LET’S
BUILD
TOMORROW
TODAY
Programming the Network: Let's Get Started

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Technical Solutions Architect

BRKDEV-2003
Agenda

• Understanding the Situation
• Planning for Programmability
• Applying the Technology
The Right Tool is Important
The Tools We Have Don't Cut It

- Manual CLI
- More Efficient Manual CLI

- Powerful, Bulky Management Tools
  (Steam-powered Saw)

What We Want
Merging our Tools with Powerful Engines

What We're Seeing

- Software + Existing Tools

- Can be dangerous and unproven
- Excess of new tools
- Risk of choosing the tool before the project

Power tools are still awesome
How does it impact me?
What is Technical Debt?

Reload the Router?

Do the Right Thing

vs

Cisco Technical Assistance Center
I For One, Welcome Our New Software Overlords

Largest Disruption in History of Networking

Software Brings New Advantages

- Established Toolsets
- Huge Skillset Pool
- Testing Methodologies
- Compliance and Auditing Procedures
- Requirements Gathering
- Efficient and Automated
- Scale with Accuracy
Programmability and API's are Coming

Brownfield Integration of Programmability

Orchestration

Management Platform

API Proliferation

API

Integration

API

Device

API

Router

Development

SDK

Programmatic Control

Python

Scripts

import cli
import requests
for interface in interfaces:
    cli.send("show command")
    open w as file("device.txt")

Overlay Networking

Orchestration

New Glue in the Infrastructure

Development

Integration

API

Overlay Networking

Router

Device

Switch

Overlay Networking

Latest Integration

Python

API

Integration

API

Development

SDK

API

Overlay Networking

Integration

API

Python

SDK

Overlay Networking

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Development

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Integration

API
Fully Programmatic Networks

Greenfield Programmability Solutions

- **SDK**
- **API**
- **Automation**

**ACI Fabric**

**Productized Solutions**

**Cloud and Orchestration**

- **Public Cloud**
- **Private Cloud**

**Niche Use Cases**

**Designed for Automation and Programmability**

Cisco Live!
Reasons to Start Programmability Now

- It's Inevitable – The Cloud will eat you alive
- It will be in your network, and it will break
- More aligned to business objectives
- To Start Adopting an Automation Mindset
- Understand Software Architectures + Concepts
Misconceptions

"Network engineers need to become programmers"
Network engineers need to understand programmers

"Nobody is doing SDN or Network Programming"
Cloud is SDN Native, plus many pockets of customers

"I don't want to automate myself out of a job"
There's more than enough work for us. Relevancy is different.

"Network Programming doesn't provide stability"
With experience and practice it provides better stability

"If it's not OpenFlow, it's not Open"
SDN ≠ Open ≠ Programmability ≠ OpenFlow. Different Concepts
Realities

"This isn't for everyone, at least today"
Some will lag – this is largely in the early adopter phase

"All organizations aren't ready for this kind of change"
Full automation can require organizational change

"All the code is not fully matured"
Many of the solutions are still early and not production ready

"That feature, product, or ability already exists, it's called …"
Because a handsaw exists, it doesn't mean we can't use better tools
“If you think adventure is dangerous, try routine; it is lethal.”

Paulo Coelho
Foundational Technologies
Foundational Technologies
At least Conversational In..

- DevOps
- Linux
- REST API's
- Python
- Git + GitHub
- OpenStack

Notes:
Each of these can be a career separately, stay practical and high level initially.
DevOps Has Done Programmability

We need to learn DevOps concepts, and start extending their processes into networking.

1 Server Admin : 100-200 Servers  
   to  
1 Server Admin : 5,000 – 10,000 Servers

Manual + Bash scripts + Reactive configuration  
   to  
Orchestrated configuration and integration with development

**Note:** Networking ≠ Servers and there are unique challenges being addressed in this space.
Perception: AUTOMATE ALL THE THINGS

Reality: It's a People Problem

Credit: Hyperbole and a Half, memegenerator.net
Linux is the Home of Open Source

• Majority of Tools and Endpoints are Linux Systems
• Aim for end-user proficiency
• Software Development and DevOps are Linux Cultures

Examples
• Containers, Linux Utilities, BASH, Nexus 9000, Cloud Operating Systems
Python and Programming

