Software Defined Network (SDN) for Service Providers

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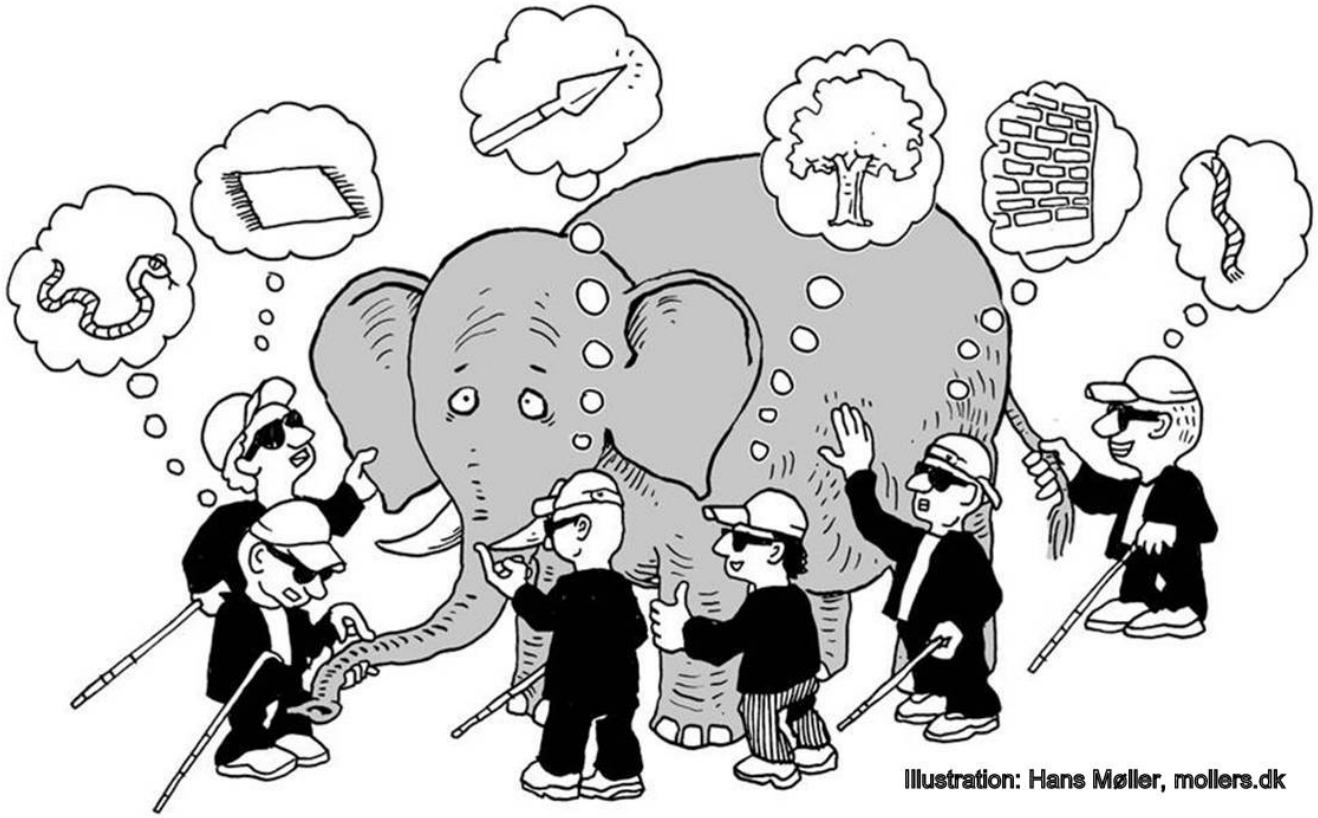


OPEN NETWORKING FOUNDATION

"…In the SDN architecture, the control and data planes are decoupled, network intelligence and state are logically centralized, and the underlying network infrastructure is abstracted from the applications…"

OpenFlow™

"..open standard that enables researchers to run experimental protocols in campus networks. Provides standard hook for researchers to run experiments, without exposing internal working of vendor devices……"

SDN

"A way to optimize link utilization in my network, through new multi-path algorithms"

"An open solution for customized flow forwarding control in the Data-Center"

"An open solution for VM mobility in the Data-Center"

"A platform for developing new control planes"

"Develop solutions software speeds: I don't want to work with my network vendor or go through lengthy standardization."

"A way to reduce the CAPEX of my network and leverage commodity switches"

"A way to avoid lock-in to a single networking vendor"

"A solution to build a very large scale layer-2 network"

"A means to do traffic engineering without MPLS"

Diverse Drivers
Common Concepts
Different Execution Paths

"A means to scale my fixed/mobile gateways and optimize their placement"

"A way to define virtual networks with specific topologies for my multi-tenant Data-Center"

"A way to build my own security/ encryption solution, avoiding RSA"

"A solution to build virtual topologies with optimum multicast forwarding behavior"

"A way to configure my entire network as a whole rather than individual devices"

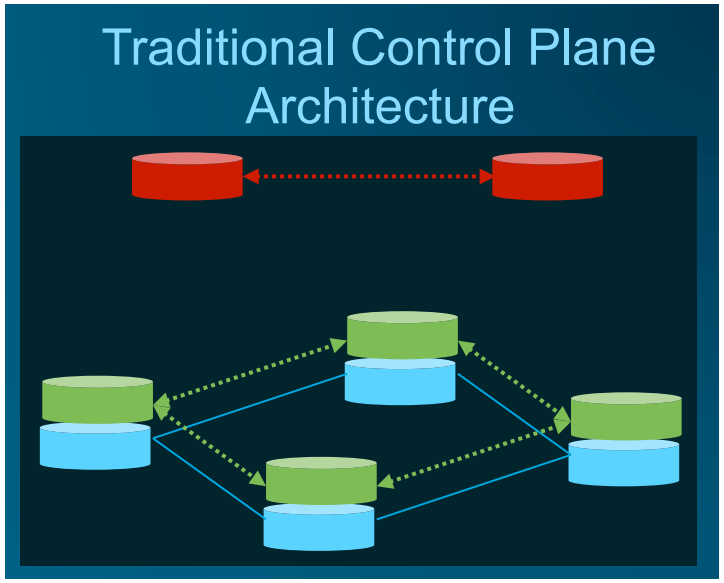
"A way to scale my firewalls and load balancers"

