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

Signalling requirements and protocols for SDN – Resource
control protocols

**Signalling requirements for automatic
management of IP address pools by
software-defined networking technologies on a
broadband network gateway**

Recommendation ITU-T Q.3717

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Recommendation ITU-T Q.3717

Signalling requirements for automatic management of IP address pools by software-defined networking technologies on a broadband network gateway

Summary

Recommendation ITU-T Q.3717 describes the signalling requirements for the implementation of automatic management and efficient utilization of IP address resources using software-defined networking technologies on broadband network gateways. The signalling is used to automatically implement the allocation, monitoring and reclaiming of IP address resources.

History

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Automatic management, IP address pool, software-defined networking.

* 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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Recommendation ITU-T Q.3717

Signalling requirements for automatic management of IP address pools by software-defined networking technologies on a broadband network gateway

1 Scope

This Recommendation describes the signalling requirements for the implementation of automatic management and efficient utilization of IP address resources using software-defined networking technologies on broadband network gateways.

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 Y.3300] Recommendation ITU-T Y.3300 (2014), *Framework of software-defined networking*.
- [ITU-T Y.3302] Recommendation ITU-T Y.3302 (2017), *Functional architecture of software-defined networking*.
- [ITU-T Q.3315] Recommendation ITU-T Q.3315 (2015), *Signalling requirements for flexible network service combination on broadband network gateway*.

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API	Application Programming Interface
BNG	Broadband Network Gateway
CGN	Carrier-Grade NAT
DNS	Domain Name System
DS-Lite	Dual Stack Lite
IP	Internet Protocol
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6

NAT	Network Address Translation
NFV	Network Function Virtualization
SDN	Software Defined Networking
vBNG	Virtualized Broadband Network Gateway
vNAT	Virtualized Network Address Translation

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The keyword "should" indicates a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

The keyword "may" indicates an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option, and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

6 Introduction of automatic management of IP address resources

As networks evolve towards software-defined networking/network function virtualization (SDN/NFV) enabled networks, intensive operations and resource pooling to improve resource use efficiency is the development trend of networks. It requires intensive resource management capabilities to manage network resources, such as IP address resources, session resources and forwarding resources. SDN/NFV technologies provide an effective means for intensive resource management. This Recommendation uses the intensive management of IP addresses resource as an example to describe the implementation.

Generally, operators will face the following problems when they manage IP address resources in current networks:

- Manually configuring IP address resources of network devices, such as a broadband network gateway / virtualized broadband network gateway (BNG/vBNG), is complicated and it has high maintenance costs. Moreover the IP address usage rate is low.
- For physical or virtual network functional units (e.g., carrier-grade NAT (CGN), Ds-Lite, etc.), insufficient sharing of IP addresses and port resources will lead to wasted resources.

A method for the automatic management of IP address resources based on SDN/NFV technologies is proposed to solve the problems. In this method, an IP address resource management application interacts with the SDN controller to allocate and reclaim IP addresses. Using this method has the following advantages:

- The centralized management of IPv4/IPv6 addresses enables automatic request, allocation, and reclaim of IPv4/IPv6 address resources, replacing the traditional manual configuration method, and improves IP address resources utilization.
- It enables IP address resources to be centrally controlled and highly shared on the physical interfaces, virtual interfaces and tunnel interfaces.
- Real-time dynamic adjustment and intelligent allocation of IP addresses through open programmable interfaces (APIs) is possible.

The automatic management of IP address resources is based on a centralized control mode, which facilitates centralized/unified control and sharing, and helps achieve the efficient utilization IP address resources among the BNG/vBNG devices. Moreover, differentiated requirements also can be satisfied through open application programming interfaces (APIs).

7 Architecture of automatic management of IP address resources

7.1 General architecture

The architecture of the automatic management of IP address resources, which is required to be kept aligned with the framework of a software-defined networking model defined in [ITU-T Y.3300], consists of three parts: an app for automatic management of IP address resources, SDN controller and forwarding devices. This is shown in Figure 7-1.

