NANOG 80 Hackathon Recap

Michael Costello (just one of a cast of tens)

Hackathon stats

- 11th Hackathon (first virtual)
- Participants worked from 13:00 EDT Saturday to 17:00 EDT Sunday
- Participants from the US, Canada, and South Africa

Hackathon overview

- In support of NANOG's educational mission
- Organized by the Program Committee
- Weekend before the general conference
- Participants work individually or self-organize into groups
- Participants choose their own projects

Projects included

- A from-scratch BGP daemon
- Performance monitoring and notifications using home control systems
- Simulate traffic and visualize streaming telemetry data
- gnmi-gateway Kafka exporter and Netbox target loader
- A modern NNTP client library in Rust

Projects you'll see here today

- RIB compliance using Model Driven Telemetry
- A fully automated data center Proof of Concept
- A simple, automated, and easy-to-deploy SDN solution

Hackathon for NANOG 81

- We’re looking for participants, mentors, and sponsors
- We’ll be reviewing survey results ahead of planning
- See you in February

Lawrence Bird
https://github.com/TheBirdsNest/
https://www.linkedin.com/in/lawrenceabird/

Yordan Sutanto
https://github.com/yordangit12/
https://www.linkedin.com/in/yordan-sutanto-5ba4487/

BGP RIB COMPLIANCE USING MDT

https://github.com/petermoorey/NANOG-80-Hackathon/

NANOG-80 Hackathon

Peter Moorey
https://github.com/petermoorey/
https://www.linkedin.com/in/pmoorey/

Vladimir Yakovlev
https://github.com/VladimirGHC/
https://www.linkedin.com/in/vladimir-yakovlev-398ba5a0/

GOAL

- Evaluate various technology stacks
- Evaluate network telemetry capabilities
- Develop a network capable of showcasing various routing scenarios
- Provide real-time evaluation of BGP routes to detect:
  - Poorly configured route-maps
  - Incorrect provider policies
  - Route hijacking

TECHNOLOGY STACK

- CSR 1000v
- CML

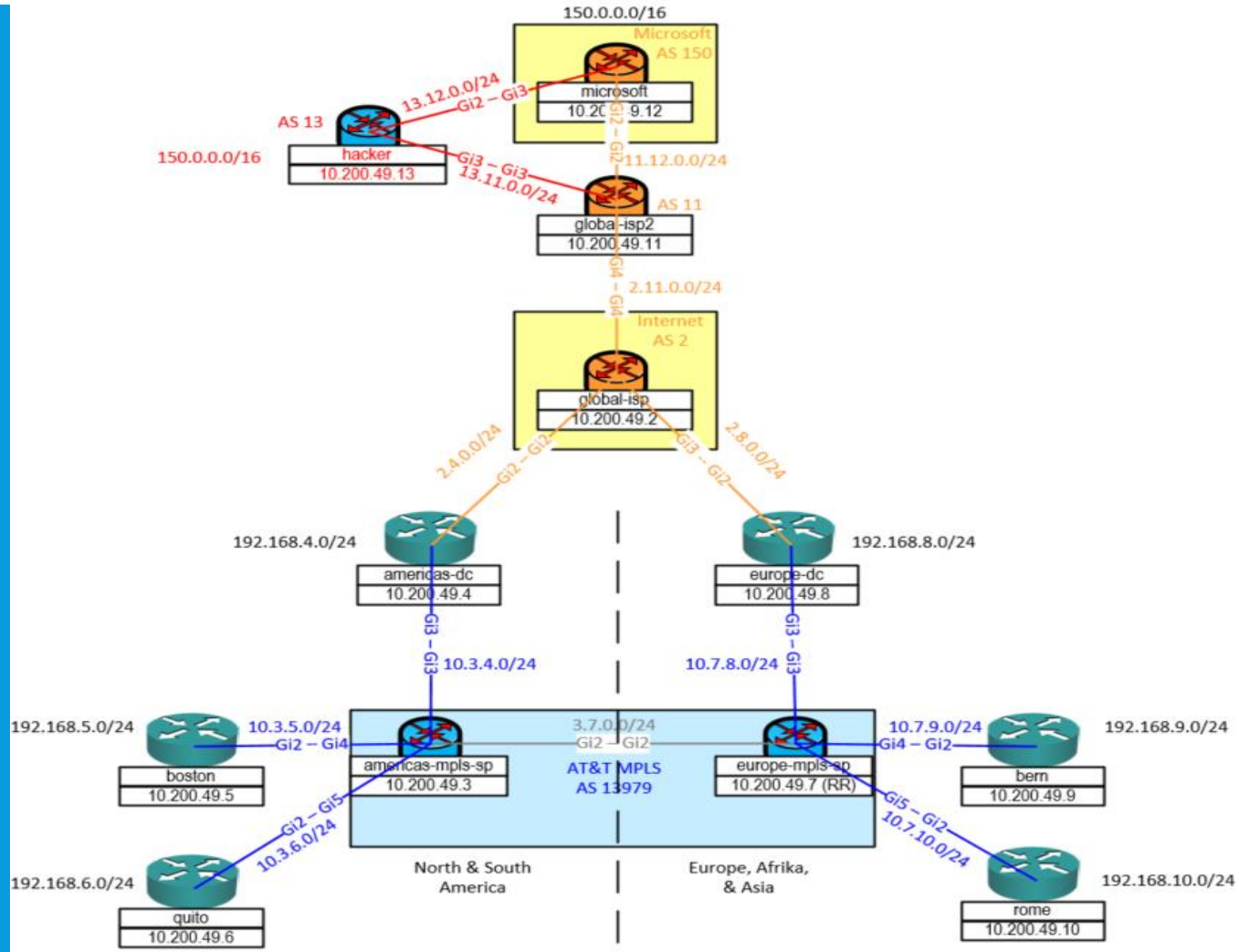
- Service Provisioning
- Service Chaining

- InfluxDB
- Telegraf
- Chronograph

- Policy Processing
- Notification Handling
- Websocket Manager

LAB SETUP

- Challenges:
  - Are the regional route preferences being honored for the default route?
  - Is traffic to/from our providers being hijacked?



DATA COLLECTION

templates > mdt_xml.jinja2

```
<config>
 <mdt-config-data xmlns="http://cisco.com/ns/yang/Cisco-IOS-XE-mdt-cfg">
{% for id, sub in data["subscriptions"].items() %}
  <mdt-subscription>
   <subscription-id>{{ id }}</subscription-id>
   <base>
    <stream>yang-push</stream>
    <source-vrf>{{ sub["sourcevrf"] }}</source-vrf>
    <encoding>encode-kvgpb</encoding>
{% if sub["period"] == "on_change" %}
    <no-synch-on-start>false</no-synch-on-start>
{% else %}
    <period>{{ sub["period"] }}</period>
{% endif %}
    <xpath>{{ sub["xpath"] }}</xpath>
   </base>
   <mdt-receivers>
    <address>{{ sub["rx"]["ip"] }}</address>
    <port>{{ sub["rx"]["tcp_port"] }}</port>
    <protocol>grpc-tcp</protocol>
   </mdt-receivers>
  </mdt-subscription>
{% endfor %}
 </mdt-config-data>
</config>
```

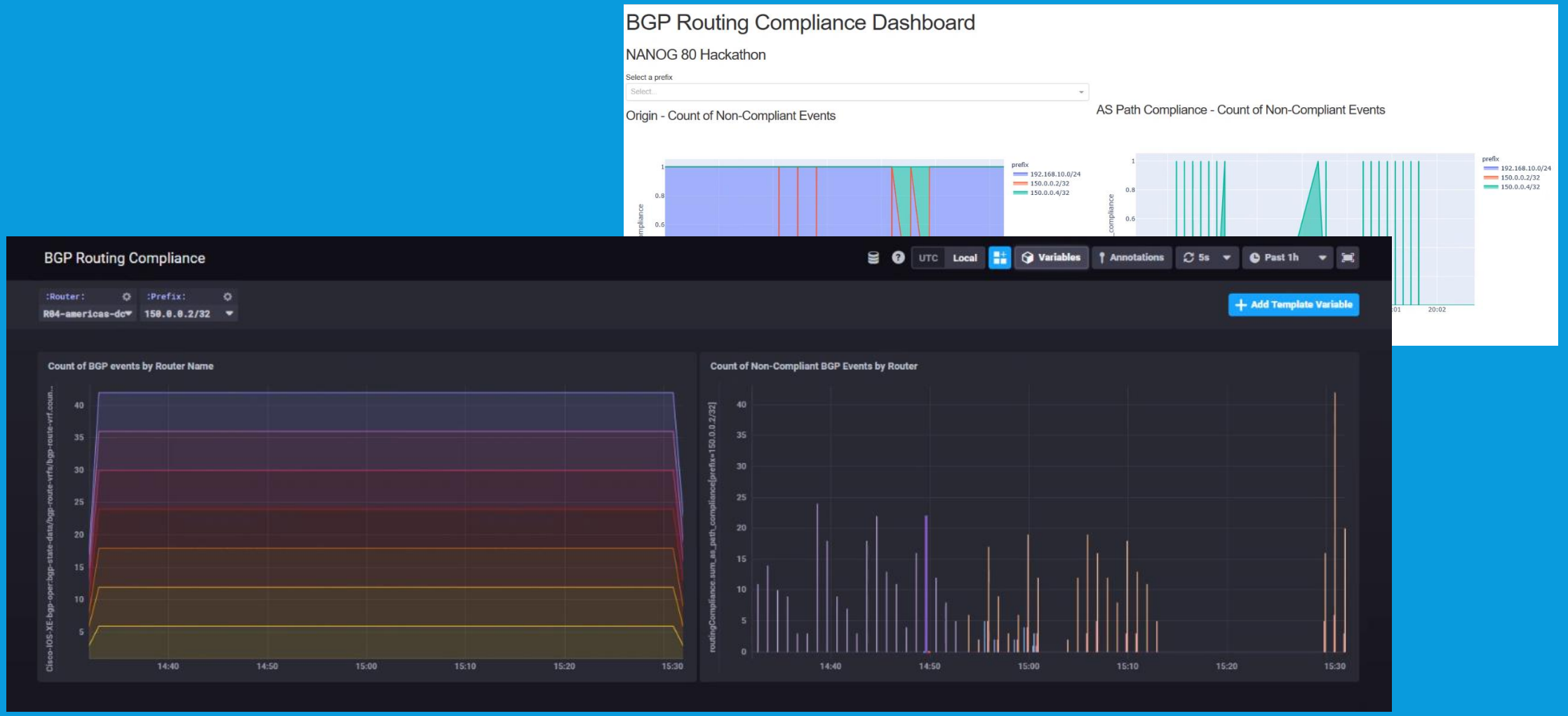
```python
def main(grpc_host):

    hosts = []

    with open("mdt_subscriptions.yml", "r") as f:
        mdt_sub = safe_load(f)

    with open(INVENTORY_FILE, "r") as f:
        inventory = safe_load(f)

    for router in inventory['routers']:
        if inventory['routers'][router]['mdt_bgp']:
            hosts.append(inventory['routers'][router]['ip'])

    for subscription in mdt_sub['subscriptions']:
        mdt_sub['subscriptions'][subscription]['rx']['ip'] = grpc_host
    j2_env = Environment(loader=FileSystemLoader("."), trim_blocks=True, autoescape=True)
    template = j2_env.get_template("templates/mdt_xml.jinja2")
    new_config = template.render(data=mdt_sub)

    for host in hosts:

        connect_params = {
            "host": host,
            "username": USER,
            "password": PWD,
            "hostkey_verify": False,
            "allow_agent": False,
            "look_for_keys": False,
            "device_params": {"name": "csr"},
        }

        with manager.connect(**connect_params) as conn:
            print(f"NETCONF session connected: {host}")

            # Perform the update, and if success, print a message
            config_resp = conn.edit_config(target="running", config=new_config)
            if config_resp.ok:
                print(f"Added ({len(mdt_sub['subscriptions'])}) subscriptions")

        print(f"NETCONF session disconnected: {host}")
```

