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February 15 - 19, 2016 • Berlin, Germany

## We're ready. Are you?

APIC-EM-WRiedel-BRKCRS-3011-20160213.pptx

# APIC-EM

## A scale out architecture for SDN in the Enterprise

Wolfgang Riedel

BRKCRS-3011



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ENG Product Management – Architecture  
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# Who is Wolfgang Riedel ???



- **Personal:**

- Location: Erlangen, Germany (between Munich – Frankfurt)
- Other Interests: Alpine Snowboarding, High-End Audio, AS51871, Data Center, Real World LAB, High-performance sports cars, Geothermal DC cooling research project, ...

- **Background:**

- Joined CISCO January 2001
- Before; self-employed as an in-depended consultant in the Networking and IT space for more then fifteen years.
  - ✓ SE – RS Germany (2001 – 2006) -> Campus with a DC attached
  - ✓ CSE – DC EMEA (2006 - 2008) -> DC with Campus attached
  - ✓ CE – Cisco CTO Office (2008 – 2011)
  - ✓ PE – ARND (2011 – 2013)
  - ✓ PE – CTO Team ENG (2013 - 2014)
  - ✓ PE – Architecture Team ENG (2014 – ...)
- HA Campus & DC Design, Routed Access, DC POD Design
- CCIE RS, VCP 3/4/5 and pile of CPOC's
- Worked with more then 250 customers within several projects over the last +15 years
- Individual Contributor: Cat4k, Cat6k, N7k, ASR1k, FC, FCoE, DCB, UCS, N5k, N2k, N1k, PoE FEX, vPC, OTV, LISP (Pioneer Award), OF, SDN

- **Stuff I am currently working on:**

- Network Transformation, Architecture (Mark, Matthias, Tim, Dave, Jason, Simone, I)
- APIC-EM, DNS-AS, AVC, USP
- TECSDN-3600 + BRKCRS-3011 + BRKSDN-3004

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# Agenda



1. Introduction
2. World of Controllers and Technologies
3. Controllers
  1. OpenFlow – Stanford Clean Slate
  2. APIC-DC - Application Policy Infrastructure Controller for the Datacenter
  3. Virtual Managed Services
  4. OSC – Open SDN Controller
  5. ODL – Open Day Light Controller
  6. APIC-EM - Application Policy Infrastructure Controller for the Enterprise
  7. PI and APIC-EM
4. APIC-EM
  1. Policy Infrastructure
  2. Auto Scale Architecture
  3. Grapevine Cloud Deployment
  4. Use Cases
5. Demo
6. A Few Conclusions and Q&A, if we have time



# 1. Introduction



# Industry trends in Networking

Cloud (2008)

 **OpenFlow** Networking (Stanford clean slate) (2011)

**Software Defined Networking (2012)**



**Open Daylight Project (2013)**

**DevOps, The API Driven Datacenter (2013)**

**Network Function Virtualization (2013)**

**Managing Networks through abstractions (2014)**

**Metadata Driven Networking (2016)**

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**Atomic Services (2018)**

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# SDN – Still Don't kNow – Stanford Defined Networking

The Promise of OF/SDN had been “Decoupling Policy from Configuration”

“An open solution for customized flow control in the Data-Center”

**Physical separation of control and data plane**

“A way to reduce the number of switches and leverage commodity switches”

“A platform for developing new control planes”

**Managing the network through abstractions**

“With SDN I can develop solutions to my problems far faster – at software speed – without going through length standardization”

**Whitebox routing and switching**

“A means to do traffic engineering without MPLS”

“An open solution for VM mobility in the Data-Center”

**Packet forwarding on x86 compute**

“A means to scale my fixed/mobile gateways and support multi-tenancy”

“A solution to build virtual topologies with custom forwarding behavior”

**Software Defined Networking**

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

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

**Running networks in agile DEV-OPS model**

“A way to build a network solution avoiding SD-WAN”

“A way to scale my firewalls and loadbalancers”

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

**You can't just buy SDN.  
It's an architecture which you  
have to embrace and live**

“A way to configure my entire network as a single entity”

“A way to optimize network resource usage with new multi-path algorithms”

“A means to get a global view of the network – topology and state”

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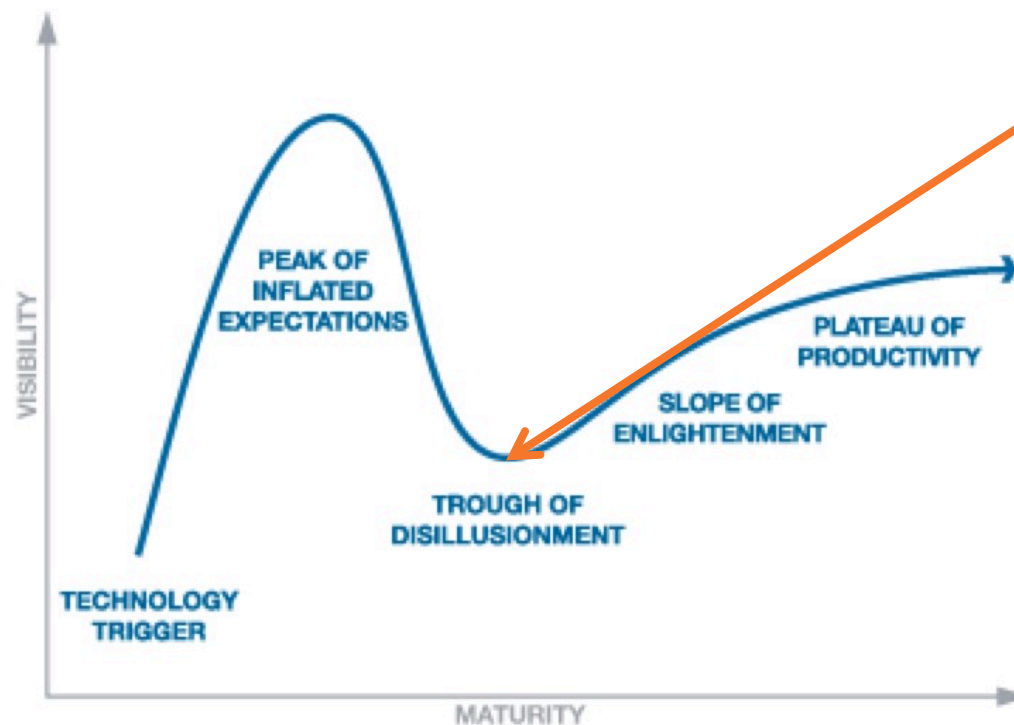
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# SDN – Hype Cycle

Where we are with SDN 2016, five years later



- Technology Trigger
- Peak of Inflated Expectations
- **Trough of Disillusionment**
  - Interest wanes as experiments and implementations fail to deliver.
  - Producers of the technology shake out or fail.
  - Investments continue only if the surviving providers improve their products to the satisfaction of early adopters.
- Slope of Enlightenment
- Plateau of Productivity

# Today's DC Architectural Battle

System administration is over - we should stop doing it

## Web Approach (MSDC)

- ☐ IT infrastructure core of its business
- ☐ Warehouse Datacenter
- ☐ Scale-Out Architecture
- ☐ ~100.000 of physical servers
- ☐ Single Application Optimization
- ☒ **Small Number of Applications**, like Gmail, Google+, Office 360, Xbox, Bing, ...
- ☐ Application Designed for Failure
- ☐ Automate everything possible
- ☐ It's all about being super-cheap commodity systems; costs must grow in a "sub-linear" fashion
- ☐ Open Source
- ☐ Backbone Bandwidth Calendaring
- ☐ TDM style provisioning with custom TCP stack
- ☐ L3 Topology

## Enterprise Approach (EPDC)

- ☐ IT infrastructure is an expense
- ☐ "Discovery" Datacenter
- ☒ **Scale-Up Architecture**
- ☐ ~10.000 physical servers
- ☒ **Thousands of Applications**
- ☐ Application trust boundaries
- ☐ HA failover model
- ☐ Transactional
- ☐ Application specific Infrastructure
- ☐ Commercial Of The Shelf
- ☐ L2 Topology

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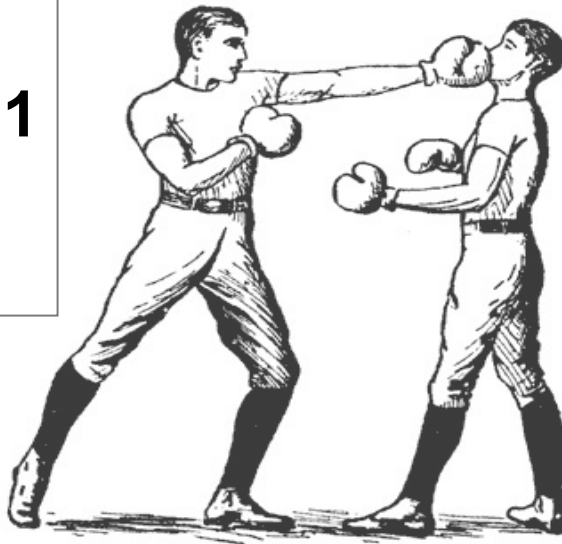


# Today's DC Architectural Battle

## Device to Admin Ratio

**2009**

**Traditional IT: 50:1**  
**Amazon: 200:1**  
**Google: 10000:1**



**2013**

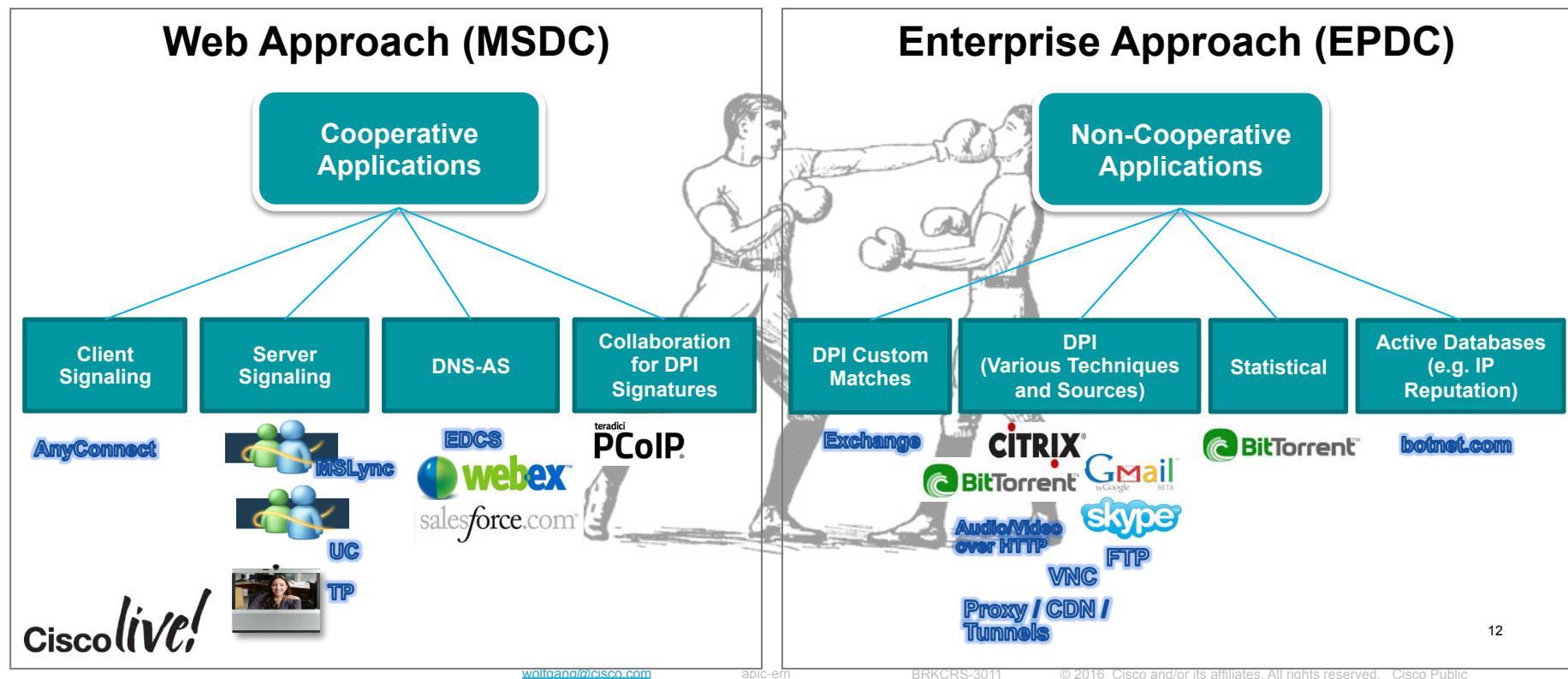
**Traditional IT 50:1**  
**Amazon 10000:1**  
**Google: 30000:1**

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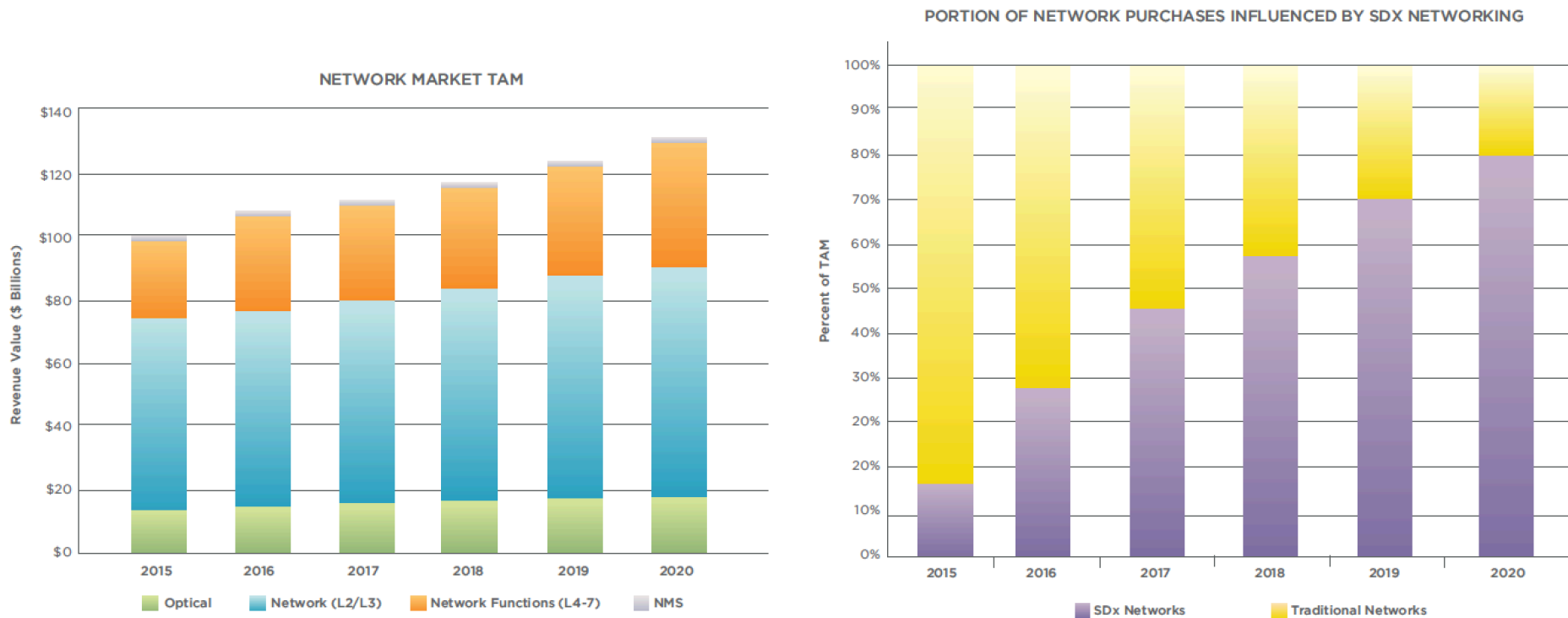


# Today's DC Architectural Battle

It's all about the Application



# SDx Influences Network Purchases



Source: SDx Central

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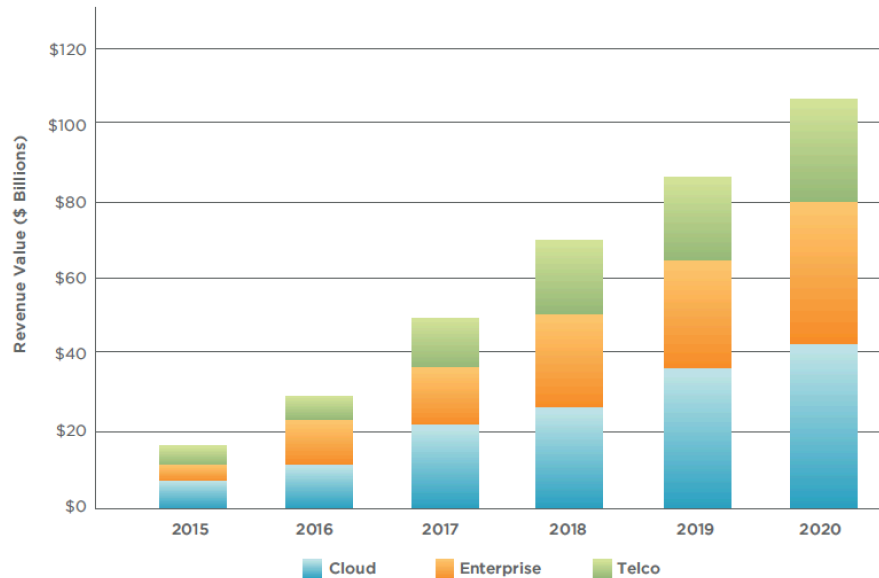
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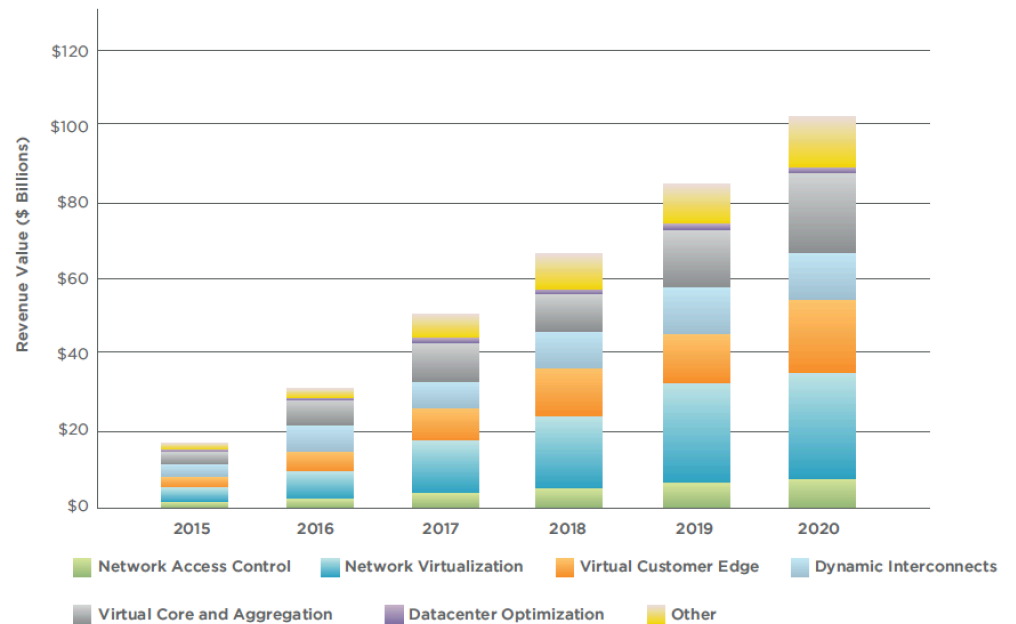
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# SDx Spending by Customer and Use Cases

SDx NETWORKING SPEND FORECAST  
BY CUSTOMER SEGMENT



SDx NETWORKING SPEND  
BY UMBRELLA USE CASES



Source: SDx Central

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# Managing the network through abstractions

There are two approaches to Control Systems

## IMPERATIVE CONTROL



Baggage handlers follow sequences of simple, basic instructions

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## DECLARATIVE CONTROL



Air traffic control tells where to take off from, but not *how* to fly the plane

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# Managing the network through abstractions

There are two approaches to Control Systems

## IMPERATIVE CONTROL



## DECLARATIVE CONTROL



It's 2016 and network admins still enjoy being  
“masters of complexity”

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# APIC - EM Design Points

Validated with FAT & CAT

	Abstraction and Automation of Manual Network Operations
Reduce Network Complexity	
	Advanced Visualization (HTML5/JavaScript) and REST oriented interface
Brownfield Support – No Software / Hardware upgrade required	
	Start with small set of solvable problems Configuration Management, Zero Touch Deployment and IWAN as key applications with identifiable metrics (OPEX savings, ROI)
Low Risk adoption of SDN	
	Elastic Services Infrastructure ensures scaling as adoption grows
Enterprise Scale	Network automation network use
	Auto-Translation of high level business intent into network control function
Programmer minimal to no programming requirement	
	Advanced analytics for real time network visibility and faster response time

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# Enterprise SDN customer asks in an iPhone world

TYPICAL APPLE PRODUCT...

A GOOGLE PRODUCT...

YOUR COMPANY'S APP...

FIRST NAME:	<input type="text"/>	TYPE CD:	<input type="text"/>	<div>4 - K AA2- DK9B KKA? CN3 AA-9</div> <div>NEW</div> <div>DEL</div>	
LAST NAME:	<input type="text"/>	TQP STAT:	<input type="checkbox"/>		
SSN:	<input type="text"/>	FT/PT:	<input checked="" type="checkbox"/>		
ID:	<input type="text"/>	VER:	<input type="text"/>		
PHONE 1:	<input type="text"/>	CAT CD:	<input type="text"/>		
PHONE 2:	<input type="text"/>	CITY:	<input type="text"/>		
ADDR 1:	<input type="text"/>	STATE:	<input type="text"/>		
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OKAY APPLY SAVE UNDO HELP DELETE EDIT

SELECT BROWSE ERRORS

By Eric Burke

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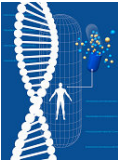
STUFFTHATHAPPENS.COM BY ERIC BURKE

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# New Network Needs for the Digital Business

## Information Era Network

Closed and Hardware Centric

Manual Box-by-Box Management

Perimeter Based Reactive Security

IT & Historical Analytics

## Digital Ready Network

Open , Programmable, Software Driven

Network Wide Policy Based Automation

Proactive Context-Based Security Everywhere

Business & Real Time Analytics

powered by  
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# Principles for the New Network Architecture

Open and Software-Driven



## Cloud

Services & Apps Built for  
Cloud Consumption

On-Demand Scale  
Faster IT Innovation

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## Controllers

Complete Controller-  
based Automation

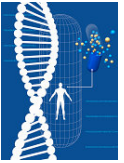
Simplicity through Abstraction  
Centralized Policy



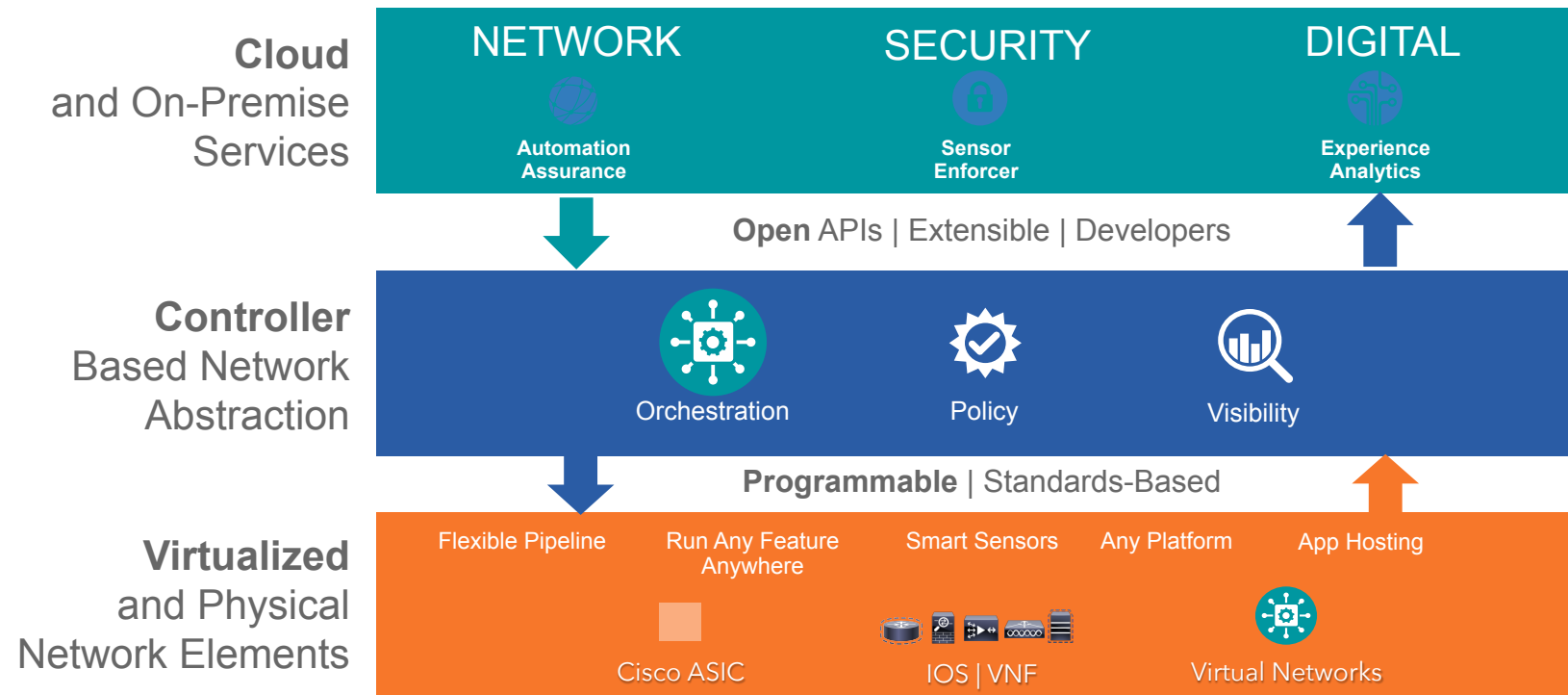
## Virtualization

Virtualized Networks  
Functions and App Hosting

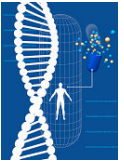
Freedom of Choice - Any Platform  
Run Applications over the Network



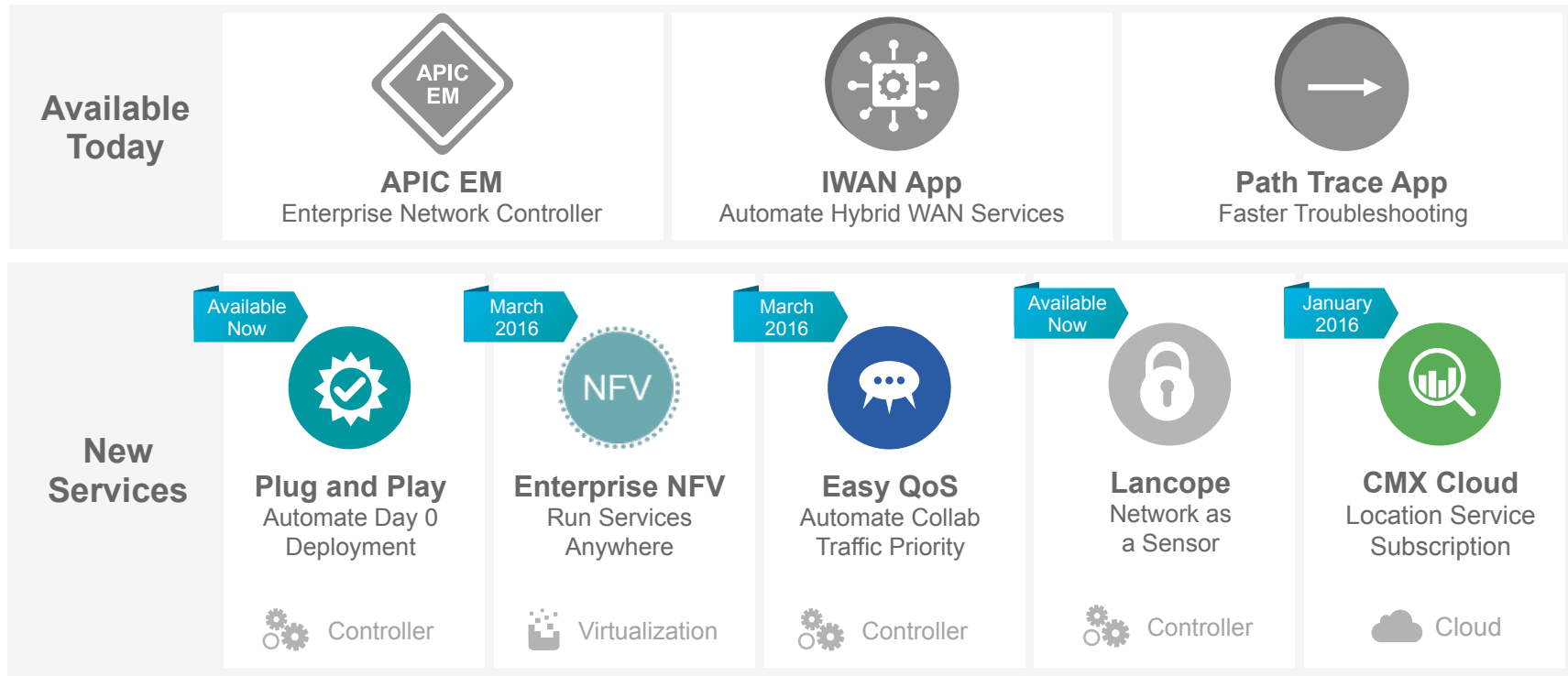
# Digital Network Architecture (DNA)



