Programming and Python for Network Engineer

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Agenda

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• Network Operational Problems
• Evolution Drift to DevOps
• Programming to rescue
• Why learn Programming
• Programming in Networks
• Orchestration vs Automation
• Automation A Smart way out
• Types of Languages
• Languages for Automation

Session 2:
• Which programming language should we learn
• Why Python
• What is Python
• Python and other languages
• Getting started with Python
• Installing Python
• Python programming modes
• Deeper into python

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• Network Integration with Python
• GNS3 DEMO
• Telnet
• Netmiko
• Napalm
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• Thinking Process
• Python Code
• Python for Network Engineers
• Closing remarks
Tedious Networking Operations

- Vendor dependent command line syntax and structures
- Follow Standard Operating Procedures for tasks
- Low level operational works
- Daily chores drain out technical ability of an Engineer
- Maintenance of manual databases of many non-tech entities
- Learning theoretical network concepts to perform troubleshooting of seldom issues
Network Operational Problems

- Daily repetitive tasks
- Highly time consuming operations
- Fat fingers and mistakes
- Infrastructure scaling
- Difficulty of understanding complex scenarios by less technical team members
Evolutional Drift to DevOps

- Software-defined networks using centralized controllers

- Introduction of GUI and replacing CLI legacy

- Inclusion of DevOps is changing networking infrastructure rapidly

- Era of cloud computing and mobility, businesses are demanding more agility from their IT professionals

- Addition of programming skillset in bucket
Programming to the Rescue

- Networker Engineers no longer need to learn all the different syntax from diverse vendors, codes can do that!

- Predefined code, eliminates the need to follow long configuration steps

- Scalability of networks, adding new operational nodes to the networks in just few clicks.

- Zero tolerance to humanistic errors

- Routine network operations made easy for all

- One window solution for all operational tasks
Why learn Programming

• If software eats everything, are network engineers on the menu?

• An Essential Skill For Network Engineers to enhance his capabilities.

• Programming to simplify or automate tasks.

• Programming languages are not just for programmers. If you are a network engineer, knowing a programming language (or two or three) can come in handy.
Programming in Networks

• Manages network more efficiently.

• Network Automation.

• Software define networking.

• Big vendors heading towards software based operations i.e. Cisco, Juniper.

"Your network is a crime scene, and you are the detective. You need better ways to investigate what happened, and prove guilt or innocence."

-- Jeremy
Orchestration vs Automation

- Automation
  - Well specified task run on its own

- Orchestration
  - Automating a lot of things at once
  - Multiple tasks to execute a workflow
  - Is automation, coordination and management

- Automation is the first step towards orchestration
Orchestration vs Automation

Scenario – Network Engineer needs to configure Customer link

What information Network Engineer is looking for:

- Last mile configuration (Metro Fiber)
  - Free switch interface
  - Free vlan

- Configuring the Router
  - Interface (vlan)
  - IP required (Public/Private)
  - Bandwidth

Each individual tasks can be automated, and the whole process is orchestrated
“Automation” A Smart Way Out!

- **Network Automation** is a methodology in which programmed scripts automatically configures, provisions, manages and tests network devices.

- **Why Automation?** - Programmed management tools are designed to reduce the complexity of manually configuring and managing distributed infrastructure resources by enabling speed, ensuring reliability and compliance.

- Using different **programming languages** provide different paths to achieve a common goal of managing infrastructure efficiently.
Languages For Automation

- Strong binding between Network Automation Tools and Programming languages.

- Puppet, Chef and Ansible are different paths to achieve a common goal of managing infrastructure efficiently.

- All these configuration management tools are designed to reduce the complexity of configuring distributed infrastructure resources, enabling speed, ensuring reliability and compliance.
Which Programming Language should we learn

- Easy Learning
- User Friendly
- Technical Online Resources
- Size of Community
- What People are available
- Market demands!
- Which Language?
Type of Languages

- **Frontend** development is the practice of converting data to graphical interface for user to view and interact with data.

- The digital interaction is accomplished by using HTML, CSS and JavaScript.

- **Backend** of an application is responsible for things like calculations, logic, database interactions, and performance.

- If we talk about networks, it is used to interact with Nodes and perform actions such as run commands, gather stats, perform configurational changes and view output.
What is Python

• Python is a high-level programming language

• Open source and community driven

• “Batteries Included”
  • a standard distribution includes many modules

• Dynamic typed

• Source can be compiled or run just-in-time

• Similar to perl, tcl, ruby
Why Python
Why Python

• Easy to understand and readable language.

• Dominating language at this point of time in Network Automation space.

• A high level language, don’t have to write a lot of blue codes to get things done.

• Powerful enough to be used as a convenient tool for daily parsing tasks, performance management, and configuration.

• It does not have to be compiled, which makes debugging really fast and easy.
Why Python

• Interpreted
  • You run the program straight from the source code.
  • Python program → Bytecode → a platform's native language
  • You can just copy over your code to another system and it will auto-magically work! *with python platform

• Object-Oriented
  • Simple and additionally supports procedural programming

• Extensible – easily import other code

• Embeddable – easily place your code in non-python programs

• Extensive libraries
  • (i.e. reg. expressions, doc generation, CGI, ftp, web browsers, ZIP, WAV, cryptography, etc...)
    (wxPython, Twisted, Python Imaging library)
Why Python

• Simple
  • Python is a simple and minimalistic language in nature
  • Reading a good python program should be like reading English
  • Its Pseudo-code nature allows one to concentrate on the problem rather than the language

• Easy to Learn

• Free & Open source
  • Freely distributed and Open source
  • Maintained by the Python community

• High Level Language – memory management

• Portable – *runs on anything c code will
Python and Other Languages

• Python is Code-Friendly
  The code syntax of Python are simple, concise, and much like English language. This makes coding an interactive and engaging activity.

• It is Procedural and Object-Oriented Programming Language
  Another best thing about Python is that it follows both the Procedure-oriented and Object-Oriented concepts. Because of this, it is able to provide developers with an environment that no other language concentrating on a single concept is able to offer.

