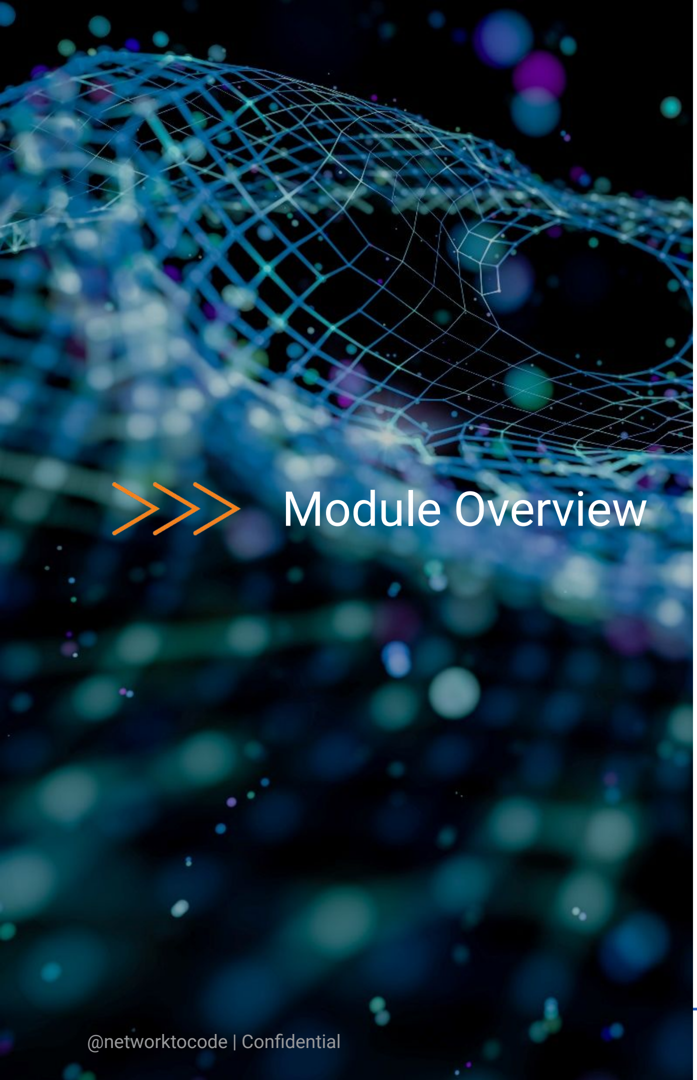
>>> network.toCode()

Network Automation with Python

Module 3: Working With Network Device APIs



Module Overview

- HTTP-Based APIs
- non-RESTful HTTP-Based APIs
  - Cisco Nexus NX-API
  - Arista eAPI
- RESTful HTTP-Based APIs
  - Cisco IOS-XE RESTCONF
  - Using Postman
- Consuming HTTP-Based APIs with Python requests

Module Table of Contents

Lecture 9: Network APIs

Topic 18 - Understanding APIs for Network Devices

Topic 19 - non-RESTful HTTP APIs

Lab 20

Topic 18: Understanding APIs for Network Devices

HTTP APIs

HTTP Request Types

HTTP Response Codes

Data Encoding Formats

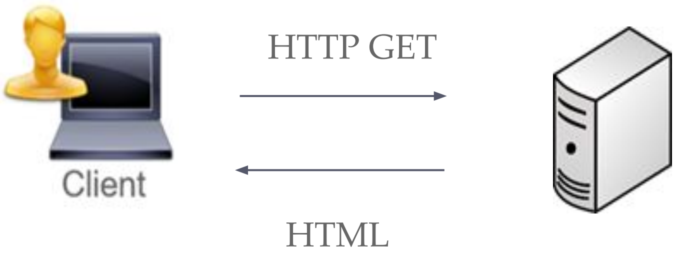
From CLI to API

The industry is transitioning to an API first model

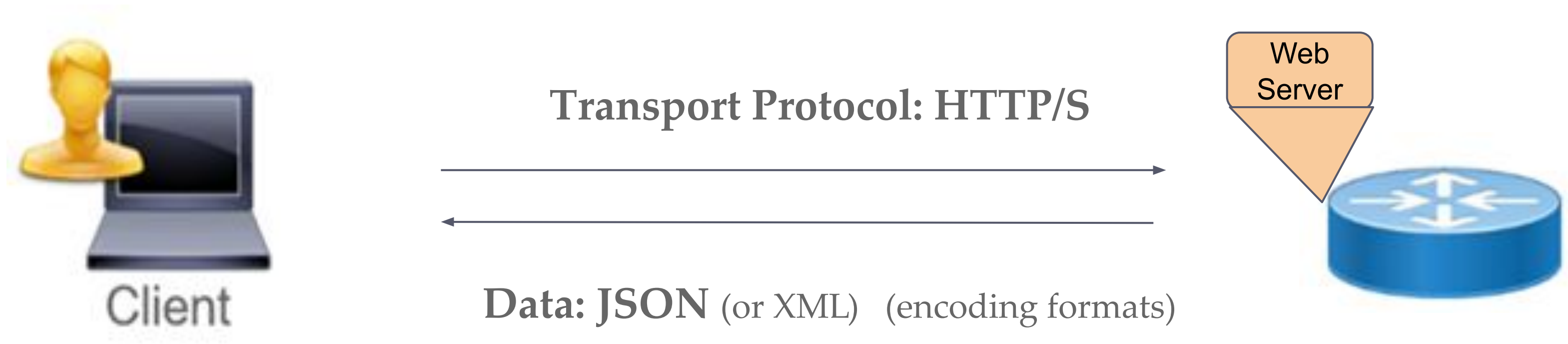
- CLI is for humans
- APIs are for machine to machine communication
- APIs do not replace CLI
- APIs can have a profound impact on operations
- APIs facilitate operational efficiency

APIs on Network Devices

- If you understand how to work with a web browser, you understand the concepts of APIs
- Same HTTP Request Methods and Response Codes are used



Examining an API



What is the client?

