

Network Automation with Python

The networking industry is telling us all that we need to learn Python, programmability, and network automation. But for most of us using the CLI nothing has changed, and we are thinking what is all the fuss about? Using Python for Network Automation is a skill that all network engineers need to be developing. This lab will walk you through several different scenarios using Python to automate your network. This is a precursor to using Ansible or Nornir.

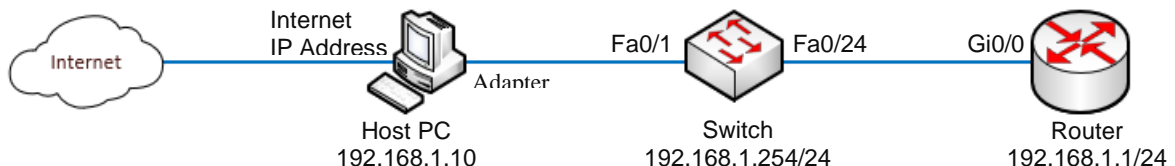
Equipment

- One Windows 10 PC with two network adapters (one Internet connections; one LAN connection)
- One 2960 Switch running IOS 12 or higher (SSH capable)
- One 1841, 1941, 4000 series or later Router running IOS 12.4 or higher (SSH capable)
- Two Straight-thru cables
- One Rollover cable for initial configuration

Software

- Windows Subsystem for Linux enabled in Windows Programs and Features
- Windows Terminal app (install from Windows Store)
- Ubuntu (install from Windows Store)
- Python3 (latest version)
- PiP3 (latest version)
- Git (latest version)
- Netmiko (latest version)
- Visual Studio Code (any text editor like Nano) to edit Python code
- Django web server (latest version)
- json2html

Topology



Netmiko common connection methods:

- `send_command()` - Send command to a device and return output back (pattern based)
- `send_config_set()` - Send configuration commands to remote device
- `send_config_from_file()` - Send configuration commands loaded from a file
- `enable()` - Enter enable mode
- `find_prompt()` - Return the current router prompt
- `save_config()` - Save the running-config to the startup-config
- `disconnect()` - Close the connection
- `send_command_expect()` - Wait for a command to finish (timing based)
- `send_command_timing()` - Send commands to a device and return output back (timing based)
- `commit()` - Execute a commit action on IOS-XR
- `check_config_mode()` - Check config mode status
- `check_enable_mode()` - Check
- `exit_config_mode()` - Exit Global Configuration
- `exit_enable_mode()` - Exit Privileged mode

Netmiko connection setup methods:

- **device_type** – Types of Cisco device software (cisco_ios, cisco_ios_telnet, cisco_asa, cisco_ios-xe, cisco_ios-xr, cisco_nx-os)
- **ip** – IP address of the Router or Switch (**host** is interchangeable)
- **username** – account name (if configured)
- **password** – account login password
- **port** – telnet: 23 or SSH: 22 (configured by default)
- **protocol** – telnet or SSH (default)
- **secret** – Privileged mode password (if configured)
- **command** – Configuration commands

Part 1: Basic Switch and Router Configuration

1. You should have two interfaces. One to the internet and one to the practice network. Configure the practice network adaptor with the information below:

Host PC

IP address: **192.168.1.10**

SM: **255.255.255.0**

DG: **192.168.1.1**

2. From the Ubuntu terminal, check the IP configuration (**ip address**).
3. Each network device needs a basic configuration before starting to gain access over the network. Using a rollover cable and your preferred terminal app (PuTTY, HyperTerminal), configure a basic router and switch with SSH capabilities:

Note: Only configure these settings (interfaces may vary).

