 1 + 1 protection capability whilst another domain does not.

The NCC and CC at the network edge and boundaries perform different functions.

The call controllers perform the following:

- the NCC correlates the SNCs to the call;
- the NCC works with the calling/called party call controller at the network edge to correlate LC(s) to the call;
- the NCC works with its peer NCC at domain boundaries to correlate LC(s) to a call;
- the NCC correlates the LC and SNCs that are associated with the same call;
- the CC establishes the connections that are associated to each call segment.

As the communication between the controllers are defined as an external interface in [ITU-T G.8080], messages are defined in this Recommendation to help the exchange of information.

The end-to-end establishment of a call involves requesting the call, requesting connections, and set up of different types of resources to create a connection. Figure 6-2 illustrates the connection that is set up to support a call.

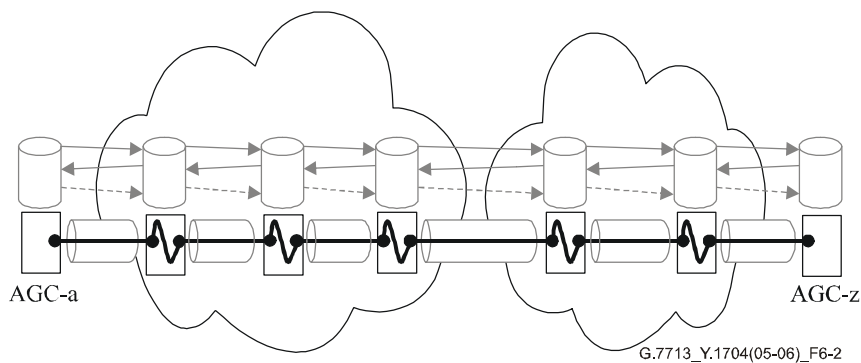


Figure 6-2 – LC and SNC establishment for a call request

The following resources are used for call setup:

- subnetwork point (SNP);
- SNP pool (SNPP);
- link connection (LC).

The LC is established by the allocation of SNPs, which may be negotiated between LRMs. This then allows the CC to create an SNC. Allocation of SNPs may be represented as a change of state of the SNP (e.g., from AVAILABLE to PROVISIONED; note that SNPs with state of POTENTIAL or BUSY cannot be used for connection setup). SNP states are described in [ITU-T G.8080].

Figure 6-3 illustrates the establishment of LC by the LRMs.

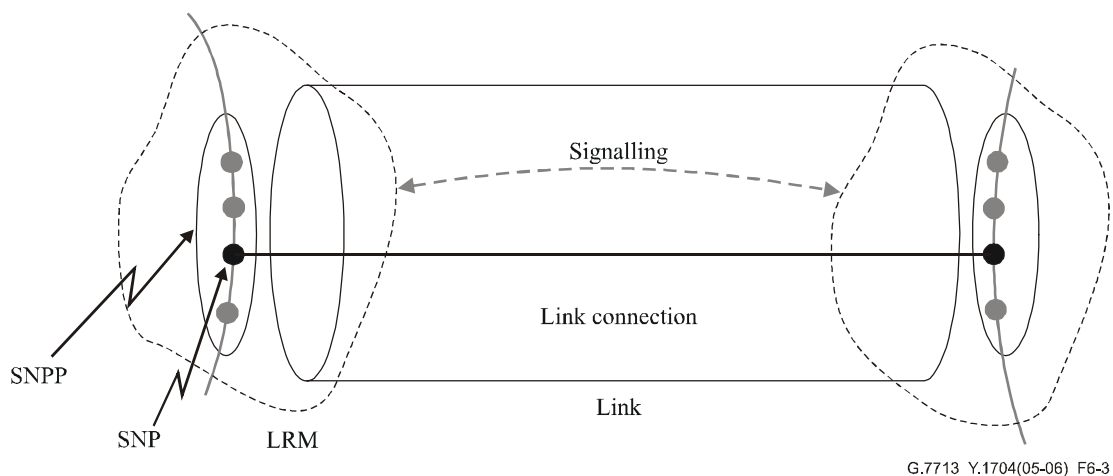


Figure 6-3 – Establishment of link connection by allocating the SNPs

NOTE 1 – In the case of establishing an LC, alternate behaviours are possible, e.g., for user → network signalling, the user may also specify the LC to use (i.e., the user specifies the SNP); however, the network may choose an alternate LC to use, i.e., specify a different SNP.

In order to set up an SNC, SNPs must already exist and be identified by the LRM in order to bind these SNPs to create an SNC. This involves the LRM negotiating with the upstream LRM for an SNP (which may represent an LC) and negotiating with the downstream LRM for an SNP (which may represent an LC). These incoming and outgoing LCs (and their associated ingress and egress SNPs) identify the SNPs that are used to create the SNC.

NOTE 2 – Choosing resources for a connection operation does not imply allocation of these resources. Resource allocation may occur at any phase of the signalling, e.g., allocation may occur during the initial request or during response to the request. In addition, these resources may first be "reserved" prior to allocation. Reserved in the context of call set up refers to identifying the resources that are available for use,

but not committing these resources until the allocation phase occurs. Using reservation prevents another request from identifying the same resource for use, and it avoids the resources from undergoing state changes if the call was denied. All this may be handled as part of setting the status of SNPs and interactions with LRM components. [ITU-T G.8080] provides the list of possible states of the SNPs.

Setting up of an SNC is a process that occurs internal to a subnetwork and is controlled by the CC. An SNC is created after determining the SNPs for both ingress and egress connection points. The ingress and egress SNPs are identified as part of the establishment of the LCs (via the LRM). Figure 6-4 depicts an SNC that has been set up along with the associated connection controller and the SNP pair that are involved with setting up an SNC.

