# Segment Routing

## “Chasm”を越えてついに実用段階へ
## そしてこれからのNetwork Programmability

Miya Kohno
Distinguished Systems Engineer, Cisco Systems

27 July 2017

# Segment Routingのこれまで（主要マイルストーン）

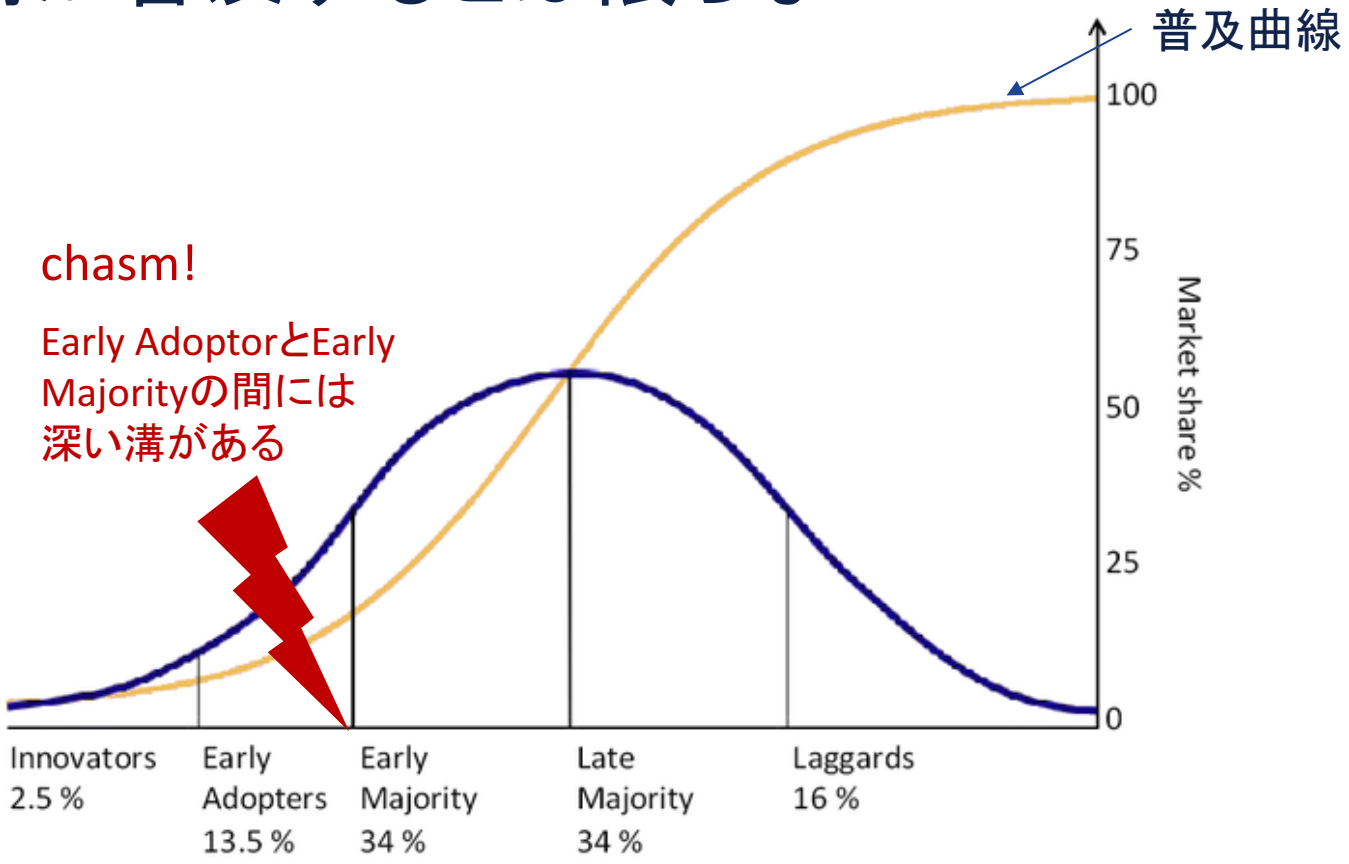
- 2012年10月　Cisco NAG[*1] Meetingにて初めてコンセプト紹介
- 2013年7月　Janog32 LTにて紹介
- 2013年10月　IETF SPRING WG発足
- 2014年4月　Segment Routing Architecture (draft-filsfils-spring-segment-routing-00)
- 2016年3月　Use cases @ MPLS SDN World Congress Paris
- 2016年6月　Tech field day – Segment Routing Roundtable [*2]

[*1] Network Architecture Geeks : Cisco Private Meeting
[*2] http://techfieldday.com/event/srr1/

# Outline

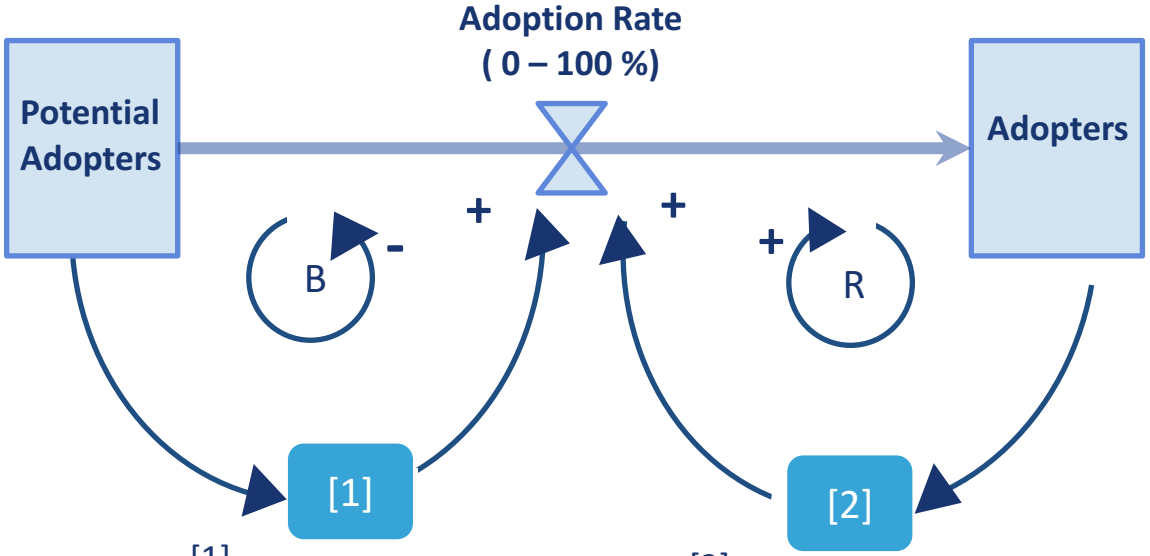
- *技術の普及とSegment Routing技術の価値について*
- Digital時代のネットワークシステムアーキテクチャ
- 参考資料

