L2VPN Workgroup
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Ali Sajassi
Samer Salam
Sami Boutros
Cisco

Wim Henderickx
Jorge Rabadan
Alcatel-Lucent

Jim Uttaro
AT&T

John Drake
Wen Lin
Juniper

Aldrin Isaac
Bloomberg

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E-TREE Support in EVPN & PBB-EVPN
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Abstract

The Metro Ethernet Forum (MEF) has defined a rooted-multipoint Ethernet service known as Ethernet Tree (E-Tree). [ETREE-FMWK] proposes a solution framework for supporting this service in MPLS networks. This document discusses how those functional requirements can be easily met with (PBB-)EVPN and how (PBB-)EVPN offers a more efficient implementation of these functions.

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1 Introduction

The Metro Ethernet Forum (MEF) has defined a rooted-multipoint Ethernet service known as Ethernet Tree (E-Tree). In an E-Tree service, endpoints are labeled as either Root or Leaf sites. Root sites can communicate with all other sites. Leaf sites can communicate with Root sites but not with other Leaf sites.

[ETREE-FMWK] proposes the solution framework for supporting E-Tree service in MPLS networks. The document identifies the functional components of the overall solution to emulate E-Tree services in addition to Ethernet LAN (E-LAN) services on an existing MPLS network.

[EVPN] is a solution for multipoint L2VPN services, with advanced multi-homing capabilities, using BGP for distributing customer/client MAC address reach-ability information over the MPLS/IP network. [PBB-EVPN] combines the functionality of EVPN with [802.1ah] Provider Backbone Bridging for MAC address scalability.

This document discusses how the functional requirements for E-Tree service can be easily met with (PBB-)EVPN and how (PBB-)EVPN offers a more efficient implementation of these functions.

1.1 Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [KEYWORDS].

2 E-Tree Scenarios and EVPN / PBB-EVPN Support

In this section, we will categorize support for E-Tree into three different scenarios, depending on the nature of the site association (Root/Leaf) per PE or per Ethernet Segment:

- Leaf OR Root site(s) per PE

- Leaf AND Root site(s) per PE

- Leaf AND Root site(s) per Ethernet Segment

2.1 Scenario 1: Leaf OR Root site(s) per PE

In this scenario, a PE may receive traffic from either Root sites OR Leaf sites for a given MAC-VRF/bridge table, but not both

concurrently. In other words, a given MAC-VRF/bridge table on a PE is either associated with a root or leaf. The PE may have both Root and Leaf sites albeit for different MAC-VRFs/bridge tables.

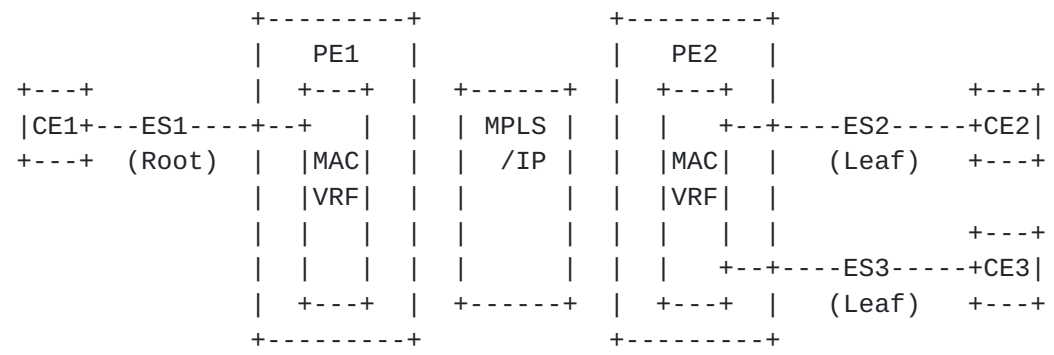


Figure 1: Scenario 1

In such scenario, an EVPN PE implementation MAY provide topology constraint among the PEs belonging to the same EVI associated with an E-TREE service. The purpose of this topology constraint is to avoid having PEs with only Leaf sites importing and processing BGP MAC routes from each other, thereby unnecessarily exhausting their RIB tables. To support such topology constrain in EVPN, two BGP Route-Targets (RTs) are used for every EVPN Instance (EVI): one RT is associated with the Root sites and the other is associated with the Leaf sites. On a per EVI basis, every PE exports the single RT associated with its type of site(s). Furthermore, a PE with Root site(s) imports both Root and Leaf RTs, whereas a PE with Leaf site(s) only imports the Root RT. If the number of EVIs is very large (e.g., more than 32K or 64K), then RT type 0 as defined in [RFC4360] SHOULD be used; otherwise, RT type 2 is sufficient.