POLICY EVALUATION

```yaml
# BGP RIB Compliance Policy file for demo lab

root_source: Cisco-IOS-XE-bgp-oper:bgp-state-data/bgp-route-vrfs/bgp-route-vrf
root_path: bgp_route_af/bgp_route_filter/bgp_route_entry/bgp_path_entry/
regions:
    emea:
        - 10.200.49.9       # Bern
        - 10.200.49.10      # Rome
    americas:
        - 10.200.49.5       # Boston
        - 10.200.49.6       # Quito
    external:
        - 10.200.49.4       # Americas DC
        - 10.200.49.8       # Europe DC
policy:
    0.0.0.0/0:                          # Match default route
        match: explicit                 # Match type is explicit. RIB prefix must match 0.0.0.0/0 exactly
        region: americas                # Region to monitor for RIB updates on
        attributes:                     # List of attributes to evaluate and expected values
            community: 100:1            # Community value expected in RIB update
    0.0.0.0/0:                          # Match default route
        match: explicit                 # Match type is explicit. RIB prefix must match 0.0.0.0/0 exactly
        region: emea                    # Region to monitor for RIB updates on
        attributes:                     # List of attributes to evaluate and expected values
            community: 100:2            # Community value expected in RIB update
    192.168.0.0/16:
        match: any                      # any match will include any network prefix that is within the subnet, or the subnet itself
        region: external
        attributes:
            origin: 100
            # community: 100
            as_path: 13979 13979
    150.0.0.0/16:
        match: any
        region: external
        attributes:
            origin: 150
```

```python
def is_in_policy(self, prefix: str) -> str:
    try:
        target_network = IPNetwork(prefix)

        for prefix, policy in self.policies.items():
            parent_network = IPNetwork(prefix)

            if policy['match'] == 'any':
                if target_network in parent_network:
                    print(f"{target_network} in {parent_network}")
                    return str(parent_network)
            elif policy['match'] == 'explicit':
                    if target_network == parent_network:
                        print(f"{target_network} is {parent_network}")
                        return prefix
            else:
                raise NotImplementedError
    except KeyError:
        print("Malformed Policy")

    return None

def evaluate(self) -> bool:
    query = f'SELECT * FROM "{self.source}" WHERE time > now() - 15s'
    print(query)
    results = self.db.query(query)
    for result in results.get_points(self.source):
        prefix_path = 'bgp_route_af/bgp_route_filter/bgp_route_entry/prefix'
        prefix = result[prefix_path]
        print(f"Prefix is {prefix} on source {result['source']}")

        if prefix:
            compliance = {}
            policy_prefix = self.is_in_policy(prefix)
            print(f"Policy prefix: {policy_prefix}")
            print(f"evaluating prefix {prefix} in policy")
            if policy_prefix:
                policy = self.policies[policy_prefix]

                for key, value in policy['attributes'].items():
                    for attr in result:
                        if 'bgp_neighbor' not in attr:
                            if re.search(f"/{key}$", attr):
                                if result[attr] == value:
                                    compliance[f"{key}_compliance"] = 0
```

VISUALIZATION



NANOG 80 HACKATHON

- Aakash Rawal
- Hast Patel
- Mukesh Jaiswal
- Nikhil Gadre
- Swati Niture

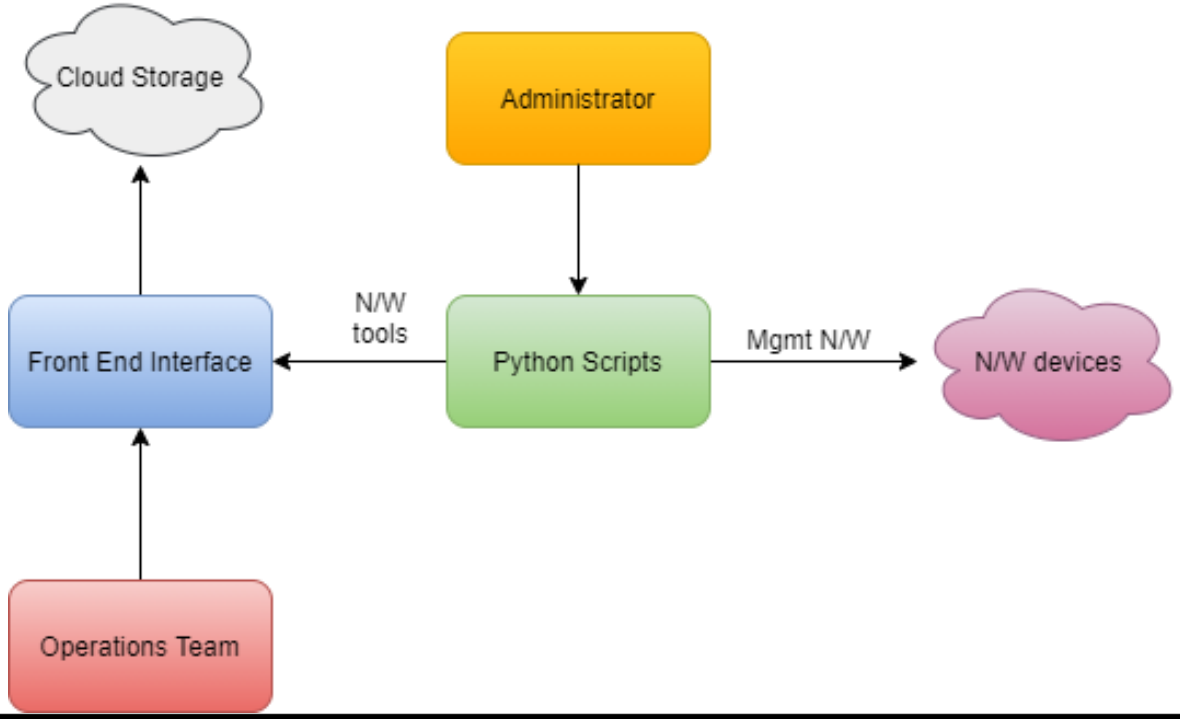
PROPOSAL

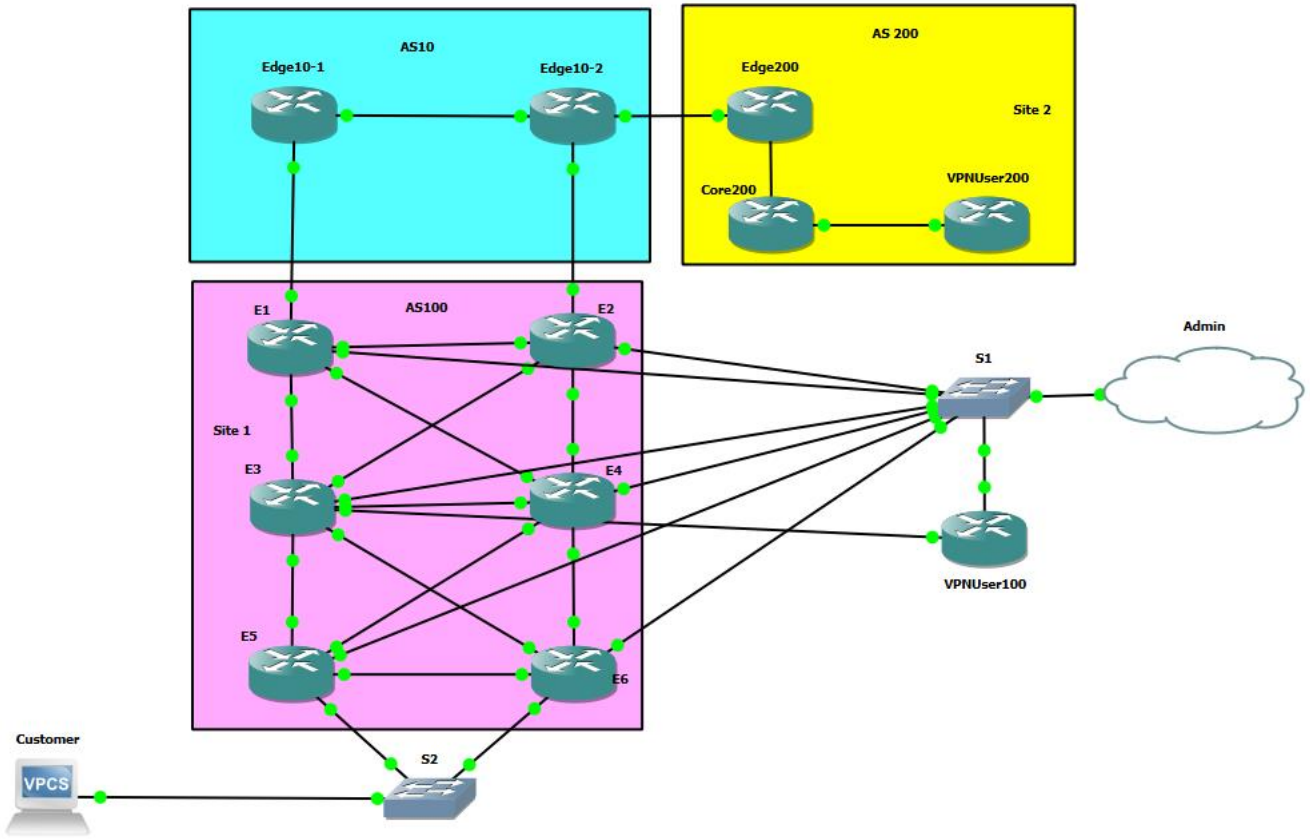
Proof of Concept for a fully automated Tier 2 ISP Data Center – Deployment and Monitoring