# 良い技術が普及するとは限らない




https://ja.wikipedia.org/wiki/%E6%99%AE%E5%8F%8A%E5%AD%A6

# Systems Dynamics的に記述すると




[1]
- 調査研究
- 技術精査、検討

[2]
- コミュニティ活動
- 標準化活動
- オープンソース活動（貢献、利用）
- 口コミ

**B : Balancing**

Negative feedback loop
変化を打ち消す動き

- 新技術への抵抗、リスク
- 導入・移行のコスト、リスク
- 普及の飽和状態

**R : Reinforcing**

Positive feedback loop
変化を強化する動き

- 普及による利便性
- ネットワーク効果

9.3.3. The Bass Diffusion Model, Business Dynamics – Systems thinking and modeling for a complex world, John D Sterman より改編

# 技術の普及とSegment Routing技術の価値について

ここで、宮坂さん・松嶋さんに

- Segment Routing技術に着目した理由
- 技術検討のポイントや考慮点

などについてお伺いする

# Outline

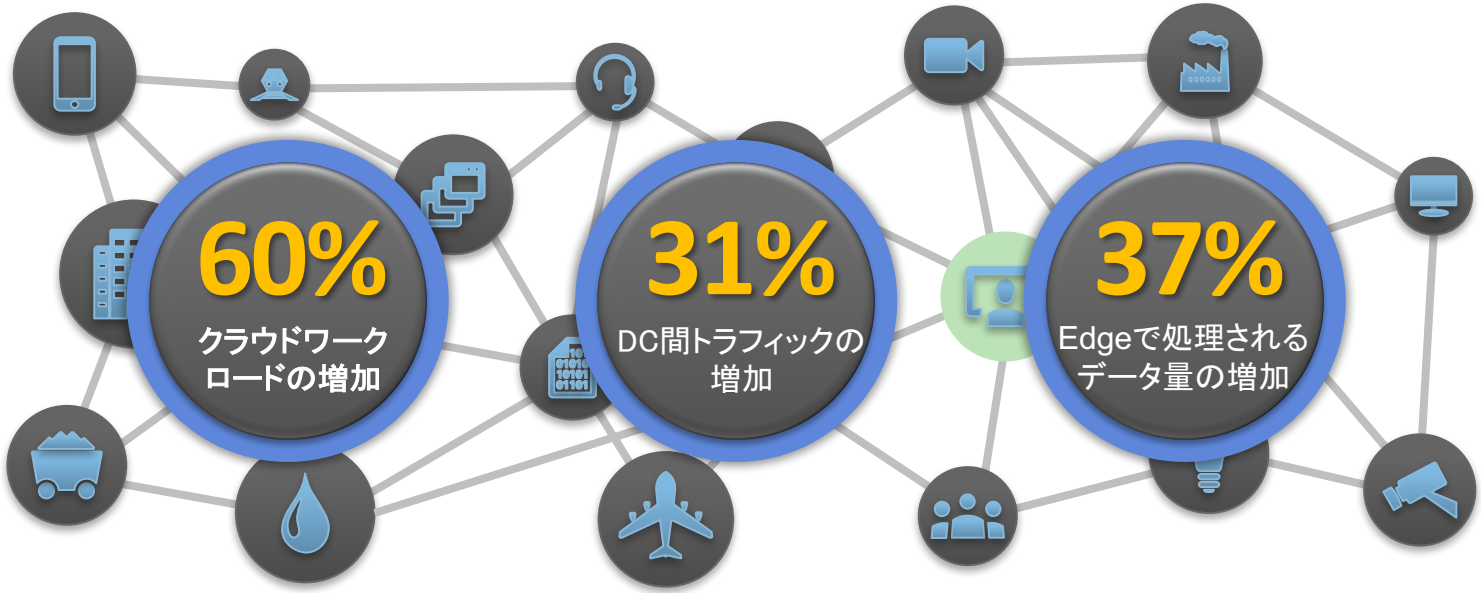
- 技術の普及とSegment Routing技術の価値について
- *Digital時代のネットワークシステムアーキテクチャ*
- 参考資料

# Digital時代のネットワークアーキテクチャ

## ディジタル化されるデータ量の急増

2014 - **3.4 ZB**　2019 - **10.4 ZB**

- 多くのものがつながる
- 多くのことが”As A Service”として提供される (Sharing Economy)
- 多くのデータが照合され，統計的，人工知能的に分析される