2.2 Scenario 2: Leaf OR Root site(s) per AC

In this scenario, a PE may receive traffic from either Root OR Leaf sites on a given Attachment Circuit (AC) of a MAC-VRF/bridge table. In other words, an AC (ES or ES/VLAN) is either associated with a Root or Leaf (but not both).

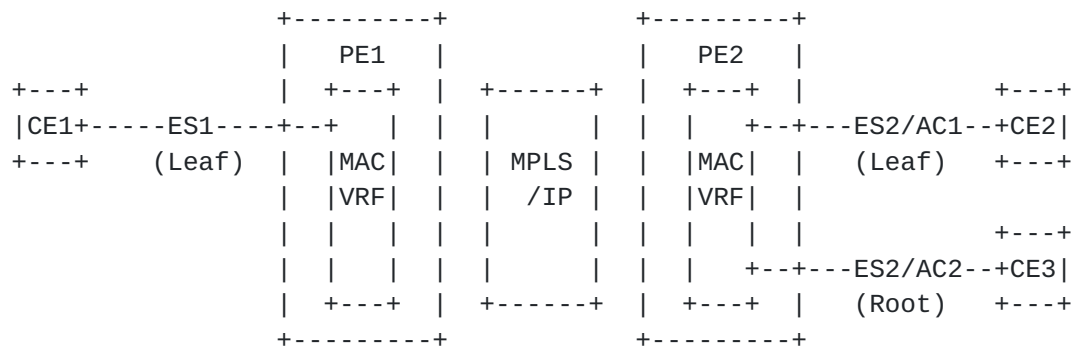


Figure 2: Scenario 2

In this scenario, if there are PEs with only root (or leaf) sites per EVI, then the RT constrain procedures described in section 2.1 can also be used here. However, when a Root site is added to a Leaf PE (or vise versa), then that PE needs to process MAC routes from all other Leaf PEs and add them to its forwarding table. If for a given EVI, the PEs can eventually have both Leaf and Root sites attached, even though they may start as Root-only or Leaf-only PEs, then it is recommended to use a single RT per EVI and avoid additional configuration and operational overhead.

2.3 Scenario 3: Leaf OR Root site(s) per MAC

In this scenario, a PE may receive traffic from both Root AND Leaf sites on a given Attachment Circuit (AC) of a MAC-VRF/bridge table. Since an Attachment Circuit (ES or ES/VLAN) carries traffic from both Root and Leaf sites, the granularity at which Root or Leaf sites are identifies is on a per MAC address. This scenario is considered in this draft for EVPN service with only known unicast traffic - i.e., there is no BUM traffic.

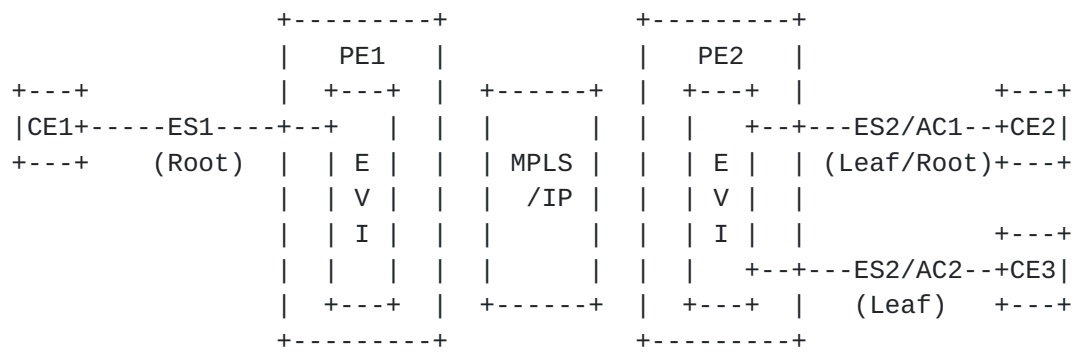


Figure 3: Scenario 3

3 Operation for EVPN

[EVPN] defines the notion of ESI MPLS label used for split-horizon filtering of BUM traffic at the egress PE. Such egress filtering capabilities can be leveraged in provision of E-TREE services as seen shortly. In other words, [EVPN] has inherent capability to support E-TREE services without defining any new BGP routes but just defining a new BGP Extended Community for leaf indication as shown later in this document.

