
TOMORROW starts here.
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Advances In Routing

BRKRST-3370

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Topics of Interest

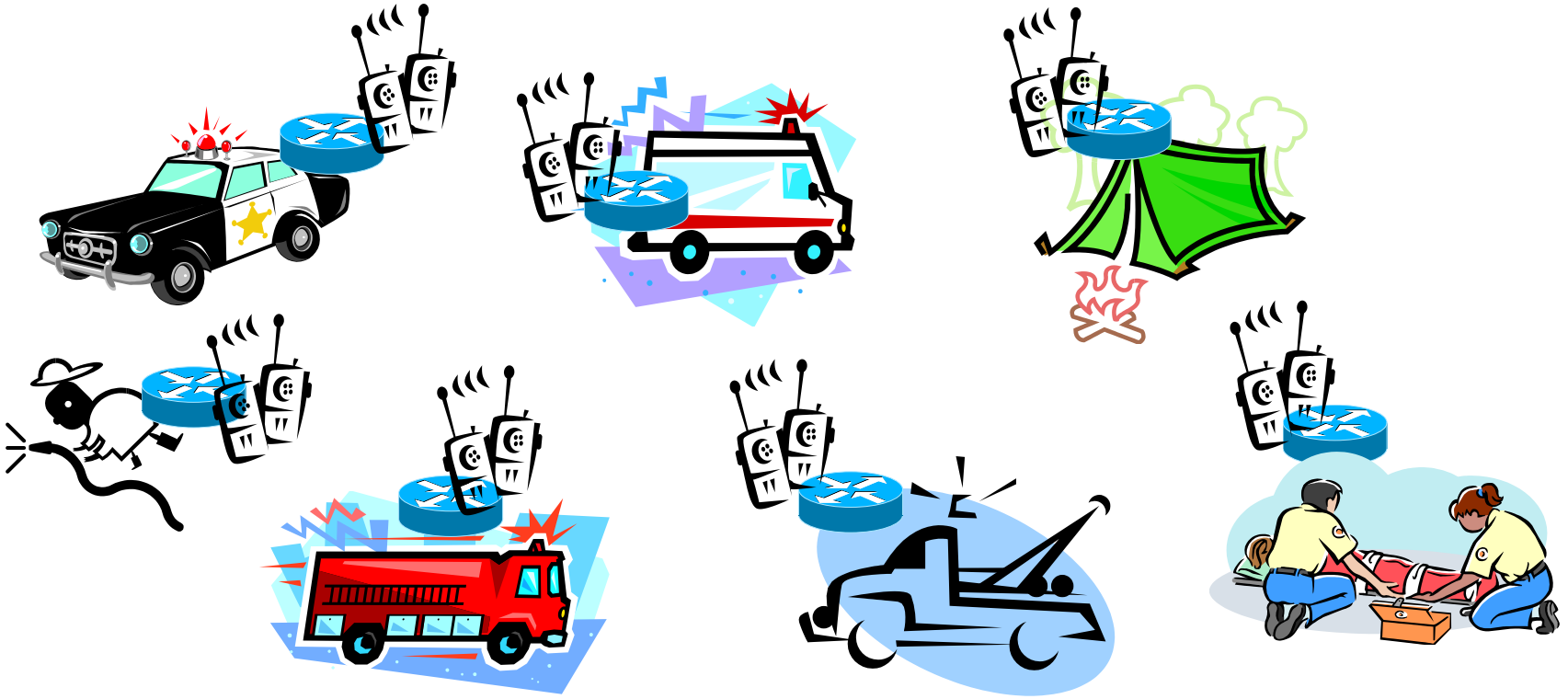
- Mobile Ad Hoc Network (MANET)
  - Radio Aware Routing
  - OSPFv3 Extensions
  - Cisco Embedded Services Routers
- Segment Routing
  - MPLS dataplanes
  - Simplicity, Scalability
  - Application Integration
- Cisco eXtensible Network Controller (XNC)
  - Monitor manager
  - Network slicing
  - Topology independent forwarding

Mobile Ad Hoc Network (MANET)

"People connecting and communicating how, when and where they want with no limitations on location, while the network continuously adapts to their needs without a reliance on pre-defined fixed infrastructure."

Cisco Mobile Ready Net

Definition of MANET



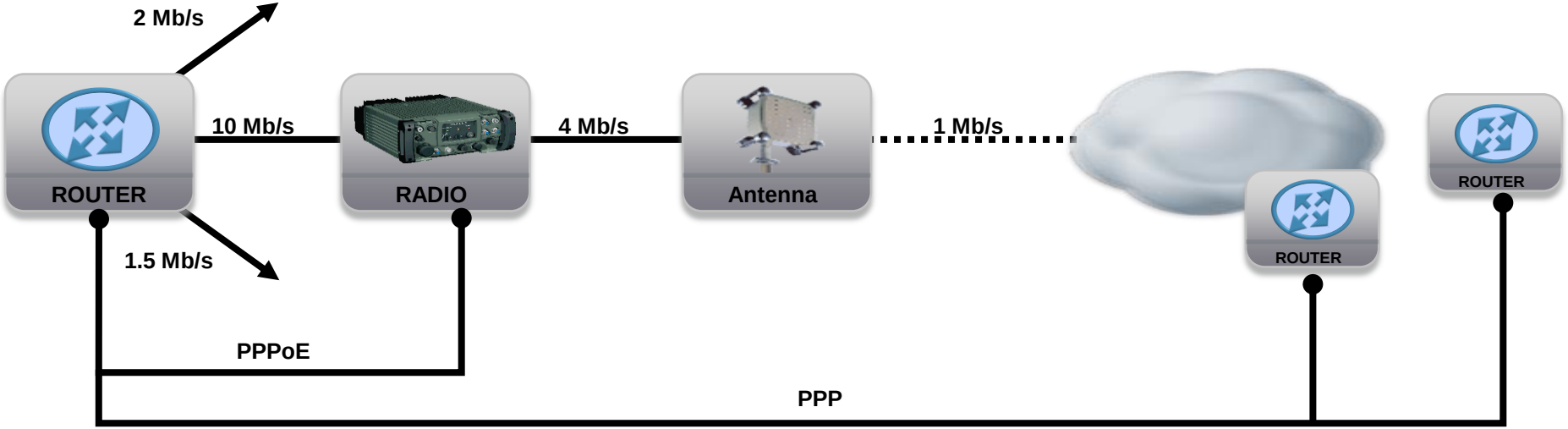
Characteristics of MANET

- Dynamic topologies
  - Random interconnection
  - Highly mobile
- Bandwidth constrained, variable capacity links
  - Wireless links have lower capacity
  - Throughput lesser than radio transmission rate
- Energy constrained operations
  - Nodes are powered by batteries
  - Network and routing optimisation need to conserve energy
- Limited physical security
  - Mobile wireless networks are more prone to security threats (eavesdropping, spoofing, and DoS attacks)

Radio Aware Routing

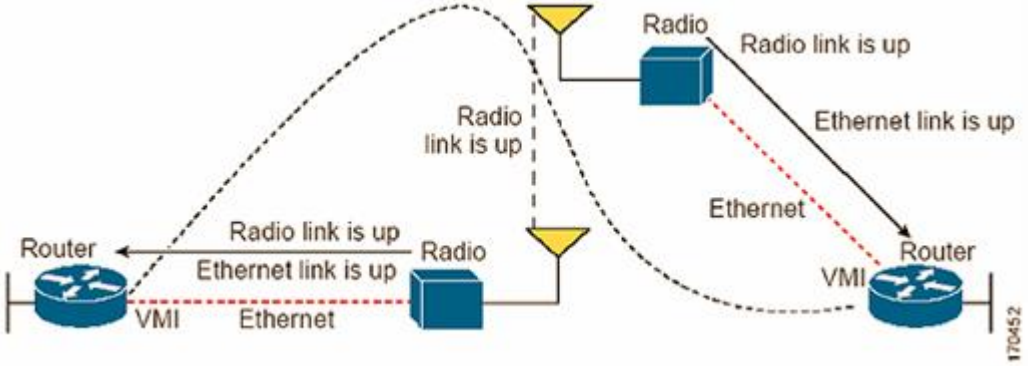
- Radio interacts with routing protocols (OSPFv3, EIGRP) to signal the appearance, disappearance and link conditions of one hop routing neighbours.
- Improves the efficiency and effectiveness of networks using radio links
  - Constantly adapts to changes in neighbour status to select optimal path
  - Ensure the delivery of critical data
- Cisco supports both point-to-point and broadcast type radios
  - RFC 5578: PPP over Ethernet (PPPoE) Extensions for Credit Flow and Link Metrics
  - Dynamic Link Exchange Protocol (DLEP)
  - Radio-Router Control Protocol (R2CP)
- Virtual Multipoint Interface (VMI)

Radio Aware Routing Signalling



- PPPoE session establishment
- PPPoE Credit-Based Flow Control
- Cross-Layer Feedback for Router-Radio Integration
- Neighbour Up/Down Signalling
- Link Quality Metrics Reporting

