OIF Carrier WG Requirements on Transport Networks in SDN Architectures
Transport SDN

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For additional information contact:
The Optical Internetworking Forum, 48377 Fremont Blvd.,
Suite 117, Fremont, CA 94538
510-492-4040 ☞ info@oiforum.com

www.oiforum.com

Working Group: Carrier

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SOURCE:

TECHNICAL EDITOR

Christoph Gerlach
Deutsche Telekom
Winterfeldtstr. 21
10781 Berlin – Germany
Phone: +49.30.8353.74964
Email: cgerlach@telekom.de

WORKING GROUP CHAIR

Hans Martin Foisel
Deutsche Telekom
Winterfeldtstr. 21
10781 Berlin - Germany
Phone: +49.30.8353.74960
Email: H.Foisel@telekom.de

ABSTRACT:
This document summarizes the OIF Carrier WG requirements on Transport Network features and functionalities to support deployment of SDN architectures, application, services and technologies.

List of Contributors

Contributor	Company
Eve Varma, Steve Trowbridge	Alcatel-Lucent
Doug Zuckerman	Applied Communications Sciences
Monica Lazer	AT&T
Lyndon Ong	Ciena
Junjie Li	China Telekom
Evelyne Roch, Maarten Vissers	Huawei
Scott McNown	Department of Defense
Hans-Martin Foisel, Christoph Gerlach, Armin Ehrhardt	Deutsche Telekom
Takehiro Tsuritani	KDDI R&D Labs
Ben Wright	Metaswitch
John McDonough	NEC
Thierry Marcot	Orange
Jonathan Sadler	Tellabs
Dacian Demeter	TELUS
Vishnu Shukla, Stephen Liu	Verizon

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OIF OPTICAL INTERNETWORKING FORUM

2 List of Figures

3 Summary

This document summarizes the OIF Carrier WG requirements on Transport Network features and functionalities to support deployment of Software Defined Networking (SDN) architectures, application, services and technologies.

4 Disclaimer

This document has been reviewed by the Carrier Working Group Members, but may not necessarily represent the position of any particular company participating in the Carrier WG.

This document contains a set of requirements agreed to by all the participants. Individual carriers may have additional requirements.

5 Introduction and Scope

This document is a contribution to support the evolution of Transport Networks (TN) towards SDN architectures.

Among carriers a strong desire exists for a consistent set of SDN related standards and specifications to enable a seamless migration to SDN architectures.

The scope of the document is to outline generic TN and orchestration requirements needed to support SDN architectures. This document will be liaised to appropriate Standards Developing Organizations (SDO) and forums dealing with standardization and specification of interfaces among SDN components, such as network elements, different types of controllers and orchestrators.

Requirements in this document are aimed to be independent of specific implementations and protocols used to ultimately realize and deploy SDN enabled transport networks. However, the programmability of the controller functionality is assumed.

The intention of this document is to identify:

- Functions that need to be provided by a Control Plane (CP) enabled TN to an SDN controller or Orchestrator for realizing SDN use cases, applications and services (see Figure 1).
- Orchestrator functional requirements to ensure the desired coordination between functions and services spanning across multiple layers in a TN and crossing multiple SDN domains to achieve end-to-end service orchestration.

The combination of TN-relevant SDN architecture components – Data Plane, Control and Management (Mgt) Plane, and Orchestrator – and the relationship among them are referred to as "Transport SDN" within this document (see Figure 2).

Figure 1 shows an exemplary subset of interfaces used for Control Plane/Management Plane ⬄ Data Plane communication comprising single technology implementations, e.g. Management Plane or Open Flow (OF) only, and hybrid examples containing multiple suites of protocols.

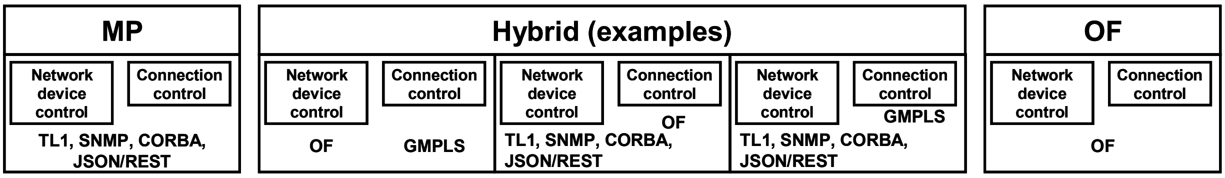

Figure 1: Potential interfaces between Control Plane and Data Plane

6 Reference Architectures

6.1 SDN Reference Architecture

This section provides definitions of Transport SDN components and a short description of the SDN architecture.

