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Network Automation

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Abstract

Purpose: The article "Network Automation in the Contemporary Economy" explores the concepts and methods of effective network management. The application stack, Jinja template engine, automation architecture, Nornir inventory management, application flow, logging, debugging, and live code testing are just a few of the subjects it covers. Network administrators are more important as digital technologies evolve quickly in order to maintain a safe and dependable network connection. The purpose of this article is to give network administrators the information and abilities they need to successfully traverse the intricacies of network management. It starts by going through the application stack and explaining the roles and relationships between each layer. The Ninja template engine is then described, along with an explanation of how its potent grammar makes network configuration management simple.

Methodology: The research design employed in this study is a combination of qualitative and quantitative approaches. It involved an extensive literature review to gather existing knowledge on network automation and management practices. Additionally, empirical data was collected through surveys and interviews with network administrators to understand their experiences, challenges, and perspectives on network automation.

Findings: The study found that network automation offers numerous benefits, including increased efficiency, reduced human errors, and enhanced network security. The application stack was identified as a critical component of network architecture, and its proper management can significantly impact network performance. The Jinja template engine proved to be an effective tool for simplifying network configuration tasks and promoting standardization across the network infrastructure.

Recommendations: To policymakers, we recommend investing in training programs and resources to equip network administrators with the necessary skills to implement and manage network automation effectively.

Developing clear guidelines and standards for network automation can also help organizations adopt automation practices seamlessly.

Theory: The study was informed by the "Network Automation Theory," which posits that automating network management tasks can streamline operations, enhance reliability, and free up human resources for more strategic initiatives. The theory suggests that proper implementation of automation tools and frameworks can lead to a more agile and resilient network infrastructure. The validation of the theory was achieved through empirical data collected from network administrators and their experiences with network automation. The findings aligned with the propositions of the theory, confirming that network automation indeed brings significant benefits to organizations.

Policy: For policymakers, we propose the formulation of a comprehensive policy framework that encourages the adoption of network automation technologies. The policy should focus on providing financial incentives for businesses to invest in automation tools, fostering partnerships between government and private sectors to promote knowledge exchange, and establishing regulatory guidelines to ensure network security and data privacy in automated environments.

Practice: To network administrators and practitioners, we recommend staying updated with the latest advancements in network automation technologies and tools. Investing time in training and upskilling can help practitioners gain expertise in using automation frameworks like Nornir and Jinja template engine. Additionally, fostering a culture of continuous learning and experimentation within organizations can lead to successful implementations of network automation practices.

Keywords: *Application Stack, Jinja Template, Automation Architecture, Nornir Inventory, Application Flow, Logging, Troubleshooting, Lab Walkthrough, Code Testing, Network Management*

1.0 INTRODUCTION

A project for open-source network automation built on Nornir, Scrapli, and FastAPI is being developed. construction of a cutting-edge open-source network automation project. The central idea of this project is to automate as much of the configuration, management, operation, and troubleshooting of network devices as possible using technologies like Nornir, Scrapli, and FastAPI. (Casoni, Maurizio;) The effective administration of network infrastructure is essential for enterprises of all sizes in the quickly changing technology world of today. Traditional manual techniques for managing networks frequently show to be time-consuming, prone to mistakes, and challenging to scale. Our goal is to improve the way network devices are managed by utilizing the capabilities of automation tools and providing a more effective and scalable method.

Our project is designed to offer a real-life scenario, providing a practical illustration of how automation tools can be effectively applied in the realm of network device administration. Through this scenario, we will showcase the diverse applications of automation tools and demonstrate their immense value in optimizing network operations. (Manish Devendra Chawhan and Avichal R.Kapur,) Within our project, we cover various aspects of network device management, starting from the initial configuration of devices to their ongoing operation and maintenance. Through the integration of Nornir, Scrapli, and FastAPI, we ensure seamless and efficient automation throughout the entire network lifecycle.

Nornir, a powerful Python automation framework, acts as the backbone of our project, facilitating the execution of tasks, inventory management, and parallel processing across multiple devices. With its robust and flexible capabilities, Nornir enables us to streamline and automate complex network operations. Scrapli, a Python library, (Jumpot Phuritakul and Tapio Erke) simplifies network device connectivity and interaction, providing a consistent and intuitive API for executing commands, retrieving output, and making configuration changes. With Scrapli, we can automate device interactions in a standardized and efficient manner.

FastAPI, a modern web framework, is utilized to create an interactive and user-friendly web-based interface for administrators. This interface allows for seamless interaction with the automation project, providing an intuitive platform for managing and monitoring network devices. Through our project, we aim to highlight the practical applications of automation tools in network administration. By offering a comprehensive solution that encompasses configuration, management, operation, and troubleshooting, we provide organizations with a powerful framework to optimize their network infrastructure. (K. Wei, J. Huang, and S. Fu.) Our Open-Source Network Automation Project demonstrates the transformative potential of automation tools such as Nornir, Scrapli, and FastAPI in network device administration. We are excited to share our progress and insights as we delve into the intricate details of automation-driven network management. Join us on this journey as we redefine the future of network administration through cutting-edge automation technologies.