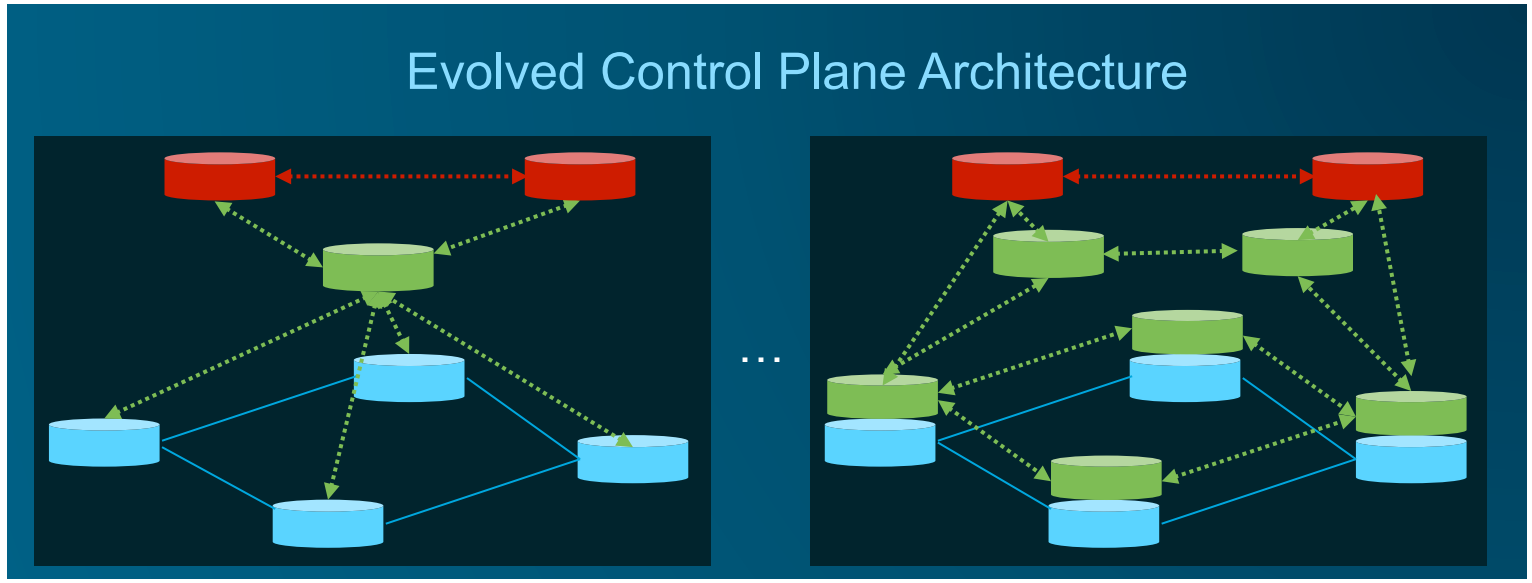
"A solution to get a global view of the network – topology and state"

"A way to distribute policy/intent, e.g. for DDoS prevention, in the network"

Towards the Open Network Environment for SDN

Implementation Perspective: Evolve the Control-Plane Architecture



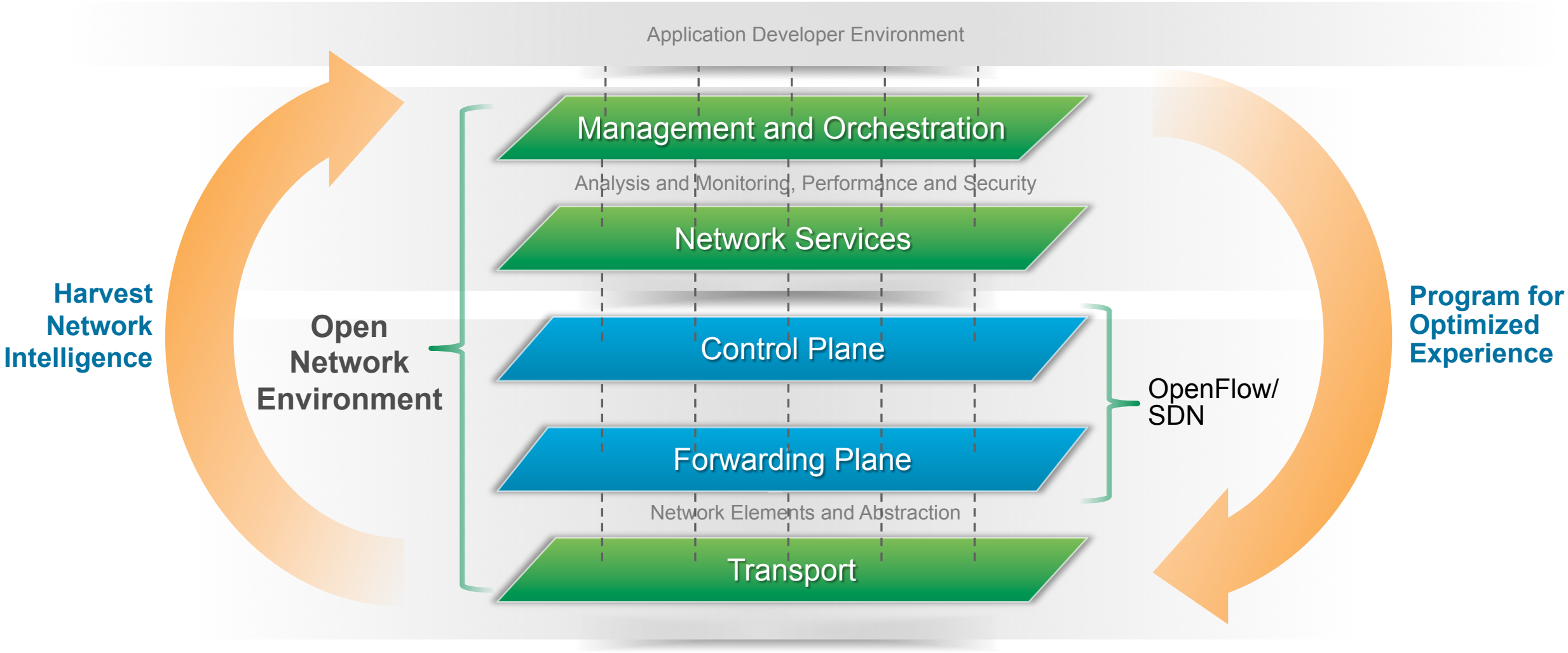


- Enable modularization and componentization of network control- and data-plane functions, with associated open interfaces. This allows for optimized placement of these components (network devices, dedicated servers, application servers) and close interlock between applications and network functions.
- Anticipated benefits include: Closely align the control plane with the needs of applications, enable componentization with associated APIs, improve performance and robustness, enhance manageability, operations and consistency

Control-plane component(s) Data-plane component(s) Applications

Cisco Open Network Environment (ONE)

