Network Working Group
Internet Draft
Intended status: Standard
Expires: May 18, 2021

L. Dunbar
Futurewei
S. Hares
Hickory Hill Consulting
R. Raszuk
Bloomberg LP
K. Majumdar
CommScope

November 18, 2020

BGP UPDATE for SDWAN Edge Discovery
draft-dunbar-idr-sdwan-edge-discovery-01

Abstract

The document describes encoding of BGP UPDATE messages for the SDWAN edge node discovery.

In the context of this document, BGP Route Reflectors (RR) is the component of the SDWAN Controller that receives the BGP UPDATE from SDWAN edges and in turns propagates the information to the intended peers that are authorized to communicate via the SDWAN overlay network.

Table of Contents

1. Introduction

[SDWAN-BGP-USAGE] illustrates how BGP is used as control plane for a SDWAN network. SDWAN network is an overlay network with some special properties.

The document describes a BGP UPDATE for SDWAN edge nodes to announce its properties to its RR which then propagates to the authorized peers.

2. Conventions used in this document

Cloud DC: Off-Premise Data Centers that usually host applications and workload owned by different organizations or tenants.

Controller: Used interchangeably with SDWAN controller to manage SDWAN overlay path creation/deletion and monitor the path conditions between sites.

CPE-Based VPN: Virtual Private Secure network formed among CPEs. This is to differentiate from most commonly used PE-based VPNs a la RFC 4364.

MP-NLRI: The MP_REACH_NLRI Path Attribute defined in RFC4760.

SDWAN End-point: can be the SDWAN edge node address, a WAN port address (logical or physical) of a SDWAN edge node, or a client port address.

OnPrem: On Premises data centers and branch offices

SDWAN: Software Defined Wide Area Network. In this document, "SDWAN" refers to the solutions of policy-driven transporting IP packets over multiple different underlay networks to get better WAN bandwidth management, visibility.and control.

SDWAN Instance: Same as SDWAN Segment

SDWAN Segmentation: Segmentation is the process of dividing the network into logical sub-networks. One SDWAN Segment is very much like a VPN except that SDWAN segment is over hybrid of underlay networks.

3. Framework of SDWAN Edge Discovery

3.1. The Objectives of SDWAN Edge Discovery

The objectives of SDWAN edge discovery is for a SDWAN edge node to discover its authorized peers to which its attached clients traffic need to communicate. The attributes to be propagated includes the SDWAN segmentations supported, the attached routes under specific SDWAN segmentations, and the properties of the underlay networks over which the client routes can be carried.

Some SDWAN peers are connected by both trusted VPNs and untrusted public networks. Some SDWAN peers are connected only by untrusted public networks. For the portion over untrusted networks, IPsec Security Associations (IPsec SA) have to be established and maintained. If an edge node has network ports behind the NAT, the NAT properties needs to be discovered by authorized SDWAN peers.

Just like any VPN networks, the attached client's routes belonging to specific SDWAN segmentations can only be exchanged to the SDWAN peer nodes that are authorized to communicate.

3.2. Basic Schemes

As described in [SDWAN-BGP-USAGE], two separate BGP UPDATE messages are used for SDWAN Edge Discovery:

- UPDATE U1 for the attached client routes,
  This UPDATEs is for a SDWAN node to advertise the attached client routes to remote peers. This UPDATE will continue using the existing BGP AFI/SAFI for IP or VPN. Detailed underlay tunnel specification can be recursively resolved by using the Recursive Next Hop Resolution as specified by the section 8 of [Tunnel-Encap].

  A new Tunnel Type (SDWAN-Hybrid) needs to be added, to be used by Encapsulation Extended Community or the Tunnel-Encap Path Attribute [Tunnel-encap] to indicate mixed underlay networks.

- UPDATE U2, advertised by the Next hop address of the UPDATE U1 to propagate the properties tunnels terminated at the edge node.
  This UPDATE is for an edge node to advertise the properties of directly attached underlay networks, including the underlay network ISP information, NAT information, pre-configured IPsec SA identifiers. Also can include the detailed IPsec SA attributes, such as keys, nonce, encryption algorithms, etc.

  This UPDATE U2 is for peers to discover remote node's underlay network properties.

In the following figure: there are four types underlay paths between C-PE1 and C-PE2:

a) MPLS-in-GRE path;

b) node-based IPsec tunnel [2.2.2.2<->1.1.1.1].

c) port-based IPsec tunnel [192.0.0.1 <-> 192.10.0.10]; and

d) port-based IPsec tunnel [172.0.0.1 <-> 160.0.0.1];

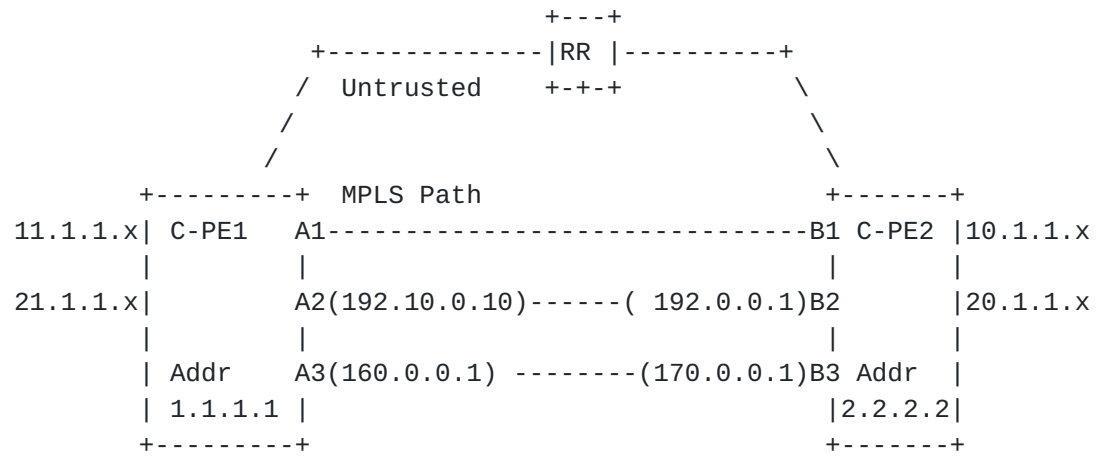


Figure 1: Hybrid SDWAN

C-PE2 uses UPDATE U1 to advertise the attached client routes:

UDPATE U1:

Extended community: RT for SDWAN Segmentation 1
NLRI: AFI=? & SAFI = 1/1
Prefix: 10.1.1.x; 20.1.1.x
NextHop: 2.2.2.2 (C-PE2)
Encapsulation Extended Community: tunnel-type=SDWAN-hybrid
Color Extended Community: RED

The UPDATE U1 is recursively resolved to the UPDATE U2 which specifies the detailed hybrid WAN underlay Tunnels terminated at the C-PE2:

UPDATE U2:

NLRI: SAFI = SDWAN
(With Color RED encoded in the NLRI Site-Property field)
Prefix: 2.2.2.2
Tunnel encapsulation Path Attribute [type=SDWAN-Hybrid]
IPSec SA for 192.0.0.1
Tunnel-End-Point Sub-TLV [Section 3.1 of Tunnel-encap]
IPsec SA sub-TLV [See the Section 5]

```
          Tunnel encapsulation Path Attribute [type=SDWAN-Hybrid]
            IPSec SA for 170.0.0.1
            Tunnel-End-Point Sub-TLV /*the address*/
            IPsec SA sub-TLV

          Tunnel Encap Attr MPLS-in-GRE [type=SDWAN-Hybrid]
            Sub-TLV for MPLS-in-GRE [Section 3.2.6 of Tunnel-encap]
```

Note: [Tunnel-Encap] Section 11 specifies that each Tunnel Encap Attribute can only have one Tunnel-End-Point sub-TLV. Therefore, two separate Tunnel Encap Attributes are needed to indicate that the client routes can be carried by either one.