Based on this architecture, unified IP address resource management can be implemented on the physical network elements interfaces, virtual network element interfaces and tunnel interfaces (such as tunnels for IPv4/IPv6 transition). In addition, this architecture implements the automatic management of IP address resources by a separate application, rather than adding a module to the SDN controller, which simplifies the complexity of the SDN controller.

1) App for automatic management of IP address resources

The app for the automatic management of IP address resources implements a unified configuration of the IP address resource pool and performs the main decision functions, e.g., IP address resource allocation and reclaiming. At the same time, it supports the query of the use status of the IP address resources, including current use status, historical use status and the usage log of the IP address resources, etc.

2) SDN controller

The SDN controller obtains the usage status of the IP address resources from the forwarding devices through the southbound interface, and then reports it to the app of automatic management of IP address resources through the northbound interface. Moreover, the SDN controller requests or reclaims an IP address block from the app, and supports the configuring of network devices.

3) Device

The device (e.g., BNG/CGN) supports the notification of the current IP address usage status and assigns an IP address from the configured IP address pool to the user terminal.

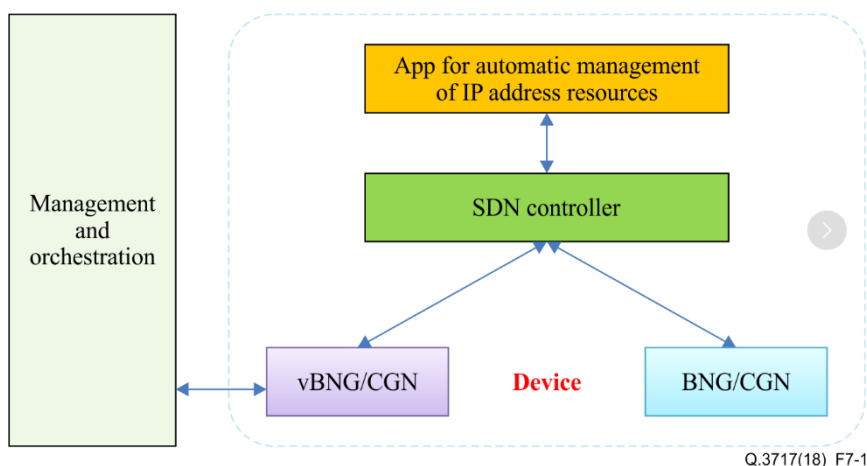


Figure 7-1 – Architecture of automatic management of IP address resources

7.2 Functional entities

Figure 7-2 depicts the functional entities and interfaces of the architecture of automatic management of IP address resources.