• It comes with Plenty of Libraries and Frameworks
  Python, unlike many other programming languages, avails a wide range of libraries and frameworks that gives developers an escape from writing code from scratch. And eventually, lower down the time and cost of development.

• Python Enjoys Growing Market Popularity
  Above all, Python is one of the trending programming languages with the support of a wider community. Also, its popularity graph as per Google Trends is growing astronomically - something that is making developers choose Python over other available options.
Python and Other Languages

- Since 2012, Python has been consistently growing in popularity, and the trend is likely to continue, if not increase, in the future.
Getting started with Python

Usually a system may have one of the 3 famous Operating System.

- Microsoft Windows
- Apple Mac OS
- Linux Distribution OS

Python development environment is not included in Windows default setup. For **Windows 10**, a small patch does the trick where as for earlier versions proper setup is required. Coding could be done on CMD window.

In **Mac OS X**, Python 2 and its built-in **Interactive Development Environment (IDE)** comes pre-installed. Everything could be done in Terminal that includes creating the code and its execution.

Famous **Linux Distributions** also have Python enabled on default setup. Just as Mac OS, a user can start coding and execute it in Linux terminal window using CLI.
Installing Python

• Linux
  $sudo apt-get install python3-minimal

• Windows
Download 64 bit python

- Python on default download is 32 bit hence we have to download a specific release and version from python download release section.

- Hence chose your respective python version as per your requirements.
What is PIP

• PIP is a package manager for Python packages, or modules.

• You use PIP to install and update packages and modules as per required by your python code.

• You can check if PIP is installed by typing following command
  • C:\Users\Your Name\AppData\Local\Programs\Python\Python36-32\Scripts>pip --version

• If you do not have PIP installed, you can download and install it from,
  • https://pypi.org/project/pip/
Download Package

• Downloading a package in python is very easy.
  • Open the command line interface and tell PIP to download the package you want.
  • Make sure to navigate your command line to the location of Python's script directory, and type the following:
    • pip install packageName

Example

Download a package named "camelcase":

C:\Users\Your Name\AppData\Local\Programs\Python\Python36-32\Scripts>pip install camelcase
Python Development Interfaces

- **Python Shell** – running 'python' from the Command Line opens this interactive shell
- **IDLE** – a cross-platform Python development environment
- **Spyder** - It is a scientific integrated development environment written in Python, available through Anaconda
- **PyCharm** - a cross-platform IDE, that can be used on Windows, macOS, and Linux.
- **Sublime Text 3** - Sublime Text 3 is a code editor which supports many languages including Python
- **Visual Studio Code** - The editor provides smart code completion based on function definition, imported modules, as well as variable types
- **PythonWin** – a Windows only interface to Python, It provides a simple graphical interface for editing and running Python programs
- **Jupyter** - It supports for Numerical simulation, data cleaning machine learning data visualization, and statistical modelling.

- For the exercises, we'll use Spyder, but you can try them all and pick a favorite
IDLE – Integrated Development Environment

• IDLE helps you program in Python by:
  • color-coding your program code
  • debugging
  • auto-indent
  • interactive shell
Python Programming Modes

1. Interpreter Mode

2. Normal Mode (Script Mode)
Python Programming Modes

Interactive mode is a command line shell which gives immediate feedback for each statement.

The “>>>” indicates that the shell is ready to accept interactive commands.
Python Programming Modes

**Normal mode** is the mode where the scripted (.py) files are run in the Python interpreter.

Python programs are nothing more than text files, and they may be edited with a standard text editor program. For example Vim, Nano, Notepad++, Sublime Text.

Instead of having to run one line or block of code at a time, you can type up all your code in one text file, or script, and run all the code at once.

To run the script, either select “Run” -> “Run Module” or press F5.

One more way of execute the python (.py) file from Linux distribution is
Python Shell

- command line shell is one of the most basic interface for python development.
- You can specifically use this environment for immediate testing of new libraries installed
Python Jupyter

- You can add new python jupyter files
- Major advantage of jupyter is that you can execute your code line by line or chunk by chunk
- You don’t need to create a separate file for development and separate shell environment for outputs
Python Spyder

• Allows you to run Python code by cell, line, or file.
• Plot a histogram or time-series, make changes in date frame.
• It offers automatic code completion and horizontal/vertical splitting.
• Find and eliminate bottlenecks
• An interactive way to trace each step of Python code execution.
Installing an IDE

- Anaconda is a free and open-source distribution of the Python programming language for scientific computing, that aims to simplify package management and deployment.

- Anaconda Navigator is a desktop graphical user interface (GUI) included in Anaconda distribution that allows users to launch applications and manage conda packages, environments and channels without using command-line commands.
Online Python IDE

• https://repl.it/
Deeper into Python
Deeper into Python

Variable:
Variables are reserved memory locations to store values.
Numbers | Strings | List | Tuple | Dictionary

Operators:
Operators are the constructs which can manipulate the value of operands.
• Arithmetic Operators
• Comparison (Relational) Operators
• Assignment Operators
• Logical Operators
• Bitwise Operators
• Membership Operators
• Identity Operators
Deeper into Python

Control Flow Tools:
These are the tools which control the logical flow of the program based on the following parameters.

- **Value**: Basic units of data. Eg. 10, 'string'.
- **Variable**: A name that refers to a value. Eg. var=10, var is the variable.
- **Statement**: A section of code that represents a command or action.
- **Operator**: A symbol that performs operations on operands. Eg. * is for multiplication
- **Expression**: A combination of variables, operators, and values to perform a task.

Types:
- if statement
- while statement
- for statement
- break, continue and pass
Deeper into Python

**Iteration:**
Computers are often used to automate repetitive tasks. Repeated execution of a set of statements is called iteration.

**Conditionals:**
In python conditional statements are features which perform different computations or actions depending on whether a programmer specified boolean condition evaluates to true or false.

**Regular Expressions:**
A regular expression is a special sequence of characters that helps you match or find other strings or sets of strings, using a specialized syntax held in a pattern.
Deeper into Python

Function:
A function is a block of organized, reusable code that is used to perform a single or multiple related action.