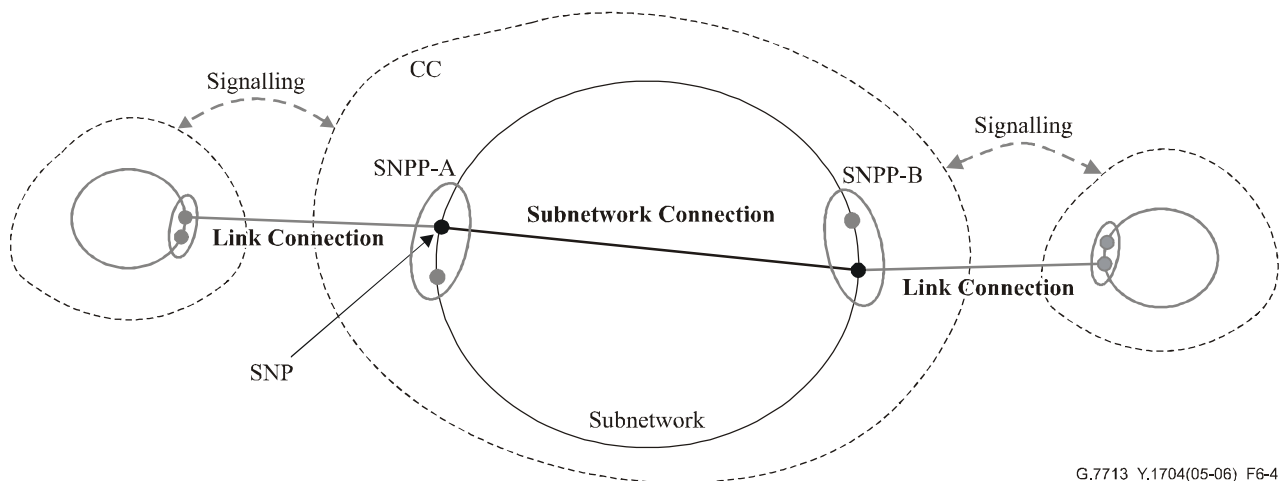


Figure 6-4 – Creation of subnetwork connection after link connection establishments

6.1.1 Process for call request

To support switched connection (SC) service, a call request is initiated by the A-end user request agent (CCC-a) via a "call setup request" message sent by the CCC-a (user CallC) to a calling party call controller. This call request specifies the information associated with the call that the user is requesting. The information may include service-related information and policy-related information. This information is received by the CallC within the ASC. The CallC next processes the call request and interacts with other components within the ASC to support the call request.

To support soft permanent connection (SPC) service, the client call controller is handled by the management plane, with management requesting the NCC to establish calls. The transport plane location of this call endpoint is an SPC endpoint, and a UNI transport resource identifier is associated with those resources. Where there is a common transport network address administration for SNPPs, a UNI transport resource identifier is not required for the SPC endpoint.

NOTE – To provide error handling and prevent non-deterministic transitions, a timeout (timer expiry) mechanism is required. The timeout mechanism is initiated by the user upon call request (for both call setup request and call release request). Specific details of exception handling related to timeout is specified in clause 6.3.

6.1.1.1 SPC and SC interworking

An SPC endpoint is associated with an NCC that supports SPC service initiation and termination. Similarly an SC endpoint is associated with an NCC that supports SC service initiation and termination. Each type of endpoint has UNI transport resource identifiers that are used to identify the transport resources between the client and the network at the UNI reference point.

An SPC endpoint can make calls to an SC endpoint using the UNI transport resource identifier of that SC endpoint. Similarly, an SC endpoint can make calls to an SPC endpoint using the UNI transport resource identifier of that SPC endpoint. Either SPC or SC endpoint may release the

call. Procedures described in later clauses apply to this type of call for all ingress to egress NCC communication.

A particular SNP for the SPC endpoint can be specified in either calling or called cases. If left unspecified, the CC associated with the SPC endpoint is free to assign the SNP.

6.1.1.2 Setting up a call

Figure 6-5 illustrates the set up of a call, and the associated signal flows between the relevant components.

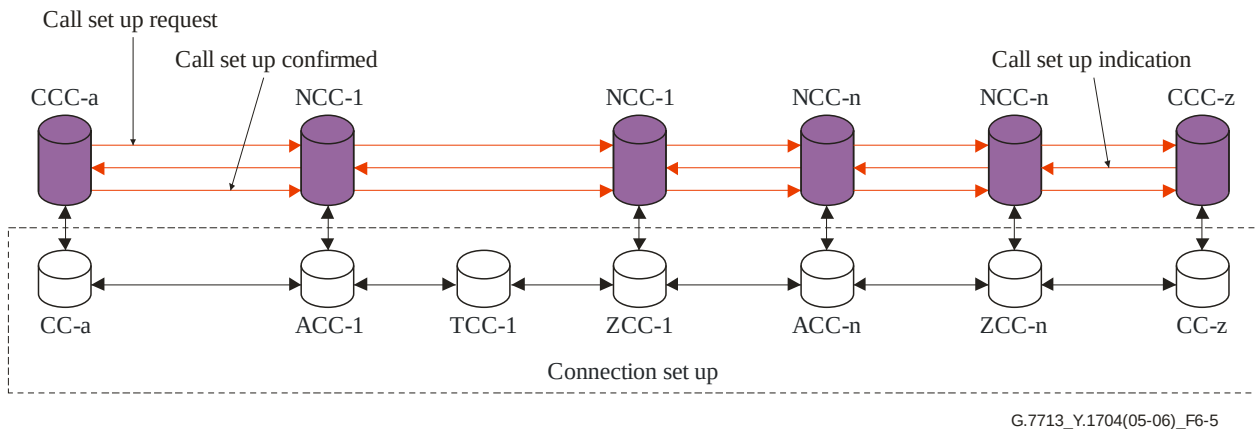


Figure 6-5 – Call set up request processing: Logical request progression

For a call request to set up a call, the steps include:

