Segment Routing

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Agenda

- Introduction
- Technology
- Use Cases
- Conclusion

Introduction

Goals and Requirements

- Make things easier for operators
  - Improve scale, simplify operations
  - Minimize introduction complexity/disruption
- Enhance service offering potential through programmability
- Leverage the efficient MPLS dataplane that we have today
  - Push, swap, pop
  - Maintain existing label structure
- Leverage all the services supported over MPLS
  - Explicit routing, FRR, VPNv4/6, VPLS, L2VPN, etc
- IPv6 dataplane a must, and should share parity with MPLS

Operators Ask For Drastic LDP/RSVP Improvement

- Simplicity
  - less protocols to operate
  - less protocol interactions to troubleshoot
  - avoid directed LDP sessions between core routers
  - deliver automated FRR for any topology
- Scale
  - avoid millions of labels in LDP database
  - avoid millions of TE LSP's in the network
  - avoid millions of tunnels to configure

Operators Ask For A Network Model Optimized For Application Interaction

- Applications must be able to interact with the network
  - cloud based delivery
  - internet of everything
- Programmatic interfaces and Orchestration
  - Necessary but not sufficient
- The network must respond to application interaction
  - Rapidly-changing application requirements
  - Virtualization
  - Guaranteed SLA and Network Efficiency

Segment Routing

- Simple to deploy and operate
  - Leverage MPLS services & hardware
  - straightforward ISIS/OSPF extension to distribute labels
  - LDP/RSVP not required
- Provide for optimum scalability, resiliency and virtualization
- SDN enabled
  - simple network, highly programmable
  - highly responsive

IETF

- Simple ISIS/OSPF extension
- Welcoming contribution

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Segment Routing with IS-IS Routing Protocol
draft-previdi-filsfils-isis-segment-routing-02

Abstract

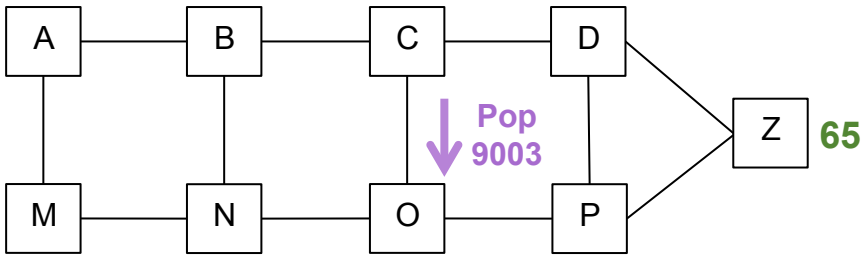
Segment Routing (SR) enables any node to select any path (explicit or derived from IGPs SPT computations) for each of its traffic classes. The path does not depend on a hop-by-hop signaling technique (neither LDP nor RSVP). It only depends on a set of "segments" that are advertised by the IS-IS routing protocol. These segments act as topological sub-paths that can be combined together to form the desired path.

Segment Routing

Segment Routing

- Forwarding state (segment) is established by IGP
  - LDP and RSVP-TE are not required
  - Agnostic to forwarding dataplane: IPv6 or MPLS
- MPLS Dataplane is leveraged without any modification
  - push, swap and pop: all that we need
  - segment = label
- Source Routing
  - source encodes path as a label or stack of segments
  - two segments: node or adjacency