Classes:
Python uses classes to keep related things together.

Modules:
A Python module is a Python source file which can expose classes, functions and global variables. A Python package is a directory of Python module.

Repeatable Code (Writing Reusable Code):
Programmers like to be lazy. If something has been done before, why should you do it again?

That is what functions cover in Python. You've had your code do something and now you want to do it again. You put that code into a function, and re-use it. You can refer to a function anywhere in your code, and the computer will always know what you are talking about.
Python semantics

• Each statement has its own semantics, the def statement doesn’t get executed immediately like other statements

• Python uses duck typing, or latent typing
  • Allows for polymorphism without inheritance
  • This means you can just declare
    “somevariable = 67” don’t actually have to declare a type
  • print “somevariable = “ + tostring(somevariable)”
  strong typing, can’t do operations on objects not defined without explicitly asking the operation to be done
When a program is running, it flows from one step to the next. We as programmers set up “paths” for the program to follow.
Conditional Steps

When a program is running, it flows from one step to the next step based on the condition designed.
Repeated Steps

Loops (repeated steps) have iteration variables that change each time through a loop. Often these iteration variables go through a sequence of numbers.

Program:

```python
n = 5
while n > 0 :  
    print n
    n = n - 1
print 'Blastoff!'
```
Variables Types

- Variables
- Constants
Variables

A variable is a named place in the memory where a programmer can store data and later retrieve the data using the variable “name”

Programmers get to choose the names of the variables

You can change the contents of a variable in a later statement

x = 12.2
y = 14
Fixed values such as numbers, letters, and strings are called “constants” - because their value does not change.

Numeric constants are as you expect.

String constants use single-quotes (') or double-quotes ("").

```python
>>> print 123
123
>>> print 98.6
98.6
>>> print 'Hello world'
Hello world
```
Data Types

In Python variables, literals, and constants have a “data type”

In Python variables are “dynamically” typed. In some other languages you have to explicitly declare the type before you use the variable

In C/C++:

```c
int a;
float b;
a = 5
b = 0.43
```

In Python:

```python
a = 5
a = “Hello”
a = [ 5, 2, 1]
```
Some Data Types in Python

• Integer (Examples: 0, 12, 5, -5)

• Float (Examples: 4.5, 3.99, 0.1)

• String (Examples: “Hi”, “Hello”, “Hi there!”)

• Boolean (Examples: True, False)

• List (Example: [“hi”, “there”, “you”])

• Tuple (Example: (4, 2, 7, 3))
String Data Type

- A string is a sequence of characters
- A string literal uses quotes ‘Hello’ or “Hello”
- For strings, + means “concatenate”
- When a string contains numbers, it is still a string

```python
>>> str1 = "Hello"
>>> str2 = 'there'
>>> bob = str1 + str2
>>> print bob
Hellothere

>>> str3 = '123'
>>> str3 = str3 + 1
Traceback (most recent call last): File "<stdin>", line 1, in <module>
TypeError: cannot concatenate 'str' and 'int' objects
```
Looking Inside Strings

- We can get at any single character in a string using an index specified in square brackets.
- The index value must be an integer and starts at zero.
- The index value can be an expression that is computed.

```python
>>> fruit = 'banana'
>>> letter = fruit[1]
>>> print letter
a
>>> n = 3
>>> w = fruit[n - 1]
>>> print w
n
```
Slicing Strings

- We can also look at any continuous section of a string using a colon operator.

- The second number is one beyond the end of the slice - “up to but not including”.

- If the second number is beyond the end of the string, it stops at the end.

```python
>>> s = 'Monty Python'
>>> print s[0:4]
Mont
>>> print s[6:7]
P
>>> print s[6:20]
Python
```
Slicing Strings

- If we leave off the first number or the last number of the slice, it is assumed to be the beginning or end of the string respectively.

```python
>>> s = 'Monty Python'
>>> print s[:2]
Mo
>>> print s[8:]
thon
>>> print s[:]
Monty Python
```
String Concatenation

• When the + operator is applied to strings, it means "concatenation"

```python
>>> a = 'Hello'
>>> b = a + 'There'
>>> print b
HelloThere

>>> c = a + ' ' + 'There'
>>> print c
Hello There
```
Handling User Input

- We prefer to read data in using strings and then parse and convert the data as we need.

- This gives us more control over error situations and/or bad user input.

- Raw input numbers must be converted from strings.

```python
>>> name = raw_input('Enter:')
Enter:Chuck
>>> print name
Chuck
>>> apple = raw_input('Enter:')
Enter:100
>>> x = apple - 10
Traceback (most recent call last):  File "<stdin>", line 1, in <module>
TypeError: unsupported operand type(s) for -: 'str' and 'int'
>>> x = int(apple) - 10
>>> print x
90
```
Casting

- **Int()**
- **Float()**
- **Str()**

### Integers:
```
x = int(1)  # x will be 1
y = int(2.8)  # y will be 2
z = int("3")  # z will be 3
```

### Floats:
```
x = float(1)  # x will be 1.0
y = float(2.8)  # y will be 2.8
z = float("3")  # z will be 3.0
w = float("4.2")  # w will be 4.2
```

### Strings:
```
x = str("s1")  # x will be 's1'
y = str(2)  # y will be '2'
z = str(3.0)  # z will be '3.0'
```
Python Collections (Arrays)

• There are four collection data types in the Python programming language:
• **List** is a collection which is ordered and changeable. Allows duplicate members.
• **Tuple** is a collection which is ordered and unchangeable. Allows duplicate members.
• **Set** is a collection which is unordered and unindexed. No duplicate members.
• **Dictionary** is a collection which is unordered, changeable and indexed. No duplicate members.
• When choosing a collection type, it is useful to understand the properties of that type. Choosing the right type for a particular data set could mean retention of meaning, and, it could mean an increase in efficiency or security.
Lists

• A list is a collection which is ordered and changeable. In Python lists are written with square brackets.
• You access the list items by referring to the index number.
• You can specify a range of indexes by specifying where to start and where to end the range.
• When specifying a range, the return value will be a new list with the specified items.

```python
thislist = ["apple", "banana", "cherry"]
print(thislist)

thislist = ["apple", "banana", "cherry"]
print(thislist[1])
```
Tuples