What does the data look like?

Examining an API

What is the client?

Python, Ansible, cURL, anything that speaks HTTP, e.g. Postman, cURL

What does the data look like?

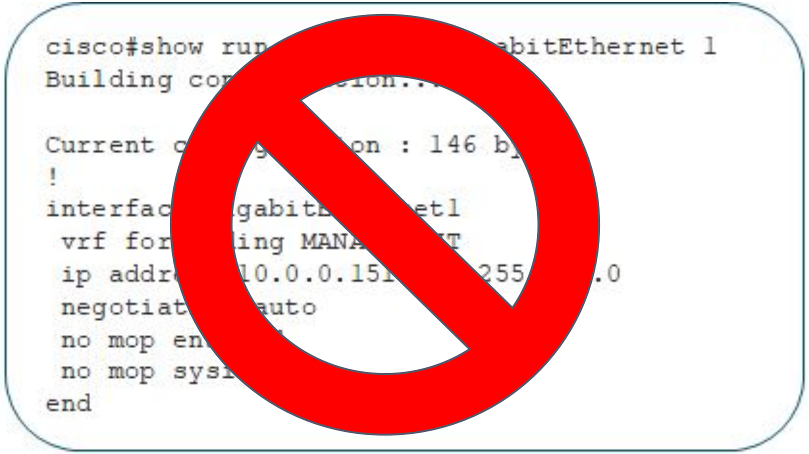
```
cisco#show run interface GigabitEthernet 1
Building configuration...

Current configuration : 146 bytes
!
interface GigabitEthernet1
 vrf forwarding MANAGEMENT
 ip address 10.0.0.151 255.255.255.0
 negotiation auto
 no mop enabled
 no mop sysid
end
```

This is formatted text, not structured data

>>> Examining Data

What does the data look like?



Although that can still be returned by APIs sometimes (and SSH)

<u>This is formatted text, not structured data</u>

Structured Data: JSON & XML

```json
{
  "Cisco-IOS-XE-native:GigabitEthernet": {
      "name": "1",
      "vrf": {
          "forwarding": "MANAGEMENT"
      },
      "ip": {
          "address": {
              "primary": {
                  "address": "10.0.0.151",
                  "mask": "255.255.255.0"
              }
          }
      },
      "mop": {
          "enabled": false,
          "sysid": false
      }
  }
}
```

JSON

```xml
<GigabitEthernet>
  <name>1</name>
  <vrf>
    <forwarding>MANAGEMENT</forwarding>
  </vrf>
  <ip>
    <address>
      <primary>
        <address>10.0.0.151</address>
        <mask>255.255.255.0</mask>
      </primary>
    </address>
</ip>
<mop>
  <enabled>false</enabled>
  <sysid>false</sysid>
</mop>
</GigabitEthernet>
```

XML

HTTP-Based APIs

There are two main types of HTTP-Based APIs:

- RESTful HTTP-Based APIs
- non-RESTful HTTP-Based APIs

In other words, those that adhere to the principles of REST and those that do not.

Both use HTTP(s) as transport.

Sample HTTP Requests

- Authentication Type
- HTTP Request Type
- URL
- Headers
  - Accept
  - Content-Type
- Data (Body)

Example 1:

```
Basic Auth: ntc/ntc123
Request: GET
Accept: application/json
URL: http://csr1/interfaces/Loopback/100/
```

Example 2:

```
Basic Auth: ntc/ntc123
Request: POST
Content-Type: application/json
URL: http://device/path/to/resource
Body: {"interface": "Eth1", "admin_state": "down"}
```

Take note of the body

HTTP Methods

What **operation** will be performed on a resource?

Method	Operation	Network Example
GET	Retrieve a resource	show interfaces
POST	Create a resource	create interface
PATCH	Update a resource	change interface IP address
PUT	Replace a resource	update full interface configuration
DELETE	Delete a resource	delete an interface

HTTP Response Codes

Response Code	Description
2xx (200-299)	Success
4xx (400-499)	Client Error
5xx (500-599)	Server Error

Note: the response code types for HTTP-based APIs are no different than standard response codes.

Data Encoding

Data is sent over the wire as XML or JSON

- JavaScript Object Notation (JSON).
- Open Standard for data communication.
- Uses **`name:value`** pairs.
- Maps directly to Python dictionaries.

