ALL IN

cisco Live!

DevNet Zone

#CiscoLiveAPJC

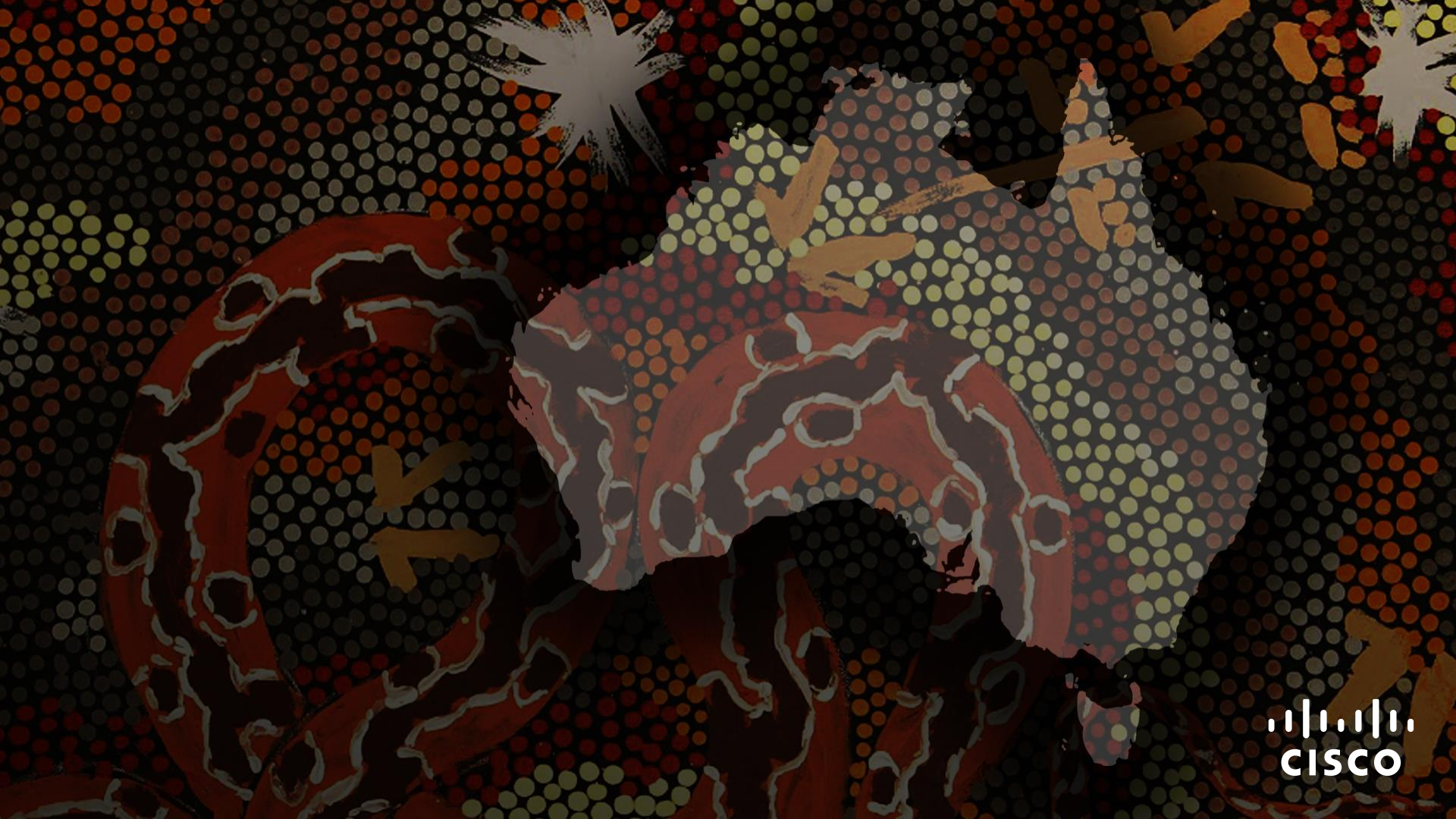
The bridge to possible

Industrial Automation

From Day0 to Microsegmentation

Thomas Kjaer-Olsen

DEVNET-1243


CISCO

Cisco Webex App

Questions?

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with the speaker after the session

How

1. Find this session in the Cisco Live Mobile App
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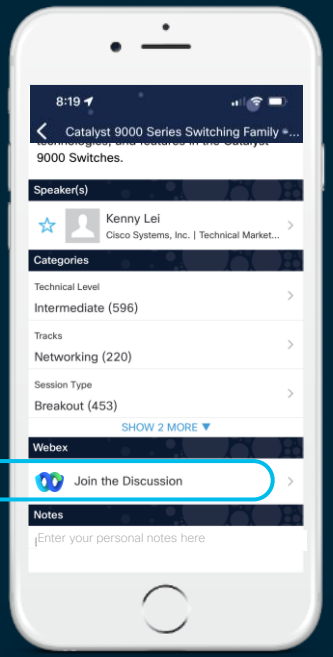

https://ciscolive.ciscoevents.com/ciscolivebot/#DEVNET-1243

Webex spaces will be moderated
by the speaker until Thursday 22 December, 2022.

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Agenda

- Introduction
- Day0 (PnP) via DNAC
- DayN Templates via DNAC
- Configuration via direct Device Programmability
  - Manual Micro-segmentation example
- Conclusion

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Join my

Industrial Automation – From Day0 to Microsegmentation

DEVNET-1243

6th December 2022 at 4pm

cisco Live!
DevNet Zone

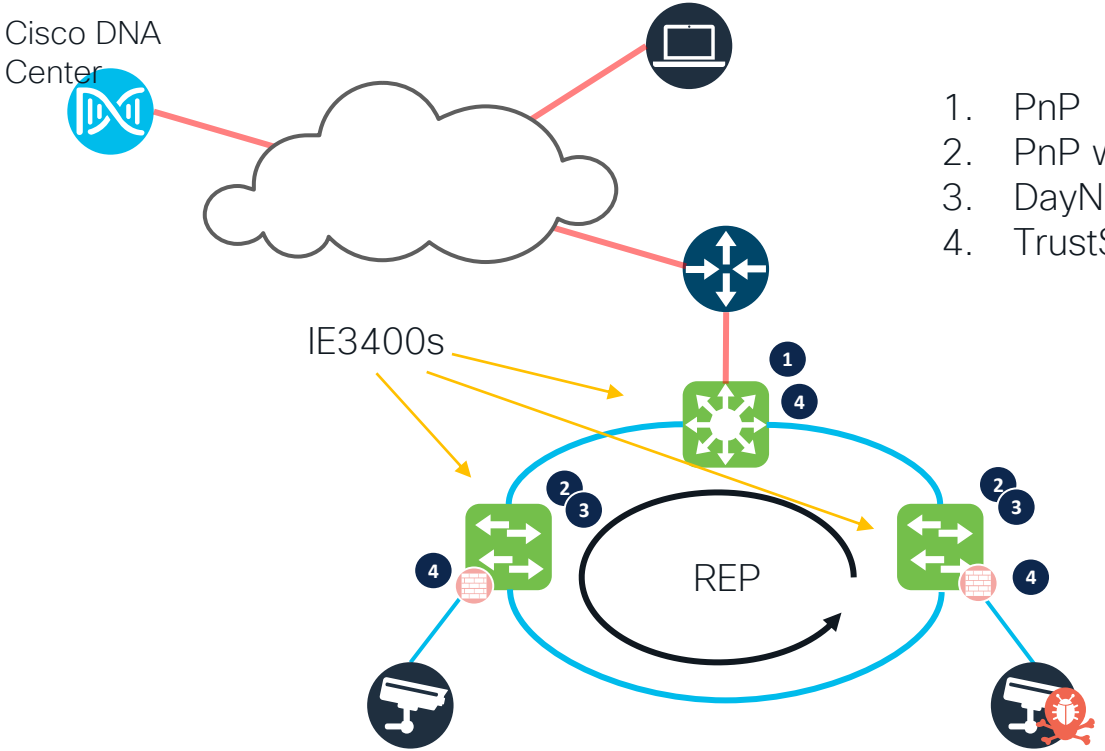
Get the code:

https://github.com/tkj-scythe/clmel-devnet1243

Intro - What

Intro
- PnP Via DNAC
  - Demo newer Industrial Automation Capabilities
    - REP ZTP
- Driving DNAC PnP via REST API
- DayN Templates
- Pushing config directly via Netconfig-yang
  - Demo Microsegmentation via TrustSec

Intro - Topology



1. PnP
2. PnP with REP ZTP
3. DayN Templates
4. TrustSec Microsegmentation

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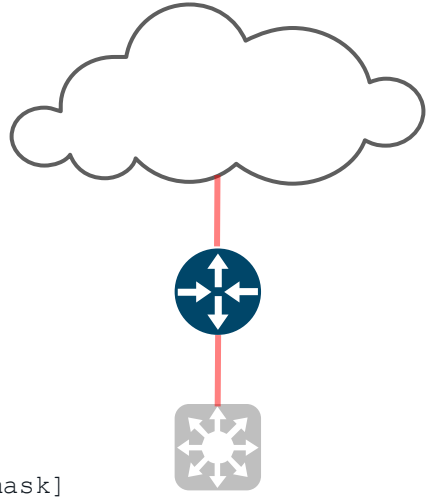
Day -1: Network settings

Upstream connectivity:

- PNP Requirements:



1. Configure PnP VLAN

```
UPSTREAM-SWITCH#

pnp startup-vlan [Vlan number]

interface Vlan[number]
 ip address [network] [subnetmask]
 ip helper-address [DHCP Server IP]
```

2. Configure DHCP + DNS (or use DHCP Option 43)

```
DHCP-Server#
ip dhcp pool pnp-dhcp-pool
 network [network] [subnet mask]
 default-router [router ip]
 dns-server [dns server]
 domain-name [yourdomain]

ip dhcp excluded-address [router ip]
```