Neighbour Up/Down Signalling



- Nodes may move into, or out of, radio range at a fast pace
- Each time a node joins or leaves, the network topology must be reconfigured by the router
- Reliance on timer-driven mechanisms slows convergence
- Routers use session initiation or termination signals from radios as Neighbour Up/Down triggers
- Routing protocols respond immediately to these link status signals

OSPFv3 Extensions for MANET

- Optimise OSPFv3 behaviour for more efficient routing in MANET
  - Adaptive to constantly changing network topology with limited bandwidth
  - As defined in draft-chandra-ospf-manet-ext-02
- Reduce overhead traffic in MANET environments so that network clusters can scale to support more users
- Boost performance for delay sensitive, mission critical voice, video, and data traffic
- Facilitate the integration of wireless MANET with existing wire-line products
- Dynamic cost metric is calculated each time the router receives Packet Discovery Quality (PADQ) packet from the radio for a peer

OSPFv3 Extensions Optimisations

- Tightly couples OSPFv3 with RAR compliant radios
  - Provide faster convergence and reconvergence through neighbour presence indications and help determine accurate, real-time link metric costs
- Incremental hellos messages
  - Reduce OSPFv3 packet size
- Caching multicast link-state advertisements (LSAs)
  - Minimise the OSPFv3 packet transmissions
- Selective flooding with overlapping relay
  - Minimise the number of flooded LSAs
- Selective peering
  - Reduce the number of adjacencies based on shortest path tree information

Link Quality Metrics (PADQ)

- Maximum Data Rate (MDR)
  - Theoretical maximum data rate of the radio link, uses scalar for units
- Current Data Rate (CDR)
  - Current data rate achieved on the link, uses scalar for units
- Latency
  - Transmission delay packets encounter, in milliseconds (can help distinguish a satellite link from a point-to-point radio link)
- Resources
  - A percentage (0-100) that can represent the remaining amount of a resource (such as battery power)
- Relative Link Quality
  - A numeric value (0-100) representing relative quality, with 100 being the highest quality (represents the overall of usefulness for a link)

OSPFv3 MANET Metric Formulas

- Link Cost = OC + BW * S1/100 + RES * S2/100 + LAT * S3/100 + L2_Factor * S4/100

  - OC = The "default OSPF Cost“. Calculated using reference_bw / (MDR*1000) (reference_bw=10^8)
  - S1,S2,S3,S4 = Scalar weighting factors input from CLI. These scalars scale DOWN the values. (Note: value of 0 disables and value of 100 enables full 0-64k range for one component)
  - Bandwidth (BW) = (2^16 * (100 - (CDR * 100 / MDR)))/100
  - Resources (RES) = ((100 - RES)^3 * 2^16 / 10^6)
  - Latency (LAT) = (LAT)
  - L2_Factor = ((100 - RLQ) * 2^16)/100

OSPFv3 MANET Configurations

```
!
router ospfv3 1
 router-id 10.1.1.1
 timers throttle spf 1000 2000 2000
 !
 address-family ipv6 unicast
 exit-address-family
!
interface Virtual-Template1
 no ip address
 ipv6 enable
 no peer default ip address
 no keepalive
!
```

```
!
interface vmi1
 no ip address
 ipv6 enable
 ospfv3 1 area 0 ipv6
 ospfv3 1 network manet
 ospfv3 1 cost dynamic hysteresis threshold 1000
 ospfv3 1 cost dynamic weight throughput 0
 ospfv3 1 cost dynamic weight latency 29
 ospfv3 1 cost dynamic weight L2-factor 29
 ospfv3 1 area 0 ipv6 instance 1
 physical-interface Ethernet 0/1
!
```

Cisco Embedded Service Routers

- Optimised for mobile and embedded networks
- Flexible, compact form factors
- Cisco IOS Software, and Cisco Mobile Ready Net capabilities
- Provide highly secure data, voice, and video communications to stationary and mobile network nodes across wired and wireless links

Cisco 5940 ESR Form Factors

- Conduction-cooled
- To meet the most severe environmental conditions

- Air-cooled
- For development systems and applications with less-severe environmental requirements

- High performance with 4GE interfaces and hardware encryption
- Providing power for today and the future

Cisco 5940 ESR Solutions

- Designed for use in harsh environments
- Offering reliable operation in mobile applications

- Solves critical size, weight and power (SWaP) challenges
- Small, lightweight and low power

- High performance with 4GE interfaces and hardware encryption
- Providing power for today and the future

References

- RFC 5578
  - PPP over Ethernet (PPPoE) Extensions for Credit Flow and Link Metrics
- draft-chandra-ospf-manet-ext-02
  - Extensions to OSPF to Support Mobile Ad Hoc Networking
- draft-ietf-manet-dlep-04
  - Dynamic Link Exchange Protocol (DLEP)
- draft-dubois-r2cp-00
  - Radio-Router Control Protocol (R2CP)
- Cisco 5900 Series Embedded Services Routers
  - http://www.cisco.com/go/5900
- IP Mobility: Mobile Networks Configuration Guide, Cisco IOS Release 15M&T
  - http://www.cisco.com/en/US/docs/ios-xml/ios/mob_ntwks/configuration/15-mt/mob_ntwks-15-mt-book.html

MPLS Segment Routing

"The state is no longer in the network, but in the packet!"

Goals and Requirements

- Make things easier for operators
  - Improve scale, simply operations
  - Minimise introduction complexity/disruption
- Leverage the efficient MPLS dataplane today
  - Maintain existing label structure and operations
- Leverage all the services supported over MPLS
  - Explicit routing, fast reroute, VPNv4/v6, VPLS, L2VPN, etc
- Enhance service offering potential through programmability
- Support for IPv6 dataplane and share parity with MPLS

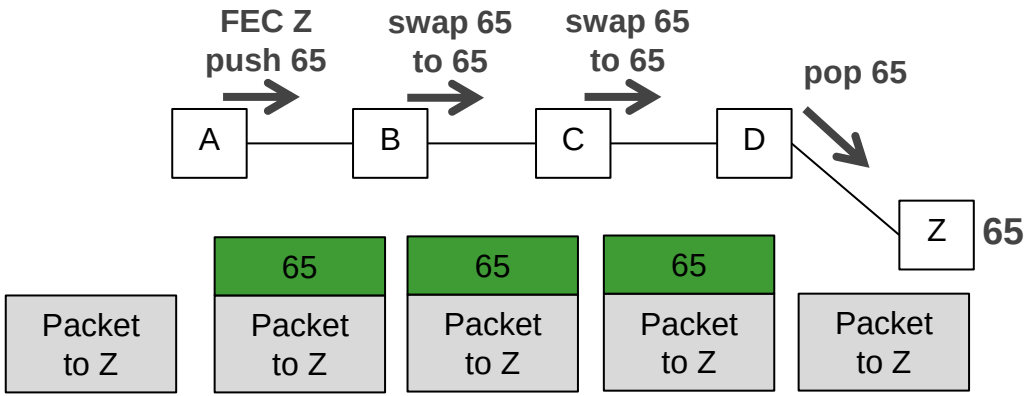
Overview

- A 32-bit segment can represent any instruction (service, context, locator, IGP)
- Ordered list of segments
  - Chain of topological and service instructions
- Forwarding state (segment) is established by IGP
  - LDP and RSVP-TE are not required
  - Agnostic to forwarding dataplane, MPLS or IPv6
- MPLS dataplane is leveraged without any modification
  - Segment = Label
  - Push, Swap, Pop
- Source routing
  - Source encodes path as a label or stack of segments
  - Two key segments: Node (prefix) or Adjacency

IGP Segments

- Node (prefix) Segment
  - Global segment within the SR IGP domain
  - Allocated to a prefix that identifies a specific node (e.g. loopback)
  - Steers traffic along ECMP-aware shortest-path to the related IGP prefix
- Adjacency Segment
  - Local segment related to a specific SR node
  - Steers traffic towards an adjacency or a set of adjacencies
- SR Global Block
  - A subset of the segment space
  - All global segments must be allocated from SRGB
  - Unique allocation within the SR domain
- Per-flow state only at ingress SR edge node
  - Ingress edge node pushes and segment list onto the packet

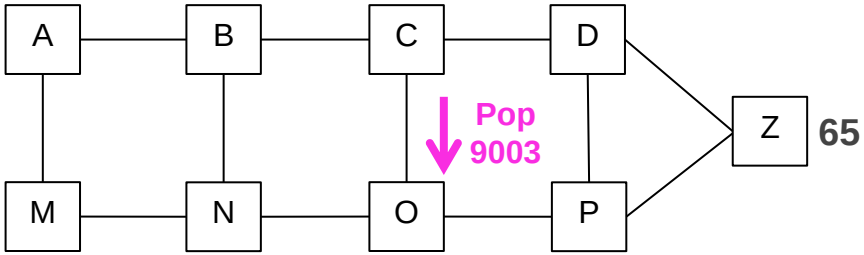
Node Segment



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

- Z advertises its node segment [65]
  - Simple ISIS sub-TLV extension
- All remote nodes install the node segment to Z in the MPLS dataplane

