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Centralized EVPN DF Election
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Abstract

This document proposes a centralized DF Designated Forwarder election mechanism to be used between an SDN (Software Defined Network) controller and each PE (Provider Edge) device in an EVPN network. Such a mechanism overcomes some issues with the current standalone DF election defined in RFC 7432. A new BGP capability and an additional DF Election Result Route Type are specified to support this centralized DF election mechanism.

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1. Introduction

[RFC7432] defines a standardized Designated Forwarder (DF) election mechanism in EVPN networks to appoint one Provider Edge (PE) device as the DF from a candidate list of PEs for each VLAN (or VLAN bundle) connecting to a multi-homed Customer Edge (CE) device or access network. The DF PE is responsible for sending broadcast, multicast and unknown unicast traffic (BUM) to the multi-homed CE device or network and non-DF PEs must drop such traffic. This DF based mechanism is used to prevent duplicated packet injection into the multi-homed access network via multiple PEs.

In [RFC7432] the DF is selected according to the VLAN modulus "service-carving" algorithm in order to perform load balancing for multi-destination traffic destined to a given segment. The algorithm can ensure each participating PE independently and unambiguously determines which one of the participating PEs is the DF; however, use of this algorithm has some drawbacks as follows [EVPN-HRW-DF]:

1. Uneven load balancing in some VLAN configuration cases when the Ethernet tags have a non-uniform distribution, for instance when the Ethernet tags in use are all even or all odd.

2. Unnecessary service disruption when PEs join or leave a redundancy group. In Figure 1 below, say v1, v2 and v3 are VLANs configured on ES2 with associated Ethernet tags of value 3, 4 and 5 respectively. So PE1, PE2 and PE3 are also the DFs for v1, v2 and v3 respectively. Now when PE3 goes down, PE2 will become the DF for v1 and v3 while PE1 will become the DF for v2, so needless churn of v1 and v2 occurs causing unnecessary service disruption in v1 and v2.

3. Lack of user control over DF election. In some cases, the user may want to flexibly control the load balancing based on VLAN number, bandwidth consumption, and other factors. The user should be allowed to use some specific DF re-election algorithm to avoid service disruption. The user also should be allowed to specify revertive and non-revertive mode for on-demand DF switchover in order to carry out some maintenance tasks.

This document specifies a centralized DF election method to overcome the issues aforementioned. A physically distributed but logically centralized controller is deployed to perform the DF election calculation for all multi-homed PEs. Each individual multi-homed PE in the redundancy group should disable its own DF election process and listen to the DF election result from the SDN controller. [RFC7432] DF election procedures are extended for the interaction between the SDN Controller and each PE.

2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

The following terms and acronyms are used:

CE: Customer Edge device, e.g., a host, router, or switch.

DF: Designated Forwarder.

Ethernet Segment (ES): When a customer site (device or network) is connected to one or more PEs via a set of Ethernet links, then that set of links is referred to as an "Ethernet segment".

ESI: Ethernet Segment Identifier: A unique non-zero identifier that identifies an Ethernet segment.

EVI: An EVPN instance spanning the Provider Edge (PE) devices participating in that EVPN.

EVPN: Ethernet Virtual Private Network [RFC7432].

PE: Provider Edge device.

NLRI: Network Layer Reachability Information.

SDN: Software Defined Networking.

VLAN: Virtual Local Area Network.