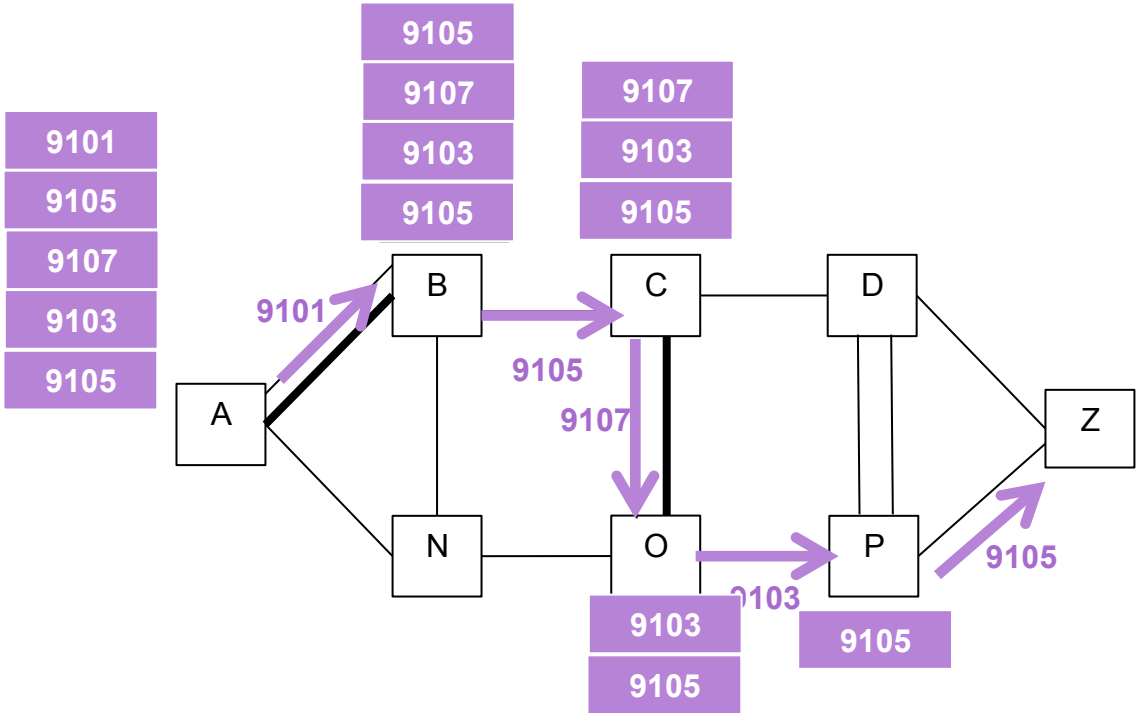
Adjacency Segment



A packet injected at node C with label 9003 is forced through datalink CO

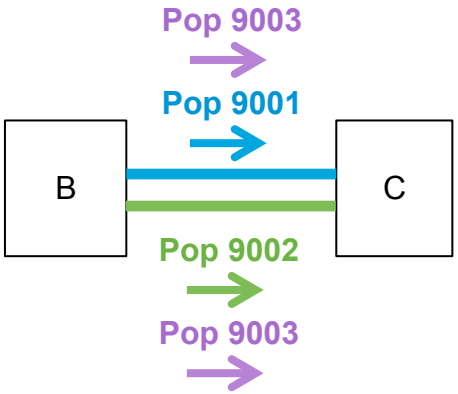
- C allocates a local label
- C advertises the adjacency label in ISIS
  - simple sub-TLV extension
- C is the only node to install the adjacency segment in MPLS dataplane

A path with Adjacency Segments



- Source routing along any explicit path
  - stack of adjacency labels
- SR provides for entire path control

Datalink and Bundle



9001 switches on blue member

9002 switches on green member

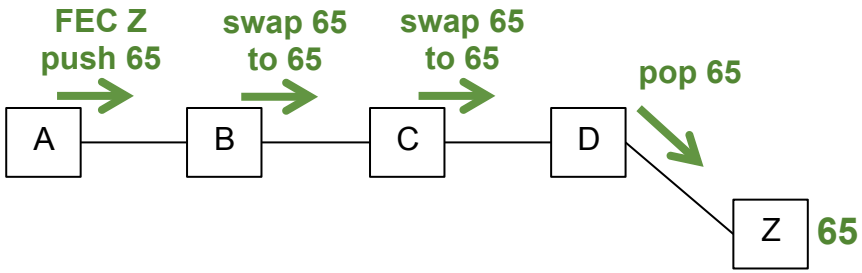
9003 load-balances on any member of the adj

- Adjacency segment represents a specific datalink to an adjacent node
- Adjacency segment represents a set of datalinks to the adjacent node

Node SR Range

- SR requires only 1 label per node in the IGP domain
  - insignificant: < 1% of label space
- Node SR Range
  - a range of labels allocated to the SR control-plane
  - e.g. [64, 5000]
- Each node gets one unique label from SR Range
  - Node Z gets label 65