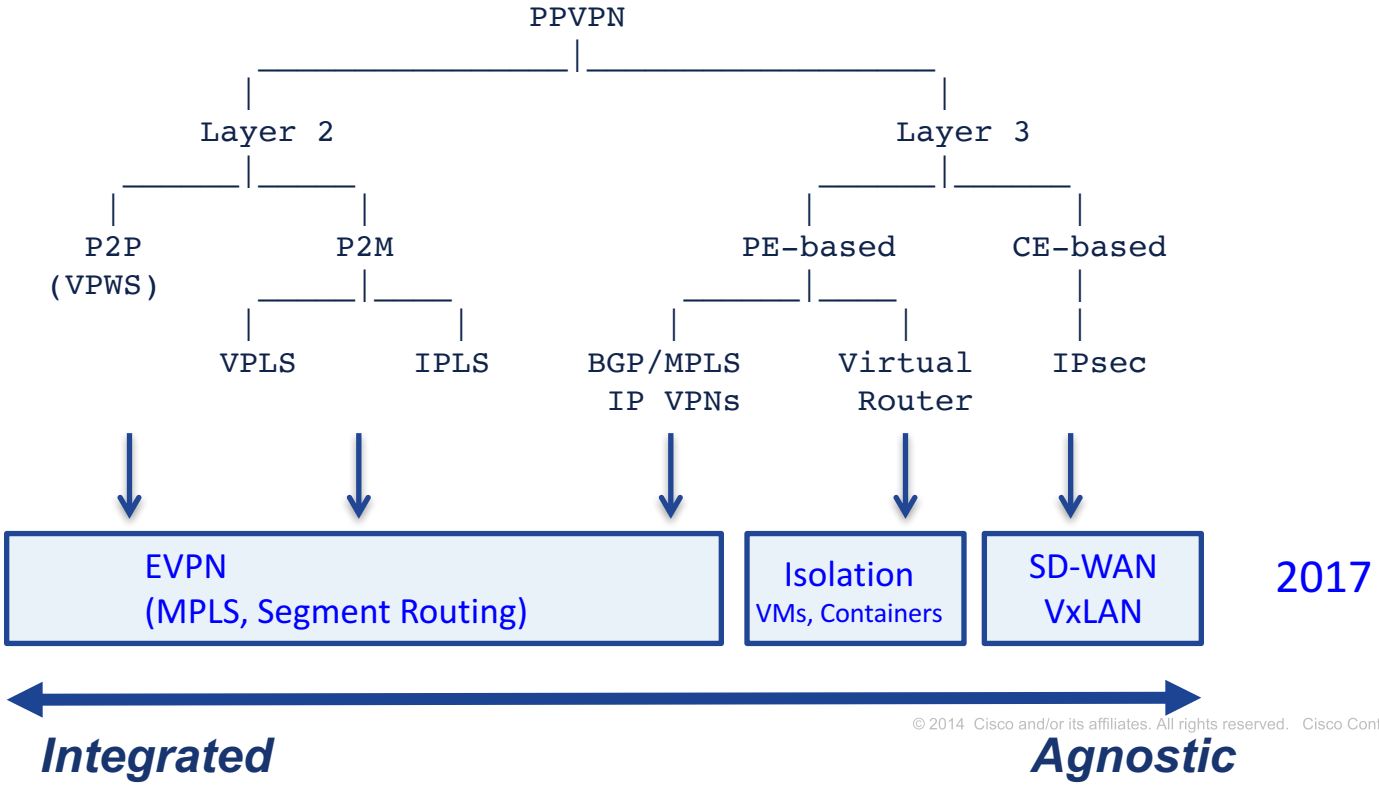

Source: Cisco Consulting Services Global IoT Study, 2014; 1230 respondents
Cisco Global Cloud Index Forecast, 2014–2019

# Digital時代のネットワークアーキテクチャ

- 運用側面
  - モデル化、可視化、合理化、自動化
- 機能・性能側面
  - コンピューティングとネットワーキングの融合
  - アプリケーション要求への対応
  - 分散処理への親和性
- サービス側面
  - Infrastructure Agnostic or Integrated ?!

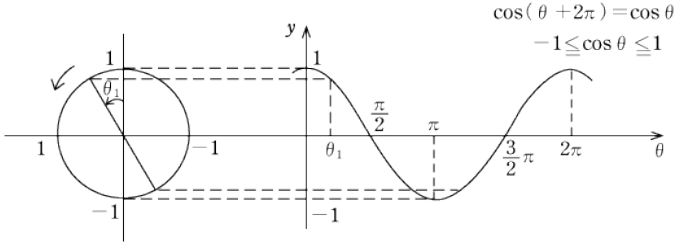
# Infrastructure agnostic or integrated - VPNの場合

"Classification of VPNs", RFC4026, 2005



# Infrastructure Agnostic or Integrated ?

- Infrastructure Agnostic
  インフラは問わない




| PPTP | IP Sec | GRE | GTP Tunnel | DC Overlay VxLAN | SD-WAN |
|---|---|---|---|---|---|

- Possibly Infrastructure Integrated
  インフラと協調可能性

| MPLS BGP VPN | EVPN-MPLS | LISP | Open flow | SRv6 |
|---|---|---|---|---|

# Agnostic or Integrated - 仮説

- まずは個別に最適化が行われる
  → サービスはサービスとして、インフラを問わず進化したい
  → Infra Agnostic

- サービス提供とインフラ提供の組織や事業体が別であることが多い
  → やはり個別に最適化が行われる
  → Infra Agnostic

- しかし物理は重要であり、リソースは有限である
  → インフラを意識した最適化もやっぱり必要
  → Infra Integrated

# Digital時代のネットワークシステムアーキテクチャ

ここで、宮坂さん・松嶋さんに

- **これからのネットワークアーキテクチャに求められること**
- **システムの進化、展望**

などについてお伺いする

# Outline

- 技術の普及とSegment Routing技術の価値について
- Digital時代のネットワークシステムアーキテクチャ
- *参考資料*

# 参考資料

本参考資料のセクションでは、Segment Routingの特徴と、ユースケース（2017年6月末現在迄に公開されているもの）についてまとめています。

実際の運用予定について確認したものではありませんのでご注意ください。

# Segment Routingが可能にすること

Stateless Traffic Steering

Programmability

End to End

## Segment Routing

- ステートレス性によるシンプル化・スケール性向上
  - Traffic SteeringやFast Protectionのためのシグナリングやノードでのステート保持の必要なし
- ポリシーを柔軟かつ迅速に実現するHybrid SDN (分散と集中のHybrid)

## SRv6 (Segment Routing IPv6)

- End-to-end (App/Servers, DC fabric, Access, Aggregation, Backbone, IoT..) における共通転送メカニズム
- Data plane (SR Header)を用いたNetwork Programmability

# Use cases – Cloud scale/OTTs

- Google
- Microsoft
- LinkedIn
- Facebook

# Google

## 基幹文書の共著者
- Architecture
- TE policy

[Docs] [txt|pdf] [Tracker] [Email] [Nits]

Versions: 00

Network Working Group
Internet-Draft
Intended status: Standards Track

C. Filsfils
S. Sivabalan
Cisco Systems, Inc.
D. Yoyer
Bell Canada.
M. Nanduri
Microsoft Corporation.
S. Lin
A. Bogdanov
Google, Inc.
M. Horneffer
Deutsche Telekom
F. Clad
Cisco Systems, Inc.,
D. Steinberg
Steinberg Consulting
B. Decraene
S. Litkosky
Orange Business Services
February 18, 2017

**ng Policy for Traffic Engineering**
**pring-segment-routing-policy-00.txt**

lows a headend node to steer a packet flow
ediate per-flow states are eliminated thanks
headend node steers a flow into an SR Policy.
steered in an SR Policy is augmented with the
s associated with that SR Policy. This
ncepts of SR Policy and steering into an SR

[Docs] [txt|pdf] [Tracker] [WG] [Email] [Diff1] [Diff2] [Nits]

Versions: (draft-filsfils-spring-segment-routing)
00 01 02 03 04 05 06 07 08 09 10 11

Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: August 20, 2017

C. Filsfils, Ed.
S. Previdi, Ed.
Cisco Systems, Inc.
B. Decraene
S. Litkowski
Orange
R. Shakir
Google, Inc.
February 16, 2017

**Segment Routing Architecture**
**draft-ietf-spring-segment-routing-11**

Abstract

Segment Routing (SR) leverages the source routing paradigm. A node steers a packet through an ordered list of instructions, called segments. A segment can represent any instruction, topological or service-based. A segment can have a semantic local to an SR node or global within an SR domain. SR allows to enforce a flow through any topological path and service chain while maintaining per-flow state only at the ingress nodes to the SR domain.