- The calling party call controller (CCC-a) requests call set up. At the ingress NCC-1, processes are initiated to check the call request (this may include checking for authentication and integrity of the request as well as constraints placed by policy decisions). The request is also sent to the intermediate network call controllers. Processes included in the egress NCC (NCC-n associated with ZCC-n in Figure 6-5) may include verifying that the call request is accepted end-to-end (e.g., request for CCC-z call verification).
- Upon successful checking, the calling party call controller (CCC-a) continues the call set up request by initiating a connection set up request to the CC. The process for connection set up request is described in clause 6.1.2. Note that, based on different protocol design decisions, initiation of connection set up request may occur in a different order as shown in Figure 6-5. The requirement is that a network connection is set up before the call is completed.
- Upon successful indication by the connection set up request process (across all call segments) the call set up request is successfully completed, and transfer of user characteristic information may begin.

If the connection set up request process was unsuccessful, a call denied notification is sent to the user.

An interface exists between a call controller and connection controller in the [ITU-T G.8080] component description for initiating a connection request, but is not described in this Recommendation.

6.1.1.3 Releasing a call

Figure 6-6 illustrates the release of a call, and the associated signal flows between the relevant components.

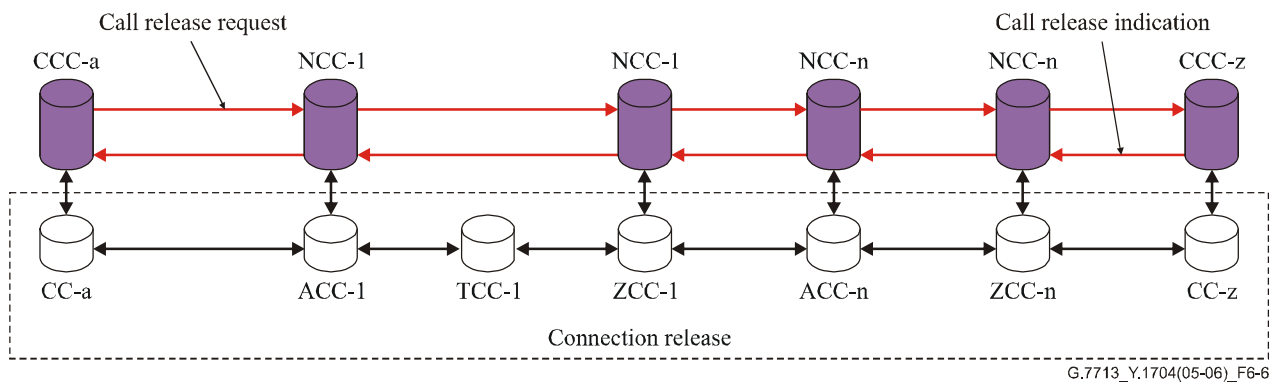


Figure 6-6 – Call release request processing: Logical request progression

Any call controller may initiate a call release request. A call release request (upon verification) must always result in a successful call release. However, any defects associated with the release request may be subsequently reported to a management system (including specific information regarding any partial connections not released), and procedures may be in place to prevent access/use of the connection that was unsuccessfully released. For a call release request originating from the calling party call controller as in Figure 6-6:

- Check the call release request at the ingress network call controller (ingress NCC-1). This may include checking for authentication and integrity of the request, as well as constraints placed by policy decisions.
- Upon successful checking, the call release request continues by initiating a connection release request. The process for connection release request is described in clause 6.1.2.2. Note that based on different protocol design decisions, initiation of connection release request may occur in a different order as shown in Figure 6-6. The requirement is that a connection is released before a call is released. If there are multiple connections associated with a call segment, all of them are released.
- Upon indication by the connection release request process(es), the call release request is successfully completed.

While connection set up may be denied and thus result in call denial, a connection release that is denied (e.g., due to inability to de-allocate resources, release an SNC or free an LC) results in notification to the MP; however, the call release request should indicate successful release of a call. This assumes that the call release request has been successfully checked prior to connection release being initiated.

NOTE – Depending on the "characteristics" of the transport network (e.g., whether monitoring and trace is enabled), race conditions may occur between the call release request message and the connection release request. Based on this race condition between the signalling progression from CCC-a to CCC-z, and the transport signal (e.g., unequipped or OCI) progression from AGC-a to AGC-z, certain alarms may be raised at downstream subnetworks. To support such an environment, a mechanism is needed to allow for disabling/enabling of the monitoring/trace capabilities associated with the call prior to de-allocation of connections. For example, this may include initiation of ARC or TPmode/PortMode process prior to any initiation of connection release request. Defect reporting suppression may be needed to prevent triggering the protection/restoration process.

6.1.2 Process for connection request

A connection request is initiated as a result of a call request process. The connection request performs the coordination to set up and release connections and the allocation and de-allocation of resources to affect the connection.

Figure 6-7 illustrates the end-to-end progression of the signalling and connection request that sets up the resources to create a connection and complete a call.

SNP pair is updated to: provisioned. The CC then continues the connection set up process by communicating with the downstream CC.

- This process is continued until the connection request reaches CCC-z.
- At CCC-z CC, an ingress SNP is identified as determined by the ingress SNP ID. After the CC processes the connection request, a response message is sent to indicate that the connection is processed.
- Optionally, once the CCC-a CC receives the indication, a third message is sent from the CC to signal confirmation of the connection.

When setting up a connection, several high level behaviours may be specified for the network:

- If the route cannot be set up, then the subnetwork responds with a denied connection message.

For bidirectional connections, it shall be possible to specify the same SNP index values for a given CP handling both directions. For example, the same time slot number in both directions on a port on a transport network element.

