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SERIES Q: SWITCHING AND SIGNALLING, AND ASSOCIATED MEASUREMENTS AND TESTS

Signalling requirements and protocols for SDN – Network signalling and signalling requirements for services

Signalling requirements for SD-WAN service

Recommendation ITU-T Q.3741

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Recommendation ITU-T Q.3741

Signalling requirements for SD-WAN service

Summary

Recommendation ITU-T Q.3741 specifies signalling requirements for software-defined wide area networking (SD-WAN) service launched by service providers. The signalling is to support the automated provision and management of the enterprise SD-WAN service.

SD-WAN is an ecosystem of hardware, software and services that enable service providers to launch software-defined wide area network (WAN) services for enterprises. It provides high quality WAN performance, reliability and security in various ways.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Q.3741	2019-07-29	11	11.1002/1000/13978

Keywords

SD-WAN, signalling requirements.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Signalling requirements for SD-WAN service

1 Scope

The Recommendation includes:

– general description of software-defined wide area networking (SD-WAN) service launched by service providers;

– signalling architecture of SD-WAN service;

– information flow of interface SFi between SD-WAN controller and customer-premises equipment (CPE)/virtualized customer premises equipment (vCPE)/wide area network (WAN) gateway;

– signalling requirements of interface SFi.

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.

None.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 software-defined networking [b-ITU-T Y.3300]: A set of techniques that enables to directly program, orchestrate, control and manage network resources, which facilitates the design, delivery and operation of network services in a dynamic and scalable manner.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 SD-WAN: An ecosystem of hardware (including customer-premises equipment, such as edge devices), software (including controllers) and services that enable enterprise-grade performance, reliability and security of WAN services in various software-defined manners.

3.2.2 WAN gateway: A gateway that provides WAN access for individuals and enterprises.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADSL Asymmetric Digital Subscriber Line

CPE Customer-Premises Equipment

IPFPM IP Flow-Performance Monitor

LTE	Long Term Evolution
MOS	Mean Opinion Score
MPLS	Multiprotocol Label Switching
NQA	Network Quality Analyser
SDN	Software-Defined Networking
SD-WAN	Software-Defined Wide Area Networking
TWAMP	Two-Way Active Measurement Protocol
VPN	Virtual Private Network
vCPE	Virtualized Customer Premises Equipment
WAN	Wide Area Network

5 Convention

None.

6 General description of SD-WAN service

Enterprise WAN has become increasingly complex and is costly to be managed and maintained. Service providers are facing difficulties in meeting enterprises' requirements. Some of these difficulties are listed below:

– significant delays and cost in remote site deployment;

– heterogeneous network access results in complicated configuration, monitoring and management for virtual private network (VPN), multicast and link bundling;

– inefficient WAN bandwidth utilization for enterprises.

SD-WAN service can be launched by service providers using software-defined networking (SDN) technologies and can satisfy the following key capabilities:

– automated provisioning of services;

– creating scalable and redundant networks;

– dynamic multi-path optimization;

– automatic monitoring and capacity testing;

– application steering and link remediation.

Figure 6-1 presents the framework of the SD-WAN service launched by service providers.