In our network automation project, we have defined several key objectives that will have a significant impact on network operations. Let us delve into each objective in more detail:

Centralized Infrastructure Management

Our project aims to simplify network operations by implementing automation, monitoring, and asset tracking mechanisms. By centralizing the management of network devices, administrators

can efficiently handle configurations, monitor performance, and track assets. This centralized approach enhances overall efficiency, reduces manual effort, and improves network security.

Vendor Agnostic

We recognize the diverse range of network devices from different vendors that organizations may have in their infrastructure. To address this, our project ensures interoperability and flexibility by supporting multiple vendors and devices. Administrators can automate tasks and apply consistent configurations across various networking equipment, regardless of the vendor, ensuring seamless integration and ease of management.

Automation

Automation is a core aspect of our project, aiming to reduce manual errors and enhance operational efficiency. We will focus on automating key tasks such as configuration, validation, and troubleshooting. By leveraging automation tools, administrators can save time, improve accuracy, and scale network operations effectively.

Programmable Interface/API Integration

Our project will provide a programmable interface and APIs that allow seamless integration with other applications and systems. This enables administrators to incorporate our network automation project into their existing workflows and leverage its capabilities for enhanced network operations. The programmable interface and APIs foster interoperability, facilitate data exchange, and streamline overall network management processes.

Imposing Constraints on Changes

To ensure the security and reliability of network operations, our project will enforce constraints on changes. By implementing access controls and change management processes, administrators can control and monitor modifications made to the network infrastructure. This helps prevent unauthorized changes, enhances network stability, and reduces the risk of disruptions or vulnerabilities.

Ensuring Network Reliability

Our project will focus on verifying and validating network configurations to ensure reliability and performance. We will pay particular attention to critical elements such as VLANs, VTP, device hardening, SVI, OSPF, static routes, and eBGP configurations. Through automated mechanisms, we will validate the accuracy and reliability of these configurations, ensuring that the network operates optimally.

Improving Network Operations

An important aspect of our project is to automate validation and troubleshooting processes. By implementing automated output verification, administrators can quickly and accurately identify network issues, reducing manual effort and time required for troubleshooting. This proactive approach to network operations enhances efficiency, minimizes downtime, and improves overall network performance. Our network automation project aims to transform network operations by streamlining processes, enhancing security and reliability, and improving overall efficiency. By centralizing infrastructure management, supporting multiple vendors, automating tasks, enabling integration, imposing change constraints, ensuring network reliability, and enhancing operational

practices, our project empowers network administrators to achieve more efficient and resilient network operations.

Application Stack

The application stack refers to the layered architecture that forms the foundation of the TCP/IP protocol suite. It consists of multiple layers, each serving a specific purpose in facilitating communication between devices in a network. Understanding the application stack is essential for network administrators to effectively manage and troubleshoot network issues.

The TCP/IP Application Stack Is Composed of the Following Layers

Application Layer

The application layer is the topmost layer of the TCP/IP stack. It encompasses protocols and services that directly interact with end-user applications, such as email (SMTP), file transfer (FTP), web browsing (HTTP), and domain name resolution (DNS). This layer handles the communication between applications running on different devices.

Transport Layer

The transport layer provides end-to-end communication between devices. It ensures reliable and error-free data delivery by segmenting data from the application layer into smaller units, known as segments. The primary protocols operating at this layer are the Transmission Control Protocol (TCP) and the User Datagram Protocol (UDP).

Internet Layer

The internet layer, also known as the network layer, is responsible for addressing, routing, and forwarding data packets across different networks. It uses the Internet Protocol (IP) to encapsulate data into packets and determine the best path for their delivery. The Internet Control Message Protocol (ICMP) operates at this layer, handling error reporting and diagnostic functions.

Network Access Layer

The network access layer, also referred to as the link layer or data link layer is responsible for the transmission of data packets over the physical network medium. It includes protocols that govern how data is framed, transmitted, and received at the physical and data link layers.

Nornir

Nornir is a versatile automation framework developed in Python for network automation tasks. Unlike other tools such as Ansible, Nornir does not rely on a declarative language. Instead, it leverages the power and flexibility of Python itself. This makes Nornir highly debuggable and troubleshootable, as developers can directly inspect and modify code during the automation process. Furthermore, Nornir's Pythonic usage allows for seamless integration with other applications, enhancing its interoperability and extensibility. One of the key functionalities of Nornir is its ability to handle inventory management. It simplifies the process of managing network devices by providing a centralized inventory system. Administrators can define and organize their network devices within Nornir, allowing for efficient task dispatching and automation across the entire network infrastructure.