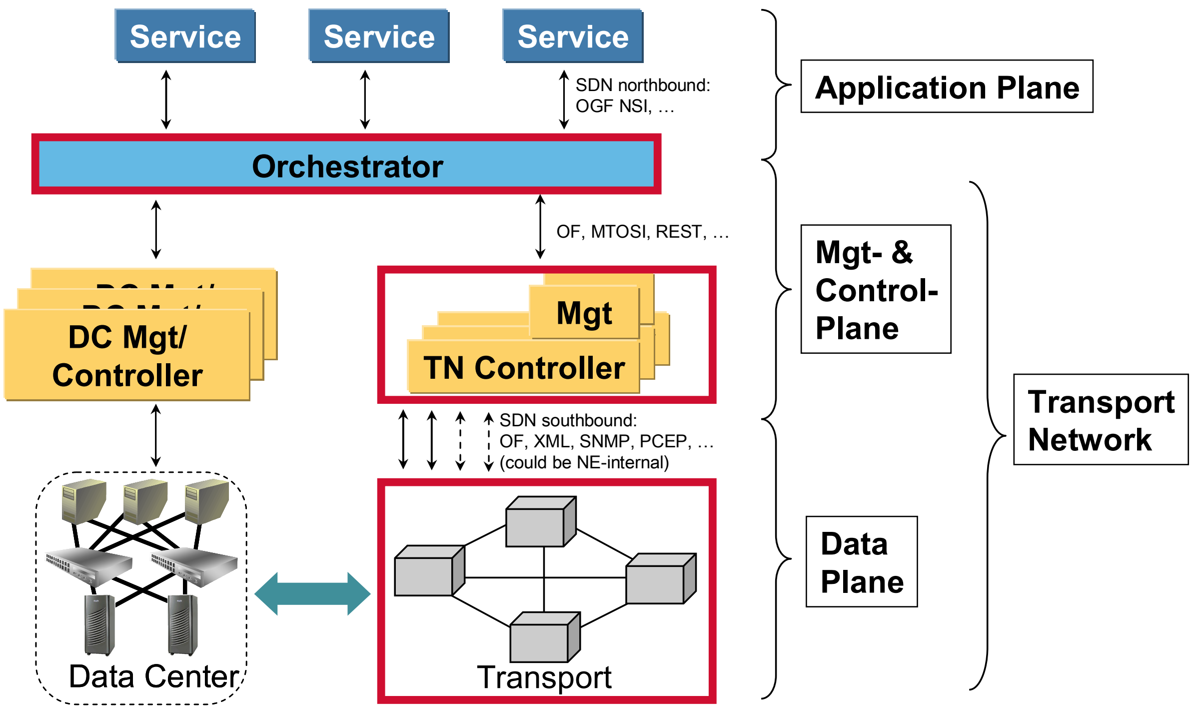

Figure 2: SDN reference architecture; the Transport SDN components covered by this document are marked red

Figure 2 shows the SDN reference architecture assumed throughout this document. This architecture is not aimed at a particular set of protocols or specific hardware and software implementations. The Key for a thriving SDN ecosystem is the separation of Management, Control and Data Planes by means of well defined interfaces and standardized protocols. To reach the desired level of interoperability between network components, vendor implementations, carrier network domains, and Data Center functions, this applies for packet as well as for circuit switching technologies.
Hardware and software used in the Data Plane, the Management and Control Plane, and the Orchestrator should be highly modular to profit from COTS (commercial cff the shelf) components wherever possible.

Data Plane
The Data Plane is sometimes referred to as "Transport Plane" or "Forwarding Plane". In this document, the term Data Plane is assumed to cover multiple transport technologies - circuit switched, and connection oriented packet switched - as well as the upper layers in carrier transport networks, which use the transport service. Examples include the OTN (digital and optical switching), MPLS-TP and Ethernet as transport technologies, as well as IP and TCP as upper layers.

Control and Management Plane
Various controller implementations may be used to support SDN architectures.
In such architectures, the Control Plane has a broader scope than the traditional ASON /GMPLS Control Plane. It needs to support additional functions, e.g. virtualized resources NFV.
The reference architecture is not prescriptive with respect to controller implementations. Example implementations are:

- single controller / multiple controllers of the same technology / a mixture of different types of controllers (hybrid)
- centralized or distributed

Traditional management functions are still required to operate the SDN network.

Orchestrator
The Orchestrator is positioned between the Application Plane and the Management/Control Plane to control facilities of Data Center and TN. It coordinates between Data Center management and the Control Plane of the TN and it controls slicing the transport network infrastructure. The Orchestrator's standardized APIs guarantee fast implementation of new applications.
The reference architecture is not prescriptive to actual implementation details. Different degrees of abstraction shall be allowed resulting in different levels of

information details, intra-domain information disclosure and computational workload.

6.2 Definitions and Terminology

The table below shows the nomenclature comparison among various SDOs and Forums:

ITU-T (SG 15)	ITU-T (SG 13)	ONF OTWG	OIF
		Application Layer	Application Plane
Ctrl.+ Mgt. Plane	Services Stratum	Control Layer	Ctrl.+ Mgt. Plane
Data Plane	Transport Stratum	Infrastructure Layer	Data Plane

(ONF OTWG: Open Networking Foundation Optical Transport Working Group)

SDN (Software Defined Networking)

From Heavy Reading:

SDN is an architectural concept that encompasses the programmability of multiple network layers – including management, network services, control, forwarding and transport planes – to optimize the use of network resources, increase network agility, unleash service innovation, accelerate service time-to-market, extract business intelligence and ultimately enable dynamic, service-driven virtual networks.