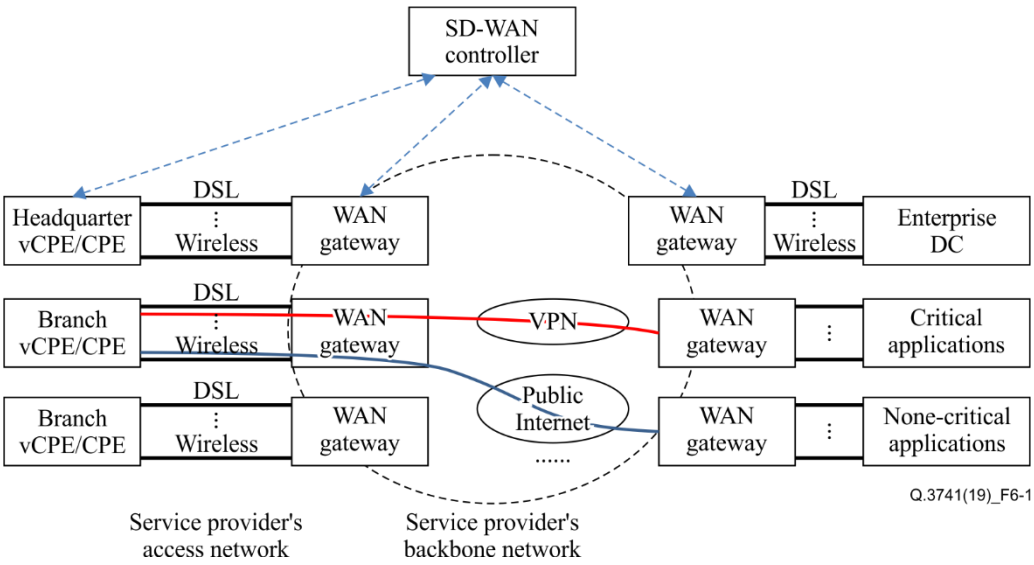

Figure 6-1 – Framework of SD-WAN service

As shown in Figure 6-1, a service provider uses an SD-WAN controller dynamically to configure and manage all branch office WAN connections for an enterprise. A service provider's SD-WAN controller can monitor entire network traffic and choose appropriate connections for a specific enterprise. In an access network, a service provider can choose any network access technology, for example, asymmetric digital subscriber line (ADSL) [b- IETF RFC 2662] or wireless access technologies, to connect to the backbone-network. In a backbone-network, a service provider can choose a VPN [b-RFC 4346] to optimize bandwidth usage at a low cost. For example, in some scenarios (blue line), the SD-WAN controller chooses wireless technology and public Internet service which have a lower cost for non-critical applications. While in other scenarios (red line), when CPE/vCPE visits the enterprise data centre, the SD-WAN controller can choose ADSL and multiprotocol label switching (MPLS) channels for the purpose of security.

7 Signalling architecture of SD-WAN service

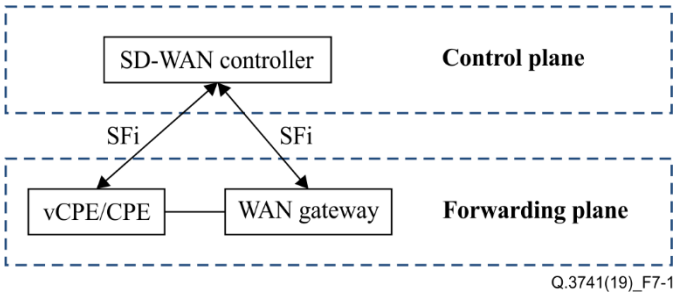

Figure 7-1 – Signalling architecture of SD-WAN service

Figure 7-1 presents the signalling architecture of the SD-WAN service. The SD-WAN controller in the control plane monitors the status of the forwarding plane, including vCPE/CPE and WAN gateway in the forwarding plane, and exchanges information with the forwarding plane to reveal the most appropriate forwarding solution based on a service provider's policy or business demands. The vCPE/CPE and WAN gateway provide an end-to-end connection for the enterprise. The interface SFi, between the SD-WAN controller and vCPE/CPE or WAN gateway, is responsible for monitoring and configuring information exchange.

8 The information flow of SFi

The SD-WAN service consists of three procedures:

1) registration,

2) statistic collection, and

3) dynamic WAN path control.

This clause provides the information flows of each procedure.

8.1 The information flow of registration and automatic installation

Figure 8-1 presents the information flow of registration and automatic installation.

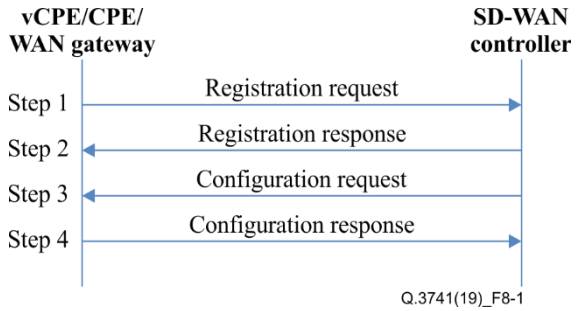

Figure 8-1 – Information flow of registration and automatic installation

Step 1: vCPE/CPE/WAN gateway registers itself to the SD-WAN controller.