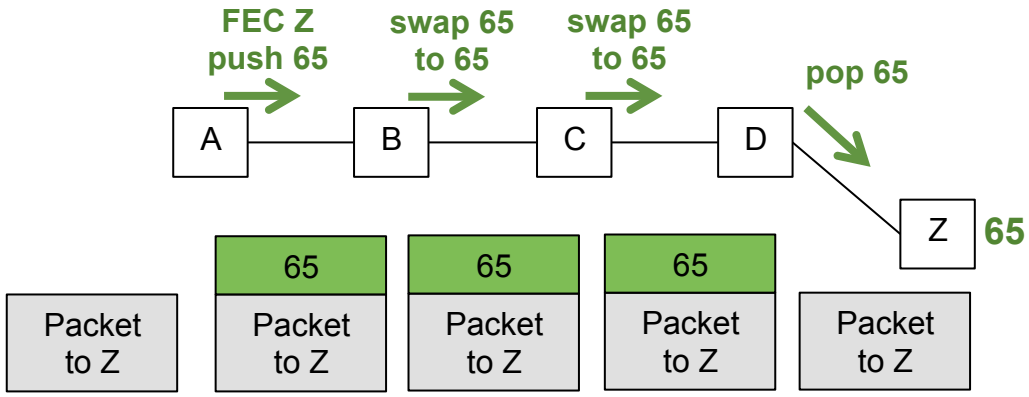
Node Segment



A packet injected anywhere with top label 65 will reach Z via shortest-path

- Z advertises its node segment
  - simple ISIS sub-TLV extension
- All remote nodes install the node segment to Z in the MPLS dataplane

Node Segment



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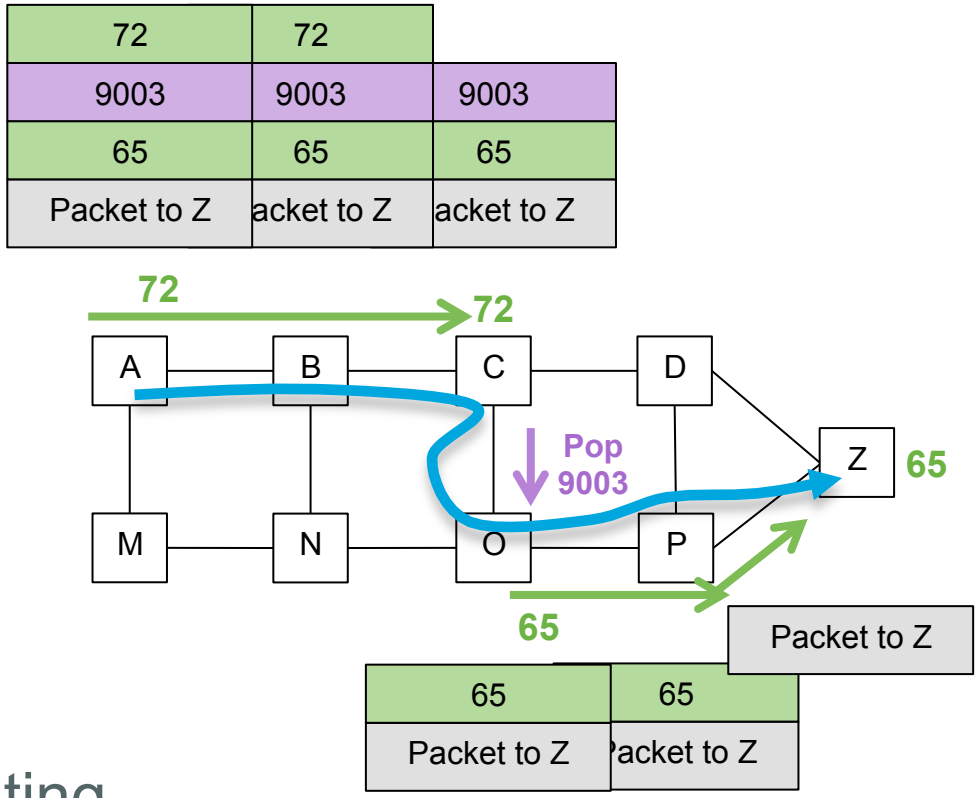
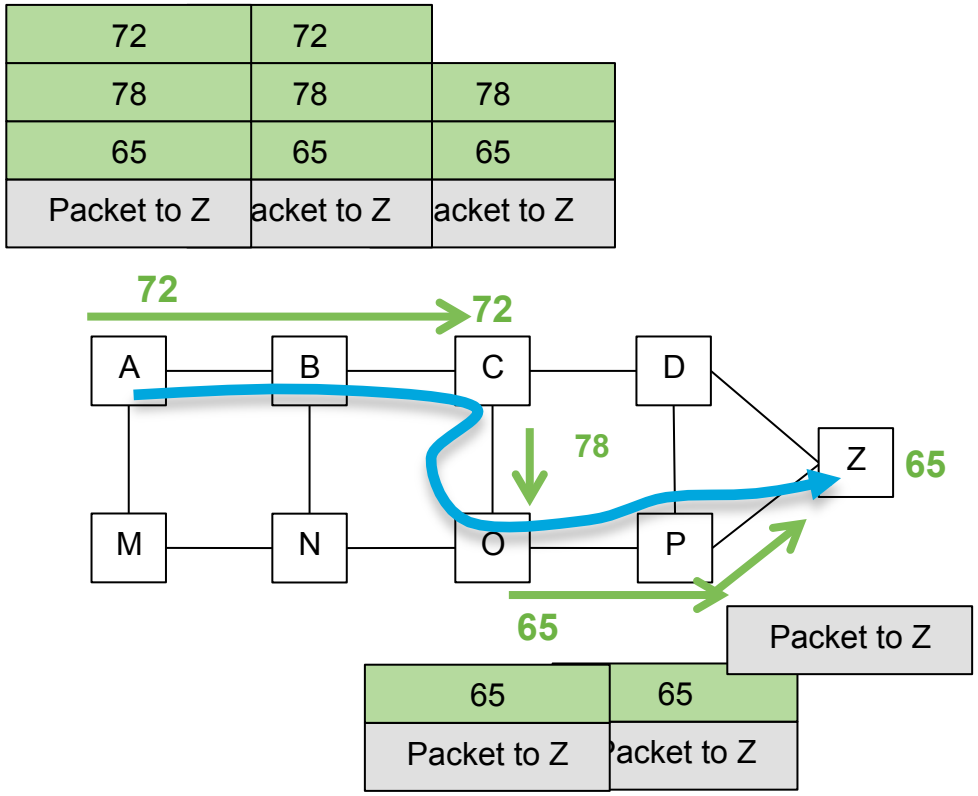
Combining Segments