3.1 Known Unicast Traffic

Since in EVPN, MAC learning is performed in control plane via advertisement of BGP routes, the filtering needed by E-TREE service for known unicast traffic can be performed at the ingress PE, thus providing very efficient filtering and avoiding sending known unicast traffic over MPLS/IP core to be filtered at the egress PE as done in traditional E-TREE solutions (e.g., E-TREE for VPLS).

To provide such ingress filtering for known unicast traffic, a PE MUST indicate to other PEs what kind of sites (root or leaf) its MAC addresses are associated with. This indication is achieved by using one of the following mechanisms:

1) For single-homing scenarios of sections 2.2 and 2.3, the PE advertises the MAC addresses received from a Leaf site, with an Extended community indicating a leaf flag. The lack of such flag indicates that the MAC address is associated with a root site.

2) For multi-homing scenario of section 2.2, where an AC is either root or leaf (but not both), the PE advertises leaf indication along with the Ethernet A-D per EVI route. Since these routes are always advertised ahead of MAC advertisements route, there is no need to append leaf-indication flag with the MAC advertisement routes. The leaf indication flag on Ethernet A-D per EVI route tells the receiving PEs that all MAC addresses associated with this <ESI, EVI> or <ESI, EVI/VLAN> are from a leaf site. The lack of such leaf-indication flag tells the receiving PEs that the MAC addresses are associated with a root site.

If a leaf site is multi-homed to PE1 an PE2, and PE1 advertises the Ethernet A-D per EVI corresponding to this leaf site with the leaf-indication flag but PE2 does not, then the receiving PE MUST notify the operator of such discrepancy and ignore the leaf-indication flag on PE1. In other words, in case of discrepancy, the multi-homing for that pair of PEs is assumed to be in default "root" mode for that <ESI, EVI> or <ESI, EVI/VLAN>.

3) For multi-homing scenario of section 2.3, where an AC is both root or leaf (i.e., root or leaf indication is at the granularity of MAC address), the PE advertises leaf indication along with each MAC advertisement route just as in (1). No leaf-indication flag SHALL be sent along with the Ethernet A-D per EVI route for this scenario.

Tagging MAC addresses with a leaf indication (either directly via MAC advertisement route or indirectly via Ethernet A-D per EVI route) enables remote PEs to perform ingress filtering for known unicast traffic - i.e., on the ingress PE, the MAC destination address lookup yields, in addition to the forwarding adjacency, a flag which indicates whether the target MAC is associated with a Leaf site or not. The ingress PE cross-checks this flag with the status of the originating AC, and if both are Leafs, then the packet is not forwarded.

To support the above ingress filtering functionality, a new E-TREE Extended Community with a Leaf indication flag is introduced [section 5.2]. This new Extended Community is advertised with either Ethernet A-D per EVI route or MAC/IP Advertisement route as described above.

3.2 BUM Traffic

For BUM traffic, it is not possible to perform filtering on the ingress PE, as is the case with known unicast, because of the multi-destination nature of the traffic. As such, the solution relies on egress filtering. In order to apply the proper egress filtering, which varies based on whether a packet is sent from a Leaf AC or a root AC, the MPLS-encapsulated frames MUST be tagged with an indication of whether they originated from a Leaf AC or not. In other words, leaf/root indication for BUM traffic is done at the granularity of AC. This can be achieved in EVPN through the use of the ESI MPLS label. Therefore, the ESI MPLS label can be used to either identify the Ethernet segment of origin per [RFC 7432] or it can be used to indicate that the packet is originated from a leaf site.

BUM traffic sent over a P2MP LSP or ingress replication, may need to carry an upstream assigned or downstream assigned MPLS label (respectively) for the purpose of egress filtering to indicate to the egress PEs whether this packet is originated from a root AC or a leaf AC.