Step 2: SD-WAN controller responds to the vCPE/CPE/WAN gateway's registration.

Step 3: SD-WAN controller sends configuration scripts to the vCPE/CPE/WAN gateway.

Step 4: vCPE/CPE/WAN gateway sends configuration response message to SD-WAN controller to inform the configuration results.

NOTE 1 – How the vCPE/CPE automatically discovers the controller's IP address is out of scope of this Recommendation.

NOTE 2 – How IP addresses are allocated to the vCPE/CPE/WAN gateway is out of scope of this Recommendation.

NOTE 3 – How the SD-WAN controller gets the service requirement is out of scope of this Recommendation.

NOTE 4 – The specific technologies for the SD-WAN service, such as VPN technologies used for establishing the enterprise virtual WAN network is out of scope of this Recommendation.

8.2 The information flow of statistics collection

Figure 8-2 presents the information flow of statistics collection.

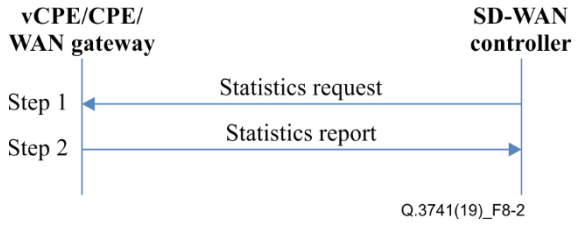

Figure 8-2 – Information flow of statistics collection

Step 1: For analysis and path control purpose, the SD-WAN controller sends the statistics request to the vCPE/CPE and WAN gateway at regular time.

Step 2: The vCPE/CPE and WAN gateway responds with related statistics report to the SD-WAN controller. The statistics include data from the application and network layers.

The data from the application layer include application type, which is by for the SD-WAN controller to differentiate different applications and application performance metrics, which is used for the SD-WAN controller to evaluate the application performance based on delay, jitter and loss of the protocol (e.g., HTTP, FTP, DNS).

The data from the network layer includes network performance data, such as packet delay, jitter and loss.

NOTE – There are lots of technologies used to collect statistics, such as IP flow-performance monitor (IPFPM) and netflow that detect and measure the applications, or two-way active measurement protocol (TWAMP) and network quality analyzer (NQA) that measures network performance. The specific technologies used to collect the statistics are out of scope of this Recommendation.

8.3 The information flow of dynamic WAN path control

Figure 8-3 presents the information flow of dynamic WAN path control.

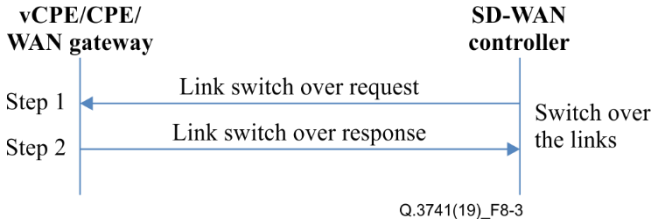

Figure 8-3 – Information flow of dynamic WAN path control

Step 1: When the SD-WAN controller detects the application or network performance degrading, it requests the vCPE/CPE/WAN gateway to change the links. For example, when a video service has bad performance, the SD-WAN controller will request the vCPE/CPE/WAN gateway to transfer the service to another link which has better network performance.

Step 2: The vCPE/CPE/WAN gateway sends the link switchover response result to the SD-WAN controller.

9 The signalling requirements of SFi

9.1 vCPE/CPE registration request and response message

The vCPE/CPE registration request message is defined as CPE-REG-RQ message.

The CPE-REG-RQ message, indicated by the message type in the message header field, is sent by the vCPE/ CPE to the SD-WAN controller to acknowledge itself.

Message format:

<CPE-REG -RQ-Message>::= < Message Header >

```
*{CPE-Management-Protocol}

{Software-Version}

{Hardware-Version}

{Mac-Address}

*{Network-Access-Technology}
```

Meanings and explanations:

1) `CPE-Management-Protocol`, uniquely specifies the available protocols installed in the vCPE/CPE in order to help the SD-WAN controller manage it, see for example [b-BBF TR069].