3.3. Edge Node Discovery

The basic scheme of SDWAN Edge node discovery using BGP consists of:

- Upon powering up, a SDWAN edge node establish a secure tunnel (such as TLS, SSL) with the SDWAN central controller whose address is preconfigured on the edge node. The central controller will inform the edge node of its local RR. The edge node will establish a transport layer secure session with the RR (such as TLS, SSL).

- The Edge node will advertise its own properties to its designated RR via the secure transport layer tunnel. This is different from traditional BGP, where each node sends its properties (BGP UPDATE) to its neighbors, which in turn propagate to all the nodes in the network.

- The RR propagates the received information to the authorized peers.

- The authorized peers can establish the secure data channels (IPsec) and exchange more information among each other.

For a SDWAN deployment with multiple RRs, it is assumed that there are secure connections among those RRs. How secure connections being established among those RRs is the out of the scope of the current draft. The existing BGP UPDATE propagation mechanisms control the edge properties propagation among the RRs.

For some special environment where the communication to RR are highly secured, [SDN-IPsec] IKE-less can be deployed to simplify IPsec SA establishment among edge nodes.

4. BGP UPDATE to Support SDWAN Segmentation

One SDWAN network can be divided to multiple segmentations. Each SDWAN edge node may need to support multiple SDWAN segments. One client's traffic may need to be mapped to different SDWAN segmentations based on client's policy. Therefore, we need encoding to differentiate SDWAN segments. For example, in the picture below, the "Payment-Flow" (payment applications) can only be propagated to "Payment-GW". Other flows can be propagated to all other nodes. This is very similar to VPNs. But need to differentiate from traditional MPLS VPNs because a SDWAN edge may also support traditional MPLS VPNs.
[Note: SDWAN Segment ID is configured the same way as VRF, or EVI as in EVPN. For node with both MPLS and IPsec ports, the label for MPLS can be used for SDWAN Segment ID]

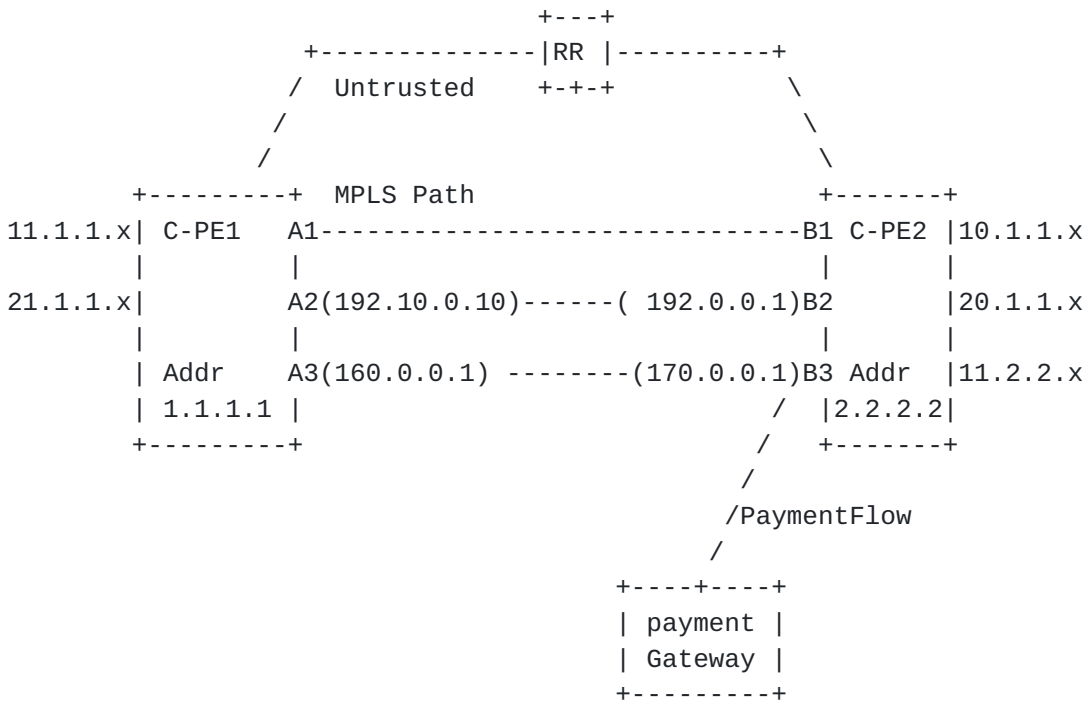


Figure 2: SDWAN Segmentation

4.1. Constrained Propagation of Edge Capability

BGP has built-in mechanism to dynamically achieve the constrained distribution of edge information. RFC4684 describes the BGP RT constrained distribution. In a nutshell, a SDWAN edge sends RT Constraint (RTC) NLRI to the RR for the RR to install an outbound route filter, as shown in the figure below:

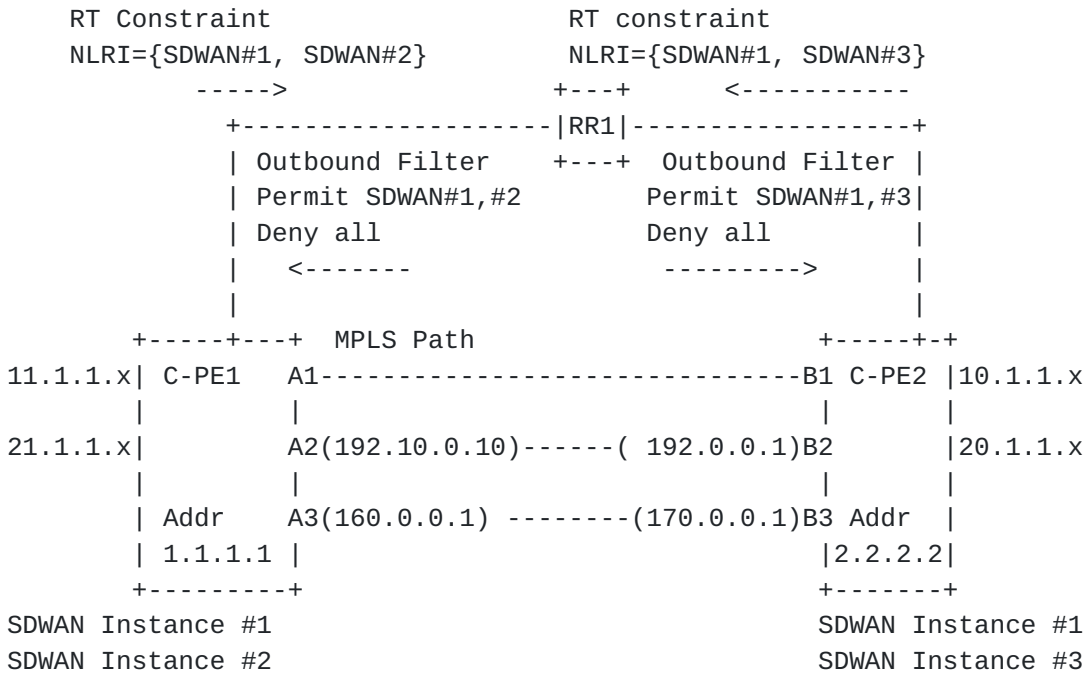


Figure 3: Constraint propagation of Edge Property

However, as SDWAN overlay network span across untrusted networks, RR can't trust the RT Constraint (RTC) NLRI BGP UPDATE from any nodes. Polices must be configured on RR to filter out unauthorized nodes to be registered as interested in certain SDWAN segments. RR can only process the RTC NLRI from authorized peers for a SDWAN segment.

