Source Packet Routing in Networking WG (spring)

IETF 90 – Toronto

Chairs: John Scudder (jgs@juniper.net)
Alvaro Retana (aretana@cisco.com)

IETF

Administrivia

- Note taker/Jabber Scribe: Need volunteers!
- Blue sheets --- please sign them!
- Agenda Bashing
- Milestones Review

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I E T F

IPR Disclosure

- Review the rules about disclosing intellectual property as expressed in RFC 3979 and at http://trac.tools.ietf.org/group/iesg/trac/wiki/IntellectualProperty.
- spring Process
  - poll authors on their compliance with IETF IPR rules prior to moving a document to the next step in the WG process, e.g., before an individual draft becomes a WG document or a WG document goes to last call

IETF 90 spring WG Agenda

- Administrivia
  Chairs — 10 minutes

- IPv6 Segment Routing Activities during Bits-n-Bytes
  John Brzozowski — 10 minutes

- Segment Routing Architecture
  http://tools.ietf.org/html/draft-filsfils-spring-segment-routing-04
  http://tools.ietf.org/html/draft-filsfils-spring-segment-routing-mpls-02
  Stefano Previdi — 5 minutes

- Spring Use Case Updates
  http://tools.ietf.org/html/draft-ietf-spring-problem-statement-01
  Stefano Previdi
  http://tools.ietf.org/html/draft-ietf-spring-ipv6-use-cases-01
  Roberta Maglione
  http://tools.ietf.org/html/draft-ietf-spring-resiliency-use-cases-00
  Stephane Litkowski
  Total — 15 minutes

- OAM Use Case
  http://tools.ietf.org/html/draft-geib-spring-oam-usecase-01
  Carlos Pignataro — 10 minutes

- Service Function Chaining Use Case for SPRING
  http://tools.ietf.org/html/draft-xu-spring-sfc-use-case-02
  Xiaohu Xu — 20 minutes

- Segment Routing in IP RAN use case
  http://tools.ietf.org/html/draft-kh-spring-ip-ran-use-case-01
  Bhumip Khasnabish — 15 minutes

- Segment Routing Centralized Egress Peer Engineering
  http://tools.ietf.org/html/draft-filsfils-spring-segment-routing-central-epe-02
  Stefano Previdi — 10 minutes

- BFD Directed Return Path
  http://tools.ietf.org/html/draft-mirsky-mpls-bfd-directed-00
  Greg Mirsky — 10 minutes

- MPLS Path Programming
  http://tools.ietf.org/html/draft-li-spring-mpls-path-programming-00
  Zhenbin Li (Robin) — 10 minutes

Document Status

- Adopted Use Case Drafts
  - SPRING Problem Statement and Requirements
    draft-ietf-spring-problem-statement-01
  - IPv6 SPRING Use Cases
    draft-ietf-spring-ipv6-use-cases-01
  - Use-cases for Resiliency in SPRING
    draft-ietf-spring-resiliency-use-cases-00

IETF

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I E T F®

IETF 90 BnB

IPV6 SEGMENT ROUTING AND SERVICE FUNCTION CHAINING

Objectives

- Demonstrate multiple, independent IPv6 Segment Routing (SR) implementations
  - Routers and hosts
  - Based on draft-previdi-6man-segment-routing-header
- Illustrate interoperability between independent implementations
- Illustrate interoperability with non-IPv6 SR capable routers and hosts
- Illustrate how SR can be used to traffic engineer or steer IPv6 flows
  - SPF versus path with optimized MTU

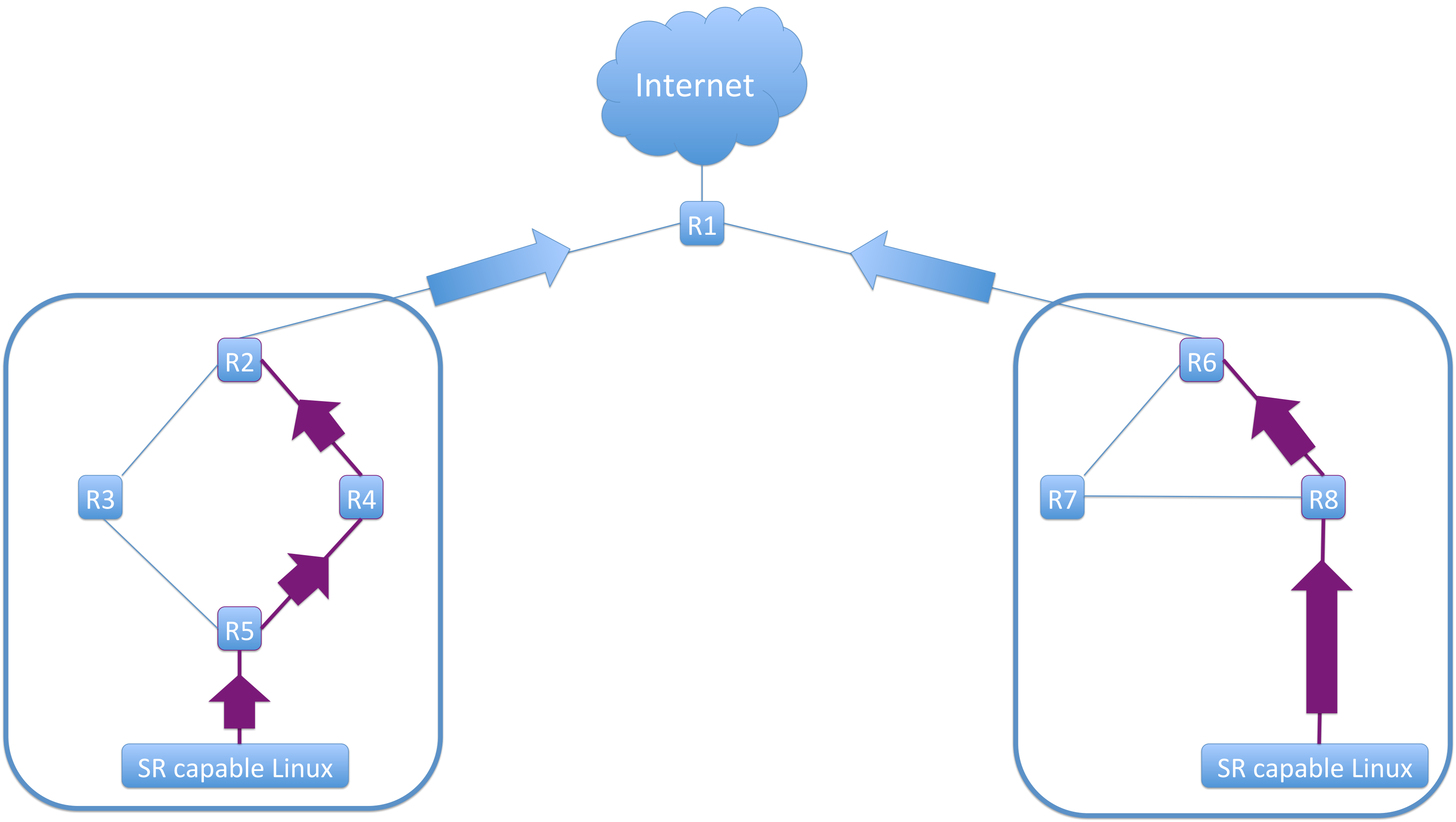
Stretch Goals

- IPv6 SR implementations query a controller to fetch segment IDs
  - getSRHByDestinationAddress()
  - getDefaultSRH()
- Utilize NETCONF/YANG as mechanism to dynamically retrieve SRHs
- Couple SRH with SFC

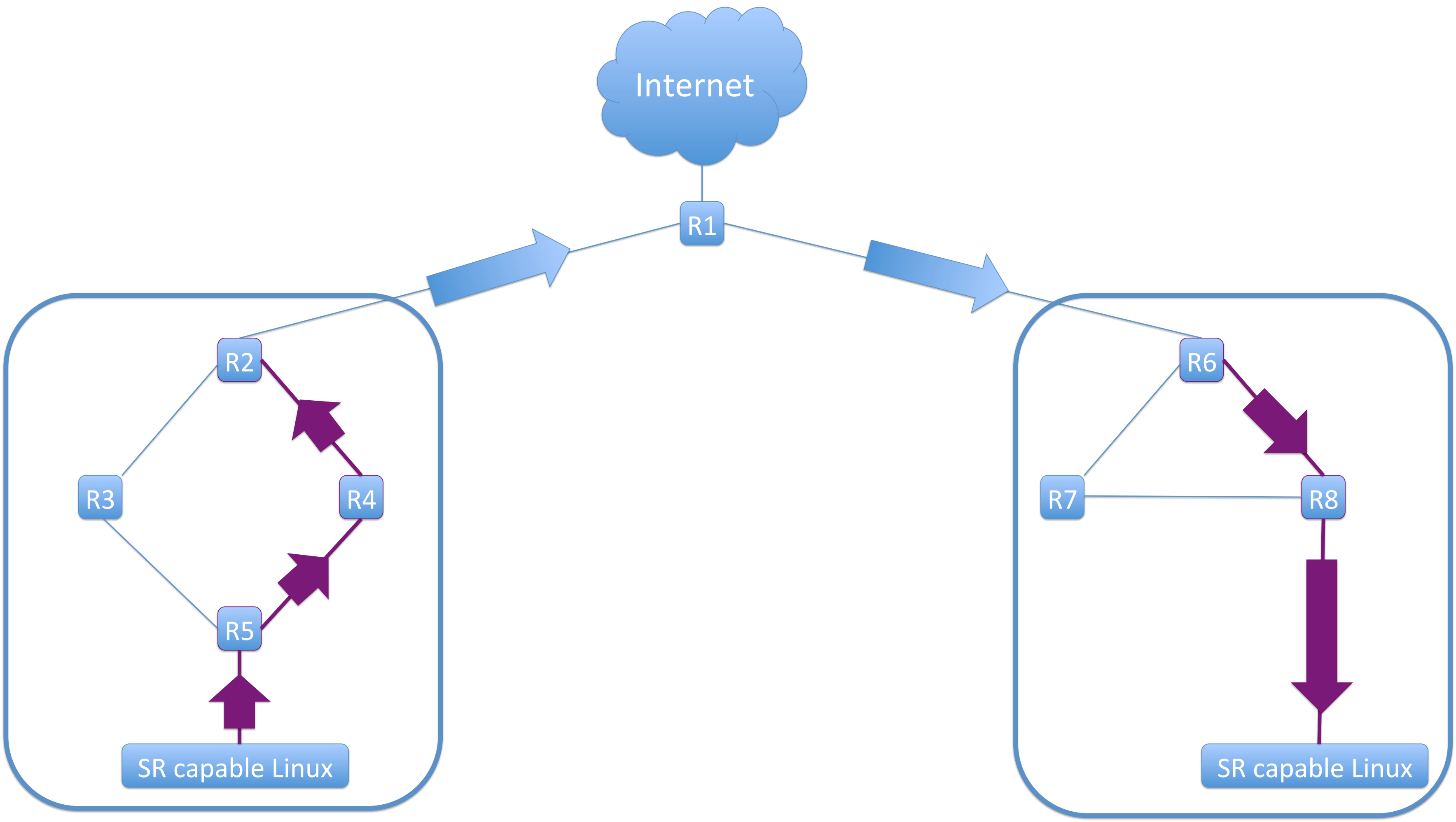
Participants

- Cisco VPP and IPv6 SR support
- SR capable home networking
  - Includes HNCP enabled by cable eRouter (HIPnet)
- Comcast IPv6 SR implementation running on Arista
- Cisco/Ecole Polytechnique IPv6 SR Distributed Cached Video Delivery use case
- University of Belgium Linux IPv6 SR implementation
- TENATIVE
  - Brocade controller for IPv6 SRH via NETCONF/YANG