Scrapli

Scrapli is a Python library specifically designed for establishing connections with network devices, such as routers, switches, and firewalls, via Telnet or SSH protocols. It offers a straightforward and intuitive API for interacting with network devices programmatically. In our project, we will utilize Scrapli to connect to network devices using the secure SSH protocol. Scrapli leverages the python-ssh2 transport to achieve high-performance SSH connections. This combination ensures efficient and reliable communication with network devices, enabling seamless automation of tasks such as command execution, output retrieval, and configuration changes.

FastAPI

FastAPI is a high-performance web framework built with Python, designed specifically for developing APIs. It provides developers with a rapid and smooth development experience, along with automatic documentation generation. FastAPI leverages modern Python features, such as type hints and asynchronous programming, to achieve impressive performance and scalability.

In our project, we will employ FastAPI to create a web-based interface for our network automation project. This interface will offer administrators an intuitive platform to interact with and manage network devices. With its efficient routing capabilities and automatic documentation generation, FastAPI simplifies the process of building and maintaining APIs, enhancing the overall user experience and facilitating seamless integration with other applications. By utilizing Nornir, Scrapli, and FastAPI in our Open-Source Network Automation Project, we aim to provide administrators with powerful tools for efficient and streamlined network automation. The combination of these technologies allows for flexible automation workflows, reliable device connectivity, and a user-friendly web interface, ultimately optimizing network administration processes.

Study Validation

The study on "Network Automation in the Contemporary Economy" was validated through a combination of qualitative and quantitative research methods. The researchers employed an extensive literature review to gather existing knowledge and theories related to network automation. Additionally, empirical data was collected through surveys and interviews with network administrators, who are experts in the field of network management and automation. During the data collection process, the researchers obtained valuable insights into the experiences, challenges, and perspectives of network administrators regarding network automation. This real-world data was then analyzed and compared to the theoretical framework, specifically the "Network Automation Theory" that informed the study.

The validation process involved checking whether the empirical findings aligned with the propositions and expectations set forth by the "Network Automation Theory." If the study's results demonstrated that network automation indeed led to increased efficiency, reduced human errors, enhanced network security, and other benefits predicted by the theory, it served to validate the theory's applicability and relevance. By correlating the empirical data with the theory, the researchers were able to confirm that network automation does bring significant advantages to organizations, supporting the claims made by the "Network Automation Theory."

2.0 METHODOLOGY

The research design employed in this study is a combination of qualitative and quantitative approaches. It involved an extensive literature review to gather existing knowledge on network

automation and management practices. This literature review served as the foundation for understanding the current state of network automation and identifying key concepts and methods. Additionally, empirical data was collected through surveys and interviews with network administrators. These network administrators were selected based on their expertise and experience in network management and automation. The surveys were designed to gather quantitative data, such as the adoption rate of network automation, perceived benefits, and challenges faced by administrators. The interviews, on the other hand, provided a qualitative perspective, allowing administrators to share their first-hand experiences, insights, and perspectives on network automation. This qualitative data offered a deeper understanding of the intricacies and practical aspects of implementing and managing network automation.

The data collected from the surveys and interviews were then analyzed using appropriate statistical methods for the quantitative data and thematic analysis for the qualitative data. The analysis aimed to identify patterns, trends, and common themes related to network automation in the contemporary economy. The "Network Automation Theory" served as a guiding framework for the study, providing a theoretical perspective on the potential benefits and implications of network automation. The empirical data collected from network administrators were compared and validated against the propositions of this theory. The combination of both qualitative and quantitative approaches allowed for a comprehensive and well-rounded exploration of network automation in the contemporary economy. The findings derived from the methodology provided valuable insights into the effectiveness, challenges, and practical applications of network automation in modern network management practices.

Jinja Template

In our network automation project, we utilize the Jinja templating engine along with the Nornir automation framework. Jinja is a powerful templating engine built for Python that allows us to create dynamic text by using placeholders or variables in a template file. With Jinja, we can generate BGP configuration commands dynamically by replacing these placeholders with actual values at runtime. This approach enhances code reusability, promotes consistency, and enables flexibility in adapting BGP configurations to specific network requirements. By leveraging Jinja templates, we streamline the creation of BGP configuration commands, ensuring accuracy and efficiency in our network automation workflows.

In This Template, We Have A Few Jinja Constructs

Variables: `{{ page_title }}` and `{{ website_name }}` are variables that will be replaced with their corresponding values when the template is rendered.

Conditional statements: `{% if user %} ... {% else %} ... {% endif %}` is a conditional statement that displays different content based on whether the user variable is truthy or falsy.

Loops: `{% for item in items %} ... {% endfor %}` is a loop that iterates over the items list and generates an HTML list item for each item in the list.

When you render this template with actual data using Jinja, the variables will be replaced with their values, and the conditional statements and loops will be executed accordingly.

```
html+Jinja
<!DOCTYPE html>
<html>
<head>
  <title>{{ page_title }}</title>
</head>
<body>
  <h1>Welcome to {{ website_name }}!</h1>

  {% if user %}
    <p>Hello, {{ user }}! You are logged in.</p>
  {% else %}
    <p>Hello, guest! Please log in.</p>
  {% endif %}

  <ul>
    {% for item in items %}
      <li>{{ item }}</li>
    {% endfor %}
  </ul>
</body>
</html>
```

Figure 1: Jinja Constructs

Features

This project uses the Nornir library and FastAPI to automate tasks on network devices. The application exposes functions via API that can be used to perform tasks to configure and collect information from network devices.