3. Solution Overview

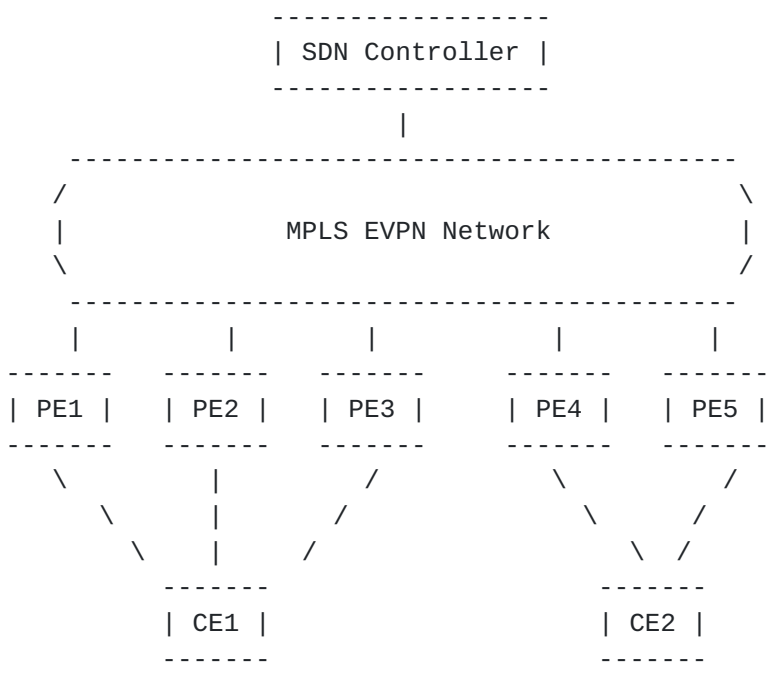


Figure 1. Centralized DF Election Scenario

In Figure 1, CE1 is multi-homed to PE1, PE2 and PE3, the ESI is 1. CE2 is multi-homed to PE4 and PE5, the ESI is 2. The SDN controller will be pre-provisioned with the entire network's ESI related configuration. This includes EVI, the Ethernet Tags on each ESI, redundancy mode of active-active or active-standby for each ESI, <ESI, Ethernet Tag> and EVI correspondence.

Before each PE and the SDN controller exchange BGP route information for DF election, the SDN controller and each PE MUST negotiate a new BGP centralized DF election capability and role when OPEN messages are first exchanged; each PE participating in multi-homing is the client for the DF election information while the SDN controller is the server. For these PEs the regular DF election process as per [RFC7432] will be disabled and each PE listens to the DF/Non-DF result from the SDN controller at the granularity of <ES,VLAN> or <ES, VLAN bundle>. For the DF election server, after it receives Ethernet Segment route from each PE, it will perform DF election calculation based on a local algorithm and will notify each EVPN PE of the election result through a new EVPN route type.

3.1 Centralized DF Election Capability

The centralized DF election capability is a new BGP capability

[RFC5492] that can be used by a BGP speaker to indicate its ability

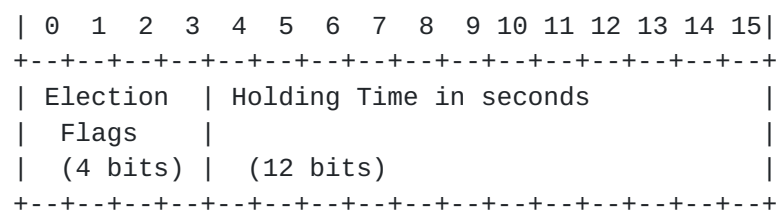
to support for the new DF election process.

This capability is defined as follows:

Capability code: TBD1

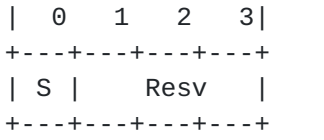
Capability length: 2 octets

Capability value: Consists of the "Election Flags" field and "Holding Time" field as follows:



The use and meaning of these fields are as follows:

Election Flags: This field contains bit flags related to restart as follows:



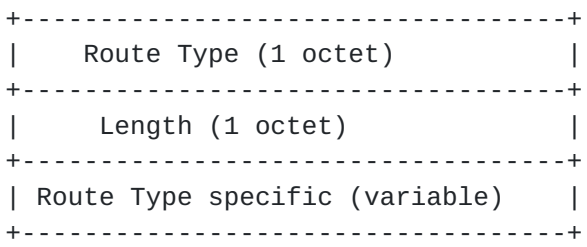
S: The most significant bit is the election Server bit. When set to 1, this bit indicates that the BGP speaker is the Server (Controller) that has the DF election calculation capability for all multi-homed PEs in the entire EVPN network. When set to 0 it indicates the BGP speaker is a Client which will await the DF election result from the Controller (Server).

Resv: Reserved bits that MUST be sent as zero and ignored on receipt.

Holding Time: This is the estimated maximum time in seconds it will take for the client to get DF election results from the controller after the BGP session is established. When no result for the DF election is received after the holding time, PEs will revert to the traditional EVPN DF election process as per [RFC7432].