- Large user community, flexible language, easy to start
- Aim for end-user proficiency
  - Hack variables together, troubleshoot simple problems
- Proficiency in other languages is an equal substitution
- Understand the terminology and challenges

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Language</th>
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<td>Novice Programmers</td>
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<td>Perl</td>
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<tr>
<td>Web Applications</td>
<td>PHP</td>
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</table>
Git – Where the Software Lives

- Git is a Version Control System
- Distributed rather than centralized
- GitHub is free place to put public code
  - Issue tracking, documentation, and collaboration
- Critical for understanding software
  - Change control and collaboration for development
- Use it to grab or share code
REST is Machine Readable HTTP

**Web Browsing**

- **HTTP GET**
- **HTML**

  Describes how data should be displayed to please human viewer

**REST API**

Twitter: IDs of last five followers

```json
{"ids":[303776224, 19449911, 607032789, 86544242, 2506725913, 17631389],
"next_cursor":0,
"next_cursor_str":"0",
"previous_cursor":0,
"previous_cursor_str":"0"}
```

**HTTP GET**

**JSON/XML**

Describes data in a format machines can understand
REST API Example

Customized Portal on Top of Orchestration

- Custom Portal
- Nexus 9000
- UCS Compute
- Storage

Orchestrator's API's

Simplified Portal using Orchestrator's API's

Orchestration Tool Identifies Resources and Sends API Calls

Devices process API Calls
OpenStack Basics
Flexible Framework for Building Clouds

IaaS / cloud orchestration software – creates, manages, and deletes virtual resources according to API- or CLI-based instructions
Planning for Programmability
Planning Items

- Create a Goal
- Identify a Use Case
- Understand the Relevant Technology
- Find Resources and Assistance
Potential Goals
Your Goal Doesn't Need to be a Program

Development
- Software Knowledge + Network Challenge = Network Program
  ```python
  import cli
  import requests
  for interface in interfaces:
    cli.send("show command")
  open w as
  ```

Architecture
- Network Operational + Technical Knowledge + Systemic Problems = Conversation and Operational Change
  ```python
  import cli
  import requests
  for interface in interfaces:
    cli.send("show command")
  open w as
  ```

Engineer
- Existing Code + Modifications + Operational Inefficiency = Customized Tool
  ```python
  import cli
  import requests
  for interface in interfaces:
    cli.send("show command")
  open w as
  ```

CiscoLive!
Better Together - Collaborate

• Mix the battle hardened team members with those more experienced with development tools
• Team Rotations
• Emphasis on Conversational Capabilities
Too much? Not sure? Can't Program?

Write Something Anyway!

Automate Something

- **Challenge:** Automate something rather than doing a repetitive task
- The process and learning opportunity outweighs the end functionality
- Start adapting a mindset of solving problems with programmability
Use Cases

- Complexities
- Risks

- Event Triggered Scripts
- DevOps Workflows
- Self Healing and Adaptive Networks

- Automated Provisioning
- Custom Integration

- Scripted Pre-Provisioning
- Subset of Existing Management Tools

- Super Commands
- Automated Troubleshooting and Data Visibility

- Real Time
- Provision
- Passive

Risk
Complexity

Cisco Live!
Use Cases

- **Super Commands**
- **Automated Troubleshooting and Data Visibility**
- **DevOps Workflows**
- **Self Healing and Adaptive Networks**
- **Event Triggered Scripts**
- **Real Time Provision**
- **Passive Provision**

- **Check your Copy and Paste Folder For Examples**

- **Complexity**
- **Risk**

- **Automated Provisioning**
- **Scripted Pre-Provisioning**
- **Super Commands**

- **DevOps Workflows**
- **Self Healing and Adaptive Networks**
- **Event Triggered Scripts**
- **Real Time Provision**
- **Passive Provision**

- **Copy and Paste Folder For Examples**
Programmability – New Problem Solving Process
Thinking and Solving Differently

- **Pain**
  - Inefficiency
  - Dread

- **Identify The Problem**
- **Capabilities Mapping**
  - What Tools Exist?
  - Feasibility of the Design? Scalability?
  - What Alternatives are there?
  - Open Source
  - Work-flow