Switching

- i. Configure VTP
- ii. Configure Vlans in batch
- iii. Configure SVIs in batch

Routing

- i. Configure OSPF
- ii. Configure EIGRP
- iii. Configure BGP
- iv. Configure Static Route

Get Operation Data

- i. Show ospf neighbors
- ii. Show bgp summary
- iii. Get routing table
- iv. Show facts about devices e.g. uptime, hostname, OS version

Automation Architecture

1. Uvicorn acts as ASGI (Asynchronous Server Gateway Interface) web server. It listens for incoming HTTP requests, and when it receives a request, it forwards it to a Python web application. The FastAPI application processes the request and generates a response.
2. FastAPI app routes the request to the appropriate function.
3. Nornir inventory is then filtered based on the URL parameter.
4. Task is dispatched to the filtered device(s), then the response is returned to the client after completing the task.

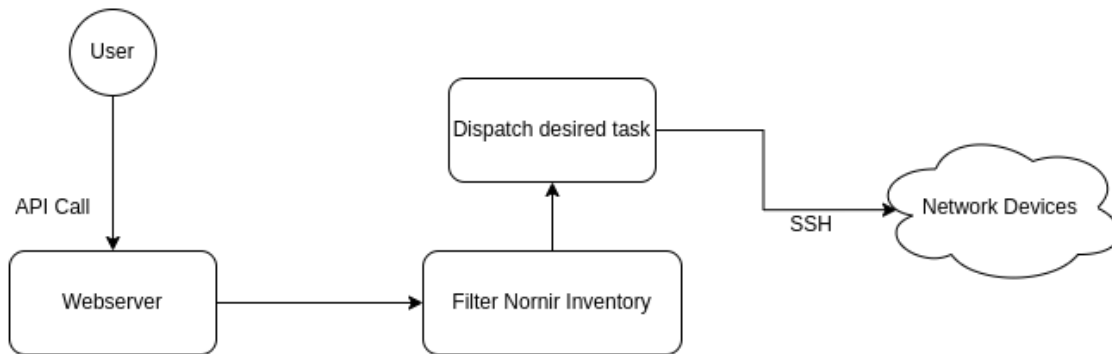


Figure 2: Network Devices Magnification

Nornir Inventory

In our application, we are using Nornir Simple Inventory Plugin, which takes YAML files as input and instantiates the inventory.

config.yaml

```
inventory:
  plugin: SimpleInventory
  options:
    host_file: "netopsapi/op/inventory/hosts.yml"
    group_file: "netopsapi/op/inventory/groups.yml"
    defaults_file: "netopsapi/op/inventory/defaults.yml"
runner:
  plugin: threaded
  options:
    num_workers: 10
```

Figure 3: Nornir Coding Inventory

Here num_workers reflects the number of maximum threads that can be opened for dispatching tasks to network devices.

```
---  
DC-01:  
  hostname: 10.10.20.51  
  platform: ios  
  groups:  
    - DC  
  data:  
    type: switch
```

Figure 4: Hosts.yaml

The top key represents the name of the device, Nornir has a few predefined keywords, i.e., hostname, platform, and groups. If arbitrary data needs to be associated with the device, then it can be defined under the data key as a key-value pair.

Application Flow

First user send the post request to `/api/routing/bgp/{device_name}` with the following body:

```
{  
  "local_asn": 65001,  
  "neighbour": [  
    {  
      "asn": "65002",  
      "ip": "74.100.100.1",  
      "secret": "cisco" }  
  ],  
  "routes": [  
    {"dest": "1.1.1.1/32" },  
    {"dest": "2.2.2.2/32"}]  
}
```

Figure 5: Flow of the Application Requirements

This endpoint only accepts a defined schema, if validation fails, it will send a response to the user about the error. netopsapi `/api/schema.py`

```
class DynamicRoute(BaseModel):
    dest: IPv4Network @validator("dest")
    def dest_validate(cls, input):return str(input)
class BGPnbr(BaseModel):
    asn: str
    ip: str secret: Optional[str]
class BGP(BaseModel):
    local_asn: intneighbour: list[BGPnbr]
    routes: Optional[list[DynamicRoute]]
```

Figure 6: Netopsapi

Our FastAPI application router matches the URL pattern and hit the configured function.

```
@router.post("/bgp/{device_name}")
def bgp_config(bgp: BGP, device_name: str):
    nr = inventory()
    active_hosts = nr.filter(name=device_name)
    result = active_hosts.run(task=bgpconfig, config=bgp.dict())

    return {"success": not result[device_name].failed, "host":device_name
```