The main difference between downstream and upstream assigned ESI MPLS label is that in case of downstream assigned not all egress PE devices need to receive the ESI label just like ingress replication procedures defined in [RFC7432].

There are four scenarios to consider:

3.2.1 BUM traffic originated from a single-homed site on a leaf AC

In this scenario, the ingress PE adds a special ESI MPLS label to the frame indicating a Leaf site. This special ESI MPLS label used for single-homing scenarios is not on a per ES basis but rather on a per PE basis - i.e., a single ESI MPLS label is used for all single-homed ES's on that PE. This special ESI MPLS label is advertised to other PE devices, using a new EVPN Extended Community called Leaf ESI MPLS label Extended Community (section 5.1) along with a set of Ethernet A-D per ES routes. The set of Ethernet A-D per ES routes may be needed if the number of Route Targets (RTs) that need to be sent exceed the limit on a single route per [RFC 7432]. The RT(s) represent EVIs with at least a leaf site in them. The ESI for the Ethernet A-D per ES route is set to zero indicating single-homed sites.

When a PE receives this special ESI MPLS label in the data path, it blocks the packet if the destination AC is of type Leaf; otherwise, it forwards the packet.

3.2.2 BUM traffic originated from a single-homed site on a root AC

In this scenario, the ingress PE does not add any ESI MPLS label and it operates per [RFC7432] procedures.

3.2.3 BUM traffic originated from a multi-homed site on a leaf AC

In this scenario, the ingress PE adds an ESI MPLS label to the frame indicating both the Ethernet Segment of origin and its Leaf type. The reason Ethernet Segment of origin needs to be identified in addition to Leaf type, is to accommodate multi-homing scenarios for Integrated Routing and Bridging (IRB) where a source (Leaf) can be on one VLAN and the receivers (roots) can be on some other VLANs for the same Ethernet Segment.

This ESI MPLS label is advertised to other PE devices, using a new EVPN Extended Community called Leaf ESI Label Extended Community (section 5.1) along with a set of Ethernet A-D per ES routes corresponding to the ES of the origin. If the egress ES is the same as the originated ES, then the receiving PE uses the same procedure for filtering BUM traffic as the one specified in [RFC 7432]. If the egress ES is different from the originated ES, then the receiving PE uses the ESI label to identify that the BUM traffic is associated with a leaf site and thus blocking the BUM traffic if the destination AC is also of type Leaf similar to section 3.2.1.

3.2.4 BUM traffic originated from a multi-homed site on a root AC

In this scenario, both the ingress and egress PE devices follows the procedure defined in [RFC 7432] for adding and/or processing an ESI MPLS label.

The ingress PE imposes the right ESI MPLS label depending on whether the Ethernet frame originated from the Root or Leaf site on that Ethernet Segment. The mechanism by which the PE identifies whether a given frame originated from a Root or Leaf site on the segment is based on the Ethernet Tag associated with the frame (e.g., whether the frame come from a leaf or a root AC). Other mechanisms for identifying whether an egress AC is a root or leaf is beyond the scope of this document.

3.3 E-TREE Traffic Flows for EVPN

Per [ETREE-FMWK], a generic E-Tree service supports all of the following traffic flows:

- Ethernet Unicast from Root to Roots & Leaf
- Ethernet Unicast from Leaf to Root
- Ethernet Broadcast/Multicast from Root to Roots & Leafs
- Ethernet Broadcast/Multicast from Leaf to Roots

A particular E-Tree service may need to support all of the above types of flows or only a select subset, depending on the target application. In the case where unicast flows need not be supported, the L2VPN PEs can avoid performing any MAC learning function.

In the subsections that follow, we will describe the operation of EVPN to support E-Tree service with and without MAC learning.

3.3.1 E-Tree with MAC Learning

The PEs implementing an E-Tree service must perform MAC learning when unicast traffic flows must be supported from Root to Leaf or from Leaf to Root sites. In this case, the PE with Root sites performs MAC learning in the data-path over the Ethernet Segments, and advertises reachability in EVPN MAC Advertisement routes. These routes will be imported by PEs that have Leaf sites as well as by PEs that have Root sites, in a given EVI. Similarly, the PEs with Leaf sites perform MAC learning in the data-path over their Ethernet Segments, and advertise reachability in EVPN MAC Advertisement routes which are imported only

by PEs with at least one Root site in the EVI. A PE with only Leaf sites will not import these routes. PEs with Root and/or Leaf sites may use the Ethernet A-D routes for aliasing (in the case of multi-homed segments) and for mass MAC withdrawal per [RFC 7432].

