



SRv6

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Segment Routing

- Source Routing
 - the topological and service (NFV) path is encoded in the packet header
- Scalability
 - the network fabric does not hold any per-flow state for TE or NFV
- Simplicity
 - automation: TILFA
 - protocol elimination: LDP, RSVP-TE, NSH...
- End-to-End
 - DC, Metro, WAN

Industry at large backs up SR



Strong customer adoption
WEB, SP, Enterprise

Standardization
IETF

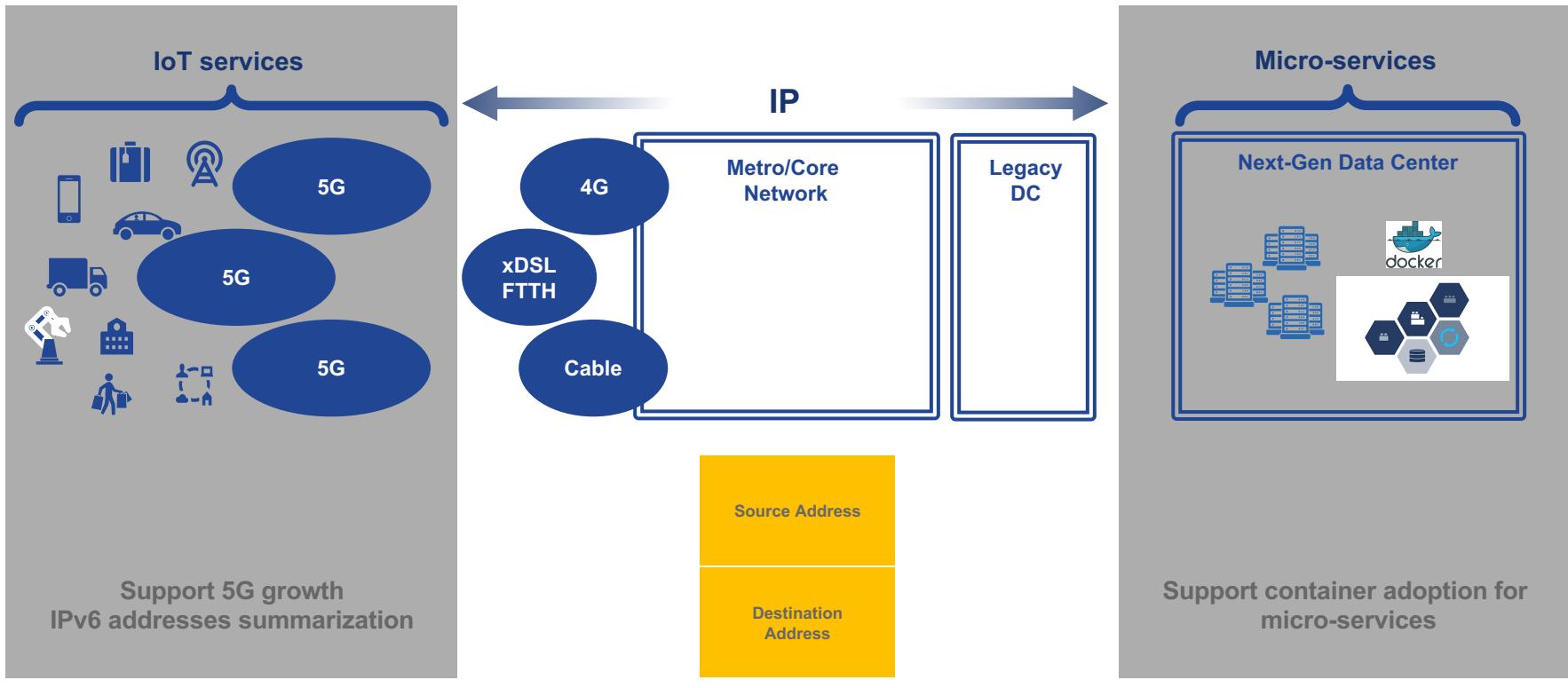
De-Facto SDN Architecture

Multi-vendor Consensus
Interop testings



Objective of SRv6

IPv6 provides reachability



SRv6 for underlay

RSVP for FRR/TE



Horrendous states scaling in $k*N^2$

IPv6 for reach

SRv6 for underlay

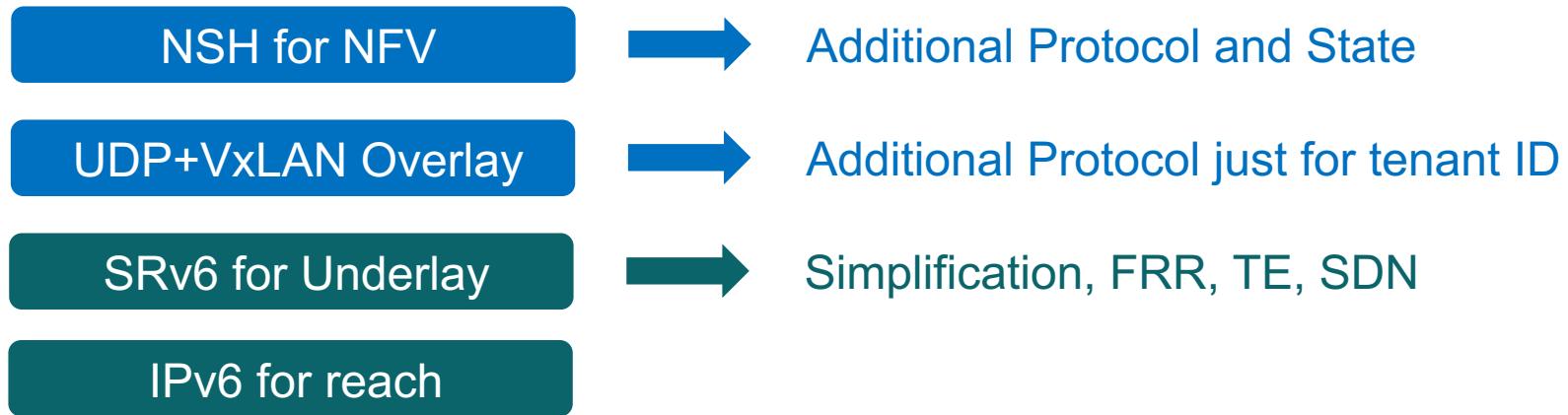
SRv6 for Underlay



Simplification, FRR, TE, SDN

IPv6 for reach

Opportunity for further simplification



- Multiplicity of protocols and states hinder network economics



Network Programming

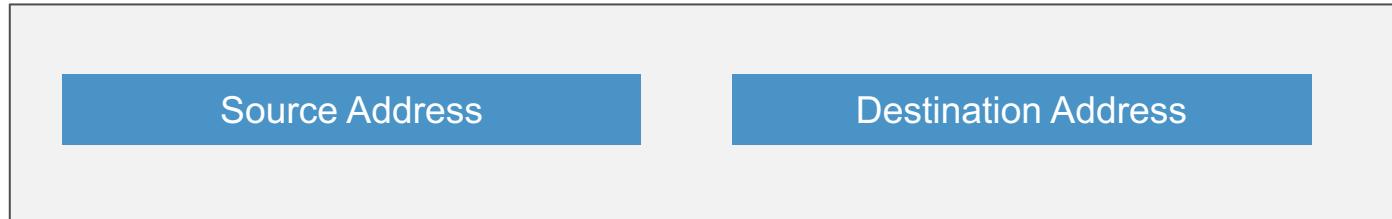
Network instruction



- 128-bit SRv6 SID
 - Locator: routed to the node performing the function
 - Function: any possible function (optional argument)
 - either local to NPU or app in VM/Container
 - Flexible bit-length selection

