Networking Working Group   L. Ginsberg
Internet-Draft   A. Bashandy
Intended status: Standards Track   C. Filsfils
Expires: April 2, 2018   Cisco Systems
                                                      B. Decraene
                                                           Orange
                                                September 29, 2017

           IS-IS Extensions to Support Routing over IPv6 Dataplane
                 draft-bashandy-isis-srv6-extensions-01.txt

Abstract

   Segment Routing (SR) allows for a flexible definition of end-to-end
   paths by encoding paths as sequences of topological sub-paths, called
   "segments". Segment routing architecture can be implemented over an
   MPLS data plane as well as an IPv6 data plane. This draft describes
   the IS-IS extensions required to support Segment Routing over an IPv6
   data plane.

Requirements Language

   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 [RFC2119].

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[1](1). Introduction

   With Segment Routing (SR)[SRARCH], a node steers a packet through an
   ordered list of instructions, called segments.

Segments are identified through Segment Identifiers (SIDs).

Segment Routing can be directly instantiated on the IPv6 data plane
through the use of the Segment Routing Header defined in [SRH]. SRv6
refers to this SR instantiation on the IPv6 dataplane.

The network programming paradigm [NP] is central to SRv6.

It describes how any function can be bound to a SID and how any
network program can be expressed as a combination of SID's.

It defines several well-known functions such as End, End.X, T.Insert,
T.Encaps, etc.

This document specifies IS-IS extensions that allow IS-IS protocol to
encode some of these functions.

Familiarity with the network programming paradigm [NP] is necessary
to understand the extensions specified in this document.

This document defines one new top level IS-IS_TLV and three new IS-
IS sub-TLVs.

The SRv6 Capabilities sub-TLV announces the ability to support SRv6
and some functions defined in [NP] as well as advertising limitations
when applying such functions.

The SRv6 SID top level TLV, the P2P SRv6 X-SID sub-TLV, and the LAN
SRv6 X-SID sub-TLV are used to advertise which SIDs are instantiated
at a node and what function is bound to each instantiated SID.

Only ISIS-related functions such as End and its variants D and X [NP]
are defined in this document.

2. SRv6-Capabilities sub-TLV

As described in [SRH] and [NP], the list of Segments is stored in the
segment routing header referred hereafter as "SRH".

A router that supports SRv6 MUST be able to process the segment
routing header as described in [SRH] and [NP] up to the limitations
set by the advertised SRv6-capabilities sub-TLV.

To announce this ability, a router uses the newly defined SRv6-
capabilities sub-TLV of the router capabilities TLV [RFC7981]. The
SRv6- capabilities sub-TLV may contain optional sub-sub-TLVs.

The SRv6 Capabilities sub-TLV has the following format:

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Type       |    Length     |            Flags              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   sub-sub-TLVs...
```

   Type: Suggested value 22, to be assigned by IANA

   Length: 2 + length of sub-sub-TLVs

   Flags: 2 octets The following flags are defined:

```
  0                   1
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
  |E|                             |
  +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   where:
     E-flag: If set, then router is able to apply "T.Encap"
     operation

   The following sections define the supported sub-sub-TLVs.

2.1. Maximum SL sub-sub-TLV

   The Maximum Segments Left sub-sub-TLV specifies the maximum value of
   the "SL" field [SRH] in the SRH of a received packet before applying
   the function associated with a SID.

```
 0                   1                   2
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |    Type       |    Length     |    Max SL     |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   Type: 1
   Length: 1
   SL Value: 1 octet
   An 8 bit unsigned integer.

   If the sub-sub-TLV is NOT advertised the value is assumed to be 0.

2.2. Maximum End Pop SRH sub-sub-TLV

The Maximum End Pop SRH sub-sub-TLV specifies the maximum number of
SIDs in the top SRH in an SRH stack to which the router can apply
"PSP" or USP" [NP] flavors.

```
 0                   1                   2
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Type        |     Length    |Max-End-Pop-SRH|
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 2
Length: 1
Max-End-Pop-SRH Value: 1 octet
An 8 bit unsigned integer.