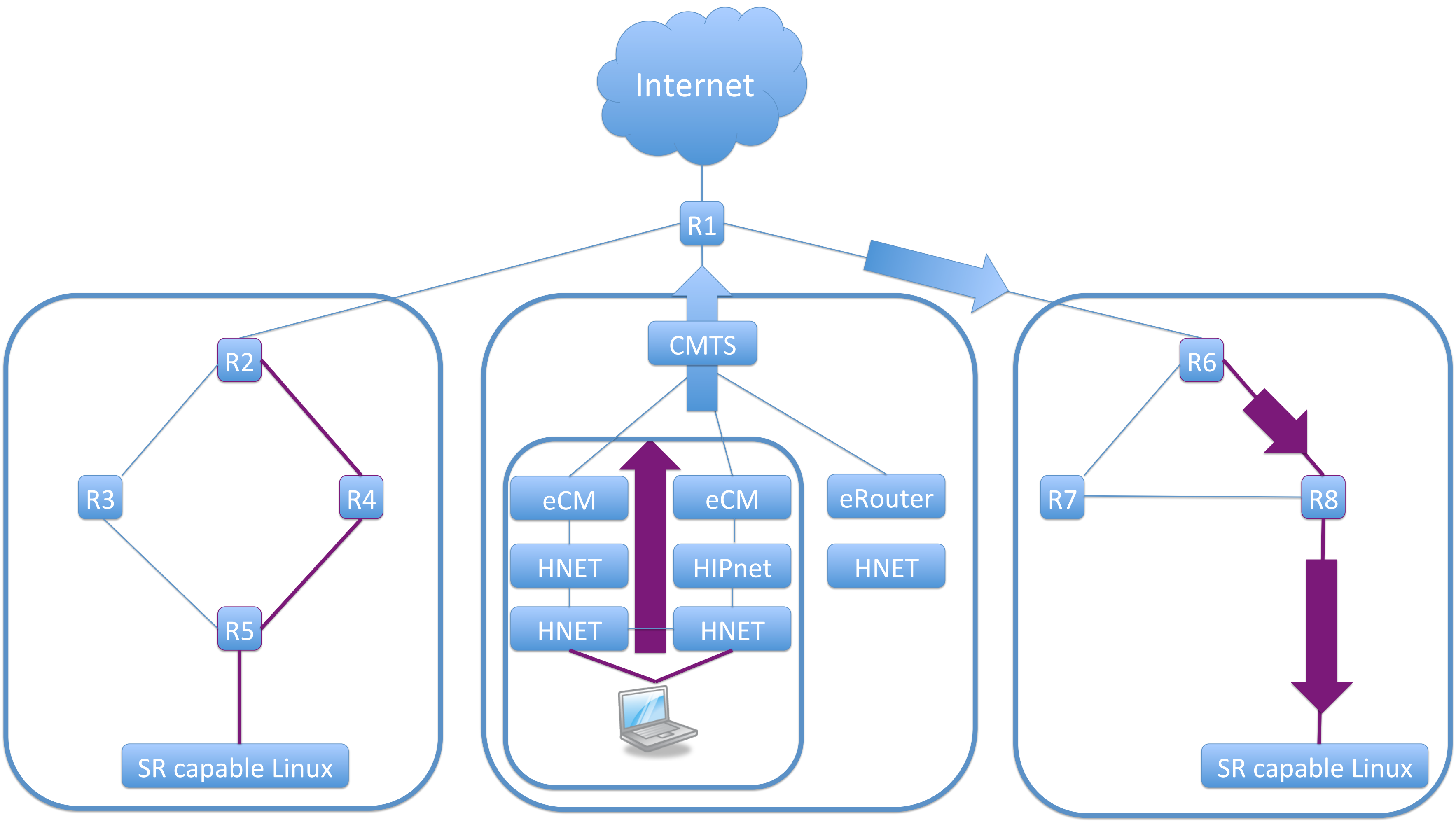
Autonomous SR



SR to SR

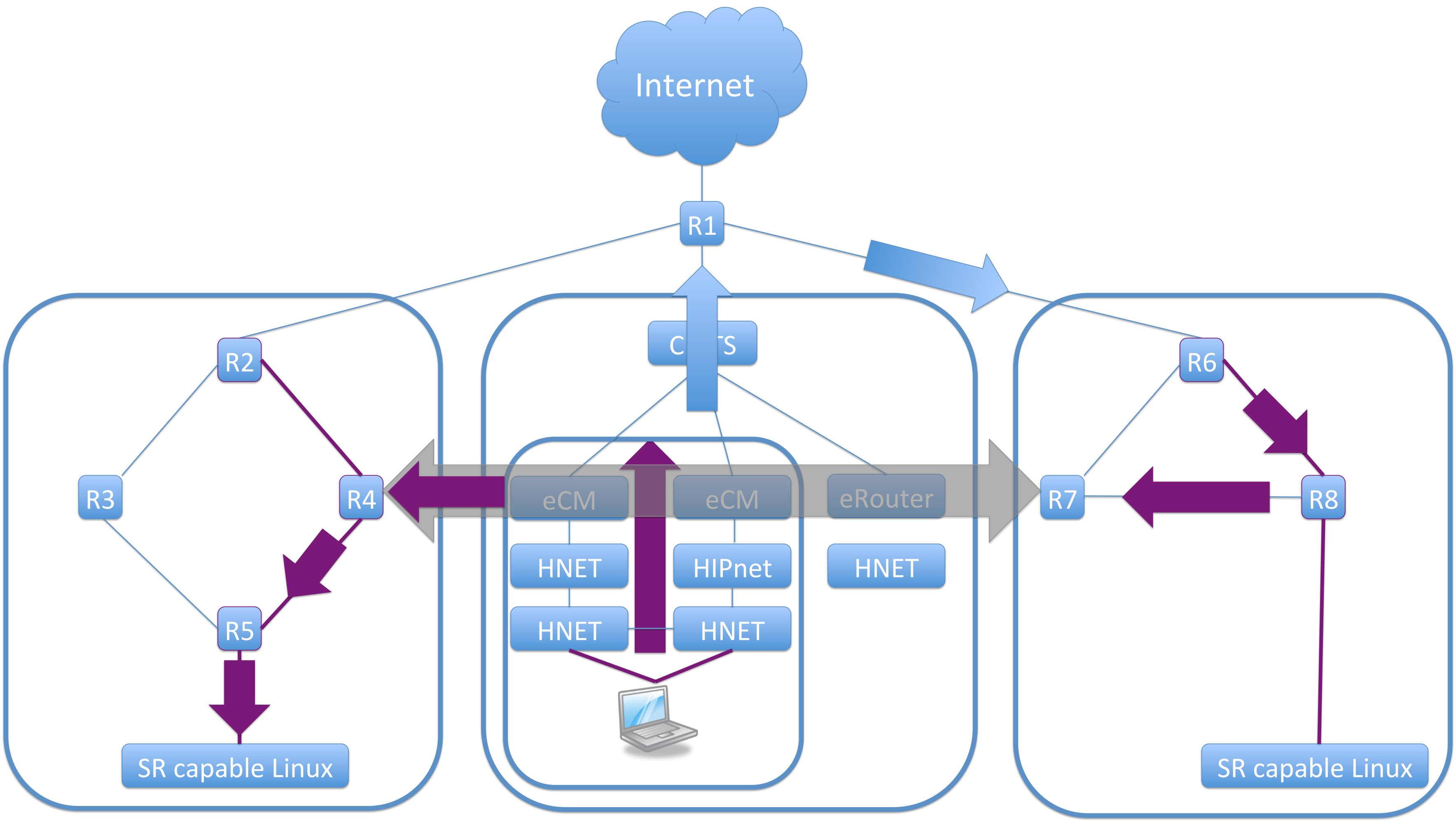

Internet
R1
R2
R3
R4
R5
SR capable Linux
R6
R7
R8
SR capable Linux

Home SR



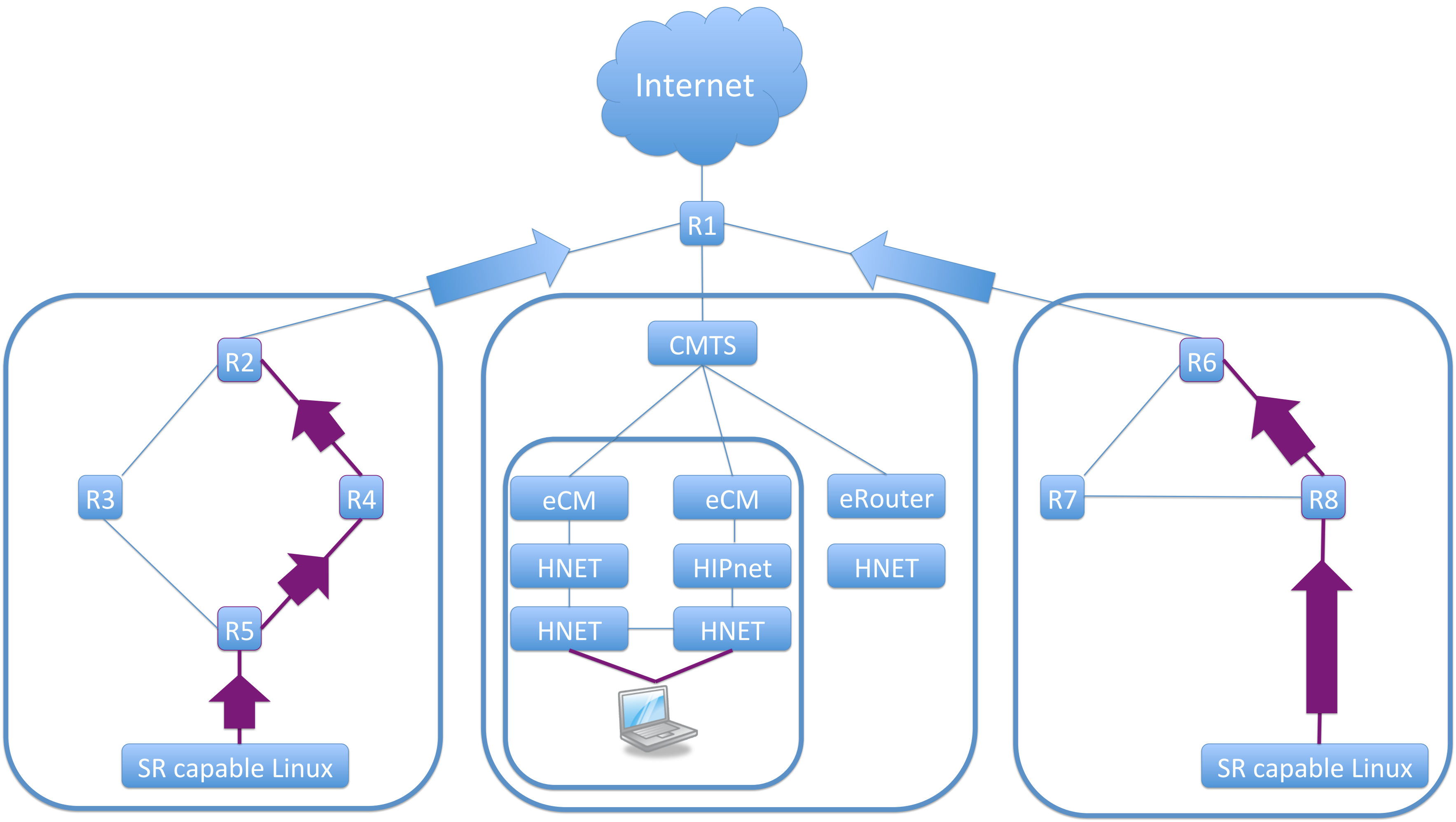
Internet
R1
CMTS
R2
R3
R4
R5
SR capable Linux
eCM
eCM
eRouter
HNET
HIPnet
HNET
HNET
HNET
R6
R7
R8
SR capable Linux

Home to SR to SR



BACKUP

Home to SR to SR



SPRING WG

Segment Routing Drafts Update

S. Previdi

Update

- draft-ietf-spring-problem-statement-01
- draft-filsfils-spring-segment-routing-04
- draft-filsfils-spring-segment-routing-mpls-02
- draft-filsfils-spring-segment-routing-ldp-interop-01
- draft-filsfils-spring-segment-routing-use-cases-00

draft-ietf-spring-problem-statement-01

- WG Item
- Describes use cases (without solution) originally defined in draft-filsfils-spring-segment-routing-use-cases

draft-filsfils-spring-segment-routing-04

- Substantially modified
- Simplified SR description
  - Abstract Model section moved to SR-IPv6 draft
  - IGP/MPLS section moved to SR-MPLS draft
- Defines SR terminology and how SR is mapped onto
  - Existing MPLS dataplane
  - IPv6 dataplane with new EH (new routing header type)

draft-filsfils-spring-segment-routing-mpls-02

- Instantiation of SR over existing MPLS dataplane
- Added section with examples of combinations of SR with
  - LDP-LSPs
  - RSVP-LSPs

draft-filsfils-spring-segment-routing-ldp-interop-01

- No changes since last meeting
- Describes SR interaction with LDP
- Heterogeneous deployments and migrations to SR

draft-filsfils-spring-segment-routing-use-cases-00

- Illustrates how problem statement use cases are addressed by Segment Routing
- Will be updated and renamed
  - "SR Illustration", "SR Applicability" , … ?

Questions?

Thanks!