Topic 19: non-RESTful HTTP APIs

What makes APIs non RESTful

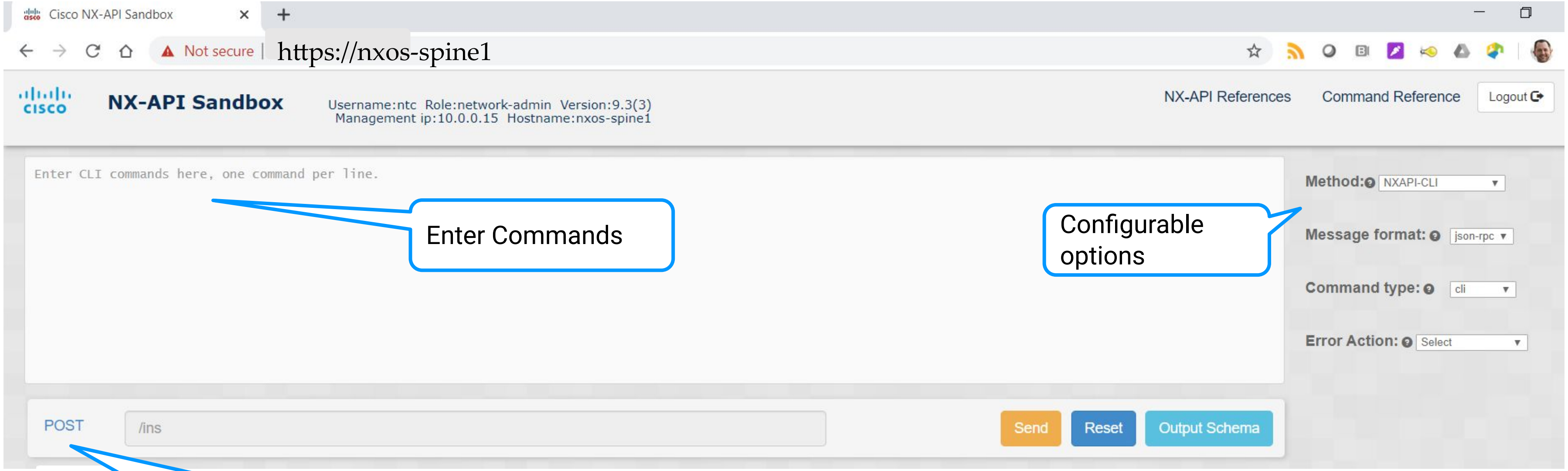
Enable NX-API and use the NX-API Sandbox

Enable Arista eAPI and use the eAPI explorer

>>> "Network" Clients

Protocol	Client
SSH	SecureCRT, Putty, Terminal
SCP	WinSCP, Cyberduck
RDP	Remote Desktop Connection
HTTP	Chrome, Firefox, IE (browsing)
HTTP	APIs: Postman, cURL, on-box clients, Python, Ansible

Cisco NX-OS NX-API Sandbox



Enter Commands

Configurable options

Note the Method and "endpoint" for all API calls

cURL

Linux command

Method

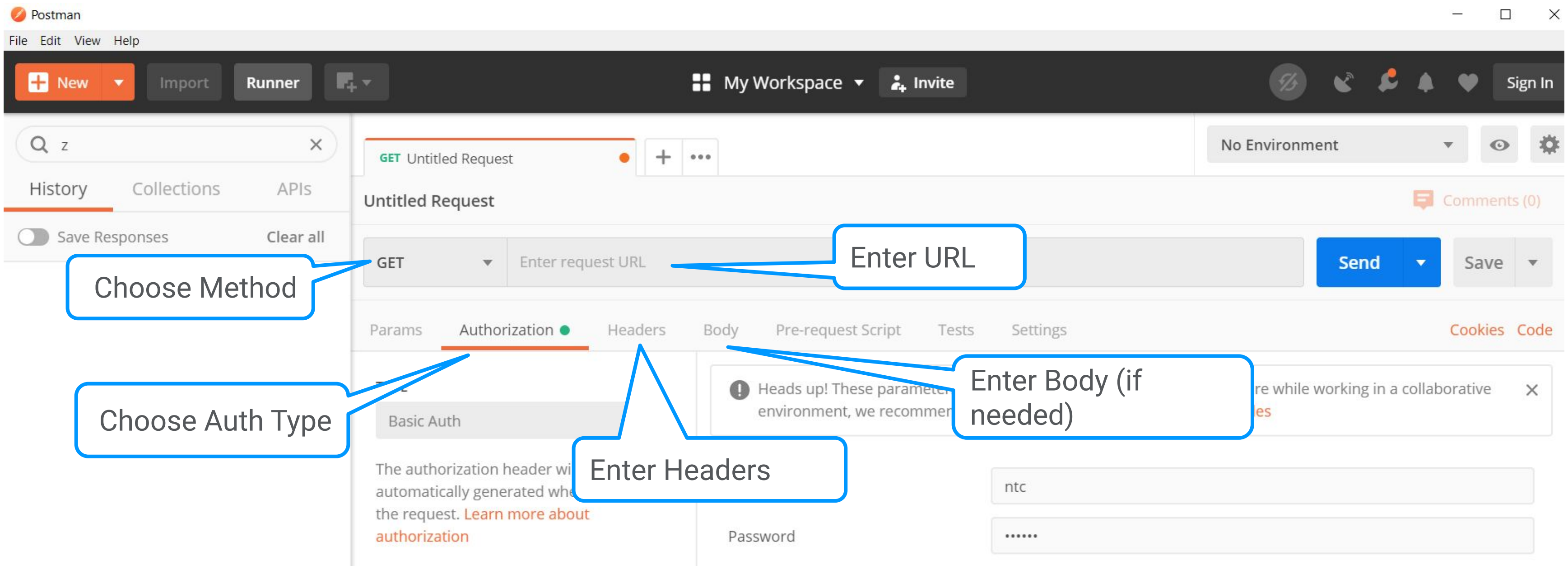
```
$ curl -X GET "https://netbox.demo.networktocode.com/api/dcim/sites/" \
-H "Authorization: Token 123456xyz0123" \
-H "Accept: application/json; indent=4"
```

