



Cisco *live!*

January 29 – February 2, 2018 · Barcelona

Enterprise SDN: Advanced Network Programming - Hands-On Lab



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EN EMEAR



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Distinguished Engineer
TAC



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Systems Engineer
WW EN

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Welcome Aboard

Embrace the Software-Defined Era! Are DevOps, Bimodal IT and dynamic service delivery not just buzzwords for you? Do you need to automate operational behavior? Are Softwareization and Digitization transforming your business? And are those business applications demanding a tighter network integration?

Your Cisco Network and DNA Center provide a wealth of Network Programming and Virtualization capabilities to solve real-life issues and architect network services in a new way. This Technical Seminar uses a combination of hands-on lab exercises, practical examples and minimal background theory to speed up your adoption of network programming capabilities. Step-by-Step lab exercises will familiarize you with key technologies including

- DevOps-style Human Interaction with Spark for ChatOps
- Controller-level policy-based REST APIs with APIC-EM and DNA Center
- Infrastructure-level Scripting and Programmability with Embedded Event Manager (EEM), Guestshell, Tcl and Python Scripting, Yang and RESTCONF

As a bonus, at the end of the day you will have code ready to take back home and put to good use. The session is relevant for architects, network planners and administrators, engineers, DevOps engineers and system integrators.



Welcome Aboard

This Session IS

- a Hands-On Lab
- using Python, Spark, IOS XE, Guest Shell and APIC-EM/DNA Center
- based on real-life Enterprise Examples
- Fun ☺

This Session IS NOT

- an introduction to SDN concepts
- a DNA or SDA overview
- a roadmap update
- a product deep dive



Agenda

- Welcome and Introduction
- Focus I
Infrastructure Level Scripting
- Focus II
Programmability and Guestshell
- Focus III
Controller Level APIs
- Summary and Close

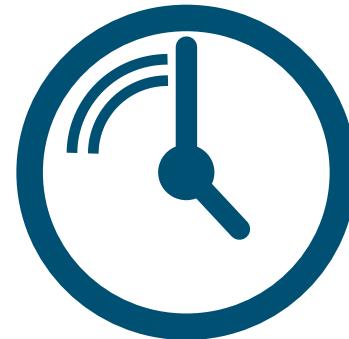
For each Focus Area

- (very!) Brief Introduction
- Hands-On Lab
- Wrap-Up



Schedule

08:45 – 10:45 Morning Part I
10:45 – 11:00 Coffee Break
11:00 – 13:00 Morning Part II
13:00 – 14:30 Lunch
14:30 – 16:30 Afternoon Part I
16:30 – 16:45 Coffee Break
16:45 – 18:45 Afternoon Part II



Cisco Spark

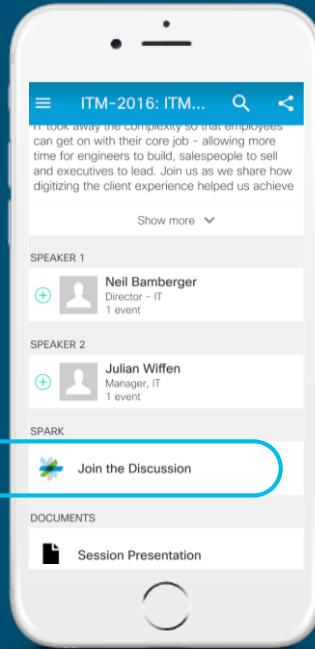


Questions?

Use Cisco Spark to communicate with the speaker after the session

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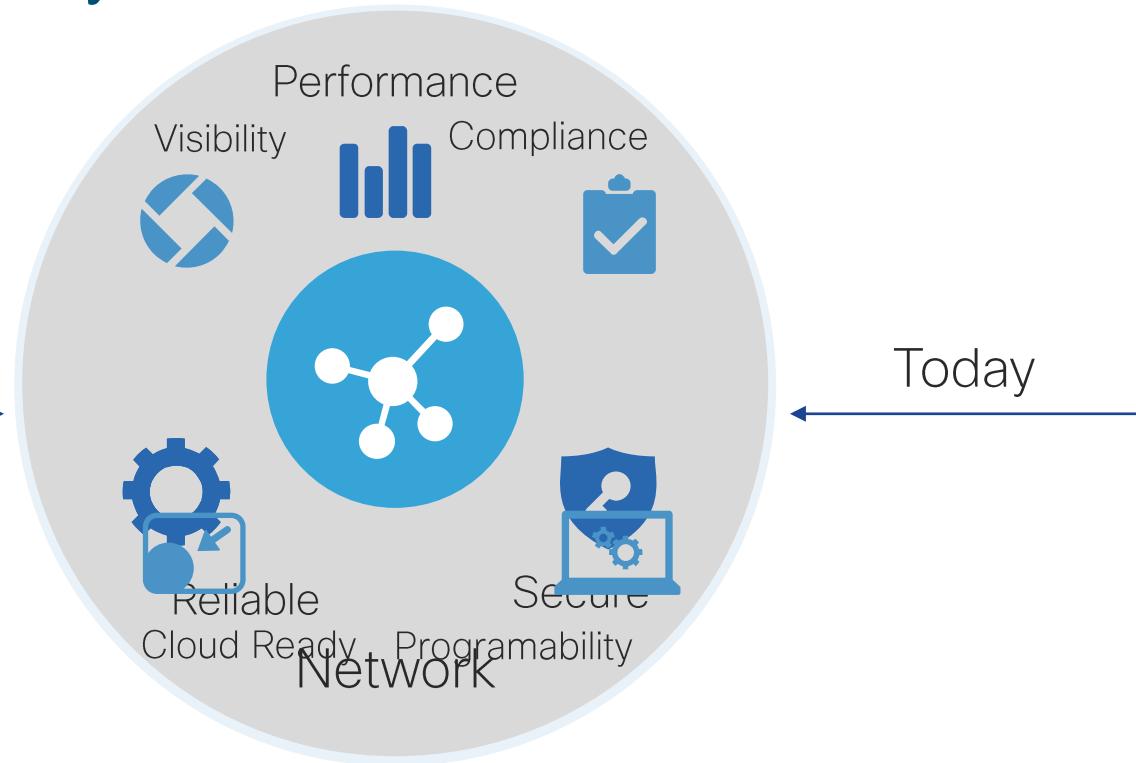
We are using 2 Spark Rooms

- Humans: <http://cs.co/ciscolivebot#TECSDN-3602>
- Scripts: <https://eurl.io/#S1dWarL4f>

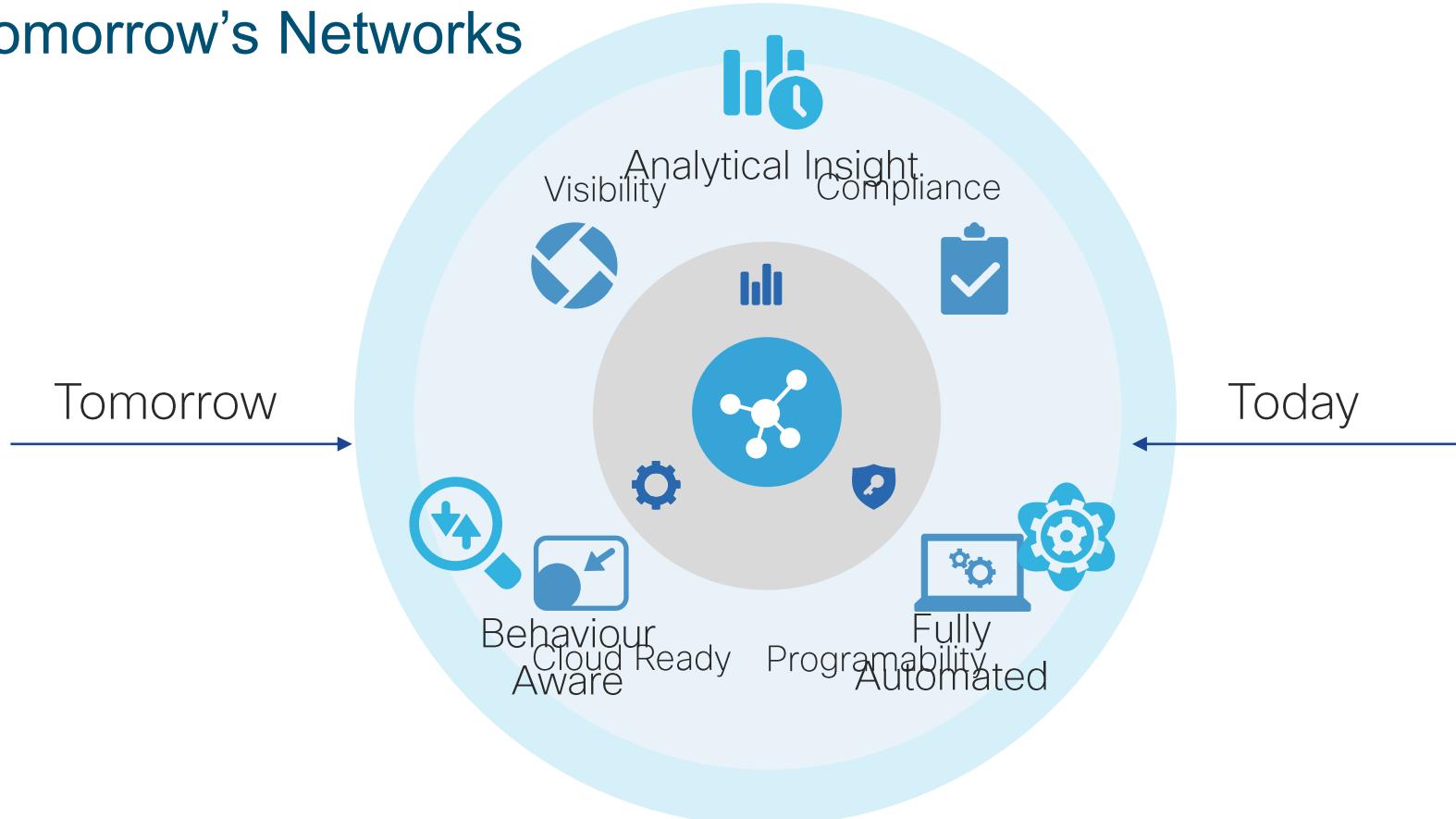
Yesterday's → Today's Networks

Yesterday's Network

Today



Tomorrow's Networks

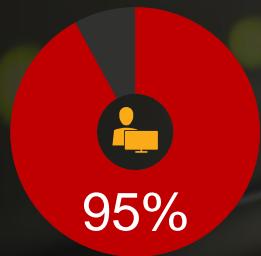


Cost and Operational Challenges

*

\$60B Spent on Network Operations Labor and Tools

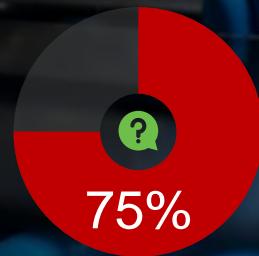
Why are companies spending so much?



Network Changes
Performed Manually



Policy Violations
Due to Human Error

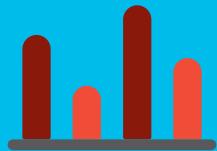


OpEx Spent on Network
Changes and Troubleshooting

* Source: McKinsey study conducted for Cisco in 2016

Traditional Networking CANNOT Keep Pace with the Demands of Digital Business

43% of IT Time is Spent on Troubleshooting



4x

Network operators
spend more time collecting
data than analyzing
while troubleshooting



Replication challenge

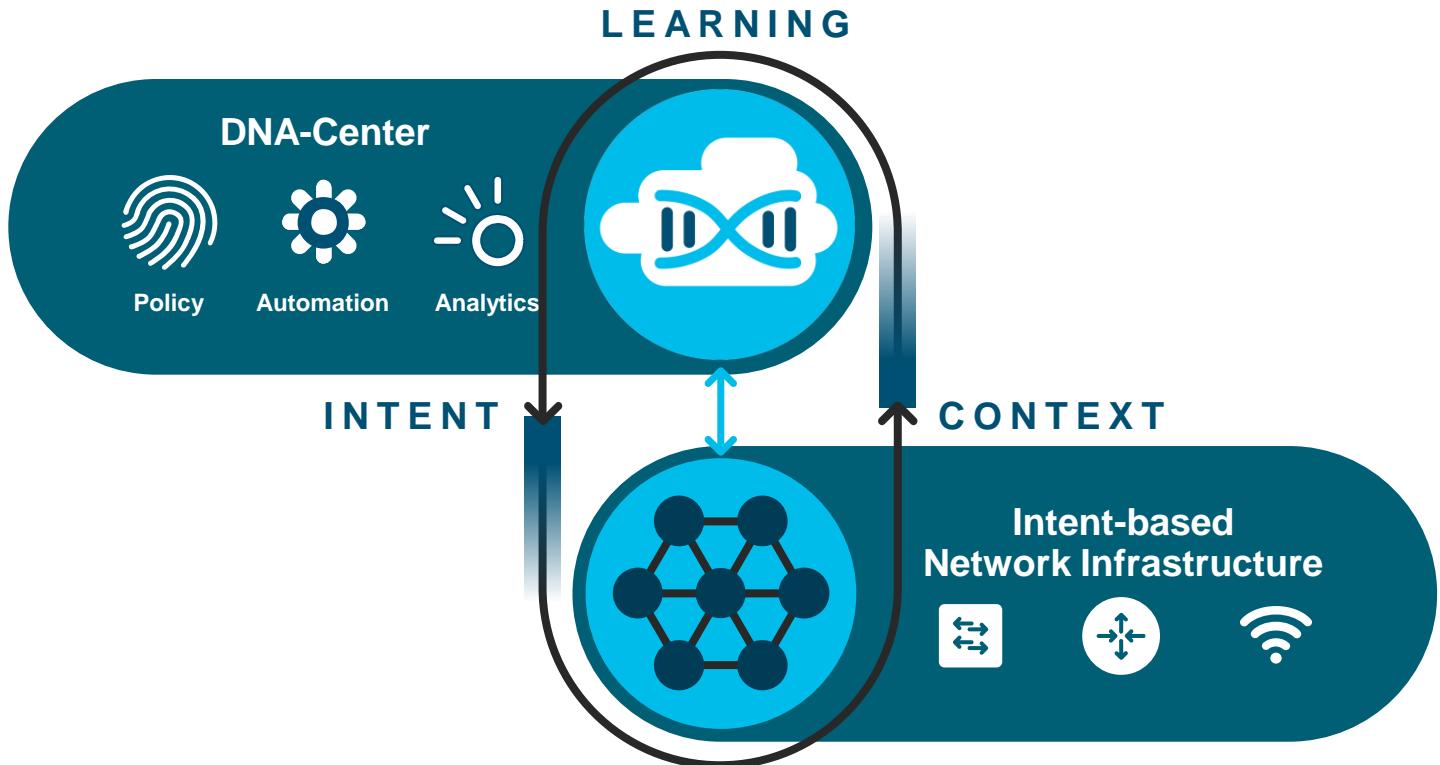
Troubleshooting an issue
can be impossible if IT can't
replicate the issue
or see the issue as it
happening real time



Slow Resolution

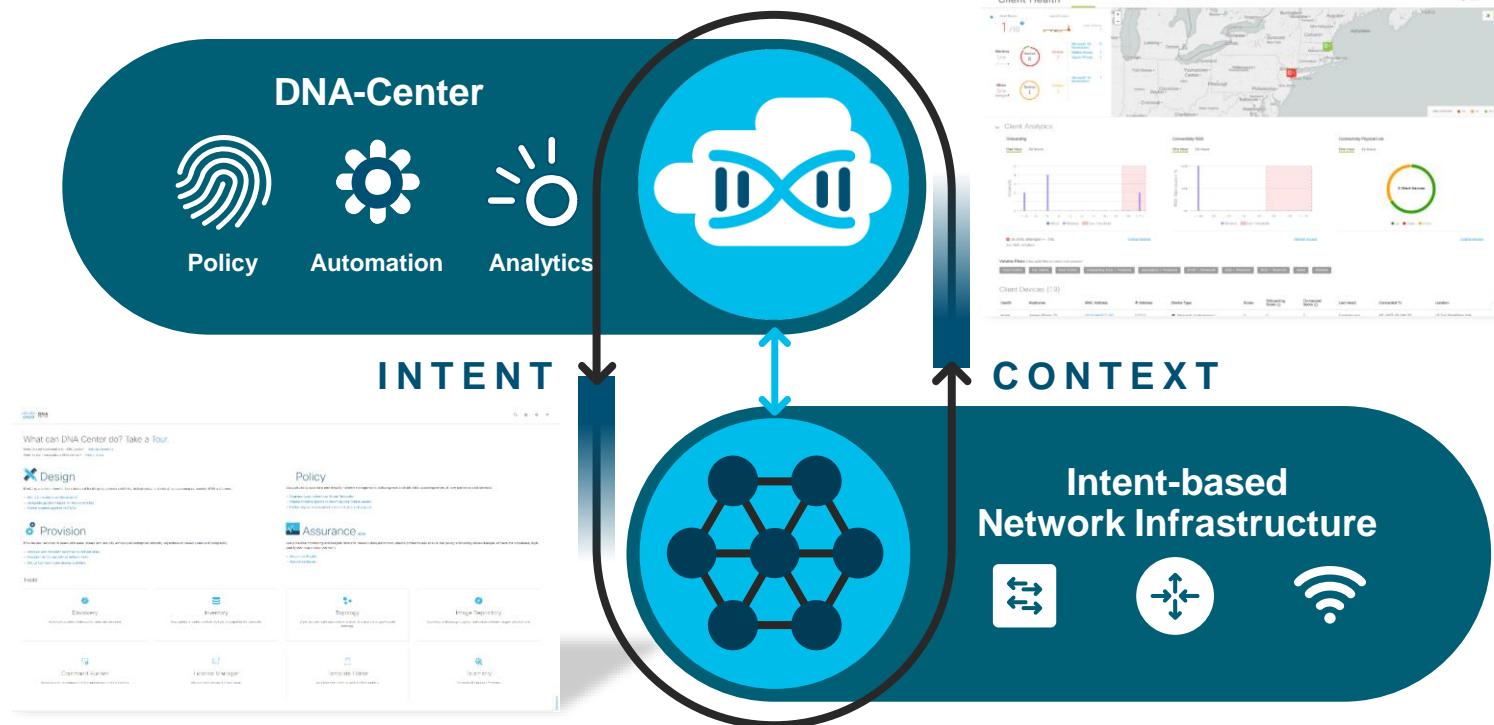
Downtime is expense;
unplanned downtime
cost Fortune 1000
\$1.25-2.5B annually

The Network. Intuitive.

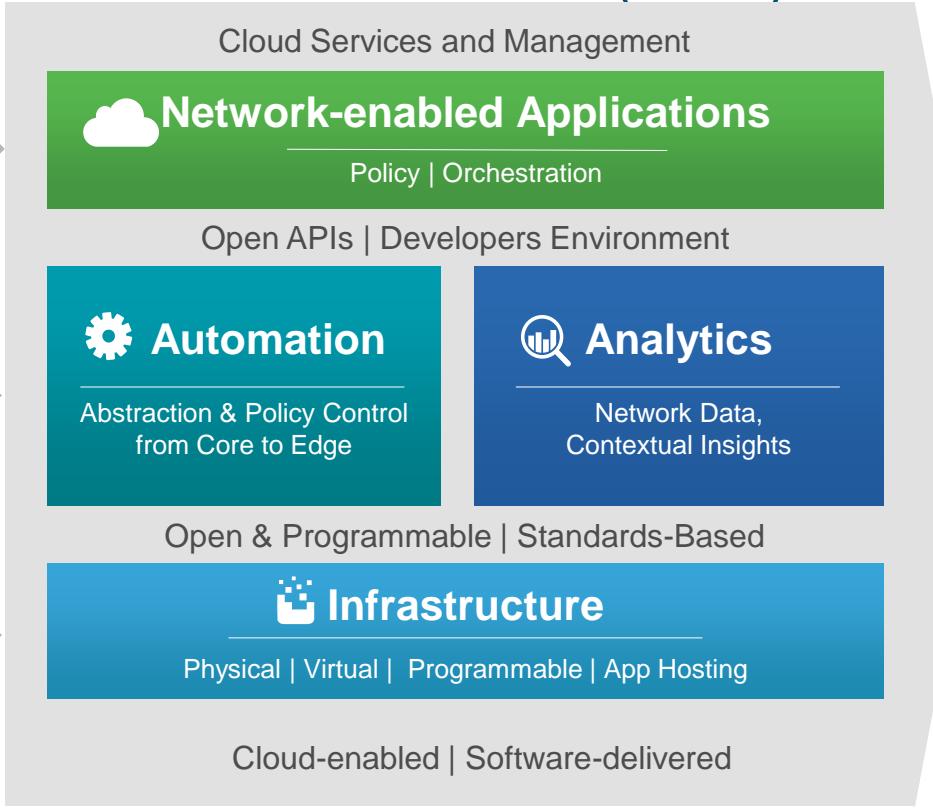
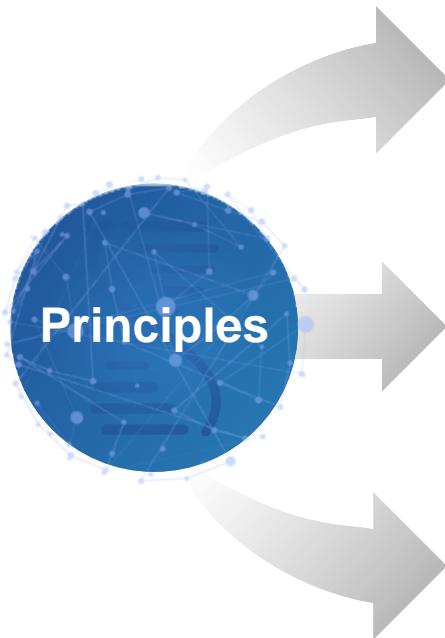


Design – Policy – Provision – Assure

LEARNING

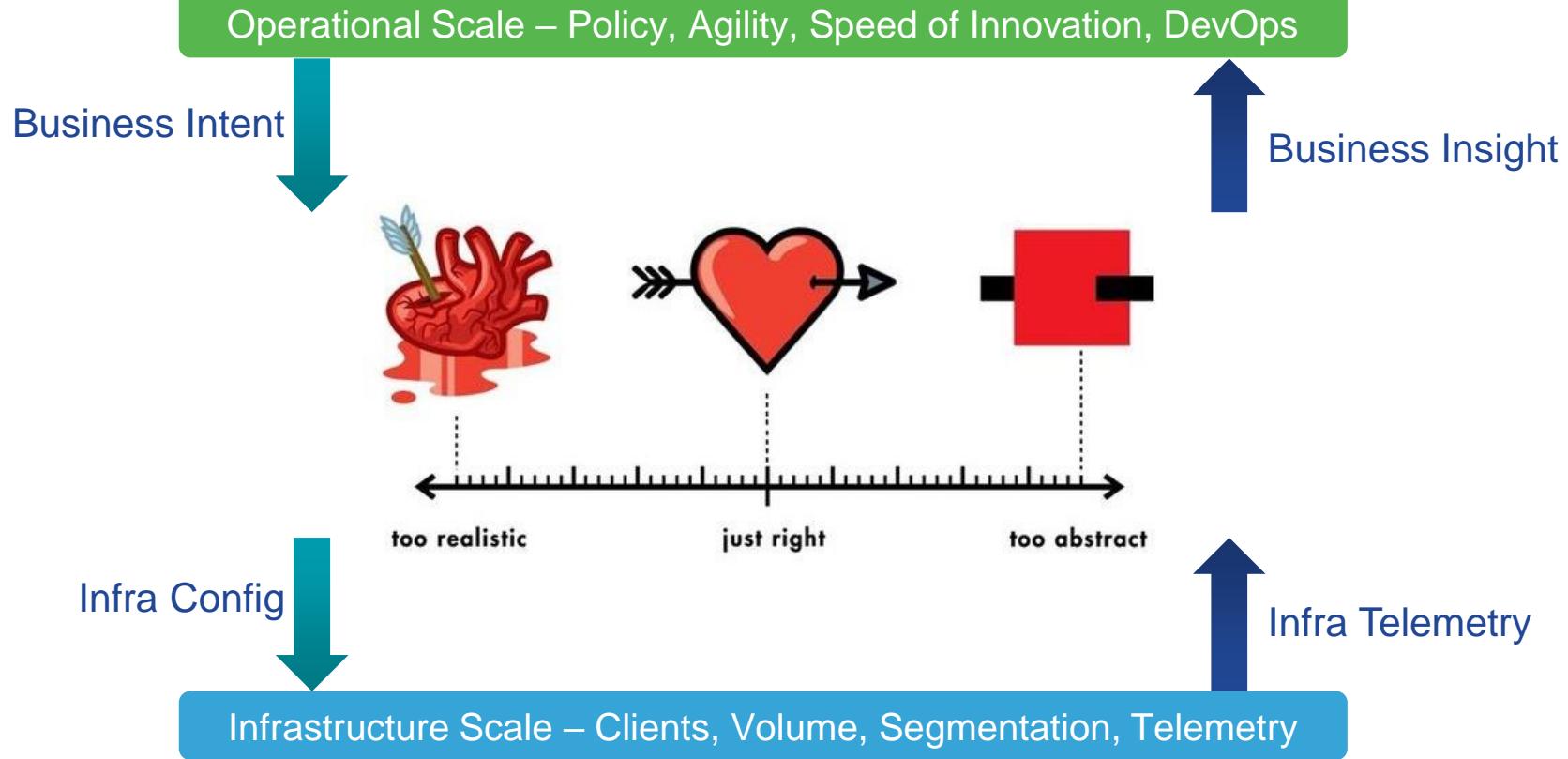


Cisco Digital Network Architecture (DNA)

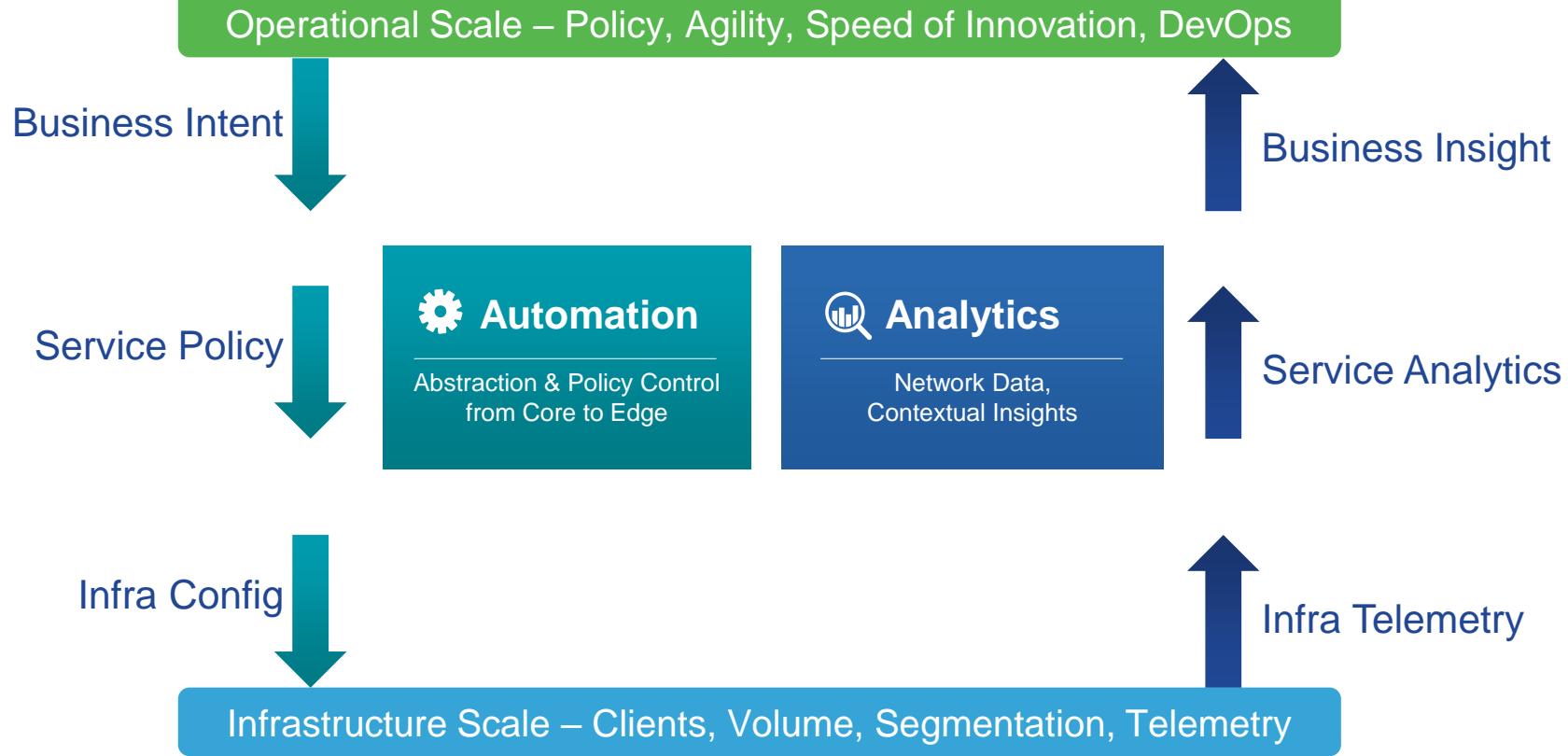


- Analytics & Insights**
- Automation & Assurance**
- Security & Compliance**

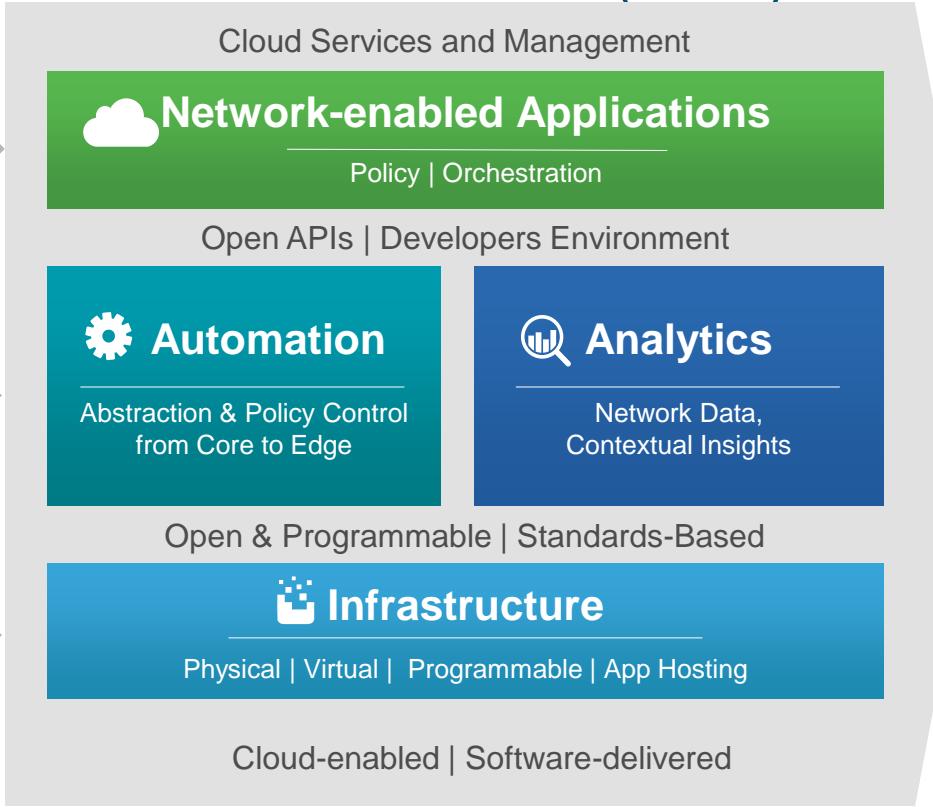
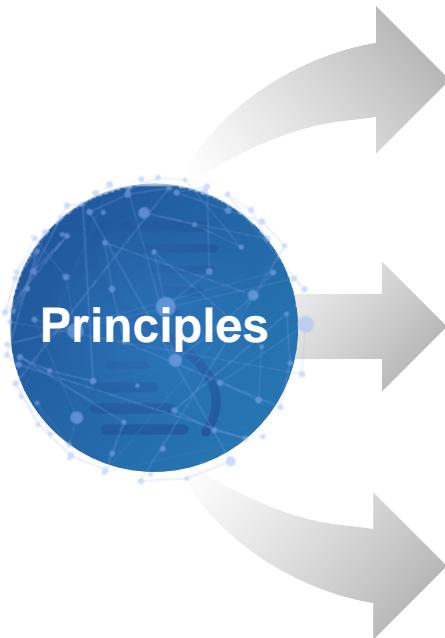
DNA – Abstraction Boundaries



DNA – Abstraction Boundaries



Cisco Digital Network Architecture (DNA)



-  **Analytics & Insights**
-  **Automation & Assurance**
-  **Security & Compliance**

DNA – Open and Programmable

Cloud Services and Management

Policy | Orchestration

Open APIs | Developers Environment

Abstraction & Policy Control
from Core to Edge

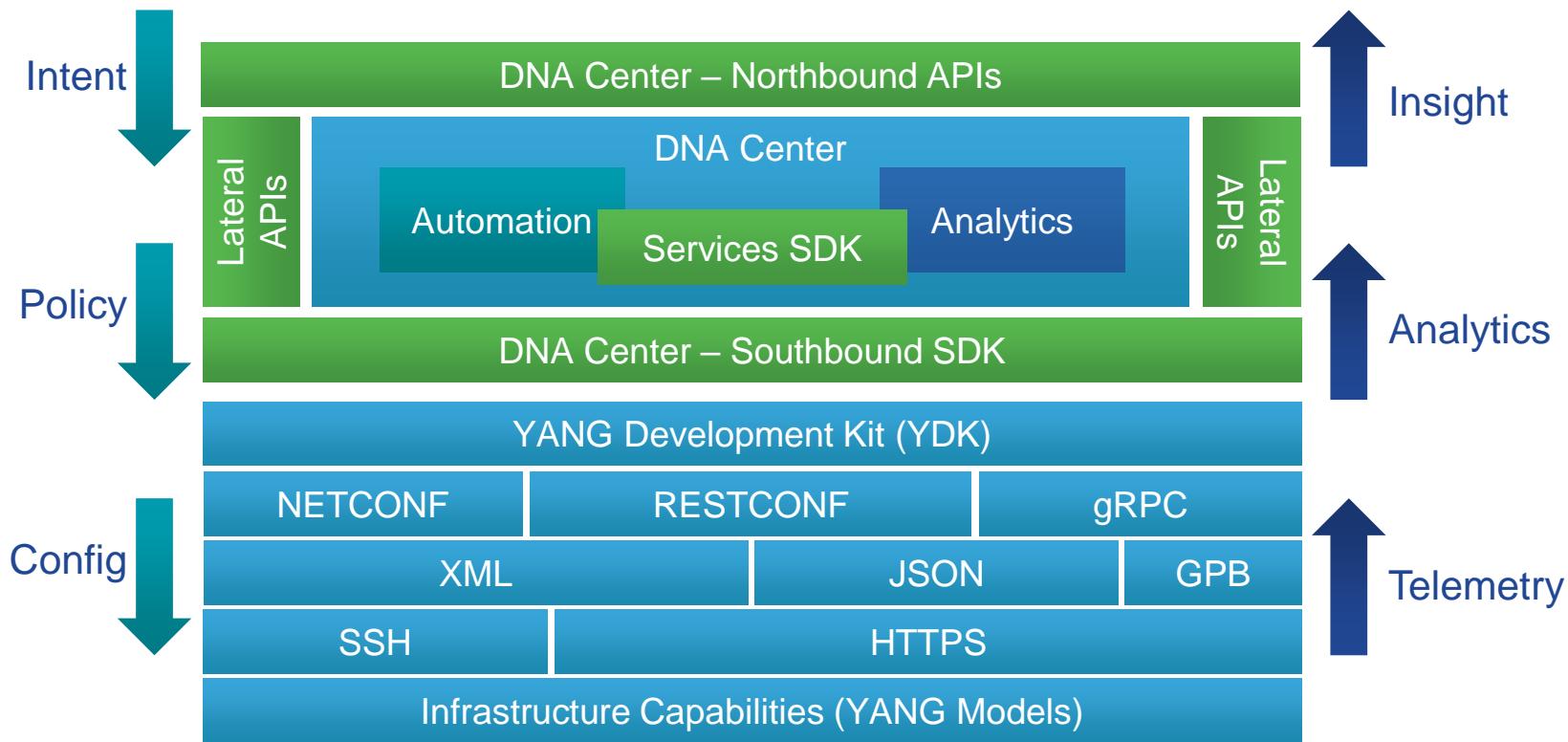
Network Data,
Contextual Insights

Open & Programmable | Standards-Based

Physical & Virtual Infrastructure | App Hosting

Cloud-enabled | Software-delivered

DNA – Model Drive Programmability



*“Civilization advances
by extending the number of
important operations
which we can perform
without thinking about them.”*

Alfred North Whitehead,
Mathematician and Philosopher

There has never been a better Time for Software Practice



Software solutions	Software licensing	Lifecycle advisory services ²	Software development
<ul style="list-style-type: none">Monetize with DNA software capabilities	<ul style="list-style-type: none">Tap into LoB OpEx budget with Cisco ONE™ subscription	<ul style="list-style-type: none">Differentiate with professional services and asset management	<ul style="list-style-type: none">Build joint solutions with open APIs and Cisco® DevNet Zone

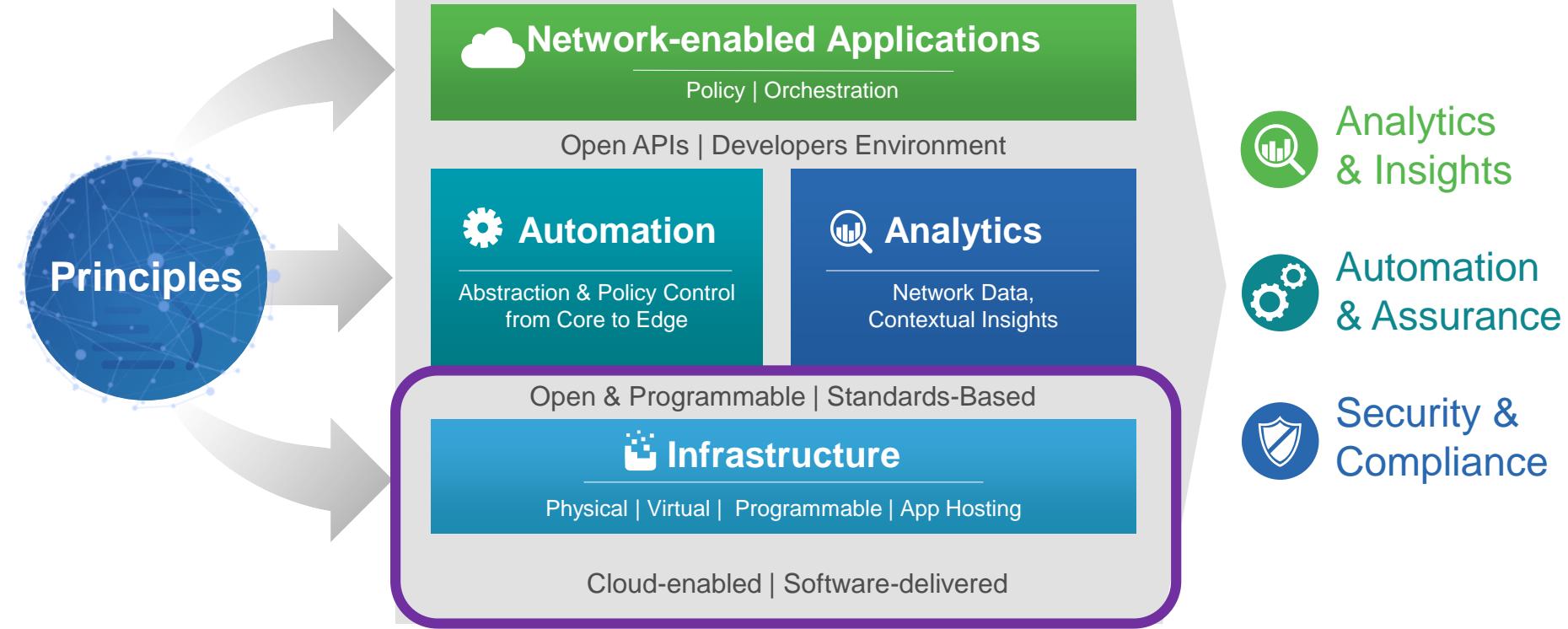
¹Source: [Gartner](#) | ²For Select Partners

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Cisco Digital Network Architecture (DNA)



Lab I

Setup Your Lab

1. Join both Spark Rooms
 - “TECSDN-3602: Enterprise SDN: Advanced Network Programming - Hands-On Lab”
 - “CLEU18 TECSDN-3602 Lab”
2. Follow “Get Started” Task
3. Follow “Prepare the Lab Environment” Task

Complete an IOS Task

1. The “IOS EEM Change Port Description Based on CDP Neighbor” Task is a great start ...

Get Started Prepare the Lab Environment

Scenario 1: DevOps Style Human Interaction

- Cisco Spark REST APIs: Find Room and Post
- NeXt UI: DevNet Tutorials
- NeXt UI: Hello Topology
- NeXt UI: Grouping of Nodes
- NeXt UI: Visualize Path Info from APIC-EM
- Tropo Scripting APIs: Text-to-Speech and IVR

Scenario 2: Device-Level Programmability and Virtualization

- IOS EEM: Change Port Description Based on CDP Neighbor
- IOS EEM: Assign Static IP If DHCP Fails
- IOS EEM: Force a Failover Based on IPSLA-Reported Latency
- IOS-XE Guestshell: Enable Guestshell
- IOS-XE Guestshell: Python interpreter
- IOS-XE Guestshell: Prepare Python environment
- IOS-XE Guestshell: Python packaging
- IOS-XE Guestshell and EEM: Record commands to the database
- IOS-XE Guestshell: Outputs collector
- IOS-XE Guestshell and EEM: Config Diff To Spark
- IOS-XE NETCONF: Configure an ACL
- IOS-XE RESTCONF: Configure an ACL
- IOS-XE RESTCONF: Operational data to Spark

Scenario 3: Controller-Level Programmability

- Device Count in APIC-EM Inventory
- Path Trace via APIC-EM REST APIs

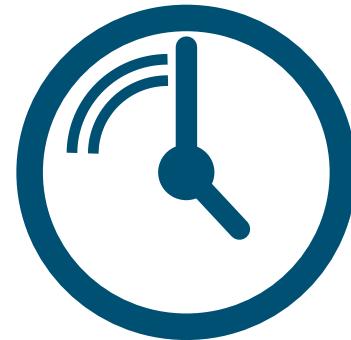
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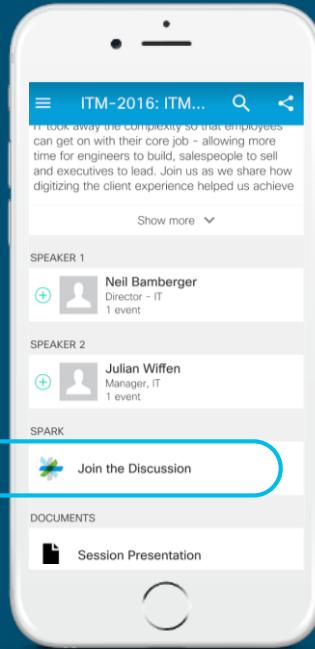


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Sample Code in GIT

Lab Examples are in GIT

1. A GIT Clone Request has already been done on the Windows Workstation in dCloud

see: C:\Users\administrator\Documents\GitHub\enterprise-network-programmability

2. Update to the latest code using git pull

> **git pull origin master**

3. Remember to copy your own work before leaving this session

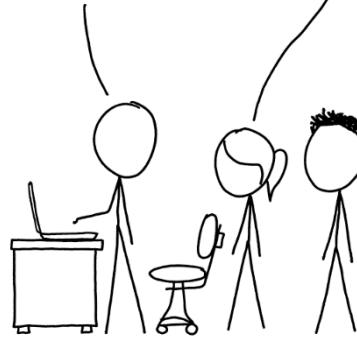
github.com/xorrkaz/enterprise-network-programmability

Cisco **live!**

THIS IS GIT. IT TRACKS COLLABORATIVE WORK ON PROJECTS THROUGH A BEAUTIFUL DISTRIBUTED GRAPH THEORY TREE MODEL.