IPv6 SPRING Use Cases

draft-ietf-spring-ipv6-use-cases-01

J. Brzozowski, J. Leddy - Comcast

I. Leung - Rogers

C. Martin , S. Previdi, M. Townsley, C. Filsfils, R. Maglione - Cisco Systems

Motivations

- MPLS may not be present everywhere:
  - lack of support in some network segments
  - operator's design choice
- MPLS may not be ready for IPv6 only:
  - gaps identified in *draft-ietf-mpls-ipv6-only-gap*

Use Cases

- Spring in the Home Network:
  - Address the problem of multiple egress points
- Spring in the Access Network:
  - Associate traffic flows to different capacity pipes
- Spring in the Data Center:
  - Build Service chaining
- Spring in the Content Delivery Network:
  - Handle Hierarchical caches
- Spring in the Core network:
  - Create Traffic Engineering paths (disjoint, latency, bandwidth, other constraints)

Changes in -01

- Incorporated Wes George's comments about the challenges of running MPLS in IPv6 only networks
- Added reference to *draft-ietf-mpls-ipv6-only-gap*

Next Steps

- Review the document and send comments
- Join us at the **Bits-N-Bites for a live demo!**

Questions?

Thanks!

draft-ietf-spring-resiliency-use-case-00

Pierre Francois, IMDEA Networks Institute

Clarence Filsfils, Cisco Systems

Bruno Decraene, Orange

Rob Shakir, BT

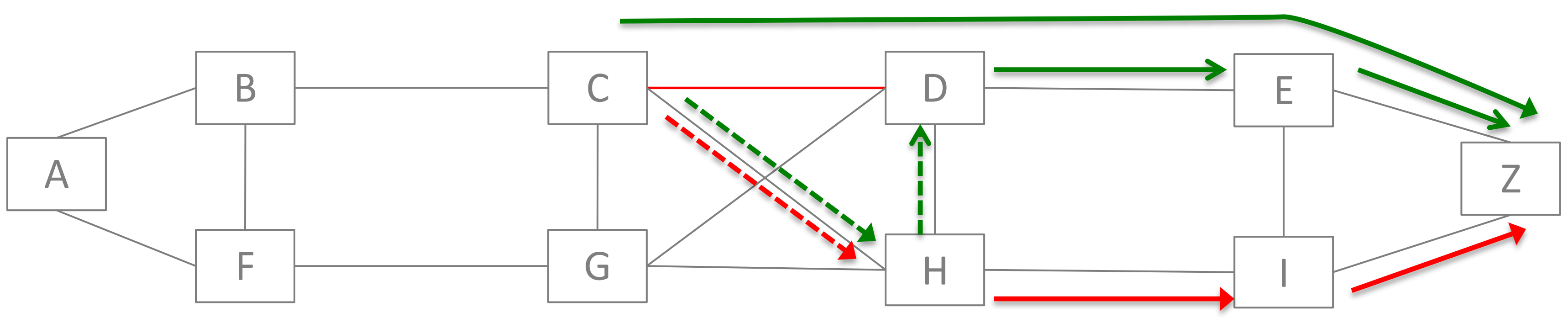
IETF 90, SPRING WG

Objective

- Analyze how resiliency can be achieved in SPRING-like networks
  - Illustrate various approaches
    - Path protection (End to end)
    - Unmanaged local protection (FRR)
    - Managed local protection (FRR)
  - Discuss co-existence of approaches in a network
- Main diff since last presented in IETF 89 (London)
  - Completely solution agnostic
  - Inclusion of different bypass protection approaches

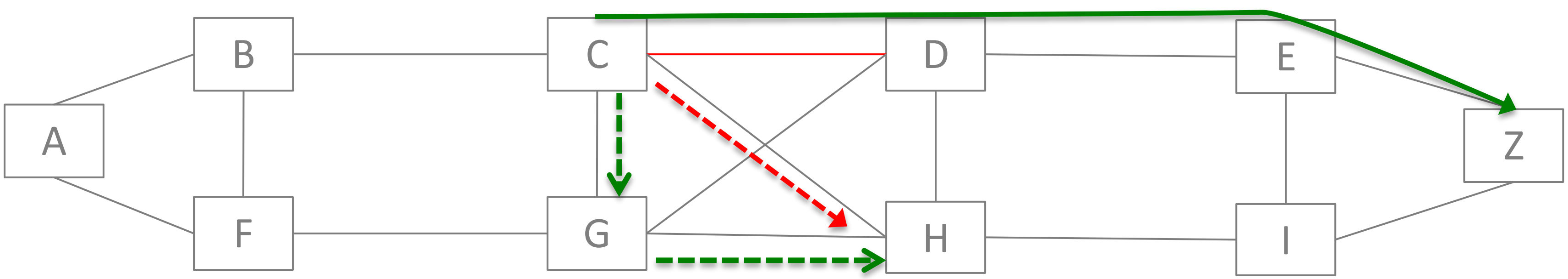
Unmanaged local protection

- Bypass or shortest path protection
  - Bypass: steer traffic to the **next-hop**
  - Shortest path protection: steer traffic to the **destination**



Managed local protection

- When default protection does not fit
  - E.g. CD and CH are part of the same SRLG. → SP wants C to install backup [H], oif G, in order to avoid CH
  - Other examples in draft-ietf-rtgwg-lfa-manageability



- Managed backup paths could stem from
  - Explicit path configuration, or
  - high-level constraints
- Applicable to both bypass and shortest path local protection.

Summary of current approaches

Thank you!

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rob.shakir@bt.com

draft-geib-spring-oam-usecase

IETF 90, Toronto

Presented by Carlos Pignataro, Cisco

Use case: MPLS path **monitoring**.

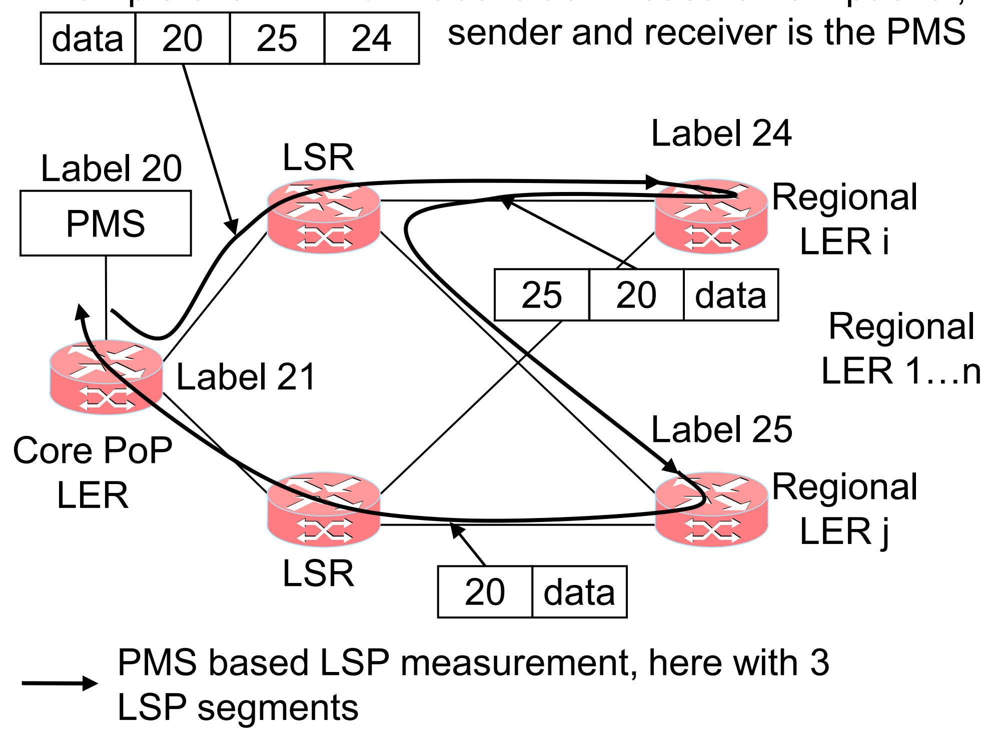
PMS: MPLS Path Monitoring System

Monitoring MPLS paths

- **by Segment Routing, the PMS is aware of the IP and MPLS network topology.**
- **the MPLS path monitoring packets remain in data plane** (part of the use case, not for discussion as a solution option only).
- a single PMS is able to address all LSPs of a domain. Segment Routing allows arbitrary path combinations.
- Example task: PMS based data plane failure detection between LER i and LER j.

In general, all MPLS LSPs of a domain can be monitored this way.

Example of a minimum label stack measurement packet, sender and receiver is the PMS



PMS based LSP measurement, here with 3 LSP segments

draft-geib-spring-oam-usecase
IETF 90, Toronto

Examples for usage given by the draft are path monitoring, monitoring of a link bundle and failure notification.

Great Discussion on the list – our Conclussions:

- The draft text needs to clarify that it proposes monitoring MPLS paths by SPRING. To verify correspondance of data plane and control plane, other tools like RFC4379 or Proxy-lsp-ping are applicable. They are not part of the use case and only serve to illustrate how the use case features may be used to support MPLS network monitoring.
- Further, the expression “solution“ must be removed from the text and replaced by “use case“.

Open Question:

- Should the use case be made more generic for any SPRING dataplane (MPLS & IPv6)?

The basic approach of the use case is stable. The authors ask for WG adoption.

Service Function Chaining Use Case for SPRING

draft-xu-spring-sfc-use-case-02

Xiaohu Xu (Huawei)

Zhenbin Li (Huawei)

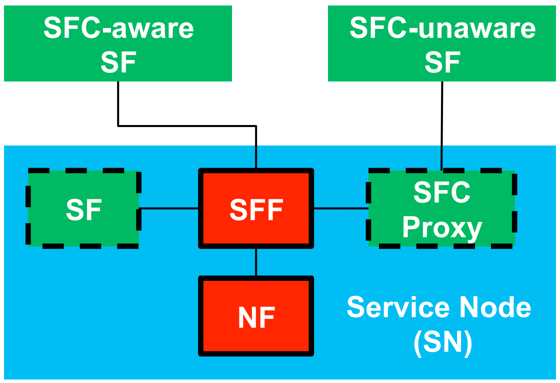
Himanshu Shah (Ciena)

Luis M. Contreras (Telefonica I+D)

IETF90, Toronto

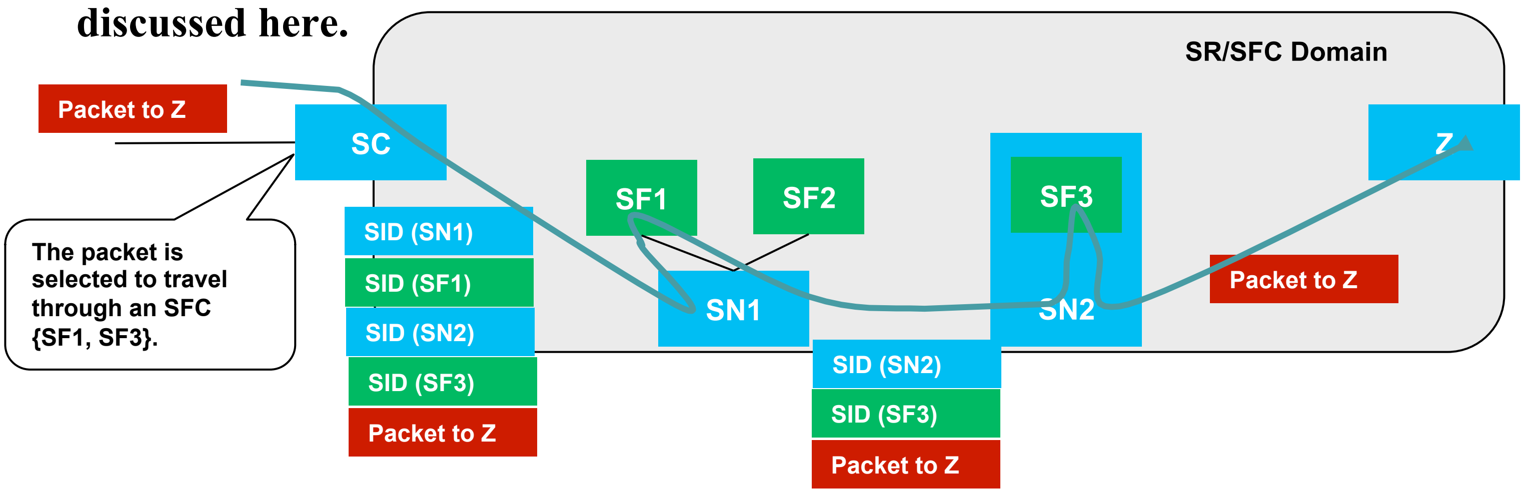
SFC Background

- **Service Function (SF): A function that is responsible for specific treatment of received packets.**
- **SF ID: A unique identifier that represents a service function within an SFC-enabled domain.**
- **Service Node (SN): A physical or virtual element that hosts one or more service functions and has one or more network locators associated with it for service delivery.**
- **Service Function Chain (SFC): An ordered set of service functions that must be applied to packets and/or frames selected as a result of classification**
- **Service Function Path (SFP): The instantiation of an SFC in the network.**
- **Network Forwarder (NF): SFC network forwarders provide network connectivity for SFF and SF.**
- **Service Function Forwarder (SFF): is responsible for delivering traffic received from the SFC network forwarder to one or more connected service functions via information carried in the SFC encapsulation.**