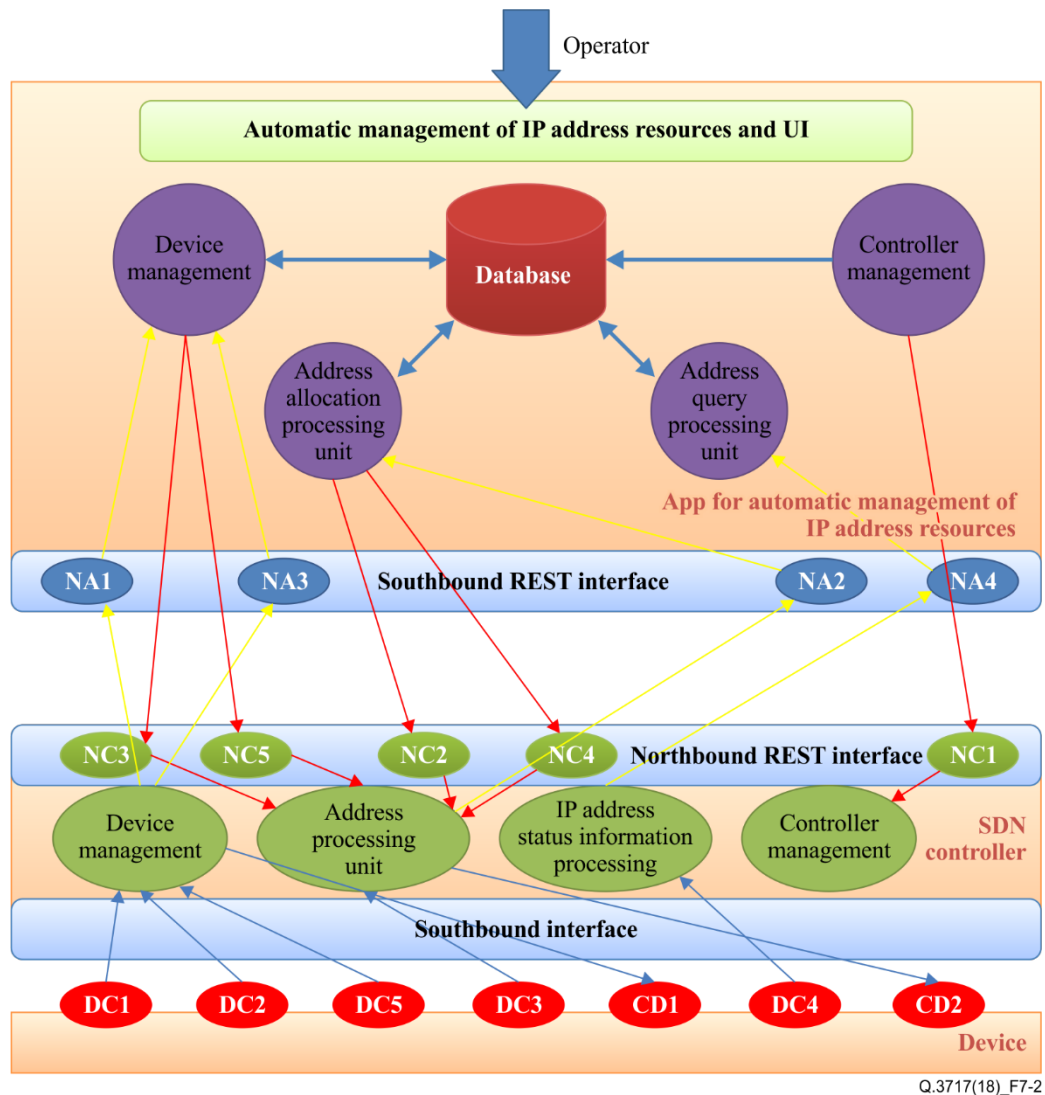


Figure 7-2 – Functional entities and interface of the architecture of automatic management of IP address resources

7.2.1 Functional entities of app for automatic management of IP address resources

- Device management
This functional entity receives the online registration message, offline notification message, and heartbeat protection message of the device reported by the SDN controller, thereby maintaining the state of the associated devices.
- Address allocation processing unit
This functional entity is used to allocate or reclaim an IP address block to the device, and then receive an execution result from the device.
- Address query processing unit
This functional entity is used to query the IP address block usage status of the device, receive the query result and then update the usage status.

- Controller management
This functional entity is used to configure and manage the SDN controller, make the SDN controller support the automatic management of the IP address resources.
- 7.2.2 Functional entities of the SDN controller used to process IP address resources**
- Device management
This function implements online registration, offline notification, heartbeat protection of the device and maintains the state of associated devices.
- Address processing unit
This functional entity is used to receive the IP address block information allocated or reclaimed by the app for the automatic management of IP address resources and processing it.
- IP address status information processing
This functional entity is used to receive the message of the app for automatic management of IP address resources, query the IP address block usage status of the device and return the query result to the app.
- Controller management
This functional entity is used to receive the management and configuration parameters for the controller from the app.