COOL. HOW DO WE USE IT?

NO IDEA. JUST MEMORIZE THESE SHELL COMMANDS AND TYPE THEM TO SYNC UP. IF YOU GET ERRORS, SAVE YOUR WORK ELSEWHERE, DELETE THE PROJECT, AND DOWNLOAD A FRESH COPY.



```
>git pull origin master
...
network-programmability
  ID
  master
```

```
Updating a097b7b..2a010e9
Fast-forward
  .gitignore
  tasks/Hello-Lab.py
  tasks/constants.py
  tasks/env.py
  tasks/guestshell/dna/scripts/__init__.py
  tasks/guestshell/dna/scripts/record_commands.py
  tasks/guestshell/setup.py
  tasks/helper.py
  tasks/netconf/__init__.py
  tasks/{netconf-acl/nc-acl.py => netconf/acl.py}
  tasks/requirements.txt
  tasks/restconf/__init__.py
  tasks/restconf/acl.py
  tasks/restconf/interface_stats.py
  14 files changed, 732 insertions(+), 54 deletions(-)
```

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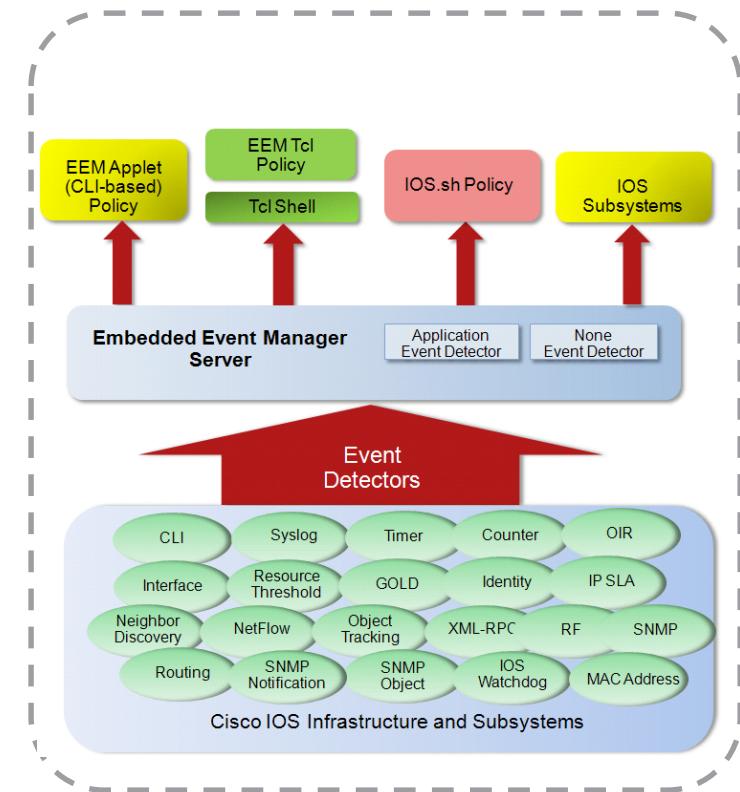
Infrastructure Perspective



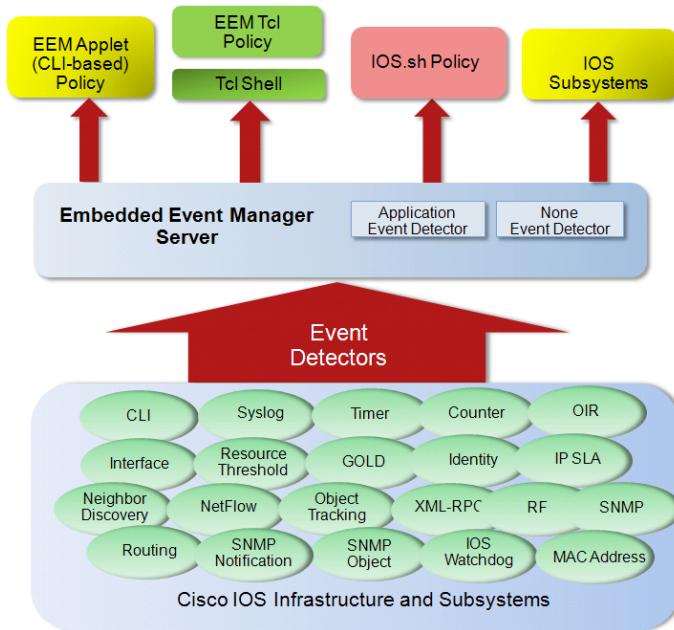
Scripting

Embedded Event Manager

- Extremely flexible and powerful subsystem within Cisco IOS Software
- Adapt device behavior and insert custom logic without IOS upgrade
- Multiple Event Detectors (ED) integrated with IOS modules for wide range of system event detection
- CLI, Tcl and Python based policy provides consistent programmability interface
- Powerful event engine supporting multi-event correlation, advance scheduling and more



1 + 1 > 2



Python

+ guestshell

(from 16.5 / 16.3.1)

EEM and Python

- Uses Python 2.7 interpreter
- Similar config to EEM Tcl scripts
 - Same event specification syntax
 - Similar built-in methods for syslog, CLI execution, SNMP traps, etc.
- Python scripts run under a **guestshell** container
- Support for a number of built-in Python modules
 - **smtplib** : send email
 - **json** : encode/decode JSON data
 - **SSL/TLS** support
 - **sqlite3** : Local SQL-based database

Interacting with Humans DevOps Style

Example: Spark

Interacting With Humans – ChatOps

```
TEXT = '**{} > {}** : {} | {} ()'

TEAM_NAME = 'CL17-Infra_team'
ROOM_NAME = 'Data Center Alarms'

headers = {
    'authorization': SPARK_TOKEN,
    'content-type': 'application/json'
}

# Get the Spark team ID

url = SPARK_API + 'teams'

try:
    response = requests.request('GET', url, headers=headers, verify=False)
    response.raise_for_status()
except Exception as e:
    print('Error retrieving teams: {}'.format(e))
    sys.exit(1)

team_id = None
for team in response.json()['items']:
    if team['name'] == TEAM_NAME:
        team_id = team['id']
        break

if team_id is None:
    print('Error finding team ID for {}'.format(TEAM_NAME))
    sys.exit(1)

# Get the Spark room ID

url = SPARK_API + 'rooms'

try:
    response = requests.request('GET', url, headers=headers, params={
        'teamId': team_id, verify=False})
    response.raise_for_status()
except Exception as e:
    print('Error retrieving room for team {}: {}'.format(TEAM_NAME, e))
    sys.exit(1)

room_id = None
for room in response.json()['items']:
    if room['title'] == ROOM_NAME:
        room_id = room['id']
        break
```



Teams / CL17-Infra_team

Spaces Members

+ New space

G General

D Data Center Alarms



Data Center Alarms
CL17-INFRA_TEAM

This starts the 'Data Center Alarms' space. Tuesday, 11:34

You added Live NOC Bot to this space. Tuesday, 12:59

Live NOC Bot Tuesday, 14:07
Test > CL-FREEBSD : "This is a test"

Live NOC Bot Tuesday, 14:08
Test > CL-FREEBSD : "This is a test"

Live NOC Bot Tuesday, 15:01
VM Health > CL-FREEBSD : Alarm 'VM Health' on CL-FREEBSD changed from Green to Red

Live NOC Bot Tuesday, 15:12
VM Health > CL-FREEBSD : Alarm 'VM Health' on CL-FREEBSD changed from Green to Red (Current values for metric/state)

Wednesday

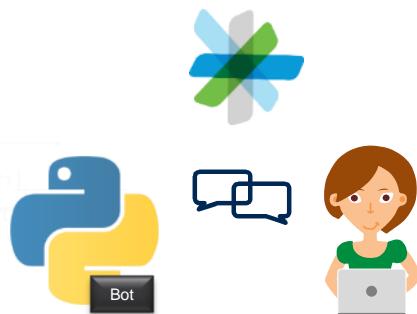
Phil Bridges joined this space. Wednesday, 09:23

Live NOC Bot Wednesday, 12:41
Video Surveillance DS > VIDEO_SURV : Alarm 'Video Surveillance DS' on VIDEO_SURV changed from Gray to Yellow

Live NOC Bot Wednesday, 12:54
034 Datastore Health > 034_NFS : Alarm '034 Datastore Health' on 034_NFS changed from Gray to Yellow

Live NOC Bot Wednesday, 12:59
Video Surveillance DS > VIDEO_SURV : Alarm 'Video Surveillance DS' on VIDEO_SURV changed from Gray to Yellow | Metric Disk Space actually used = 99% OR State = True (([Yellow metric Is above 90%; Red metric Is above 100%] OR [Red state Is equal to False]))

Example: ChatOps with Humans Bots



DHCP Queries
CL17-INFRA_TEAM

about the IP. Some question might be, @Live Noc Bot who has lease 1.2.3.4 or @Live Noc Bot what lease does 00:11:22:33:44:55 have.

You 04:32
Live Help

Live Noc Bot 04:32
To lookup a reservation, type @Live Noc Bot reservation IP. To lookup a lease by MAC, ask about the MAC. To lookup a lease by IP ask about the IP. Some question might be, @Live Noc Bot who has lease 1.2.3.4 or @Live Noc Bot what lease does 00:11:22:33:44:55 have.

You 04:33
Live Help

Live Noc Bot 04:33
To lookup a reservation, type @Live Noc Bot reservation IP. To lookup a lease by MAC, ask about the MAC. To lookup a lease by IP ask about the IP. Some question might be, @Live Noc Bot who has lease 1.2.3.4 or @Live Noc Bot what lease does 00:11:22:33:44:55 have.

You 06:12
Live Who has 172.16.10.40

Live Noc Bot 06:12
I did not find a lease for 172.16.10.40.

You 06:33
Live Who is 10.100.252.34

Live Noc Bot 06:33
I did not find a lease for 10.100.252.34.

You 06:34
Live Who is 10.100.252.43?

Live Noc Bot 06:34
10.100.252.43 is leased by a client with name **jamahal** and MAC **1:6:f4:0f:24:21:b0:af** in scope CORE-WIRELESS-MGMT.

Human: @Bot Who has the lease for 10.100.252.43?

Bot: 10.100.252.43 is leased by ...

Interacting with Humans – ChatOps



Problem: What if your Ops users are road warriors, managers and remote workers?

Real-World Example

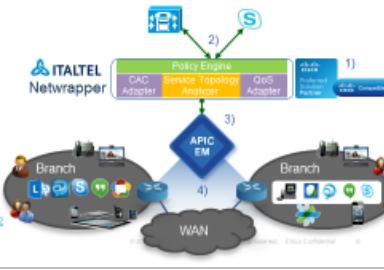
Example: Dynamic Admission Control

Problem: How to consistently and predictably implement dynamic call admission control (DAC) policies on top of an IP network, across campus and branches, supporting multiple communication and collaboration technologies ?

Solution: Leverage DNA and APIC-EM capabilities to integrate with communication and collaboration controllers

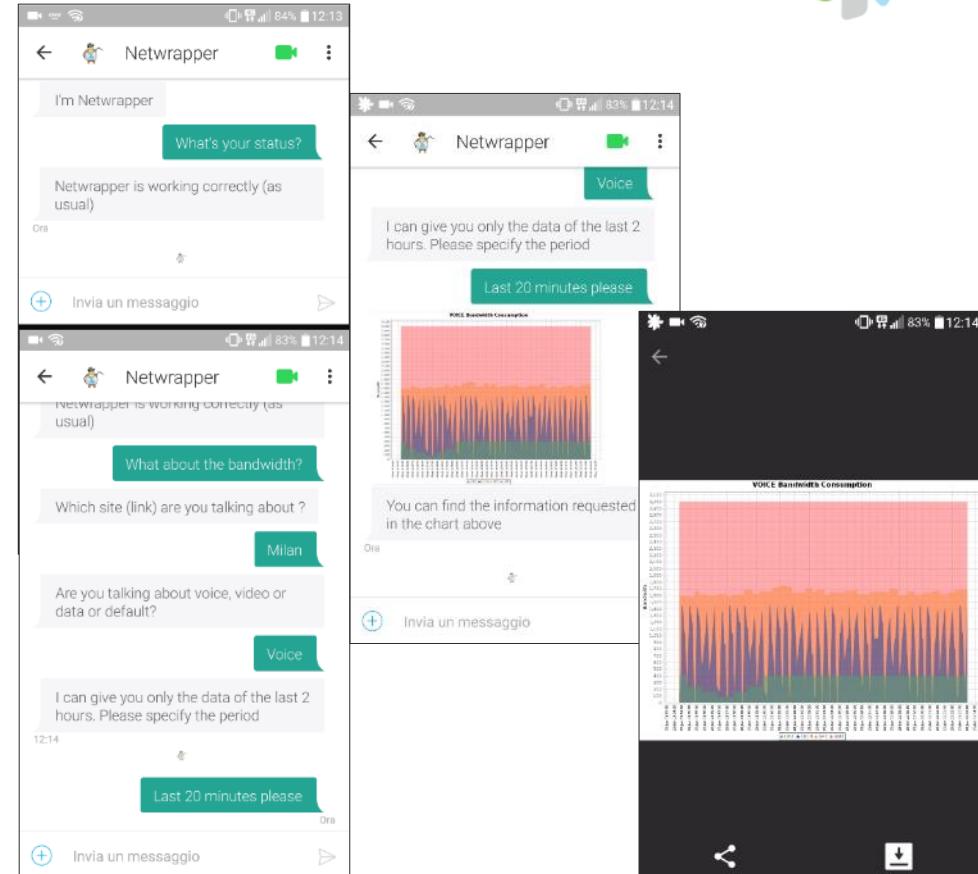
- 1) Define Admission Control Policies in Netwrapper
- 2) Integrate with Communication Controllers (Skype4Business, Cisco CUCM, ...)
- 3) Integrate with APIC-EM NIB and Easy QoS
- 4) Communicate and Operate with predictable QoS and SLA

See: www.italtel.com/products/sdn-monitoring-automation
<https://www.cisco.com/collaboration-computing/white-papers/white-paper-2>



Solution: ChatOps – Integrate via Cisco Spark REST APIs and/or Tropo.com

See also Italtel's both @ WoS





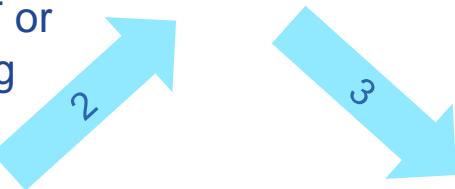
Spark API GET vs. Webhooks vs. Bots



1. User's Clients interact with the Spark Service



2. Scripts and Apps can GET or POST messages by calling the Spark API



```
1 from ciscosparkapi import CiscoSparkAPI
2
3 api = CiscoSparkAPI()
4
5 # Retrieve all Spark room information
6 all_rooms = api.rooms.list()
7
8 # Retrieve and print all room titles
9 room_titles = [room.title for room in all_rooms]
10 print("Here are your rooms!")
11 for room_title in room_titles:
12     print(room_title)
```



4. Apps which interact with other users via Spark can register as Bots – much like humanoids

See: <https://depot.ciscospark.com/>



3. A webhook allows an App to subscribe for Notifications from Spark in real time

```
{
  "name": "New message in 'Project Unicorn' room",
  "targetUrl": "http://example.com/spark-hook",
  "resource": "messages",
  "event": "created",
  "filter": "roomId=Y2lzY29zcGFyazovL3VzL1JPT00vYmJjZWIxYWQtNDNmMS0zYjU4LTkxNDctZjE0YmIwYzRkMTU0"
```

Cisco Spark for Developers



Developer Portal



Interactive Docs



24/7 Dev Support



Server SDKs

The screenshot shows the homepage of the Cisco Spark for Developers website. At the top right are links for Documentation, Blog, Support, and Log In. The main headline reads "Your team. Your tools. Your work." with the subtext "Bring them together, wherever they are, through Spark." Below this is a "Get Started" button. The background features a cityscape with a cloud containing various app icons like Trello, pd, IFTTT, GitHub, and Stripe. At the bottom, there are three call-to-action buttons: "Explore" (with a magnifying glass icon), "Share" (with a document icon), and "Create" (with a wrench icon). Each button has a brief description below it: " Dive into the Documentation to quickly find what you need.", " Show off your work or find inspiration from others in the Forum.", and " Open to integration, Spark gives you the tools to build your own apps".

PSO
CRS-
3114
<https://developer.ciscospark.com/>

Interacting with Humans – Spark



Problem: How to post instant information to a chat room and/or interact?

Solution: Use the Cisco Spark REST APIs

- Login to developer.ciscospark.com
- Copy Access Token
- Query Rooms
developer.ciscospark.com/endpoint-rooms-get.html
- Copy Room ID
- Post 😊



A screenshot of the Cisco Spark developer portal showing a user profile and an access token. The token is displayed as a long string of characters: nM0ODNmZTAtNDgy. To the right of the token is a green 'Copy' button. Below the token is the text 'My Access Token'. A large red arrow points from the 'Copy' button towards the code block below.

```
SPARK_HEADERS = {'Content-type': 'application/json',
                 'Authorization': 'Bearer YOUR-ACCESS-TOKEN'}

msg = json.dumps({'roomId': SPARK_ROOM,
                  'text':'Hello Spark'})

q = requests.post('https://api.ciscospark.com/v1/messages',
                  data=msg,
                  headers=SPARK_HEADERS)
```



A decorative graphic consisting of two curved arrows, one red and one green, that sweep across the bottom right corner of the slide.

Spark Supports Markdown



You 15.12.2016 15:35

Hello DevNet Express [Netherlands], my APIC-EM at <https://198.18.129.100/api/v1> manages 14 devices. The physical topology is:

1	Source	Source Interface	Target Interface	Status
2				
3	AP7081.059f.19ca	GigabitEthernet0	GigabitEthernet1/0/26	up
4	CAMPUS-Access1	GigabitEthernet1/0/2	GigabitEthernet5/5	up
5	CAMPUS-Core2	GigabitEthernet1/1	GigabitEthernet5/7	up
6	CAMPUS-Core1	TenGigabitEthernet1/5	TenGigabitEthernet3/1	up
7	CAMPUS-Dist1	GigabitEthernet5/48	GigabitEthernet5/48	up
8	CAMPUS-Dist1	GigabitEthernet5/38	GigabitEthernet0/0/1	up
9	Branch-Access1	GigabitEthernet1/0/2	GigabitEthernet0/2	up
10	cloud node	unknown	unknown	up
11	CAMPUS-Core1	GigabitEthernet1/1	GigabitEthernet5/7	up
12	CAMPUS-Access1	GigabitEthernet1/0/1	GigabitEthernet5/5	up
13	CAMPUS-Core2	TenGigabitEthernet1/5	TenGigabitEthernet3/1	up
14	CAMPUS-Router1	GigabitEthernet0/0/2	GigabitEthernet0/0/2	up
15	CAMPUS-Core2	GigabitEthernet1/3	GigabitEthernet0/0/1	up
16	CAMPUS-Core1	GigabitEthernet1/3	GigabitEthernet0/0/0	up
17	cloud node	unknown	unknown	up
18	Branch-Access1	GigabitEthernet1/0/1	GigabitEthernet0/2	up
19	Branch-Router1	GigabitEthernet0/1	GigabitEthernet0/1	up
20	cloud node	unknown	unknown	up



FYI

Spark API Python Wrapper

There is now a Pythonic wrapper for the Spark API!

- You no longer have to work directly with the requests Python module
- The ciscosparkapi package hides low level implementation details
- <http://ciscosparkapi.readthedocs.io/en/latest/>

```
1 from ciscosparkapi import CiscoSparkAPI
2
3 api = CiscoSparkAPI()
4
5 # Retrieve all Spark room information
6 all_rooms = api.rooms.list()
7
8 # Retrieve and print all room titles
9 room_titles = [room.title for room in all_rooms]
10 print("Here are your rooms!")
11 for room_title in room_titles:
12     print(room_title)
```



```
$ python test_spark_api.py
```

```
Here are your rooms!
```

```
Support Bot
```

```
DevNet CiscoLive
```

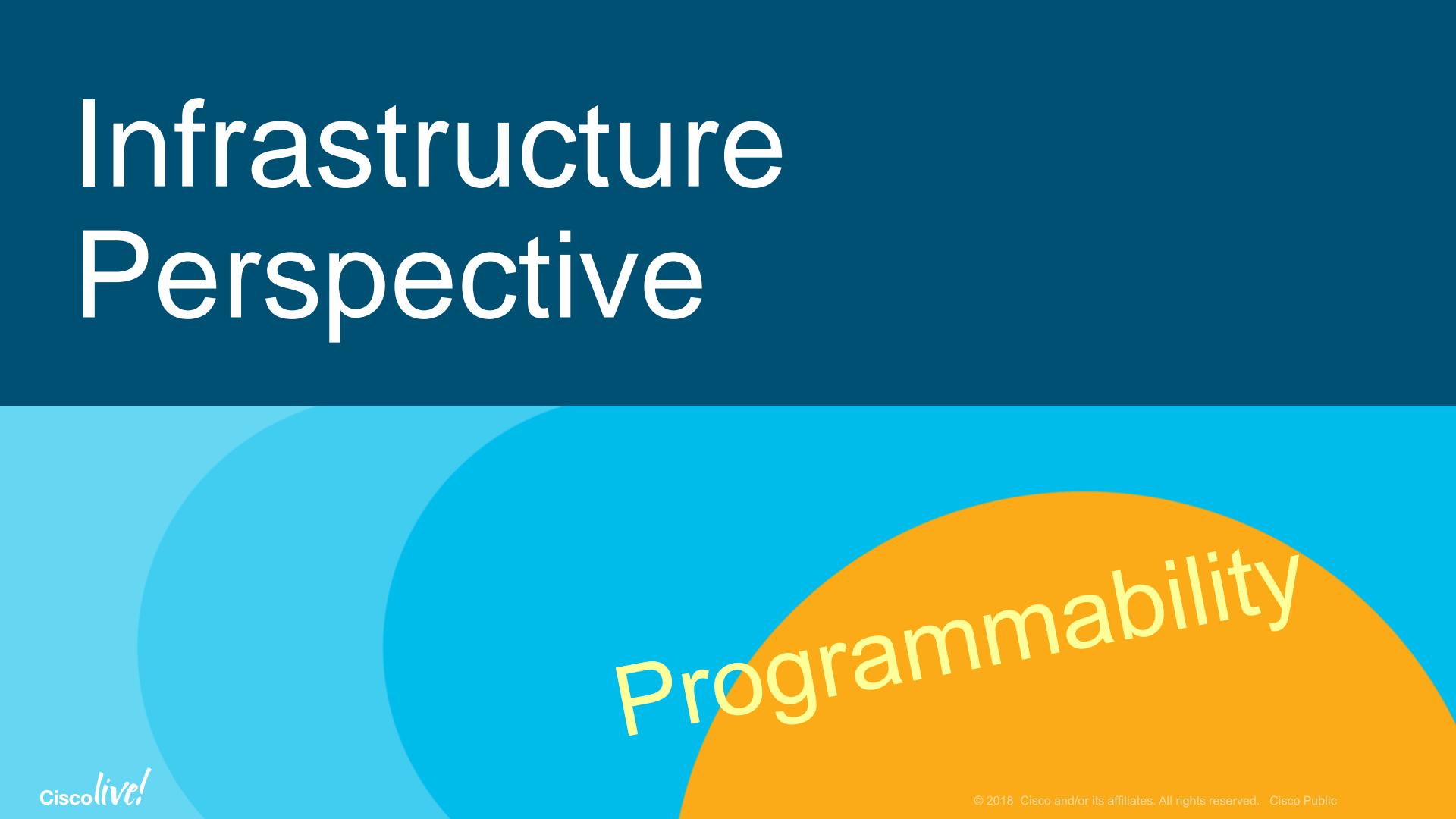
```
Sample Room
```

```
.
```

```
.
```

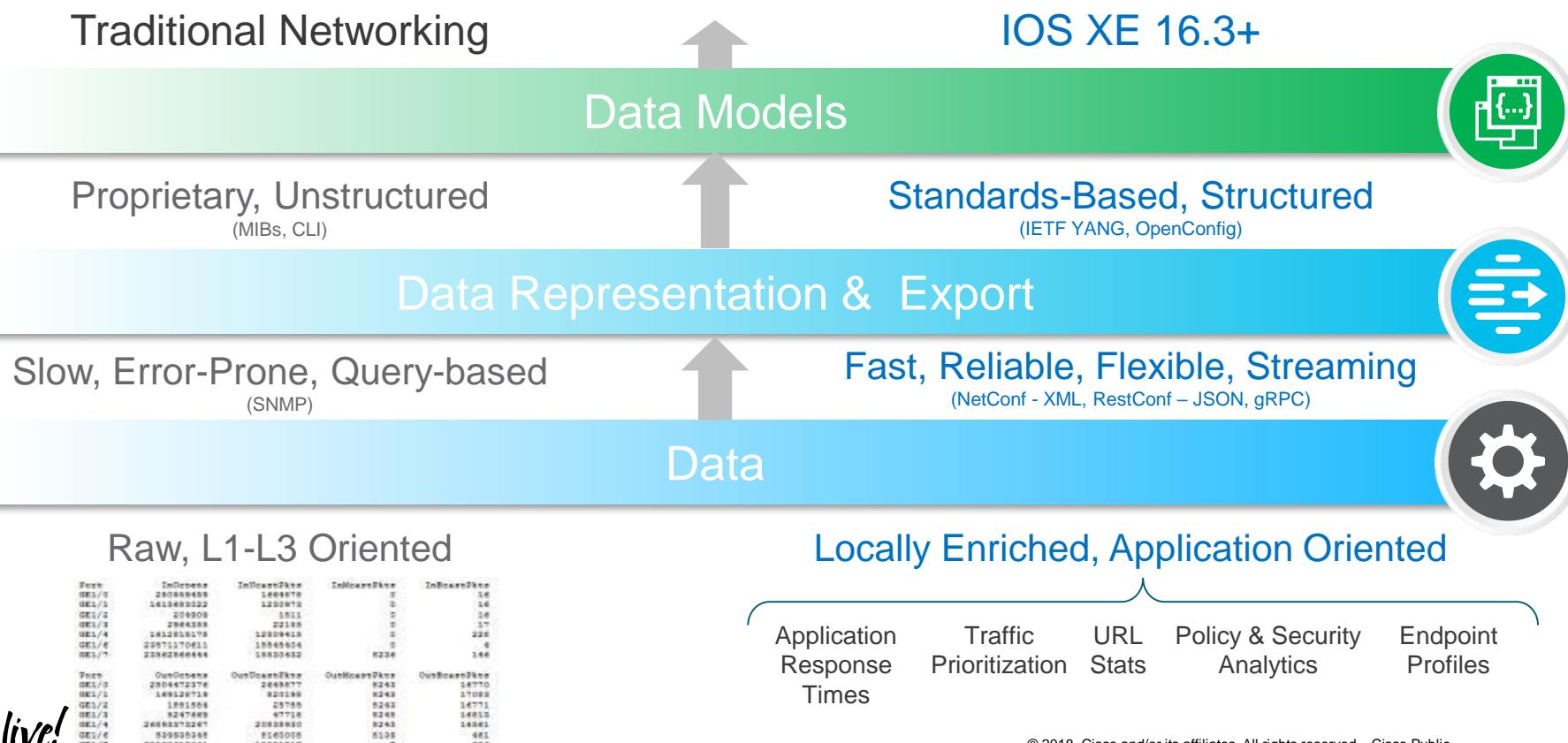
```
.
```

Infrastructure Perspective

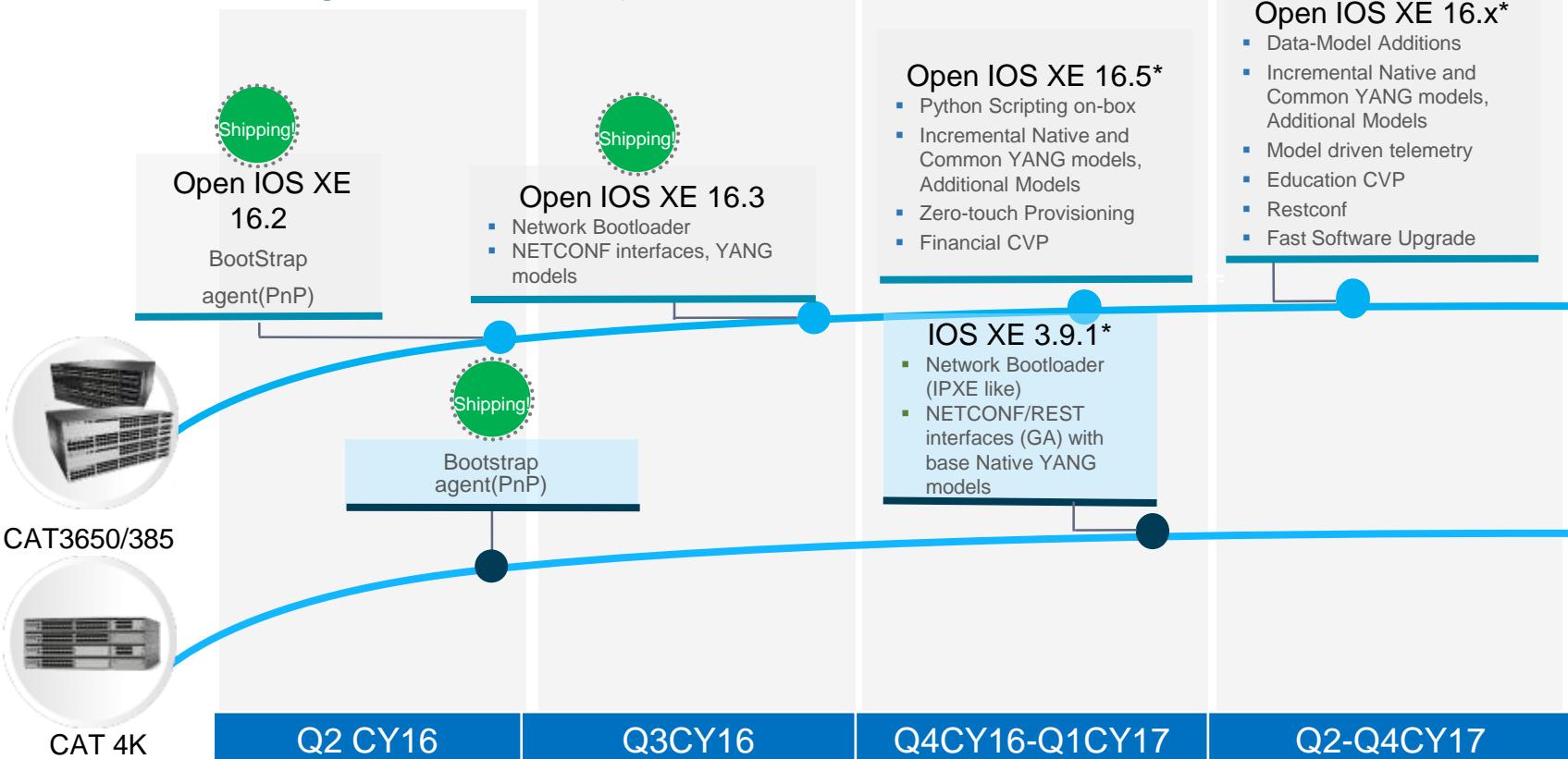


Programmability

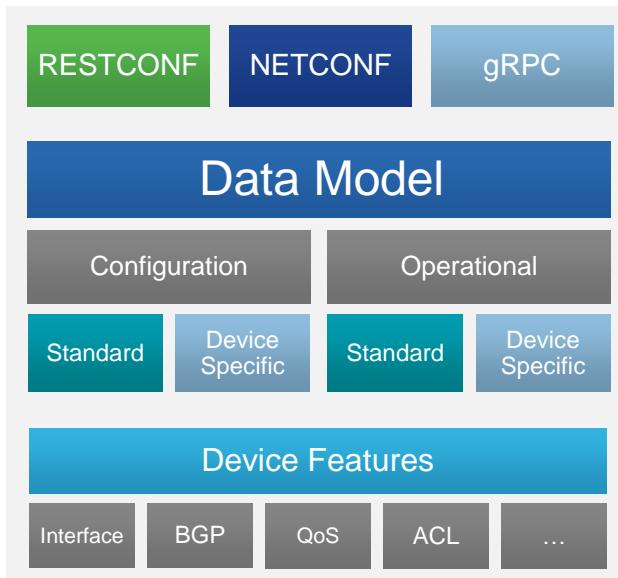
IOS XE Programmability – Data Driven



IOS XE Programmability – Deliverables



Open Device Programmability – Yang Models



(Open) Common Model

- Industry definition
- Compliant with standard (IETF, ITU, etc) definition
- Compliant with customer definition (ie OpenConfig)

Example:
ietf-diffserv-policy.yang
(IETF Diffserv data model)

(Cisco) Common Model

- Cisco definition
- Common across 2 or more Cisco operating systems

Example:
cisco-vxlan.yang
(IOS-XE/NX-OS VxLAN data model)

(Cisco) Native Model

- Cisco definition
- Unique to a single Cisco operating system

Example:
Cisco-IOS-XR-ipv4-bgp-cfg.yang
(IOS-XR BGP data model)

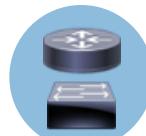
Infrastructure Perspective



Virtualization

Variety of open services available for all applications and customers to leverage today

Powerful, Rich Deployment Services



Application Hosting Framework



Application Hosting SDK



Centralized App Management

Flexible, Secure Runtime Environments



Linux & Docker Containers



Guest Shell



Virtual Machine

Structured, Open Interfaces



Data Models



APIs & Transport



Network & Policy Automation, Assurance

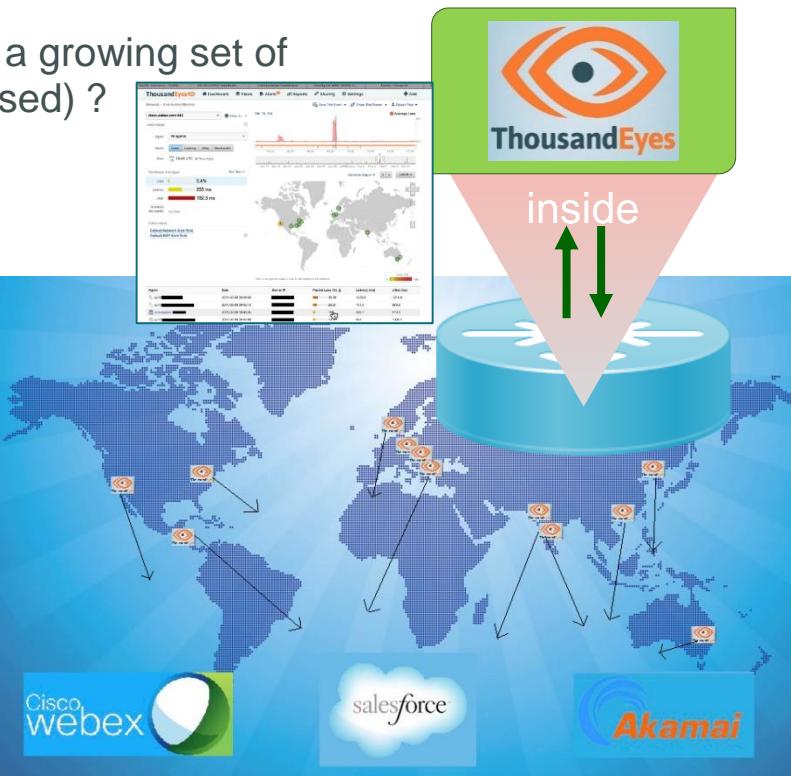
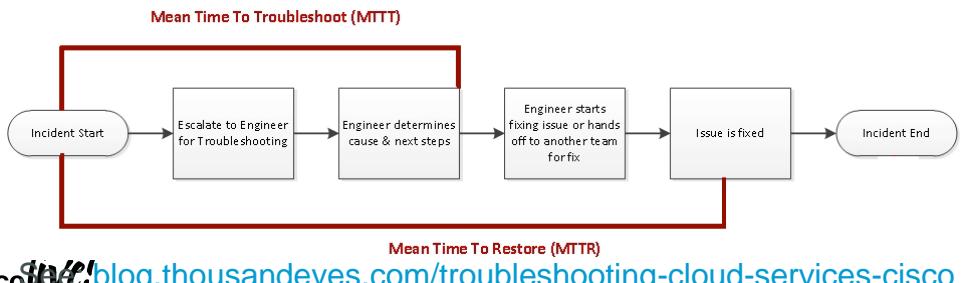


Example: Hybrid Services – Cisco IT

Problem: How to consistently monitor and troubleshoot a growing set of business critical hybrid services (on-premise + cloud-based) ?

Solution: Detect and Alert via ThousandEyes Probes:

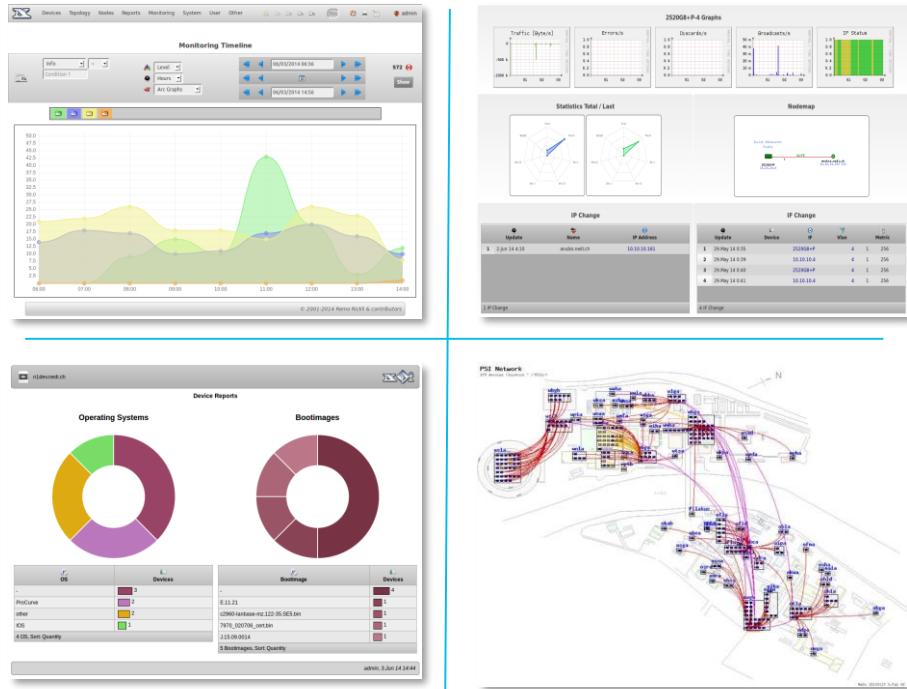
- Leverage existing Cloud-based Probes
- ~~Deploy Mac Mini Probes into key Locations~~
- Deploy Virtual Probes into key Locations (IOS XE Virtual-Service on ISR 4451)
- Reduce MTTT -43% and MTTR -8%





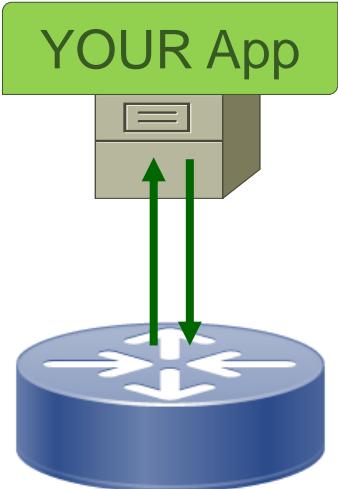
Ned.io – Open Source Network Management

<http://www.nedi.ch/running-nedi-on-a-cisco-router/>



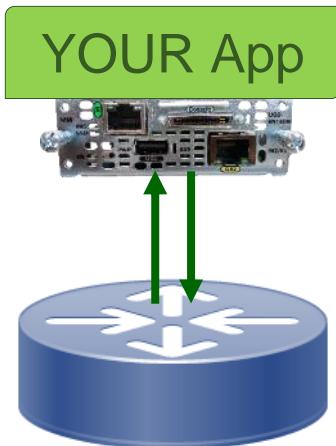
- Network Discovery, Operation and Management
- Open application built without any Cisco involvement.
- Terrific option for low-footprint branch management.

