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The bridge to possible

Cisco IOS XE & Terraform

How to become an IOS XE Terraform Expert

Jeremy Cohoe, Technical Marketing
@jeremycohoe

DEVNET-2476

Infrastructure as Code (IAC) allows us to automate provisioning and management of Cisco Catalyst 9000 devices more efficiently. In this session, automation tooling will be used to programmatically deploy BGP EVPN network fabric. Infrastructure as Code concepts will be demonstrated on the Catalyst 9000 using Terraform. Both enterprise campus and cloud-native use cases and examples will be shared. You'll leave this session with ideas to help you get started with Infrastructure as Code, understand benefits of IAC, and understand more about the Terraform tooling. With IAC and Cisco IOS XE, you can automate any tooling on any interface.

Cisco Webex App

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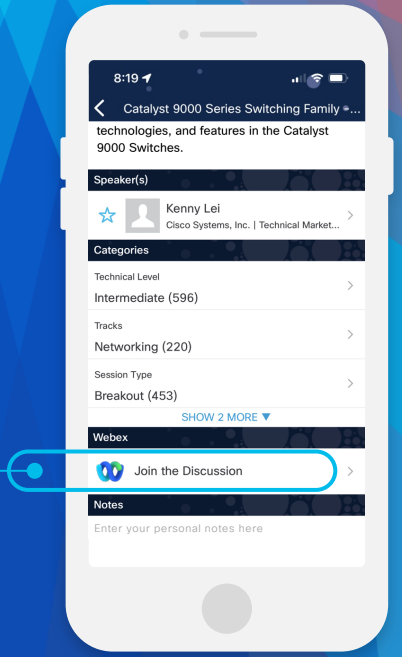

https://ciscolive.ciscoevents.com/ciscolivebot/#DEVNET-2476

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Agenda

- Introduction
- Cisco YANG Suite
- IOS XE Capabilities
- Terraform's IOS XE Integration
- Use Case Examples
- Conclusion

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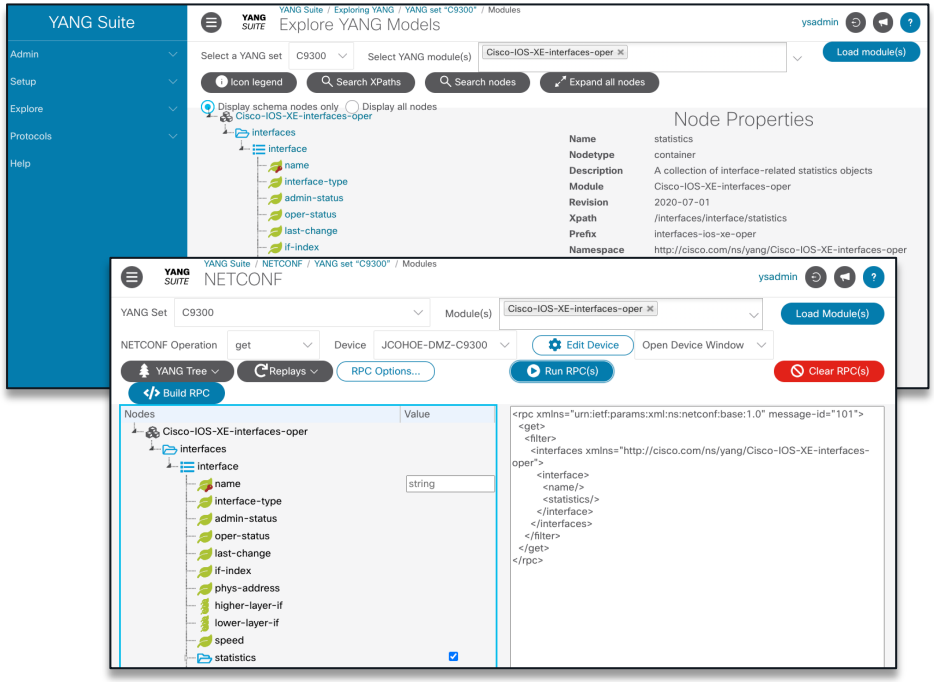
Cisco YANG Suite

Cisco YANG Suite

- YANG API Testing and Validation Environment
- Construct and test YANG based APIs over NETCONF, RESTCONF, gRPC and gNMI
- IOS XE / IOS XR / NX OS platforms



Now Generally Available !

developer.cisco.com/yangsuite

github.com/CiscoDevNet/yangsuite

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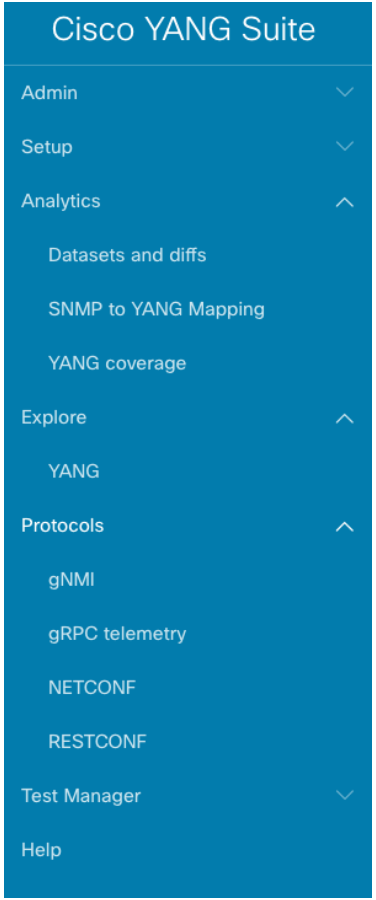
YANG Suite