- **Design, Implement, and Operate**
  - Day-2 Requirements
  - Implementation Skills Assessment
  - Scalability and Performance
  - Open-Source Strategy

Stakeholders

Requirements

Dependencies
There's still the problem of all those terms!
### SDN and Programmability: Parts and Pieces

#### Application
- **Scripts**
- **GUI**
- **Orchestration**
- **Integrations**
- **Web Portal**
- **Monitoring Tools**

#### Northbound API's
- REST
- JSON / XML
- SOAP
- JSON / XML

#### Controller Layer
- **Orchestration Tools**
  - OpenStack, UCS Director
- **Policy Controller**
  - APIC, APIC-EM
- **Configuration Management**
  - Puppet, Chef, Ansible, Salt
- **Service / Overlay Orchestration**
  - ESC, Tail-F, VTS, Embrane
- **OpenFlow Controllers**
  - OpenDaylight, COSC, XNC

#### Southbound API's + Agents
- REST
- OpFlex
- SSH
- Puppet Agent
- NETCONF/YANG
- OpenFlow
- SNMP

#### Operating System
- BASH
- Python
- Agents / Apps

#### Virtual Hardware
- VM
- CSR, vASA, vIOS
- vWAAS, vIPS

#### Hardware
- Chassis
- CPU
- ASIC

---

*Cisco Live!*
Getting Advanced: Not a Single Stack

API's allow a flexible hierarchy of Controllers and Orchestrators

Ex: Tail-F NSO controlling OpenDaylight or OpenStack on OpenStack (Triple O) or Openstack configuring APIC
Caution – Simplification Ahead

*Nearly All Technologies Can Be Used in All Environments
Programmability – Service Provider

**Application**
- Scripts
- GUI
- Orchestration
- Integrations

**Northbound API's**
- REST
- JSON / XML

**Controller Layer**
- Orchestration Tools
  - OpenStack, UCS Director
- Service / Overlay Orchestration
  - ESC, Tail-F, VTS, Embrane
- OpenFlow
  - OpenDaylight, COSC, XNC

**Southbound API's**
- NETCONF/YANG
- REST
- SSH

**Operating System**
- NX-API
- Python
- Agents / Apps

**Virtual Hardware**
- VM
  - CSR, vASA, vIOS
  - vWAAS, vIPS

**Hardware**
- Chassis
- CPU
- ASIC

**Technologies**
- Foundations
- Tail-F, ESC, VTS
- Nexus 9000, ACI, CSR
- OpenDaylight, COSC

**Architectures**
- OpenStack
- NFV, Service Chaining
- Configuration Mgmt

**Features + API's**
- NETCONF/YANG
- VXLAN, NX-API
Programmability – Cloud Focused

Technologies
- Foundations
- Nexus 9000, ACI
- UCS-Director

Architectures
- OpenStack + Neutron, Group Based Policy
- Configuration Mgmt
- Containers / Docker

Features + API's
- VXLAN, ASA, UCS, CSR API's
- Guest Shell, NX-API

Applications
- Scripts
- GUI
- Orchestration
- Integrations

Northbound API's
- REST
- JSON / XML

Controller Layer
- Orchestration Tools
  - OpenStack, GBP, UCS Director
- Configuration Management
  - Puppet, Chef, Ansible, Salt
- Policy Controller
  - APIC

Southbound API's
- Puppet Agent
- REST
- SSH

Operating System
- NX-API
- Python
- Agents / Apps

Virtual Hardware
- VM
  - CSR, vASA, vIOS
  - vWAAS, vIPS

Hardware
- Chassis
- CPU
- ASIC
Development + DevOps

Technologies
- Nexus 9000, ACI, UCSD
- VIRL, Programming Languages

Architectures
- Software Development Life Cycle (SDLC), Git, Toolsets
- Continuous Integration + Deployment, QA/Testing
- Containers, LXC, Docker
- Application/Cloud Architecture

Features + API's
- Puppet, Chef, Ansible
- Guest Shell, NX-API
NX-API Demo
Resources
Cisco DevNet
developer.cisco.com

DevNet Portal

DevNet API & SDKs

DevNet Sandbox Platform

DISCOVER
- API Map
- API Navigator
- Tutorial

BUILD
- Community
- Developer Support
- Events

TEST
- Virtualized Test Image
- Cloud Based Share Lab
- Cloud Based Dedicated Lab