6.1.2.2 Process for releasing connections

Releasing a connection reverses the process for setting up a connection. A call release request is initially signalled and processed. The following processes are performed for the connection release:

- According to clause 6.1.1.3, a release call request has been verified and allowed to proceed. Upon indication to proceed with the release connection, the release process is initiated at the ASC-1 CC.
- From the call request, the agent that initiated the release call request identifies the call to be released.
- At ASC-1 CC, the SNC is released. This involves de-allocating the SNPs. ASC-1 LRM signals TSC-1 LRM to free the LC used by TSN-1 for the call. The state of the SNP pair is updated to: available. The CC then continues the connection release process by communicating with the downstream CC.
- At TSC-1 CC, the SNC is released. TSC-1 LRM signals ZSC-1 LRM to free the LC used by ZSN-1 for the call. The state of the SNP pair is updated to: available. The CC then continues the connection release process by communicating with the downstream CC.
- This process is continued until the connection release request reaches CCC-z CC.
- At CCC-z CC, the LC used for the call is freed. After the CC processes the connection release request, a response message is sent to indicate the connection release is processed.

6.1.2.3 Process for modifying connections

Modifying connections is limited to CO-PS connections that have a data rate associated with them, e.g., Ethernet. Two types of modification are supported: increase and decrease of connection CO-PS data rate. The following processes are performed for the CO-PS data rate connection modification:

- According to clause 6.1.4, a modify call request has been verified and allowed to proceed. Upon indication to proceed with the modify connection, the modify process is initiated at the ASC-1 CC.
- The modify connection request is carried from ASC-1 to ZSC-1, then similarly between ASC-n and ZSC-n until CCC-z CC is reached. At each CC, a modification is made to the CO-PS data rate associated with the LC or SCN. This process is continued until the connection modification reaches the CCC-z CC.
- When the connection request successfully reaches CCC-z CC, the connection modification request is complete and an indication is sent in the reverse direction. At each CC, a modification is made to the CO-PS data rate associated with the LC or SCN.

- After the CC processes the connection release request, a response message is sent to indicate the connection modify is processed.

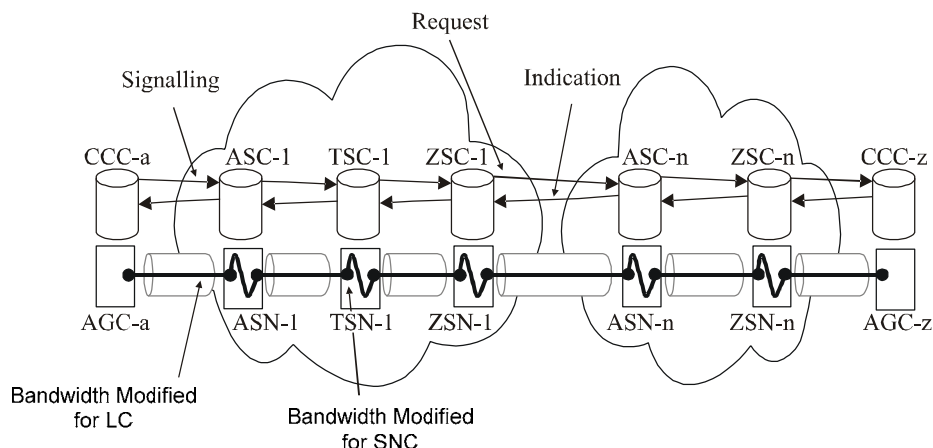


Figure 6-9 – CO-PS data rate modification in LC and SNC for a connection modify request

6.1.3 Interlayer signalling

A capability to map client characteristic information to a server layer is described in clause 6.6 of [ITU-T G.8080]. This capability may be used to provide for transfer of client characteristic information when the client layer is not continuous or connected between two access points. When the mapped CI is transported across the server layer, it is adapted back to the client layer where it may continue. The mapping can be controlled through ASON component interaction between network call controllers in adjacent layers. This pair wise relationship of NCCs is scoped to equipment that is capable of supporting multiple layers and adaptations between them.

6.1.3.1 Interlayer call set up

Steps for interlayer signalling control are described below assuming that a call/connection is progressing in the same signalling sequence. It is also assumed that client layer routing can compute a route that involves representations of server layer connectivity to which client CI can be mapped, and that it can be distinguished to connection controllers, when use of the server layer connectivity is included in a route.

- 1) When a connection request setup is received by a CC, it either includes a route or the CC obtains one from the routing component. The CC uses the route information to determine what the next CC is to pass the request to. If the next hop is an indicator that a server layer is needed, then perform step 2, otherwise perform connection set up as previously described and do not continue with the steps that follow.
- 2) An interlayer call is necessary because, according to the route, the next hop does not occur in the client layer network. The CC corresponds to the SNPP at the current hop position in the route which is at the present interlayer boundary. The CC should determine the SNPP in the route at which the next interlayer boundary occurs and this becomes the SNPP at which the mapped CI will be adapted back into the client layer.
- 3) The NCC corresponding to the CC is informed of the need for an interlayer call. An NCC must be present at this boundary.
- 4) The NCC uses the pair of SNPPs in the client layer that are to be connected in the server layer, as input to the interlayer address resolution function. This function returns a pair of UNI transport resource identifiers in the server layer. These identifiers are not associated with a UNI link but rather a set of access points in the server layer from which a connection can be created for the purpose of carrying mapped client CI.