It is out of the scope of this document on how RR is configured with the policies to filter out unauthorized nodes for specific SDWAN segments.

When the RR receives BGP UPDATE from an edge node, it propagates the received UPDATE message to the nodes that are in the Outbound Route filter for the specific SDWAN segment.

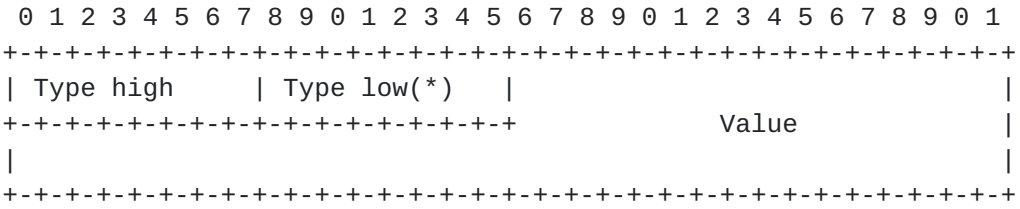
4.2. SDWAN Segmentation for Control Plane

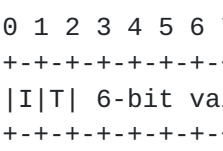
SDWAN Instances is represented by the SDWAN Target ID in the BGP Extended Community.

Same as Route Target for VPN, a different Type is used to differentiate SDWAN segments from MPLS VPN instances. This is especially useful when a CPE supports both MPLS VPN and SDWAN Segmentation (instances).

Encoding:

RFC4360: Extended Community for SDWAN Route Target





The high-order octet of the Type Field
T bit =0 (transitive) when SDWAN edge sends to its RR which then propagates to remote peers based on outbound filters.

RFC4760 states that Route Target community is transitive
For SDWAN, an edge receiving the SDWAN Update shouldn't forward it to other nodes.
T bit =1 (non-transitive) when RR propagates the UPDATE to SDWAN EDGE

[IANA Consideration:

Following the encoding scheme specified by RFC7153, need IANA to assign the following values for the "Type High" Octet:
- Transitive (when edge announce the advertisement to its RR): Ox0A, which is the number after 0x08 for Flow Spec Redirect.
- Non Transitive (when RR send to remote edges): Ox4A

Request a new value of the low- order octet of the Type field for this community (different from the VPN Route Target 0x02)?
]

4.3. SDWAN Segment Identifier in Data Plane

From data plane perspective, packets from different SDWAN network instances (or segmentations) need to have their corresponding SDWAN instance identifier encoded in the header.

For a SDWAN edge node which can be reached by both MPLS and IPsec path, the client packets reached by MPLS network will be encoded with the MPLS Labels based on the scheme specified by RFC8277.

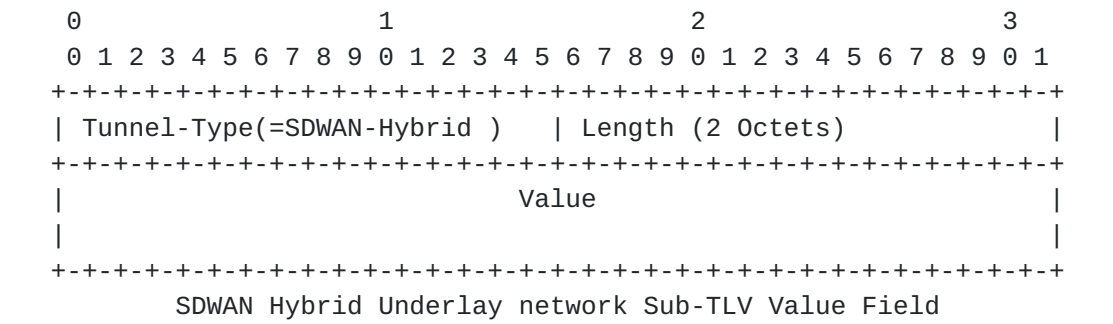
For GRE Encapsulation within IPsec tunnel, the GRE key field can be used to carry the SDWAN Instance ID. For NVO (VxLAN, GENEVE, etc.) encapsulation within the IPsec tunnel, Virtual Network Identifier (VNI) field is used to carry the SDWAN Instance ID.

[Note: the SDWAN Instance ID is same as EVI in EVPN, or VNI if VxLAN is used].

5. Hybrid Underlay

5.1. SDWAN-Hybrid Tunnel Encoding

A new Tunnel-Type=SDWAN-Hybrid (code point to be assigned by IANA)is introduced to indicate hybrid underlay networks.



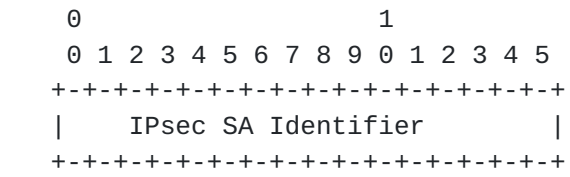
SDWAN Hybrid Underlay network Sub-TLV Value Field

Since IPsec SA has a lot of attributes, such as public keys, nonce, encryption algorithms etc., the IPsec Tunnel Identifier [ID] can be used in the SDWAN-Hybrid Value field instead of listing all IPsec SA attributes. Using IPsec Tunnel ID can greatly reduce the size of BGP UPDATE messages. Another added benefit of using IPsec Tunnel ID is that the IPsec SA attributes, or rekeying process can be advertised independently.

There are two Sub-TLVs to represent the IPsec IDs under the SDWAN-Hybrid tunnel type: IPsec-SA-ID and IPsec-SA-Group.

Editor's note: The IPSEC-SA-Group was designed to provide better scaling for multiple IPsec SA terminated at one endpoint. One end point can have multiple IPsec SAs, one SA can encrypt client data to CPE1 and another one for CPE2.

IPsec-SA-ID Sub-TLV

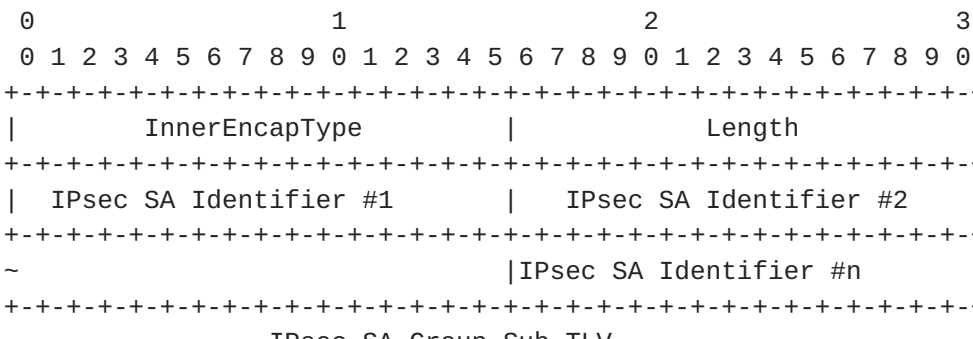


The IPsec SA identifier (2 Octet) is for cross reference the IPsec SA attributes being pre-configured or advertised by another UPDATE [Section 7].

If the client traffic needs to be encapsulated in a specific type within the IPsec ESP Tunnel, such as GRE or VxLAN, etc., the corresponding Tunnel-Encap Sub-TLV needs to be appended right after the IPsec-SA-ID Sub-TLV.

Editor Note: 4 octets can be considered as well for IPsec-SA-ID.