From ITU-T SG13:

Software-defined networking: A technology to networking which allows centralized, programmable Control Planes and Data Plane abstraction, where Control and Data Planes are separated, so that network operators can control and manage directly their own virtualized resources and networks

Programmable Control Plane: Control plane to be programmable and manageable in a centralized manner, where control and Data Planes are separated

From OIF:

SDN is an architectural concept that is not limited to a specific networking technology (packet or circuit), hardware realization (specialized box vs. x86 server / Network Function Virtualization concept) or control protocol (Open Flow (OF), Border Gateway Protocol (BGP), etc.). The architecture is based on the physical separation of the data/forwarding plane from the Control Plane for all switching technologies and standardized interfaces. Network element (NE) functionalities can reside in an external controller.

Standardized interfaces to applications (API) enable programmability and application awareness of the TN.
An Orchestrator coordinates the actions of Data Centers (DC) and Transport Networks (TN) to achieve seamless interworking and optimum support for SDN-based services. This should be independent from the underlying network technologies.
These requirements are mapped to a specific network design that can be implemented utilizing particular networking technologies. A binding process is then used to dynamically associate these network designs with specific network resources.

Transport SDN
Transport SDN is a subset of SDN architecture functions comprising the TN relevant SDN architecture components – Data Plane, Control and Management Plane and the TN relevant part of the Orchestrator.

Orchestration Function
Subset of SDN architecture functions for coordinating the actions in the Data Center and TN to support SDN services by translating application and Data Center requests originating from applications in client layers or Data Centers into TN call control parameters.

Open Flow (OF, from Open Networking Foundation)
In a classical router or switch, the fast packet forwarding (data path) and the high level routing decisions (control path) occur on the same device. An OpenFlow Switch separates these two functions. The data path portion still resides on the switch, while high-level routing decisions are moved to a separate controller, typically a standard server. The OpenFlow Switch and Controller communicate via the OpenFlow protocol, which defines messages, such as packet-received, send-packet-out, modify-forwarding-table, and get-stats.

PCE (Path Computation Element)
PCE represents a vision of networks that separate route computations from actual packet forwarding and connection setup.
Routing can be subject to a set of constraints, such as Quality of Service (QoS), policy, or price. Constraint-based path computation is a strategic component of traffic engineering in MPLS (Multi Protocol Label Switching) and GMPLS (Generalized MPLS) networks.
Path computation has previously been performed either in a management system or at the head end of each Label Switched Path (LSP). Path computation in large, multi-domain networks may be very complex and may require more computational power and network information than is typically available at a

network element, yet may still need to be more dynamic than can be provided by a management system.
Thus, a PCE is an entity capable of computing paths for a single or set of services. A PCE might be a network node, network management station, or dedicated computational platform that is resource-aware and has the ability to consider multiple constraints for sophisticated path computation. In a PCE architecture path computation does not necessarily occur on the head-end (ingress) NE, but on some other path computation entity that may physically be located elsewhere.

There are two basic models for PCE in a multilayer network: PCE per layer and PCE for several layers.
In the first model, each PCE is responsible for path computation in a single layer. Multilayer path computation requires hierarchical PCE interactions where the client layer PCE computes paths through server layers and then requests server layer PCEs to compute paths in their respective server layer domains in order for the client layer PCE to determine the optimal multilayer end-to-end path.
In the second model, a single PCE has responsibility for multiple layers. A PCE computes paths across transitional links. This is useful when a sequence of domains is traversed as in BRPC (Backwards Recursive Path Computation) where some domains have multilayer capabilities.

ALTO (Application Layer Traffic Optimization)
Distributed applications often transfer large amounts of data through connections established between nodes distributed across the Internet with little knowledge of the underlying network topology. Absent such information guiding any choices, or acting on suboptimal or local information, these applications often make less than desirable choices.
ALTO is a protocol to optimize peer selection in distributed networks. It is based on a restful API that provides topology maps and cost maps to clients for optimal initial neighbor/path selection. As such it can be implemented into an SDN Controller/Orchestrator.

NSI Connection Service Protocol 2.0 (Network Services Interface, Open Grid Forum)
The NSI Connection Service protocol has been developed to allow dynamic service networks to interoperate in a multi-provider environment. NSI v2.0 can be used as a key building block for the delivery of distributed virtual infrastructures over an inter-cloud environment.
The Network Service Interface (NSI) is defined to be the set of protocols and parameters that are used between a software agent requesting a network service and the software agent providing that Network Service. NSI provides an abstracted view of networks (separated into Service Termination Points &

Transfer Functions), hiding the underlying physical or logical infrastructure, and hence can be used in traditional GMPLS as well as SDN-controlled environments.

6.3 Examples of Transport Network Implementations in SDN Architectures

The implementation example in Figure 3 takes advantage of existing protocols' L2/L3/L4-7 matching and actions for access control. L0/L1 paths can be set up by Control Plane as directed by the Element Management Software (EMS) or Stateful PCE.