# Google

Stateless Traffic Steering

## Cloud Native Networking
## - Amin Vahdat, Fellow & Technical Lead For Networking, Google

https://www.youtube.com/watch?v=1xBZ5DGZZmQ
https://mikecborg.wordpress.com/2017/04/20/keynote-cloud-native-networking-amin-vahdat-fellow-technical-lead-for-networking-google


"I am a great fan of Segment Routing."

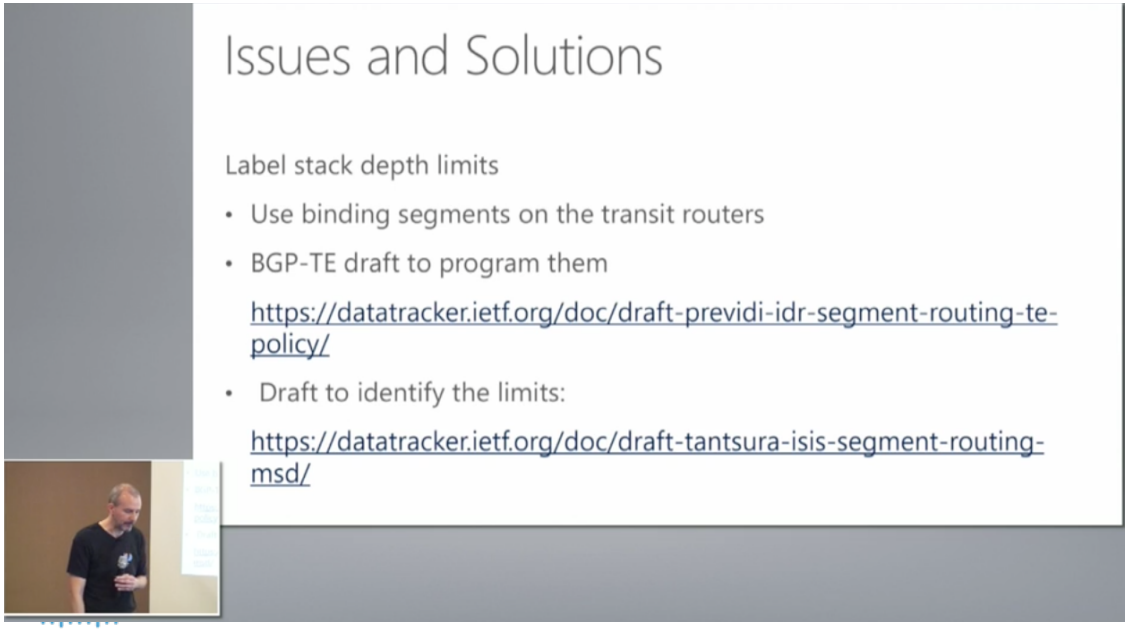
# Microsoft

Stateless Traffic Steering

## Traffic Engineering in a Large Network with Segment Routing

Paul Mattes, Software Engineer, Microsoft

http://techfieldday.com/appearance/traffic-engineering-in-a-large-network-using-segment-routing/




This presentation will describe Microsoft's experience in using Segment Routing to address the problem of engineering large-volume IP traffic on the company's internal network.

How segment routing can be used in a cloud environment like Microsoft Azure to provide traffic engineering above and beyond existing MPLS strategies

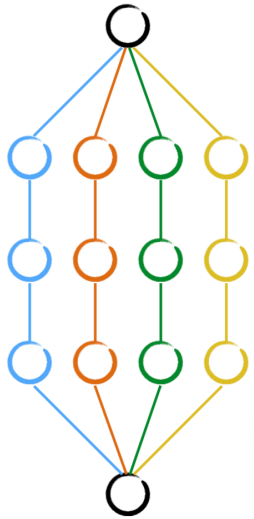
# LinkedIn

End to End

Introducing LinkedIn OpenFabric Project
Shawn Zandi, Principal Network Architect, LinkedIn
http://www.giievent.jp/upp357914/mpls-sdn-nfv_2017_agenda_day_3_track_2.shtml

## OpenFabric Project

- Self-Defined Programmable Data Center
  - Distributed Routing Protocol (v4+v6)
  - SRv6 to enable end-to-end control
  - Centralized Policies: Controller Based Traffic Optimizer
  - Enables Self-Healing Network



Introducing LinkedIn OpenFabric Project . LinkedIn is currently working on a programmable data center, starting from the concept of layering different control plane functionality. Providing an overview of the functional division, considering some tools which can be used to meet each, and then considering the resulting operational profile.

# Facebook

## Segment Routingの大規模データセンターへの適用性

Stateless Traffic Steering

End to End

[Docs] [txt|pdf|xml] [Tracker] [Email] [Nits]

Versions: 00

SPRING Working Group
Internet-Draft
Intended status: Informational
Expires: June 20, 2015

P. Lapukhov
E. Aries
G. Nagarajan
Facebook

December 17, 2014

**Use-Cases for Segment Routing in Large-Scale Data Centers**
**draft-lapukhov-segment-routing-large-dc-00**

Abstract

This document discusses ways in which segment routing (aka source routing) paradigm could be leveraged inside the data-center to improve application performance and network reliability. Specifically, it focuses on exposing path visibility to the host's networking stack and leveraging this to address a few well-known performance and reliability problems in data-center networks.

# Facebook

Stateless Traffic Steering

## Introducing Open/R — a new modular routing platform

https://code.facebook.com/posts/1142111519143652/introducing-open-r-a-new-modular-routing-platform/

### Conclusion

Though it was initially designed specifically for the Terragraph project, Open/R has been successfully adapted for use with other parts of our networking infrastructure, and we plan to open-source it at some point. The components of Open/R described in previous sections constitute the minimal routing solution for any network. It was straightforward to add more applications on top of routing, such as link utilization measurement, shaping weight computation for bandwidth fairness, and MPLS label allocation for segment routing purposes.

## Facebook Builds A Routing Platform

Social media giant builds on its homegrown approach to networking with Open/R.

http://www.networkcomputing.com/networking/facebook-builds-routing-platform/959098151

His blog post goes into additional technical detail and describes how Facebook tested Open/R's scalability. Adding more applications on top of routing, such as link utilization measurement or MPLS label allocation for segment routing has proven straightforward, he said.