Device-Level – Hosting Options



Server / Controller

- Unlimited CPU/RAM/Storage
- Any OS and/or Hypervisor
- High Latency and Delay
- Extra Deployment
- Extra Footprint



Blade

- Physical CPU/RAM/Storage
- Any OS and/or Hypervisor
- Lower Latency and Delay
- Modular
- Fate Sharing, local Visibility

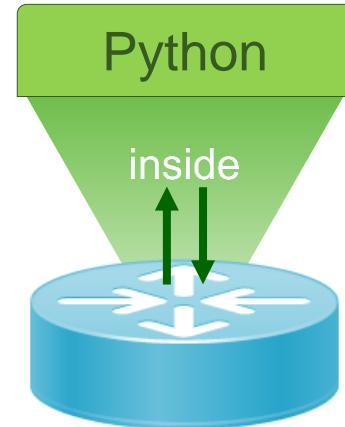


Container

- Dedicated CPU/RAM/Storage
- Any OS in a KVM OVA
- Low Latency and Delay
- Virtualized, Elastic
- Fate Sharing, local Visibility

What Is Guestshell?

- A BusyBox Linux container running next to IOS-XE
- Invoked using the `guestshell EXEC` command
- Access to the same management network as the device itself
- Access to the device's flash filesystem under `/flash`
- Guestshell commands can be run directly from IOS EXEC
- Provides a Python scripting environment



```
[Switch#guestshell  
[guestshell@guestshell ~]$ ]
```

```
[Switch#guestshell run /home/guestshell/hello_guestshell.py  
Hello Guestshell!  
Switch#]
```

Example: Time Domain Reflectometry (TDR) – 1/2

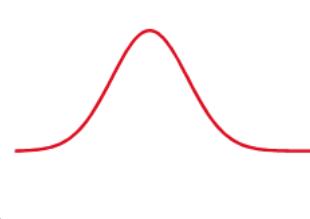
Problem: How to accurately detect cabling issues?

- most cabling issues are non-fatal (initially)
- not all wire-pairs may be affected
- may not be located at cable termination
- specialized test equipment may not be available



Solution: Time Domain Reflectometry

- injects a test signal into the cable
 - measures reflections caused by non-uniform impedance
- Detection and (approximate) location



Color Standard EIA/TIA T568B		Ethernet Patch Cable		Page 2 of 2
TX+	Orange/White Tracer	RJ45 Pin#	Pin# RJ45	
TX-	Orange	1	1 Orange/White Tracer	[PR 2]
RX+	Green/White Tracer	2	2 Orange	[PR 3]
RX-	Green	3	3 Green/White Tracer	[PR 1]
	Blue/White Tracer	4	4 Blue	[PR 3]
	Blue	5	5 Blue/White Tracer	[PR 4]
	Brown/White Tracer	6	6 Green	
	Brown	7	7 Brown/White Tracer	
		8	8 Brown	

Color Standard EIA/TIA T568B		Ethernet Crossover Cable		
TX+	Orange/White Tracer	RJ45 Pin#	Pin# RJ45	
TX-	Orange	1	1 Green/White Tracer	
RX+	Green/White Tracer	2	2 Green	
RX-	Green	3	3 Orange/White Tracer	
	Blue/White Tracer	4	4 Brown/White Tracer	
	Blue	5	5 Brown	
	Brown/White Tracer	6	6 Orange	
	Brown	7	7 Blue	
		8	8 Blue/White Tracer	

B is most recent

Common Ethernet Crossover Cables may only cross connect the Orange & Green pairs

See: http://en.wikipedia.org/wiki/Time-domain_reflectometry

On Copper Ethernet 10/100/1000 ports, (subset of) Catalyst 3k, 4k, and 6k since 12.1(19)EA1

Example: Time Domain Reflectometry (TDR) – 2/2

But: You may not want to run on all interfaces and only escalate relevant results

- 1) Run TDR Test:

```
switch# test cable-diagnostics tdr interface gigabitethernet1/0/3
TDR test on Gi1/0/9 will affect link state and traffic
TDR test started on interface Gi1/0/3
A TDR test can take a few seconds to run on an interface
Use 'show cable-diagnostics tdr' to read the TDR results.
```

Note: This will be disruptive when either GigE and/or POE are in use!

- 2) Check Results:

```
switch# show cable-diagnostics tdr interface gigabitethernet1/0/2
TDR test last run on: December 18 21:05:37
Interface Speed Local pair Pair length          Remote pair Pair status
-----  -----  -----  -----  -----  -----  -----
Gi1/0/2  auto   Pair A    0    +/- 2  meters N/A      Open
          Pair B    0    +/- 2  meters N/A      Open
          Pair C    0    +/- 2  meters N/A      Open
          Pair D    0    +/- 2  meters N/A      Open
```



+ Python
+ guestshell

(from 16.5 / 16.3.1)

Solution: Run on-box from guestshell / Python and parse / filter results before escalating

→ See https://github.com/CiscoDevNet/python_code_samples_network/tree/master/tdr-test

Example: Record User Activity To a Database

```
::cisco::eem::event_register_cli pattern ".*" sync no skip no

import eem
import sqlite3
import pprint
import sys
import os

# Log CLI commands to a local SQLite3 database

# Get the CLI event variables for this specific event.
arr_einfo = eem.event_reqinfo()
# Uncomment this line to print the variables in the array
#print(pprint.pprint(arr_einfo))
dbf = '/flash/aaa.db'
create_db = False

if not os.path.isfile(dbf):
    create_db = True

try:
    con = sqlite3.connect(dbf)
    cur = con.cursor()
except sqlite3.Error as e:
    eem.action_syslog('Failed to connect to DB: {}'.format(e.args[0]),
                      priority='3', facility='SQLITE_AAA')
    sys.exit(1)

# Schema is:
# Timestamp, Username, Host, Privilege, Command, Result_Code
if create_db:
    try:
        sql = 'CREATE TABLE command_history (ts, username, host, privilege, command, result_code)'
        cur.execute(sql)
```

Python modules

Event spec

Similar data extraction functions

```
except sqlite3.Error as e:
    eem.action_syslog('Failed to create command_history table: {}'.format(e.args[0]), priority='3', facility='SQLITE_AAA')
    sys.exit(1)

sql = 'INSERT INTO command_history VALUES (:time, :user, :host, :priv, :command, :rc)'

username = 'unknown'
host = 'unknown'
if 'username' in arr_einfo:
    username = arr_einfo['username']
if 'host' in arr_einfo:
    host = arr_einfo['host']

try:
    cur.execute(sql, {'time': arr_einfo['event_pub_sec'],
                      'user': username, 'host': host,
                      'priv': arr_einfo['privilege'], 'command': arr_einfo['msg'],
                      'rc': arr_einfo['error_code']})
    con.commit()
except sqlite3.Error as e:
    eem.action_syslog('Failed to insert to insert new user record: {}'.format(e.args[0]), priority='3', facility='SQLITE_AAA')

con.close()
```

Syslog support

Example: Execute Commands And Email Output

```

::cisco::eem::event_register_timer watchdog time 10

import eem
import smtplib
import sys

cli = eem.cli_open()
arr_envinfo = eem.env_reqinfo()

try:
    eem.cli_exec(cli, "enable")
    res = eem.cli_exec(cli, "show mac address-table")
except Exception as e:
    eem.action_syslog('Failed to execute CLI commands: {}'.format(e.args[0]), priority='3')
    sys.exit(1)

msg = """From: {}
To: {}
Subject: Output of 'show mac address-table'

{}""".format(arr_envinfo['_email_from'], arr_envinfo['_email_to'], res)

try:
    s = smtplib.SMTP(arr_envinfo['_email_server'])
    s.sendmail(arr_envinfo['_email_from'], [arr_envinfo['_email_to']], msg)
except SMTPException as e:
    eem.action_syslog('Failed to send email: {}'.format(e.args[0]), priority='3')

```

Execute CLI
commands

Send email
(including MIME
attachments)

From Joe Clarke★
Subject Output of 'show mac address-table'
To Joe Clarke★
Tags Important

Mac Address Table

Vlan	Mac Address	Type	Ports
All	0100.0ccc.cccc	STATIC	CPU
All	0100.0ccc.cccd	STATIC	CPU
All	0180.c200.0000	STATIC	CPU
All	0180.c200.0001	STATIC	CPU
All	0180.c200.0002	STATIC	CPU
All	0180.c200.0003	STATIC	CPU
All	0180.c200.0004	STATIC	CPU
All	0180.c200.0005	STATIC	CPU
All	0180.c200.0006	STATIC	CPU
All	0180.c200.0007	STATIC	CPU
All	0180.c200.0008	STATIC	CPU
All	0180.c200.0009	STATIC	CPU
All	0180.c200.000a	STATIC	CPU
All	0180.c200.000b	STATIC	CPU
All	0180.c200.000c	STATIC	CPU
All	0180.c200.000d	STATIC	CPU
All	0180.c200.000e	STATIC	CPU
All	0180.c200.000f	STATIC	CPU
All	0180.c200.0010	STATIC	CPU
All	0180.c200.0021	STATIC	CPU
All	ffff.ffff.ffff	STATIC	CPU
1	20bb.c05f.cc47	STATIC	V1
Total Mac Addresses for this criterion: 22			
Switch#			

Agenda

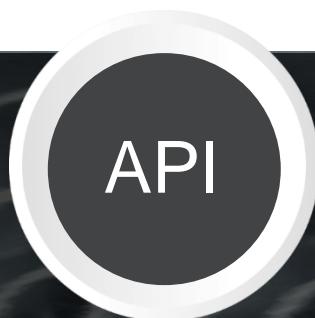
- Welcome and Introduction
- Focus I
Infrastructure Level Scripting
- Focus II
Programmability and Guestshell
- Focus III
Controller Level APIs
- Summary and Close



IOS XE 16.x: Industry-Leading Open Programmable OS



Device
Onboarding



Configuration
Automation



Application
Hosting



Telemetry

Open

Easy onboarding of devices using turnkey and open source tools

Standards Based

Consistent management of devices through machine interfaces

Extensible

Develop, deploy, test new services on devices

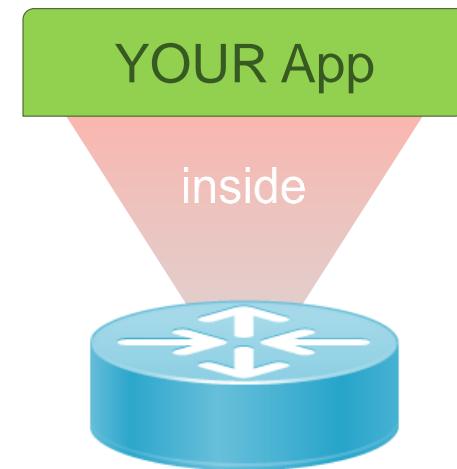
Consistent

Stream granular data for real time monitoring and troubleshooting

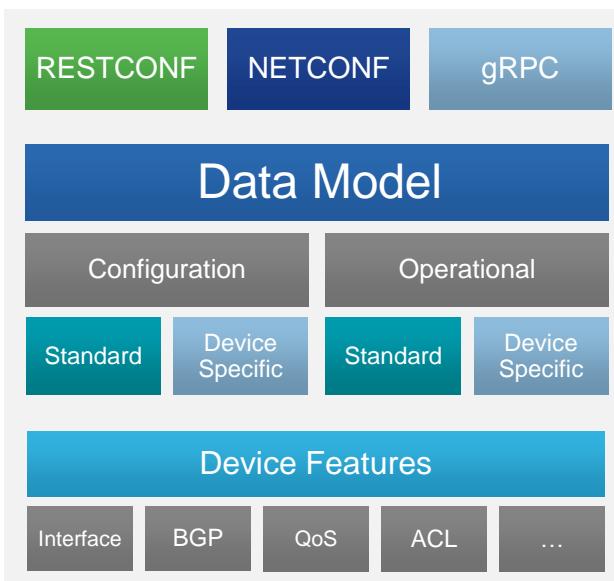
Application Hosting



Service Containers



Open Device Programmability



Set



Get



Automate

Open Device Programmability



Physical and Virtual Network Infrastructure



OpenConfig



Other vendors...



Lab II

IOS XE Guestshell

NETCONF/RESTCONF

Get Started
Prepare the Lab Environment

Scenario 1: DevOps Style Human Interaction

- Cisco Spark REST APIs: Find Room and Post
- NeXt UI: DevNet Tutorials
- NeXt UI: Hello Topology
- NeXt UI: Grouping of Nodes
- NeXt UI: Visualize Path Info from APIC-EM
- Tropo Scripting APIs: Text-to-Speech and IVR

Scenario 2: Device-Level Programmability and Virtualization

- IOS EEM: Change Port Description Based on CDP Neighbor
- IOS EEM: Assign Static IP If DHCP Fails
- IOS EEM: Force a Failover Based on IPSLA-Reported Latency
- IOS-XE Guestshell: Enable Guestshell
- IOS-XE Guestshell: Python interpreter
- IOS-XE Guestshell: Prepare Python environment
- IOS-XE Guestshell: Python packaging
- IOS-XE Guestshell and EEM: Record commands to the database
- IOS-XE Guestshell: Outputs collector
- IOS-XE Guestshell and EEM: Config Diff To Spark
- IOS-XE NETCONF: Configure an ACL
- IOS-XE RESTCONF: Configure an ACL
- IOS-XE RESTCONF: Operational data to Spark

Scenario 3: Controller-Level Programmability

- Device Count in APIC-EM Inventory
- Path Trace via APIC-EM REST APIs

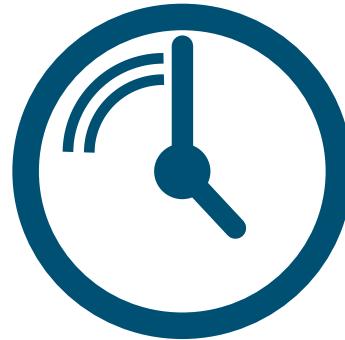
Agenda

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Schedule

08:45 – 10:45 Morning Part I
10:45 – 11:00 Coffee Break
11:00 – 13:00 Morning Part II
13:00 – 14:30 Lunch
14:30 – 16:30 Afternoon Part I
16:30 – 16:45 Coffee Break
16:45 – 18:45 Afternoon Part II



Sample Code in GIT

Lab Examples are in GIT

1. A GIT Clone Request has already been done on the Windows Workstation in dCloud

see: C:\Users\administrator\Documents\GitHub\enterprise-network-programmability

2. Update to the latest code using git pull

> **git pull origin master**

3. Remember to copy your own work before leaving this session

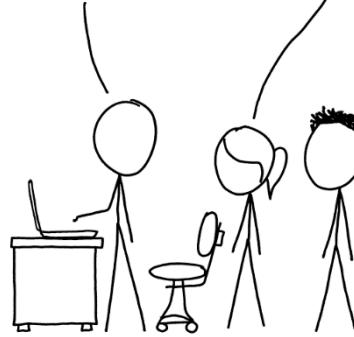
github.com/xorrkaz/enterprise-network-programmability

Cisco **live!**

THIS IS GIT. IT TRACKS COLLABORATIVE WORK ON PROJECTS THROUGH A BEAUTIFUL DISTRIBUTED GRAPH THEORY TREE MODEL.

COOL. HOW DO WE USE IT?

NO IDEA. JUST MEMORIZE THESE SHELL COMMANDS AND TYPE THEM TO SYNC UP. IF YOU GET ERRORS, SAVE YOUR WORK ELSEWHERE, DELETE THE PROJECT, AND DOWNLOAD A FRESH COPY.



```
>git pull origin master
...
network-programmability
  ID
  master
```

```
Updating a097b7b..2a010e9
Fast-forward
  .gitignore
  tasks/Hello-Lab.py
  tasks/constants.py
  tasks/env.py
  tasks/guestshell/dna/scripts/__init__.py
  tasks/guestshell/dna/scripts/record_commands.py
  tasks/guestshell/setup.py
  tasks/helper.py
  tasks/netconf/__init__.py
  tasks/{netconf-acl/nc-acl.py => netconf/acl.py}
  tasks/requirements.txt
  tasks/restconf/__init__.py
  tasks/restconf/acl.py
  tasks/restconf/interface_stats.py
  14 files changed, 732 insertions(+), 54 deletions(-)
```

Lab II

IOS XE Guestshell

NETCONF/RESTCONF

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Prepare the Lab Environment

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Scenario 3: Controller-Level Programmability

- Device Count in APIC-EM Inventory
- Path Trace via APIC-EM REST APIs

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Application Hosting



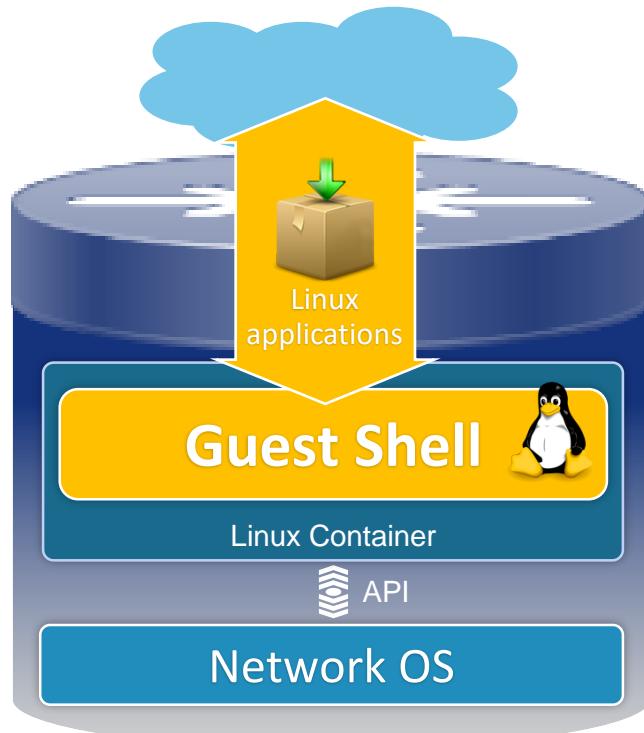
Service Containers



Guest Shell

Virtualized Linux Environment On IOS-XE

- Secure Linux shell environment
- On-box rapid prototyping
- Application Hosting



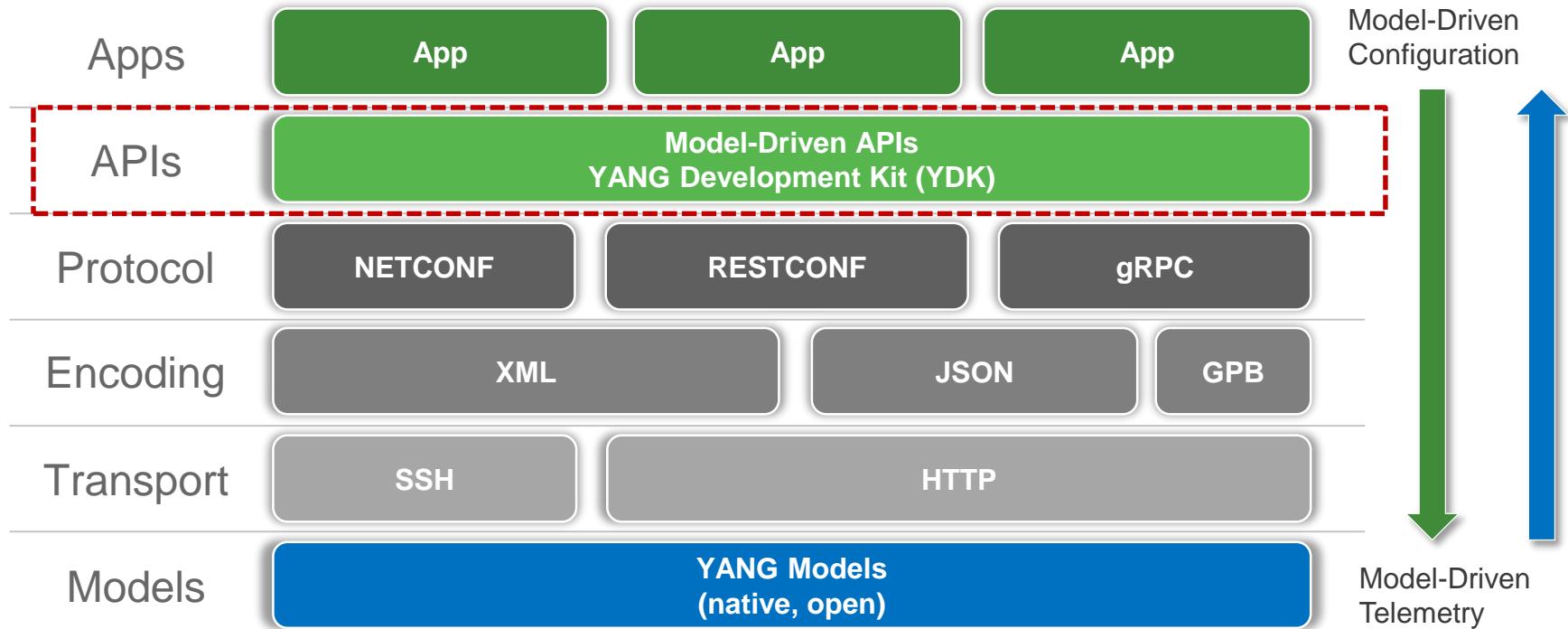
On-box Python



Advantages

- Access CLI from the container
- Trigger syslog messages
- Integration with Embedded Event Manager
- Access to the device filesystem
- Zero Touch Provisioning
- Enables **Edge computing**

DNA Model-Driven Programmability Stack



Data models

- Explicitly and precisely defines Data
 - Structure
 - Syntax
 - Semantics
- Examples: SNMP MIB, YANG models

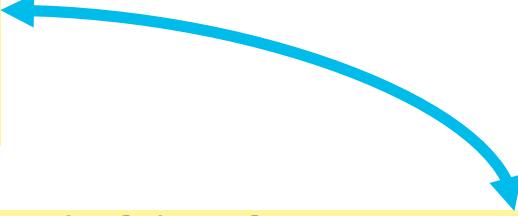
Interface Model **definition**

```
ietf-interfaces@2014-05-08.yang
```

```
/*
 * Configuration data nodes
 */
container interfaces {
    description
        "Interface configuration parameters.";
    list interface {
        key "name";
        description
        leaf name {
            type string;
        }
        leaf description {
            type string;
        }
        leaf type {
            type identityref {
                base interface-type;
            }
            mandatory true;
        }
        leaf enabled {
            type boolean;
            default "true";
        }
}
```

YANG Data Model Structure

```
!  
interface GigabitEthernet0/0/0  
description whatever  
ip address 1.1.1.1 255.255.255.0  
shutdown  
negotiation auto  
end
```



```
module: ietf-interfaces  
++-rw interfaces  
|  +-+rw interface* [name]  
|    +-+rw name          string  
|    +-+rw description?  string  
|    +-+rw type           identityref  
|    +-+rw enabled?       boolean  
|    +-+rw link-up-down-trap-enable? enumeration {if-mib}?
```

Where are YANG models?



Models installed on device automatically with IOS-XE.



Also can be downloaded from GitHub.

<https://github.com/YangModels/yang/tree/master/vendor/cisco>

The screenshot shows a GitHub repository page for the 'yang' repository. The URL is <https://github.com/YangModels/yang/tree/master/vendor/cisco>. The repository has 113 watchers, 211 stars, and 138 forks. The master branch is selected. The repository contains 11 issues, 1 pull request, 0 projects, and 0 wiki pages. The 'Code' tab is active. The commit history shows a single commit by pgohite titled 'Cisco IOS XE 16.3.2 Release Yang Models' made on Nov 28, 2016. The commit message also includes 'Latest commit 55bd294 on Nov 28, 2016'. The commit details show files like MIBS, README.md, cat3k-netconf-capability.xml, check-models.sh, cisco-acl-oper.yang, and cisco-bfd-state.yang, all released on Nov 28, 2016.

File	Description	Released
MIBS	Cisco IOS XE 16.3.2 Release Yang Models	2 months ago
README.md	Cisco IOS XE 16.3.2 Release Yang Models	a month ago
cat3k-netconf-capability.xml	Cisco IOS XE 16.3.2 Release Yang Models	2 months ago
check-models.sh	Cisco IOS XE 16.3.2 Release Yang Models	2 months ago
cisco-acl-oper.yang	Cisco IOS XE 16.3.2 Release Yang Models	2 months ago
cisco-bfd-state.yang	Cisco IOS XE 16.3.2 Release Yang Models	2 months ago

Who defines the YANG models?

Vendors

- Only work on specific vendor devices
- Greater feature coverage
- Can be OS-unique (IOS-XE, XR, etc.)

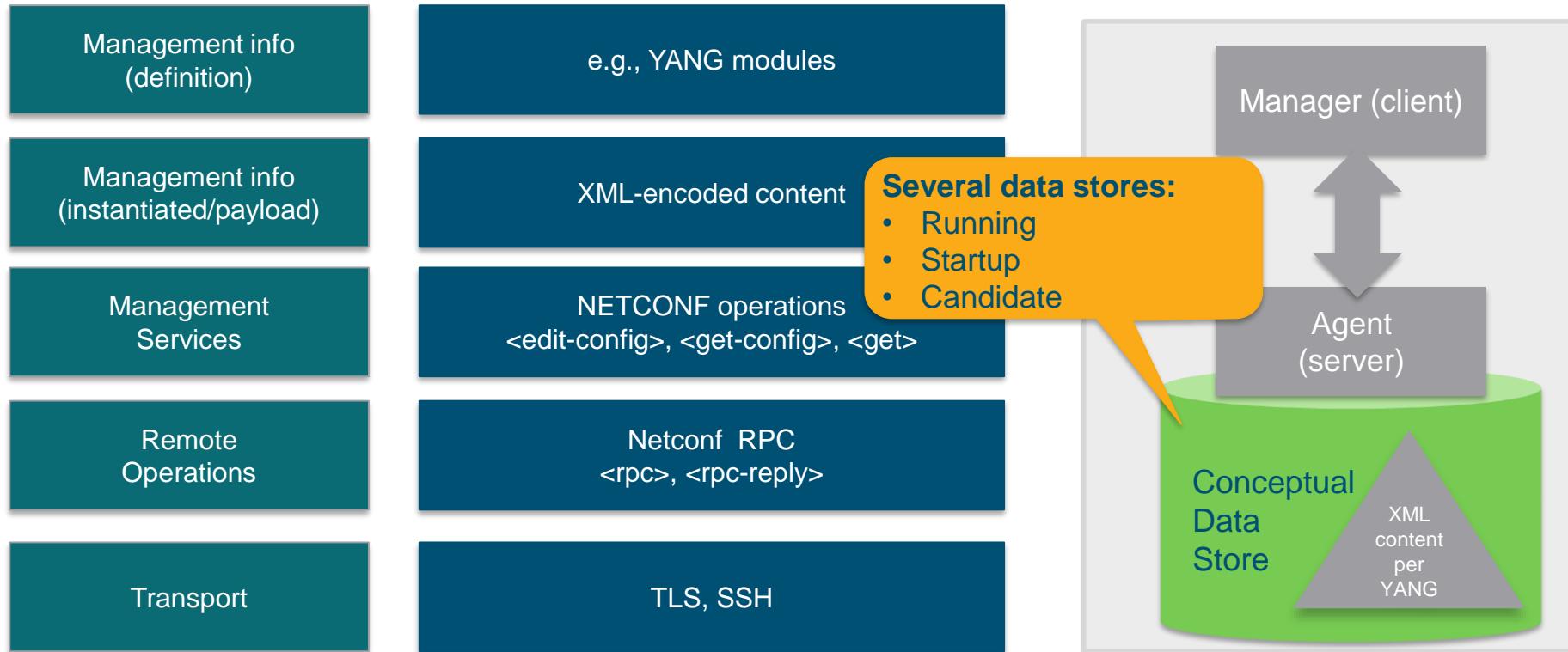


Standards Bodies

- Multi-vendor support
- More limited feature coverage
- Allow vendor-specific extensions



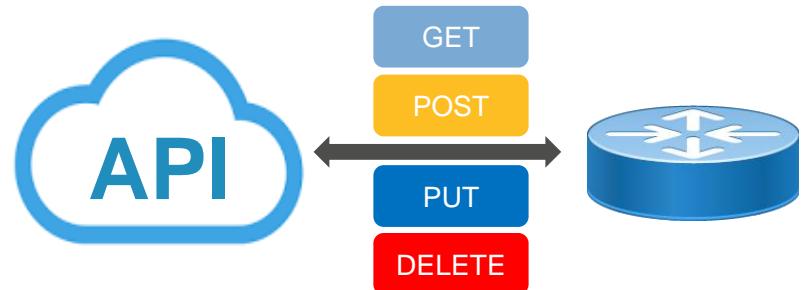
NETCONF



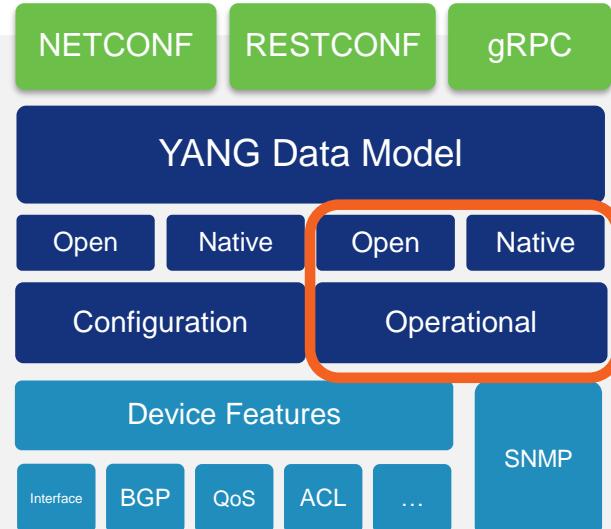
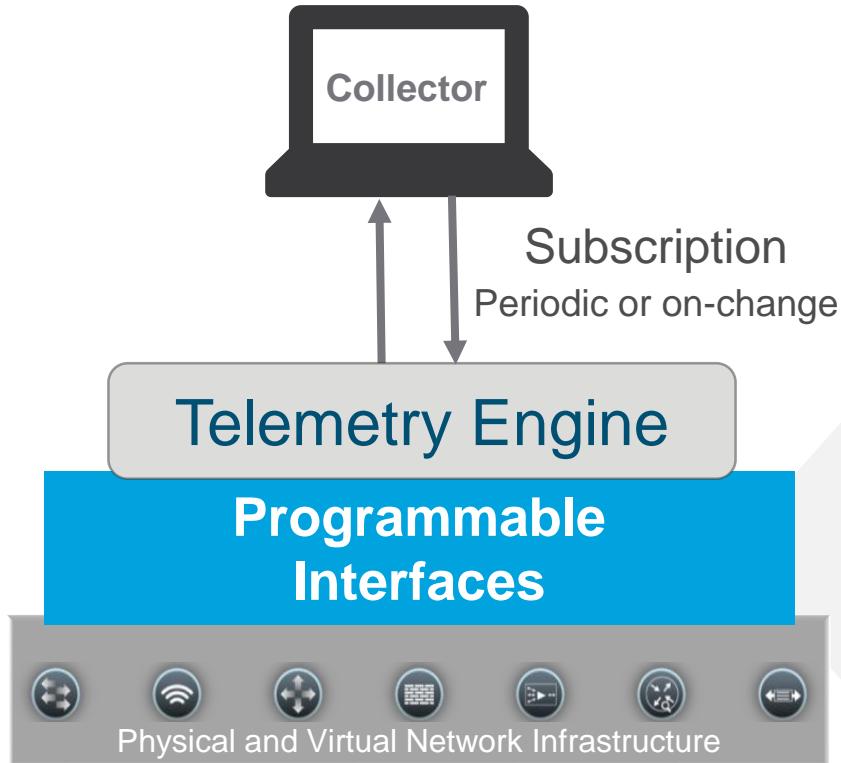
RESTCONF

“REST-like protocol running over HTTP for accessing data defined in YANG using Datastores defined in NETCONF”

- It defines how a YANG model is mapped to a RESTful interface
- Supports OPTIONS, GET, PUT, POST, DELETE operations
- Request and response in XML or **JSON format**
- **HTTPS** transport
- IETF **Standard** RFC8040



Streaming Telemetry

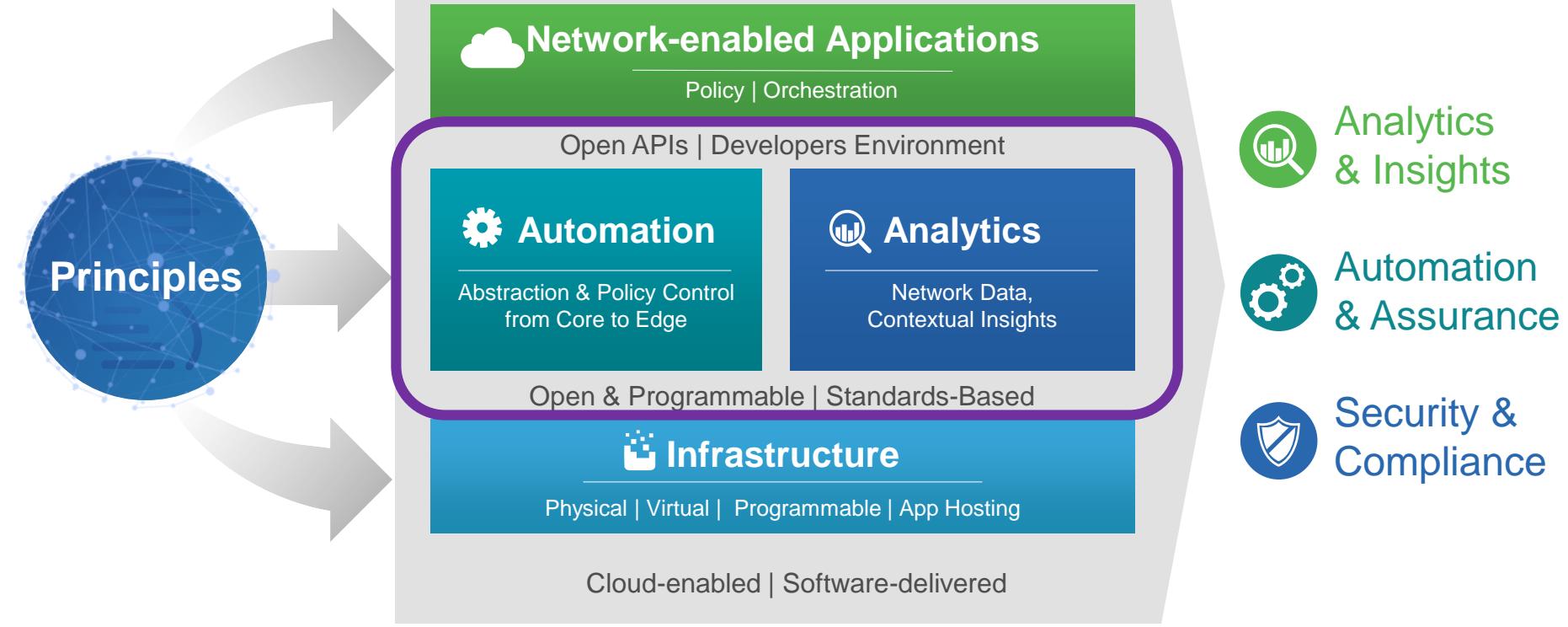


Agenda

- Welcome and Introduction
- Focus I
Infrastructure Level Scripting
- Focus II
Programmability and Guestshell
- Focus III
Controller Level APIs
- Summary and Close



Cisco Digital Network Architecture (DNA)



What can DNA Center do? Take a Tour.

Need to add functionality to DNA Center? [Add applications](#)

Want to learn more about DNA Center? [Watch video](#)

Design

Model your entire network, from sites and buildings to devices and links, both physical and virtual, across campus, branch, WAN and cloud.

- [Add site locations on the network](#)
- [Designate golden images for device families](#)
- [Create wireless profiles of SSIDs](#)

Provision

Provide new services to users with ease, speed and security across your enterprise network, regardless of network size and complexity.

- [Discover and provision switches to defined sites](#)
- [Provision WLCs and APs to defined sites](#)
- [Set up Campus Fabric across switches](#)

Tools

Discovery

Automate addition of devices to controller inventory

Inventory

Add, update or delete devices that are managed by the controller

Topology

Visualize how devices are interconnected and how they communicate

Image Repository

Download and manage physical and virtual software images automatically

Command Runner

Allows you to run diagnostic CLIs against one or more devices

License Manager

Visualize and manage license usage

Template Editor

An interactive editor to author CLI templates

Telemetry

Telemetry Design and Provision

DNA Center – Open and Extensible

Extensions

Extension points across automation and analytics



APIs



SDK



Connectors



Firehose

Integrations

Integration with complementary platforms

Cisco assets

ACI Meraki Tetration

APPDYNAMICS

Industry integrations

Infoblox  splunk >

servicenow  +ableau 

Enablement

Enablement for developer community



DNAC As A Platform

DNA Center as a Platform – DNAC 1.1 API Coverage

DISCOVERY

- CRUD device credentials
- Start discovery jobs
- Device retrieval

HOST

- Host/user retrieval with filters
- Host number

SYSTEM

- Namespaces
- File management
- PKI management

DEVICE

- CRUD inventory
- CRUD roles
- CRUD location

SWIM

- Trigger process
 - Schedule/now
 - Per-group
- CRUD images
- Image details
- Recommendation report

PnP

- Image management
- CRUD projects
- CRUD devices

Interacting with Humans DevOps Style

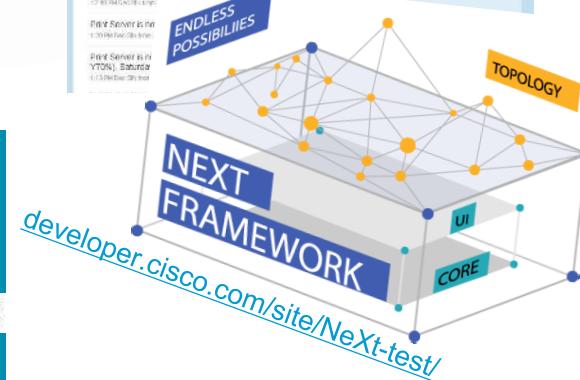
Interacting with Humans

Digitization and Softwarization are about Automated workflows using APIs.

Problem: However – many (ad-hoc) workflows involve human interaction. How to quickly, rapidly and easily implement DevOps style human interactions ?

Solutions: Many and growing ...

- We've had tweeting routers for almost a decade with EEM / Tcl
- Cisco Spark REST APIs
- NeXt UI Framework
- Tropo REST API for Voice and SMS interaction
- ...



Lab I

Use a Controller API

1. Work through APIC-EM REST API Task
2. Combine APIC-EM with Spark, NeXt UI Toolkit or Tropo

Under The Hood

1. DNA Center Preview and Demo

Get Started
Prepare the Lab Environment

Scenario 1: DevOps Style Human Interaction

- Cisco Spark REST APIs: Find Room and Post
- NeXt UI: DevNet Tutorials
- NeXt UI: Hello Topology
- NeXt UI: Grouping of Nodes
- NeXt UI: Visualize Path Info from APIC-EM
- Tropo Scripting APIs: Text-to-Speech and IVR

Scenario 2: Device-Level Programmability and Virtualization

- IOS EEM: Change Port Description Based on CDP Neighbor
- IOS EEM: Assign Static IP If DHCP Fails
- IOS EEM: Force a Failover Based on IPSLA-Reported Latency
- IOS-XE Guestshell: Enable Guestshell
- IOS-XE Guestshell: Python interpreter
- IOS-XE Guestshell: Prepare Python environment
- IOS-XE Guestshell: Python packaging
- IOS-XE Guestshell and EEM: Record commands to the database
- IOS-XE Guestshell: Outputs collector
- IOS-XE Guestshell and EEM: Config Diff To Spark
- IOS-XE NETCONF: Configure an ACL
- IOS-XE RESTCONF: Configure an ACL
- IOS-XE RESTCONF: Operational data to Spark

Scenario 3: Controller-Level Programmability

- Device Count in APIC-EM Inventory
- Path Trace via APIC-EM REST APIs

APIC-EM Automation

APIC
EM

Path Trace

From

- Reactive
- Multi-stage Escalation
- Manual investigation
- Slow
- Expensive

To

- Proactive
- Simple-to use and Integrate
- Automated flow-analysis
- Rapid
- Free

APIC-EM Flow Analysis – UI

5 Tuple Input

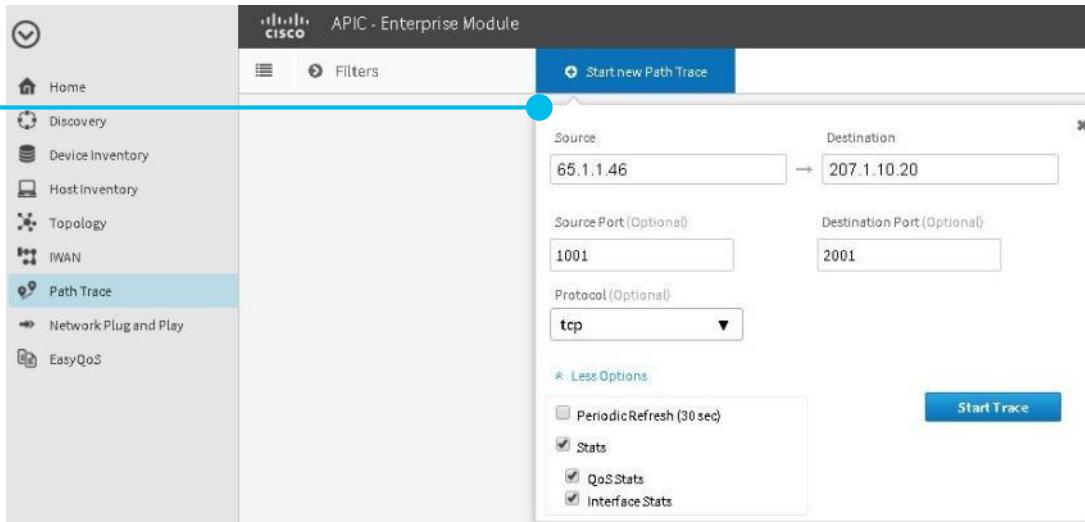
Source IP

Destination IP

Source Port

Destination Port

Protocol



APIC-EM Flow Analysis – UI

Task Overview

APIC-EM provides status of Flow Analysis Tasks

- In Progress
- Active (periodic)
- Completed

The screenshot shows the APIC-EM Enterprise Module interface. On the left, there's a sidebar with various icons. The main area is titled 'Path Traces' and is divided into three sections: 'IN PROGRESS', 'ACTIVE', and 'COMPLETED'. The 'IN PROGRESS' section contains one entry: '207.1.10.20 > 65.1.1.46' with Source Port 2001 and Destination Port 1001, using TCP, and a note about errors. The 'ACTIVE' section also contains one entry: '207.1.10.20 > 65.1.1.46' with the same details, plus a note about being updated a minute ago. The 'COMPLETED' section contains one entry: '65.1.1.46 > 207.1.10.20' with Source Port 1001 and Destination Port 2001, using TCP, and a note about being updated a few seconds ago. A blue circle highlights the 'Start new Path Trace' button at the top right of the main panel. A modal dialog box is open over the main panel, titled 'Start new Path Trace'. It has fields for 'Source' (65.1.1.46) and 'Destination' (207.1.10.20), optional 'Source Port' (1001), optional 'Destination Port' (2001), and a dropdown for 'Protocol (Optional)' set to 'tcp'. Below these are 'Less Options' checkboxes for 'Periodic Refresh (30 sec)', 'Stats' (which is checked), 'QoS Stats', and 'Interface Stats'. A 'Start Trace' button is at the bottom right of the dialog.