- Initial Release: YANG Suite + core plugins
- Second release: RESTCONF, gNMI
- Next release: June 2023
    1. gRPC Dial-Out with TLS Support
    2. SNMP OID to YANG XPATH
    3. NETCONF/RESTCONF/gNMI to Ansible YAML
    4. Pip install support + Docker

https://github.com/CiscoDevNet/yangsuite/
https://developer.cisco.com/yangsuite/
https://eurl.io/#MaW78CeIS YANG Suite General (external)



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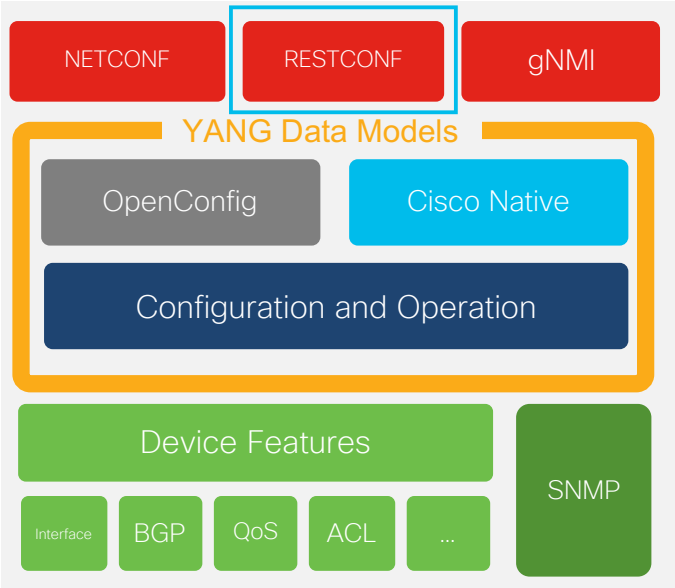
Terraform uses the RESTCONF API on IOS XE

Open-source Infrastructure as Code (IaC) Software Tool providing a consistent CLI workflow to manage hundreds of cloud services. Terraform codifies cloud APIs into declarative configuration files.

Resources:

Ask IOS XE Terraform Provider Webex space:
https://eurl.io/#PtsT8eJFl
GitHub Repository:
https://github.com/CiscoDevNet/terraform-provider-iosxe/
Provider Documentation:
https://registry.terraform.io/providers/CiscoDevNet/iosxe/latest

Terraform uses the RESTCONF API



Terraform image source: https://registry.terraform.io/

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IOS XE

Prerequisites: Enable AAA, NETCONF & RESTCONF

```
Cat9k-1#conf t
Enter configuration commands, one per line.  End with
CNTL/Z.
Cat9k-1(config)#aaa new-model
Cat9k-1(config)#aaa authentication login default local
Cat9k-1(config)#aaa authorization exec default local
Cat9k-1(config)#username admin privilege 15 password cisco

Cat9k-1(config)#netconf-yang

Cat9k-1(config)#restconf
```

Enable AAA

Enable NETCONF

Enable RESTCONF

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CLI to YANG

This CLI "show run | format" brings additional visibility into the YANG modelled configuration, either for NETCONF with XML or JSON with RESTCONF
Easily convert CLI into YANG to re-use in tooling, scripts, and automation and orchestration systems

```
show run | format netconf-xml
show run | format restconf-json
```

```
C9300#show run | format netconf-xml
<config xmlns="http://tail-f.com/ns/config/1.0">
  <native xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-native">
    <version>17.7</version>
    <memory>
      <free>
        <low-watermark>
          <processor>131752</processor>
        </low-watermark>
```

```
C9300#show run | format restconf-json
{
  "data": {
    "Cisco-IOS-XE-native:native": {
      "version": "17.7",
      "memory": {
        "free": {
          "low-watermark": {
            "processor": 131923
```

```
C9300#
C9300#show run | i netconf-yang
netconf-yang
C9300#
```

Requires `netconf-yang` Data Model Interfaces to be enabled
CLIs with corresponding native YANG and modeled in show run are returned

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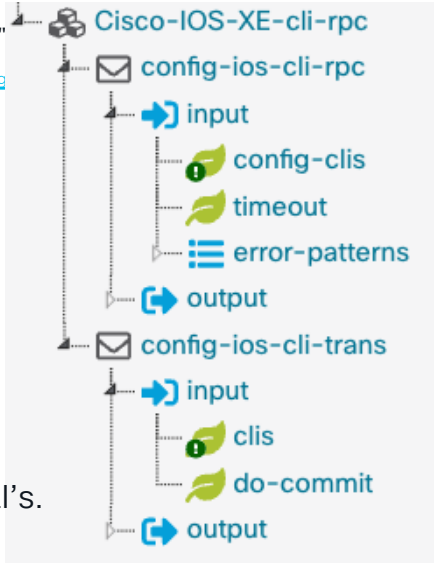
YANG model for CLI execution

Any configure CLI can now be sent within the YANG payload

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
message-id="101">
<config-ios-cli-rpc xmlns=http://cisco.com/ns/yang/Cisco-
IOS-XE-cli-rpc>
<config-clis>
interface Loopback111
description configured-via-CLI-YANG
no shutdown
</config-clis>
</config-ios-cli-rpc>
</rpc>]]>]]>
```

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
message-id="101">
<config-ios-cli-trans xmlns=http://cisco.com/ns/yang
IOS-XE-cli-rpc>
<clis>
interface Loopback111
description configured-via-CONFD-YANG
no shutdown
</clis>
</config-ios-cli-trans>
</rpc>]]>]]>
```



clis

config-clis

"cli rpc" sends CLI to the IOS parser
- This is similar to configuring CLI on the VTY
- Directly into running-config, then **synchronized** to ConfD

