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Data over Transport – Generic aspects – Transport
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Architecture for SDN control of transport networks

Recommendation ITU-T G.7702



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Recommendation ITU-T G.7702

Architecture for SDN control of transport networks

Summary

Recommendation ITU-T G.7702 describes the reference architecture for software defined networking (SDN) control of transport networks applicable to both connection-oriented circuit and/or packet transport networks. This architecture is described in terms of abstract components and interfaces that represent logical functions (abstract entities versus physical implementations).

History

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Recommendation ITU-T G.7702

Architecture for SDN control of transport networks

1 Scope

This Recommendation specifies the architecture and requirements for software defined networking (SDN) control of transport networks, consistent with the principles of SDN and complementary to SDN related work in SG11, SG13 and SG17. This architecture is applicable to both connection-oriented circuit and packet transport networks.

The reference architecture describes SDN control of transport networks in terms of abstract control components that are used for manipulating transport network resources in order to provide the desired functionality. These components represent abstract entities rather than instances of implementable software and use UML-like notation.

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.800] Recommendation ITU-T G.800 (2016), *Unified functional architecture of transport networks*.
- [ITU-T G.805] Recommendation ITU-T G.805 (2000), *Generic functional architecture of transport networks*.
- [ITU-T G.872] Recommendation ITU-T G.872 (2017), *Architecture of optical transport networks*.
- [ITU-T G.7701] Recommendation ITU-T G.7701 (2016), *Common control aspects*.
- [ITU-T G.7711] Recommendation ITU-T G.7711/Y.1702 (2018), *Generic protocol-neutral management Information Model for Transport Resources*.
- [ITU-T G.7712] Recommendation ITU-T G.7712/Y.1703 (2010), *Architecture and specification of data communication network*.
- [ITU-T G.8080] Recommendation ITU-T G.8080/Y.1304 (2012), *Architecture for the automatically switched optical network*.
- [ITU-T Y.3300] ITU-T Recommendation Y.3300 (2014), *Framework of software-defined networking*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 adaptation: [ITU-T G.800].

3.1.2 address: [ITU-T G.7701].

- 3.1.3 **administrative domain:** [ITU-T G.7701].
- 3.1.4 **architectural component:** [ITU-T G.805].
- 3.1.5 **call:** [ITU-T G.7701].
- 3.1.6 **call controller:** [ITU-T G.7701].
- 3.1.7 **calling/called party call controller:** [ITU-T G.7701].
- 3.1.8 **characteristic information (CI):** [ITU-T G.800].
- 3.1.9 **client/server relationship:** [ITU-T G.805].
- 3.1.10 **component:** [ITU-T G.7701].
- 3.1.11 **component interface:** [ITU-T G.7701].
- 3.1.12 **connection:** [ITU-T G.805].
- 3.1.13 **connection controller (CC):** [ITU-T G.7701].
- 3.1.14 **control domain:** [ITU-T G.7701].
- 3.1.15 **domain:** [ITU-T G.7701].
- 3.1.16 **layer network:** [ITU-T G.805].
- 3.1.17 **link:** [ITU-T G.805].
- 3.1.18 **link connection:** [ITU-T G.805].
- 3.1.19 **network call controller (NCC):** [ITU-T G.7701].
- 3.1.20 **policy:** [ITU-T G.7701].
- 3.1.21 **recovery domain:** [ITU-T G.7701].
- 3.1.22 **resource database (RDB):** [ITU-T G.7701].
- 3.1.23 **route:** [ITU-T G.7701].
- 3.1.24 **routing area (RA):** [ITU-T G.7701].
- 3.1.25 **routing controller (RC):** [ITU-T G.7701].
- 3.1.26 **routing domain:** [ITU-T G.7701].
- 3.1.27 **software defined networking:** [ITU-T Y.3300].
- 3.1.28 **subnetwork:** [ITU-T G.805].
- 3.1.29 **subnetwork connection:** [ITU-T G.805].
- 3.1.30 **subnetwork point (SNP):** [ITU-T G.7701].
- 3.1.31 **subnetwork point pool (SNPP):** [ITU-T G.7701].
- 3.1.32 **trail:** [ITU-T G.805].
- 3.1.33 **transitional link:** [ITU-T G.800].
- 3.1.34 **virtual network (VN):** [ITU-T G.7701].