APIC-EM Flow Analysis – UI

APIC - Enterprise Module

Hosts: 65.1.1.46 → 207.1.10.20 Source Port: 1001 Destination Port: 2001 Protocol: tcp

[View in Topology](#)

CAMPUS-Access1
212.1.10.1 Switches and Hubs
→ Switched
Tunnels: CAPWAP Tunnel
Ingress Interface: GigabitEthernet1/0/26 View Stats
Egress Interface: GigabitEthernet1/0/1 View Stats

CAMPUS-Dist1
55.1.1.100 Switches and Hubs
→ Switched
Tunnels: CAPWAP Tunnel
Ingress Interface: GigabitEthernet5/5 View Stats
Egress Interface: GigabitEthernet5/38 View Stats

Campus-WLC-5508
55.1.1.2 Wireless Controller
→ Switched

Link Statistics Area of Interest

CAMPUS-Dist1
55.1.1.100 Switches and Hubs
→ Switched
Tunnels: CAPWAP Tunnel
Ingress Interface: GigabitEthernet5/5

Hide Stats	
Admin Status	up
Input Queue Drops	0
Input Queue Count	0
Input Rate(bps)	55000
Output Drop	▲3
Output Queue Count	0
Output Rate(bps)	1000
Refreshed At	3/2/2016, 6:45:36 PM

Egress Interface: GigabitEthernet5/38 View Stats

Link Information Sources

CAPWAP Tunnel

ECMP Accuracy

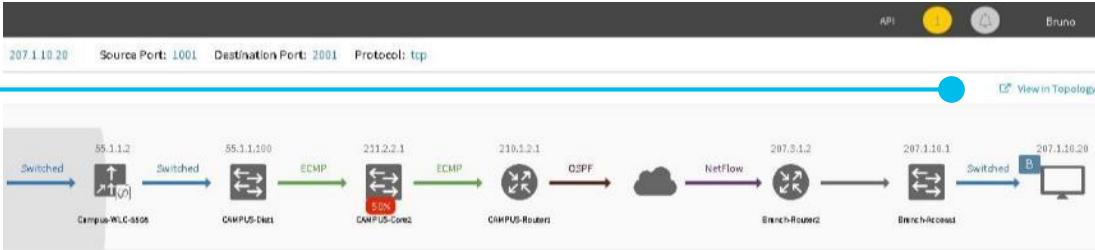
FYI

Cisco live!

APIC-EM Flow Analysis – UI

Topology View

Flow Analysis
Overlay on
Topology



APIC-EM Flow Analysis – UI

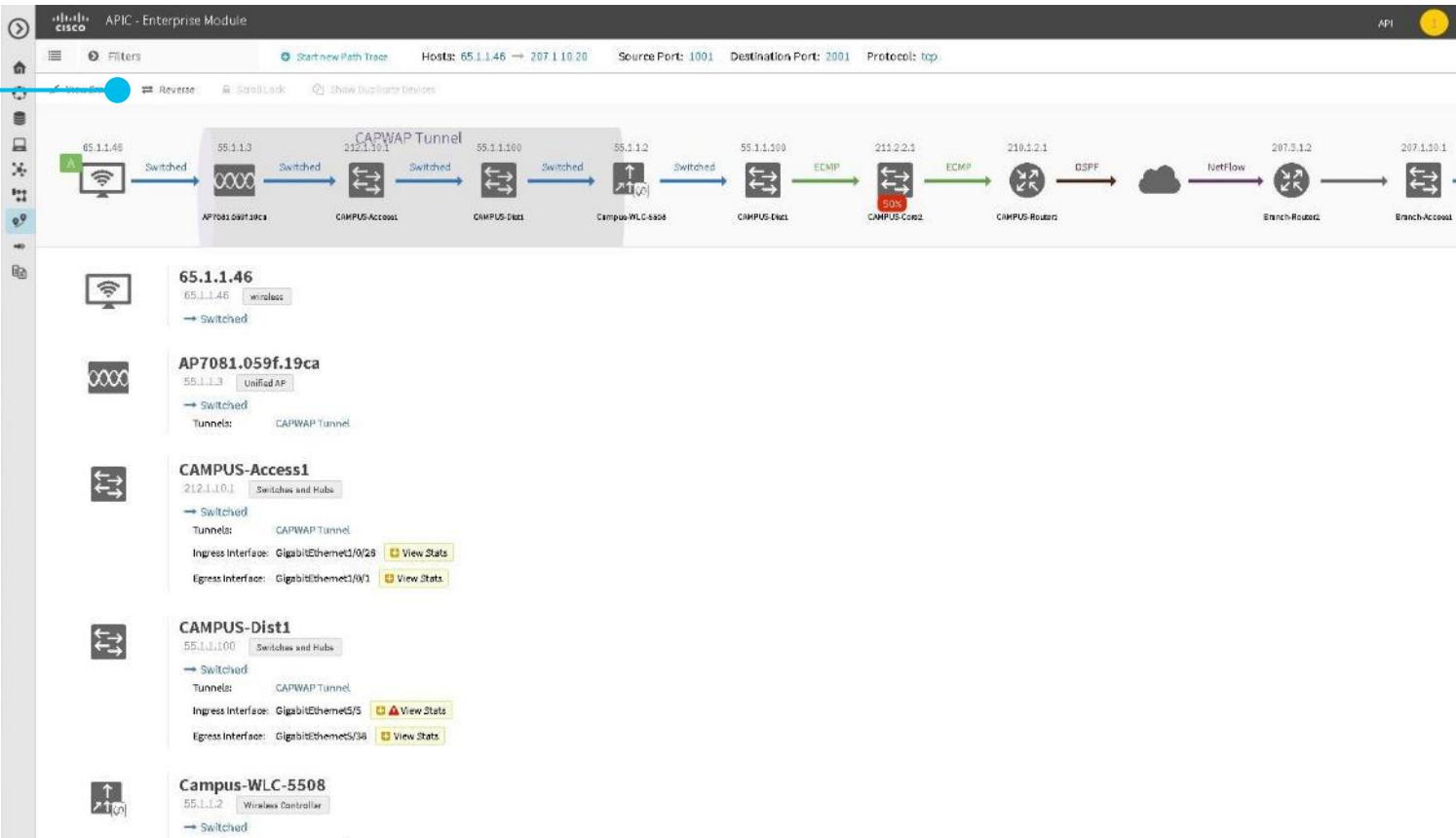
Topology View

Flow Analysis
Overlay on
Topology



APIC-EM Flow Analysis – UI

Reverse Path Side-by-Side Comparison

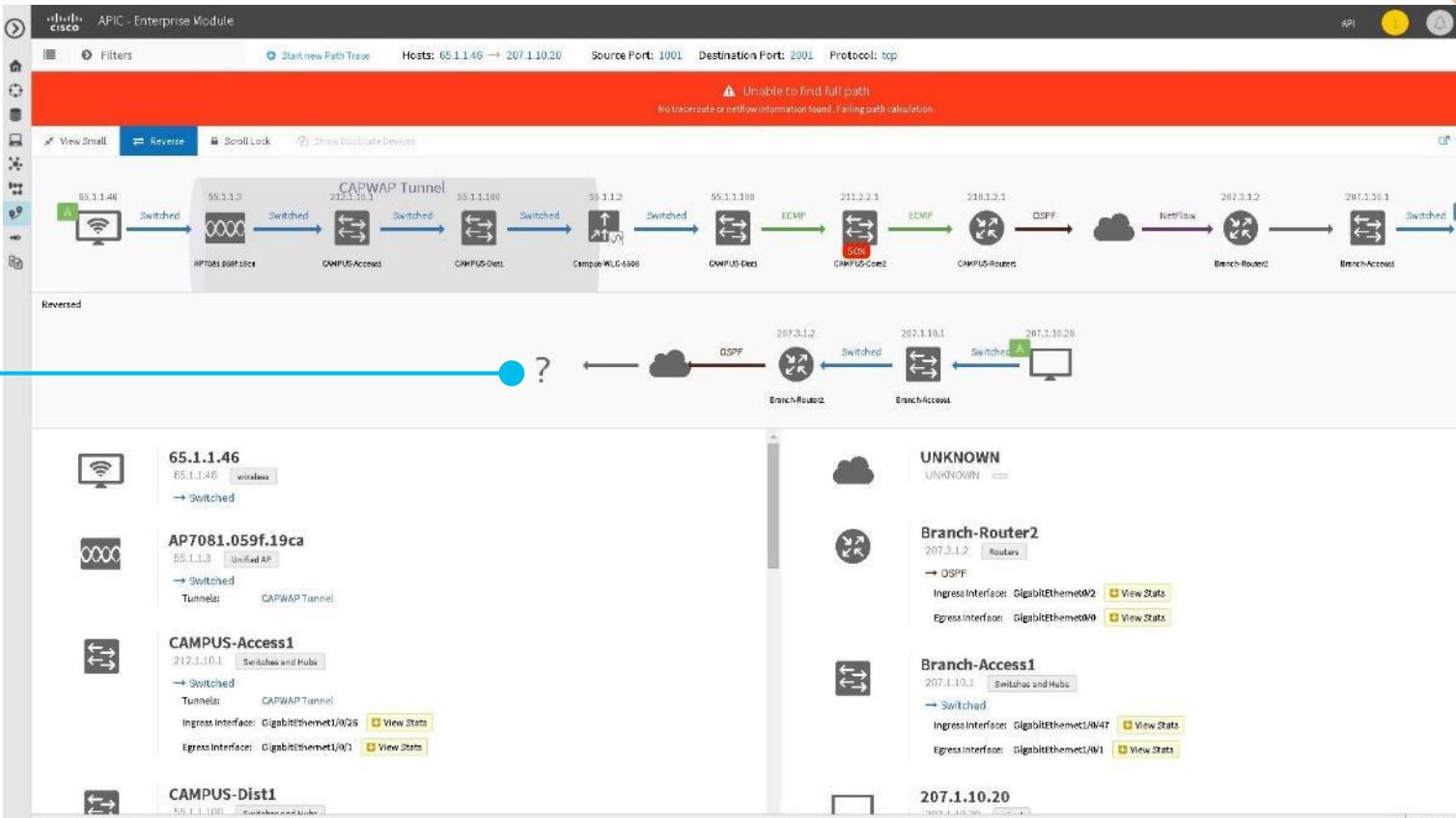


APIC-EM Flow Analysis – UI

Reverse Path
Side-by-Side
Comparison

Locate Issue

In our case: on
the reverse path



APIC-EM Flow Analysis – REST API

APIC - Enterprise Module API Bruno

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

Flow Analysis

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

[Terms of service](#)

[Cisco DevNet](#)

flow-analysis : Flow Analysis API

POST /flow-analysis Initiates a new flow analysis

Implementation Notes

Initiates a new flow analysis with periodic refresh and stat collection options. Returns a request id and a task id to get results and follow progress.

Response Class

Model | Model Schema

```
FlowAnalysisRequestResultOutput {
    version (string, optional),
    response (FlowAnalysisRequestResult, optional)
}
FlowAnalysisRequestResult {
    url (string, optional),
    taskId (string, optional),
    flowAnalysisId (string, optional)
}
```

Response Content Type: application/json

Parameters

Parameter	Value	Description	Parameter Type	Data Type
flowAnalysisRequest	<pre>{ "sourceIP": "65.1.1.46", "destIP": "207.1.10.20" }</pre>	flowAnalysisRequest	body	Model Model Schema

Parameter content type: application/json ▾

```
FlowAnalysisRequest {
    protocol (string, optional); Protocol,
    sourceIP (string); Source IP address,
    sourcePort (string, optional); Source Port,
    destIP (string); Destination IP address,
    destPort (string, optional); Destination Port,
    periodicRefresh (boolean, optional);
    periodicRefresh of path for every 30 sec,
    inclusions ([arrayString], optional);
    Subset of [INTERFACE-STATS, QOS-STATS]
```

I wish this page would..

5 Tuple Input

```
{
  "sourceIP": "65.1.1.46",
  "destIP": "207.1.10.20"
}
```

APIC-EM Flow Analysis – REST API

The screenshot shows the APIC-Enterprise Module REST API documentation for the Flow Analysis endpoint. The URL is <https://172.28.97.201/api/v1/flow-analysis>. The request body is defined as follows:

```
flowAnalysisRequest
{
  "sourceIP": "65.1.1.46",
  "destIP": "207.1.10.20"
}
```

The response body example is:

```
{
  "response": {
    "flowAnalysisId": "4c5593bf-82cf-4d05-b48f-c7d281d6ec1d",
    "taskId": "4f7fb14a-5b48-4033-a484-e03a160a3f28",
    "uri": "/api/v1/flow-analysis/4c5593bf-82cf-4d05-b48f-c7d281d6ec1d"
  },
  "version": "1.0"
}
```

The page also includes sections for Error Status Codes and Request URL.

Flow Analysis ID

4c5593bf-82cf-4d05-b48f-c7d281d6ec1d



APIC-EM Flow Analysis – REST API

The screenshot shows the APIC - Enterprise Module interface with the "Flow Analysis" API selected. The main content area displays the "Flow Analysis" API documentation, including its specification based on the Swagger™ 1.2 specification, terms of service, and implementation notes. It also includes a "Response Class" section and a detailed "Parameters" table. A large blue arrow points from the text "Flow Analysis ID" to the "flowRequestId" parameter in the "Parameters" table.

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

Flow Analysis

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

[Terms of service](#)

[Cisco DevNet](#)

flow-analysis : Flow Analysis API

Method	Path	Description
POST	/flow-analysis	Initiates a new flow analysis
GET	/flow-analysis	Retrieves a summary of all flow analyses stored
GET	/flow-analysis/{flowRequestId}	Retrieves result of a previously requested flow analysis

Implementation Notes

Retrieves result of a previously requested flow analysis by its request id

Response Class

Model | Model Schema

```
PathResponseResult<  
    version (string, optional),  
>
```

Parameters

Parameter	Value	Description	Parameter Type	Data Type
flowRequestId	4c5593bf-82cf-4d05-b48f-c7d281d6ec1d	Flow analysis request id	path	string

Error Status Codes

HTTP Status Code	Reason
200	This Request is OK
403	This user is Forbidden Access to this Resource
401	Not Authorized Yet, Credentials to be supplied
404	No corresponding flow analysis result for requested id

Request URL

<https://172.28.97.201/api/v1/flow-analysis/4c5593bf-82cf-4d05-b48f-c7d281d6ec1d>

Flow Analysis ID

4c5593bf-82cf-4d05-b48f-c7d281d6ec1d

APIC-EM Flow Analysis – REST API

Flow Analysis

JSON Format

Verify Status = COMPLETED

The screenshot shows the APIC - Enterprise Module interface. On the left, there's a sidebar with icons for Home, Topology, Devices, and Applications. The main area has tabs for 'Request URL' and 'Response Body'. The 'Request URL' tab shows the URL: `https://172.28.97.201/api/v1/flow-analysis/4c5593bf-82cf-4d05-b48f-c7d281d6ec1d`. The 'Response Body' tab displays a JSON response with the following structure:

```
{
  "response": {
    "request": {
      "sourceIP": "65.1.1.46",
      "destIP": "207.1.10.20",
      "periodicRefresh": false,
      "id": "4c5593bf-82cf-4d05-b48f-c7d281d6ec1d",
      "status": "COMPLETED",
      "createTime": 1456963660187,
      "lastUpdateTime": 1456963662051
    },
    "lastUpdate": "Thu Mar 03 00:13:54 UTC 2016",
    "networkElementsInfo": [
      {
        "id": "d826268d-d34b-416f-b16b-b37f9c49d314",
        "type": "wireless",
        "ip": "65.1.1.46",
        "linkInformationSource": "Switched"
      },
      {
        "id": "727376ea-f586-4cce-8fb0-eab891694c6e",
        "name": "AP7081.059f.19ca",
        "type": "Unspecified"
      }
    ]
  }
}
```

The 'Response Headers' tab shows the following headers:

```
{
  "Pragma": "no-cache, no-store",
  "Strict-Transport-Security": "max-age=31536000; includeSubDomains, max-age=31536000; includeSubDomains",
  "Content-Control": "no-cache, no-store, no-cache, no-store",
  "Transfer-Encoding": "chunked",
  "Date": "Thu, 03 Mar 2016 00:13:54 GMT",
  "X-Frame-Options": "SAMEORIGIN, SAMEORIGIN",
  "Content-Type": "application/json; charset=UTF-8"
}
```

At the bottom, there's a red button labeled 'DELETE /flow-analysis/{flowRequestId}' with the note: 'Deletes a flow analysis request'.

APIC-EM Flow Analysis

Accurate 5-tuple path flow-analysis – available via GUI and REST APIs



UNKNOWN UNKNOWN

Branch-Router2 Routers

- CPU Usage: 5 Mins Usage(%) 4, 5 Secs Usage(%) 0, 1 Min Usage(%) 3, Refreshed At 6/5/2016, 10:55:43 PM
- Memory Usage: Refreshed At 6/5/2016, 10:55:43 PM, Memory Usage(bytes) 104372920
- Ingress Interface: GigabitEthernet0/0 Egress Interface: GigabitEthernet0/3

Branch-Access1 Switches and Hubs

- Device Stats: Ingress Interface: GigabitEthernet1/0/1, Egress Interface: GigabitEthernet1/0/47

CAPWAP Tunnel

ACL Check

Stats: Device, Interface, QoS, Perfmon

d/or i

Link Source Information

APIC-EM Flow Analysis

Accurate 5-tuple path flow-analysis – available via GUI and REST APIs

APIC - Enterprise Module

Path Trace: IPs: 65.1.1.83 → 212.1.10.20

Trace Results

View Small Show Reverse Scroll Lock Show Duplicate Devices View in Topology

Reversed

```

    "response": {
      "request": {
        "sourceIP": "212.1.10.20",
        "destIP": "65.1.1.6"
      },
      "lastUpdate": "Thu Apr 23 01:23:21 UTC 2015",
      "properties": [ ],
      "networkElementsInfo": [
        {
          "id": "424621be-d2b4-4d42-ad16-92d4d5c19fa4",
          "type": "WIRED",
          "ip": "212.1.10.20",
          "linkInformationSource": "Wired"
        },
        {
          "id": "8beada2e-cd2c-421d-941f-3ba42696c489",
          "name": "CAMPUS-Access1",
          "type": "SWITCH",
          "ip": "212.1.10.1"
        }
      ]
    }
  
```

developer.ciscospark.com

NWP Lab Pod 1 February 3 16:57 Hello CiscoLive TECSND-3602, my APIC-EM at 198.18.129.100 manages 9 Devices.

NWP Lab Pod 1 February 3 16:57 Hello CiscoLive TECSND-3602, nodes from 65.1.1.83 to 212.1.10.20 are: AP7081.059f.19ca CAMPUS-Access1 CAMPUS-Dist1 Campus-WLC-5508 CAMPUS-Dist1 CAMPUS-Access1 .

65.1.1.83 IP: 65.1.1.83 Type: wireless Link Source: Switched

AP7081.059f.19ca IP: 55.1.1.3 Type: Unified AP Link Source: Switched

CAMPUS-Access1 IP: 212.1.10.1 Type: Link Source: Link Source

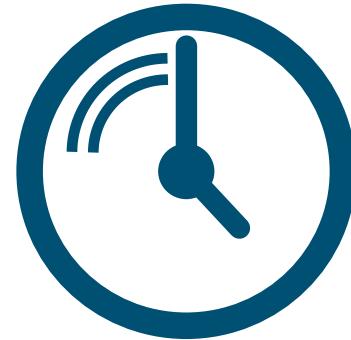
Agenda

- Welcome and Introduction
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Infrastructure Level Scripting
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Controller Level APIs
- Summary and Close



Schedule

08:45 – 10:45 Morning Part I
10:45 – 11:00 Coffee Break
11:00 – 13:00 Morning Part II
13:00 – 14:30 Lunch
14:30 – 16:30 Afternoon Part I
16:30 – 16:45 Coffee Break
16:45 – 18:45 Afternoon Part II



Sample Code in GIT

Lab Examples are in GIT

1. A GIT Clone Request has already been done on the Windows Workstation in dCloud

see: C:\Users\administrator\Documents\GitHub\enterprise-network-programmability

2. Update to the latest code using git pull

> **git pull origin master**

3. Remember to copy your own work before leaving this session

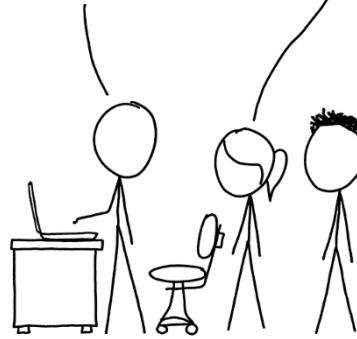
github.com/xorrkaz/enterprise-network-programmability

Cisco **live!**

THIS IS GIT. IT TRACKS COLLABORATIVE WORK ON PROJECTS THROUGH A BEAUTIFUL DISTRIBUTED GRAPH THEORY TREE MODEL.

COOL. HOW DO WE USE IT?

NO IDEA. JUST MEMORIZE THESE SHELL COMMANDS AND TYPE THEM TO SYNC UP. IF YOU GET ERRORS, SAVE YOUR WORK ELSEWHERE, DELETE THE PROJECT, AND DOWNLOAD A FRESH COPY.



```
>git pull origin master
...
network-programmability
  ID
  master
```

```
Updating a097b7b..2a010e9
Fast-forward
  .gitignore
  tasks/Hello-Lab.py
  tasks/constants.py
  tasks/env.py
  tasks/guestshell/dna/scripts/__init__.py
  tasks/guestshell/dna/scripts/record_commands.py
  tasks/guestshell/setup.py
  tasks/helper.py
  tasks/netconf/__init__.py
  tasks/{netconf-acl/nc-acl.py => netconf/acl.py}
  tasks/requirements.txt
  tasks/restconf/__init__.py
  tasks/restconf/acl.py
  tasks/restconf/interface_stats.py
  14 files changed, 732 insertions(+), 54 deletions(-)
```

Lab I

Use a Controller API

1. Work through APIC-EM REST API Task
2. Combine APIC-EM with Spark, NeXt UI Toolkit or Tropo

Under The Hood

1. DNA Center Preview and Demo

Get Started
Prepare the Lab Environment

Scenario 1: DevOps Style Human Interaction

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- IOS-XE Guestshell: Prepare Python environment
- IOS-XE Guestshell: Python packaging
- IOS-XE Guestshell and EEM: Record commands to the database
- IOS-XE Guestshell: Outputs collector
- IOS-XE Guestshell and EEM: Config Diff To Spark
- IOS-XE NETCONF: Configure an ACL
- IOS-XE RESTCONF: Configure an ACL
- IOS-XE RESTCONF: Operational data to Spark

Scenario 3: Controller-Level Programmability

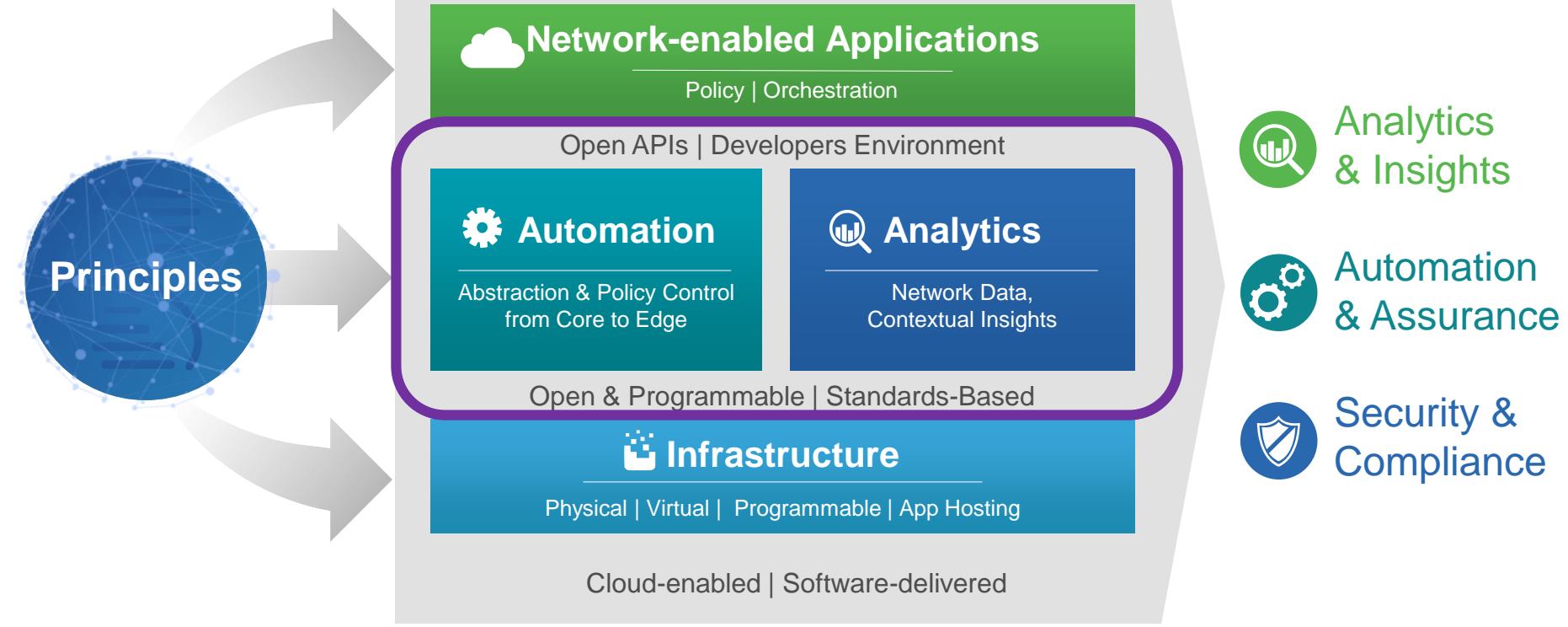
- Device Count in APIC-EM Inventory
- Path Trace via APIC-EM REST APIs

Agenda

- Welcome and Introduction
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Cisco Digital Network Architecture (DNA)



DNA Center as a Platform – Strategy

Goal with DNA Center as a platform (DNACaaP) is to deliver world-class integration capabilities and development environment that will generate greater partner business, drive broader adoption and result in greater customer satisfaction.



Critical list of API's at from raw data to well-defined business flows



Ability for partners to generate new sources of revenue from solutions built using platform integration capabilities



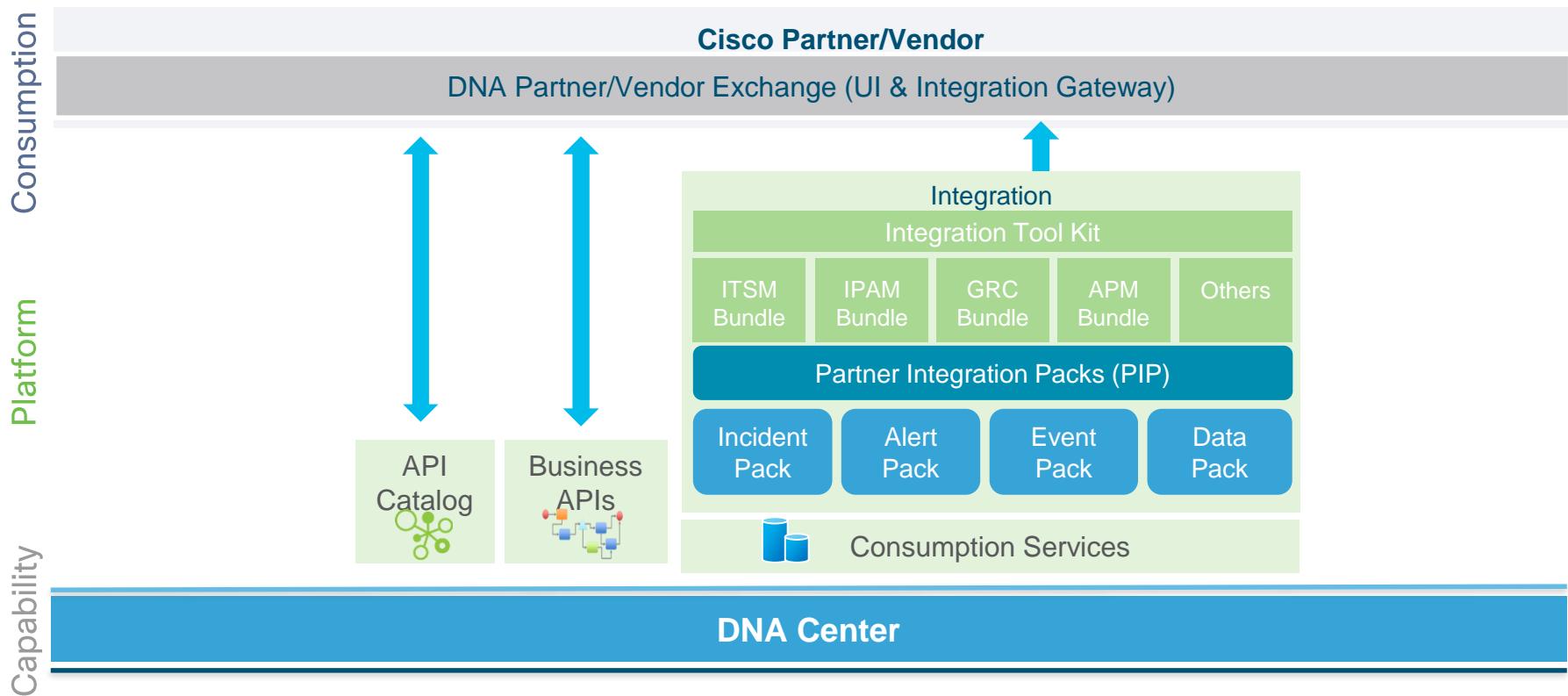
Access to sample code, testing sandbox, scripts and documentation



Active forum for exchange of ideas, feedback, samples and best practices

A rich and active DevNet community will flourish with DNA solutions if the associated API's and integration capabilities are simple to consume and continually demonstrates customer value while bridging the network and IT value chain disconnect

DNA Center as a Platform – Integration Tool Kits



DNA Center as a Platform – DNAC 1.1 API Coverage

DISCOVERY

- CRUD device credentials
- Start discovery jobs
- Device retrieval

HOST

- Host/user retrieval with filters
- Host number

SYSTEM

- Namespaces
- File management
- PKI management

DEVICE

- CRUD inventory
- CRUD roles
- CRUD location

SWIM

- Trigger process
 - Schedule/now
 - Per-group
- CRUD images
- Image details
- Recommendation report

PNP

- Image management
- CRUD projects
- CRUD devices

DNA Center as a Platform – DNAC 1.1 API Coverage

Nicht sicher | <https://dnac1.cisco.com/dna/apidoc>

CISCO DNA CENTER DESIGN POLICY PROVISION ASSURANCE

Categories

- Authentication/Authorization
- Network Discovery
- Network Device**
- Network Host
- SWIM
- System

Network Device

Method	Action	Description	⋮
GET	Retrieves all network devices	Gets the list of first 500 network devices sorted lexicographically based on host name. It can be filtered using management IP address, mac address, hostname and location name. If...	⋮
PUT	Updates network device role	Updates the role of the device as access, core, distribution, border router	⋮
GET	Retrieves network device count	Gets the count of network devices filtered by management IP address, mac address, hostname and location name	⋮
POST	Export network-device to file	Export the selected network-device to a file	⋮
GET	Retrieves network device by IP address	Gets the network device with the given IP address	⋮
POST	Associates location with device	Associates the given location to the given device	⋮
GET	Retrieves device location	Gets the list of network devices that has a location	⋮
GET	Retrieves network device by location ID	Gets list of network devices that are associated with the given location	⋮
GET	Gives all the modules associated with given device id	Get modules of the given device id	⋮
GET	Gives total number of Modules	Get Module Count	⋮
GET	Gives Module Info by its Id	Get module by Id	⋮
GET	Retrieves network device by serial number	Gets the network device with the given serial number	⋮
GET	Retrieves network device by ID	Gets the network device for the given device ID	⋮
DELETE	Delete network device by ID	Removes the network device for the given ID	⋮
GET	Retrieves network device brief by ID	Gets brief network device info such as hostname, management IP address for the given device ID	⋮
DELETE	Removes network device location	Removes the association between device and location for the given device	⋮
GET	Retrieves device location by device ID	Gets the location for the given device ID	⋮

DNA Center as a Platform – DNAC 1.1 API Coverage

The screenshot shows the Cisco DNA Center API documentation interface. The top navigation bar includes the Cisco DNA Center logo and links for DESIGN, POLICY, PROVISION, and ASSURANCE. The left sidebar lists categories: Authentication/Authorization, Network Discovery, Network Device (selected), Network Host, SWIM, and System. The main content area is titled "Network Device" and describes the "Retrieves network device count" service. It includes sections for General Information (Method: GET, Path: /network-device/count, Description: Gets the count of network devices filtered by management IP address, mac address, hostname and location name), Parameters (none listed), and Response (JSON schema: { "version": "string", "Response": "integer" }). Below this, a list of various API endpoints is shown, each with a color-coded icon (GET, PUT, POST, DELETE) and a brief description.

Method	Description
GET	Retrieves all network devices
PUT	Updates network device info
GET	Retrieves network device info
POST	Export network-device to file
GET	Retrieves network device info
POST	Associates location with device
GET	Retrieves device location
GET	Retrieves network device info
GET	Gives all the modules associated with device
GET	Gives total number of Modules
GET	Gives Module info by its id
GET	Retrieves network device info
GET	Retrieves network device info
DELETE	Delete network device by its id
GET	Retrieves network device info
DELETE	Removes network device info
GET	Retrieves device location by its id

DNA Center Automation & Analytics

DNA Center



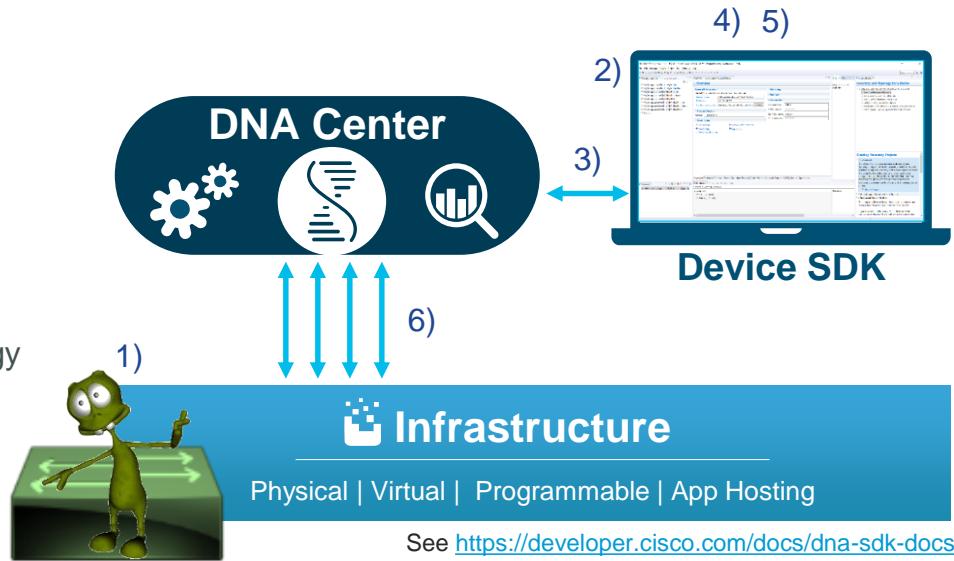
Device SDK

DNA Center – Adding Device Support

Problem: DNA Center supports a vast range of Enterprise Routing, Switching and Wireless platforms out of the box (check release notes). But what if you need 3rd party or Cisco legacy device support ?