IPsec-SA-Group Sub-TLV:



IPsec-SA-Group Sub-TLV

IPsec-SA-Group Sub-TLV is for the scenario that multiple IPsec SAs have the same inner encapsulation. Multiple IPsec SA IDs are included in the IPsec-ID-Group Sub-TLV. If different inner encapsulation is desired within IPsec tunnels, then multiple IPsec-SA-Group Sub-TLVs can be included within one Tunnel Encap Path Attribute.

InnerEncapType (2 octet) indicates the encapsulation type for the payload within the IPsec ESP Tunnel. The Inner Encap Type value will take the value specified by the IANA Consideration Section (12.5) of [Tunnel-Encap]:

- types 8 (VXLAN), 9 (NVGRE), 11 (MPLS-in-GRE), and 12 (VXLAN-GPE) in the "BGP Tunnel Encapsulation Tunnel Types" registry.
- types 1 (L2TPv3), 2 (GRE), and 7 (IP in IP) in the "BGP Tunnel Encapsulation Tunnel Types" registry.

For each of the Tunnel Types specified, the detailed encapsulation value field as specified by Section 3.2 of [Tunnel-Encap] is appended right after the IPsec Sub-TLV.

The Tunnel Ending Point Sub-TLV specified by the Section 3.1 of [Tunnel-Encap] has to be attached to identify the IPsec Tunnel terminating address.
There can be multiple IPsec tunnels terminating at one WAN port or at one node, e.g. one tunnel for going to destination "A", another one for going to destination "B". Use SDWAN for retail industry as an example, it is necessary for all shops at any location to only

exchange Payment System traffic with the Payment Gateway, while other traffic can be exchanged with any nodes.
Therefore, there could be multiple IPsec Sub-TLVs bound with one Tunnel Ending Point Sub-TLV.

However, it is quite common in SDWAN deployment that all IPsec attributes from one node or one port are the same for all destinations. In that case, IPsec SA ID is set to 0 and the terminating address can be used to cross reference the IPsec SA attributes which are advertised by the Underlay Network Property advertisement UPDATE.

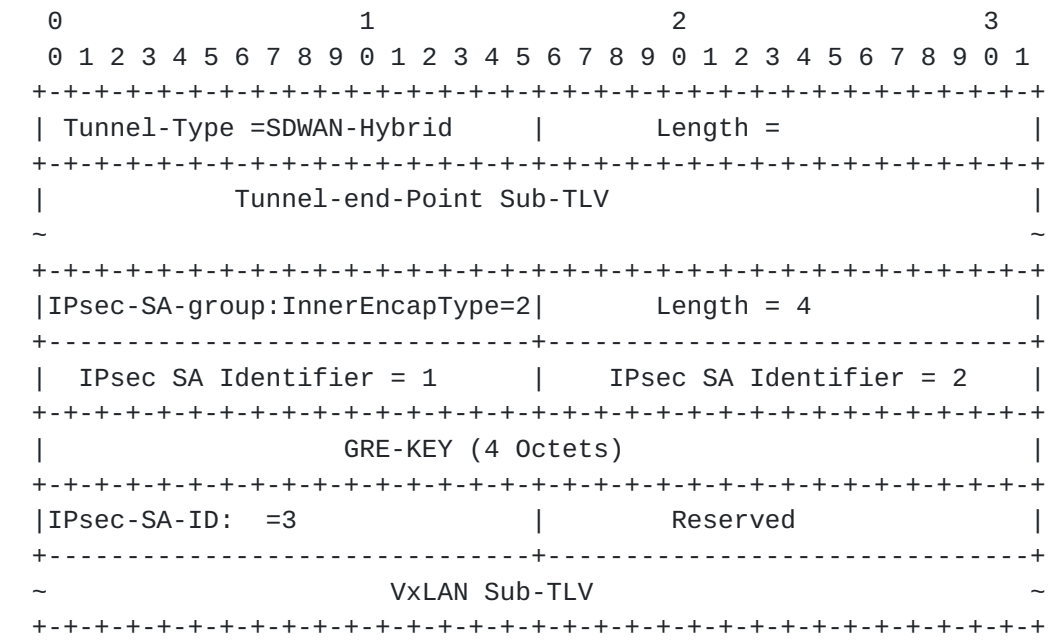
5.2. Encoding Example

5.2.1. Multiple IPsec SAs Sharing One Tunnel End Point

The encoding example is for the following scenario:

- there are three IPsec SAs terminating at the same WAN Port address (or the same node address)
- Two of the IPsec SAs use GRE (value =2) as Inner Encapsulation within the IPsec Tunnel
- One of the IPsec SA uses VxLAN (value = 8) as the Inner Encapsulation within its IPsec Tunnel.

Here is the encoding for the scenario:



The Length of the Tunnel-Type = SDDWAN-Hybrid is the sum of the following:

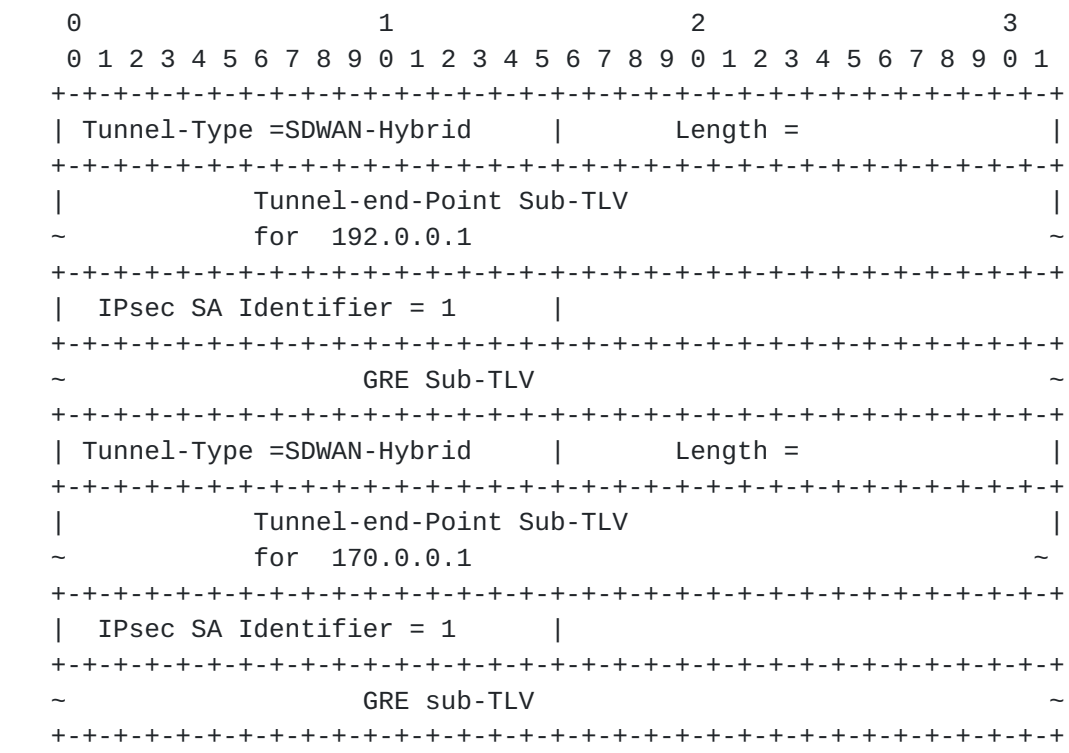
- Tunnel-end-point sub-TLV total length
- the IPsec-SA-Group Sub-TLV length + 4 (the two octets for InnerEncapType + the two octets for the Length field)
- GRE-Key Length (4)
- The IPsec-SA-ID Sub-TLV length: 4
- The VxLAN sub-TLV total length

5.2.2. Multiple IPsec SAs with different Tunnel End Points

If IPsec SAs are terminating at different addresses, then multiple Tunnel Encap Attributes have to be included.