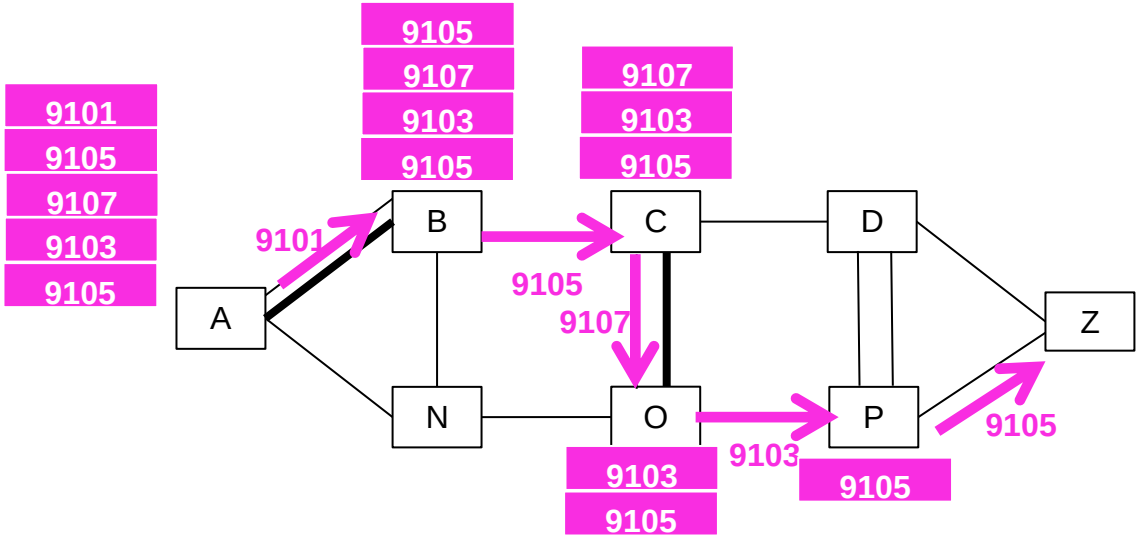
Adjacency Segment



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

- C allocates local label for C➔O
- C advertises the adjacency label in ISIS or OSPF
  - Simple sub-TLV extension
- C is the only node to install the adjacency segment in MPLS dataplane

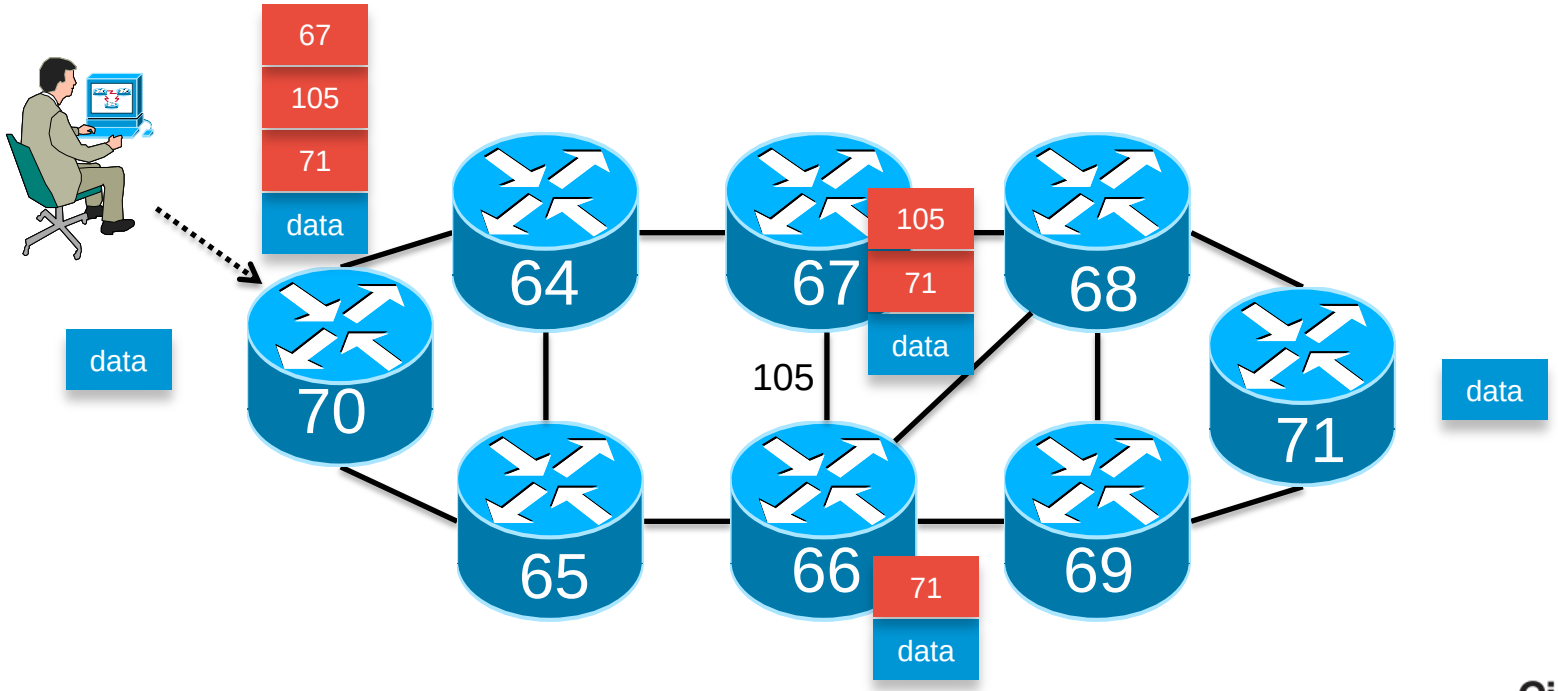
Set path with Adjacency Segments



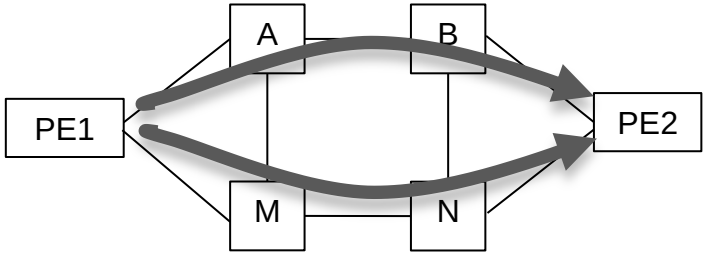
- Source routing along any explicit path
  - Stack of adjacency labels
- SR provides for entire path control

Combining Segments

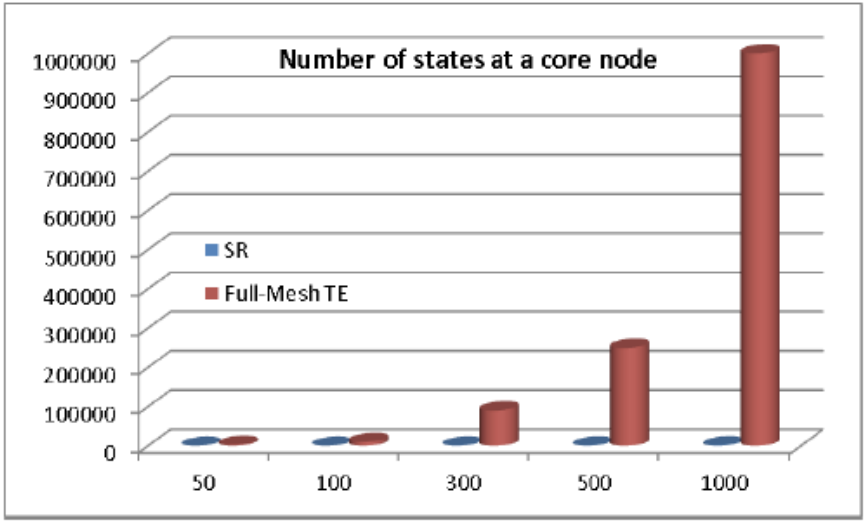
- Program packet to traverse specific network path [65]➔[66]➔[68]



Simplicity/Scalable TE

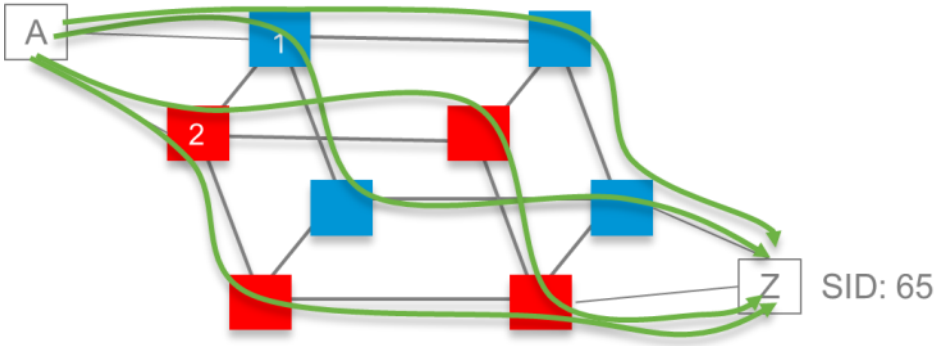


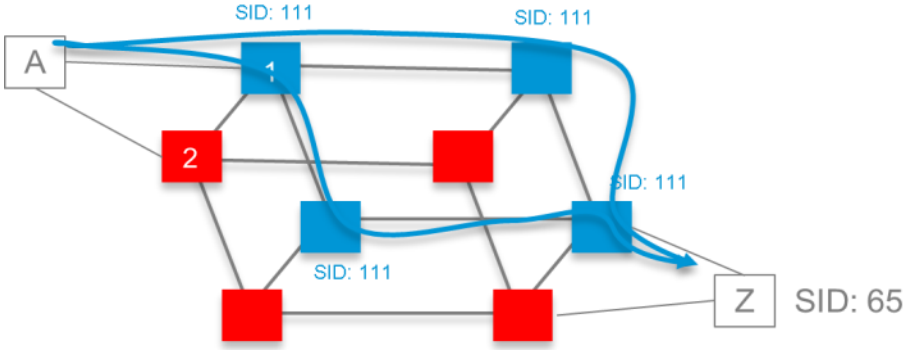
All VPN services ride on the node segment to PE2