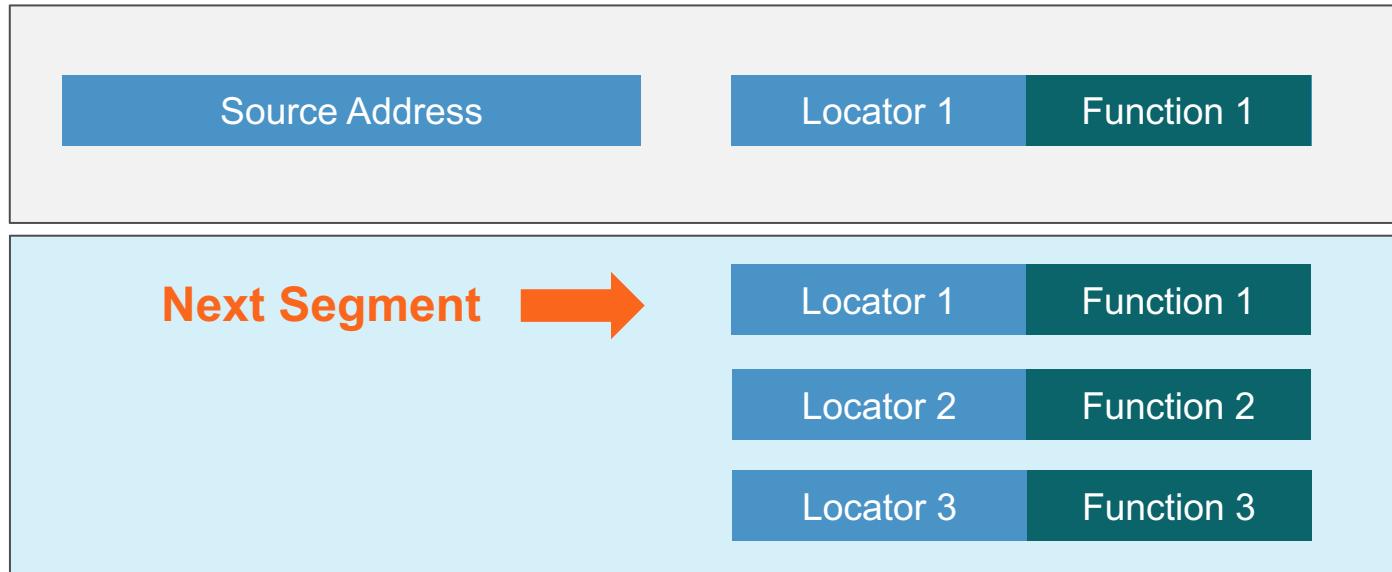
Network Program in the packet header

IPv6
Header



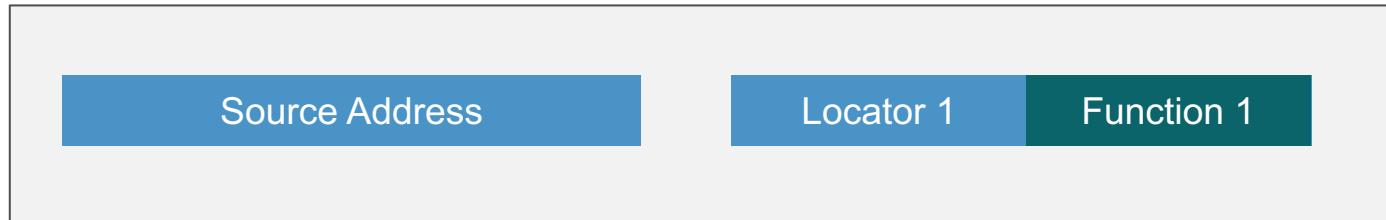
Network Program in the packet header

IPv6
Header



Network Program in the packet header

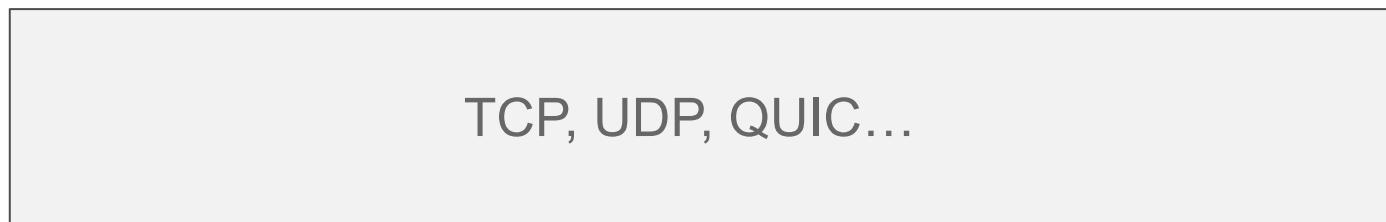
IPv6
Header



Segment
Routing
Header



IPv6
Payload



Network Program

Next Segment



Locator 1

Function 1

Locator 2

Function 2

Locator 3

Function 3

Locator 2

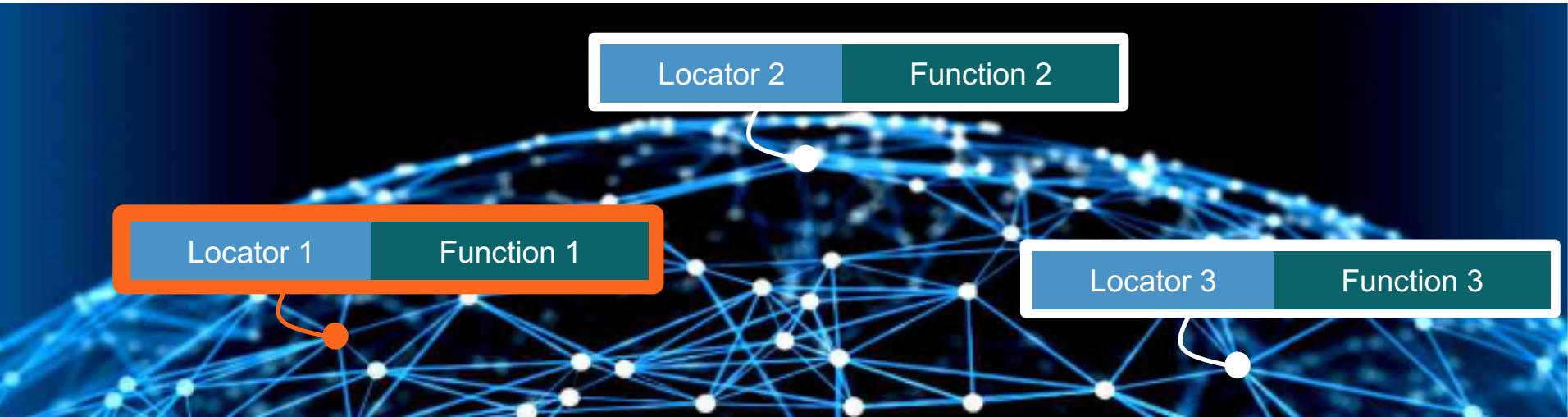
Function 2

Locator 1

Function 1

Locator 3

Function 3



Network Program

Next Segment



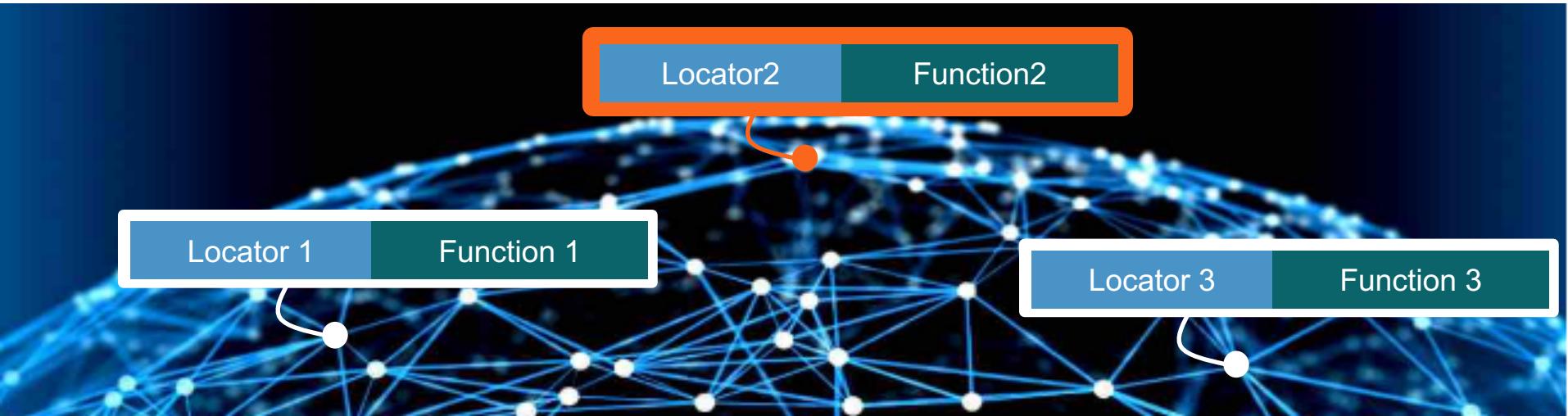
Locator2 Function2

Locator 1

Function 1

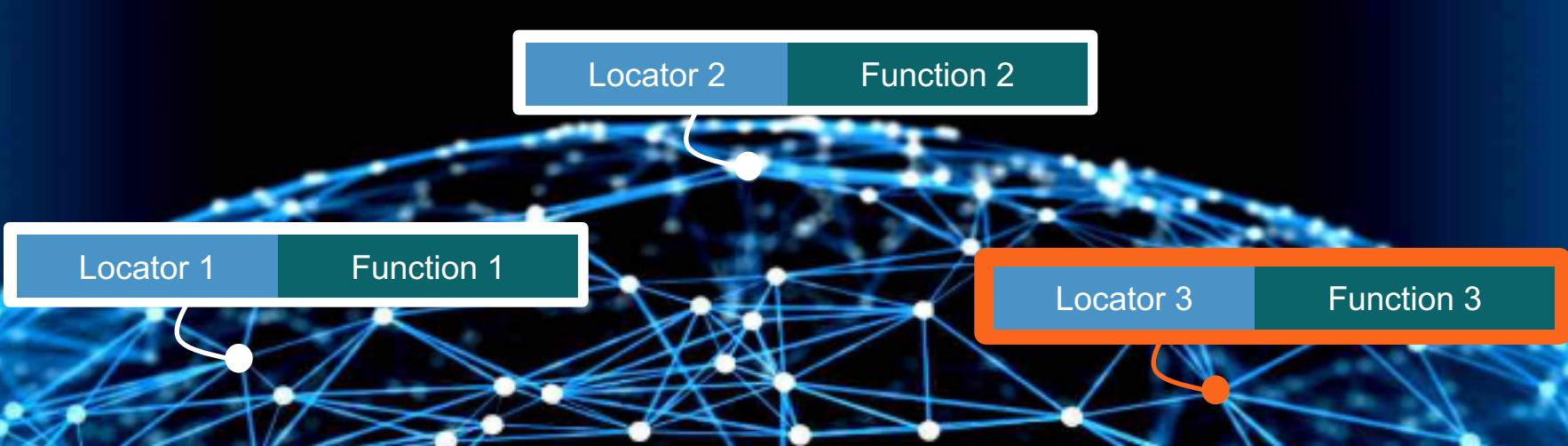
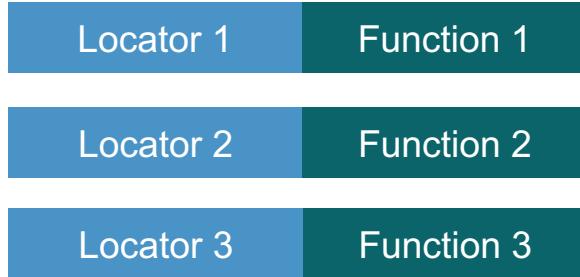
Locator 3

Function 3

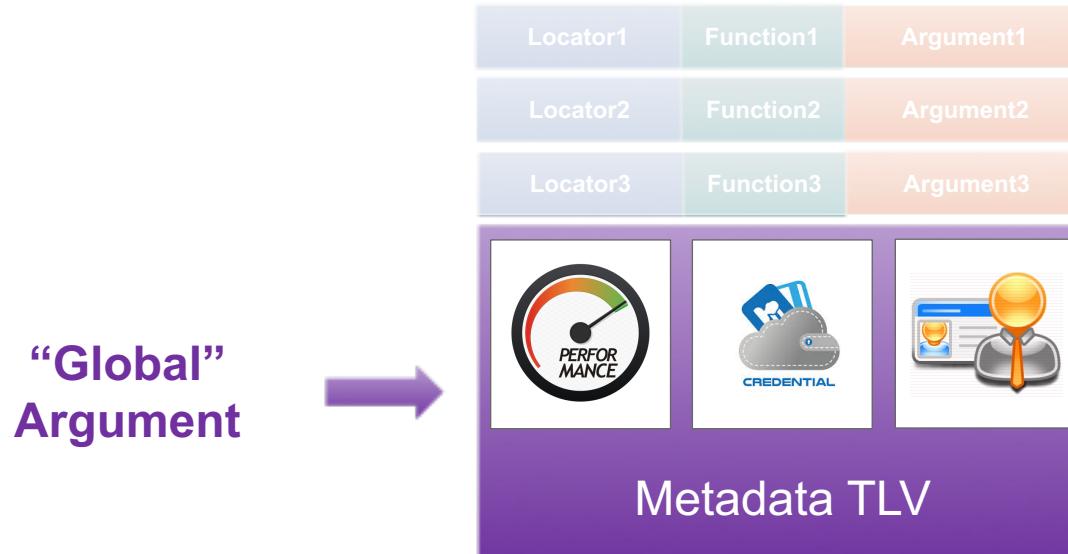


Network Program

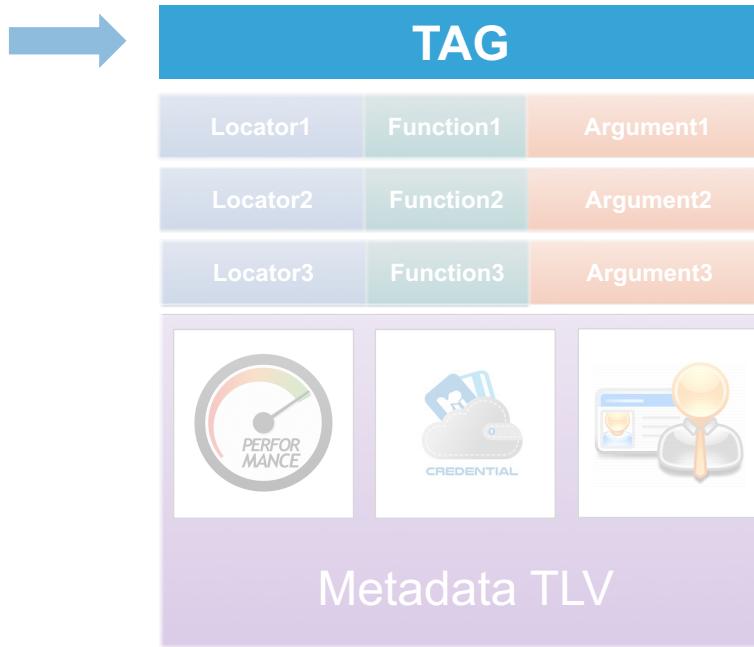
Next Segment



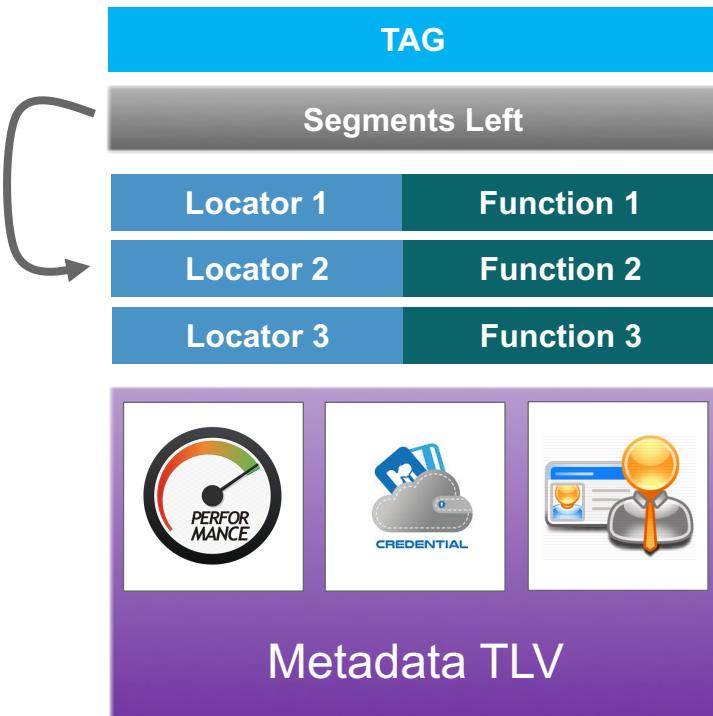
Argument shared between functions



Group-Based Policy

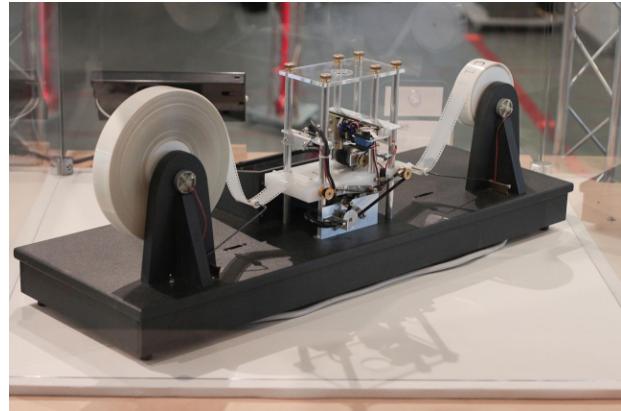
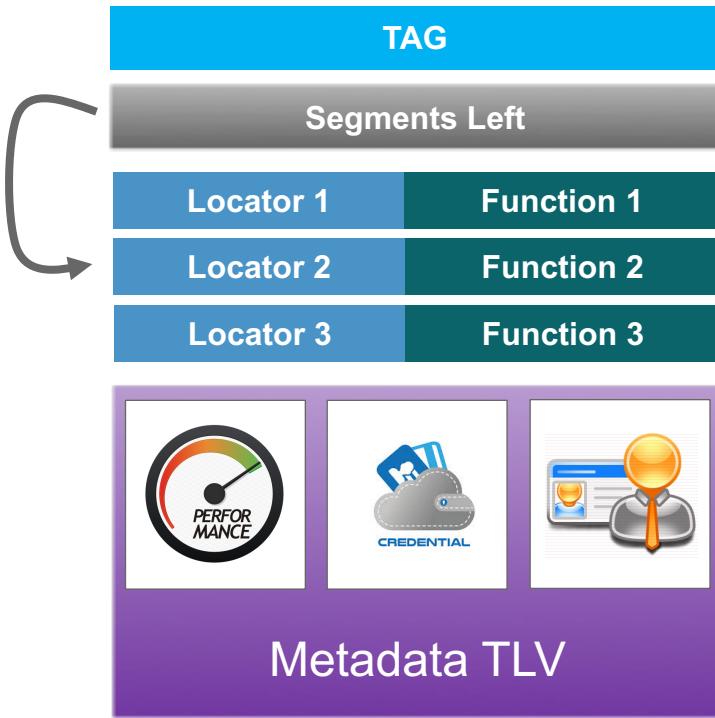


SR Header



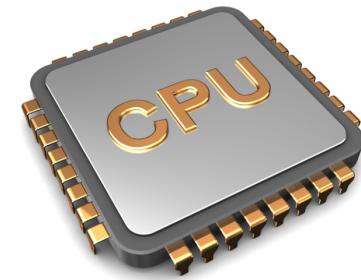
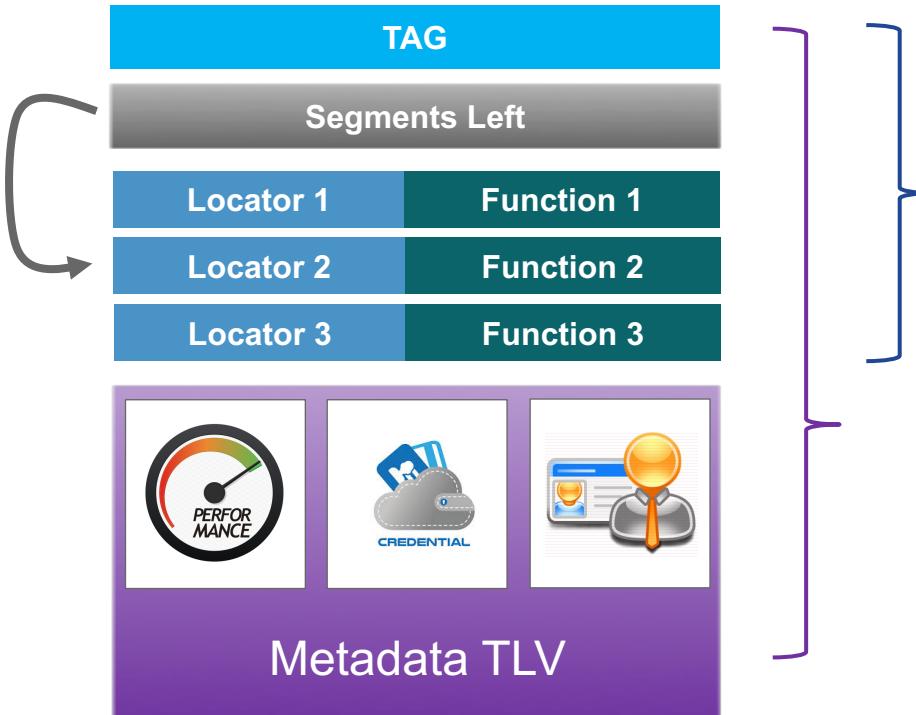
0	1	2	3
0 1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1 2 3 4 5 6 7 8 9 0	1
Next Header	Hdr Ext Len	Routing Type	Segments Left
+	+	+	+
Last Entry	Flags	Tag	
+	+	+	+
	Segment List[0] (128 bits IPv6 address)		
+	+	+	+
	...		
+	+	+	+
	Segment List[n] (128 bits IPv6 address)		
+	+	+	+
//	Optional Type Length Value objects (variable)	//	//
//	//	//	//
+	+	+	+

SRv6 for anything



Turing

SRv6 for anything



Lead Operators

- Standardization
- Multi-Vendor Consensus



SPRING
Internet-Draft
Intended status: Standards Track
Expires: September 10, 2017

C. Fisfils
Cisco Systems, Inc.
J. Leddy
Comcast
D. Voyer
D. Bernier
Bell Canada
D. Steinberg
Steinberg Consulting
R. Raszuk
Bloomberg LP
S. Matsushima
SoftBank Telecom
D. Lebrun
Universite catholique de Louvain
B. Decraene
Orange
B. Peirens
Proximus
S. Salsano
Universita di Roma "Tor Vergata"
G. Naik
Drexel University
H. Elmalky
Ericsson
P. Jonnalagadda
M. Sharif
Barefoot Networks
A. Ayyangar
Arista
S. Mynam
Dell Force10 Networks
A. Bashandy
K. Raza
D. Dukes
F. Clad
P. Camarillo, Ed.
Cisco Systems, Inc.
March 9, 2017

Inter-Domain Routing

Internet-Draft

Intended status: Standards Track

Expires: September 13, 2017

G. Dawra, Ed.

C. Filsfils

D. Dukes

P. Brissette

P. Camarilo

Cisco Systems

J. Leddy

Comcast

D. Voyer

D. Bernier

Bell Canada

D. Steinberg

Steinberg Consulting

R. Raszuk

Bloomberg LP

B. Decraene

Orange

S. Matsushima

SoftBank Telecom Japan

March 12, 2017

BGP Signaling of IPv6-Segment-Routing-based VPN Networks

[draft-dawra-bgp-srv6-vpn-00.txt](#)

Network Working Group

Internet Draft

Intended status: Standard Track

Expires: September 2017

A. Bashandy, Ed.

C. Filsfils

L. Ginsberg

Cisco Systems

Bruno Decraene

Orange

March 10, 2017

IS-IS Extensions to Support Segment Routing over IPv6 Dataplane

[draft-bashandy-isis-srv6-extensions-00](#)

Network Working Group

Internet-Draft

Intended status: Standards Track

Expires: September 14, 2017

S. Previdi, Ed.

C. Filsfils

K. Raza

D. Dukes

Cisco Systems, Inc.