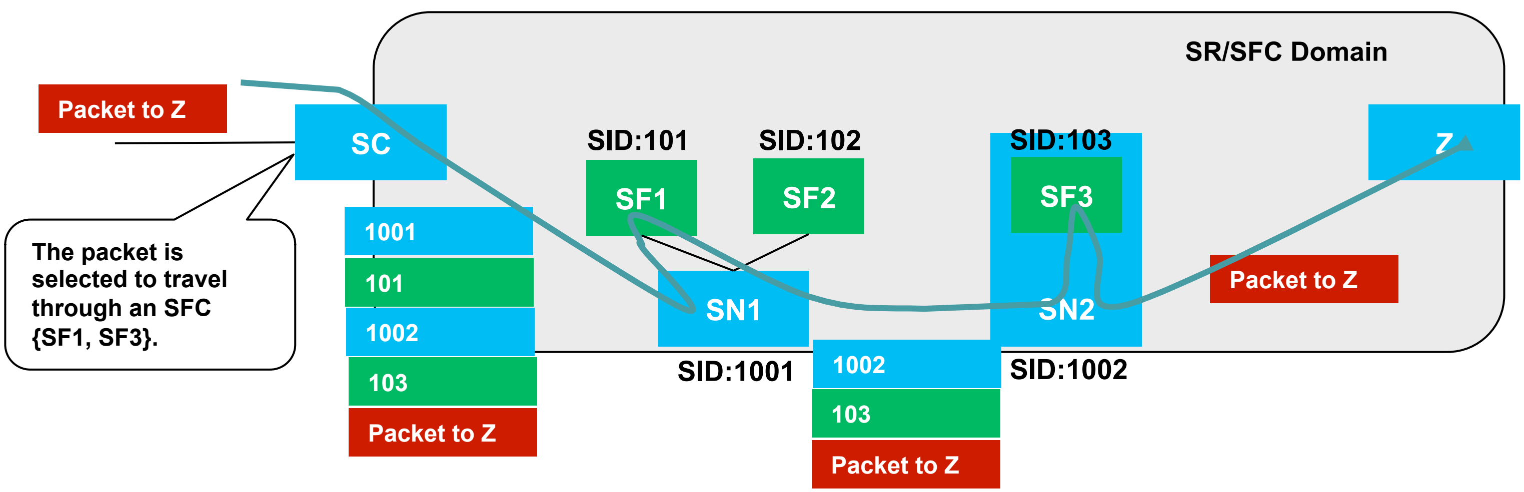
Motivation

- **When applying a particular SFC (e.g., {SF1,SF3}) to the selected traffic, the traffic needs to be steered through the corresponding SFP (e.g.,{SN1, SF1, SN2, SF3}) in the SFC-enabled network.**
- **It's obvious that the SPRING-based source routing mechanism could be leveraged to steer the traffic through a particular SFP.**
  - **The SFP (or the SFC) information could be encoded in the MPLS label stack or the IPv6-SR header. To simplify the illustration, only MPLS-SPRING-based SFC is discussed here.**



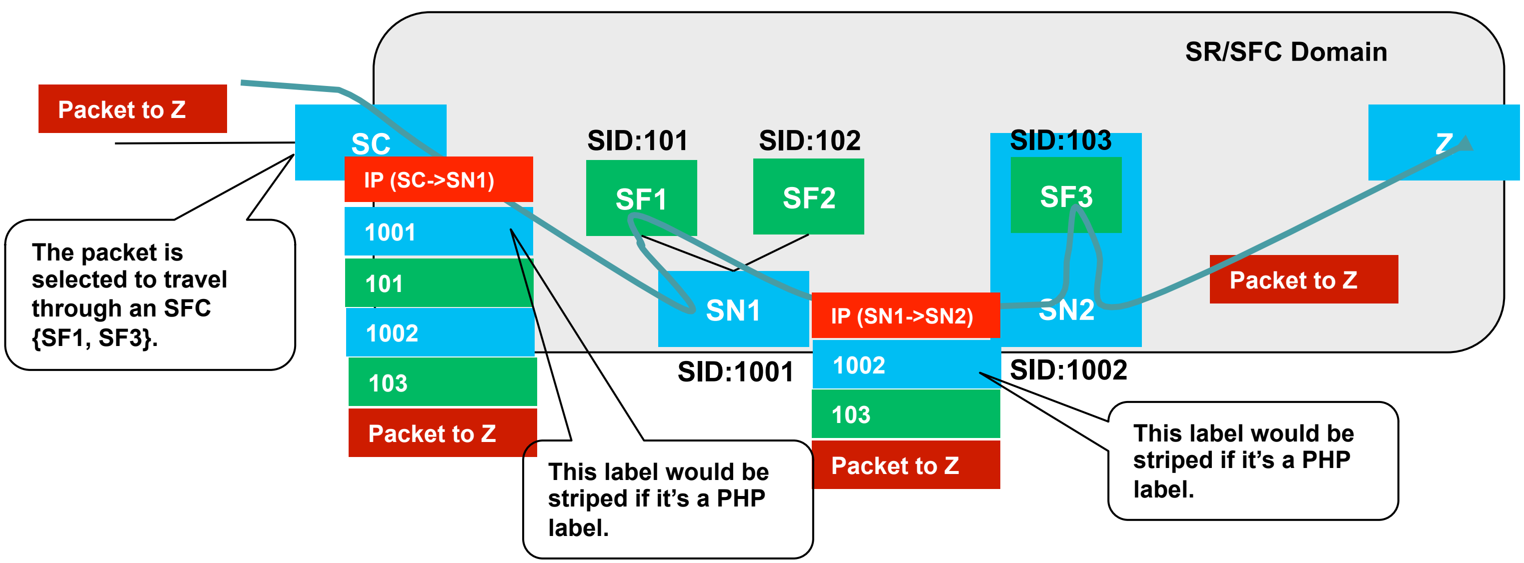
Encoding the SFP as an Label Stack

- **Service Nodes (SN) allocate local MPLS labels for their associated SFs.**
- **An MPLS label stack indicating a particular SFP (i.e., an ordered list of SNs and SFs) to be traversed is imposed on the selected packet by the Classifier.**



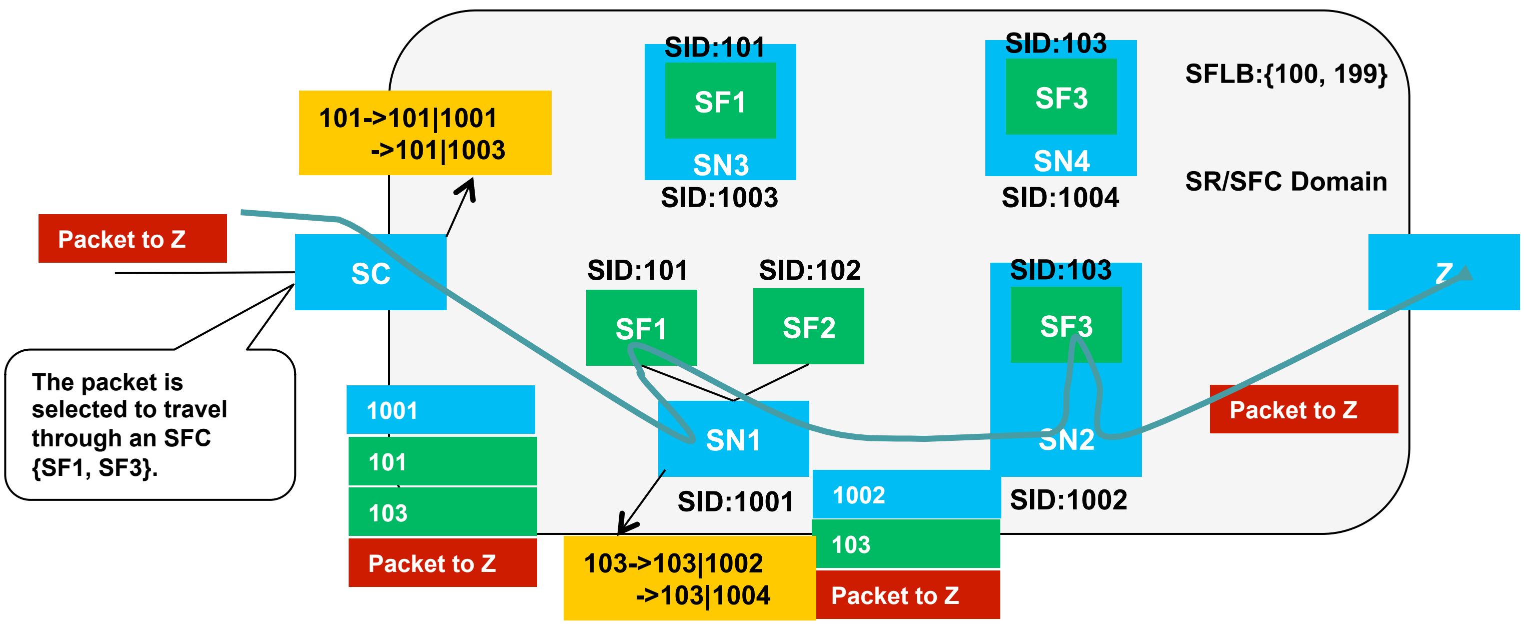
Encoding the SFP as an Label Stack (cont)

- Service Nodes (SN) allocate local MPLS labels for their associated SFs.
- An MPLS label stack indicating a particular SFP (i.e., an ordered list of SNs and SFs) to be traversed is imposed on the selected packet by the Classifier.
- When SNs are separated by IP networks, IP tunnels (e.g., MPLS-over-GRE) instead of LSPs could be used between SNs.



Encoding the SFC as a Label Stack

- **Once global labels are allocated for SFs, the Classifier could choose to impose an MPLS label stack just indicating a particular SFC (i.e., an ordered list of SFs),**
  - **SNs/Classifiers should be capable of resolving the appropriate SN for the next SF.**