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# DNA Service Innovation

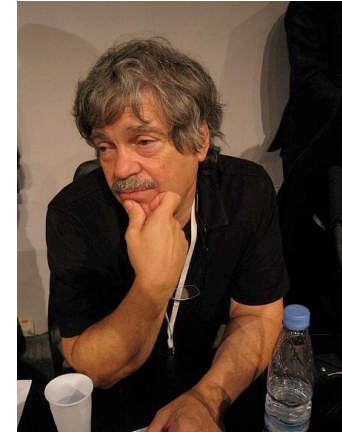


Available on DNA-Ready Infrastructure through Cisco ONE Software

ISR 4000 | ASR 1000 | Catalyst 6800 | Catalyst 4000-E | Catalyst 3850 | Catalyst 3650 | Aironet 802.11ac

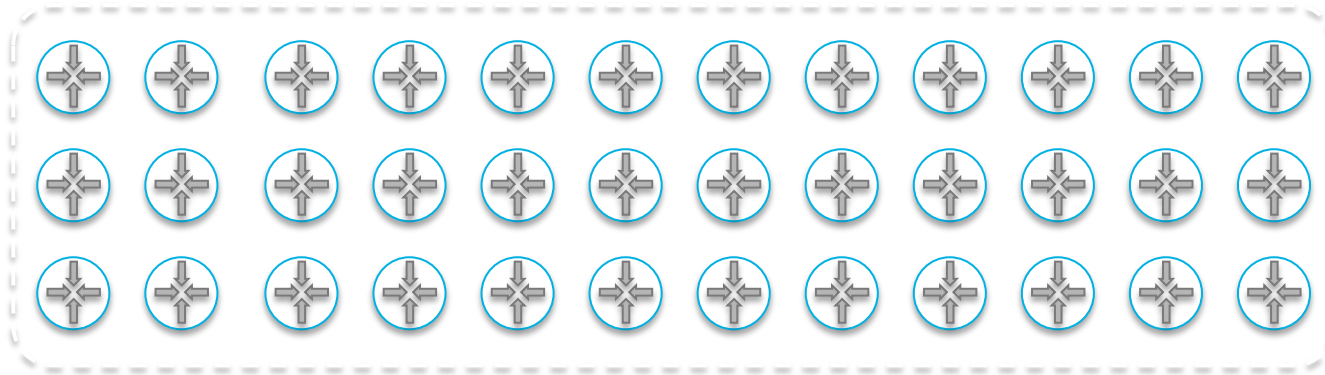
*“People who are really serious about software should make their own hardware.”*

Alan Kay, 1982



# 1.1 Analogies

Distributed Networking has **worked**

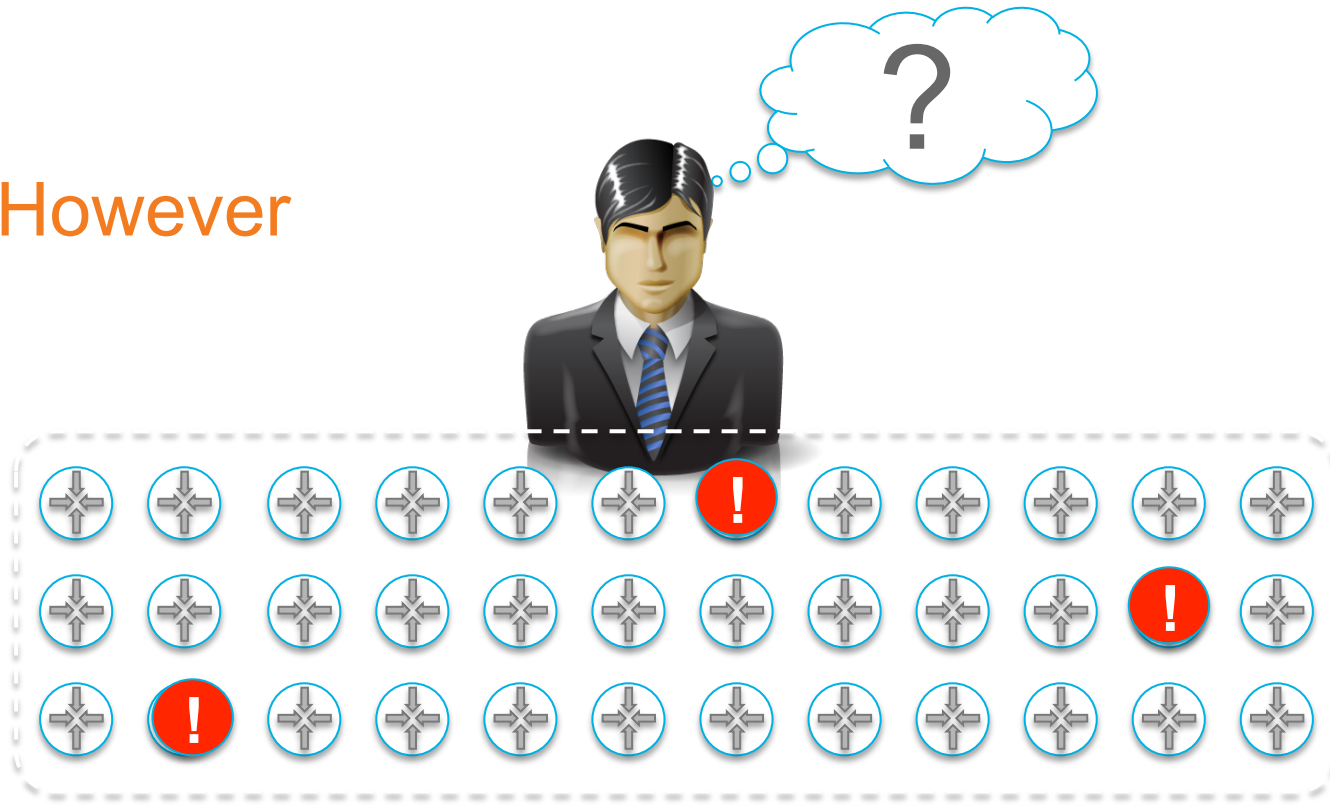


Resiliency/Scale has been **proven**

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Distributed Networking has **worked**

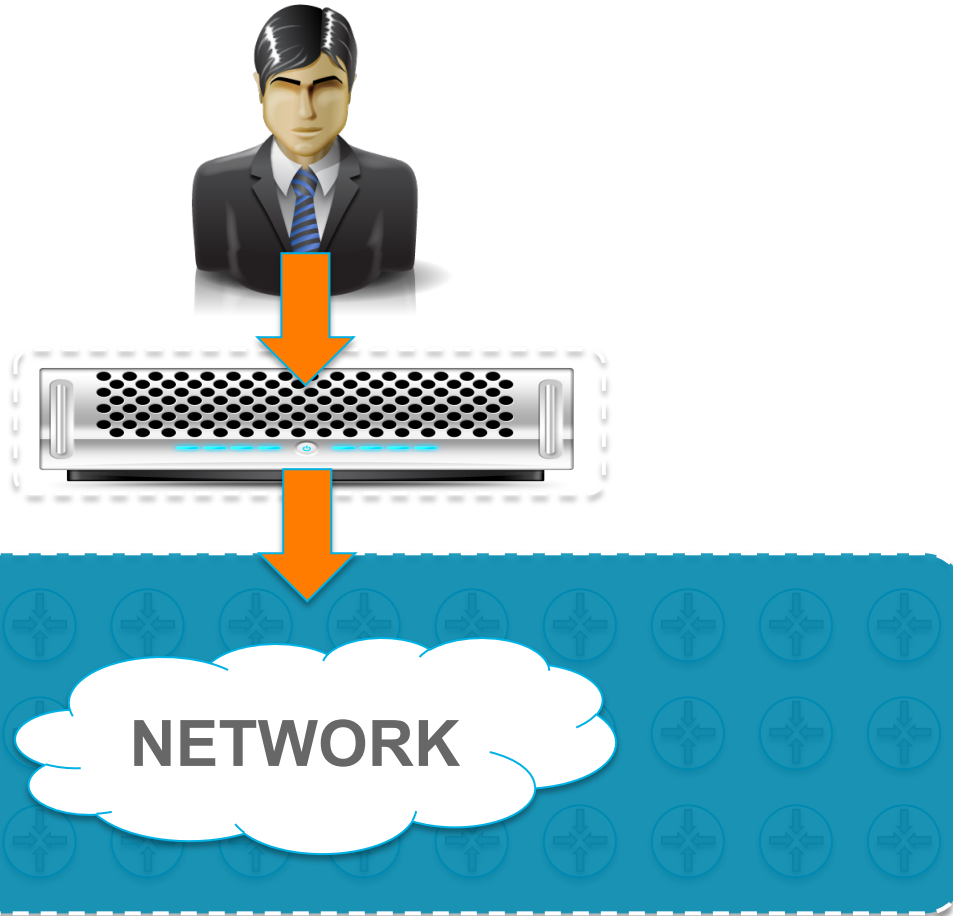
However



**Cisco** *live!* Distributed Networking adds complexity to **manage/comprehend**

# Admin still makes network behavior decisions

But uses controller  
to mask complexity



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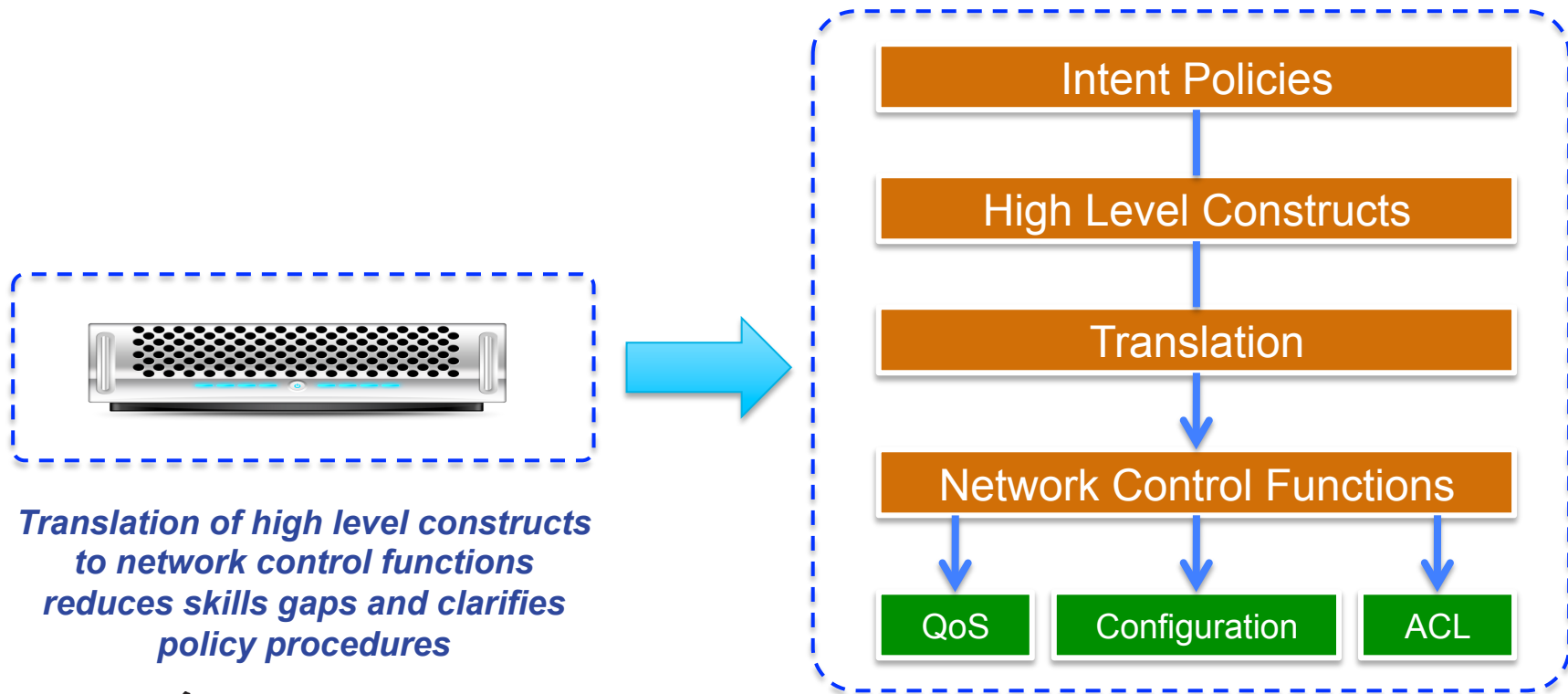
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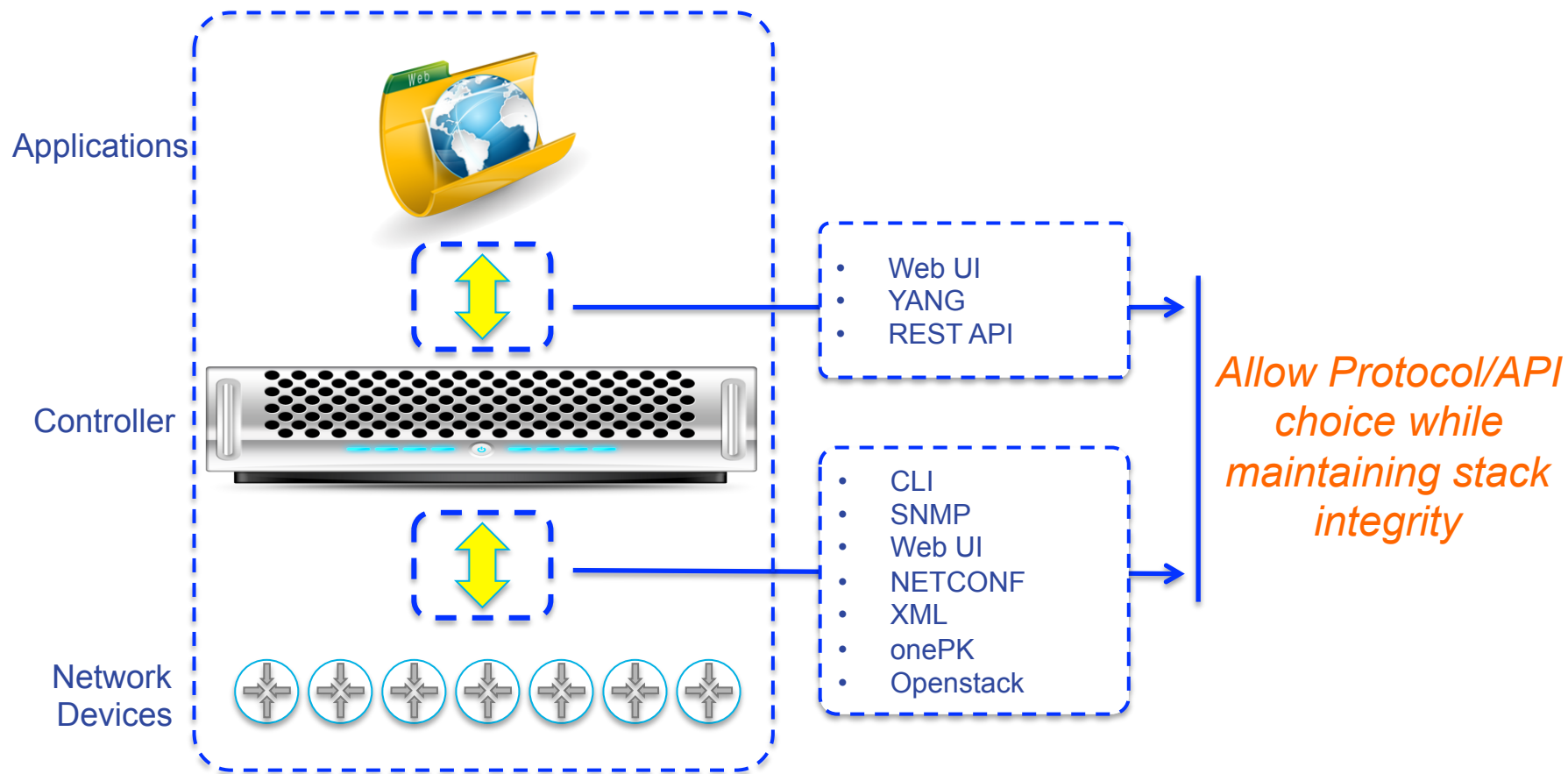
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# Cisco Intent Policy Management

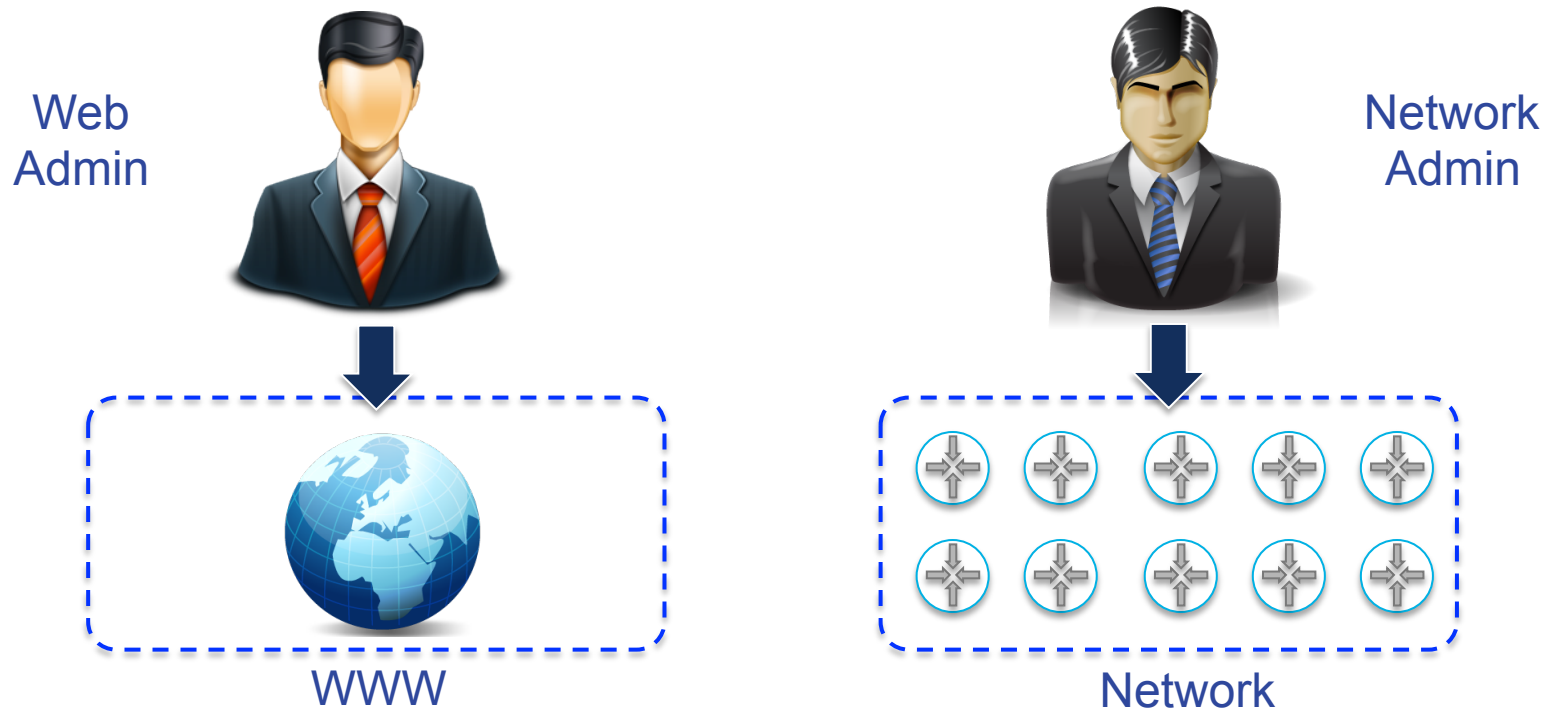


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Both at one time had **direct admin control**



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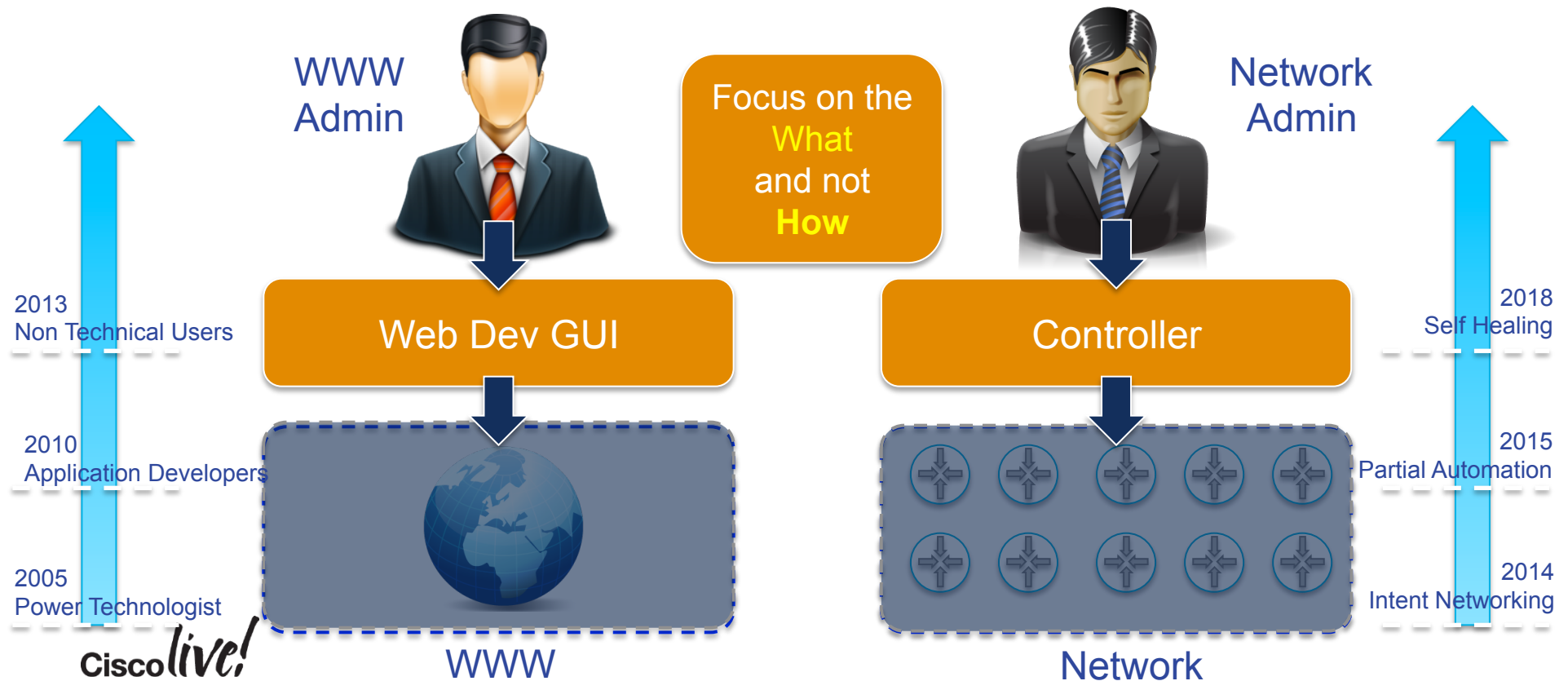
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# Direction to abstract complexity

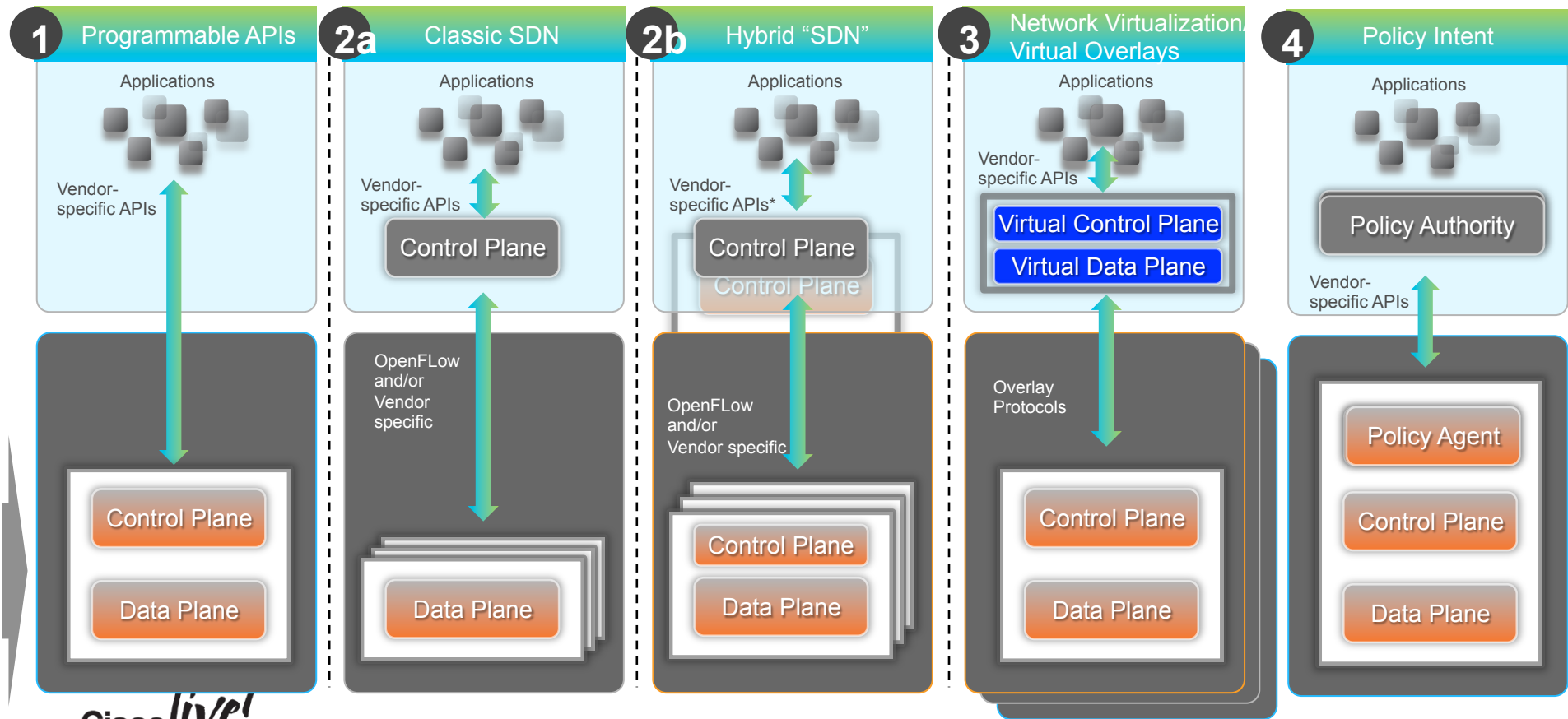
Network Management should follow Web Development





## 2. World of Controllers and Technologies

# Network Programmability Models



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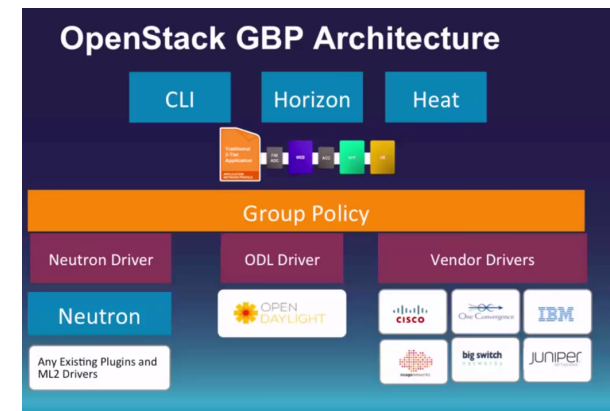


# SDN Controllers – Types

There's nothing like the SDN controller

- SDN **Config-Pusher**
  - Orchestration (robot micromanaging manual to-do's)
  - NCM (Network Configuration Management)
  - Customers may see or edit any part of the config
  - ✓ Prime Infrastructure, Action Packed, Solarwinds
  - ✓ Puppet, Chef
  - ✓ Openstack
  - ✓ Netconf
- SDN **Policy-Compiler**
  - Customer is never exposed to nor has access to nor influence over direct snippets of configuration elements.
  - They express their intent only – like in a programming language – and the conversion to machine language is invisible.
  - ✓ Cisco APIC-EM
- SDN **Policy-Enabler**
  - ✓ Cisco APIC-DC
- SDN **Overlay Controller**
  - ✓ VMWare: VCS, VCD, NSX
  - ✓ VSM (N1kv), EVP, VTS
  - ✓ Windows Server, Microsoft System Center)
- SDN **Open Flow Controller**
  - ✓ Primary for research

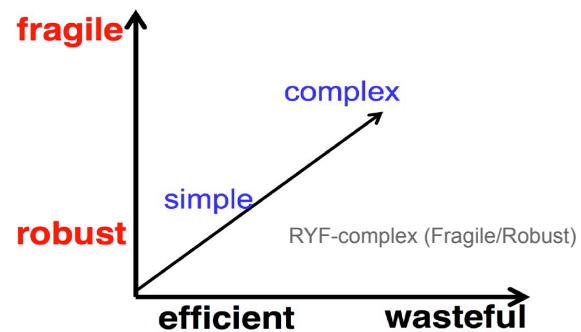
Group Based Policy / NIC





# SDN Controllers – Types

## Start with the End in Mind - the RYF-complex (Fragile/Robust)



Five dimensions of robustness in complex systems

- (1) Reliability
- (2) Efficiency
- (3) Scalability
- (4) Modularity
- (5) Evolvability

