

Technical Specification

**ONUG-OSE-1**

**Software Defined WAN (SD-WAN): Network Architecture Framework**

Modification History

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| --- | --- | --- | --- |
| Revision | Date | Originator | Comments |
| 0.1 | 01-Sep-2016 | Steve Wood | First Revision. Whole of document created. |
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# Abstract

This document provides the ONUG generic architectural framework for Software-Defined Wide Area Networks (SD-WAN). The architecture framework describes the a high-level model of the various architectural components of any SD-WAN transport service, user and group policy service and application services layer networks. The ONUG architecture model describes the management, control and dataplane strcuture of the SDWAN including external and internal interface reference points.

Not all reference points are intended to be standardized within the architecture. Some reference points and functional blocks are described for purposes of compleness and understanding of the model and are not subject to normative specifications. These are generally internal reference points and blocks. The OSE service specifications are mainly concerned with normative specifications of external SDWAN interfaces and reference points. Exceptions will be specifically noted.

# Objectives

The objective of the Open SDWAN Exchange or OSE is to provide a set of common definitions for SDWAN customer-facing-services (CFS). This includes common definition of service parameters and behaviours within any SDWAN implementation. The goal is to create common set of CFS specifications for all SDWAN services. The OSE approach is to use a declarative model for these services without specifying how the particular service is implemented. Implementation of the imperative model for the service, the resource-facing-service (RFS) is left to the vendor.

To facilitate service-level instantiation and interworking amongst SDWAN via software control, a set of APIs are also defined for communicating the parameters and options needed to instantiate a client-facing service policy within the SDWAN.

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# Terminology

A **Customer Facing Service** defines the properties of a particular related Service that represents a realization of that service within and SDWAN network.  This is in contrast to Resource Facing Services, which support the network/infrastructure facing part of the service.   Customer Facing Services are directly related to SDWAN service delivered to the client as well as to Resource Facing Services. A VPN is an example of a Customer Facing Service, while the sub-services that perform different types of routing between network devices making up the VPN are examples of Resource Facing Services.

A **Resource Facing Service** is an abstraction that defines the characteristics and behaviour of a service that is used internally as part of the composition of a Customer Facing Service.  Resource Facing Services are services internal to an SDWAN management controller, network controller or external network provider and may be composed of other Resource Facing Services and Resources. ResourceFacingServices are “internal” Services that are required to support a *Customer Facing Service.* A VPN is an example of a Customer Facing Service, while the sub-services that perform different types of routing between network devices making up the VPN are examples of Resource Facing Services.

# Scope

The architecture framework provides the generic model used by ONUG to describe internal and external architectural components of a Software Defined Wide Area Network (SD-WAN). The document is intended to describe the layer network decomposition model for an SD-WAN in terms of a) SD-WAN control services, transport services and application services layer networks components, and b) the generic architectural components associated with layer networks. The framework is also intended to describe the interactions among SD-WAN architectural components across well-defined interfaces and their associated reference points.

The architecture framework is not intended to require, or exclude, any specific networking technology from being used on any given implementation of an SD-WAN. The generic architecture framework provides a common structural view for the specification and decomposition of the SD-WAN transport and services capabilities. Detailed Technical Specifications and Implementation Agreements for specific architectural elements are outside the scope of this document.

# Compliance Levels

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in RFC 2119. All key words must be use upper case, bold text.

# SDWAN Reference Models

## SD-WAN Architecture Reference Model

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| Figure 1: SD-WAN Reference Model |

The basic reference model of an SD-WAN is depicted in Figure 1. There are a number of functional components involved:

1. the SD-WAN Client
2. the SD-WAN Transport Network
3. the SD-WAN Controller
4. the SD-WAN Manager
5. the Service Control applications: system visibility, orchestration, infrastructure and policy

An SD-WAN may interconnect to a number of different external networks and services for the purpose of access to resources and interconnection of networks that are required for the customer’s business operations.