- 5) Call the appropriate server layer NCC(s) associated with the adaptation "between" the client NCC (where this procedure is running) and server NCC(s). The call includes the UNI transport resource identifiers and any other parameters needed to obtain server layer connections that can satisfy the call parameters of the client call request.
- 6) If successful, the server layer NCC will return a pair of TCPs that can be used by the client/server adaptation for transferring client information. The request can be satisfied by creating server layer calls, or returning pairs of TCPs from existing server layer calls. From a client's perspective, the two cases cannot be distinguished.
- 7) When the client NCC receives the pairs of TCPs, it hands them to the CC to bind local TCPs to the adaptation function that accomplishes the mapping of the client CI to the server layer.
- 8) The call/connection setup continues at the interlayer boundary where the client CI is adapted back into the client layer. At this point, the other TCP is bound to the adaptation.

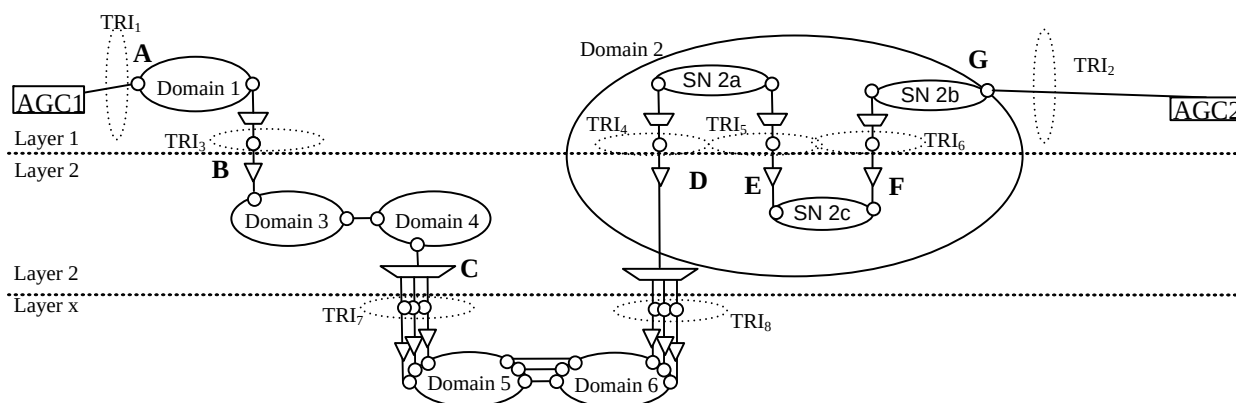


Figure 6-10 – Resource view for recursive interlayer with inverse multiplexing

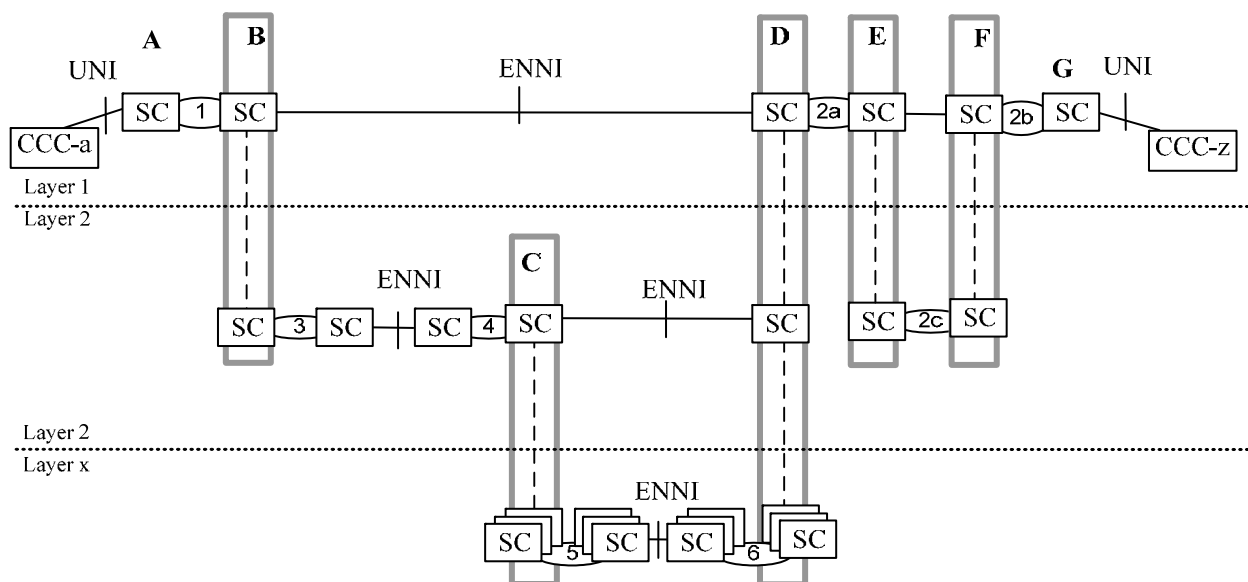


Figure 6-11 – Signalling controllers organization

Applying the interlayer procedure to Figures 6-10 and 6-11, setting up a call from Client1 to Client2 would have the high-level sequence illustrated in Figure 6-12 for the mapped server case, following alphabetical ordering of steps. To simplify the figure, 1:1 correspondence between CCs and NCCs is assumed at boundaries, SCs are represented. For the independent set up scenario, the order may vary depending on which layer is pre-established. For example, f through g could be performed first, followed by a through e and h through zb if layer x was independently established. Another example is d through k is performed first, followed by a through c and l through zb if layer 2 and x were established prior to layer 1. In all cases, the requirement is that the server layer connections are set up before the client layer call establishment completes. Interlayer SC-SC interactions are specifically NCC-NCC interactions. Within a layer, SC-SC interactions include both NCC-NCC and CC-CC interactions.