Flexibility in Deriving Abstractions



Open Network Environment

- Open Network Environment – Complementing the Intelligent Network

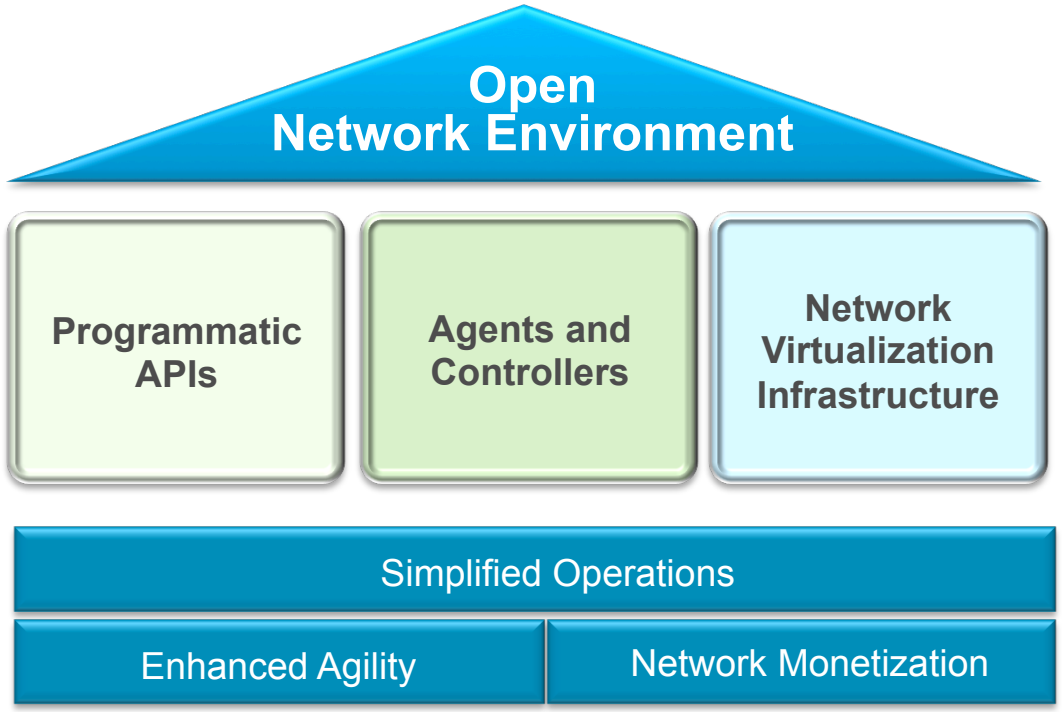
  Preserve what is working:
  Resiliency, Scale and Security,
  Comprehensive feature-set

  Evolve for Emerging Requirements:
  Operational Simplicity, Programmability,
  Application-awareness

- The Open Network Environment integrates with existing infrastructure

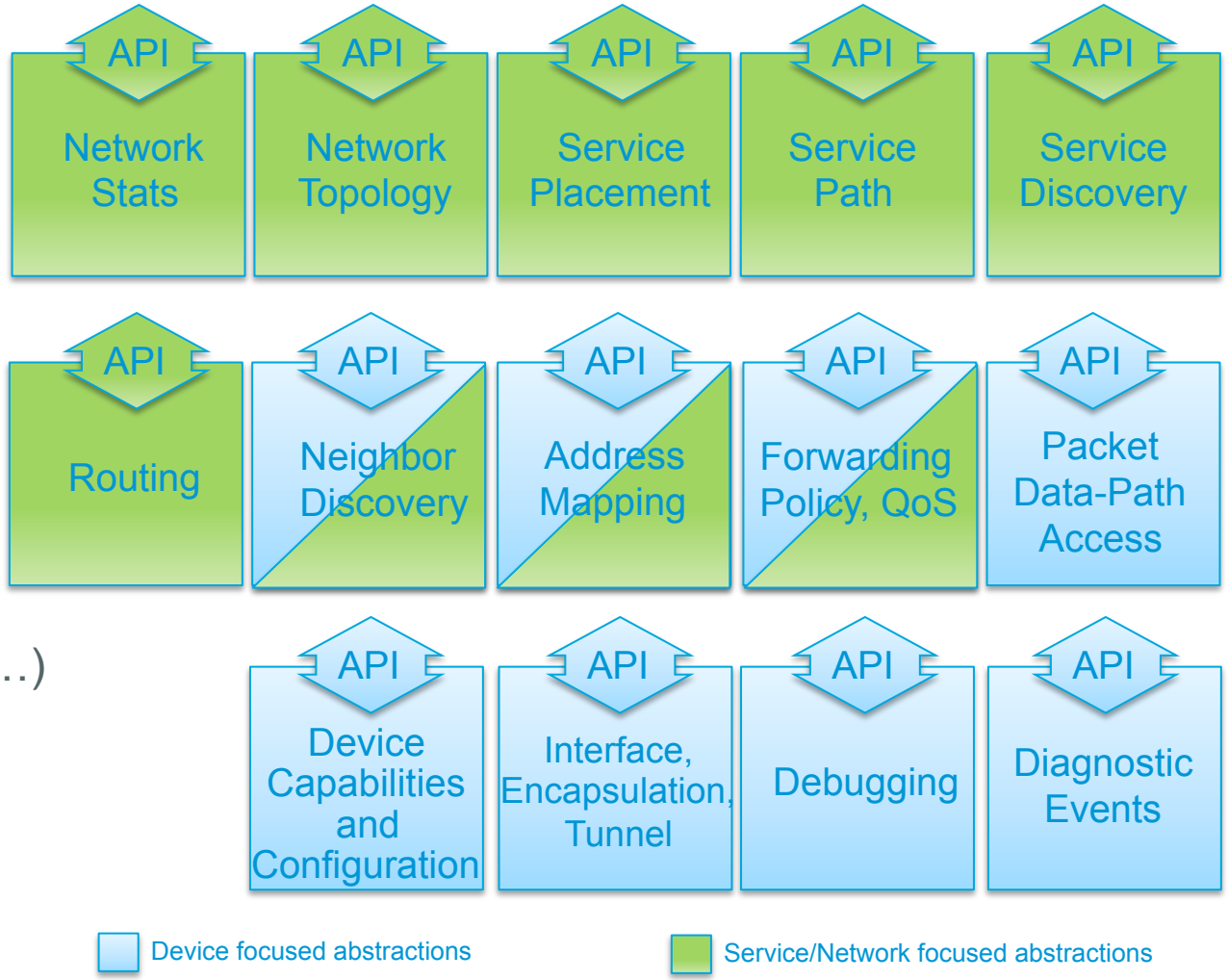
  Software Defined Network concepts are a component of the Open Network Environment

  The OpenFlow protocol can be used to link agents and controllers, and as such is component of SDN as well



Programatic APIs
Approaching abstractions for Networking

- Abstractions allow the definition of associated APIs
  - Enable API platform kit across all platforms, to integrate with development environments
  - Accelerate development of network applications: Completely integrated stack from device to network
  - Multiple deployment modes (local and remote (blade/server) based APIs)
  - Multiple Language Support (C, Java, Python…)
  - Integrate with customer development to deliver enhanced routing, forwarding..