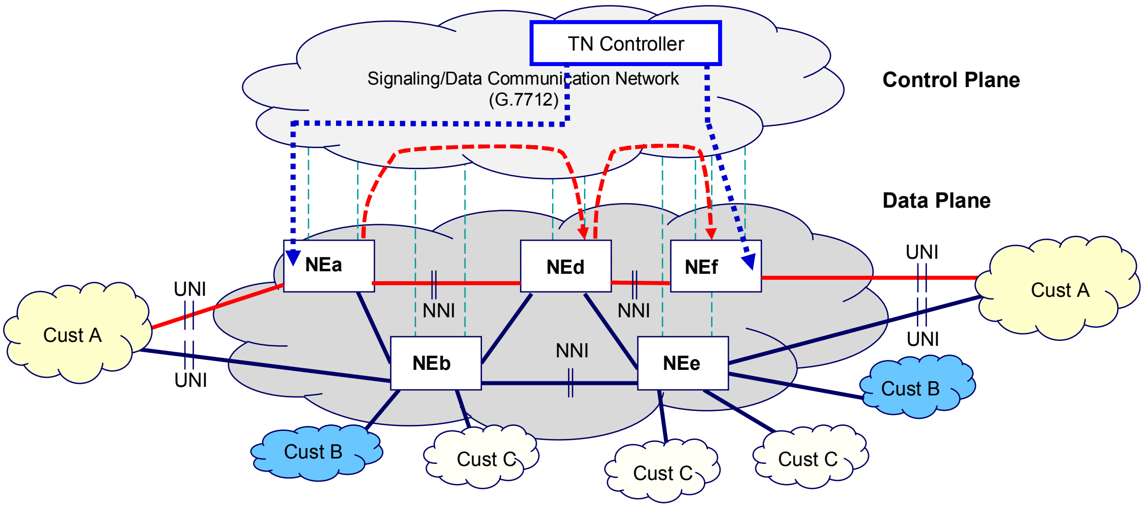

Figure 3: Concept #1 - Use SDN to provision packet mapping into optical paths

In the example in Figure 4 a mediation device (could be EMS or PCE) mediates application requests and virtualizes network topology. This implementation requires optical-/circuit-aware SDN protocols, it maintains network policy/security and facilitates resource sharing/allocation across multiple network users. Internal network control is masked from the application.

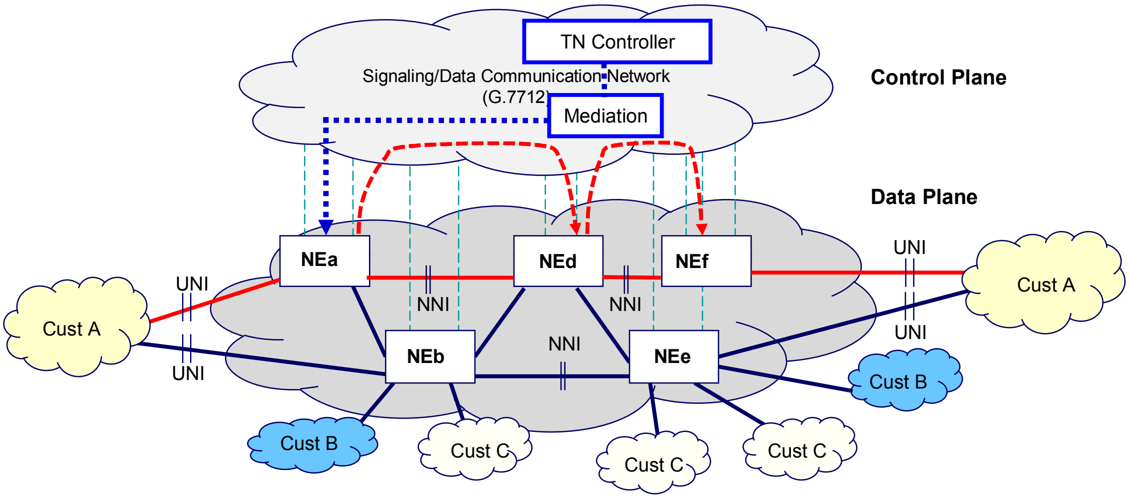

Figure 4: Concept #2 - Use SDN as a programmatic interface to the service provider network

The implementation in Figure 5 requires optical-/circuit-aware SDN protocols and a direct interface to each NE with controller - NE communication about optical impairments/characteristics. Currently it would require simplified optical network environment.