# Use cases – Transformational SPs

- Bell Canada + Barefoot Networks
- Comcast
- Vodafone Germany
- Orange
- Colt

# Bell Canada + Barefoot Networks

## The Extensible Network

### Evolution in Protocol and Data Plane Agility

Daniel Bernier, *Bell Canada*; Milad Sharif, *Barefoot Networks*; Clarence Filsfils, *Cisco Systems*

P4 Workshop 2017

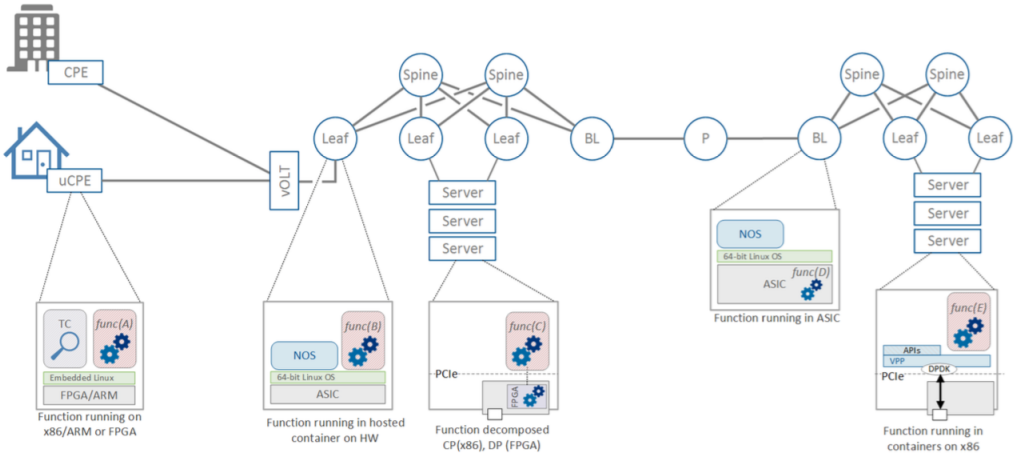
http://p4.org/wp-content/uploads/2017/06/p4-ws-2017-the-extensible-network.pdf

# Bell Canada + Barefoot Networks

Stateless Traffic Steering

## Scaling Things Out

- Make the underlying network stateless
  - Push state to the edges
  - Simplify the protocol soup.
- Distribute functions where they make most sense
  - Functions can be placed anywhere … from network elements to the cloud.
  - That's where a common language for multiple targets comes in handy.
- Distribute function processing
  - 100s of distributed functions will scale better then a few big ones.
- Leverage abstracted function identifiers
  - Make them referenceable and potentially supporting resolution




- Massive network simplification, automation and virtualisation program.
- Disaggregation of connectivity and value-add services from the underlying physical network.

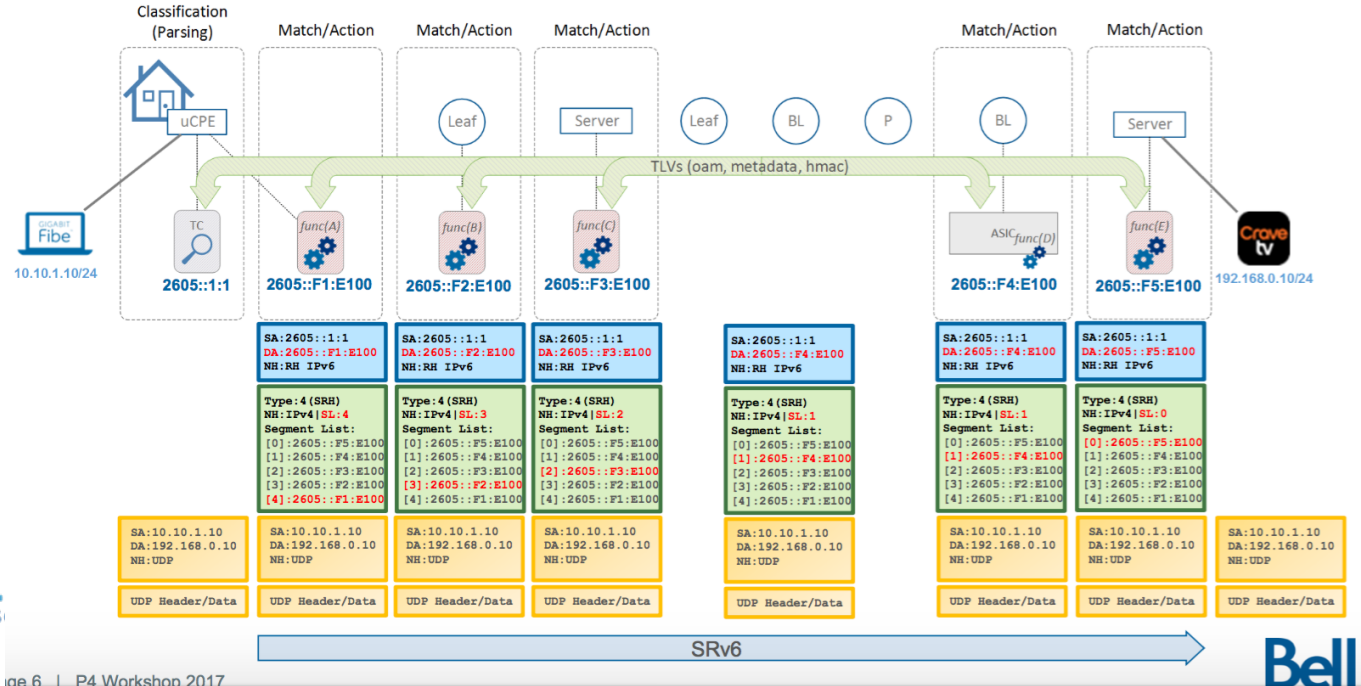
# Bell Canada + Barefoot Technologies

Programmability

End to End

## The "*Network-as-an-ASIC*"

- Traffic classification at the edge of the network → e.g. parsing.
- Simplified *Match/Action* primitive looking at the function Identifier.
- Contextual metadata carried through TLVs
- Programming at All Layers
  - P4 to define the END and TRANSIT behaviors in data plane.
  - SRv6 to define the "*end to end network behavior*"