7.2.3 Interface message

This clause describes the interface message shown in Figure 7-2.

- Northbound interface message of the SDN controller
The northbound interface supports the delivery of various operation commands from the app to the SDN controller and the reporting of the IP address usage status in the device to the app.
- Southbound interface message of the SDN controller
The southbound interface connects the devices of different manufacturers and implements the allocation, reclaim and status query of the IP address block.

8 Signalling requirements of the automatic management of IP address resources

8.1 Northbound interface message of the controller

8.1.1 Controller configuration message

The controller configuration message, which is numbered NC1, sent from the app to the SDN controller is used to configure the controller id and devices which are managed by the SDN controller.

Input parameters of the controller configuration message are described in Table 8-1.

Table 8-1 – Input parameters of the controller configuration message

Parameter name	Type	Optional	Meanings and explanations
controller_id	Int	N	The unique identifier of the SDN controller
device_list	List<Device>	N	A list of devices managed by the SDN controller

Table 8-1 – Input parameters of the controller configuration message

Parameter name	Type	Optional	Meanings and explanations
device_keep_alive_interval	Int	N	Heartbeat interval of the device status required by the SDN controller
ipv4_address_pool_usage_threshold	Float	N	Threshold of applied for a new IPv4 address pool
ipv6_address_pool_usage_threshold	Float	N	Threshold of applied for a new IPv6 address pool
state_update_interval	Int	N	Time interval for refreshing device status to the SDN controller
device_sampling_interval	Int	N	Time interval of sampling status of IP address pool by the device
device_id	Int	N	The unique identifier of the device assigned by the app
device_type	String	N	Device type, including vBNG, CGN, etc.
device_ip	String	N	IP address of the device
device_port	Int	N	The port number range assigned to the device used in NAT

Output parameters of the controller configuration message is one of the following options.

- Success, if the command is successfully executed;
- Failure, if the command fails to execute.

8.1.2 Request reclaim message

The request reclaim message, which is numbered NC2, sent from the app to the SDN controller is used to request the SDN controller to reclaim the specified IP address block from the specified device. The format of this message is similar to the text format of the Netconf protocol. When the value of the leasing time of the IP address block is set to 0, it should be reclaimed.

Input parameters of the request reclaim message are described in Table 8-2.

Table 8-2 – Input parameters of the request reclaim message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app
address_block__id	Int	N	The unique identifier of IP address block assigned by the app
protocol_type	Int	N	0 indicates IPv6, 1 indicates IPv4
address_block_name	String	N	The name of IP address block assigned by the app
address_pool_id	Int	N	The unique identifier of the IP address pool assigned by the app
address_pool_name	String	N	The name of the IP address pool assigned by the app

Table 8-2 – Input parameters of the request reclaim message

Parameter name	Type	Optional	Meanings and explanations
leasing_time	Int	N	The lease time of the IP address block. Note: The IP address block should be reclaimed when leasing time set to 0

Output parameters of the request reclaim message is one of the following options:

- Success, if the specified IP address block from the specified device is successfully reclaimed;
- Failure, if the specified IP address block from the specified device is failed to reclaim.

8.1.3 Send heartbeat message

The send heartbeat message, which is numbered NC3, sent from the app to the SDN controller is used to request the device's online status. This message may simultaneously confirm the online status of the SDN controller and devices which are managed by the SDN controller.

The input parameter of the send heartbeat message is described in Table 8-3.

Table 8-3 – Input parameter of the send heartbeat message

Parameter name	Type	Optional	Meanings and explanations
controller_id	Int	N	The unique identifier of the SDN controller

Output parameters of the send heartbeat message is described in the following Table 8-4.