Header(s)
Also uses --header

Use for line breaks and readability

>>> Postman

API Requests Development Environment



Getting Familiar with JSON Output

- Supported by many vendors who implement web based (REST) APIs
- Certain CLIs allow you to pipe commands to JSON

```
nxos-spine1# show hostname
nxos-spine1.ntc.com


nxos-spine1# show vlan brief
VLAN Name                             Status    Ports
---- -------------------------------- ---------
----------------
1    default                          active    Eth2/5,
Eth2/6
100  web_vlan                         active
```

```
nxos-spine1# show hostname | json
{
 "hostname": "nxos-spine1.ntc.com"
}
```

```
nxos-spine1# show vlan brief | json
{
 "TABLE_vlanbriefxbrief": {
   "ROW_vlanbriefxbrief": [
     {
       "vlanshowbr-vlanid": 16777216,
       "vlanshowbr-vlanid-utf": 1,
       "vlanshowbr-vlanname": "default",
       "vlanshowbr-vlanstate": "active",
     },
     {
       "vlanshowbr-vlanid": 1677721600,
       "vlanshowbr-vlanid-utf": 100,
       "vlanshowbr-vlanname": "web_vlan",
     }
   ]
output modified for brevity
```

Cisco NX-API Developer Sandbox

- On-box web utility that allows you to practice making API calls
- Visually see response objects before writing code
- Simply browse to the Nexus switch using a web browser

Cisco Nexus NX-API

Enable NX-API

```
feature nxapi
```

Configure ports as needed:

```
nxapi https port 8443
nxapi http port 8080
```

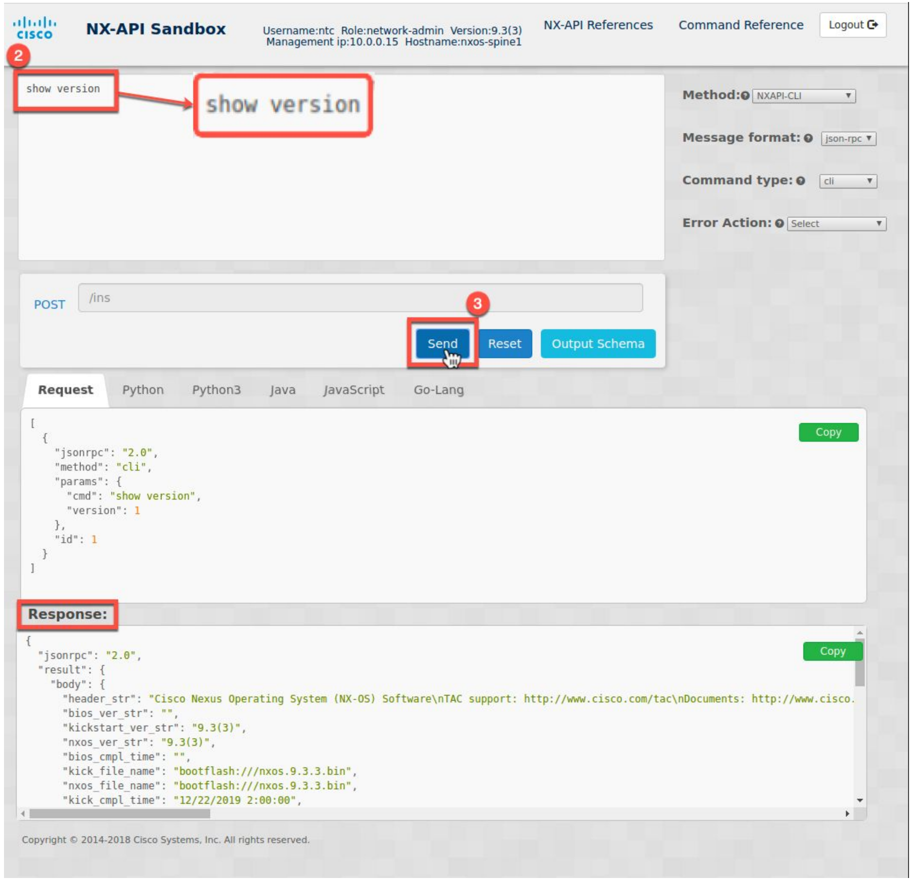
Certain platforms require a command to enable the sandbox:

```
nxapi sandbox
```

Certain platforms have VRF support:

```
n9k(config)# nxapi ?
      certificate Https certificate configuration
      http        Http configuration
      https       Https configuration
      user-vrf    Vrf to be used for nxapi communication
```