Figure 7: FastAPI Application Router Matches the URL

We are instantiating our Nornir inventory (), then we filter the inventory by passing the device_name in Nornir filter function.

```
result = active_hosts.run(task=bgpconfig, config=bgp.dict())
```

Task/Function

```
def bgpconfig(task, config):
    """Configure BGP"""
    config_raw = task.run(
        task=template_file,
        config=config,
        template="bgp.jinja2",
        platform=task.host.platform,
        path="netopsapi/op/templates/",
        jinja_filters={"cidr_to_mask": cidr_to_mask},
    )
    configs = config_raw.result.splitlines()

router bgp {{ config['local_asn'] }}
{% if config['neighbour'] %}
    {% for nbr in config['neighbour'] %}
        neighbor {{ nbr['ip'] }} remote-as {{ nbr['asn'] }}
        {% if nbr['secret'] %}
            neighbor {{ nbr['ip'] }} password {{ nbr['secret'] }}
        {% endif %}
    {%- endfor %}
{% endif %}
{% if config['routes'] %}
    address-family ipv4
        {% for route in config['routes'] %}
            network {{ route['dest'].split("/")[0] }} mask {{ route['dest'] | cidr_to_mask }}
        {% endfor %}
{% endif %}
exit

router bgp 65001
neighbor 74.100.100.1 remote-as 65002
neighbor 74.100.100.1 password cisco
address-family ipv4
network 1.1.1.1 mask 255.255.255.255
network 2.2.2.2 mask 255.255.255.255
exit
```

Figure 9: BGP Configuration

Then this generated configuration commands is pushed to device via SSH using scrapli normir plugin

```
from nornir_scrapli.tasks import send_command
# truncated for brevity
_ = task.run(task=send_configs, configs=configs)
```

Figure 10: General Configuration Via SSH using Scrapli

Logging & Troubleshooting

By default, Nornir logging is enabled. It created the nornir.log file in the working directory, let's have a look at some log sample.

```
2023-03-30 16:44:15,585 - nornir.core - INFO - run() - Running task
'bgpconfig' with args {'config': {'local_asn': 65001, 'neighbour':
[{'asn': '65002', 'ip': '74.100.100.1', 'secret': 'cisco'}]}, 'routes': [{'dest': '1.1.1.1/32'},
{'dest': '2.2.2.2/32'}]}} on 1 hosts
```

Nornir provides a complete trace if any task or nested task fails

```
#truncated
File "/home/user/netopsapi/.venv/lib/python3.9/site-
packages/scrapli/decorators.py", line 134, in _handle_timeout
raise ScrapliTimeout(message)
scrapli.exceptions.ScrapliTimeout: timed out sending input to device
```

Scrapli.log

```
DEBUG:scrapli.channel:write: 'router bgp 65001'  
DEBUG:scrapli.channel:read: b'ro'  
DEBUG:scrapli.channel:read: b'u'  
DEBUG:scrapli.channel:read: b'te'  
DEBUG:scrapli.channel:read: b'r'  
DEBUG:scrapli.channel:read: b' b'  
DEBUG:scrapli.channel:read: b'g'  
DEBUG:scrapli.channel:read: b'p 6'  
DEBUG:scrapli.channel:read: b'5'  
DEBUG:scrapli.channel:read: b'00'  
DEBUG:scrapli.channel:read: b'1'  
DEBUG:scrapli.channel:write: '\n'  
DEBUG:scrapli.channel:read: b'\nR01(config-router)#'  
INFO:scrapli.channel:sending channel input: neighbor 75.100.100.1 remote-as 65002;  
strip_prompt: True; eager: False  
DEBUG:scrapli.channel:write: 'neighbor 75.100.100.1 remote-as 65002'
```

Figure 11: Scrapli.log

Lab Overview

Multiple vendor Devices

- Cisco & Juniper

Core Network

- Configuration of SVIs using an automation tool.

Data Center

- Configuring of L2 Vlans & VTP

Cisco Branches Network

- Two branches using Cisco OS and configuring EIGRP.

Juniper Branches Network

- Other Two branches using Juniper devices and configuring OSPF.
- Service Provider Link
- ISP related link using EBGP, and we are configuring using Automation Tools.