"transitional cli rpc" sends a list of CLI to ConfD
- This is similar to sending edit-config RPCs corresponding to the CLI's.
- Synchronized from ConfD into the CLI running-config

https://github.com/YangModels/yang/blob/main/vendor/cisco/xe/1791/Cisco-IOS-XE-cli-rpc.yang

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CLI RPC: Operational examples

Use the CLI RPC to send un-structured CLI over YANG to:

- Configure single feature: conf t
- Configure multiple features
- Privileged EXEC commands: clock/clear
- Show commands: show ver
- Show commands with redirect: show ver | redirect tftp

Config-IOS-CLI-RPC example payloads:

```
hostname jcohoe

int lo99
ip address 192.169.254.1 255.255.255.0

no hostname
no int lo99
hostname jcohoe-c9300

do clock set 16:20:59 sep 12 2023

do sh ver | redirect flash:shver.txt
do sh tech | redirect tftp://10.1.1.3/sh-tech.txt
```

```
Sending:

#336
<nc:rpc xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="urn:uuid:7c8e9760-222d-4b4b
    <config-clis>

do sh ver | redirect flash:shver.txt

</config-clis>
  </config-ios-cli-rpc>
</nc:rpc>

##

Received message from host

<?xml version="1.0" ?>
<rpc-reply message-id="urn:uuid:7c8e9760-222d-4b4b-a94d-f49043eab97f" xmlns="urn:ietf:params:xml:n
  <result xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-cli-rpc">RPC request successful</result>


</rpc-reply>
```


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Terraform resource utilizing the CLI RPC

https://registry.terraform.io/providers/CiscoDevNet/iosxe/latest/docs/resources/cli

iosxe_cli (Resource)

This resources is used to configure arbitrary CLI commands. This should be considered a last resort in case YANG models are not available, as it cannot read the state and therefore cannot reconcile changes.

Example Usage

```
resource "iosxe_cli" "example" {
  cli = <<-EOT
  interface Loopback123
  description configured-via-restconf-cli
  EOT
}
```


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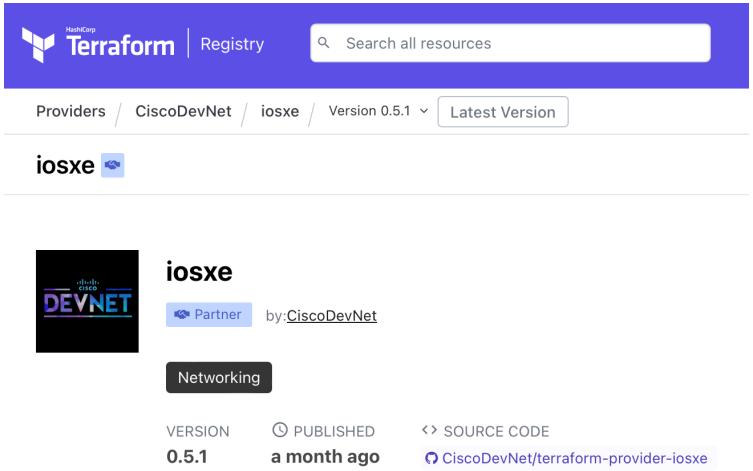
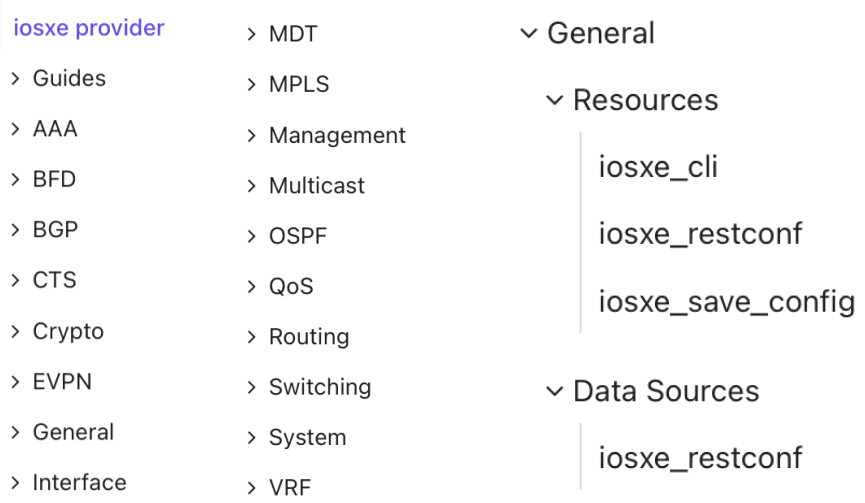
Terraform on IOS XE

IOS XE Terraform Provider

Documentation and details about the provider are available on the Hashicorp Registry
https://registry.terraform.io/providers/CiscoDevNet/iosxe/latest

Source code is in the GitHub Repository: https://github.com/CiscoDevNet/terraform-provider-iosxe/