- Simplicity
  - No LDP/IGP synchronisation troubleshooting
  - Less protocol to operate
- Scalable TE
  - SR core router scales much better than with RSVP-TE (N+A vs N^2)
  - The state is not in the router but in the packet

Simple Disjointness



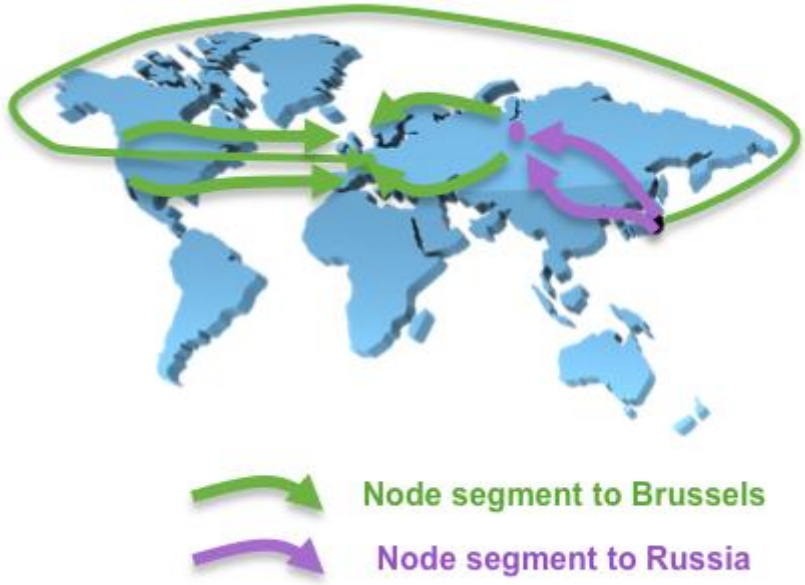


- A sends traffic with [65]
  - Classic ECMP

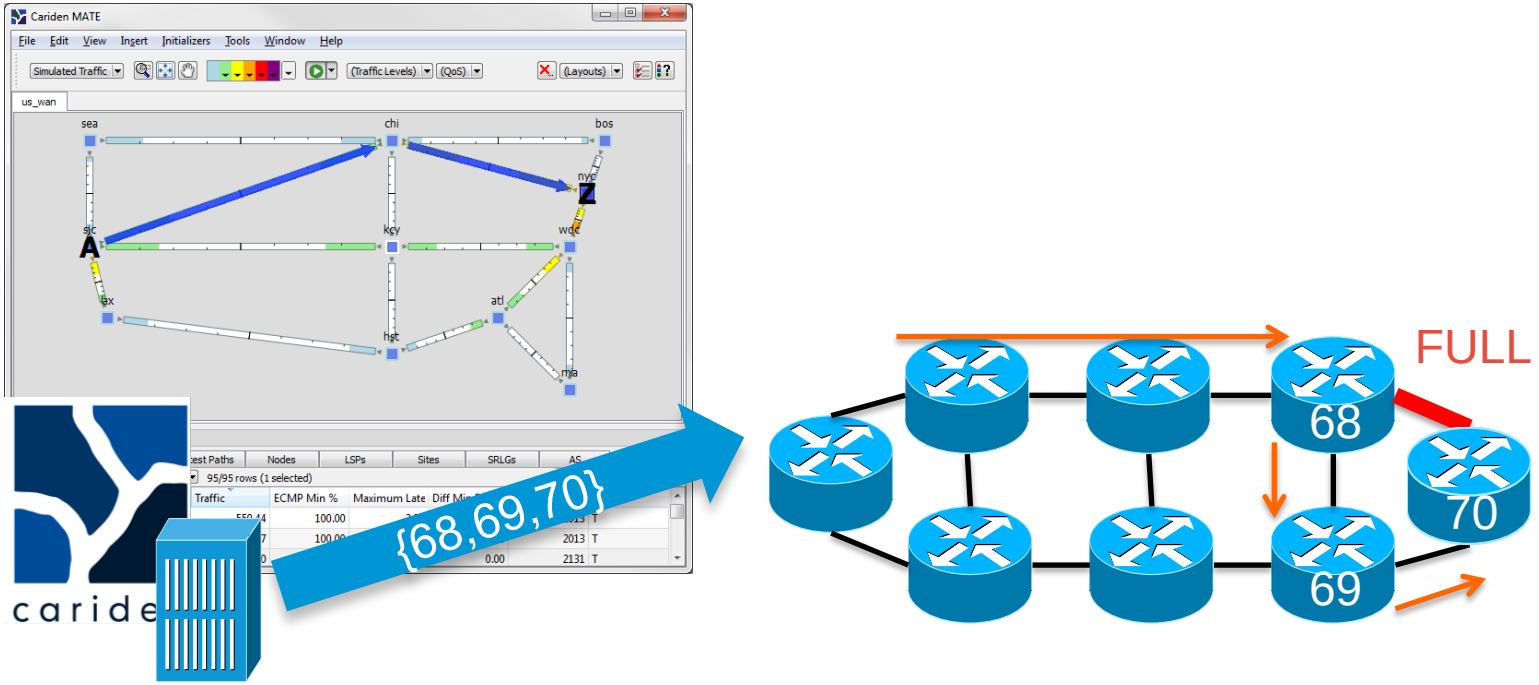
- A sends traffic with [111, 65]
  - Packet gets attracted in blue plane and then uses classic ECMP

CoS-Based TE

- Tokyo to Brussels
  - Data via US, cheap capacity
  - VoIP via Russia, low latency
- CoS-Based policy
  - Data: Push the node segment to Brussels
  - VoIP: Push Anycast node to Russia, and then push Brussels
- ECMP-aware, service specific shortest path
  - No TE tunnel enumeration
  - No TE state in the core



SR in Software Defined Networks (SDN)



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

In Summary

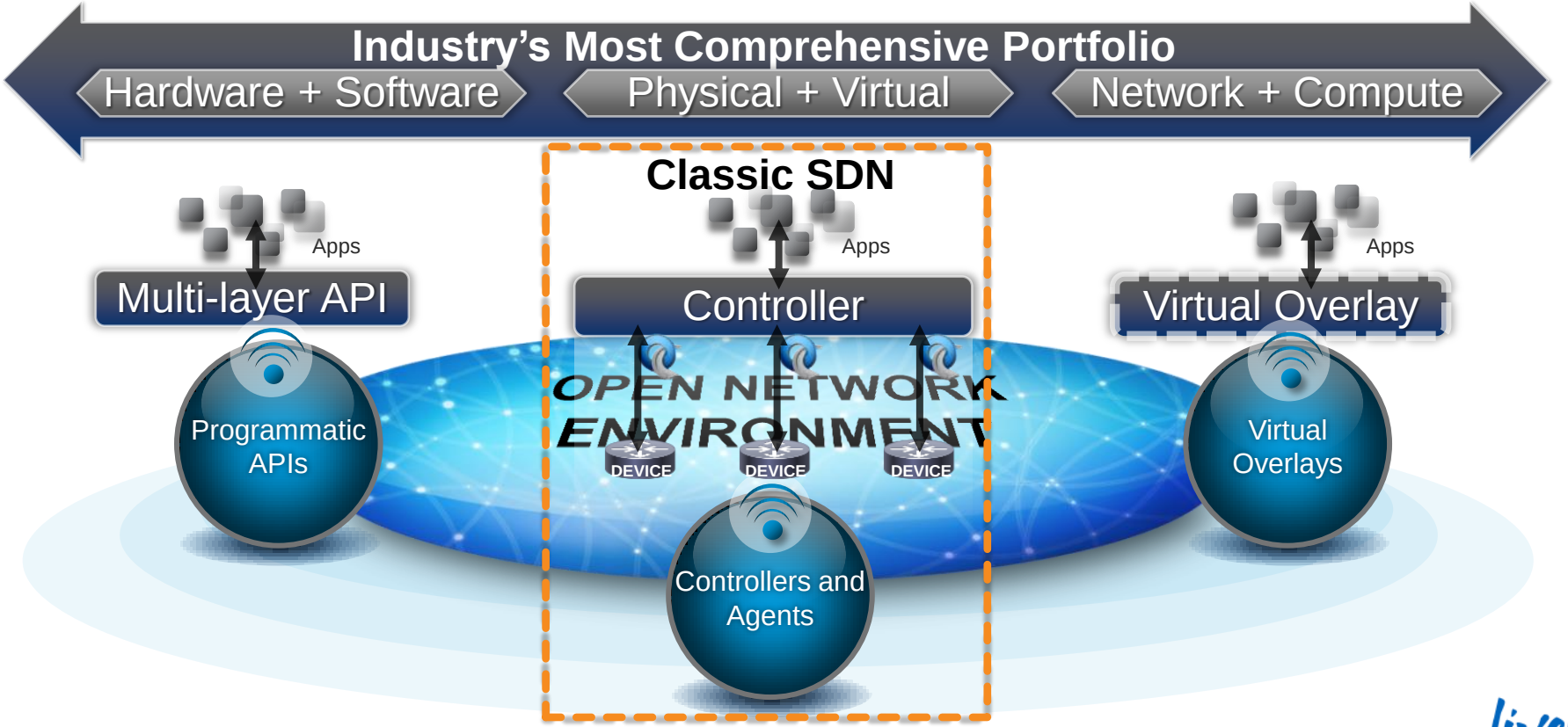
- Simple to deploy and operate
  - Leverage MPLS services and hardware
  - Straightforward ISIS/OSPF extension
  - LDP/RSVP not required
- Provide optimum scalability, resiliency, and virtualisation
- Integration with application through central optimisation/PCE system
  - Simple network, highly programmable
  - Highly responsive
- EFT demo and IETF available – test and contribute