Solution: Use the Device SDK

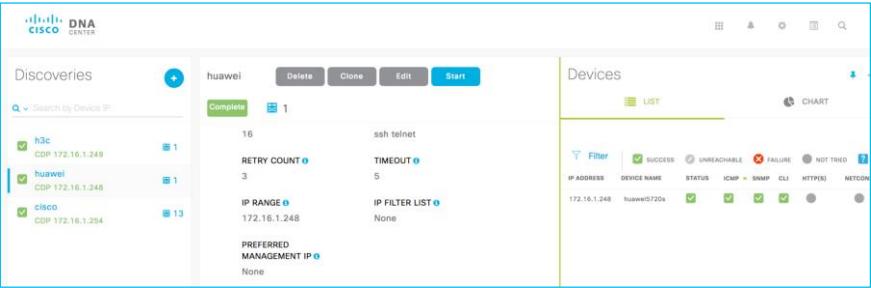
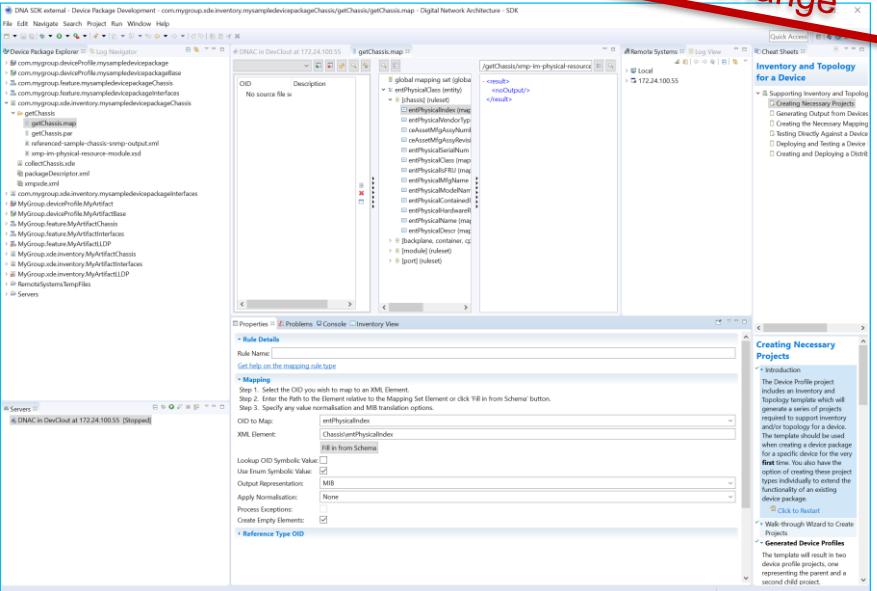
1. Put DNA Center and Device into Lab
2. Deploy Device SDK on DevOps Station
3. Connect Device SDK to DNA Center
4. Create Device Package
 1. - Specify Device
 - Select Features
 - initial Scope: Discovery, Inventory, Topology
 - Develop Mappings
5. Develop Device Package
6. Build and Test Device Package



Currently in EFT
Subject to Change

DNA Center – Device SDK

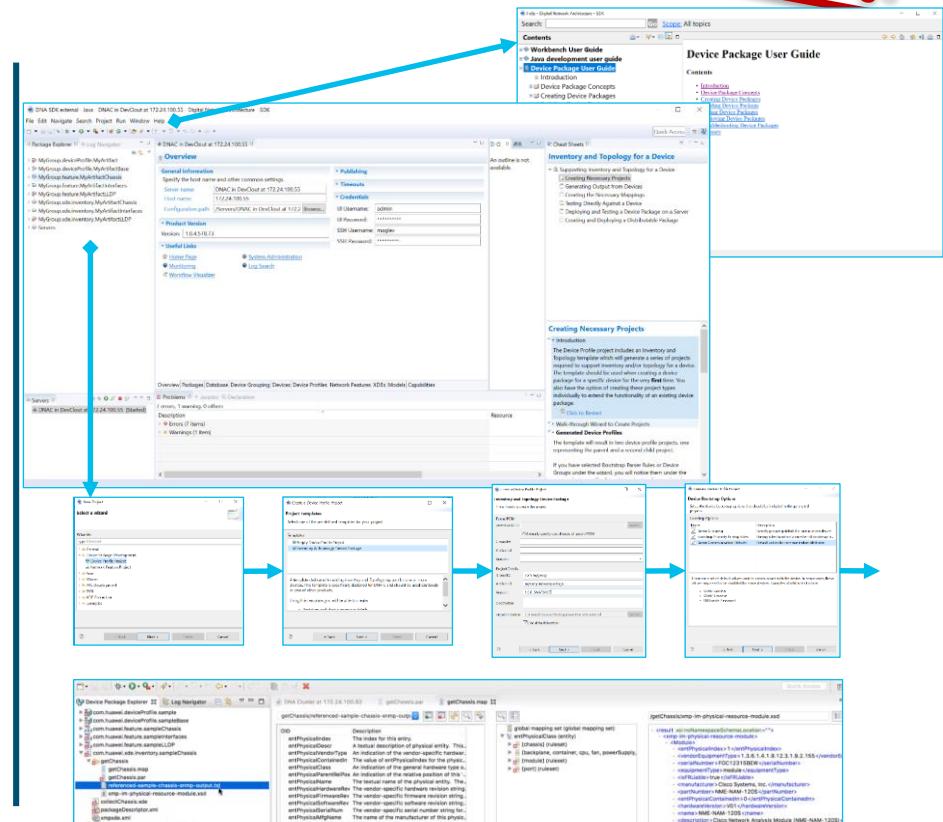
- Eclipse based SDK for
 - Ubuntu
 - Windows
 - Mac OS X
- Protocol Adapters for
 - NETCONF
 - SNMP
 - SSH / command line
- Help Documentation
- Step-by-Step Cheatsheets
- Package Creation Wizard
- DNA Center Connection Management
- Map Device Specific Data to Common Device Data Model



Currently in EFT
Subject to Change

DNA Center – Device SDK

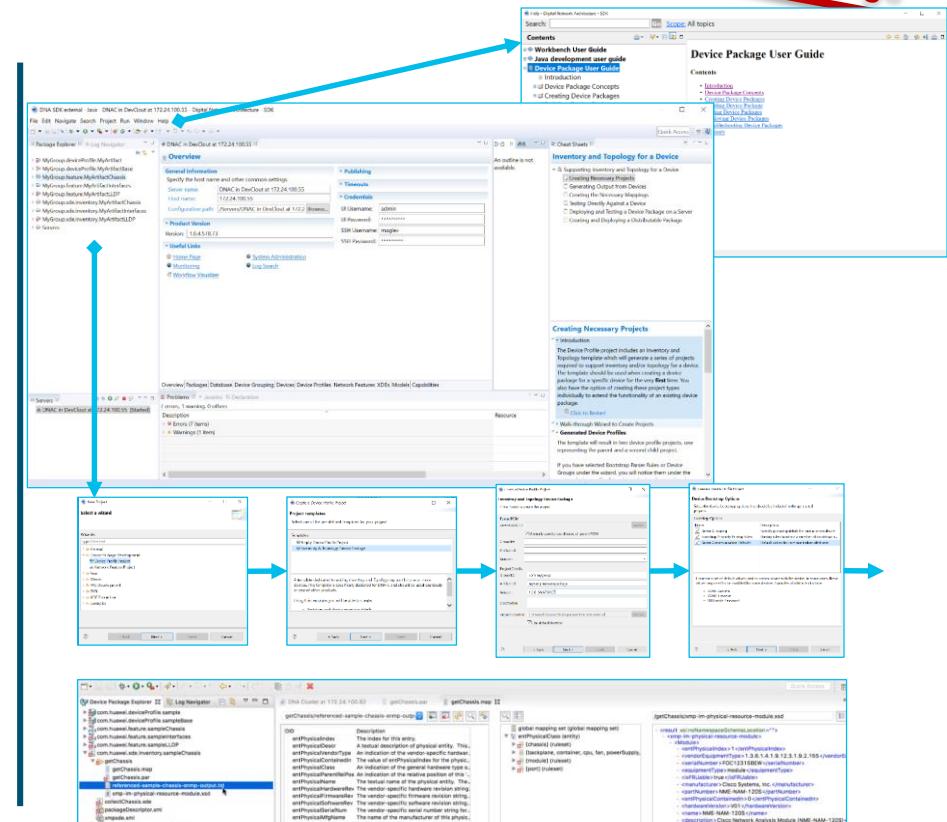
- Launch DNA SDK Eclipse
- Walk through «Device Package User Guide» under [Help][Help Contents]
- Connect SDK to DNA Center Server
- Walk through Tabs under DNA Center
 - Device Grouping
 - Device Profiles
 - Network Features
- Create Your New Device Package
 - New Projects [Device Profile Project]
 - Select «Inventory & Topology» Template
 - ... follow wizard
- Develop the Package
 - Map Device Data to Common Model (*.xde .*)



Currently in EFT
Subject to Change

DNA Center – Device SDK

- Test/Debug Device Package locally
 - Run XDE procedure locally against a device
 - Full debugging capabilities: breakpoints, step over, view variables, etc...
- Deploy Device Package to DNA Center
 - DNA Center Connection Manager
 - Deploy Package from SDK
- Verify on DNA Center
 - Add Devices to runtime DNA Center from SDK
 - Run Features developed/supported in package
 - Analyze logs from within SDK to verify correct execution of newly developed Device Package



DNA Center Automation & Analytics

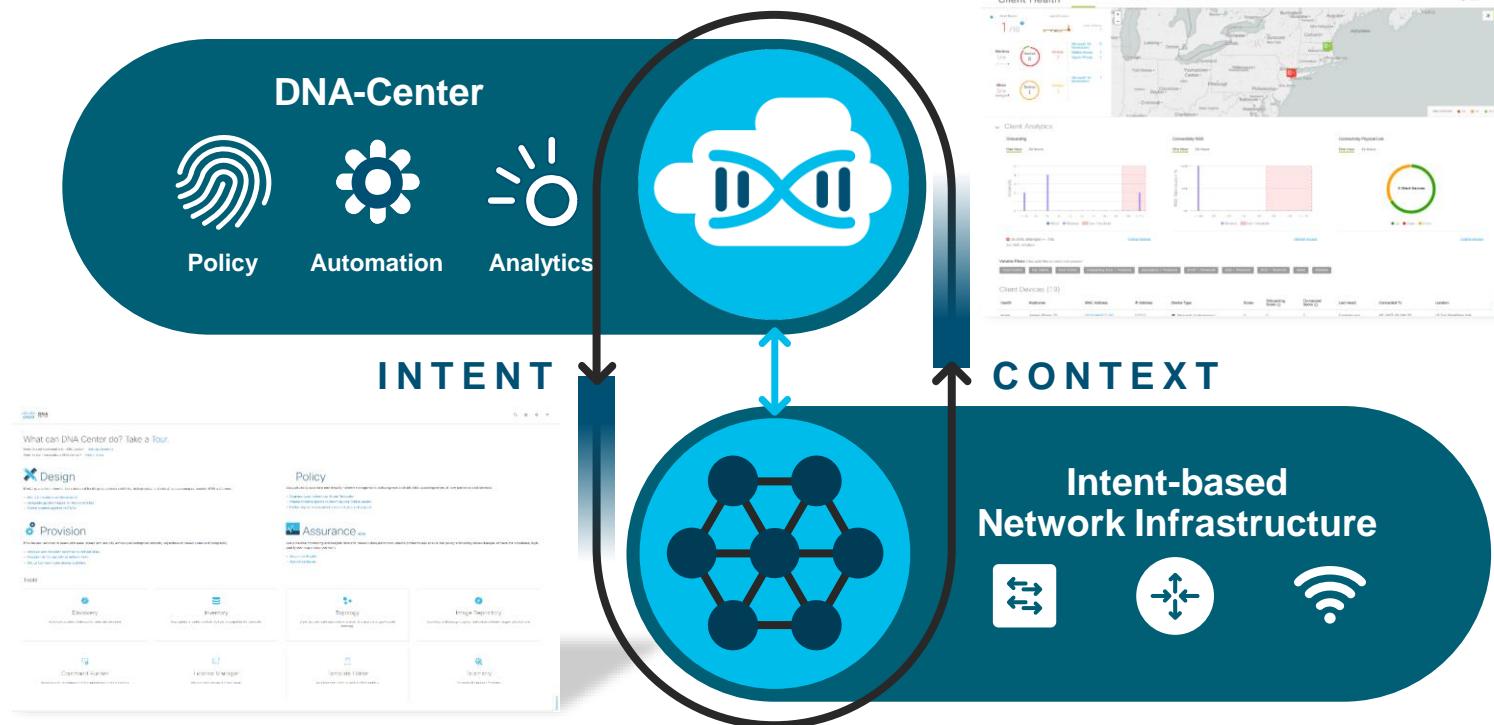
DNA Center



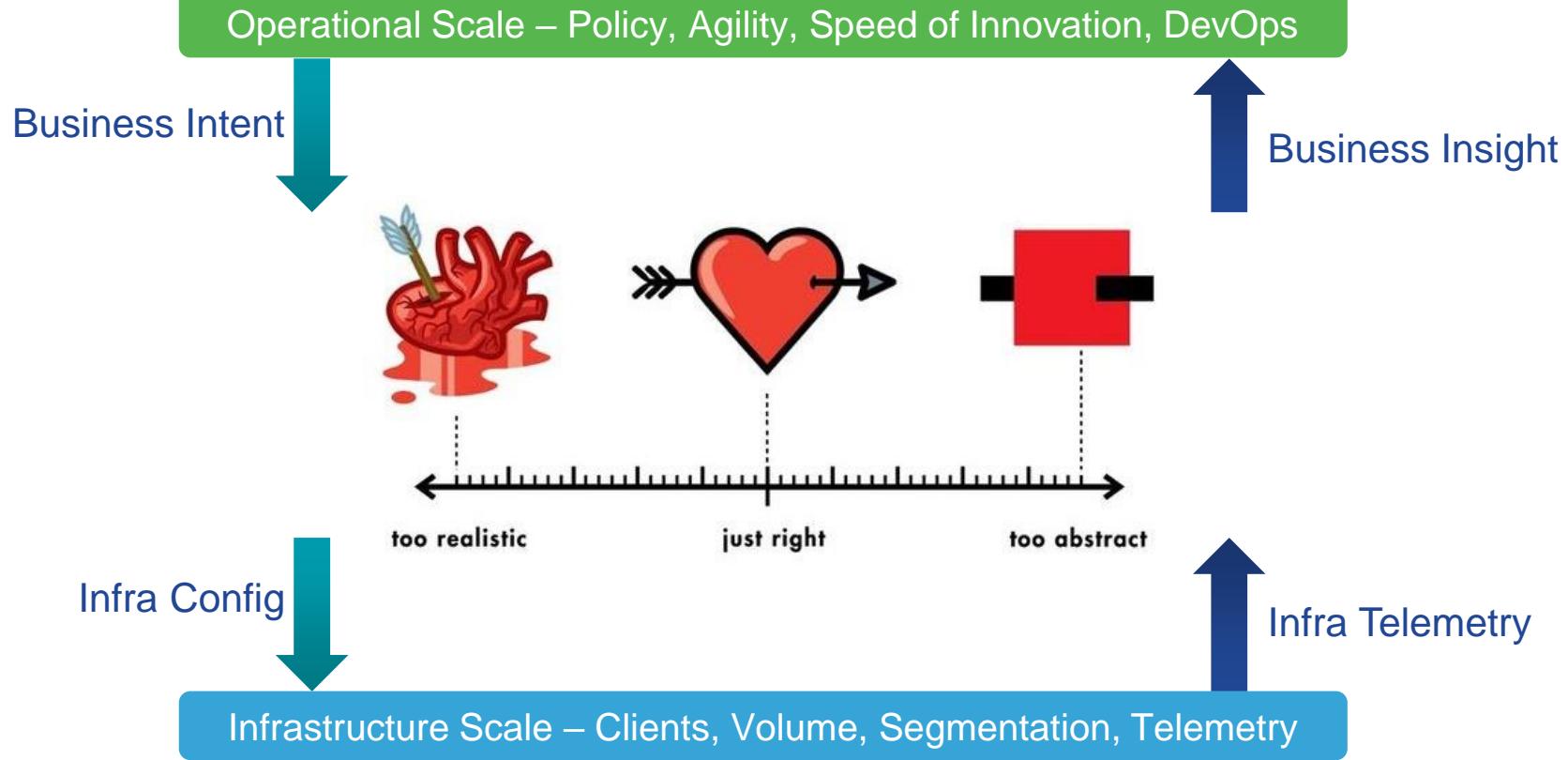
Platform
Overview

Design – Policy – Provision – Assure

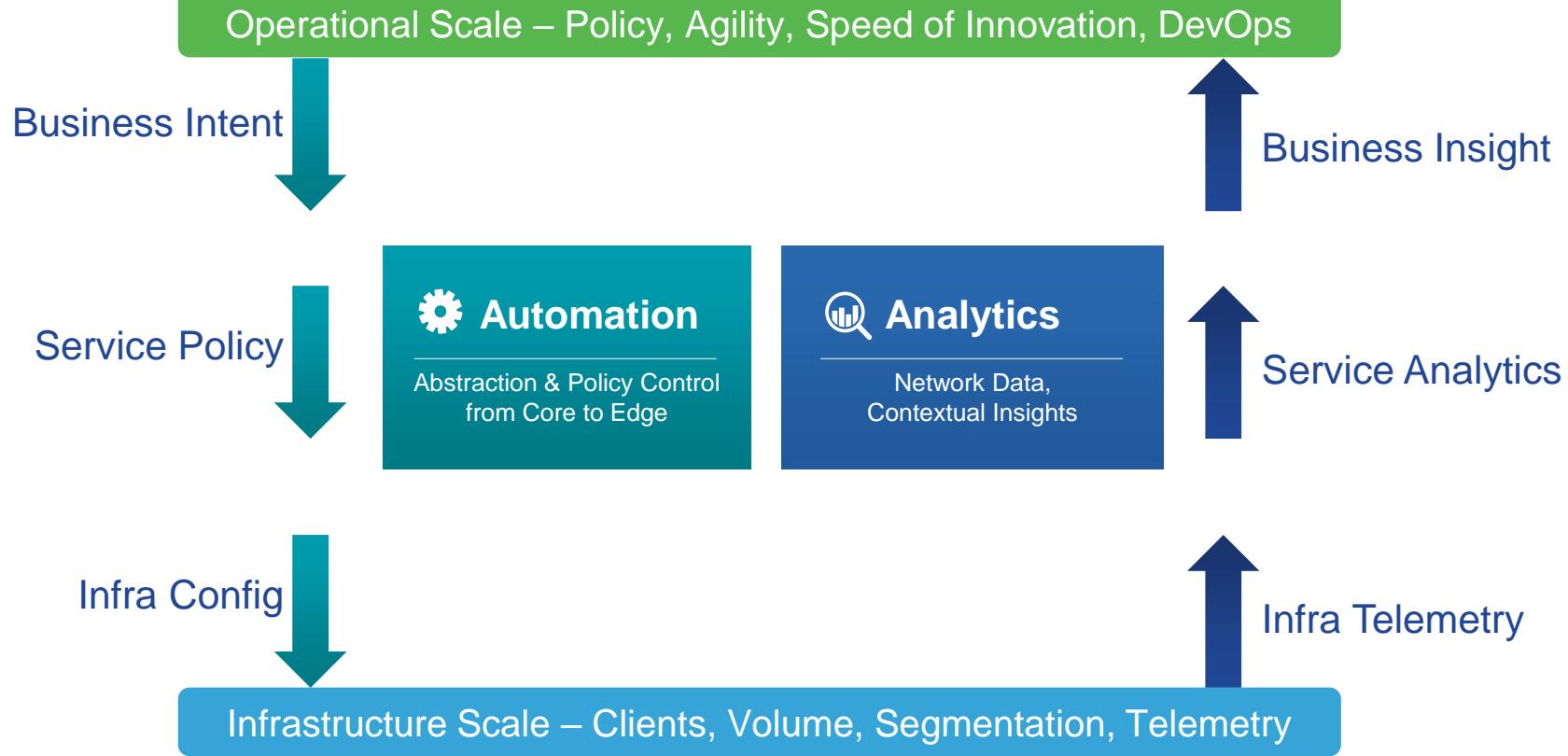
LEARNING



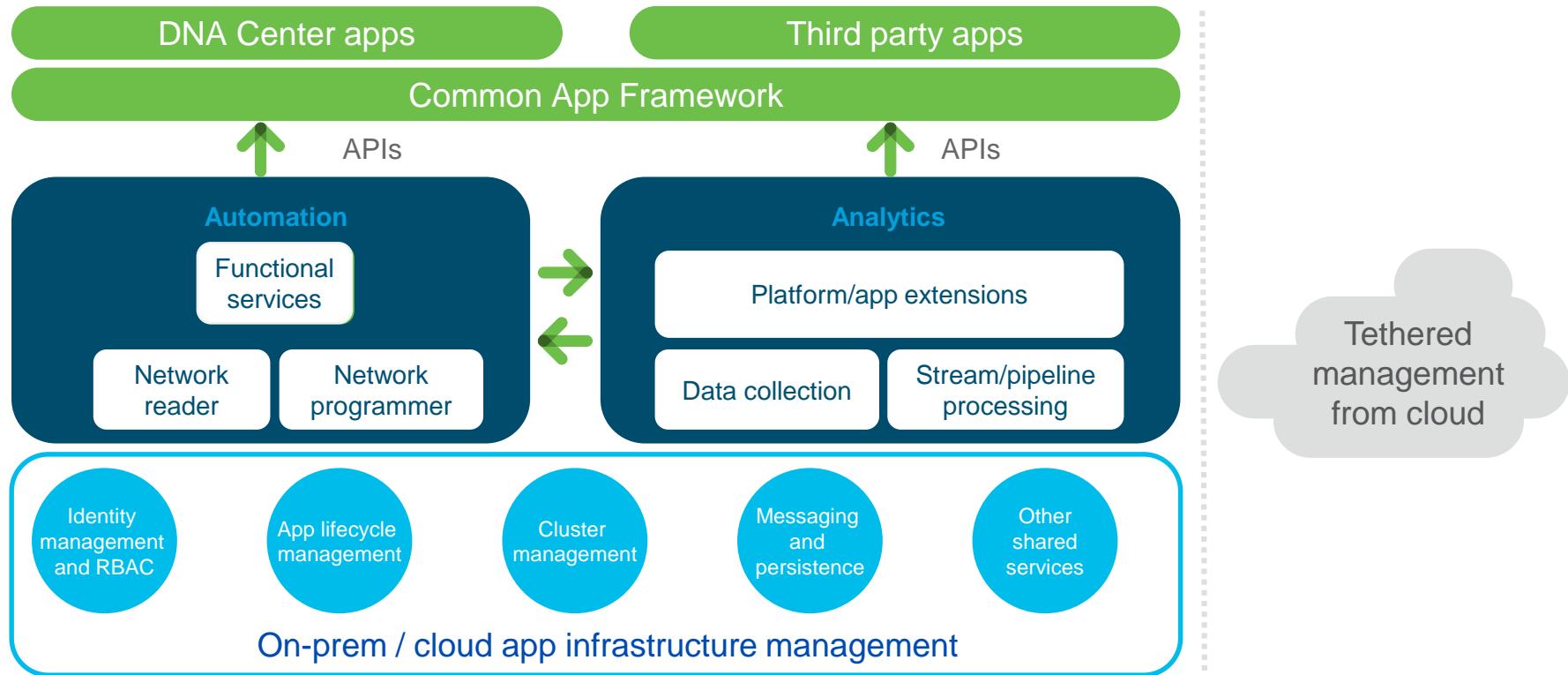
DNA – Abstraction Boundaries



DNA – Abstraction Boundaries



DNA Center – Design, Policy, Provision, Assure



DNA Center – Cloud Tethered Software Update

Benefits:

- Continuous Delivery
- Continuous Integration
- Rapid Innovation
- Business Agility

How it Works:

1. Service Catalog hosted in Cloud (AWS EC2)
2. Cisco publish new version of an App / Service to the Service Catalog
3. Customer automatically get notified and have the option to deploy the new version

The screenshot shows the DNA Center interface under the 'App Management' tab. The 'Packages' section displays a table of available updates. The columns are 'Package', 'Version', 'Status', and 'Actions'. The packages listed include Automation Core, DNA Assurance, Device Onboarding, Image Management, NCP, Network Visibility, Path Trace, SD Access, Sensor Automation, and ndp. Most packages are marked as 'Running', while DNA Assurance is shown as 'Deploying'.

Packages	Version	Status	Actions
Automation Core ⓘ	2.1.0.62245	Running	Install Uninstall Update
DNA Assurance ⓘ	1.0.4.355	Deploying	Install Uninstall Update
Device Onboarding ⓘ	2.1.0.62245	Running	Install Uninstall Update
Image Management ⓘ	2.1.0.62245	Running	Install Uninstall Update
NCP ⓘ	2.1.0.62245	Running	Install Uninstall Update
Network Visibility ⓘ	2.1.0.62245	Running	Install Uninstall Update
Path Trace ⓘ	2.1.0.62245	Running	Install Uninstall Update
SD Access ⓘ	2.1.0.62245	Running	Install Uninstall Update
Sensor Automation ⓘ	2.1.0.62245	Running	Install Uninstall Update
ndp	1.0.3.524	Running	Install Uninstall Update

The screenshot shows the DNA Center interface under the 'App Management' tab. The 'Available Updates' section displays a table of packages. The columns are 'Package', 'Version', 'Status', and 'Actions'. The package listed is DNA Assurance, which is currently 'Downloading'. A blue 'Download' button is visible at the bottom right of the table.

Packages	Version	Status	Actions
DNA Assurance ⓘ	1.0.4.355	Downloading ⓘ	Download

DNA Center – Release Cadence

1

3 Major / Minor Releases Per year
With in-between Cloud Tethered Updates



2

Customer validation process

EFT: Early Field Trials is a separate release outside of the production release

In-product Beta: Capability available in the production release as Beta

GA: General Availability



DNA Center – Upcoming EFTs (Jan-Mar)

Platform

- DNA Center Device SDK: 3rd Party and Legacy Device support
- ServiceNow Phase 2: workflow integration
(DNAC Automation triggered, Operator Action triggered and SNow triggered scenarios)

Automation

- ACA and CPP Apps: Access control automation and cloud policy provisioning
- SWIM: custom pre- and post-checks
(scripted checks prior to after image deployment)

Analytics

- ‘Kairos’: Machine Learning and BigData Analytics
(as an extension of DNA Assurance)

DNA Center Appliance

- DNA Center Integrated Appliance
 - Policy Automation
 - Assurance and Analytics
- On-premise, cloud tethered
- Built in Network Telemetry collection (FNF, SNMP, Syslog)
- Built in Contextual connectors (ISE/PxGrid, IPAM)

Scale and Performance Numbers are published per minor release

The screenshot shows the Cisco DNA Center web interface. At the top, there's a navigation bar with icons for Home, Devices, Policies, and more. Below it, a section titled "What can DNA Center do?" is divided into four main categories:

- Design**: Model your entire network, from sites and buildings to devices and links, both physical and virtual, across campus, branch, WAN and cloud.
 - Add site locations on the network
 - Designate golden images for device families
 - Create wireless profiles of SSIDs
- Policy**: Use policies to automate and simplify network management, reducing cost and risk while speeding rollout of new and enhanced services.
 - Segment your network in Virtual Networks
 - Create scalable groups to describe your critical assets
 - Define segmentation policies to meet your policy goals
- Provision**: Provide new services to users with ease, speed and security across your enterprise network, regardless of network size and complexity.
 - Discover and provision switches to defined sites
 - Provision WLCs and APs to defined sites
 - Set up Campus Fabric across switches
- Assurance**: Use proactive monitoring and insights from the network data platform to predict problems and ensure that policy and configuration changes achieve the the consistent, high-quality user experience you want.
 - Assurance Health
 - Assurance Issues

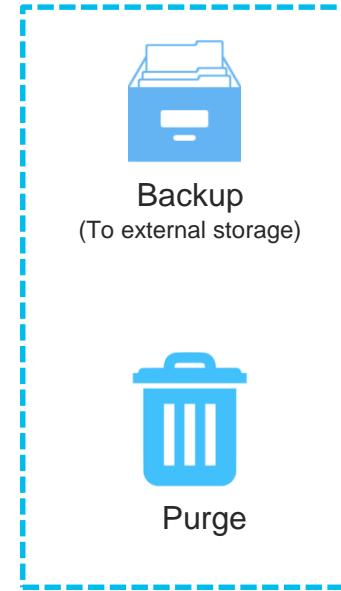
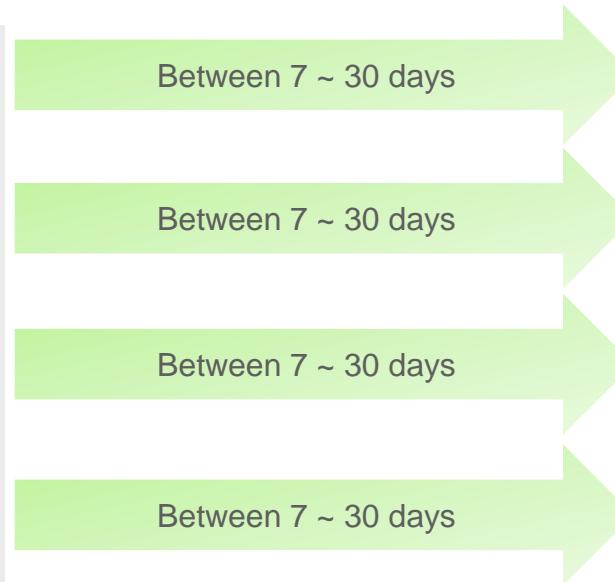
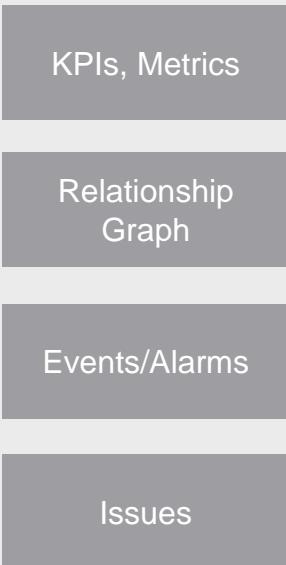
At the bottom of the interface, there's a large image of the Cisco DNA Center Appliance, which is a rack-mounted server unit.

DNA-C v1.1: RBAC - Roles and Privileges

			Role	Privileges
Cisco DNA CENTER	DESIGN	POLICY	System Administrator (SYSTEM-ADMIN-ROLE)	Provides full administrative privileges to all Cisco® DNA Center resources
	System 360	App Management	Network Administrator (NETWORK-ADMIN-ROLE)	Similar to System Admin Role but with no access to DNA Center Admin settings (add/delete users etc.)
	Users - Internal Users	User Management	Observer (OBSERVER-ROLE)	Provides primarily read-only privileges to all Cisco® DNA Center resources
	Role based access control	Roles	Network Installer (INSTALLER-ROLE)	Allows an installer to use the Network PnP mobile app to access the DNA Center PnP Application
	Password Policy	Authentication Time Out	External Authentication	0 people have this role in your network

DNA Center – Data Retention – DNAC 1.1

- Data storage for 5000 devices, 25,000 clients
- Customizable retention policy
- Storage monitoring and alerting
- Provide meaningful assurance troubleshooting, issues and trending dashboard data



Note:

- Max data retention timeline will be published closer to GA date
- DNAC 1.1 UI provides 24hr and 7day Views
- DNAC (March) target for 30day Views, Report Engine, Predefined Reports

DNA Center – Appliance Ordering Options

Greenfield

- DN1-HW-APL (List Price: \$77,160)

Brownfield – restricted to customers owning physical APIC-EM Appliance

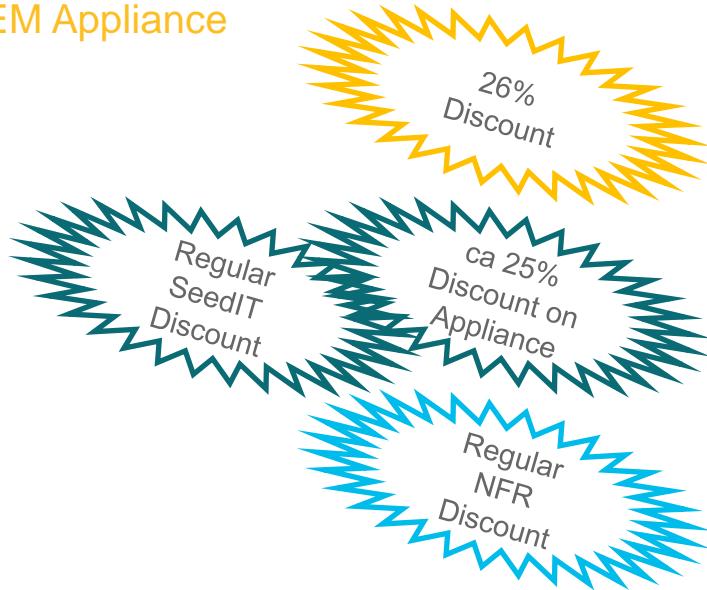
- DN1-HW-APL-U (List Price: \$57,160)
- Identical to DN1-HW-APL

SDA Bundles

- SDA-W-LABKIT and SDA-WW-LABKIT (see next slide)
- Include DN1-HW-APL

Partner -NFR Program

- Available for both DN1-HW-APL as well as SDA-*****-LABKIT
(Note: NFR discount applies to non-discounted list price)





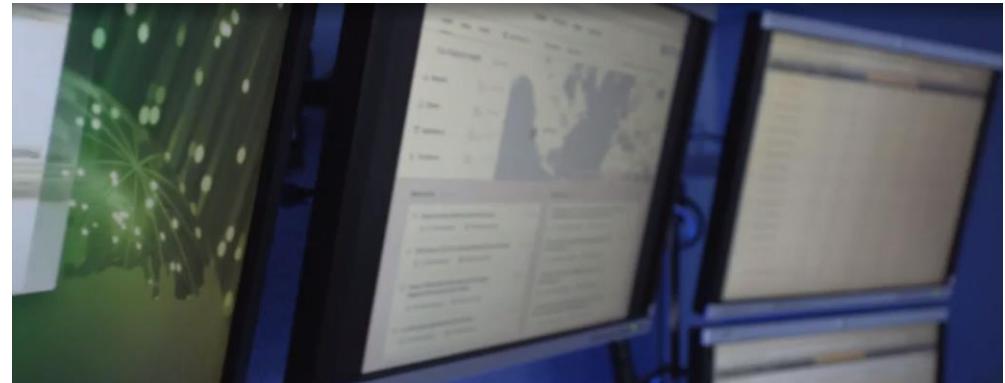
EMEAR Ecosystem

Case Study: DNA Center at IBM MultiNetwork Services

Network automation and analytics drive competitive advantage

IBM MultiNetwork Services increases client bandwidth and decreases costs with network automation and analytics. Cisco DNA helps IT now stay ahead of business needs and become the business enabler.

<https://www.cisco.com/c/en/us/about/case-studies-customer-success-stories/ibm.html>



“With Cisco Analytics, the Network can learn and predict problems before they occur”



Markus Vögele
Senior Network Architect
IBM MNWS

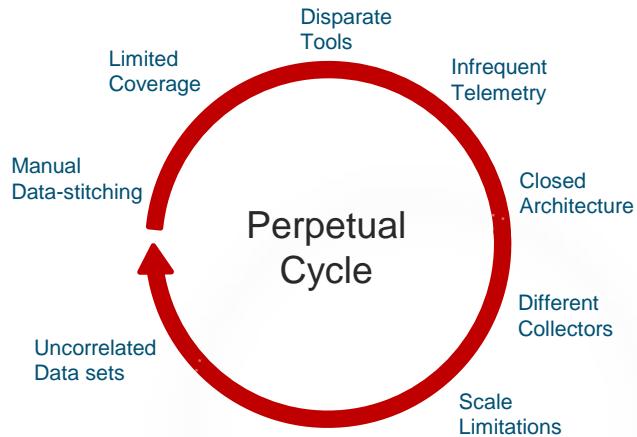
DNA Center Automation & Analytics

DNA Center



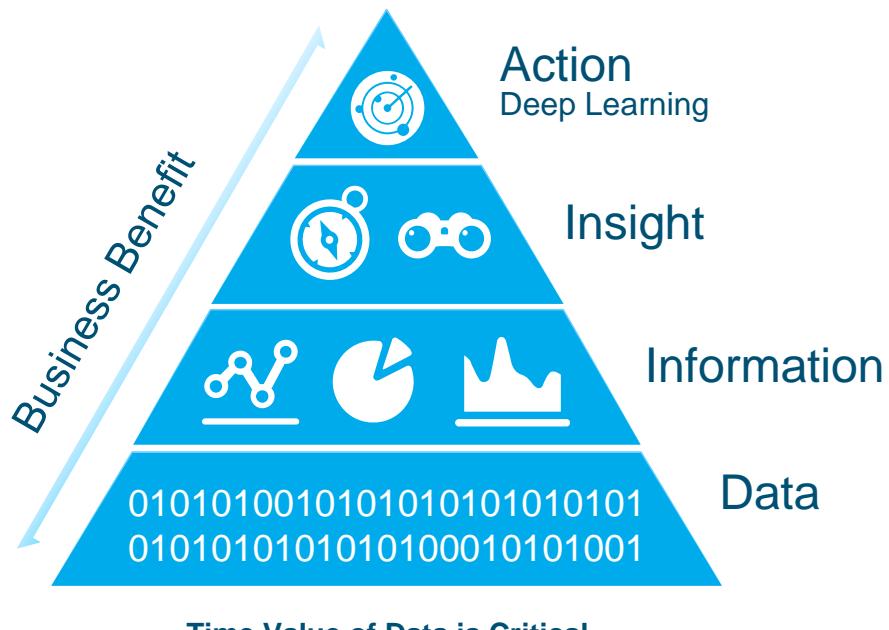
Assurance

Transform Networking using Data Science



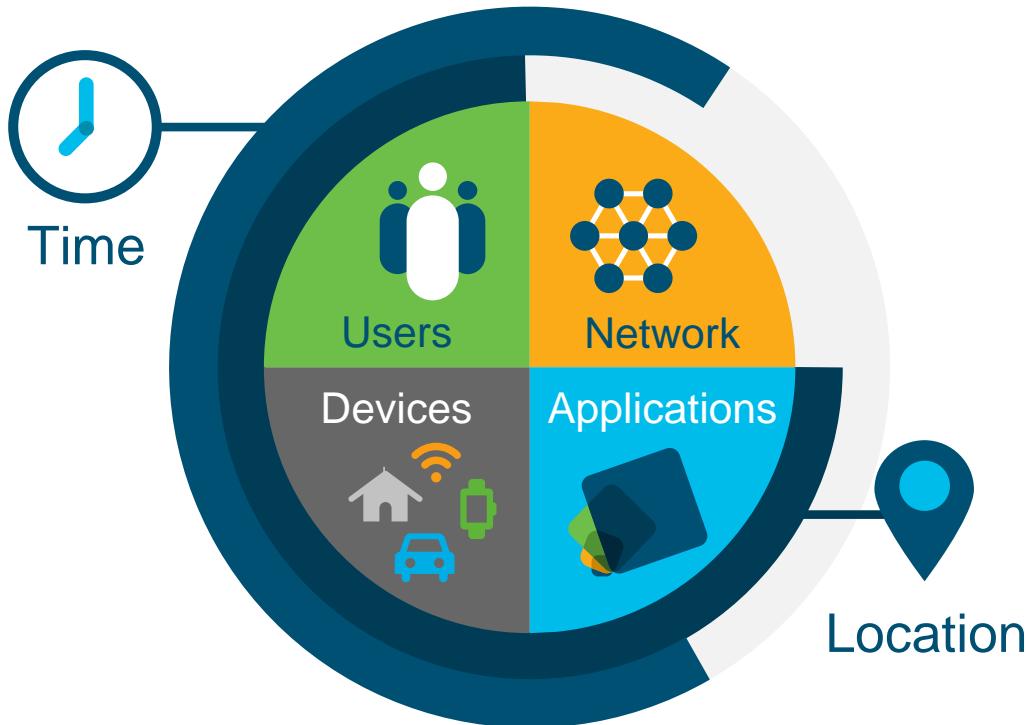
- Network data collection is cumbersome
- Closed architecture limits extensibility
- Business potential of network data is limited

Current State –Inefficiency



Future State – Networking & Data Science

In This Environment, Context is Key



Cisco Context

360-degree Visibility



Data Granularity



Historical, Real-time, Future

Rich Context Increases Business Productivity and Frees Up IT Time

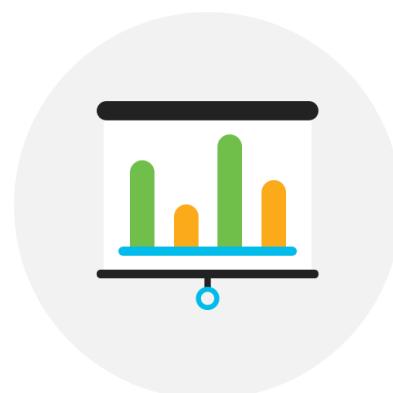
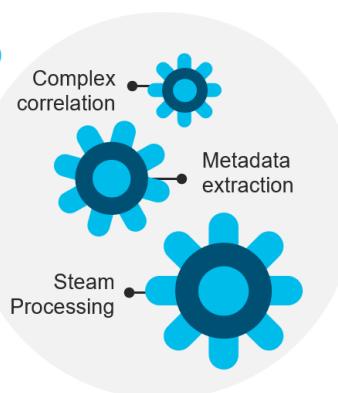
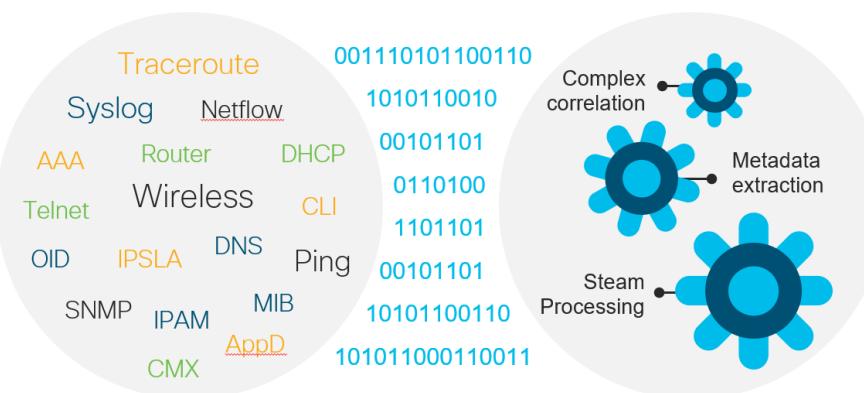
DNA Assurance

Network Telemetry
Contextual Data

Complex Event
Processing

Correlated Insights

Guided
Remediation



Telemetry and Sensors at Source
Clients | Applications | Wireless | Switching | Routing

DNA Assurance – Overall Health

The screenshot shows the Cisco DNA Center interface under the 'ASSURANCE' tab. The main title is 'Overall Health'. It displays a table of network sites with their location, overall health percentage, and detailed client and network health metrics. The table includes columns for Client Health (% Healthy Devices), Network Health (% Healthy Devices), Client Count, and Network Device Count.