2) `Software-Version`, uniquely specifies the software version of the vCPE/CPE.

3) `Hardware-Version`, uniquely specifies the hardware version of the vCPE/CPE.

4) `Mac-Address`, uniquely specifies the MAC address of the vCPE/CPE to help the SD-WAN controller to identify it.

5) `Network-Access-Technology`, uniquely specifies the network access technology. There may be multiple network access technologies.

The vCPE/CPE registration response message is defined as CPE-REG-RP message.

The CPE-REG-RP message, indicated by the message type in the message header field, is sent by the SD-WAN controller to the vCPE/CPE to respond to its request.

Message format:

<CPE-REG -RP-Message>::= < Message Header >

```
{Selected-CPE-Management-Protocol}

{Device-ID}
```

Meanings and explanations:

1) `Selected-CPE-Management-Protocol`, uniquely specifies the protocols selected by the SD-WAN controller.

2) `Device-ID`: uniquely specifies the vCPE/CPE identification designated by the SD-WAN controller.

9.2 WAN gateway registration request and response message

The WAN gateway registration request message is defined as WG-REG-RQ message.

The WG-REG-RQ message, indicated by the message type in the message header field, is sent by the WAN gateway to the SD-WAN controller to acknowledge itself.

Message format:

<WG –RES-RQ-Message>::= < Message Header >

```
{WG-Management-Protocol}

{Software-Version}

{Hardware-Version}

{Mac-Address}

*{Backbone-Network-Connection-Technology}
```

Meanings and explanations:

1) `WG-Management-Protocol`, uniquely specifies the available protocols installed in the WAN gateway in order to help the SD-WAN controller to manage it.

2) `Software-Version`, uniquely specifies the software version of WAN gateway.

3) `Hardware-Version`, uniquely specifies the hardware version of WAN gateway.

4) `Mac-Address`, uniquely specifies the MAC address of the WAN gateway to help the SD-WAN controller to identify it.

5) `Backbone-Network-Connection-Technology`, uniquely specifies the backbone-network connection technology. There may be multiple backbone-network connection technologies, e.g., MPLS VPN, IPSec VPN.

The WAN gateway registration response message is defined as WG-REG-RP message.

The WG-REG-RP message, indicated by the message type in the message header field, is sent by the SD-WAN controller to the WAN gateway to respond the request.

Message format:

<WG –REG-RP-Message>::= < Message Header >

```
{Selected-WG-Management-Protocol}

{Device-ID}
```

Meanings and explanations:

1) `Selected-WG-Management-Protocol`, uniquely specifies the protocols selected by the SD-WAN controller.

2) `Device-ID`: uniquely specifies the WAN gateway identification designated by the SD-WAN controller.

9.3 vCPE/CPE configuration request and response message

The vCPE/CPE configuration message is defined as CPE-CG message.

The CPE-CG message, indicated by the message type in the message header field, is sent by the SD-WAN controller to the vCPE/CPE to transfer the configuration script.

Message format:

<CPE-CG-Message>::= < Message Header >

```
  * {SD-WAN-Service-Type-ID}

{Software-Version}

{Reboot}

{Factory-Reset}

{Upload-Download-Action}

{Application-Layer-Performance-Detection}

{Network-Layer-Performance-Detection}
```

Meanings and explanations:

1) `SD-WAN-Service-Type-ID`, uniquely indicates the type of SD-WAN service. There may be multiple SD-WAN service types.

   NOTE 1 – The number of SD-WAN service type IDs is equal to the number of network access technologies times the number of backbone connection technologies.

   NOTE 2 – The first SD-WAN service type ID is chosen to be used by default, when the SD-WAN service is established.

2) `Software-Version`, uniquely specifies the target software version for installation.

3) `Reboot`, uniquely specifies whether the reboot action is requested.

4) `Factory-Reset`, uniquely specifies the factory reset action requested by the SD-WAN controller.

5) `Upload-Download-Action`, uniquely specify the upload/download actions which aim to download the software with a specific version from the SD-WAN controller, and upload the real-time running information to the SD-WAN controller.

6) `Application-Layer-Performance-Detection`, uniquely specify the tool name and its version, which will be installed in the vCPE/CPE for application layer performance detection, such as IPFPM and netflow, and the related parameters, such as mean opinion score (MOS) value and HTTP response time.