J. Leddy

B. Field

Comcast

D. Voyer

D. Bernier

Bell Canada

S. Matsushima

Softbank

I. Leung

Rogers Communications

J. Linkova

Google

E. Aries

Facebook

T. Kosugi

NTT

E. Vyncke

Cisco Systems, Inc.

D. Lebrun

Universite Catholique de Louvain

D. Steinberg

Steinberg Consulting

R. Raszuk

Bloomberg

March 13, 2017

IPv6 Segment Routing Header (SRH)

[draft-ietf-6man-segment-routing-header-06](#)

SRv6 for Next-generation Mobile

SPRING and DMM

Internet-Draft

Intended status: Standards Track

Expires: January 18, 2018

S. Matsushima

SoftBank

C. Filsfils

Cisco Systems, Inc.

July 17, 2017

SRv6 for Mobile User-Plane

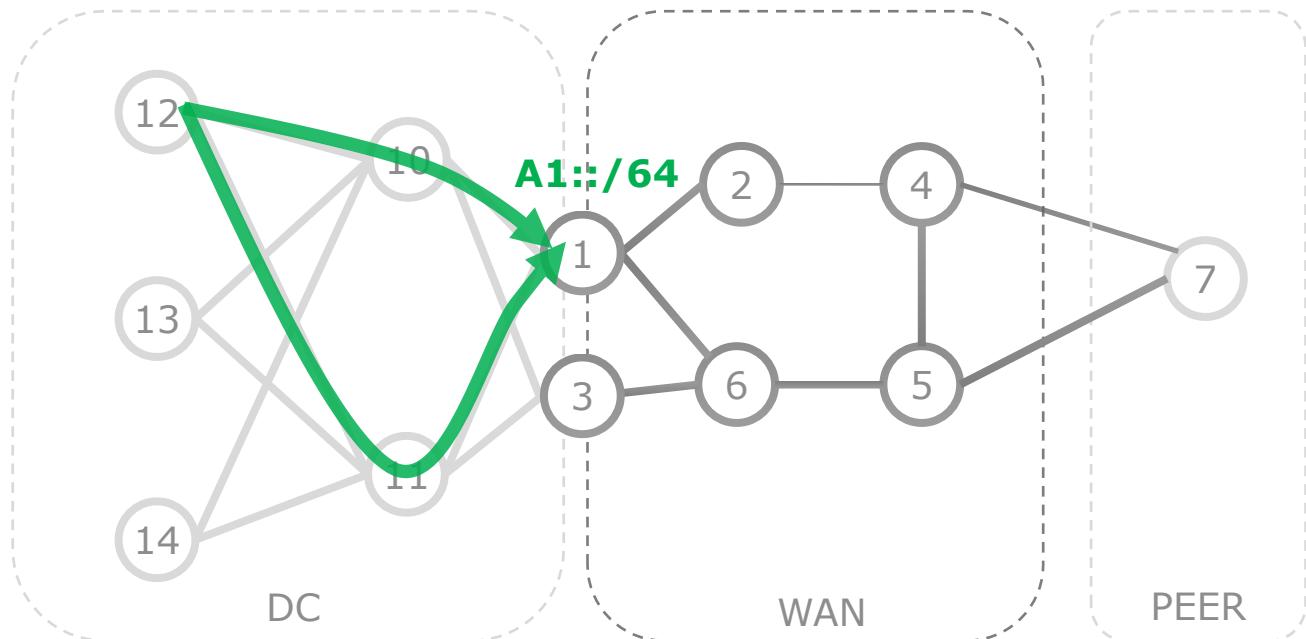
[draft-matsushima-spring-dmm-srv6-mobile-uplane-01](#)



Use-Cases

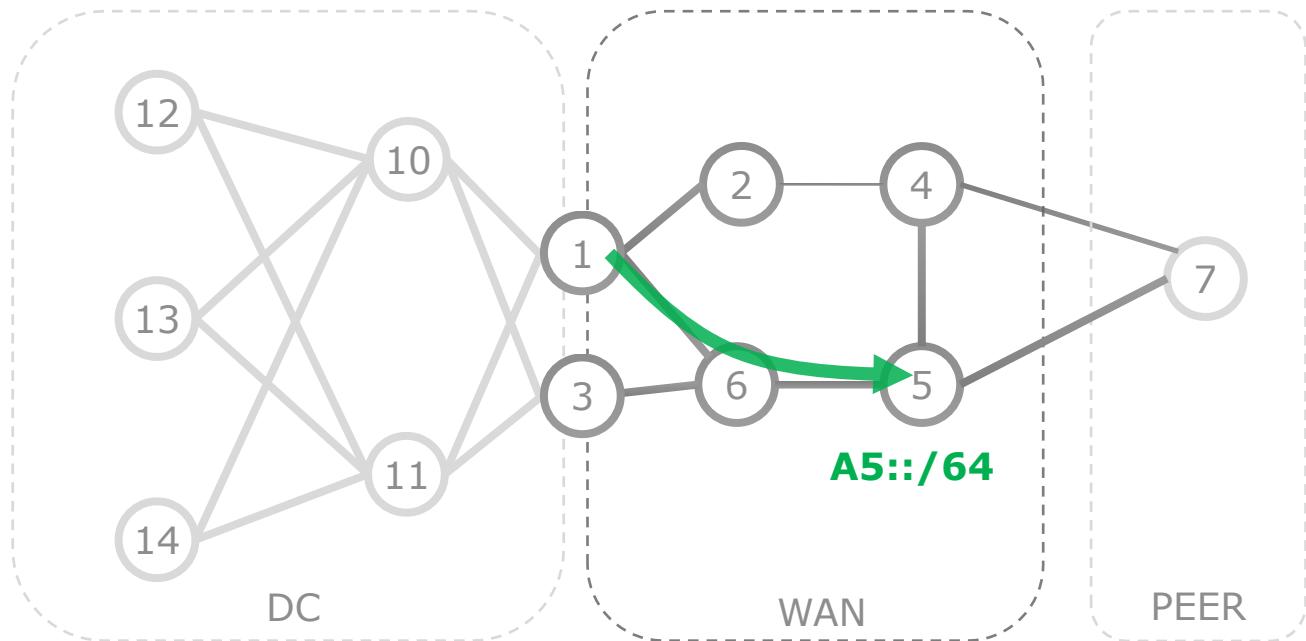
SID allocation for illustration purpose

- For simplicity
- Node K advertises prefix AK::/64
- The function is encoded in the last 64 bits



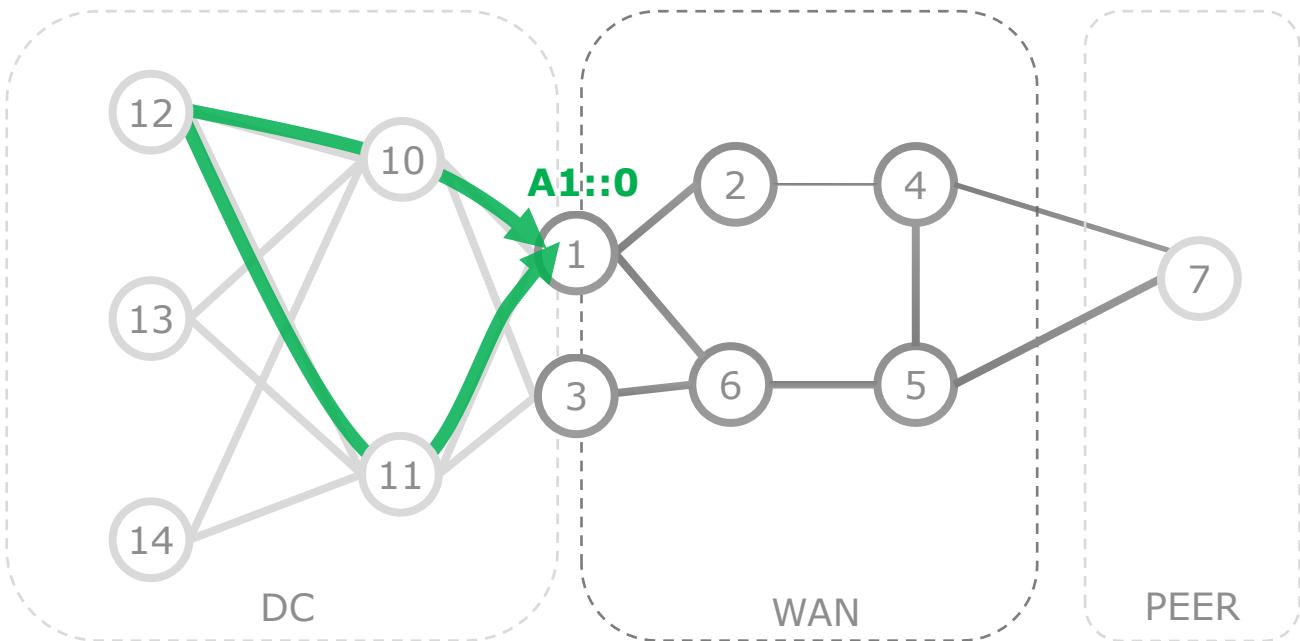
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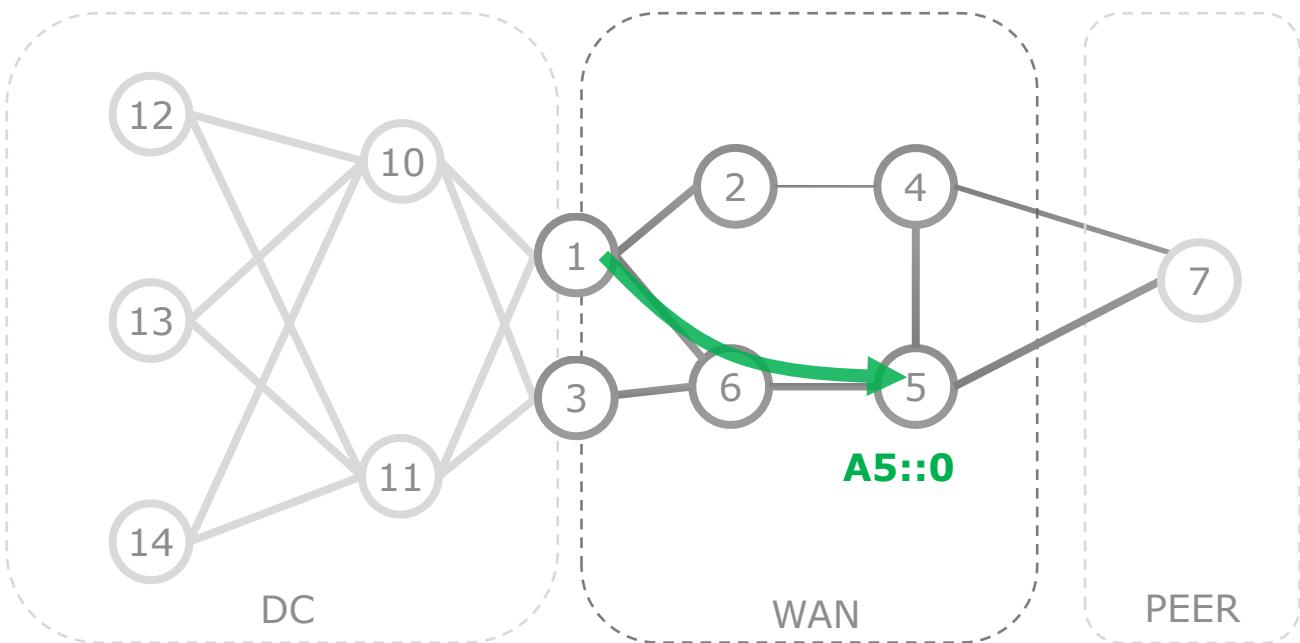
Endpoint

- For simplicity
- Function 0 denotes the most basic function
- Shortest-path to the Node

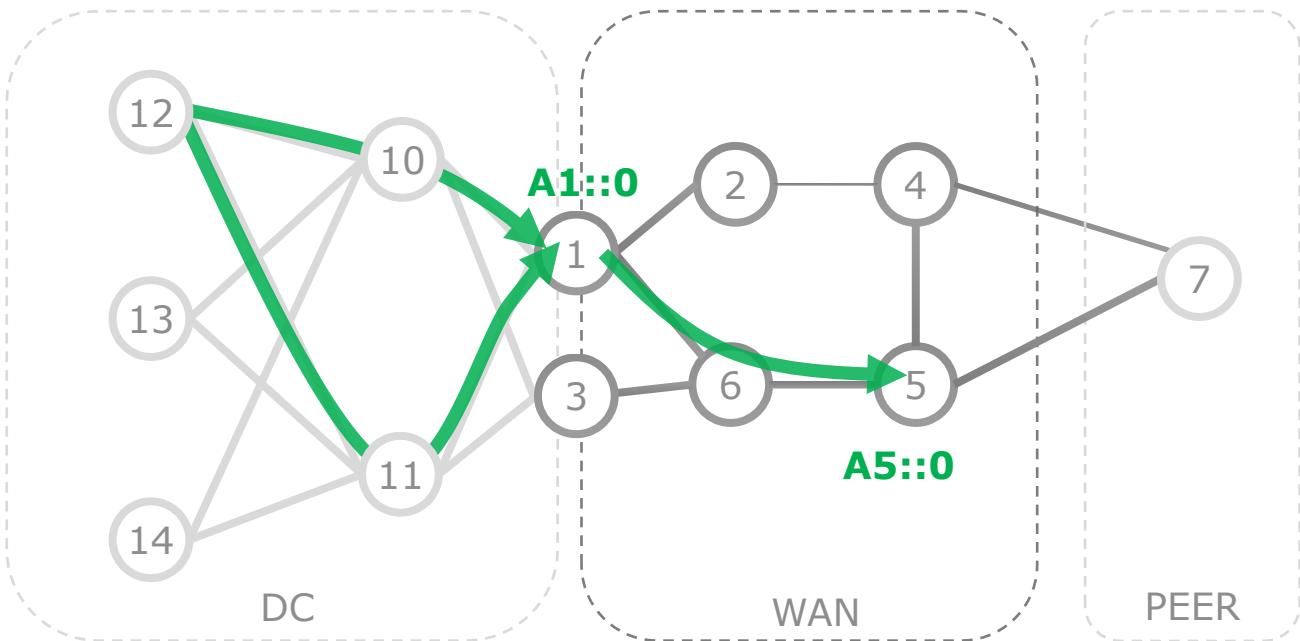


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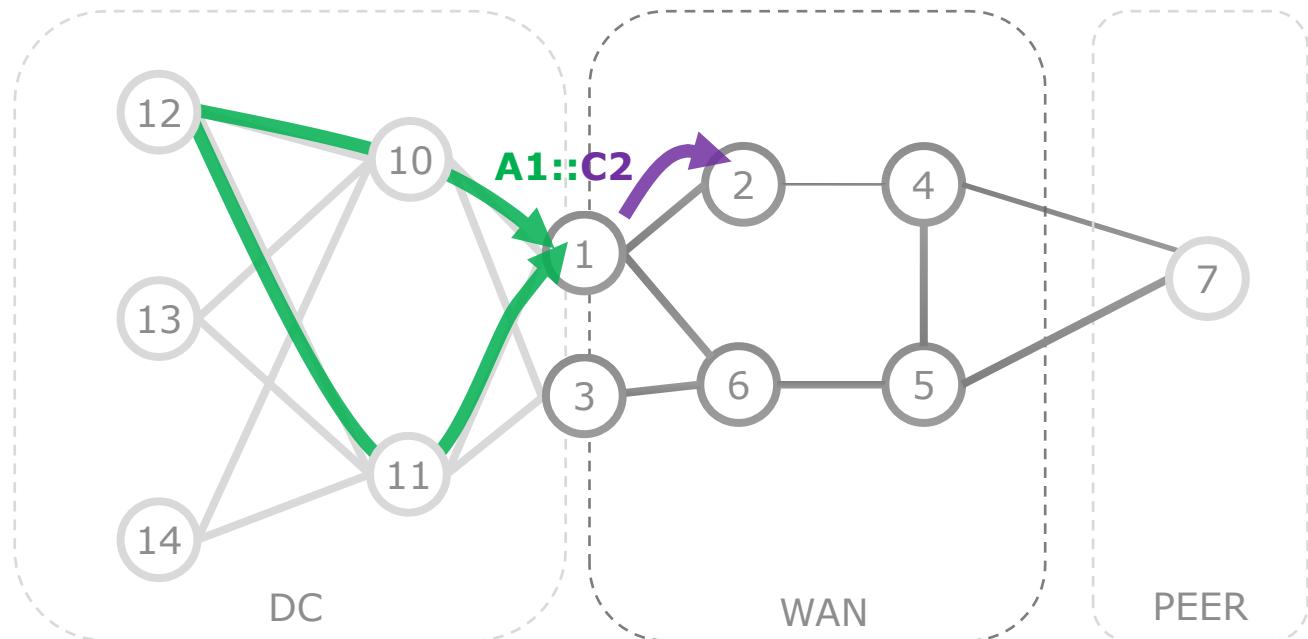