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAA	Authentication, Authorization and Accounting
AVC	Attribute Value Change
BRI	Boundary Resource Identifier
BSS	Business Support System
CC	Connection Controller
CCC	Calling/called party Call Controller
CCN	Control Communication Network
CI	Characteristic Information
CIM	Common Information Model
CPI	Control Plane Interface
DA	Discovery Agent
DS	Directory Service
EMS	Element Management System
FCAPS	Fault, Configuration, Accounting, Performance and Security
FFS	For Further Study
FP	Forwarding Point
IM	Information Model
LLDP	Link Layer Discovery Protocol
LRM	Link Resource Manager
LTP	Link Termination Point
MCC	Management-Control Continuum
MPLS	Multi-Protocol Label Switching
MPLS-TP	MPLS Transport Profile
NCC	Network Call Controller
NE	Network Element
NMS	Network Management System
OSS	Operation Support System
OTN	Optical Transport Network
QoS	Quality of Service
RA	Routing Area
RC	Routing Controller
RDB	Resource Database
SDN	Software Defined Networking
SLA	Service Level Agreement
SNC	Subnetwork Connection
SNP	Subnetwork Point
SNPP	Subnetwork Point Pool

TAP	Termination and Adaptation Performer
TLS	Transport Layer Security
UML	Unified Modelling Language
VN	Virtual Network

5 Conventions

This Recommendation uses the diagrammatic conventions defined in [ITU-T G.800] to describe the transport resources.

This Recommendation uses the diagrammatic conventions defined in [ITU-T G.7701] to describe controller components.

6 Overview

The transport network needs to accommodate growing bandwidth demand, support rapid service deployment from application providers and provide real-time responsiveness to capacity/QoS changes. Application and service providers desire the ability to request and provision edge-to-edge connections with guaranteed service level agreements (SLAs), in terms of e.g., bandwidth, delay, availability and error performance, over multiple types of transport infrastructures, including optical transport network (OTN), Ethernet and multi-protocol label switching transport profile (MPLS-TP). SDN is a technology that is intended to address some of these needs and desires. This Recommendation describes the application of the SDN architecture to transport networks.

The purpose of the application of SDN for transport networks is to:

- Provide enhanced support for connection control in multi-domain, multi-layer (etc. multi-technology) and multi-level transport networks, including network virtualization, network optimization, centralized restoration;
- Enable technology-agnostic control of connectivity and the necessary support functions across multi-layer transport networks, facilitating optimization across circuit and packet layers;
- By separating out the connection control aspect from the operation support system (OSS)/ network management system (NMS), SDN can open an interface that allows it to be exposed to clients/servers without exposing the rest of the OSS infrastructure.

This Recommendation deals with the SDN for transport network architectural components and their interaction with the transport data plane and management functions.

SDN control of the media layer is also within the scope of this Recommendation. This introduces the concept of media layer specific controllers. The architecture and management of the media layer is specified in [ITU-T G.872].

6.1 Functional characteristics of SDN for transport networks

Service providers may offer a wide range of services based upon differing business models. Operators continue to require protection of their commercial business operating practices and resources from external scrutiny or control, as well as to maintain the ability to differentiate the services they offer. The security and reliability of the underlying transport network remains a high priority. The SDN for transport architecture must thus provide for boundaries of policy and information sharing to accommodate, for example, the range of business models and varying trust relationships among users and providers, among users and among providers. Security at the boundary of SDN controller constrains the capability offered to clients across the control plane interface (CPI) (see clause 13.2).

Transport network operators may select among a wide breadth of existing and emerging transport technologies, infrastructure granularity options, flexible capacity adjustment schemes, survivability strategies and infrastructure evolution choices. For a network operator/service provider, the optimal network layering, convergence choices and equipment selection depends upon multiple factors, such as:

- network size, geography, scalability;
- service offerings portfolio, QoS committed in SLAs;
- resource utilization, performance, survivability/resiliency trade-offs;
- deployment schemes of control and management environment; and
- whether services traverse multiple operator domains.