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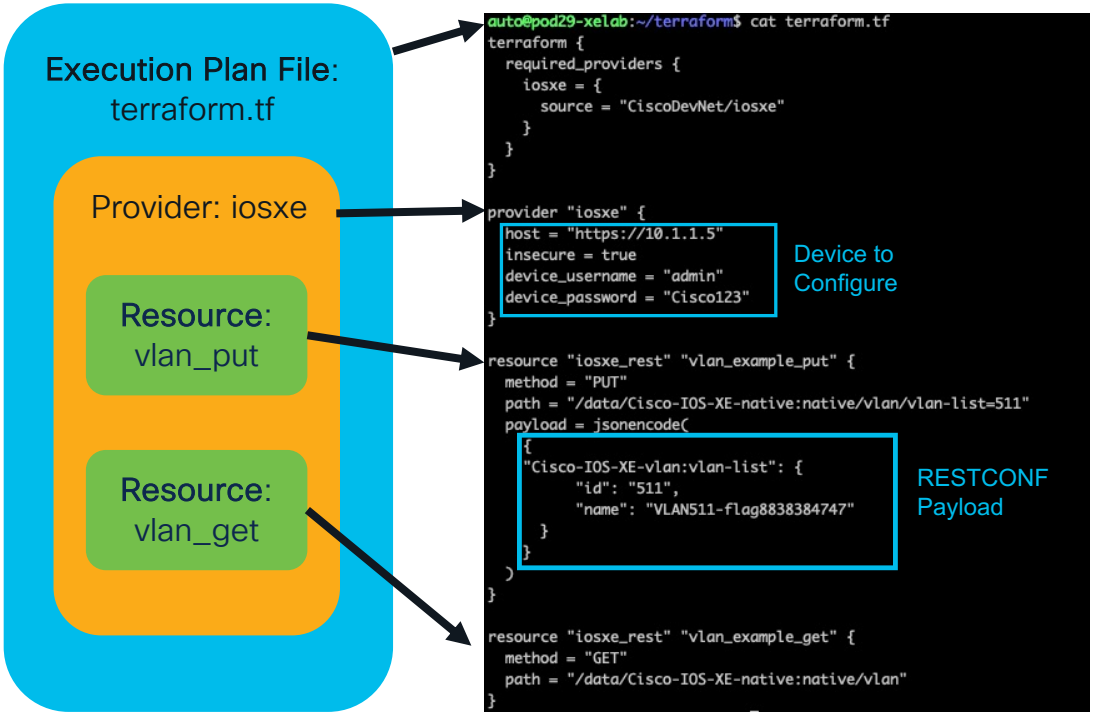
Terraform Terminology

Terraform uses an execution plan file with a provider and resource definitions.

An **execution plan file** defines the provider and resources. It is written in HashiCorp Configuration Language (HCL), similar to JSON, and stored with a .tf extension

A **provider** is a plugin to make a collection of resources accessible

A **resource** (or infrastructure resource) describes one or more infrastructure objects managed by Terraform. With the IOS XE Terraform provider, resources can be considered the same as a configurable feature



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Getting Started with Terraform + IOS XE Provider

1. Enabling the RESTCONF API on the switch

```
Switch# conf t
Switch(config)# restconf
```

2. Install Terraform

```
$ apt install terraform
```

3. Clone the IOS XE Terraform Provider GitHub repository

```
$ git clone https://github.com/CiscoDevNet/terraform-provider-iosxe
```

4. Apply Terraform VLAN example

```
$ terraform apply acl_and_vlan.tf
```


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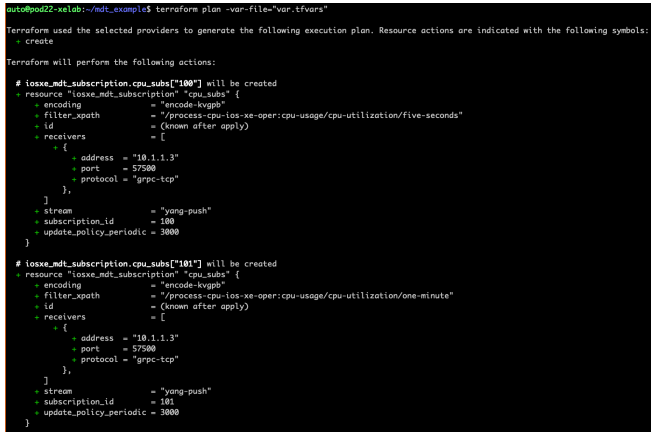
Use Case Examples

Terraform for Model Driven Telemetry

Enable gRPC Dial-Out telemetry subscriptions for the POE and Basic Device Monitoring use cases



```
auto@pod22-xelab:~/mdt_example$ terraform plan -var-file="var.tfvars"

Terraform used the selected providers to generate the following execution plan. Resource actions are indicated with the following symbols:
  + create

Terraform will perform the following actions:

  # iosxe_mdt_subscription.cpu_subs["100"] will be created
  + resource "iosxe_mdt_subscription" "cpu_subs" {
      + encoding             = "encode-kvgpb"
      + filter_xpath         = "/process-cpu-ios-xe-oper:cpu-usage/cpu-utilization/five-seconds"
      + id                   = (known after apply)
      + receivers            = [
          + {
              + address  = "10.1.1.3"
              + port     = 57500
              + protocol = "grpc-tcp"
            },
        ]
      + stream               = "yang-push"
      + subscription_id      = 100
      + update_policy_periodic = 3000
    }

  # iosxe_mdt_subscription.cpu_subs["101"] will be created
  + resource "iosxe_mdt_subscription" "cpu_subs" {
      + encoding             = "encode-kvgpb"
      + filter_xpath         = "/process-cpu-ios-xe-oper:cpu-usage/cpu-utilization/one-minute"
      + id                   = (known after apply)
      + receivers            = [
          + {
              + address  = "10.1.1.3"
              + port     = 57500
              + protocol = "grpc-tcp"
            },
        ]
      + stream               = "yang-push"
      + subscription_id      = 101
      + update_policy_periodic = 3000
    }
```

Lab Guide Steps:

1. Introduction
2. IOS XE CLI pre-req
3. Terraform Install & headers, device variables
4. Variables and config for MDT subscription
5. Terraform configuration for device monitoring
6. TF Workflow: init, plan, apply & destroy
7. Validation with TF and CLI
8. Conclusion

iosxe_mdt_subscription (Resource)

This resource can manage the MDT Subscription configuration.