IETF Status

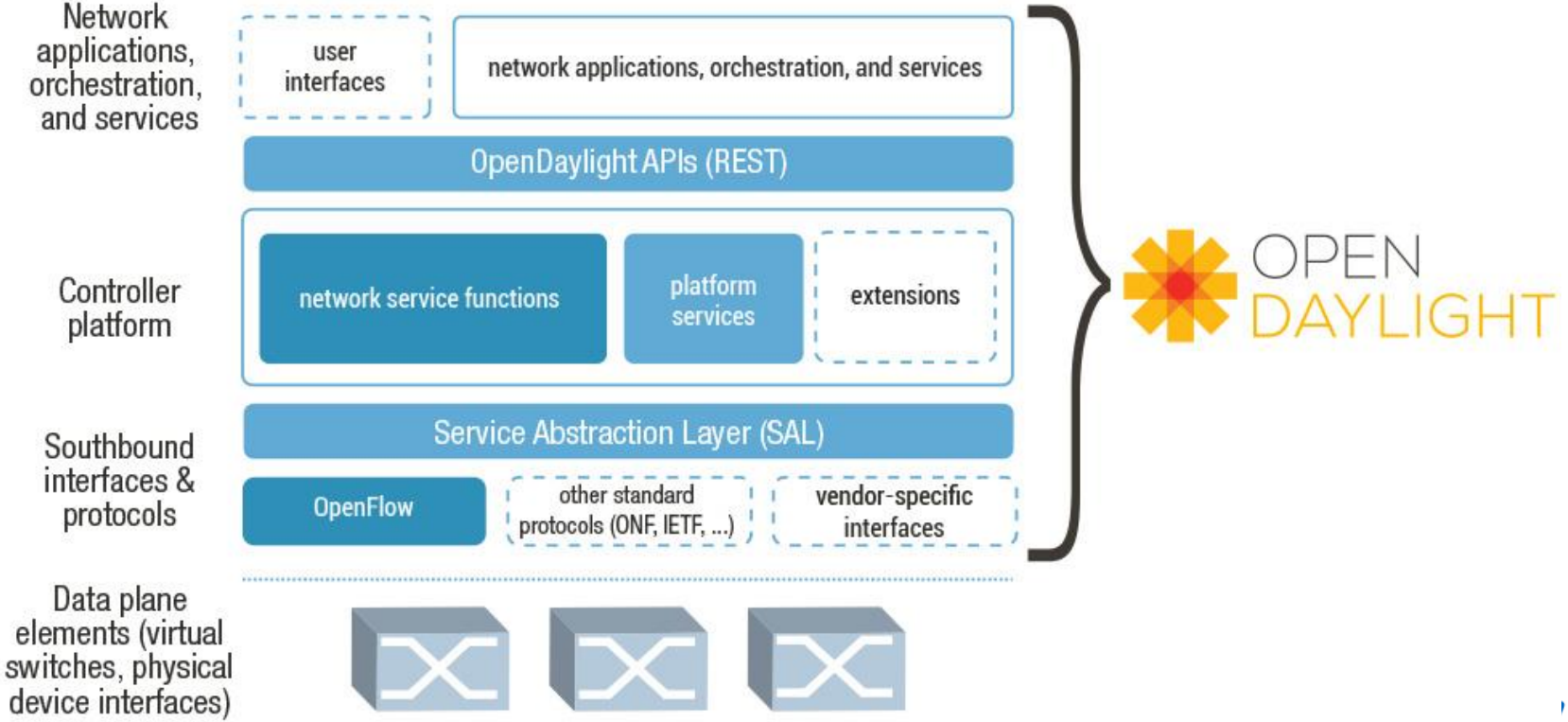
- Architecture overview
  - draft-filsfils-rtgwg-segment-routing
- Use case
  - draft-filsfils-rtgwg-segment-routing-use-cases
- IGP extensions
  - draft-previdi-isis-segment-routing-extensions
  - draft-psenak-ospf-segment-routing-extensions
  - draft-psenak-ospf-segment-routing-ospfv3-extension
- MPLS implementations
  - draft-filsfils-spring-segment-routing-mpls
  - draft-filsfils-spring-segment-routing-ldp-interop
  - draft-kumar-mpls-spring-lsp-ping
  - draft-gredler-rtgwg-igp-label-advertisement

Cisco Extensible Network Controller (XNC)

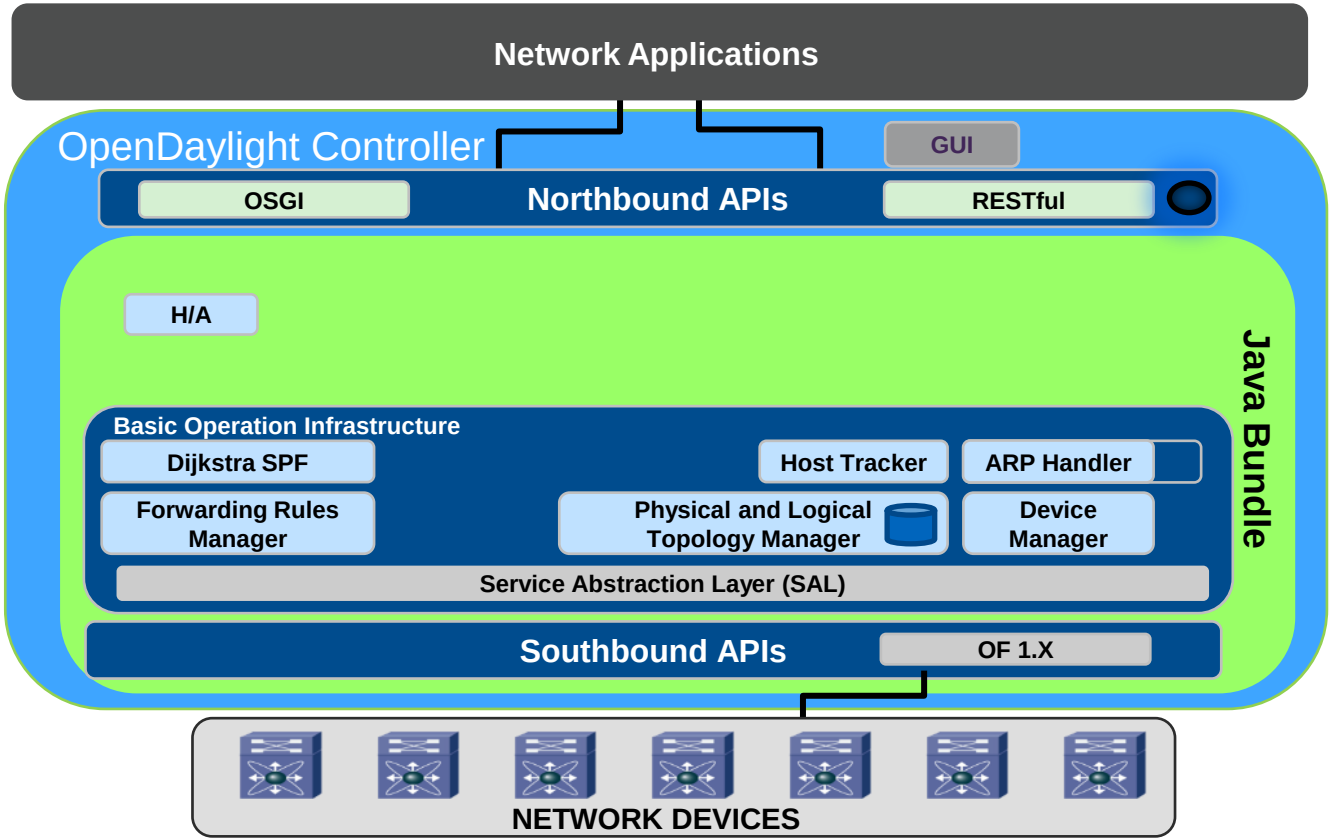
Cisco Open Network Environment (ONE)