Consequently, the architecture of SDN control of transport network must be designed to allow for multi-dimensional heterogeneity and not preclude network operators from optimizing their network design and supporting service realization as they see fit. The architecture must thus support the ability to decouple the services offered from their service delivery mechanisms and decouple QoS from its realization mechanisms.

As described in clause 11 of [ITU-T G.7701], distinct and independent sets of name spaces exist, from which identifiers are drawn, for:

- Resources in the transport network
- Control view of transport resources
- Control components
- Control Artefacts
- Reference points
- Control communications network.

These considerations lead to the following architectural principles:

- Provide a construct that reflects a service association that is distinct from its infrastructure/realization mechanisms
- Establish a modular architecture with interfaces at policy decision points (e.g., trust domain boundaries)
- Offer capability to distinguish identity from address (including distinguishing between and among, transport resources, controller entities and control communication network addresses).

6.2 Architecture of SDN for transport networks

This clause describes the functional entities that form the architecture of SDN for transport networks. The basic concept of SDN encompasses SDN applications exercising control of abstracted network resources and SDN controllers providing logically centralized control of network resources. The high-level architecture (see clause 12) is described in terms of a hierarchy of SDN controllers inter-connected by a control plane interface (CPI). Any SDN controller in the hierarchy can support applications.

Within this Recommendation the term layer is used as defined in [ITU-T G.800]. Within this Recommendation the term level is used to describe a hierarchy of SDN controllers or hierarchical transport network views. The level of a controller in a hierarchy is similar to, but distinct from, routing levels as defined in [ITU-T G.7701] and used in [b-ITU-T G.7715]. In both cases, level refers to a position within a hierarchy.

In SDN hierarchies, a server SDN controller presents a view of resources to its client(s). These are known as virtual networks (VNs). Furthermore, a given SDN controller may have both VNs and non-VNs in the scope of its management-control continuum (MCC) as described in [ITU-T G.7701].

As shown in Figure 6-1 an SDN controller may have multiple clients and multiple servers, this is referred to as a client/server relationship within the SDN architecture.

Within an SDN controller, a particular client is supported by a set of information including for example a virtual network (VN), relating to that client as well as management-control functions. Together, this is known as the client context.

Similarly when a server is used by an SDN controller, it is supported by a set of information relating to that server as well as management-control functions and this is known as the server context.

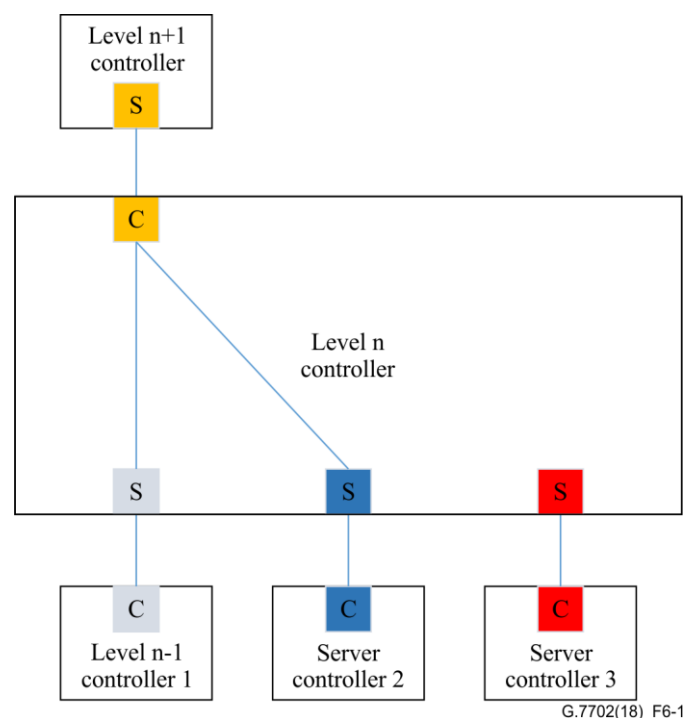


Figure 6-1 – Client/server relationships in the SDN architecture

When two SDN controllers are adjacent in a hierarchy, the SDN controller with the client role has a server context that has a 1:1 relationship with the client context in the SDN controller with the server role.