Example Usage

```
resource "iosxe_mdt_subscription" "example" {
  subscription_id         = 101
  stream                  = "yang-notif-native"
  encoding                = "encode-kvgpb"
  source_vrf              = "Mgmt-vrf"
  source_address          = "1.2.3.4"
  update_policy_on_change = true
  filter_xpath            = "/ios-events-ios-xe-oper
  receivers = [
    {
      address  = "5.6.7.8"
      port     = 57600
      protocol = "grpc-tcp"
    }
  ]
}
```

https://registry.terraform.io/providers/CiscoDevNet/iosxe/latest/docs/resources/mdt_subscription
https://registry.terraform.io/providers/CiscoDevNet/iosxe/latest/docs/data-sources/mdt_subscription
https://github.com/jeremycohoe/cisco-ios-xe-panda-lab-terraform

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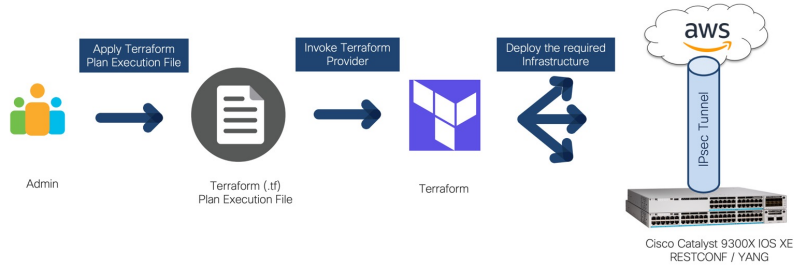
Terraform

TF Code

TF Code

IPsec tunnel + cloud automation with Terraform

1. Terraform configures the IPsec tunnel between the 9300X and the cloud service where the internal resources are available
2. Terraform also manages the cloud-native resources including certificate key management and IP subnetting
3. Connections between VPC, VPN, CG Wand device certificates, tunnels, and interfaces are created



1. Virtual Private Cloud (VPC)
2. Virtual Private Network (VPN)
3. Customer Gateway (CGW)

1. Tunnel
2. Proposal
3. Policy
4. Keyring
5. Profile
6. IPSEC Transform
7. IPSEC Profile
8. Tunnel Interface

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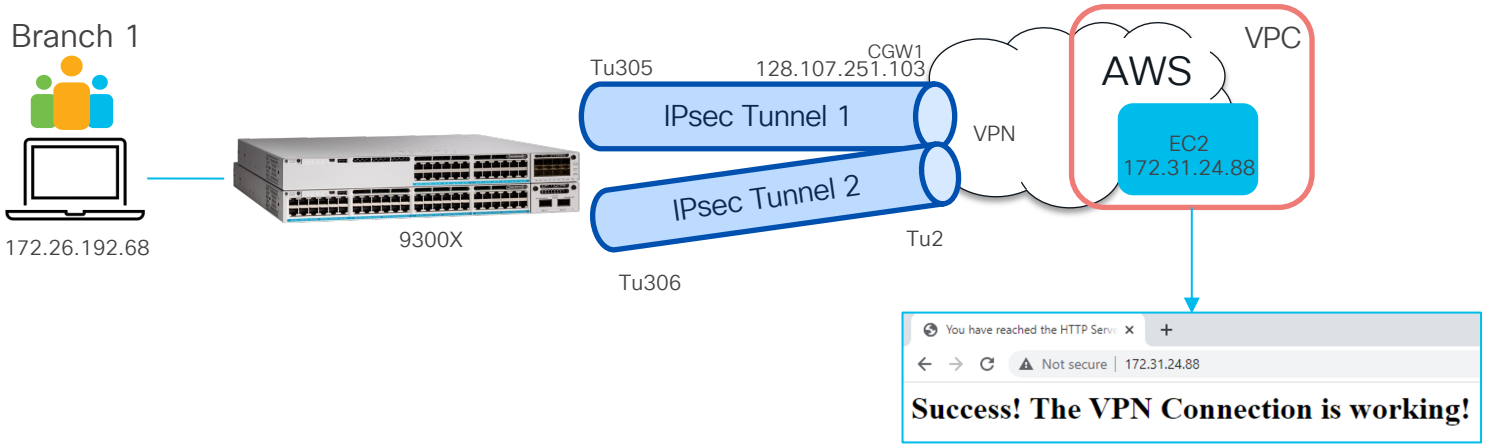
Topology

YouTube video coming soon!