A1::0 and then A5::0



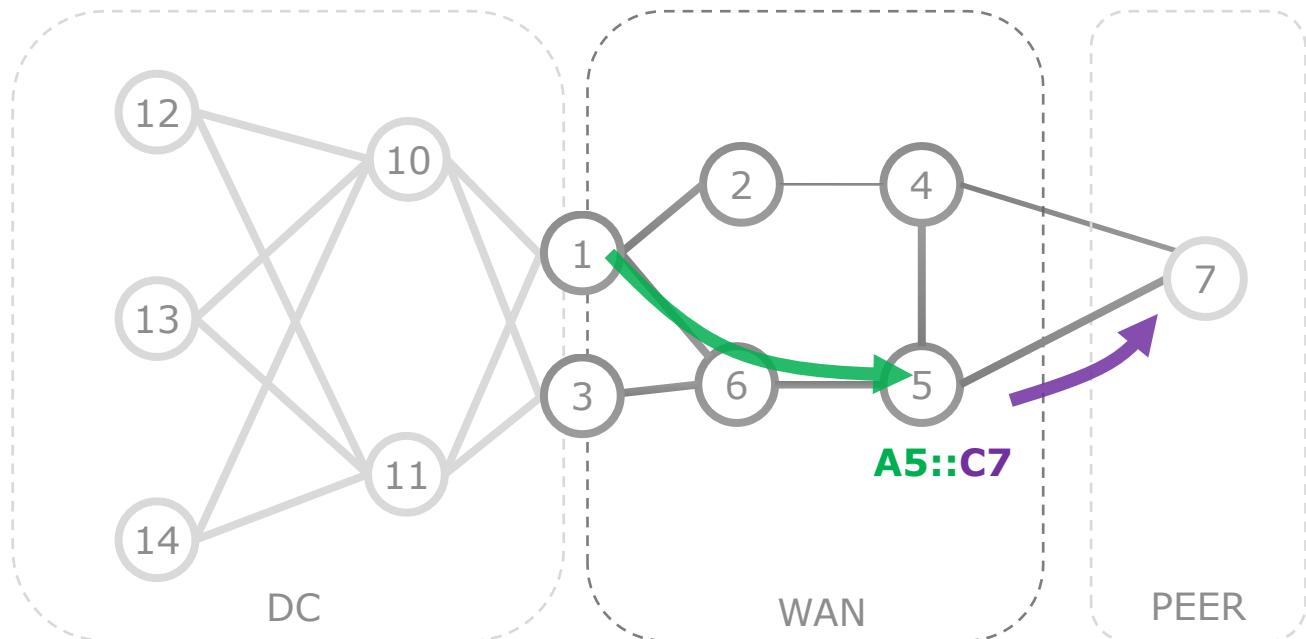
Endpoint then xconnect to neighbor

- For simplicity
- AK::CJ denotes
Shortest-path to the
Node K and then
x-connect (function
C) to the neighbor J

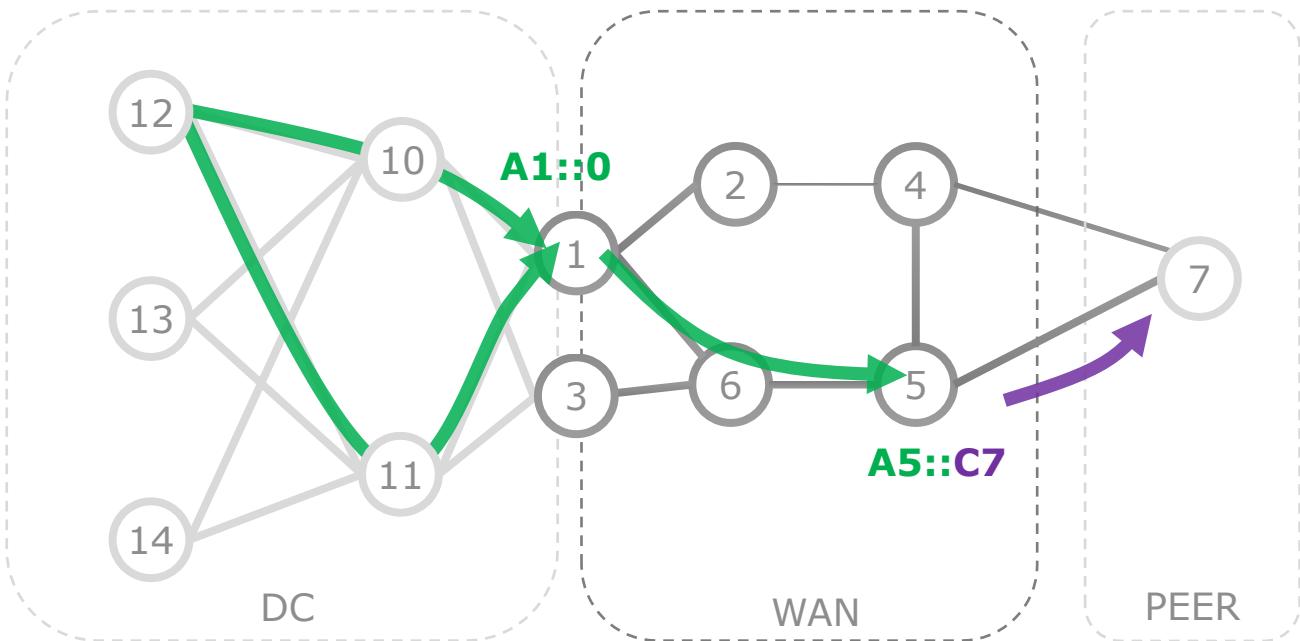


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Shortest-path to the
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C) to the neighbor J

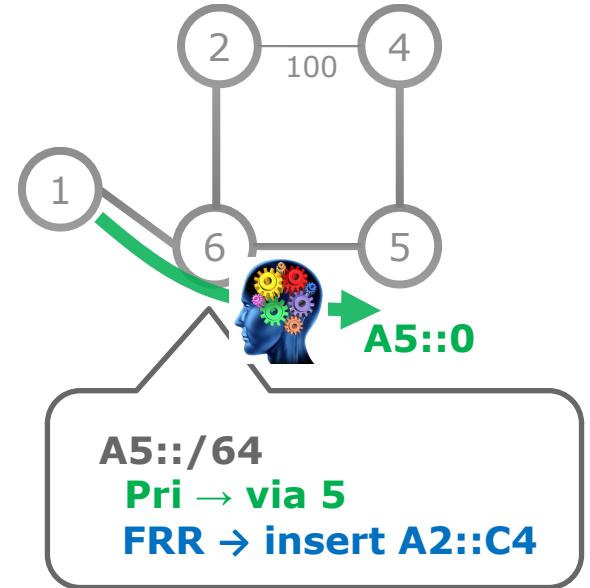


A1::0 and then A5::C7



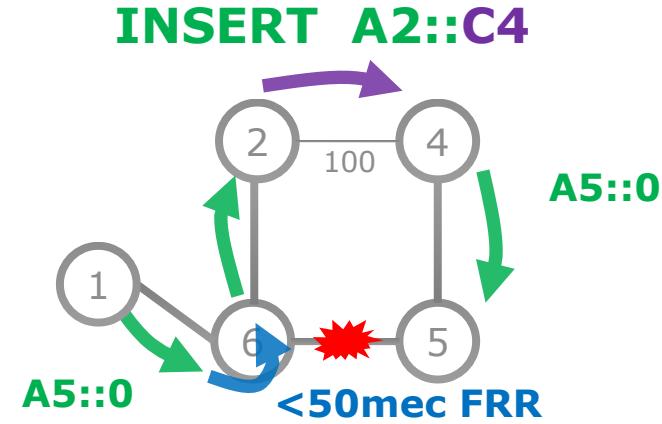
TILFA

- 50msec Protection upon local link, node or SRLG failure
- Simple to operate and understand
 - automatically computed by the router's IGP process
 - 100% coverage across any topology
 - predictable (backup = postconvergence)
- Optimum backup path
 - leverages the post-convergence path, planned to carry the traffic
 - avoid any intermediate flap via alternate path
- Incremental deployment
- Distributed and Automated Intelligence

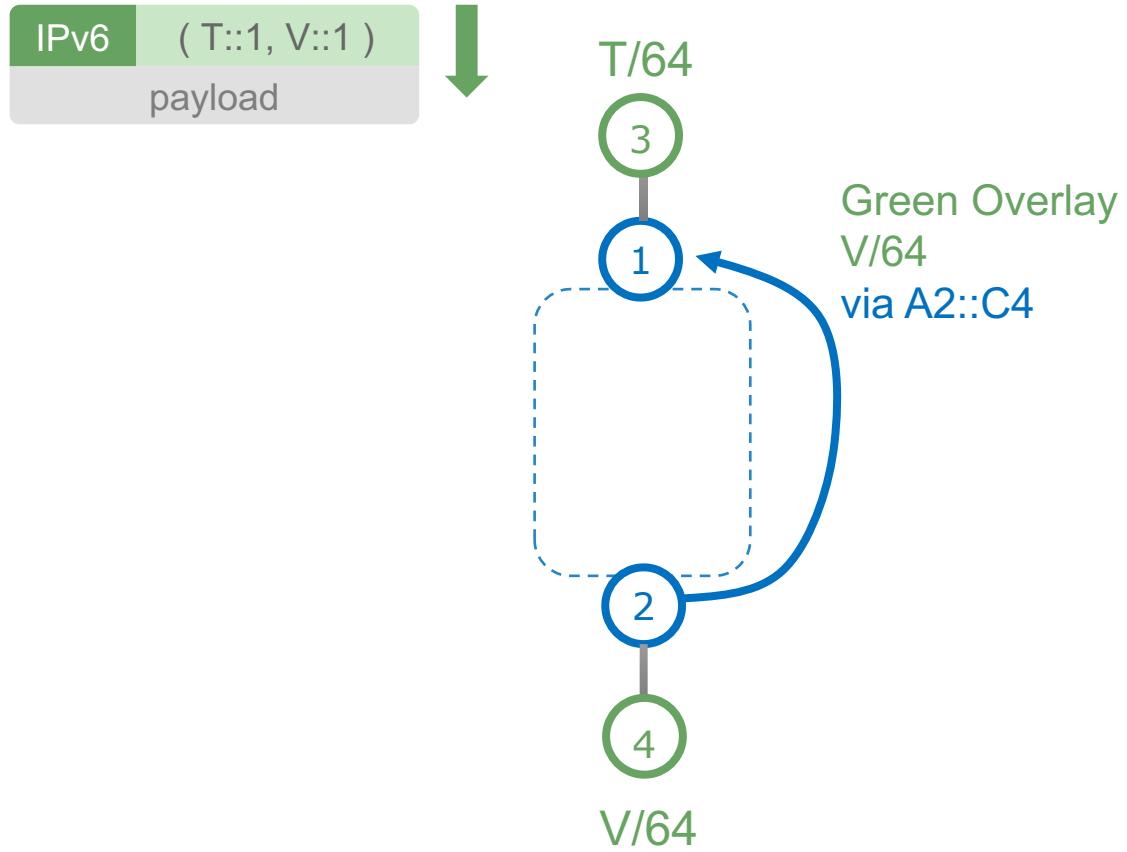


TILFA

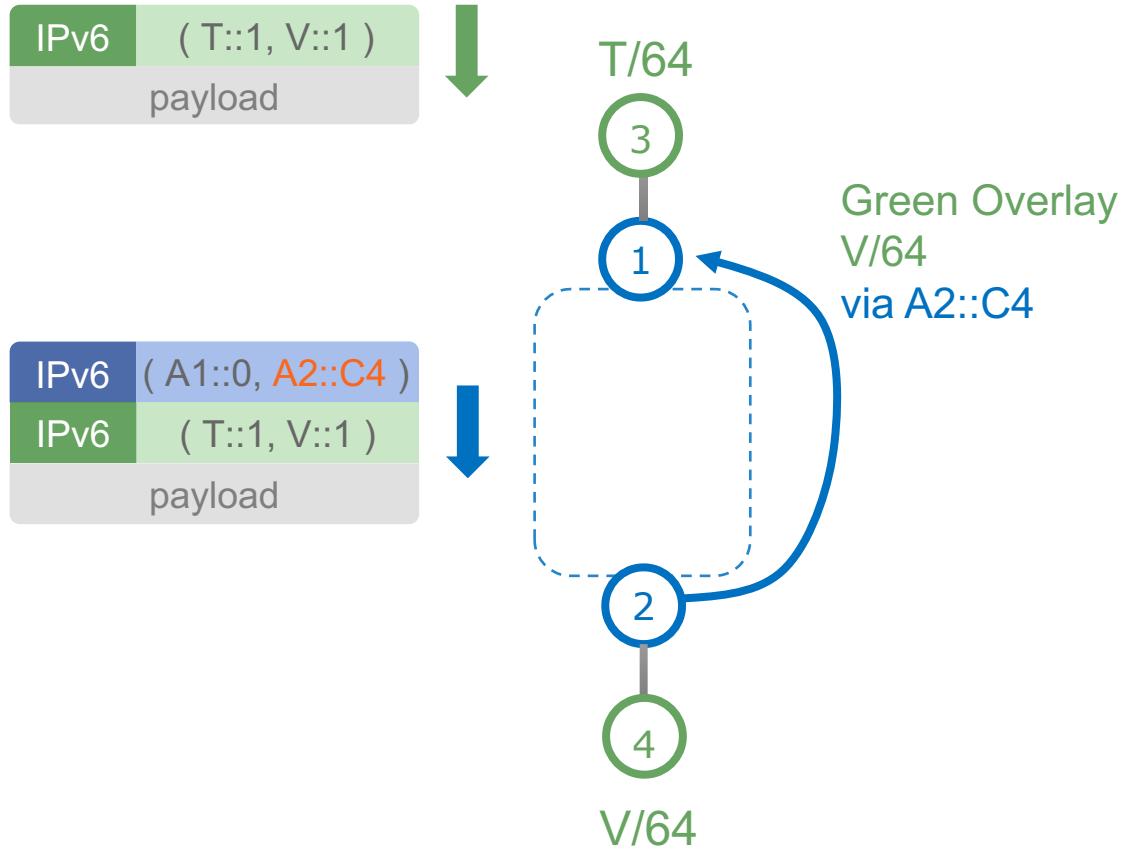
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Overlay