The VN provided to a client by a server controller is stored in a server context.

The server assembles resources for a given client, such an assembly of resources is identified by a client context that is communicated to the client. The client uses a server context to identify the server that supplied the resources.

Figure 6-2 shows the architecture of SDN for transport networks.

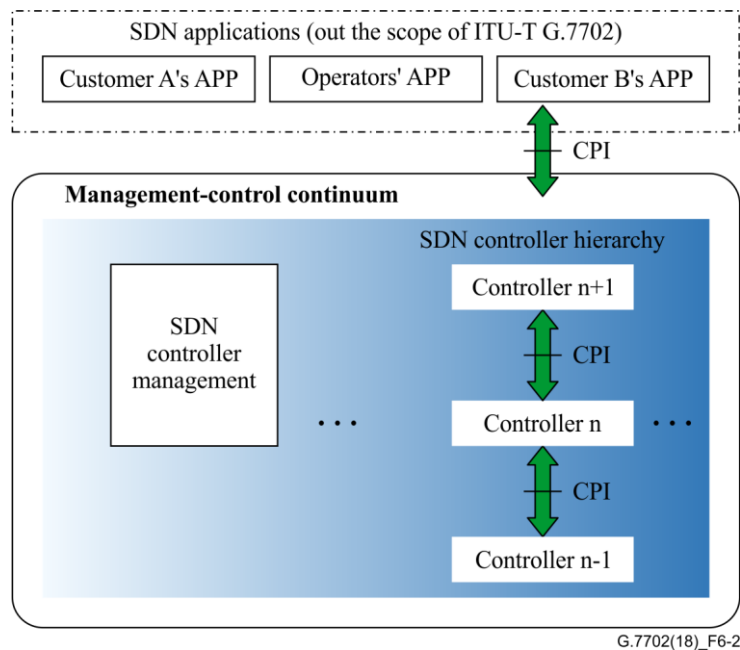


Figure 6-2 – Architecture of SDN for transport networks

6.3 Interaction between SDN controller and transport network

When the MCC functions in an SDN controller directly control the transport resources, these functions view the [ITU-T G.800] forwarding point (FP) name space for those resources and forwarding can be configured. At other levels in the recursion, the server SDN controller presents an abstract view of the transport resources to the client SDN controller using subnetwork point (SNP) and subnetwork point pool (SNPP) identifiers. These SDN controllers only have SNP/SNPP identifiers for resources in their scope and therefore cannot configure forwarding for those resources. In this case, a request must be sent to a server controller. This is described in more detail in clause 7 (Controller arrangements).

6.4 Interaction between SDN controller and applications

The client context in an SDN controller at any level in the hierarchy can communicate with the server context of another controller as described in clause 6.3 or it can communicate with an application.

From the perspective of an SDN controller supporting an application, the application is not distinguishable from that of another client controller. As illustrated in Figure 6-1, applications can be supported by SDN controllers at any level and applications and controllers are indistinguishable from the perspective of a server controller.

6.5 Management functions interactions

The management-control continuum (MCC) described in [ITU-T G.7701] expresses the view that management and control functions are essentially the same and thus they can be grouped into one set of MCC functions. There are MCC functions that directly manage resources and MCC functions that manage other MCC functions (e.g., configuration of call control). Many of these MCC functions are still essential in an SDN environment. Relevant management functions include functionalities for supporting fault management, configuration management, accounting management, performance management and security management (FCAPS) as described in [b-ITU-T M.3400]. For example, in the transport network, management is minimally required for initial configuration of the transport network resources, assigning the SDN-controlled parts and configuring their associated SDN controller(s). In the SDN controllers, management needs to configure the policies defining the scope of control given to the SDN application and to monitor the