https://github.com/sdeweese/terraform-ipsec-tunnel-to-cloud

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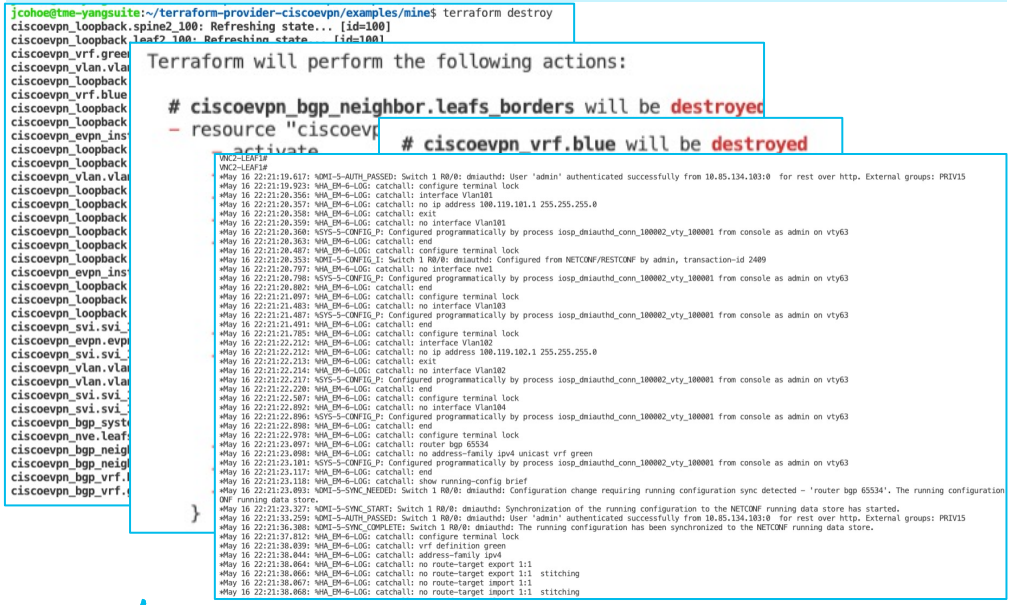
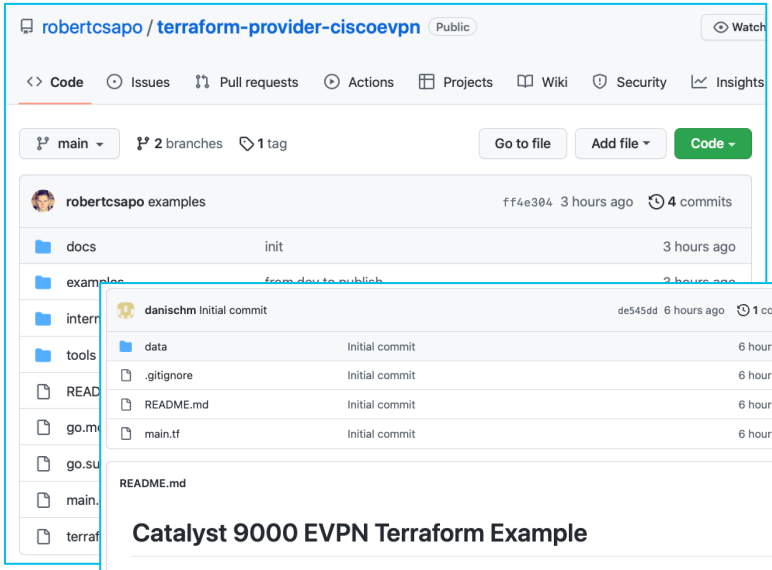
Declarative EVPN management with Terraform

Both Declarative providers leverage the ios-xe-go client that was developed in Terraform Phase 1:

Robert: https://github.com/robertcsapo/terraform-provider-ciscoevpn/
https://registry.terraform.io/providers/robertcsapo/ciscoevpn/latest
Daniel: https://github.com/netascode/terraform-iosxe-evpn-example
EVPN OSPF Underlay Module: https://registry.terraform.io/modules/netascode/evpn-ospf-underlay/iosxe/latest
EVPN Overlay Module: https://registry.terraform.io/modules/netascode/evpn-overlay/iosxe/latest





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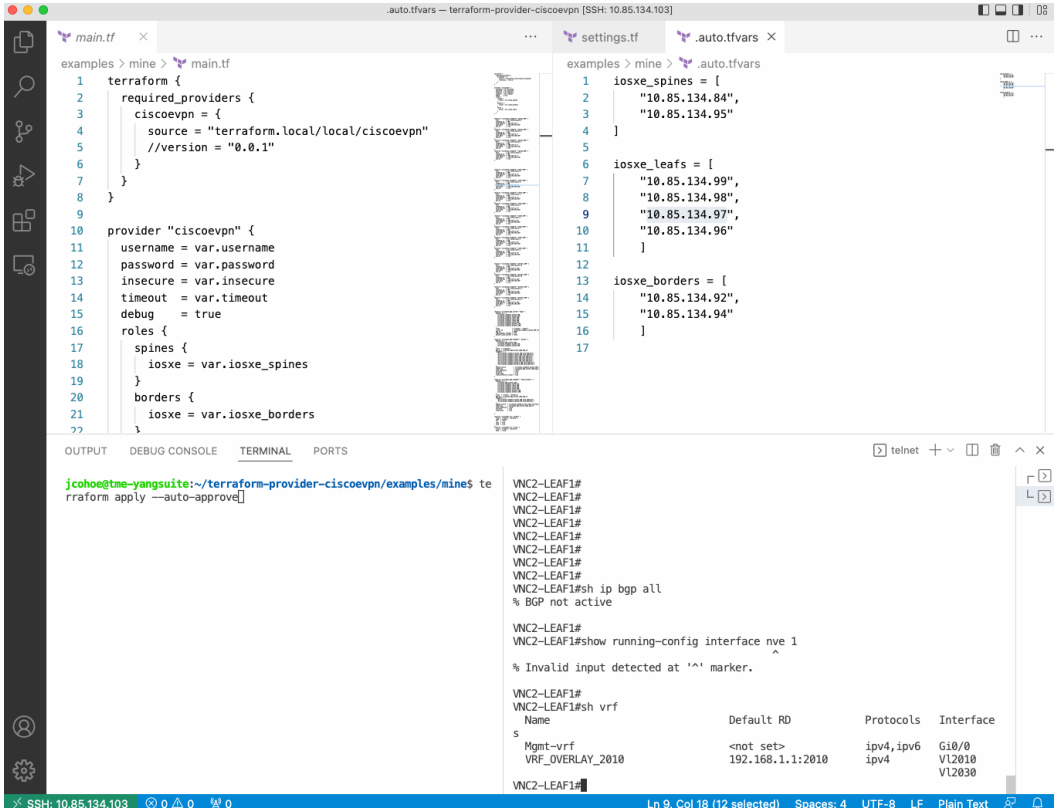
EVPN with Terraform Demo



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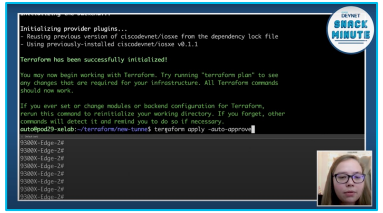
Resources