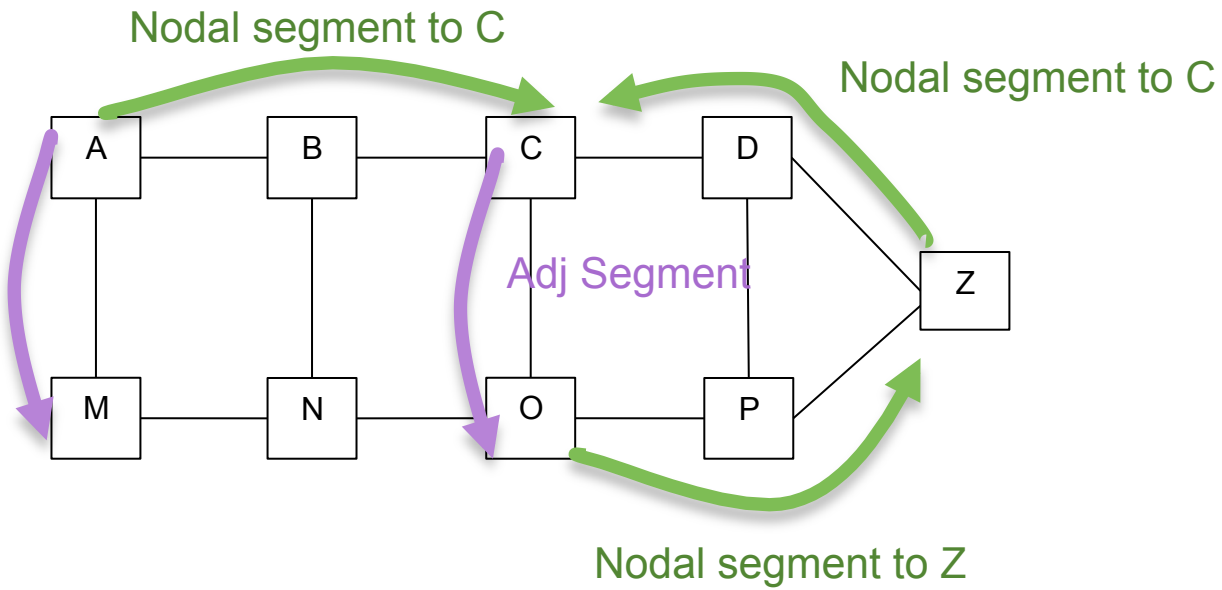
- Source Routing
- Any explicit path can be expressed: ABCOPZ

Combining Segments



- Node Segment is at the heart of the proposal
  - ecmp multi-hop shortest-path
  - in most topologies, any path can be expressed as list of node segments