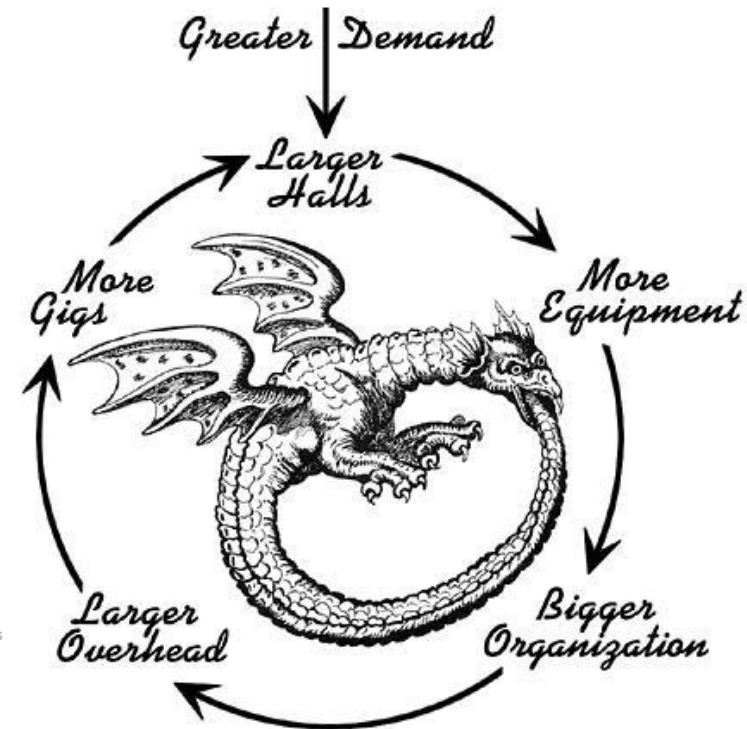
See J. Doyle, et. al.,  
"Robustness and the Internet:  
Theoretical Foundations"

Alderson and Doyle identify four kinds  
of constraints on system robustness:

- (1) Component-level
- (2) System-level
- (3) Protocols
- (4) Emergent constraints

Complex systems science as conflicting constraints  
John C. Doyle, HOT and SF networks

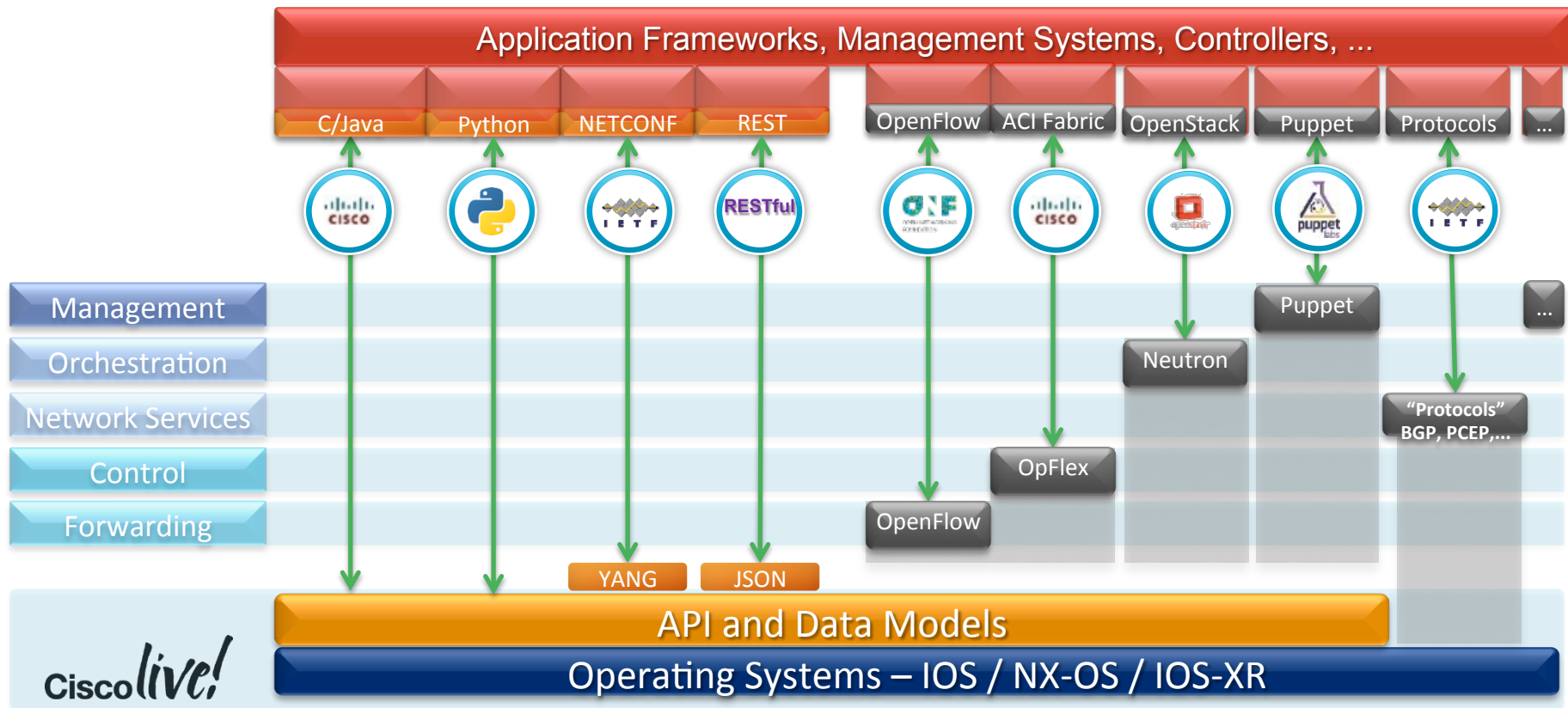
Grateful Dead Sources  
How the Dragon Uroboorus ([Giga Exponentia](#))  
Makes Us Go Round and Round



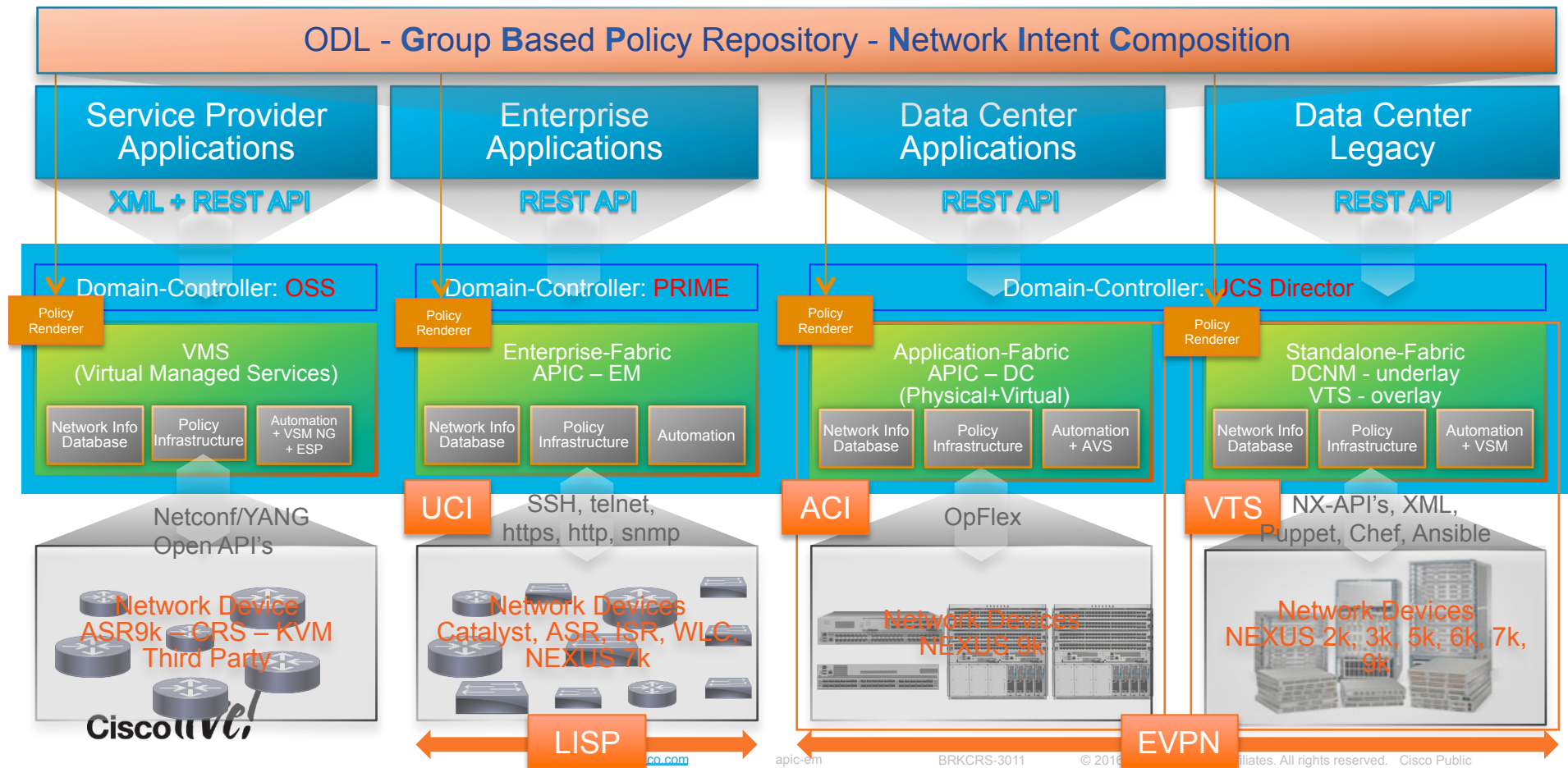
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# Device Programmability Options

No Single Answer!

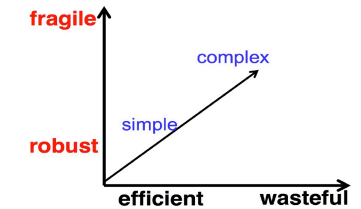


# Cross Domain Controller Architecture



# SDN Controller – Overview

OK that looks really ugly but wait a minute...



... all cars



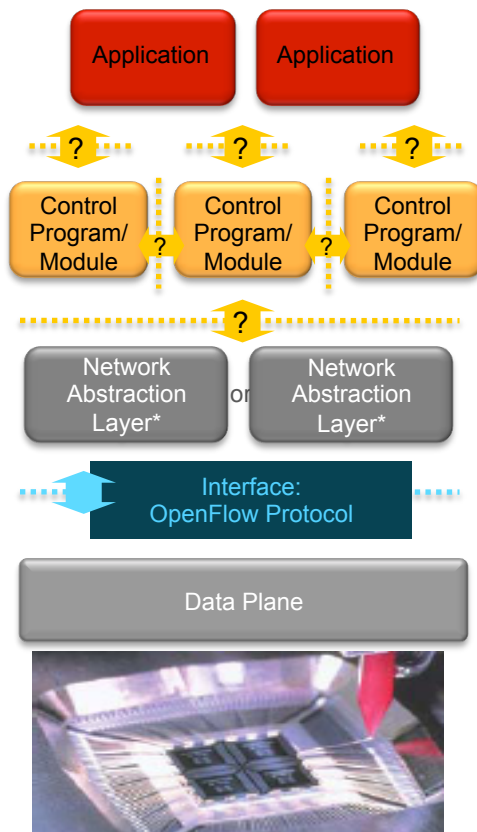
- Four wheels
- Steering wheel
- Gas pedal
- Brake pedal

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But complete  
different use-  
cases

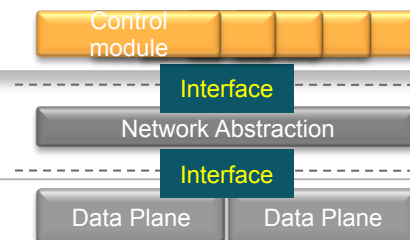
# 3. Controllers

# 3.1 OpenFlow - Stanford Clean Slate



# SDN

- Mandates a separation of control and data plane and an interface to it
- Higher level abstraction to store state information
- Classical networking relies on distributed state but *local* decision making
- SDN Networks is all about distributed state but *central* decision making
- Enabler to deal with the networks in a different way as we do today



# OF

- Separation of control plane and data plane on packet switched networks
- Allows for optimized placement of these components
- Low-level interaction set of changing the state of the network data plane via an switch API (similar to Broadcom, Fulcrum, Cisco ASIC API's)
- A Communications protocol which allows the SDN controller to manipulate flow tables with simple primitives of match/action operations
- Pro-active mode pretty much like CEF, Re-active mode similar to flow based switching
- Asynchronous reporting of statistics
- *OpenFlow* allows up to 12-tuple wildcard and/or exact match

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# SDN Controllers – Types



There's nothing like “a OpenFlow controller”

## SDN Open Flow Controller

- ✓ [NOX](#) (C++/Python) NOX was the first OpenFlow controller.
- ✓ [POX](#) (Python) Pox as a general SDN controller that supports OpenFlow. It has a high-level SDN API including a queriable topology graph and support for virtualization.
- ✓ [Jaxon](#) (Java) Jaxon is a NOX-dependent Java-based OpenFlow Controller.
- ✓ [Trema](#) (C/Ruby) Trema is a full-stack framework for developing OpenFlow controllers in Ruby and C.
- ✓ [Beacon](#) (Java) Beacon is a Java-based controller that supports both event-based and threaded operation.
- ✓ [Floodlight](#) (Java) The Floodlight controller is Java-based OpenFlow Controller. It was forked from the Beacon controller, originally developed by David Erickson at Stanford.
- ✓ [Maestro](#) (Java) Maestro is an OpenFlow "operating system" for orchestrating network control applications.
- ✓ [NDDI - OESS](#) OESS is an application to configure and control OpenFlow Enabled switches through a very simple and user friendly User Interface.
- ✓ [Ryu](#) (Python) Ryu is an open-sourced Network Operating System (NOS) that supports OpenFlow.
- ✓ [NodeFlow](#) (JavaScript) NodeFlow is an OpenFlow controller written in pure JavaScript for Node.JS.
- ✓ [ovs-controller](#) (C) Trivial reference controller packaged with Open vSwitch.
- ✓ [RouteFlow](#) RouteFlow, is an open source project to provide virtualized IP routing services over OpenFlow enabled hardware. RouteFlow is composed by an OpenFlow Controller application, an independent RouteFlow Server, and a virtual network environment that reproduces the connectivity of a physical infrastructure and runs IP routing engines (e.g. Quagga).
- ✓ [Flowvisor](#) (Java) FlowVisor is a special purpose OpenFlow controller that acts as a transparent proxy between OpenFlow switches and multiple OpenFlow controllers.
- ✓ [SNAC](#) (C++) SNAC is an OpenFlow controller built on NOX, which uses a web-based policy manager to manage the network.
- ✓ [Resonance](#) Resonance is a Network Access Control application built using NOX and OpenFlow.
- ✓ [Oflops](#) (C) OFlops (OpenFlow Operations Per Second) is a standalone controller that benchmarks various aspects of an OpenFlow switch.
- ✓ [RouteFlow](#) RouteFlow, is an open source project to provide virtualized IP routing services over OpenFlow enabled hardware. RouteFlow is composed by an OpenFlow Controller application, an independent RouteFlow Server, and a virtual network environment that reproduces the connectivity of a physical infrastructure and runs IP routing engines (e.g. Quagga).
- ✓ [Flowvisor](#) (Java) FlowVisor is a special purpose OpenFlow controller that acts as a transparent proxy between OpenFlow switches and multiple OpenFlow controllers.
- ✓ [XNC](#) Cisco Extensible Network Controller (XNC) is the first commercial version of the [OpenDaylight](#) controller
- ✓ [ODL](#) Linux-Foundation: community-driven, open source controller framework (Brocade, Cisco, Citrix, Ericsson, IBM, Juniper, Microsoft, RedHat)





# SDN Controllers – Types

## comparison of open source controllers



Controllers	Trema	Nox/Pox	RYU	Floodlight	ODL	ONOS***
Use-Cases						
Network Virtualization by Virtual Overlays	YES	YES	YES	PARTIAL	YES	NO
Hop-by-hop Network Virtualization	NO	NO	NO	YES	YES	YES
OpenStack Neutron Support	NO	NO	YES	YES	YES	NO
Legacy Network Interoperability	NO	NO	NO	NO	YES	PARTIAL
Service Insertion and Chaining	NO	NO	PARTIAL	NO	YES	PARTIAL
Network Monitoring	PARTIAL	PARTIAL	YES	YES	YES	YES
Policy Enforcement	NO	NO	NO	PARTIAL	YES	PARTIAL
Load Balancing	NO	NO	NO	NO	YES	NO
Traffic Engineering	PARTIAL	PARTIAL	PARTIAL	PARTIAL	YES	PARTIAL
Dynamic Network Taps	NO	NO	YES	YES	YES	NO
Multi-Layer Network Optimization	NO	NO	NO	NO	PARTIAL	PARTIAL
Transport Networks - NV, Traffic-Rerouting, Interconnecting DCs, etc.	NO	NO	PARTIAL	NO	PARTIAL	PARTIAL
Campus Networks	PARTIAL	PARTIAL	PARTIAL	PARTIAL	PARTIAL	NO
Routing	YES	NO	YES	YES	YES	YES



### [SDN Series Part Eight: Comparison Of Open Source SDN Controllers](#)

## 3.2 APIC-DC

(Application Policy Infrastructure  
Controller for the Datacenter)

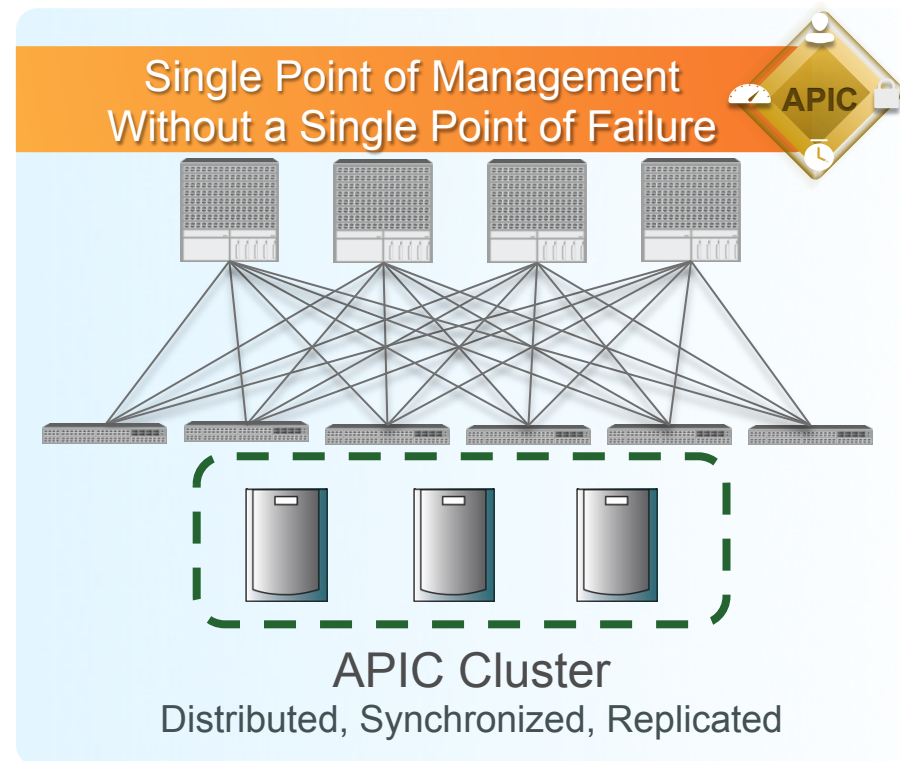
# Cisco ACI: Full Stack SDN in Data Center

## Centralized Automation and Fabric Management

ACI = CONTROLLER + POLICY MODEL+  
NEXUS 9k

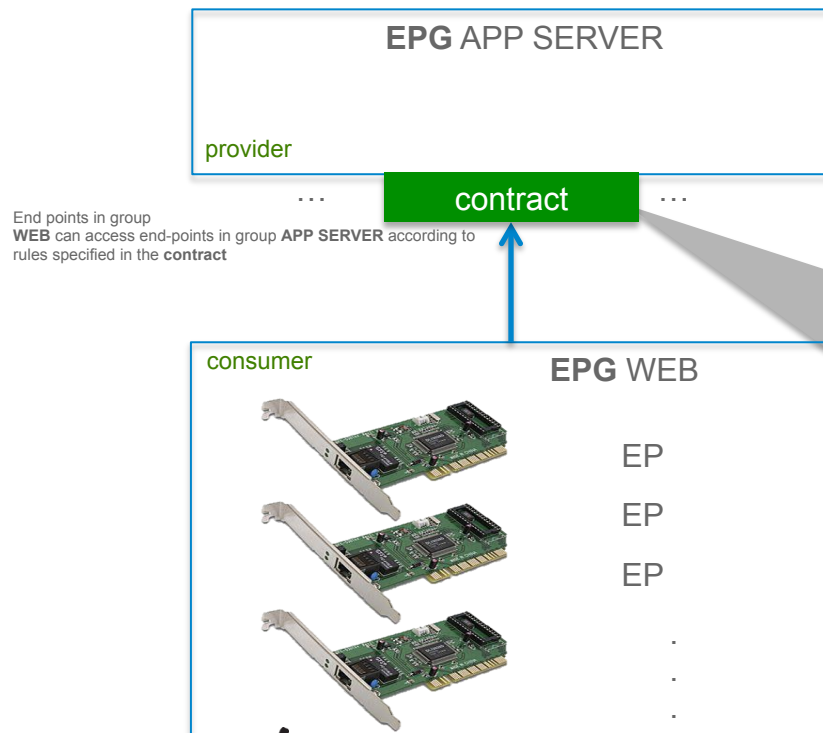
- Turnkey integrated solution with security, centralized management, compliance and scale
- L4-L7 Service Graph
- Automated application centric-policy model with embedded security
- Simplify provisioning, operating through relational object-model
- Fully programmable (REST API, Python bindings)
- Broad and deep ecosystem

**Cisco**live!

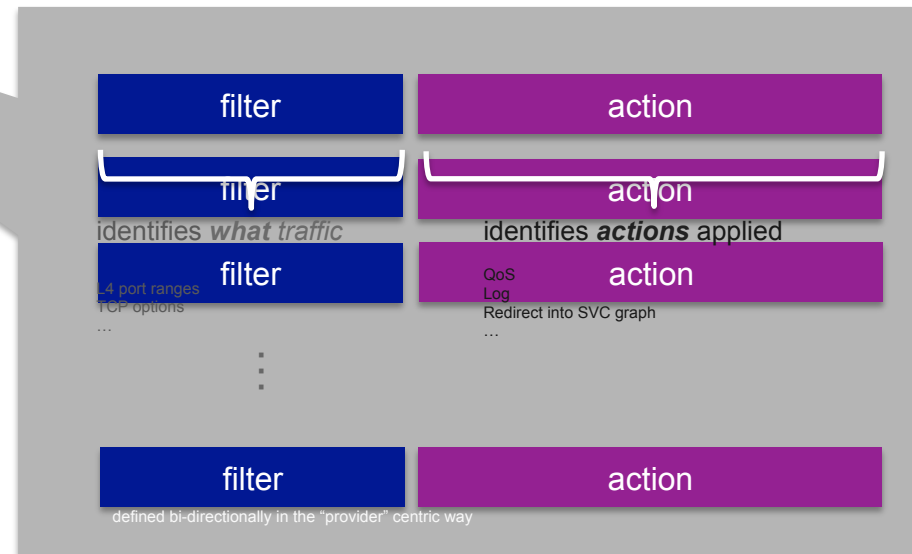


# What is APIC-DC

End Point → End Points Groups → Contracts



Contract specifies rules and policies on groups of **physical** or **virtual** end-points without understanding of specific identifiers and **regardless** of physical **location**.

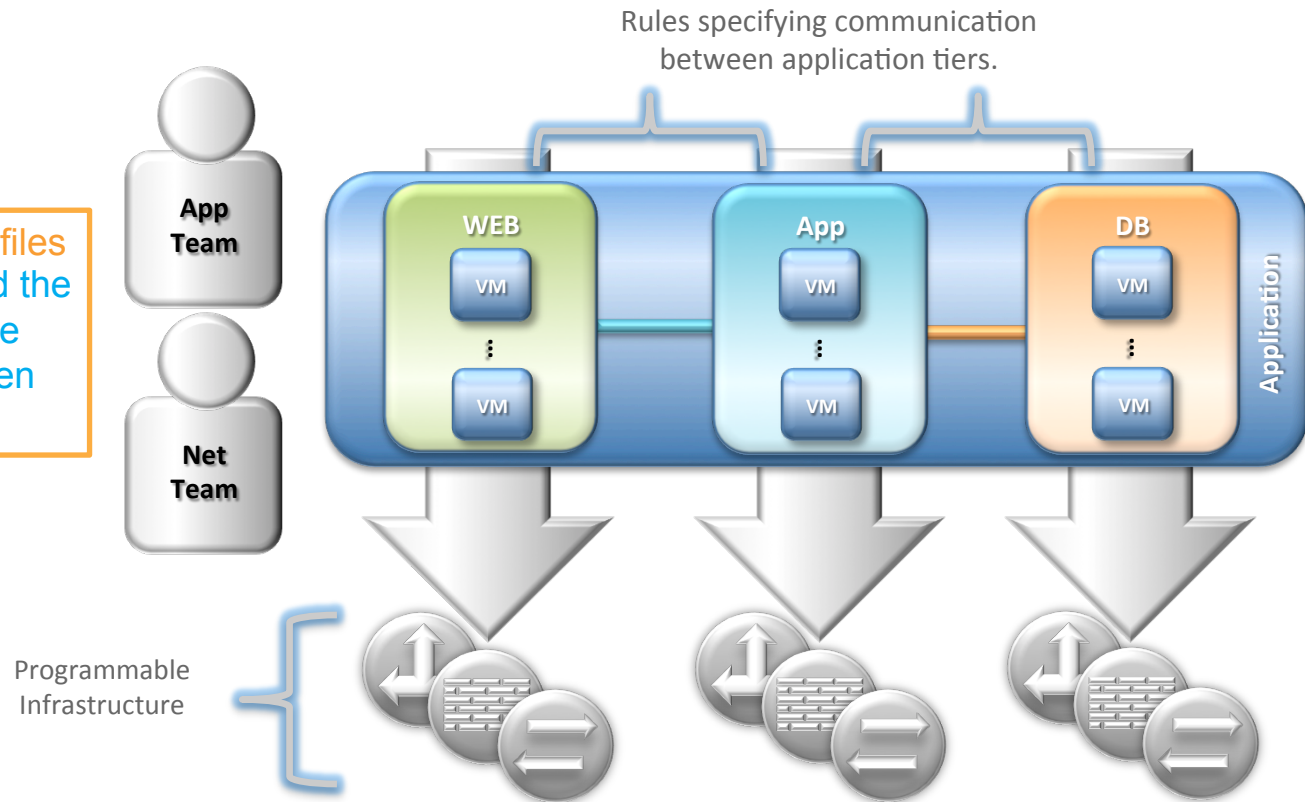


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# Application Network Profiles

## Applying Contracts between Application Tiers

Application Network Profiles are a group of EPGs and the policies that define the communication between them.