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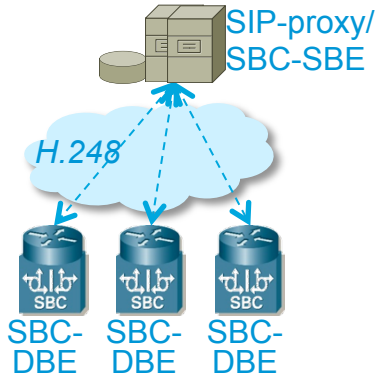
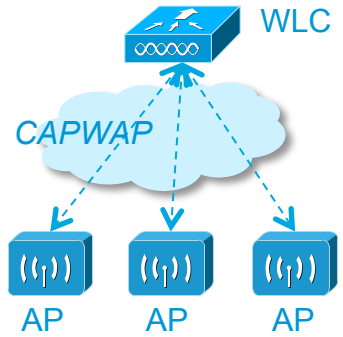
Agents and Controllers

Agent-Controller pairs: A few well-known and evolving examples

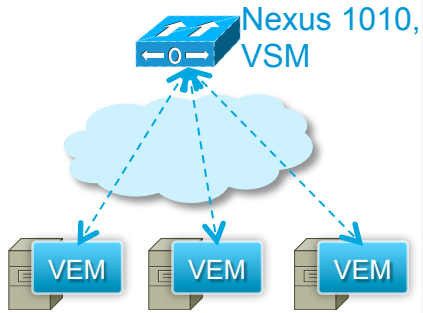
Session Border Control



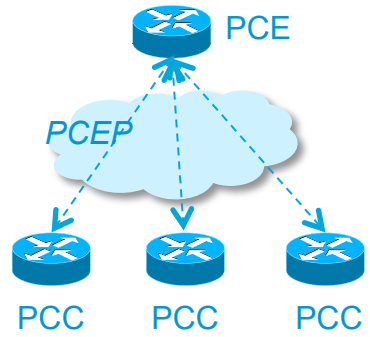
Wireless LAN Control



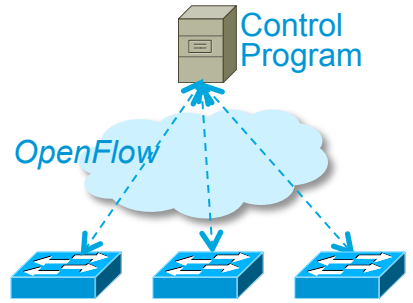
Virtual Switch Control



Path Computation



Flow Control with SDN



- Agents and Controllers are a component of Open Network Environments and a key component of the evolving “Software Defined Network” concept
- The Concept of Agents and Controllers exists in the Industry for quite some time
- Agent-Controller pairs always serve a specific task (or set of tasks) in a specific domain

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OpenFlow
Basics

- OpenFlow Components

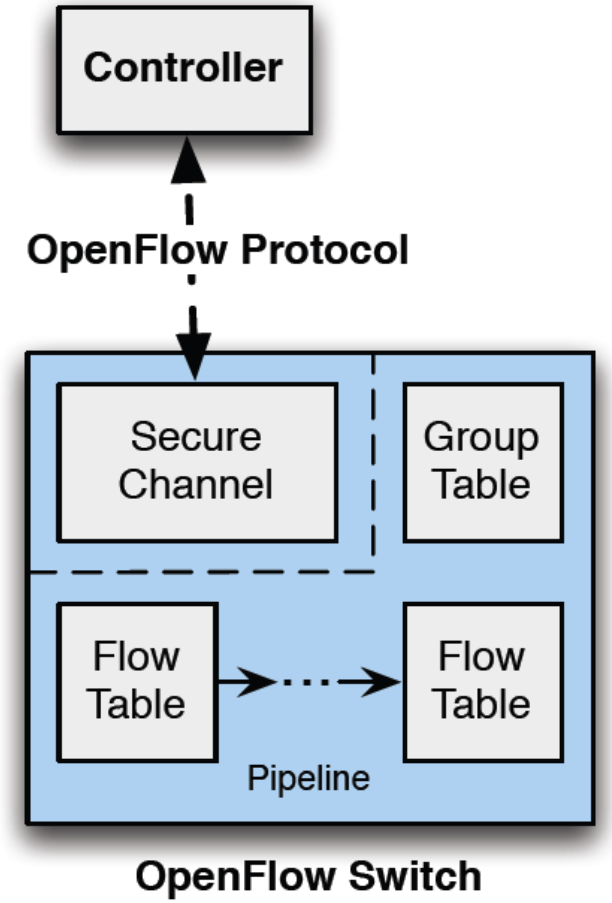
  Application Layer Protocol: OF-Protocol

  Device Model: OF-Device Model (abstraction of a device with Ethernet interfaces and a set of forwarding capabilities)

  Transport Protocol: Connection between OF-Controller and OF-Device*

- Observation:

  OF-Controller and OF-Device need pre-established IP-connectivity



Source: OpenFlow 1.3.0 specification, figure 1

* TLS, TCP – OF 1.3.0 introduces auxiliary connections, which can use TCP, TLS, DTLS, or UDP.