Table 8-4 – Output parameters of the send heartbeat message

Parameter name	Type	Optional	Meanings and explanations
controller_id	Int	N	The unique identifier of the SDN controller
device_list	List<Device>	N	A list of devices managed by the SDN controller
device_id	Int	N	The unique identifier of the device assigned by the app
Is_alive	String	N	Indicates whether the device is online

8.1.4 Manual allocation message

The manual allocation message, which is numbered NC4, sent from the app to the SDN controller is used to manually add a specific IP address block to a specified IP address pool in the specified device.

Input parameters of the manual allocation message are described in Table 8-5.

Table 8-5 – Input parameters of the manual allocation message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app
device_type	String	N	Device type, including vBNG, CGN, etc.
device_ip	String	N	IP address of the device
device_port	Int	N	The port number range assigned to the device used in t NAT
address_block_id	Int	N	The unique identifier of IP address block assigned by the app
protocol_type	Int	N	0 indicates Ipv6, 1 indicates IPv4
address_block_name	String	N	The name of IP address block assigned by the app
address_pool_id	Int	N	The unique identifier of the IP address pool assigned by the app
address_pool_name	String	N	The name of the address pool assigned by the app
domain_name	String	N	Domain name
ip_prefix	String	N	Represents a prefix of IPv4 address or IPv6 address
ip_prefix_length	Int	N	The length of IP address prefix
usergateway	String	N	IP address of the user gateway
gwnetmask	Int	N	The mask length of IP address of the user gateway
dns_server_list	String	N	Include at least one of primary domain name system (DNS) and secondary DNS
leasing_time	Int	N	The lease time of the IP address block. Note: The default recommended value is 3days.

Output parameters of the manual allocation message is one of the following options:

- Success, if the command is successfully executed;
- Failure, if the command fails to execute.

8.1.5 Manual offline message

The manual offline message, which is numbered NC5, sent from the app to the SDN controller is used to take the specified device offline. After receiving the command, the SDN controller delivers it to the device, and then the device should kick the online users offline and delete the configuration related to the IP address pool. The device responds the command execution result to the SDN controller, and the SDN controller delivers the result to the app.

The input parameter of the manual offline message is described in Table 8-6.

Table 8-6 – Input parameter of the manual offline message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app.

Output parameters of the manual offline message is one of the following options:

- Success, if the command is successfully executed;
- Failure, if the command fails to execute.

8.1.6 Report a new device message

The report a new device message, which is numbered NA1, sent from the SDN controller to the app is used to inform the app when a new device is registered to the SDN controller.

The input parameter of the report a new device message is described in Table 8-7.

Table 8-7 – Input parameter of the report a new device message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app

Output parameters of report a new device message is one of the following options:

- Success, if the command is successfully executed;
- Failure, if the command fails to execute.

8.1.7 Report status message

The report status message, which is numbered NA2, sent from the SDN controller to the app is used to report the IP address pool status to the app when the SDN controller receives it from the device.

Input parameters of the report status message are described in Table 8-8.

Table 8-8 – Input parameters of the report status message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app
time	Double	N	The time of the SDN controller report status to the app
address_pool	List<Address_Pool>	N	List of all IP address pools
address_pool_id	Int	N	The unique identifier of the IP address pool assigned by the app
address_pool_name	String	N	The name of the address pool assigned by the app
protocol_type	Int	N	0 indicates IPv6, 1 indicates IPv4
address_pool_ranges	List<Address_pool_range>	N	List of all IP address blocks in an IP address pool
address_block_id	Int	N	The unique identifier of the IP address block
address_block_name	String	N	The name of the IP address block
average_address_usage_ratio	Float	N	An IP address block usage rate in a period of time

Output parameters of the report status message is one of the following options:

- Success, if the command is successfully executed. Moreover, the app will be triggered to allocate an IP address block to the device if the average IP address usage ratio is more than

a threshold. Otherwise, the app will be triggered to reclaim an IP address block from the device if the parameter is less than a threshold.

- Failure, if the command fails to execute.