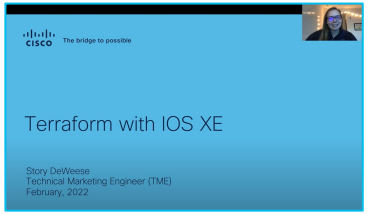
Blog and Resources: Terraform

https://github.com/CiscoDevNet/terraform-provider-iosxe/
https://registry.terraform.io/search/providers?namespace=CiscoDevNet

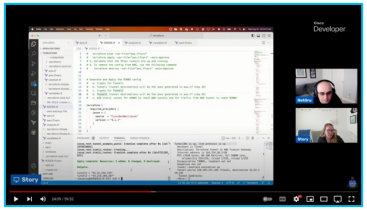
Questions? Join the Ask IOS XE Terraform Provider Webex space:
https://eurl.io/#PtsT8eJFI



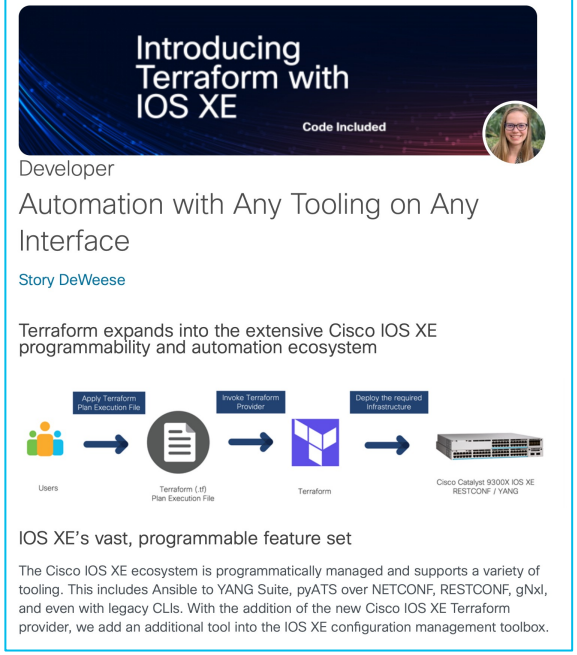
Demo Create a Crypto Tunnel Video:
https://www.youtube.com/watch?v=bPS0bhPacDw



Intro to IOS XE Terraform Provider Video:
https://www.youtube.com/watch?v=GEY_hyXimbA



Crypto IPsec Live Stream with DevRel:
https://www.youtube.com/watch?v=WkgDlE0HpXs



https://blogs.cisco.com/developer/terraformiosxe01

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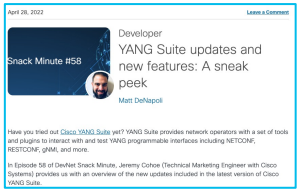
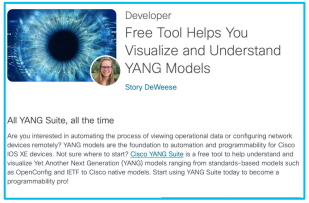
YANG Suite Resources

Blogs

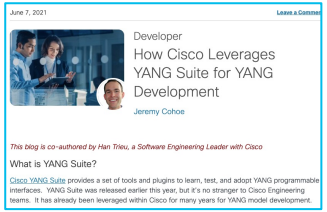
https://blogs.cisco.com/developer/363-yangsuite-01



https://blogs.cisco.com/developer/2023yangsuiteupdatesfeatures01

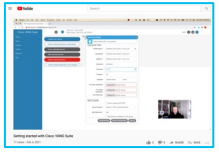


https://blogs.cisco.com/developer/yangallthetime01



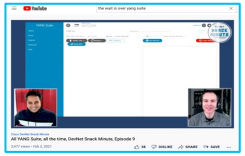
https://blogs.cisco.com/developer/leverageyangsuite01?dtid=osscdc000283

YouTube Videos

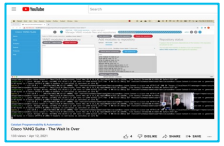


https://youtu.be/smrhjL5Ayz0

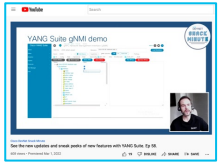
https://www.youtube.com/watch?v=dTun33611JA



https://www.youtube.com/watch?v=3zmNDfn8b38



https://www.youtube.com/watch?v=PkbAOzZ1vNk



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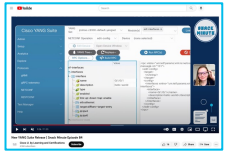

https://www.youtube.com/watch?v=zVsOO9_6rAU

Additional Resources

https://github.com/CiscoDevNet/yangsuite/
https://developer.cisco.com/yangsuite/
https://eurl.io/#MaW78CeIS YANG Suite General (external)