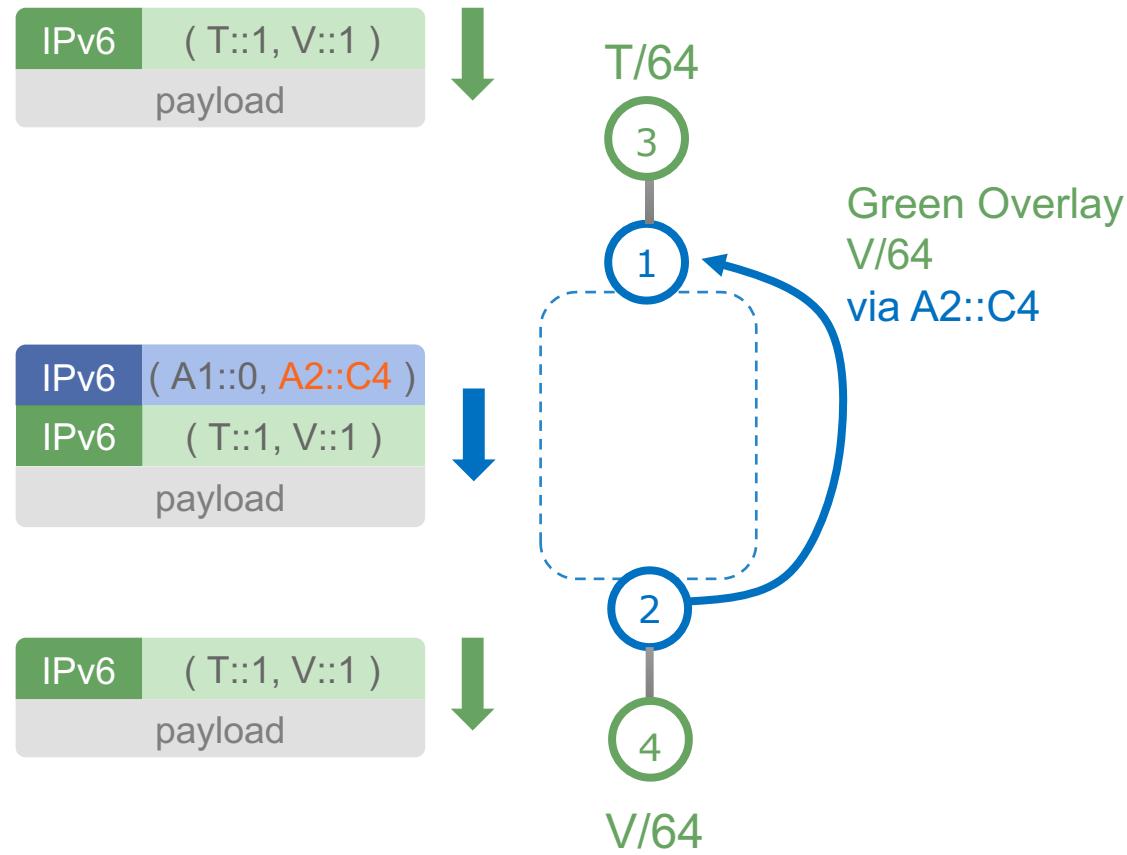


Overlay

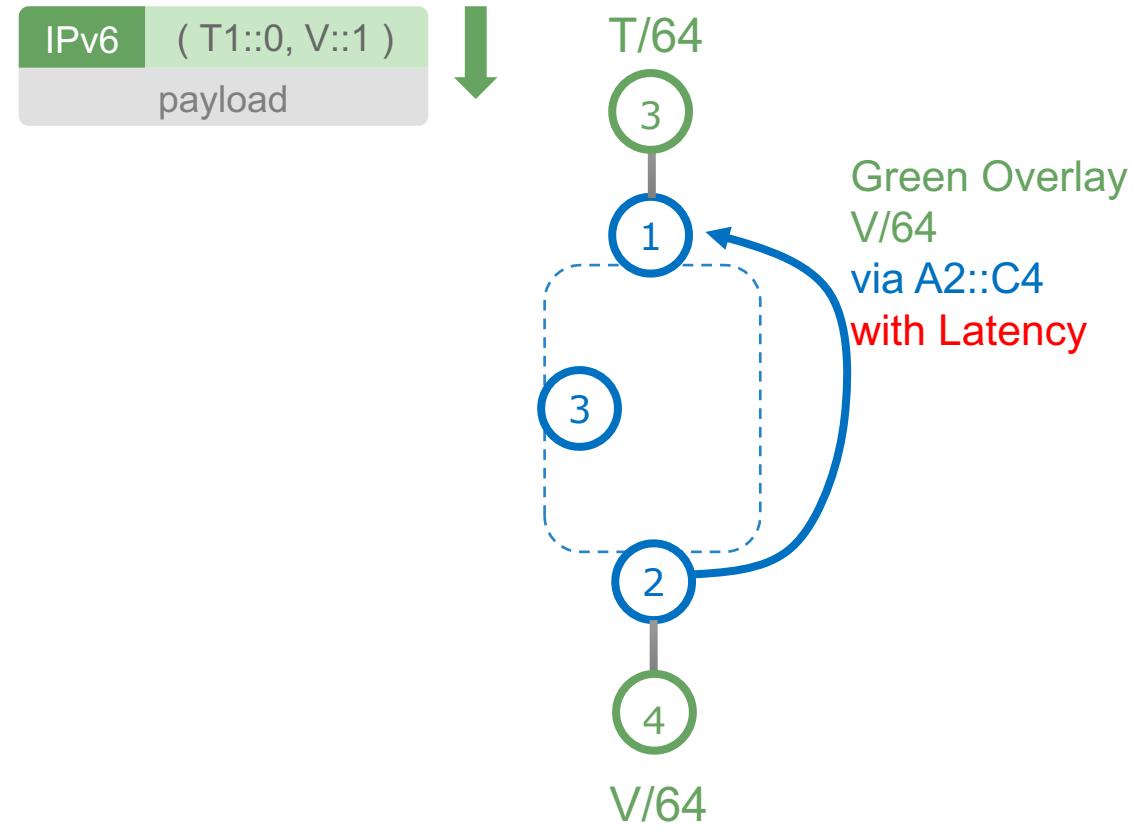


Overlay

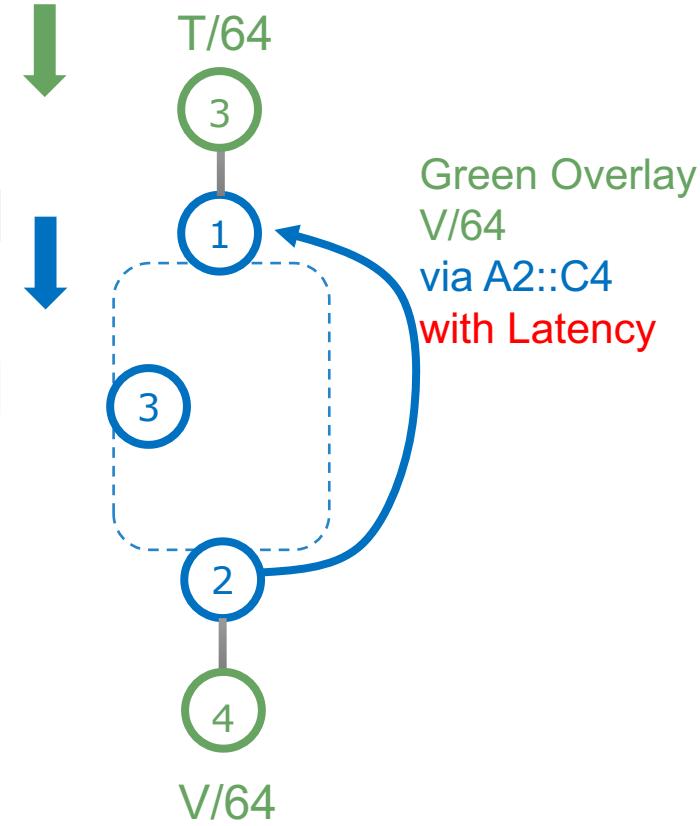
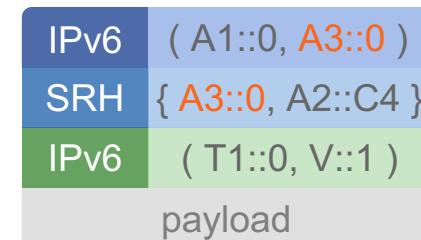
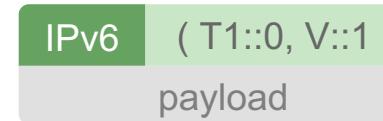
- Simple
 - Protocol elimination
- Automated
 - No tunnel to configure
- Efficient
 - SRv6 for everything
 - Reuse BGP/VPN signaling



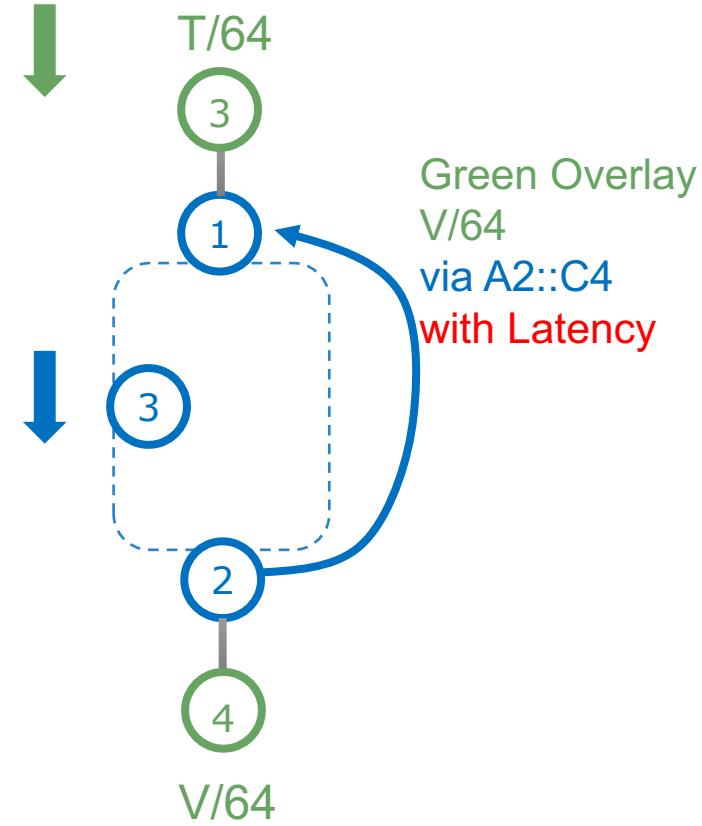
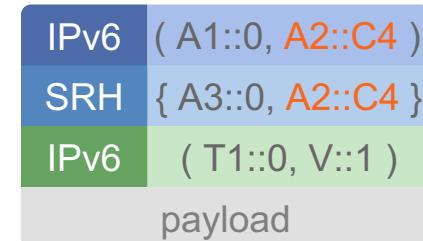
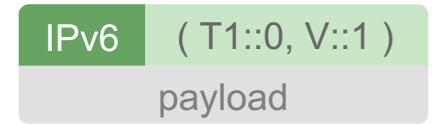
Overlay with Underlay SLA