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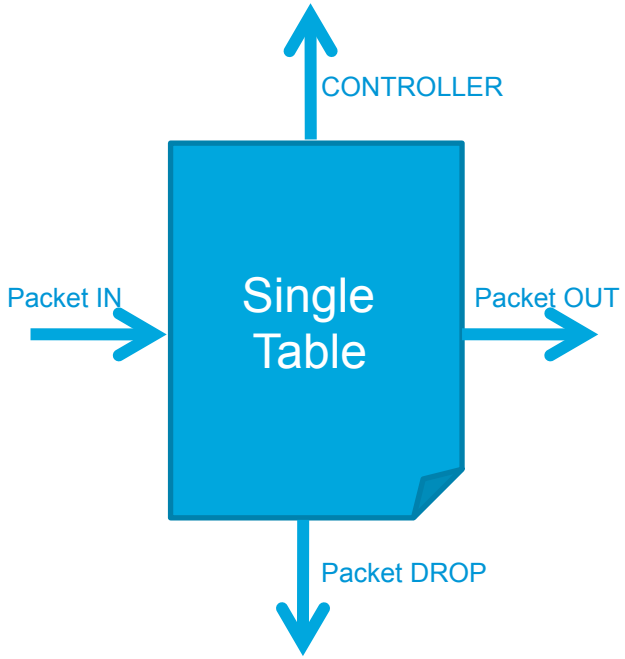
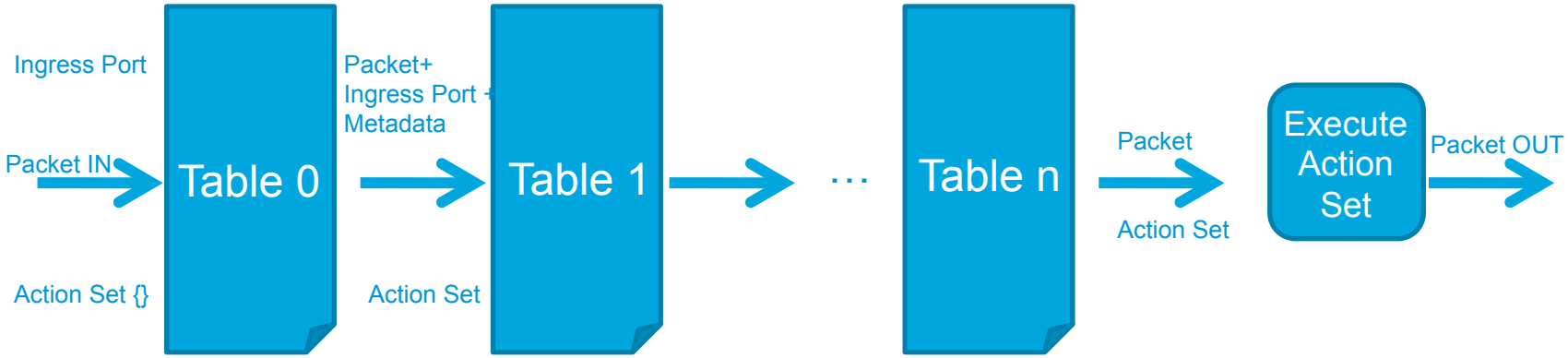
OpenFlow Processing Pipeline

OF 1.0 model
(single lookup)



OF 1.1 and beyond model
(multiple lookups)



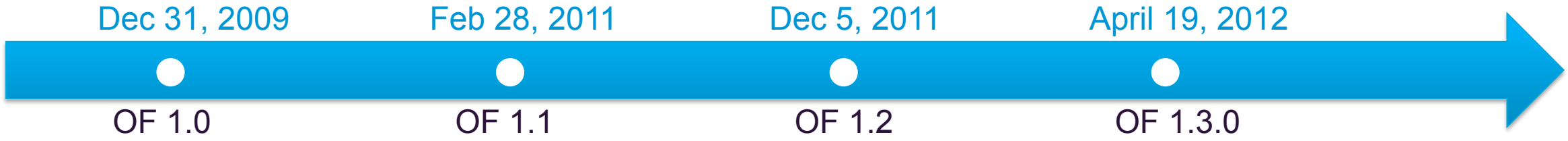
① Find highest-priority matching flow entry

② Apply instructions:
- i. Modify packet & update match fields (apply actions instruction)
- ii. Update action set (clear actions and/or write actions instructions)
- iii. Update metadata

③ Send match data and action set to next table

Source: OpenFlow 1.3.0 specification, figure 2

OpenFlow Protocol Specification Evolution



OF 1.0

- Single Table
- L2, IPv4 focused matching

OF 1.1

- Multiple Tables
- MPLS, VLAN matching
- Groups: {Any-,Multi-}cast
- ECMP

OF 1.2

- IPv6
- Flexible-length matching

OF 1.3.0

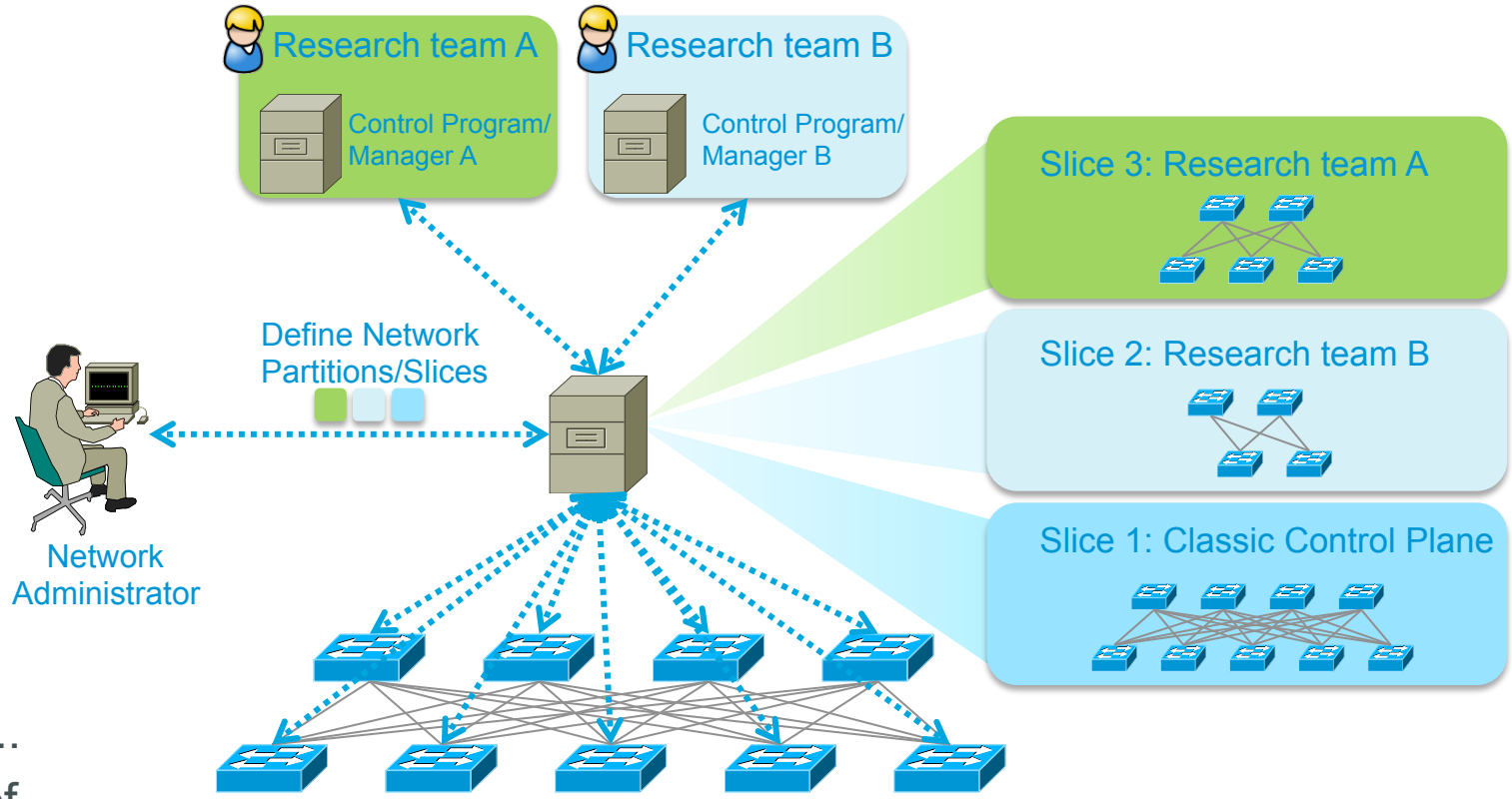
- 802.1ah PBB
- Multiple parallel channels between Switch and Controller