Site Building Floor	All	Client Health (% Healthy Devices)	Network Health (% Healthy Devices)	Client Count	Network Device Count
All Sites	87%	83%	83%	43	29
USA	87%	70%	70%	38	24
Canada	100%	100%	100%	3	2
Netherlands	100%	67%	67%	2	3

Toggle Overview

Topology | Map | List

Health Summary

- Network Health
- Client Health
- Application Health
- Compliance

Top 10 Issues

Top 10 Issues (5) Jan 24, 2018 11:30 am to Jan 25, 2018 11:30 am

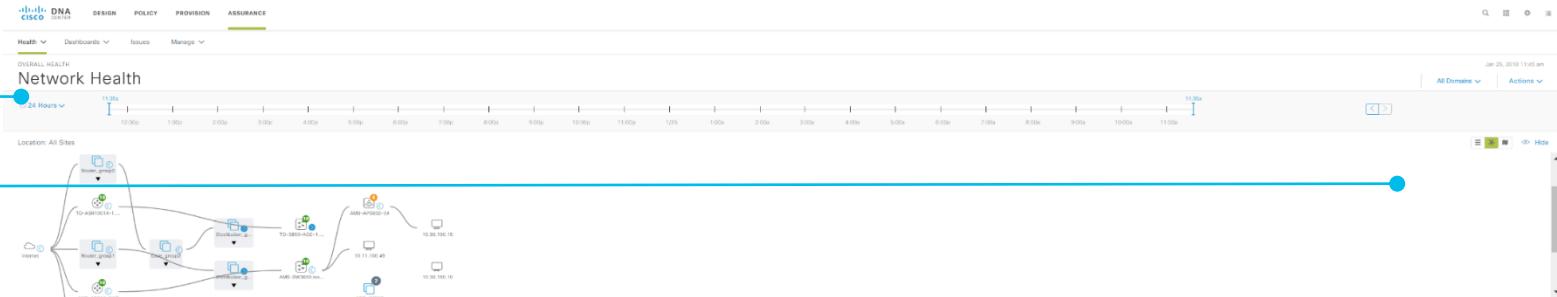
Connectivity
IGMP Adjacency Failed on Device "10.32.255.100" Interface TenGigabitEthernet1/0/22 with Neighbor 10.32.250.10
Total occurrences: 1

Connectivity
IGMP Adjacency Failed on Device "10.32.255.101" Interface TenGigabitEthernet1/0/22 with Neighbor 10.32.250.10
Total occurrences: 1

Connectivity
OSPF Adjacency Failed on Device "10.30.255.2" Interface GigabitEthernet0/0/1 with Neighbor 10.30.255.101
Total occurrences: 809

DNA Assurance – Network Health

Time Travel



Toggle Overview

Topology | Map | List

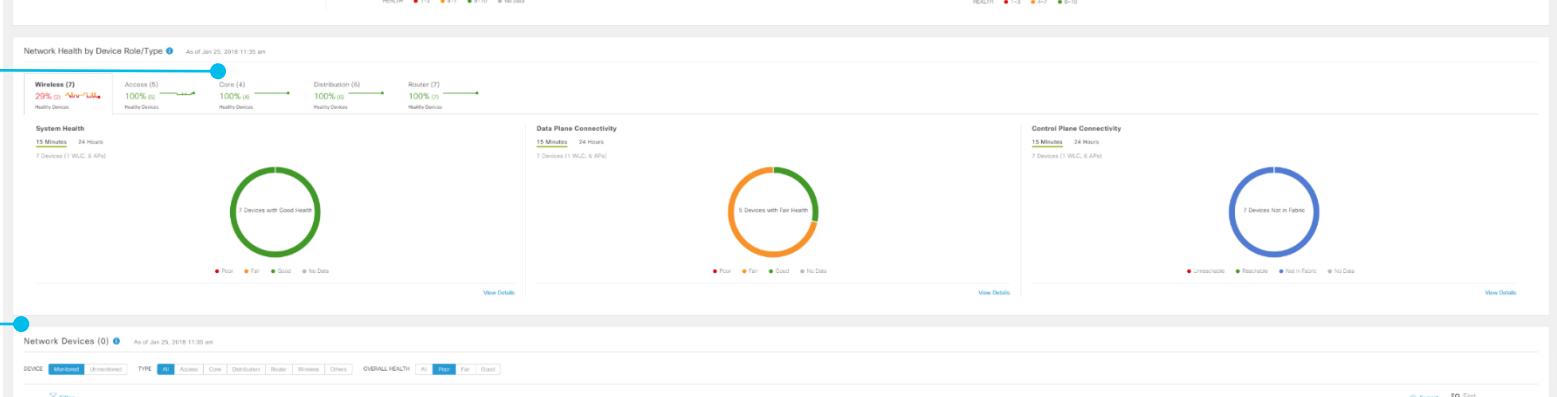
Health Summary



Health by Role

- Wireless vs Wired
- Core vs Access
- Data vs Control
- etc

Quick Filters



DNA Assurance – Client Health

Time Travel

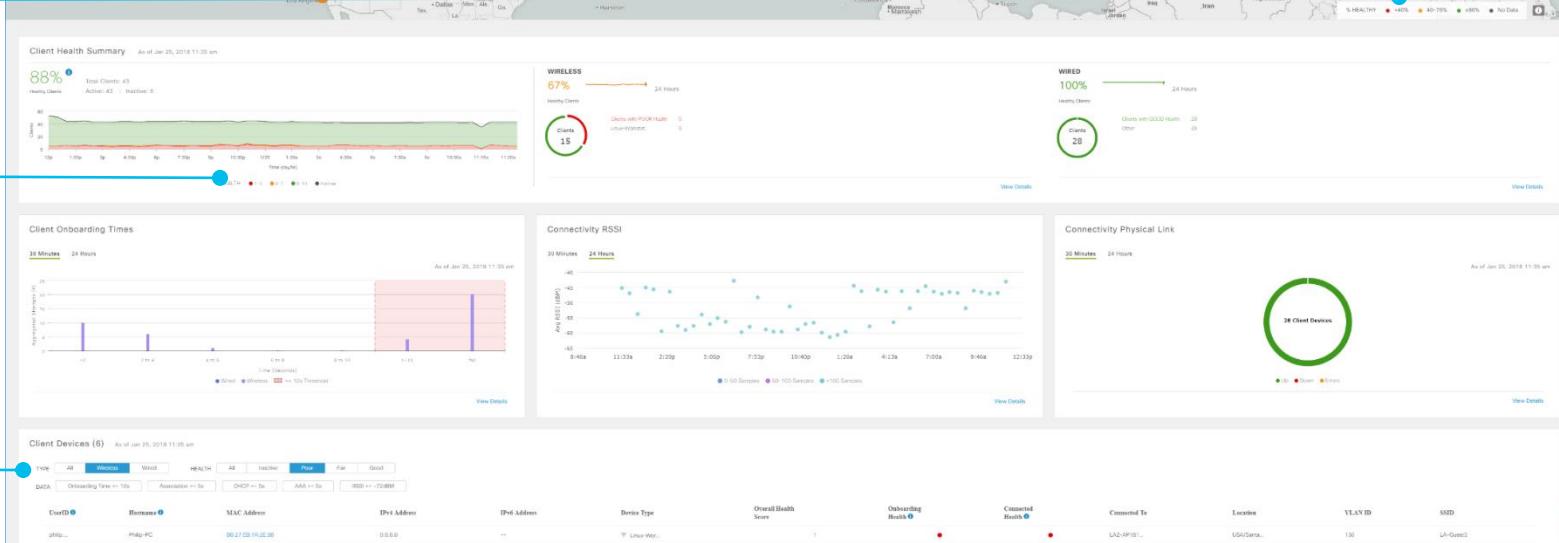


Toggle Overview

Map | List

Health Summary

- Wireless vs Wired
- Onboarding Times
- RSSI
- etc



Quick Filters

Cisco live!

DNA Assurance – Client Health – Search

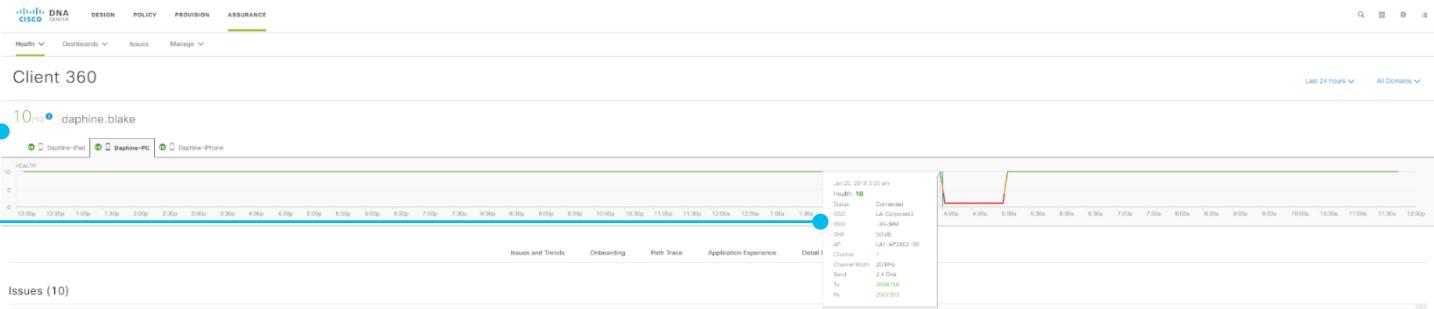
The screenshot displays the Cisco DNA Assurance Client Health search interface. At the top, there's a navigation bar with tabs: DNA, DESIGN, POLICY, PROVISION, and ASSURANCE. The ASSURANCE tab is selected. Below the navigation bar, there's a search bar with the query "daphne.blake". A modal window titled "User 360" is open, showing details for "daphne.blake" including a 24-hour timeline chart and various status indicators.

The main content area is titled "Client Health" and shows a "Client Health Summary" as of Jan 25, 2018 11:58 am. It includes a large green progress bar indicating 88% healthy clients, a "WIRELESS" section with 64% healthy clients (14 clients), and a "WIRED" section with 100% healthy clients (28 clients). Below these are sections for "Client Onboarding Times" (20 Minutes, 24 Hours) and "Connectivity RSSI" (20 Minutes, 24 Hours).

At the bottom, there's a table titled "Client Devices (6)" with columns for User ID, Name, MAC Address, IPv4 Address, IP6 Address, Device Type, Overall Health Score, Onboarding Health, Connected Health, Connected To, Location, VLAN ID, and SNID. The table shows six client devices with their respective details.

DNA Assurance – Client Health – Client 360 – 1/3

Client Devices



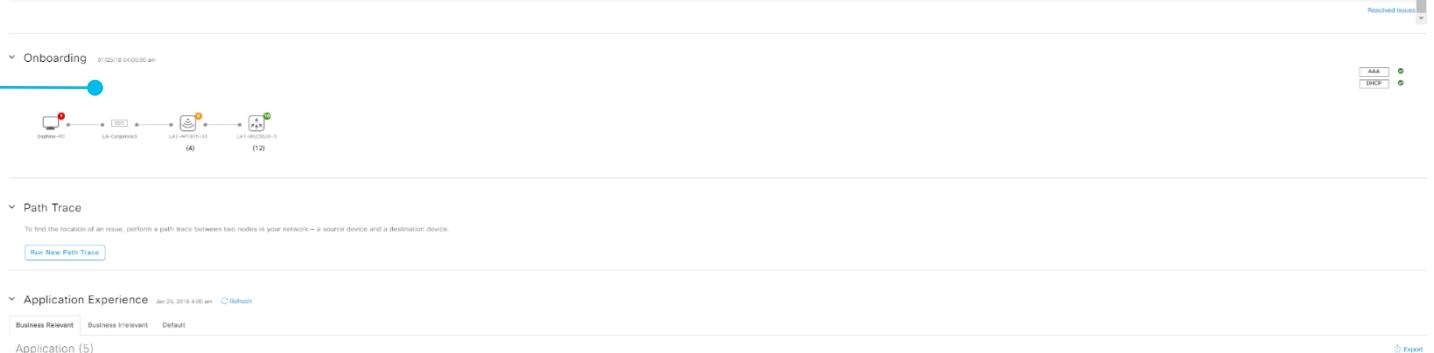
Time Travel



Client Issues

- Correlated
- Integrated with ITSM

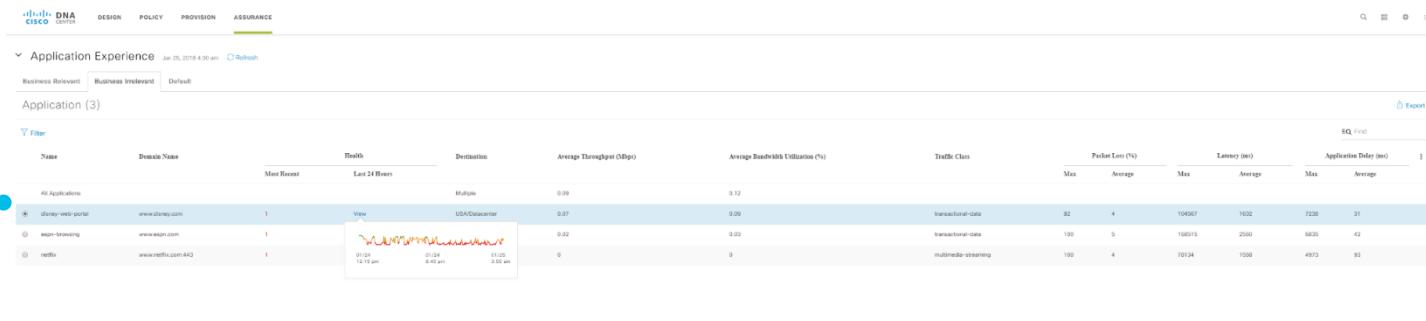
Local Topology



DNA Assurance – Client Health – Client 360 – 2/3

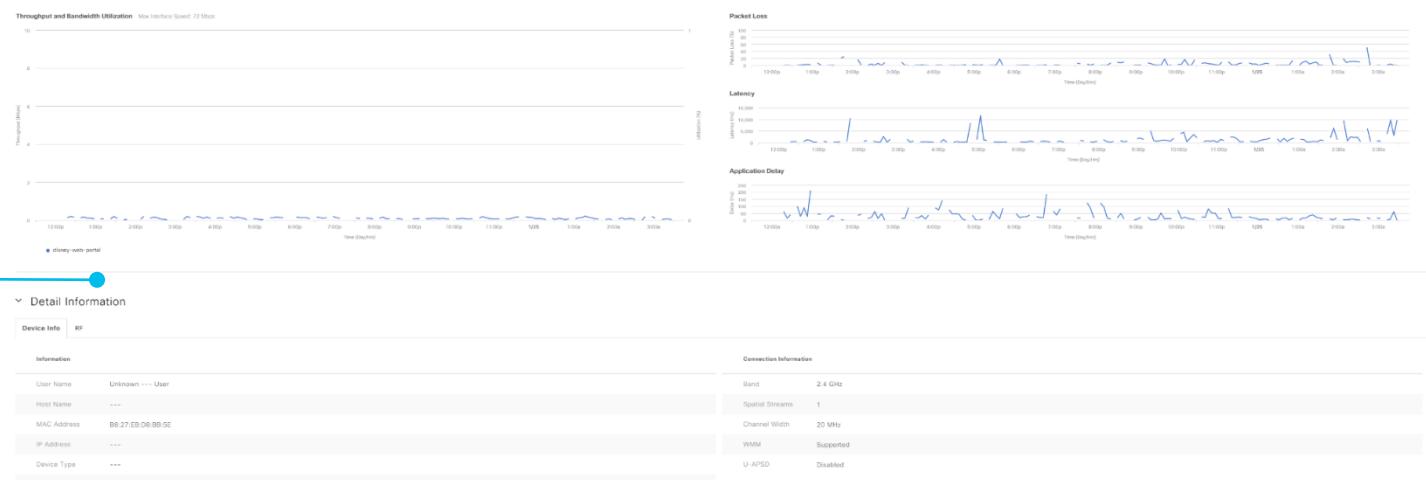
Application Experience

- Business Relevant vs. Default vs. Irrelevant
- Bandwidth and Usage
- App 360 Links



Device Details

- Hardware / Firmware
- RF Details
- Apple iOS Analytics



DNA Assurance – Client Health – Client 360 – 3/3



The screenshot shows the Cisco DNA Client 360 interface. At the top, there are tabs for DESIGN, POLICY, PROVISION, and ASSURANCE, with ASSURANCE selected. Below the tabs are sub-tabs for Health, Dashboards, Issues, and Manage, with Health selected. The main area displays a device named "daphne.blake" with three connected devices: Daphne-iPad, Daphne-PC, and Daphne-iPhone. The iPhone is highlighted. A detailed table provides information about the iPhone's connection, including Device ID (iPhone 7), Version (4.0.1), Mac (AA:4E:27:36:7B:11), IP (10.0.100.29), Location (USA/US/Los Angeles/Level 21), and Connection Status (Connected). Below the table are tabs for Issues and Trends, Onboarding, Path Trace, Application Experience, Detail Information, and iOS Analytics. The "Issues (1)" section lists an onboarding issue: "Onboarding: Wireless client took a long time to connect (SSID: La-Corporate), AP: LA1-AP002-31, Band: 5.0 GHz) - Excessive time for Onboarding. Total execution: 1". A timestamp indicates the issue was resolved at 01/24 4:43am.

Apple iOS Analytics

- Cisco – Apple Partnership
- RF Client's View
- Client Side Behavior

The screenshot shows the Cisco DNA Client Disassociation Details interface. It displays a table of disassociation events for a specific AP (LA1-AP002-31) on Wednesday, January 24, 2018. The columns include Time, Disconnection Reason, Disassociated AP, Session Duration, and AP Location. The table shows multiple entries where users disconnected from the AP due to user-triggered disassociation. Below the table, a small diagram illustrates a device connected to a wireless access point (AP).

Time	Disconnection Reason	Disassociated AP	Session Duration	AP Location
Wednesday, January 24, 2018 9:47 PM	User triggered disassociation	LA1-AP002-31		Level 21
Wednesday, January 24, 2018 9:26 PM	Device idle	LA1-AP002-31		Level 21
Wednesday, January 24, 2018 9:19 PM	User triggered disassociation	LA1-AP002-31		Level 21
Wednesday, January 24, 2018 9:11 PM	Device idle	LA1-AP002-31		Level 21
Wednesday, January 24, 2018 9:09 PM	User triggered disassociation	LA1-AP002-31		Level 21
Wednesday, January 24, 2018 8:47 PM	User triggered disassociation	LA1-AP002-31		Level 21
Wednesday, January 24, 2018 8:33 PM	Device idle	LA1-AP002-31		Level 21
Wednesday, January 24, 2018 8:28 PM	User triggered disassociation	LA1-AP002-31		Level 21
Wednesday, January 24, 2018 8:19 PM	Device idle	LA1-AP002-31		Level 21

DNA Assurance – Apple Insights



Device



Network

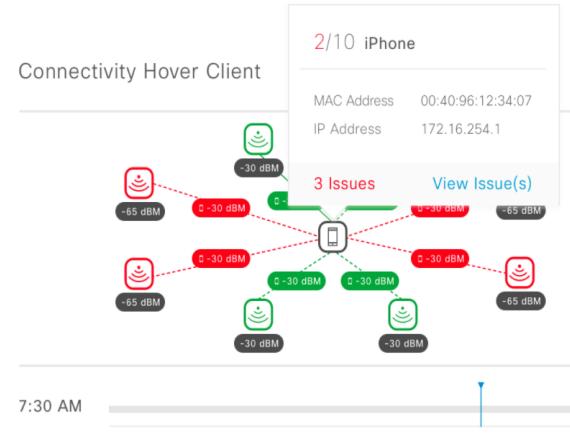


Connectivity



- Real data about end points
- Actual Networks connected by end points
- End Point view of performance

Connectivity Hover Client



DNA Assurance – Issue Details

Issue Summary

- Description
- Impact
 - Locations
 - Clients

Context Information

Guided Resolution

- Step by Step
- Automation on managed Devices

Wireless clients failed to connect (Site: Global/USA/Santa Monica/Level 1) - DHCP Timeout

Status: Open ▾ Last Occurred: Jan 25, 2018 11:00 AM

Description
Clients located in "Global/USA/Santa Monica/Level 1" timed out and have not been assigned an IP address from the DHCP server.

Impact

- Location:
1 Building
- Clients
6 Wireless Clients

Client DHCP Attempts (Site: null)
Jan 24, 2018 11:00 am to Jan 25, 2018 11:00 am

Client Attempts (#)

Time (Day/Hrs)

● Failed Attempts - DHCP Server or Client Timeout ● Success Attempts

Failure Alarm Threshold

Impacted Client...

Suggested Actions (8)

- 1 Verify that the DHCP scope is configured correctly and has adequate free IP addresses since the DHCP server will not respond if the DHCP scope is used up.
- 2 Reduce the DHCP lease time so that clients that are gone do not continue to be assigned an IP address. Best practice - DHCP lease time for high-density, high mobile environment is 15-30 min.
- 3 Verify that the IP helper address on the router is configured correctly to make sure the DHCP server is getting the DHCP messages from the client.
- 4 Verify that the DHCP server has a route to the VLAN's subnet.
- 5 Check whether the clients moved during the IP addressing phase.
- 6 Check whether the DHCP function for all the clients is responsive.
- 7 Verify that the clients are in the range of access points.
- 8 Verify that the clients are configured for IPv4 DHCP.

DNA Assurance – Issue Details

Issue Summary

- Description
- Impact
 - Locations
 - Clients

Context Information

Guided Resolution

- Step by Step
- Automation on managed Devices

Wireless clients failed to connect (Site: Global/USA/Santa Monica/Level 1) - DHCP Timeout

Status: Open ▾

Last Occurred: Jan 25, 2018 11:00 AM

Description

Clients located in "Global/USA/Santa Monica/Level 1" timed out and have not been assigned an IP address from the DHCP server.

Impact

- Location:
1 Building
- Clients
6 Wireless Clients

Impacted Wireless Clients

Impacted Locations

Hostname	Mac Address	Device Type	AP	SSID / VLAN	WLC
Unknown	B8:27:EB:7A:2A:A0	WIRELESS	LA2-AP1815-33	LA-Guest3 / 130	LA1-WLC5520-3
Unknown	B8:27:EB:7A:32:70	WIRELESS	LA2-AP1815-33	LA-Guest3 / 130	LA1-WLC5520-3
Unknown	B8:27:EB:7A:36:58	WIRELESS	LA2-AP1815-33	LA-Guest3 / 130	LA1-WLC5520-3
Philip-PC	B8:27:EB:7A:2E:88	WIRELESS	LA2-AP1815-33	LA-Guest3 / 130	LA1-WLC5520-3

Authentication ...

Suggested Actions (8)

- 1 Verify that the DHCP scope is configured correctly and has adequate free IP addresses since the DHCP server will not respond if the DHCP scope is used up.
- 2 Reduce the DHCP lease time so that clients that are gone do not continue to be assigned an IP address. Best practice - DHCP lease time for high-density, high mobile environment is 15-30 min.
- 3 Verify that the IP helper address on the router is configured correctly to make sure the DHCP server is getting the DHCP messages from the client.
- 4 Verify that the DHCP server has a route to the VLAN's subnet.
- 5 Check whether the clients moved during the IP addressing phase.
- 6 Check whether the DHCP function for all the clients is responsive.
- 7 Verify that the clients are in the range of access points.
- 8 Verify that the clients are configured for IPv4 DHCP.

DNA Assurance – Issue Details

OSPF Adjacency Failed on Device "10.30.255.2" Interface GigabitEthernet0/0/1 with Neighbor 10.30.255.101

Status: Open ▾ Last Occurred: Jan 25, 2018 11:50 AM

Description
OSPF adjacency failed on GigabitEthernet0/0/1 at Los Angeles with 10.30.255.101.

Syslog Events
Jan 24, 2018 11:50 am to Jan 25, 2018 11:56 am

12:00p 1:00p 2:00p 3:00p 4:00p 5:00p 6:00p 7:00p 8:00p 9:00p 10:00p 11:00p 1/25 1:00a 2:00a 3:00a 4:00a 5:00a 6:00a 7:00a 8:00a 9:00a 10:00a 11:00a
Time [Day/Year]

● Down ● Up >

Suggested Actions (6)

- 1 Ping the neighbor IP to verify connectivity. Run
`ping neighbor IP`
`ping 10.30.255.101`
- 2 Check OSPF neighbors. Run
- 3 If the Neighbor is in "Init" state. Check if there is authentication configured using "show run | sec OSPF". Authentication type and keys should match on both routers Run
- 4 If the Neighbor is in "Exstart" state. Check if the MTU settings are same on the interface connecting the routers. Run
- 5 Check interface GigabitEthernet0/0/1 has any incrementing errors Run
- 6 If you are unable to resolve the issue, contact Cisco TAC for support. Run

Guided Resolution

- Step by Step
- Automation on managed Devices

DNA Assurance – Issue Details ↔ ITSM Integration

The screenshot shows a serviceNow ITSM interface for an incident record. The incident number is INC0010067, created by Leah Riley, categorized as Inquiry / Help. The issue title is "Poor network performance". The Cisco DNA tab is selected, showing a summary of the issue and suggested actions:

Cisco 360 View: <https://dnac-dev.cisco.com/dna/assurance/home#/user/triley>

360 Analysis:

Onboarding - Passed | Connectivity - Poor
Health: Leah-IPad 6/10, Leah-PC 5/10
1 Issue: Misbehaving Client - This dual band capable client is preferring 2.4GHz over 5GHz.
This issue has happened 38 times
Impact: 1 Clients Impacted

SUGGESTED ACTIONS:

1. If available - Set 5GHz as the preferred band within the client driver.
2. Update the client driver to the latest version.

Cisco DNA Issue Context

- DNAC Center User 360 Link
- Description
- Impact
 - Locations
 - Clients
- Guided Resolution

DNA Center Automation & Analytics

DNA Center



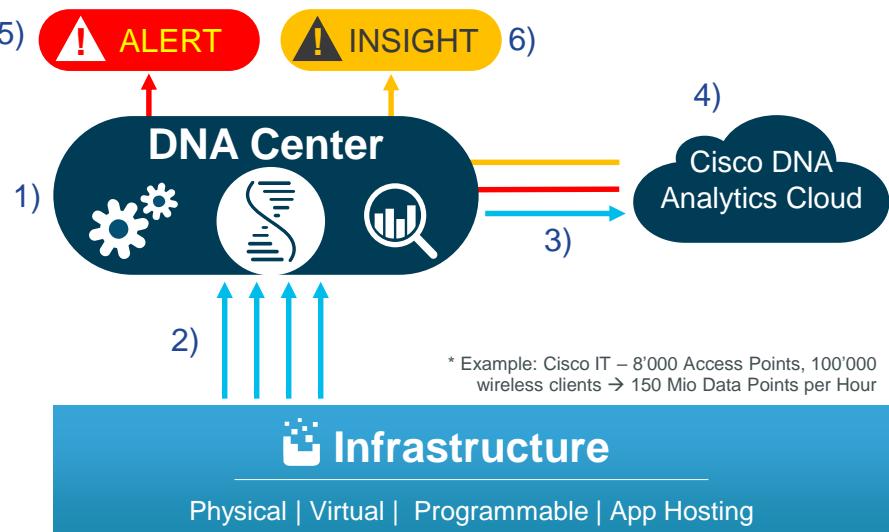
Assurance
Machine Learning

DNA Analytics – Detect and Predict

Problem: Networks are complex, troubleshooting networks is challenging. Networks create massive amount of Telemetry*. Data from your network alone may not be sufficient. Predicting issues before they have an impact is difficult.

Solution: Use Machine Learning in DNA Analytics

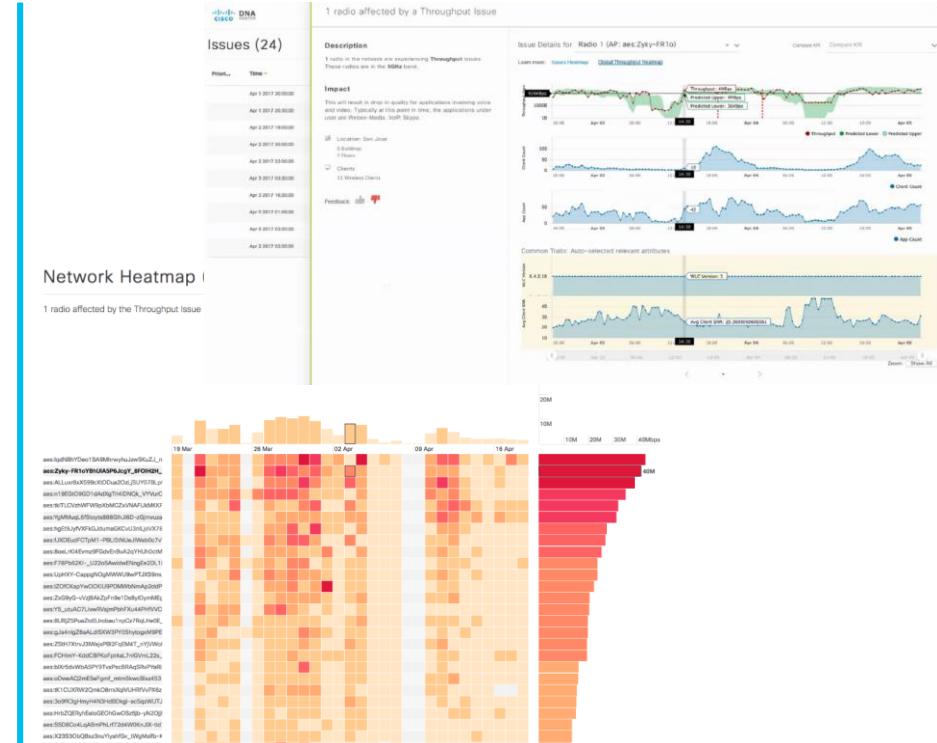
1. Deploy 'Kairos' Package in DNA Center
2. Telemetry is collected across wireless, routing, switching
(no hardware/software upgrade required)
3. (Anonymized) data is sent to the cloud
4. Advanced Machine Learning continuously adapts using vast and diverse set of Big Data
5. Detect existing Issues (**Cognitive Analytics**)
6. Predict upcoming Issues (**Predictive Analytics**)



DNA Analytics – Actionable Insight from Data

Machine Learning ...

- Learns what is a “normal”
(throughput, rate of roaming failure, number of reset, ...)
- Selects correlated data points which could explain an issue
- Keeps learning and improving, based on user feedback
- Provides heat maps of issues in the network, based on ML algorithms to identify patterns
- Provides insights on related metrics
(such as mobility paths, ...)



Issues (24)

Priority	Time
	Apr 03 2017 20:00:00
	Apr 03 2017 20:30:00
	Apr 04 2017 19:00:00
	Apr 04 2017 20:00:00
	Apr 04 2017 22:00:00
	Apr 05 2017 03:30:00
	Apr 12 2017 16:30:00
	Apr 14 2017 01:00:00
	Apr 14 2017 03:00:00
	Apr 18 2017 03:00:00

1 radio affected by a Throughput Issue

Description

1 radio in the network are experiencing **Throughput** issues. These radios are in the **5GHz** band.

Impact

This will result in drop in quality for applications involving voice and video. Typically at this point in time, the applications under user are Webex-Media, VoIP, Skype.

Location: San Jose

 5 Buildings
 7 Floors

Clients

12 Wireless Clients

Feedback:

Issue Details for Radio 1 (AP: aes:Zyky-FR1o)

Learn more: [Issues Heatmap](#) [Global Throughput Heatmap](#)

DNA Analytics – Where to Start ?

‘Kairos’ extends DNA Assurance

- Deploy DNA Center with DNA Advantage License
- Enroll for ‘Kairos’ Customer ID and one-time Password
- Install ‘Kairos’ Package in DNA Center (System Settings > App Management)
- Wait for auto Configuration to complete
- Detect and Prevent Issues

Packages	Package	Version	Status	Actions
Available Updates	Automation Core ⓘ	2.1.0.63869	✓ Running	Install Uninstall Update
	Base Provision Core ⓘ	2.1.0.63869	✓ Running	Install Uninstall Update
	Command Runner ⓘ	2.1.0.63869	⚠ Not Deployed	Install Uninstall Update
	kairos	0.4784.636	✓ Running	Install Uninstall Update

Note: ongoing EFT, limited seats available, unicast if interested

Note: open in-product beta from DNA Center March release

DNA Center Automation & Analytics

DNA Center



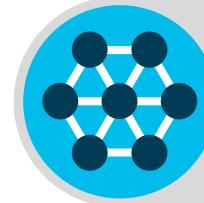
Analytics
Platform

Streaming Telemetry vs. SNMP Polling

Traditional Telemetry

SNMP / Legacy data pull methods

Streaming Telemetry



Intent-based Wireless Infrastructure



Streaming Telemetry

Pull based data import



Push based data export

CPU overhead with data crawlers



Low CPU overhead

Data intensive without optimizations



Optimized for Data export (KPI, Events)

No real time notification and false alarms



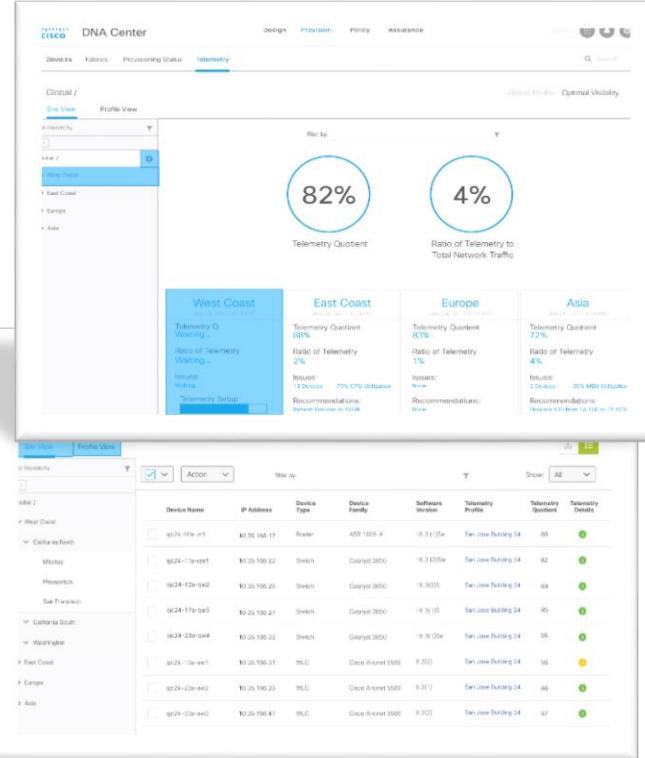
Notification send seconds after change

Min polling has too many black holes



Reduced delay in management data

Collection / Ingest – Telemetry Assessment



Network Visibility

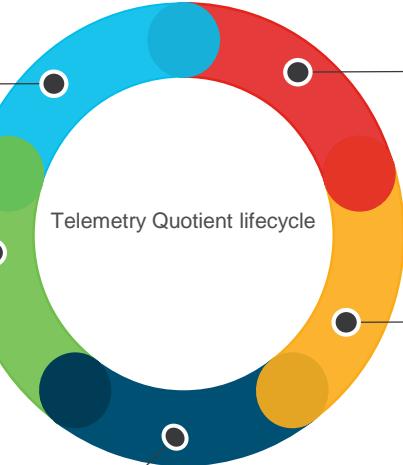
What is my network topology?
What devices are connected and how?

Sync

Automatic sync with Controller to receive Topology, discovery and inventory of devices in the network

Recommendation

Instruct controller to implement changes to the network based on acceptance of recommendation?



Network Telemetry Capability

What protocols are turned on? And where?
What else can I turn on for better telemetry?

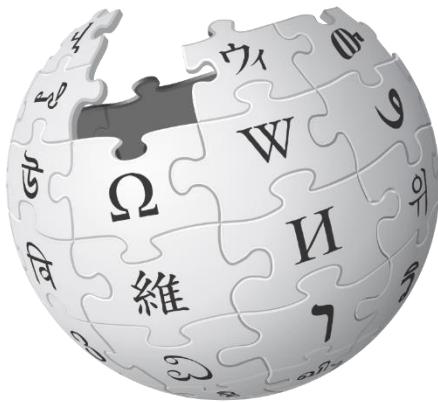
Telemetry Analysis and Recommendations

Is too much telemetry turned on or too less?
Will it effect my device performance?
Will it effect my network performance?
Can my devices support it?
What to turn off/turn on for optimized telemetry collection and analysis based on all inputs

NDP – Data Correlation and Analysis



Event Processing



WIKIPEDIA
The Free Encyclopedia

“Event processing is a method of tracking and analyzing streams of information about things that happen (events), and deriving a conclusion from them.”

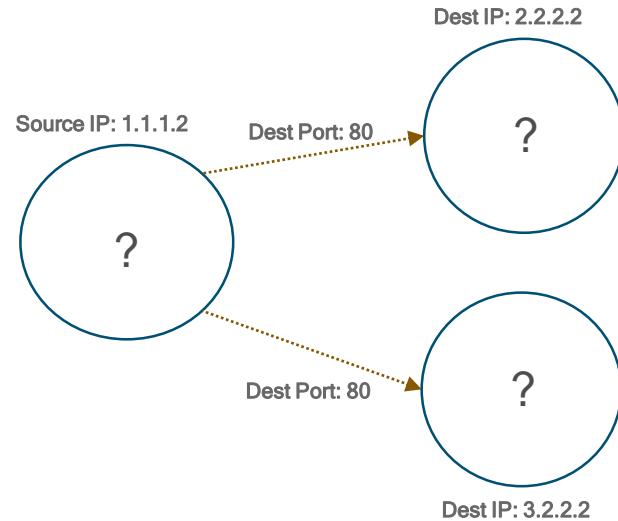
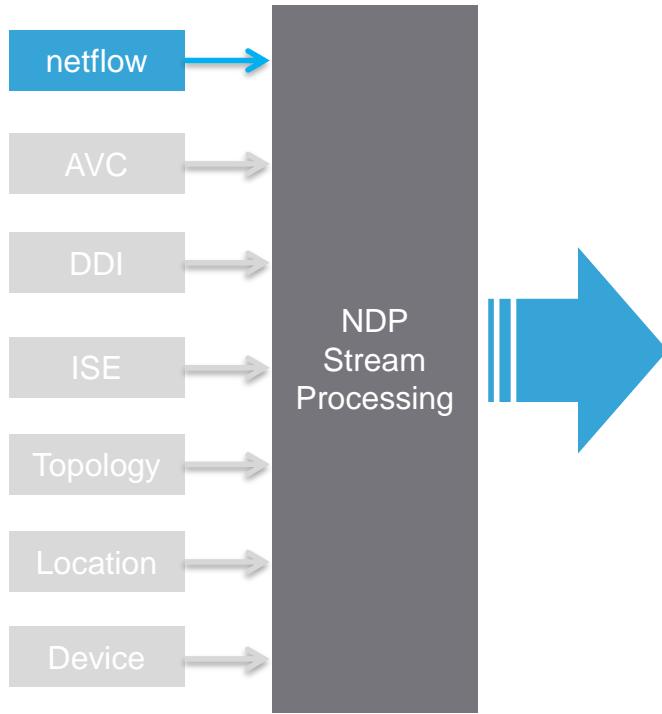
Complex Event Processing (CEP)



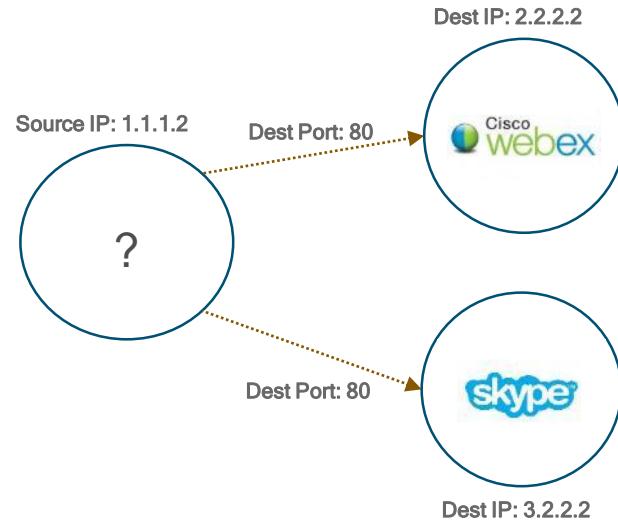
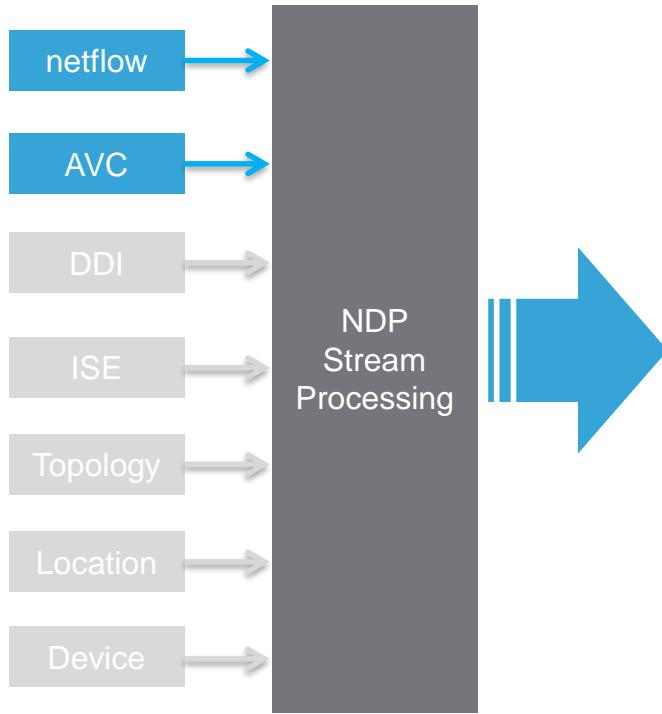
WIKIPEDIA
The Free Encyclopedia

“CEP is event processing that combines data from multiple sources to infer events or patterns that suggest more complicated circumstances. The goal ... is to identify meaningful events”

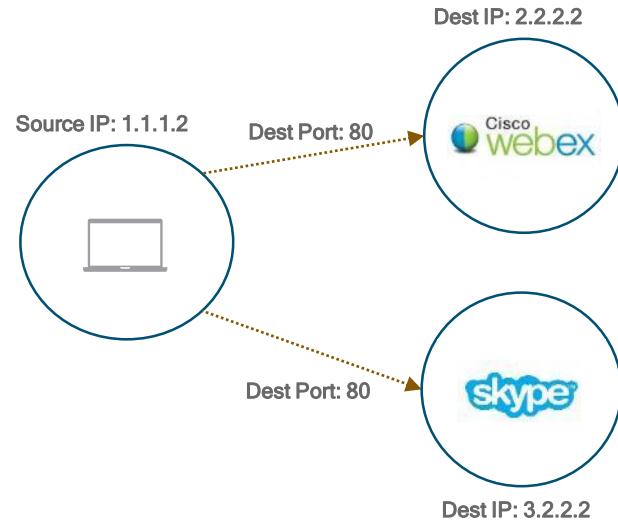
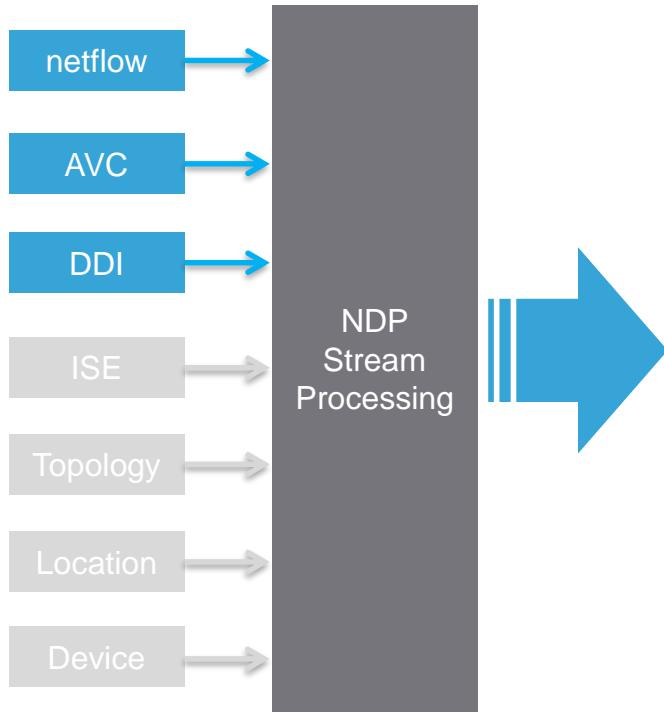
NDP – Data Correlation and Analysis