Cisco NX-API Developer Sandbox



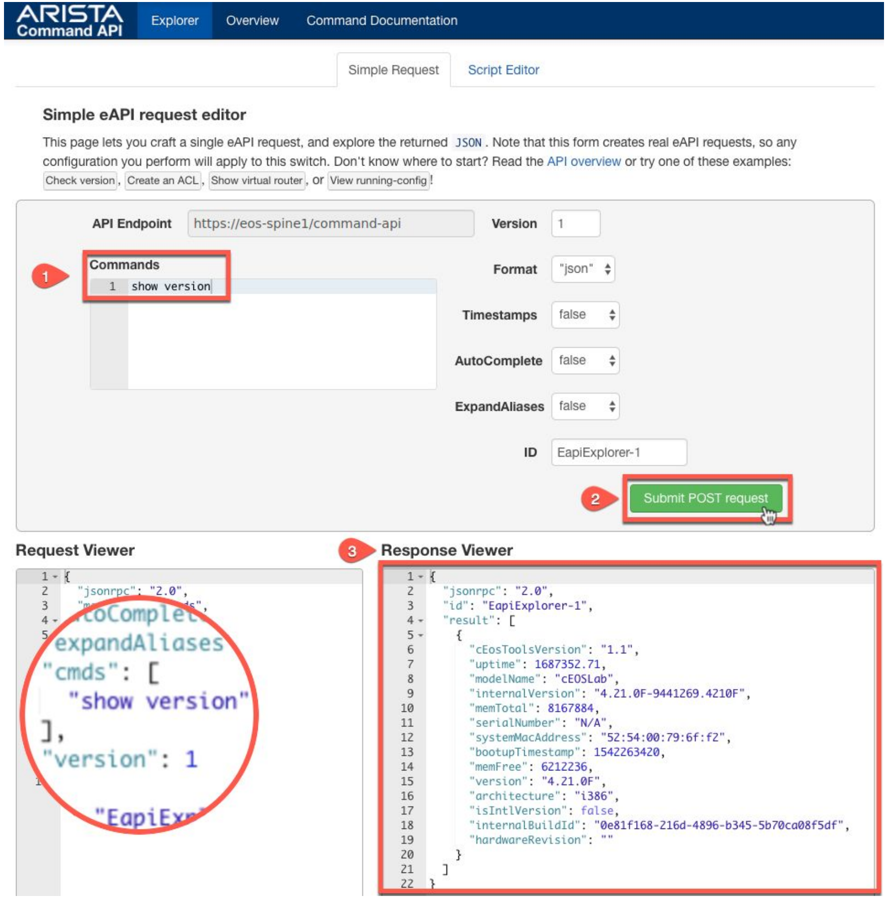
Arista eAPI Command Explorer

- On-box web utility that allows you to practice making API calls
- Visually see response objects before writing code
- Simply browse to the Arista switch using a web browser

- Enable eAPI

```
management api http-commands
   protocol http
   no shutdown
   vrf MANAGEMENT
      no shutdown
!
```

eAPI Command Explorer



Demo

- Cisco Nexus NX-API Sandbox
- Arista eAPI Command Explorer

Note: these are learning and development / testing tools.

Lecture 9: Network APIs

Lab 20

>>> Lab Time

- Lab 20 - Exploring eAPI and NXAPI
    - Lab 20.1 - Exploring the Arista eAPI
    - Lab 20.2 - Exploring the Cisco Nexus NX-API
- Please complete **both** of these labs.