OpenDaylight Framework

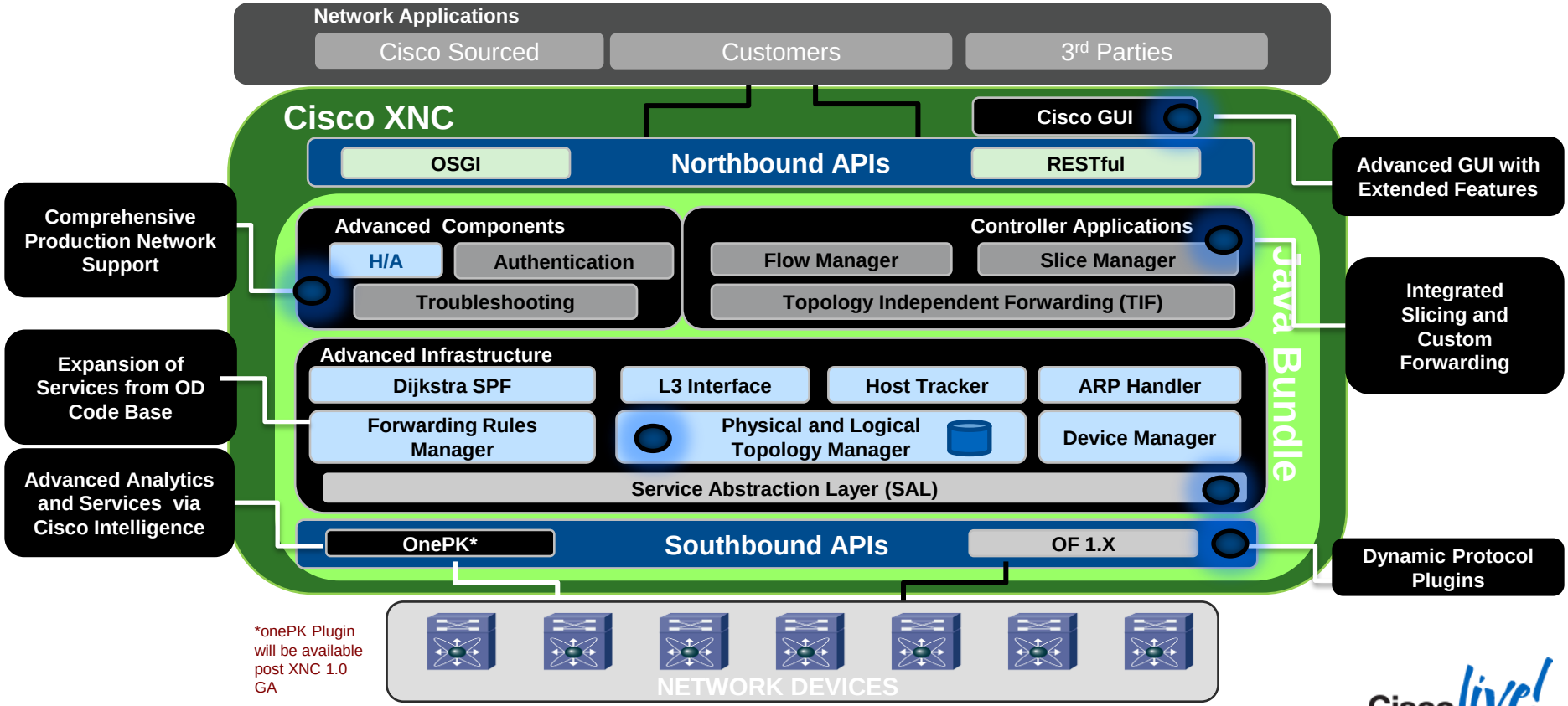


OpenDaylight Controller



Cisco XNC Architecture

Based on JAVA OSGi and OpenDaylight



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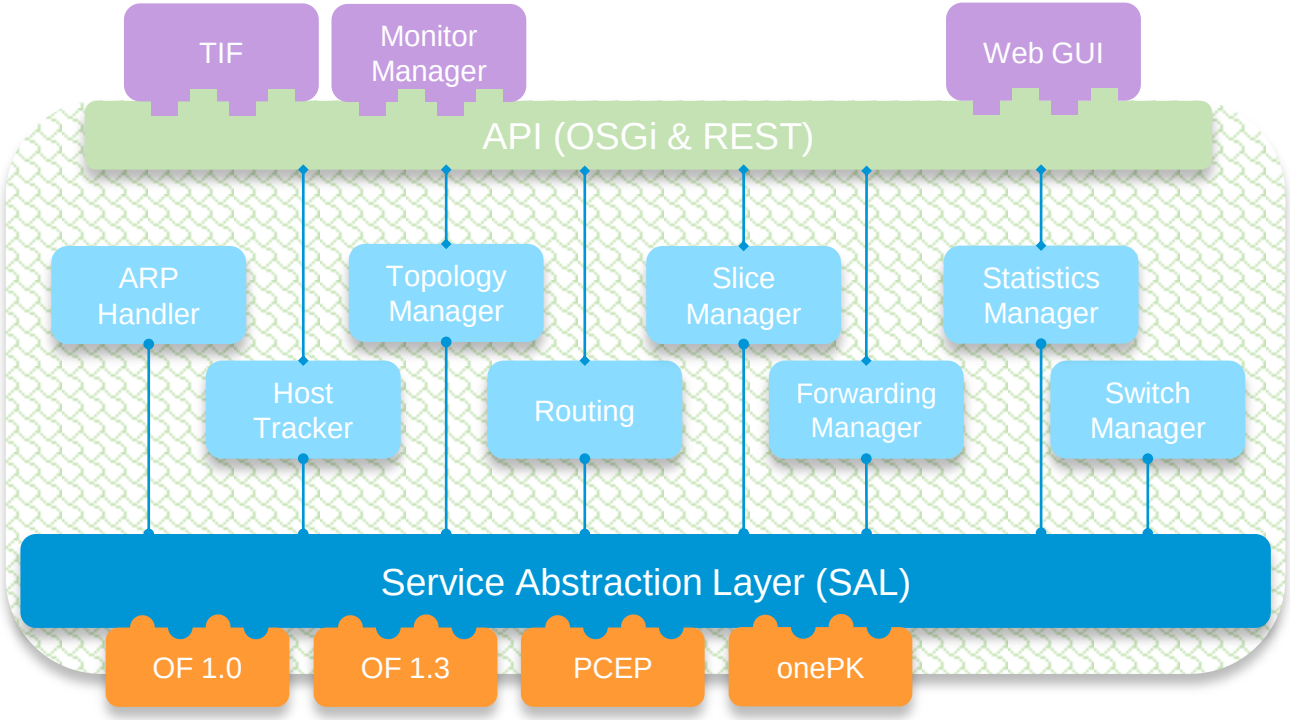
XNC Detailed Architecture

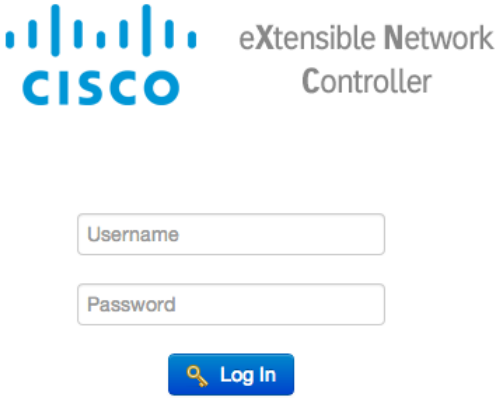


Cisco XNC System Details

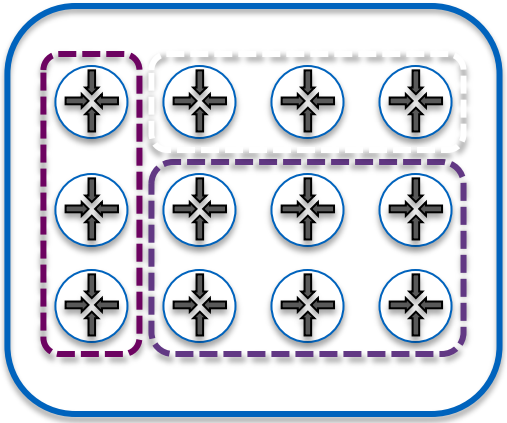
- Deployed on any Linux OS (Bare metal or Virtual Machine)
  - Requires Java 1.7
  - 64-bit Linux Operating System
- Controller can be deployed as stand alone or Cluster mode to provide High Availability
- Devices can communicate to the Controller in-band or through management interface
- Applications Available
  - Network Slicing
  - Topology Independent Forwarding
  - Monitor Manager