3. Add DNS entry for pnpserver

pnpserver	Host (A)	[illegible]	static

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Day -1: Cisco DNA Center Setup

DNA-C Requirements:

1. Set up network hierarchy
2. Configure Day0 Templates
3. Create Network Profile
   1. Assign templates to network profile
   2. Assign network profile to network sites

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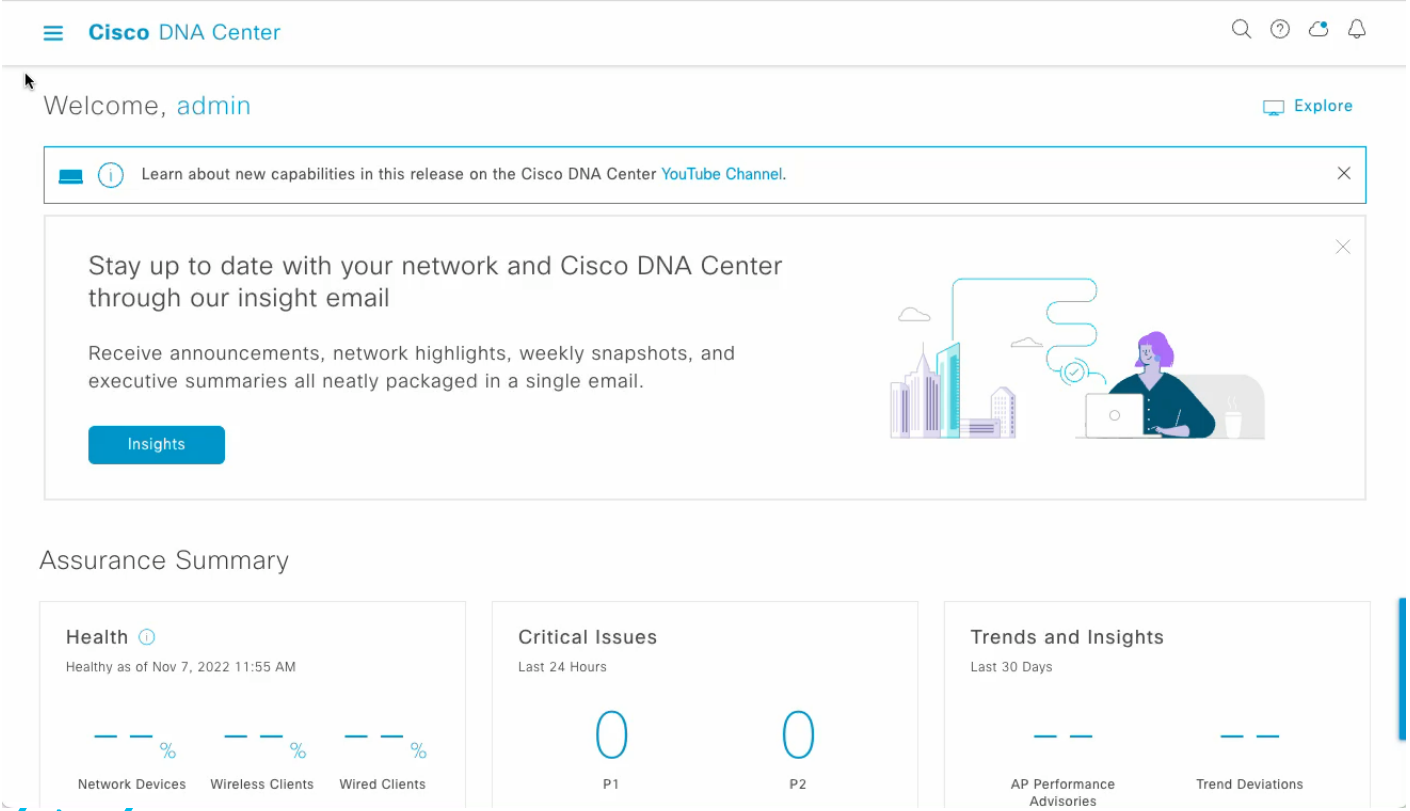
Day -1: DNAC Setup



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Day -1: Day0 Template Setup

Cisco DNA Center

Welcome, admin

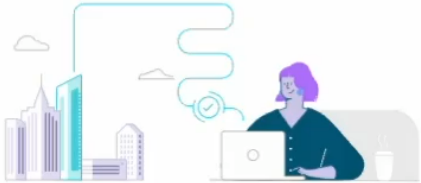
Explore

Learn about new capabilities in this release on the Cisco DNA Center YouTube Channel.

Stay up to date with your network and Cisco DNA Center through our insight email

Receive announcements, network highlights, weekly snapshots, and executive summaries all neatly packaged in a single email.

Insights



Assurance Summary

Health

Healthy as of Nov 7, 2022 11:55 AM

— — % Network Devices

— — % Wireless Clients

— — % Wired Clients

Critical Issues

Last 24 Hours

0 P1

0 P2

Trends and Insights

Last 30 Days

— — AP Performance

0 Trend Deviations

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Day -1: Network Profile Setup

Cisco DNA Center

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Receive announcements, network highlights, weekly snapshots, and executive summaries all neatly packaged in a single email.

Insights

Assurance Summary

Health

Healthy as of Nov 10, 2022 8:55 PM

-- % Network Devices

-- % Wireless Clients

-- % Wired Clients

View Details

Critical Issues

Last 24 Hours

0 P1

0 P2

View Details

Trends and Insights

Last 30 Days

-- AP Performance Advisories

0 Trend Deviations

View Details

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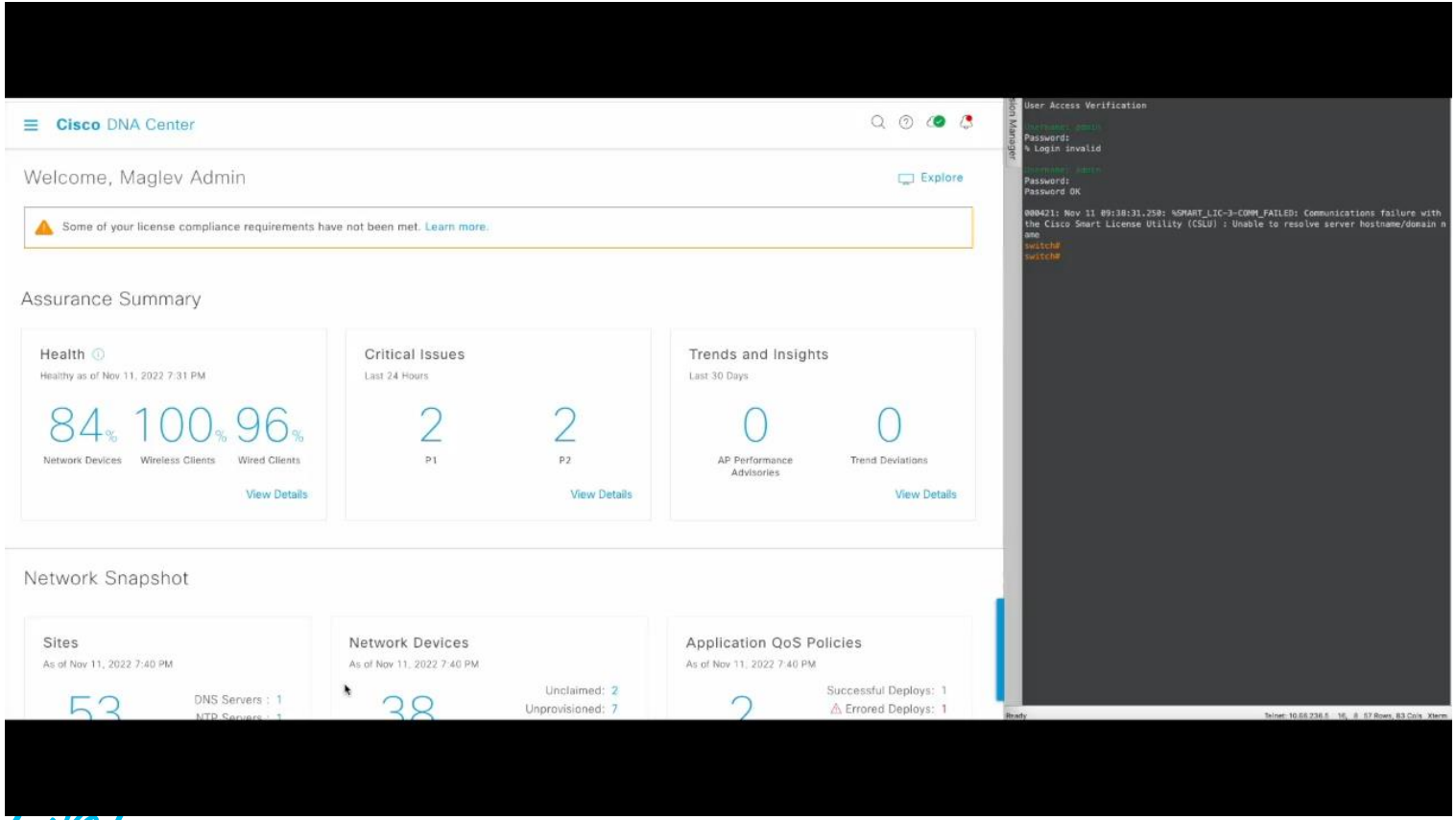
Day 0: PnP – via GUI



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Day 0: PnP – via API

Good:

Using templates, single source of truth, work asynchronously with field staff

Bad:

Clicking through GUIs is time consuming at scale
Still prone to human error

Solution:

Drive PnP via API

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Sidebar: REP ZTP

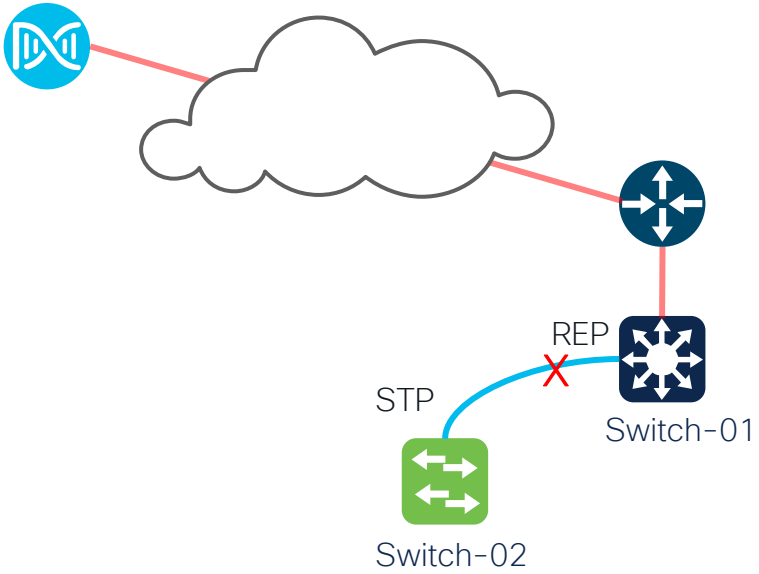
Next Step: PnP Switch 2

Problem?