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DevNet Sandbox

https://devnetsandbox.cisco.com

- Free, On-demand
- Wide range of product support
- REST API 101
- APIC-EM, NX-API, Collaboration, Wireless, and more
VIRL: Virtual Internet Routing Lab
virl.cisco.com

A multi-purpose, extensible network virtualization and simulation platform:

• Create highly-accurate models of real-world / future networks
• Leverage ‘real’ network operating systems – build-synced, not emulated
• Scale from 10’s to 100’s of virtual network and server devices
• Integrate virtual networks and appliances into physical lab networks
Resources for Foundational Knowledge

Open Source is About Information Sharing

• [http://www.codecademy.com](http://www.codecademy.com)

• Python the Hard Way

• User's Groups

• Podcasts

• Wiki Sites

• Blogs

• Project Sites
Network Programmability User's Group (NPUG)

- User's Group focused on Network Programmability Topics
- Diverse Group of Users
- Combination of User Stories and Educational Material
- Recorded Meetings and Active Wiki

http://cs.co/NPUG
Applying Programmability
Tools – Integrated Development Environment (IDE)

- Text Editing, Build/Compile, Code Validation, Testing, Integrations (git, chat, etc), Plugin Extensibility
- Language Dependent or Independent
- Text Editors
  - Notepad++, Sublime
  - Emacs / Vim
- IDEs
  - PyCharm, Eclipse
Tools – REST API Testing with Postman

- Build and Edit Requests
- Save REST Calls
- Easy to manipulate data and test API's
- Postman – Chrome Extension
- PAW – OSX Application
What Exists To Program?

**Enterprise Networking**
- ASA, Sourcefire
- IOS, IOS-XE, IOS-XR
- APIC-EM
- Cloud Services Router

**Service Provider**
- Tail-F
- OpenDaylight
- Cisco Open SDN Controller

**Datacenter**
- Nexus Switches
- ACI
- UCS Manager, UCS Director
- OpenStack Integration

**Management + Tools**
- Prime Infrastructure
- Prime Network Services Catalog
- IPAMs, DHCP, IT Tools

*slides taken from respective products in this section*
Cisco Security Solutions – API Overview

**NORTHBOUND API**

- **CSM(v)**: Cisco Security Manager
  - XML/HTTPS
- **PNMC**: Hypervisor manager
  - XML/HTTPS
- **ASA(v)**: Firewall
  - JSON/HTTPS
- **VSG**: Hypervisor Firewall
  - XML/HTTPS
- **PxGrid**: Identity Management
  - XML/HTTPS
- **ISE (v)**: Identity Management
  - XML/HTTPS
- **FIRESIGHT(v)**: NGIPS Management
  - HTTPS
- **FIREPOWER(v)**: NGIPS
  - HTTPS
- **WSA(v)**: Web Security
  - HTTPS
- **SMA(v)**: Email and Web Security Management
  - HTTPS
- **ESA(v)**: Email Security
  - HTTPS

**SOUTHBOUND API**
Select a feature from the left-hand panel to view its APIs.

Select an API operation for the selected feature.

Export API operation to script.
REST API Examples

**Create an ACL Entry**

```
POST /api/access/out/inside/rules
{
  "permit": true,
  "sourceAddress": {
    "kind": "IPv4Address",
    "value": "192.168.1.1"
  },
  "destinationAddress": {
    "kind": "IPv4Network",
    "value": "172.16.171.0/24"
  },
  "sourceService": {
    "kind": "NetworkProtocol",
    "value": "ip"
  },
  "destinationService": {
    "kind": "NetworkProtocol",
    "value": "ip"
  },
  "active": true,
  "remarks": [],
  "position": 1
}
```

**Execute Arbitrary Command**

```
POST /cli
{
  "commands": [
    "show version | i Serial"
  ]
}
```

**Retrieve an Object by Name**

```
GET /api/objects/networkobjects/DNS
{
  "kind": "object#NetworkObj",
  "selfLink": "/api/objects/networkobjects/DNS",
  "name": "DNS",
  "host": {
    "kind": "IPv4Address",
    "value": "4.2.2.2"
  },
  "objectId": "DNS"
}
```