• A tuple is a collection which is ordered and unchangeable. In Python tuples are written with round brackets.
• You can access tuple items by referring to the index number, inside square brackets.
• Negative indexing means beginning from the end.
• You can specify a range of indexes by specifying where to start and where to end the range.
• When specifying a range, the return value will be a new tuple with the specified items.

```python
this_tuple = ("apple", "banana", "cherry")
print(this_tuple)
```

```python
this_tuple = ("apple", "banana", "cherry")
print(this_tuple[1])
```
Sets

• A set is a collection which is unordered and unindexed. In Python sets are written with curly brackets.
• You cannot access items in a set by referring to an index, since sets are unordered the items has no index.
• But you can loop through the set items
• Once a set is created, you cannot change its items, but you can add new items.

```python
thisset = {"apple", "banana", "cherry"}
print(thisset)
```
Dictionary

- A dictionary is a collection which is unordered, changeable and indexed. In Python dictionaries are written with curly brackets, and they have keys and values.
- You can access the items of a dictionary by referring to its key name, inside square brackets.
- You can change the value of a specific item by referring to its key name.
- You can loop through a dictionary.
- When looping through a dictionary, the return value are the keys of the dictionary, but there are methods to return the values as well.

```python
thisdict = {
    "brand": "Ford",
    "model": "Mustang",
    "year": 1964
}
print(thisdict)
```
Operators

- Arithmetic Operators
- Assignment Operators
- Logical Operators
- Membership Operators
## Arithmetic Operators

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Operator Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Addition</td>
<td>Adds the values on either side of the operator and calculate a result.</td>
</tr>
<tr>
<td>-</td>
<td>Subtraction</td>
<td>Subtracts values of right side operand from left side operand.</td>
</tr>
<tr>
<td>*</td>
<td>Multiplication</td>
<td>Multiplies the values on both sides of the operator.</td>
</tr>
<tr>
<td>/</td>
<td>Division</td>
<td>Divides left side operand with right side operand.</td>
</tr>
<tr>
<td>%</td>
<td>Modulus</td>
<td>It returns the remainder by dividing the left side operand with right side operand.</td>
</tr>
<tr>
<td>**</td>
<td>Exponent</td>
<td>Calculates the exponential power</td>
</tr>
</tbody>
</table>
# Assignment Operators

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Operator Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>=</td>
<td>Equal</td>
<td>Assigns the values of right side operand to left side operand.</td>
</tr>
<tr>
<td>+=</td>
<td>Add AND</td>
<td>Adds right side operand value to the left side operand value and assigns the results to the left operand.</td>
</tr>
<tr>
<td>-=</td>
<td>Subtract AND</td>
<td>Subtracts right side operand value to the left side operand value and assigns the results to the left operand.</td>
</tr>
<tr>
<td>*=</td>
<td>Multiply AND</td>
<td>Similarly does their respective operations and assigns the operator value to the left operand.</td>
</tr>
</tbody>
</table>
# Logical Operators

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Operator Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>or</td>
<td>Logical OR</td>
<td>If any of the two operands are non-zero, then the condition is true.</td>
</tr>
<tr>
<td>and</td>
<td>Logical AND</td>
<td>If both the operands are true, then the condition is true.</td>
</tr>
<tr>
<td>not</td>
<td>Logical NOT</td>
<td>It is used to reverse the logical state of its operand.</td>
</tr>
</tbody>
</table>
Membership Operators

- **In**
  - The result of this operation becomes True if it finds a value in a specified sequence and False otherwise.

- **Not in**
  - The result of this operation becomes True if it doesn't find a value in a specified sequence and False otherwise.
Decision making

- if Statement
- if else Statements
- elif Statements
Decision making

**Syntax**

```python
if expression:
    #execute your code

Syntax:

```python
if expression:
    #execute your code
else:
    #execute your code

Syntax:

```python
if expression:
    #execute your code
elif expression:
    #execute your code
else:
    #execute your code
```
Decision making

Example:

```python
a = 15
b = 20

if a > b:
    print("a is greater")
else:
    print("b is greater")
```

Output:

```
b is greater
```

Example:

```python
a = 15
b = 15

if a > b:
    print("a is greater")
elif a == b:
    print("both are equal")
else:
    print("b is greater")
```

Output:

```
both are equal
```
Example:

```python
str1 = input('Please enter first string: ')
str2 = input('Please enter second string: ')
if str2 in str1:
    print(str2+' found in the first string. ')
else:
    print(str2+' not found in the first string. ')
```

Output:

```
Please enter first string: We are writing core python
Please enter second string: python
python found in the first string.
```
Loops

• For
• While
• Nested for
Looping with For

- We could use a for loop to perform geoprocessing tasks on each layer in a list.
- We could get a list of features in a feature class and loop over each, checking attributes.
- Anything in a sequence or list can be used in a For loop.
- Just be sure not to modify the list while looping.
Looping with For

• For allows you to loop over a block of code a set number of times

• For is great for manipulating lists:
  ```python
  a = ['cat', 'window', 'defenestrate']
  for x in a:
      print x, len(x)
  ```
  Results:
  cat 3
  window 6
  defenestrate 12
For loop

Syntax:

```python
for iterating_var in sequence:
    #execute your code
```

Example 01:

```python
for x in range(0,3):
    print ('Loop execution %d' % (x))
```

Output:

```
Loop execution 0
Loop execution 1
Loop execution 2
```
While loop

Syntax:
```python
while expression:
    #execute your code
```

Example:
```python
#initialize count variable to 1
count = 1

while count < 6:
    print(count)
    count += 1
#the above line means count = count + 1
```

Output:
```
1
2
3
4
5
```
Nested Loops

Syntax:

```python
for iterating_var in sequence:
    for iterating_var in sequence:
        #execute your code
        #execute your code
```

Example:

```python
for g in range(1, 6):
    for k in range(1, 3):
        print("%d * %d = %d" % (g, k, g+k))
```

Output:

```
1 * 1 = 1
1 * 2 = 2
2 * 1 = 2
2 * 2 = 4
3 * 1 = 3
3 * 2 = 6
4 * 1 = 4
4 * 2 = 8
5 * 1 = 5
5 * 2 = 10
```
Functions in Python

- There are two kinds of functions in Python

- Built-in functions that are provided as part of Python - `raw_input()`, `type()`, `float()`, `max()`, `min()`, `int()`, `str()`, ...