- Switch 1 is configured for REP
- Switch 2 is factory default with STP
- Switch 1 will block VLANs

Solution?

- REP Zero Touch Provisioning (ZTP)



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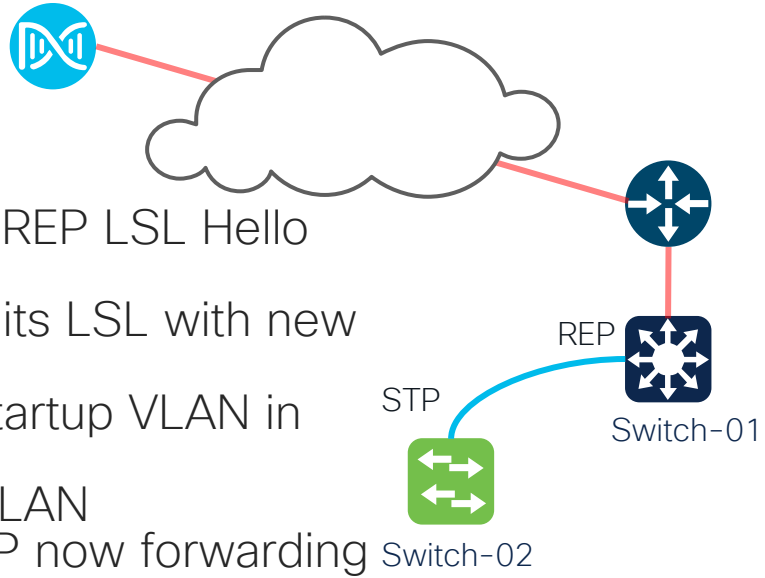
Sidebar: REP ZTP



Steps:

1. Switch 1 configured with REP – Sends REP LSL Hello pkts
2. Switch 2 boots with no config – transmits LSL with new TLV
3. Switch 1 receives TLV and puts PNP startup VLAN in FWD mode (all other VLANs blocked)
4. Switch 2 does DHCP/PnP via startup VLAN
5. Switch 2 gets REP config via PnP – REP now forwarding as normal

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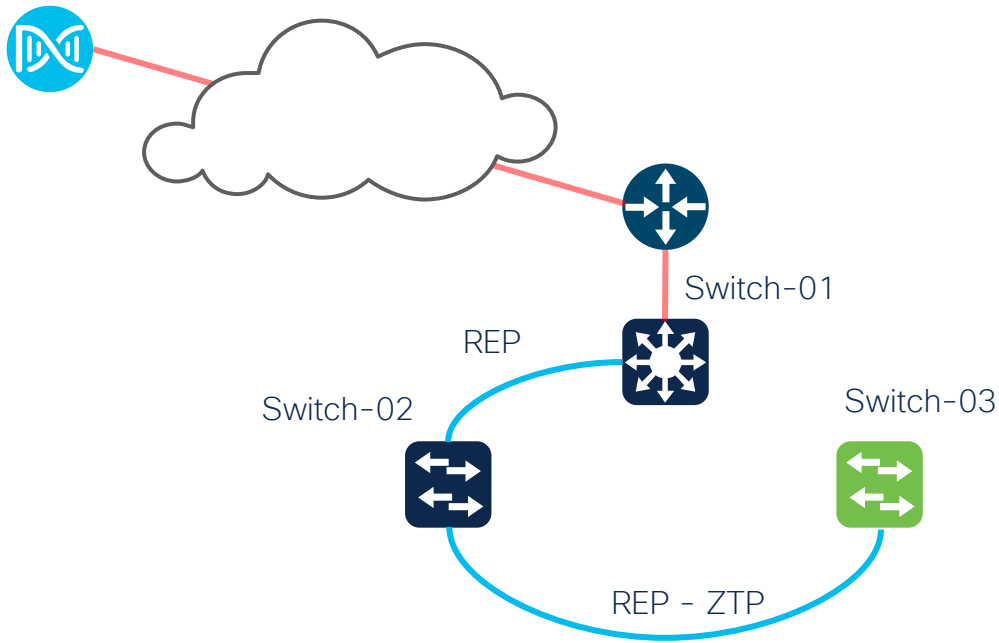
Sidebar: REP ZTP



And for the next switch..
etc

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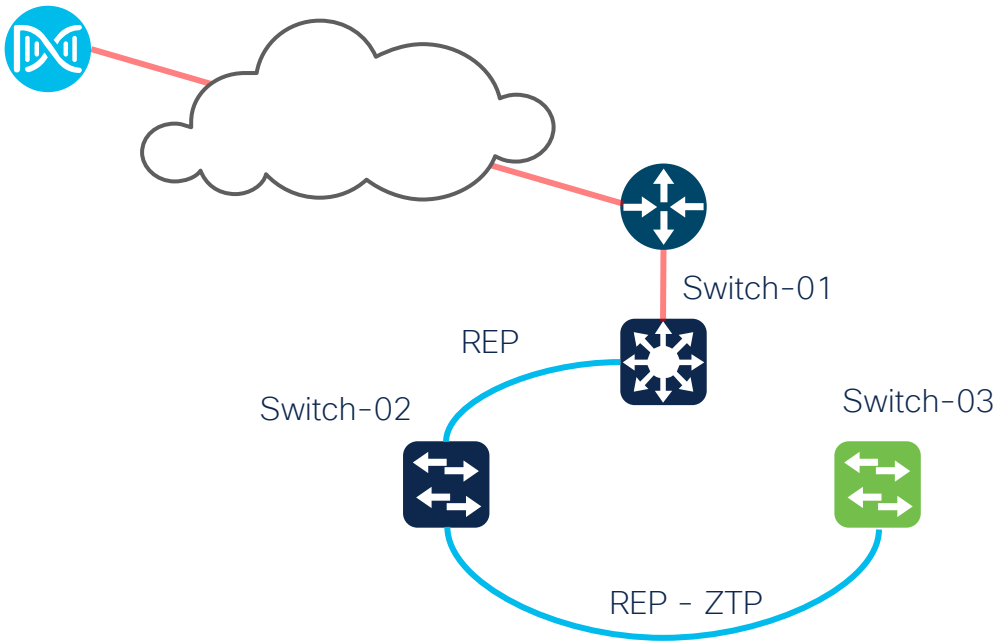
Sidebar: REP ZTP

Configuration:

```
Switch-01#
interface Gi1/1
     rep ztp-enable
```



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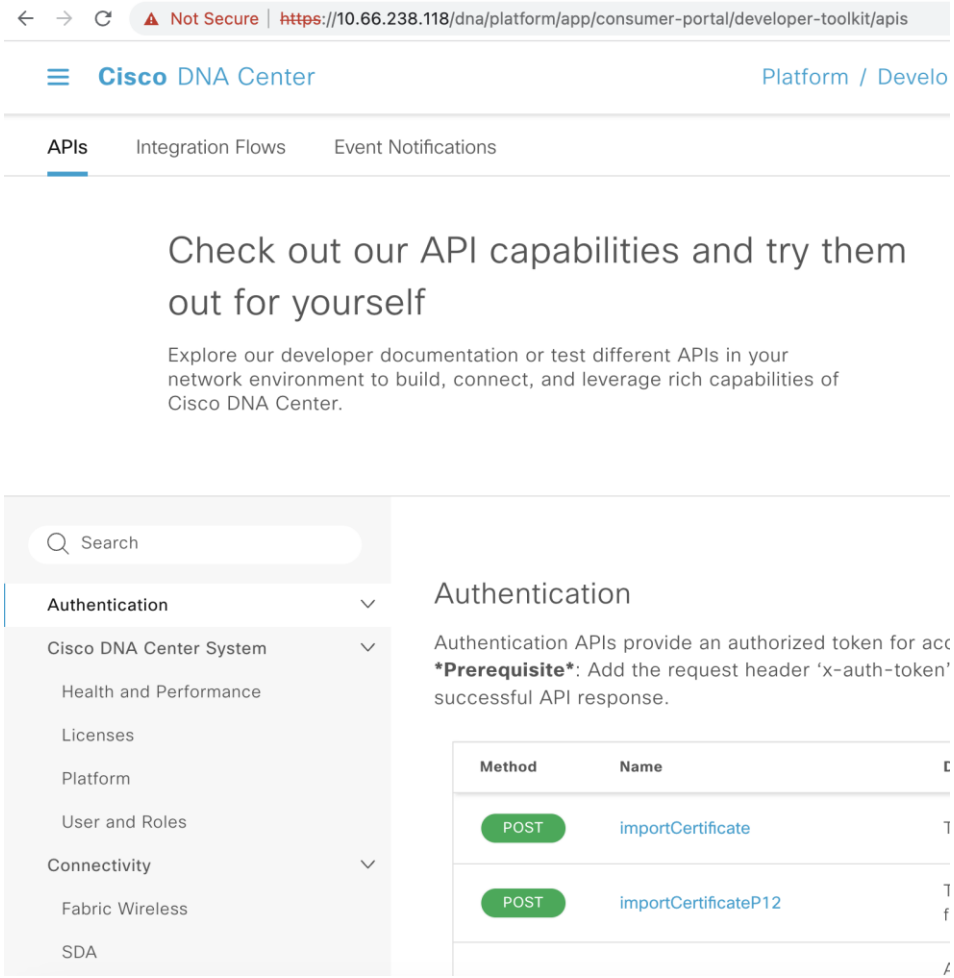
Exploring the APIs:

Platform -> Developer Toolkit



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Example: Driving Cisco DNA-Center PnP via APIs

Process:

1. Authenticate (get token via username/password)
2. Add device (by serial) – before it has connected via PnP
3. Wait for device to connect to DNA-C
4. Gather device information: DeviceID, TemplateID, SiteID, IOS-ID
5. Claim device to site

Demo via Postman

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Postman Collection

CLMEL2022-DEVNET-1243

- POST 1.0 Get Token
- POST 2.0 Add Device with Serial
- GET 3.0 Get Device ID
- GET 3.1 Get IOS Image ID
- GET 3.2 Get Template ID
- GET 3.3 Get Site ID
- POST 4.0 Claim Device with Device ID

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Setup Postman Environment Variables

POST 4.0 Cl | POST 2.0 | GET telei | GET 3.0 (| CLMEL | GET 3.1 Get | GET 3.2 (| GET 3.3 Ge | CME | CMEL2022-DEVNET-1243

CMEL2022-DEVNET-1243

Fork 0 | Save | Share

	VARIABLE	TYPE	INITIAL VALUE	CURRENT VALUE
☑	device_id	default		636eead32c9582000bf5d723
☑	serial	default	FOC2351V0XH	FOC2351V0XH
☑	dnac	default	10.66.238.118	10.66.238.118
☑	token	default		eyJhbGciOiJSUzI1NiIsInR5cCI6IkpXVCJ9.eyJzdWIi...
☑	device_serial	default	FOC2351V0XH	FOC2351V0XH
☑	pid	default	IE-3400-8T2S	IE-3400-8T2S
☑	image_id	default		c0760a8c-c0fd-474a-a642-e493b7dc2a34
☑	template_id	default		7343d271-3153-4667-a02c-4862641272a8
☑	site_id	default		468f08fe-c274-41c7-a651-30492440ff66
☑	port	default	443	443
☑	password	default	Cisco12345	Cisco12345
	Add a new variable			

Persist All | Reset All

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Day 0: PnP – via API

1.1. Get Token

POST https://{{dnac}}:{{port}}/api/system/v1/auth/token Send

Params | Authorization ● | Headers (12) | Body | Pre-request Script | Tests ● | Settings | Cookies

Type: Basic Auth

The authorization header will be automatically generated when you send the request. Learn more about authorization ↗

Username: {{username}}

Password: {{password}}

☑ Show Password

1.2. Save Token

POST https://{{dnac}}:{{port}}/api/system/v1/auth/token

Params | Authorization ● | Headers (12) | Body | Pre-request Script | Tests ● | Settings

```
var data = JSON.parse(responseBody);
postman.setEnvironmentVariable("token", data.Token);
```


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Day 0: PnP – via API

2. Add Device

POST https://{{dnac}}:{{port}}/dna/intent/api/v1/onboarding/pnp-device Send

Params Authorization Headers (12) Body Pre-request Script Tests Settings Cookies

none form-data x-www-form-urlencoded raw binary GraphQL JSON Beautify

```
1 {
2     "deviceInfo": {
3         "hostname": "FJORM-IE3400-01",
4         "serialNumber": "{{device_serial}}"
5         }
6     }
```

Devices (3) Focus: Default Auto-refresh: 30 s

Search Table

0 Selected Actions Add Devices As of: Nov 12, 2022 6:57 PM Refresh

#	Device Name	Serial Number	Product ID	IP Address	Source	State	Onboarding Progress	Site	Las
1	TKO-QUASAR-FAIB-C9300-01	FCW2228G0UL	C9300-24T	10.66.235.197	Network	Unclaimed	40%	NA	No
2	FJORM-IE3400-01	FOC2351V0XH	Unavailable	Unavailabl	User	Unclaimed	0%	NA	No

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Day 0: PnP – via API

3. Wait for device to connect

Device Status: Unclaimed (3) | Error (0) | Provisioned (12) | All (15)

Devices (3) Focus: Default

Auto-refresh: • 30 s

Search Table

0 Selected Actions Add Devices

As of: Nov 12, 2022 6:59 PM Refresh

#	Device Name	Serial Number	Product ID	IP Address	Source	State	Onboarding Progress	Site
1	TKO-QUASAR-FAIB-C9300-01	FCW2228G0UL	C9300-24T	10.66.235.197	Network	Unclaimed	40%	NA
2	FJORM-IE3400-01	FOC2351V0XH	IE-3400-8T2S	10.66.235.166	User	Unclaimed	40%	NA

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Day 0: PnP – via API

4. Gather device details:

GET https://{{dnac}}:{{port}}/dna/intent/api/v1/onboarding/pnp-device?serialNumber={{device_serial}}

Params • Authorization Headers (10) Body Pre-request Script Tests • Settings

any

```
var data = JSON.parse(responseBody);
postman.setEnvironmentVariable("device_id", data[0].id);
postman.setEnvironmentVariable("pid", data[0].deviceInfo.pid)
```

GET https://{{dnac}}:{{port}}/dna/intent/api/v1/image/importation?family=ie3x00&version=17.09.02

Params • Authorization Headers (10) Body Pre-request Script Tests • Settings

```
var data = JSON.parse(responseBody);
postman.setEnvironmentVariable("image_id", data.response[0].imageUuid);
```


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Day 0: PnP – via API

4. Continue gathering device details:

GET https://{{dnac}}:{{port}}/dna/intent/api/v2/template-programmer/template?name=IE-Automation-PnP-IE3400-Stubs-Jinja_7101221235110

Params • Authorization Headers (10) Body Pre-request Script Tests • Settings

```
var data = JSON.parse(responseBody);
postman.setEnvironmentVariable("template_id", data.response[0].id);
```

GET https://{{dnac}}:{{port}}/dna/intent/api/v1/site?name=global/Niflheim/Hvergelmir/River+Level

Params • Authorization Headers (10) Body Pre-request Script Tests • Settings

```
var data = JSON.parse(responseBody);
postman.setEnvironmentVariable("site_id", data.response[0].id);
```


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Day 0: PnP – via API

5. Claim device:

POST https://{{dnac}}:{{port}}/dna/intent/api/v1/onboarding/pnp-device/site-claim?= Send

Params • Authorization Headers (11) Body • Pre-request Script Tests • Settings Cookies

none form-data x-www-form-urlencoded raw binary GraphQL JSON Beautify

```
1  {
2      "deviceId": "{{device_id}}",
3      "siteId": "{{site_id}}",
4      "type": "Default",
5      "imageInfo": {
6          "imageId": "{{image_id}}",
7          "skip": false
8      },
9      "configInfo": {
10         "configId": "{{template_id}}",
11         "configParameters":[
12
13             {
14             "key":"mgmt_ipaddress_input",
15             "value": "10.1.2.1 255.255.255.0"
16             }
17         ]
18     }
19 }
```


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Day 0: PnP – via API

5. Claim device:

Devices (3) Focus: Default

Auto-refresh: · 30 s

Search Table

0 Selected Actions Add Devices

As of: Nov 12, 2022 7:04 PM Refresh

#	Device Name	Serial Number	Product ID	IP Address	Source	State	Onboarding Progress	Site
1	TKO-QUASAR-FAIB-C9300-01	FCW2228G0UL	C9300-24T	10.66.235.197	Network	Unclaimed	40%	NA
2	FJORM-IE3400-01	FOC2351V0XH	IE-3400-8T2S	10.66.235.166	User	Planned	40%	Global/Ni

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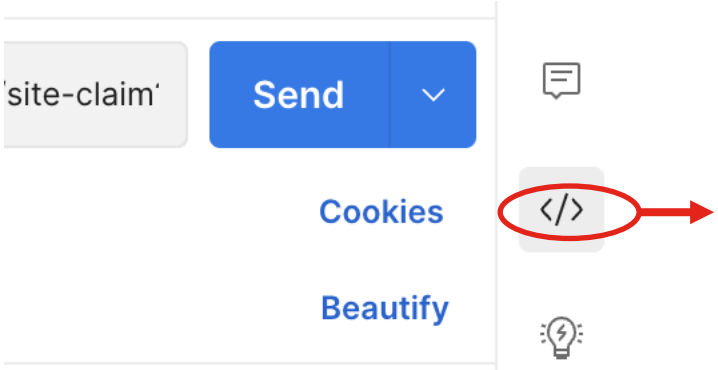
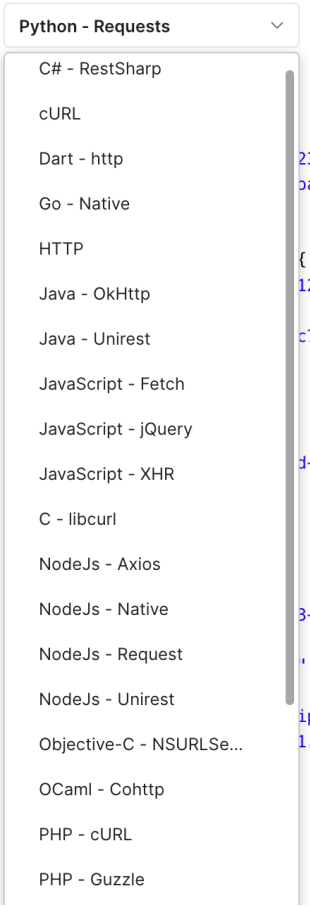
That was still via a GUI…?





