

## NetSim Multi-Parameter Sweeper

### Software Recommended:

NetSim v12.2 (32/64 bit), Python 3.7.4 (Optional)

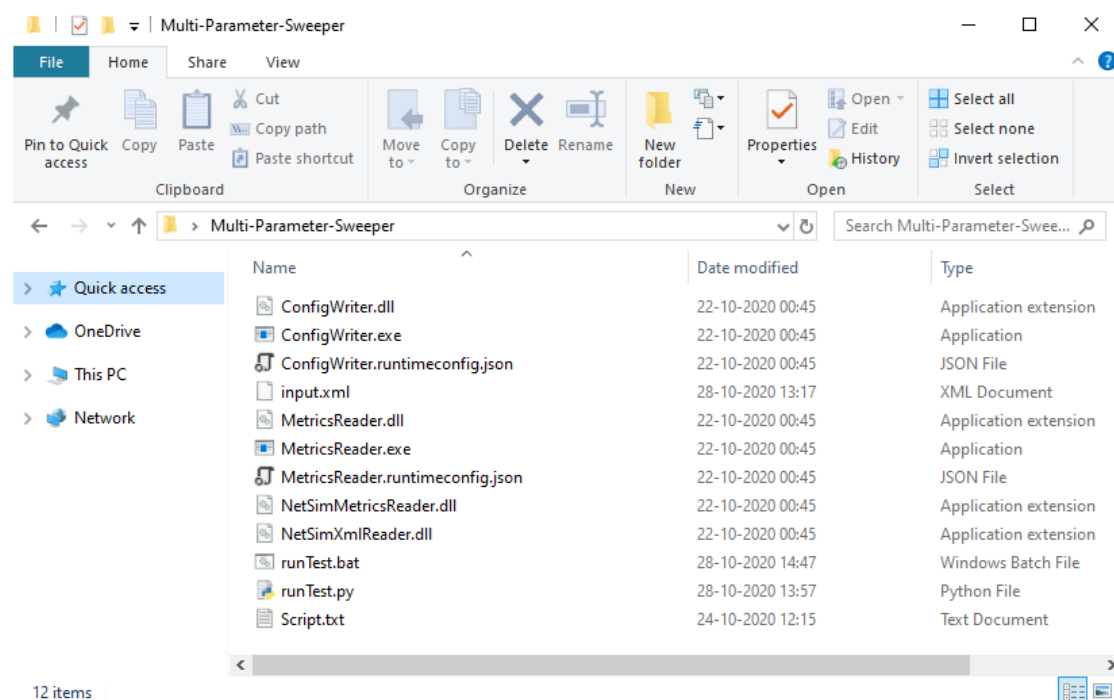
### Introduction:

NetSim Command Line Interface (CLI) allows automating the simulation process without the need for GUI. NetSim Multi-Parameter Sweeper meets Advance user requirements which involves changing the values of multiple parameters between simulation runs and compare and analyse the performance metrics of each run.

NetSim multi-parameter sweeper allows users to introduce a series of changes to the network parameters, simulate, save results and log specific output parameters during each run for analysing the impact.

Consider the example, where a user wishes to create and simulate a network scenario for all possible values of one or more parameters for different combinations and store and analyse the performance metrics of each simulation run. It is too time consuming to do this manually using the GUI. However, this can be done by using NetSim multi-parameter sweeper which runs NetSim via CLI without the need for any manual intervention.