8.1.8 Report offline message

The report offline message, which is numbered NA3, sent from the SDN controller to the app is used to report the device offline status when the SDN controller receives an offline message from the device or the SDN controller detects the device offline status by heartbeat message.

Input parameters of the report offline message are described in Table 8-9.

Table 8-9 – Input parameters of the report offline message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app
offline_reason	String	N	Description of the device offline reason

Output parameters of the report offline message is one of the following options:

- Success, if the command is successfully executed;
- Failure, if the command fails to execute.

8.1.9 Report result message

The report result message, which is numbered NA4, sent from the SDN controller to the app is used to report the processing result for a single address block.

Input parameters of the report result message are described in Table 8-10.

Table 8-10 – Input parameters of the report result message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app
device_ip	String	N	IP address of the device
domain_name	String	N	Domain name
time	Double	N	The time of the SDN controller report result to the app
address_pool_id	Int	N	The unique identifier of the IP address pool assigned by the app
address_pool_name	String	N	The name of the IP address pool assigned by the app
protocol_type	Int	N	0 indicates IPv6, 1 indicates IPv4
address_block_id	Int	N	The unique identifier of IP address block
address_block_name	String	N	The name of IP address block
ip_prefix	String	N	Represents a prefix of IPv4 address or IPv6 address
ip_prefix_length	Int	N	The length of IP address prefix
result	Int	N	0 means allocate successfully

Table 8-10 – Input parameters of the report result message

Parameter name	Type	Optional	Meanings and explanations
			1 means reclaim successfully 2 means failed to allocate 3 means failed to reclaim.

Output parameters of the report result message is one of the following options:

- Success, if the command is successfully executed;
- Failure, if the command fails to execute.

8.2 Southbound interface message of the controller

The design of the southbound interface in this section uses the Netconf protocol. Taking the YANG model implementation as an example, other southbound interface protocols, such as radius and openflow, can be easily adapted to the related parameters. The device serves as the server side of the Netconf protocol and the SDN controller serves as the client side of Netconf protocol.

8.2.1 Register message

The register message, which is numbered DC1, sent from the device to the SDN controller is used to register and report the initial parameters of the device to the SDN controller.

The input parameter of the register message is described in the following Table 8-11.

Table 8-11 – Input parameter of the register message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app

Output parameters of the register message is one of the following options:

- Success, if the command is successfully executed;
- Failure, if the command fails to execute.

8.2.2 Report state message

The report state message, which is numbered DC2, sent from the device to the SDN controller is used to report the device state. The device may report its state in one of the following cases:

- app active inquiry;
- the local IP address pool reaches the usage threshold and the device actively applies for a new IP address block;
- the local address block reaches the reclamation threshold and the device actively applies for reclaiming the IP address block;
- the device periodically reports the state;
- the device report state after first successful registration.

Input parameters of the report state message are described in Table 8-12.

Table 8-12 – Input parameters of the report state message

Parameter name	Type	Optional	Meanings and explanations
time	Double	N	The time of the device report state to the SDN controller
domain_name	String	N	Domain name
device_id	Int	N	The unique identifier of the device assigned by the app
address_pool_name	String	N	The name of the IP address pool assigned by the app
address_pool_id	Int	N	The unique identifier of the IP address pool assigned by the app
ipv4_address_block_name	String	N	The name of ipv4 address block
ipv4_address_block_id	Int	N	The unique identifier of ipv4 address block
ipv6_address_block_name	String	N	The name of ipv6 address block
ipv6_address_block_id	Int	N	The unique identifier of ipv6 address block
average_address_usage_ratio	Float	N	An IP address block usage rate in a period of time

Output parameters of the report state message is one of the following options:

- Option 1
- The SDN controller allocate a new IP address block to the device, either IPv4 address block or IPv6 address block.
 - 1) Parameters of an IPv4 address block are described in Table 8-13.