What did we achieve ?

- Centralized control and monitoring of the network
- Cost-effectiveness (reduces OpEx)
- One-click configuration and deployment (saves time)
- Reduction in human errors

HIGH-LEVEL DIAGRAM




AS10
Edge10-1
Edge10-2
AS 200
Edge200
Site 2
Core200
VPNUser200
AS100
E1
E2
Site 1
E3
E4
E5
E6
S1
Admin
VPNUser100
Customer
VPCS
S2

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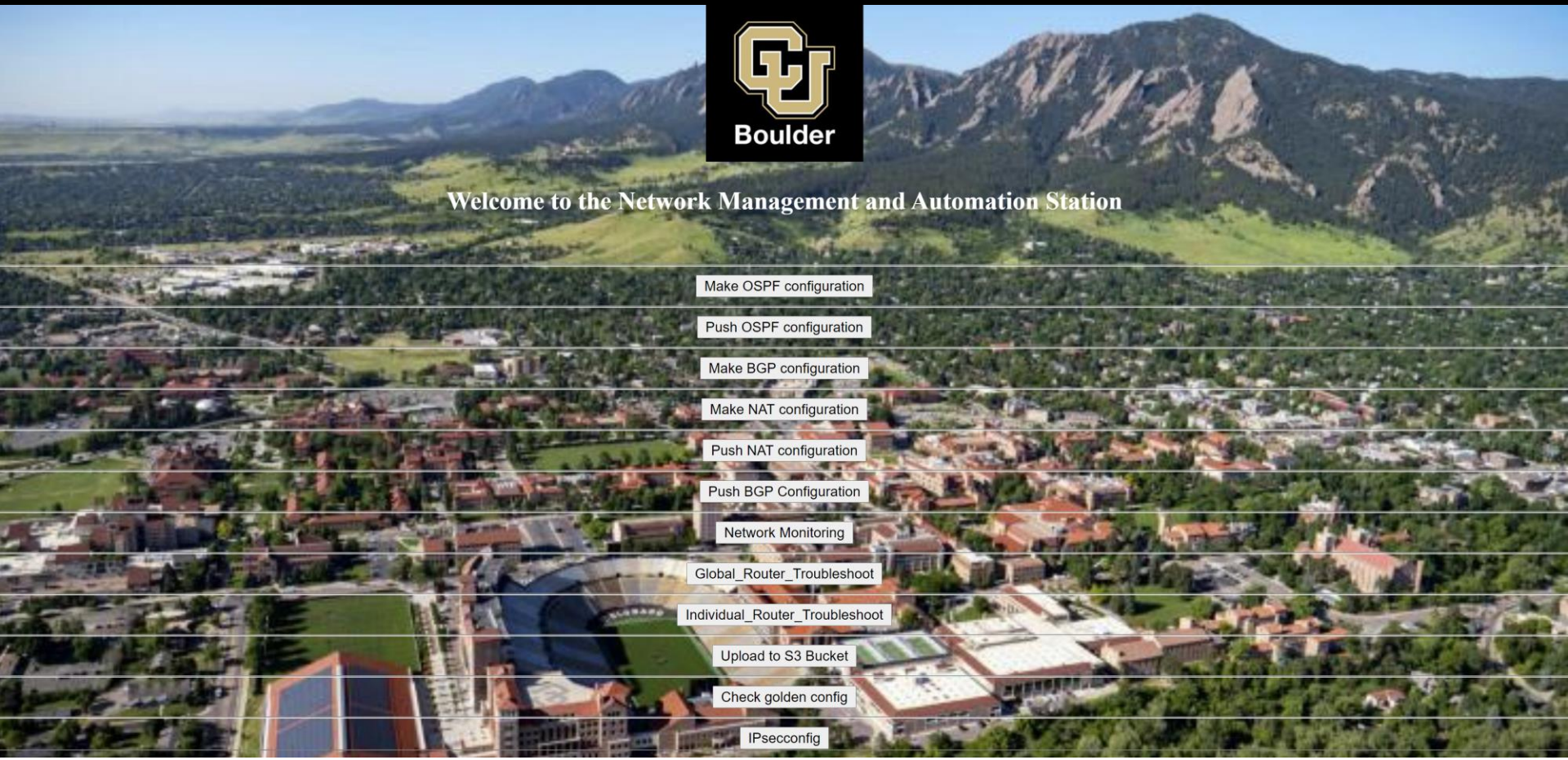

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NETWORK MANAGEMENT AND AUTOMATION SYSTEM (NMAS)

Web App

- Generate Configuration Files
- Push Configuration to Devices
- Monitor Individual Devices and Network
- Compare Running Config to Golden Config
- Backup Configuration to Cloud

GENERATING CONFIG FILES

- Python
- Jinja2 Templates
- Modules
  - Netmiko
  - NAPALM
  - Flask
- Multi-threading

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```
{% for k in natinfo["Interfaceout"] %}
interface {{ k }}
ip nat outside
{% endfor %}

{% for k in natinfo["Interfacein"] %}
int {{ k }}
ip nat inside
{% endfor %}

{% for k in natinfo["accesslist1"] %}
access-list {{ k }}
{% endfor %}

{% set count=namespace(value=1) %}
{% if natinfo["accesslist1"] | length == 1 %}
ip nat inside source list 1 interface {{natinfo["Interfaceout"]
{% else %}
    {% for k in natinfo["Interfaceout"] %}
ip nat inside source list {{count.value}} interface {{k}} overl
    {% set count.value=count.value +1 %}
    {% endfor %}
{% endif %}
```

```
{% for k in ospfinfo["int"] %}
int {{ k }}
ip address {{ ospfinfo["int"][k] }}
no shut
exit
{% endfor %}
{% for j in range((ospfinfo["network"])|length) %}
router ospf {{ ospfinfo["pid"] }}
network {{ ospfinfo["network"][j] }} area {{ ospfinfo["area"] }
exit
{% endfor %}
```

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nat_info.txt - Notepad

File Edit Format View Help

```
{

"R1":
{"Interfaceout":["fa4/1"], "accesslist1": ["1 permit 198.51.0.0
0.0.255.255"], "Interfacein":["fa0/1","fa1/0","f0/0"]},

"R2":
{"Interfaceout":["fa4/1"], "accesslist1": ["1 permit 198.51.0.0
0.0.255.255"], "Interfacein":["fa0/1","fa1/0","f0/0"]},

"R5":
{"Interfaceout":["fa1/1","fa2/0","fa0/0"], "accesslist1": ["1 permit
205.0.0.0 0.0.255.255","2 permit 205.0.0.0 0.0.255.255","3 permit
205.0.0.0 0.0.255.255"], "Interfacein":["fa4/1"]},

"R6":
{"Interfaceout":["fa1/1","fa2/0","fa0/0"], "accesslist1": ["1 permit
205.0.0.0 0.0.255.255","2 permit 205.0.0.0 0.0.255.255","3 permit
205.0.0.0 0.0.255.255"], "Interfacein":["fa4/1"]}

}
```

R6_natconf.txt - Notepad

File Edit Format View Help

```
interface fa1/1
ip nat outside
interface fa2/0
ip nat outside
interface fa0/0
ip nat outside

int fa4/1
ip nat inside

access-list 1 permit 205.0.0.0 0.0.255.255
access-list 2 permit 205.0.0.0 0.0.255.255
access-list 3 permit 205.0.0.0 0.0.255.255