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# Cisco APIC Provides Full FCAPS

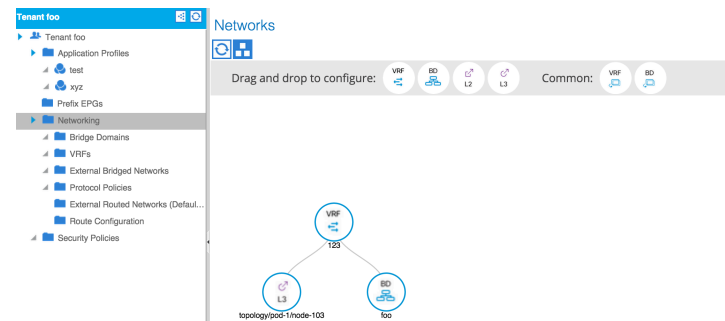
*fault, configuration, accounting, performance, security*

## Troubleshooting Wizards

## Capacity Dashboard



## Drag and Drop Configuration



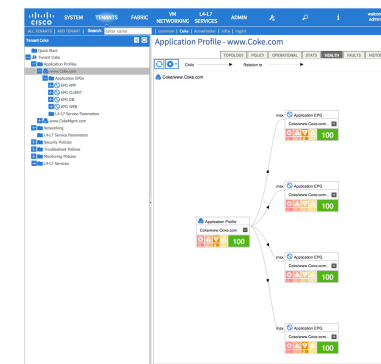
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apic-em

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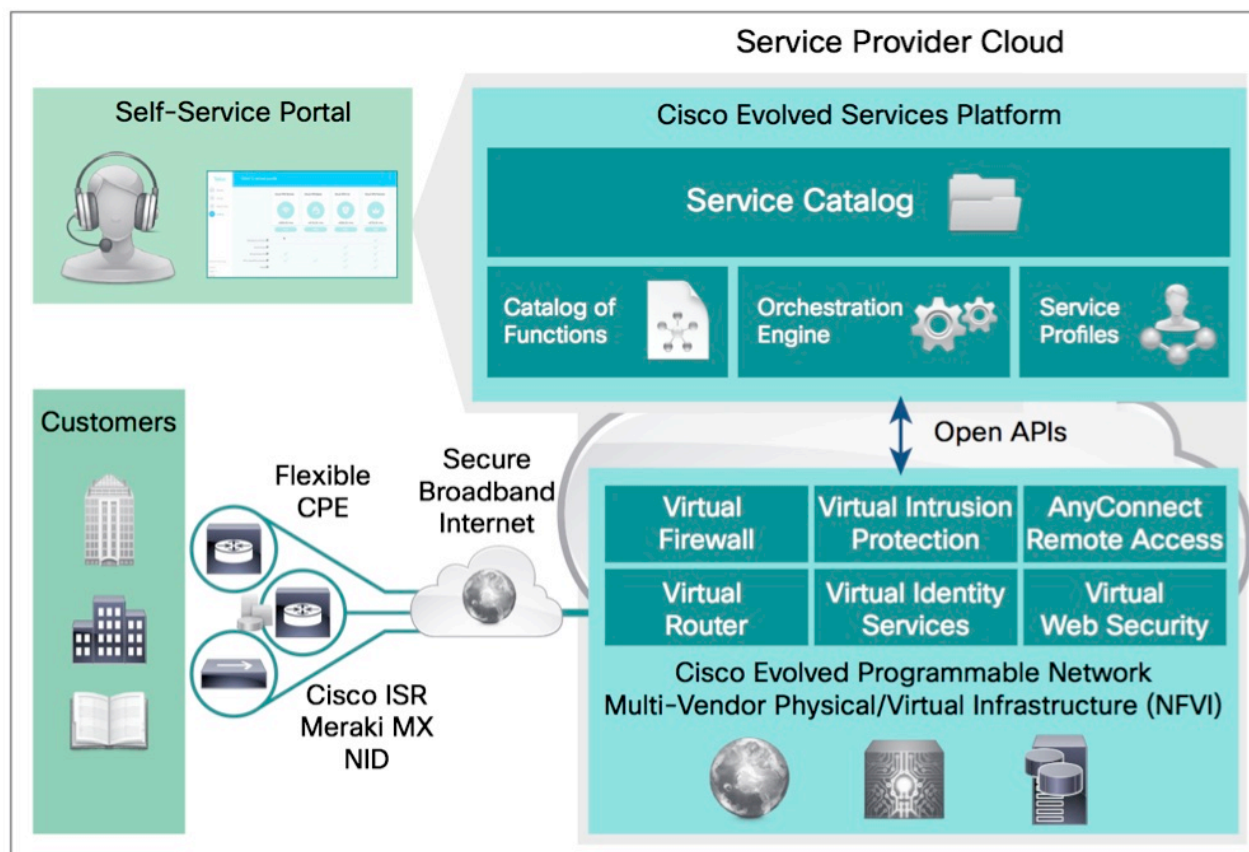
## App Health Score



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# 3.3 Virtual Managed Services (aka Mozart – ESP – DSC - VMS)

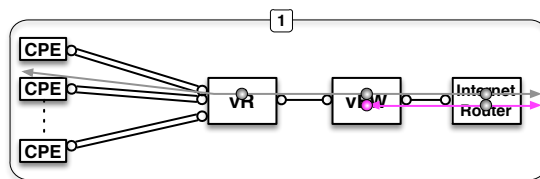
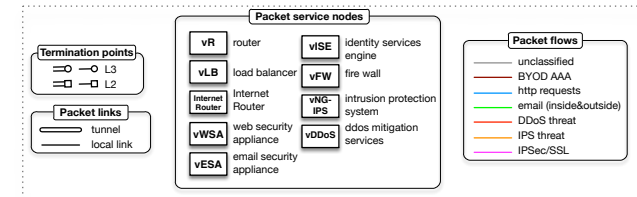
# Cisco Virtual Managed Services (VMS)



Cisco *live!*



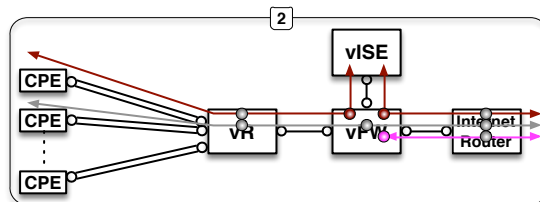
# Flexible Service Chains



**1**

**vIPVPN with FW and RA**

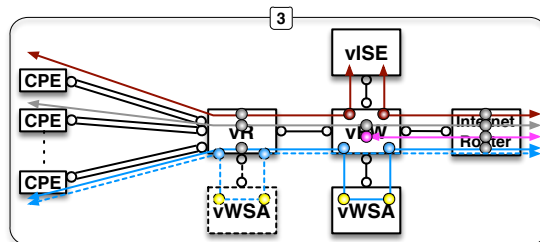
- vFW with NAT and FW policy.
- vFW with IPSec/SSL Remote Access (RA) incl. remote end-host security posture verification.



**2**

**vIPVPN with BYOD, FW and RA**

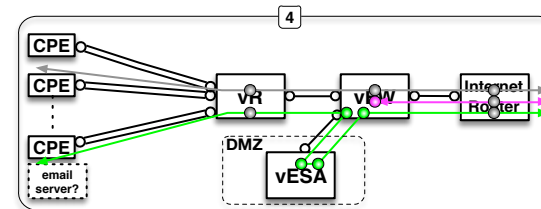
- vFW with NAT and FW policy.
- vFW with IPSec/SSL remote access incl. remote end-host security posture verification.
- vISE for BYOD svc auth (AAA, trust-sec label to IP binding)



**3**

**vIPVPN with BYOD, FW, RA, WebSec**

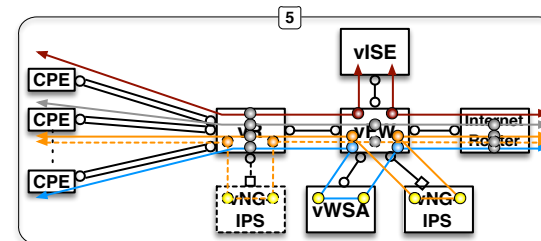
- vFW with NAT and FW policy.
- vFW with IPSec/SSL remote access incl. remote end-host security posture verification.
- vISE for BYOD svc auth (AAA, trust-sec label to IP binding)
- vWSA for Enhanced Web Security



**4**

**vIPVPN with BYOD, FW, RA, EmailSec**

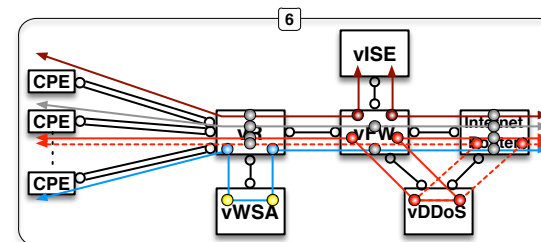
- vFW with NAT and FW policy.
- vFW with IPSec/SSL remote access incl. remote end-host security posture verification.
- vESA for Critical Information Protection (inbound and outbound Emails)



**5**

**vIPVPN with BYOD, FW, RA, WebSec, nglIPS**

- vFW with NAT and FW policy.
- vFW with IPSec/SSL remote access incl. remote end-host security posture verification.
- vISE for BYOD svc auth (AAA, trust-sec label to IP binding)
- vWSA for Enhanced Web Security
- vNG-IPS (SourceFire) for advanced threat protection and real-time contextual awareness



**6**

**vIPVPN with BYOD, FW, RA, WebSec, DDoS**

- vFW with NAT and FW policy.
- vFW with IPSec/SSL remote access incl. remote end-host security posture verification.
- vISE for BYOD svc auth (AAA, trust-sec label to IP binding)
- vWSA for Enhanced Web Security
- vDDoS (Radware DefensePro) for volumetric and application DDoS visibility and mitigation services

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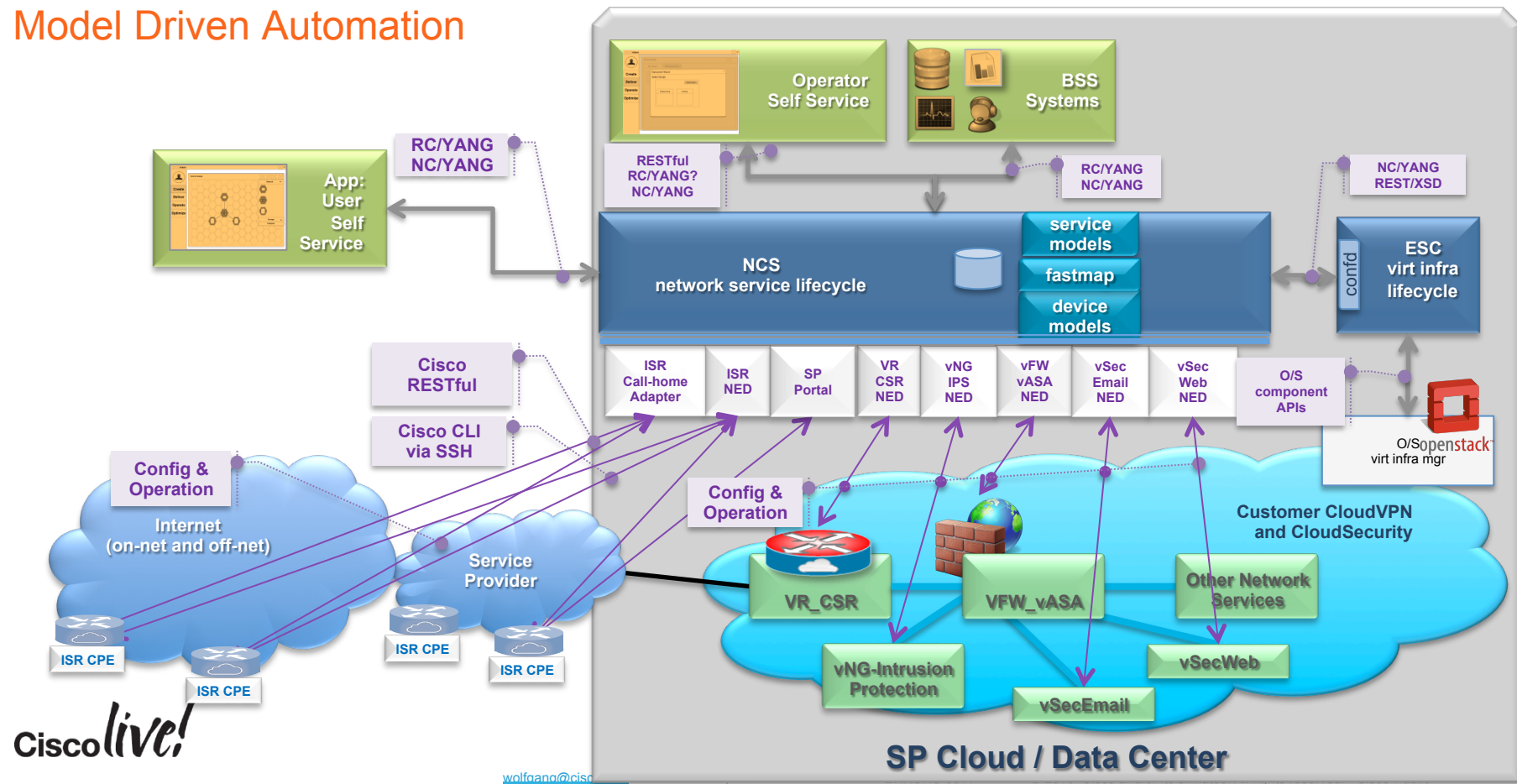
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# Cisco VMS Service Delivery Workflow

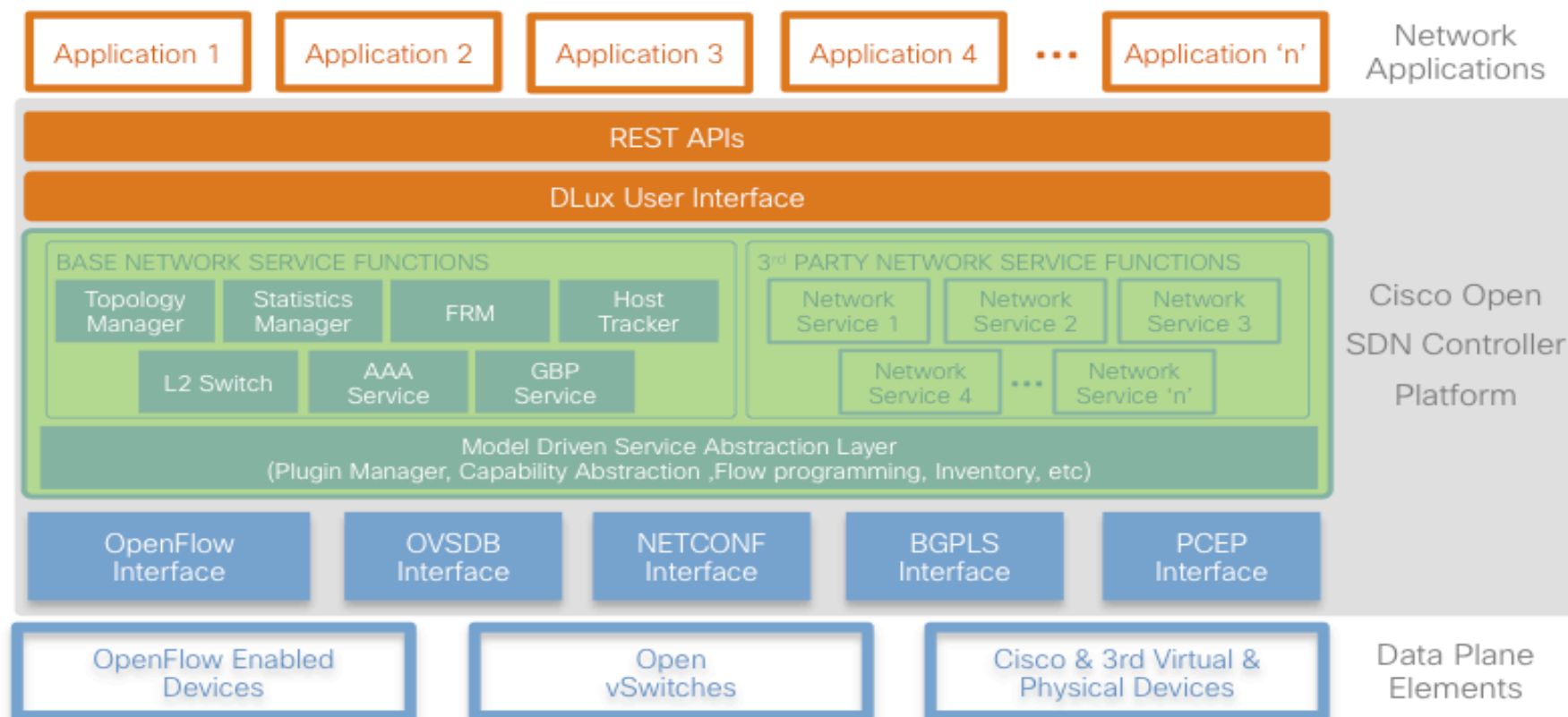
## Model Driven Automation



# 3.4 OSC - Open SDN Controller



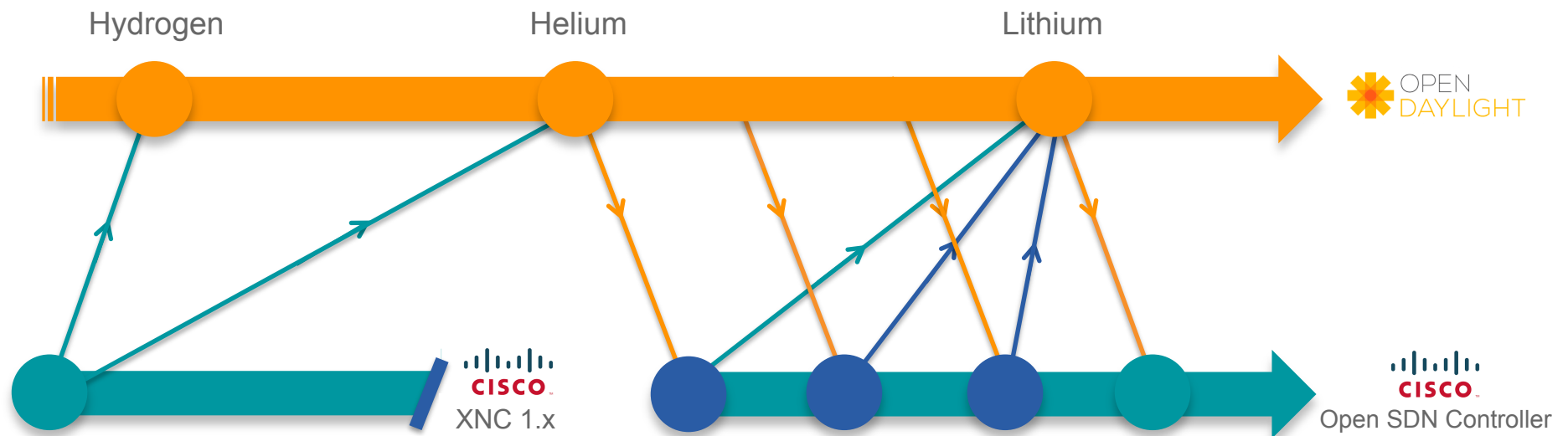
# CISCO - Open SDN Controller



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# CISCO - Open SDN Controller

## Re-bases XNC on OpenDaylight Helium Release



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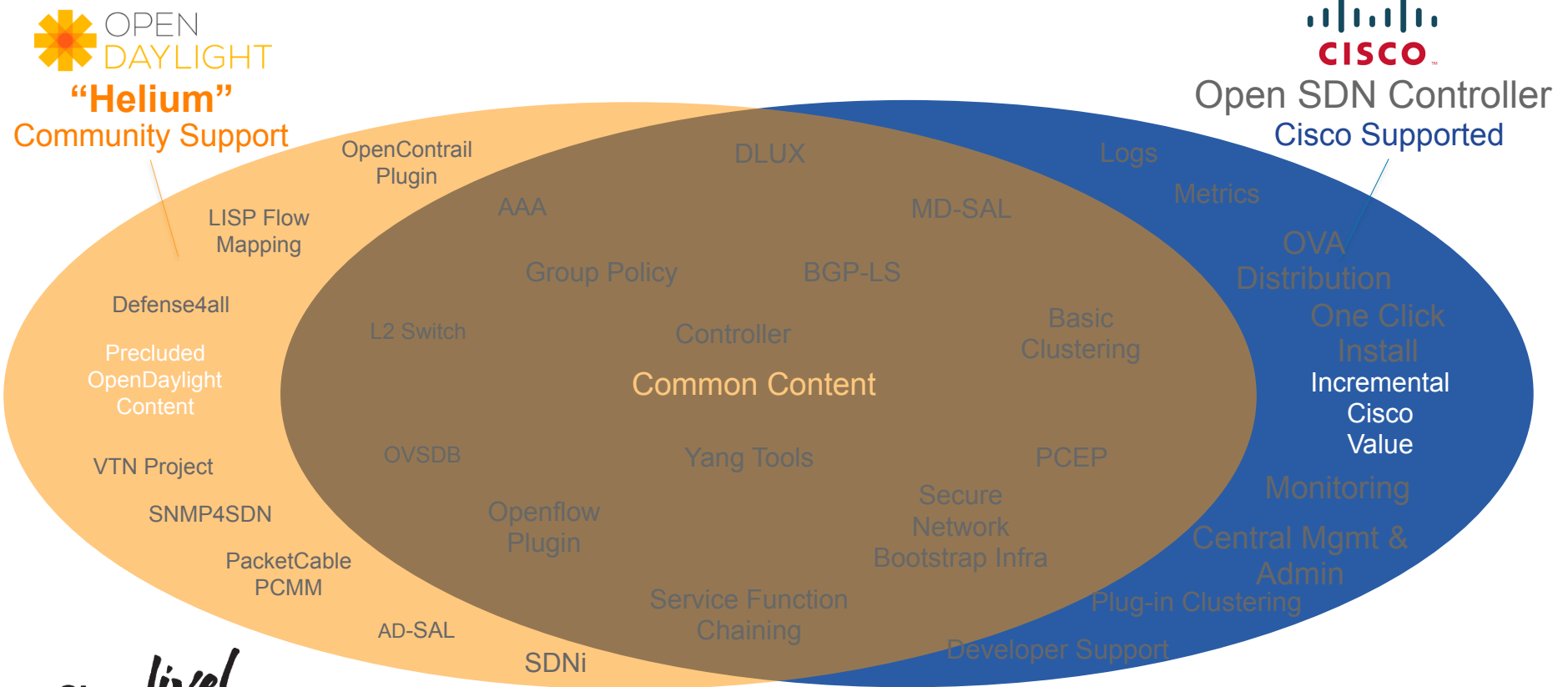
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# CISCO - Open SDN Controller

## Open SDN Controller vs OpenDaylight Helium



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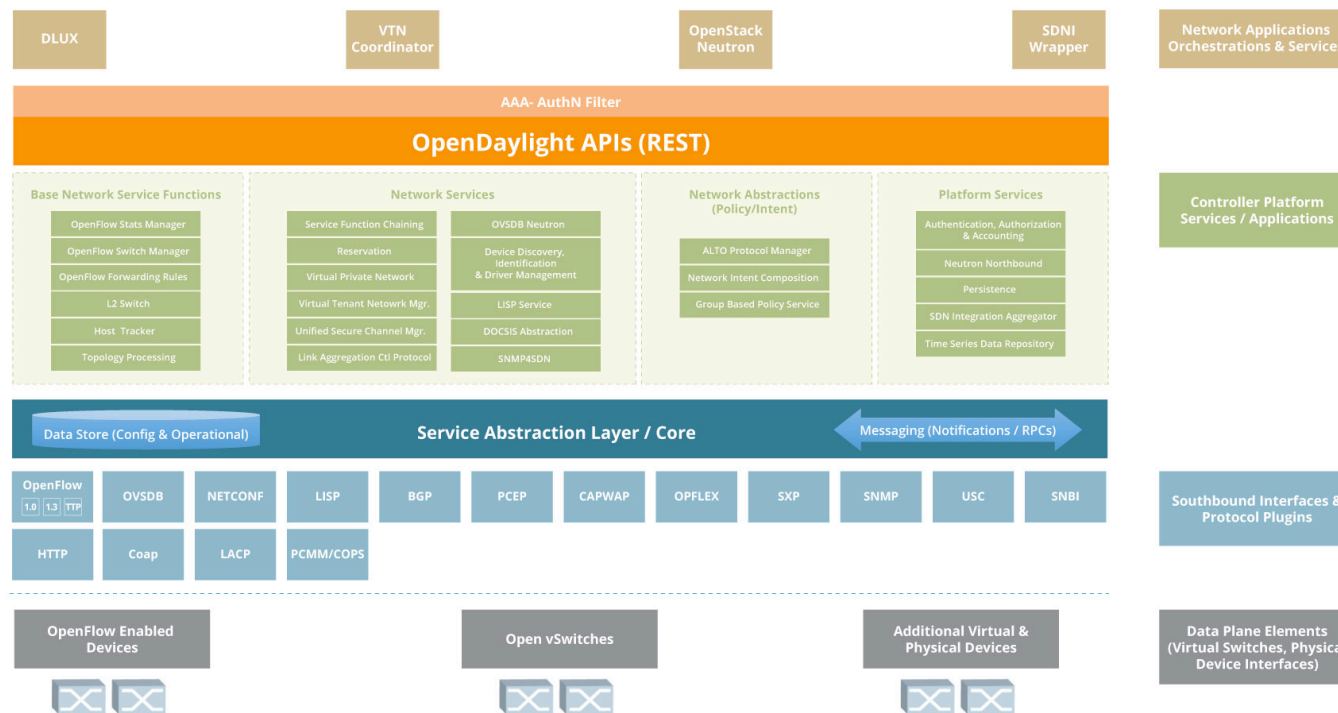
## 3.5 ODL- Open Day Light Controller



# OpenDaylight Platform



Open Source SDN Platform  
Lithium, 3rd Release, June 2015



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## Hydrogen

- Released February 2014

## Helium

- Released October 2014
- 1.87M+ lines of code
- 28 Projects
- 256 Contributors

## Lithium

- [Lithium-SR3](#)  
December 3, 2015

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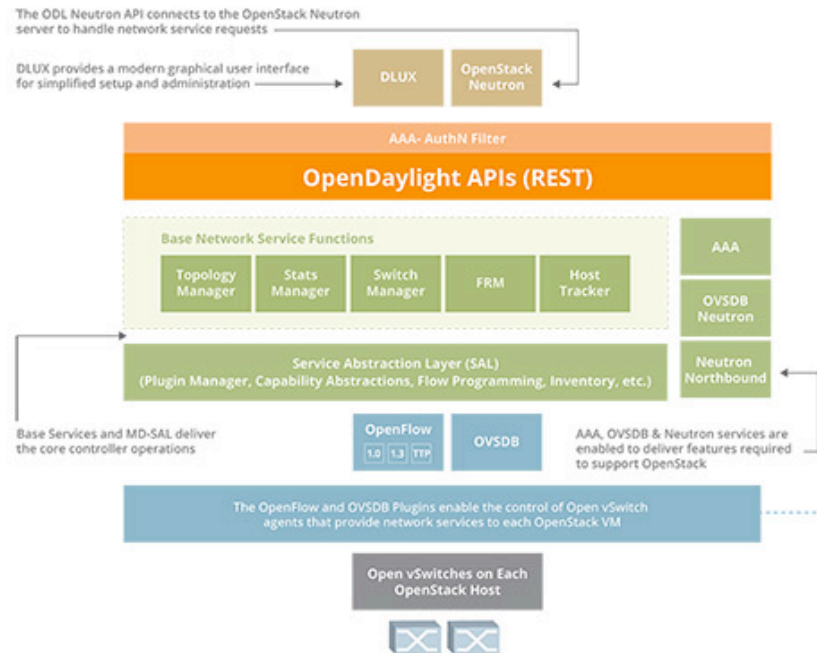
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# OpenDaylight Platform



**"Lithium"**  
Example OpenStack Use Case



Additional Services that could be added on to base use case:

LISP Service	GBP Service	DOCSIS Abstraction	Reservation	VPN	Persistence
LACP	SFC	L2 Switch	SDNI Aggregator	DIDM	TOPO Processing
USC Mgr.	VTN Manager	NIC	TSDR		

Additional plugins that base use case could be extended to:

CAPWAP	CoAP	NETCONF	PCMM/COPS	USC
HTTP	SNMP	SXP	ALTO	OPFLEX
PCEP	SNBI	LISP	BGP	

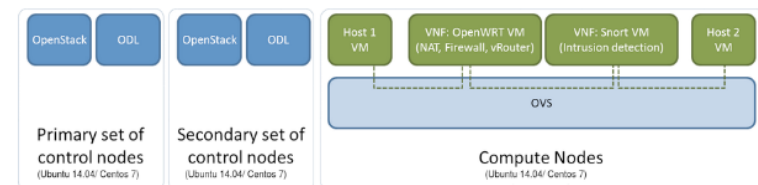
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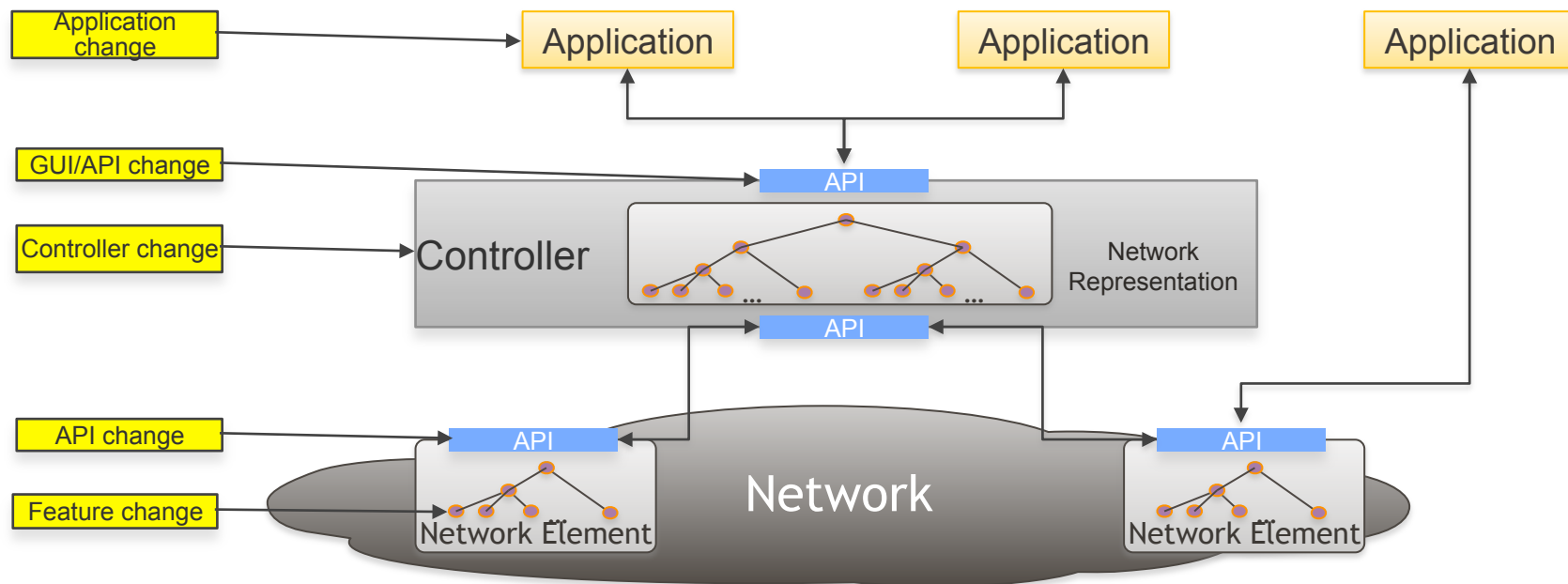
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# Network Application Life Cycle (Today)