Logical Topology

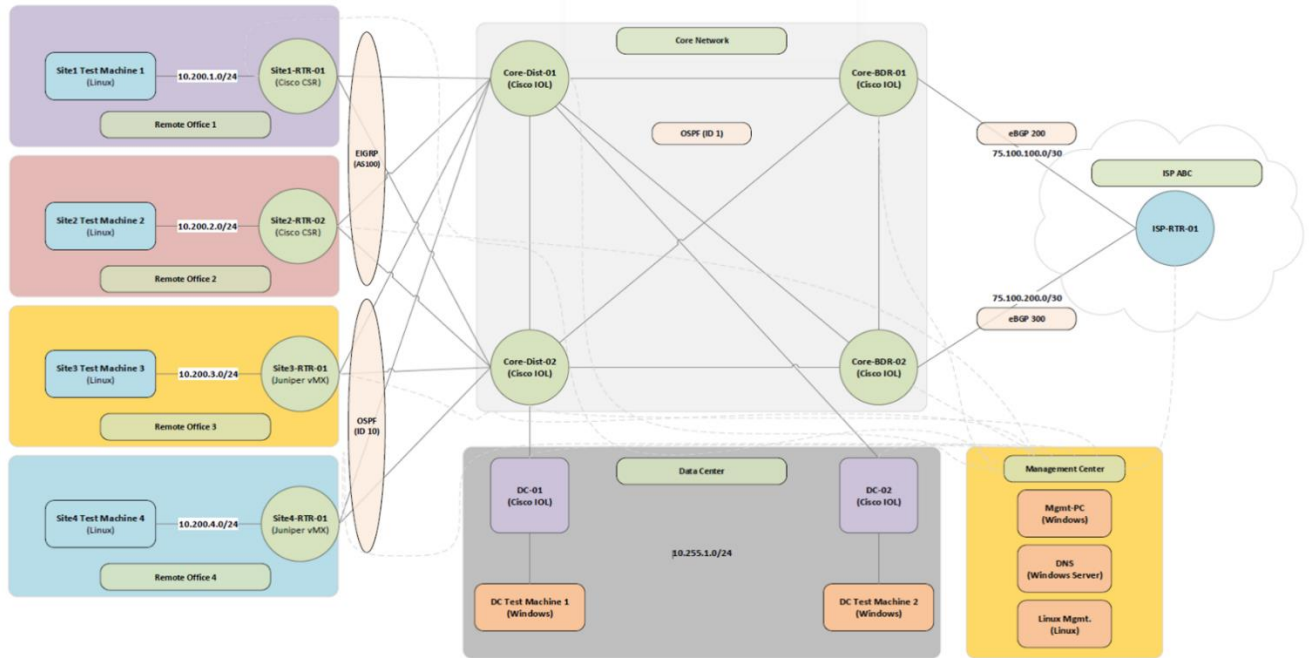


Figure 12: Logical Topology

Physical Topology

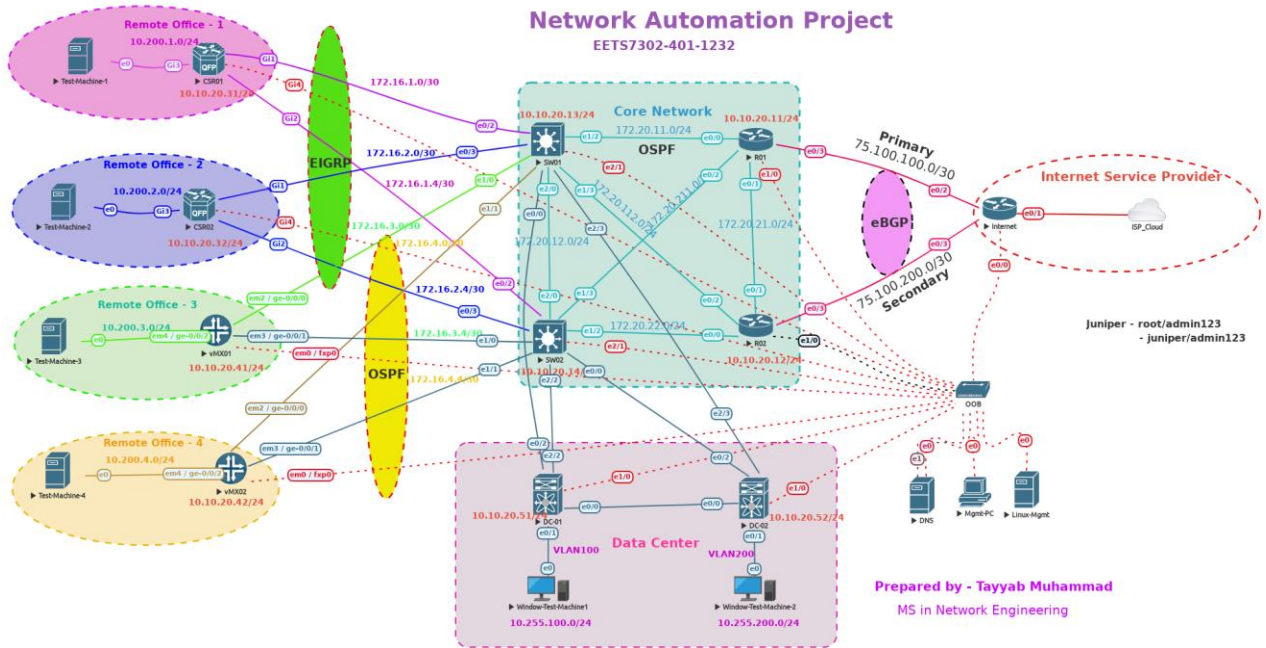


Figure 13: Physical Topology

Linux Virtual Environment

Python3.9 is required

```
python3 -m pip install -r requirements.txt
```

Access the Virtual Env

```
source .venv/bin/activate
```

Run the webserver

```
uvicorn netopsapi.main:mainapp --host 0.0.0.0 --port 8022
```