ip nat inside source list 1 interface fa1/1 overload
ip nat inside source list 2 interface fa2/0 overload
ip nat inside source list 3 interface fa0/0 overload
```

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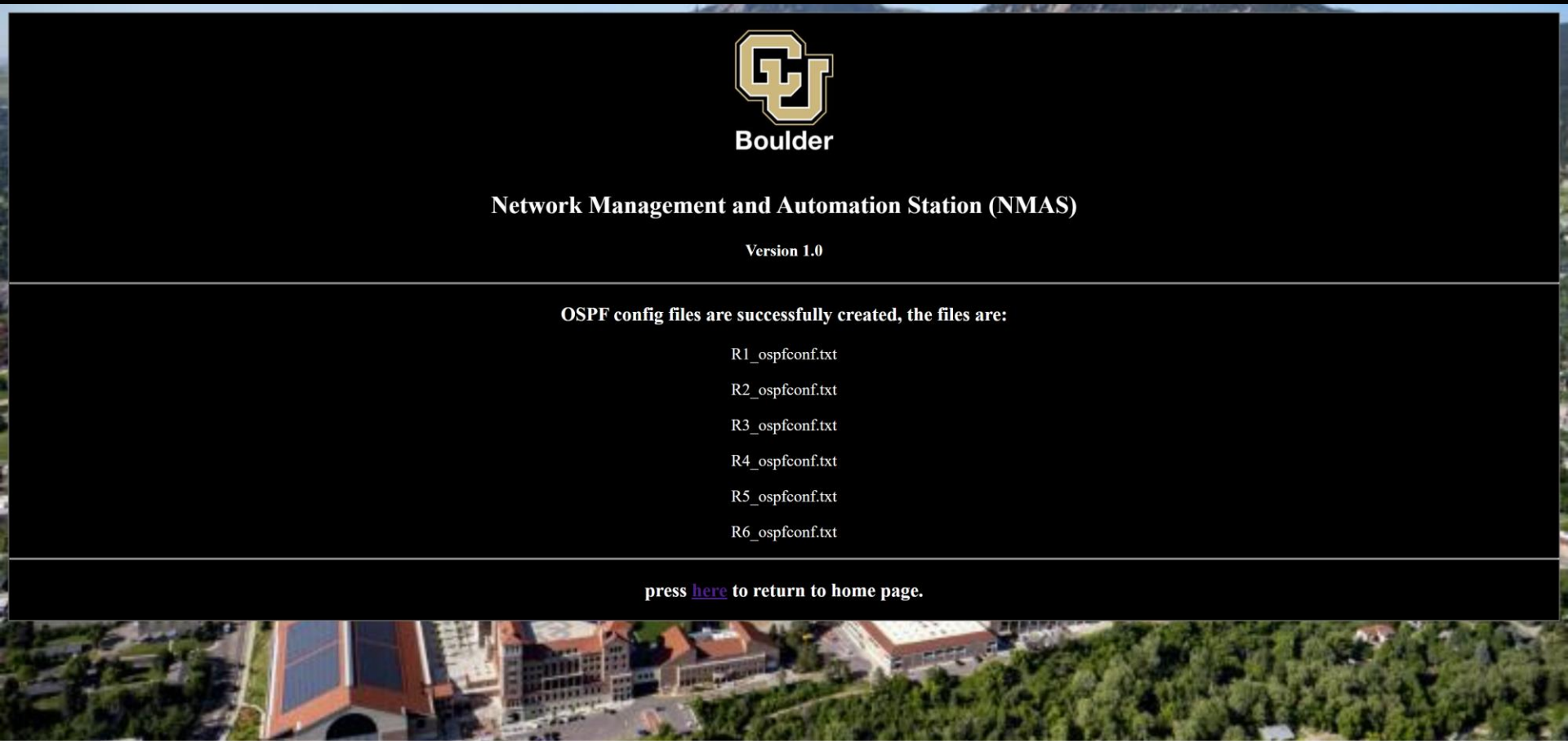

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Network Management and Automation Station (NMAS)

Version 1.0

OSPF config files are successfully created, the files are:

R1_ospfconf.txt

R2_ospfconf.txt

R3_ospfconf.txt

R4_ospfconf.txt

R5_ospfconf.txt

R6_ospfconf.txt

press here to return to home page.

PUSH CONFIGS TO DEVICES

Netmiko, Napalm

- Interface Configs
- OSPF
- NAT
- BGP
- IPSec
- 6to4 Tunneling

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Network Management and Automation Station (NMAS)

Version 1.0

OSPF files are successfully loaded into routers, press here to return to home page.

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Local tunnel ep	Remote tunnel ep	No. of encrypted pkts	No. of decrypted pkts	Tunnel status
70.70.70.1	60.0.0.2	8	8	ACTIVE

Type escape sequence to abort. Sending 5, 100-byte ICMP Echos to 2001::3, timeout is 2 seconds: Packet sent with a source address of 2001::1 !!!!! Success rate is 100 percent (5/5), round-trip min/avg/max = 200/300/504 ms

MONITOR INDIVIDUAL DEVICES

- Device Interfaces
  - IP / Status
- OSPF Neighborship
- BGP Neighborship
- View Running Config
- Show Commands

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Network Management and Automation Station (NMAS)

Version 1.0

Interfaces IPs

BGP data

OSPF data

Running configs

press here to return to home page.

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Network Management and Automation Station (NMAS)

Version 1.0

Router	Interface	IP
R1	FastEthernet0/0	198.51.101.1
R1	FastEthernet0/1	198.51.103.1
R1	FastEthernet1/0	198.51.102.1
R1	FastEthernet1/1	unassigned
R1	FastEthernet4/0	192.168.100.1
R1	FastEthernet4/1	200.0.0.1
R2	FastEthernet0/0	198.51.101.2
R2	FastEthernet0/1	198.51.105.2