Cisco XNC GUI

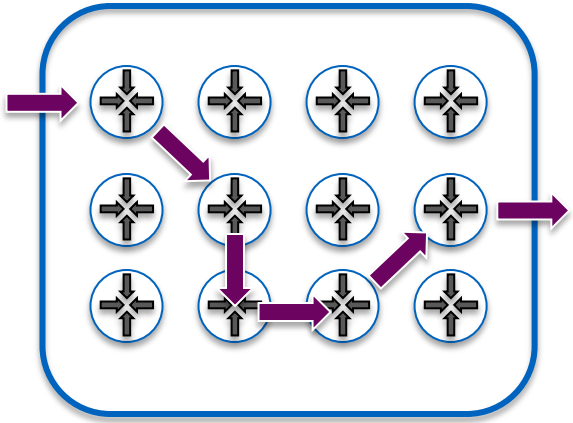
- Web based GUI to support both
  - Device Management
  - Network Topology Visualisation
  - Troubleshooting
  - Flow Programming
  - Network Slice Management
  - AAA Functions
- Application Specific GUI
  - Monitor Manager policy and device management
  - Traffic Forwarding policy management



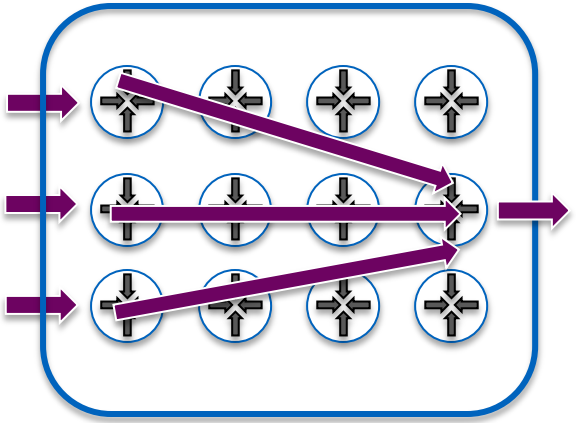
Cisco XNC Use Cases



- Network Segmentation
  - Campus slicing



- Topology Independent Forwarding
  - Traffic steering



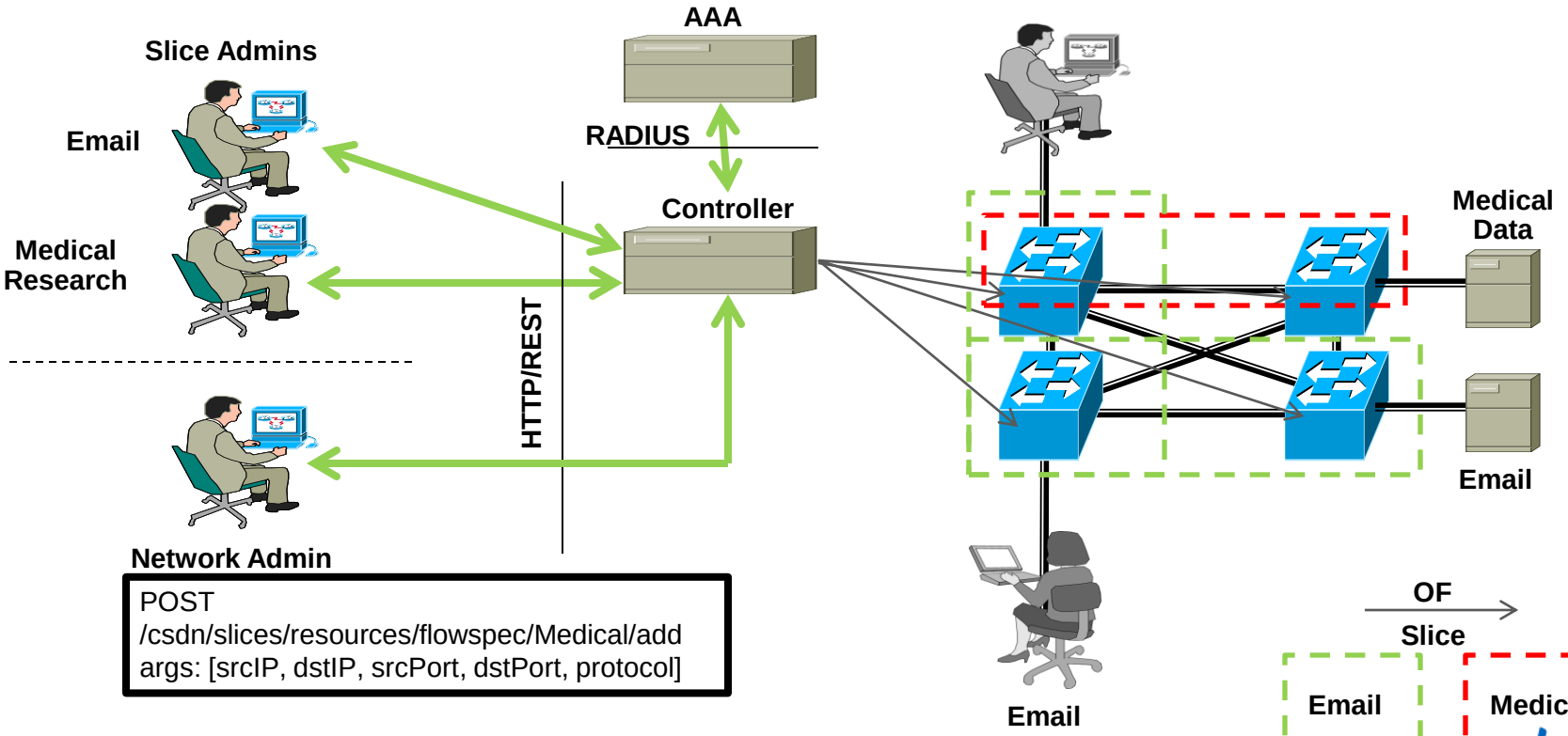
- Network Tapping
  - Matrix use case

XNC Use Cases

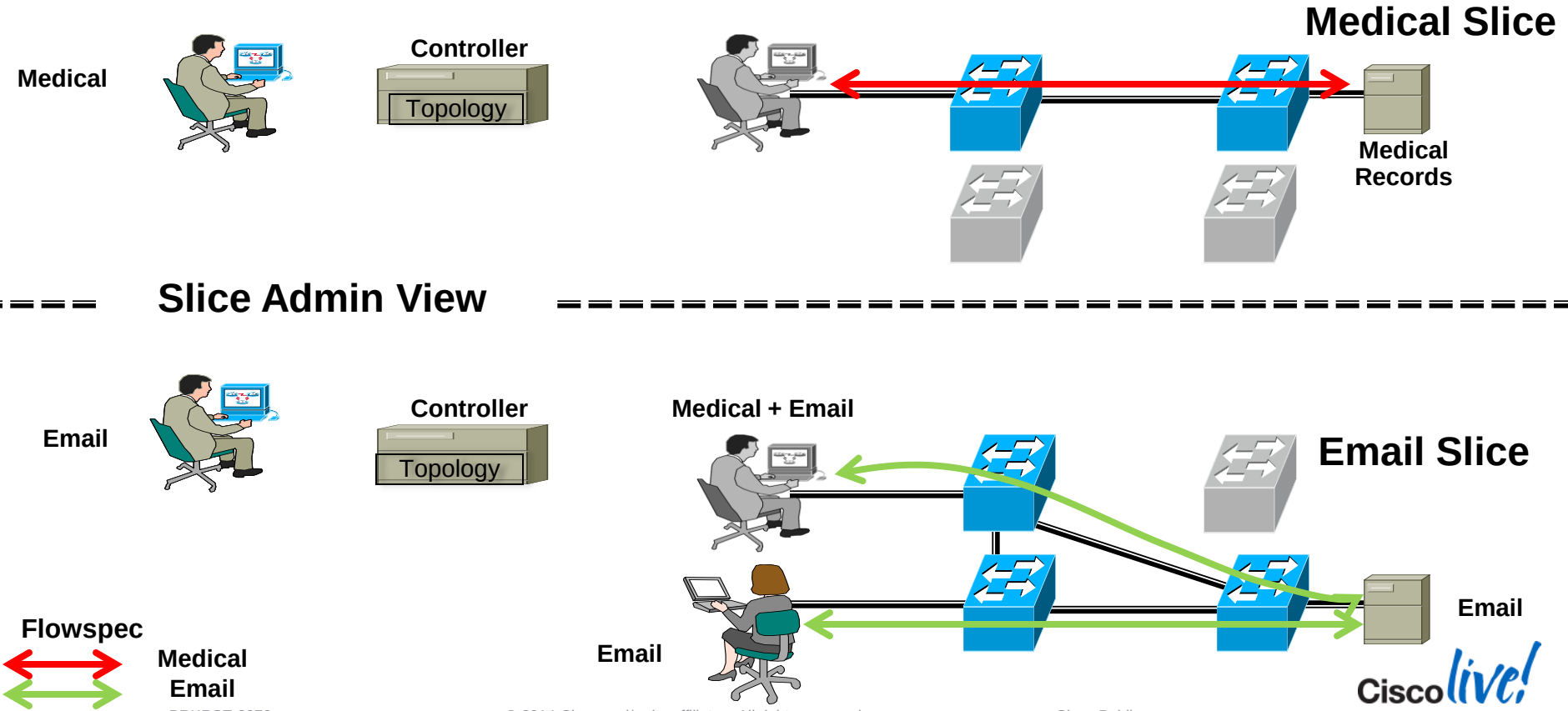
Network Segmentation

- Allows administrator to “slice” the network into logical partitions based on:
  - Physical devices
  - Interfaces
  - Traffic Characteristics (Protocol, port, etc.)
- Primarily requested by universities and research institutions to partition portions of the network for testing