Encoding the SFC as a Label Stack

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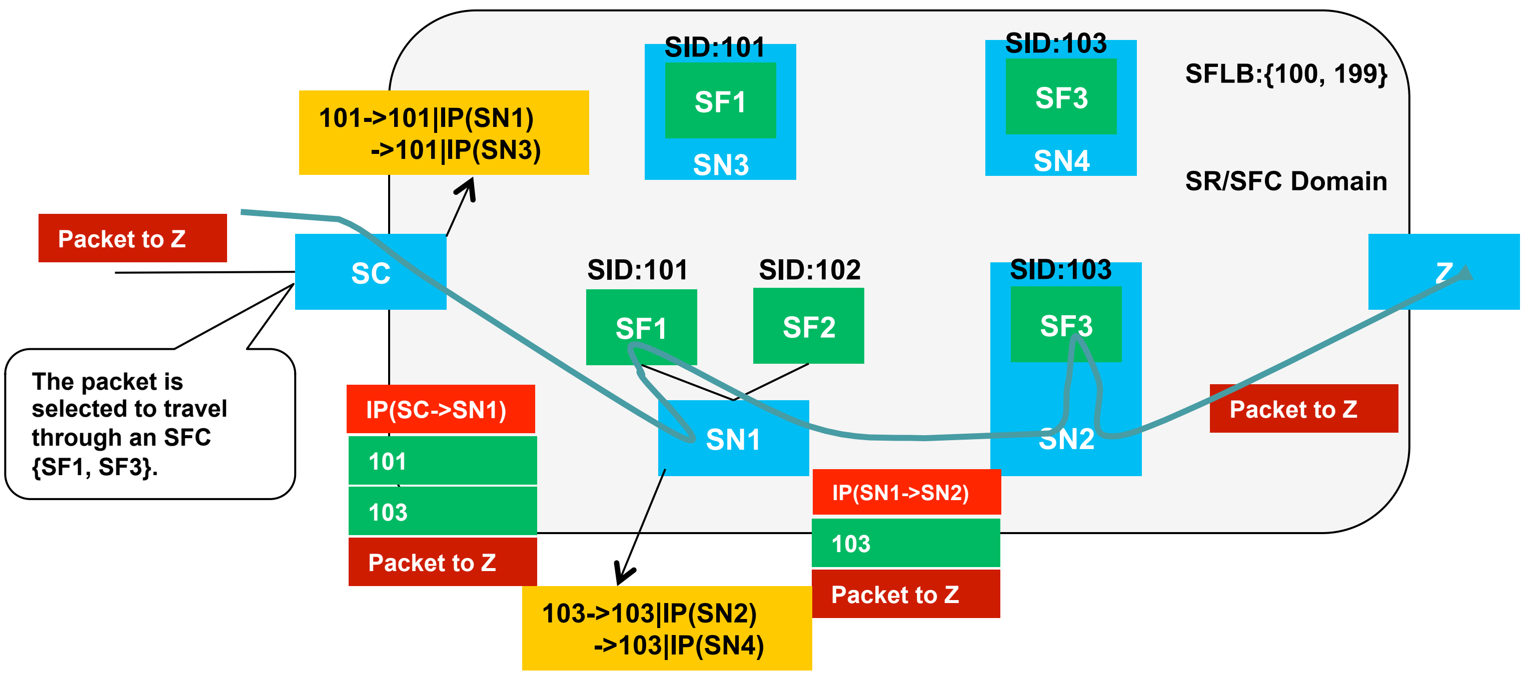
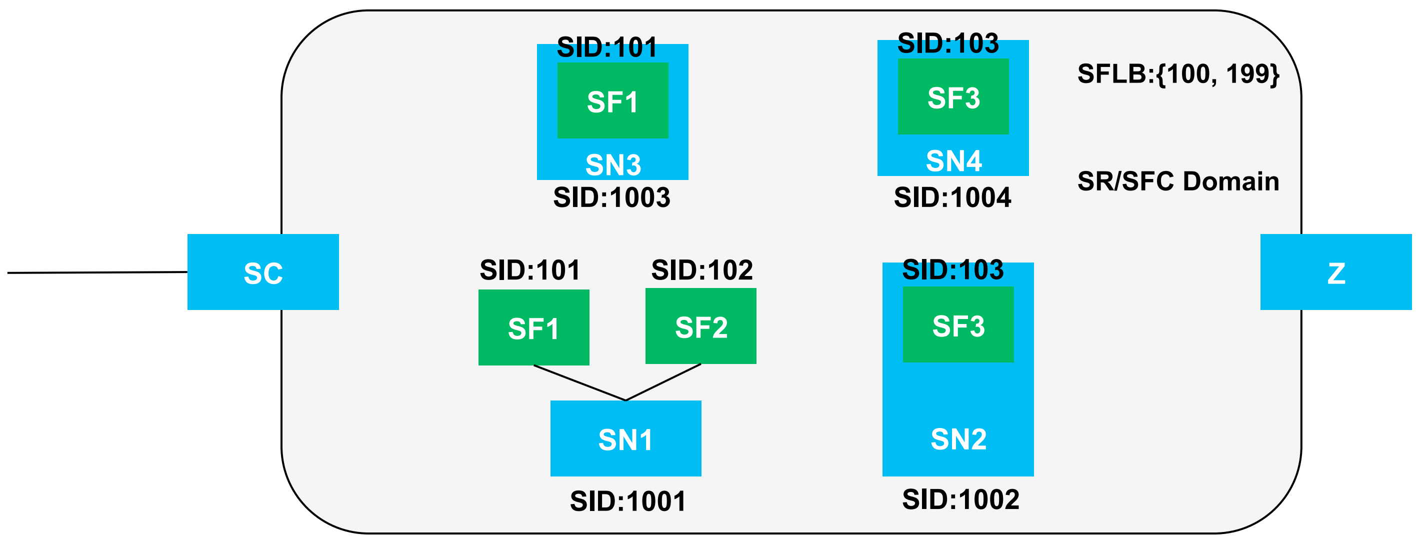
  - **SNs/Classifiers should be capable of resolving the appropriate SN for the next SF.**
  - **When SNs are separated by IP networks, IP tunnels (e.g., MPLS-over-GRE) instead of LSPs could be used between SNs. Furthermore, no need for node SIDs anymore.**



How to Allocate Global Labels for SFs

- A common label block, referred to as SF Label Block (SFLB) is reserved by all SNs and Classifiers for SF SIDs.
- The unique label for a given SF could be automatically determined by adding the SF ID of that SF to the first label value of the above SFLB.



Next Step

- **WG adoption?**

draft-kh-spring-ip-ran-use-case-01.txt

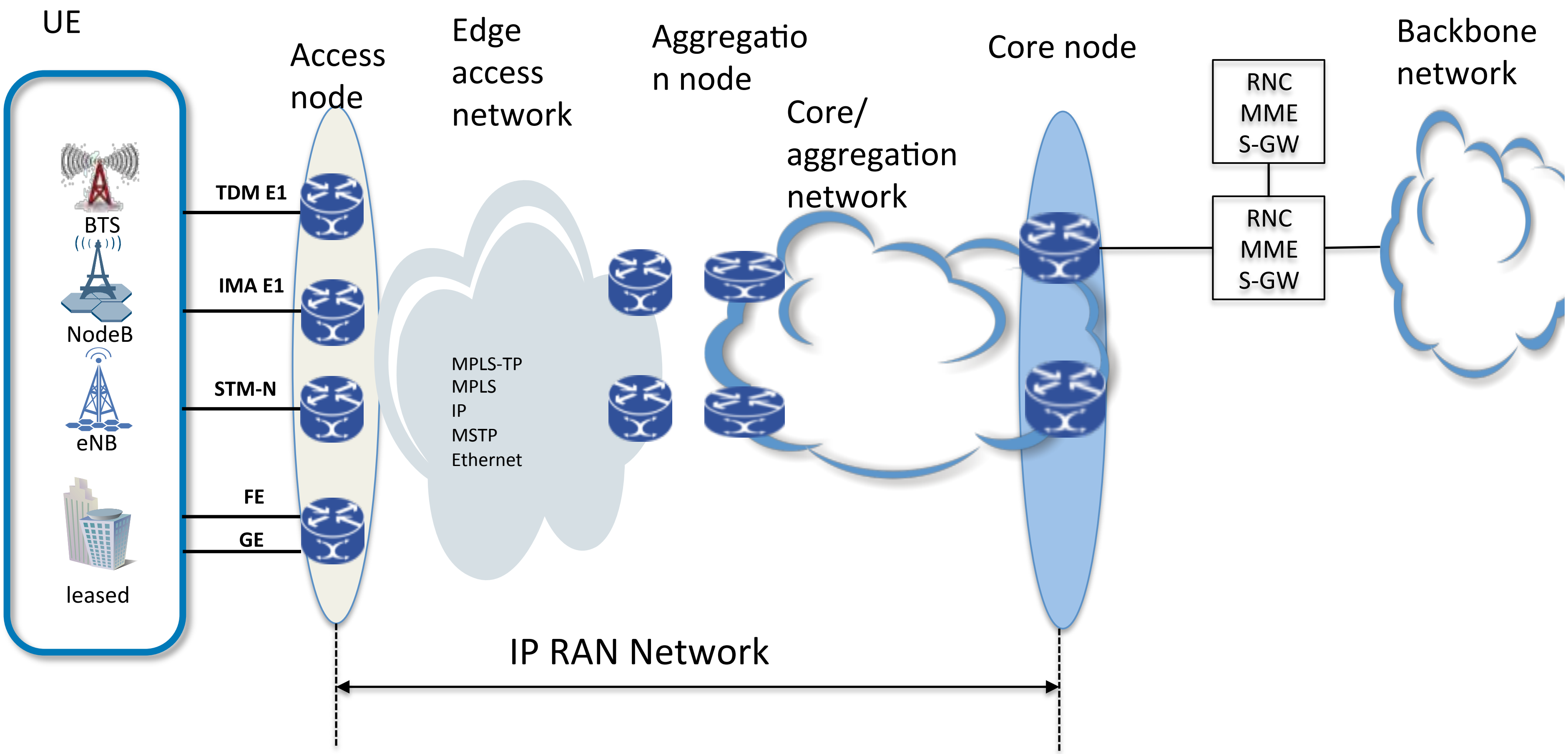
SPRING WG
IETF90, Toronto, Canada, July 23, 2014

Bhumip Khasnabish(ZTE USA)
Fangwei Hu(ZTE)
Luis M. Contreras(Telefonica I+D)

Motivation

- Try to analysis the segment routing use case in IP RAN network
- Initiate the discussion of the topic
- Have a consistent agreement
    - Segment routing is useful and helpful for IP RAN network (based on discussion with Operators)

Traditional IP RAN network



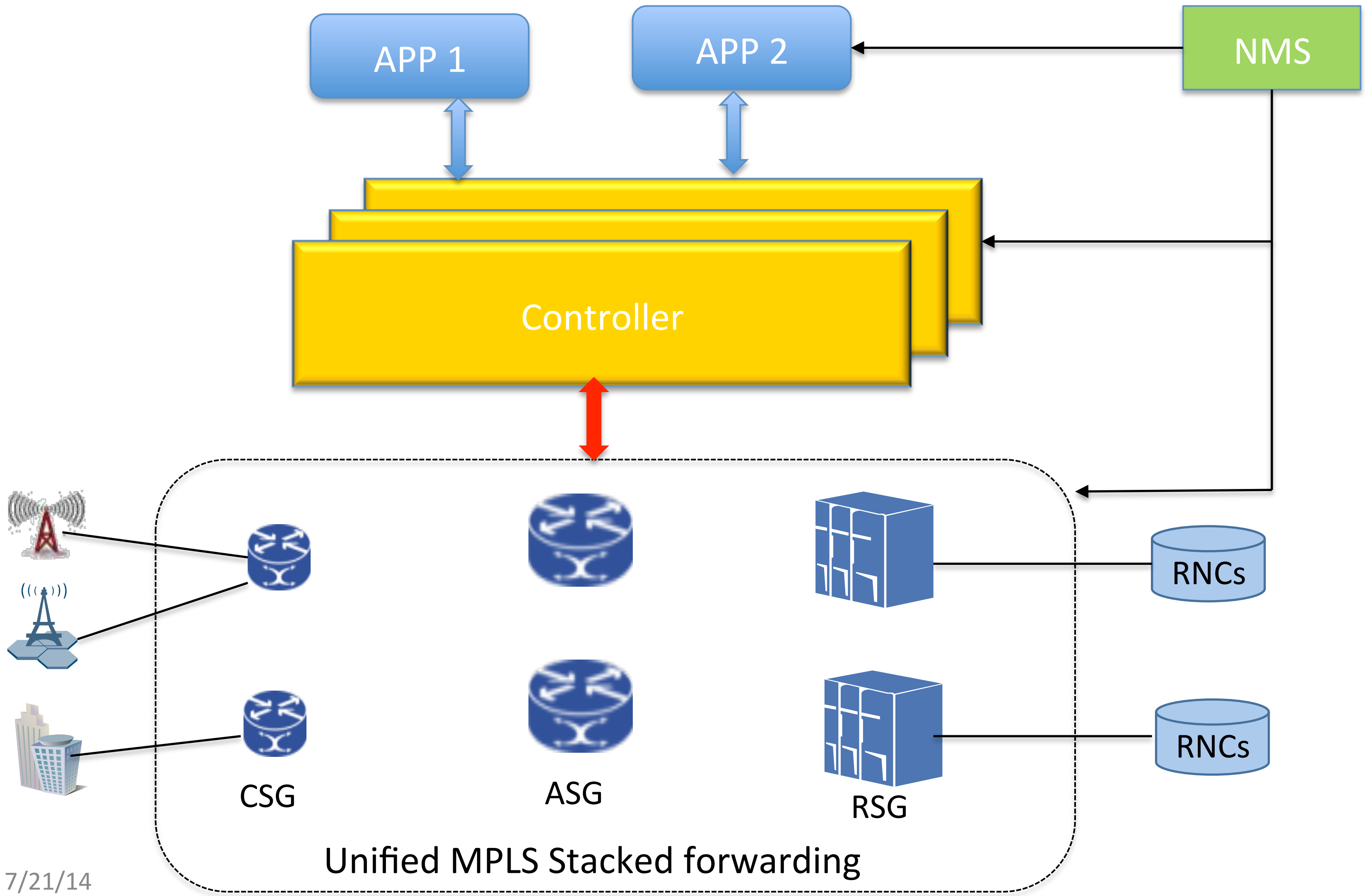
Requirements for traditional IP RAN network

- End-to-end transport LSP
- OAM
- Protection
- Scalability
- Security
- Survivability
- Flexibility and Overheads

What Segment Routing can bring to IP RAN

- Simplifies
  - end-to-end LSP tunnel establishment
  - management and operations
- Supports
  - Network virtualization
  - Unified OAM mechanism
  - Traffic engineering
  - Fast ReRoute
  - Flexible policy deployment

Unified Service Deployment



Requirements for the controller

- Needs to support
  - Network topology collection
  - Network resource management
  - Route computation
  - Distribution of MPLS label to the forwarding nodes
  - Interworking and extensions
- Support service chaining
- Support secure channel

Next Step

- Solicited request for comments and suggestions
- Inviting others to work with us on this topics

Thank you!