R2	FastEthernet1/0	198.51.104.2

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Network Management and Automation Station (NMAS)

Version 1.0

Enter show command

show ip bgp | Submit

- show running-config
- debug ip bgp
- show ip interface brief
- show ip bgp
- show ip route
- show running-config

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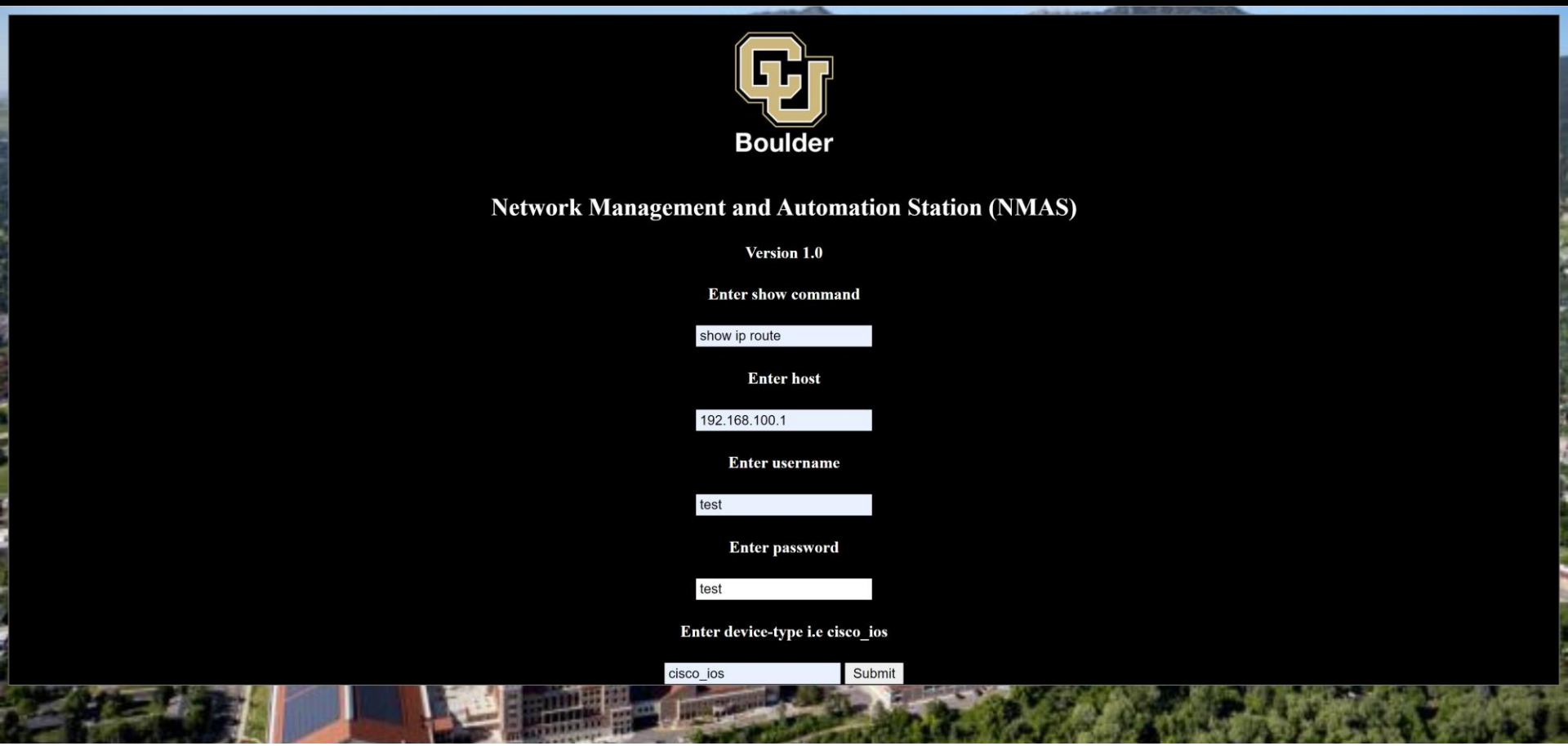

COMPARE RUNNING CONFIG TO GOLDEN CONFIG

- Backup Running Config
- Compare
  - Latest Backed Up Running Config
  - Golden Config
- Show Difference

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['Difference found for R1', 'Difference found for R2', 'Difference found for R3', 'Difference not found for R4', 'Difference found for R5', 'Difference found for R6', 'Difference not found for R12']

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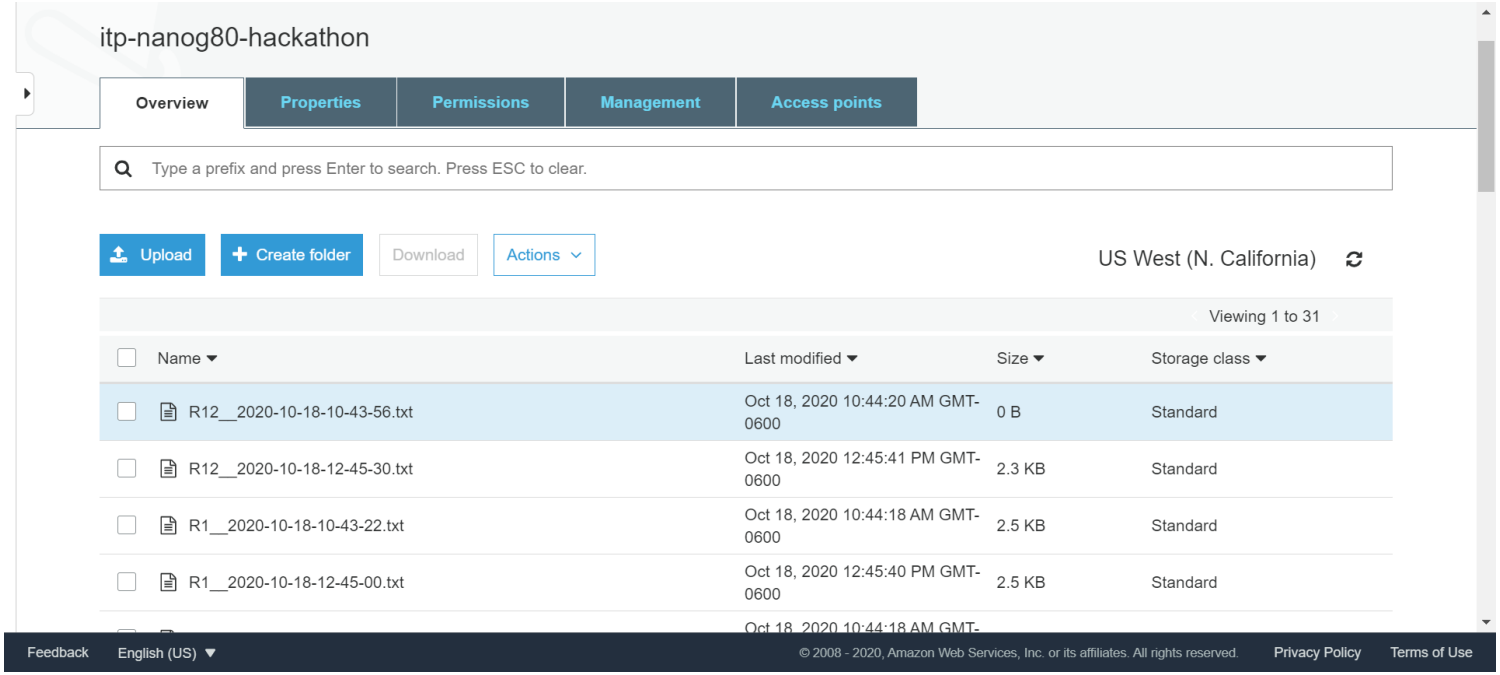
BACKUP CONFIG FILES TO CLOUD



FUTURE ENHANCEMENTS

- Zero Touch Provisioning (ZTP) – Management Network
- Automated Device Backups – Cron Job
- Security
  - Firewall
  - Access-lists
- Redundancy
  - For Default Gateway

THANK YOU

A Simple, Automated and Easy to Deploy SDN Solution

Roni Mukherjee

MS, Telecommunications 2019-21, CU Boulder

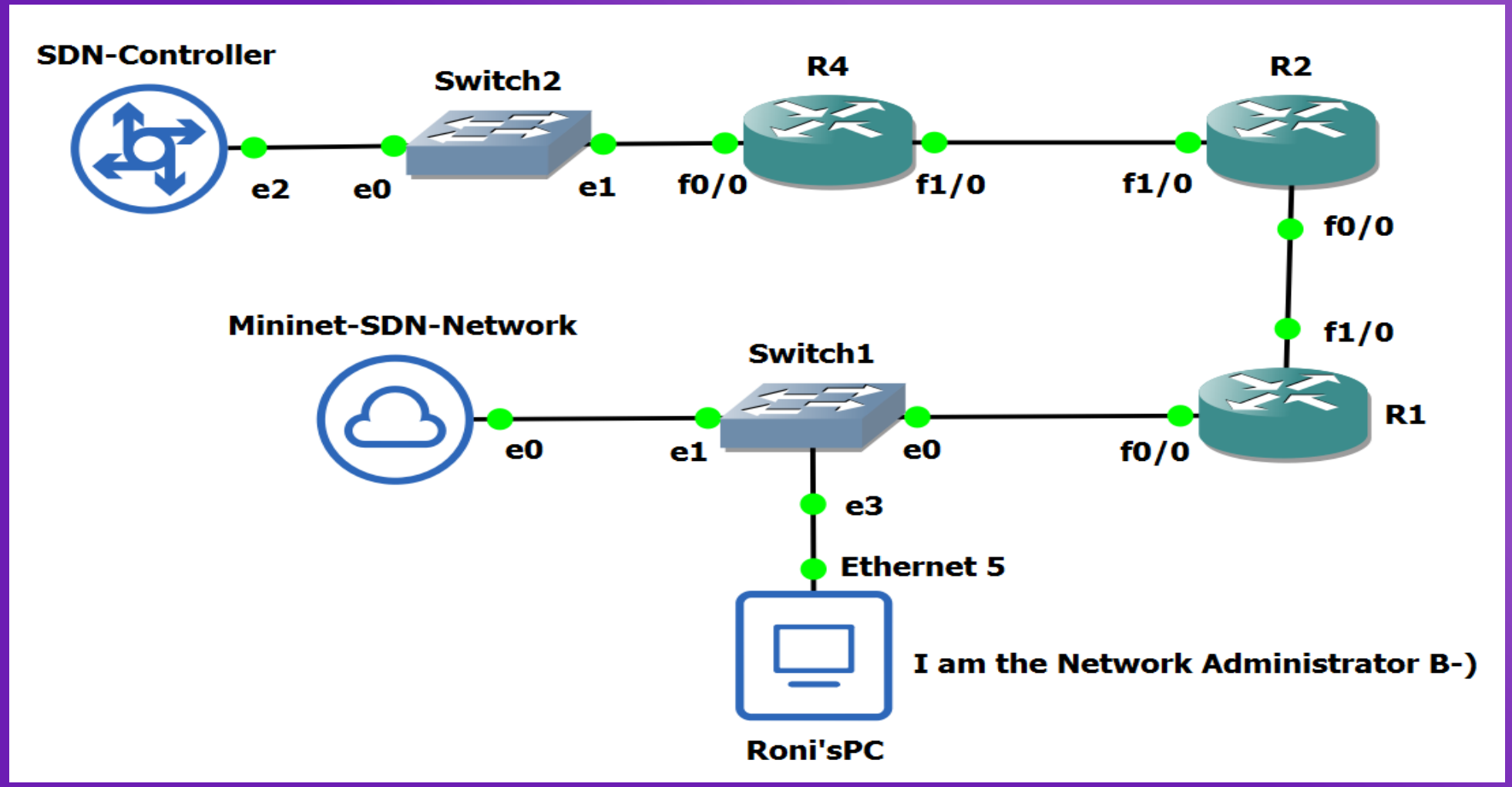
Why SDN?

- Reduced CapEx: Simple device – move control away from devices
- Reduced OpEx: Simplified network monitoring – automation
- Build your solution
- Faster troubleshooting

Hybrid Network

- Combination of SDN and Traditional Routing and Switching Networks
- No need to change traditional network
- SDN network is spun up to join the network
- Based on the implementation, SDN Controller can be anywhere in the network
  - Only, IP connectivity is required to establish a TCP/TLS connection between the SDN switch (s) and the controller (s)

Hybrid Network – Proof of Concept



Automated SDN Deployment

- Mininet boots up, gets DHCP address, routing enabled, controller configured – Automated