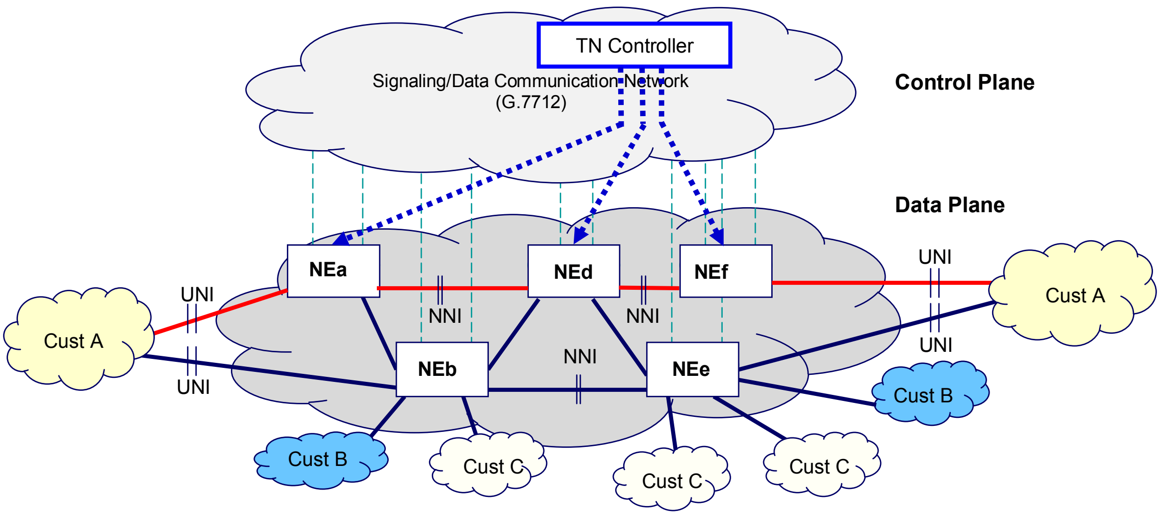

Figure 5: Concept #3 - Use SDN controller to control each network element individually

6.4 Functions available in current Control Plane enabled Transport Networks which support SDN Architectures

Many existing CP and DP standards and specifications are needed as a basis for interoperable implementations of SDN architectures. Details are listed in Appendix 8.1.

7 Requirements on Transport Networks to support SDN features, services and applications

This section describes at a very high level requirements on SDN components in the context of optical transport networks and on the communication mechanisms among those components. Please note that only Transport SDN specific requirements are listed. Control and Data Plane are assumed to be separated and to provide carrier grade functions typical to traditional transport networks.

7.1 Communication between SDN Components

Message exchanges between SDN components, such as exchanges between Orchestrator and CP/MP, or between CP/MP and DP must be supported by data communication capabilities that can meet operator needs of resilience, scalability, performance, and security. We may assume dedicated data communications networks. The DCN being used for SDN purposes does not need to be identical with an existing (legacy) DCN/SCN already in operation.

Requirements on the communication among individual entities within the SDN architecture as defined in 6.1 and shown in Figure 1 (such as between the Orchestrator and the CP/MP, between the components of the CP/MP, and between CP/MP and DP) are:

R 1 *SDN protocols must include mechanisms to ensure that connectivity exists at any time.*

R 2 *SDN protocols must include flow control to ensure that no messages are lost and that proper sequencing is ensured.*

R 3 *SDN protocols must support re-start and resynchronization procedures and message exchanges to recover for loss of communications.*

R 4 *SDN protocols must support congestion control mechanisms.*

R 5 *Network elements, controllers, their interfaces, and the protocols used to communicate among them should be consistent with the security guidelines described in OIF-SMI-03.1 - Security for Management Interfaces to Network Elements 2.0.*

R 6 *Strong security mechanisms must be supported for all inter-plane DCN communication. Security mechanisms which provide this functionality for the OIF Control Plane are specified in OIF-SEP-03.2 - Security Extension for UNI and E-NNI 2.1.*

R 7 *Network elements and controllers should be able to generate and communicate verifiable and complete audit information, in a manner consistent with the approach taken in OIF-SLG-01.3 - OIF Control Plane Logging and Auditing with Syslog.*

R 8 *SDN protocols must support performance characteristics in conformance with ITU-T Y.1731 (OAM functions and mechanisms for Ethernet based networks). The Performance Tier Model (Levels PT1 – PT4) described in MEF IA 23.1 (Carrier Ethernet Class of Service – Phase 2), section 6.6.1, may be used to classify requirements initially. Performance characteristics include::*

- *frame loss / packet loss rate;*
- *delay;*
- *delay variation;*

- *availability.*

7.2 Orchestrator

The Orchestrator is responsible for the coordination and management of SDN services. It requests TN service primitives from the control and Management Plane, depending on specific network implementations. It also represents the TN to the Application Plane using virtualization and abstraction.

R 9 *The Orchestrator needs to coordinate Data Center and TN activities as they apply to the application, control/management, and Data Planes.*

R 10 *The Orchestrator needs to provide the translation function for communication between Data Center and TN controllers.*

R 11 *The Orchestrator needs to provide computational resources to TN and Data Center to address events such as alerts, service requests, alarms, notifications.*

R 12 *The Orchestrator needs to provide virtualization models for TN (e.g., network functions virtualization) and Data Center (e.g., virtual machines).*

R 13 *The Orchestrator needs to provide rules engines to execute policies based on applications, conditions, and events.*

R 14 *The Orchestrator needs to provide structured, extensible, flexible, well defined interfaces to allow interoperable implementations:*