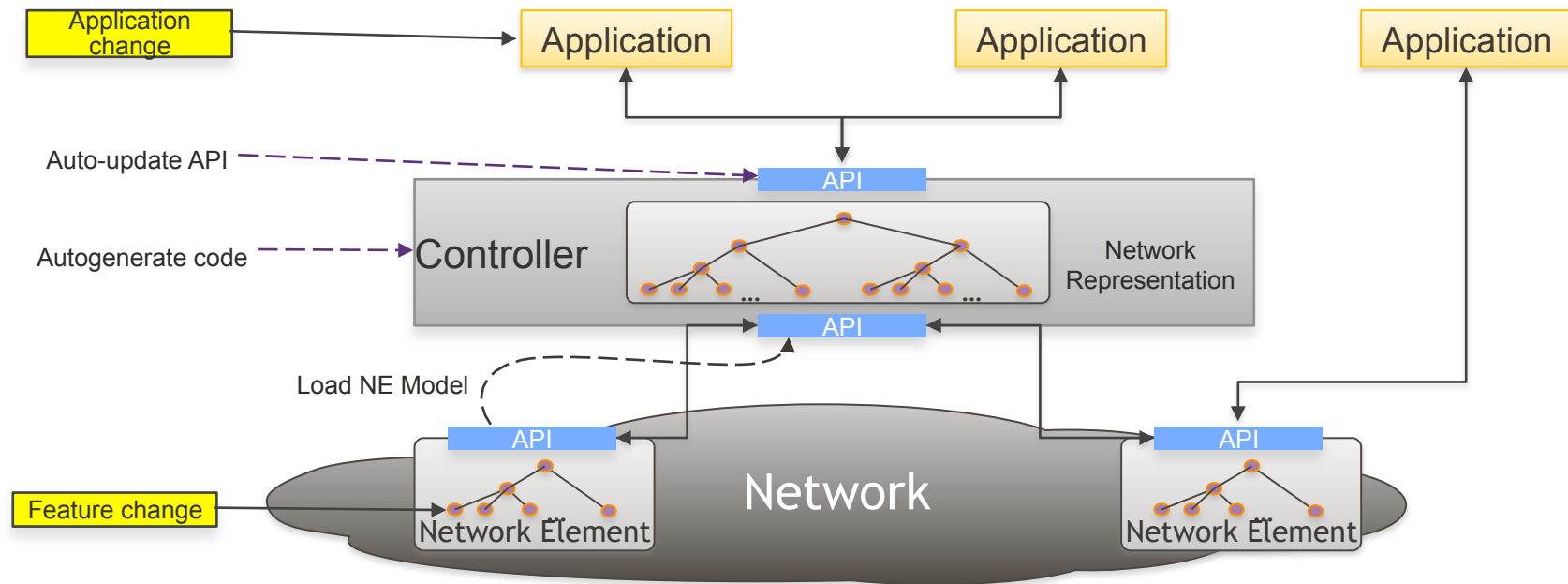
## Hop-by-Hop API-Driven Architecture



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# Network Application Life Cycle (Tomorrow)

## End-to-End Model-Driven Architecture



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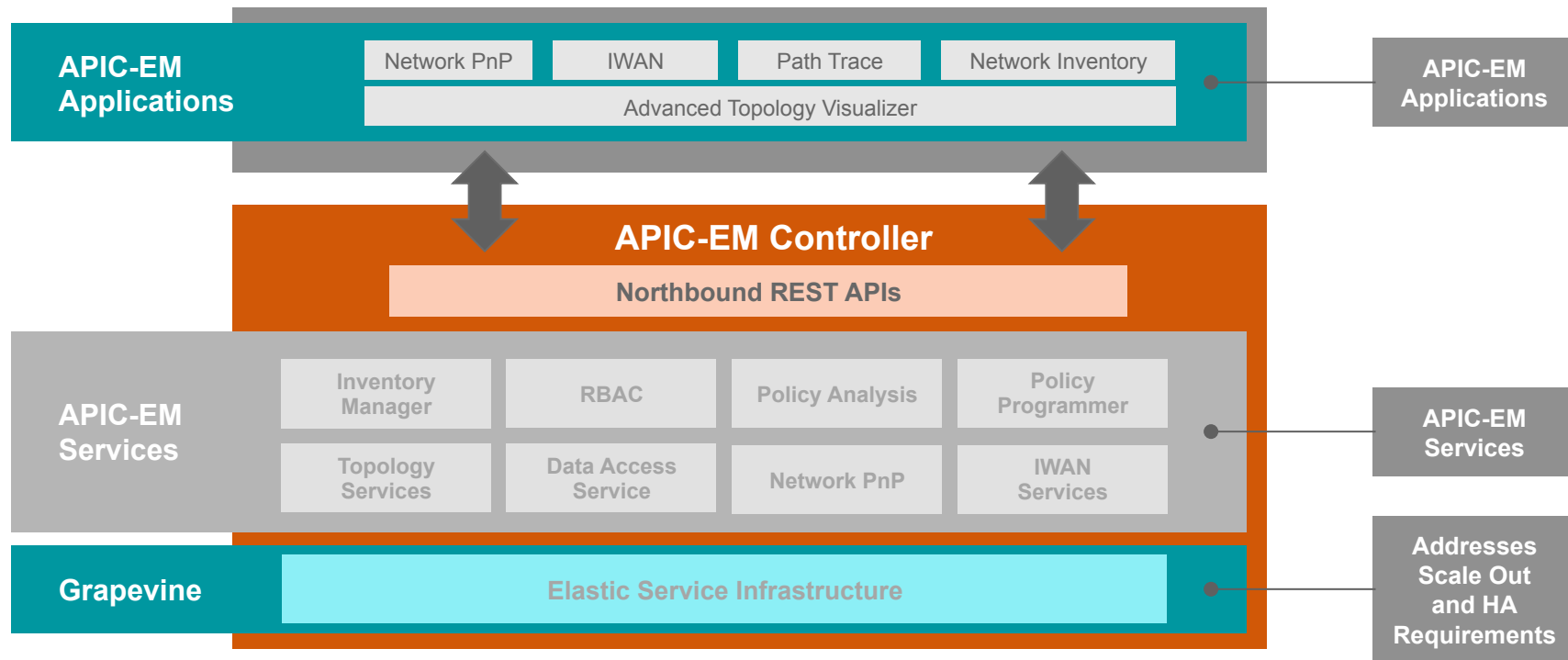
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## 3.6 APIC-EM

# APIC-EM

## Platform Architecture



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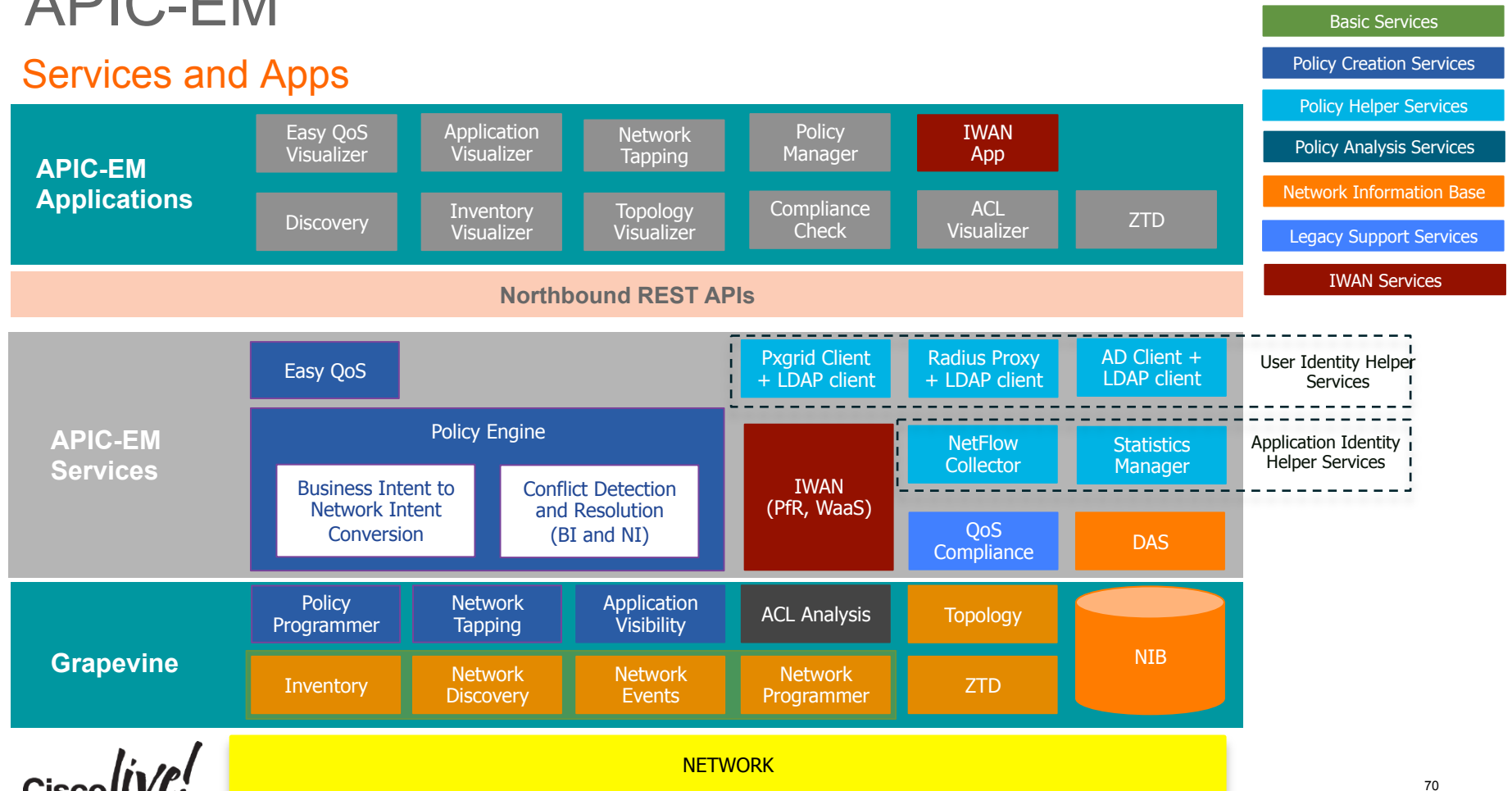
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# APIC-EM

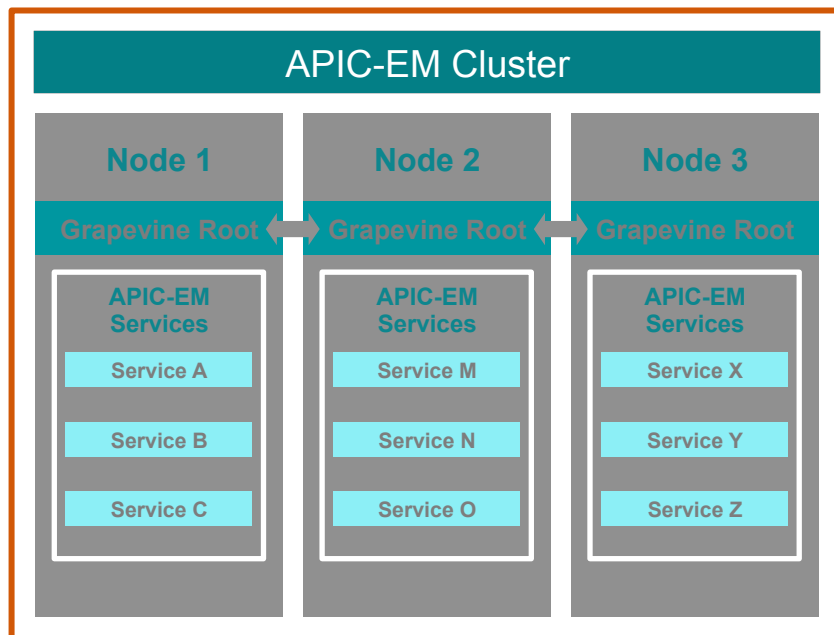
## Services and Apps



# APIC-EM

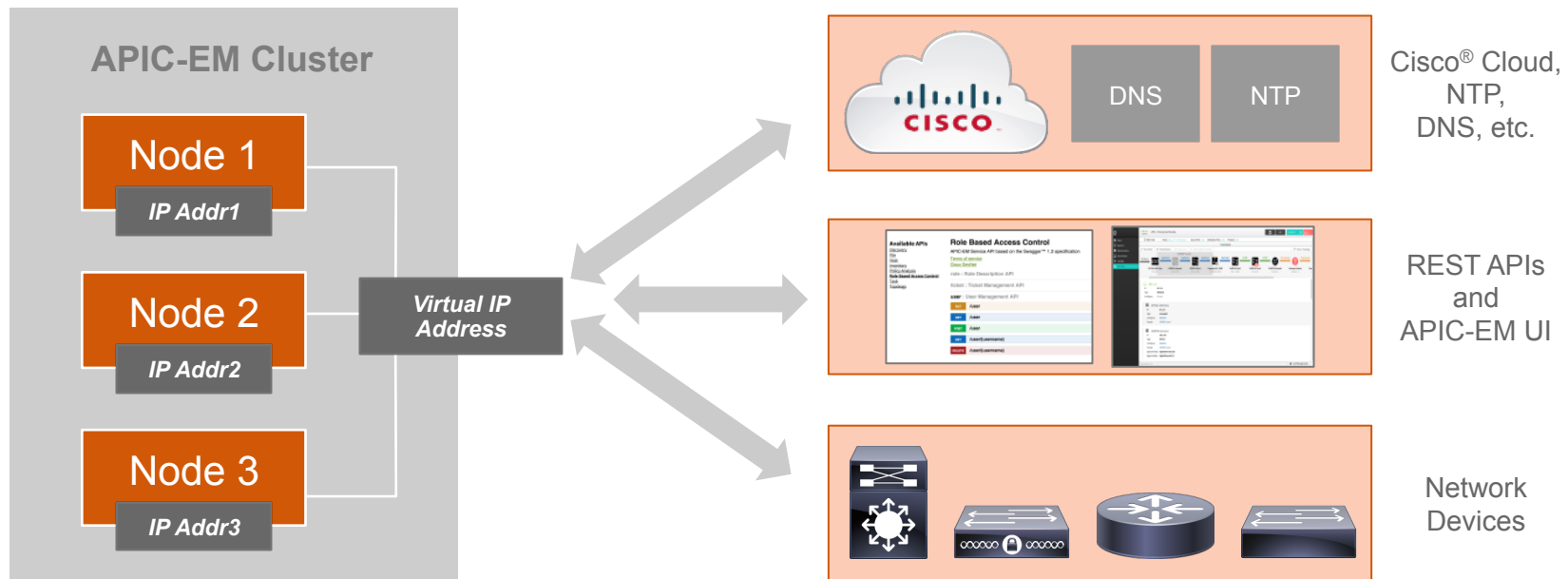
## High-Availability (HA) Design

- Multiple instances of the GV root across different physical hosts and operating in **Active-Active** mode for optimal performance, load-sharing, and high availability
- Data persistence layer that has instances spread across different physical nodes; provides support for HA and scale
- Non-HA deployment (single/dual hosts):
  - Supports SW failure (APIC-EM services)
  - No support for HW (host) failure
- HA deployment (3 hosts):
  - Supports SW failure (APIC-EM services)
  - Supports HW failure of single host



# APIC-EM

## Multi-Host Deployment



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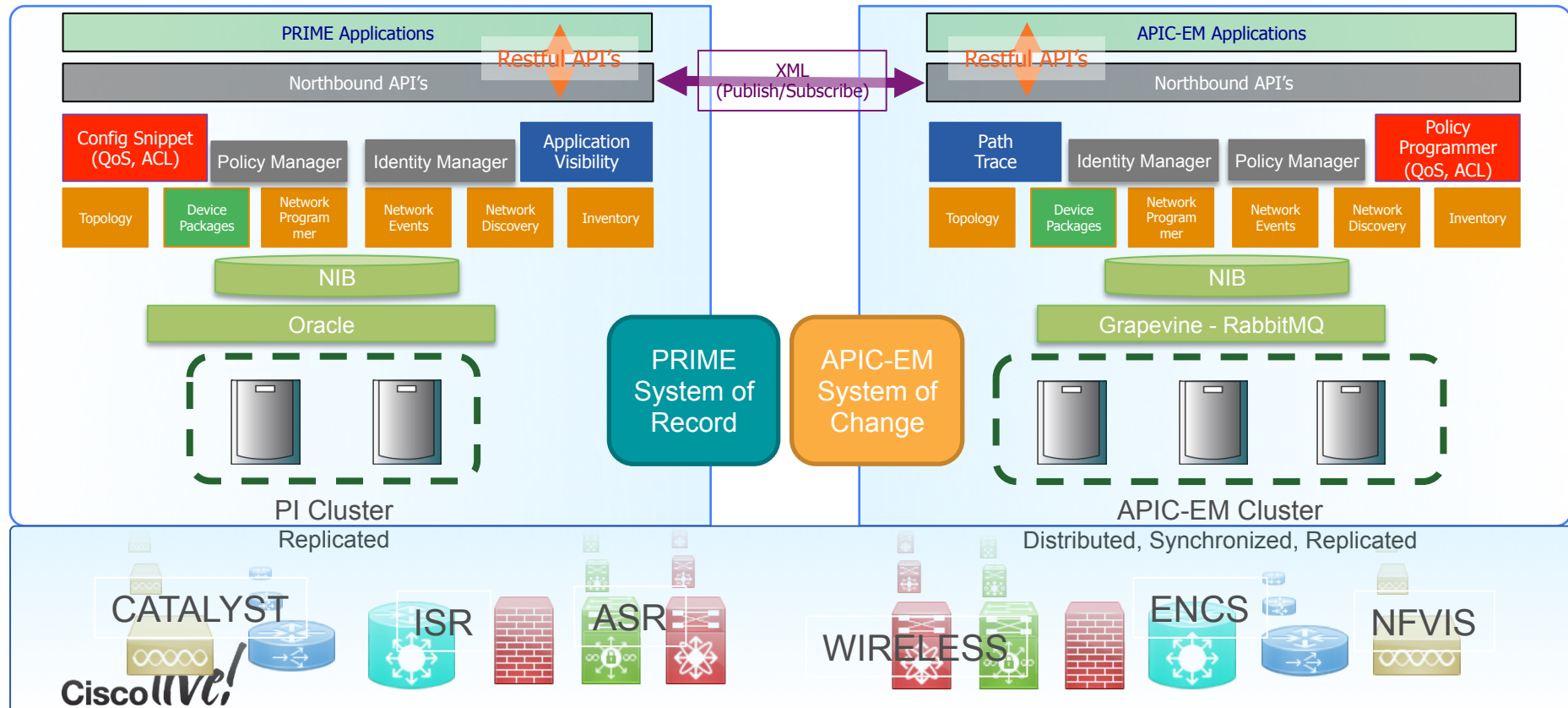
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## 3.7 PI and APIC-EM

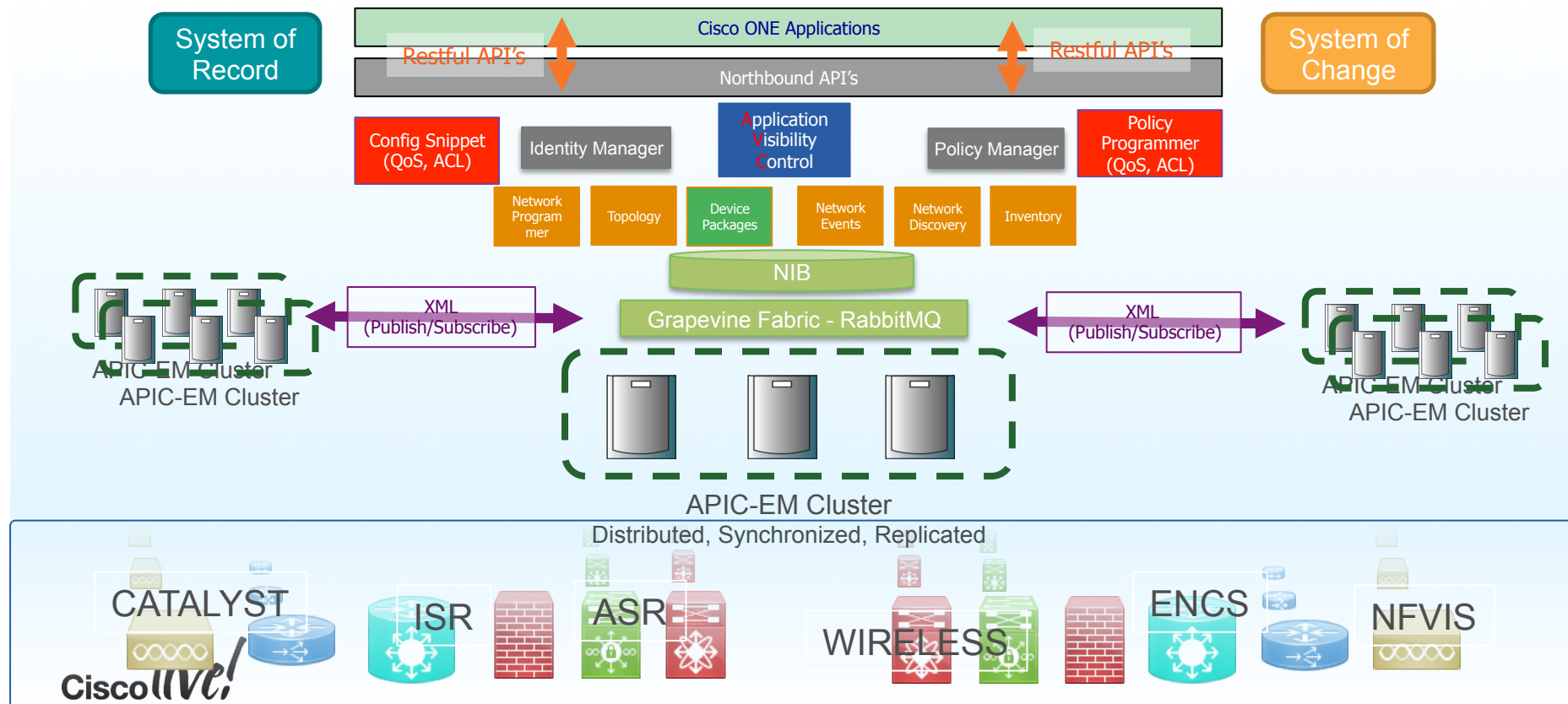
# Prime Infrastructure and APIC-EM - Today

## East-West API and Work Flow Integration



# Prime Infrastructure and APIC-EM - Tomorrow

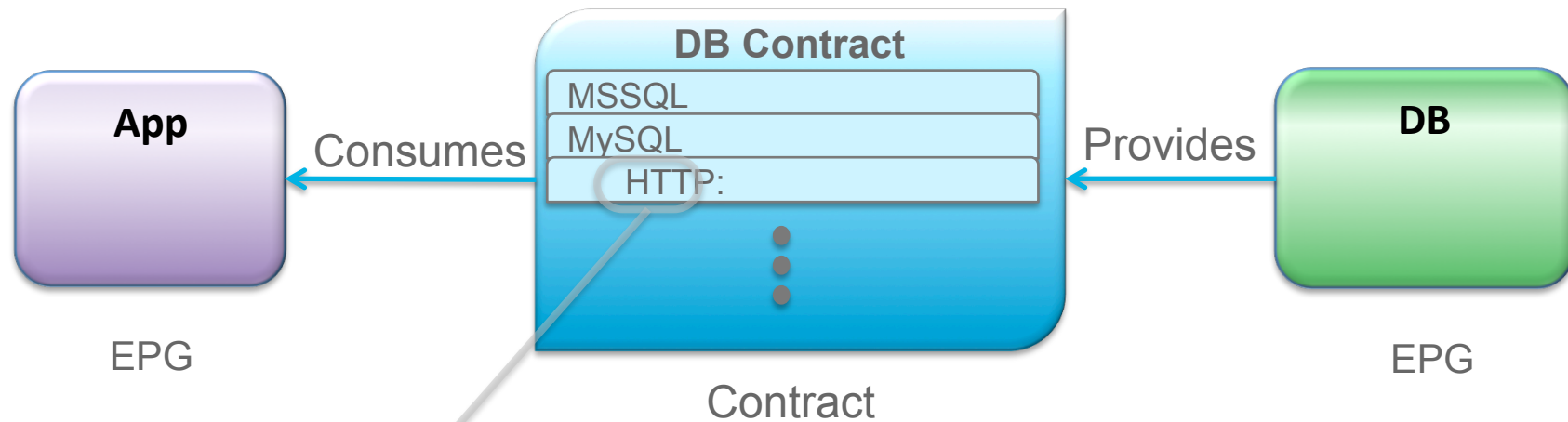
Wolfgang's view: Common Services with Common northbound App's and API's



## 4.1 APIC-EM - Policy Infrastructure

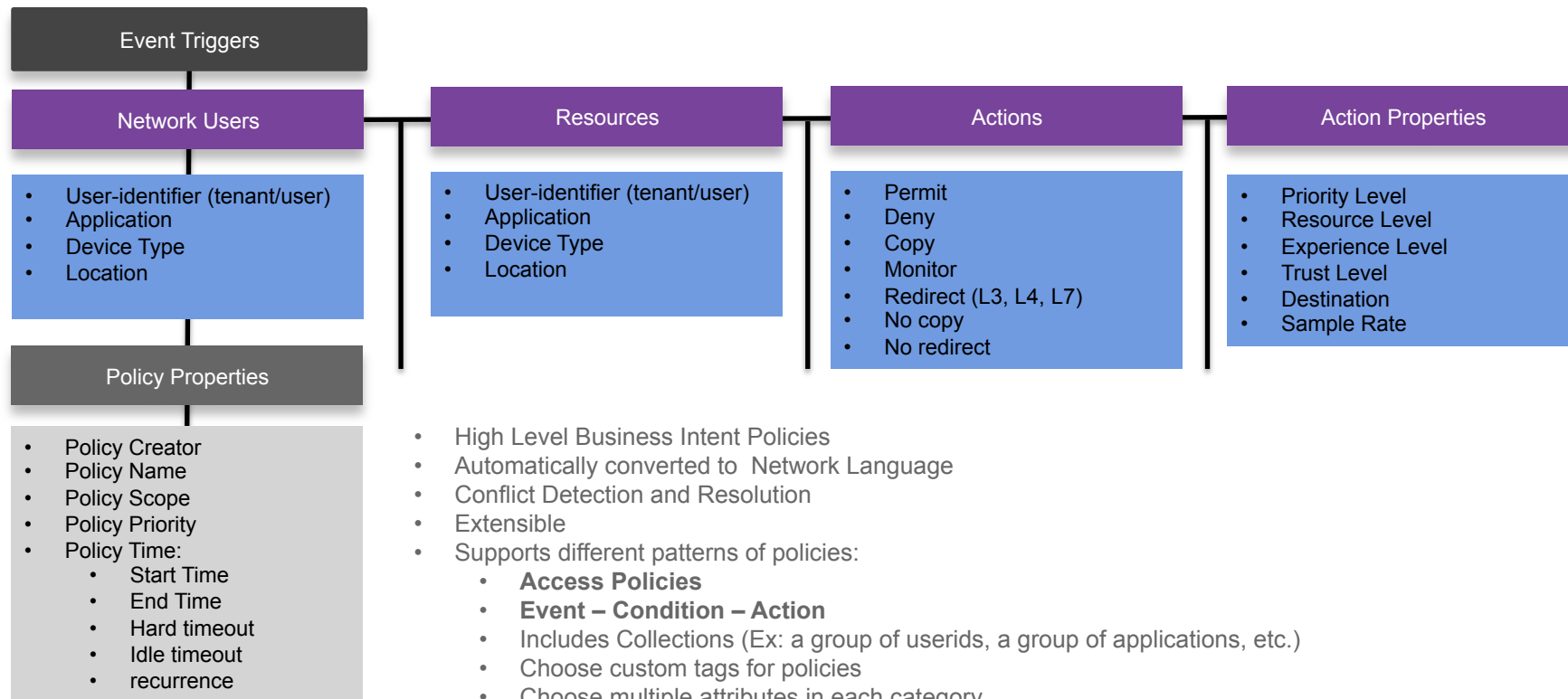
# APIC-DC Policy Model

## Recap: EPGs and Contract



ACI Model will be extended for  
APIC EM Utilization

# APIC-EM Policy Construct



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# APIC-EM

## Extensions for Enterprise use cases

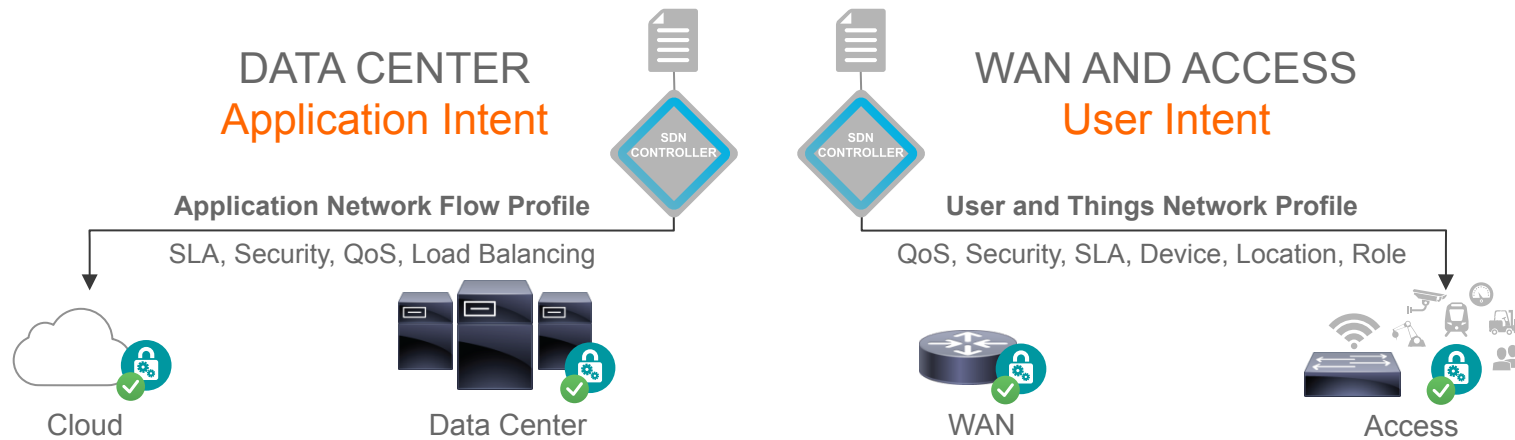
- Accommodation for Groups
  - ✓ Every EP is part of multiple groups in real-life
  - ✓ Groups are sometimes overlapping
  - ✓ Groups could be defined from multiple context-attributes
- Finer grain access
  - ✓ involves combination of consumer EP attributes and producer EP
  - ✓ implies overlapping rules. Resolution TBD
- Contract extensions
  - ✓ Need to extend contracts to include DPI-based application/groups.
  - ✓ Need rich set of actions such as Permit, Monitor, Permit with Warning, etc.
  - ✓ Actions include additional rule profiles such as: IPS-profile, File-filter-profile, QOS-profile etc.
- Question about implicit deny:
  - ✓ explicit 'permit' action
  - ✓ explicit 'deny' action



# APIC-EM

## Common Policy Model from Branch to Data Center

**POLICY** (Common Namespace for **Business Intent**)



### CISCO® ADVANTAGE

BROWNFIELD AND  
GREENFIELD

END TO END

POLICY FRAMEWORK: FOCUS ON  
APPLICATION AND USER ENABLEMENT



# Common End-Points

End 2 End Communication, do we talk?