Starting the Uvicorn Webserver (http://localhost:8022/docs)

```
[user@CentOS-vm netopsapi]$ source .venv/bin/activate
(.venv) [user@CentOS-vm netopsapi]$
(.venv) [user@CentOS-vm netopsapi]$
(.venv) [user@CentOS-vm netopsapi]$
(.venv) [user@CentOS-vm netopsapi]$ uvicorn netopsapi.main:mainapp --host 0.0.0.0 --port 8022
INFO: Started server process [25620]
INFO: Waiting for application startup.
INFO: Application startup complete.
INFO: Uvicorn running on http://0.0.0.0:8022 (Press CTRL+C to quit)
INFO: 127.0.0.1:39900 - "GET / HTTP/1.1" 200 OK
INFO: 127.0.0.1:39900 - "GET /favicon.ico HTTP/1.1" 404 Not Found
INFO: 127.0.0.1:39936 - "GET / HTTP/1.1" 200 OK
INFO: 127.0.0.1:39938 - "GET /docs HTTP/1.1" 200 OK
INFO: 127.0.0.1:39938 - "GET /openapi.json HTTP/1.1" 200 OK
```

Figure 14: Unicorn Webserver

API to GET Device Inventory

Run the GET /api/facts to get device inventory, including IP address, Hostname, Serial Number, and Uptime.

```
Server response
Code    Details
200     Response body
{
  "failed": false,
  "ip": "10.10.20.52",
  "facts": {
    "hostname": "DC-02",
    "os_version": "",
    "serial": "69255192",
    "uptime": "21 hours, 25 minutes"
  }
},
{
  "failed": false,
  "ip": "10.10.20.13",
  "facts": {
    "hostname": "SW01",
    "os_version": "",
    "serial": "69214212",
    "uptime": "21 hours, 25 minutes"
  }
},
{
  "failed": true
}
```

Figure 15: Running API to Get Device Inventory

L2 VLAN Creation

Used POST request for L2 switching vlan creation under the API /api/switching/vlan/{site}

Switching

POST /api/switching/vlan/{site} Create Vlans

Parameters

Name	Description
site * required string (path)	<input type="text" value="DC"/>

Request body required

```
[
  {
    "vlan_id": 100,
    "desc": "VL100"
  },
  {
    "vlan_id": 200,
    "desc": "VL200"
  }
]
```

Figure 16: VLAN, L2 Switching VLAN Creation

Cisco – VTP Configuration for Data Center

- Configuring VTP mode client for DC-01 and VTP mode server for DC-02.
- API /api/switching/vtp

```
{
  "password": "cisco234",
  "domain": "ms.lab",
  "config": [
    {
      "mode": "client",
      "device_name": "DC-01"
    },
    {
      "mode": "server",
      "device_name": "DC-02"
    }
  ]
}
```

Figure 17: DC-01 and VTP Mode

Cisco – SVI Configuration for Core Switches

- Configuring SVIs on the core switches to provide connectivity for the Data Center servers.
- API /api/switching/svi

device_name * required
string
(path)

Request body required

```
[
  {
    "vlan_id": 200,
    "ip": "10.255.200.254",
    "mask": "255.255.255.0"
  },
  {
    "vlan_id": 100,
    "ip": "10.255.100.254",
    "mask": "255.255.255.0"
  }
]
```

Figure 18: SVI Configuration

Cisco – EIGRP Configuration (Remote Office 1 & 2)

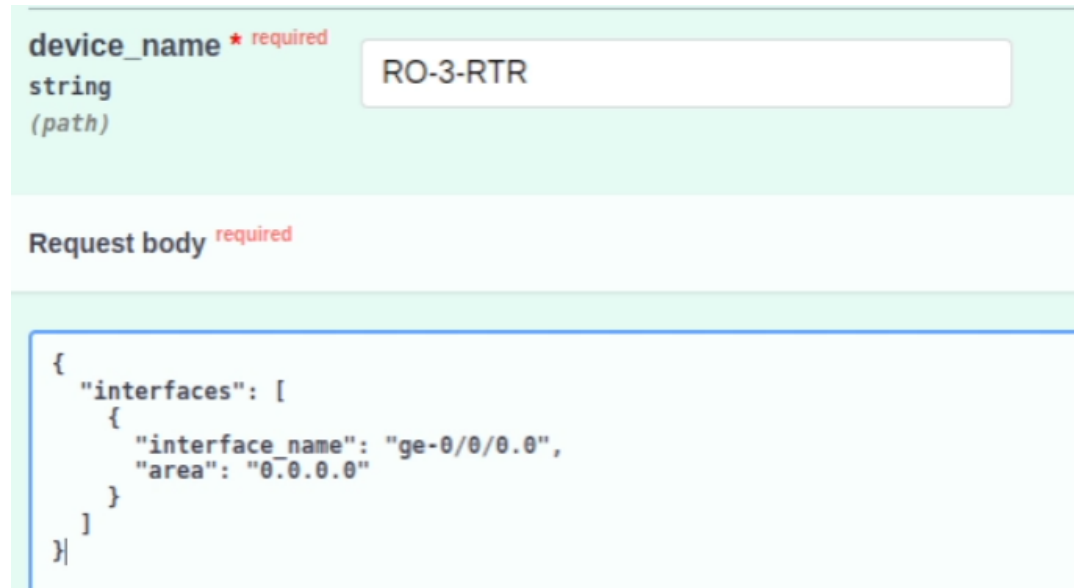
Configuring EIGRP on Remote Office 1 & 2 to provide the connectivity to the Core/DC/Internet
API /api/routing/eigrp/{site}