**Rule direction**

(in or out)

True for permit or false for deny

**Source IP address**

**Destination IP address**

Insert at position 1

**Network object name**

Network object

IP address

Cisco Live!
Cisco security solutions – API overview

- CSM API:

- ASA API List:
  - v1.1.1:

- PNMC:

- ISE:
APIC Enterprise Module
Controller for Campus + WAN: Catalyst, Wireless, IOS

QoS    ACL    ZTD    Policy Management

Advanced Network Visualizer

EN Controller

REST APIs

Inventory and State    Identity and Location    Application Awareness    Policy Enforcement

Enterprise Services

Elastic Infrastructure

SAL

CLI
APIC-EM Reference


- REST 101 With APIC-EM:
  https://learninglabs.cisco.com/#/labs/coding-101-rest-basics/step/1
Web Services Management Agent (WSMA)
Widely Available – Catalyst and IOS

• Less Modern, But Available
• Transports:
  • SSH
  • HTTP/S
  • TLS
• XML Data Modeling
• Supports Both Push and Pull Models
DevNet + WSMA Reference

- WSMA:
  - https://developer.cisco.com/site/xmlmi/overview/tech-overview.gsp
  - https://developer.cisco.com/site/xmlmi/resources/index.gsp
  - http://cisco.com/go/wsma
Embedded Event Manager (EEM)
Available on IOS, IOS-XE, IOS-XR, Catalyst, NX-OS

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

**Challenge 1:** Every few weeks a router is running low on memory around 2am, and I want to find out what's happening

- **Solution:** EEM script could be triggered based on the memory utilization, capture the memory information and send the output with Syslog or Email

**Challenge 2:** If my ACL configuration gets changed, I want to get notified, but I can’t sit there monitor it all the time

- **Solution:** EEM script could be triggered by CLI command, take a snapshot of the logged in user, changed configuration, and send an email to you

**Challenge 3:** I want to save energy, but I can’t go around turn off everyone’s IP phone everyday

- **Solution:** Timer ED can be used to trigger the execution of an EEM script to turn off your IP phone at 7pm everyday and turn it back on 7am the next day
References – Embedded Automations

Embedded Automation Systems (EASy)

1. Browse and Download EASy Packages
   www.cisco.com/go/easy

2. Make Sure to also download EASy Installer

3. Browse Other Embedded Automations
   www.cisco.com/go/ciscobeyond

4. Learn About The Technology Under The Hood
   www.cisco.com/go/instrumentation
   www.cisco.com/go/eem
   www.cisco.com/go/pec

5. Discuss, Ask Questions, Suggest Answers
   supportforums.cisco.com

6. Upload your own Examples to CiscoBeyond
   www.cisco.com/go/ciscobeyond

7. Engage via ask-easy@cisco.com
Cisco OnePK

- Create, Modify, Customize Applications once across platforms
- Run Apps within NX-OS Container for protected execution
- Apps can exist on-box or off-box (Server)

C, JAVA Program (eg. Chef, Puppet, OpenFlow Agents)

onePK API Presentation

onePK API Infrastructure

IOS, IOS-XE
Catalyst, ISR, ASR1K

NX-OS
Nexus Platforms

IOS-XR
ASR 9K, CRS
What is NETCONF/YANG?

NETCONF is an IETF network management protocol designed to support management of configuration, including:

- Distinction between configuration and state data
  - Multiple configuration data stores (candidate, running, startup)
- Configuration change validations
- Configuration change transactions
- Selective data retrieval with filtering
- Streaming and playback of event notifications
- Extensible remote procedure call mechanism

YANG is a modeling language defined in RFC 6020

- Analogous to XML schema and SMI for SNMP (but more powerful)
- Models configuration, operational, and RPC data
- Provides semantics to better define NETCONF data
- Reusable structures
- YANG is extensible and modular
- YANG modules are for NETCONF what MIBs are for SNMP

Note: NETCONF without YANG (Ex: NETCONF/XML) does not follow RFC standards.
NETCONF/YANG: Cisco OS Harmonization