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Hey, I meant from a policy Intent point of view!

## 4.2 APIC-EM – Auto Scale Architecture

# APIC-EM Grapevine

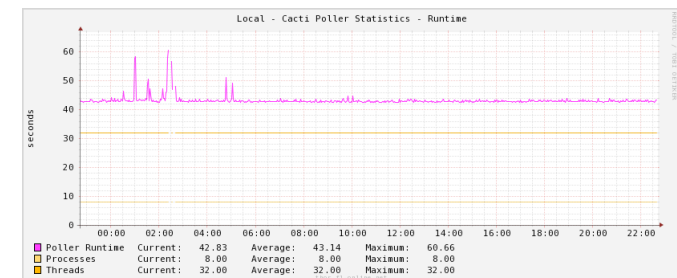
## Why do we need a "Platform for Service Elasticity"?



- **Distributed service behavior is both unpredictable and dissimilar**
- A "one size fits all" approach to service scaling and management lacks the comprehension to manage both, the autonomic and bespoke requirements of a service ecosystem.
- Service groups can be managed by monitoring the container (the virtual machine)
- Events as common as log overflows, memory leaks, and runaway processes will quickly fool any system lacking both service introspection and strong policy into generating all of the classic distributed system failure conditions: storms, flaps, unmanaged contention, and deadlocks.
- Services themselves require support for:
  - **specialized policies for scaling in both directions**
  - inter-instance communication for building quorum and consensus on scale events
  - unified security for access and authorization
  - unified model and data views for elements managed by multiple services

### Remember Cacti – Spine – Poller issues?

output: **Time:42.6984** Method:spine Processes:8 Threads:32 Hosts:79  
HostsPerProcess:10 DataSources:8985 RRDsProcessed:2616  
Poller[0] Maximum runtime of 58 seconds exceeded. Exiting.



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# APIC-EM Grapevine

## What is Grapevine?

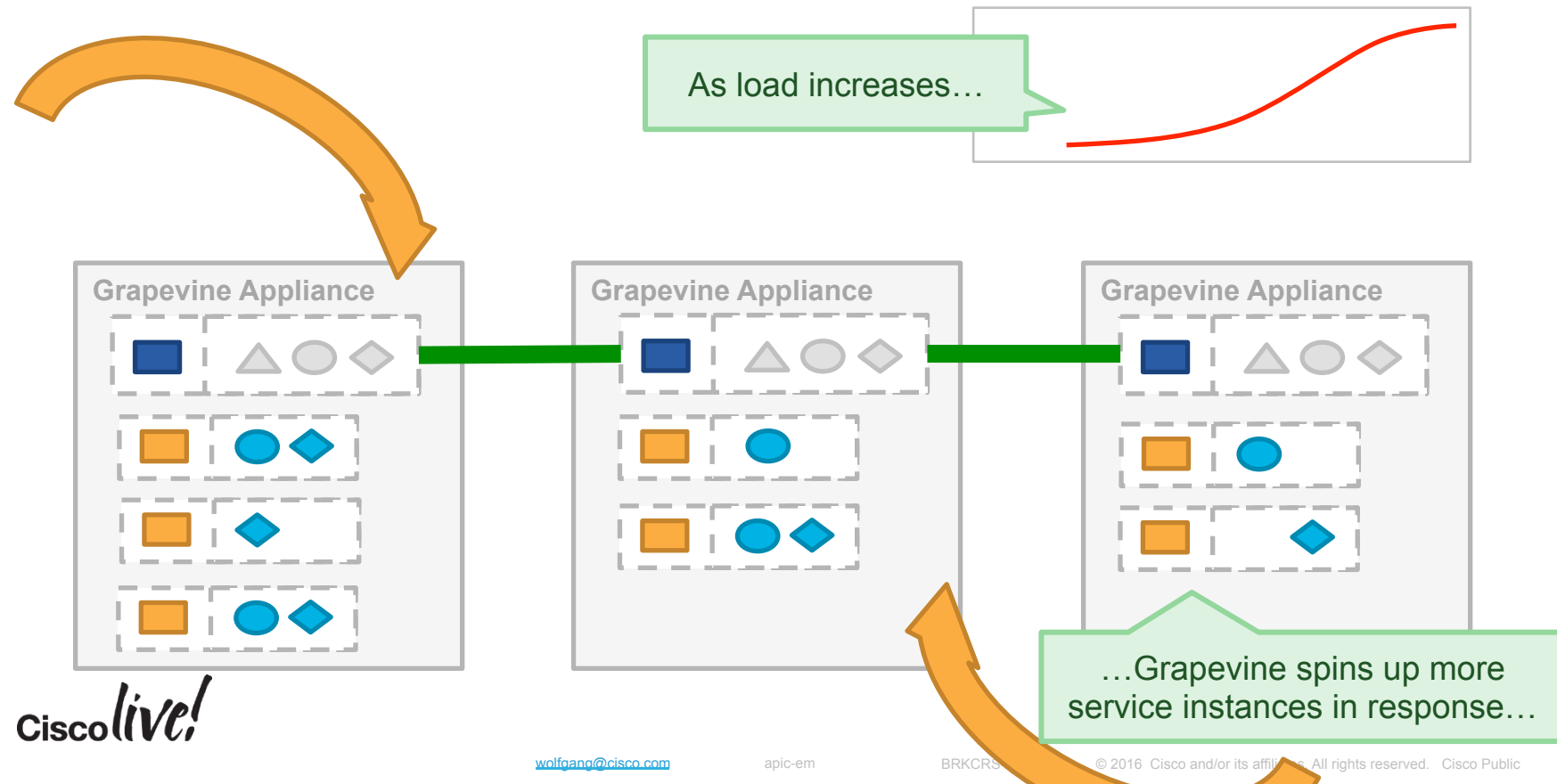


- **Grapevine** and **APIC-EM** are **de-coupled** from a technical perspective.  
Grapevine is the horizontal scale \*platform\* on which \*services\* such as those for APIC-EM run
  - **Cisco groups** wanted to create a new solution XYZ (that was completely unrelated to APIC-EM) that needed scale, HA, rolling-upgrades, service life-cycle management, etc... **could use Grapevine** (as long as they adhere to the Grapevine service design requirements) without needing to deploy/use any of the APIC-EM services
- 
- Is a PaaS (**Platform as a Service**) with an associated SDK
  - SDN developers can use to write their "services" (similar to a Google AppEngine or VMware Cloud Foundry model).
  - Is a simplified refinement of the PaaS model provided by both Amazon and Google for their cloud services. While you can run any program you like on their IaaS, using the PaaS requires adherence to a framework.
  - The major difference is that Grapevine **introspects at the service level** and **autoscales at the VM level** rather than breaking scaled resources down to the level of compute, block storage, network, etc.
  - It is important to note that Grapevine **controls elasticity at the granularity of "services"** rather than at the more coarse-grained, **virtual machine** granularity.
  - You can run Grapevine on bare-metal as also within VM's or in a mix of physical and virtual machines
  - Advantages of controlling elasticity at the service granularity are:
    - ✓ Avoids **VM boot up / shutdown time** in the
    - ✓ Better determine whether or not a service is **indeed healthy and is working as expected** vs just knowing whether or not a VM is running or not
    - ✓ **Better utilize** a VM's capacity by running instances of different services within the same VM instance
    - ✓ **Perform service-specific monitoring** to better determine whether an instance is "under heavy load"

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# APIC-EM Grapevine

## Automatic Scaling



# APIC-EM Grapevine

## Grapevine, the 20,000 foot view

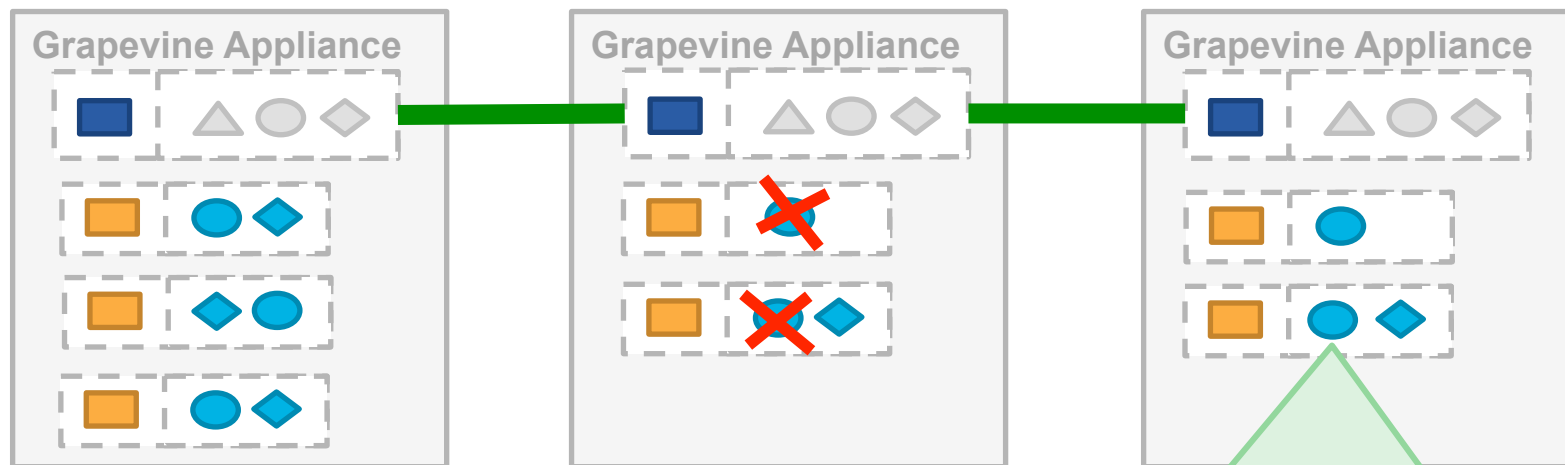


- With Grapevine you would define "service bundles".
- Each "service bundle" deployed runs as a separate process.
- Can deploy a single instance of these services or multiple instances of these services, on the same server or across multiple virtual as also physical servers.
- You can add, remove, start, stop, update these services at runtime without downtime
- Services can be written in pretty much any programming language (Java, C/C++, Go, Python, Ruby, Perl, Tcl, Bash, etc) and would communicate with each other via remote able APIs based on HTTP, AMQP, Thrift, etc.
- Given this, you can easily deploy services like OSGi within Grapevine
- Grapevine will monitor the load of these services
- Grapevine will provide scale for these services
  - In the presence of increased load, Grapevine will "grow" multiple instances of the services to provide horizontal scale.
  - In the presence of decreased load, Grapevine will "harvest" service instances
- Grapevine will provide HA for these services. In the presence of software/hardware failures Grapevine will grow replacement service instances to take over the workload of those instances that have failed
- Grapevine will provide "rolling upgrades" for these services.
  - You can deploy new services, or updates to existing services to the cloud.
  - Grapevine would periodically poll the cloud for updates and would download and deploy them onto the Grapevine cluster when they're available with minimal to no downtime.



# APIC-EM Grapevine

High Availability

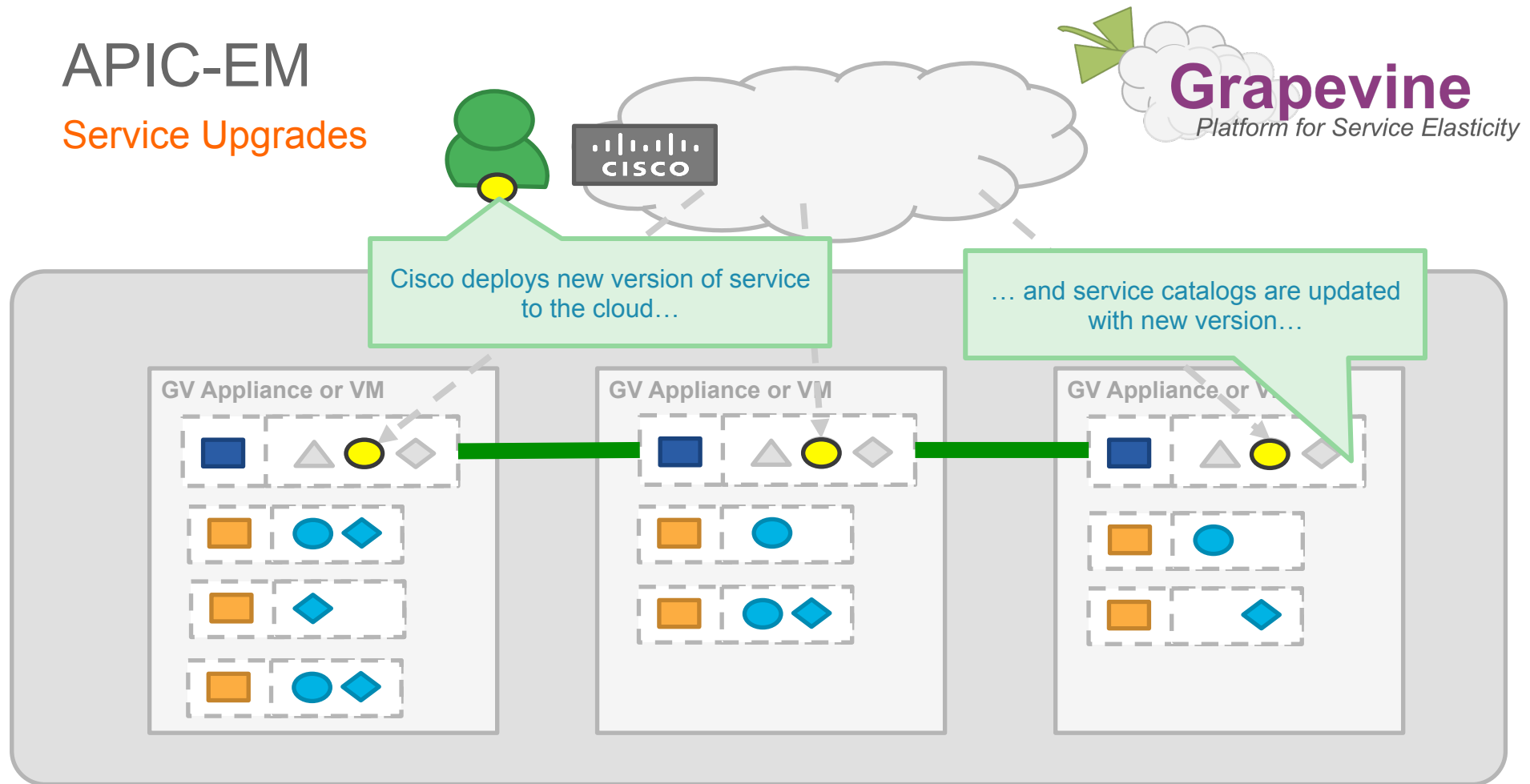


When a service fails, Grapevine starts a replacement instance, ensuring service's "min instance count" requirements are maintained...

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# APIC-EM

## Service Upgrades

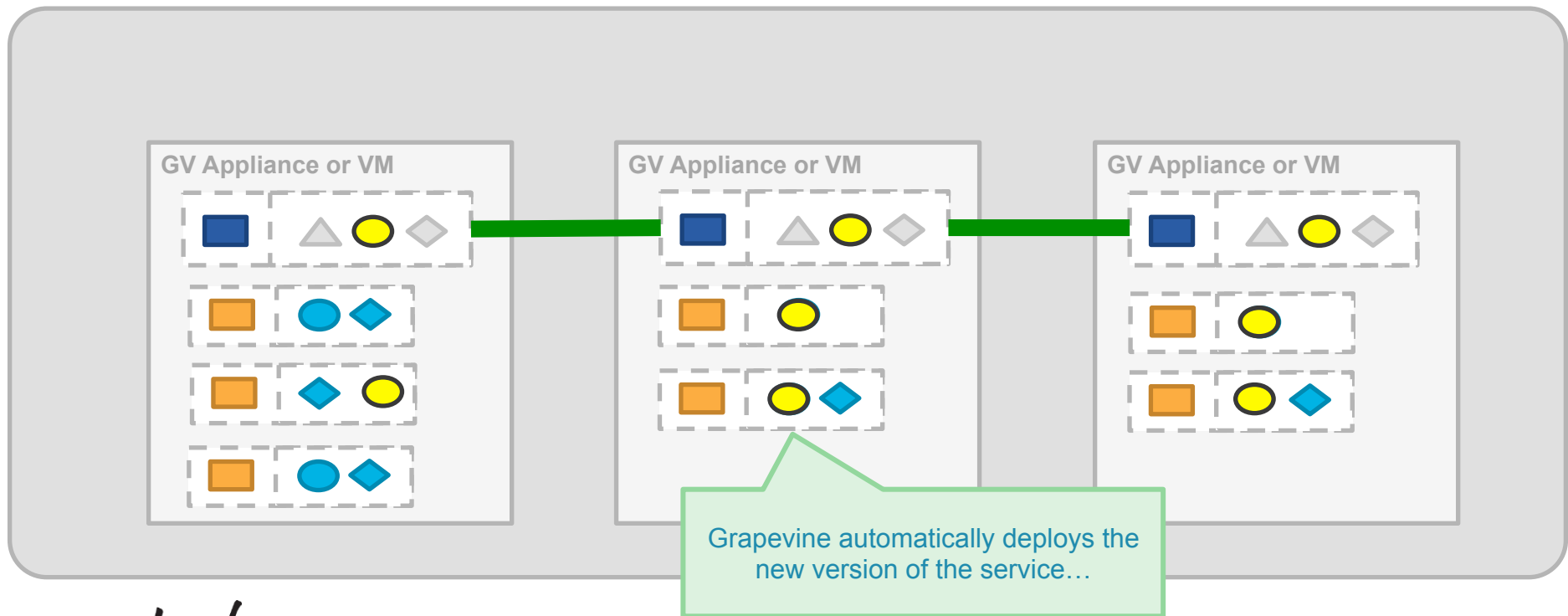


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# APIC-EM

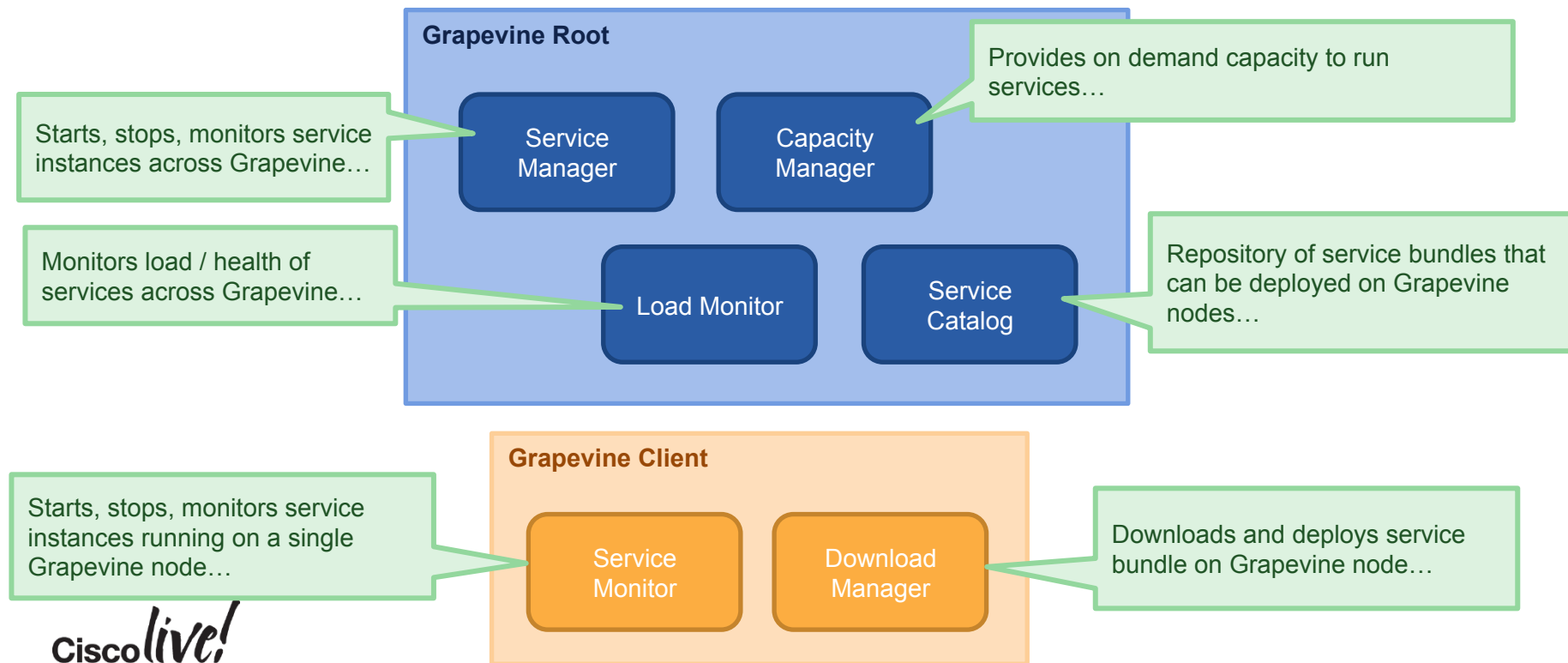
## Service Upgrades



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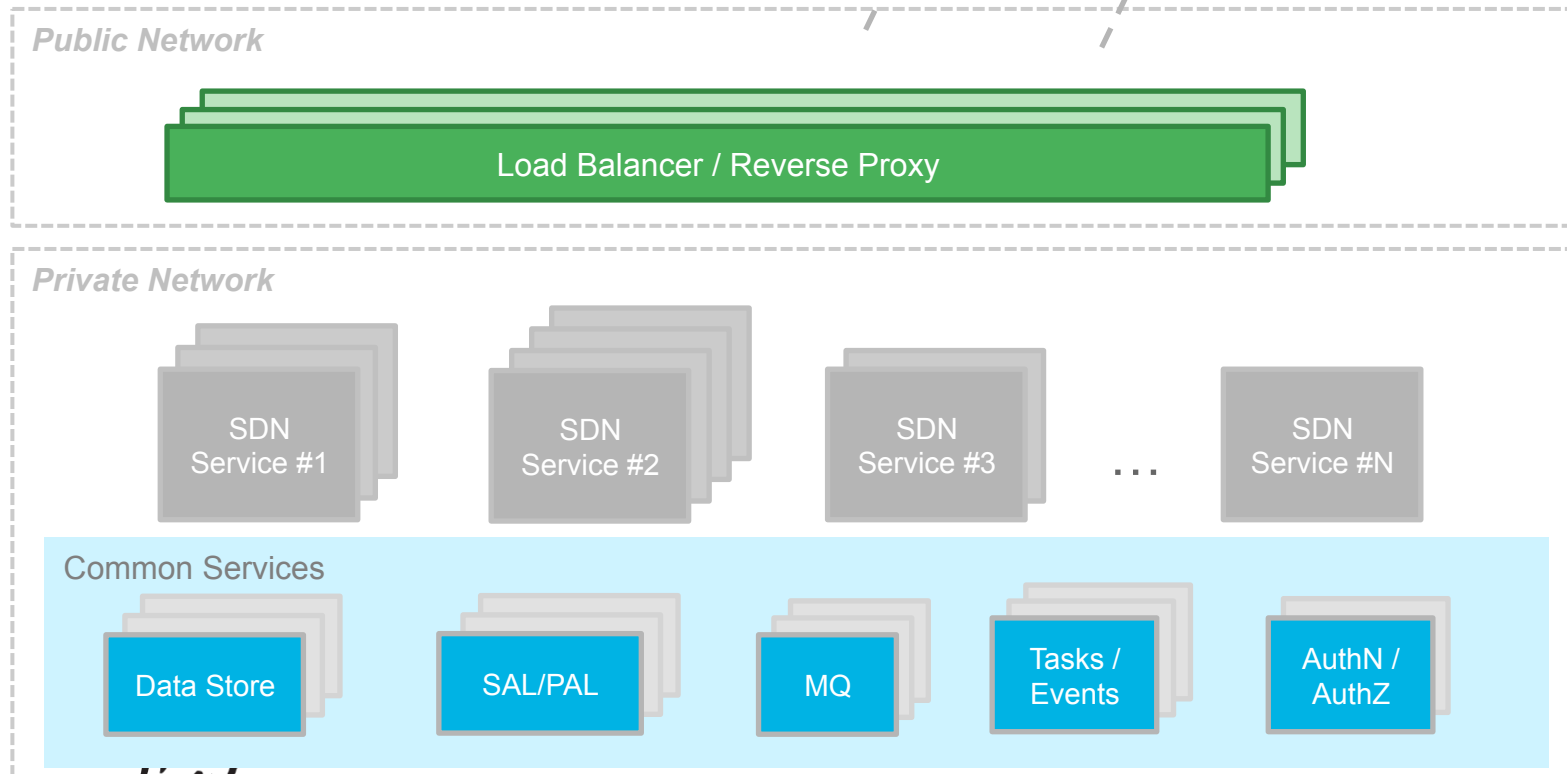
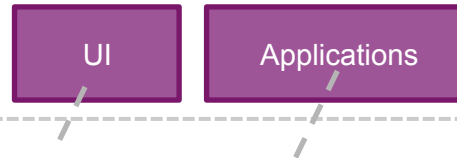
# APIC-EM Grapevine

## Grapevine Components: Grapevine



# APIC-EM Grapevine

## Grapevine Components: Services



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# APIC-EM Grapevine Services

## Grapevine Services Console



192.168.167.241

CPU	14376.3 / 14400.0 MHZ
Memory	29.3 / 62.9 GB
Storage	14.0 / 448.5 GB

Sat Feb 13 2016 12:17:23 GMT+0100 (CET)

Running Services

apic-em-event-service  
apic-em-inventory-manager-service  
apic-em-jboss-ejbca  
apic-em-network-programmer-service  
apic-em-pki-broker-service  
app-vis-policy-programmer-service  
cas-service  
election-service  
file-service  
ip-pool-manager-service  
ipgeo-service  
log-aggregator  
nbar-policy-programmer-service  
network-poller-service  
node-ui  
pfr-policy-programmer-service  
pnp-service  
policy-analysis-service  
policy-manager-service  
postgres  
qos-lan-policy-programmer-service  
qos-policy-programmer-service  
rbac-service  
remote-ras  
reverse-proxy  
router  
scheduler-service  
task-service  
telemetry-service  
topology-service  
visibility-service

Overview

Clients

Hosts

Waiting Queue

Services

Grapevine  
Service Elasticity Platform

Developer Console 0.4.0.1447.dev393-g5856d96 | Deployed Services: 34 Running Clients: 25 Faulted Clients: 0 Waiting Instances: 0 [REST API](#) [admin Logout](#)

192.168.167.243

CPU	1184.4 / 14400.0 MHZ
Memory	9.3 / 31.4 GB
Storage	10.3 / 480.0 GB

Sat Feb 13 2016 15:07:29 GMT+0100 (CET)

Running Services

apic-em-network-programmer-service  
election-service  
ip-pool-manager-service  
nbar-policy-programmer-service  
node-ui  
pfr-policy-programmer-service  
postgres  
reverse-proxy  
router

192.168.167.241

CPU	1878.3 / 14400.0 MHZ
Memory	24.1 / 62.9 GB
Storage	10.9 / 448.5 GB

Sat Feb 13 2016 15:07:21 GMT+0100 (CET)

Running Services

apic-em-inventory-manager-service  
apic-em-jboss-ejbca  
apic-em-pki-broker-service  
election-service  
pnp-service  
policy-analysis-service  
policy-manager-service  
postgres  
rbac-service  
remote-ras  
reverse-proxy  
router  
scheduler-service  
task-service  
telemetry-service  
topology-service  
visibility-service

192.168.167.242

CPU	2029.8 / 14400.0 MHZ
Memory	14.6 / 31.4 GB
Storage	10.3 / 480.0 GB

Sat Feb 13 2016 15:07:25 GMT+0100 (CET)

Running Services

apic-em-event-service  
app-vis-policy-programmer-service  
cas-service  
election-service  
file-service  
ipgeo-service  
log-aggregator  
network-poller-service  
postgres  
qos-lan-policy-programmer-service  
qos-policy-programmer-service  
reverse-proxy  
router

Tasks

Details

Instance Logs

Client Logs

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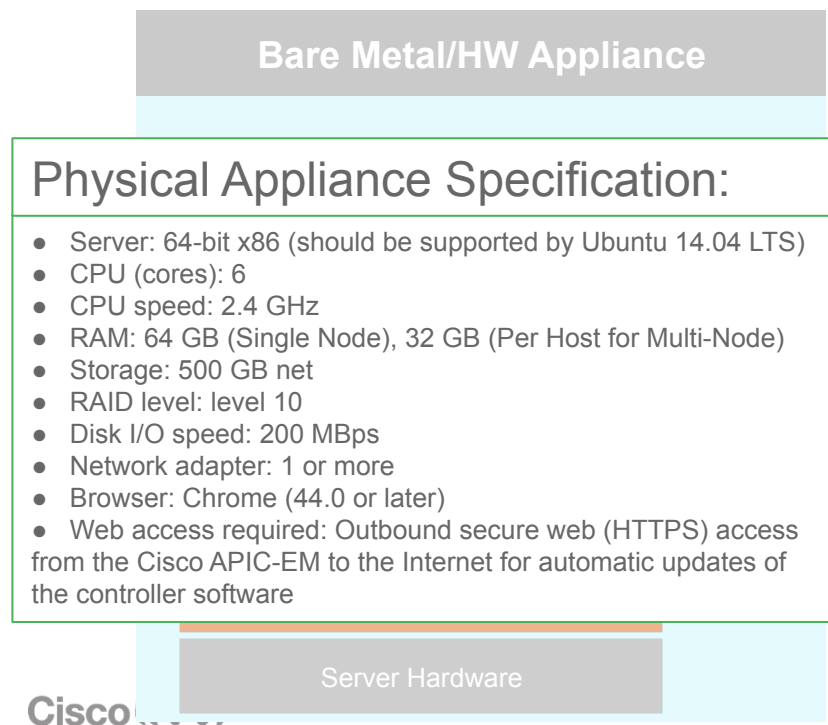
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# APIC-EM Grapevine

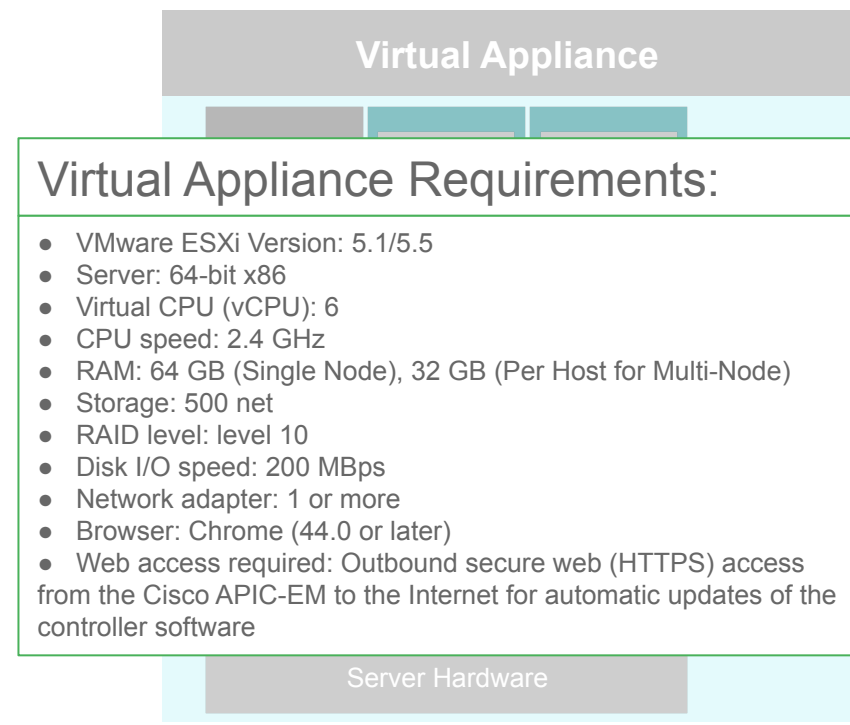
## Deployment Considerations - System Requirements



The [APIC-EM](#) platform and its hosted applications can run as a virtual appliance when installed on a hypervisor or a bare-metal server. It is also available as a hardware appliance. System resources to run these two different form factors follow.