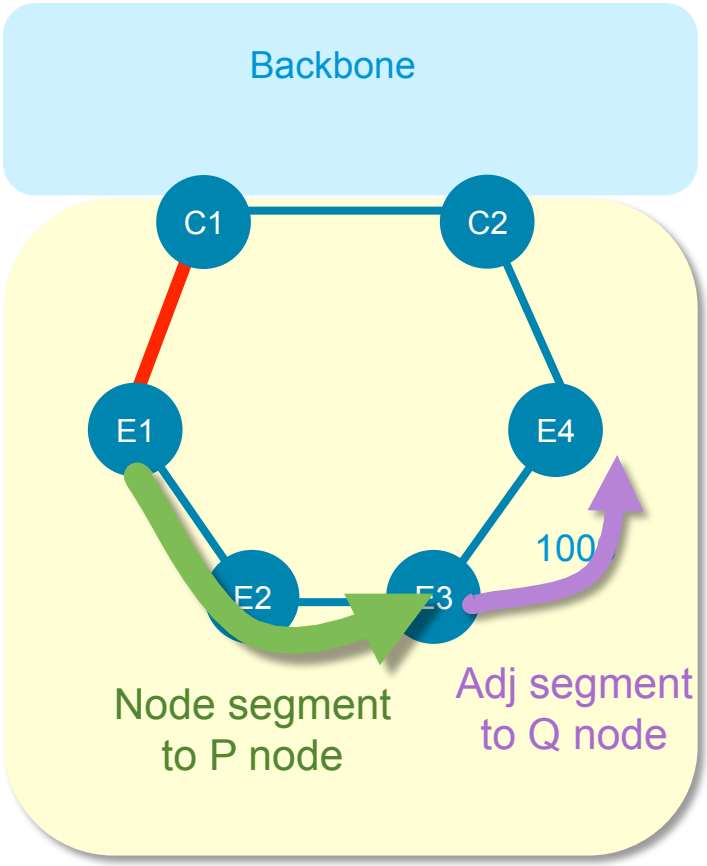
ISIS automatically installs segments



- Simple extension
- Excellent Scale: a node installs N+A FIB entries
  - N node segments and A adjacency segments

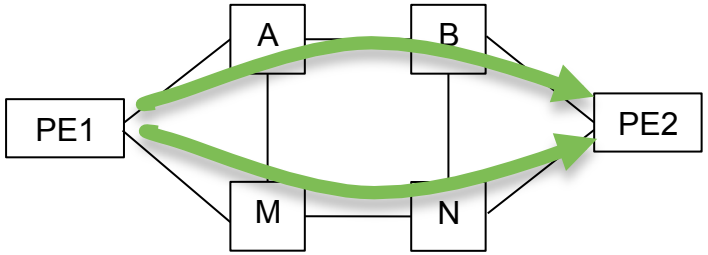
Automated & Guaranteed FRR

- IP-based FRR is guaranted in any topology
  - 2002, LFA FRR project at Cisco
  - draft-bryant-ipfrr-tunnels-03.txt
- Directed LFA (DLFA) is guaranteed when metrics are symetric
- No extra computation (RLFA)
- Simple repair stack
  - node segment to P node
  - adjacency segment from P to Q



Use Cases

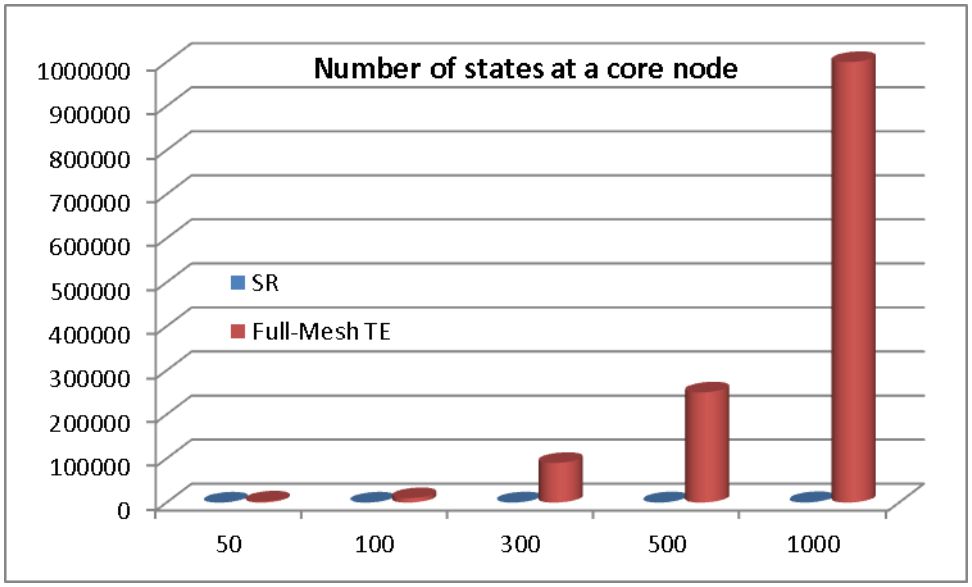
Simple and Efficient Transport of MPLS services