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SPRING WG

Segment Routing Centralized Egress Peer Engineering

draft-filsfils-spring-segment-routing-central-epe-02

C. Filsfils, S. Previdi, K. Patel (Cisco)
E. Aries, S. Shaw (Facebook)
D. Ginsburg, D. Afanasiev (Yandex)

IETF90 – Toronto, July 2014

Motivations

- draft-spring-problem-statement section 5.1.1.2.

```
                 +------+
                 |      |
             +---D      F
+---------+ /    | AS 2 |\ +------+
|         |/     +------+ \|   Z  |
A         C                |      |
|         |\     +------+ /| AS 4 |
B   AS1   | \    |      |/ +------+
|         |  +---E      G
+---------+      | AS 3 |
                 +------+\
```

- Requirement: steer traffic towards an egress point, an egress interface (or a set of), a peer (or a set of), a peer AS, or a combination of all the above

Motivations

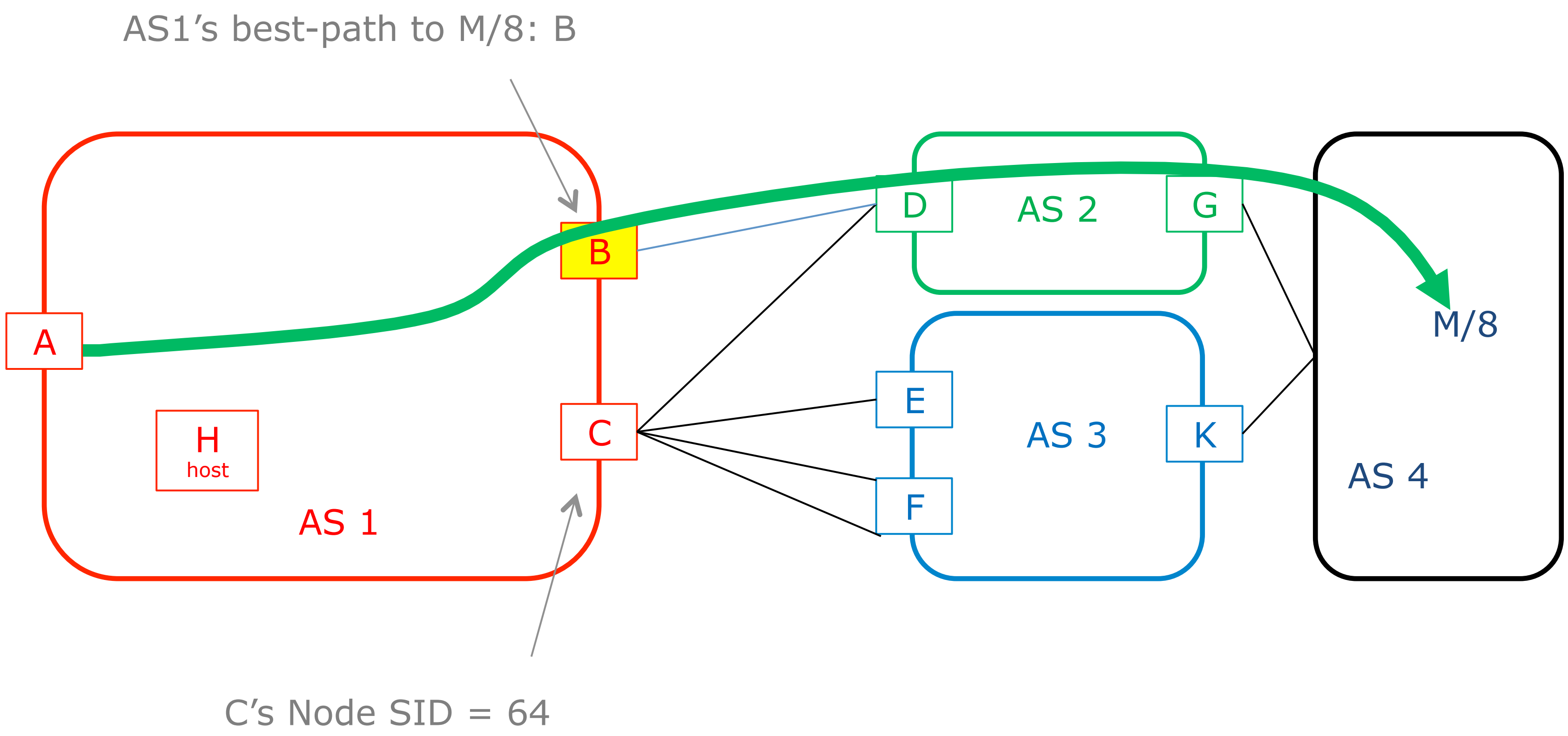
- Revised diagram in draft-filsfils-spring-segment-routing-central-epe

```
+----------+      +-------+
|          |      |       |
|    H     B------D       G
|          | +---/| AS 2  |\   +-------+
|          |/     +-------+ \  |       |---L/8
A    AS1   C---+             \|        |
|          |\\  \  +-------+ /| AS 4   |---M/8
|          | \\  +-E       |/ +-------+
|    X     |  \\   |       K
|          |   +===F AS 3  |
+----------+       +-------+
```

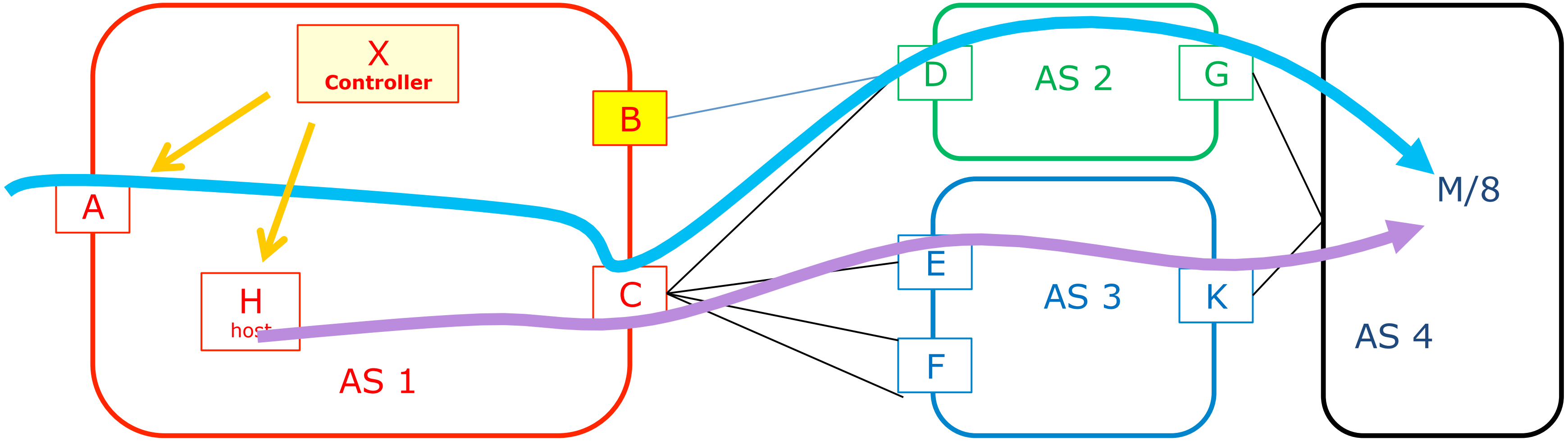
- Section 1.2 Problem Statement

  A **centralized controller** should be able to instruct an ingress PE or a content source within the domain to use a specific egress PE and a specific external interface to reach a particular destination.

Reference Diagram

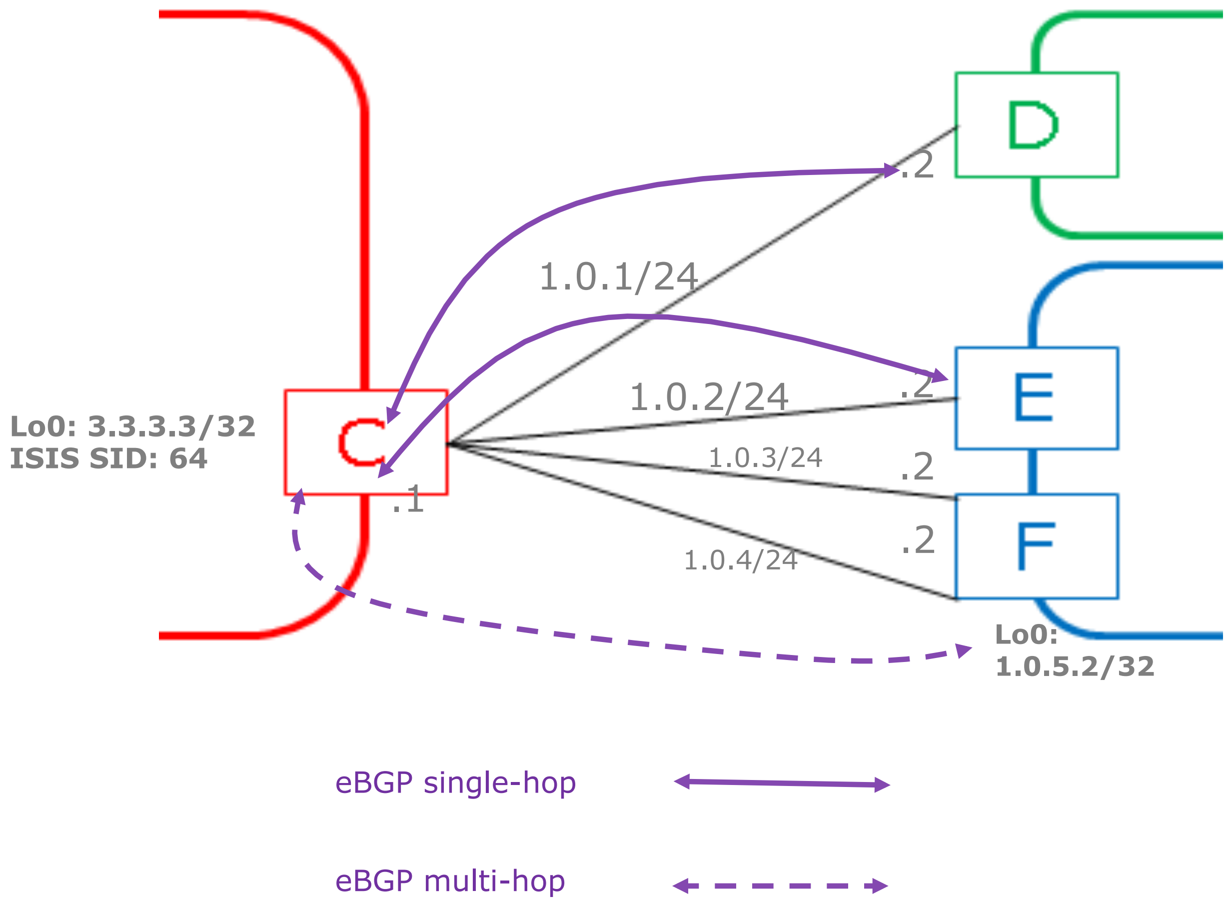


Objective: centralized egress peer engineering



- Per-Flow TE state only at the source node
  - Ingress router or directly at the source host