A few topics of ongoing work

- High availability model for device and controller (state re-sync etc.)
- Hardware friendly switch model – "typed tables" → New Forwarding Abstractions WG
- Security model (granular access control)
- Layer 3 forwarding model
- Enhanced Statistics
- Management infrastructure (evolution of OF-CONFIG)
- Testing and certification framework
- Hybrid device/network deployment capability (→ Hybrid WG)

Virtualization: Network Partitioning
Example: Network Slicing for Research Environments

- Business Problem
  - University desires to “slice” the network into multiple partitions:
  - Production network – classic control plane
  - Several research networks – experimentation with new control algorithms, programs etc.
- Solution
  - Network Slicing Manager (built as an app on top of the ONE controller) partitions the network based on e.g. ports, VLANs, aggregate flow matches,..
  - Effects of a particular control function of a partition/slice limited to that partition/ slice



Open Network Environment: Standards Context

Orchestrating Efforts across multiple SDOs/Fora, including IETF, IEEE, ONF, ITU, …

IETF

Network Configuration (NETCONF WG)
Application Layer Traffic Optimization (ALTO WG)
Content Delivery Networks Interconnection (CDNI WG)
Extensible Messaging and Presence Protocol (XMPP WG)
Software Driven Networks (SDNP BOF)
Infrastructure-to-application information exposure (I2AEX BOF)

ONF OPEN NETWORKING FOUNDATION

OpenFlow Device Configuration (ONF Config WG)

IETF

Path Computation Control (PCE WG)
Forwarding & Control Separation (FORCES WG)

ONF OPEN NETWORKING FOUNDATION

OF Hybrid Devices/Networks (Hybrid WG)
OF Protocol Extensions (Extensibility WG)
OF Futures: “FPMOD/OF2.0” (Futures group)

ITU – Future Networks

Y.FNsdn: SDN Framework
Y.FNsdn-fm: Requirements formal specification and verification methods for SDN

IETF

Network Virtualization Overlays (NVO3 WG)
L2VPN WG
L3VPN WG
Locator/ID Separation Protocol (LISP WG)
Pseudowire Emulation Edge to Edge (PWE3 WG)

IEEE Networking the World™

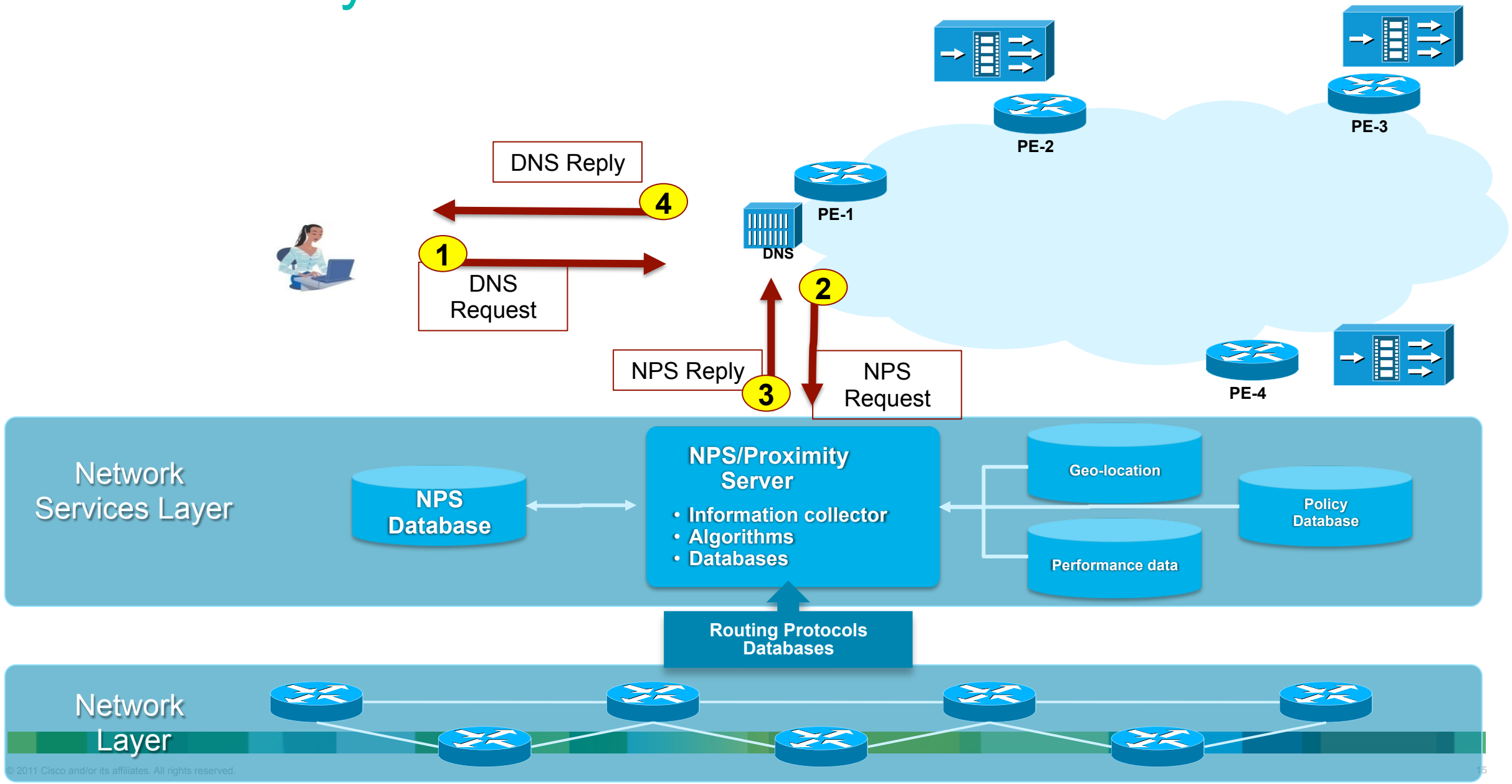
802.1aq Shortest Path Briding
802.1Qbp Equal Cost Multiple Paths
802.1Qbg – Edge Virtual Bridging
802.1BR – Bridge Port Extension