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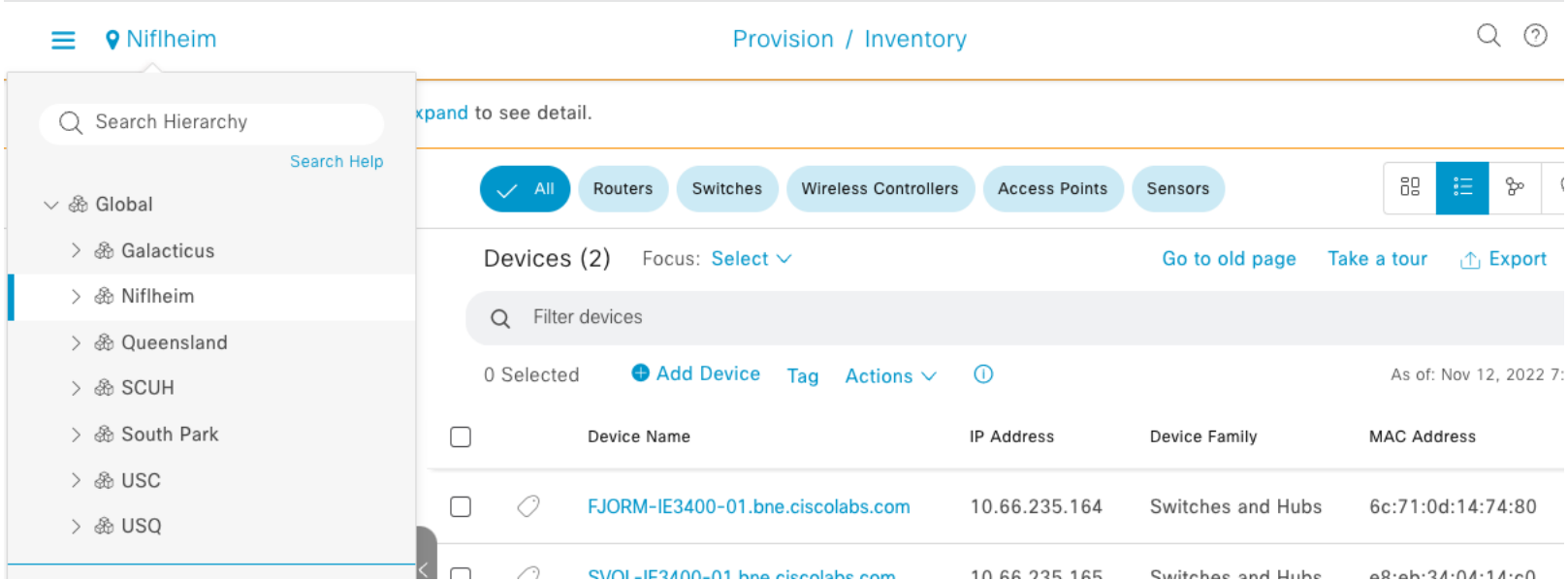
How did that REP ZTP go?



It worked didn't it? ☺

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How did that REP ZTP go?

Upstream debugs:

```
SVOL-IE3400-01#debug rep lslsm
REP debug lsl sm debugging is on
003051: Nov 12 19:34:10.429:     rep_lsl_rx Gi1/1: during state INIT_DOWN, got event 1(phy_link_down)
003052: Nov 12 19:34:10.429: @@@ rep_lsl_rx Gi1/1: INIT_DOWN -> INIT_DOWN
003053: Nov 12 19:34:10.430:     rep_lsl_tx Gi1/1: during state DOWN, got event 1(phy_link_down)
003054: Nov 12 19:34:10.430: @@@ rep_lsl_tx Gi1/1: DOWN -> DOWN
003055: Nov 12 2022 19:34:12.453: %LINK-3-UPDOWN: Interface GigabitEthernet1/1, changed state to up
003056: Nov 12 19:34:13.433:     rep_lsl_rx Gi1/1: during state INIT_DOWN, got event 0(phy_link_up)
003057: Nov 12 19:34:13.433: @@@ rep_lsl_rx Gi1/1: INIT_DOWN -> WAIT
003058: Nov 12 19:34:13.433:     rep_lsl_tx Gi1/1: during state DOWN, got event 0(phy_link_up)
003059: Nov 12 19:34:13.433: @@@ rep_lsl_tx Gi1/1: DOWN -> IDLE
003060: Nov 12 2022 19:34:14.436: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet1/1, changed state to up
003062: Nov 12 19:34:23.431:     rep_lsl_rx Gi1/1: during state WAIT, got event 6(age_timeout)
003063: Nov 12 19:34:23.431: @@@ rep_lsl_rx Gi1/1: WAIT -> NO_NEIGHBOR
003074: Nov 12 19:34:26.872:     rep_lsl_rx Gi1/1: during state NO_NEIGHBOR, got event 13(rep_ztp_enable)
003075: Nov 12 19:34:26.872: @@@ rep_lsl_rx Gi1/1: NO_NEIGHBOR -> NO_NEIGHBOR
003076: Nov 12 2022 19:34:26.873: %REP-6-ZTPPORTFWD: Interface GigabitEthernet1/1 moved to forwarding on ZTP notification
003077: Nov 12 2022 19:34:27.431: %LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan10, changed state to up
```


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Sidebar: TrustSEC / SGTs / SGACLs speedrun

- What are SGTs
  - Tags assigned to traffic at the ingress port – identify the source of the traffic without relying on IP and DNS
  - How? dot1x, manually …
- How are they carried
  - Carried in the packet header at layer 2
- What are SGACLs
  - Like ACLs – but based on source and destination IP

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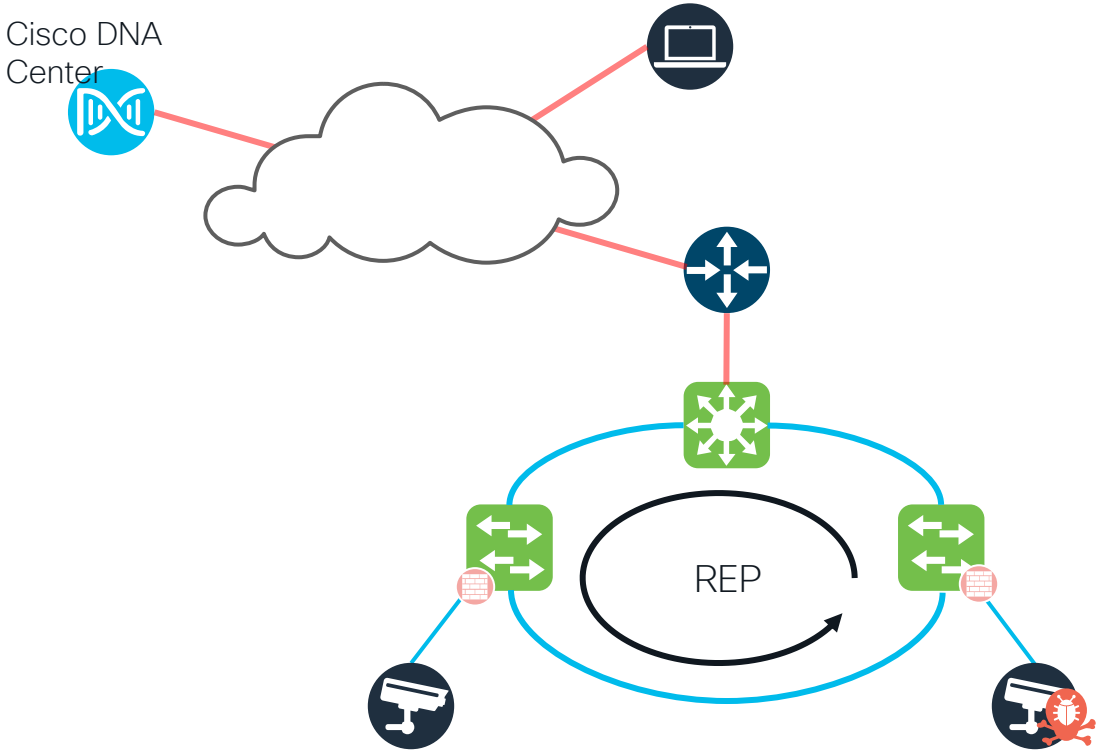
Sidebar: Microsegmentation



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DayN Templates

1. Create template
2. Add template to Network Profile
3. Provision device

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DayN Templates

Interface Template Update:

```
template IP_CAMERA_INTERFACE_TEMPLATE
 spanning-tree portfast
 spanning-tree bpduguard enable
 switchport access vlan 40
 switchport mode access
 switchport block unicast
 switchport port-security
```

Update Access Interfaces:

```
{% for interface in interfaces %}

  interface {{ interface }}
    no switchport access vlan
    no shutdown
    source template IP_CAMERA_INTERFACE_TEMPLATE
    description CCTV ACCESS PORT

{% endfor %}
```

Interface Template Update with TrustSec:

Template

```
template IP_CAMERA_INTERFACE_TEMPLATE
 spanning-tree portfast
 spanning-tree bpduguard enable
 switchport access vlan 40
 switchport mode access
 switchport block unicast
 switchport port-security
 device-tracking attach-policy IPDT_POLICY
 cts manual
  policy static sgt 40
  no propagate sgt
```