The project directory consists of several binaries which are responsible for different tasks during a multi-parameter sweep:

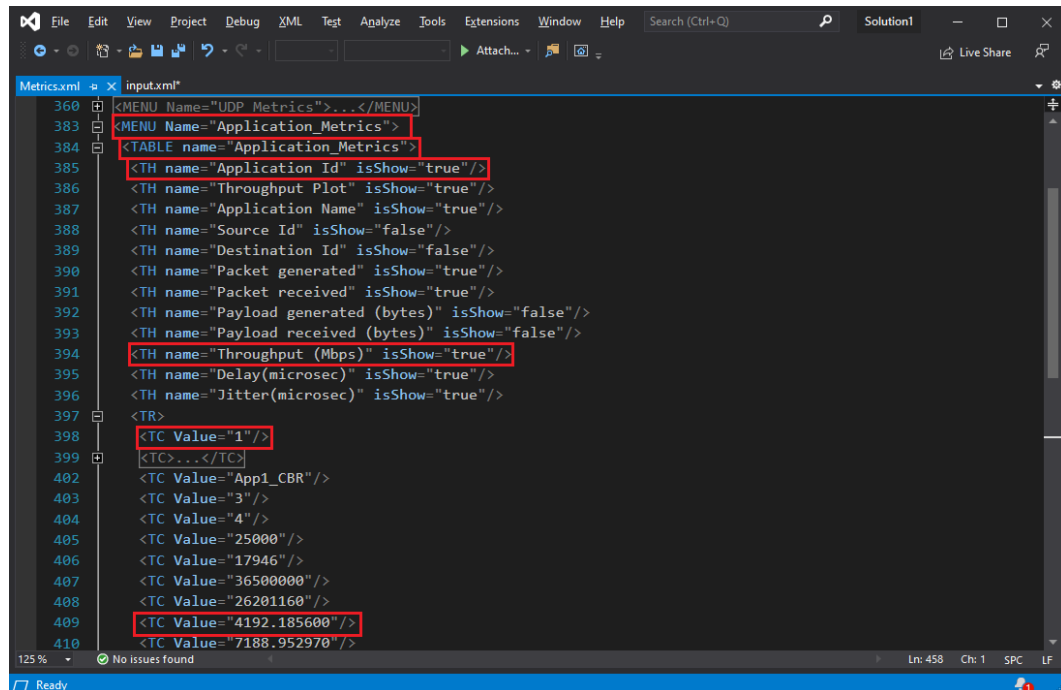




At the end of every simulation, NetSim generates a Metrics.xml file which contain the performance metrics written in a specific format based on which it is loaded in the results dashboard.

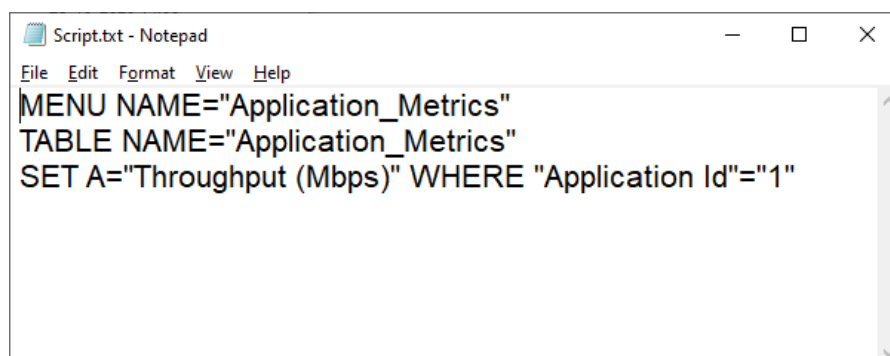
Each Metric is part of a results table which can be accessed using a menu in the results dashboard.

A NetSim Metrics.xml file is shown below:



```
360 <MENU Name="UDP Metrics">...</MENU>
383 <MENU Name="Application_Metrics">
384 <TABLE name="Application_Metrics">
385 <TH name="Application Id" isShow="true"/>
386 <TH name="Throughput Plot" isShow="true"/>
387 <TH name="Application Name" isShow="true"/>
388 <TH name="Source Id" isShow="false"/>
389 <TH name="Destination Id" isShow="false"/>
390 <TH name="Packet generated" isShow="true"/>
391 <TH name="Packet received" isShow="true"/>
392 <TH name="Payload generated (bytes)" isShow="false"/>
393 <TH name="Payload received (bytes)" isShow="false"/>
394 <TH name="Throughput (Mbps)" isShow="true"/>
395 <TH name="Delay(microsec)" isShow="true"/>
396 <TH name="Jitter(microsec)" isShow="true"/>
397 <TR>
398 <TC Value="1"/>
399 <TC>...</TC>
402 <TC Value="App1_CBR"/>
403 <TC Value="3"/>
404 <TC Value="4"/>
405 <TC Value="25000"/>
406 <TC Value="17946"/>
407 <TC Value="36500000"/>
408 <TC Value="26201160"/>
409 <TC Value="4192.185600"/>
410 <TC Value="7188.952970"/>
```