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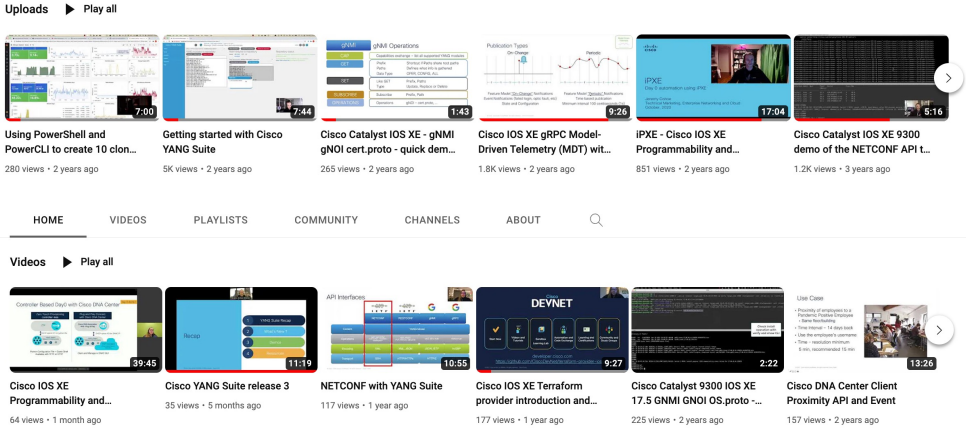
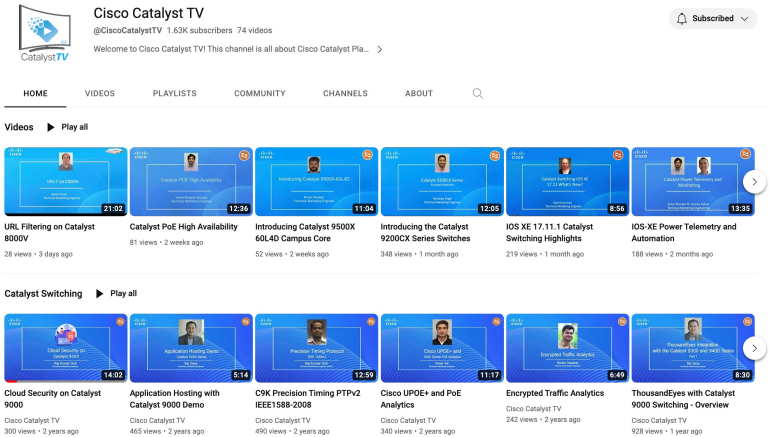
Cisco Programmability on YouTube

https://www.youtube.com/jeremycohoe1
https://www.youtube.com/ciscoenprogrammability
https://www.youtube.com/ciscocatalysttv





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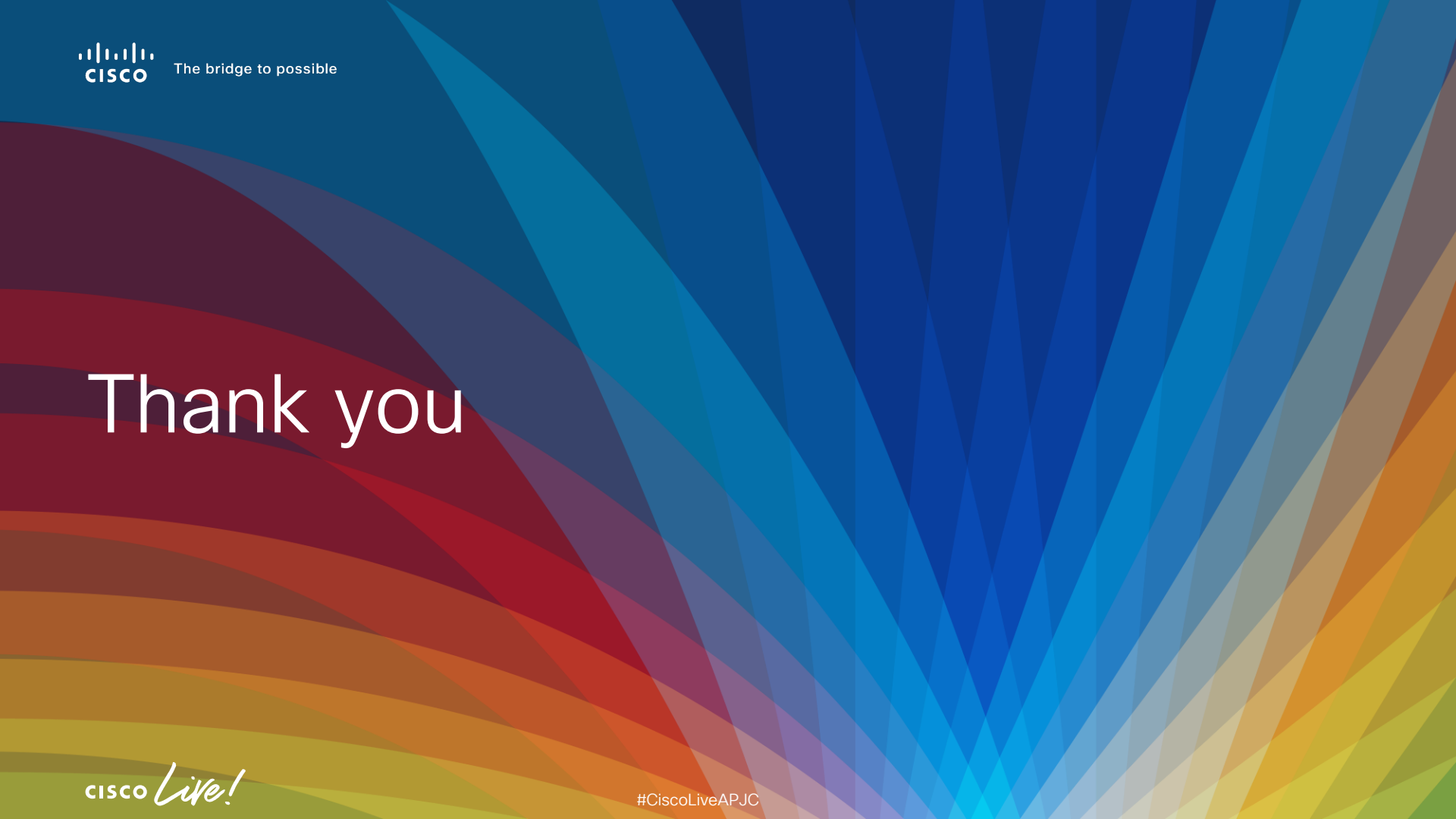
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