Overlay with Underlay SLA

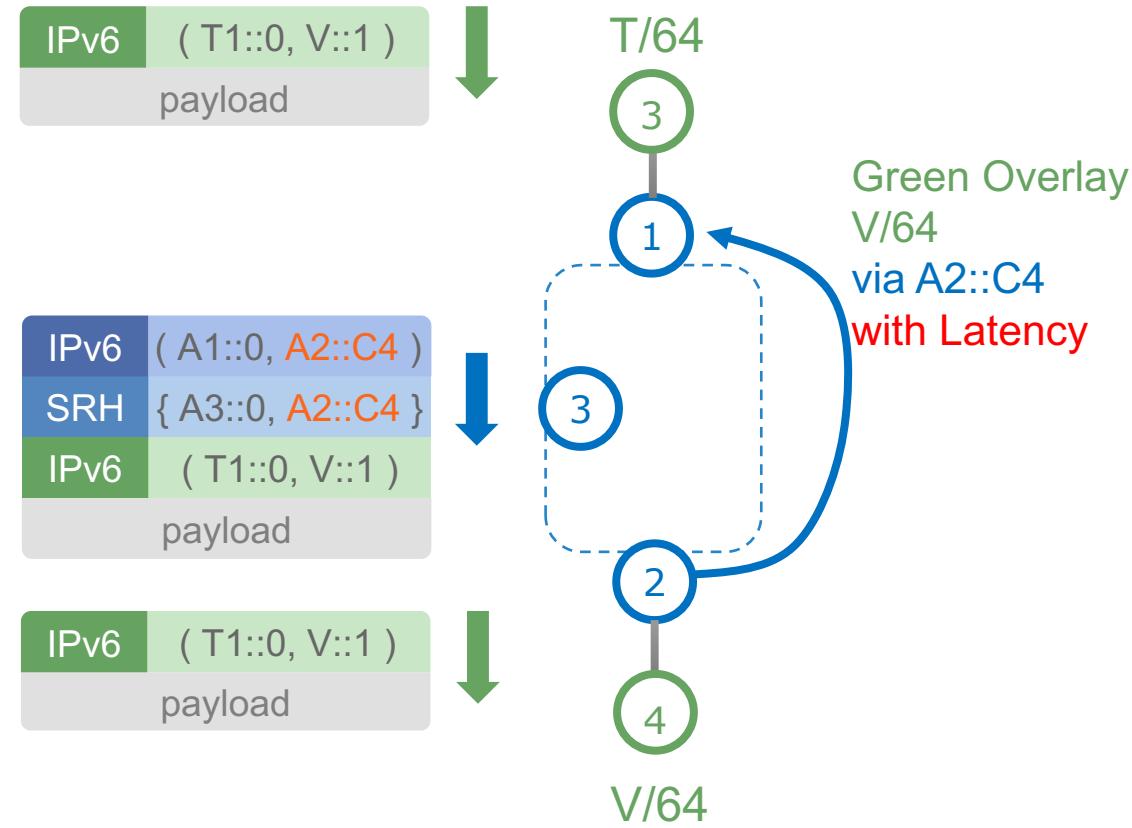


Overlay with Underlay SLA

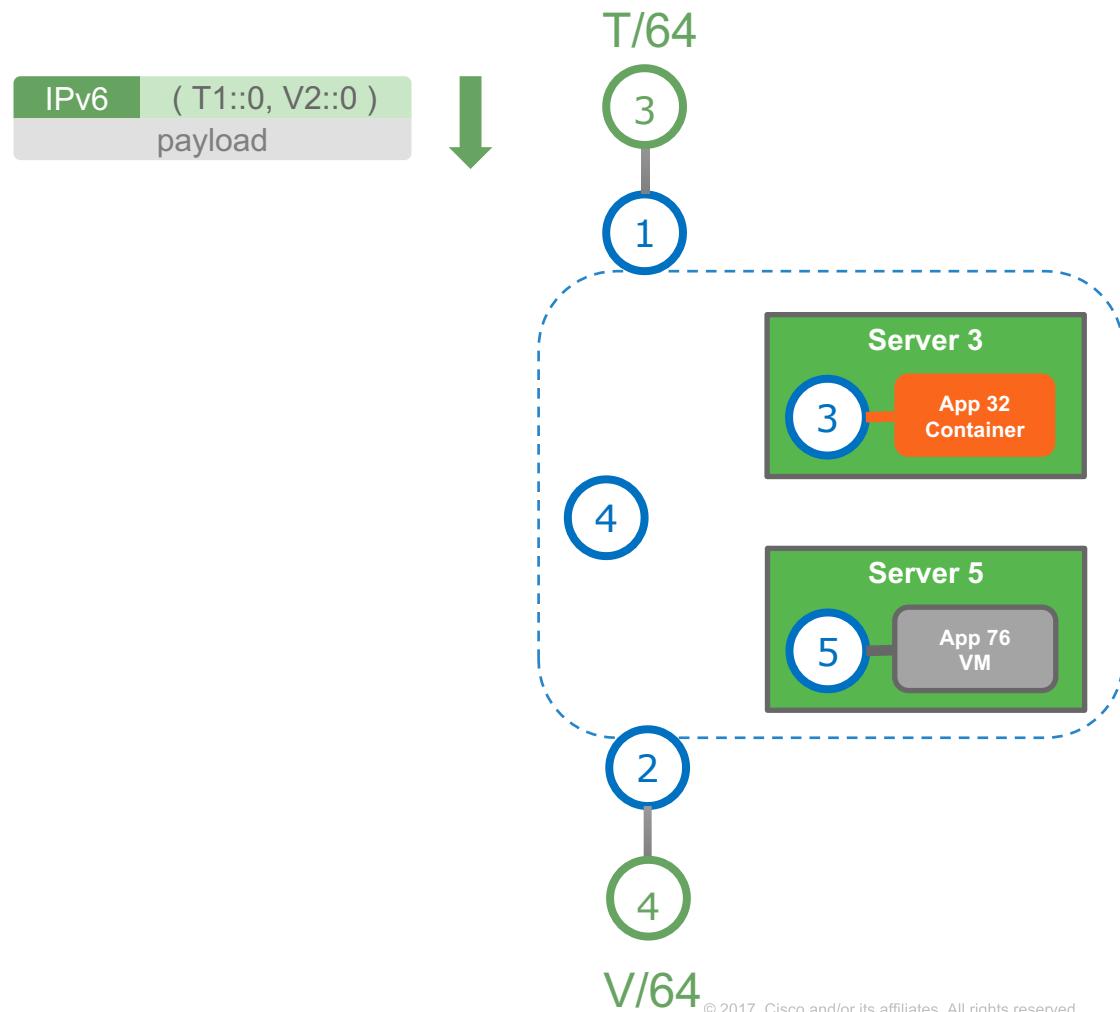


Overlay with Underlay SLA

- SRv6 does not only eliminate unneeded overlay protocols
- SRv6 solves problems that these protocols cannot solve
- Also support IPv4 and Ethernet VPN's

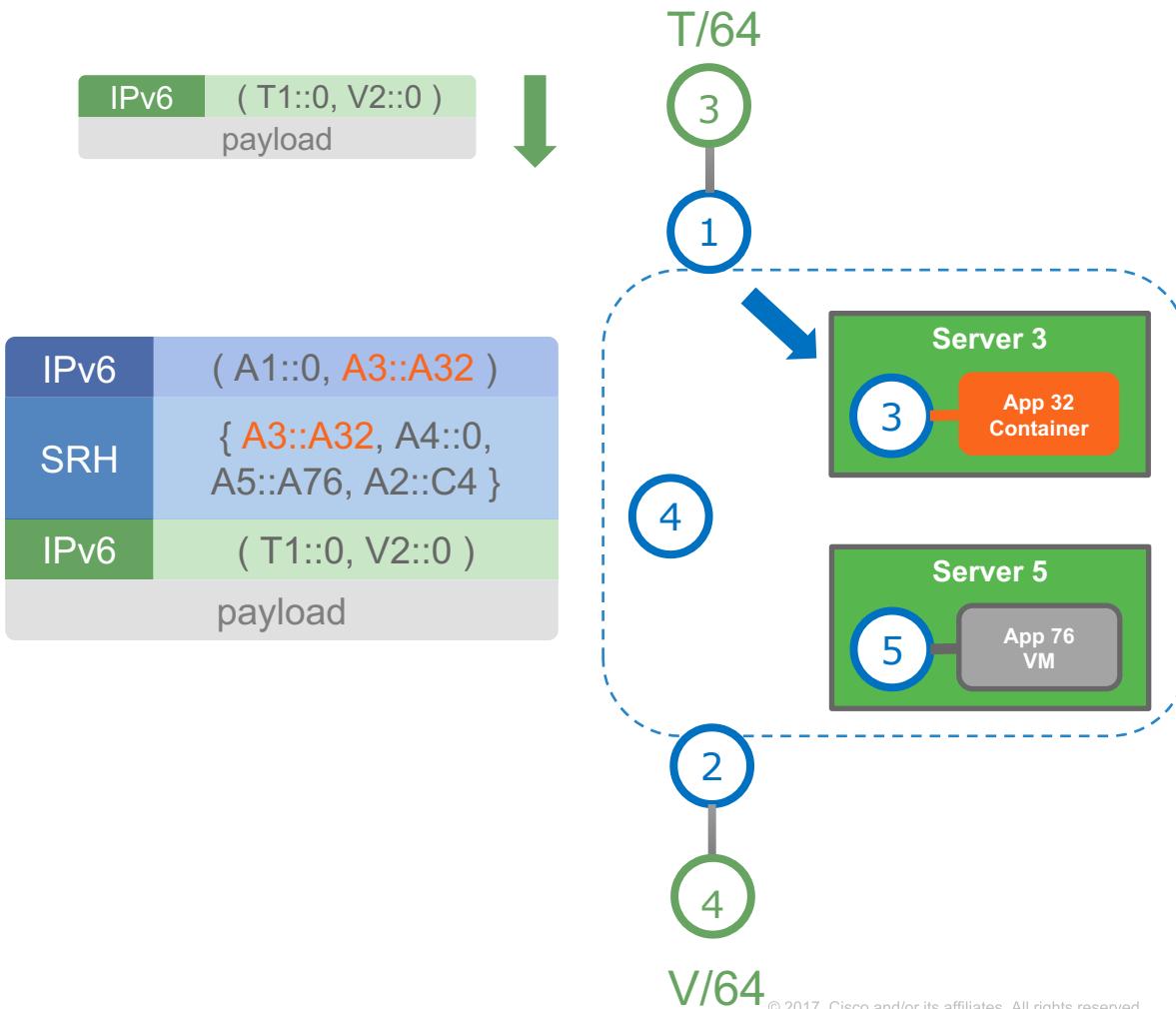


Integrated NFV



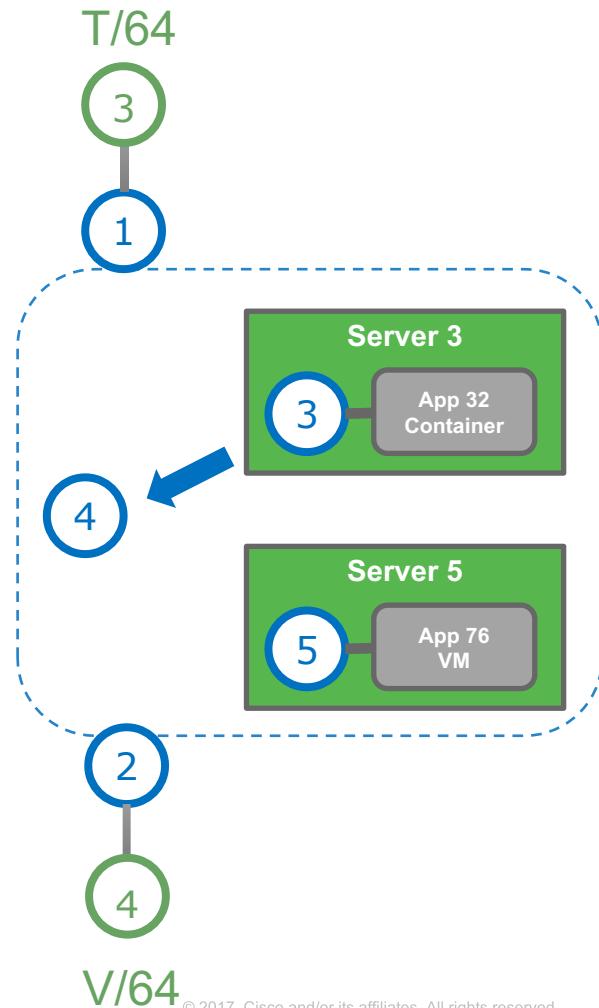
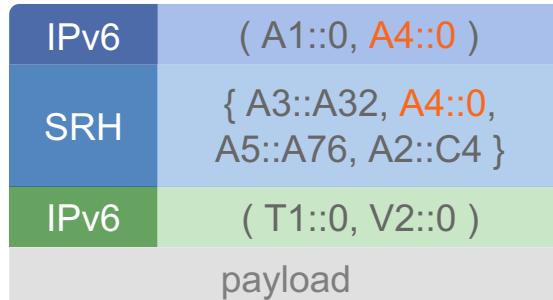
Integrated NFV

- Stateless Service Chaining
 - NSH creates per-chain state in the fabric
 - SR does not
- App is SR aware or not
- App can work on IPv6 or IPv4 inner packets



Integrated NFV

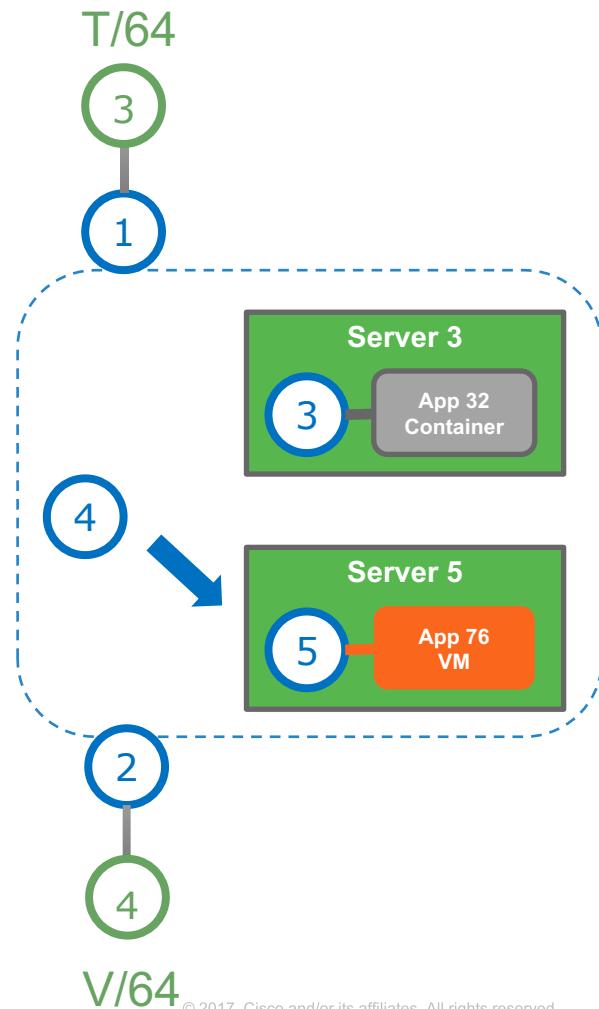
- Integrated SLA



Integrated NFV

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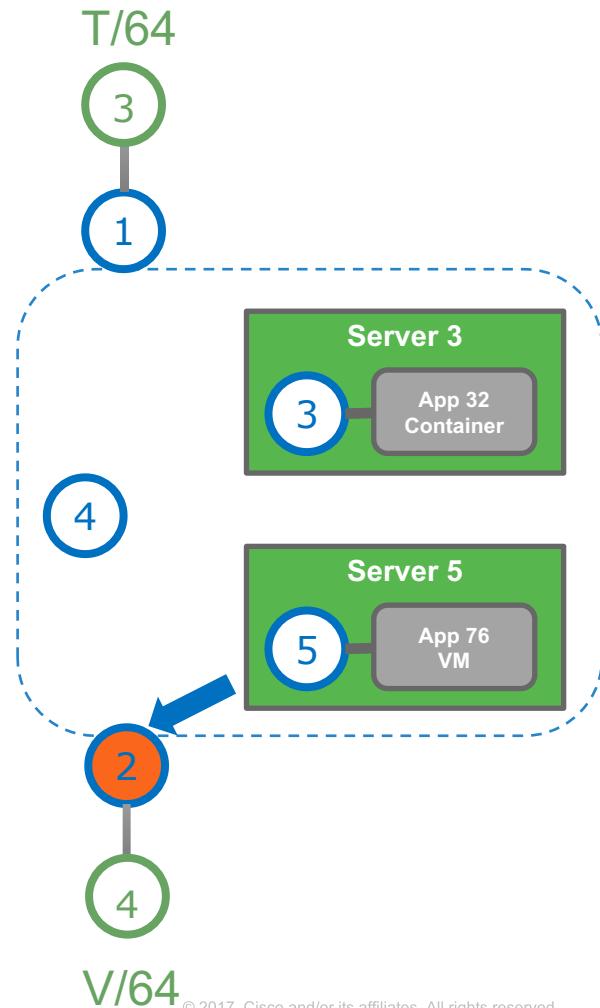
IPv6	(A1::0, A5::A76)
SRH	{ A3::A32, A4::0, A5::A76 , A2::C4 }
IPv6	(T1::0, V2::0)
	payload



Integrated NFV

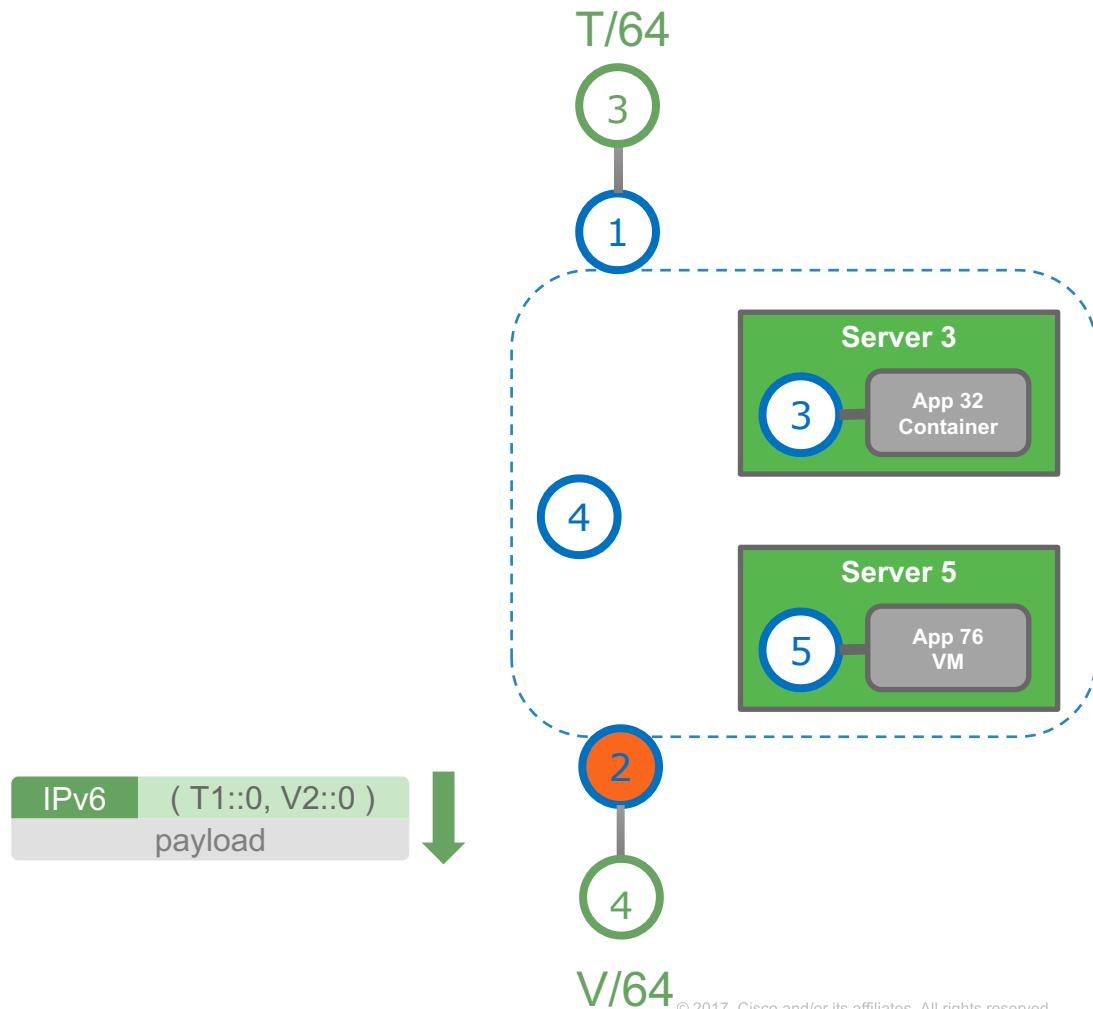
- Integrated with Overlay

IPv6	(A1::0, A2::C4)
SRH	{ A3::A32, A4::0, A5::A76, A2::C4 }
IPv6	(T1::0, V2::0)
	payload