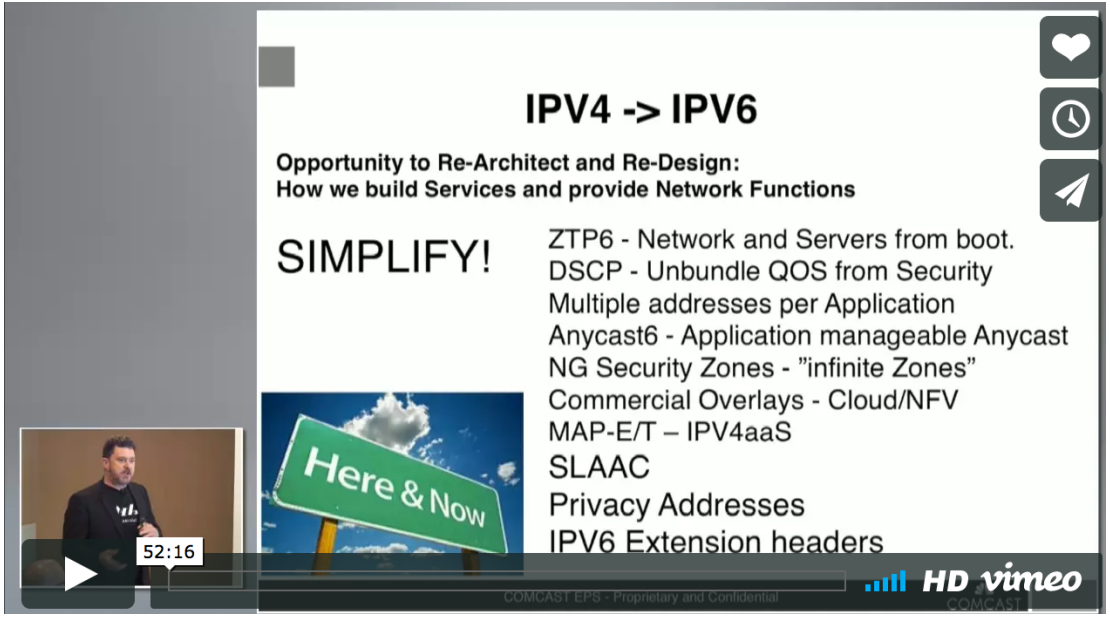
# Comcast

Stateless Traffic Steering

Programmability

## Comcast and the Smarter Network
## John Leddy, Comcast

http://techfieldday.com/appearance/comcast-presents-at-segment-routing-field-day/




John Leddy, Network Engineering with Comcast, discusses how Comcast is leveraging segment routing to help transition their service provider network to something smarter with increased IPv6 capabilities, IPv4 transition mechanisms, and enhanced service delivery.

# Comcast

End to End

## SRv6 use cases

[Docs] [txt|pdf|xml|html] [Tracker] [WG] [Email] [Diff1] [Diff2] [Nits]

Versions: (draft-martin-spring-segment-routing-ipv6-use-cases)
00 01 02 03 04 05 06 07 08 09 10 11

Spring
Internet-Draft
Intended status: Informational
Expires: December 15, 2017

J. Brzozowski
J. Leddy
Comcast
C. Filsfils
R. Maglione, Ed.
M. Townsley
Cisco Systems
June 13, 2017

**IPv6 SPRING Use Cases**
**draft-ietf-spring-ipv6-use-cases-11**

Abstract

The Source Packet Routing in Networking (SPRING) architecture describes how Segment Routing can be used to steer packets through an IPv6 or MPLS network using the source routing paradigm. This document illustrates some use cases for Segment Routing in an IPv6 only environment.

SRv6 use cases for:

- Home Network
- Access Network
- Data Center
- Content Delivery Network
- Core Network

# Vodafone Germany

Stateless Traffic Steering

**SP360: Service Provider**

## Segment Routing Blazes a Trail in Germany!

Jonathan Davidson - June 8, 2017 - 1 Comment

## Segment Routing from Cisco Paves Way for SDN at Vodafone Germany

Linda Hardesty
June 9, 2017
6:45 am PT

- Segment routing architecture seeks the right balance between distributed intelligence and centralized optimization.
- Per-flow states are encoded in the packet header, not in the network fabric. The network fabric is stateless.

https://blogs.cisco.com/sp/segment-routing-blazes-a-trail-in-germany
https://www.sdxcentral.com/articles/news/segment-routing-cisco-paves-way-sdn-vodafone-germany/2017/06/?c_action=related_articles

# Orange

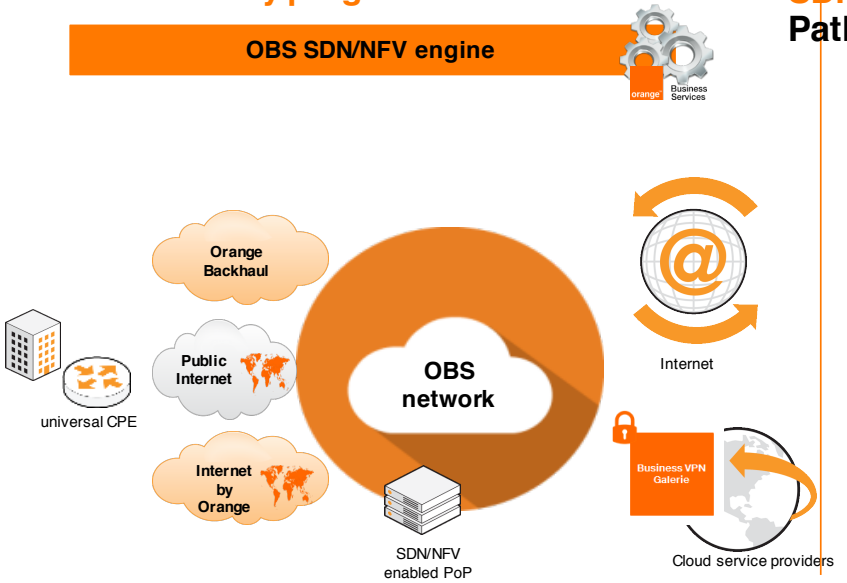
Stateless Traffic Steering

## NFV/SDN deployment update

Stéphane Litkowski, Network Architect, Orange Expert

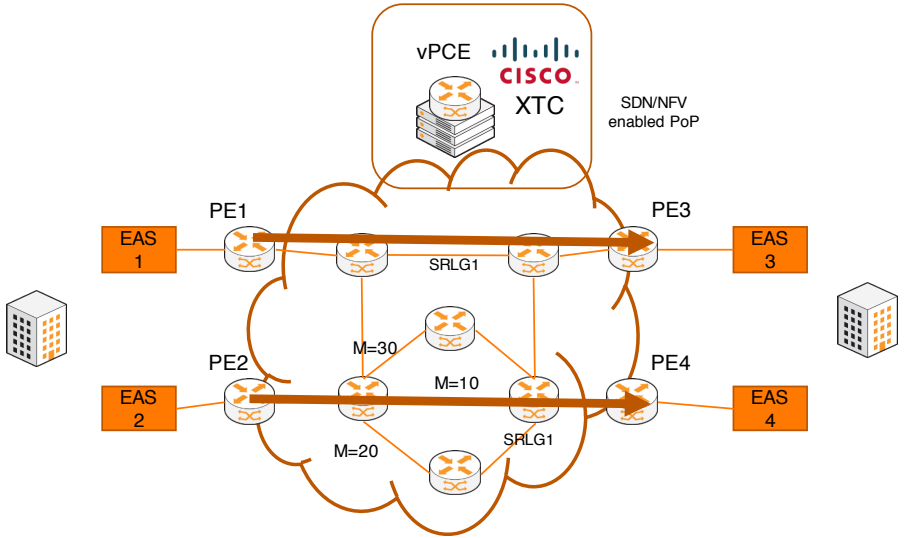
https://www.slideshare.net/StephaneLitkowski/mpls-sdn-nfv-world17-sdn-nfv-deployment-update