If the value is zero or the sub-sub-TLV is NOT advertised,
then it is assumed that the router cannot apply PSP or USP flavors.

2.3. Maximum T.Insert SRH sub-sub-TLV

The Maximum T.Insert SRH sub-sub-TLV specifies the maximum number of
SIDs that can be inserted as part of the "T.insert" behavior [NP].

```
 0                   1                   2
   0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Type        |     Length    | Max-T.Insert  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type: 3
Length: 1
Max-T.Insert Value: 1 octet
An 8 bit unsigned integer.

If the value is zero or the sub-sub-TLV is omitted,
then the router is assumed not to support any variation
of the "T.insert" behavior.

2.4. Maximum T.Encap SRH sub-sub-TLV

The Maximum T.Encap SRH sub-sub-TLV specifies the maximum number of
SIDs that can be included as part of the "T.Encap" behavior [NP].

```
   0                   1                   2
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    Type         |     Length    | Max-T.Encap  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
   Type: 4
   Length: 1
   Max-T.Encap Value: 1 octet
   An 8 bit unsigned integer.
```

```
   If this value is zero or the sub-sub-TLV is omitted and
   the "E" flag is set in the associated SRv6 Capabilities
   sub-TLV, then it is assumed that the router can apply T.Encap
   by encapsulating the incoming packet in another IPv6 header
   without SRH the same way IPinIP encapsulation is performed.
   If the "E" flag is clear, then this sub-sub-TLV SHOULD NOT
   be transmitted and MUST be ignored on receipt.
```

[2.5](2.5). Maximum End D SRH sub-sub-TLV

   The Maximum End D SRH sub-sub-TLV specifies the maximum number of
   SIDs in an SRH when applying "End.DX6" and "End.DT6" functions.

```
   0                   1                   2
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    Type         |     Length    | Max End D    |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

```
   Type: 5
   Length: 1
   Max End D Value: 1 octet
   An 8 bit unsigned integer.
```

```
   If this value is zero or the sub-sub-TLV is omitted,
   then it is assumed that the router cannot apply
   "End.DX6" or "End.DT6" functions if the extension
   header right underneath the outer IPv6 header is an SRH.
```

[3](3). SRv6-function Descriptor

   The SRv6 SID TLV defined in Section 4, P2P SRv6 X-SID sub-TLV
   specified in Section 6.1, and LAN SRv6 X-SID sub-TLV specified in
   section 6.2 MUST include one SRv6 function Descriptor.

When included in the SRv6 SID TLV, the descriptor is encoded as a
sub-TLV. When included in a P2P/LAN SRv6 X-SID sub-TLV, the
descriptor is encoded as a sub-sub-TLV.

The SRv6-function Descriptor encodes the function (and its flavors)
bound to the SRv6 SID advertised in the SRv6 SID TLV [NP].

The SRv6 SID function Descriptor has the following format:

```
   0                   1
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
   +-+-+-+-+-+-+-+-+
   |   Type        |
   +-+-+-+-+-+-+-+-+
   |   Length      |
   +-+-+-+-+-+-+-+-+
   |   Flags       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | Function (2 octets)           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   Type: See IANA considerations in Section 7.

   Length: 3

   Flags:

```
       0 1 2 3 4 5 6 7
      +-+-+-+-+-+-+-+-+
      |P|U| Reserved  |
      +-+-+-+-+-+-+-+-+
```

   This document defines two flags to specify the
   flavor(s) [NP] associated with the SRv6 function
   specified in the "Function" field:

      P bit: If set, then the PSP flavor [NP] is associated with the
      function encoded in the "function" field

      U bit: If set, then the USP flavor [NP] is associated with the
      function encoded in the "function" field

      Reserved Bits SHOULD be transmitted as 0 and MUST be ignored on
      receipt.

   The second two octets encode the function. Function code points
   are defined in Section 5.

   For a given SRv6 SID function encoded in the "Function" field,
   the "P" and "U" bits are set/cleared according to the rules of
   enabling/disabling the PSP and USP flavors, respectively, for
   that function as specified in [NP].

4. SRv6-SID TLV

   A new top level TLV is introduced to advertise SRv6 Segment
   Identifiers (SID) and their attributes.

   The new TLV is used to advertise SRv6 SIDs with any of the functions
   defined in [NP] whose code point is defined in this document except
   those SIDs which must be associated with a particular neighbor in
   order to be correctly applied [NP]. SRv6 SIDs associated with a
   neighbor are advertised in the sub-TLVs defined in Section 6.

   This new TLV shares the sub-TLV space defined for TLVs 135, 235, 236
   and 237. The SRv6 SID TLV has the following format:

```
 0                   1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |    Type       |    Length     |    flags      |   SID-size    |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |        SID (variable) . . .                                   |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 | sub-tlv-len   |        Sub-TLVs (variable) . . .             |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   Type: 27 (Suggested value to be assigned by IANA)

   Length: variable.

   One or more SID entries, each of which has the following format:

   Flags: 1 octet. The following flags are defined

```
     0
     0 1 2 3 4 5 6 7
    +-+-+-+-+-+-+-+-+
    |D| Reserved    |
    +-+-+-+-+-+-+-+-+
```

    where:
      D bit: When the SID is leaked from level-2 to level-1, the D
      bit MUST be set. Otherwise, this bit MUST be clear. SIDs with
      the D bit set MUST NOT be leaked from level-1 to level-2. This
      is to prevent looping.

      The remaining bits are reserved for future use. They SHOULD be
      set to zero on transmission and MUST be ignored on receipt.

   SID-Size: 1 octet. Number of bits in the SID field.

   SID: 1-16 octets. This field encodes the advertised SRv6 SID. The
   "SID-size" field can have the values 1-128 and indicates the
   number of bits in the SID. The SRv6 SID is encoded in the
   minimal number of octets for the given number of bits. The owning
   router may associate one or more functions as specified in [NP],
   in other documents, or as locally configured.

   Sub-TLV-length: 1 octet. Number of octets used by sub-TLVs

   The function associated with the advertised SID is specified by
   the SRv6-Function Descriptor sub-TLV specified in Section 3.

5. **Function Code Points**

    This section defines the code points for supported functions
    associated with SRv6 SIDs. Functions are defined in [NP].

    o 0: Reserved

    o 1: End Function

    o 2: End.X Function

    o 3: End.DX6 Function

    o 4: End.DT6 Function

6. **Advertising SRv6 SIDs associated with a Neighbor**

    Certain SRv6 functions [NP] must be associated with a particular
    neighbor, and in case of multiple layer 3 links to the same neighbor,
    with a particular link in order to be correctly applied.

    This document specifies how to advertise two such functions in IS-
    IS, namely End.X and End.DX6 [NP].

    SIDs associated with End.X and End.DX6 functions are advertised
    within neighbor reachability TLVs.

    This document defines two new sub-TLVs of TLV 22, 23, 222, 223, and
    141 - namely "P2P SRv6 X-SID" and "LAN SRv6 X- SID".

6.1. **P2P Srv6 X-SID sub-TLV**

    This sub-TLV is used to advertise one or more SRv6 SIDs associated
    with End.X and End.DX6 [NP] functions over a point to point
    adjacency.