ITU

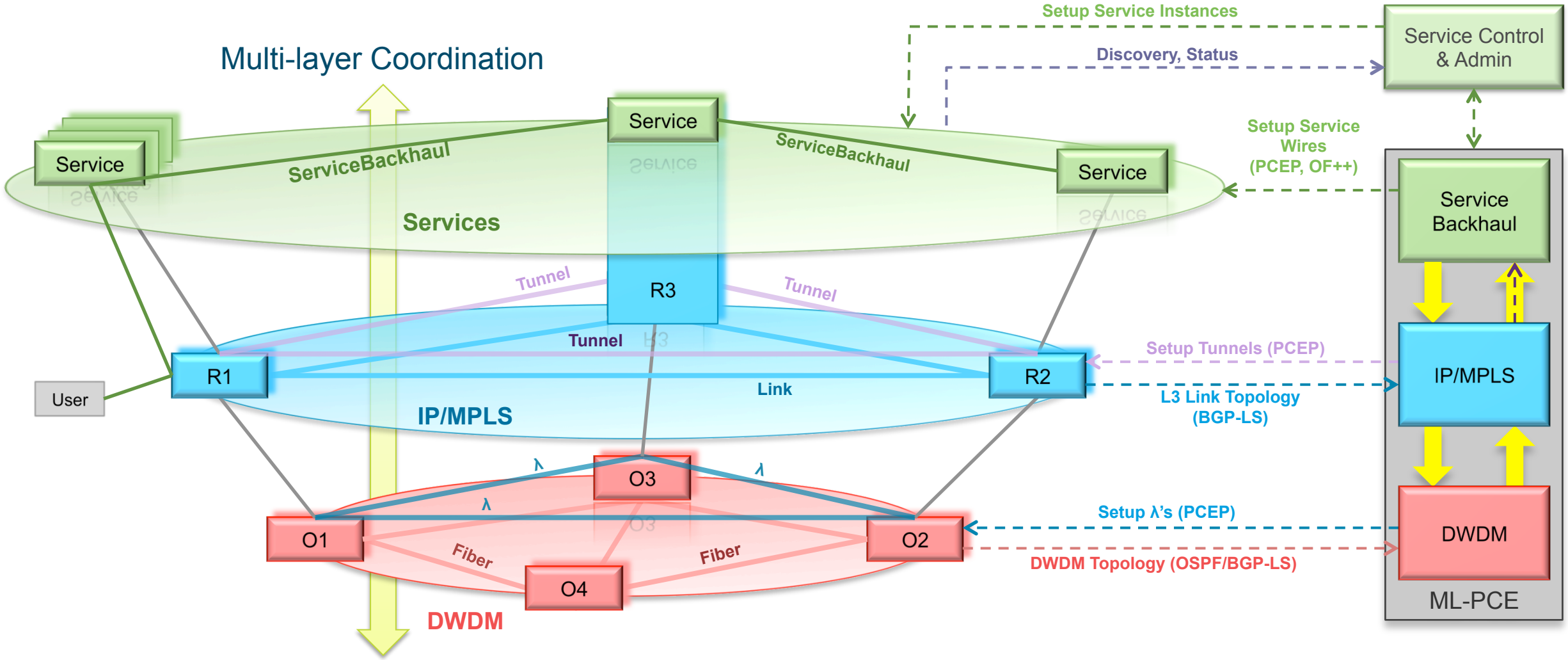
SG13 – Future Networks
(Y.Fnvirtreq - Requirement of network virtualization)

SDN For Service Providers
A Few Use Cases

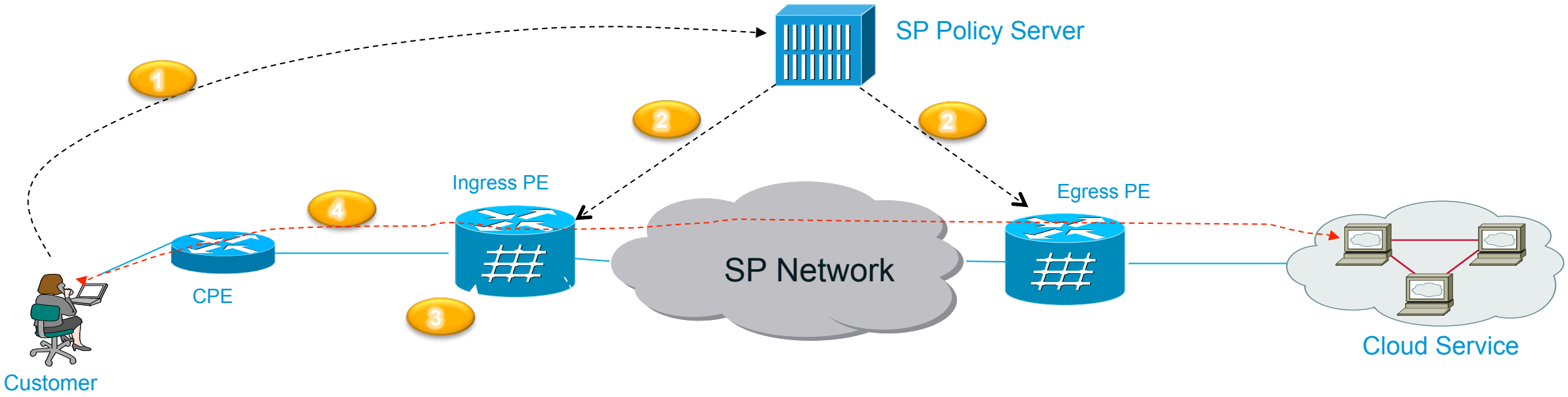
DNS Proximity Guided Resolution



Multi Layer Path Computation Element



Dynamic Cloud Service Modification (Turbo Boost)



1. Customer requests premium access (eg, priority QoS, incremental BW) to XYZ cloud service
2. Policy server pushes customer policy changes to Ingress & Egress PE(s) attached to customer sites
3. OnePK application overrides default VPN behavior
4. Customer traffic matching the policy is given premium treatment