- Functions (user defined) that we define ourselves and then use

- We treat the built-in function names like reserved words (i.e. we avoid them as variable names)
Definition of Function

- In Python a function is some reusable code that takes arguments(s) as input does some computation and then returns a result or results

- We define a function using the `def` reserved word

- We call/invoke the function by using the function name, parenthesis and arguments in an expression
Functions

- Using 'def' statement for defining a function

**Example:**

```python
def avg(first, *rests):
    return (first + sum(rests)) / (1 + len(rests))

# Sample use, putting values

print(avg(1, 2))
print(avg(1, 2, 3))
print(avg(1, 2, 3, 4))
```

**Output:**

```
1.5
2.0
2.5
```
The range() function

- range() is a built-in function that allows you to create a sequence of numbers in a range

  ```python
  x = range(5)
p = print x
[0, 1, 2, 3, 4]
  ```

- Very useful in “for” loops which are discussed later in the Iteration chapter

  ```python
  x = range(3, 7)
p = print x
[3, 4, 5, 6]
  ```

- Takes as an input 1, 2, or 3 arguments. See examples.

  ```python
  x = range(10, 1, -2)
p = print x
[10, 8, 6, 4, 2]
  ```
Modules

• Modules are functions and variables defined in separate files

• Items are imported using from or import
  • from module import function
  • function()
  • import module
  • module.function()

• Modules are namespaces
  • Can be used to organize variable names, i.e.
    • atom.position = atom.position - molecule.position
Why use Modules?

- **Code reuse**
  - Routines can be called multiple times within a program
  - Routines can be used from multiple programs

- **Namespace partitioning**
  - Group data together with functions used for that data

- **Implementing shared services or data**
  - Can provide global data structure that is accessed by multiple subprograms
OOP Terminology

• **class** -- a template for building objects
• **instance** -- an object created from the template (an instance of the class)
• **method** -- a function that is part of the object and acts on instances directly
• **constructor** -- special "method" that creates new instances
"Special" methods

- All start and end with `__` (two underscores)

- Most are used to emulate functionality of built-in types in user-defined classes

- e.g. operator overloading
  - `__add__`, `__sub__`, `__mul__`, ...
  - see python docs for more information
Classes

• A Class is like an object constructor, or a "blueprint" for creating objects.

```python
class Person:
    def __init__(self, name, age):
        self.name = name
        self.age = age

    def myfunc(self):
        print("Hello my name is " + self.name)

p1 = Person("John", 36)
p1.myfunc()
```
Defining a Class

class Thing:

    """This class stores an arbitrary object."""

    def __init__(self, value):
        """Initialize a Thing."""
        self.value = value

    def showme(self):
        """Print this object to stdout."""
        print "value = %s" % self.value
Using a Class

• `t = Thing(10)` # calls `__init__` method
• `t.showme()` # prints "value = 10"
• `t` is an instance of class `Thing`
• `showme` is a method of class `Thing`
• `__init__` is the constructor method of class `Thing`
• when a `Thing` is created, the `__init__` method is called
• Methods starting and ending with `__` are "special" methods
Using a Class

print t.value  # prints "10"

value is a field of class Thing

t.value = 20  # change the field value

print t.value  # prints "20"
File Handling

• Files are manipulated by creating a file object
  • `f = open("points.txt", "r")`

• The file object then has new methods
  • `print f.readline() # prints line from file`

• Files can be accessed to read or write
  • `f = open("output.txt", "w")`
  • `f.write("Important Output!")`

• Files are iterable objects, like lists
File Opening and Attributes

Syntax:
```
file_object = open(filename [,mode] [,buffering])
```

Example:
```
# file opening example in Python
fo = open("sample.txt", "wb")
   print ("File Name: ", fo.name)
   print ("Mode of Opening: ", fo.mode)
   print ("Is Closed: ", fo.closed)
   print ("Softspace flag : ", fo.softspace)
```

Output:
```
File Name: sample.txt
Mode of Opening: wb
Is Closed: False
Softspace flag: 0
```
## Modes of File opening

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>r</code></td>
<td>Opens a file for reading only. (It's a default mode.)</td>
</tr>
<tr>
<td><code>w</code></td>
<td>Opens a file for writing. (If a file doesn't exist already, then it creates a new file. Otherwise, it's truncate a file.)</td>
</tr>
<tr>
<td><code>x</code></td>
<td>Opens a file for exclusive creation. (Operation fails if a file does not exist in the location.)</td>
</tr>
<tr>
<td><code>a</code></td>
<td>Opens a file for appending at the end of the file without truncating it. (Creates a new file if it does not exist in the location.)</td>
</tr>
<tr>
<td><code>t</code></td>
<td>Opens a file in text mode. (It's a default mode.)</td>
</tr>
<tr>
<td><code>b</code></td>
<td>Opens a file in binary mode.</td>
</tr>
<tr>
<td><code>+</code></td>
<td>Opens a file for updating (reading and writing.)</td>
</tr>
</tbody>
</table>
File Reading / Writing

Example:

```python
# read the entire file as one string
with open('filename.txt') as f:
    data = f.read()

# Iterate over the lines of the File
with open('filename.txt') as f:
    for line in f:
        print(line, end=' ')
# process the lines
```

Example:

```python
# Write text data to a file
with open('filename.txt', 'wt') as f:
    f.write('hi there, this is a first line of file.
    f.write('and another line.
```

Output:

```
hi there, this is a first line of file.
and another line.
```
Python has a module named “time” to handle time-related tasks. To use functions defined in the module, we need to import the module first.