```
PS C:\MyCanvas\NANOG80_hackathon\submission> python .\sdn_network_spinup.py
********* The IP leased to Mininet VM is: 192.168.100.2


********* Routing enabled on: ios_r1
********* Routing enabled on: ios_r2
********* Routing enabled on: ios_r4


******** OpenFlow version changed to --> 1.3

******** Controller configured!
******** Controller connected!
PS C:\MyCanvas\NANOG80_hackathon\submission>
```

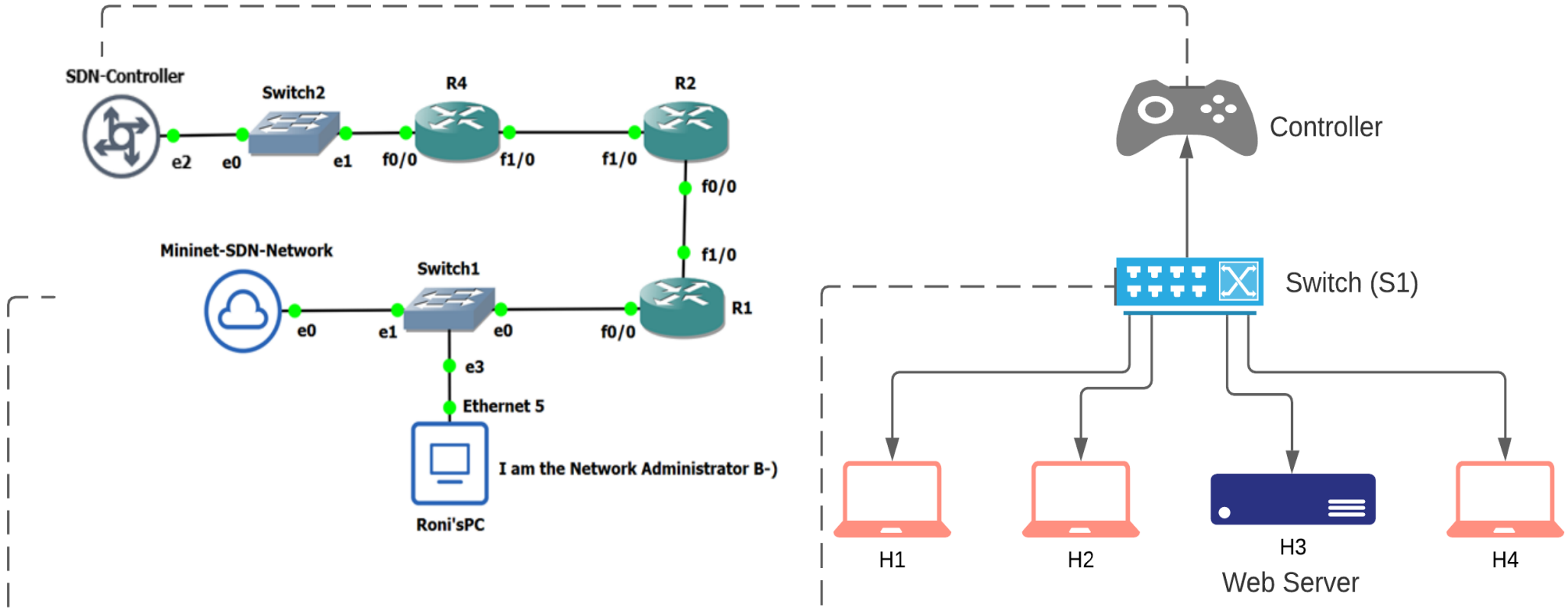
Advantages of the proposed solution

- Easy to deploy – Automated script (boot up/routing/monitoring)
- SDN – Centralized control, global view, reduced CapEx and OpEx
- API – Use of APIs make it faster and human readable
- No need to change existing network
- Reuse SDN multipurpose simple devices
- GUI: Greatly increased troubleshooting efficiency

SDN GUI – Reusable/Extendable Global View

- Purpose-built for the proposed network
- Web Application Console logs
- Web GUI
- Real-time graphical plots of the network (auto-refresh every 5 seconds)
- Greatly reduced troubleshooting steps – match on 40 fields and create own flow

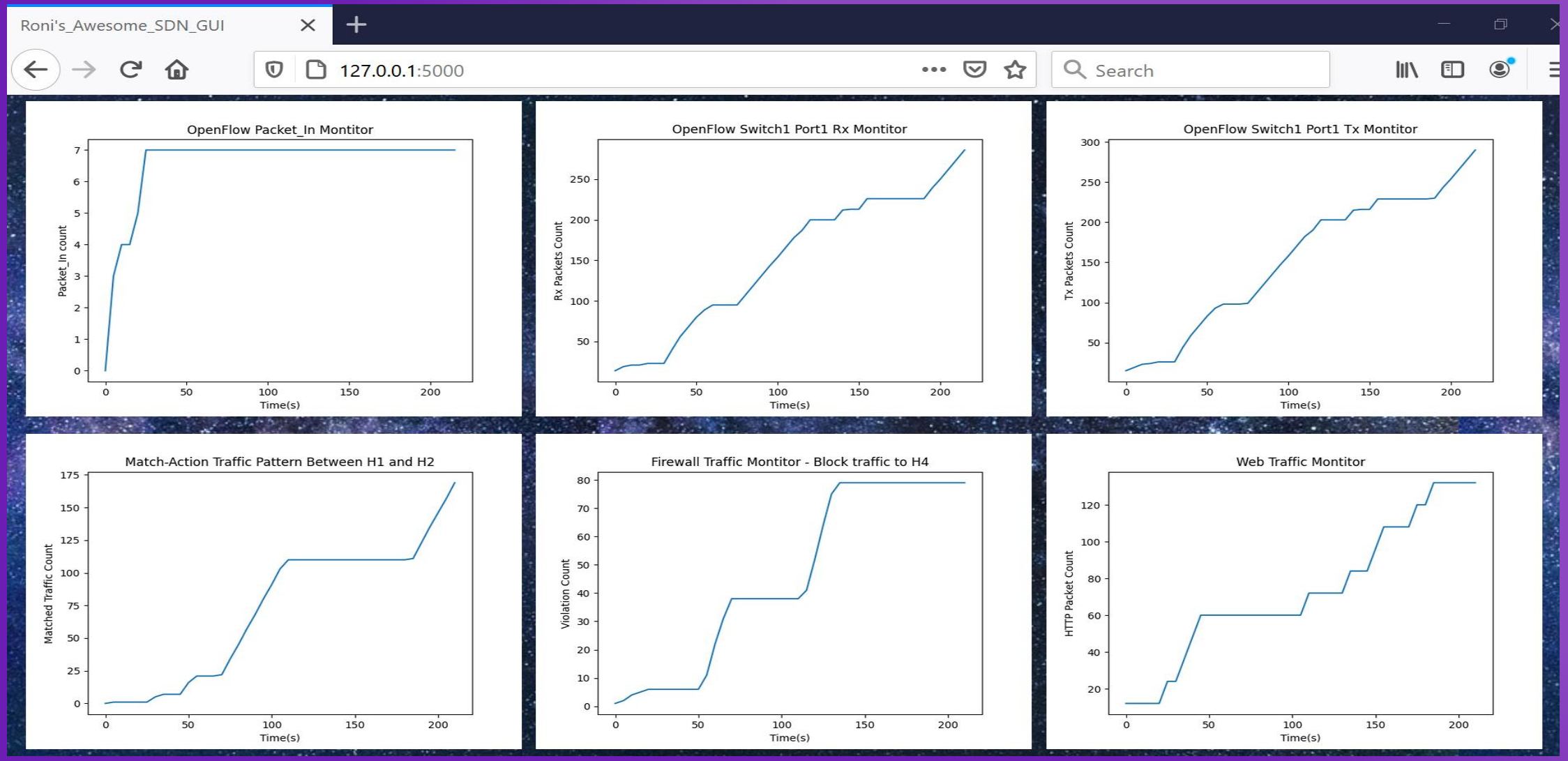
SDN Topology



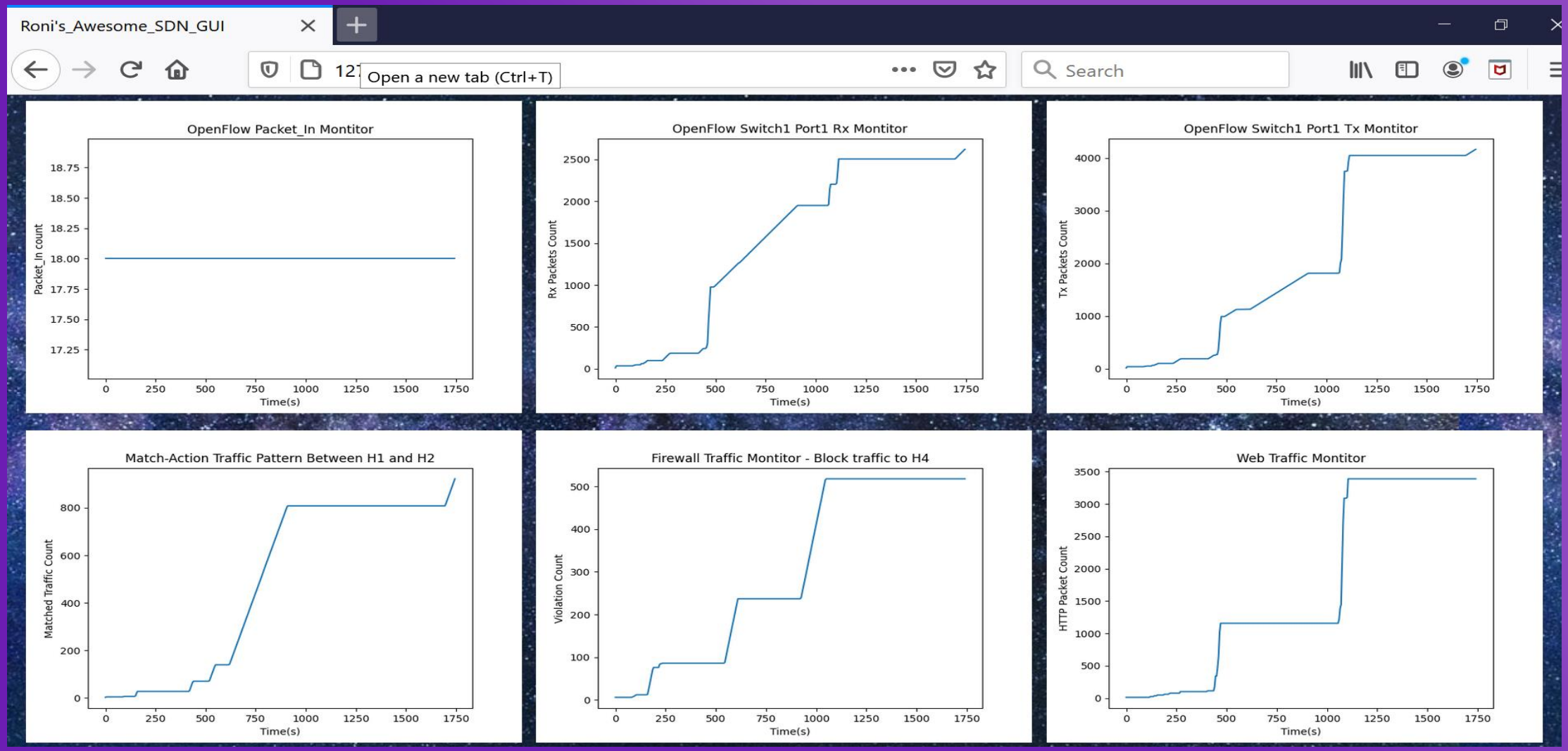
SDN GUI – Console Logs