To support multicast/broadcast from Root to Leaf sites, either a P2MP tree rooted at the PE(s) with the Root site(s) or ingress replication can be used. The multicast tunnels are set up through the exchange of the EVPN Inclusive Multicast route, as defined in [RFC7432].

To support multicast/broadcast from Leaf to Root sites, ingress replication should be sufficient for most scenarios where there is a single Root or few Roots. If the number of Roots is large, a P2MP tree rooted at the PEs with Leaf sites may be used.

3.3.2 E-Tree without MAC Learning

The PEs implementing an E-Tree service need not perform MAC learning when the traffic flows between Root and Leaf sites are multicast or broadcast. In this case, the PEs do not exchange EVPN MAC Advertisement routes. Instead, the Ethernet A-D routes are used to exchange the EVPN labels.

The fields of the Ethernet A-D route are populated per the procedures defined in [RFC7432], and the route import rules are as described in previous sections.

4 Operation for PBB-EVPN

In PBB-EVPN, the PE must advertise a Root/Leaf indication along with each B-MAC Advertisement route, to indicate whether the associated B-MAC address corresponds to a Root or a Leaf site. Similar to the EVPN case, this flag will be added to the new E-TREE Extended Community defined in section [5.2], and advertised with each MAC Advertisement route.

In the case where a multi-homed Ethernet Segment has both Root and Leaf sites attached, two B-MAC addresses are allocated and advertised: one B-MAC address implicitly denoting Root and the other explicitly denoting Leaf. The former B-MAC address is not advertised with the E-TREE extended community but the latter B-MAC denoting Leaf is advertised with the new E-TREE extended community.

The ingress PE uses the right B-MAC source address depending on whether the Ethernet frame originated from the Root or Leaf site on that Ethernet Segment. The mechanism by which the PE identifies whether a given frame originated from a Root or Leaf site on the segment is based on the Ethernet Tag associated with the frame. Other

mechanisms of identification, beyond the Ethernet Tag, are outside the scope of this document. It should be noted that support for both Root and Leaf sites on a single Ethernet Segment requires that the PE performs the Ethernet Segment split-horizon check on a per Ethernet Tag basis.

In the case where a multi-homed Ethernet Segment has only Root OR Leaf sites attached, then a single B-MAC address is allocated and advertised per segment.

Furthermore, a PE advertises two special global B-MAC addresses: one for Root and another for Leaf, and tags the Leaf one as such in the MAC Advertisement route. These B-MAC addresses are used as source addresses for traffic originating from single-homed segments.

4.1 Known Unicast Traffic

For known unicast traffic, the PEs perform ingress filtering: On the ingress PE, the C-MAC destination address lookup yields, in addition to the target B-MAC address and forwarding adjacency, a flag which indicates whether the target B-MAC is associated with a Root or a Leaf site. The ingress PE cross-checks this flag with the status of the originating site, and if both are a Leaf, then the packet is not forwarded.

4.2 BUM Traffic

For BUM traffic, the PEs must perform egress filtering. When a PE receives a MAC advertisement route, it updates its Ethernet Segment egress filtering function (based on the B-MAC source address), as follows:

- If the MAC Advertisement route indicates that the advertised B-MAC is a Leaf, and the local Ethernet Segment is a Leaf as well, then the source B-MAC address is added to the B-MAC filtering list.

- Otherwise, the B-MAC filtering list is not updated.

When the egress PE receives the packet, it examines the B-MAC source address to check whether it should filter or forward the frame. Note that this uses the same filtering logic as baseline [PBB-EVPN] and does not require any additional flags in the data-plane.

The PE places all Leaf Ethernet Segments of a given bridge domain in a single split-horizon group in order to prevent intra-PE forwarding among Leaf segments. This split-horizon function applies to BUM traffic.