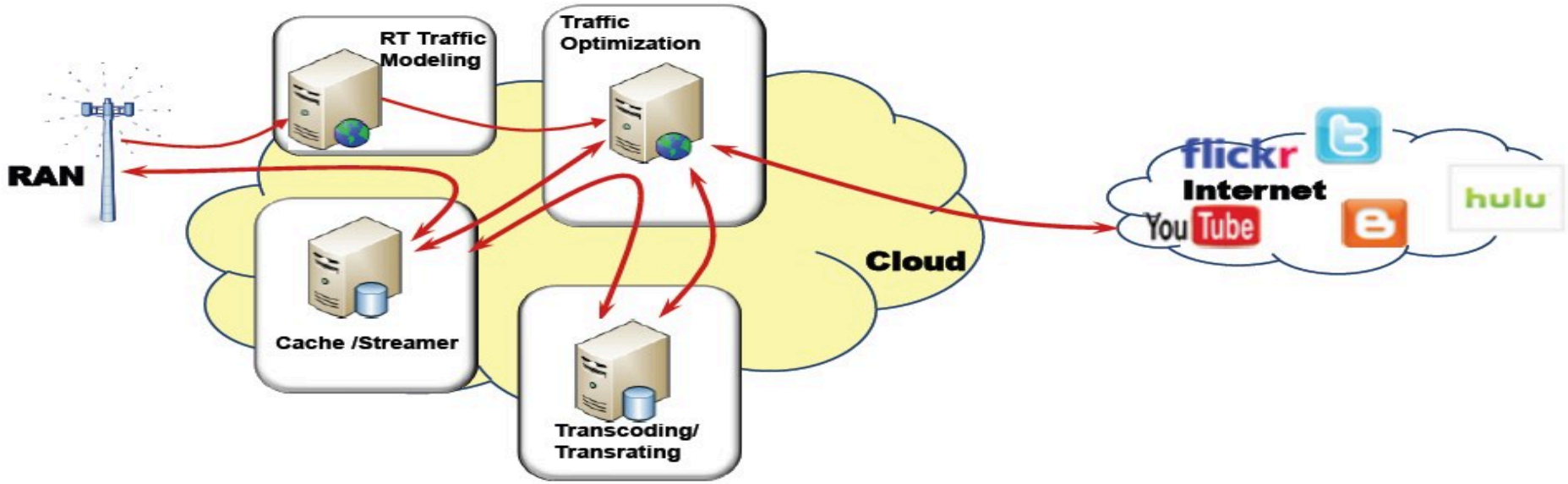
Using Programatic Access, SPs can build such custom apps to create differentiated, revenue generating services

Use Case from Verizon – Mobile Video Optimization in RAN

verizon

Software Defined Networking Today:
Traffic Steering for Content Management & Distribution

- By subscriber based on subscriber policy
- By application type through content inspection
- By cache asset based on URL
- By destination based on RAN congestion signaling
- By server based on performance and availability



Summary – SDN for SP

Preserve What's Working

Evolution, not Revolution

- Use SDN to Augment capabilities
- Hybrid mode Ops/Architecture
- Use case driven

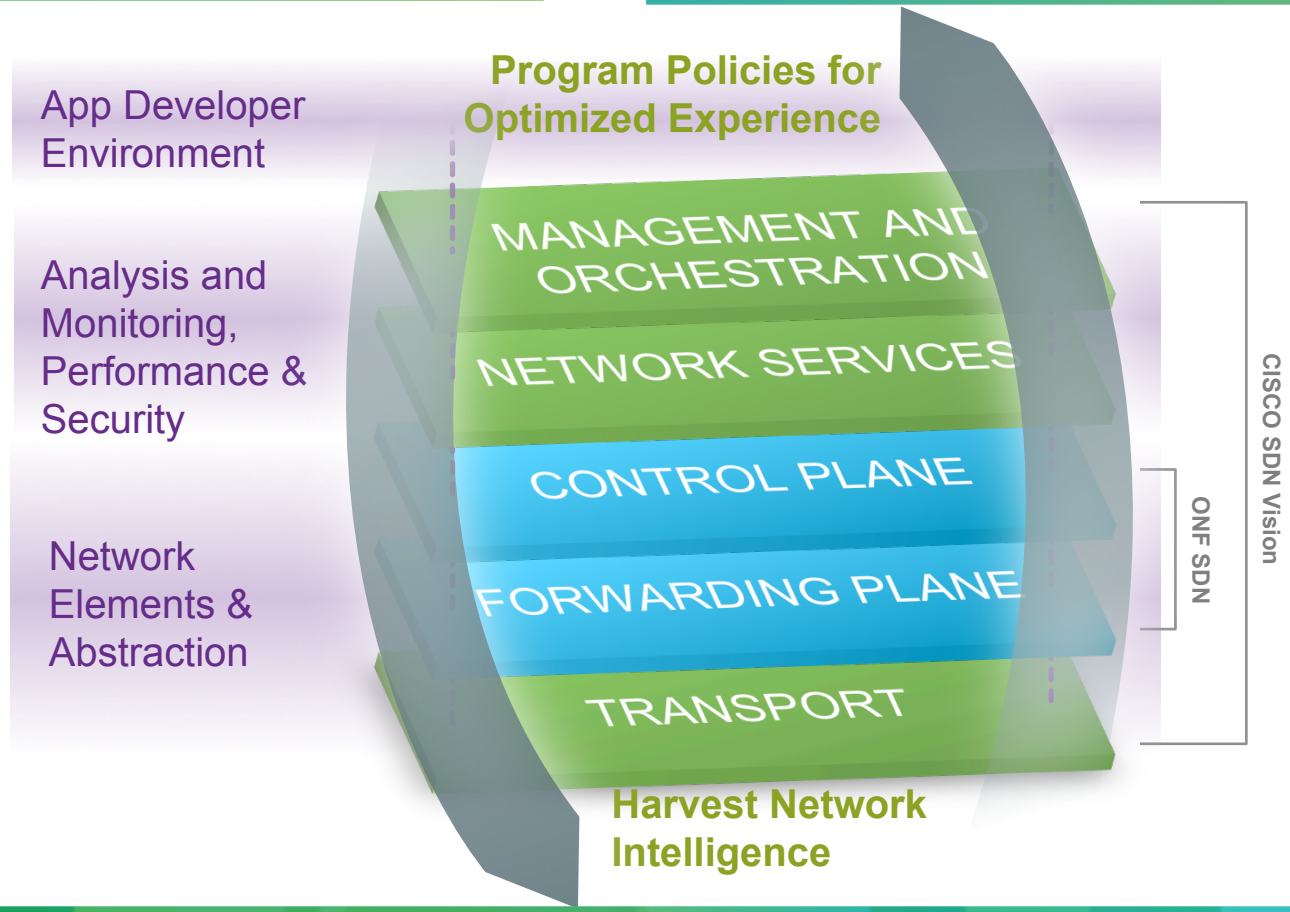
SDN is an architecture, OpenFlow is a protocol

- SDN is much broader
- OpenFlow is just one component alongside others

No one size fits all

- Diverse segment will have diverse requirement, will require different solutions

Evolve for Emerging Requirements



Any Object

- Switch/Router
- ASIC
- Network Fabric
- Compute

Any Service

- Cloud
- Collaboration
- Video
- Security
- Mobility

Any Layer

- L1-7
- Control/Data Plane
- Hardware/Software
- ASICs/OS

Use Case Driven – Making Network More Intelligent

Thank you.