Router

```
enable
configure terminal
hostname R1
enable secret class
username admin password cisco
ip domain name netauto.com
crypto key generate rsa
1024
ip ssh version 2
interface GigabitEthernet0/0
ip address 192.168.1.1 255.255.255.0
no shutdown
exit
line con 0
login local
line vty 0
login local
transport input ssh
end
terminal length 0
copy run start
```

Switch

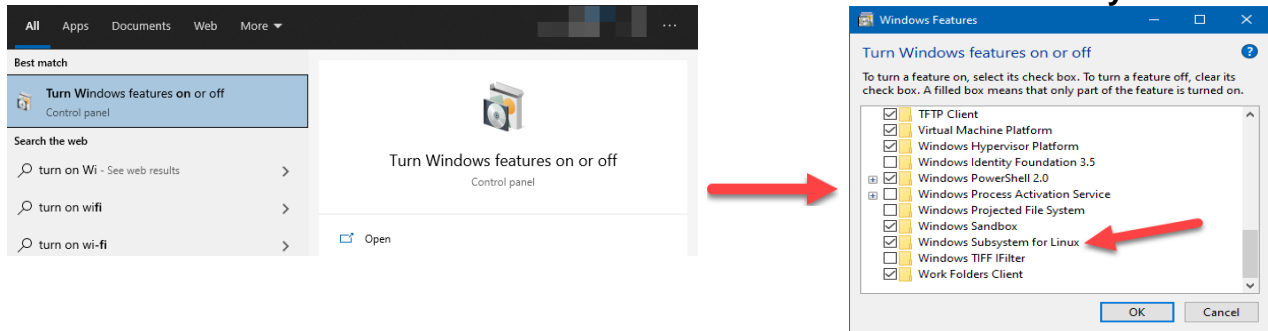
```
enable
configure terminal
hostname S1
enable secret class
username admin password cisco
ip domain-name netauto.com
crypto key generate rsa
1024
ip ssh version 2
interface vlan 1
ip address 192.168.1.254 255.255.255.0
no shutdown
exit
ip default-gateway 192.168.1.1
line con 0
login local
line vty 0
login local
transport input ssh
end
terminal length 0
copy run start
```

4. Be sure you can ping between all devices. Troubleshoot as needed.

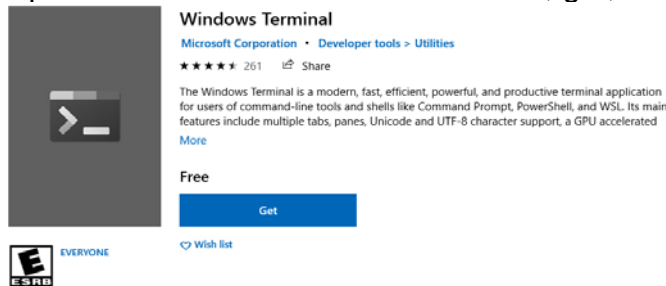
Part 2: Install Applications

1. Install Windows Subsystem for Linux:

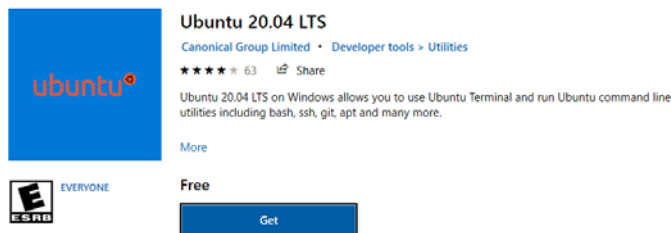
Search for **Turn Windows Features on and off** and turn on **Windows Subsystems for Linux**



2. Open the **Microsoft Store**. Search for, get, install, and launch **Windows Terminal**:



3. Open the **Microsoft Store**. Search for, get, install, and launch **Ubuntu**:



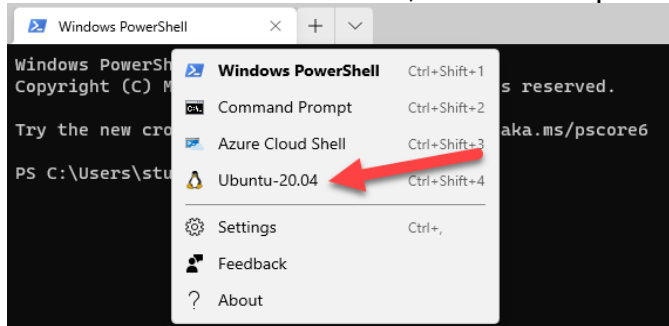
4. After Ubuntu is installed, configure the username as **cisco** and the password as **cisco**.