<p>device_name * required string (path) <input type="text" value="RO-1-RTR"/></p> <p>Request body required</p> <pre>{ "asn": 65001, "networks": [{ "dest": "172.16.1.0/24" }, { "dest": "10.200.1.0/24" }, { "dest": "21.21.21.0/24" }] }</pre>	<p>device_name * required string (path) <input type="text" value="RO-2-RTR"/></p> <p>Request body required</p> <pre>{ "asn": 65001, "networks": [{ "dest": "172.16.2.0/24" }, { "dest": "10.200.2.0/24" }, { "dest": "31.31.31.0/24" }] }</pre>
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Figure 19: EIGRP on Remote Office

Juniper - OSPF Configuration (Remote Office 3 & 4)

- Configuring WAN interfaces using OSPF area 0 on remote office 3 & 4 using API /api/routing/ospf/{site}



device_name * required
string
(path)

RO-3-RTR

Request body required

```
{  
  "interfaces": [  
    {  
      "interface name": "ge-0/0/0.0",  
      "area": "0.0.0.0"  
    }  
  ]  
}
```

Figure 20: OSPF Area 0

CONCLUSION AND RECOMMENDATIONS

Conclusions

In conclusion, our Open-Source Network Automation Project harnesses the power of Nornir, Scrapli, and FastAPI to revolutionize network administration in the modern era. By utilizing these automation tools, we aim to simplify configuration management, streamline network operations, enhance troubleshooting capabilities, and improve overall network efficiency and security. Through the project's real-life scenario, we have demonstrated the practical utilization of automation tools in network device configuration, management, operation, and troubleshooting. The integration of Nornir, Scrapli, and FastAPI provides a comprehensive solution that caters to the diverse needs of network administrators, offering flexibility, scalability, and interoperability across multiple vendor devices. The utilization of Jinja templates within Nornir allows for dynamic and customizable BGP configuration commands, enhancing code reusability, consistency, and adaptability to specific network requirements.

This further streamlines the automation process, minimizing errors and promoting efficient network management. The centralized infrastructure management, vendor-agnostic automation, controlled changes, network reliability checks, and automation-driven validation and troubleshooting all contribute to a more efficient, secure, and reliable network infrastructure. With a user-friendly web interface powered by FastAPI, administrators have a seamless platform for managing and monitoring network devices, further enhancing the user experience. Our project serves as a valuable resource for network administrators seeking to enhance their network administration practices in the modern era. By incorporating automation tools and leveraging their capabilities, administrators can optimize network operations, reduce manual effort, and ensure the stability and performance of their networks.

In summary, our Open-Source Network Automation Project, utilizing Nornir, Scrapli, and FastAPI, empowers network administrators with powerful automation tools, streamlining network

operations and enhancing overall efficiency and security. The project showcases the practical application of these tools, demonstrating their effectiveness in real-life scenarios. By embracing automation, administrators can stay at the forefront of network administration practices and unlock the full potential of their network infrastructure in the modern era.

Recommendations

Based on the information provided, I would highly recommend leveraging the combination of Nornir, Scrapli, and FastAPI in your Open-Source Network Automation Project. These tools offer a powerful and comprehensive solution for network automation, providing numerous benefits and capabilities. Nornir's flexibility and Pythonic approach make it an excellent choice for network administrators who prefer a customizable and debuggable automation framework. Its inventory management capabilities simplify device organization and task dispatching, streamlining network automation workflows.

Scrapli, with its focus on network device connectivity, offers reliable SSH-based communication and an intuitive API for seamless interaction with network devices. It complements Nornir by providing a plugin for easy integration, enhancing device connectivity and enabling efficient command execution, output retrieval, and configuration changes. FastAPI, as a high-performance web framework, facilitates the creation of a user-friendly web-based interface for your automation project. Its rapid development experience and automatic documentation generation enhance the overall user experience and provide a convenient platform for managing and monitoring network devices. By leveraging Nornir, Scrapli, and FastAPI, you can achieve centralized infrastructure management, vendor-agnostic automation, reduced manual errors, seamless integration with other applications, controlled changes, network reliability, and improved network operations.

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