All VPN services ride on the node segment
to PE2

- Efficient packet networks leverage ecmp-aware shortest-path!
  - node segment!
- Simplicity
  - no complex LDP/ISIS synchronization to troubleshoot
  - one less protocol to operate

Scalable TE



- An SR core router scales much than with RSVP-TE
  - The state is not in the router but in the packet
  - N+A vs N^2

N: # of nodes in the network
A: # of adjacencies per node

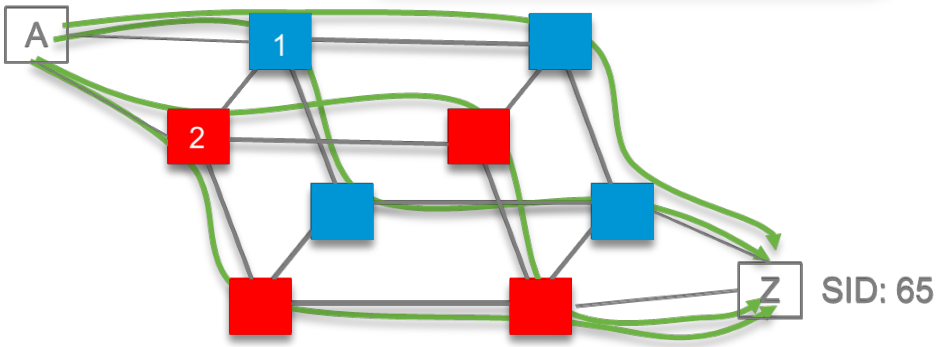
Simple Disjointness

SR avoids state in the core

SR avoids enumerating RSVP-TE tunnels for each ECMP paths

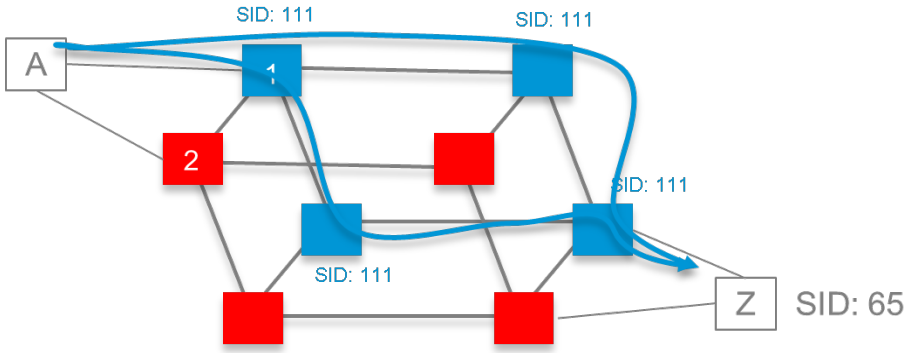
- A sends traffic with [65]

  Classic ECMP “a la IP”



- A sends traffic with [111, 65]

  Packet gets attracted in blue plane and then uses classic ecmp “a la IP”



ECMP-awareness!