5. Close Ubuntu.

6. Open the Windows Terminal:

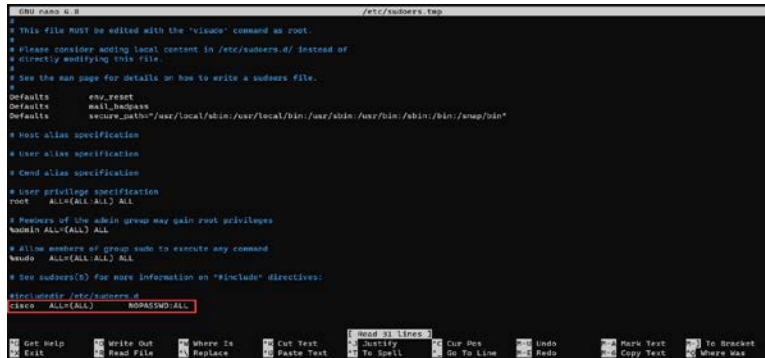
Start > **Windows Terminal** or run > **wt**

7. From the Windows Terminal, click the dropdown and select **Ubuntu**



8. Remove the requirement to enter a password for sudo. Open the `/etc/sudoers` file and at the end of the file add this line:

```
sudo visudo
cisco    ALL=(ALL) NOPASSWD:ALL
```



```
#!/usr/sbin/sudoedit
# This file MUST be edited with the 'visudo' command as root.
#
# Please consider using local content in /etc/sudoers.d/ instead of
# directly modifying this file.
# See the man page for details on how to write a sudoers file.
#
Defaults    env_reset
Defaults    mail_badpass
Defaults    secure_path="/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin"

# Host alias specification

# User alias specification

# Cmnd alias specification

# User privilege specification
root    ALL=(ALL) ALL

# Members of the sudo group may gain root privileges
%sudo    ALL=(ALL) ALL

# Allow members of group sudo to execute any command
sudo    ALL=(ALL) ALL

# See sudoers(5) for more information on "include" directives:

@include::etc/sudoers.d
cisco    ALL=ALL
```

9. Save, Close, and reopen Windows Terminal.

10. Add user to the sudo group:

```
sudo usermod -aG sudo cisco
```

11. Check the user was added to the group:

```
grep '^sudo' /etc/group
```

```
sudo:x:27:cisco
```

12. Update Ubuntu:

```
sudo apt update && sudo apt full-upgrade -y
```

13. Check Python and PIP versions:

```
python3 --version
```

```
Python 3.8.5
```

```
pip3 --version
```

```
pip 20.0.2 from /usr/local/lib/python3.8/dist-packages/pip (python 3.8)
```

14. If needed, install Python:

```
sudo apt install python3 -y
```

15. If needed, install PiP3:

```
sudo apt install python3-pip -y
```

16. Check Netmiko and PyInstaller versions:

```
pip3 freeze
```

```
netmiko==2.4.2
```

```
pyinstaller==4.3
```

17. If needed, install Netmiko:

```
sudo apt install python3-netmiko -y
```

18. If needed, install Pyinstaller:

```
pip3 install pyinstaller
```

19. Install Git:

```
sudo apt install git-all -y
```

20. Clone my GitHub repository and change into it:

```
git clone https://github.com/Scott4564/python.git
```

```
cd python
```

Note: This creates a new folder on your physical machine at C:\Users\student\python.

21. Run Python3 :

```
python3
```

Note: `exit()` will stop Python and return to the WSL command prompt.

Part 3: Connect to a Switch or Router using Python and Netmiko

The simplest way to connect to a Cisco device using Python is via telnet, but for most environments, telnet is disabled. The best option is SSH, which we will use for the initial show and configuration commands.