### Towards a fully programmable network




### SDN for the IP/MPLS network

**Path disjointness computation using a PCE**



# Colt

Stateless Traffic Steering

## Cisco to build Colt's new network

Alan Burkitt-Gray | Thursday, December 08, 2016

**Colt Technology Services announces Cisco as provider of its planned 100Gbps network upgrade**


Cisco has announced that it has won the contract from Colt Technology Services to upgrade its European and Asian network to 100Gbps.

Colt revealed its plans in November to invest in its core infrastructure to enable critical business connectivity by building out a multi-terabit optical backbone and next generation packet network optimised for 100Gbps connectivity.

Now Colt and Cisco say they will be working together on the upgrade in order to deliver high-performance connectivity for cloud-scale, business-critical applications to its enterprise, carrier and web-centric customers.

- The Cisco-built network uses end-to-end segment routing technology, an enhancement to IP MPLS, to simplify and automate network operation and significantly reduce operating costs.
- “With the quality, speed, capacity and flexibility to meet application-specific service quality requirements, Colt customers will benefit from an infrastructure designed for enabling digital businesses,” said Colt.

https://www.globaltelecomsbusiness.com/article/b11vy94bwrdbf7/cisco-to-build-colt39s-new-network

# Backup slides

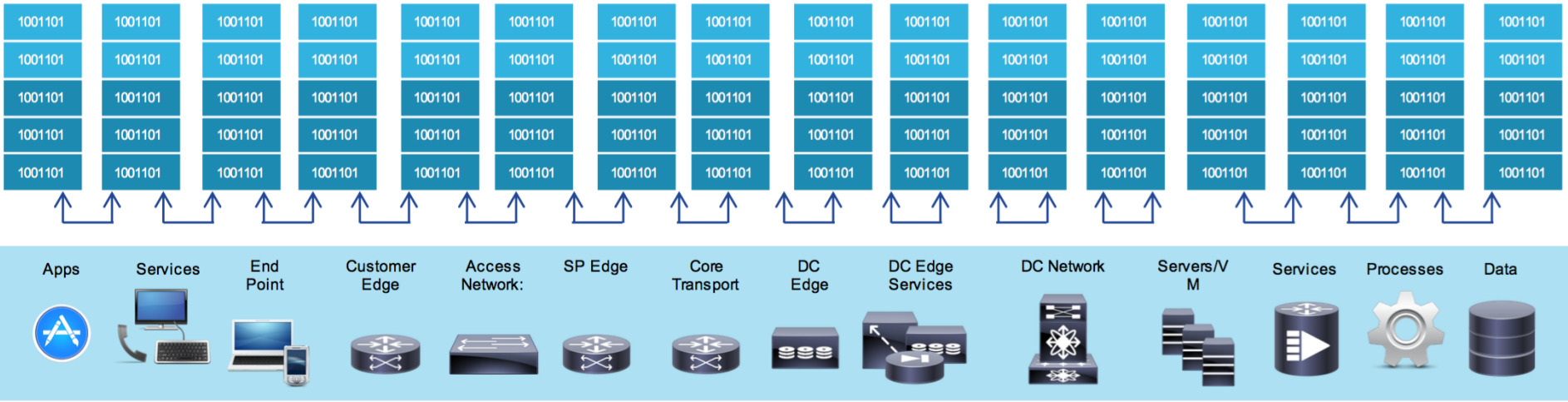
[Reference]

Making Network SDN-Ready With Segment Routing

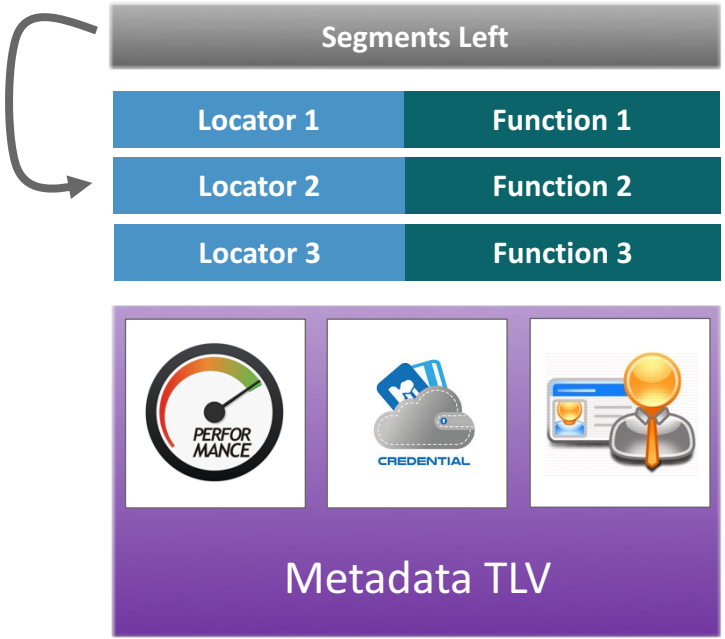
http://www.segment-routing.net/images/lightreading_report.pdf

# IPv6 Centric Networkingへ

- フォワーディングの統一　(Access, WAN, DC, Applications..)
  → シンプル性
- SRv6(Segment Routing IPv6)によるunderlay高度化とプログラマビリティ