Lecture 10: Exploring Postman

Topic 20 - non-RESTful API Calls with Postman

Topic 21 - RESTful HTTP APIs

Lab 21

Topic 20: non-RESTful API Calls with Postman

What is Postman

Using the Postman GUI

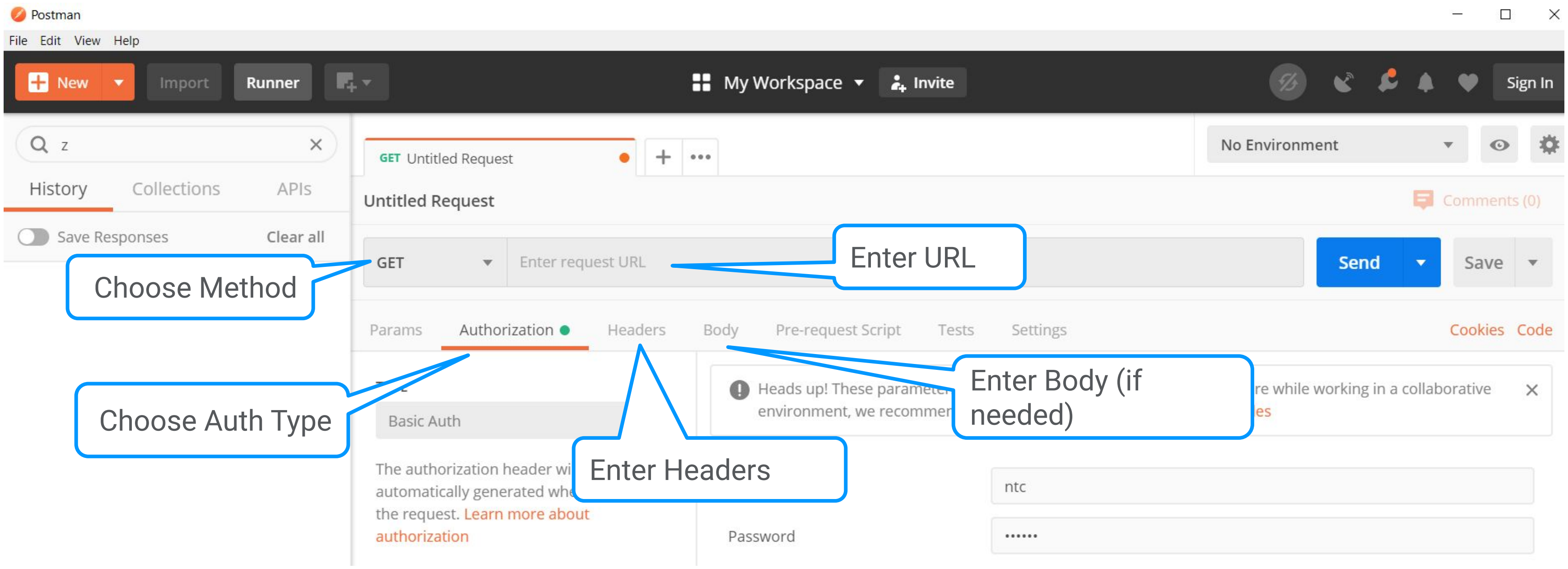
Postman

- User intuitive GUI application to interact with HTTP-based APIs.
- Used for testing, development, and learning.
- You can create a job collection to organize and share with others
- Get it for free - https://www.postman.com/downloads/

>>> Postman

API Requests Development Environment

POSTMAN



Demo

- Prototype API Requests from sandboxes into Postman
  - Cisco Nexus NX-API Sandbox
  - Arista eAPI Command Explorer

Topic 21: RESTful HTTP APIs

What is RESTCONF

Enable and Use the RESTCONF API on IOS-XE

RESTful APIs

- The structure of modern web-based REST APIs came from a PhD paper called Architectural Styles and the Design of Network-based Software Architectures by Roy Fielding in 2000.
- Goal is to define the detail of working with networked systems on the Internet that use the architecture defined as REST
- REST architecture includes six (6) constraints that must be adhered to. Three (3) of them that help understand REST for this course:
    - Client-Server
    - Stateless
    - Uniform interface

REST Architecture

- **Client-Server** - Having a client-server architecture allows for **portability and changeability of client applications** without the server components being changed. This could mean having different clients that consume the server resources (back-end API).
- **Stateless** - the communication between the client and server must be stateless. Clients that use stateless forms of communications **must send all data required for the server to understand and perform the requested operation in a single request.** This is in contrast to interfaces such as SSH where there is a persistent connection between a client and a server.
- **Uniform interface** - individual resources in scope within an API call are identified in HTTP request message. For example, in RESTful HTTP-based systems, **the URL used will reference a particular resource**. In the context of networking, the resource maps to a network device construct such as a hostname, interface, routing protocol configuration, or any other resource that exists on the device. The uniform interface also states that the client should have enough information about a resource to create, modify, or delete a resource.

What is REST?

- **RE**presentational **S**tate **T**ransfer
- Architectural style for information resources
- Perform operations on resources in a stateless manner
- Think:
  - **C**reating a new interface
  - **R**eading information about an interface
  - **U**pdating the description of an interface
  - **D**eleting an interface
- Interact with RESTful services via HTTP

They are HTTP APIs

- Are you using a POST to “retrieve data”?
- Is it always the same URL?
- Are show commands being sent via HTTP?
- Does it only use GET and POST?

If so, it’s more than likely not RESTful.

If different, hierarchical URLs are used to work with different resources and the API supports multiple methods, it’s probably RESTful.

What is RESTCONF?

- Functional sub-set of NETCONF
- Exposes YANG models via a REST API (URL)
- Uses HTTP(S) as transport
- Uses XML or JSON for encoding
- Uses standard HTTP verbs in REST APIs
- Content-Type & Accept Headers:
    - application/yang-data+json
    - application/yang-data+xml

RESTCONF on IOS-XE

Enabling RESTCONF

```
restconf
!
username <username> privilege 15 password
<password>
!
ip http server
ip http secure-server
!
```

RESTCONF Example 1

Retrieve a full running configuration modeled as JSON.

```
Method: GET
URL: 'http://csr1/restconf/data/Cisco-IOS-XE-native:native?content=config'
Accept-Type: application/yang-data+json
```


```
"interface": {
            "GigabitEthernet": [
                {
                    "name": "1",
                    "description": "MANAGEMENT_INTEFACE__DO_NOT_CHANGE",
                    "ip": {
                        "address": {
                            "dhcp": {}
                        }
                    },
                    "mop": {
                        "enabled": false,
                        "sysid": false
                    },
                    "Cisco-IOS-XE-cdp:cdp": {
                        "enable": true
                    },
                    "Cisco-IOS-XE-ethernet:negotiation": {
                        "auto": true
                    }
                },
                {
                    "name": "10",
                    "shutdown": [
                        null
                    ],
                    "ip": {
                        "no-address": {
                            "address": false,
                            #output removed for example
                        }
                    }
                }
            ]
        }
    }
```

RESTCONF Example 2

The depth-query parameter is used to limit the depth of subtrees returned by the server.

```
Method: GET
URL:
'http://csr1/restconf/data/Cisco-IOS-XE-native:native?content=config&depth=3'
Accept-Type: application/yang-data+json
```