eBGP Peering Topology
BGP Peering Segments

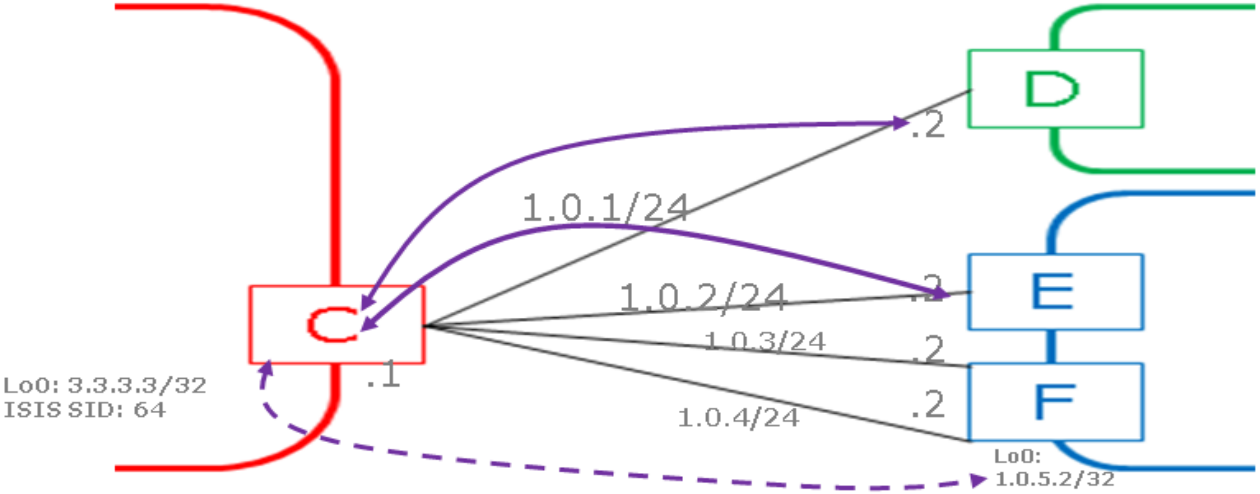


Automated BGP Peering SID allocation

BGP Peering SID’s in C’s MPLS Dataplane

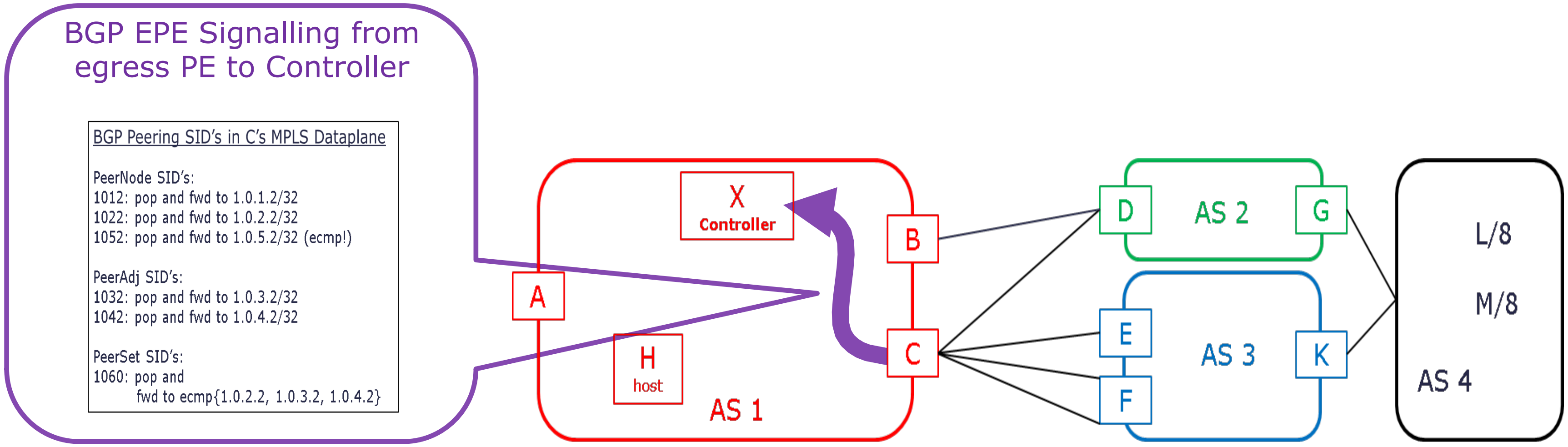
PeerNode SID’s:
1012: pop and fwd to 1.0.1.2/32 (D)
1022: pop and fwd to 1.0.2.2/32 (E)
1052: pop and fwd to 1.0.5.2/32 (ecmp to F)

PeerAdj SID’s:
1032: pop and fwd to 1.0.3.2/32 (upper link to F)
1042: pop and fwd to 1.0.4.2/32 (lower link to F)



BGP EPE Routes

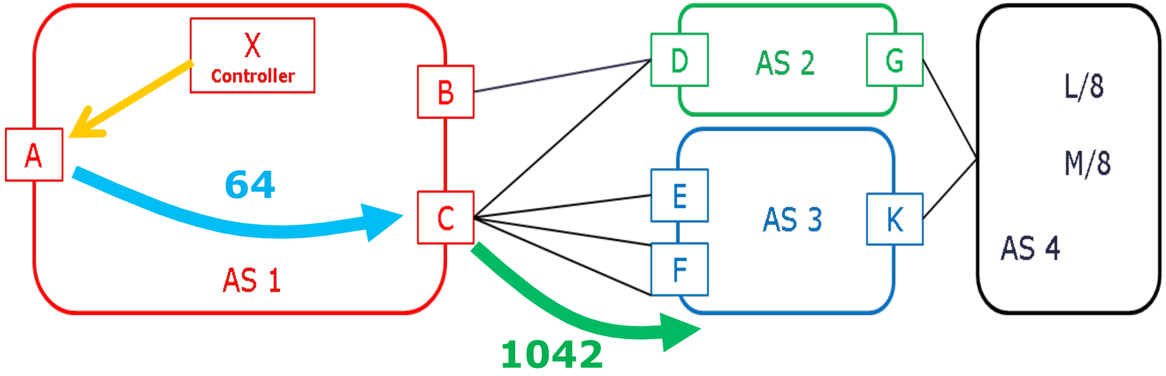
- The controller learns the BGP Peering SID's and the external topology of the egress border router via BGP-LS EPE routes
  – draft-previdi-idr-bgpls-segment-routing-epe



Controller – Decision

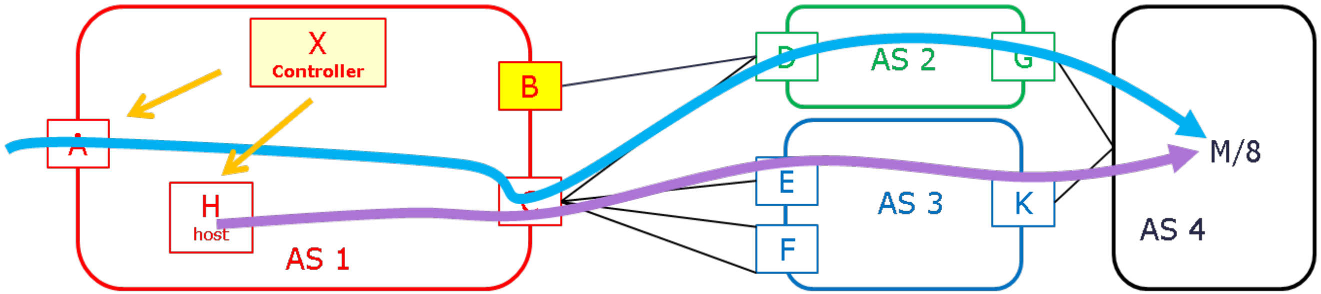
- Collects valid internet routes from peers
- Collect performance information across peers
  - EPE solution allows to target probes across probed peer
- Based on business policy and performance information, decides to engineer a flow via an explicit peer different than the best-path
- Outside the scope of the IETF drafts

Controller Programming



- Draft does not define/mandate any specific programming method (out of scope)
- As an illustrative example:
  - PCEP extension to instantiate at A an SR Traffic Engineering Tunnel
  - Tunnel1: push {64, 1042}
  - PBR Policy: any traffic to M/8, set next-hop = tunnel T1
- Other methods: BGP-3107 policy route, Netconf…

Conclusion



- No assumption on the iBGP design with AS1 (nhop-self is fine)
- Integrated intra-domain and inter-domain TE
- EPE functionality only required at EPE egress border router and EPE controller
- Ability to deploy the same input policy across hosts connected to different routers
  - global property of the IGP prefix SID
- Per-flow TE state only at the source host or ingress border router

Questions?

Thanks!

Directed BFD Return Path

draft-mirsky-mpls-bfd-directed-00

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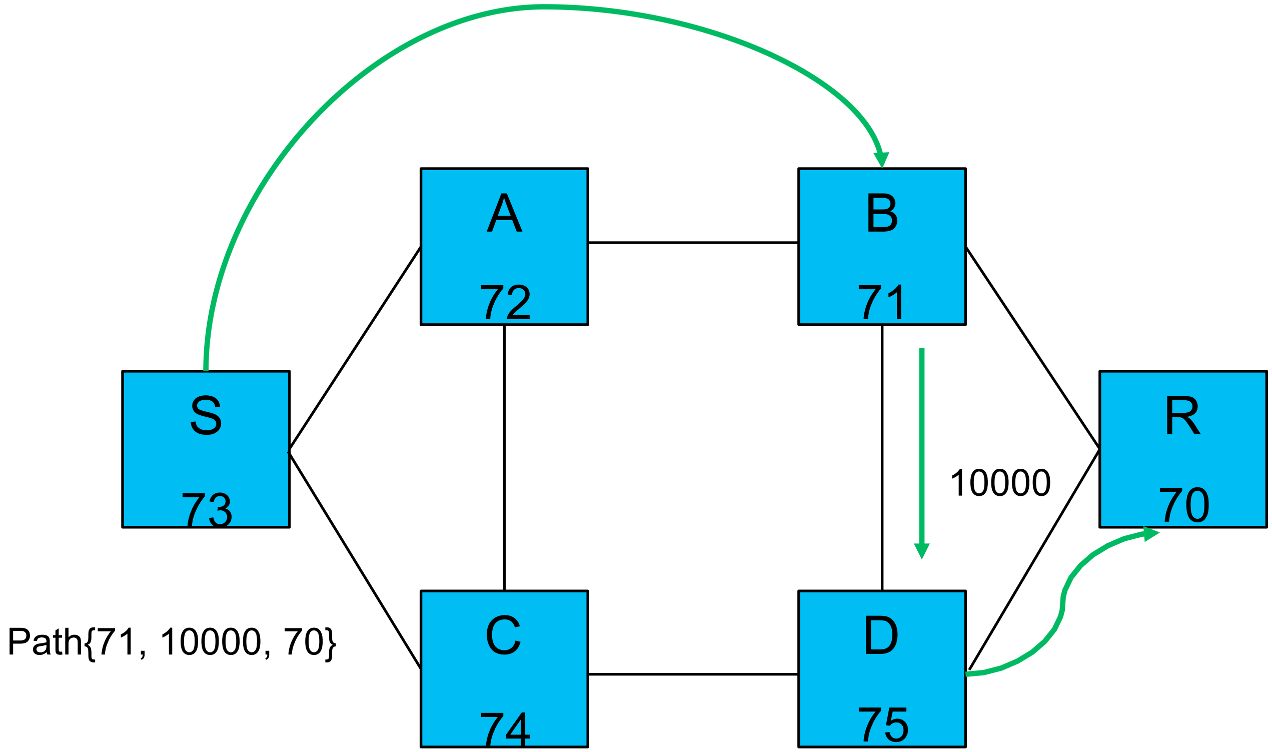
IETF90 July, 2014, Toronto

Problem Statement



- Node S wants to monitor the Path{71, 10000, 70}
- Node R would use the best route R-B-A-S for BFD session reverse direction
- If link R-B fails, e.g. overloaded or high error rate, S will detect failure and may treat it as bi-directional defect. Hence we get false positive that may trigger unnecessary actions on the tunnel, e.g. protection switchover.

Problem Statement

- Ability to interpret uni-directional defect as by-directional failure depends on co-routedness of OAM flows
- BFD implicitly uses co-routedness of IP:
  - single hop – IP links presumed bi-directional co-routed;
  - multi-hop – IP best route model creates bi-directional and mostly (ECMP is the exception) co-routed BFD sessions
- Directing reverse direction of an BFD session is useful, e.g. when forward direction uses explicitly routed path
- MPLS data plane – primary interest
- IPv6 data plane - considered

Proposed solution

- LSP Ping is used to bootstrap a BFD session in IP/MPLS environment [RFC 5884]
- Introduce BFD Reverse Path TLV
  - sub-TLV would characterize the return path
  - can re-use sub-TLVs defined in IANA registry MPLS LSP Ping TLVs sub-registry sub-TLVs for TLV Type 1
  - introduce two new sub-TLVs:
    - Segment Routing MPLS Tunnel
    - Segment Routing IPv6 Tunnel
  - New sub-TLVs may be used in Return Path TLV [RFC 7110]

BFD Reverse Path TLV

<table>
<tr><td>BFD Reverse Path TLV Type</td><td>Length</td></tr>
<tr><td colspan="2">Reverse Path sub-TLV</td></tr>
</table>