- Time function returns the number of seconds passed since epoch
- Ctime function takes seconds passed since epoch as an argument and returns a string representing local time
- Sleep function suspends (delays) execution of the current thread for the given number of seconds.

```python
import time
seconds = time.time()
print("Seconds since epoch =", seconds)
```
Types of errors

- **IndexError** is thrown when trying to access an item at an invalid index.
- **ModuleNotFoundError** is thrown when a module could not be found.
- **KeyError** is thrown when a key is not found.
- **ImportError** is thrown when a specified function can not be found.
- **TypeError** is thrown when an operation or function is applied to an object of an inappropriate type.
- **ValueError** is thrown when a function's argument is of an inappropriate type.
- **NameError** is thrown when an object could not be found.
- **ZeroDivisionError** is thrown when the second operator in the division is zero.
- **KeyboardInterrupt** is thrown when the user hits the interrupt key (normally Control-C) during the execution of the program.
Exception handling

• try/except
  • catch the error and recover from exceptions hoist by programmers or Python itself.

• try/finally
  • Whether exception occurs or not, it automatically performs the clean-up action.

• Assert
  • triggers an exception conditionally in the code.
Example 01:
(a,b) = (6,0)
try:
    # simple use of try-except block for handling errors
    g = a/b
except ZeroDivisionError:
    print("This is a DIVIDED BY ZERO error")

Output:
This is a DIVIDED BY ZERO error

Example 02:
(a,b) = (6,0)
try:
    g = a/b
except ZeroDivisionError as s:
    k = s
    print(k)
# Output will be: integer division or modulo by zero

Output:
division by zero
Comments

- Single-Line Comment

  Example:
  
  #Defining a variable to store number.  
  n = 50 #Store 50 as value into variable n.

- Multi-Line Comment

  Example:
  
  
  ***
  Author: www.w3schools.in
  Description:
  Writes the words Hello World on the screen
  ***
Indentation Rules

- Increase indent after an if statement or for statement (after : )

- Maintain indent to indicate the scope of the block (which lines are affected by the if/for)

- Reduce indent to back to the level of the if statement or for statement to indicate the end of the block

- Blank lines are ignored - they do not affect indentation

- Comments on a line by themselves are ignored w.r.t. indentation
Python uses whitespace and indents to denote blocks of code.

Lines of code that begin a block end in a colon:

Lines within the code block are indented at the same level.

To end a code block, remove the indentation.

You'll want blocks of code that run only when certain conditions are met.
Indentation

Example:
```python
if a==1:
    print(a)
    if b==2:
        print(b)
print('end')
```

Example:
```python
print(a)
if b==2:
```
• Whitespace is meaningful in Python: especially indentation and placement of newlines.

• Use a newline to end a line of code
  Use \ when must go to next line prematurely.

• No braces {} to mark blocks of code, use consistent indentation instead
  • First line with less indentation is outside of the block.
  • First line with more indentation starts a nested block.

• Colons start of a new block in many constructs, e.g. function definitions, then clauses
Naming Rules

• Names are case sensitive and cannot start with a number.

• They can contain letters, numbers, and underscores.
  
  bob  Bob  _bob  _2_bob_  bob_2  BoB

• There are some reserved words:

  and, assert, break, class, continue, def, del, elif, else, except, exec, finally, for, from, global, if, import, in, is, lambda, not, or, pass, print, raise, return, try, while
Naming conventions

- The Python community has these recommended naming conventions.

- `joined_lower` for functions, methods and attributes.

- `joined_lower` or `ALL_CAPS` for constants.

- `StudlyCaps` for classes.

- `camelCase` only to conform to pre-existing conventions.

- Attributes: `interface`, `_internal`, `__private`
Accessing Non-Existent Name

Accessing a name before it’s been properly created (by placing it on the left side of an assignment), raises an error

```python
>>> y

Traceback (most recent call last):
  File "<pyshell#16>", line 1, in top-level-
    y
NameError: name 'y' is not defined

>>> y = 3

>>> y
3
```
## Keywords