The encoding example for the Figure 1:

- there is one IPsec SA terminating at the WAN Port address 192.0.0.1; and another IPsec SA terminating at WAN Port 170.0.0.1;
- Both IPsec SAs use GRE (value =2) as Inner Encapsulation within the IPsec Tunnel



6. Hybrid Underlay Detailed Attributes

6.1. SDWAN NLRI for Underlay Network Properties

For the MPLS VPN, the underlay network is controlled by the VPN service provider, therefore, there is no need for nodes to advertise any underlay properties to remote peers.

For the untrusted underlay network to which a SDWAN edge is connected, many attributes need to be advertised to remote nodes, such as:

- ISP information of the underlay network,
- NAT property
- the geolocation of the SDWAN edge
- IPsec SA attributes, such as public keys, nonce, supported encryption algorithms, etc.
- the IPsec tunnel termination address

A new SDWAN NLRI is specified within the MP_REACH_NLRI Path Attribute of RFC4760, with SAFI=SDWAN (code = 74):

```
+------------------+
|   NLRI Length    | 1 octet
+------------------+
|   Site-Type      | 1 Octet
+------------------+
|   Port-Local-ID  | 4 octets
+------------------+
|  SDWAN-Color     | 4 octets
+------------------+
|  SDWAN-Node-ID   | 4 or 16 octets
+------------------+
```

where:

- NLRI Length: 1 octet of length expressed in bits as defined in [RFC4760].
- Site Type: 1 octet value. The SDWAN Site Type defines the different types of Site IDs to be used in the deployment. The draft defines the following types:
  Site-Type = 1: For simple deployment, such as all edge nodes under one SDWAN management system, a simple identifier is enough for the SDWAN management to map the site to its precise geolocation.
  Site-Type = 2: to indicate that the value in the site-ID is locally significant, therefore, need a Geo-Loc Sub-TLV to fully describe the accurate location of the node. This is for large SDWAN heterogeneous deployment where Site IDs has to be described by proper Geo-location of the Edge Nodes [LISP-GEOLoc].
- Port local ID: SDWAN edge node Port identifier, which can be locally significant. The detailed properties about the network connected to the port are further encoded in the Tunnel Path Attribute. If the SDWAN NLRI applies to multiple ports, this field is NULL.
- SDWAN-Color: is used to correlate with the Color-Extended-community included in the client routes UPDATE. It can also represent some common properties shared by a set of SDWAN edge

nodes, such as the property of a specific geographic location shared by a group of SDWAN edge nodes.
- SDWAN Edge Node ID: a routable address (IPv4 or IPv6) within the WAN to reach this node or port.

[Editor's note on using SDWAN SAFI for the underlay network property advertisement:
SDWAN SAFI [IANA assigned =74] is used instead of IP SAFI in the MP-NLRI [RFC4760] Path Attribute to advertise the underlay network properties to emphasize that the address in the NLRI is NOT client addresses.
If the same IP SAFI used, receiver needs to add extra logic to differentiate regular BGP MP-NLRI client routes advertisement from the SDWAN underlay network properties advertisement. The benefit of using the same IP SAFI is that the UPDATE can traverse existing routers without being dropped. Since the SDWAN underlay network UPDATE is only between SDWAN edge and its corresponding RR, there won't be any intermediated routers. Therefore, this benefit becomes not applicable.
]

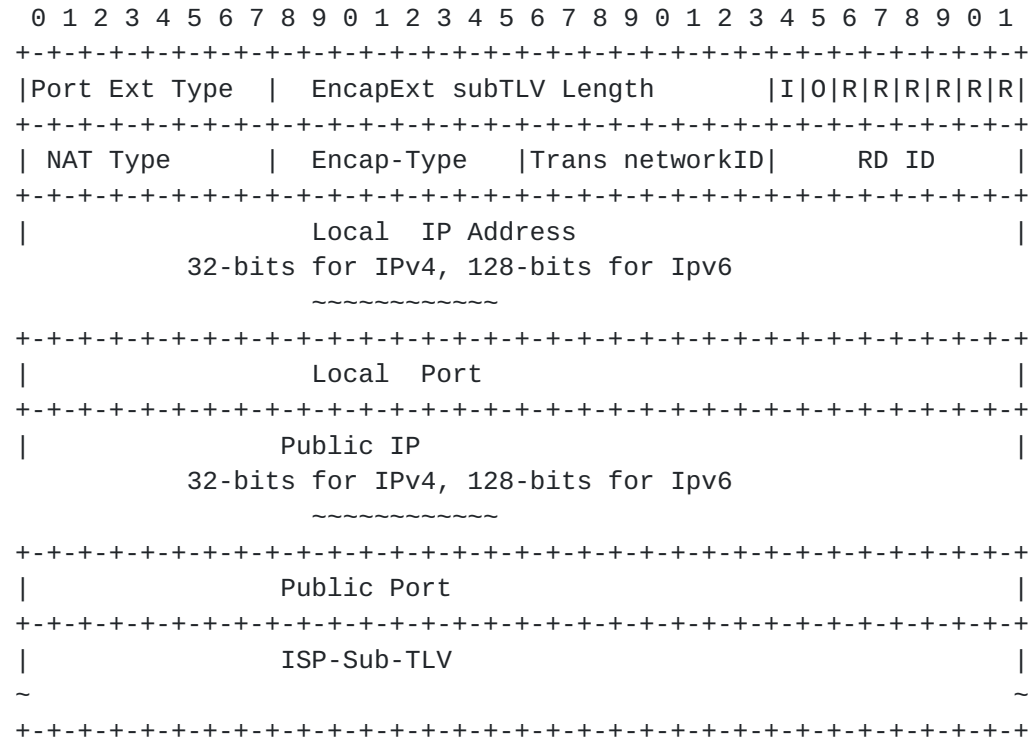
6.2. Extended Port Sub-TLV

When a SDWAN edge node is connected to an underlay network via a port behind NAT devices, traditional IPsec uses IKE for NAT negotiation. The location of a NAT device can be such that:
- Only the initiator is behind a NAT device. Multiple initiators can be behind separate NAT devices. Initiators can also connect to the responder through multiple NAT devices.
- Only the responder is behind a NAT device.
- Both the initiator and the responder are behind a NAT device.

The initiator's address and/or responder's address can be dynamically assigned by an ISP or when their connection crosses a dynamic NAT device that allocates addresses from a dynamic address pool.

Because one SDWAN edge can connect to multiple peers via one underlay network, the pair-wise NAT exchange as IPsec's IKE is not efficient. In BGP Controlled SDWAN, NAT information of a WAN port is advertised to its RR in the BGP UPDATE message. It is encoded as an Extended sub-TLV that describes the NAT property if the port is behind a NAT device.

A SDWAN edge node can inquire STUN (Session Traversal of UDP Through Network Address Translation RFC 3489) Server to get the NAT property, the public IP address and the Public Port number to pass to peers.



Where:

- Port Ext Type: indicate it is the Port Ext SubTLV.
- PortExt subTLV Length: the length of the subTLV.
- Flags:
  - I bit (CPE port address or Inner address scheme)

If set to 0, indicate the inner (private) address is IPv4.
If set to 1, it indicates the inner address is IPv6.

- O bit (Outer address scheme):
If set to 0, indicate the public (outer) address is IPv4.
If set to 1, it indicates the public (outer) address is IPv6.