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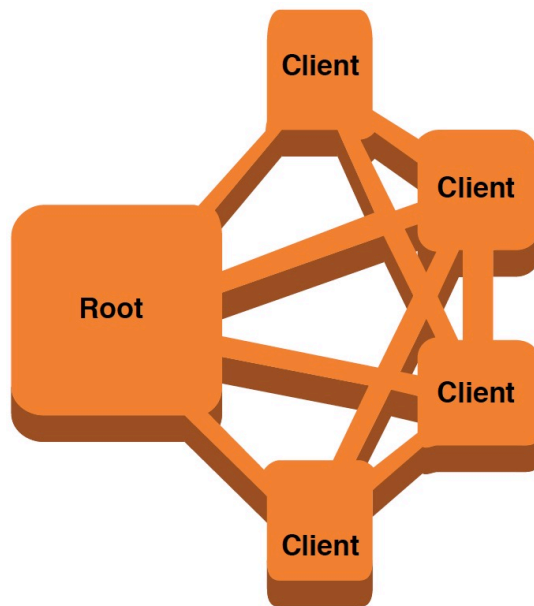
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## 4.3 APIC-EM – Grapevine Cloud Deployment



# APIC-EM Grapevine

## GV Deployment: Elastic Service Management Framework



### Mandatory Requirements:

- Easy to adopt
- Low cost of operation
- Cloud-like user experience

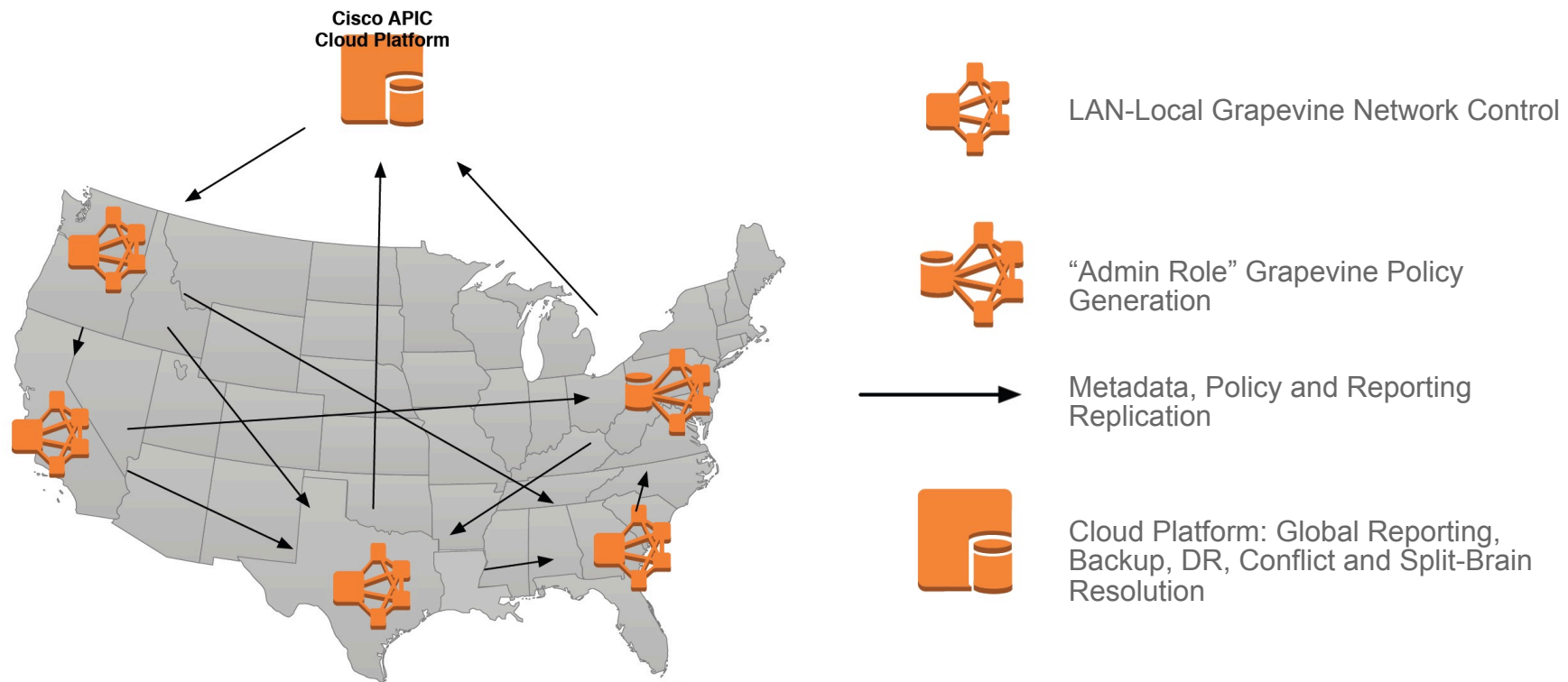
### Goals:

- Manages mix of physical and virtual machines
- Common solution for physical and virtual
- Balances service instances between containers
- Services set elasticity policies
- Admin sets service priority policy
- Provides introspection of physical capacity
- Provides intelligent service routing to ensure optimal utilization
- Scales automatically into any provided resource
- No operational overhead to user
- Provides high-scale common services - data, queue, security, etc

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# APIC-EM Grapevine

## GV Deployment: Platform Wide-Geo Deployment



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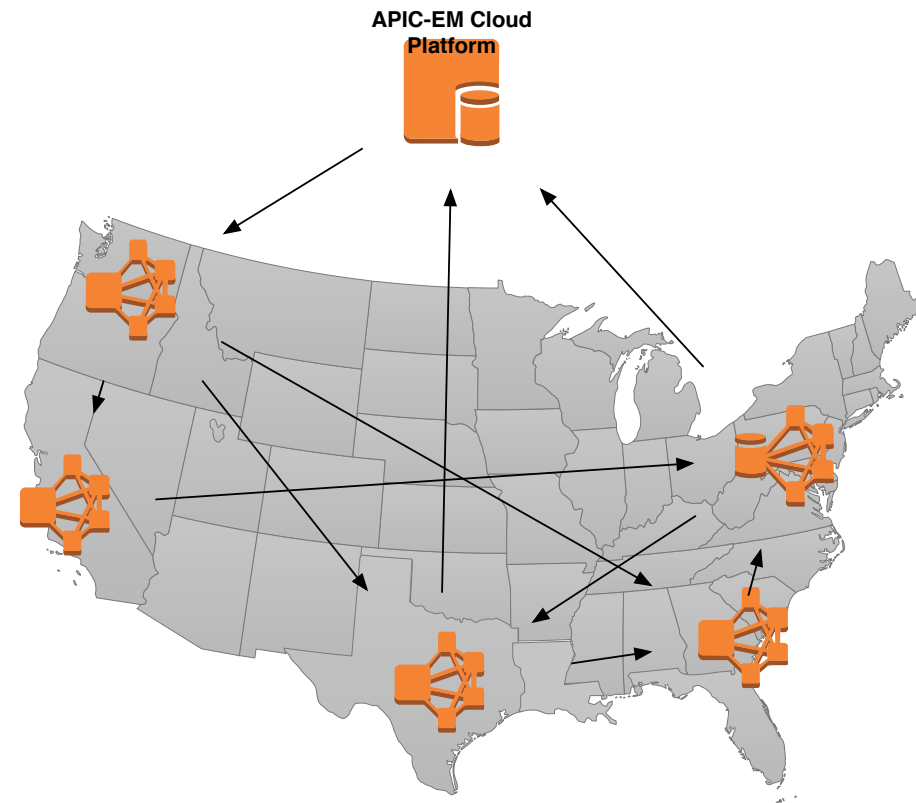


# APIC-EM

## Cloud Connect Support Model

- Modern software uses **cloud** today
- Controller **releases** will be **incremental** (no big releases)
- Partially opt-in and fully auditable
- Core value is seamless, “**never-touch-it**” upgrade
- Data secured in Cisco **cloud**
- **Single**, global reporting system for your networks
- Config, state, and policy backup
- Split-brain resolution
- Push notification to mobile devices

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## 4.4 APIC-EM - Use Cases

# APIC-EM Applications

Things we have on our radar....

- Use Case: Path Trace  
One Click Host to Host connection analysis
- Use Case: Traffic Prioritization  
One Click QoS Policy Enforcement (Easy QoS)
- Use Case: Granular Control  
Per User Per Application Access Policy Enforcement
- Use Case: Next Generation Security Management  
Sourcefire and APIC-EM
- Use Case: DDoS Protection:  
Per User Network Traffic Redirection
- Use Case: Traffic Monitoring  
Per User Per Application Network Traffic Tapping
- Use Case: IWAN - Smart Routing  
Automated Provisioning of Routing Paths
- Use Case: Zero Touch Deployment (ZTD)  
Automated Provisioning and Deployment



# APIC-EM – Application Slide burst

Fasten your seatbelts



FASTEN YOUR SEATBELT



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# Controller Application - Network Discovery

Home

Discovery

Device Inventory

Host Inventory

Topology

IWAN

Path Trace

Network Plug and Play

Logs

Discoveries

Add New

No Scans to show. Fill out the form to the right and start your first scan!

Discovery Name

Give this discovery a unique name

Scan Name

IP Ranges

IPs of the devices you want to scan

Discovery Type CDP 0.0.0.0

SNMP

Try different SNMP settings than global ones

show SNMP settings

CLI Credentials

Credentials are what you use to log in the devices.

show CLI Credentials settings

Advanced

Specify advanced settings

show Advanced settings

Start Discovery

Add a New Discovery

Use Discovery to scan and find devices in your network and place them in your inventory. When you run Discovery again, APIC-EM will scan the network and update your inventory with any new devices it finds.

DISCOVERY TYPE

Choose from two types of scans: Cisco Discovery Protocol (CDP) or Range (range of IP addresses). For CDP, you enter a single IP address, which CDP uses to begin the process of obtaining information about other directly connected Cisco devices. For Range, you enter beginning and ending IP addresses that APIC-EM scans sequentially beginning with the first IP address and stopping with the ending IP address.

CREDENTIALS

Enter the CLI Credentials used to log into the device. If an Enable Password is used for added security on the devices in your network, enter that password as well.

SNMP

SNMPv2c uses a community-based form of security. The community of SNMP managers that are able to access the agent MIB is defined by an IP address access control list (ACL) and password.

SNMPv3 uses authentication and encryption to ensure SNMP data packet integrity. It provides AuthPriv (authentication based on the HMAC-MD5 or HMAC-SHA algorithms), DES 56-bit encryption in addition to authentication based on the CBC-DES (DES-56) and AES-128 standards, AuthNoPriv (authentication based on the HMAC-MD5 or HMAC-SHA algorithms), and NoAuthNoPriv (uses a username match for authentication).

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# Network Discovery - Input Parameters

**Discovery Name**  
Give this discovery a unique name

**IP Ranges**  
IPs of the devices you want to scan  
Discovery Type: **CDP** (selected), Range

**SNMP**  
Try different SNMP settings than global ones  
[show SNMP settings](#)

**CLI Credentials**  
Credentials are what you use to log in the devices  
[show CLI Credentials settings](#)

**Advanced**  
Specify advanced settings  
[show Advanced settings](#)

**Start Discovery**

**Seed IP address for CDP-based network discovery**

**Discovery Name**  
Give this discovery a unique name

**IP Ranges**  
IPs of the devices you want to scan  
Discovery Type: **Range** (selected), CDP  
  **Add**

Entered ranges will appear here. Click 'Add' to add a range.

**SNMP**  
Try different SNMP settings than global ones  
[show SNMP settings](#)

**CLI Credentials**  
Credentials are what you use to log in the devices  
[show CLI Credentials settings](#)

**Advanced**  
Specify advanced settings  
[show Advanced settings](#)

**Start Discovery**

**IP address range for discovery scope - Click on the Add icon to provide multiple IP address ranges**

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# Network Discovery - Input Parameters

The image displays two side-by-side configuration panels for network discovery. The left panel, titled 'CLI Credentials', includes a 'hide CLI Credentials settings' section with fields for 'Username' (username), 'Password' (password), and 'Enable Password' (password). Below this is an 'Advanced' section with 'hide Advanced settings' and a 'Protocol Order' section where 'SSH' and 'Telnet' are selected. The right panel, titled 'SNMP', includes a 'hide SNMP settings' section. It features 'SNMP v2c' settings for 'Read Community' and 'Write Community', and 'SNMP v3' settings for 'Username' (username), 'Mode' (a dropdown menu), 'Auth Type' (SHA), 'Auth Password', 'Privacy Type' (DES), and 'Privacy Password'. At the bottom of the right panel are 'Timeout (in Seconds)' (5) and 'Retry Count' (0). A central grey text box with arrows pointing to the 'SNMP v3' settings and the 'Start Discovery' button contains the text: 'SNMP settings and device credentials for collecting network inventory information from the network devices'.

**CLI Credentials**  
Credentials are what you use to log in the devices.

hide CLI Credentials settings

Username: username  
Password: password  
Enable Password: password

**Advanced**  
Specify advanced settings

hide Advanced settings

Protocol Order  
Drag and drop the order, you may also deselect any.

SSH  
Telnet

**SNMP**  
Try different SNMP settings than global ones

hide SNMP settings

**SNMP v2c**

Read Community:   
Write Community:

**SNMP v3**

Username: username  
Mode:   
Auth Type: SHA  
Auth Password:   
Privacy Type: DES  
Privacy Password:

Timeout (in Seconds): 5  
Retry Count: 0

**Start Discovery**

SNMP settings and device credentials for collecting network inventory information from the network devices

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# Network Discovery - Discovery Status

Discoveries

Add New

ACTIVE

Campus-Discovery  
cdp 172.28.97.253

9

Branch-Discovery  
cdp 207.3.1.1

3

Devices

3

Status for Branch-Discovery

Active

Stop

DISCOVERY DETAILS

CDP Level

16

Protocol Order

ssh telnet

Retry Count

3

TimeOut

5

Discovery Condition

Complete

IP List

207.3.1.1

DEVICES FOUND IN THIS DISCOVERY

Host Name	IP	Status
Branch-Router1	207.3.1.1	Success
Branch-Router2	207.3.1.2	Success
Branch-Access1	207.1.10.1	Success

Detailed information about all existing discovery jobs

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# Network Discovery - Northbound REST APIs

<b>Available APIs</b> <a href="#">File</a> <a href="#">Flow Analysis</a> <a href="#">IP Geolocation</a> <a href="#">IP Pool Manager</a> <b>Inventory</b> <a href="#">Network Discovery</a> <a href="#">Network Plug and Play</a> <a href="#">PKI Broker Service</a> <a href="#">Policy Administration</a> <a href="#">Role Based Access Control</a> <a href="#">Scheduler</a> <a href="#">Task</a> <a href="#">Topology</a>	<b>Inventory</b>		
	APIC-EM Service API based on the Swagger™ 1.2 specification		
	<a href="#">Terms of service</a>		
	<a href="#">Cisco DevNet</a>		
	<b>device-credential : Device Credential API</b>		<a href="#">Show/Hide</a>   <a href="#">List Operations</a>   <a href="#">Expand Operations</a>   <a href="#">Raw</a>
	<b>discovery : Discovery API</b>		<a href="#">Show/Hide</a>   <a href="#">List Operations</a>   <a href="#">Expand Operations</a>   <a href="#">Raw</a>
	PUT	/discovery	Updates an existing discovery specified by id - only for starting/stopping the discovery
	DELETE	/discovery	Deletes all discovery
	POST	/discovery	Starts a new discovery process and returns a task-id
	GET	/discovery/count	Returns the number of discovery
	DELETE	/discovery/{id}	Deletes the discovery specified by id
	GET	/discovery/{id}	Returns the discovery specified by id
	GET	/discovery/{id}/network-device	Returns the network devices discovered in the discovery specified by id
	GET	/discovery/{id}/network-device/count	Returns the number of network devices discovered in the discovery specified by id
	GET	/discovery/{id}/network-device/{startIndex}/{recordsToReturn}	Returns the network devices discovered in the given range
	DELETE	/discovery/{startIndex}/{recordsToDelete}	Deletes the discovery in the given range
	GET	/discovery/{startIndex}/{recordsToReturn}	Returns the discovery in the given range



# Controller Applications - Device Inventory

<div><div></div><div>Home</div><div>Discovery</div><div>Device Inventory</div><div>Host Inventory</div><div>Topology</div><div>IWAN</div><div>Path Trace</div><div>Network Plug and Play</div><div>Logs</div></div>	APIC - Enterprise Module									
	Filters		Layout: Hardware							
	<input type="checkbox"/>	Device Name	IP Address	MAC Address	IOS/Firmware	Platform	Serial Number	Config	Device Role	Device Family
	<input type="checkbox"/>	AP7081.059f.19ca	55.1.1.3	68:bc:0c:63:4a:b0	8.1.14.16	AIR-CAP3502I-A-K9	FGL1548S2YF	<a href="#">View</a>	ACCESS	Unified AP
	<input type="checkbox"/>	Branch-Access1	207.1.10.1	64a0.e7d4.9bc1	12.2(55)SE3	WS-C2960S-48LPS-L	FOC1537W1ZY	<a href="#">View</a>	ACCESS	Switches and Hubs
	<input type="checkbox"/>	Branch-Router1	207.3.1.1	7c0e.ce9f.3cd9	15.2(4)M6a	CISCO2911/K9	FTX1840ALC1	<a href="#">View</a>	BORDER ROUTER	Routers
	<input type="checkbox"/>	Branch-Router2	207.3.1.2	107f.06bb.dc81	15.2(4)M6a	CISCO2911/K9	FTX1840ALBY	<a href="#">View</a>	BORDER ROUTER	Routers
	<input type="checkbox"/>	CAMPUS-Access1	212.1.10.1	f029.295c.30e2	03.03.00.SE	WS-C3850-48U	FOC1703V36B	<a href="#">View</a>	ACCESS	Switches and Hubs
	<input type="checkbox"/>	CAMPUS-Core1	211.1.1.1	24e9.b33f.b180	15.1(1)SY3	WS-C6503-E	FXS1825Q1PA	<a href="#">View</a>	CORE	Switches and Hubs
	<input type="checkbox"/>	CAMPUS-Core2	211.2.1.1	24e9.b33f.b1c0	15.1(1)SY3	WS-C6503-E	FXS1825Q1P8	<a href="#">View</a>	CORE	Switches and Hubs
	<input type="checkbox"/>	CAMPUS-Dist1	55.1.1.100	0007.7dc5.e7ff	03.02.00.XO	WS-C4507R+E	FOX1524GV2Z	<a href="#">View</a>	DISTRIBUTION	Switches and Hubs
	<input type="checkbox"/>	CAMPUS-Dist2	212.3.1.2	30e4.db25.753f	03.04.00.SG	WS-C4507R+E	FOX1525G5S1	<a href="#">View</a>	DISTRIBUTION	Switches and Hubs
	<input type="checkbox"/>	CAMPUS-Router1	210.1.1.1	f44e.05cf.2e30	15.4(3)S	ISR4451-X/K9	FTX1842AHM2	<a href="#">View</a>	BORDER ROUTER	Routers
	12 Devices									
10										First Previous 1 Next Last

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# Device Inventory - Hardware Layout

Device Name	IP Address	MAC Address	IOS/Firmware	Platform	Serial Number	Config	Device Role	Device Family
AP7081.059f.19ca	55.1.1.3	68:bc:0c:63:4a:b0	8.1.14.16	AIR-CAP3502I-A-K9	FGL1548S2YF	<a href="#">View</a>	ACCESS	Unified AP
Branch-Access1	207.1.10.1	64a0.e7d4.9bc1	12.2(55)SE3	WS-C2960S-48LPS-L	FOC1537W1ZY	<a href="#">View</a>	ACCESS	Switches and Hubs
Branch-Router1	207.3.1.1	7c0e.ce9f.3cd9	15.2(4)M6a	CISCO2911/K9	FTX1840ALC1	<a href="#">View</a>	BORDER ROUTER	Routers
Branch-Router2	207.3.1.2	f07f.06bb.dc81	15.2(4)M6a	CISCO2911/K9	FTX1840ALBY	<a href="#">View</a>	BORDER ROUTER	Routers
CAMPUS-Access1	212.1.10.1	f029.295c.30e2	03.03.00.SE	WS-C3850-48U	FOC1703V36B	<a href="#">View</a>	ACCESS	Switches and Hubs

Detailed device inventory information

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# Device Inventory - Hardware Layout

APIC - Enterprise Module

API [Settings] [User] [Notifications] admin [Settings]

Filters Layout: Hardware

Device Name	IP Address	MAC Address	IOS/Firmware	Platform	Serial Number	Config	Device Role	Device Family
Branch-Access1					48S2YF	<a href="#">View</a>	ACCESS	Unified AP
					637W1ZY	<a href="#">View</a>	ACCESS	Switches and Hubs
					40ALC1	<a href="#">View</a>	BORDER ROUTER	Routers
					40ALBY	<a href="#">View</a>	BORDER ROUTER	Routers
					703V36B	<a href="#">View</a>	ACCESS	Switches and Hubs

Building configuration...

Current configuration : 4641 bytes

```
!  
version 12.2  
no service pad  
service timestamps debug datetime msec  
service timestamps log datetime msec  
no service password-encryption  
!  
hostname Branch-Access1  
!  
boot-start-marker  
boot-end-marker  
!  
enable password xxxxxxxx  
!  
username xxxxxx  
!  
!
```

Real-time Device Configuration

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# Device Inventory - Tagging Layout

Device Name	IP Address	MAC Address	Device Role	Location	Tag
AP7081.059f.19ca	55.1.1.3	68:bc:0c:63:4a:b0	ACCESS	San Jose, CA	3
Branch-Access1	207.1.10.1	64a0.e7d4.9bc1	ACCESS	New York, NY	1
Branch-Router1	207.3.1.1	7c0e.ee9f.3cd9	BORDER ROUTER	New York, NY	1
Branch-Router2	207.3.1.2	f07f.06bb.dc81	BORDER ROUTER	New York, NY	1
CAMPUS-Access1	212.1.10.1	f029.295c.30e2	ACCESS	San Jose, CA	3

Sophisticated and automated devices are given a role assignment based on intelligent matching against pre-set templates and attributes

Geo-site (location) and custom tags for complete flexibility in grouping and classification of devices based on business logic (for example, lines of business, service mix, etc.)