4. DF Election Result Route Type

The current BGP EVPN NLRI as defined in [RFC7432] is shown below:



This document defines an additional Route Type used for the server (SDN Controller) to send DF election results to each client (PE). The Route Type is named the "DF Election Result Route Type".

The detailed encoding of this route and associated procedures are described in the following sections.

4.1 DF Election Result Route Encoding

The route type specific information for a DF Election Result Route NLRI consists of the following fields:

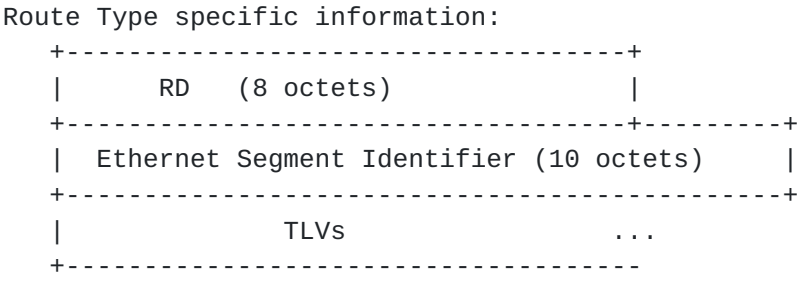


Figure 2: DF Election Result Router Type specific information

RD: The Route Distinguisher (RD) MUST be a Type 1 RD [RFC4364]. The value field comprises an IP address of the Controller (typically, the loopback address) followed by a number unique to the Controller.

ESI: Ethernet Segment Identifier: Is a non-zero 10-octet identifier for an Ethernet Segment.

TLVs: Information in the TLVs field is encoded in Type/Length/Value triplets. Multiple TLVs can be included. This document specifies type 1, the VLAN Bitmap type, whose structure is as follows:

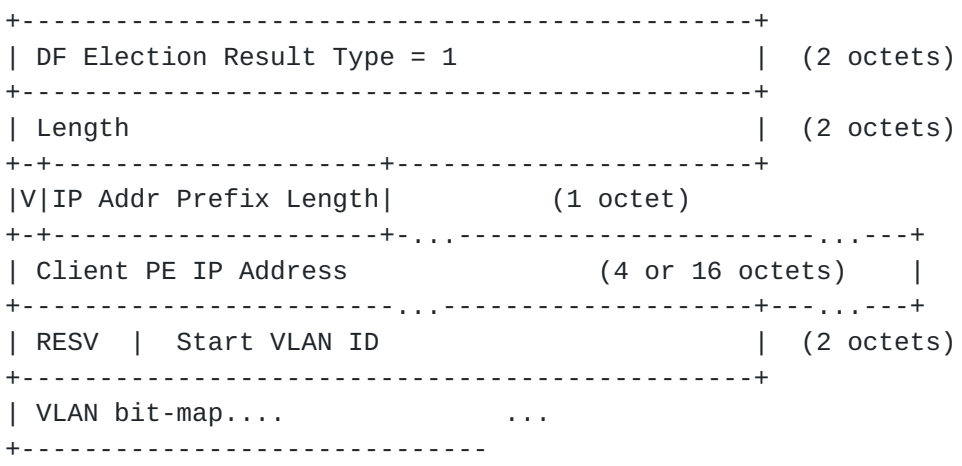


Figure 3. DF Election Result TLV Format

- DF Election Result Type (2 octets): Identifies the type of DF Election result as an unsigned integer in network byte order. This document defines type 1 as the "VLAN Bitmap" Type. TLVs withe unknown types are ignored and skipped upon receipt.

- Length (2 octets): The total number of octets of the value part of the TLV as an unsigned integer in network byte order.

The type and length are followed by the variable length value. This value, for the VLAN Bitmap type, consists of the following fields:

- V: A one bit field that indicates which version of IP the TLV uses. A value of 1 implies ipv6 while 0 implies ipv4.

- The IP Prefix Length can be set to a value between 0 and 32 (bits) for ipv4 and between 0 and 127 for ipv6. If IP Prefix Length is greater than 32 for ipv4, the TLV is corrupt and MUST be ignored.

- The Client PE IP Address will be a 32 or 128-bit field (ipv4 or ipv6 depending on the value of the V field) as PE's identification.