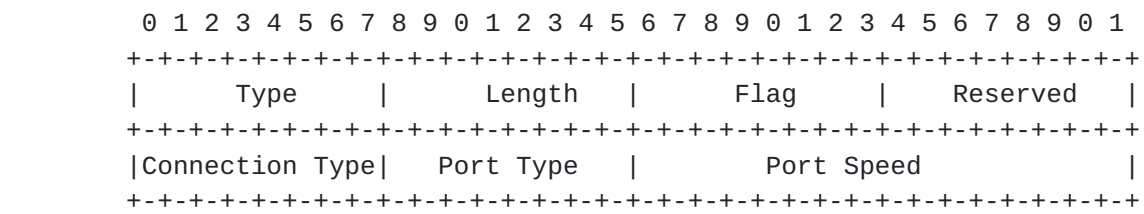
- R bits: reserved for future use. Must be set to 0 now.

o NAT Type.without NAT; 1:1 static NAT; Full Cone; Restricted Cone; Port Restricted Cone; Symmetric; or Unknown (i.e. no response from the STUN server).
o Encap Type.the supported encapsulation types for the port facing public network, such as IPsec+GRE, IPsec+VxLAN, IPsec without GRE, GRE (when packets don't need encryption)
o Transport Network ID.Central Controller assign a global unique ID to each transport network.
o RD ID.Routing Domain ID.need to be global unique.
o Local IP.The local (or private) IP address of the port.
o Local Port.used by Remote SDWAN edge node for establishing IPsec to this specific port.
o Public IP.The IP address after the NAT. If NAT is not used, this field is set to NULL.
o Public Port.The Port after the NAT. If NAT is not used, this field is set to NULL.

6.3. ISP of the Underlay network Sub-TLV

The purpose of the Underlay network Sub-TLV is to carry the ISP WAN port properties with SDWAN SAFI NLRI. It would be treated as optional Sub-TLV. The BGP originator decides whether to include this Sub-TLV along with the SDWAN NLRI. If this Sub-TLV is present, it would be processed by the BGP receiver and to determine what local policies to apply for the remote end point of the Underlay tunnel.

The format of this Sub-TLV is as follows:



Where:

Type: To be assigned by IANA

Length: 6 bytes.

Flag: a 1 octet value.

Reserved: 1 octet of reserved bits. It SHOULD be set to zero on transmission and MUST be ignored on receipt.

Connection Type: There are two different types of WAN Connectivity. They are listed below as:

Wired - 1
WIFI - 2
LTE - 3
5G - 4

Port Type: There are different types of ports. They are listed Below as:

Ethernet - 1
Fiber Cable - 2
Coax Cable - 3
Cellular - 4

Port Speed: The port seed is defined as 2 octet value. The values are defined as Gigabit speed.

7. IPsec Security Association Property Sub-TLVs

7.1. Controller Facilitated IPsec Tunnels for SDWAN Networks

IPsec is a common technique used to encrypt traffic traversing untrusted networks. IPSec operation between two peer nodes need to perform Internet Key Exchange (IKEv2), which can be broken down into the following steps:

- IKE_SA_INIT exchanges: This pair of messages negotiate cryptographic algorithms, exchange nonces, and do a Diffie-Hellman exchange.

- IKE_AUTH: this pair of messages authenticate the previous messages, exchange identities and certificates, and establish the first Child SA. Based on the authentication used: Pre-Shared Key, RSA certificates or EAP the number of messages exchanged in IKE_AUTH can grow.

- CREATE_CHILD_SA - This is simply used to create additional CHILD-SAs as needed

- INFORMATIONAL- During an IKEv2 SA lifetime, peers may desire to exchange some control messages related to errors or have notifications of certain events. This function is accomplished by INFORMATIONAL exchange.

In SDWAN environment, each SDWAN edge node might need to establish IPsec tunnels to multiple peers, and there can be multiple IPsec tunnels for different client traffic between any two peers. In addition, SDWAN edge nodes can be far apart. Upon powering up, a SDWAN edge might not know their authorized communication peers and might not have the policies configured for aligning traffic with their specific IPsec Tunnels. Therefore, the IPsec operation in SDWAN environment are usually facilitated by its SDWAN Controller.

[SDN-IPsec] describes two different mechanisms to achieve controller facilitated IPsec configuration: IKE case vs. IKE-less case. Under the IKE case, the Controller is in charge of provisioning the required information to IKE, the Security Policy Database (SPD) and the Security Association Database (PAD). The SDWAN peers exchange the Internet Key Exchange (IKE) protocol and manage SPD and SAD. Under the IKE-less case, the Controller will provide the required parameters to create valid entries in the SPD and the SAD into the edge nodes. Therefore, the edge node will only need to

implementation IPsec encryption while automated key management functionality is moved to the Controller.

For BGP controlled SDWAN networks, since there is already a secure management tunnel established between RR and the edge nodes, all the negotiations exchanged in IKEv2 can be carried by BGP UPDATE messages to/from the Route Reflector (RR). RR will propagate the information to the intended destinations. More importantly, when an edge node needs to establish multiple IPsec tunnels to many different SDWAN edge nodes, all the management information can be multiplexed into the secure management tunnel between RR and the edge node. Therefore, there is reduced amount of work on authentication in processing in BGP Controlled SDWAN networks.

Editor's Note:

RFC7296 specifies the IPsec SA attributes exchange among two peers to establish peer-wise IPsec SA. [Controller-IKE] specifies the structure for a controller to facilitate the exchange of the RFC7296 specified IPsec SA attributes among many nodes.

[CONTROLLER-IKE] specifies the Device Information Message (DIM) for the edge node to advertise to its controller, which includes DH public number, nonce, peer identity, an indication whether this is the initial distributed policy, and rekey counter. The originating edge node distributes the DH public value along with the other values in the DIM (using IPsec Tunnel TLV in Tunnel Encapsulation Attribute) to other remote C-PEs via the RR. Each receiving C-PE uses this DH public number and the corresponding nonce in creation of IPsec SA pair to the originating C-PE - i.e., an outbound SA and an inbound SA. The detail procedures are described in section 5.2 of [CONTROLLER-IKE].

[SECURE-VPN] proposes the BGP UPDATE Sub-TLV structure to carry the information specified by [Controller-IKE] to be propagated among peers via BGP.

To expedite the standardization process, this draft aligns with the IPsec Sub-TLVs described in the Section 6.1, 6.2 and 6.3 of [SECURE-EVPN], with some optimization.

For scalability reason, this draft advertises the IPSec SA related attributes at a different pace than client routes UPDATEs. Client Routes UPDATE only references the identifier for the prior established IPsec SAs.