- The value of the “depth” parameter is either an integer between 1 and 65535 or the string “unbounded”
- If not present in URI, the default value is: “unbounded”
- Only allowed for GET/HEAD method


```
{
#output removed for example
"interface": {
            "GigabitEthernet": [
                {
                    "name": "1",
                    "description": "MANAGEMENT_INTEFACE__DO_NOT_CHANGE",
                    "ip": {},
                    "mop": {},
                    "Cisco-IOS-XE-cdp:cdp": {},
                    "Cisco-IOS-XE-ethernet:negotiation": {}
                },
                {
                    "name": "10",
                    "shutdown": [
                        null
                    ],
                    "ip": {},
                    "mop": {},
                    "Cisco-IOS-XE-ethernet:negotiation": {}
                },
                {
                    "name": "11",
                    "shutdown": [
                        null
                    ],
                    "ip": {},
                    "mop": {},
                    "Cisco-IOS-XE-ethernet:negotiation": {}
                }
            ]
        }
    }
```

RESTCONF Example 2

Narrowing the scope and examining the hierarchy


```
{
  "Cisco-IOS-XE-native:GigabitEthernet": {
    "GigabitEthernet": [
      {
        "name": "3",
        "ip": {
          "address": {
            "primary": {
              "address": "10.2.0.151",
              "mask": "255.255.255.0"
            }
          }
        }
      }
    ]
  }
}
#output omitted
```


Pattern

`Cisco-IOS-XE-native:GigabitEthernet (dict) -> GigabitEthernet (list) -> ip (dict) -> address (dict) -> primary (dict)`

RESTCONF Example 3

Request:

```
Method: GET
URL: 'http://csr1/restconf/data/Cisco-IOS-XE-native:native/interface/GigabitEthernet=3/ip'
Accept-Type: application/yang-data+json
```

Response:


```
{
    "Cisco-IOS-XE-native:ip": {
        "address": {
            "primary": {
                "address": "10.2.0.151",
                "mask": "255.255.255.0"
            }
        }
    }
}
```

RESTCONF Example 4

Understanding PUT, PATCH, POST by Updating an Interface

Existing Configuration:

```
interface Loopback100
 ip address 222.22.2.2 255.255.255.0 secondary
 ip address 100.2.2.2 255.255.255.0
```

BODY Used for POST, PATCH, PUT:

```
{
    "Cisco-IOS-XE-native:Loopback": {
        "name": 100,
        "ip": {
            "address": {
                "primary": {
                    "address": "100.2.2.2",
                    "mask": "255.255.255.0"
                }
            }
        }
    }
}
```

RESTCONF Example 4 - The Result

Request 1:

POST `http://csr1/restconf/data/Cisco-IOS-XE-native:native/interface/`

Response `409; Error: Object Already Exists; No change in config`

–

Request 2:

PATCH `http://csr1/restconf/data/Cisco-IOS-XE-native:native/interface/Loopback`

Response `204; No change in config`

–

Request 3:

PUT `http://csr1/restconf/data/Cisco-IOS-XE-native:native/interface/Loopback=100`

Response `204;`

RESTCONF Example 4 - The Result

RESULT FOR THE PUT

Existing Configuration

```
interface Loopback100
 ip address 100.2.2.2 255.255.255.0
```

Static Route Management

Using RESTCONF to manage static route configuration

Starting Configuration:

```
csr1# show run | inc route
 ip route 0.0.0.0 0.0.0.0 10.0.0.2
```

RESTCONF Example 5 - PATCHing Routes

PATCH http://csr1/restconf/data/Cisco-IOS-XE-native:native/ip/route

Body:


```
{
    "Cisco-IOS-XE-native:route": {
        "ip-route-interface-forwarding-list":[
         {
            "prefix":"172.16.0.0",
            "mask":"255.255.0.0",
            "fwd-list":[
               {
                  "fwd":"192.168.1.1"
               }
            ]
         },
         {
            "prefix":"10.0.100.0",
            "mask":"255.255.255.0",
            "fwd-list":[
               {
                  "fwd":"192.168.1.1"
               }
            ]
         }
      ]
   }
}
```

RESTCONF Example 5 - PATCHing Routes (cont’d)

Resulting New Configuration:

```
csr1# show run | inc route
ip route 0.0.0.0 0.0.0.0 10.0.0.2
ip route 10.0.100.0 255.255.255.0 192.168.1.1
ip route 172.16.0.0 255.255.0.0 192.168.1.1
```

RESTCONF Example 6 - PUTing Routes

Starting Configuration:

```
csr1#show run | inc route
ip route 0.0.0.0 0.0.0.0 10.0.0.51
ip route 10.0.100.0 255.255.255.0 192.168.1.1
ip route 172.16.0.0 255.255.0.0 192.168.1.1
```

RESTCONF Example 6 - PUTing Routes (cont'd)

```
PUT http://csr1/restconf/data/Cisco-IOS-XE-native:native/ip/route
```

Body:

```
{
   "Cisco-IOS-XE-native:route": {
      "ip-route-interface-forwarding-list":[
         {
            "prefix":"0.0.0.0",
            "mask":"0.0.0.0",
            "fwd-list":[
               {
                  "fwd":"10.0.0.2"
               }
            ]
         }
      ]
   }
}
```

RESTCONF Example 6 - PUTing Routes (cont'd)

Resulting New Configuration:

```
csr1# show run | inc route
ip route 0.0.0.0 0.0.0.0 10.0.0.2
```

Summary

- True REST APIs are powerful
- Be careful using PUTs
- With great power comes great responsibility

Lecture 10: Exploring Postman

Lab 21

Lab Time

- Lab 21 - Exploring Postman
  - Lab 21.1 Exploring IOS-XE RESTCONF API
  - Lab 21.2 Exploring Arista eAPI