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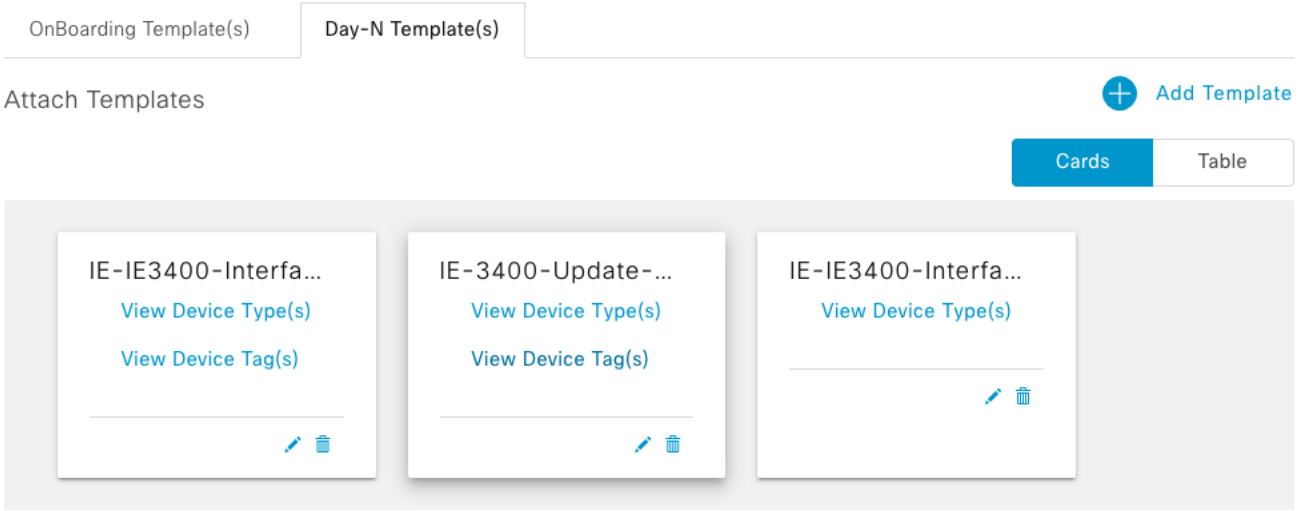
Day N: Templates



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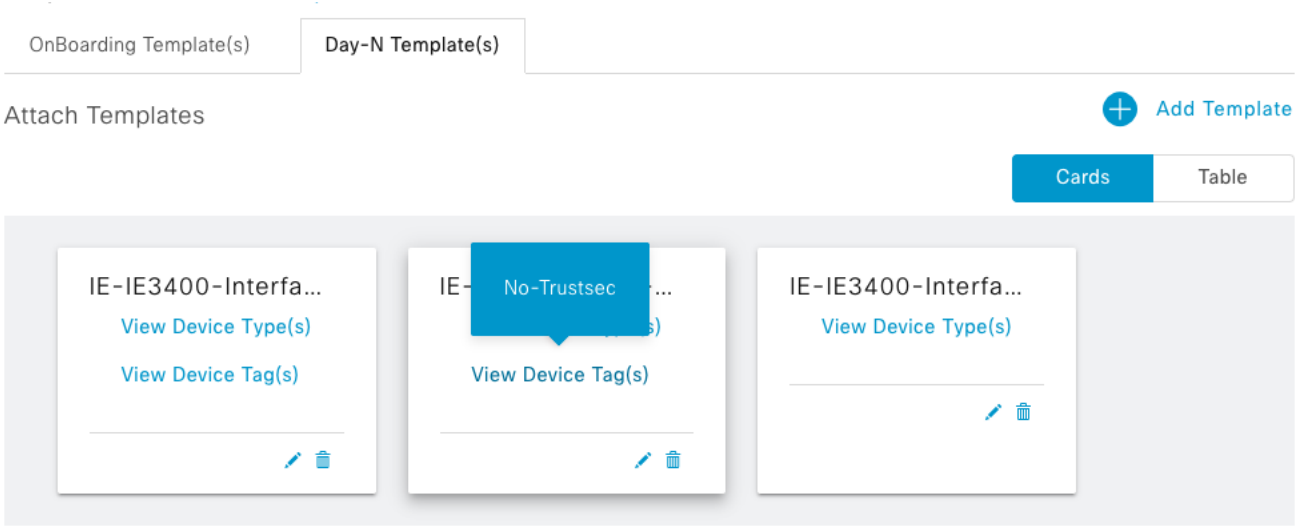
Day N: Templates



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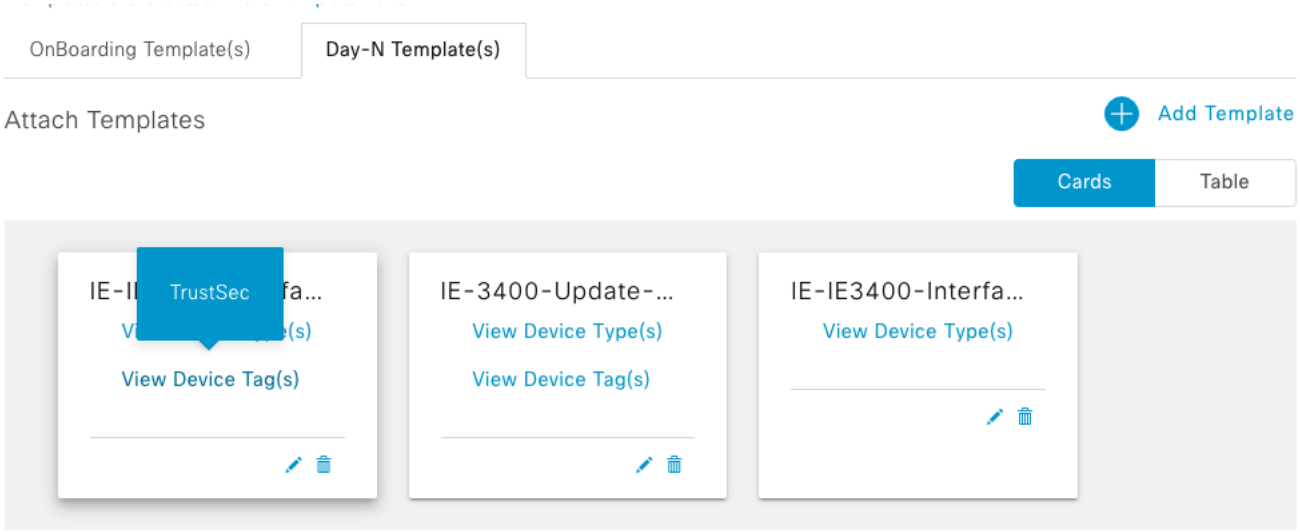
Day N: Templates



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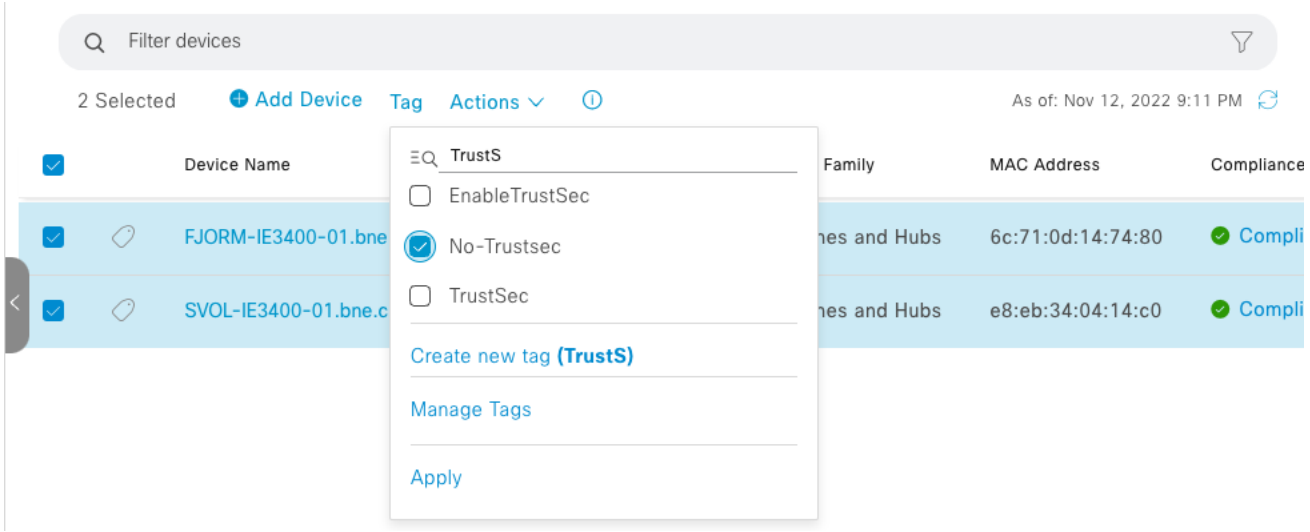
Day N: Templates

Tag devices:



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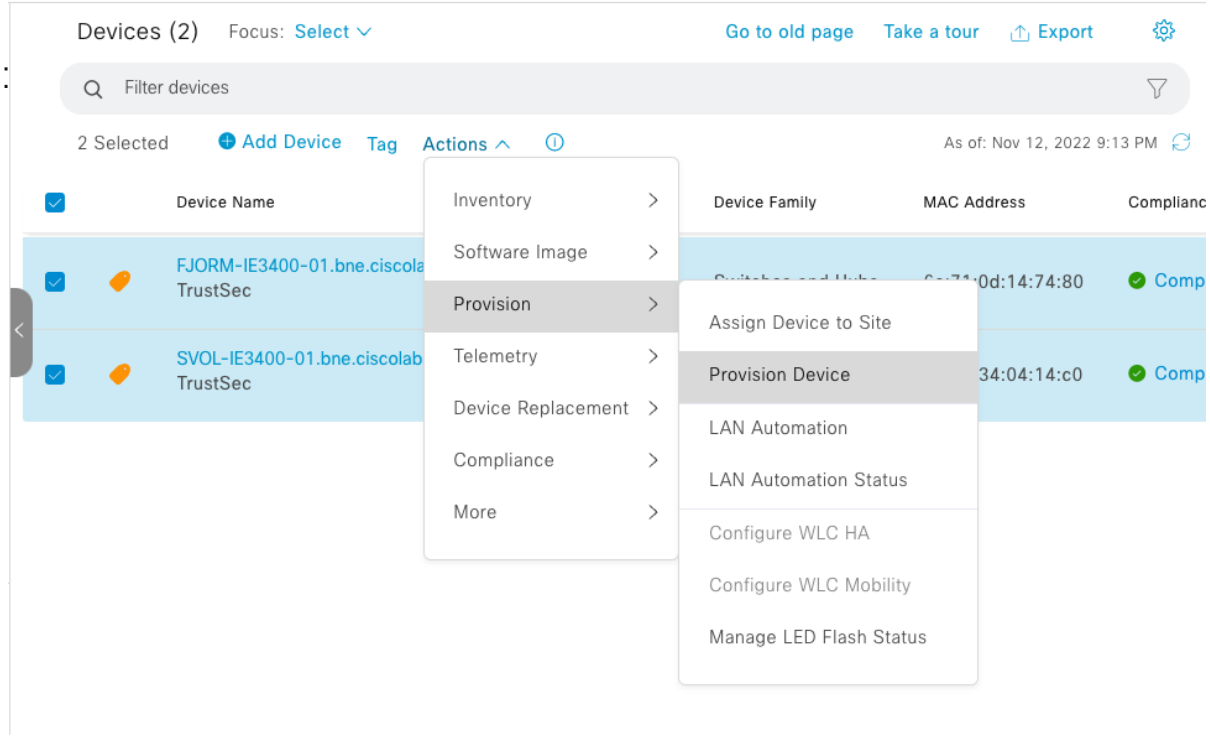
Day N: Templates

Provision Devices:



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Day N: Templates

Confirm config:

```
SVOL-IE3400-01#show run | s template
template IP_CAMERA_INTERFACE_TEMPLATE
spanning-tree portfast
 spanning-tree bpduguard enable
 switchport access vlan 40
 switchport mode access
 switchport block unicast
 switchport port-security

SVOL-IE3400-01#show run int gi1/3
interface GigabitEthernet1/3
 description CCTV ACCESS PORT
 switchport mode access
 source template IP_CAMERA_INTERFACE_TEMPLATE
 spanning-tree portfast
```


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Day N: Templates

Update template

1. Re-tag device
2. Re-provision device with new template

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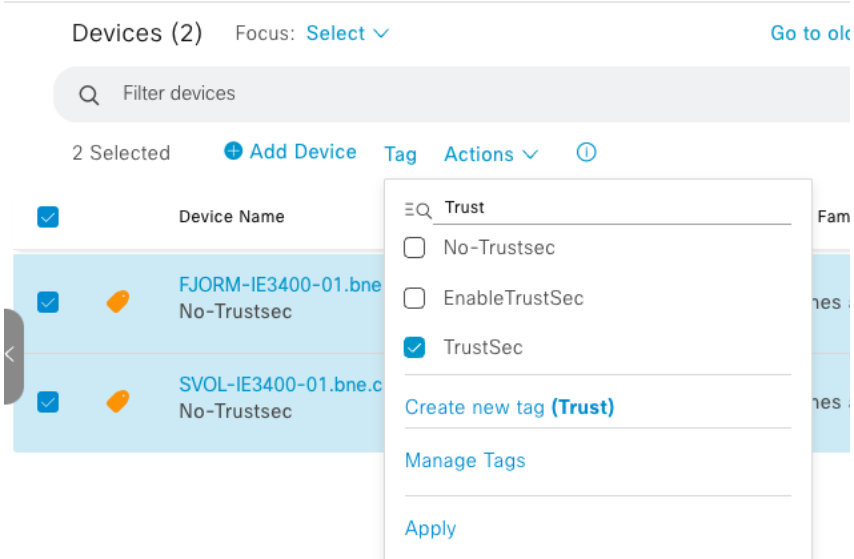
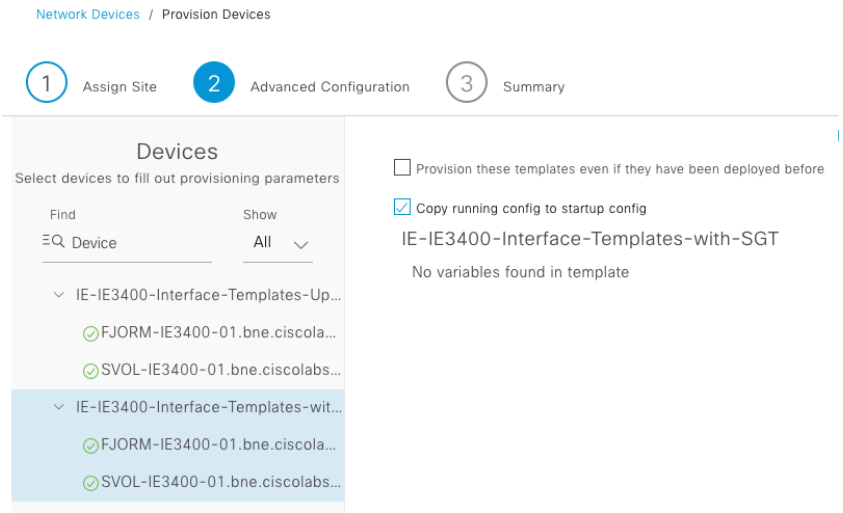
Day N: Templates

Update tag:



Provision Devices



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Check config:

```
SVOL-IE3400-01#show run | s role
ip access-list role-based allow-all
 10 permit ip
ip access-list role-based allow-ping-only
 10 permit icmp
 20 deny ip
ip access-list role-based allow-ssh-only
 10 permit tcp dst eq 22
 20 deny ip
ip access-list role-based deny-all
 10 deny ip
cts role-based enforcement
SVOL-IE3400-01#show run | s template
template IP_CAMERA_INTERFACE_TEMPLATE
 cts manual
  policy static sgt 40
  no propagate sgt
 spanning-tree portfast
 spanning-tree bpduguard enable
 switchport access vlan 40
 switchport mode access
 switchport block unicast
 switchport port-security
 device-tracking attach-policy IPDT_POLICY
```


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Check config:

```
SVOL-IE3400-01#show cts interface
Global Dot1x feature is Disabled
Interface GigabitEthernet1/3:
    CTS is enabled, mode:    MANUAL
    IFC state:               OPEN
    Interface Active for 10:04:02.876
    Authentication Status:   NOT APPLICABLE
        Peer identity:       "unknown"
        Peer's advertised capabilities: ""
    Authorization Status:    SUCCEEDED
        Peer SGT:            40
        Peer SGT assignment: Untrusted
    SAP Status:              NOT APPLICABLE
    Propagate SGT:           Disabled
    Cache Info:
        Expiration            : N/A
        Cache applied to link : NONE
[config snipped]..
```


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Direct Device Programmability

Netconf:

Network Configuration Protocol (NETCONF)

Operates on SSH, port 830 by default

Has a series of base commands:

- get, get-config, edit-config, copy-config etc

RFC: https://www.rfc-editor.org/rfc/rfc6241

Yang:

Data modelling language

RFC: https://www.rfc-editor.org/rfc/rfc7950

Netconf/yang:

More reading: https://community.cisco.com/t5/networking-blogs/getting-started-with-netconf-yang-part-1/ba-p/3661241

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Device Programmability

Turning it on:

```
SVOL-IE3400-01(config)#netconf-yang
```

That's it

```
SVOL-IE3400-01#show netconf-yang status
netconf-yang: enabled
netconf-yang candidate-datastore: disabled
netconf-yang side-effect-sync: enabled
netconf-yang ssh port: 830
netconf-yang turbocli: disabled
```


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Device Programmability

Python module: ncclient

Repo: https://github.com/ncclient/ncclient

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Device Programmability – getting example yang xml

```
import sys
import logging
from ncclient import manager

def iosxe_connect(host, port, user, password):
        return manager.connect(host=host,
                port=port,
                username=user,
                password=password,
                device_params={'name': "iosxe"},
                timeout=30,
                hostkey_verify=False
)

def export_config(host, user, password):
        with iosxe_connect(host, port=830, user=user, password=password) as m:
                config = m.get_config(source='running')
        with open("output.xml", "w") as f:
                f.write(config.xml)

if __name__ == '__main__':
        export_config(sys.argv[1], sys.argv[2], sys.argv[3])
```


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Device Programmability – getting example yang xml

python3 main.py 10.66.235.165 cisco cisco12345 get_config


```
▼<rpc-reply xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="urn:uuid:9ca9a8a7-1df8-4181-9dda-e02c6f4239d8">
  ▼<data>
    ▼<native xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-native">
      <version>17.9</version>
      ▼<memory>
        ▼<free>
          ▼<low-watermark>
            <processor>63466</processor>
          </low-watermark>
        </free>
      </memory>
      ▼<call-home>
        <contact-email-addr xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-call-home">sch-smart-licensing@cisco.com</contact-email-addr>
        ▼<tac-profile xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-call-home">
          ▼<profile>
            ▼<CiscoTAC-1>
              <active>true</active>
              ▼<destination>
                <transport-method>http</transport-method>
              </destination>
            </CiscoTAC-1>
          </profile>
        </tac-profile>
      </call-home>
      ▼<service>
        <password-encryption/>
        ▼<timestamps>
          ▼<debug-config>
            ▼<datetime>
              <msec/>
              <localtime/>
            </datetime>
```


etc…

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Device Programmability – updating an SGACLs

```
import sys
import logging
from ncclient import manager

UPDATE_RBACL = """
<config xmlns:xc="urn:ietf:params:xml:ns:netconf:base:1.0" xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <native xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-native">
    <cts>
      <role-based xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-cts">
        <permissions>
          <from>
            <range>
              <range >{src_sgt}</range>
              <to>
                <range>
                  <range >{dst_sgt}</range>
                  <ACL-name-new >{acl_name}</ACL-name-new>
                  <ACL-name>{acl_name}</ACL-name>
                  <name>{acl_name}</name>
                </range>
              </to>
            </range>
          </from>
        </permissions>
      </role-based>
    </cts>
  </native>
</config>
"""
```