The Netmiko library has made it easier to connect to network devices using Python & SSH. This library works across a broad variety of networking devices, including Cisco.

Note: Change the IP address, username, and password to what you configured in Part 1.

1. Run these commands from the **Python3** command prompt to show the interfaces on the Router:

```
1 line of code { from netmiko import ConnectHandler
                  connection = ConnectHandler(device_type='cisco_ios', ip='192.168.1.1',
                  username='admin', password='cisco')
                  print(connection.send_command('show ip int brief'))
                  connection.disconnect()
```

2. Run these commands from the Python3 command prompt to show the interfaces on the Switch:

```
1 line of code { from netmiko import ConnectHandler
                  connection = ConnectHandler(device_type='cisco_ios', ip='192.168.1.254',
                  username='admin', password='cisco')
                  print(connection.send_command('show ip int brief'))
                  connection.disconnect()
                  exit()
```

Part 4: Connect to a Switch or Router using Python from a Script

1. Open and type the following code in a text editor (Nano, VS Code) and save it as **show-int.py**:
Note: The Python3 "She-bang" `#!/usr/bin/python3` is always recommended but has been omitted in these examples.

```
import netmiko

# Connect to a Cisco Router using SSH and run show commands
router = {
    'device_type': 'cisco_ios',
    'ip': '192.168.1.1',
    'username': 'admin',
    'password': 'cisco',
    'secret': 'class',
}

# Establish a connection
connection = netmiko.ConnectHandler(**router)

# Show output
output = connection.send_command('show ip int brief')
device = connection.find_prompt()
print(device + '\n' + output)

# Disconnect
connection.disconnect()
```

```
# Connect to a Cisco Switch using SSH and run show commands
switch = {
    'device_type': 'cisco_ios',
    'ip': '192.168.1.254',
    'username': 'admin',
    'password': 'cisco',
    'secret': 'class',
}

# Establish a connection
connection = netmiko.ConnectHandler(**switch)

# Show output
output = connection.send_command('show ip int brief')
device = connection.find_prompt()
print(device + '\n' + output)

# Disconnect
connection.disconnect()
```

2. Run the Python script and you should see an output of the IP interfaces on your Router or Switch.

python3 show-int.py

```
R1>
Interface          IP-Address      OK?    Method    Status          Protocol
GigabitEthernet0/0  192.168.1.1     YES    manual    up              up
GigabitEthernet0/1  unassigned      YES    unset     administratively down  down
S1>
Interface          IP-Address      OK?    Method    Status          Protocol
Vlan1               192.168.1.254   YES    manual    up              up
FastEthernet0/1     unassigned      YES    unset     up              up
<Output omitted>
FastEthernet0/24    unassigned      YES    unset     up              up
GigabitEthernet0/1  unassigned      YES    unset     down            down
GigabitEthernet0/2  unassigned      YES    unset     down            down
```

Part 5: Configure an interface on a Cisco Router

1. Open and add the following code in a text editor (Nano, VS Code) and save it as **show-config.py**
Note: Copy the Router code from show-int.py and add some configuration information so that your Python script can actually configure the router.

```
import netmiko

# Use Netmiko to connect to a Cisco Router using SSH and run simple commands
router = {
    'device_type': 'cisco_ios',
    'ip': '192.168.1.1',
    'username': 'admin',
    'password': 'cisco',
    'secret': 'class',
}

# Commands to configure a loopback
config_commands = ['interface loopback 0', 'ip address 1.1.1.1 255.255.255.255']

# Establish a connection
connection = netmiko.ConnectHandler(**router)

# Enter privileged mode
connection.enable()

# Run commands
config = connection.send_config_set(config_commands)
print (config)

# Show output
output = connection.send_command('show ip int brief')
device = connection.find_prompt()
print (device + '\n' + output)

# Disconnect
connection.disconnect()
```

2. Run the Python script and you should see an output of the IP interfaces on your Router.

python3 show-config.py

config term

Enter configuration commands, one per line. End with CNTL/Z.