- *R.14.a To the application plane (northbound API);*
- *R.14.b To the TN control and Management Plane (southbound);*
- *R.14.c To the Data Center control and management systems (southbound);*
- *R.14.d Between SDN controllers, in a hierarchical and/or federated manner.*

R 15 *The Orchestrator should provide mechanisms that enable load balancing among Data Center and TN resources.*

- *R.15.a It recognizes and resolves overload situations for Data Center as well as transport resources, based on input parameters.*
- *R.15.b It communicates solutions to the Data Center management (for it to take proper action in terms of VM reconfiguration/relocation/migration) and TN Controller and/or Management system.*

R 16 *The Orchestrator should support reservation and scheduled services.*

R 17 *The Orchestrator needs to support Service Level Agreements (SLA) and related TN requirements.*

R 18 *The Orchestrator should support service reliability, by coordinating the use of various protection and restoration mechanisms in support of reliable, but cost effective services (e.g. via 1:M resiliency and/or shared restoration vs. replicated hardware available at the Data Plane). The Orchestrator must be aware of available protection and restoration (P&R) support of TN and Control Plane, and must have the intelligence to translate service reliability requirements into appropriate P&R schemes to be provisioned.*

7.3 Control and Management Plane

This section contains high level requirements on the control plane and on the management plane, in the context of the SDN architecture. The requirements are separated into control plane requirements and management plane requirements for easier readability. This does NOT mandate network function duplication; efficient function allocation is highly recommended.

7.3.1 Control Plane

The Control Plane provides call and connection management to the Orchestrator. Examples include creation, termination and tracking of TN service primitives. It also provides the Orchestrator with network and network services information (e.g., resilience, topology, utilization).

R 19 *The Control Plane supports connection management, discovery mechanisms (e.g., neighbor, topology), resilience functions (e.g., restoration), dissemination, and abstraction functions. Please see OIF Carrier WG Guideline Document on "Control Plane Requirements for Multi- Domain Optical Transport Networks", CWG # OIF-CWG-Control PlaneR-01.0.*

R 20 *The Control Plane needs to operate in a network functions virtualization environment.*

R 21 *The Control Plane requires a northbound interfaces to the Orchestrator to support:*

- R.21.a *Provision of abstract topology, network state, and network utilization;*
- R.21.b *Requests from Orchestrator.*

R 22 *The Control Plane provides the southbound interface(s) for communication to the Data Plane.*

R 23 *The Control Plane needs to support an interface for communication with the Management Plane.*

R 24 *The Control Plane needs to support virtual networks in a multi-layer TN context.*

R 25 *The Control Plane must not be restricted to a specific protocol suite.*

7.3.2 Management Plane

The Management Plane is responsible for the support of all aspects of network and network element management. These functions are not specific to SDN networks – they are currently provided by the Management Plane. The Management Plane provides fault, configuration, accounting, performance, security management (FCAPS). The Management Plane supports southbound interfaces to the Data Plane.

R 26 *The Management Plane requires a northbound interfaces to the Orchestrator to support:*

- R.26.a *Provision of abstract network state, resource availability, network utilization;*
- R.26.b *Requests from Orchestrator.*

R 27 *The Management Plane needs to support virtual networks in a multi-layer TN context.*

R 28 *The Management Plane needs to support an interface for communication with the Control Plane.*

7.4 Data Plane

The Data Plane supports functions such as encapsulation, cross-connecting physical or logical input and output ports, forwarding and transmission while enforcing policies and rules provided by the Management and Control Plane.

R 29 The Data Plane requires northbound interfaces to the Control Plane and the Management Plane to support:

R.29.a Provision of physical parameters, network state, resource availability, network utilization information;

R.29.b Requests from Management Plane and Control Plane.

R 30 The Data Plane must be able to provide northbound interfaces to multiple Control Plane instances.

R 31 The Data Plane should support a variety of protection mechanisms to allow for the selection of cost efficient resiliency

R 32 The Data Plane needs to support network slicing in a multi-layer TN context using:

R.32.a Dedicated Data Plane resources per service;

R.32.b *Sharable resources among services.*

8 Appendix

8.1 Functions available in current Control Plane enabled Transport Networks which support SDN Architectures

8.1.1 Data Plane

This section contains a list of Data Plane recommendations, standards, and specifications for the technologies relevant in the context of the SDN architecture. They cover the following areas of networking topics and categories:

- Transport network architectures
- Optical transport networks
- Access networks
- Home networks
- Ethernet networks
- MPLS-TP and packet networks
- Synchronization and timing
- Telephony and voice services
- Network management
- Protection, restoration and availability

ITU-T

- Transport network architectures
  - G.800: Unified functional architecture of transport networks
  - G.805: Generic functional architecture of transport networks
  - G.872: Architecture of OTN
  - G.8010 Architecture of Ethernet Layer Networks
  - G.8110.1 MPLS-TP Architecture

- Optical transport networks
  - G.709: Interfaces for the optical transport network
  - G.798: Characteristics of optical transport network hierarchy equipment functional blocks
  - G.806: Characteristics of transport equipment - Description methodology and generic functionality
  - G.870: Terms and definitions for optical transport networks
  - G.959.1: Optical transport network physical layer interfaces
  - G.7041: Generic framing procedure (GFP)
  - G.7042: Link capacity adjustment scheme (LCAS) for virtual concatenated signals
  - G.7044: Hitless adjustment of ODUflex