NMS/OSS – multi-platform, multi-vendor

Network Application

API Presentation

API Infrastructure

IOS, IOS-XE
Catalyst, ISR, ASR900, ASR1000

NX-OS
Nexus Platforms

IOS-XR
ASR9000, CRS, NCS
Useful Reading

- IETF NETMOD and NETCONF WG pages:
  - http://trac.tools.ietf.org/wg/netconf/trac/wiki
  - http://trac.tools.ietf.org/wg/netmod/trac/wiki

- NETCONF Central
  - http://www.netconfcentral.org/

- OpenDaylight

- YANG Central
  - http://www.yang-central.org/twiki/bin/view/Main/WebHome
Cloud Services Router
Virtualized IOS with support for REST API

- Token-services
- Global
  - host-name, domain-name, local-users, running-config, dns-servers, ntp
- Interface
- DHCP
- Routing (OSPF, BGP, EIGRP)
- ACL (IOS extended ACL)
- NAT
- ZBFW (Zone Based Firewall)
- IPSEC site-site VPN
- Licensing
- Monitoring

XE 3.10

XE 3.11
- Sub-interface
- EzVPN
- VRF (ip route, logging, SNMP, static route, NTP)
- BGP best path, neighbor failover
- Banner
- IP pools
- Logging server
- SNMP server
- Local user
- TACACS server

XE 3.12
- VRF (S2S VPN, DHCP)
- Call home
- Reload

Datacenter – ACI, NX-OS, UCS, UCS Director

Programmability
ACI Fabric – Completely Accessible Via REST

- REST API
- Full Object Model exposed
  - Objects
  - Attributes
  - Children
  - Relationships
  - Relative and Distinguished Names
- JSON or XML

https://github.com/datacenter
ACI API Resources

API User Guide:  

Object Model Documentation:  

DevNet: https://developer.cisco.com/site/apic-dc/


Using the API Inspector + SDK:  

Examples: http://github.com/datacenter

Cisco
Nexus 9000: Openness of Linux

Programmable
- NX-API
  - JSON-RPC
  - XML/JSON
- Python scripting
- Customizable CLIs
- BASH access
- Broadcom shell access
- Linux containers
- OpenFlow support
- Cisco onePK™

Automation and Orchestration
- OpenStack network plugin
- Chef
- Puppet
- XMPP support
- OpenDaylight integration

Visibility
- Dynamic buffer monitoring
- Enhanced Ethanalyzer
- SMTP email “pipe” output
- Embedded Event Manager (EEM)
- Flow monitoring
- vTracker