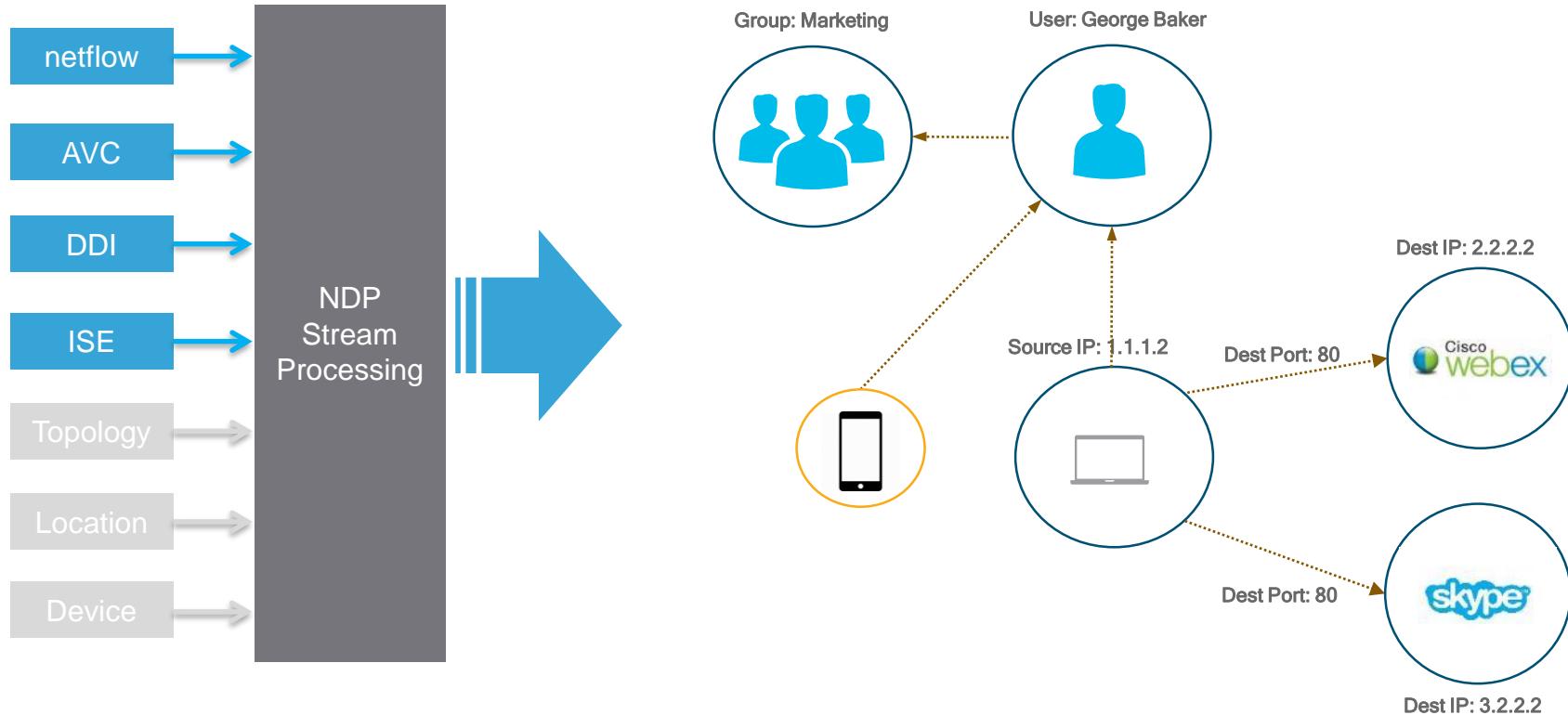
NDP – Data Correlation and Analysis



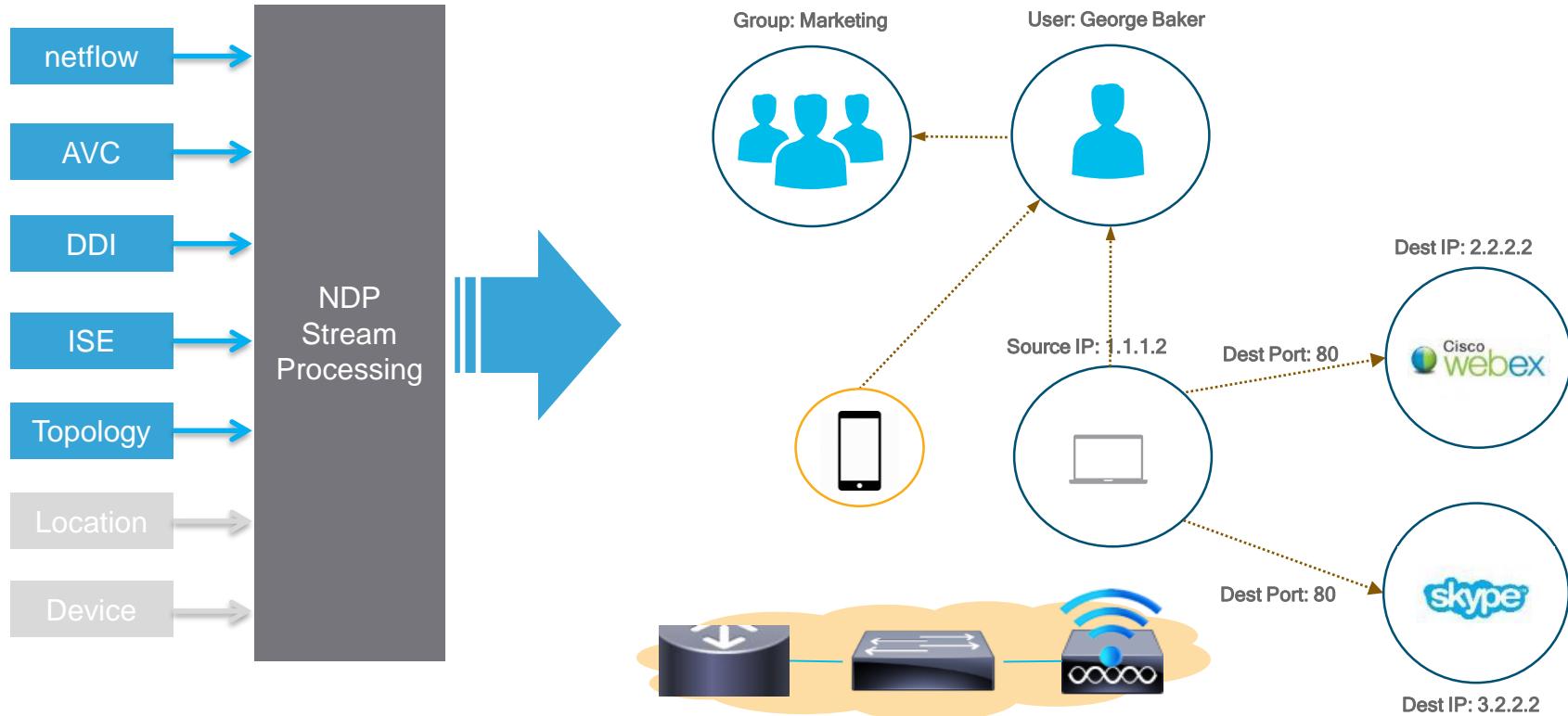
NDP – Data Correlation and Analysis



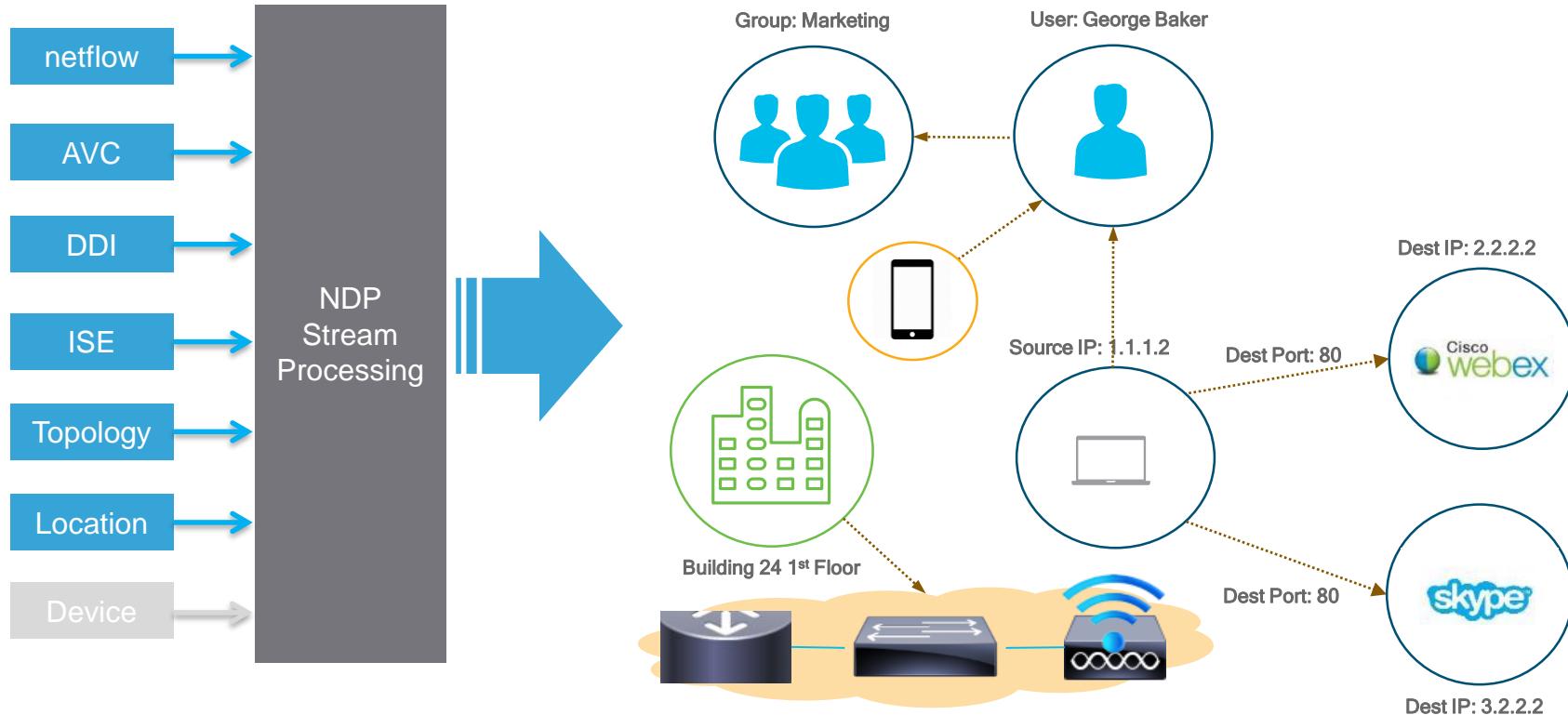
NDP – Data Correlation and Analysis



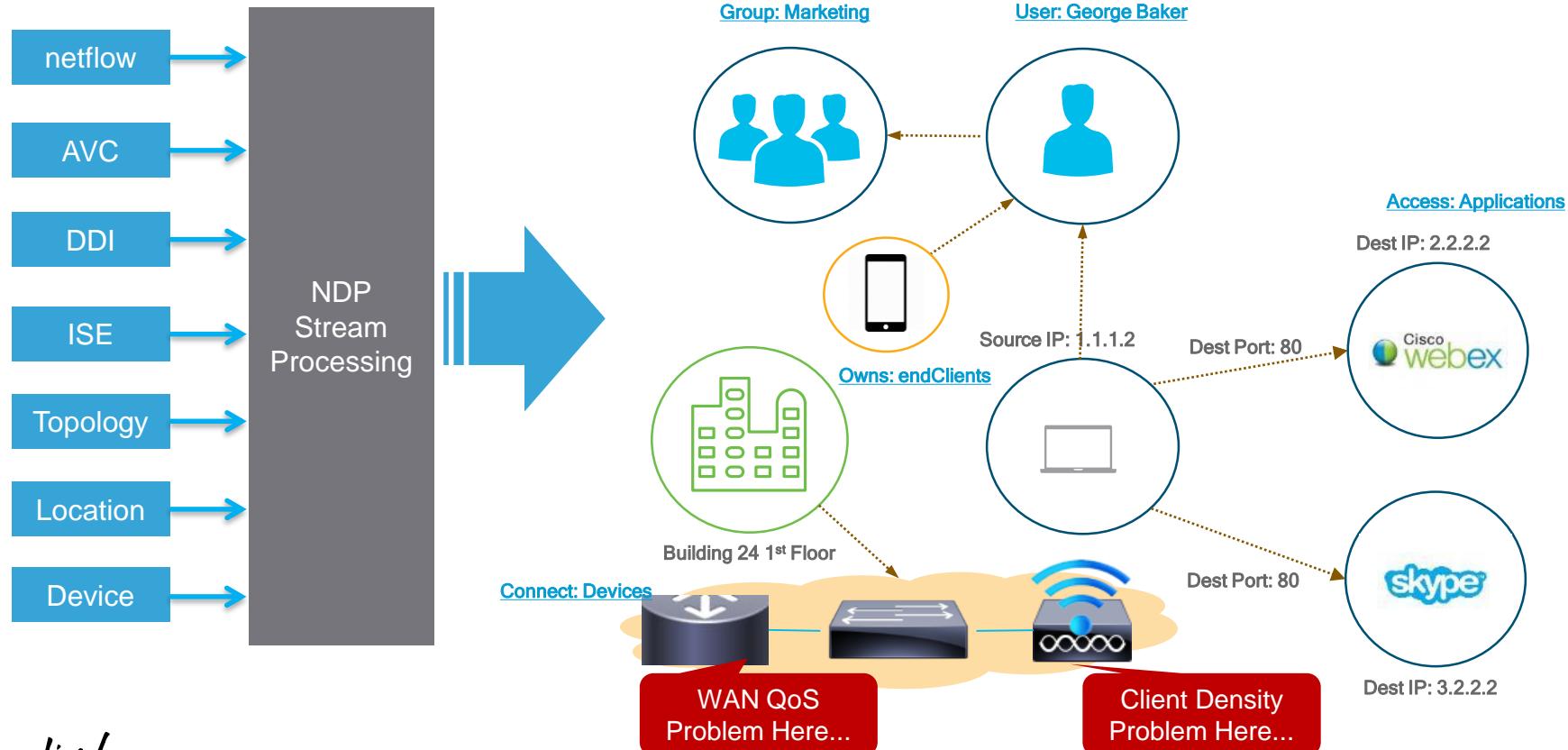
NDP – Data Correlation and Analysis



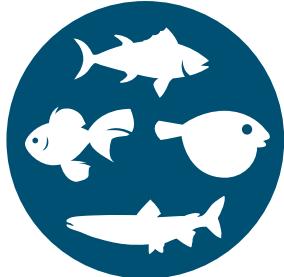
NDP – Data Correlation and Analysis



NDP – Data Correlation and Analysis



Generating Value in the Data Economy



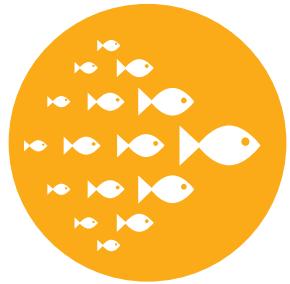
Different entities generate data relevant to their operation.

AP / Switch / Router / End Point



How fast do we need access to the data and which data?

Thresholds/Pull/Push



Proactive Correlation & Deep Learning needs larger time windows

Netflow/SNMP/Syslog/Stream Telemetry



Which data points to pick to get the most accurate analytics?

Topology/Location/Device Type/Timing

Variety

Velocity

Volume

Veracity

APIC-EM Automation



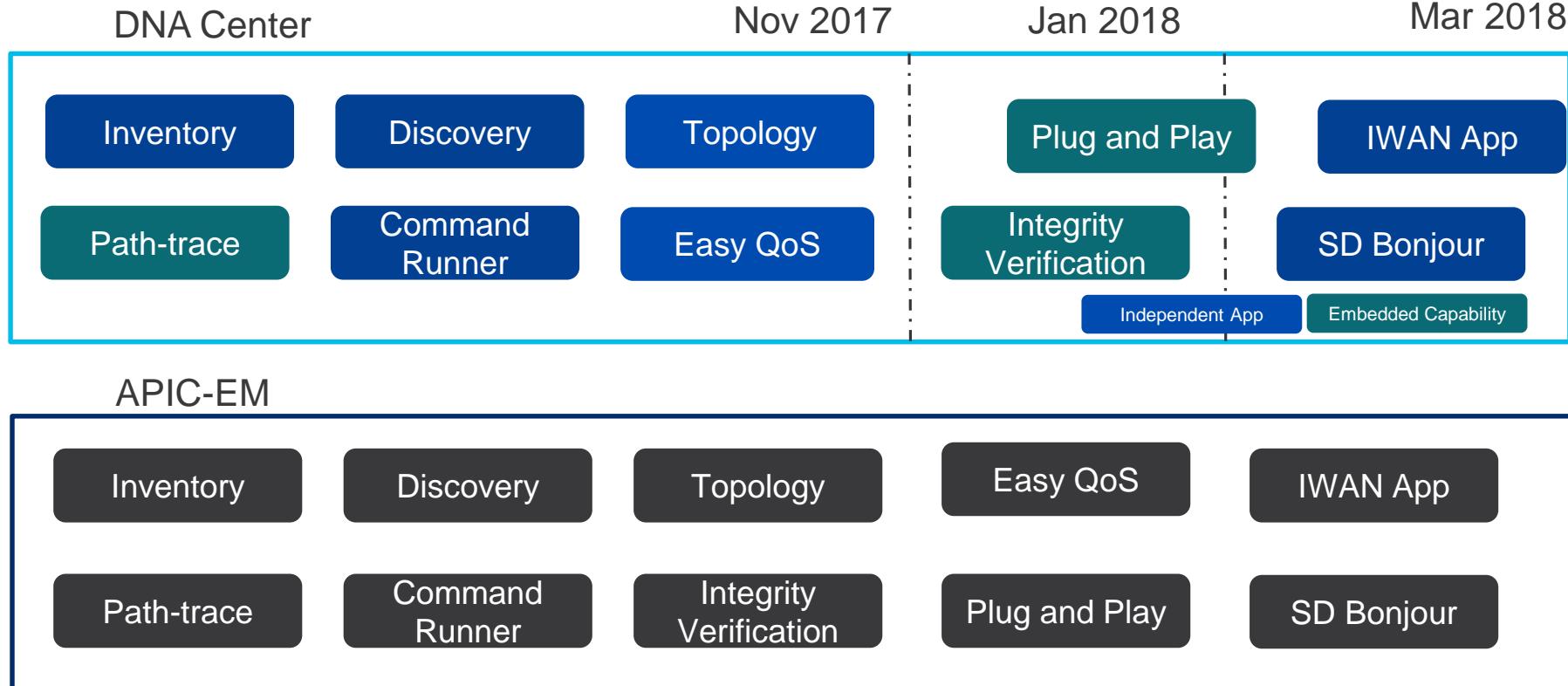
DNA Center Automation & Analytics

DNA Center



Automation

DNA Center – APIC-EM App Migration



Policy Based Automation

Access Policy

↓
Authentication/
Authorization

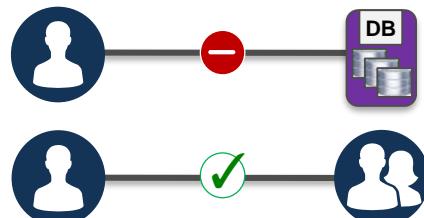
Group Assignment
Based on
Authentication methods



Access Control Policy

↓
Who can access what

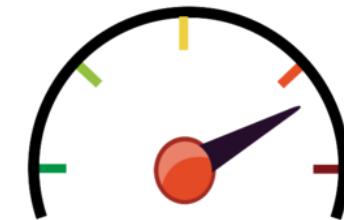
Rules for x-group access
Permit group to app
Permit group to group



Application Policy

↓
Traffic treatment

QoS for Application
Path Optimization
Application compression
Application caching

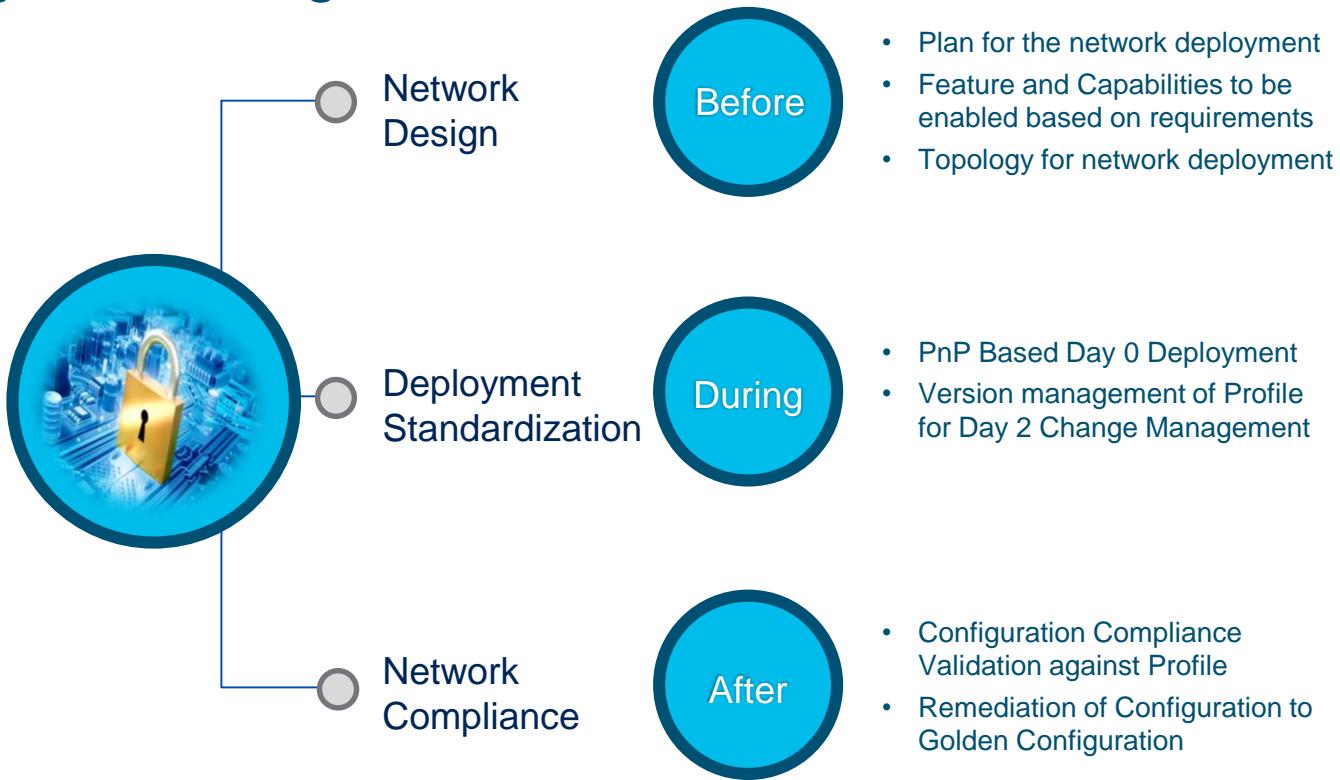


Network Deployment using Profile



Profile Based Deployment

Simplified Network Deployment



Configuration Consistency

Integrated IT Process Flows

DNA Center Automation & Analytics

DNA Center



SWIM

DNA Center – Software Image Management (SWIM)

The screenshot shows a table with columns: Version, Golden Image, and Device Role. It lists two entries: 15.7.1 SMU (1) under ALL and 16.6.1 SMU (2) under ACCESS, CORE, BORDER ROUTER. Each entry has a star icon, edit, and delete buttons.

Version	Golden Image	Device Role
15.7.1	SMU (1)	ALL
16.6.1	SMU (2)	ACCESS CORE BORDER ROUTER

Intent based Network Upgrades

Intent based network upgrades allows for image standardization, much desired by all network admins.

The screenshot shows the 'Recent Tasks (Last 50)' page. It displays two completed tasks: '3. Distribute Operation' and '4. SMU Activation Operation'. The '3. Distribute Operation' task details: 'The image is already present in the device', 'SMU Activation of Image : isr4400-universalk9.2017-07-20_22.36_epapouts.1.GS0vb/3s1/SSA.smu.bin on device : 10.104.62.16 completed successfully.' Below this is a table for 'Script Name' with rows for CPU Health Check, Verifying Disk Space, Verifying Route Summary, CPU Health Check, Verifying File Space, and Software Summary. To the right are 'Type' (Pre Check, Post Check) and 'Log Details' (View) buttons.

Upgrade Pre/Post Checks

Pre and post checks allows network admins more control and visibility over network upgrades

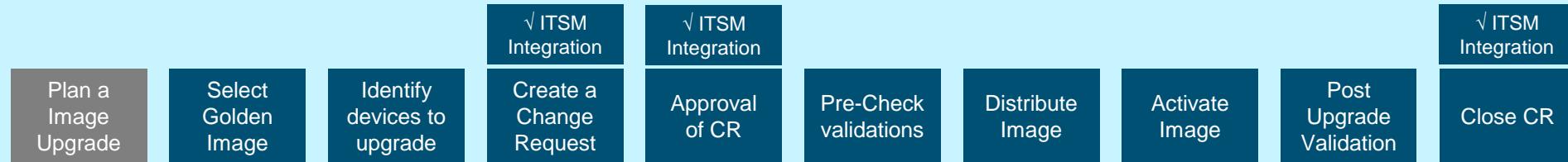
The screenshot shows the 'SMU List' page. It lists three SMU entries for ISR4400 devices: 1. ISR4400-universalk9.2017-07-20_22.36_epapouts.1.GS0vb/3s1/SSA.smu.bin, 2. ISR4400-universalk9.2017-07-20_22.41_epapouts.3.GS0vb/73520.55A.smu.bin, and 3. ISR4400-universalk9.2017-06-19_10_06_epapouts.3.GS0vb/73520.smu.bin. Each entry includes fields for Description, Device ID, Status, and Category.

Patching Support

Patches are supported in DNAC from intent to pre-post checks in same way we manage regular images

DNA Center – Software Image Management (SWIM)

DNA Center Software Image Update



Traditional NMS Software Image Update



Process Steps to Update Software Image



DNA Center – SWIM and IT Service Mgmt Integration

SWIM →
ServiceNow
Integration

The screenshot shows the ServiceNow Change Request interface for a specific change request (CHG0030328). The interface includes a navigation bar at the top with the ServiceNow logo and user information. Below the navigation bar, there is a breadcrumb trail indicating the workflow steps: New, Assess, Authorize, Scheduled, Implement, Review (which is currently selected), Closed, and Canceled. The main form contains various fields for the change request, including:

- Number: CHG0030328
- Requested by: Tejeswar Das
- Category: Other
- Configuration item: CSR1K-DNA-PNP-1.cisco.com
- Priority: 4 - Low
- Risk: Moderate
- Impact: 3 - Low
- Type: Standard
- State: Review
- On hold: (checkbox)
- Conflict status: Not Run
- Conflict last run: (empty field)
- Assignment group: Network
- Assigned To: (empty field)
- Skills: (empty field)
- Title: Upgrades a DNA-controlled Cisco device to latest OS version
- Description: Execute DNA APIs to upgrade the device automatically

At the bottom of the form, there are tabs for Planning, Schedule, Conflicts, Notes, Closure Information, and Cisco DNA Center. The Notes tab is currently active.

DNA Center Automation & Analytics

DNA Center



PnP

Day 0



Network Plug and Play (PnP)



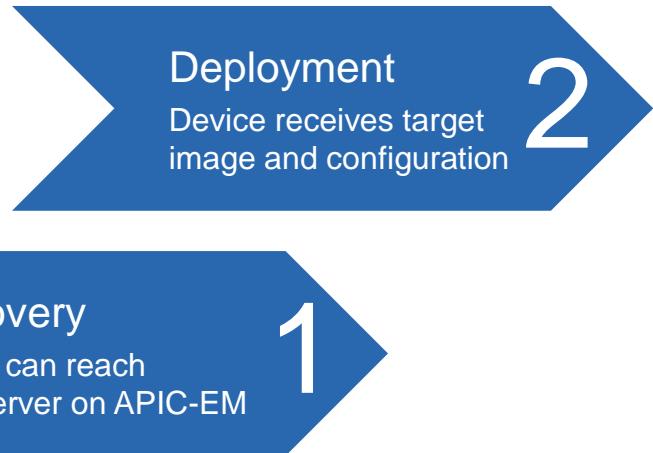
Routers (ISR, ASR)



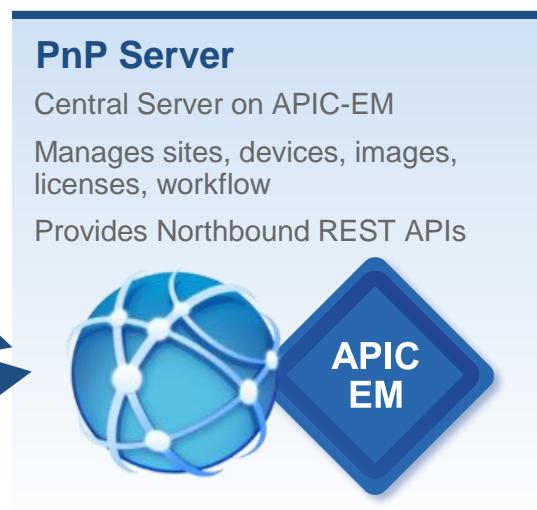
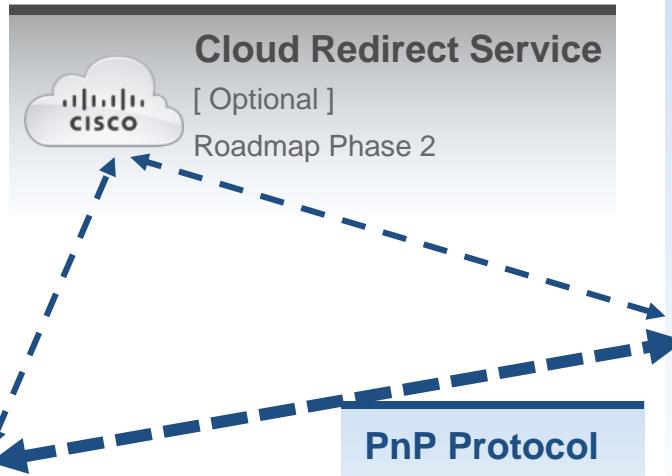
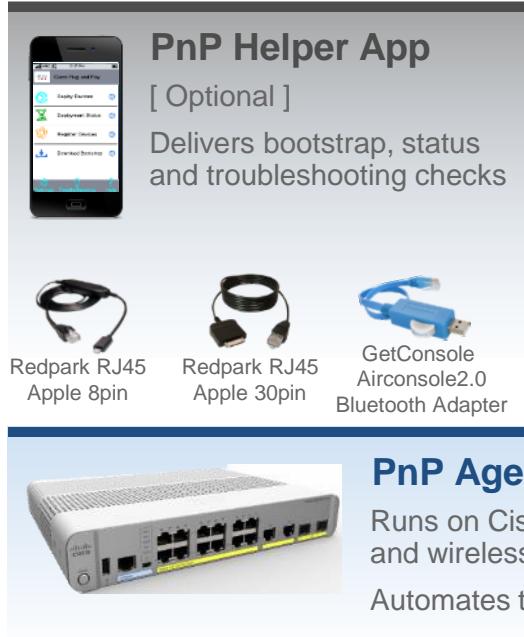
Switches (Catalyst®)



Wireless Access Points



Network Plug and Play (PnP) – Components



PnP – Discovery Options



Wireless Access Points



Routers (ISR, ASR)



Switches (Catalyst®)



1	DHCP Server	DHCP with options 60 and 43 PnP string: 5A1D;B2;K4; 172.19.45.222 ;J80
2	DNS Server	DNS lookup <code>pnpserver.localdomain ---- 172.19.45.222</code> (PnP Server)
3	Cisco Cloud Redirect Service icon	Cloud Redirect Service – roadmap (Q2CY2016) https://devicehelper.cisco.com/device-helper re-directs to 172.19.45.222 (PnP Server)
4	USB port icon	USB-based bootstrapping
5	Smartphone icon	Manual - using the Cisco® Installer App iPhone, iPad, Android, (roadmap - Windows mobile and PC)
X		Others Any other manual or automated discovery method – Scripting, AN, EEM, NAP, etc.

PnP – DHCP Discovery Example

Sample DHCP Server Config

```
ip dhcp pool pnp_pool
  network 10.51.89.160 255.255.255.248
  default-router 10.51.89.254
  option 43 ascii "5A1D;B2;K4;I10.51.89.147;J80"
```

Option 43 Format

5A = PnP DHCP ID
1D = PnP DHCP debug on
1o = PnP DHCP debug off
token.K = <protocol>
 1: XMPP-starttls;
 2: XMPP-socket;
 3: XMPP-tls;
 4: HTTP;
 5: HTTPS
token.B = <address type> 1:host; 2:ipv4; 3:ipv6
token.I = <remote server ip add / hostname>
token.J = <remote server port>
token.P = <server jid>
token.N = user <name>
token.O = <password>

Resulting PnP Profile in running-config

```
pnp profile pnp-zero-touch
  transport http ipv4 10.51.89.147 port 80
```



Example: PnP for Wireless using Android

Problem: How to automate deployment of Wireless AP and their WLC Association ?

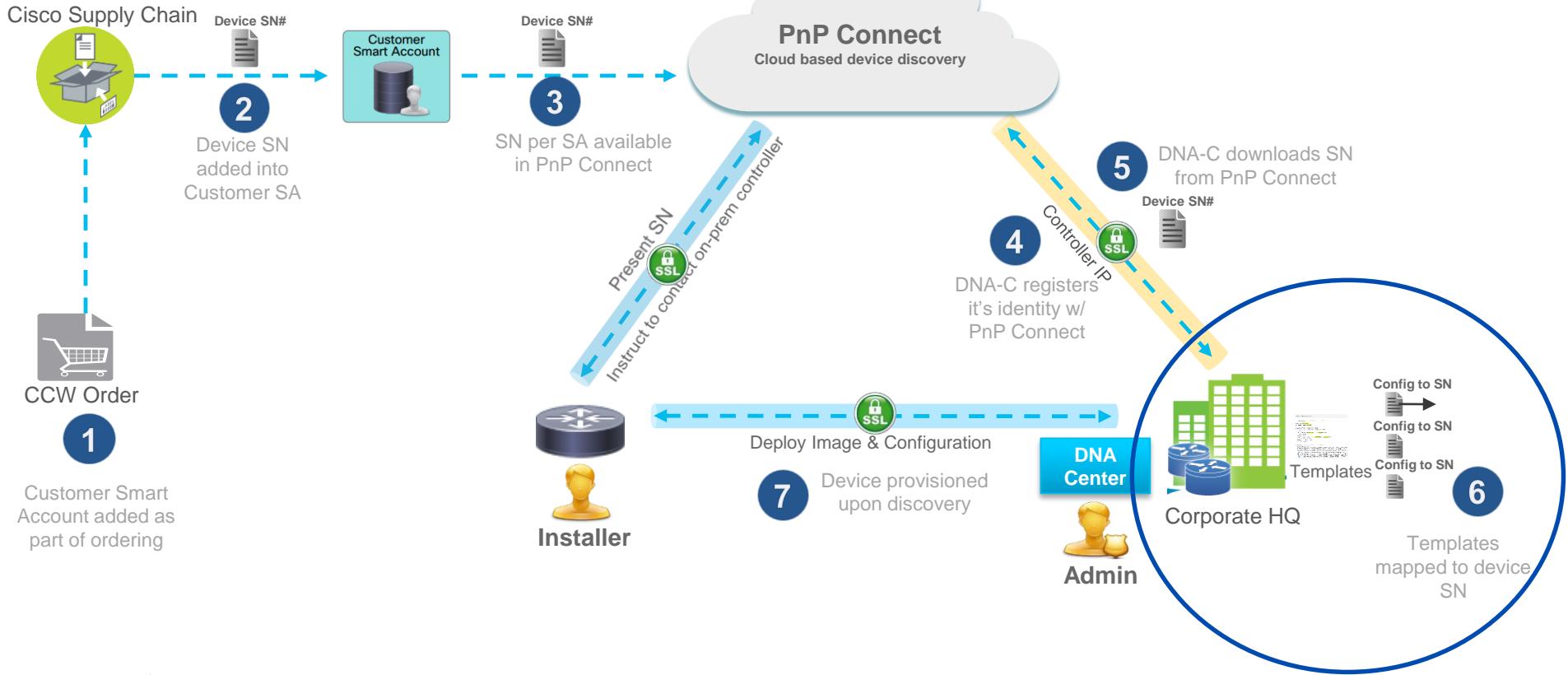
Solution: Leverage APIC-EM
PnP and Android to automate

1. Scan Access Point Serial
2. Load List of PnP Projects from APIC-EM
3. Assign AP to Project Site
4. Auto-Provision AP into correct WLC Group



Credits: Hans Donnerborg and Rene Andersen

PnP Connect: End to End Workflow (With PnP App)



PnP Connect: End to End Workflow (With Profiles)

Cisco Supply Chain



Device SN#

2

Device SN
added into
Customer SA



CCW Order

1

Customer Smart
Account added as
part of ordering



Customer
Smart Account

Device SN#

3

SN per SA available
in PnP Connect

PnP Connect

Cloud based device discovery



Installer

Present SN
Instruct to contact on-prem controller

Controller IP
DNA-C registers
it's identity w/
PnP Connect

4



Device SN#

DNA-C downloads SN
from PnP Connect



7

Deploy Image & Configuration
Device provisioned
upon discovery

DNA
Center



Admin



Corporate HQ

Config to SN
Config to SN
Config to SN

Profile

Profile mapped to Site
&
SN mapped to Site

6

DNA Center Automation & Analytics

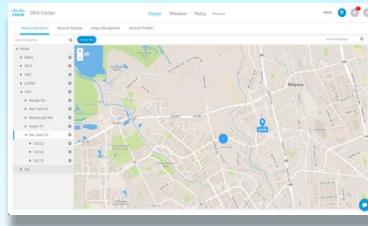
DNA Center



SD-Access

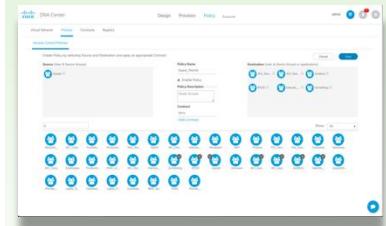
DNA Center – SD-Access Workflow

Design



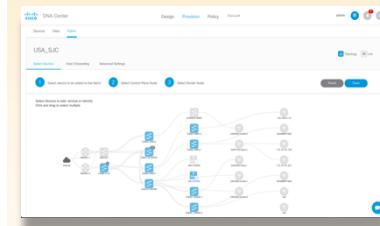
- Global Settings
- Site Profiles
- DDI, SWIM, PNP
- User Access

Policy



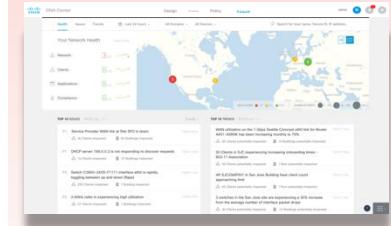
- Virtual Networks
- ISE, AAA, Radius
- Endpoint Groups
- Group Policies

Provision



- Fabric Domains
- CP, Border, Edge
- FEW / OTT WLAN
- External Connect

Assurance



- Network Health
- 360° Views
- FD, Device, Client
- Path Traces

Planning & Preparation

Installation & Integration

DNA Center – SD-Access Design

1. Setup Sites, Buildings & Floors

- Organize your Regions, Cities & Buildings
- Import floorplans in CAD, PNG or JPG
- Virtual layout of Routers, Switches & APs

2. Setup Global & Site-Specific Settings

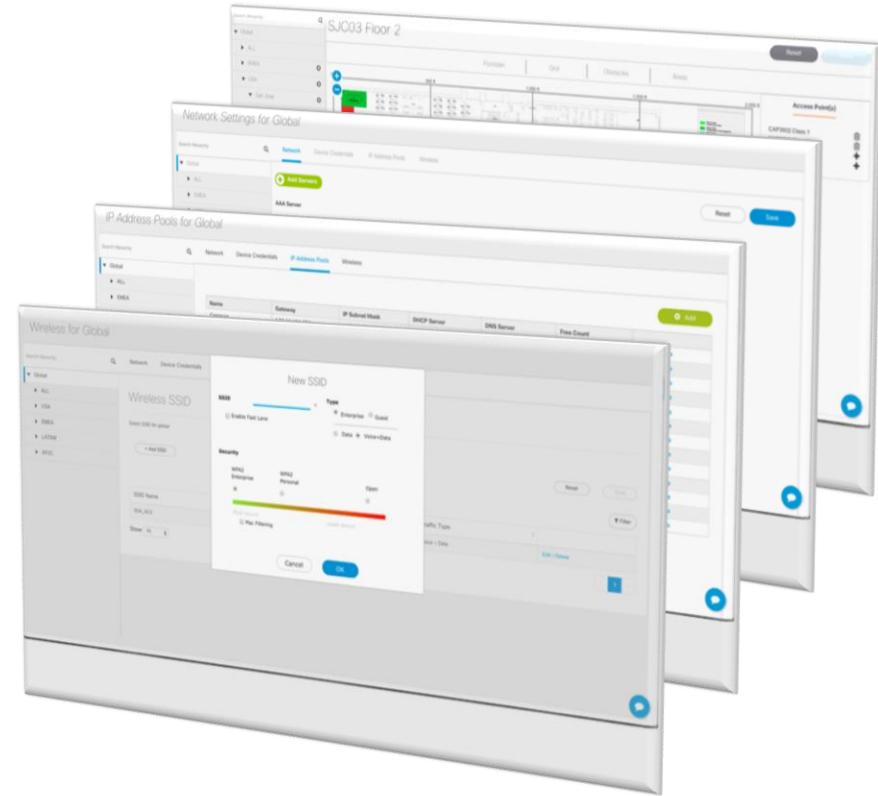
- Establish a common set of Global Servers
- Each Site inherits settings from level above
- Override Global settings with Site-Specific

3. Setup IP Address Pools or IPAM

- IP Address Management uses Site hierarchy
- Add or modify IP Pools manually
- You can also import from IPAM tools via APIs

4. Setup Wireless SSID Settings

- Manage Fabric Wireless WLANs per Site
- Associate the SSIDs with IP Pools
- Automated setup of the WLC & APs via APIs



DNA Center – SD-Access Policy

1. Setup Virtual Networks

- Add Scalable Groups to a Virtual Network
- A “Default” Virtual Network created automatically
- Option to add / remove new Virtual Networks
- Enables VN ID on SDA enabled Devices*

2. Setup Scalable Groups

- Option to import Groups from ISE (or AD)
- Option to create Groups via Static Mapping
- Enables SGT ID on SDA enabled Devices*

3. Manage Group Policies

- Groups provide native SGT based segmentation
- Intra-VN policies set to Default Permit or Deny
- Create simple To / From Group-Based Policies

4. Manage VN Policies *

- VNs provide native VRF network segmentation
- Inter-VN policies mapped to Firewall instances*



DNA Center – SD-Access Provision

1. Setup Fabric Domains

- Add Devices to one of the configured Sites
- A “Default” Fabric Domain created automatically
- Option to add / remove new Fabric Domains

2. Add Devices & Assign Roles

- Add SDA capable Devices to the Fabric Domain
- Designate 1+ Devices as Border and Control
- All other Devices are configured as an Edge

3. Setup Host Onboarding

- Add various IP Pools to the Fabric Domain
- Designate IP Pools for Wired or Wireless
- Define the Host Authentication and options
- Option to Static Assignment of Pools to Ports

4. Advanced Settings

- (Optional) Enable Multicast in the Fabric Domain



DNA Center – SD-Access Assurance

1. Assurance Dashboard

- Global Health Scores (based on 360 Views)
- Graphical status view of Health and Alarms
- Track common Network Issues & Trends
- Universal search for elements of the Network

2. Device 360 Views

- Summary and Real-time Device statistics
- Track Issues and Trends of each Device
- View connected Neighbors, Clients & Apps

3. Client 360 Views

- Summary and Real-time Client statistics
- Track Issues and Trends of each Client
- Initiate Pathtrace per Client Application

4. Application 360 Views

- Summary and Real-time App statistics
- Track Issues and Trends of each App



Interacting with Humans DevOps Style

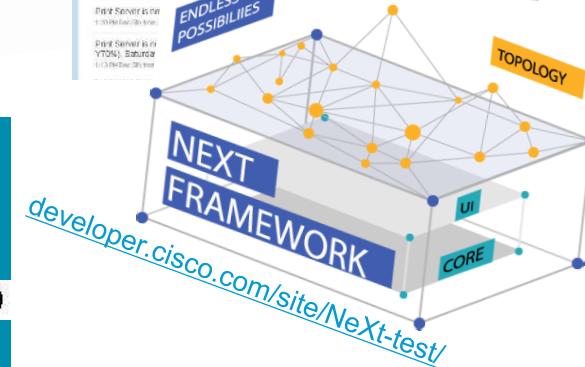
Interacting with Humans

Digitization and Softwarization are about Automated workflows using APIs.