  - G.8201: Error performance parameters and objectives for multi-operator international paths within the Optical Transport Network (OTN)
  - G.8251: The control of jitter and wander within the optical transport network (OTN)
  - G.Sup43: Transport of IEEE 10GBASE-R in optical transport networks (OTN)

- Access networks
  - G.902: Framework Recommendation on functional access networks (AN) - Architecture and functions, access types, management and service node aspects
  - G.983: Broadband optical access systems based on Passive Optical Networks (PON)
  - G.984: Gigabit-capable passive optical networks (GPON)
  - G.985: 100 Mbit/s point-to-point Ethernet based optical access system
  - G.986: 1 Gbit/s point-to-point Ethernet-based optical access system
  - G.987: 10-Gigabit-capable passive optical network (XG-PON) systems
  - G.989: 40-Gigabit-capable passive optical networks (NG-PON2)
  - G.991: High bit rate digital subscriber line (HDSL) transceivers
  - G.992: Asymmetric digital subscriber line (ADSL) transceivers
  - G.993: Very high speed digital subscriber line transceivers (VDSL)
  - G.999: Interface between the link layer and the physical layer for digital subscriber line (DSL) transceivers
  - G.Sup50: Overview of digital subscriber line Recommendations
  - G.fast

- Home networks
  - G.9970: Generic home network transport architecture
  - G.9971: Requirements of transport functions in IP home networks
  - G.9973: Protocol for identifying home network topology
  - G.9980: Remote management of customer premises equipment over broadband networks - Customer premises equipment WAN management protocol

- Ethernet networks
  - G.8001: Terms and definitions for Ethernet frames over transport
  - G.8011: Ethernet service characteristics
  - G.8012.1: Ethernet UNI and Ethernet NNI
  - G.8013: OAM functions and mechanisms for Ethernet based networks
  - G.8021: Characteristics of Ethernet transport network equipment functional blocks

- MPLS-TP and packet networks
  - G.8101: Terms and definitions for MPLS transport profile
  - G.8112: Interfaces for the MPLS transport profile (MPLS-TP) layer network
  - G.8113.1: Operations, administration and maintenance mechanisms for MPLS -TP networks
  - G.8121: Characteristics of MPLS -TP equipment functional blocks

- Synchronization and Timing
  - G.8260: Definitions and terminology for synchronization in packet networks
  - G.8261: Timing and synchronization aspects in packet networks
  - G.8262: Timing characteristics of a synchronous Ethernet equipment slave clock
  - G.8263: Timing characteristics of packet-based equipment clocks
  - G.8264: Distribution of timing information through packet networks
  - G.8265: Architecture and requirements for packet-based frequency delivery
  - G.8271: Time and phase synchronization aspects of packet networks
  - G.8272: Timing characteristics of primary reference time clock

- Telephony and voice services
  - G.109: Definition of categories of speech transmission quality
  - G.114: One-way transmission time
  - G.142: Transmission characteristics of exchanges
  - G.161: Interaction aspects of signal processing network equipment
  - G.172: Transmission plan aspects of international conference calls

- Transport network and equipment management
  - G.852: Enterprise Viewpoint
  - G.874: Management aspects of optical transport network elements
  - G.874.1: Optical transport network (OTN) protocol-neutral management information model for the network element view
  - G.7710: Common equipment management function requirements
  - G.8051: Management aspects of the Ethernet-over-Transport (EoT) capable network element
  - G.8151: Management aspects of the MPLS -TP network element
  - G.8601: Architecture of service management in multi-bearer, multi-carrier environment

- Protection, restoration and availability
  - G.808.1: Generic protection switching – Linear trail and sub-network protection

- G.808.2: Generic protection switching - Ring
- G.808.3: Generic Protection Switching - Shared Mesh Protection
- G.873.1: Optical Transport Network (OTN) : Optical Transport Network (OTN): – Linear protection
- G.873.2 - ODUk Shared Ring Protection
- G.911: Parameters and calculation methodologies for reliability and availability of fiber optic systems
- G.8031: Ethernet linear protection switching
- G.8032: Ethernet ring protection switching
- G.8131: Linear protection switching for transport MPLS (T- MPLS) networks
- G.Sup51: Passive optical network protection considerations
- G.Sup52: Ethernet ring protection switching

MEF

- Specifications related to SDN
  - MEF 6.1, Metro Ethernet Services Definitions Phase 2
  - MEF 6.1.1, Layer 2 Control Protocol Handling Amendment to MEF 6.1
  - MEF 10.2, MEF 10.2 Ethernet Services Attributes Phase 2
  - MEF 10.2.1, Performance Attributes Amendment to MEF 10.2
  - MEF 17, Service OAM Framework and Requirements
  - MEF 33, Ethernet Access Service Definition
  - MEF 23.1 Class of Service Phase 2 Implementation Agreement
  - MEF 26.1 External Network Interface (ENNI) - Phase 2
  - MEF 28 External Network Network Interface (ENNI) Support for UNI Tunnel Access and Virtual UNI
  - MEF 35 Service OAM Performance Monitoring Implementation Agreement
  - MEF 7.2 Carrier Ethernet Management Information Model
  - MEF 36 Service OAM SNMP MIB for Performance Monitoring
  - MEF 41 UNI and EVC Definition of Managed Objects