SNMP (v1, v2, v3), Syslog, NETCONF, RMON, CLI
## Nexus Programmability

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<th>Nexus 3K</th>
<th>Nexus 5K/6K</th>
<th>Nexus 7K</th>
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<tr>
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<td>Ansible</td>
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<td>Y – with NX-API</td>
<td>Y – with NX-API</td>
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<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Y</td>
<td>Y</td>
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<td><strong>Protocols and Data Models</strong></td>
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<td>Roadmap</td>
<td>Y</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td>LDAP</td>
<td>Future</td>
<td>Y</td>
<td>Y</td>
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<td></td>
<td>NetConf/XML</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td></td>
<td>NX-API</td>
<td>Y</td>
<td>7.2</td>
<td>7.2</td>
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<tr>
<td></td>
<td>Openflow</td>
<td>Y</td>
<td>Y</td>
<td>(OF 1.0)</td>
</tr>
<tr>
<td></td>
<td>YANG</td>
<td>Roadmap</td>
<td>Roadmap</td>
<td>Roadmap</td>
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<td></td>
<td>REST</td>
<td>Roadmap</td>
<td>Roadmap</td>
<td>Roadmap</td>
</tr>
<tr>
<td><strong>Programmatic Interfaces</strong></td>
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<td>Y</td>
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<td>Integrated container</td>
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<tr>
<td></td>
<td>OpFlex</td>
<td>Roadmap</td>
<td>Future</td>
<td>Future</td>
</tr>
</tbody>
</table>
Your python code

```python
#!/usr/env python

import json
import requests

url = "http://172.25.91.139/ins"

payload = [{
    "jsonrpc": '2.0',
    "method": 'cli',
    "params": [
        'show version',
    ],
    "id": '1'}]

...
Bash Access & Linux Containers
Nexus 9000

Ins1eme-N9K# bash
Ins1eme-N9K(shell)> for i in {1..5}
> do
> echo "RX Counters"
> date
> ifconfig eth0 | grep "RX packets" | cut -d ':' -f2 | cut -d '-' -f1
> sleep 1
> done
RX Counters
Sun Feb 6 03:07:04 UTC 2011
763939
RX Counters
Sun Feb 6 03:07:05 UTC 2011
763944
RX Counters
Sun Feb 6 03:07:06 UTC 2011
763955
RX Counters
Sun Feb 6 03:07:07 UTC 2011
763964
RX Counters
Sun Feb 6 03:07:08 UTC 2011
763969
Ins1eme-N9K(shell)> ifconfig eth0 down
SIOCSIFFLAGS: Permission denied
Ins1eme-N9K(shell)>
Run a Python Script with EEM
Nexus 7000 + 9000

switch#
switch# conf t
Enter configuration commands, one per line. End with CNTL/Z.
switch(config)# event manager applet testplan
switch(config-applet)# description "Running a python script from an EEM policy test"
switch(config-applet)# event syslog pattern "InsiemeABC"
Configuration accepted successfully
switch(config-applet)# action 1.0 cli local python bootflash:/home/admin/testplan.py
switch(config-applet)# action 2.0 syslog msg testplan done
switch(config-applet)# exit
switch(config)# exit
switch# term mon
switch# python
Copyright (c) 2001-2012 Python Software Foundation; All Rights Reserved

switch# >>> from onxos import *
switch# >>> py_syslog(1, "InsiemeABC")
switch# >>> 2011 Mar 14 17:09:06 switch vshd: InsiemeABC
2011 Mar 14 17:09:06 switch %VSHD-5-VSHD_SYSLOG_CONFIG_I: Configured from vty by admin on vsh.21499
OpenFlow Support
Nexus 3000 + 9000

• OpenFlow 1.0 and 1.3 support
• Integration with Cisco ONE Controller and OpenDaylight
• Implemented as an App on Cisco onePK
UCS API – Everything is an Object

XML API
UCS API Documentation

Developer Guide

Fault Reference

Object Model
http://developer.cisco.com/web/unifiedcomputing/docs

Third Party Tools
http://developer.cisco.com/web/unifiedcomputing/docs

Stand-Alone Guide

SNMP MIB Guide
UCS Director API

- Login Operations
- User Account Operations
- Report Operations
- Approval Operations
- Catalog Operations
- Chargeback Operations
- Funds Operations
- Group Operations
- Inventory (Cloud) Operations
- LOV Provider Operations
- Payment Status Operations
- Resource Accounting and Limits
- Service Container Operations
- Service Request Operations
- Task Operations
- VDC Operations
- VM Operations
- Workflow Operations
UCS Director API References

• Developer Guide:

• SDK Installation:

• REST API Browser:
Service Provider

But not exclusively*

Programmability
Tail-f NSO Main Features

- **Applications**
  - REST, NETCONF, Java, Python, Erlang, CLI, Web UI
  - Service Manager
  - Device Manager
  - Network Equipment Drivers (NEDs)

- **Engineers**
  - VNFM
  - Controller Apps
  - EMS and NMS

- Structured representations of:
  - Service instances
  - Network configuration and state

- Mapping service operations to network configuration changes
- Transactional integrity
- Multiprotocol and multivendor support

- Logically centralized network services
- Data models for data structures
OpenDaylight Platform

Hydrogen
- Released February 2014