Table 8-13 – Parameters of an IPv4 address block

Parameter name	Type	Optional	Meanings and explanations
time	Double	N	The time of the SDN controller allocating a new IPv4 address block
domain_name	String	N	Domain name
device_id	Int	N	The unique identifier of the device assigned by the app
address_pool_name	String	N	The name of the IPv4 address pool assigned by the app
address_pool_id	Int	N	The unique identifier of the IPv4 address pool assigned by the app
IPv4_address_block_id	Int	N	The unique identifier of IPv4 address block
IPv4_address_block_name	String	N	The name of ipv4 address block
IPv4_ip_prefix	String	N	Represents a prefix of IPv4 address
IPv4_prefix_length	Int	N	The length of IPv4 address prefix
usergateway	String	N	IP address of the user gateway

Table 8-13 – Parameters of an IPv4 address block

Parameter name	Type	Optional	Meanings and explanations
gwnetmask	Int	N	The mask length of IP address of the user gateway
dns_list	String	N	Include at least one of primary DNS and secondary DNS
leasing_time	Int	N	The lease time of the IP address block. Note: The default recommended value is 3days.

2) Parameters of an IPv6 address block are described in Table 8-14.

Table 8-14 – Parameters of an IPv6 address block

Parameter name	Type	Optional	Meanings and explanations
time	Double	N	The time of the SDN controller allocating a new IPv6 address block
domain_name	String	N	Domain name
device_id	Int	N	The unique identifier of the device assigned by the app
address_pool_name	String	N	The name of the IPv6 address pool assigned by the app
address_pool_id	Int	N	The unique identifier of the IPv6 address pool assigned by the app
IPv6_address_block_id	Int	N	The unique identifier of IPv6 address block
IPv6_address_block_name	String	N	The name of ipv6 address block
IPv6_ip_prefix	String	N	Represents a prefix of IPv6 address
IPv6_prefix_length	Int	N	The length of IPv6 address prefix
usergateway	String	N	IP address of the user gateway
gwnetmask	Int	N	The mask length of IP address of the user gateway
dns_list	String	N	Include at least one of primary DNS and secondary DNS
leasing_time	Int	N	The lease time of the IP address block. Note: The default recommended value is 3days.

- Option 2
- The SDN controller requires the device to reclaim the IP address block; input parameters are described in Table 8-15.

Table 8-15 – Input parameters of the SDN controller requiring the device to reclaim the IP address block

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app
address_pool_name	String	N	The name of the IP address pool assigned by the app
address_pool_id	Int	N	The unique identifier of the IP address pool assigned by the app
IPv4_address_block_id	Int	N	The unique identifier of IPv4 address block
IPv4_address_block_name	String	N	The name of ipv4 address block
IPv6_address_block_id	Int	N	The unique identifier of IPv6 address block
IPv6_address_block_name	String	N	The name of ipv6 address block
leasing_time	Int	N	The lease time of the IP address block. Note: The default recommended value is 3days.

- Option 3: Status report is successful, IP address allocation or reclaim has not been triggered.
- Option 4: Status report is failed, IP address allocation or reclaim has not been triggered.

8.2.3 Report acquiring IP address message

The report acquiring IP address message, which is numbered DC3, sent from the device to the SDN controller is used to report the information of acquiring the IP address block. The message is divided into two sub-messages: 1) The device reports the configuration confirmation message to the SDN controller when the configuration module completes the configuration and stores the configuration command or file in the database. 2) The device sends a service processing confirmation message to the SDN controller when the service module completes the service processing (such as user routes and uplink routes are successfully advertised) of the IP address.

Input parameters of the report acquiring IP address message is described in Table 8-16.

Table 8-16 – Input parameters of the report acquiring IP address message

Parameter name	Type	Optional	Meanings and explanations
IP_address_block_allocate_ack	Int	N	0 indicates that an IP address block is successfully allocated. 1 indicates that an IP address block fails to be allocated.

Output parameter is none.