# SRv6 Header



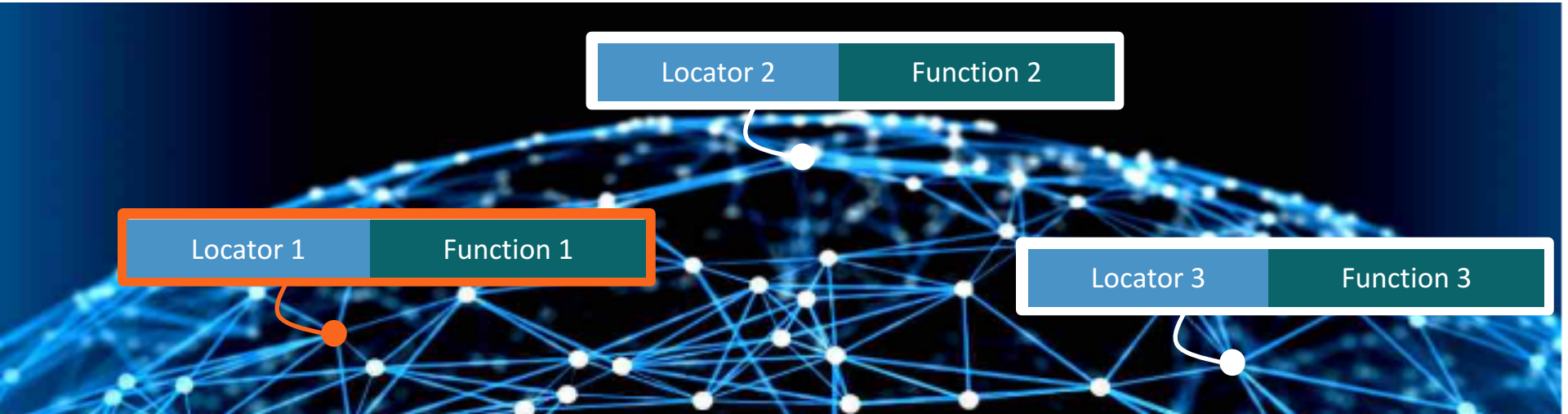

```
Internet-Draft      IPv6 Segment Routing Header (SRH)     September 2016


     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 |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    | First Segment |             Flags             |   RESERVED    |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    |            Segment List[0] (128 bits IPv6 address)            |
    |                                                               |
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    |                                                               |
                                  ...
    |                                                               |
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    |            Segment List[n] (128 bits IPv6 address)            |
    |                                                               |
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    //                                                             //
    //         Optional Type Length Value objects (variable)       //
    //                                                             //
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

# SRv6によるNetwork Programmability

**Next Segment**

| Locator 1 | Function 1 |
|---|---|
| Locator 2 | Function 2 |
| Locator 3 | Function 3 |



# SRv6の可能性

SRv6 for Anything Else (SRv6 Net Programmability)

- L2/L3 VPN, Service Overlay
- NSH (Service Chain for NFV)
- Content Networking
- Load Balancing

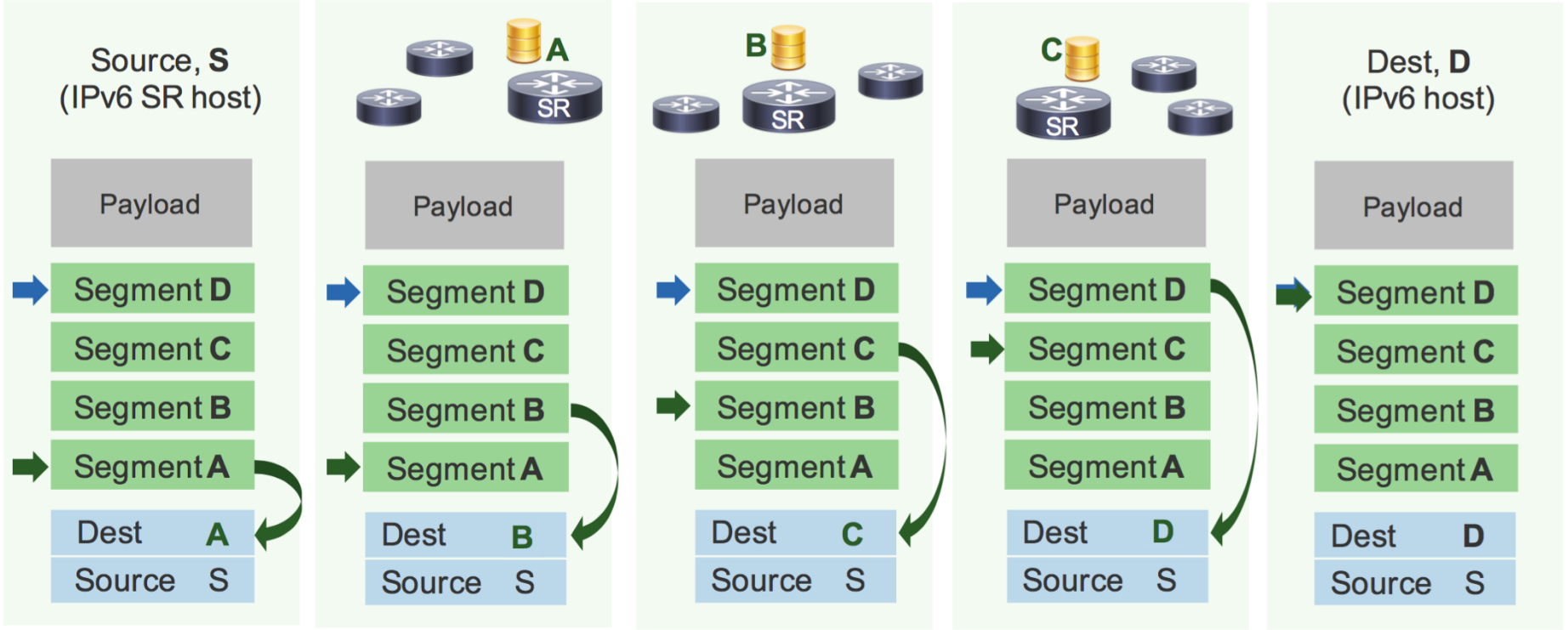
SRv6 for Underlay — Fast Protection, Traffic Steering

IPv6 for reachability — Seamless Reachability

実装：IOS-XE, IOS-XR, Linux, fd.io..

End-to-Endでの共通転送メカニズム　+ Programmability

# SRv6によるContent Routing



# SRv6 まとめ

## End-to-Endでの共通転送メカニズム

- シームレスな到達性とセグメンテーション
- Access, WAN, DC, Compute共通の転送メカニズム
- シンプル化
  - RSVPなどのコントロールプレーンの排除
  - MPLS/Shim layerの排除
- Underlayの高度化
  - Fast Protection, Traffic Steeringの実現

## SRv6 SIDによるNetwork Programmability

- SRv6 for Any Service
  - VPN, NFV Service Chaining, Content Networking, etc.


*TOMORROW starts here.*