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# Device Inventory - Status Layout

Device Name	IP Address	Device Status	Up Time	Last Updated Time	Last Inventory Collection Status
<a href="#">AP7081.059f.19ca</a>	55.1.1.3	Reachable	NA	a few seconds ago	Managed
<a href="#">Branch-Access1</a>	207.1.10.1	Reachable	308 days, 17:55:44.99	6 minutes ago	Managed
<a href="#">Branch-Router1</a>	207.3.1.1	Reachable	308 days, 17:28:08.24	6 minutes ago	Managed
<a href="#">Branch-Router2</a>	207.3.1.2	Reachable	308 days, 17:26:40.80	7 minutes ago	Managed
<a href="#">CAMPUS-Access1</a>	212.1.10.1	Reachable	54 days, 4:31:37.69	27 minutes ago	In Progress

Real-time device inventory status

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# Device Inventory - Northbound REST APIs

<b>Available APIs</b> <a href="#">File</a> <a href="#">Flow Analysis</a> <a href="#">IP Geolocation</a> <a href="#">IP Pool Manager</a> <b>Inventory</b> <a href="#">Network Discovery</a> <a href="#">Network Plug and Play</a> <a href="#">PKI Broker Service</a> <a href="#">Policy Administration</a> <a href="#">Role Based Access Control</a> <a href="#">Scheduler</a> <a href="#">Task</a> <a href="#">Topology</a>	<b>Inventory</b>			
	APIC-EM Service API based on the Swagger™ 1.2 specification			
	<a href="#">Terms of service</a> <a href="#">Cisco DevNet</a>			
	<b>device-credential : Device Credential API</b>			
	Show/Hide	List Operations	Expand Operations	Raw
	<b>discovery : Discovery API</b>			
	Show/Hide	List Operations	Expand Operations	Raw
	<b>host : host API</b>			
	Show/Hide	List Operations	Expand Operations	Raw
	<b>interface : Interface API</b>			
	Show/Hide	List Operations	Expand Operations	Raw
	<b>location : Location API</b>			
	Show/Hide	List Operations	Expand Operations	Raw
<b>network-device : network-device API</b>				
Show/Hide   List Operations   Expand Operations   Raw				
GET	/network-device	getAllNetworkDevice		
PUT	/network-device/brief	updateNetworkDevice		
GET	/network-device/count	getNetworkDeviceCount		
GET	/network-device/ip-address/{ipAddress}	getNetworkDeviceByIp		
GET	/network-device/location	getNetworkDeviceLocation		
POST	/network-device/location	addNetworkDeviceLocation		
GET	/network-device/location/{locationId}	getNetworkDeviceByLocationId		
GET	/network-device/location/{locationId}/{startIndex}/{recordsToReturn}	getNetworkDeviceByLocationByRange		
GET	/network-device/location/{startIndex}/{recordsToReturn}	getNetworkDeviceLocationByRange		



# Controller Applications - Host Inventory

Home

Discovery

Device Inventory

Host Inventory

Topology

IWAN

Path Trace

Network Plug and Play

APIC - Enterprise Module

API

admin

Host MAC Address	Host IP Address	Host Type	Connected Network Device IP Address	Connected Interface Name	Host Name
30:e4:db:25:75:3f	212.1.20.2	WIRED	212.1.10.1	GigabitEthernet1/0/2	
5c:f9:dd:52:07:78	212.1.10.20	WIRED	212.1.10.1	GigabitEthernet1/0/47	
e8:9a:8f:7a:22:99	207.1.10.20	WIRED	207.1.10.1	GigabitEthernet1/0/47	

10 per page ▼

3 Hosts

<

Previous

1 of 1

Next>

Detailed host information

Network attachment point for host

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# Host Inventory - Northbound REST APIs

**Available APIs**

- [File](#)
- [Flow Analysis](#)
- [IP Geolocation](#)
- [IP Pool Manager](#)
- [Inventory](#)**
- [Network Discovery](#)
- [Network Plug and Play](#)
- [PKI Broker Service](#)
- [Policy Administration](#)
- [Role Based Access Control](#)
- [Scheduler](#)
- [Task](#)
- [Topology](#)

## Inventory

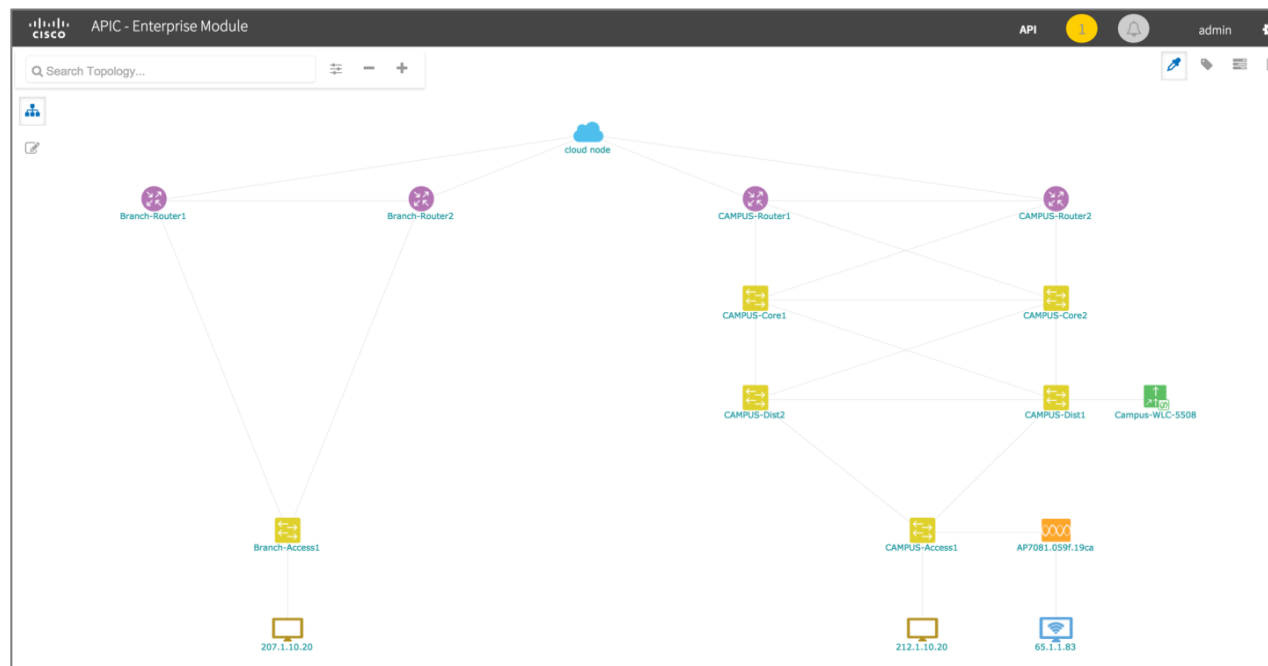
APIC-EM Service API based on the Swagger™ 1.2 specification

[Terms of service](#)  
[Cisco DevNet](#)

<b>device-credential : Device Credential API</b>		<a href="#">Show/Hide</a>	<a href="#">List Operations</a>	<a href="#">Expand Operations</a>	<a href="#">Raw</a>
<b>discovery : Discovery API</b>		<a href="#">Show/Hide</a>	<a href="#">List Operations</a>	<a href="#">Expand Operations</a>	<a href="#">Raw</a>
<b>host : host API</b>		<a href="#">Show/Hide</a>	<a href="#">List Operations</a>	<a href="#">Expand Operations</a>	<a href="#">Raw</a>
<a href="#">GET</a>	<a href="#">/host</a>	Retrieve hosts			
<a href="#">GET</a>	<a href="#">/host/count</a>	Gives total number of hosts			
<a href="#">GET</a>	<a href="#">/host/{id}</a>	Retrieves host based on id			
<b>interface : Interface API</b>		<a href="#">Show/Hide</a>	<a href="#">List Operations</a>	<a href="#">Expand Operations</a>	<a href="#">Raw</a>
<b>location : Location API</b>		<a href="#">Show/Hide</a>	<a href="#">List Operations</a>	<a href="#">Expand Operations</a>	<a href="#">Raw</a>
<b>network-device : network-device API</b>		<a href="#">Show/Hide</a>	<a href="#">List Operations</a>	<a href="#">Expand Operations</a>	<a href="#">Raw</a>
<b><u>network-device-config</u> : Network Device Configuration API</b>		<a href="#">Show/Hide</a>	<a href="#">List Operations</a>	<a href="#">Expand Operations</a>	<a href="#">Raw</a>
<b>tag : Tag API</b>		<a href="#">Show/Hide</a>	<a href="#">List Operations</a>	<a href="#">Expand Operations</a>	<a href="#">Raw</a>



# Controller Applications - Topology Visualizer



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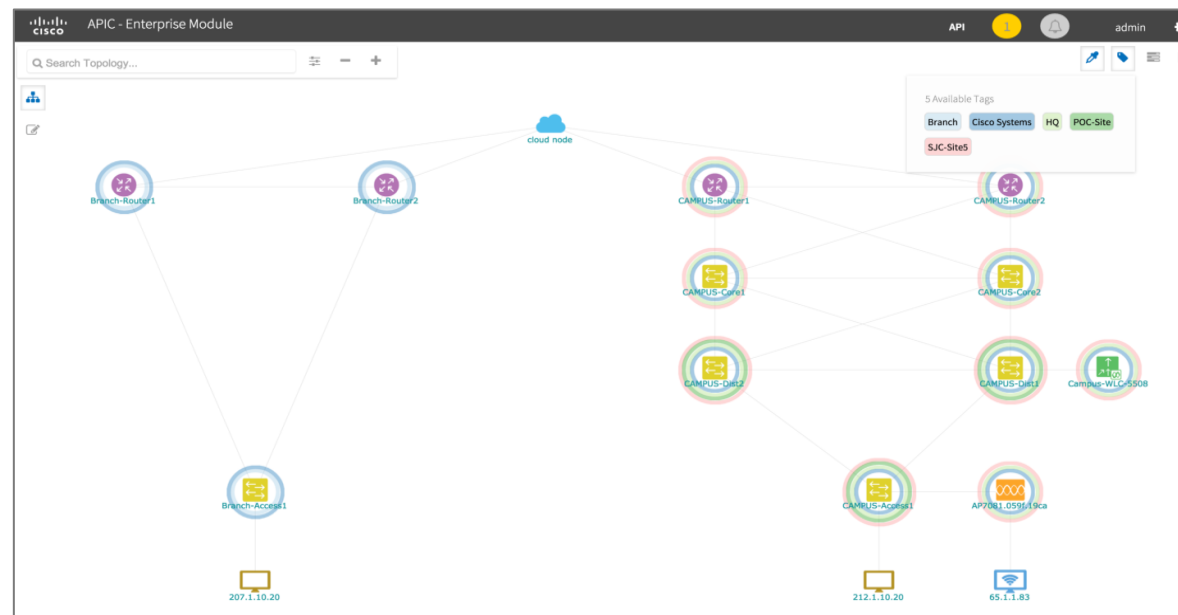
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# Topology Visualizer - TAG View



Ability to visualize device TAGs in the topology view

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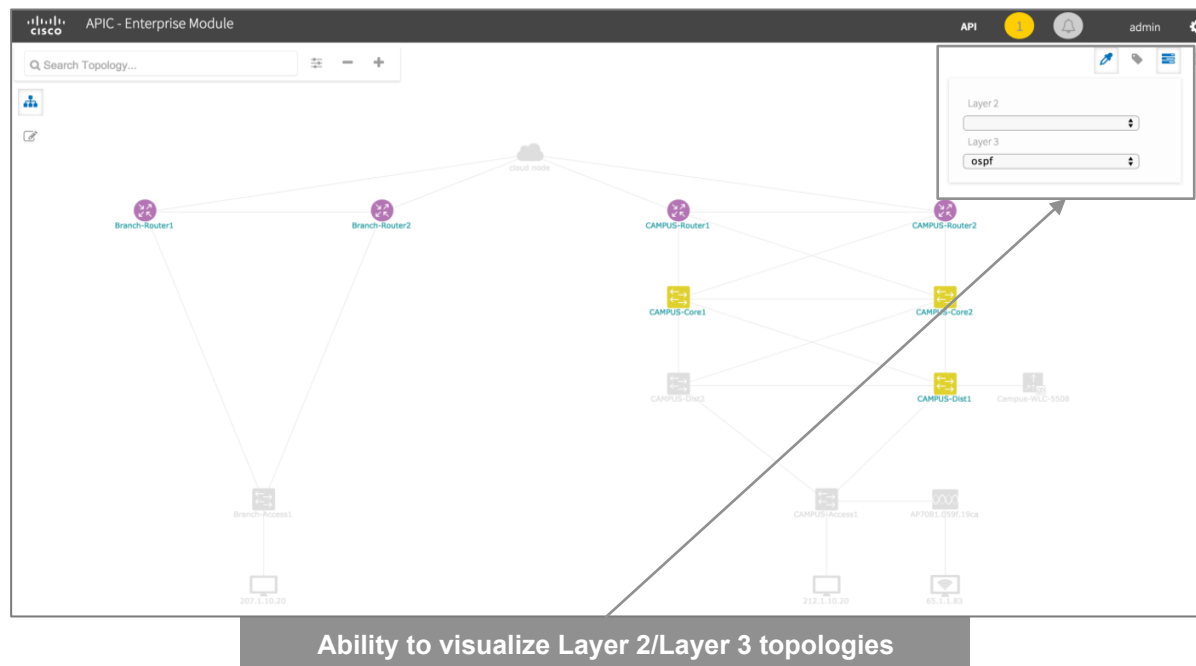
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# Topology Visualizer - L2/L3 Topology View



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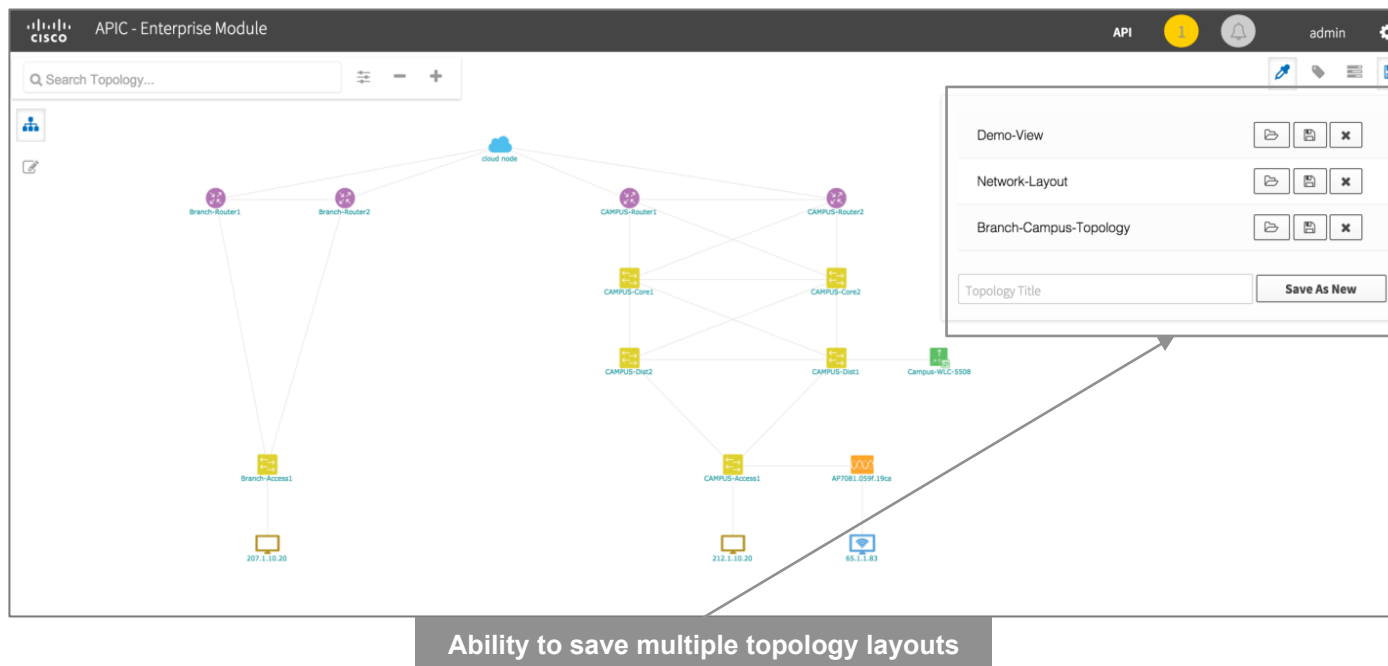
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# Topology Visualizer - Saved Layouts



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# Topology Visualizer - Northbound REST APIs

**Available APIs**

- [File](#)
- [Flow Analysis](#)
- [IP Geolocation](#)
- [IP Pool Manager](#)
- [Inventory](#)
- [Network Discovery](#)
- [Network Plug and Play](#)
- [PKI Broker Service](#)
- [Policy Administration](#)
- [Role Based Access Control](#)
- [Scheduler](#)
- [Task](#)
- [Topology](#)**

## Topology

APIC-EM Service API based on the Swagger™ 1.2 specification

[Terms of service](#)  
[Cisco DevNet](#)

### topology : Topology Service

Show/Hide | List Operations | Expand Operations | Raw

GET	/topology/custom	loadCustomTopology
POST	/topology/custom	saveCustomTopology
GET	/topology/l2/{vlanID}	getL2Topology
GET	/topology/l3/{topologyType}	getL3Topology
GET	/topology/physical-topology	getPhysicalTopology

### topology-application-page-view : Topology Application-Page-View Service

Show/Hide | List Operations | Expand Operations | Raw

### vlan : Vlan Service

Show/Hide | List Operations | Expand Operations | Raw

GET	/topology/vlan/vlan-names	getVlanNames
GET	/vlan/vlan-names	getVlanNames



# Path Trace

## 5-Tuple Input



APIC - Enterprise Module

API Hi, admin

Path Trace

Enter in two host IP's (required) and their ports and protocol (optional) to visualize the path

Host Source IP  
65.1.1.6

Host Destination IP  
212.1.10.20

Source Port (Optional)  
80

Destination Port (Optional)  
80

Protocol (Optional)  
tcp

Trace

Trace Results

Please enter the fields above and press Trace to view a path.

Cisco*live!*

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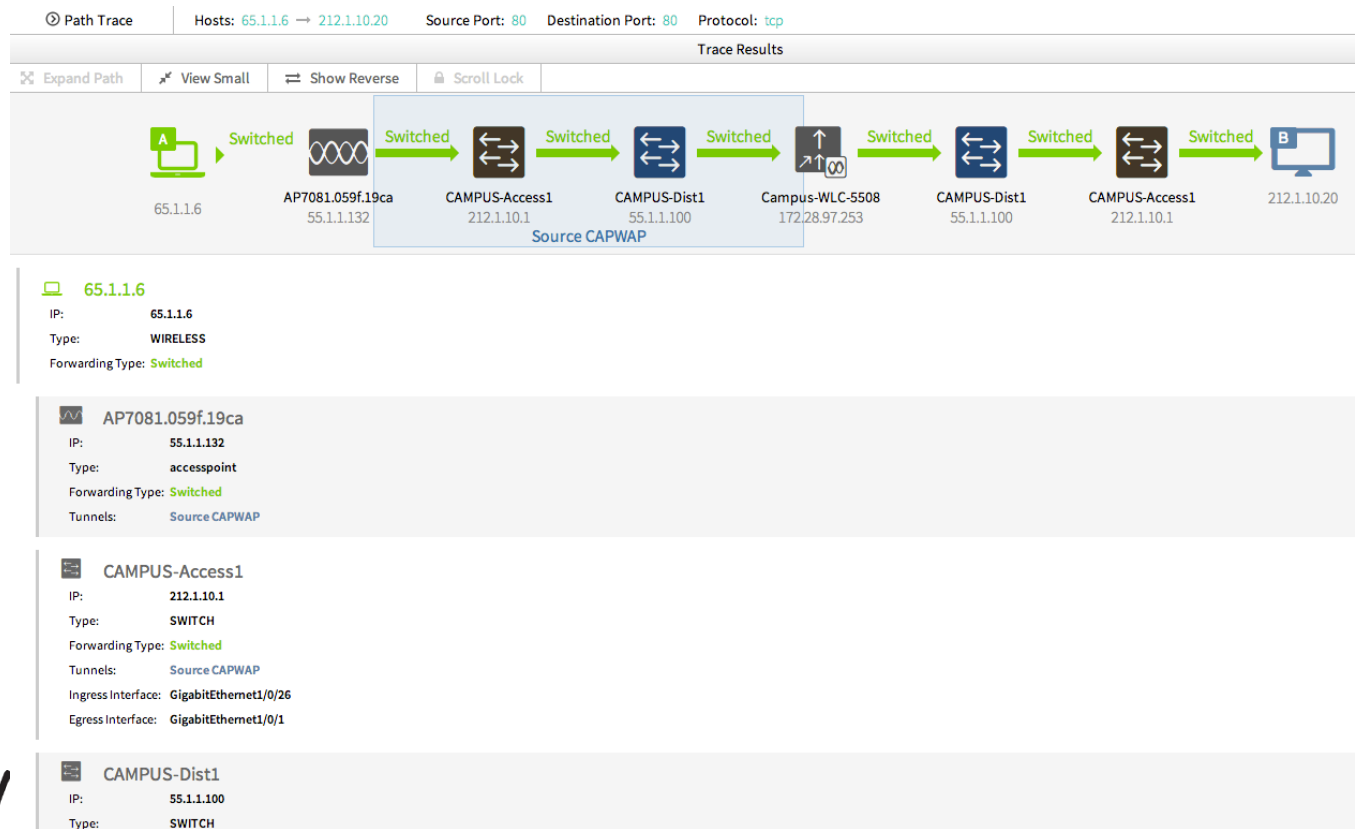
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# Path Trace

## Results



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# Policy Analysis

## ACL Analysis



**APIC - Enterprise Module**

Home | Discovery | Device Inventory | Host Inventory | Topology | Policy | Quality of Service | **Policy Analysis**

**ACL Analysis** | ACL Trace

Analyze | Device: BLD6-Dist | ACL: one\_big\_acl\_for\_conflict

**Conflicts**

1	7	1
shadowed	redundant	correlated

There are 9 conflicts found in this acl.  
Select any line to the left to view more details

▼ one\_big\_acl\_for\_conflict

1.	DENY	TCP	host 140.192.37.20	any eq WWW
2.	PERMIT	TCP	any	host 161.120.33.40 eq WWW
3.	PERMIT	TCP	host 161.120.33.41	host 161.120.33.40 eq WWW
4.	DENY	TCP	host 140.192.37.1	host 140.11.25.55 eq WWW
5.	DENY	TCP	100.6.3.0/24	any eq FTP
6.	PERMIT	TCP	140.192.37.0/24	any eq FTP
7.	PERMIT	TCP	140.192.37.0/24	host 161.120.33.40 eq FTP
8.	DENY	TCP	140.192.37.0/24	host 161.120.33.40 eq WWW
9.	DENY	TCP	any	any eq FTP
10.	DENY	TCP	any	any eq 458
11.	DENY	UDP	any	any eq 458
12.	PERMIT	IP	any	any

CiscoLive!

# Policy Analysis

## ACL Trace

Boxes greyed out once traffic is blocked for easy visualization



ACL Analysis

ACL Trace

Trace Path

Type in two host IP's to trace a path

A

100.6.2.24

B

100.1.3.34

Applications

apple

▼ apple

Apple AirPlay wireless media streaming

Apple Remote Desktop

apple quick time

iCloud - Apple cloud services

Trace Results

```
graph LR; A[A 100.6.2.24] -- green --> BLD6-Access2[BLD6-Access2 110.6.2.1]; BLD6-Access2 -- green --> BLD6-Dist[BLD6-Dist 120.6.1.2]; BLD6-Dist -- red --> EW-CORE1[EW-CORE1 172.28.97.114]; EW-CORE1 -- green --> BLD1-Dist[BLD1-Dist 120.1.1.2]; BLD1-Dist -- green --> BLD1-Access3[BLD1-Access3 110.1.3.1]; BLD1-Access3 -- green --> B[B 100.1.3.34];
```

apple quick time  
ports tcp 458 udp 458

A

100.6.2.24

✓ BLD6-Access2

✓ GigabitEthernet1/0/10 (ingress)

✓ GigabitEthernet1/0/48 (egress)

✗ BLD6-Dist

✗ GigabitEthernet1/0/2 (ingress)  
one\_big\_acl\_for\_conflict

10. DENY TCP any any eq 458 Blocks tcp 458

11. DENY UDP any any eq 458 Blocks udp 458

✓ GigabitEthernet1/0/25 (egress)

✓ EW-CORE1

# Easy QoS

Easy customization of policies



APIC - Enterprise Module

Home | Discovery | Device Inventory | Host Inventory | Topology | Policy | **Quality of Service** | Policy Analysis

Maps | CVD

Scope	Status	Applications
all	disabled	
Toronto		
Production		
Voice		voice-and-video <ul style="list-style-type: none"><li>Cisco IP Phones and PC-based Unified Communicators</li><li>Cisco Jabber Client; Audio Calls and Voice Mail</li><li>MS Lync Audio flows classification</li><li>Real Time Protocol</li><li>Real Time Protocol Audio</li></ul>
Multimedia Streaming		
Transactional Data		

Applications: 5

Applications: 0

Applications: 66

Applications: 9

Applications: 9

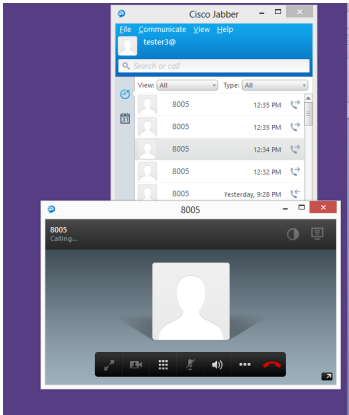
Applications: 38

Applications: 5

Applications: 7

Applications: 38

# Dynamic QoS Classification



CISCO

APIC - Enterprise Module

Settings

Applications

Home

Discovery

Device Inventory

Host Inventory

Topology

Policies

Quality of Service

ACL Analysis

Zero Touch Deployment

Collaboration Services

+

Create Policy

×

Delete All Policies

Current Policies										
Name	Scope	Users: Users	Users: Application	Resources: Users	Resources: Application	Actions	Priority Level	Destination	Status	Actions
createPolicy:: UCPolicy172.28.97.52:32013		172.28.97.52	0,0,UDP	172.28.97.51	0,0,UDP	PERMIT	32	N/A	Active	
createPolicy:: UCPolicy172.28.97.51:32016		172.28.97.51	0,0,UDP	172.28.97.52	0,0,UDP	PERMIT	32	N/A	Active	

Displaying Two of Two Policies

Delete All

Refresh



# 5. Demo

- **World Of Solutions**
- Whisper suite sessions

# Demo

# 6. Conclusion and Open Discussion

The image features a high-resolution satellite view of the Earth, centered on the North Pole. The Arctic region is visible at the top, surrounded by swirling cloud patterns. The continents of North America, Europe, and Asia are partially visible, with the Atlantic Ocean in the center. The background is a deep black space filled with numerous small, distant stars. Overlaid on the image are several semi-transparent geometric shapes: a large blue triangle on the left, a dark blue triangle on the right, and a teal triangle at the bottom. The text 'The World is CHANGING' is centered over the image, with 'The World is' in a light orange serif font and 'CHANGING' in a large, bold, white sans-serif font.

The World is  
**CHANGING**





# And it's CHANGING FAST

Market  
Transitions

Technology  
Transitions

Economic  
Transitions

In a “share economy” world of “real time” and “co-innovation”,  
the relationship between supplier and customer is blurring.





“The biggest risk is not taking any risk...”

In a world that changing really quickly, the only strategy that is guaranteed to fail is not taking risks.”

Zuck's



# SDN Hard Problems

## Some musings on SDN for EN

### ■ Technology

- Separation of **Control and Data Planes**:
  - ✓ Control Plane Scalability and Resilience
  - ✓ State Management: Logically Centralized?
  - ✓ State Distribution Trade-offs in SDN
    - Control State Consistency ./ Application Optimality
    - Application Complexity ./ Robustness to Inconsistency
  - ✓ Combinatorial **state explosion**: Feasibility, CAP theorem, ...
  - ✓ Control Plane Performance:  
$$\Omega = \text{RTT}(\text{switch} \rightarrow \text{packet}) + \text{pps}(\text{switch}) + \text{pps}(\text{controller})$$
- Hybrid Switch Implications
- Flow Setup Scalability and Performance
- Topology Discovery and response times
- CPUs ./ TCAMs = overlay ./ underlay = state ./ Speed
- **Abstractions**
  - ✓ Sweet spot: Leverage ideas from distributed systems, programming languages, and other areas to bridge the gap between the centralized controller abstraction and the distributed/hierarchical reality
  - ✓ “northbound” + “southbound” abstractions
  - ✓ Forwarding targets – ASICs and TCAMs
- **Policy Controller**
- **Reasoning Systems, Big Data**
- “network as a computer”, network compilers...
- OpenFlow, A Retrospective on Evolving SDN  $\Rightarrow$  MPLS
- [OpenStack](#)

### ■ Sociology

- OF/SDN approach challenges much of our **central dogma**
- Remember QoS **trust boundaries**
- Not the least of which are
  - ✓ Circuits vs. Hop-by-hop forwarding
  - ✓ Centralized ./ Distributed control planes ./ “flow-based”
- **Operational Models**
  - ✓ Operational change is quite substantial (ITIL & ITSM)
  - ✓ How to you build/operate/debug these networks?
  - ✓ **Who is in charge** of creating a 12-tuple?
  - ✓ How to Combine Compute, Storage, Networking and App teams
  - ✓ How to translate **business intent** into policies
  - ✓ Convolution of policy and configuration
- **A solution looking for a problem**
- Controller – Agent – Troubleshooting ./ Single BU
- Have we been **unwilling or unable** to abstract complexity.
- Believe network teams do NOT have the **skills** and experience to implement and manage SDN
- **Influence shift** from from NetOps  $\Rightarrow$  DevOps
- **Is it really about NetOps or more about DEV ./ OPS ?**

### ■ Economics

- Well...all of the above
- **RYF-complex** (Fragile/Robust)
- Product “de-siloing”
- **Does it really become “cheaper”???**

# Lunch and Learn

LALCRS-0006 - APIC-EM - Thursday 18 February 13:00 – 14:15

During lunch on Tuesday, Wednesday and Thursday, you can join Cisco subject matter experts and your peers in these casual conversations about topics of interest to you.

The Lunch and Learn tables are located in the Catering Area in Hall 4.1.

For a full list of topics on each day, go to:

**Cisco** *live!*



<http://cs.co/berlin-lal>



# SDN @ CiscoLive

- Recommended Learning Path on SDN
- 60+ Sessions
  - Technical Seminars
  - Breakout Sessions
  - Hands-on Labs
  - Panel Discussion
- DevNet Zone
- Demos, MTE, Lunch&Learn, Whisper Suites, and more ....

**Cisco**live!

[wolfgang@cisco.com](mailto:wolfgang@cisco.com)



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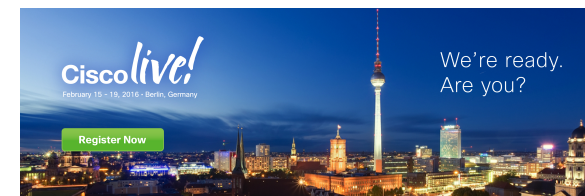
+ Recommended Learning

- SDN
  - ☐ Architectures and Use Cases
  - ☐ Deployment and Virtualization
  - ☐ Network Programming
  - ☐ SDN Overview

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<https://cisco.rainfocus.com/scripts/catalog/cleu16.jsp>

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# Enterprise SDN @ CiscoLive



Monday	Advanced APIC Enterprise Module: SDN Controller for the Campus and Branch - TECSDN-3600
Monday	Enterprise SDN: Architectures and Key Concepts - TECSDN-2602
Monday	Enterprise SDN: Advanced Network Programming - Hands-On Lab TECSDN-3602
Tuesday	APIC-EM: Controller Workflow and Use Cases - BRKARC-3004
Tuesday	IWAN management via APIC-EM (SDN Controller) - BRKSDN-2099
Tuesday	CCIE Skill Transformation to SDN Kungfu Master - BRKSDN-4005
Wednesday	SDN Enabled QoS-A Deep Dive - BRKSDN-2046
Wednesday	Hitchhiker's Guide to Device APIs - BRKSDN-1119
Wednesday	Containers on routers and switches: Run your apps and tools natively on Cisco boxes - BRKSDN-2116
Wednesday	Playing With Your Traffic: Exploring Software-Defined Packet Control - BRKSDN-3014
Wednesday	Cisco Application Policy Infrastructure Controller Enterprise Module (APIC-EM) – Hands on Lab - LTRSDN-1914
Thursday	APIC-EM: The evolution from traditional management to SDN-led, policy-based automation - BRKNMS-2031
Thursday	Cisco Open SDN Controller Hands-on Lab - LTRSDN-1913
Thursday	Deploying Cisco IOS Autonomic Networking Infrastructure - BRKSDN-2047
Thursday	DNS-AS: Done with SDN and Tired of Dealing with Snowflake Network Complexity? Change the Game with a Simple TXT String! - BRKSDN-3004
Friday	Solutions Enablement by Cisco Open SDN Controller - BRKSDN-1020



More SDN Sessions in the Recommended Learning Path

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# Thank you



## Some more fun stuff to watch...

- Fundamentals of Cisco APIC-EM  
<https://www.youtube.com/watch?v=17IDRT9tuWY>
- Metadata-Defined Data Center, Mike Dvorkin, Cisco Systems  
<http://techfieldday.com/appearance/introducing-the-next-generation-sddc-leaders-1>
- Developing OpenDaylight Apps with MD-SAL  
<https://www.youtube.com/watch?v=uBnDJNsd6Qo>
- Application Centric Infrastructure (ACI) Overview  
<http://www.youtube.com/watch?v=VZWwjNAiUpI>
- APIC EM Demo, Apr 2014 - VT Recording  
<http://videosharing.cisco.com/p.jsp?i=10394>
- CCO:  
<http://www.cisco.com/c/en/us/products/cloud-systems-management/application-policy-infrastructure-controller-enterprise-module/index.html?wcmode=preview>

**Cisco** *live!*