1. Other SD-WAN networks: interface to other managed SD-WAN domain
2. Extranet VPNs: External B2B connectivity
3. Cloud services: connection to SaaS, Public Cloud, and Virtual Private Cloud
4. SD-WAN Clients: network elements (e.g. SDWAN border elements) or hosts (e.g. Access routers, Remote teleworkers, Mobile Clients)
5. Other network domain: any other external IP network

The reference model defines a set of interfaces to the SDWAN and between functional blocks. These interfaces or reference points are denoted by names (e.g. Gc, Gm) that can be used to unambiguously identify the interface in question.

As can be seen in the figure, there are set of reference points that are considered external to the SDWAN model (those extending outside the dotted grey box) and a set of reference points that are considered internal (those inside the dotted grey box). The OSE APIs are primarily concerned with the specification of external reference points. Internal reference points specification are left to vendor implementation and may be subject to specification in future revisions of OSE service specifications.

## OSE Interworking Model

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| Figure 2: Open SDWAN Reference Network |

The SDWAN reference network model shows the interrelationship of various entities within a customer network which may be composed of a number of SDWAN domains.

Each SDWAN domain has its own Management plane and Network Controller which may implement the network control plane as a separate entity in a centralized control plane model. Distributed control-plane models are not precluded, in which case the Network Controller functional block is distributed throughout the network elements.

The model defines both Intradomain as well as Interdomain communication for data, control and management plane information. The following terminology is defined for the interworking model:

* SDWAN Domain: a set of elements (virtual or physical) that implement a single SDWAN system under the administrative control of a single SDWAN manager and controller.
* Intradomain interface: communication contained within an SDWAN domain.
* Interdomain interface: communication between SDWAN domains across the Nsw interface.
* External interface: communication between non-SDWAN and SDWAN domain across the N interface set, excluding Nsw.
* Service Interface: communication between and external orchestrator and the SDWAN management plane or control plane servers via the G interface.

In order to specify interdomain communication as well as external communications, we define the OSE gateway as a functional element in the architecture. The OSE gateway defines a set of common functions and APIs to permit standard interdomain and external communication for the SDWAN. It does not imply the need for a separate network element. Such implementation details are left to the vendor.

The OSE specifications are primarily concerned with Interdomain, External and Service interface API specifications.

## OSE Orchestration Model

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| Figure 3: Multiple Transport Area Interworking Model |

Figure 3 shows the generic service interworking model for orchestrating OSE SDWAN services across multiple SDWAN network domains.

The model consists of one or more SDWAN domains, running over separate transport areas. These transports areas are considered different administrative domains that do not necessarily have inteconnectivity between them at the transport layer. If they do, then a single area model can be used as shown in Figure 4.

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| Figure 4: Single Transport Area Interworking Model |

### Serving SDWAN Manager

Each area has a Serving SDWAN Manager which is the vendor specific SDWAN manager and controller required to configure, manage and control a particular SDWAN domain. To create OSE SDWAN services, a higher layer orchestrator may use OSE defined API calls to create the desired SDWAN services within each domain via the serving SDWAN manager.

### Infrastructure Services

Infrastructure services are the set of services that control the network infrastructure setup of the SDWAN endpoint devices, control and management planes that are required to implement SDWAN policy services within a single SDWAN domain. This includes device configuration, onboarding and initial fabric setup for both physical and virtual SDWAN endpoints in the data plane or management and control planes.

The responsibility for infrastructure service configuration lies entirely within the domain SDWAN manager. The SDWAN may present APIs for such infrastructure configuration but the specification of those APIs is currently outside the scope of the OSE specifications.

### Policy and Application Services

Policy and Application Services are those services that can be instantiated on the SDWAN fabric, once established using the domain infrastructure manager and controller.

Policy and applications services are accessed via APIs at the serving SDWAN controller component. Services currently defined by OSE specifications include:

* Application Path Management Services
* OSE Gateway Reachability Services
* VPN Segmentation Services
* Traffic Management Services

### External Connectivity Services

External Connectivity Services are those services that create exit points to outside networks and services.