Integrated NFV

- Integrated with Overlay

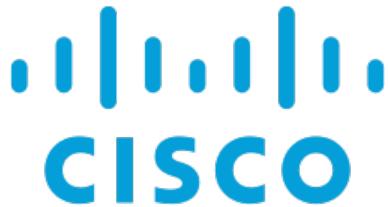


More use-cases

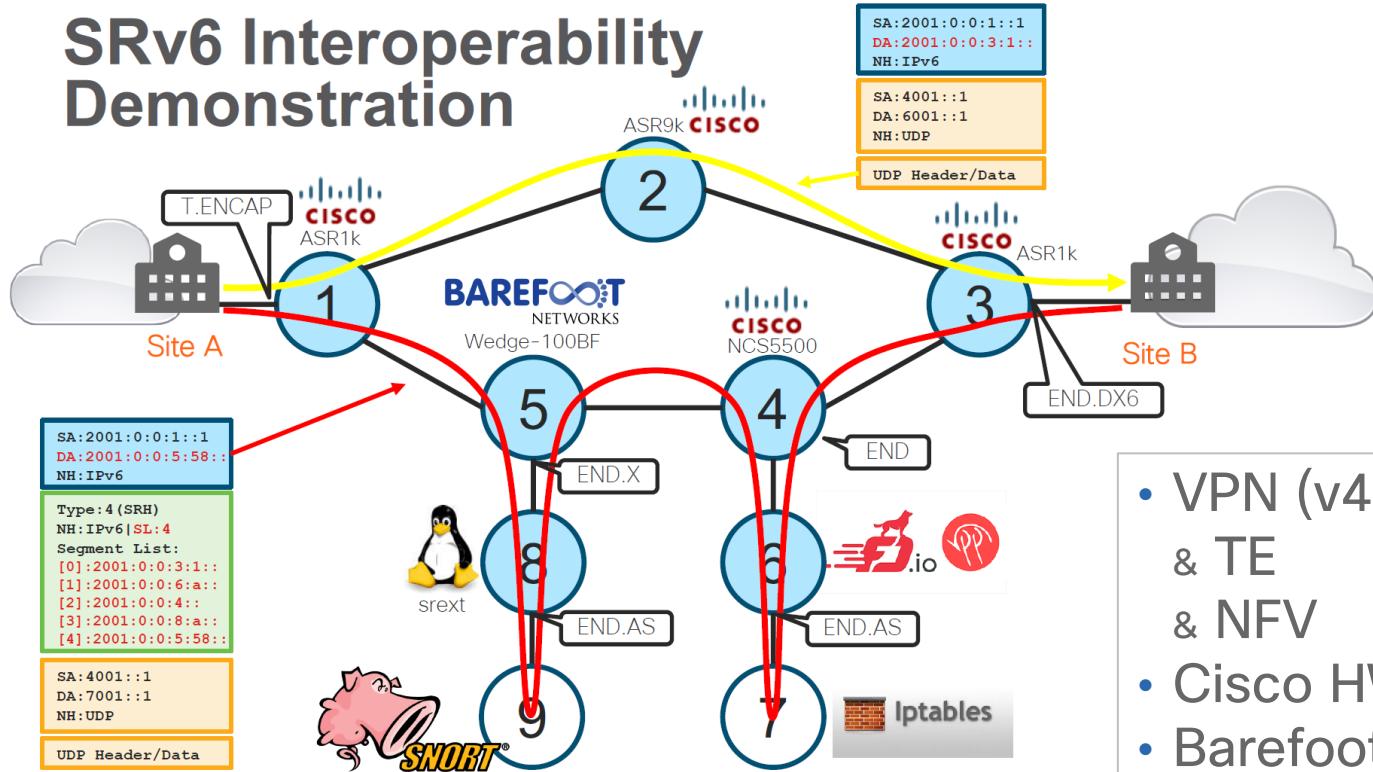
- 6CN: enhancing IP to search for Content
- 6LB: enhancing load-balancers
 - Better flow stickiness and load distribution
- Video Pipeline
- 5G Slicing
- 5G Ultra-Low Latency

Implementations

- Cisco HW
 - NCS5k - XR
 - ASR9k - XR
 - ASR1k - XE
- Open-Source
 - Linux 4.10
 - FD.IO
- Barefoot HW



SRv6 Interoperability Demonstration



- VPN (v4 and v6)
& TE
& NFV
- Cisco HW with XR and XE
- Barefoot HW with P4 code
- FD.IO
- Linux

blogs.cisco.com/sp/segment-routing-ipv6-interoperability-demo-is-already-there

Deployments

- Comcast
 - Efficient transport of video traffic
- Others



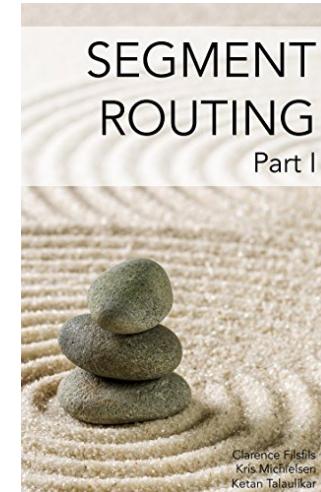
Conclusion

Segment Routing

- Strong industry support
- Fantastic deployment rate
- Bold architecture: network programming
- Numerous use-cases
- Feel free to join the lead-operator team!

Stay Up-To-Date

amzn.com/B01I58LSUO



segment-routing.net



linkedin.com/groups/8266623



twitter.com/SegmentRouting



facebook.com/SegmentRouting/



Thank you



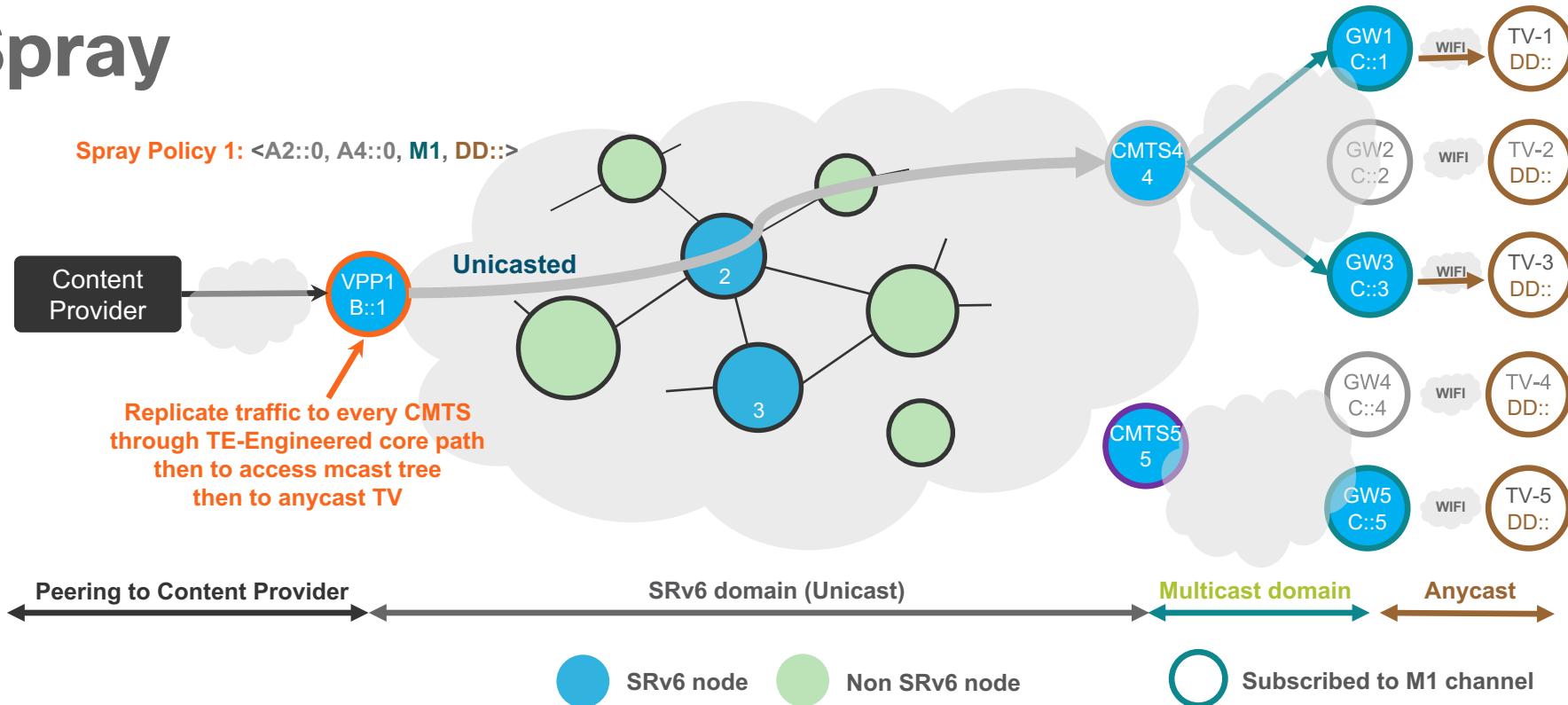


Appendix



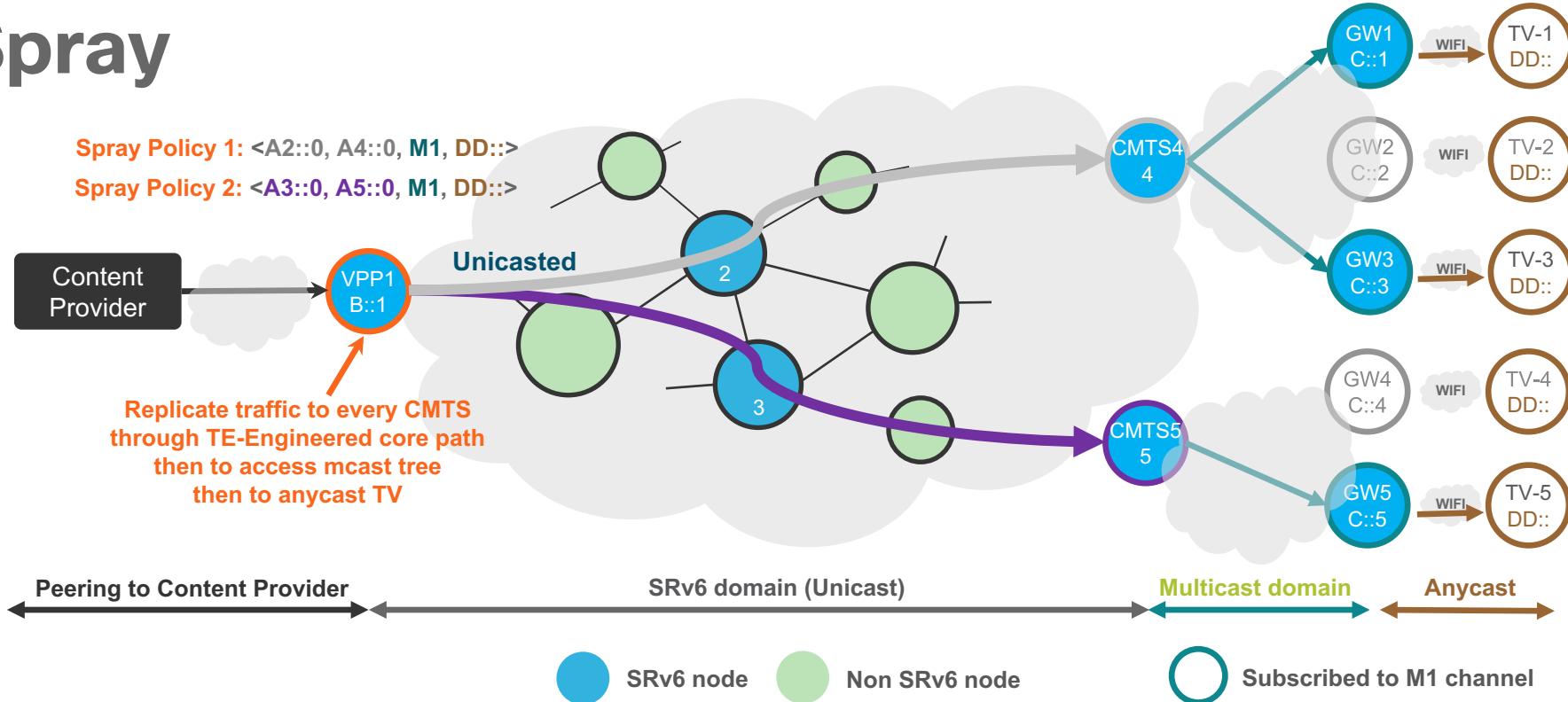
Other use-cases

Spray



Flexible, SLA-enabled and Efficient content injection without multicast core

Spray



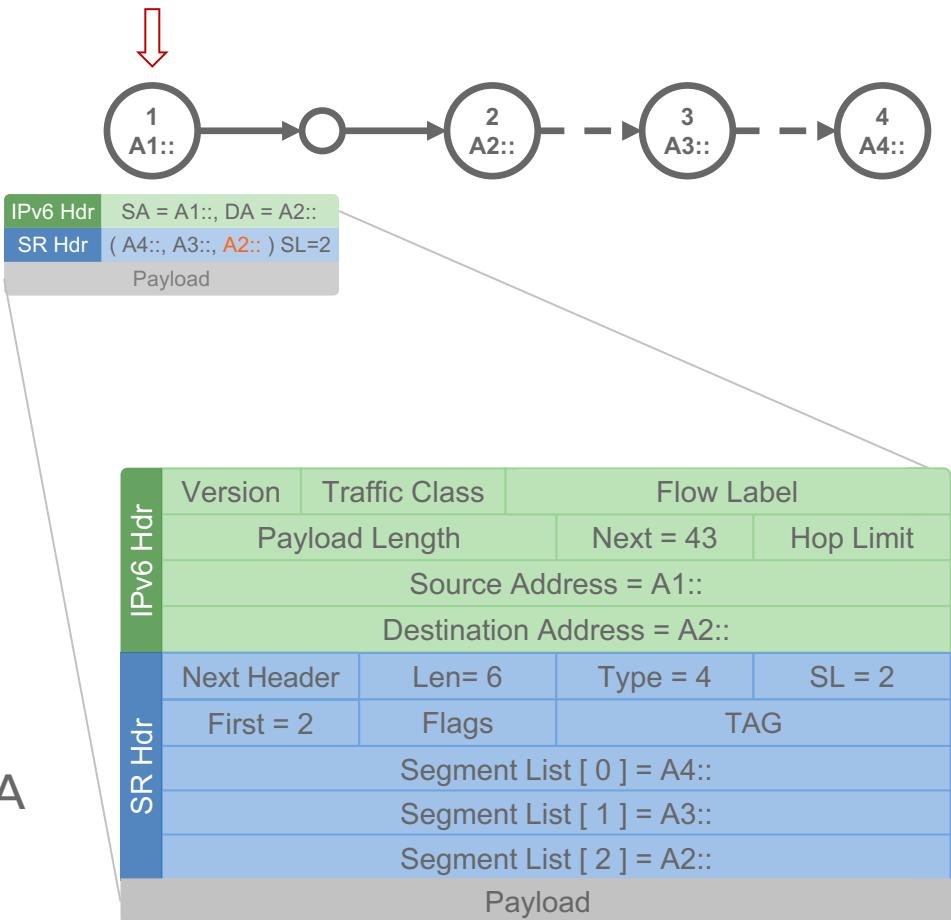
Flexible, SLA-enabled and Efficient content injection without multicast core