Network Segmentation



Network Segmentation by Traffic Type

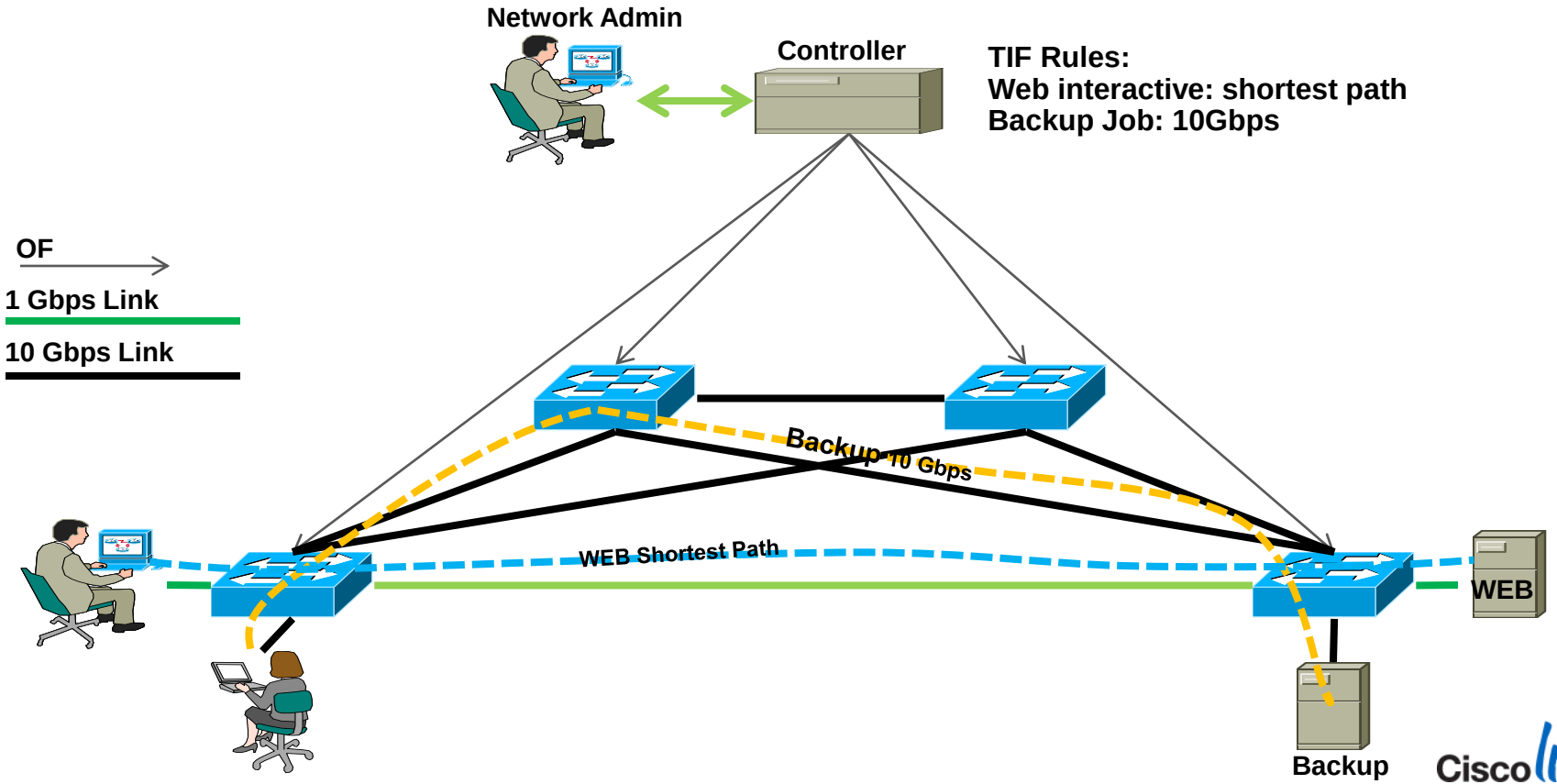


XNC Use Cases

Topology Independent Forwarding (TIF)

- Topology Independent Forwarding (TIF) allows the administrator to configure a path for specifics flows based on:
  - Source/Destination IP Address
  - Protocol
  - Source/Destination Port
- Traffic forwarding is configurable based on a number of factors, including:
  - Link Cost
  - Link Bandwidth
  - String Regular Expression

Topology Independent Forwarding

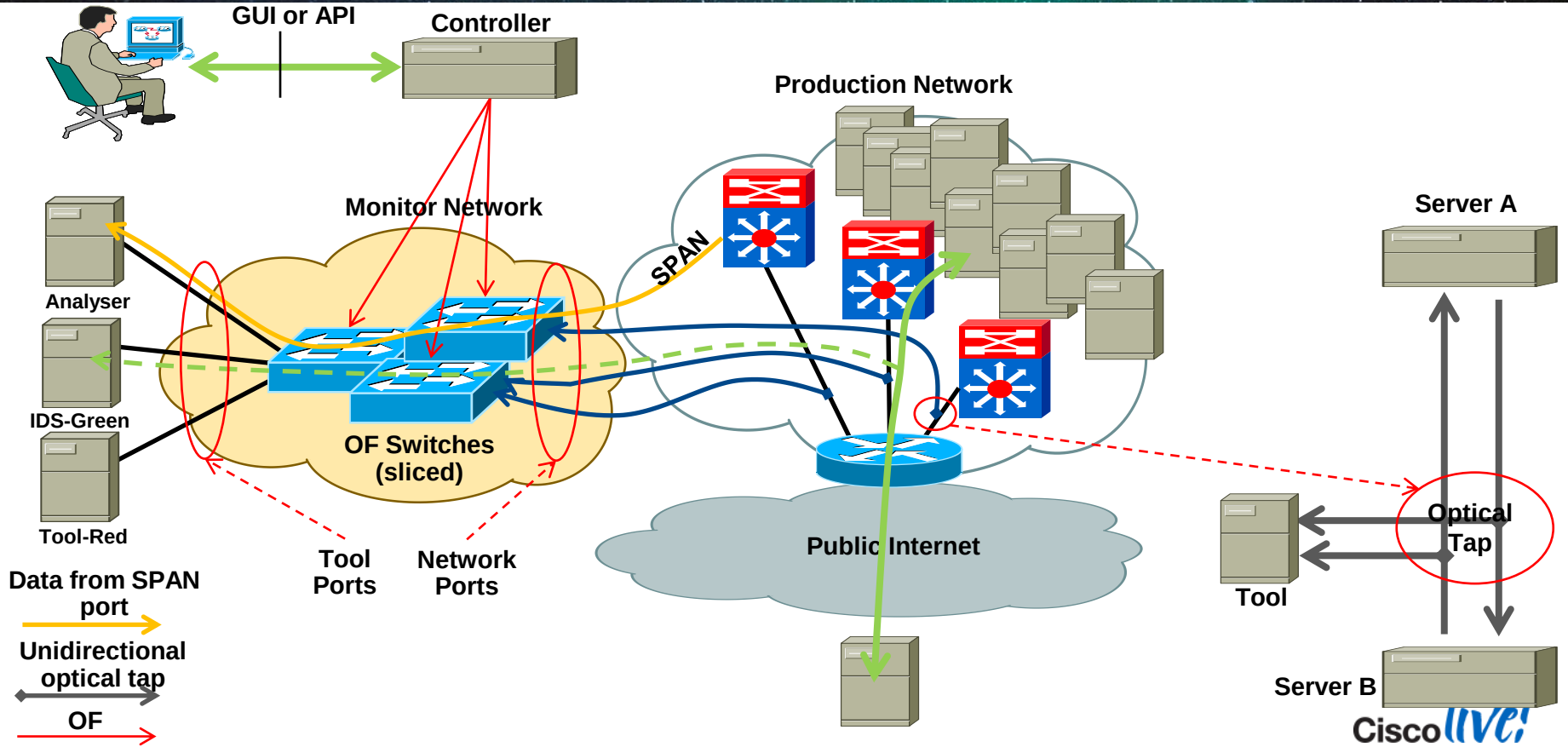


XNC Use Cases

Network Tapping

- Ability to forward traffic from multiple devices to a central tapping point
- Central tapping point can be one or more Nexus 3000 switches
- XNC Monitor Manager application used to:
  - Dynamic Manage Topology
  - Direct Traffic to Monitor Devices
- Solution Advantages:
  - Cost effective alternative to dedicated hardware tapping devices
  - Overcomes concurrent SPAN session limitations
  - Safe way to introduce SDN technology into an environment

Network Tapping



References

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- Cisco Extensible Network Controller (XNC)
  - http://www.cisco.com/go/xnc
- Cisco onePK
  - http://www.cisco.com/go/onepk
  - http://www.cisco.com/go/getyourbuildon




Q & A

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