8.2.4 Report reclaiming IP address message

The report reclaiming IP address message, which is numbered DC4, sent from the device to the SDN controller is used to report the information of reclaiming the IP address block. The message is divided into two sub-messages: 1) The device reports the reclaim confirmation message to the SDN controller when the configuration module deletes the database and recycles the IP address pool. 2) The device sends a service processing confirmation message to the SDN controller when the service module

completes the service processing (such as user routes and uplink routes are withdrawn) of the IP address.

The input parameter of the report reclaiming IP address message is described Table 8-17.

Table 8-17 – Input parameter of the report reclaiming IP address message

Parameter name	Type	Optional	Meanings and explanations
IP_address_block_reclaim_ack	Int	N	0 indicates that an IP address block is successfully reclaimed. 1 indicates that an IP address block fails to be reclaimed.

Output parameter is none.

8.2.5 Report offline message

The report offline message, which is numbered DC5, sent from the device to the SDN controller is used to report the device offline state. The offline message is divided into three cases: 1) The device is active offline. 2) The SDN controller requests the device offline. 3) The device is abnormal offline. The message is used to actively report the device offline status to the SDN controller.

The input parameter of the report offline message is described in Table 8-18.

Table 8-18 – Input parameter of the report offline message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app

Output parameters of the report offline message is one of the following options:

- Success, if the command is successfully executed;
- Failure, if the command fails to execute.

8.2.6 Query state message

The query state message, which is numbered CD1, sent from the SDN controller to the device is used to query the device status information according to the app request.

Input parameters of the query state message are described in Table 8-19.

Table 8-19 – Input parameters of the query state message

Parameter name	Type	Optional	Meanings and explanations
address_pool_name	String	N	The name of the IP address pool assigned by the app
address_pool_id	Int	N	The unique identifier of the IP address pool assigned by the app
device_id	Int	N	The unique identifier of the device assigned by the app.
ipv4_address_block_name	String	N	The name of ipv4 address block

Table 8-19 – Input parameters of the query state message

Parameter name	Type	Optional	Meanings and explanations
ipv4_address_block-id	Int	N	The unique identifier of IPv4 address block
ipv6_address_block_name	String	N	The name of ipv6 address block
ipv6_address_block-id	Int	N	The unique identifier of IPv6 address block
average_address_usage_ratio	Float	N	An IP address block usage rate in a period of time

When receiving the query message, the device will report the status to the SDN controller. Output parameters of the query state message are described in Table 8-20.

Table 8-20 – Output parameters of the query state message

Parameter name	Type	Optional	Meanings and explanations
address_pool_name	String	N	The name of the IP address pool assigned by the app
address_pool_id	Int	N	The unique identifier of the IP address pool assigned by the app
device_id	Int	N	The unique identifier of the device assigned by the app.
ipv4_address_block_name	String	N	The name of ipv4 address block
ipv4_address_block-id	Int	N	The unique identifier of IPv4 address block
ipv6_address_block_name	String	N	The name of ipv6 address block
ipv6_address_block-id	Int	N	The unique identifier of IPv6 address block
average_address_usage_ratio	Float	N	An IP address block usage rate in a period of time

8.2.7 Manual offline message

The manual offline message, which is numbered CD2, sent from the SDN controller to the device is used to request the device offline. The app issues the command of requesting the device offline, and then the SDN controller receives it and deliver it to the device. When receiving the message, the device kicks the online users offline, reclaims the IP address resources and then reports the execution result to the SDN controller. At the same time, the device stops the heartbeat message.

The input parameter of the manual offline message is described in Table 8-21.

Table 8-21 – Input parameter of the manual offline message

Parameter name	Type	Optional	Meanings and explanations
device_id	Int	N	The unique identifier of the device assigned by the app

Output parameters of the manual offline message is one of the following options:

- Success, if the command is successfully executed;
- Failure, if the command fails to execute.

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