External Connectivity Services are transport or overlay services are accessed via APIs at the serving SDWAN controller component. Services currently defined by OSE specifications include:

* External network interface
* Cloud Provider interface
* SaaS or public cloud service interface (Direct Internet Access)
* Extranet network interface

# SDWAN Architectural Components

## SD-WAN Client

The SD-WAN client is a virtual or physical endpoint that provides the interface between applications, users and other processes to the SD-WAN transport fabric. This interface definition is described by the Uu interface reference point. The Uu interface defines the overlay network interface to the SD-WAN fabric including procedures for establishing dataplane confidentiality.

The SD-WAN client may be a network element, application process or other end-point such as a mobile or IoT device that can attach directly to the SD-WAN Fabric.

## SD-WAN Fabric

The SD-WAN Fabric is the overlay transport network that implements mesh connnectivity between all SD-WAN clients and external network intefaces. An SD-WAN client implements all SD-WAN transport and interface functions required to connect to the defined SD-WAN fabric interface reference points. These reference points are either User-Network or Network-to-Network interfaces.

The SD-WAN fabric delivers the overlay connectivity, carries segmentation, user and application metadata needed to deliver the end-to-end SD-WAN services defined in the ONUG OSE Services specifications.

The SD-WAN fabric ensures confidentiality of client frames carried across the overlay.

## SD-WAN Manager

The SD-WAN Manager is a reference block that encompasses the following:

1. Functions and procedures associated with programming or configuration the SD-WAN network elements and endpoints for SD-WAN operations. This includes both network transport configurations as well as higher-layer network policies.
2. Functions and procedures associated with collecting, processing and exposing telemetry data and/or analytics information contained in the SD-WAN network and endpoints.

The SD-WAN manager communicates with upper-layer orchestration processes via the G-interface reference points.

From the user service perspective, there is one management controller per SD-WAN domain. However this does not preclude the implementation of multiple, clustered and possible geographically dispersed management service instances as required to scale the service. OSE specifications do not specify this, nor the methods for achieving such distribution and clustering within an SDWAN domain.

However, OSE specifications do specify interface reference points definitions for communication to and from another SDWAN domain manager or controller. These are the Cx and Cy interfaces respectively.

## SD-WAN Network Controller

The SD-WAN Controller is a reference block that encompasses the network control-plane functions required to operate the SDWAN network. The may include but are not limited to:

* Overlay fabric connection control (establishment, maintenance and termination)
* Route distribution, filtering and control
* Segmentation and VPN topology control
* Secure connection establishement and maintenance
* Traffic engineering enforcement
* Other control-plane mechanisms as need to deliver SD-WAN services

The SD-WAN network controller delivers control-plane/data-plane separation the is the realization of SDN architecture within the SD-WAN usecase.

There may be one or more network controller instance per SD-WAN domain, but each network controller has a full view of the SD-WAN domain.

Each SD-WAN network controller is managed and configured by the SD-WAN manager. The interface between SDWAN network controller and SD-WAN network manager for this purpose is currently outside the scope of OSE.

## Client Orchestration

The Client Orchestration layer is an abstraction of a service level orchestrator or software that implements control the the SDWAN through the defined OSE APIs. The OSE service specifications do not specify the functions and procedures within this entity apart from the fact that it would use the OSE APIs.

The client orchestration layer is a functional block which would implement OSE API calls to one or more serving SDWAN managers

## External Connectivity

The SD-WAN architecture defines two primary external connectivity types:

1. Management-plane and control-plane interfaces
2. Data-plane or Network-to-Network interfaces

These interfaces may be either protocol-based or API-based interfaces based on the specific Service Model specfications defined in the ONUG Open SDWAN Service Exchange working group.

### Management Interface

The SDWAN reference model currently defines an interface for manager-to-manager connectivity. This interface is designated as the Cx reference point. The purpose of the Cx interface is to define intercommuncation and standard formats and access methods for management information transfer between SD-WAN management entities.