R1(config)#interface loopback 0

R1(config-if)#ip address 1.1.1.1 255.255.255.255

R1(config-if)#no shutdown

R1(config-if)#end

R1#

Interface	IP-Address	OK?	Method	Status	Protocol
GigabitEthernet0/0	192.168.1.1	YES	manual	up	up
GigabitEthernet0/1	unassigned	YES	unset	administratively down	down
Loopback0	1.1.1.1	YES	manual	up	up

Part 6: Configure multiple devices at once with one command

1. Create a new Python script names **config.py**

```
sudo nano config.py
```

2. Add the following code:

```
import netmiko

router = {
    'device_type': 'cisco_ios',
    'ip': '192.168.1.1',
    'username': 'admin',
    'password': 'cisco',
    'secret': 'class',
    'command': ['interface loopback 1', 'ip address 2.2.2.2 255.255.255.255',
                'interface loopback 2', 'ip address 3.3.3.3 255.255.255.255'],
    'output': 'show ip int brief'
}

switch = {
    'device_type': 'cisco_ios',
    'ip': '192.168.1.254',
    'username': 'admin',
    'password': 'cisco',
    'secret': 'class',
    'command': ['vlan 10', 'name TEACHERS', 'vlan 20', 'name STUDENTS',
                'vlan 30', 'name ADMINISTRATORS'],
    'output': 'show vlan brief'
}

# Create a loop to run commands
for device in (router, switch):
    # Retrieve the configuration commands and fill a variable
    command = device.pop('command')
    output = device.pop('output')
    connection = netmiko.ConnectHandler(**device)
    connection.enable()

    # Send the commands to the devices and view an output
    config = connection.send_config_set(command)
    print (config)
    outputs = connection.send_command(output)
    print (outputs)
    connection.disconnect()
```


- Run the Python script and you should see an output on your Router or Switch.

python3 config.py

config term

Enter configuration commands, one per line. End with CNTL/Z.

R1(config)#interface loopback 1

R1(config-if)#ip address 2.2.2.2 255.255.255.255

R1(config-if)#no shutdown

R1(config-if)#interface loopback 2

R1(config-if)#ip address 3.3.3.3 255.255.255.255

R1(config-if)#no shutdown

R1(config-if)#end

R1#

Interface	IP-Address	OK?	Method	Status	Protocol
GigabitEthernet0/0	192.168.1.1	YES	manual	up	up
GigabitEthernet0/1	unassigned	YES	manual	administratively down	down
Loopback0	1.1.1.1	YES	manual	up	up
Loopback1	2.2.2.2	YES	manual	up	up
Loopback2	3.3.3.3	YES	manual	up	up

config term

Enter configuration commands, one per line. End with CNTL/Z.

S1(config)#vlan 10

S1(config-vlan)#name TEACHERS

S1(config-vlan)#vlan 20

S1(config-vlan)#name STUDENTS

S1(config-vlan)#vlan 30

S1(config-vlan)#name ADMINISTRATORS

S1(config-vlan)#end

S1#

VLAN	Name	Status	Ports
1	default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4, Fa0/5, Fa0/6, Fa0/7, Fa0/8, Fa0/9, Fa0/10, Fa0/11, Fa0/12, Fa0/13, Fa0/14, Fa0/15, Fa0/16, Fa0/17, Fa0/18, Fa0/19, Fa0/20, Fa0/21, Fa0/22, Gi0/1, Gi0/2
10	TEACHERS	active	
20	STUDENTS	active	
30	ADMINISTRATORS	active	
1002	fddi-default	act/unsup	
1003	token-ring-default	act/unsup	
1004	fddinet-default	act/unsup	
1005	trnet-default	act/unsup	

Part 7: Configure device from a file

1. If needed, clone your **router_config.txt** and **switch_config.txt** files to the Ubuntu subsystem

```
ls
```

```
config.py router_config.txt show-config.py show-int.py switch_config.txt
```