<table>
<thead>
<tr>
<th>and</th>
<th>assert</th>
<th>in</th>
</tr>
</thead>
<tbody>
<tr>
<td>del</td>
<td>else</td>
<td>raise</td>
</tr>
<tr>
<td>from</td>
<td>if</td>
<td>continue</td>
</tr>
<tr>
<td>not</td>
<td>pass</td>
<td>finally</td>
</tr>
<tr>
<td>while</td>
<td>yield</td>
<td>is</td>
</tr>
<tr>
<td>as</td>
<td>break</td>
<td>return</td>
</tr>
<tr>
<td>elif</td>
<td>except</td>
<td>def</td>
</tr>
<tr>
<td>global</td>
<td>import</td>
<td>for</td>
</tr>
<tr>
<td>or</td>
<td>print</td>
<td>lambda</td>
</tr>
<tr>
<td>with</td>
<td>class</td>
<td>try</td>
</tr>
<tr>
<td>exec</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## String Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>lstrip()</code></td>
<td>Returns a left trim version of the string</td>
</tr>
<tr>
<td><code>replace()</code></td>
<td>Returns a string where a specified value is replaced with a specified value</td>
</tr>
<tr>
<td><code>rfind()</code></td>
<td>Searches the string for a specified value and returns the last position of where it was found</td>
</tr>
<tr>
<td><code>rindex()</code></td>
<td>Searches the string for a specified value and returns the last position of where it was found</td>
</tr>
<tr>
<td><code>rsplit()</code></td>
<td>Splits the string at the specified separator, and returns a list</td>
</tr>
<tr>
<td><code>rstrip()</code></td>
<td>Returns a right trim version of the string</td>
</tr>
<tr>
<td><code>split()</code></td>
<td>Splits the string at the specified separator, and returns a list</td>
</tr>
<tr>
<td><code>splitlines()</code></td>
<td>Splits the string at line breaks and returns a list</td>
</tr>
<tr>
<td><code>startswith()</code></td>
<td>Returns true if the string starts with the specified value</td>
</tr>
<tr>
<td><code>strip()</code></td>
<td>Returns a trimmed version of the string</td>
</tr>
<tr>
<td><code>swapcase()</code></td>
<td>Swaps cases, lower case becomes upper case and vice versa</td>
</tr>
<tr>
<td><code>title()</code></td>
<td>Converts the first character of each word to upper case</td>
</tr>
<tr>
<td><code>upper()</code></td>
<td>Converts a string into upper case</td>
</tr>
<tr>
<td><code>zfill()</code></td>
<td>Fills the string with a specified number of 0 values at the beginning</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>capitalize()</td>
<td>Converts the first character to upper case</td>
</tr>
<tr>
<td>count()</td>
<td>Returns the number of times a specified value occurs in a string</td>
</tr>
<tr>
<td>encode()</td>
<td>Returns an encoded version of the string</td>
</tr>
<tr>
<td>endswith()</td>
<td>Returns true if the string ends with the specified value</td>
</tr>
<tr>
<td>find()</td>
<td>Searches the string for a specified value and returns the position of where it was found</td>
</tr>
<tr>
<td>format()</td>
<td>Formats specified values in a string</td>
</tr>
<tr>
<td>index()</td>
<td>Searches the string for a specified value and returns the position of where it was found</td>
</tr>
<tr>
<td>isalnum()</td>
<td>Returns True if all characters in the string are alphanumeric</td>
</tr>
<tr>
<td>isalpha()</td>
<td>Returns True if all characters in the string are in the alphabet</td>
</tr>
<tr>
<td>isdecimal()</td>
<td>Returns True if all characters in the string are decimals</td>
</tr>
<tr>
<td>isdigit()</td>
<td>Returns True if all characters in the string are digits</td>
</tr>
<tr>
<td>islower()</td>
<td>Returns True if all characters in the string are lower case</td>
</tr>
<tr>
<td>isnumeric()</td>
<td>Returns True if all characters in the string are numeric</td>
</tr>
<tr>
<td>isspace()</td>
<td>Returns True if all characters in the string are whitespaces</td>
</tr>
<tr>
<td>istitle()</td>
<td>Returns True if the string follows the rules of a title</td>
</tr>
<tr>
<td>isupper()</td>
<td>Returns True if all characters in the string are upper case</td>
</tr>
<tr>
<td>join()</td>
<td>Joins the elements of an iterable to the end of the string</td>
</tr>
<tr>
<td>lower()</td>
<td>Converts a string into lower case</td>
</tr>
</tbody>
</table>
# List Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>append()</td>
<td>Adds an element at the end of the list</td>
</tr>
<tr>
<td>clear()</td>
<td>Removes all the elements from the list</td>
</tr>
<tr>
<td>copy()</td>
<td>Returns a copy of the list</td>
</tr>
<tr>
<td>count()</td>
<td>Returns the number of elements with the specified value</td>
</tr>
<tr>
<td>extend()</td>
<td>Add the elements of a list (or any iterable), to the end of the current list</td>
</tr>
<tr>
<td>index()</td>
<td>Returns the index of the first element with the specified value</td>
</tr>
<tr>
<td>insert()</td>
<td>Adds an element at the specified position</td>
</tr>
<tr>
<td>pop()</td>
<td>Removes the element at the specified position</td>
</tr>
<tr>
<td>remove()</td>
<td>Removes the item with the specified value</td>
</tr>
<tr>
<td>reverse()</td>
<td>Reverses the order of the list</td>
</tr>
<tr>
<td>sort()</td>
<td>Sorts the list</td>
</tr>
</tbody>
</table>
## Sets Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>add()</td>
<td>Adds an element to the set</td>
</tr>
<tr>
<td>clear()</td>
<td>Removes all the elements from the set</td>
</tr>
<tr>
<td>copy()</td>
<td>Returns a copy of the set</td>
</tr>
<tr>
<td>difference()</td>
<td>Returns a set containing the difference between two or more sets</td>
</tr>
<tr>
<td>difference_update()</td>
<td>Removes the items in this set that are also included in another, specified set</td>
</tr>
<tr>
<td>discard()</td>
<td>Remove the specified item</td>
</tr>
<tr>
<td>pop()</td>
<td>Removes an element from the set</td>
</tr>
<tr>
<td>remove()</td>
<td>Removes the specified element</td>
</tr>
<tr>
<td>symmetric_difference()</td>
<td>Returns a set with the symmetric differences of two sets</td>
</tr>
<tr>
<td>symmetric_difference_update()</td>
<td>inserts the symmetric differences from this set and another</td>
</tr>
<tr>
<td>union()</td>
<td>Return a set containing the union of sets</td>
</tr>
<tr>
<td>update()</td>
<td>Update the set with the union of this set and others</td>
</tr>
</tbody>
</table>
Network Integration with Python

- Telnet
- Netmiko
- NAPALM
GNS3 DEMO

- Download gns3
  - [https://www.gns3.com/](https://www.gns3.com/)

- Download the GNS3 VM
  - Edit/Preference/GNS3VM/download here
GNS3 DEMO

- Use VMware workstation to import the GNS3VM
- Download the GNS3 appliance

This container provides the popular tools used for network automation: Netmiko, NAPALM, Pyntc, and Ansible.
GNS3 DEMO

- Import the appliance
  - File/import appliance
**GNS3 DEMO**

- Drag the Network Automation appliance, NAT Cloud and Switch.