This interface may exist between two or more management controllers.

### Controller Interface

The SDWAN reference model currently defines an interface for controller-to-controller connectivity. This interface is designated as the Cy reference point. The purpose of the Cy interface is to define intercommuncation and standard formats and access methods for management information transfer between SD-WAN network controller entities.

This interface may exist between two or more management controllers.

### Cloud Interface

The Cloud NNI defines the interface between the SD-WAN fabric and external cloud services such as SaaS, PaaS and IaaS. The intent is to define a common interface dataplane and control-plane to establish connectivity and service consumption with external cloud services.

The Cloud NNI extends SD-WAN services and policy control to the access edge of any cloud service via placement of an SD-WAN endpoint at the cloud edge. This endpoint may be virtual or physical.

### Extranet Interface

The Extranet NNI defines the interface between the SD-WAN fabric and external networks for business partner access. The intent is to define a common interface dataplane and control-plane to establish connectivity and access control for business-to-business network access via the SD-WAN network.

The Extranet NNI extends SD-WAN services and policy control to the extranet edge via placement of an SD-WAN endpoint at the extranet edge. This endpoint may be virtual or physical. The interface allows SD-WAN services such as segmentation, VPN and path control to be applied to Extranet traffic coming into the SD-WAN.

### External Network Interface

The External Network NNI (Ex-NNI) defines the interface between the SD-WAN fabric and external networks for other network access. The intent is to define a common interface dataplane and control-plane to establish connectivity and access control other network services such as Internet and SaaS.

The Ex-NNI extends SD-WAN services and policy control to the extranet edge via placement of an SD-WAN endpoint at the external-network edge. This endpoint may be virtual or physical.

### SDWAN Network Interface

The SD-WAN Network NNI (SW-NNI) defines the interface between to SD-WAN network domains. The intent is to define a common interface dataplane and control-plane to establish connectivity, access control and SD-WAN services end-toend across SD-WAN domains.

Each domain may be comprised of different vendor SD-WAN vendor components and the purpose of the SW-NNI is to provide an open interface for interworking of services, connectivity and secure communication between SD-WAN domains.

The Ex-NNI extends SD-WAN services and policy control between SD-WAN domains via placement of an SD-WAN endpoint at the external-network edge. This endpoint may be virtual or physical.

The SW-NNI works in conjunction with the SD-WAN manager for NNI configuration and the SD-WAN network controller for exchange of network state information required for full interworking between SD-WAN domains. SD-WAN managers and controllers communicated cross-domain via the Cx and Cy interfaces to achieve the end-to-end service.

# SD-WAN Interface Reference Points

A number of interface reference points are defined for interconnection to external networks and between SD-WAN functional components. These interfaces are defined to provide standardized interconnect and service exchange between SD-WAN and non-SD-WAN networks. Some interfaces allow for SD-WAN service extension while others are service termination points.

## G Reference Points

OSE Reference Architecture defines a set of reference points between the SD-WAN network and SD-WAN clients.

Interfaces to the SD-WAN Network Manager for visibility and network configuration:

1. Gc – Open analytics interface
2. Gm – Open traffic management interface
3. Go – SD-WAN Orchestrator Interface

Interfaces to the SD-WAN Network Controller:

1. Gx – Open Infrastructure control interface
2. Gy – Open Policy control interface

### Gc

#### General Description

The reference point Gc connects a visibility or analytics client application, possibly via intermediate networks, to the analytics collection service of an SD-WAN management entity. For the purposes of architectural definition, it is assumed that the SD-WAN manager contains an analytics collection service but this specfication does not mandate the actual functional partitioning of such services, only that the service data shall be accessble by an interface that follows the format and content specified by in ONUG Open Analytics service specifications [xref: service spec].

#### Functionality

The functionality of the Gc reference point is to provide access to SD-WAN network analytics at the device and aggregate network level. This access is via API into the domain SD-WAN Manager. It is the responsibility of the domain SD-WAN manager to expose an interface for access to services defined across the Gc reference point that is compliant with Open SD-WAN analytics interface definitions as specified in [xref: OTMF specs].