CoS-based TE

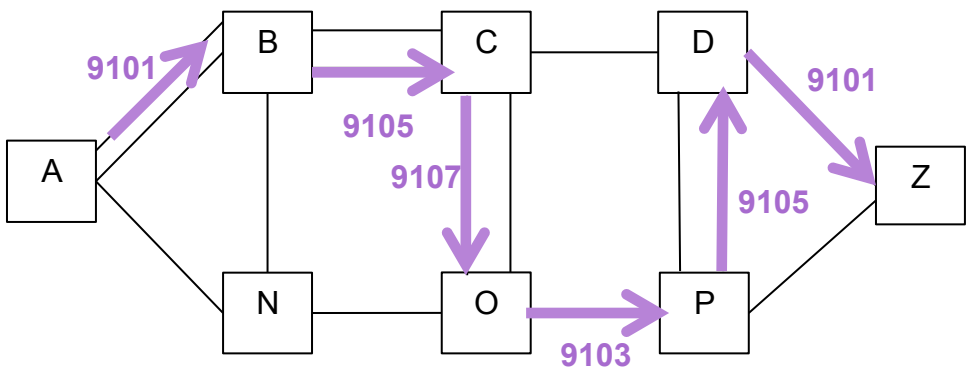
- Tokyo to Brussels
  - data: via US: cheap capacity
  - voip: via russia: low latency
- CoS-based TE with SR
  - IGP metric set such as
    - > Tokyo to Russia: via Russia
    - > Tokyo to Brussels: via US
    - > Russia to Brussels: via Europe
  - Anycast segment “Russia” advertised by Russia core routers
- Tokyo CoS-based policy
  - Data and Brussels: push the node segment to Brussels
    - ➔ ECMP-aware shortest-path to Brussels
  - VoIP and Brussels: push the anycast node to Russia, push Brussels
    - ➔ ECMP-aware shortest-path to Russia, followed by ECMP-aware shortest-path to Brussels