- Modify Network Automation appliance to add one more Network Adapter
Telnet
In Python telnet is implemented by the module telnetlib which has the Telnet class which has the required methods to establish the connection

```python
import telnetlib
import time

password = ("cisco")

tn = telnetlib.Telnet("192.168.1.10")
 tn.read_until("Password: ")
 tn.write(password + "\n")

tn.write("enable \n")
 tn.read_until("Password: ")
 tn.write(password + "\n")

 tn.write("conf t \n")
 time.sleep(1)
 tn.write("interface loopback10 \n")
 time.sleep(1)
 tn.write("ip address 10.1.1.1 255.255.255.0 \n")
 time.sleep(1)
 tn.write("end \n")
 time.sleep(1)
 tn.write("exit \n")

print tn.read_very_eager()
print("\nThank You")
```

```
root@NetworkAutomation:~# python telnet.py

SW1#conf t
Enter configuration commands, one per line.  End with CTNR/L.
SW1(config)#interface loopback100
SW1(config-if)#ip address 100.1.1.1 255.255.255.0
SW1(config-if)#end
SW1#
```
import telnetlib
import time

username = ("cisco")
password = ("cisco")

tn = telnetlib.Telnet("192.168.1.10")
tn.read_until("Username: ")
tn.write(username + "\n")

for x in range (2,10):
    tn.write("vlan " + str(x) + "\n")
    time.sleep(1)

print(tn.read_very_eager())
print("Thank You")
Netmiko
Netmiko

The purposes of this library are the following:

• Successfully establish an SSH connection to the device
• Simplify the execution of show commands and the retrieval of output data
• Simplify execution of configuration commands including possibly commit actions

Do the above across a broad set of networking vendors and platforms
from netmiko import ConnectHandler

ios = {
    'device_type': 'cisco_ios',
    'ip': '192.168.1.10',
    'username': 'cisco',
    'password': 'cisco'
}

net_connect = ConnectHandler(**ios)
output = net_connect.send_command('show ip int brief')
print (output)

config_commands = ['int loop 0', 'ip address 1.1.1.1 255.255.255.0']
output = net_connect.send_config_set(config_commands)
print (output)
NAPALM
NAPALM

NAPALM (Network Automation and Programmability Abstraction Layer with Multivendor support) is a Python library that implements a set of functions to interact with different network device Operating Systems using a unified API.

NAPALM supports several methods to connect to the devices, to manipulate configurations or to retrieve data.

Supported Network Operating Systems:

• Arista EOS
• Cisco IOS
• Cisco IOS-XR
• Cisco NX-OS
• Juniper JunOS

## NAPALM

<table>
<thead>
<tr>
<th></th>
<th>EOS</th>
<th>IOS</th>
<th>IOSXR</th>
<th>JUNOS</th>
<th>NXOS</th>
<th>NXOS_SSH</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>get_arp_table</code></td>
<td>✔</td>
<td>✔</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td><code>get_bgp_config</code></td>
<td>✔</td>
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<td>✔</td>
<td>✔</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td><code>get_bgp_neighbors</code></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><code>get_bgp_neighbors_detail</code></td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✗</td>
<td>✗</td>
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<tr>
<td><code>get_config</code></td>
<td>✔</td>
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<tr>
<td><code>get_environment</code></td>
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<tr>
<td><code>get_facts</code></td>
<td>✔</td>
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</tr>
<tr>
<td><code>get_firewall_policies</code></td>
<td>✗</td>
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<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
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<tr>
<td><code>get_interfaces</code></td>
<td>✔</td>
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</tr>
</tbody>
</table>
from napalm import get_network_driver

driver = get_network_driver('ios')

g = driver('192.168.1.10', 'cisco', 'cisco')

g.open()

g_output = g.get_facts()

print (g_output)
Use Case

Case I:
Configure Vlan on multiple switches and interfaces simultaneously.
Thinking Process!

• Problem identification
  • Configure Vlan on multiple switches and its interfaces simultaneously.
  • Error handling.
  • Time mismanagement.

• Implementing a Plan
  • Automate vlan creation.
  • Use programming language
  • Debugging issues
  • Determine format of output
  • Integration of frontend and backend code.

• Solution
  • No more manual configuration
  • Error less provisioning
  • Efficient utilization of time

• Future Enhancements
  • Multi vendor support
<!DOCTYPE HTML>
<html>
<body>

<h2>Vlan Configuration</h2>
<form method="post" action="submit.php">
<table>
  <tr>
    <td><p>Enter Username</p><br /></td>
    <td><input type="text" name="user" /></td>
  </tr>
  <tr>
    <td><p>Enter Password</p><br /></td>
    <td><input type="password" name="password" /></td>
  </tr>
  <tr>
    <td><p>Enter Vlan</p><br /></td>
    <td><input type="text" name="vlan" maxlength="4" /></td>
  </tr>
  <tr>
    <td><p>Enter Vlan Name</p><br /></td>
    <td><input type="name" name="name" /></td>
  </tr>
  <tr>
    <td><br /></td>
    <td><input type="submit" name="ok" /></td>
  </tr>
</table>
</form>

<?php
$vlan=$_POST['vlan'];
$name=$_POST['name'];
$user=$_POST['user'];
$password=$_POST['password'];
echo shell_exec("python /var/www/html/vlan/huaweiconfig.py "$vlan "$name "$user "$password");
echo nl2br(file_get_contents("/var/www/html/vlan/final"));
file_put_contents("/var/www/html/vlan/final", '');
?>
</body>
</html>
Frontend HTML Page

Vlan Configuration

Enter Username
Enter Password
Enter Vlan
Enter Vlan Name
Submit Query
Backend Python Code
Debug session on Network Node
What happened when vlan already exists!

Vlan Configuration

- Enter Username
- Enter Password
- Enter Vlan
- Enter Vlan Name

[Submit Query]
Enter incorrect vlan!

Vlan Configuration

Enter Username
Enter Password
Enter Vlan
Enter Vlan Name

Submit Query
Python for Network Engineers

• The language which is widely opt by Network community and there is a very big gap between Python and other prevalent languages such as Perl, Ruby, Go as far as the size of the community.

• For new comers make simple scripts then move to complicated ones.

• There is a vast amount of available network libraries.

• Use various Python tools/modules to handle network devices from several networking vendors: Cisco (IOS, IOS XE, IOS XR), Juniper, Arista, HP, Avaya.

• Execute CLI commands on several network devices simultaneously.
Closing Remarks

• If you are really interested in moving forward, try making your mind and picking up a choice.

• Community is there to support you.

• Start small, celebrate the little things, and build, build, build!

• At the end of the day the true reason for happiness is creating something out of nothing.

A good mentor of mine told me if you want to create a flying car, then start with making some wheels into a skateboard, enjoy the skateboard and turn that into a bike and so on. – Yad Faeg

Questions!
Thank You

You will never be 100% ready to change. Don’t wait for the perfect time. It will never come.

Start today!