For Example, if the application throughput is to be logged for each simulation run then the scrip file can be updated as shown below:

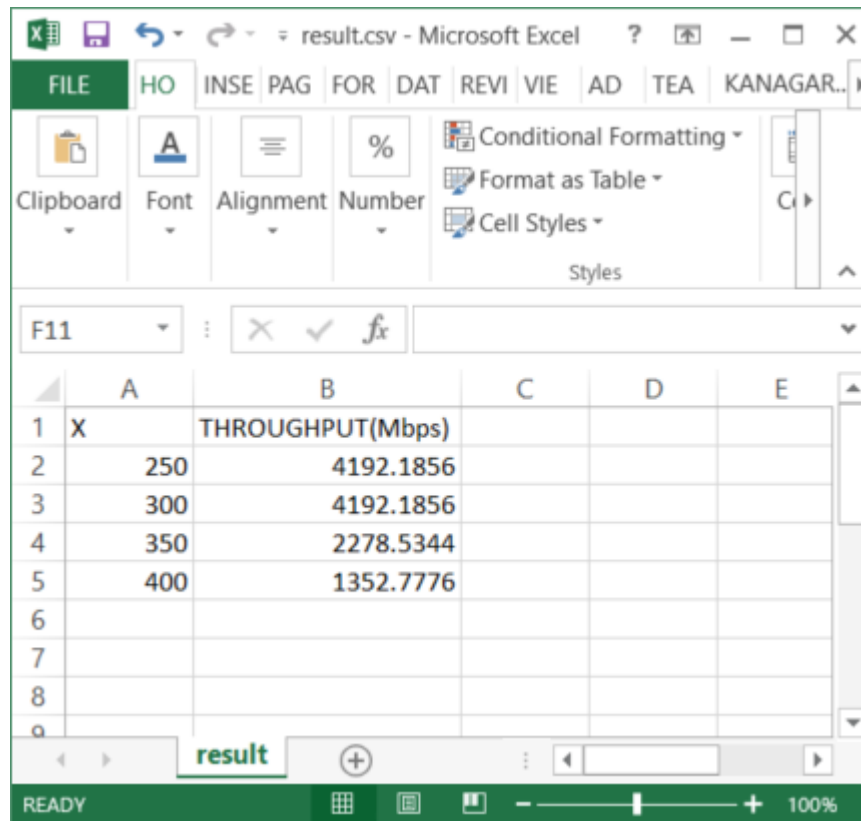


```
Script.txt - Notepad
File Edit Format View Help
MENU NAME="Application_Metrics"
TABLE NAME="Application_Metrics"
SET A="Throughput (Mbps)" WHERE "Application Id"="1"
```

3. **ConfigWriter.exe:** This executable takes one or more command line arguments as input and generated Configuration.netsim file by replacing the arguments in place of the variable parameters specified in the input.xml file.

If there are two variable parameters specified in the input.xml file ({0} and {1}) then two arguments need to be passed while calling ConfigWriter.exe.

4. **MetricsReader.exe:** This executable is responsible for reading the output parameter from the Metrics.xml file generated after each simulation and logging it to the results file. Users the Script.txt file to determine which parameter to read from the Metrics file. If multiple parameters are to be read and logged then the MetricsReader.exe can be called multiple times with Script.txt file having information about the parameter to be read each time.