    The "P2P SRv6 X-SID" sub-TLV has the following format:

```
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Type      |    Length    |    Flags     |   SID-size    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        SID (variable) . . .                                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|sub-sub-tlv-len|    Sub-sub-TLVs (variable) . . .            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   Type: 40 (Suggested value to be assigned by IANA)

   Length: variable.

   One or more SIDs each of which has the following format:

   Flags: 1 octet. No flags defined in this document

   SID-Size: 1 octet. Number of bits in the SID field.

   SID: 1-16 octets. This field encodes the advertised SRv6 SID. The
   "SID-size" field can have the values 1-128 and indicates the
   number of bits in the SID. The SRv6 SID is encoded in the
   minimal number of octets for the given number of bits. The owning
   router may associate one or more functions as specified in [NP],
   in other documents, or as locally configured.

   Sub-sub-TLV-length: 1 octet. Number of octets used by sub-sub-
   TLVs

The function associated with the advertised SID is specified by the
SRv6-Function Descriptor sub-sub-TLV specified in Section 3. If the
SRv6-Function Descriptor is encoded in the P2P SRv6 X-SID sub-TLV,
then the encoded SRv6 SID function MUST include only the code points
of SRv6 SID functions that require the specification of a neighbor to
be correctly applied. This document specifies the code points of two
such functions, namely End.X and End.DX6 [NP].

6.2. LAN SRv6 X-SID sub-TLV

This sub-TLV is used to advertise one or more SRv6 SIDs associated
with End.X and End.DX6 [NP] functions over a LAN adjacency. The "LAN
SRv6 X-SID" sub-TLV has the following format:

```
   0                   1                   2                   3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    Type       |    Length     |    System ID (6 octets)       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                                 |
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |    Flags      |   SID-size    |    SID (variable) . . .       |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |sub-sub-tlv-len|     sub-sub-TLVs (variable) . . .             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

     Type: 41 (Suggested value to be assigned by IANA)
     Length: variable.

     System-ID: 6 octets of IS-IS System-ID of length "ID Length" as
     defined in [ISO10589].

     One or more SIDs each of which has the following format:

     Flags 1 Octet. No flags are defined in this document

     SID-Size: 1 octet. Number of bits in the SID field.

     SID: 1-16 octets. This field encodes the advertised SRv6 SID. The
     "SID-size" field can have the values 1-128 and indicates the
     number of bits in the SID. The SRv6 SID is encoded in the
     minimal number of octets for the given number of bits. The owning
     router may associate one or more functions as specified in [NP],
     in other documents, or as locally configured.

     Sub-sub-TLV-length: 1 octet. Number of octets used by sub-sub-
     TLVs.

   The function associated with the advertised SID is specified by the
   SRv6-Function Descriptor sub-sub-TLV specified in Section 3. If the
   SRv6-Function Descriptor is encoded in the P2P SRv6 X-SID sub-TLV,
   then the encoded SRv6 SID function MUST include only the code points
   of SRv6 SID functions that require the specification of a neighbor to
   be correctly applied. This document specifies the code points of two
   such functions, namely End.X and End.DX6 [NP].

7. IANA Considerations

   This documents request allocation for the following TLVs, sub- TLVs,
   and sub-sub-TLVs as well updating the ISIS TLV registry and defining
   a new registry.

7.1. SRv6 SID TLV and sub-TLVs

   This document adds the following new TLV to the IS-IS TLV Codepoints
   registry.

   Value: 27 (suggested - to be assigned by IANA)

   Name: SRv6 SID

   The name of the "Sub-TLVs for TLVs 135, 235, 236 and 237 registry"
   needs to be changed to "Sub-TLVs for TLVs 27, 135, 235, 236 and 237
   registry".

   This document adds a new sub-TLV to the (renamed) "Sub-TLVs for TLVs
   27, 135, 235, 236 and 237 registry".

   Value: 5 (Suggested - to be assigned by IANA)

   Name: SRv6-function Descriptor

   The revised table of sub-TLVs in the registry should be:

```
   Type  27 135 235 236 237

   1      n   y   y   y   y
   2      n   y   y   y   y
   3      y   y   y   y   y
   4      y   y   y   y   y
   5(new)y   n   n   n   n
   11     y   y   y   y   y
   12     y   y   y   y   y
```

7.2. IS-IS SRv6-functions Codepoints Registry

   This document requests the creation of a new IANA managed registry to
   identify SRv6 SID functions. The registration procedure is "Expert
   Review" as defined in [RFC7370]. Suggested registry name is "SRv6
   SID Function Types". A function identifier is an unsigned 8 bit
   value. The following values are defined by this document:

   0 Reserved

   1 End function.

   2 End.X function

   3 End.DX6 function.

   4 End.DT6 function.

7.3. SRv6 Capabilities sub-TLV

   This document adds the definition of a new sub-TLV in the "Sub- TLVs
   for TLV 242 registry".