2. Create a new Python script names **config-file.py**

```
sudo nano config-file.py
```

3. Add the following code:

```
import netmiko
```

```
router = {  
    'device_type': 'cisco_ios',  
    'ip': '192.168.1.1',  
    'username': 'admin',  
    'password': 'cisco',  
    'secret': 'class',  
    'command': 'router_config.txt',  
    'output': 'show ip int brief'  
}
```

```
switch = {  
    'device_type': 'cisco_ios',  
    'ip': '192.168.1.254',  
    'username': 'admin',  
    'password': 'cisco',  
    'secret': 'class',  
    'command': 'switch_config.txt',  
    'output': 'show vlan brief'  
}
```

```
# Create a loop to run commands
```

```
for device in (router, switch):
```

```
    # Retrieve the configuration commands and fill a variable
```

```
    clicommand = device.pop('command')
```

```
    output = device.pop('output')
```

```
    connection = netmiko.ConnectHandler(**device)
```

```
    connection.enable()
```

```
    # Send the commands to the devices and view an output
```

```
    config = connection.send_config_from_file(clicommand)
```

```
    print (config)
```

```
    outputs = connection.send_command(output)
```

```
    print (outputs)
```

```
    connection.disconnect()
```

4. Run the Python script and you should see an output on your Router or Switch.

```
python3 config-file.py
```

Part 8: Creating a Webpage to view Interfaces

1. Install Django, ntc-templates, and json2html applications:

```
pip3 install Django or sudo apt install python3-django -y
pip3 install json2html
```
2. From the Python directory, add a new project names **webint**:

```
django-admin startproject webint
```
3. Change to the **webint** directory and install ntc-templates and set the path:

```
cd webint
git clone https://github.com/networktocode/ntc-templates.git
export NET_TEXTFSM='./ntc-templates/ntc_templates/templates'
```
4. Migrate the settings:

```
ls
db.sqlite3 manage.py ntc-templates webint
python3 manage.py migrate
```
5. Run the server and test the website:

```
python3 manage.py runserver
```

Watching for file changes with StatReloader
Performing system checks...

System check identified no issues (0 silenced).
April 30, 2020 - 21:43:23
Django version 3.0.5, using settings 'showint.settings'
Starting development server at http://127.0.0.1:8000/
Quit the server with CONTROL-C.
6. Open a browser and type the URL shown in the output (**127.0.0.1:8000/**).



The install worked successfully! Congratulations!

You are seeing this page because `DEBUG=True` is in
your settings file and you have not configured any
URLs.

7. Use **CTRL+C** in the command prompt to stop the server.
8. Change to the next level **webint** directory.

```
cd webint
ls
__init__.py __pycache__ asgi.py settings.py urls.py wsgi.py
```

9. Open **urls.py** and append this code:

```
sudo nano urls.py

from django.contrib import admin
from django.urls import path
from . import views

urlpatterns = [
    path('admin/', admin.site.urls),
    path('', views.output, name='output'),
]
```

10. Save and close the file

11. Create a new file named **views.py** and add this code:
Note: You can reuse some of the code from show-int.py.

```
sudo nano views.py

from django.http import HttpResponse
import netmiko
import json
from json2html import *
from datetime import datetime

def output(request):
    router = {
        'device_type': 'cisco_ios',
        'ip': '192.168.1.1',
        'username': 'admin',
        'password': 'cisco',
        'secret': 'class',
        'command': 'show ip int brief'
    }

    clicommand = router.pop('command')

    connection = netmiko.ConnectHandler(**router)

    connection.enable()

    output = connection.send_command(clicommand, use_textfsm=True)

    # Get device name
    device = connection.find_prompt()

    connection.disconnect()

    # Get the current time
    t = datetime.now()
```

```
# Format the output as a readable HTML page
```

```
show = json2html.convert(json = output)
```

```
# Display on a webpage
```

1 line
of code

```
return HttpResponse('<center>' + str(t) + '<br><br><span style="font-size:20px;"><b>' + clicommand + ' for ' + str(device) + '</b></span><br>' + show)
```