```
PS C:\MyCanvas\NANOG80_hackathon\submission> python .\sdn_gui.py
******** SDN GUI running
 * Serving Flask app "sdn_gui" (lazy loading)
 * Environment: production
   WARNING: This is a development server. Do not use it in a production deployment.
   Use a production WSGI server instead.
 * Debug mode: on
 * Restarting with stat
******** SDN GUI running
 * Debugger is active!
 * Debugger PIN: 123-884-149
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
Number of Packet_INs to controller in this iteration is: 3
Number of Rx packets of port1 of switch1 in this iteration is: 31
Number of Tx packets of port1 of switch1 in this iteration is: 31
Number of matched traffic pattern sourced from H1 and destined to H2 in this iteration is: 0
Number of violation count for the block traffic flow rule to H4 in this iteration is: 1
Number of HTTP packets at switch1 in this iteration is: 24
127.0.0.1 - - [17/Oct/2020 23:15:10] "GET / HTTP/1.1" 200 -
127.0.0.1 - - [17/Oct/2020 23:15:10] "GET /static/img/1.jpg HTTP/1.1" 304 -
Number of Packet_INs to controller in this iteration is: 4
Number of Rx packets of port1 of switch1 in this iteration is: 33
Number of Tx packets of port1 of switch1 in this iteration is: 35
Number of matched traffic pattern sourced from H1 and destined to H2 in this iteration is: 1
Number of violation count for the block traffic flow rule to H4 in this iteration is: 3
Number of HTTP packets at switch1 in this iteration is: 24
127.0.0.1 - - [17/Oct/2020 23:15:22] "GET / HTTP/1.1" 200 -
127.0.0.1 - - [17/Oct/2020 23:15:22] "GET /static/img/1.jpg HTTP/1.1" 304 -
```

SDN GUI – Web GUI

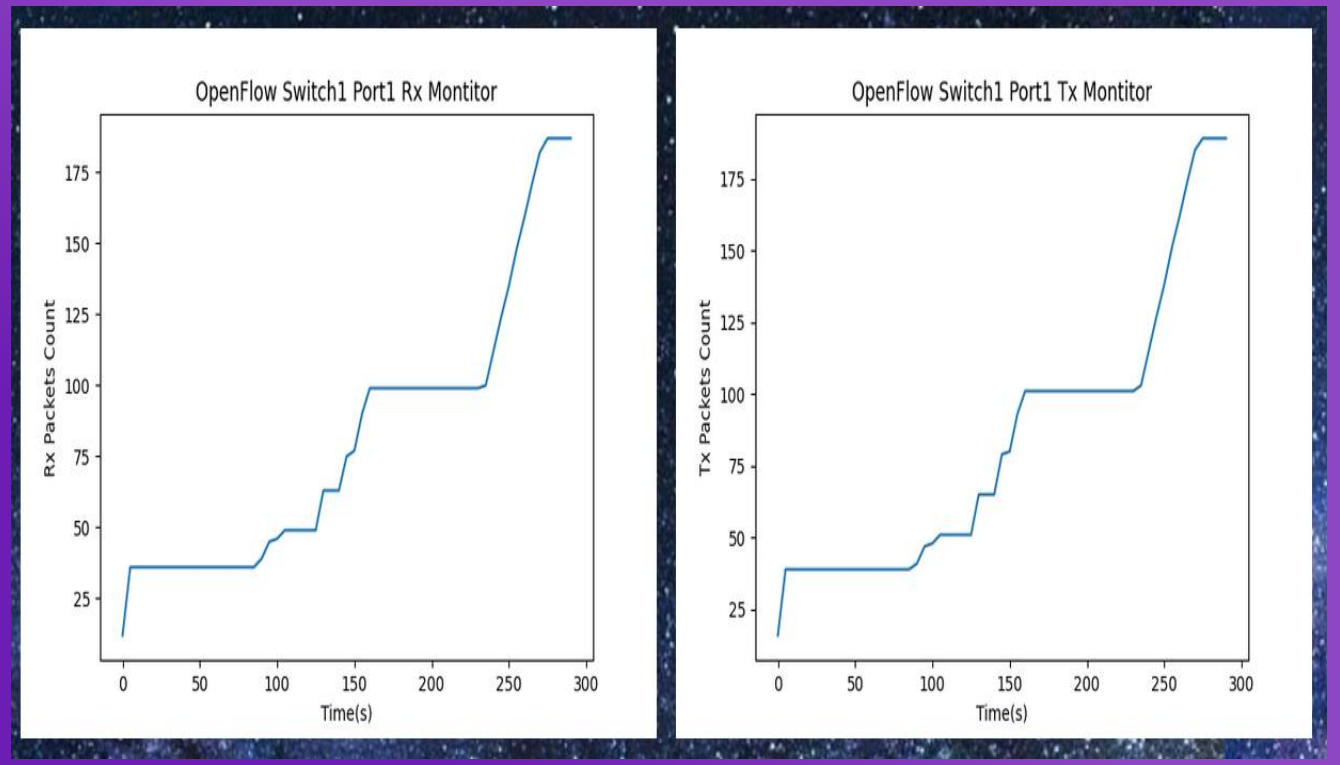


SDN GUI – Web GUI



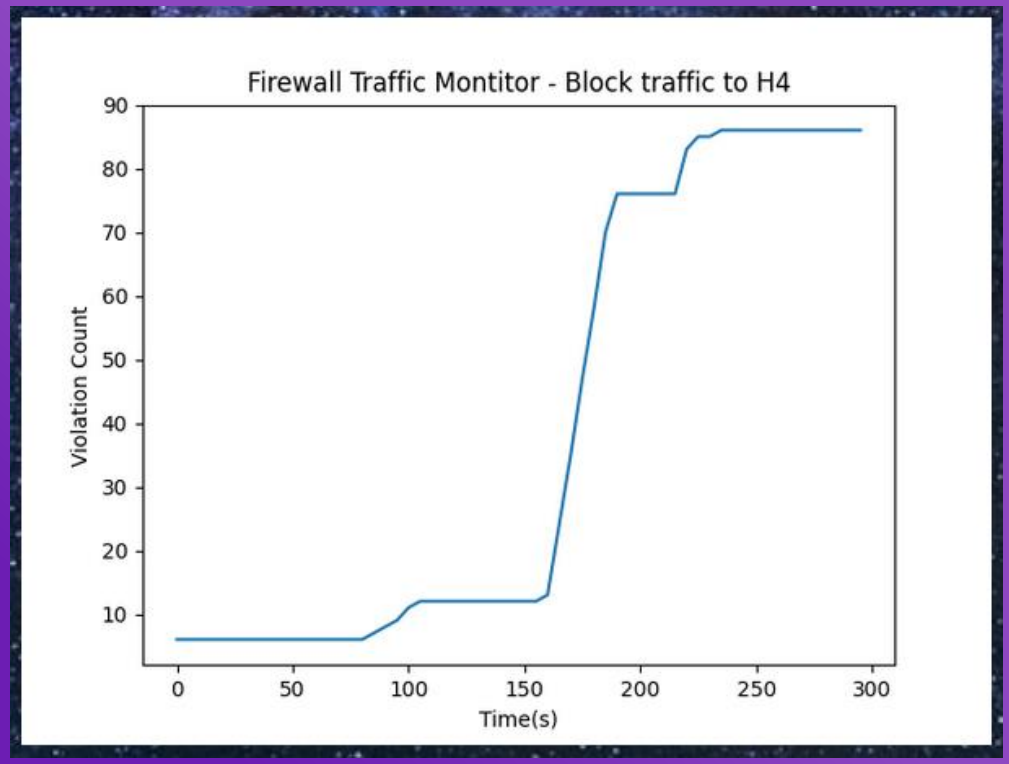
SDN Web GUI – Switch Tx/Rx Monitor

- Tx/Rx traffic has a similar pattern.
- If there is a significant difference between Tx/Rx traffic, captured on graph and an email is sent to the administrator for immediate action.
- Graph is plotted against real-time data and refreshed every 5 seconds.