Lecture 11: APIs with Python

Topic 22 - Consuming HTTP APIs with Python requests

Lab 22

Topic 22: Consuming HTTP APIs with Python requests

Python requests

Using requests with eAPI

Using requests with IOS-XE

Python requests

- Python module to interact with HTTP based APIs (REST)
- Useful functions are post and get
  - Function per HTTP verb, i.e. post is used for POST requests and get is used for GET requests
- Optional, helper method for basic Authentication
- Headers used to dictate data encoding

```
import requests
from requests.auth import HTTPBasicAuth

auth = HTTPBasicAuth('ntc', 'ntc123')

headers = {
    'Content-Type': 'application/json',
    'Accept': 'application/json'
}
```

Sample GET:

```
response = requests.get('http://<device>', headers=headers, auth=auth)
```

Python requests

- data must be a JSON string - must use json.dumps()
- data, headers, and auth are defined parameters that must be used within the requests library
- payload is an arbitrary variable that maps back to device API requirements

```python
import requests
import json
from requests.auth import HTTPBasicAuth

auth = HTTPBasicAuth('ntc', 'ntc123')


headers = {
    'Content-Type': 'application/json',
    'Accept': 'application/json'
}
payload = {# some dictionary #}

url = 'http://eos-spine1/command-api'

response = requests.post(url, data=json.dumps(payload), headers=headers, auth=auth)
```

Python requests - Example on Arista eAPI

```python
#!/usr/bin/env python
import requests
import json
from requests.auth import HTTPBasicAuth

if __name__ == "__main__":
    auth = HTTPBasicAuth('ntc', 'ntc123')
    headers = {
        'Content-Type': 'application/json'
    }
    payload = {
        "jsonrpc": "2.0",
        "method": "runCmds",
        "params": {
            "version": 1,
            "cmds": [
                "show version"
            ],
            "format": "json",
            "timestamps": False
        },
        "id": "ntc"
    }
    url = 'http://eos-spine1/command-api'
    response = requests.post(url, data=json.dumps(payload),
headers=headers, auth=auth)
    rx_object = json.loads(response.text)
    print('Status Code: ' + str(response.status_code))
```

- Run show version on a Arista switch.
- Print status_code, text and OS version.
- The text attribute contains the response of a request as a JSON string.
- The status_code attribute contains the HTTP response code.

```
Status Code: 200
{
    "jsonrpc": "2.0",
    "result": [
        {
            "memTotal": 3895836,
            "version": "4.15.2F",
            "internalVersion": "4.15.2F-2663444.4152F",
            "serialNumber": "",
            "systemMacAddress": "2c:c2:60:28:54:dd",
            "bootupTimestamp": 1477365548.64,
            "memFree": 1621108,
            "modelName": "vEOS",
            "architecture": "i386",
            "internalBuildId": "0ebbad93-563f-4920-8ecb-731057802b9c",
            "hardwareRevision": ""
        }
    ],
    "id": "ntc"
}
```

Python requests - Example on Arista eAPI

```python
#!/usr/bin/env python
import requests
import json
from requests.auth import HTTPBasicAuth
if __name__ == "__main__":
    auth = HTTPBasicAuth('ntc', 'ntc123')
    headers = {
        'Content-Type': 'application/json'
    }
    payload = {
        "jsonrpc": "2.0",
        "method": "runCmds",
        "params": {
            "version": 1,
            "cmds": [
                "show hostname",
                "show vlan"
            ],
            "format": "json",
            "timestamps": False
        },
        "id": "ntc"
    }
    url = 'http://eos-spine1/command-api'
    response = requests.post(url, data=json.dumps(payload), headers=headers, auth=auth)
    rx_object = json.loads(response.text)
    print('Status Code: ' + str(response.status_code))
    result = rx_object['result']
    print("Hostname: ", json.dumps(result[0], indent=4))
    print("VLANs: ", json.dumps(result[1], indent=4))
```

The cmds request parameter is a list.

- Run show hostname and show vlan at the same time.
- Result is a list and can be used to print individual command output.

```
Status Code: 200
Hostname:  {
    "hostname": "eos-spine1",
    "fqdn": "eos-spine1.ntc.com"
}
VLANs:  {
    "sourceDetail": "",
    "vlans": {
        "1": {
            "status": "active",
            "interfaces": {},
            "dynamic": false,
            "name": "default"
        }
    }
}
```

Using requests with IOS-XE

```python
#!/usr/bin/env python
import requests
import json
from requests.auth import HTTPBasicAuth

if __name__ == "__main__":
    auth = HTTPBasicAuth('ntc', 'ntc123')
    headers = {
        'Accept-Type': 'application/vnd.yang.data+json',
        'Content-Type': 'application/vnd.yang.data+json'
    }

    url = 'http://csr1/restconf/api/config/native/interface'
    response = requests.get(url, headers=headers, auth=auth)
    print('Status Code: ' + str(response.status_code))
    print("\nInterfaces Object: ", response.text)
```

```
Status Code: 200
```



```json
{
  "ned:interface": {
    "GigabitEthernet": [
      {
        "name": "1"
      },
      {
        "name": "2"
      },
      {
        "name": "3"
      },
      {
        "name": "4"
      }
    ]
  }
}
```

Lecture 11: APIs with Python

Lab 22

Lab Time

- Lab 22 - Using Python requests:
  - Lab 22.1 - Using Python requests with Arista eAPI
  - Lab 22.2 - Using Python requests with Cisco NX-API