The screenshot shows a Microsoft Excel window titled 'result.csv - Microsoft Excel'. The ribbon includes 'FILE', 'HOME', 'INSERT', 'PAGE LAYOUT', 'FORMULAS', 'DATA', 'REVIEW', 'VIEW', 'ADD-INS', 'TEA', and 'KANAGAR...'. The 'HOME' ribbon is active, showing 'Clipboard', 'Font', 'Alignment', 'Number', and 'Styles' groups. The formula bar shows 'F11' and a function icon. The spreadsheet has columns A through E and rows 1 through 9. The data is as follows:

	A	B	C	D	E
1	X	THROUGHPUT(Mbps)			
2	250	4192.1856			
3	300	4192.1856			
4	350	2278.5344			
5	400	1352.7776			
6					
7					
8					
9					

The status bar at the bottom shows 'READY', a grid icon, a zoom slider, and '100%'.

5. **Supporting DLL's:** Some the supporting files such as ConfigWriter.dll, MetricsReader.dll, NetSimMetricsReader.dll, NetSimXmlReader.dll, etc. which are present in the project folder are used by other executable such as ConfigWriter.exe and MetricsReader.exe for various purposes during a multi-parameter sweep.

6. **runTest** script files: The files runTest.bat, runTest.py are the main script files that can be used to start a multi-parameter sweep process. Both files differ in the programming language used for the script.

**runTest.bat** uses Windows commands that can be executed by the windows command line interpreter. Batch scripts may get complex as the number of input and output parameters increases.

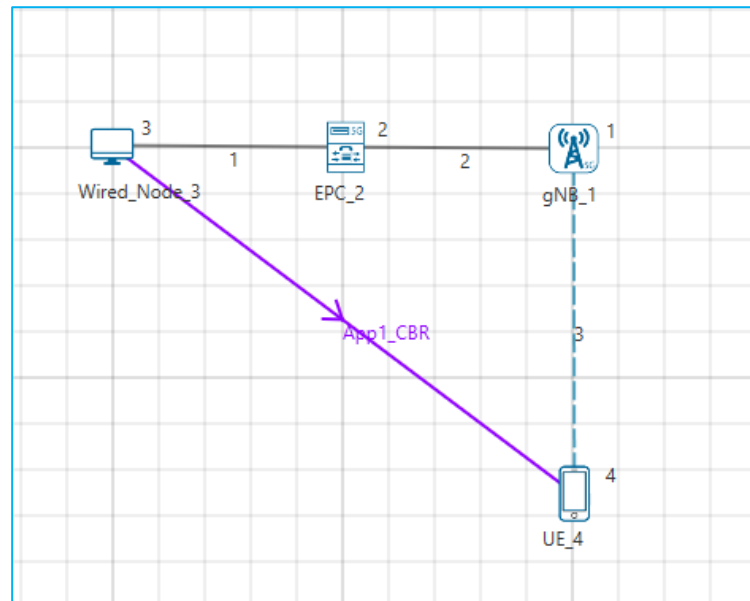
**runTest.py** uses python programming language which is less complex and offers more flexibility as the number of input and output parameters increases.

Users can also write the script to run the multi-parameter sweep process in a preferred programming language as per the convenience.

The script runs multiple simulation iterations based on the number of parameters to be varied and the range of values of each parameter.

Running a Multi-Parameter Sweep process:

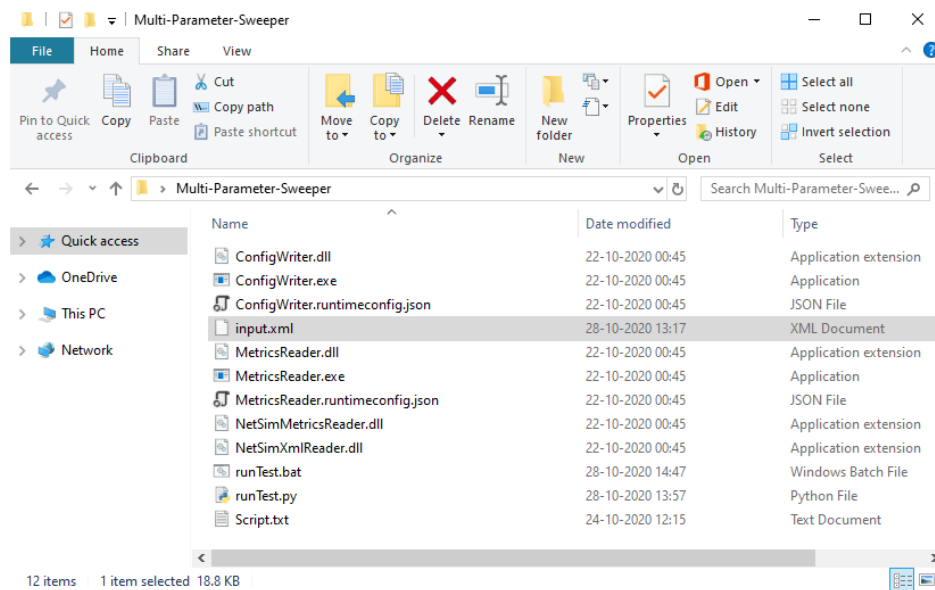
Consider the following network 5G network scenario in NetSim, comprising of a Wired Node, EPC, gNB and a UE.



The network configuration has the initial distance between the gNB and UE as 50 meters with the gNB located at (1000,200) and UE located at (1000,250).

Multi-Parameter Sweeper is configured to run simulations for different distance between the gNB and UE by varying the UE Y coordinate value from 250 to 400 in steps of 50 meters.

1. The network configuration information is copied from the saved Configuration.netsim file to the input.xml file present in the Multi-Parameter-Sweeper project folder.