The optimized IPsec SA attributes are represented by a set of Sub-TLVs:

- IPsec SA Nonce Sub-TLV
- IPsec SA Public Key Sub- TLV
- IPsec SA Proposal Sub-TLV: to indicate the number of Transform Sub-TLVs
  - o Transforms Substructure Sub-TLV

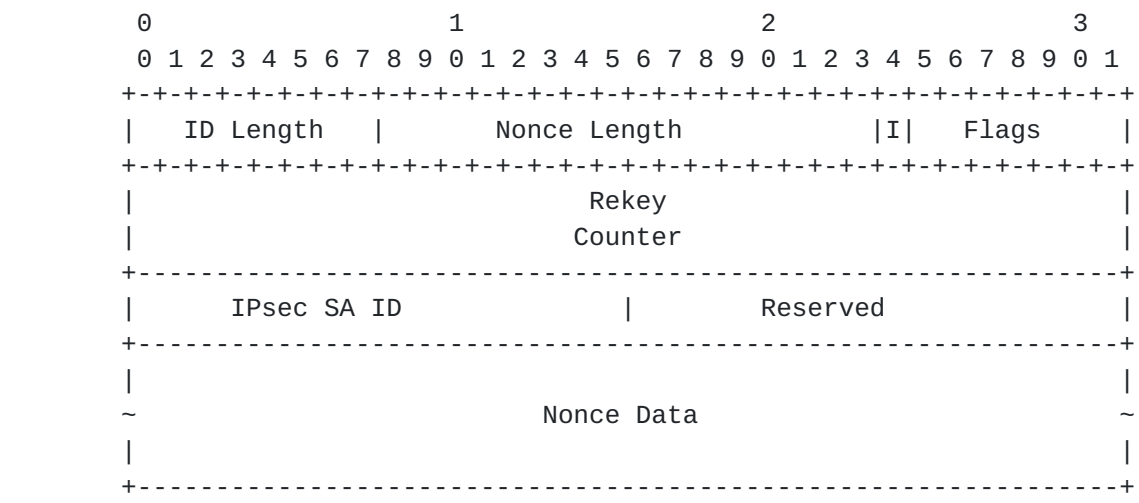
For BGP controlled SDWAN network, very often an edge node doesn't know its peer identity. Then the peer identity field can be null.

7.2. IPsec SA Nonce Sub-TLV

The Nonce Sub-TLV is based on the Base DIM sub-TLV as described the Section 6.1 of [SECURE-EVPN]. IPsec SA ID is added to the sub-TLV, which is to be referenced by the client route NLRI Tunnel Encap Path Attribute for the IPsec SA. The following fields are removed because:

- the Originator ID is carried by the NLRI,
- the Tenant ID is represented by the Route Target Extended Community, and
- the Subnet ID are carried by the BGP route UPDATE.

The format of this Sub-TLV is as follows:

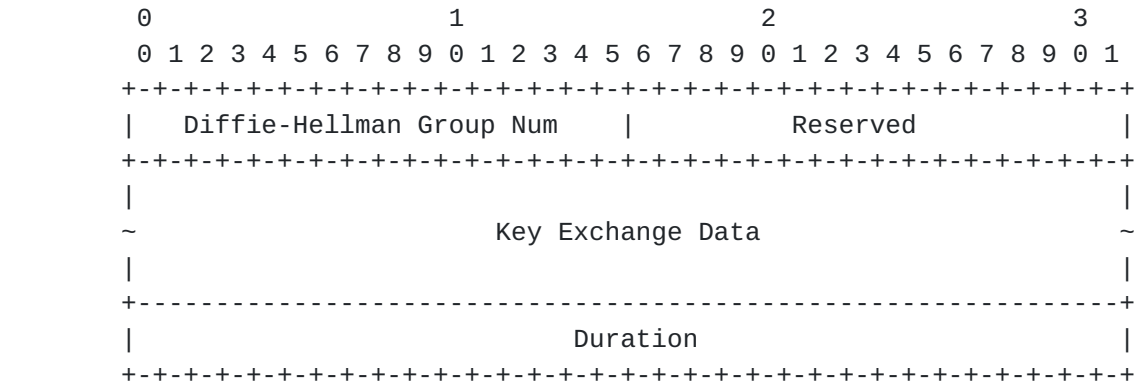


IPsec SA ID - The 2 bytes IPSec SA ID could 0 or non-zero values. It is cross referenced by client route's IPSec Tunnel Encap IPSec-SA-ID or IPSec-SA-Group Sub-TLV in Section 5. When there are multiple IPsec SAs terminated at one address, such as WAN port address or the node address, they are differentiated by the different IPsec SA IDs.

7.3. IPsec Public Key Sub-TLV

The IPsec Public Key Sub-TLV is derived from the Key Exchange Sub-TLV described in [SECURE-EVPN] with an addition of Duration filed to define the IPSec SA life span. The edge nodes would pick the shortest duration value between the SDWAN SAFI pairs.

The format of this Sub-TLV is as follows:



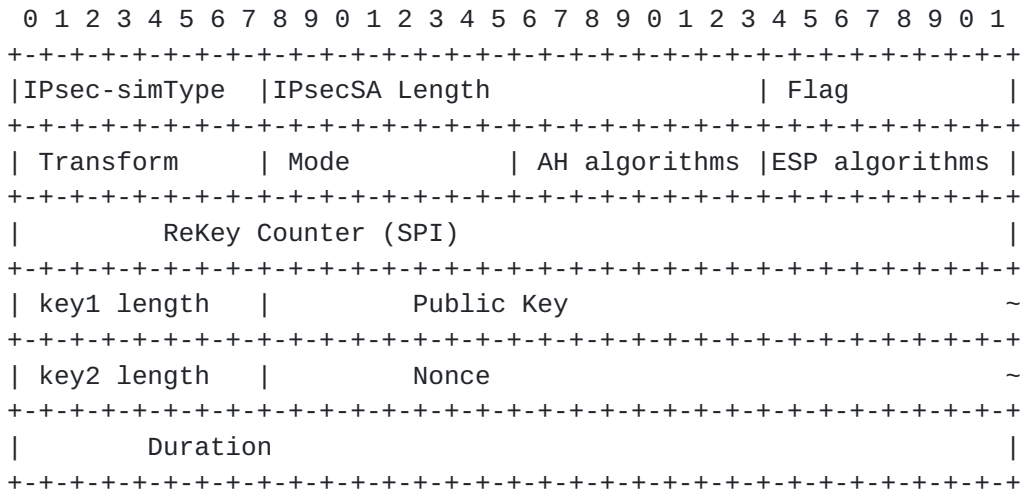
7.4. IPsec SA Proposal Sub-TLV

The IPsec SA Proposal Sub-TLV is to indicate the number of Transform Sub-TLVs. This Sub-TLV aligns with the sub-TLV structure from [SECURE-VPN]

The Transform Sub-sub-TLV will following the section 3.3.2 of RFC7296.

7.5. Simplified IPsec Security Association sub-TLV

For a simple SDWAN network with edge nodes supporting only a few pre-defined encryption algorithms, a simple IPsec sub-TLV can be used to encode the pre-defined algorithms, as below:



Where:

- IPsec-SimType: The type value has to be between 128~255 because IPsec-SA subTLV needs 2 bytes for length to carry the needed information.
- IPsec-SA subTLV Length (2 Byte): 25 (or more)
- Flags: 1 octet of flags. None are defined at this stage. Flags SHOULD be set to zero on transmission and MUST be ignored on receipt.
- Transform (1 Byte): the value can be AH, ESP, or AH+ESP.

- o IPsec Mode (1 byte): the value can be Tunnel Mode or Transport mode
- o AH algorithms (1 byte): AH authentication algorithms supported, which can be md5 | sha1 | sha2-256 | sha2-384 | sha2-512 | sm3. Each SDWAN edge node can have multiple authentication. algorithms; send to its peers to negotiate the strongest one.
- o ESP (1 byte): ESP authentication algorithms supported, which can be md5 | sha1 | sha2-256 | sha2-384 | sha2-512 | sm3. Each SDWAN edge node can have multiple authentication algorithms; send to its peers to negotiate the strongest one. Default algorithm is AES-256.
  - o When node supports multiple authentication algorithms, the initial UPDATE needs to include the "Transform Sub-TLV" described by [SECURE-EVPN] to describe all of the algorithms supported by the node.

- o Rekey Counter (Security Parameter Index)): 4 bytes
- o Public Key: IPsec public key
- o Nonce.IPsec Nonce
- o Duration: SA life span.