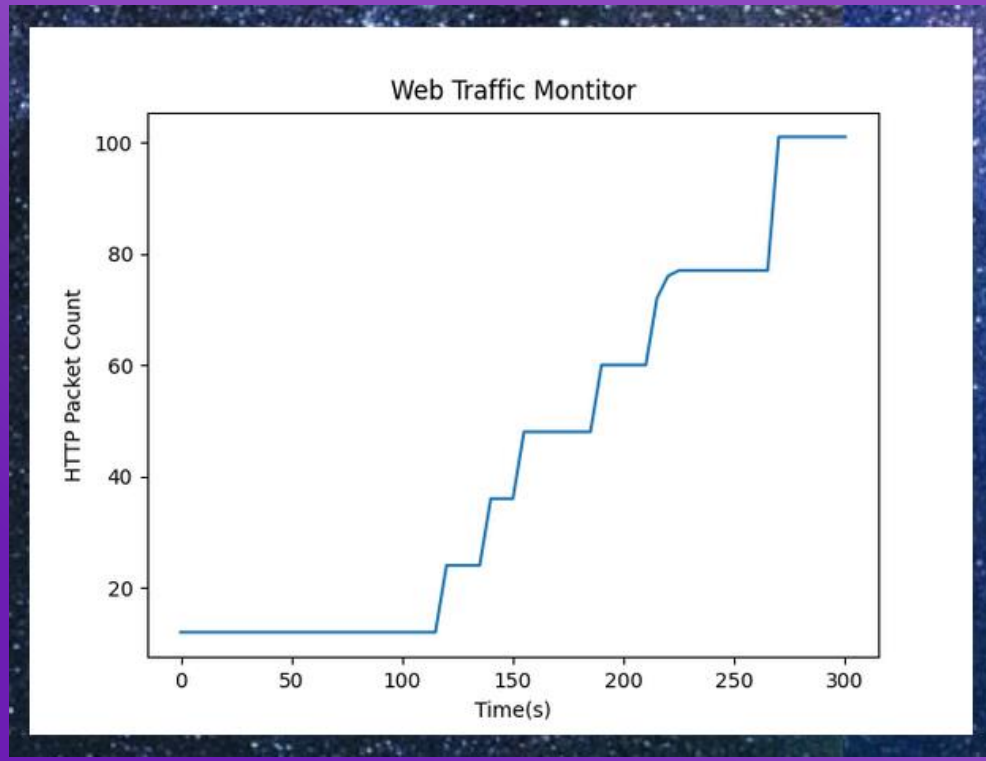
SDN Web GUI – Firewall Monitor

- Custom firewall rule is created.
- If there is a significant increase in violation count, captured on graph and email is sent to administrator for immediate action.
- Graph is plotted against real-time data and refreshed every 5 seconds.



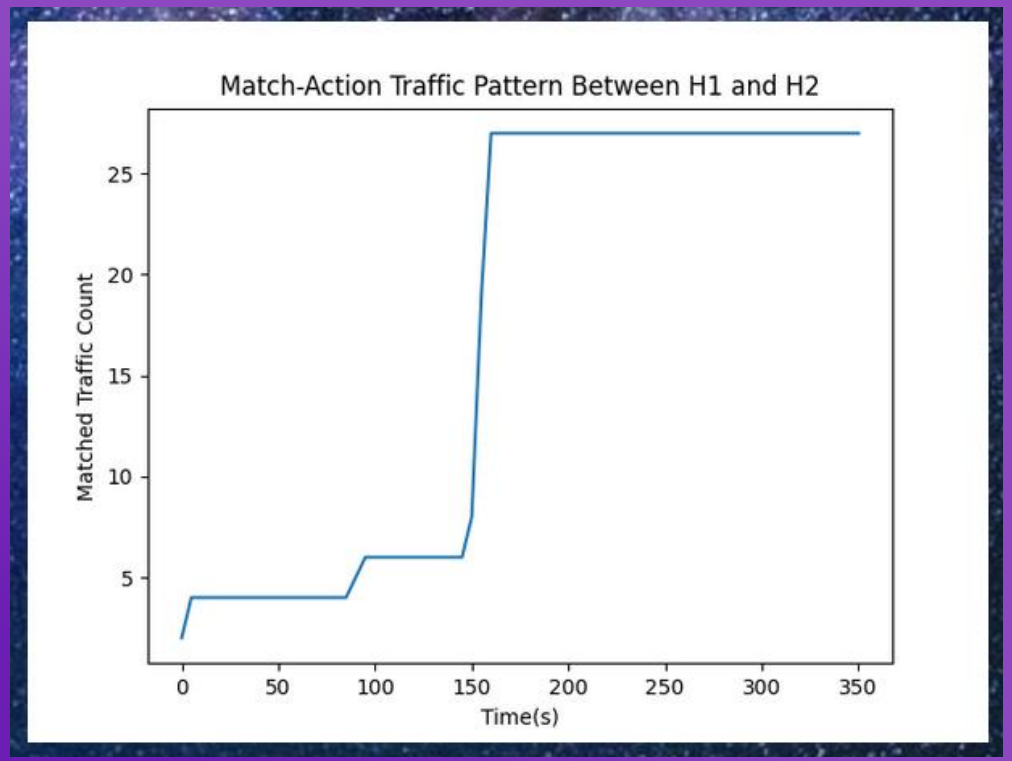
SDN Web GUI – Web Traffic Monitor

- One of the host is web server and serving HTTP requests.
- This is a critical service.
- If there is a significant change in traffic pattern, captured on graph and an email is sent to the administrator for immediate action.
- Graph is plotted against real-time data and refreshed every 5 seconds.



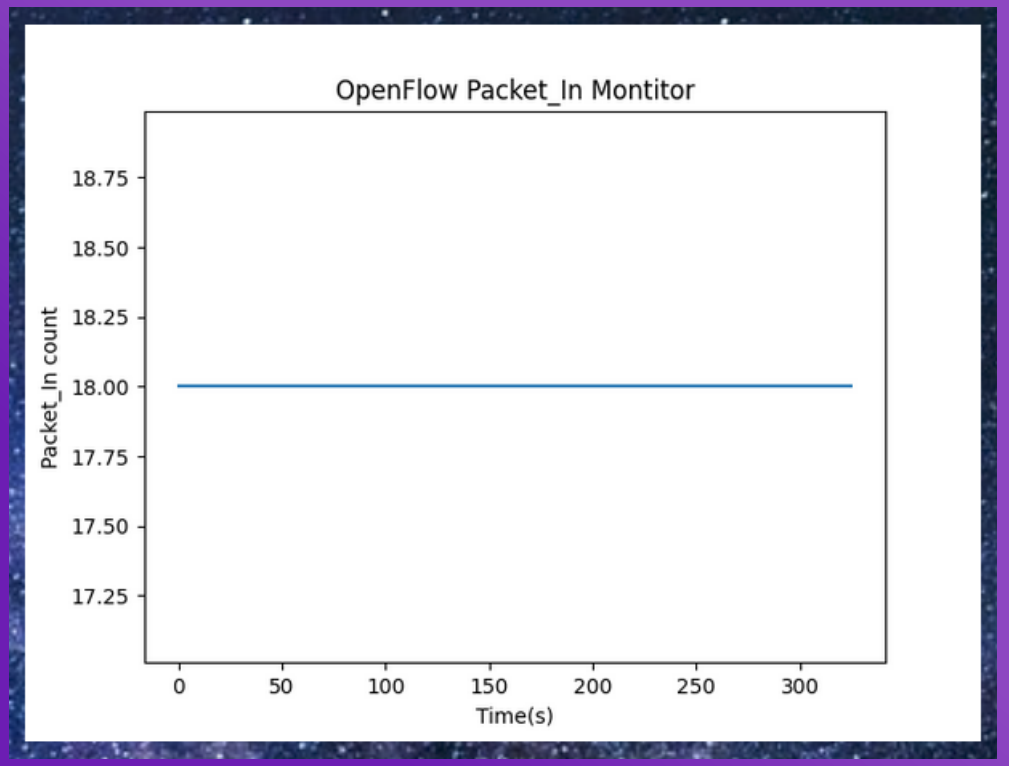
SDN Web GUI – Pattern Traffic Monitor

- Custom match is created for traffic pattern, e.g. traffic sourced from MAC address of H1 and destined to MAC address of H2.
- This is considered as critical service.
- If there is a significant change in traffic pattern, captured on graph and an email is sent to the administrator for immediate action.
- Graph is plotted against real-time data and refreshed every 5 seconds.

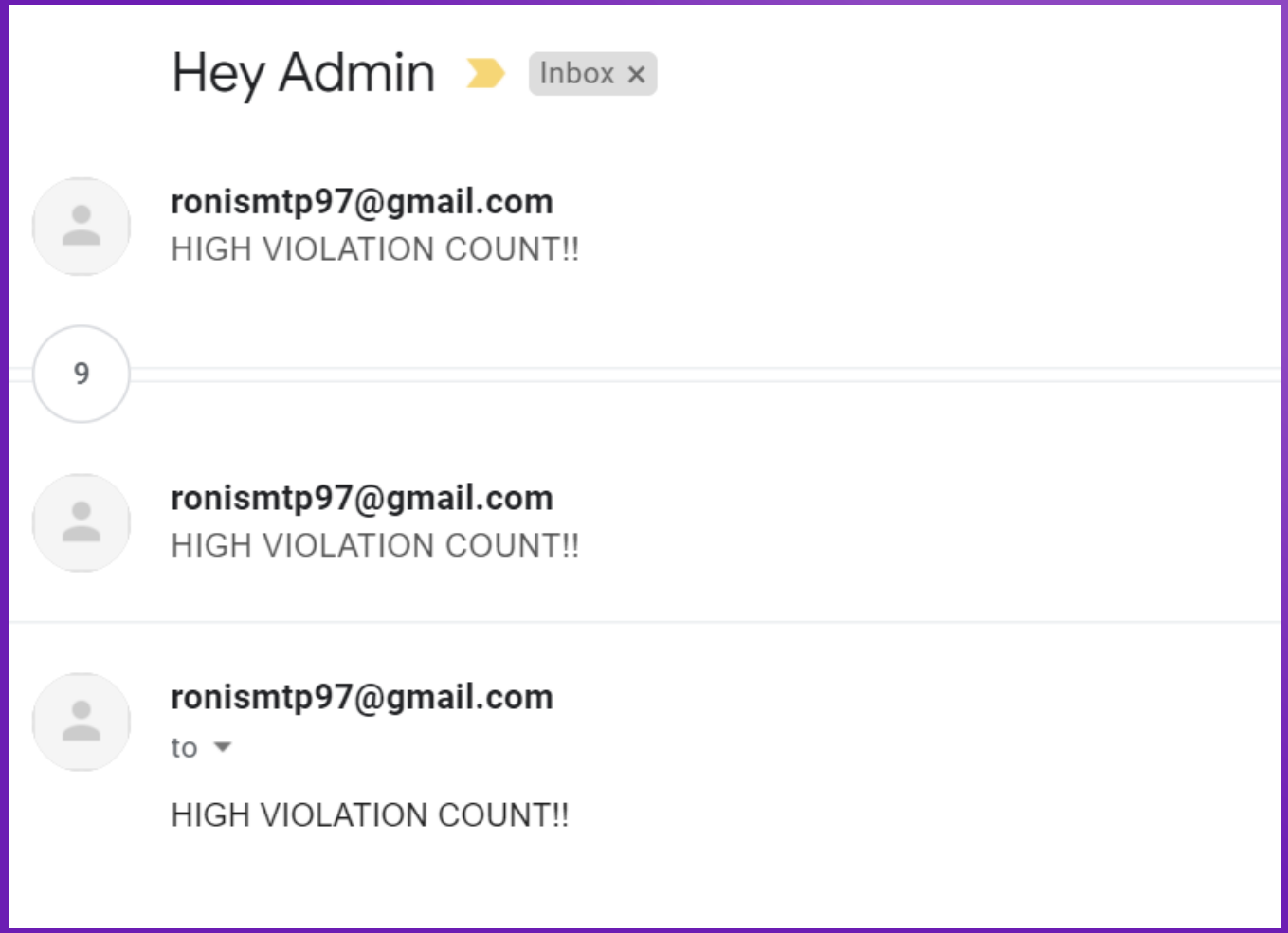


SDN Web GUI – OpenFlow Packet_In Monitor

- Traffic from switch to controller.
- This is the traffic that matches table-miss.
- Graph is plotted against real-time data and refreshed every 5 seconds.



SDN Web GUI – Violation email



Tools used

- GNS3
- Cisco IOS routers
- Mininet
- Ryu SDN controller
- Ubuntu VMs
- VirtualBox
- Flask
- HTML/CSS
- Netmiko
- NETCONF
- Python
- Wireshark

Conclusion

- Custom flow rules using any match criteria (from 40 different fields)
- Graphical representation – significantly increased troubleshooting efficiency
- Hybrid Network
  - Reduced CapEx: Simple device, reusability
  - Reduced OpEx: Significantly improved network monitoring and troubleshooting through automation
- Automated deployment of the Hybrid-SDN solution

GitHub

- https://github.com/rm-viable/NANOG80-hackathon

Questions