Node segment to Brussels

Node segment to Russia

No TE tunnel enumeration,
no TE state in the core

Full control and OAM



- For Traffic Engineering
- or for OAM

Google

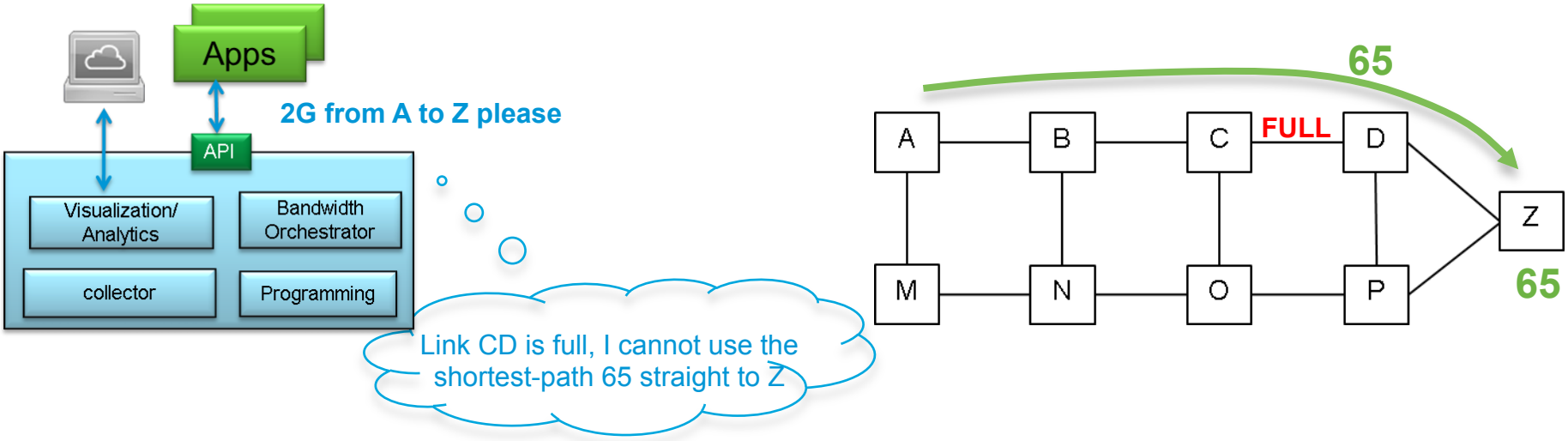
Localizing packet loss

In a large complex network

Nicolas Guilbaud nguilbaud@google.com
Ross Cartlidge rossc@google.com

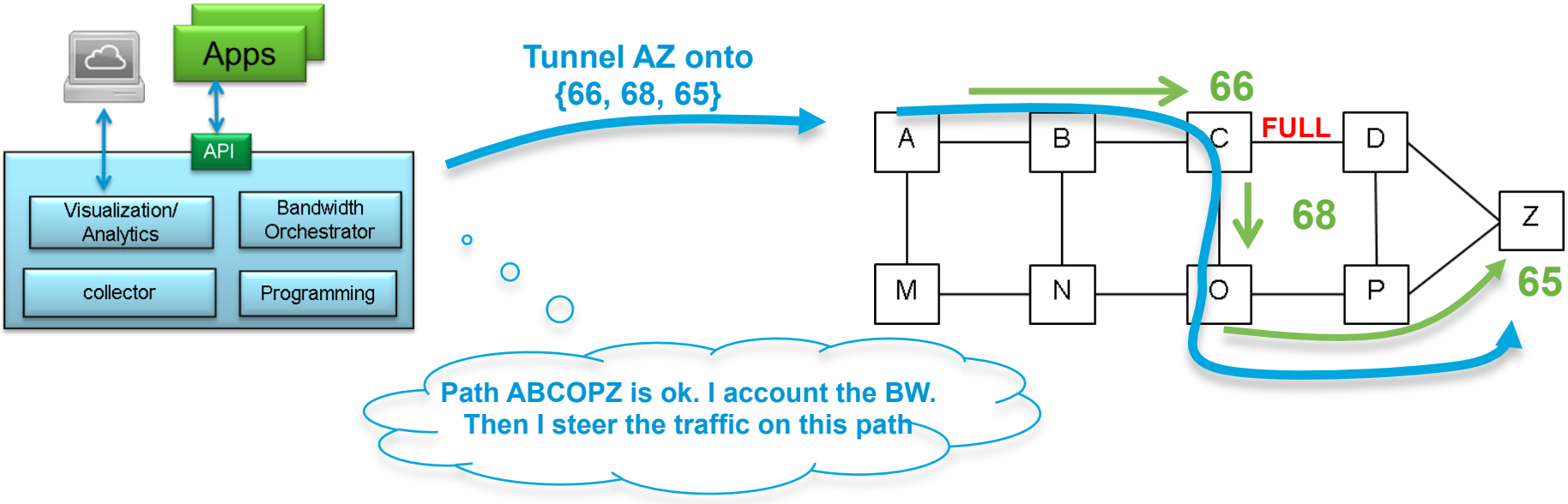
Nanog57, Feb 2013

Application controls – network delivers



- The network is simple, highly programmable and responsive to rapid changes
  - The controller abstracts the network topology and traffic matrix
  - Perfect support for centralized optimization efficiency, if required

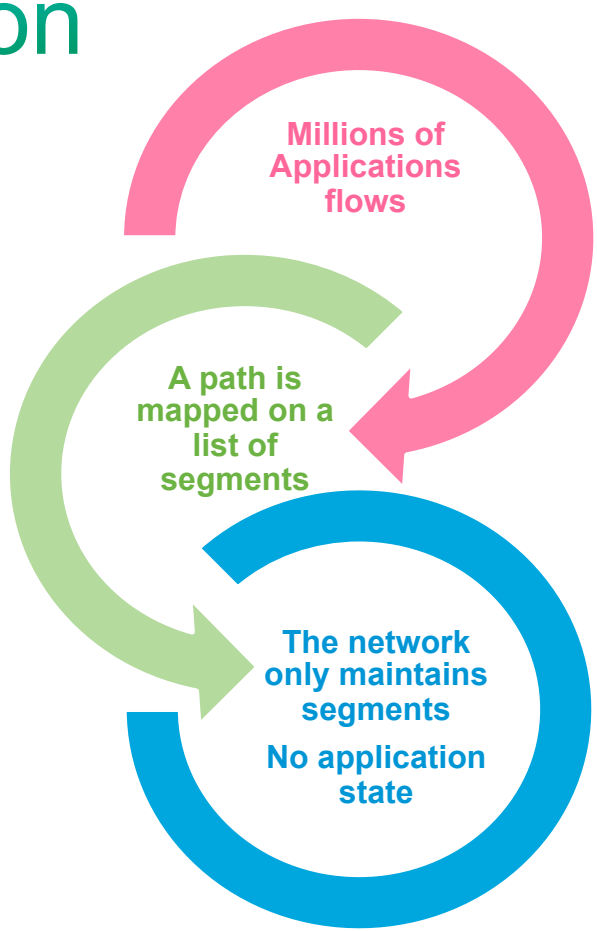
Application controls – network delivers



- The network is simple, highly programmable and responsive to rapid changes

Scalability and Virtualization

- Each engineered application flow is mapped on a path
  - millions of paths
  - maintained in the orchestrator, scaled horizontally
- A path is expressed as an ordered list of segments
- The network maintains segments
  - thousands of segments
  - completely independent of application size/frequency



Conclusion

Segment Routing

- Simple to deploy and operate
  - Leverage MPLS services & hardware
  - straightforward ISIS/OSPF extension
- Provide for optimum scalability, resiliency and virtualization
- Perfect integration with application
- EFT and IETF available – test and contribute