IEEE

- Standards related to SDN
  - 802.1 Bridging and Management
    - 802.1Q-2011 VLAN Bridges
    - 802.1 AR-2009 Secure Device Identity (DevID)
    - 802.1 AS-2011 Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks
    - 802.1BR-2012 Bridge Port Extension VN-Tag
  - 802.3
    - 802.3-2012 EEE Standard for Information technology--Telecommunications and information exchange between

systems--Local and metropolitan area networks--Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications

8.1.2 Control Plane

This section contains a list of Control Plane recommendations, standards, and specifications for the technologies relevant in the context of the SDN architecture.

ITU-T

- G.7712: Architecture and specification of data communication network
- G.7713/Y.1704: Distributed call and connection management (DCM)
- G.7714/Y.1705: Generalized automatic discovery for transport entities
- G.7714.1/Y.1705.1 - Protocol for Automatic Discovery in SDH and OTN Networks
- G.7715/Y.1706: Architecture and requirements for routing in the automatically switched optical networks
- G.7715.1/Y.1706.1 - ASON Routing Architecture and requirements for Link State Protocols
- G.7715.2/Y.1706.2 - ASON Routing Architecture and Requirements for Remote Path Query
- G.7716/Y.1707: /Y.1707 - Control Plane Initialization, Reconfiguration, and Recovery
- G.7718/Y.1709: Framework for ASON management
- G.7718.1/Y.1709.1 - Protocol-neutral management information model for the Control Plane view
- G.8080: Architecture for the automatically switched optical network
- G.8081: Terms and definitions for automatically switched optical networks

IETF – GMPLS

A list of all GMPLS RFCs could be found at the following URL:

https://datatracker.ietf.org/doc/search/?name=gmpls&rfcs=on&activeDrafts=on&search_submit=

A subset of the documents most often referenced RFC in OIF is listed below:

- Signaling
    - RFC3471: Generalized MPLS - Signaling Functional Description
    - RFC3473: Generalized MPLS - RSVP-TE Signaling Functional Description
    - RFC4328: GMPLS Signaling Extensions for G.709 Optical Transport Networks Control

- RFC6002: Generalized MPLS (GMPLS) Data Channel Switching Capable (DCSC) and Channel Set Label Extensions
- RFC6003: Ethernet Traffic Parameters
- RFC6004: Generalized MPLS (GMPLS) Support For Metro Ethernet Forum and G.8011 Ethernet Service Switching

- Routing
    - RFC3630: Traffic Engineering (TE) Extensions to OSPF Version 2
    - RFC4202: Routing Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)
    - RFC4203: OSPF Extensions in Support of Generalized Multi-protocol Label Switching
    - RFC4328: Generalized Multi-Protocol Label Switching (GMPLS) Signaling Extensions for G.709 Optical Transport Networks Control
    - RFC4397: A Lexicography for the Interpretation of Generalized Multiprotocol Label Switching (GMPLS) Terminology within the Context of the ITU-T's Automatically Switched Optical Network (ASON) Architecture
    - RFC4655: A Path Computation Element (PCE)-Based Architecture
    - RFC4657: Path Computation Element (PCE) Communication Protocol Generic Requirements
    - RFC5787: OSPFv2 Routing Protocol Extensions for ASON Routing

MEF
- Specifications related to SDN
    - MEF 16, Ethernet Local Management Interface

IEEE
- Standards related to SDN
    - 802.1 Bridging and Management
        - 802.1aq-2012 Shortest Path Bridging
        - 802.1 Qbb-2011 Priority-based Flow Control

OIF
- Series of 2.0 interface specifications
    - Multi-layer amendment to E-NNI 2.0 – common part
    - Multi-layer amendment to E-NNI 2.0 – RSVP-TE signaling
    - Multi-layer amendment to E-NNI 2.0 – OSPFv2 based routing
    - User Network Interface (UNI) 2.0 signaling specification R2 – RSVP extensions for UNI 2.0
    - Security extensions for UNI and E-NNI 2.1
    - OIF Control Plane logging and auditing with Syslog
    - Security for management interfaces to network elements 2.0

  - o E-NNI 2.0 signaling specification
  - o E-NNI 2.0 OSPF based routing specification
  - o UNI 2.0 signaling specification

ONF (Open Networking Foundation)

- o ONF specifications can be downloaded at https://www.opennetworking.org/sdn-resources/onf-specifications
  - o OpenFlow Switch Specification 1.3.1
  - o OpenFlow Configuration and Management Protocol 1.1.1

ETSI-NFV (Network Functions Virtualization)

- o http://portal.etsi.org/portal/server.pt/community/NFV/367