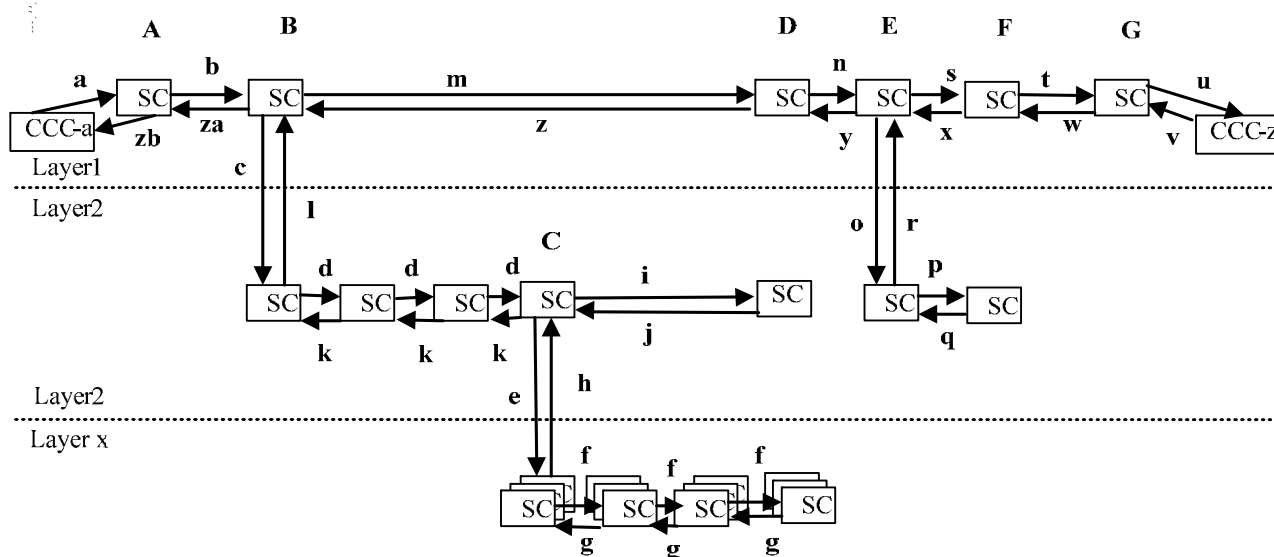


Figure 6-12 – High-level sequence

6.1.3.2 Interlayer call release

In the case of interlayer call release, there is a requirement that the client layer call is informed of the release prior to removing the server layer call. In Figure 6-12, assuming the arrows represent the call release request ($\rightarrow$) and call release indication ($\leftarrow$), this would correspond to a-b-k-l-q-r-s-t-u-v-w completing prior to m through p, x completing prior to c through j.

When a call on the client side of an interlayer boundary is released, the association with its server layer call or calls is removed. The server NCC coordination out interface from the ITU-T G.8080 NCC component is used to inform the server layer(s). This is similar to initiating a connection release in the non-interlayer case. Server layer calls involved in the removal of the association may or may not be released and this is subject to server layer policy. In cases where the server layer does not release the call, it is then available for other client interlayer associations.

When a call on the server side of an interlayer boundary is released, the association with its client layer call or calls is removed. The client NCC coordination out interface from the ITU-T G.8080 NCC component is used to inform the client layer(s). This is similar to initiating a connection release in the non-interlayer case. Client layer calls involved in the removal of the association may or may not be released and this is subject to client layer policy. The client layer call may make another server layer call as a part of a recovery process or it may also choose to release itself.

6.1.4 Call modification for non-disruptive bandwidth modification

Non-disruptive bandwidth modification is defined as a call modification that does not impact user traffic. In order for the control plane to support non-disruptive bandwidth modification, the underlying transport plane technology must support the ability to non-disruptively modify the bandwidth. There are three types of non-disruptive bandwidth modification to consider:

- Type 1: Connection modification: Call modification that increases/decreases the data rate of an existing CO-PS connection. A change in data rate of a user flow is made that is within the available resources for the connection. For example, an Ethernet connection is modified by increasing its CO-PS data rate from 40 Mbit/s to 60 Mbit/s.
- Type 2: Connection resizing: Call modification that increases/decreases the number of connections associated with the call. For example, a call is decreased from three STM-16 connections to two STM-16 connections. This is not an inverse multiplexing case in the layer being considered. Mechanisms in the client layer that use the modified call are expected to adjust to the change in number of connections.
- Type 3: Group resizing: Call modification that increases/decreases the group size. This is an inverse multiplexing case. For example, a call is increased from a VC-4-5v to a VC-4-6v.

There are similarities between the last two bullets in that the number of connections is modified. There is a major difference: the number of layers involved in the network.

Scenario 1: Single layer – Connection modification (type 1) and connection resizing (type 2)

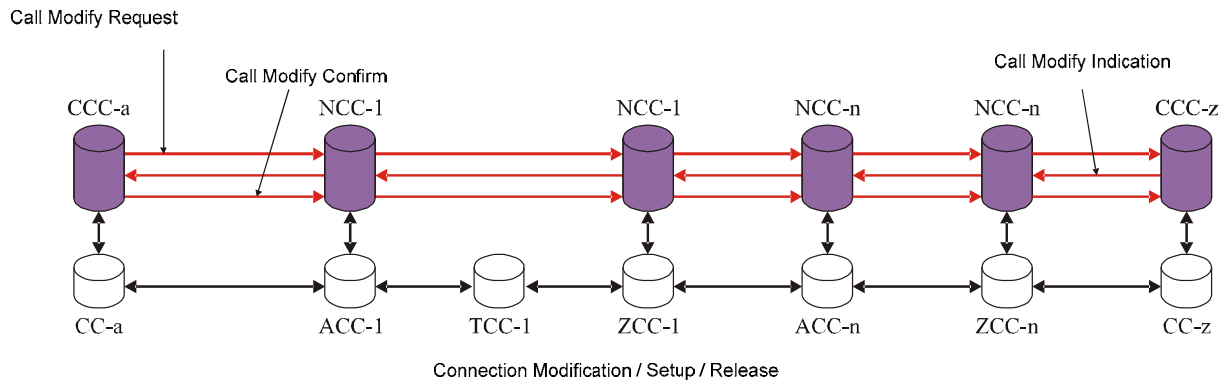


Figure 6-13 – Connection modification and connection resizing

For a call modify request for non-disruptive bandwidth modification, the steps include:

- The calling party call controller (CCC-a) requests call modification. At the ingress NCC-1, processes are initiated to check the call modification (this may include checking for authentication and integrity of the request as well as constraints placed by policy decisions). The request is also sent to the intermediate network call controllers. Processes included in the egress NCC (NCC-n associated with ZCC-n in Figure 6-13) may include verifying that the call modification is accepted end-to-end (e.g., request for CCC-z call verification).
- Upon successful indication by the call modification request process, the calling party call controller (CCC-a) continues the call modification request by initiating a connection modification request to the CC or by requesting the set-up of a new connection or release of an existing connection. The process for connection set up request and connection release is described in clause 6.1.2. The process for connection modification is described in clause 6.1.2.3. Note that, based on different protocol design decisions, initiation of connection modification/setup/release request may occur in a different order as shown in Figure 6-13. The only requirement is that a network connection modification/setup/release is completed before the call modification is completed.
- Upon successful indication by the connection modification/setup/release request process (across all call segments), the call modification request is successfully completed.

An interface exists between a call controller and connection controller in the [ITU-T G.8080] component description for initiating a connection setup/release/modification request, but is not described in this Recommendation.

Scenario 2: Interlayer group resizing (type 3)

This scenario describes a case where a bandwidth modification at one layer triggers a group size modification at server layer, in turn triggering the set up or release of its server layer calls. Figure 6-14 illustrates a group size modification for an inverse multiplexing scenario.

NOTE – An example of this scenario occurs when a virtual concatenated signal is operational and link capacity adjustment scheme (LCAS) in ITU-T G.7042 is applied to the virtual concatenation group (VCG) to change the size of the VCG without affecting the traffic in the virtual concatenated signals that are not added or removed from the VCG. For a decrease, LCAS is run prior to connection release in control plane; and for an increase, LCAS is run after a new connection is set up in control plane.

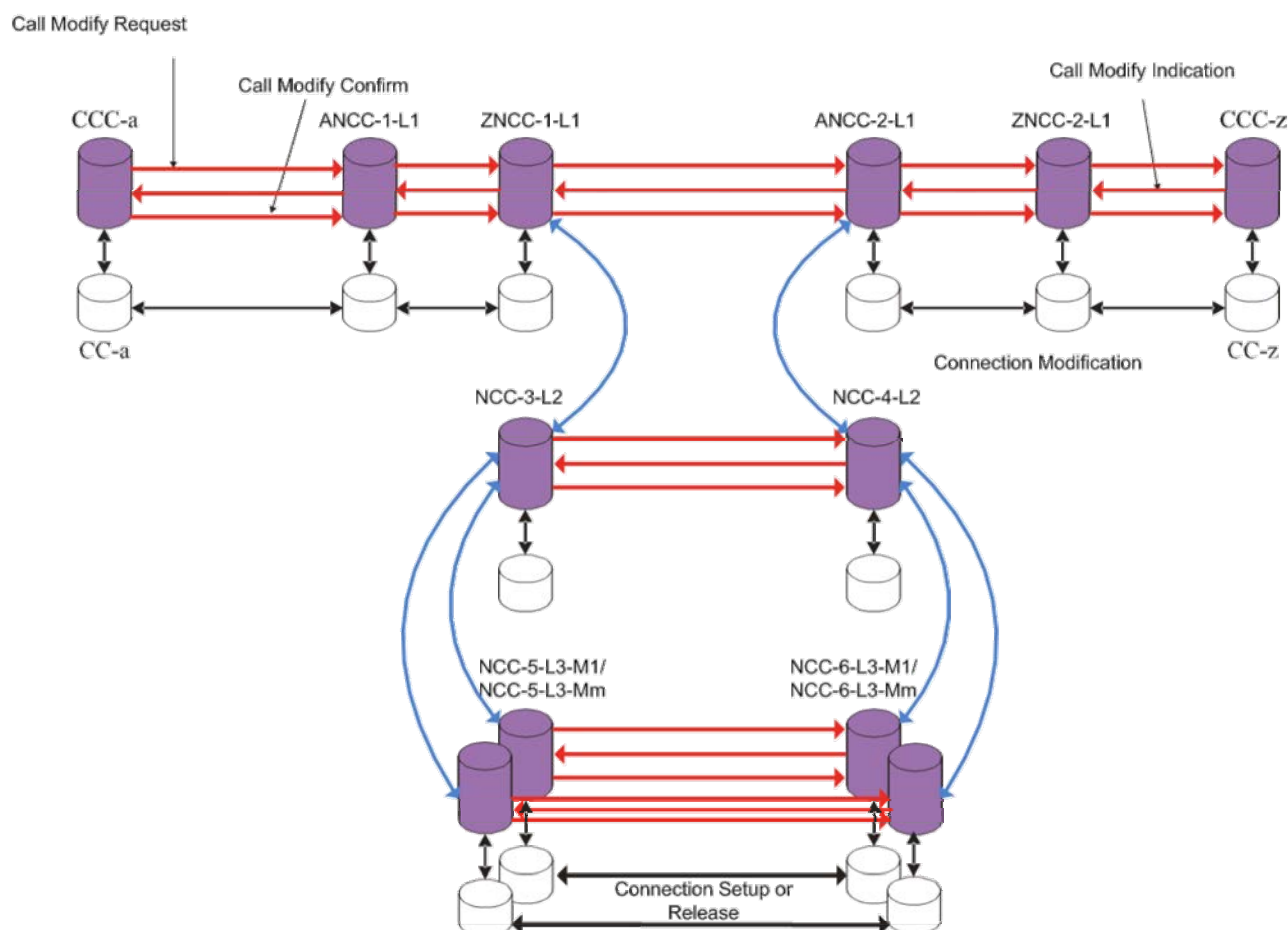


Figure 6-14 – Interlayer group resizing

For a call modify request to increase/decrease the group size, the steps include:

- The calling party call controller (CCC-a) requests call modification. At ANCC-1-L1, processes are initiated to check the call modification (this may include checking for authentication and integrity of the request as well as constraints placed by policy decisions). Processes included in ZNCC-2-L1 may include verifying that the call modification is accepted end-to-end (e.g., request for CCC-z call verification). The request is also sent to the intermediate network call controllers. At interlayer call boundaries, ZNCC-1-L1, an interlayer call modification request is made to NCC-3-L2 to modify the group size. In turn, NCC-3-L2 requests a new call set up to NCC-5-L3-M1 to NCC-5-L3-Mm for a group size increase or a call release for a group size decrease.
- Upon successful indication by the call modification request process, the calling party call controller (CCC-a) continues the call modification request by initiating a connection modification request to the CC. Similarly, the call controllers at interlayer boundaries continue the modification request by initiating a connection modification request, connection set up request or connection release request to the corresponding connection controller.
- Upon successful indication by the connection modification request process (across all call segments at all layers) the call modification request is successfully completed.

- Note that, based on different protocol design decisions, initiation of connection modification/setup/release request and interlayer call requests may occur in a different order as shown in Figure 6-14. The only requirements are as follows:
 - Overall network connection modification/setup/release is completed before the call modification is completed.
 - For increases, call and connection modifications at server layers must be completed before the client layer call modification completes.
 - For decrease, the request must be validated at the client layer before the interlayer call modification request is made, i.e., the client layer must be in the Call Modify Indication or Call Modify Confirm phase.

6.2 Signalling controller resilience

Signalling controller resilience refers to its ability to continue operating under failure conditions. The signalling controller could be located at the UNI, I-NNI, E-NNI to support call and/or connection establishment and teardown procedures. Its operation depends upon the data communication network (DCN), the transport plane, the management plane and the internal components of the control plane itself.

6.2.1 Signalling controller failure detection and indication

The signalling controller is considered to have failed if the control plane loses the communication to the transport plane, and/or the signalling controller loses the communication to its adjacent signalling controller. The failure could be caused by DCN failure or other reasons (e.g., adjacent signalling controller defect).

The control plane must have mechanisms to detect failures of the communications to transport plane, and the signalling controller should be informed of this failure. The failure of communications between control plane and transport plane is not necessary to cause signalling channel failure.

Signalling channel maintenance must be supported by a signalling protocol. Signalling channel failure could be caused by DCN failure or adjacent signalling controller failure. The failure detection mechanism in the signalling protocol should work for either case.

When any failure happens:

- The existing completed calls and their connections must not be altered during failure and recovery time.
- The signalling channel failure must be alarmed, and the failure should be notified to other signalling controllers. The management plane may be notified if the failure persists and requires operator intervention.
- No signalling messages are accepted or processed.
- If the failure is between control plane and transport plane, and the signalling controller is still reachable, the new call request/teardown request flows or new connection request/teardown flows will be failed with proper error indication.
- If the failure is caused by signalling channel down, the new call request/call teardown flows will be lost due to signalling channel failure at the UNI, E-NNI or I-NNI. The new connection request/connection teardown flow will be lost due to signalling channel failure at I-NNI.

6.2.2 Signalling controller synchronization with transport plane

When communications between control plane and transport plane become available, the signalling controller must reconstruct the call and connection state corresponding to the connections in the transport plane. A possible resynchronization sequence is:

- The link resource manager synchronizes with the transport NE state information, including the cross-connection information on NE and ports.
- The connection controller then synchronizes with link resource manager to recover the connection state.
- The call controller (if it applies) then synchronizes with connection controller to recover the call state.

During this time, the signalling protocol controller might rely on another system to report the error (e.g., zero bandwidth), or maintain a proper state, e.g., vertical recovery state. In this state, all signalling messages will be accepted, but not processed. The proper messages with error indication must be sent back.

6.2.3 Signalling controller synchronization with adjacent signalling controller

When communications between signalling controllers become available, the signalling controller must synchronize the call and connection state with its adjacent entities. The signalling protocol controller must have proper state, e.g., horizontal recovery state. In this state, the messages to setup the new calls/connections or teardown the existing calls/connections might be rejected, and the signalling controller must examine whether the connection information is consistent with the connection information by its adjacency. The check should include:

- Call and/or connection ID. The call and/or connection is considered as invalid if its ID is only found in one side.
- Resources allocation for the same connection. The connection is considered as invalid if the resources allocated by two ends are not consistent.

After the invalid calls and/or connections are identified, the signalling protocol controller must send proper messages to delete them, so that the partial calls and/or connections will be cleaned up.

This resynchronization must not occur until the synchronization between control plane and transport plane is done.

6.3 DCM signal flow – Exception handling

Different levels of exceptions may occur within a switched network, impacting both the transport plane and the control plane. For example, an exception may include defects of the signalling communication network, defects of the connection controller, and misbehaviour of the connection controller:

- Defects of the signalling communication network may result due to disruption of the communications channel.
- Defects of the connection controller may result due to failure of different agents that make up the controller, e.g., failure of the connection set up agent.
- Misbehaviour of the connection controller may be a result of incorrect decoding of messages. Mechanisms for detection of a misbehaved component are outside the scope of this Recommendation.

Defect information is communicated by the CallC and CC to the management plane, plus any information specific to the detected defects. Figure 5-1 provides the reference diagram for call requests handled by the CallC. Using this network model, the following clauses provide different