#### Methods

Gc reference shall be based on REST-based APIs with JSON format as defined in the [OSE API reference spec]. [ref: obtain from open analytics format group].

<ADD: more info needed here>

### Go

#### General Description

The reference point Go connects a client orchestrator, possibly via intermediate networks, to a serving SD-WAN manager. The prime purpose of the information crossing this reference point is to allow common access to the SD-WAN infrastructure manager, so that certain services as defined in [xref: service spec] can be realized by the client orchestrator. The Gc interface provides service orchestraion via REST APIs with JSON data schema.

#### Functionality

The functionality of the reference point is to carry JSON structured data need to implement service APIs. For the purposes of Open SD-WAN exchange, the information carried is expected to pertain to cross-domain service interworking between SD-WAN domains. Examples of services defined on this interface include:

* Carry context for segmentation service interworking. This includes domain-specific identifiers needed for segment mapping between two SD-WAN domains.
* Carry context for VPN service interworking, for example defintion of cryptographic algorithm for communication between two SD-WAN domains
* Others as per the Open SD-WAN Services specifications.

#### Methods

Gc interface shall be an API based on REST architecture. The service parameter payload format shall be JSON.

### Gm

#### General Description

The reference point Gm connects a client orchestrator, possibly via intermediate networks, to a serving SD-WAN manager. The prime purpose of the information crossing this reference point is to allow common access to the SD-WAN infrastructure manager, so that certain services as defined in [xref: OTMF spec] can be realized by the client orchestrator. The Gm interface provides service orchestration via REST APIs with JSON data schema.

#### Functionality

The functionality of the Gm reference point is to provide access to SD-WAN traffic management analytics at the device and aggregate network level. This access is via API into the domain SD-WAN Manager. It is the responsibility of the domain SD-WAN manager to expose an interface for access to services defined across the Gc reference point that is compliant with Open SD-WAN traffic management analytics interface definitions as specified in [xref: OTMF specs].

#### Methods

Gm interface shall be an API based on REST architecture. The service parameter payload format shall be JSON.

### Gx

#### General Description

The reference point Gx connects a client orchestrator, possibly via intermediate networks, to a serving SD-WAN manager. The purpose of the information crossing this reference point is to allow common access to the SD-WAN infrastructure manager, so that certain services as defined in OSE Service Specifications can be consumed by the client orchestrator. The Gx interface provides service orchestration via REST APIs with JSON data schema.

#### Functionality

The functionality of the Gx reference point is to provide access to SD-WAN controller and orchestration services. This access is via API into the SD-WAN Manager for a specific SD-WAN domain. The services exposed to the client orchestrator through the Gx interface are as defined in the set of OSE Open-SDWAN service specifications.

#### Methods

The Gx interface shall be an API based on REST architecture. The service parameter payload format shall be JSON.

## C Reference Points

OSE Reference Architecture defines a set of reference points between the SD-WAN network and SD-WAN clients.

1. Cx – Open interface to other SD-WAN controller
2. Cy – Open interface to other SD-WAN manager
3. Cmg – Management interface to SD-WAN
4. Cn – Network Controller interface to SD-WAN

## N Reference Points

OSE Reference Architecture defines a set of reference points between the SD-WAN network and external networks:

1. Nx – Extranet network interface
2. Nc – Cloud Service network interface
3. Nsw – Other SD-WAN network interface
4. Nn – Other external network interface

## U Reference Points

OSE Reference Architecture defines a set of reference points between the SD-WAN network and SD-WAN clients:

1. Uu – SD WAN Client interface

# SD-WAN Layer Model

## Application Services Layer

## Overlay Services Layer

## Underlay Transport Services Layer

## Controller Services Layer

## System Management Layer

## Network and Services Analytics Layer

# SD-WAN Layer Relationship to Architectural Components

End of Document