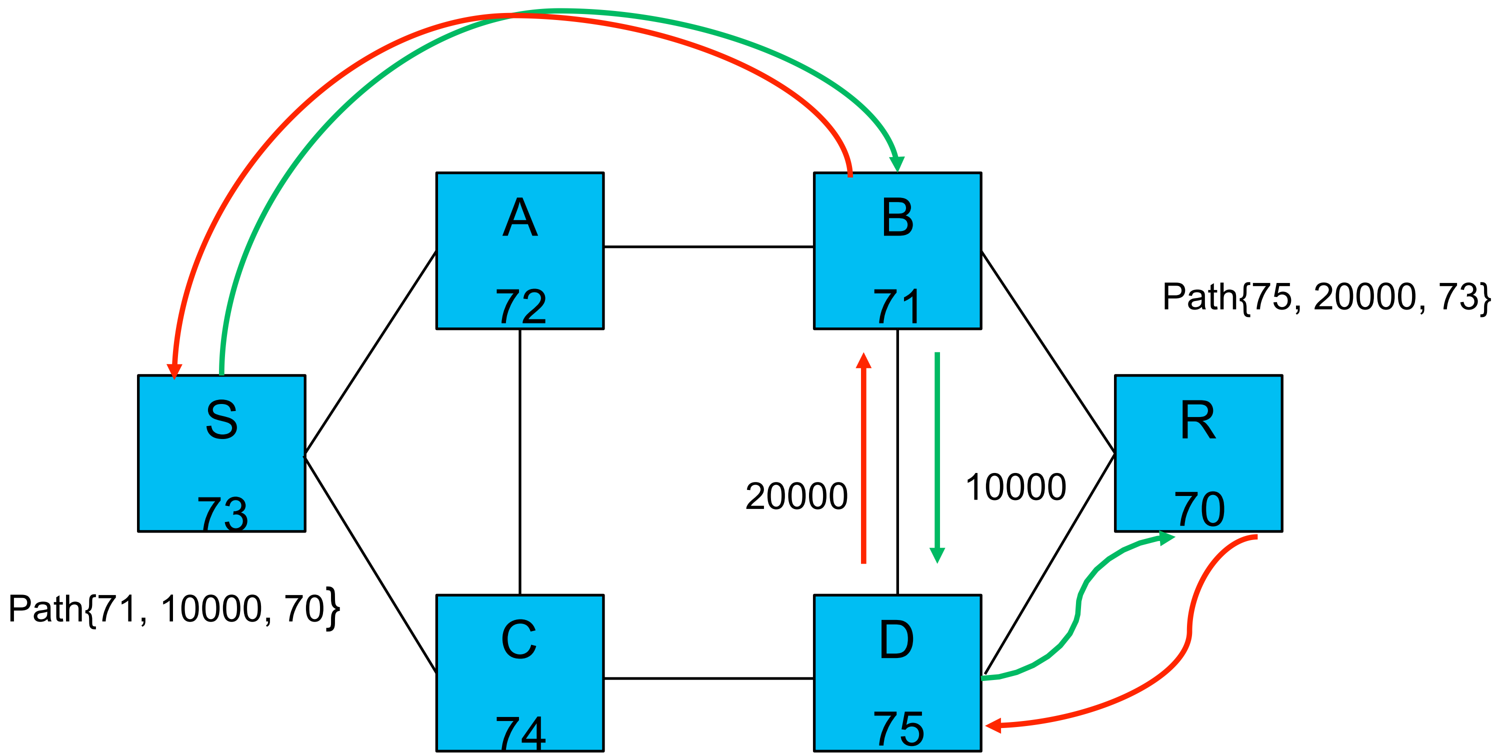
Segment Routing MPLS Tunnel sub-TLV

SR MPLS Tunnel sub-TLV Type	Length
Label Stack Element	
Label Stack Element	
Label Stack Element	
Label Stack Element	

Segment Routing IPv6Tunnel sub-TLV

SR IPv6 Tunnel sub-TLV Type	Length
IPv6 Prefix	
IPv6 Prefix	

Control reverse direction of BFD session



- Node S wants to monitor the Path{71, 10000, 70}
- Node R would use the best route R-B-A-S for BFD session reverse direction
- Node R must be instructed to use Path{75, 20000, 73} to maintain BFD session over bi-directional co-routed associated OAM channel

Next steps

- Solicit comments & feedback from the WG

Use Cases and Framework of Service-Oriented MPLS Path Programming (MPP)

draft-li-spring-mpls-path-programming-00

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Introduction

- SPRING architecture for unicast traffic (Segment Routing) has been proposed to cope with the use cases in traffic engineering, fast re-reroute, service chain, etc. It can leverage existing MPLS dataplane without any modification.
- In fact, the label stack capability in MPLS would have been utilized well to implement flexible path programming to satisfy all kinds of requirements of service bearing.
- This document defines the concept of MPLS path programming, then proposes use cases, architecture and protocol extension requirements in the service layer for the SPRING architecture.

History Review (1)

- Hierarchical LSP: e.g. Option C Inter-AS VPN which adopts LDP over TE as the transport tunnel in the ingress node.

```
+----------+---------+---------+---------+
|VPN Prefix|   BGP   |   LDP   | RSVP-TE |
|   Label  |  Label  |  Label  |  Label  |
+----------+---------+---------+---------+
```

```
+----------+---------+---------+---------+------------+
|VPN Prefix|   BGP   |   LDP   | RSVP-TE | BYPASS FRR |
|   Label  |  Label  |  Label  |  Label  |    Label   |
+----------+---------+---------+---------+------------+
```

- The MPLS label stack in the MPLS path of the example shows limited programming capability. The limitation has two reasons:
  - The limited label usage. MPLS label is always for reachability.
  - The limited path calculation capability in the distributed environment. SPF is always adopted or complex configuration for traffic engineering.

History Review (2)

- MPLS Label beyond reachability:
  - Entropy Label
  - Source Label
  - Global label use cases defined in [draft-li-mpls-global-label-usecases].
- Central Control for Enhanced MPLS Path Calculation and label combination.
  - Stateful PCE
  - PCE for Segment Routing

MPLS Path Programming Capability (1)

- MPLS path is composed by label stacks. Since in the label stack the labels in different layers can represent different meaning and the depth of the label stack can be unlimited in theory, it is possible to make up all kinks of MPLS paths based on the combination of labels.
- If we look on the combination of MPLS labels as programming, it can be seen that the MPLS path has high programming capability.
- As the introducing of central control in the network, the flexible MPLS programming capability becomes possible owing to two factors: 1. It becomes easier to allocate label for more purposes than reachability; 2. It is easy to calculate the MPLS path in a global network view.

MPLS Path Programming Capability (2)

- There are multiple layers for MPLS path to bear services which is shown in the following figure:

```
        +---+                                   +---+
+--+    |   |    +---+    +---+    +---+    |   |    +--+
|CE|----|PE1|----| P |----| P |----| P |----|PE2|----|CE|
+--+    |   |    +---+    +---+    +---+    |   |    +--+
        +---+                                   +---+

 o--------o--------- Service Layer-----------o--------o

          o--------- Network Layer -----------o

          o-------o--------o---------o-------o  Transport Layer

 o-----o   o-----o  o-----o  o-----o  o-----o   o-----o Link Layer


        Figure 1: Multiple Layers of Service Bearing
```

- Two types of MPLS path programming:
  - Transport-Oriented MPLS path programming: Segment Routing, etc.
  - Service-Oriented MPLS Path programming

Use Cases of Service-Oriented MPLS Path Programming

- Traffic Steering in Service/Network Layer : This method is to directly encapsulate the service flow with the service label stack in the ingress PE before it enters into the transport tunnel.
- Use Cases for Unicast Service
  – Basic Reachability
  – VPN Identification
  – ECMP(Equal Cost Multi-Path)
  – Service OAM
  – Traffic Steering
- Use Cases of Multicast Service
  – Basic Reachability
  – MVPN Identification
  – Source Identification
- Use Cases of MPLS Virtual Network

Use Cases for Unicast Service

- Use cases for unicast service MPLS path programming is shown as follows:

```
+----------+----------+----------+----------+----------+
|  Entropy | Steering |VPN Prefix|    VPN   |  Source  | ---> Transport
|   Label  |   Label  |   Label  |   Label  |   Label  |        Tunnel
+----------+----------+----------+----------+----------+
```

- ✓ VPN Prefix Label : Basic reachability. It is defined in [RFC4364].
- ✓ VPN Label: Identification of VPN. It is defined in [I-D.zhang-l3vpn-label-sharing].
- ✓ Entropy Label: Identification of ECMP. It is defined in [RFC6790].
- ✓ Source Label: Identification of source PE which can be used for OAM. It is defined in [I-D.chen-mpls-source-label].
- ✓ Steering Label: [I-D.filsfils-spring-segment-routing-central-epe] illustrates the application of steering label for the Egress Peer Engineering (EPE).

Use Cases of Multicast Service

- Use cases for multicast service MPLS path programming is shown as follows (using BUM in EVPN as the example) :

```
+----------+---------+---------+
| Multicast |   EVPN   |  Source  | --->     Transport
|  Payload  |   Label  |   Label  |      Multicast Tunnel
+----------+---------+---------+
```

- ✓ Basic Reachability
- ✓ MVPN Label: Identification of MVPN which can be used for such use cases as sharing multiple MVPN with one P-tunnel..
- ✓ Source Label: Identification of the source Ethernet Segment in EVPN for horizon split or summarization of C-MACs.

Use Cases of MPLS Virtual Network

- The framework of MPLS virtual network has been proposed in [I-D.li-mpls-network-virtualization-framework].
- When the unicast service or the multicast service enters into the transport tunnel, it may take different MPLS virtual network identified by the MPLS label for the purpose of QoS routing, security or virtual operations.
- The MPLS path is as follows:

```
+-------------+      +-----------------+
|   Service   | ---> | Virtual Network | ---> Transport
| Label Stack |      |      Label      |        Tunnel
+-------------+      +-----------------+
```

Use Cases Summary

- Service-oriented MPLS path programming can make full use of flexible combination of MPLS labels to satisfy different requirements for the service flow. Based on the above proposed use cases, MPLS path can be composed adopting part or whole labels for these use cases based on the service requirement.
- More flexible MPLS label combination may be provided:
  - Hierarchical process or multiple repeated process:

```
+----------+----------+----------+----------+----------+----------+
| SERVICE  |VPN Prefix| SERVICE  |   VPN    | SERVICE  |  Tunnel  |
|  LABEL   |  Label   |  LABEL   |  Label   |  LABEL   |  Label   |
+----------+----------+----------+----------+----------+----------+
```

  - Special-purpose label indicator:
    - Since the label in the service-oriented MPLS programming is for special-purpose process, it may need a special purpose label to indicate the usage of the label followed the special-purpose labels.
    - For example, the ELI(Entropy Label Indicator) is introduced for the entropy label. This may introduce more labels for the combination.

Architecture of MPLS Path Programming

- Central control plays an important role in MPLS path programming. It can extend the MPLS path programming capability easily. There are two important functionalities for the central control:
  - Central controlled MPLS label allocation: Label can be allocated centrally for special usage other than reachability. These labels can be used to compose MPLS path. We call it as MPLS Segment.
  - Central controlled MPLS path programming: Central controller can calculate path in a global network view and implement the MPLS path programming based on the collected information of MPLS segments to satisfy different requirements of services.

```
                +--------------------+
                |       Central      |
                |     Controller     |
    |----------|(Path Calculation   |--------|
    |          | /Path Programming)|        |
    |          +--------------------+        |
    |             /       |       \          |
MPLS Path        /    Segment      \      MPLS Path
    |           /    Allocation     \        |
    |      Segment        |        Segment   |
    |     Allocation      |       Allocation |
    |         /           |           \      |
    |        /            |            \     |
  +--------+         +--------+         +--------+
  | CLIENT |         | CLIENT |         | CLIENT |
  |        | ......  |        | ......  |        |
  |  (PE)  |         |  (P)   |         |  (PE)  |
  |        |         |        |         |        |
  +--------+         +--------+         +--------+
```

Figure 2 Central Control for MPLS Path Programming

Central Control for MPLS Path Programming

- For the transport-oriented MPLS path, segment routing is the typical solution:
  - MPLS segment distribution is done by IGP extensions ([I-D.ietf-isis-segment-routing-extensions]) and [I-D.ietf-ospf-segment-routing-extensions]);
  - The programmed MPLS path can be downloaded through PCEP extensions from PCE to PCC([I-D.sivabalan-pce-segment-routing]).
- For the service-oriented MPLS path programming, it not only includes composing the MPLS path in the service and network layer, but also includes determining the mapping of the service path to the transport path. Since the process corresponding to the label in the service label stack is always located at the PE nodes, BGP extensions can be introduced for service-oriented path programming.

Protocol Extensions Requirements for Service-Oriented MPLS Path Programming

- BGP
  1. REQ 01: BGP extensions SHOULD be introduced to distribute local label mapping for specific process.
  2. REQ 02: BGP extensions SHOULD be introduced to distribute global label mapping for specific process.
  3. REQ 03: BGP extensions SHOULD be introduced to download label stack for service-oriented MPLS path.
  4. REQ 04: BGP extensions SHOULD be introduced to carry the identifier of the transport MPLS path with service MPLS path to implement the mapping.
- I2RS
  1. REQ 01: I2RS clients SHOULD provide interface to I2RS agent to download policy to implement the mapping of the service path to the transport path.

Next Step

- Seek comments and feedbacks
- Revise the draft