   Type: 22 (Suggested - to be assigned by IANA)

   Description: SRv6 Capabilities

   Thuis document requests the creation of a new IANA managed registry
   for sub-sub-TLVs of the SRv6 Capability sub-TLV. The registration
   procedure is "Expert Review" as defined in [RFC7370]. Suggested
   registry name is "sub-sub-TLVs for SRv6 Capability sub-TLV". The
   following sub-TLVs are defined by this document:

   0: Reserved

   1: Max-SL

   2: Max-End-Pop-SRH

   3: Max-T-Ins-SRH

   4: Max-T-Encap-SRH

   5: Max-End-D-SR

7.4. P2P SRv6 X-SID and LAN SRv6 X-SID sub-TLVs

   This document adds the definition of two new sub-TLVs in the "sub-
   TLVs for TLV 22, 23, 141, 222 and 223 registry".

   Type: 40 (suggested - to be assigned by IANA)

   Description: Point-to-Point SRv6 X-SID

   Type: 41 (suggested - to be assigned by IANA)

   Description: LAN SRv6 X-SID

Type	22	23	141	222	223
40	y	y	y	y	y
41	y	y	y	y	y

7.5. IS-IS SRv6 X-SID sub-sub-TLV Codepoints Registry

   This document requests the creation of a new IANA managed registry to
   identify SRv6 SID functions encoded in P2P/LAN X-SID sub-TLVs. The
   registration procedure is "Expert Review" as defined in [RFC7370].
   Suggested registry name is "SRv6 X-SID sub-sub-TLV Codepoints
   Registry". The following values are defined by this document:

   Value: 5 (Suggested - to be assigned by IANA)

   Name: SRv6-function

   Descriptor This sub-sub-TLV MAY appear in either the Point-to-Point
   SRv6 X-SID or the LAN SRv6 X-SID sub-TLVs described in Section 7.4.

8. Security Considerations

   Security concerns for IS-IS are addressed in [ISO10589, [RFC5304],
   and [RFC5310].

9. Contributors

   The following people gave a substantial contribution to the content
   of this document and should be considered as co-authors:

Stefano Previdi
Cisco Systems, Inc.
Email: stefano@previdi.net

Peter Psenak
Cisco Systems
Apollo Business Center Mlynske nivy 43
Bratislava 821 09
Slovakia
Email: ppsenak@cisco.com

Paul Wells
Cisco Systems
Saint Paul,
Minnesota
United States
Email: pauwells@cisco.com

Daniel Voyer
Email: daniel.voyer@bell.ca

Satoru Matsushima
Email: satoru.matsushima@g.softbank.co.jp

Bart Peirens
Email: bart.peirens@proximus.com

Hani Elmalky
Email: hani.elmalky@ericsson.com

Prem Jonnalagadda
Email: prem@barefootnetworks.com

Milad Sharif
Email: msharif@barefootnetworks.com>

Robert Hanzl
Cisco Systems
Millenium Plaza Building, V Celnici 10, Prague 1,
Prague, Czech Republic
Email rhanzl@cisco.com

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10.1. Normative References

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Authors' Addresses

Les Ginsberg
Cisco Systems
821 Alder Drive
Milpitas, CA 95035
USA

Email: ginsberg@cisco.com

Ahmed Bashandy
Cisco Systems
170 West Tasman Dr
San Jose, CA 95134
USA

Email: bashandy@cisco.com

Clarence Filsfils
Cisco Systems
Brussels
Belgium

Email: cfilsfil@cisco.com

Bruno Decraene
Orange
Issy-les-Moulineaux
France

Email: bruno.decraene@orange.com