7) `Network-Layer-Performance-Detection`, uniquely specify the tool name and its version, which will be installed in the vCPE/CPE for network layer performance detection, and the related parameters, such as TWAMP and NQA, and the related parameters, such as jitter, delay and loss.

The vCPE/CPE configuration response message is defined as CPE-CGR message.

The CPE-CGR message, indicated by the message type in the message header field, is sent by the vCPE/ CPE to SD-WAN controller to transfer the configuration response message.

Message format:

<CPE-CGR-Message>::= < Message Header >

```
{Device-ID-configuration-result}

 * {SD-WAN-Service-Type-ID-configuration-result}

{Software-Version-configuration-result}

{Reboot-configuration-result}

{Factory-Reset-configuration-result}

{Upload-Download-Action-configuration-result}

{Application-Layer-Performance-Detection-configuration-result}

{Network-Layer-Performance-Detection-configuration-result}

   }
```

Meanings and explanations:

1) `Device-ID-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.

2) `SD-WAN-Service-Type-ID-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.

3) `Software-Version-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.

4) `Reboot-configuration-result`, if reboot is configured, equals `TRUE`, if not, equals `FALSE`.

5) `Factory-Reset-configuration-result`, if Factory-Reset is configured, equals `TRUE`, if not, equals `FALSE`.

6) `Upload-Download-Action-configuration-result`, if Upload-Download-Action is configured, equals `TRUE`, if not, equals `FALSE`.

7) `Application-Layer-Performance-Detection-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.

8) `Network-Layer-Performance-Detection-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.

9.4 WAN gateway configuration request and response message

The WAN gateway configuration message is defined as WG-CG message.

The WG-CG message, indicated by the message type in the message header field, is sent by the SD-WAN controller to the WAN gateway to transfer the configuration script.

Message format:

<WG-CG-Message>::= < Message Header >

```
* {SD-WAN-Service-Type-ID}
{Software-Version}
{Reboot}
{Factory-Reset}
{Upload-Download-Action}
{Application-Layer-Performance-Detection}
{Network-Layer-Performance-Detection}
```

Meanings and explanations:

1) `SD-WAN-Service-Type-ID`, uniquely indicates the type ID of the SD-WAN service. There may be multiple SD-WAN service type IDs.

NOTE 1 – The number of SD-WAN service type IDs is equal to the number of network access technologies times the number of backbone connection technologies.

NOTE 2 – The first SD-WAN service type ID is chosen to be used by default, when the SD-WAN service is established.

2) `Software-Version`, uniquely specifies the target software version for installation.

3) `Reboot`, uniquely specifies whether a reboot action is requested.

4) `Factory-Reset`, uniquely specifies the factory reset action requested by the SD-WAN controller.

5) `Upload-Download-Action`, uniquely specify the upload/download actions which aim to download the software with a specific version from the SD-WAN controller, and upload the real-time running information to the SD-WAN controller.

6) `Application-Layer-Performance-Detection`, uniquely specify the tools, which will be installed in the WAN gateway for application-layer performance detection, such as IPFPM and netflow, and related parameters, such as MOS value and HTTP response time.

7) `Network-Layer-Performance-Detection`, uniquely specify the tools, which will be installed in the WAN gateway for network-layer performance detection, and related parameters, such as TWAMP and NQA, and related parameters, such as jitter, delay and loss.

The WAN gateway configuration response message is defined as WG-CGR message.

The WG-CGR message, indicated by the message type in the message header field, is sent by the WAN gateway to SD-WAN controller to transfer the configuration response message.