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

Lithium
- June 2015 planned release
Cisco Open SDN Controller

REST APIs

RESTCONF APIs
For checking configuration and operational states

List of exposed Northbound APIs available via DevNet and on platform
COSC - Open Developer Eco-system

developer.cisco.com/site/openSDN

Documentation
API Reference Guides
Video
Code samples
Sandbox environment
Management Tools

Programmability
Prime Infrastructure – REST API

Cisco Prime Infrastructure API

Getting Started with the API is easy. Once done, jump right into the Detailed Prime API Resources Documentation.

Getting Started
- Things to know about the Prime Infrastructure API
- Getting Started with the Prime Infrastructure API
- Tutorials and sample use cases
- Prime Infrastructure API FAQ
- Client examples in various programming/scripting languages

The Prime Infrastructure API
- Detailed Prime Infrastructure API Resources Documentation
- Filtering, Sorting, and Paging
- Authentication
- Error codes and Responses
- Rate Limiting
- API Health
- Response/Request structure
- Sample Client Code

Notifications API
- Things to know about NBI notifications from Prime Infrastructure
- Getting Started with Prime Infrastructure NBI Notifications


3rd Party Considerations

Consider External Data and Configuration

- IPAM – REST API's
- LDAP / Authentication
- Databases
  - CRM, Business Systems, ERP, etc
- Hypervisor API's
- Service Catalogs / Portals
- Non-Infrastructure API's
  - Weather, Location, Time
  - IoT Data

- Services
  - Load Balancers
  - Firewalls
  - Intrusion Protection Systems
  - Anti-virus Solutions
  - Email Security
  - Web Application Firewalls
  - Phone System / Call Center Queue
  - Caching and DDoS Protection
  - WAN Service API's
  - Cloud Infrastructure
## Network Programmability Cisco Education Offerings

<table>
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<th>Course</th>
<th>Description</th>
<th>Cisco Certification</th>
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<tr>
<td>Integrating Business Applications with Network Programmability (NIPBA); Integrating Business Applications with Network Programmability for Cisco ACI (NPBAACI)</td>
<td>Learn networking concepts, and how to deploy and troubleshoot programmable network architectures with these self-paced courses.</td>
<td>Cisco Business Application Engineer Specialist Certification</td>
</tr>
<tr>
<td>Developing with Cisco Network Programmability (NPDEV); Developing with Cisco Network Programmability for Cisco ACI (NPDEVACI)</td>
<td>Learn how to build applications for network environments and effectively bridge the gap between IT professionals and software developers.</td>
<td>Cisco Network Programmability Developer Specialist Certification</td>
</tr>
<tr>
<td>Designing with Cisco Network Programmability (NPDES); Designing with Cisco Network Programmability for Cisco ACI (NPDESACI)</td>
<td>Learn how to expand your skill set from traditional IT infrastructure to application integration through programmability.</td>
<td>Cisco Network Programmability Design Specialist Certification</td>
</tr>
<tr>
<td>Implementing Cisco Network Programmability (NPENG); Implementing Cisco Network Programmability for Cisco ACI (NPENGACI)</td>
<td>Learn how to implement and troubleshoot open IT infrastructure technologies.</td>
<td>Cisco Network Programmability Engineer Specialist Certification</td>
</tr>
</tbody>
</table>

For more details, please visit: [http://learningnetwork.cisco.com](http://learningnetwork.cisco.com)

Questions? Visit the Learning@Cisco Booth or contact [ask-edu-pm-dcv@cisco.com](mailto:ask-edu-pm-dcv@cisco.com)
Conclusions
Remember – Just Create Something

http://github.com/nickpowpow/bieberhockey
Conclusions – What to Remember

This is happening. Get Started.

Find a problem, an API, a partner, and play with it.

Make the network a better place
Continue Your Education

- Demos in the Cisco campus
- Walk-in Self-Paced Labs
- Table Topics
- Meet the Engineer 1:1 meetings
- Related sessions
Participate in the “My Favorite Speaker” Contest

Promote Your Favorite Speaker and You Could Be a Winner

• Promote your favorite speaker through Twitter and you could win $200 of Cisco Press products (@CiscoPress)

• Send a tweet and include
  • Your favorite speaker’s Twitter handle
  • Two hashtags: #CLUS #MyFavoriteSpeaker

• You can submit an entry for more than one of your “favorite” speakers

• Don’t forget to follow @CiscoLive and @CiscoPress

• View the official rules at http://bit.ly/CLUSwin

@nickpowpow
Complete Your Online Session Evaluation

- Give us your feedback to be entered into a Daily Survey Drawing. A daily winner will receive a $750 Amazon gift card.

- Complete your session surveys though the Cisco Live mobile app or your computer on Cisco Live Connect.

Don’t forget: Cisco Live sessions will be available for viewing on-demand after the event at CiscoLive.com/Online
Thank you
TOMORROW starts here.