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Device Programmability – updating an SGACLs

```
import sys
import logging
from ncclient import manager

def update_rbacl(host, user, password, acl_name, src_sgt, dst_sgt):
        confstr = UPDATE_RBACL.format(acl_name = acl_name, src_sgt = src_sgt, dst_sgt = dst_sgt)
        with iosxe_connect(host, port=830, user=user, password=password) as m:
                m.edit_config(target='running', config=confstr)

if __name__ == '__main__':
        update_rbacl(sys.argv[1], sys.argv[2], sys.argv[3], sys.argv[4], sys.argv[5], sys.argv[6])
```


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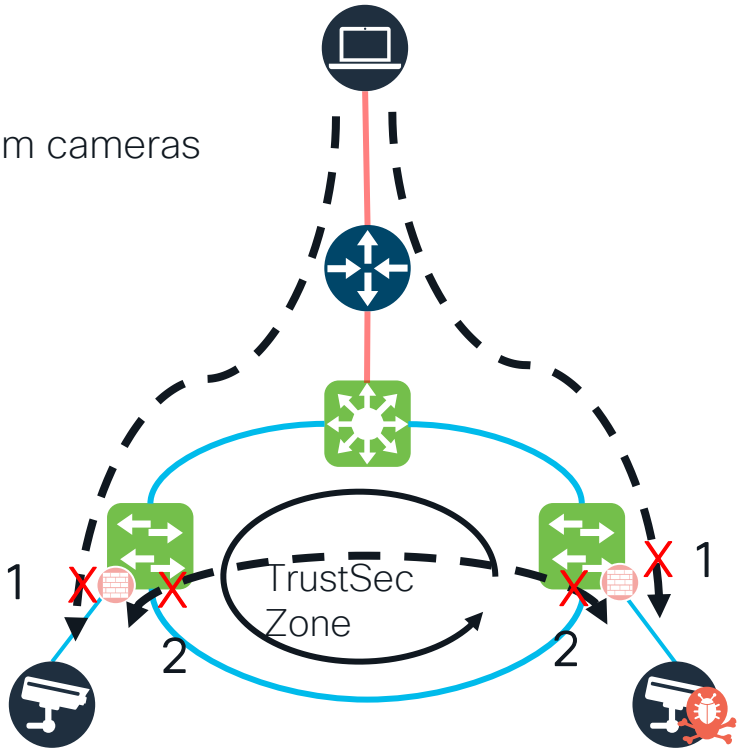
Device Programmability in action:

Using ncclient we will:

1. Block external access/unknown devices from cameras (Except SSH)
2. Block east/west traffic flows



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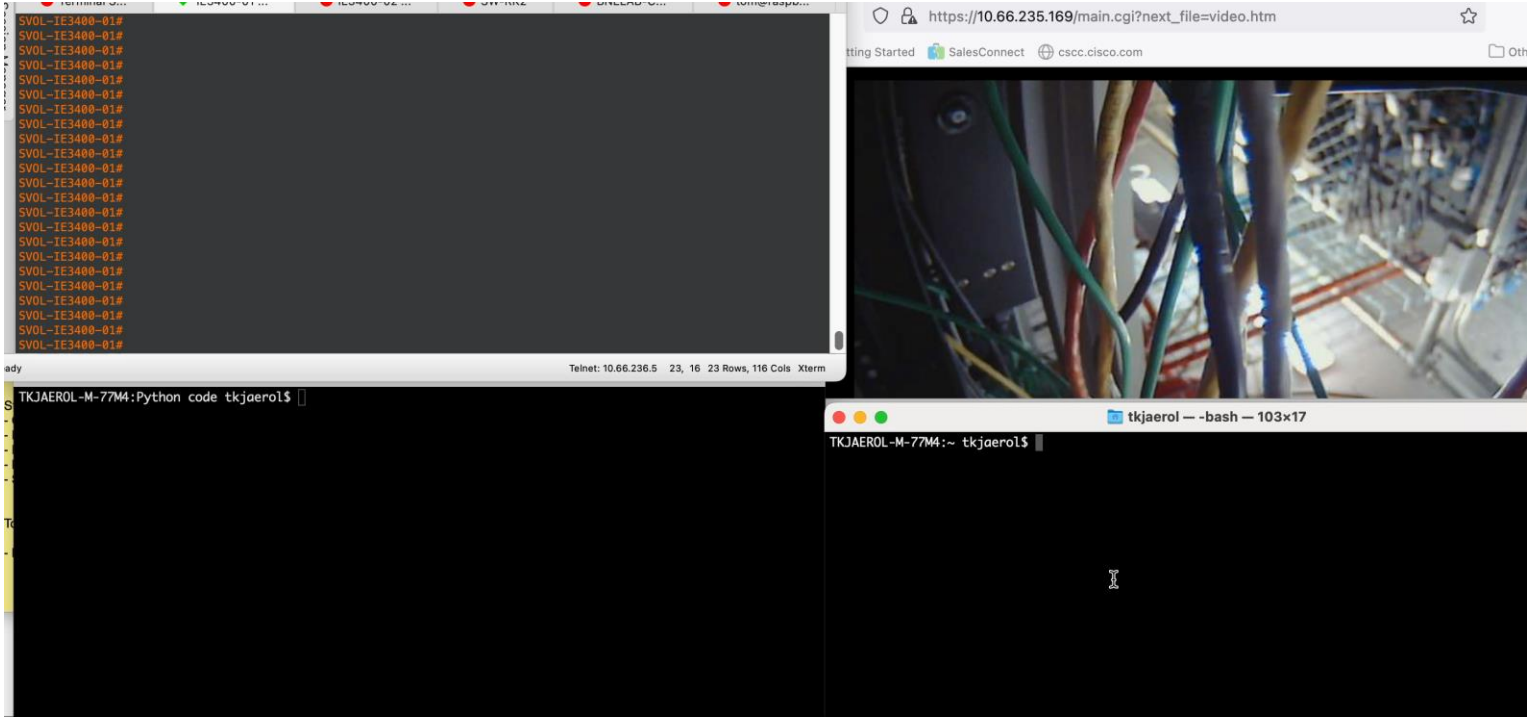
Device Programmability in action pt1:



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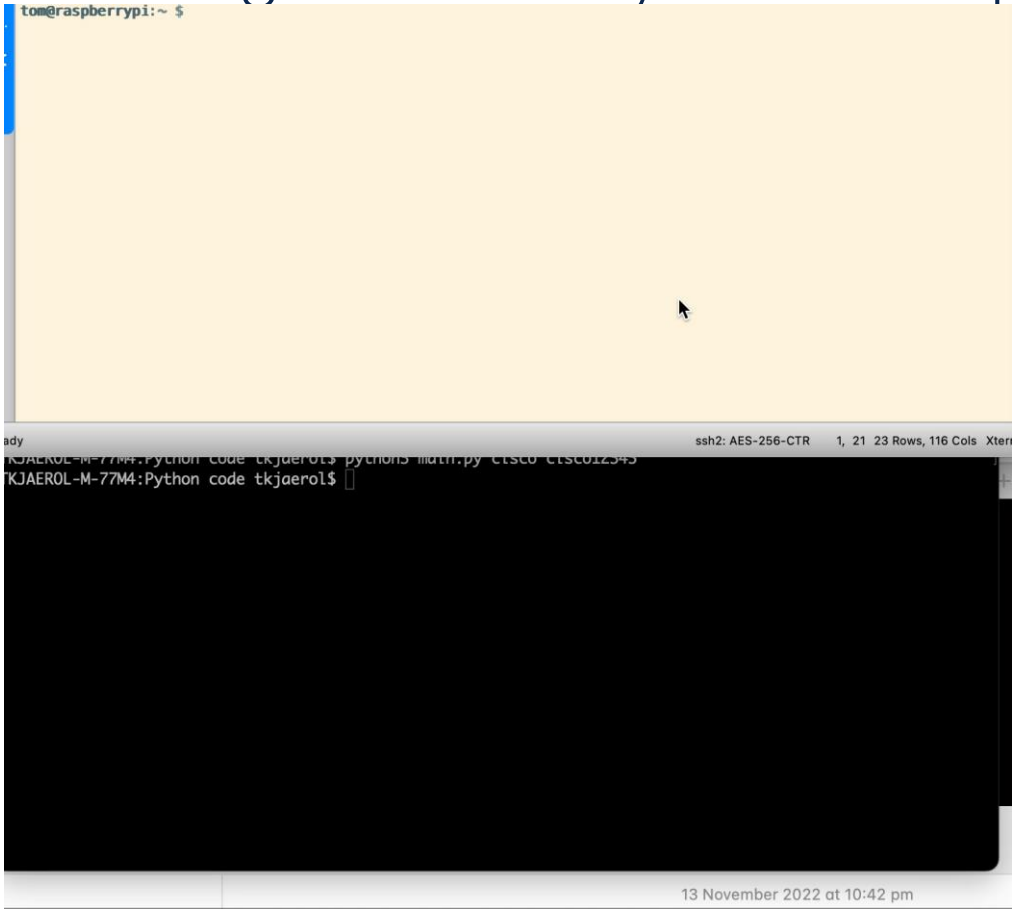
Device Programmability in action pt2:



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Speedrun Recap

- Setting up DNA-C for PnP
- Day0 PnP via DNAC
  - Drive via GUI or RESTAPI
  - Utilise REP ZTP
- DayN template
  - Using tags
- Direct device programmability
  - ncclient for netconf/yang
- Using TrustSec for microsegmentation at the edge

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Questions?

Demo code all here:

https://github.com/tkj-scythe/clmel-devnet1243

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