- RESV is a 4-bit reserved field that MUST be sent as zero and ignored on receipt.

- Start VLAN ID: The 12-bit VLAN ID that is represented by the high order bit of the first byte of the VLAN bit-map.

- VLAN bit-map: The highest order bit indicates the VLAN

equal to the start VLAN ID, the next highest bit

indicates the VLAN equal to start VLAN ID + 1, continuing to the end of the VLAN bit-map field. A bit value of 1 indicates DF and a bit value of 0 indicates non-DF.

4.2 Centralized DF Election procedures

The controller has all ES related configuration information for the entire EVPN network. After the controller boots up, it can start a boot-timer to allow the establishment of BGP EVPN sessions with all multi-homed EVPN PEs. The controller also needs to receive all ES routes from those PEs before the boot-timer timeout. The controller will preserve all EVPN PE's ES routes.

Based on a local algorithm for each ES, after it has received the above data, it can start to perform the DF election calculation. The default algorithm is the VLAN modulus method defined in section 8.5 [RFC7432] relying on local VLAN configuration for each ES. A user defined algorithm should be allowed.

After the DF election calculation is finished on the controller, it will notify each multi-homed PE using the newly defined DF Election Result Route. The DF Election Result Route is per ES, i.e., the DF election results for all PEs connecting to the same ES are carried in one route. The controller that advertises the Ethernet Segment route MUST carry an ES-Import Route Target. The DF Election Result filtering procedure is the same as the Ethernet Segment route filtering defined in [RFC7432], i.e., the DF Election Result Route filtering MUST be imported only by the PEs that are Multi-homed to the same Ethernet segment. Each Multi-homed PE compares the Client PE IP Address with its local IP Address, if the two IP addresses are same, then it gets the corresponding start VLAN and VLAN Bitmap as the DF election results.

When the failure of a multi-homed PE is detected by the controller, the controller will initiate the DF re-election process. Because it's the controller making decisions as to which PE is DF or non-DF, the controller should ensure that the DF re-election does not cause unnecessary service disruption. In the example above, the controller should only redistribute the DF VLAN on PE3 to PE1 and PE2, the existing DF VLAN on PE1 and PE2 should remain unchanged to avoid service disruption.

When the access link fails on one multi-homed PE, the PE will advertise an Ethernet Segment Withdraw message to the controller, which will trigger the DF re-election on the controller. The re-election principle in this case is same as in the node failure case to minimize service disruption.

5. Security Considerations

Procedures and protocol extensions defined in this document do not affect the BGP security model. The communications between the SDN Controller and EVPN PEs should be protected to ensure security. BGP peerings are not automatic and require configuration, thus it is the responsibility of the network operator to ensure that they are trusted entities.

6. IANA Considerations

Three IANA actions are requested as below.

IANA is requested to assign a new BGP Capability Code in the Capability Code registry as follows:

Value	Description	Reference
TBD1	Centralized DF Election	[this document]

This document requested the assignment of value TBD2 in the "EVPN Route Types" registry created by [RFC7432] and modification of the registry to add the following:

Value	Description	Reference
TBD2	DF Election Result	[this document]

IANA is requested to create a registry for "DF Election Result Types" as follows:

Name: DF Election Result Types
Registration Procedure: First Come First Served
Reference: [this document]

Type	Description	Reference
0	(Reserved)	
1	VLAN Bitmap	[this document]
2-65534	unassigned	
65535	(reserved)	

Normative References

[RFC2119] - Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

[RFC4364] - Rosen, E. and Y. Rekhter, "BGP/MPLS IP Virtual Private Networks (VPNs)", RFC 4364, DOI 10.17487/RFC4364, February 2006, <https://www.rfc-editor.org/info/rfc4364>.

[RFC5492] - Scudder, J. and R. Chandra, "Capabilities Advertisement with BGP-4", RFC 5492, DOI 10.17487/RFC5492, February 2009, <https://www.rfc-editor.org/info/rfc5492>.

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[RFC8174] - Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

Informative References

[EVPN-HRW-DF] - Mohanty S. et al. "A new Designated Forwarder Election for the EVPN", draft-mohanty-bess-evpn-df-election-02, work-in-progress, October 19, 2015.

Acknowledgments

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