Problem: However – many (ad-hoc) workflows involve human interaction. How to quickly, rapidly and easily implement DevOps style human interactions ?

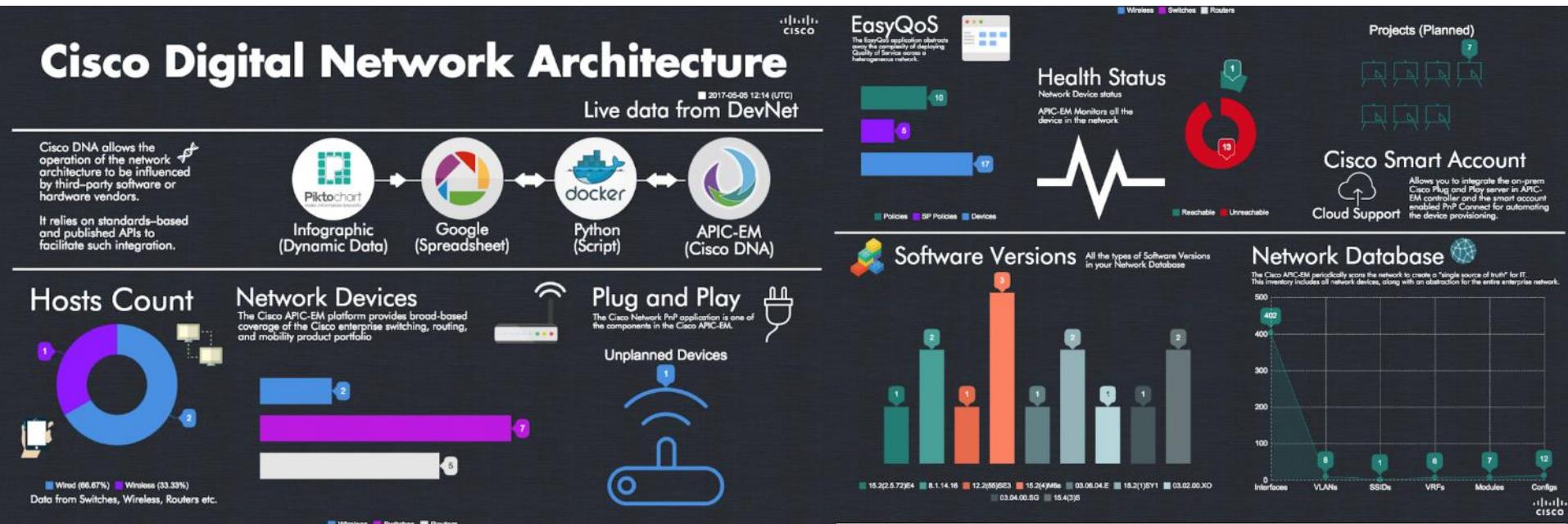
Solutions: Many and growing ...

- We've had tweeting routers for almost a decade with EEM / Tcl
- Cisco Spark REST APIs
- NeXt UI Framework
- Tropo REST API for Voice and SMS interaction
- ...





Example: Mash Up Infographics



<http://cs.co/cisco-apicem-infographic-live>

Credits: Robert Csapo

Interacting with Humans – #1 Requirement



Interacting with Humans – #1 Requirement

Enable

- **Rapid Adoption**
 - TTFHW (time-to-first helloworld): Minutes
 - TTFPP (time-to-first production pilot) : Hours
- **Scale and Quality Interaction**
 - with the same skills,
technologies, architecture
and tooling



Interacting with Humans DevOps Style

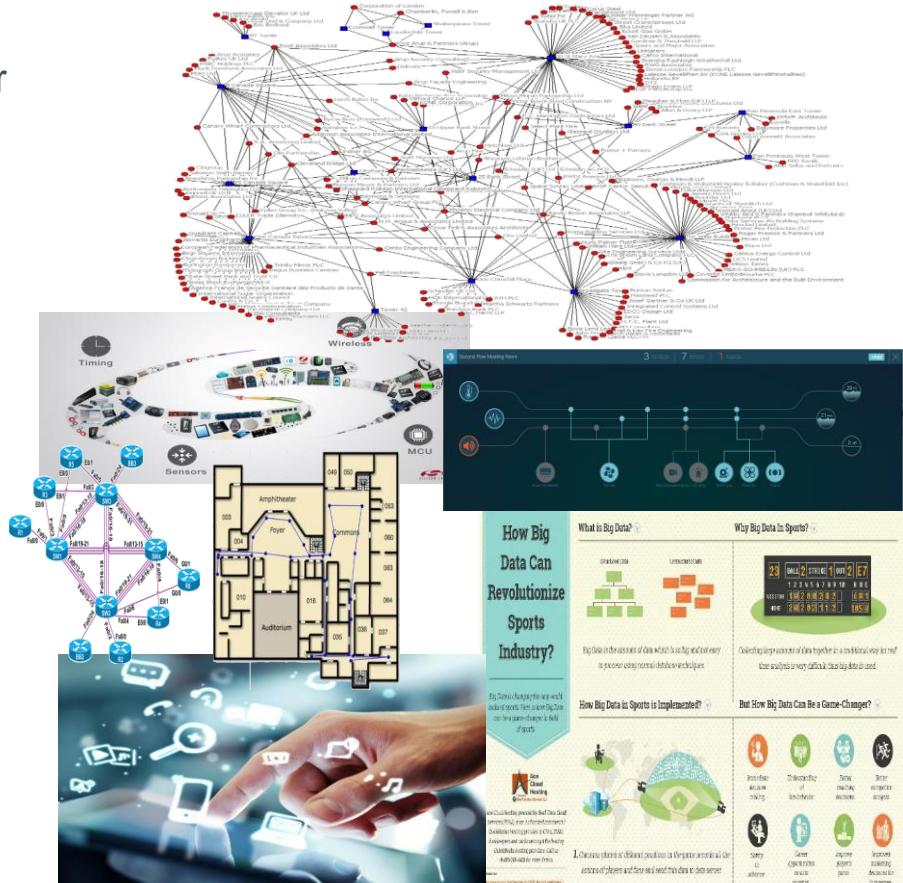
Example: NeXt

Interacting with Humans – Topology Views

Problem: How to quickly provide a Graphical UI for network-centric custom DevOps Applications ?

UI Challenges include:

- Scale and Complexity
- Variety of Symbol Languages
- Interaction Styles and Usability
- Multiple Information Domains
- (Lack of) Openness
- Ease of Adoption
- Ease of Integration



Interacting with Humans – NeXt

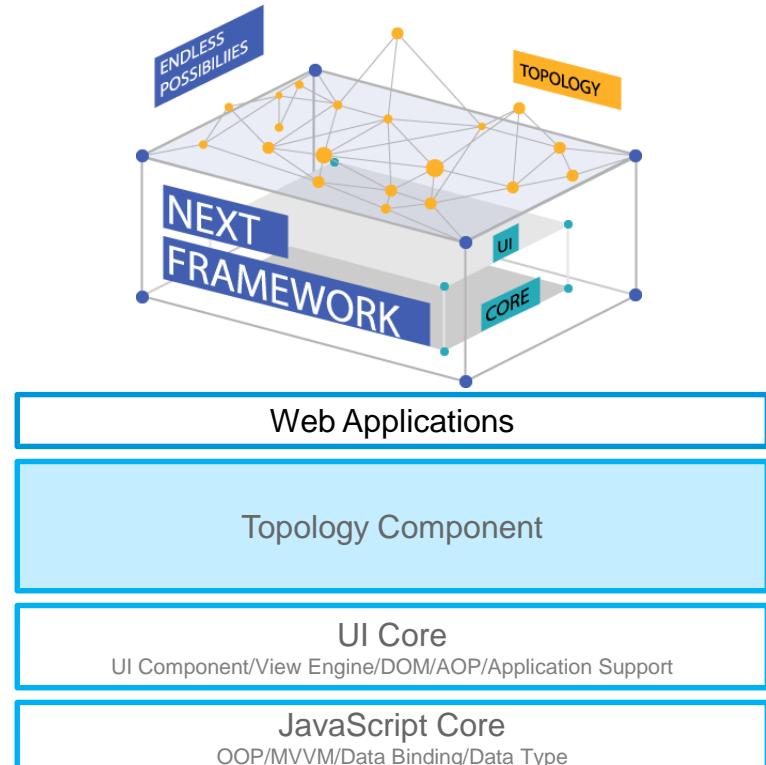
Problem: How to quickly provide a Graphical UI for network-centric custom DevOps Applications ?

Solution: NeXt UI Toolkit

Embedded User eXperience for Network UIs

- HTML 5 / JavaScript based
- Open source
- Developed within Cisco
- Used by APIC-EM, Glance, DNA and others
- Rapid Adoption

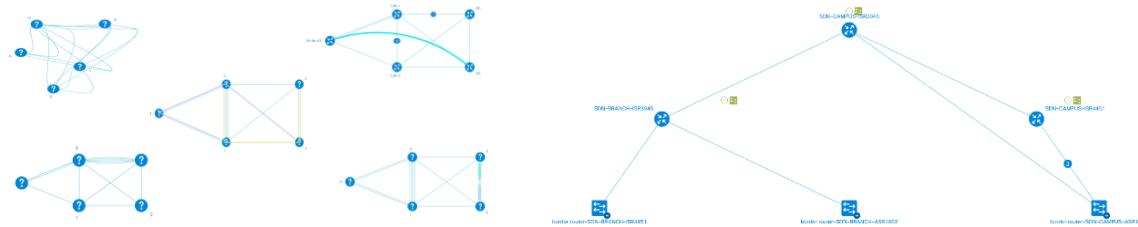
developer.cisco.com/site/neXt/



NeXt UI Toolkit

Separation of

- Topology Data
- Rendering and Interaction
 - Node / icon graphics
 - Line styles
 - Expand / collapse



Open Source, free to extend and
integrate under
Eclipse Public License v1.0

- Community on DevNet
developer.cisco.com/site/neXt/
- Download from Opendaylight
<https://www.opendaylight.org/technical-community/getting-started-for-developers/downloads-and-documentation>



FY16 CISCO
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05 11 THU
PM

PARTNER CONFERENCE

557
VISITOR

27
EXPERT

6
BOOTH

Meeting Room 5
会议室5

Meeting Room 6
会议室6

Meeting Room 7
会议室7



GLANCE For PARTNER CONFERENCE

Powered by DevNet NEXT CMX



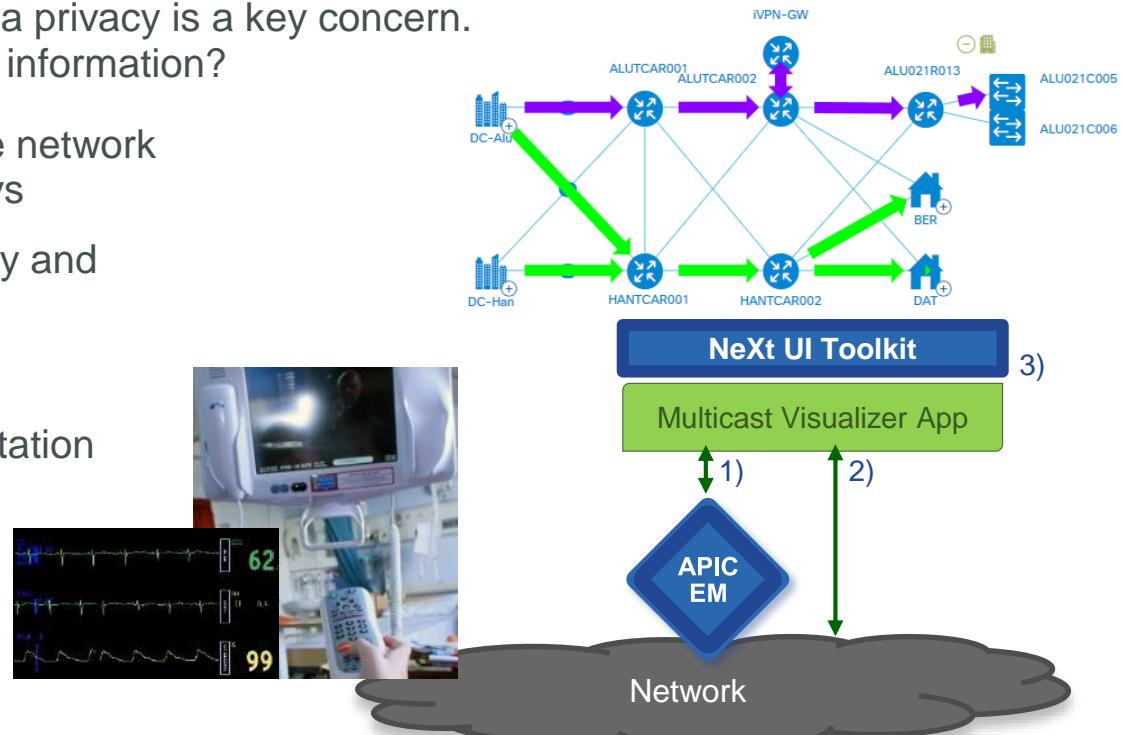
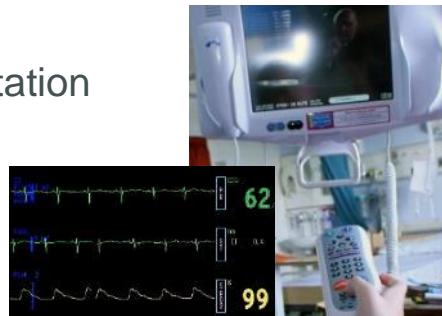
Example: Visualizing Multicast

Problem: In a Hospital, Multicast is used for critical Medical Equipment as well as Patient Entertainment and Media – data privacy is a key concern.
How to visualize the relevant multicast information?

Solution: Harvest information from the network and create custom, augmented displays

- 1) Collect relevant Topology, Inventory and Host information from APIC-EM
- 2) Augment with Multicast tree(s)
- 3) Use NeXt UI to for visual representation
- 4) Share with operational staff

Create. Connect. Control.
See: <http://www.anyweb.ch> **anyweb**
<http://www.hsr.ch>



Anatomy of a NeXt UI

- **index.html → your web page**

can be dynamic, no static body elements required

```
<html>
  <head>
    <link rel="stylesheet" href="dest/css/next.css">
    <script src="dest/js/next.js"></script>
    <script src="Data.js"></script>
    <script src="Shell.js"></script>
  </head>
  <body>
  </body>
</html>
```

- **Data.js → topology data**

single topology object, from file or in memory

- **Shell.js → (custom) behavior**

extend and override for custom behavior

default functionality is present already
(pan, zoom, select, tooltips, colors, etc)

```
var topologyData = {
  nodes: [
    {"id": 0, "x": 050, "y": 100, "name": "65.1.1.46"},
    {"id": 1, "x": 100, "y": 50, "name": "AP7081.059f.19ca"},
    {"id": 2, "x": 150, "y": 100, "name": "CAMPUS-Access1"}
  ],
  links: [
    {"source": 0, "target": 1},
    {"source": 1, "target": 2}
  ]
};
```

NeXt is on DevNet – Try it Out

NeXt UI > Discover > Demo

Topology

Basic

Base

Auto Layout

Highlight Link and Node

Topology Icons

Set node's label and icon

Disable node or link

Topology theme

Customize Node and Link style

Register new icon

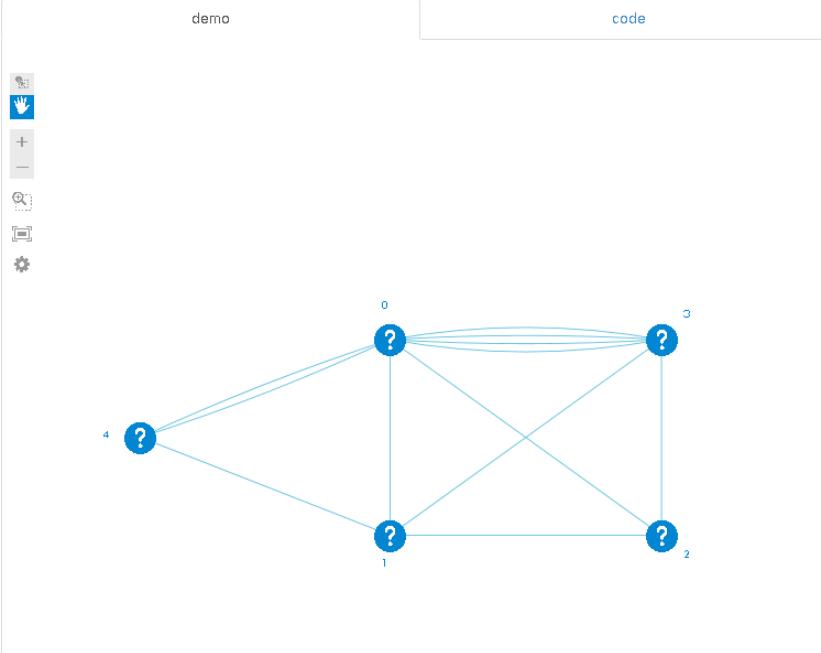
NodeSet

NodeSet

Hierarchy NodeSet (issue)

Aggregation NodeSet (issue)

Group



```
(function(nx, global) {
    var topologyData = {
        nodes: [
            {
                "id": 0,
                "x": 410,
                "y": 100,
                "name": "12K-1"
            },
            {
                "id": 1,
                "x": 410,
                "y": 280,
                "name": "12K-2"
            },
            {
                "id": 2,
                "x": 660,
                "y": 280,
                "name": "OF-9k-03"
            },
            {
                "id": 3,
                "x": 660,
                "y": 100,
                "name": "OF-9k-02"
            },
            {
                "id": 4,
                "x": 180,
                "y": 190,
                "name": "OF-9k-01"
            }
        ],
        links: [
            {
                "source": 0,
                "target": 1
            },
            {
                "source": 1,
                "target": 2
            }
        ]
    };
});
```

Sharing NeXt Code – Client Side JavaScript

NeXt on DevNet

- Documentation
- Tutorials and Labs
- Downloads
- Community

<http://developer.cisco.com/site/neXt/>

<http://communities.cisco.com/community/developer/devnetlabs/next>

Sharing and Running NeXt Examples

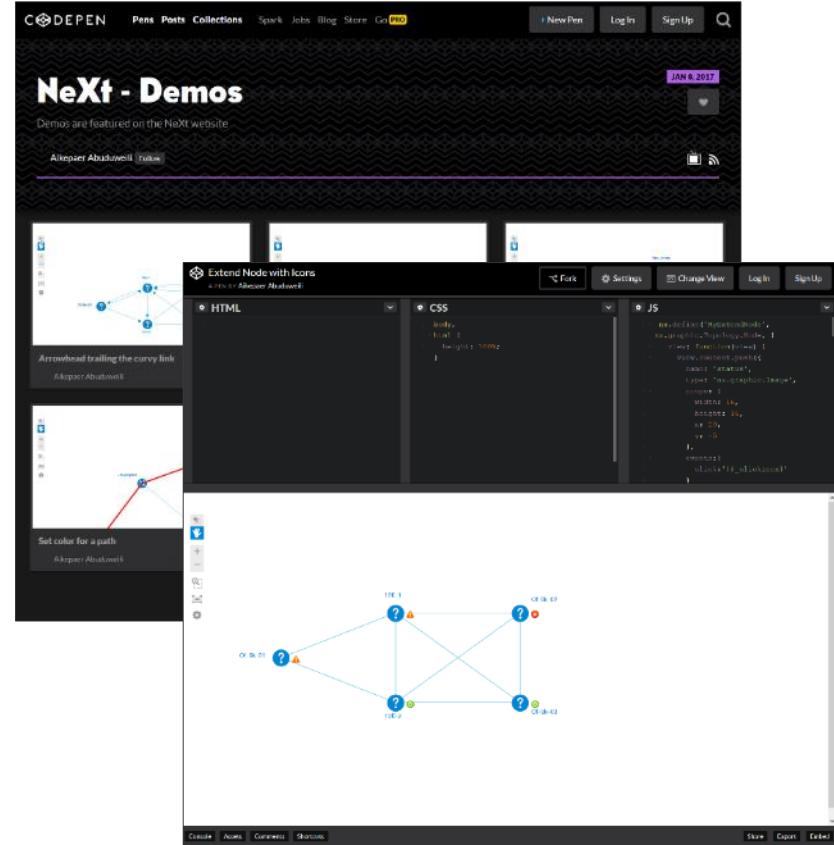
- Works best on Platforms such as JSFiddle.net or Codepen.io

<http://codepen.io/collection/nrBeEQ/>

<http://codepen.io/collection/nMWevE/>

<http://jsfiddle.net/user/nextsupport/fiddles/>

→ Engage with your peers/users



Interacting with Humans DevOps Style

Example: Tropo

Interacting with Humans – Tropo



Problem: How to automate Phone Interactions ?

Solution: Tropo Scripting and Web APIs

- Voice Interaction APIs
- SMS/Text Interaction APIs
- Custom logic can be
 - cloud-hosted (Scripting API)
 - on-premise (Web API)
- Rapid Adoption via PHP, Ruby, Python, JavaScript, JSON, Groovy, ...

www.tropo.com/docs/scripting/quickstarts

```
<?php  
answer();  
say("Hello World");  
hangup();  
?>
```

```
answer();  
say("Hello World");  
hangup();
```

```
{"tropo": [  
    {"say": "Hello World"}  
]}  
answer()  
say("Hello World")  
hangup()
```

- [Tropo Scripting API](#)
 - [Overview](#)
 - [Creating Your First Application](#)
 - [Quickstarts](#)
 - ▶ [Answering Incoming Calls](#)
 - ▶ [Making a Call](#)
 - ▶ [Sending Text Messages](#)
 - ▶ [Receiving Text Messages](#)
 - ▶ [Asking a Question](#)
 - ▶ [Mixing Text & Voice in a Single App](#)
 - ▶ [Recording Caller Input](#)
 - ▶ [Controlling Calls](#)
 - ▶ [Working with Simple Grammar](#)
 - ▶ [Advanced Call Control](#)
 - ▶ [Advanced Speech Control](#)
 - ▶ [International Features](#)
 - ▶ [Scripting API Reference](#)
- ▶ [Tropo WebAPI](#)
- ▶ [Tropo REST API](#)
- [Moving to Production](#)
- ▶ [Hosting, Debugging & Logs](#)
- [Tropo FAQ](#)
- [Messaging FAQ](#)

Interacting with Humans – Tropo

Example - Simple IVR Readout and Choice

- Create an App in Development Mode
- Script based on QuickStart Examples
- Call in to test (+41 43 508 13 03)
- Evolve ...

```
1 say("Version 42")
2 say("Hello fellow network programmers.")
3
4 result = ask("Isn't devops human interaction great for DNA programmab
5     "choices":"yes, no"})
6
7 if (result.value=="yes"):
8     say("You said " + result.value + ". I agree. Let's get started!")
9 else:
```

MY APPS
Create application

My Applications

These are all your Tropo apps. Review them or click on an app to configure its settings:

Hello-CiscoLive-App (Scripting)

Create New App

SAVE SETTINGS DELETE APPLICATION

MY APPS MY FILES LOGS BILLING ACCOUNT

Hello-CiscoLive-App

Review and change your application settings as required.

App Details

App Name: Hello-CiscoLive-App

Call App: Run | Stop

App Status

Development apps are free, but for production performance you should switch to production status (see changef). To use to make automated calls or send automated SMS, you will need to verify your account. Please open an account ticket to begin the process.

* Development

Production (Moving to production is a one way move - if you need to move back to development, contact support).

Script Details

Your app is called at the following locations:

Voice Script: <http://www.hellociscosdr002/pj> [Edit script](#) [Select my files](#)

Text Script: [Select my files](#)

SAVE SETTINGS DELETE APPLICATION

SAVE SETTINGS DELETE APPLICATION

Numbers

Phone numbers associated with your application. You can delete existing numbers or add new ones.

Number	Country	Region	Cost (monthly)	Connection Support
+41 43 508 13 03	Switzerland	Zurich	\$8	Voice Only

Add new number: Country: Region: [ADD](#)

VOIP details

You can call your app to test it using a SIP client.

SIP: <sip:090549001@sip.freecall.com>

API Keys

Your API keys can be managed here.

token: [739489744fc5d4d547307fc566579634b00e779601767d0b45464635e67577a4c4102964634d0241934](https://api.tropo.com/v1/tokens/739489744fc5d4d547307fc566579634b00e779601767d0b45464635e67577a4c4102964634d0241934) [copy to clipboard](#) [regenerate](#) [launch](#) [see token URL](#)

messaging: [468c4c05d0554435c034c0774f0290707117765588034163411b8675429374d734475707059802](https://api.tropo.com/v1/messaging/468c4c05d0554435c034c0774f0290707117765588034163411b8675429374d734475707059802) [copy to clipboard](#) [regenerate](#) [launch](#) [see token URL](#)

```
1 say("Version 42")
2 say("Hello fellow network programmers.")
3
4 result = ask("Isn't devops human interaction great for DNA programmability? Choose from: yes or no.", {
5     "choices": "yes, no"})
6
7 if (result.value=="yes"):
8     say("You said " + result.value + ". I agree. Let's get started!")
9 else:
10    say("You said " + result.value + ". Ok. No problem.")
11
12 say("Enjoy the rest of the event, and please share your feedback via the session survey!")
13
14 log(" They said " + result.value)
15
```

Agenda

- Welcome and Introduction
- Focus I
Infrastructure Level Scripting
- Focus II
Programmability and Guestshell
- Focus III
Controller Level APIs
- Summary and Close



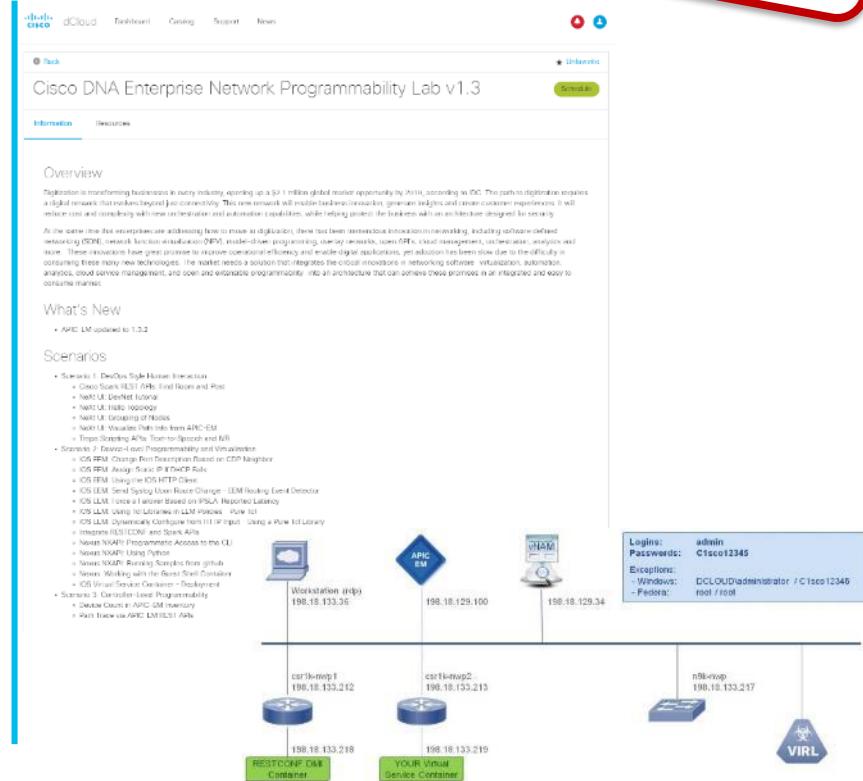
dCloud Network Programmability Lab

Today's Lab is not published in dCloud yet – stay tuned

Getting started with step-by-step exercises on:

- DevOps Style Human Interaction
 - Cisco Spark REST APIs
 - NeXT UI Toolkit
 - Tropo Scripting APIs
- Device-Level Programmability and Virtualization
 - IOS EEM
 - RESTCONF
 - Nexus NXAPI
 - Guest Shell Container
 - Virtual Service Container
- Controller-Level Programmability
 - APIC-EM REST APIs

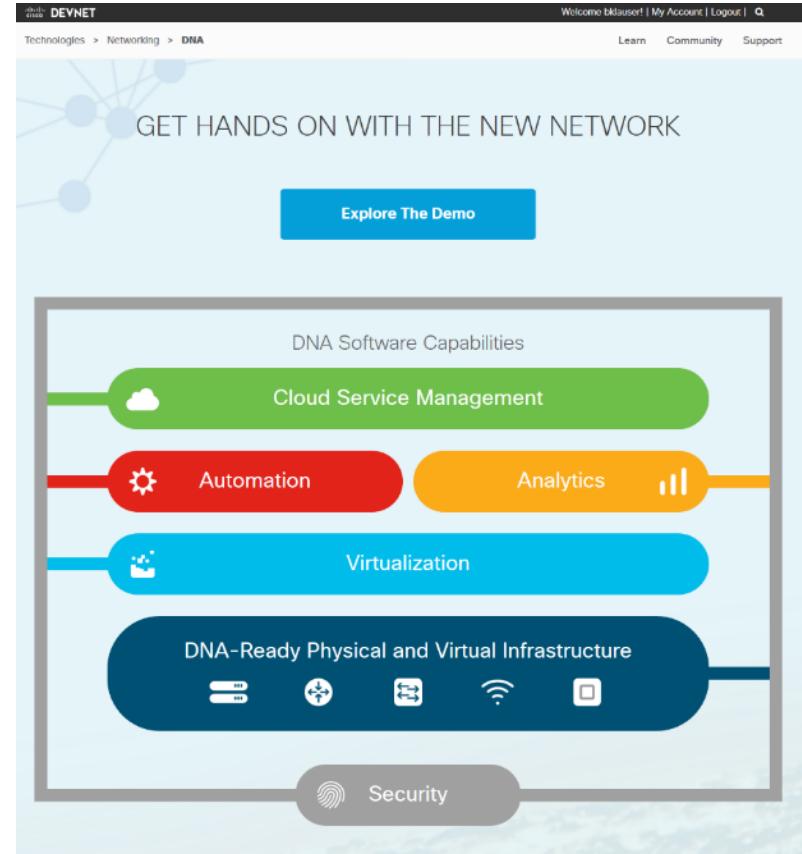
<https://dcloud2-lon.cisco.com/content/demo/171315?returnPathTitleKey=content-view>



DevNet for DNA

developer.cisco.com/site/dna

- Demos
- Tutorials and Learning Modules
- API Documentation
- Learning Labs DNA Track
- Sandboxes
- Open Source and Sample Code
- Community



DevNet Learning Labs

The screenshot shows the DevNet Learning Labs homepage. On the left, there's a red box for 'IoT' with a 'Get Started' button. In the center, there's a blue box for 'Networking' with a 'Get Started' button. At the bottom, there are three boxes: 'Springboards' (black), 'Modules' (light blue), and 'DevNet Learning Labs' (white). The 'DevNet Learning Labs' box contains a 'Get Started with Learning Labs' button.

This screenshot shows the 'Programming the Digital Network Architecture (DNA)' track page. It features several modular sections: 'Coding 101 - REST API Basics' (Python), 'Networking Basics' (including IPv4, IPv6, and MPLS), 'Network Controllers' (OpenFlow, SDN, and NFV), and 'Introduction to Device Level Interfaces (ex. NETCONF/YANG)' (NETCONF, YANG, and RESTCONF). Each module has a brief description, a 'Get Started' button, and a preview icon.

- Self paced learning
- Modular format
(modules 10 – 45 min in duration)
- Beginner and refresher content
- Content includes; programming technologies, concepts and APIs
- DNA Track at
<https://learninglabs.cisco.com/tracks/programming-dna>

learninglabs.cisco.com

Join a DevNet Express

“Educate and equip customers and partners
to begin leveraging
next-generation solution sets – powered by
APIs and Programmability.”

DevNet Express Event Team

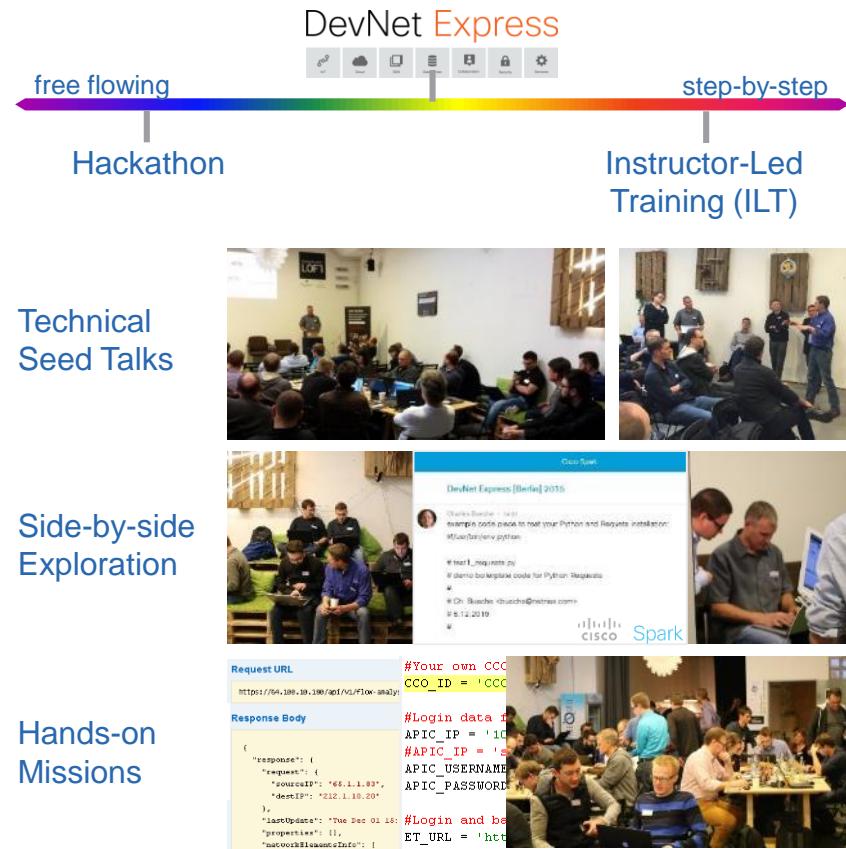
DevNet Express

DNA Programmability

- Learn and be inspired
- Meet with Peers
- Engage with DevNet
- Lead the transformation

- Seed Talks, Hands-On Missions, Fun, Collaborative and Engaging

See <http://hackathon.cisco.com/events>





Self Drive Training

DNA Center Automation and Analytics

Audience: Partner/Customer Technical

Format: Classroom ILT – 1 day
60% Presentation 40% Lab

Language: English

Delivery: Cisco Learning Partner

Upcoming:

- Pilot Class Completed in January
- Scheduled across EMEAR from Feb onwards



<https://cisco.jiveon.com/docs/DOC-1897417>

Network Programmability Certification

Network Programmability Specialists

[HOME](#)

[TRAINING & EVENTS](#)

[TRAINING & CERTIFICATIONS](#)

[CERTIFICATIONS](#)

[SPECIALIST CERTIFICATIONS](#)

[Collaboration Specialists](#)

[Data Center Specialists](#)

[Internet of Things Specialists](#)

**Network Programmability
Specialists**

[Cisco Business Application
Engineer Specialist](#)

[Cisco Network Programmability
Design and Implementation
Specialist](#)

[Cisco Network Programmability
Developer Specialist](#)

The Cisco Network Programmability Specialist certifications enhance your networking skills through foundational networking knowledge and allow you to use your software skills to develop network applications in programmable environments. Network Programmability certifications can enhance your network skills and the value you bring to your IT department.

Pre-Learning Courses Available

For candidates who are new to Network Programmability and/or Software Defined Networks (SDN), Cisco recommends taking the following course.

- [Programming for Network Engineers \(PRNE\) v1.0](#)

Network Programmability Specialists

- [Cisco Business Application Engineer Specialist](#)
- [Cisco Network Programmability Developer Specialist](#)
- [Cisco Network Programmability Design and Implementation Specialist](#)



Network Programmability Certification

Problem: « But I'm not even sure if I am ready for the PRNE or NPDESI Courses ... »

Solution: EMEAR Training Partners offering introductory courses on Network Programmability

- AnyWeb (D/E)

<https://www.anyweb-training.ch/de/module/kurs-kategorien/1-cisco-kurse/kurse>

Cisco live!

Network Programmability Specialists

HOME

TRAINING & EVENTS

TRAININGS & CERTIFICATIONS

CERTIFICATIONS

SPECIALIST CERTIFICATIONS

Collaborative Specialists

Data Center Specialists

Internet of Things Specialists

Network Programmability Specialists

Cisco Business Application Engineer Specialist

Cisco Network Programmability Design Implementation Specialist

Cisco Network Programmability Developer Specialist

The Cisco Network Programmability Specialist certification enhances your networking skills through foundational networking knowledge and allows you to use your software skills to develop network applications in programmable environments. Network Programmability certifications can enhance your network skills and the value you bring to your IT department.

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- Programming for Network Engineers (PRNE) v1.1
- Network Programmability Specialists
- Cisco Business Application Engineer Specialist
- Cisco Network Programmability Developer Specialist
- Cisco Network Programmability Design and Implementer Specialist

Create. Connect. Control.

anyweb

AnyWeb Training

Cisco Certified Learning Center



Introduction to Network Programmability

Building skills and know how to cover network programmability solutions becomes more and more important for System and Network Engineers. It is not easy to keep track of the matter due to the abundance of new terms and concepts. AnyWeb Training enables engineers to perform well with two introductory courses and thus to build up basic knowledge.

NPI - Introduction to Cisco Network Programmability

This course reflects Cisco's deployment of network programmability and offers an introduction for network engineers into the topic. Particular functions of SDN and network programmability are explained and the connection between those functions is shown. NPI represents an introduction to new concepts which is easy to understand.

Besides SDN concepts, utilized interfaces like REST and NETCONF, YANG data model and other established elements will be explained.

PYN - Python for Networkers

Duration: 3 days
Costs: CHF 2'700.00
Language: German or English

Content & Labs:

Introduction to SDN; SDN Controller; SDN and APIs; Data models; Version Control or Configuration Management; Exercises with REST, ACL, Python, etc.

Duration: 3 days
Costs: CHF 2'700.00
Language: German or English

PYN - Python for Networkers

SDN-based networks offer an easy way to automate the network using scripts and programs. This course is an introduction to programming with Python. Basics of Python are explained, and in addition those Python modules are explained, who are needed in connection with the SDN controller and Cisco devices.

Find more information on contents or present dates at [anyweb-training.ch](https://www.anyweb-training.ch). Questions? Please contact us by phone or email at training@anyweb.ch.

Additional Resources

EN Promotions and Partner Enablement

Rock the Foundation Upfront Discount offer

Cisco will provide an incremental 5% on eligible Catalyst 9000 Series and Aironet 2800/3800 Access Point SKUs when purchased in combination with eligible Application Appliance on the same order
More information here : <http://cs.co/enpromotions>

SD-Access Lab Kit Bundles

SDA Lab Kit Bundles for NFR (Partners only)
More information here : <http://cs.co/enpromotions>

EMEAR EN Partner Enablement Calendar

Find EMEAR Webinars and face to face trainings on Enterprise Networking here:

<http://cs.co/EMEARPartnerReadiness-EN>

Continue Your Education

- Demos in the Cisco campus
- Walk-in Self-Paced Labs
- Tech Circle
- Meet the Engineer 1:1 meetings
- Related sessions

- Please complete your Online Session Evaluations after each session
- Complete 4 Session Evaluations & the Overall Conference Evaluation (available from Thursday) to receive your Cisco Live T-shirt
- All surveys can be completed via the Cisco Live Mobile App or the Communication Stations

Don't forget: Cisco Live sessions will be available for viewing on-demand after the event at www.ciscolive.com/global/on-demand-library/.



Complete Your Online Session Evaluation

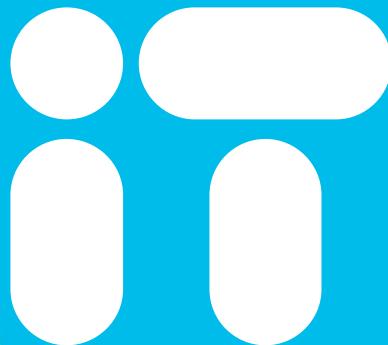




Thank you



You're



Cisco *live!*