Message format:

< WG-CGR -Message>::= < Message Header >

```
{Device-ID-Configuration-result}

 * {SD-WAN-Service-Type-ID-configuration-result}

{Software-Version-configuration-result}

{Reboot-configuration-result}

{Factory-Reset-configuration-result}

{Upload-Download-Action-configuration-result}

{Application-Layer-Performance-Detection-configuration-result}

{Network-Layer-Performance-Detection-configuration-result}

   }
```

Meanings and explanations:

1) `Device-ID-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.
2) `SD-WAN-Service-Type-ID-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.
3) `Software-Version-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.
4) `Reboot-configuration-result`, if reboot is configured, it equals `TRUE`, if not, equals `FALSE`.
5) `Factory-Reset-configuration-result`, if Factory-Reset is configured, it equals `TRUE`, if not, equals `FALSE`.
6) `Upload-Download-Action-configuration-result`, if Upload-Download-Action is configured, it equals `TRUE`, if not, equals `FALSE`.
7) `Application-Layer-Performance-Detection-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.
8) `Network-Layer-Performance-Detection-configuration-result`, if successfully configured, equals `TRUE`, if not, equals `FALSE`.

9.5 Statistic collection message and response message

The statistic request message is defined as ST-RQ message.

The ST-RQ message, indicated by the message type in the message header field, is sent by the SD-WAN controller to the CPE/vCPE/WAN gateway to collect their real-time running information.

Message format:

<ST-RQ-Message>::= < Message Header >

```
{SD-WAN-Service-Type-ID}
```

Meanings and explanations:

1) `SD-WAN-Service-Type-ID`, uniquely indicates the type ID of the SD-WAN service.

The statistic response message is defined as ST-RP message.

The ST-RP message, indicated by the message type in the message header field, is sent by the CPE/vCPE/WAN gateway to the SD-WAN controller to notify their real-time running information.

Message format:

<ST-RP-Message>::= < Message Header >

`{Delay}`

`{Jitter}`

`{Loss}`

`{MOS-value}`

`{Http-response-time}`

Meanings and explanations:

1) `Delay`, uniquely specifies the packet delay.
2) `Jitter`, uniquely specifies the packet jitter.
3) `Loss`, uniquely specifies the packet loss.
4) `MOS-value`, uniquely specifies the mean opinion score of video service.
5) `Http-response-time`, uniquely specifies the http response time for certain website.

9.6 Dynamic SD-WAN path control for vCPE /CPE request message and response message

The SD-WAN path change for vCPE/ CPE request configuration message is defined as CPE-Path-RQ message.

The CPE-Path-RQ message, indicated by the message type in the message header field, is sent by the SD-WAN controller to the vCPE /CPE to switch over the SD-WAN service type.

Message format:

<CPE-Path-RQ -Message>::= < Message Header >

`{SD-WAN-Service-type-ID}`

Meanings and explanations:

1) `SD-WAN-Service-Type-ID`, uniquely indicates the target type ID of the SD-WAN service.

The SD-WAN path change for the vCPE/ CPE response configuration message is defined as CPE-Path-RP message.

The CPE-Path-RP message, indicated by the message type in the message header field, is sent by the CPE/vCPE to the SD-WAN controller.

Message format:

<CPE-Path-RP -Message>::= < Message Header >

{`SD-WAN-Path-Change-Result`}

Meanings and explanations:

1) `SD-WAN-Path-Change-Result`, uniquely indicates the result of the SD-WAN path change. If the SD-WAN path is changed successfully, `SD-WAN-Path-Change-Result` is `TRUE`, if not, `SD-WAN-Path-Change-Result` is `FALSE`

9.7 Dynamic SD-WAN path control for WAN gateway request message and response message

The SD-WAN path change for the WAN gateway request configuration message is defined as WG-Path-RQ message.

The WG-Path-RQ message, indicated by the message type in the message header field, is sent by the SD-WAN controller to the WAN gateway to switch over the SD-WAN service instance.

Message format:

<WG-Path-RQ -Message>::= < Message Header >

{`SD-WAN-Service-Type-ID`}

Meanings and explanations:

1) `SD-WAN-Service-Type-ID`, uniquely indicates the target type ID of SD-WAN service.

The SD-WAN path change for the WAN gateway response configuration message is defined as WG-Path-RP message.

The WG-Path-RP message, indicated by the message type in the message header field, is sent by the WAN gateway to the SD-WAN controller.

Message format:

<WG-Path-RP-Message>::= < Message Header >

{`SD-WAN-Path-Change-Result`}

Meanings and explanations:

1) `SD-WAN-Path-Change-Result`, uniquely indicates the result of the SD-WAN path change. If `SD-WAN-Path-Change-Result` is `FALSE`.

Bibliography

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