7.6. IPsec SA Encoding Examples

For the Figure 1 in Section 3, C-PE2 needs to advertise its IPsec SA associated attributes, such as the public keys, the nonce, the supported encryption algorithms for the IPsec tunnels terminated at 192.0.0.1, 170.1.1.1 and 2.2.2.2 respectively.

Using the IPsec Tunnel [ISP4: 160.0.0.1 <-> ISP2:170.0.0.1] as an example: C-PE1 needs to advertise the following attributes for establishing the IPsec SA:

SDWAN Node ID
SDWAN Color
Tunnel Encap Attr (Type=SDWAN-Hybrid)
Extended Port Sub-TLV for information about the Port
(including ISP Sub-TLV for information about the ISP2)
IPsec SA Nonce Sub-TLV,
IPsec SA Public Key Sub-TLV,
IPsec SA Sub-TLV for the supported transforms

```
              {Transforms Sub-TLV - Trans 2,
              Transforms Sub-TLV - Trans 3}
```

C-PE2 needs to advertise the following attributes for establishing IPsec SA:

```
  SDWAN Node ID
  SDWAN Color
  Tunnel Encap Attr (Type=SDWAN-Hybrid)
       Extended Port Sub-TLV (including ISP Sub-TLV for information
       about the ISP2)
       IPsec SA Nonce Sub-TLV,
       IPsec SA Public Key Sub-TLV,
       IPsec SA Sub-TLV for the supported transforms
            {Transforms Sub-TLV - Trans 2,
            Transforms Sub-TLV - Trans 4}
```

As both end points support Transform #2, the Transform #2 will be used for the IPsec Tunnel [ISP4: 160.0.0.1 <-> ISP2:170.0.0.1].

8. Error & Mismatch Handling

Each C-PE device advertises SDWAN SAFI Underlay NLRI to the other C-PE devices via BGP Route Reflector to establish pairwise SAs between itself and every other remote C-PEs. During the SAFI NLRI advertisement, the BGP originator would include either simple IPSec Security Association properties defined in IPSec SA Sub-TLV based on IPSec-SA-Type = 1 or full-set of IPSec Sub-TLVs including Nonce, Public Key, Proposal and number of Transform Sub-TLVs based on IPSec-SA-Type = 2.

The C-PE devices would compare the IPSec SA attributes between the local and remote WAN ports. If there is a match on the SA Attributes between the two ports, the IPSec Tunnel would be established.

The C-PE devices would not try to negotiate the base IPSec-SA parameters between the local and the remote ports in the case of simple IPSec SA exchange or the Transform sets between local and remote ports if there is a mismatch on the Transform sets in the case of full-set of IPSec SA Sub-TLVs.

As an example, using the Figure 1 in Section 3, to establish IPsec Tunnel between C-PE1 and C-PE2 WAN Ports A2 and B2 [A2: 192.10.0.10 <-> B2:192.0.0.1]:

C-PE1 needs to advertise the following attributes for establishing the IPsec SA:

```
  NH: 192.10.0.10
  SDWAN Node ID
  SDWAN-Site-ID
  Tunnel Encap Attr (Type=SDWAN)
       ISP Sub-TLV for information about the ISP3
       IPsec SA Nonce Sub-TLV,
       IPsec SA Public Key Sub-TLV,
       Proposal Sub-TLV with Num Transforms = 1
            {Transforms Sub-TLV - Trans 1}
```

C-PE2 needs to advertise the following attributes for establishing IPsec SA:

```
  NH: 192.0.0.1
  SDWAN Node ID
  SDWAN-Site-ID
  Tunnel Encap Attr (Type=SDWAN)
       ISP Sub-TLV for information about the ISP1
       IPsec SA Nonce Sub-TLV,
       IPsec SA Public Key Sub-TLV,
       Proposal Sub-TLV with Num Transforms = 1
            {Transforms Sub-TLV - Trans 2}
```

As there is no matching transform between the WAN ports A2 and B2 in C-PE1 and C-PE2 respectively, there will be no IPsec Tunnel be established.

9. Manageability Considerations

TBD - this needs to be filled out before publishing

10. Security Considerations

The document describes the encoding for SDWAN edge nodes to advertise its properties to their peers to its RR, which propagates to the intended peers via untrusted networks.

The secure propagation is achieved by secure channels, such as TLS, SSL, or IPsec, between the SDWAN edge nodes and the local controller RR.

[More details need to be filled in here]

11. IANA Considerations

This document requires the following IANA actions.

- SDWAN Overlay SAFI = 74 assigned by IANA
- SDWAN Route Type

12. References

12.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

12.2. Informative References

[RFC8192] S. Hares, et al, "Interface to Network Security Functions (I2NSF) Problem Statement and Use Cases", July 2017

[RFC5521] P. Mohapatra, E. Rosen, "The BGP Encapsulation Subsequent Address Family Identifier (SAFI) and the BGP Tunnel Encapsulation Attribute", April 2009.

[CONTROLLER-IKE] D. Carrel, et al, "IPsec Key Exchange using a Controller", draft-carrel-ipsecme-controller-ike-01, work-in-progress.

[LISP-GEOLOC] D. Farinacci, "LISP Geo-Coordinate Use-Case", draft-farinacci-lisp-geo-09, April 2020.

[SDN-IPSEC] R. Lopez, G. Millan, "SDN-based IPsec Flow Protection", draft-ietf-i2nsf-sdn-ipsec-flow-protection-07, Aug 2019.

[SECURE-EVPN] A. Sajassi, et al, "Secure EVPN", draft-sajassi-bess-secure-evpn-02, July 2019.

[Tunnel-Encap]E. Rosen, et al, "The BGP Tunnel Encapsulation Attribute", draft-ietf-idr-tunnel-encaps-09, Feb 2018.

[VPN-over-Internet] E. Rosen, "Provide Secure Layer L3VPNs over Public Infrastructure", draft-rosen-bess-secure-l3vpn-00, work-in-progress, July 2018

[DMVPN] Dynamic Multi-point VPN: https://www.cisco.com/c/en/us/products/security/dynamic-multipoint-vpn-dmvpn/index.html

[DSVPN] Dynamic Smart VPN: http://forum.huawei.com/enterprise/en/thread-390771-1-1.html

[ITU-T-X1036] ITU-T Recommendation X.1036, "Framework for creation, storage, distribution and enforcement of policies for network security", Nov 2007.

[Net2Cloud-Problem] L. Dunbar and A. Malis, "Seamless Interconnect Underlay to Cloud Overlay Problem Statement", draft-dm-net2cloud-problem-statement-02, June 2018

[Net2Cloud-gap] L. Dunbar, A. Malis, and C. Jacquenet, "Gap Analysis of Interconnecting Underlay with Cloud Overlay", draft-dm-net2cloud-gap-analysis-02, work-in-progress, Aug 2018.

[Tunnel-Encap] E. Rosen, et al "The BGP Tunnel Encapsulation Attribute", draft-ietf-idr-tunnel-encaps-10, Aug 2018.

13. Acknowledgments

Acknowledgements to Wang Haibo, Hao Weiguo, and ShengCheng for implementation contribution; Many thanks to Jim Guichard, John Scudder, and Donald Eastlake for their review and contributions.

This document was prepared using 2-Word-v2.0.template.dot.

Authors' Addresses

Linda Dunbar
Futurewei
Email: ldunbar@futurewei.com

Sue Hares
Hickory Hill Consulting
Email: shares@ndzh.com

Robert Raszuk
Email: robert@raszuk.net

Kausik Majumdar
CommScope
Email: Kausik.Majumdar@commscope.com