12. Save and close the file.

13. Back up one level and run the server again:

```
cd ..
```

```
python3 manage.py runserver
```

14. Refresh the browser page 127.0.0.1:8000/

15. After approximately 30 seconds you should see the results load

2020-05-04 17:17:05.325548			
show ip int brief for R1#			
intf	ipaddr	status	proto
GigabitEthernet0/0	192.168.1.1	up	up
GigabitEthernet0/1	unassigned	administratively down	down
Loopback0	1.1.1.1	up	up
Loopback1	2.2.2.2	up	up
Loopback2	3.3.3.3	up	up
Loopback3	4.4.4.4	up	up

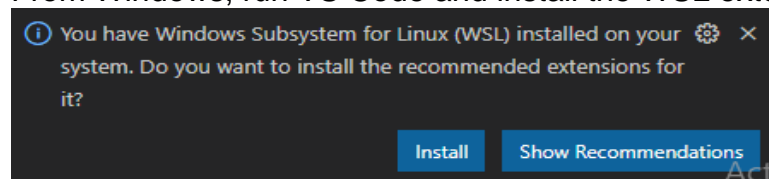
Note: You can change the show command and see different results.

Part 9: Install Visual Studio Code

1. Download and install VS code for Windows:
<https://code.visualstudio.com/download>

Note: Use the System Installer version for your computer.

2. From Windows, run VS Code and install the WSL extensions (Look for this popup):



3. Close and reopen the Ubuntu CLI. Then navigate to the Python directory and run VS Code:

```
code .
```

Note: VS Code will install an extension in Ubuntu.

4. Extensions to consider:

Error Lens

Pylance

Python

Prettier

Material Theme and

Material Icons

Bracket Pair Colorizer 2

indent-rainbow

Install directly on Ubuntu:
`sudo snap install --classic code`

Part 10: Backup the configuration files

1. Create a new text file name **devices.txt** in VS Code

```
Python > devices.txt
```

2. Add the IP addresses of all the devices you want to get the configuration:

```
192.168.1.1
```

```
192.168.1.254
```

3. Save and close the file.
4. Create a new Python script named **backup-config.py**

```
sudo nano backup-config.py
```
5. Add the following code:

```
#!/usr/bin/env python3

import getpass
import telnetlib

# Ask for username and password
user = input('Enter your telnet username: ')
password = getpass.getpass()

# Open a file called devices.txt
devices = open('devices.txt')

#Telnet to devices
for line in devices:
    host = line.strip()
    tn = telnetlib.Telnet(host)

    tn.read_until(b'Username: ')
    tn.write(user.encode('ascii') + b'\n')
    if password:
        tn.read_until(b'Password: ')
        tn.write(password.encode('ascii') + b'\n')

    # Get the running configuration and save it to a file
    print('Getting the running config from IP: ' + (line))
    tn.write(b'terminal length 0\n')
    tn.write(b'show run\n')
    tn.write(b'exit\n')

    readoutput = tn.read_all()
    output = str(readoutput)
    saveoutput = open('Device_' + host + '.txt', 'wb')
    saveoutput.write(readoutput)
    saveoutput.close
```

6. Save, close, and run the file.
7. Optional – Make the file executable from Windows

```
pyinstaller --onefile -w backup-config.py
```

Note: Move the **backup-config.exe** file into the main Python folder. You can delete dist, build, and backup-config.spec.

Supplemental: Remote Trough a Terminal Server Device Using Telnet

Taken from Part 3

```
from netmiko import ConnectHandler
connection = ConnectHandler(device_type='cisco_ios_telnet',
host='netacad11.info', port="####", username='admin', password='cisco')
print(connection.send_command('show ip int brief'))
connection.disconnect()
```

Taken from Parts 4-8

Connect to a Cisco Router using Telnet and run show commands

```
router = {
    'device_type': 'cisco_ios_telnet',
    'host': 'netacad11.info',
    'port': '####',
    'username': 'admin',
    'password': 'cisco',
    'secret': 'class',
}
```

Note: Port 23 is the default for Telnet, but a terminal Server will assign a different port to each device.