5 BGP Encoding

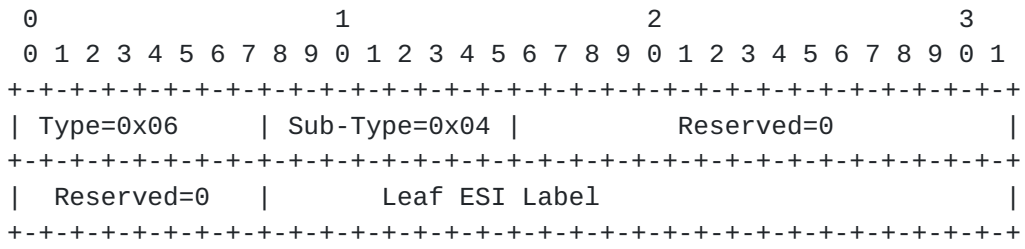
This document defines two new BGP Extended Community for EVPN.

5.1 Leaf ESI Label Extended Community

This Extended Community is a new transitive Extended Community having a Type field value of 0x06 (EVPN) and the Sub-Type 0x04. In purpose, it is similar to ESI Label EC defined in [RFC 7432] with the only difference that it is used to indicate a leaf site in addition to the Ethernet segment of origin.

It may be advertised along with Ethernet Auto-discovery routes, and it enables split-horizon procedures for multihomed sites as described in Section 3.2.1.3. The Leaf ESI Label field represents an ES with a leaf site by the advertising PE, and it is used in split-horizon filtering by other PEs that are connected to the same multihomed Ethernet segment and egress filtering by other PEs that are connected to Leaf ACs.

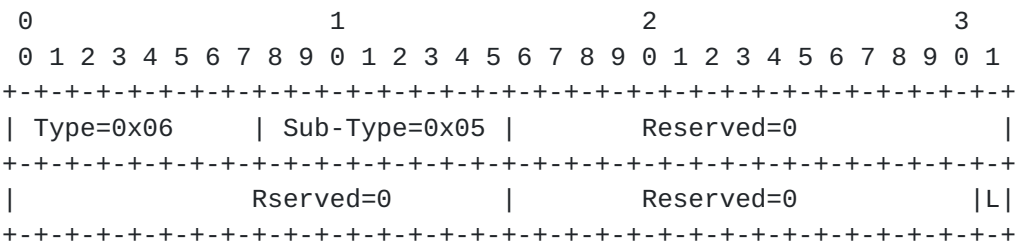
The E-TREE Extended Community is encoded as an 8-octet value as follows:



5.2 E-TREE Extended Community

A new EVPN BGP Extended Community called E-TREE is introduced here. This new extended community is a transitive extended community with the Type field of 0x06 (EVPN) and the Sub-Type of 0x05. This extended community is used to for leaf indication and it is advertised with an EVPN MAC/IP route or an Ethernet A-D per EVI route.

The E-TREE Extended Community is encoded as an 8-octet value as follows:



Leaf flag (L): A value of 1 indicates a leaf

6 Acknowledgement

We would like to thank Dennis Cai and Antoni Przygienda for their comments.

7 Security Considerations

Same security considerations as [RFC7432].

8 IANA Considerations

Allocation of Extended Community Type and Sub-Type for EVPN.

9 References

9.1 Normative References

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

[RFC4360] S. Sangli et al, ""BGP Extended Communities Attribute", February, 2006.

[RFC7432] Sajassi et al., "BGP MPLS Based Ethernet VPN", February, 2015.

9.2 Informative References

[ETREE-FMWK] Key et al., "A Framework for E-Tree Service over MPLS Network", draft-ietf-l2vpn-etree-frwk-03, work in progress, September 2013.

[PBB-EVPN] Sajassi et al., "PBB-EVPN", draft-ietf-l2vpn-pbb-evpn-

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Authors' Addresses

Ali Sajassi
Cisco
Email: sajassi@cisco.com

Samer Salam
Cisco
Email: ssalam@cisco.com

Wim Henderickx
Alcatel-Lucent
Email: wim.henderickx@alcatel-lucent.com

Jim Uttaro
AT&T
Email: ju1738@att.com

Aldrin
Bloomberg Issac
Email: aisaac71@bloomberg.net

Sami Boutros
Cisco
Email: sboutros@cisco.com