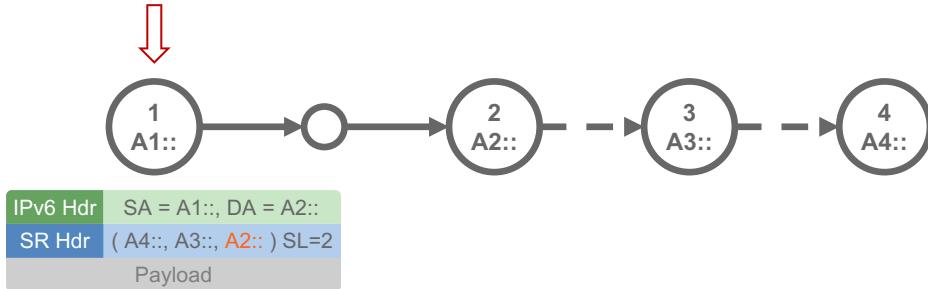
SRH Processing

Source Node

- Source node is SR-capable
- SR Header (SRH) is created with
 - Segment list in reversed order of the path
 - > Segment List [0] is the LAST segment
 - > Segment List [$n - 1$] is the FIRST segment
 - Segments Left is set to $n - 1$
 - First Segment is set to $n - 1$
- IP DA is set to the first segment
- Packet is send according to the IP DA
 - Normal IPv6 forwarding



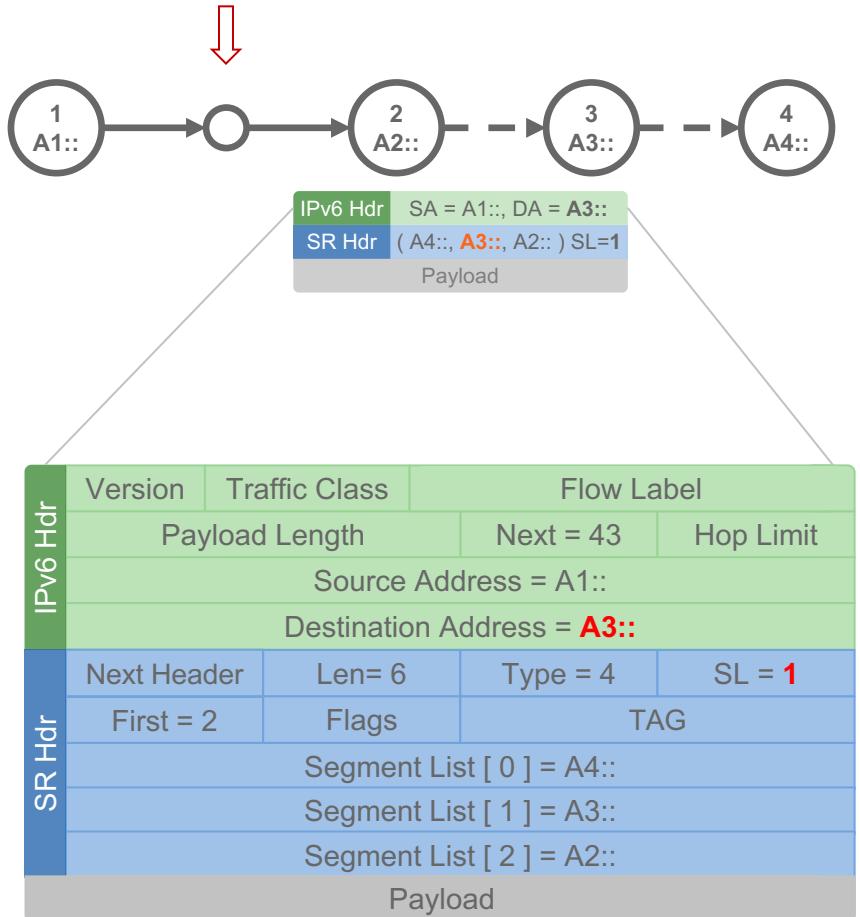
Non-SR Transit Node



- Plain IPv6 forwarding
- Solely based on IPv6 DA
- No SRH inspection or update

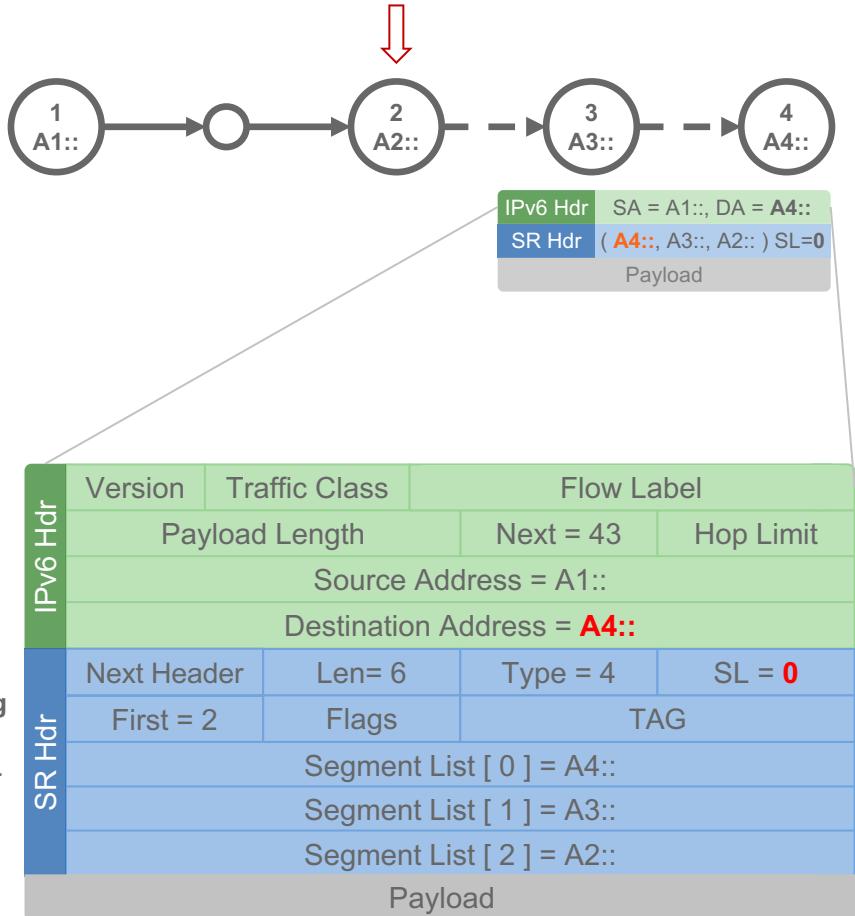
SR Segment Endpoints

- SR Endpoints: SR-capable nodes whose address is in the IP DA
- SR Endpoints inspect the SRH and do:
 - IF Segments Left > 0, THEN
 - > Decrement Segments Left (-1)
 - > Update DA with Segment List [Segments Left]
 - > Forward according to the new IP DA



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- SR Endpoints inspect the SRH and do:
 - IF Segments Left > 0, THEN
 - > Decrement Segments Left (-1)
 - > Update DA with Segment List [Segments Left]
 - > Forward according to the new IP DA
 - ELSE (Segments Left = 0)
 - > Remove the IP and SR header
 - > Process the payload:
 - Inner IP: Lookup DA and forward
 - TCP / UDP: Send to socket
 - ...





Some obvious SID functions

Segment format

<i>Locator</i>	<i>Function</i>
1111 : 2222 : 3333 : 4444	5555 : 6666 : 7777 : 8888

- SRv6 SIDs are 128-bit addresses
 - **Locator**: most significant bits are used to **route** the segment to its **parent node**
 - **Function**: least significant bits identify the **action** to be performed on the **parent node**
 - > **Argument [optional]**: Last bits can be used as a local function argument
- Flexible bit-length allocation
 - Segment format is **local knowledge** on the parent node
- SIDs have to be **specifically enabled** as such on their parent node
 - A local address **is not** by default a local SID
 - A local SID does not have to be associated with an interface

Segment format

<i>Locator</i>	<i>Function</i>
1111 : 2222 : 3333 : 4444 : 5555 : 6666 : 7777 : 8888	

- SRv6 SIDs are 128-bit addresses
 - **Locator**: most significant bits are used to **route** the segment to its **parent node**
 - **Function**: least significant bits identify the **action** to be performed on the **parent node**
 - > **Argument** [optional]: Last bits can be used as a local function argument
- Flexible bit-length allocation
 - Segment format is **local knowledge** on the parent node
- SIDs have to be **specifically enabled** as such on their parent node
 - A local address **is not** by default a local SID
 - A local SID does not have to be associated with an interface

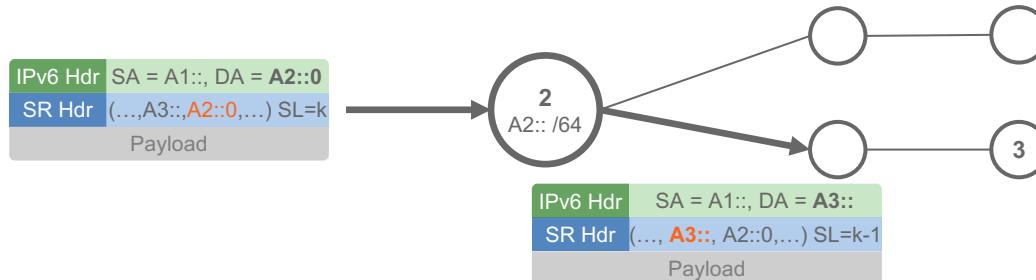
Segment format

<i>Locator</i>	<i>Function</i>
1111 : 2222 : 3333 : 4444 : 5555 : 6666 : 7777 : 8888	

- SRv6 SIDs are 128-bit addresses
 - **Locator**: most significant bits are used to **route** the segment to its **parent node**
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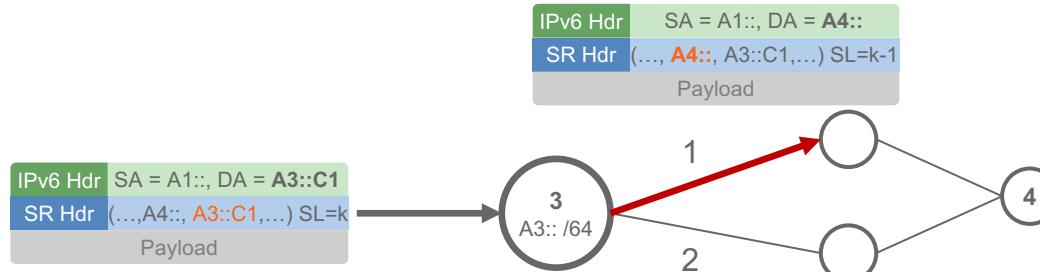
END – Default endpoint

- *Default endpoint* behavior (node segment)
 - Decrement Segments Left, update DA
 - Forward according to new DA
- Node 2 advertises prefix A2::/64 (**A2::/64 is the SID locator**)
 - Packets are forwarded to node 2 along the default routes (shortest path)
- On 2, the *default endpoint* behavior is associated with ID 0 (0 is the **function**)
- The SID corresponding to the *default endpoint* behavior on node 2 is A2::0



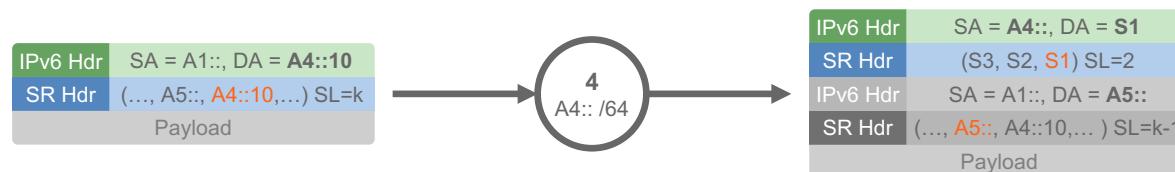
END.X – Endpoint then Xconnect

- *Endpoint xconnect* behavior (adjacency segment)
 - Decrement Segments Left, update DA
 - **Forward on the interface associated with the Xconnect segment**
- Node 3 advertises prefix A3::/64
 - Packets are forwarded to node 3 along the default routes (shortest path)
- On 3, the *endpoint xconnect* behavior for link 1 is associated with ID C1
- The SID corresponding to *endpoint xconnect-1* behavior on node 3 is **A3::C1**



END.B6.ENCAPS – IPv6 Binding Segment (encap)

- *IPv6 binding segment*
 - Decrement Segments Left, update DA
 - **Push outer IP and SR headers associated with the binding segment**
 - Forward according to outer header DA (first segment of the new SRH)
- Node 4 advertises prefix A4::/64
- The SR *encaps* policy (SA = A4::, SL = < S1, S2, S3 >) is associated with ID 10
- The corresponding *binding SID* is **A4::10**



END.B6 – IPv6 Binding Segment (insert)

- *IPv6 binding segment*
 - Do not decrement Segments Left
 - Push outer SR header associated with the binding segment
 - Update DA with the first segment of the outer SR header
 - Forward according to outer header DA (first segment of the new SRH)
- Node 4 advertises prefix A4::/64
- On 4, the SR *insert* policy < S1, S2, S3 > is associated with ID 20
- The corresponding *binding SID* is **A4::20**



END.BM – MPLS Binding Segment

- *MPLS binding segment*
 - Decrement Segments Left
 - **Push outer MPLS label stack associated with the binding segment**
 - Forward according to the top MPLS label
- Node 4 advertises prefix A4::/64
- On 4, the MPLS SR policy <L1, L2, L3> is associated with ID 30
- The corresponding *binding SID* is **A4::30**



END.PSP – Penultimate Segment Popping

- *Penultimate Segment Popping (PSP) behavior*
 - Decrement Segments Left, update DA
 - **If Segments Left = 0, remove SRH**
 - Forward according to new DA
- Node 5 advertises prefix A5::/64
- On 5, the *Penultimate Segment Popping* behavior is associated with ID 1
- The corresponding SID is A5::1



END.PSP – Penultimate Segment Popping

- *Penultimate Segment Popping (PSP)* behavior
 - Decrement Segments Left, update DA
 - **If Segments Left = 0, remove SRH**
 - Forward according to new DA
- Node 5 advertises prefix A5::/64
- On 5, the *Penultimate Segment Popping* behavior is associated with ID 1
- The corresponding SID is A5::1



END.USP – Ultimate Segment Popping

- *Ultimate Segment Popping (USP) behavior*
 - If Segments Left = 0
 - > Pop the top SRH
 - > Restart the END function processing on the modified packet
 - Decrement Segments Left, update DA
 - Forward according to new DA
- Node 6 advertises prefix A6::/64
- A6:: is the last segment in the top SRH



SID Function – Anything

- SID functions are locally defined on their parent node
 - They can do anything...
- An SR header contains a network program