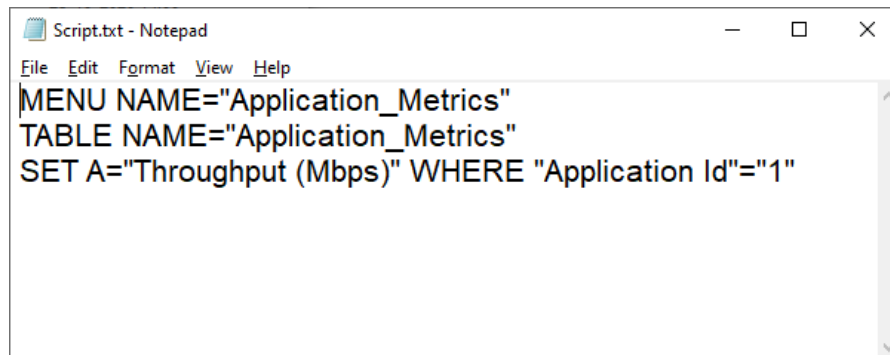


The value of the Y coordinate of UE that is to be modified during each simulation run is updated (“{0}”) in the configuration file as shown below:

```

1 <?xml version="1.0" encoding="UTF-8" standalone="no"?>
2 <TETCOS_NETSIM xmlns:ns0="http://www.w3.org/2001/XMLSchema-instance" ns0:noNamespaceSchemaLocation="Configur
3 <EXPERIMENT_INFORMATION>...</EXPERIMENT_INFORMATION>
11 <GUI_INFORMATION>...</GUI_INFORMATION>
18 <NETWORK_CONFIGURATION>
19 <DEVICE_CONFIGURATION DEVICE_COUNT="4">
20 <DEVICE DEFAULT_DEVICE_NAME="gNB" DEVICE_ID="1" DEVICE_IMAGE="gNB.png" DEVICE_NAME="gNB_1" DEVICE_TYPE
68 <DEVICE DEFAULT_DEVICE_NAME="EPC" DEVICE_ID="2" DEVICE_IMAGE="EPC.png" DEVICE_NAME="EPC_2" DEVICE_TYPE
69 <POS_3D X_OR_LON="804.99" Y_OR_LAT="200.54999999999998" Z="0"/>
70 <INTERFACE ID="1" INTERFACE_TYPE="ETHERNET">...</INTERFACE>
90 <INTERFACE ID="2" INTERFACE_TYPE="LTE_NR">...</INTERFACE>
110 <LAYER TYPE="APPLICATION_LAYER">...</LAYER>
117 <LAYER TYPE="TRANSPORT_LAYER">...</LAYER>
125 <LAYER TYPE="NETWORK_LAYER">...</LAYER>
130 </DEVICE>
131 <DEVICE DEFAULT_DEVICE_NAME="Wired_Node" DEVICE_ID="3" DEVICE_IMAGE="WiredNode.png" DEVICE_NAME="Wired
168 <DEVICE DEFAULT_DEVICE_NAME="UE" DEVICE_ID="4" DEVICE_IMAGE="UserEquipment.png" DEVICE_NAME="UE_4" DEV
169 <POS_3D X_OR_LON="1000" Y_OR_LAT="{0}" Z="0">
170 <MOBILITY_MODEL="NO_MOBILITY"/>
171 </POS_3D>
172 <INTERFACE ID="1" INTERFACE_TYPE="LTE_NR">...</INTERFACE>
189 <LAYER TYPE="APPLICATION_LAYER"/>
190 <LAYER TYPE="TRANSPORT_LAYER">...</LAYER>
198 </DEVICE>
199 </DEVICE_CONFIGURATION>
200 <CONNECTION>...</CONNECTION>
218 <APPLICATION_CONFIGURATION COUNT="1">...</APPLICATION_CONFIGURATION>
  
```

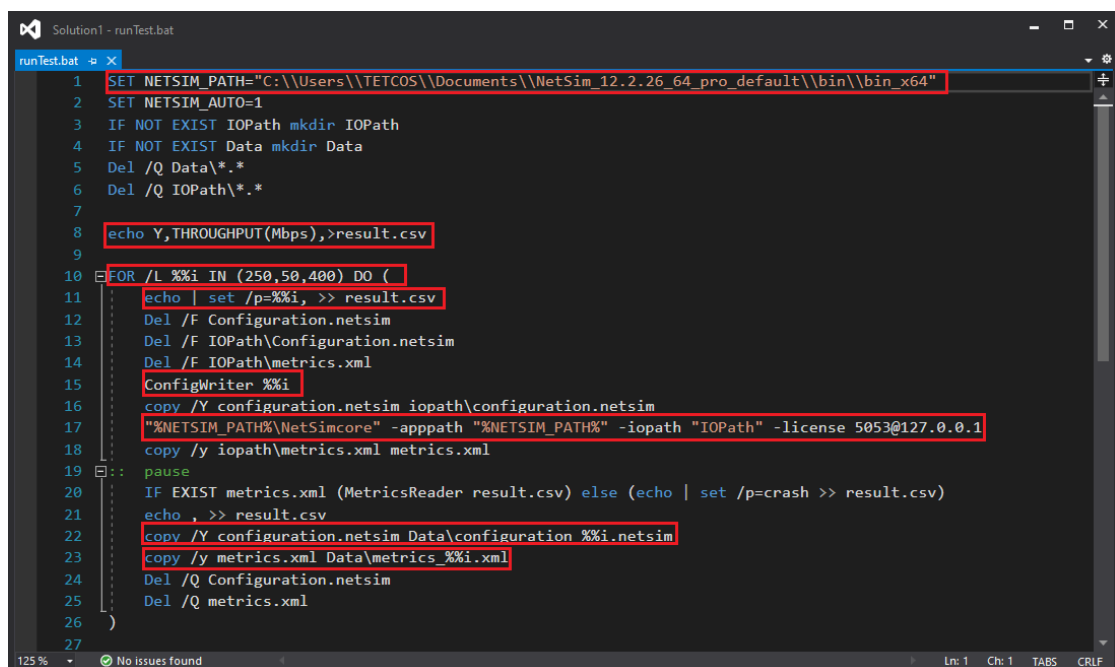
2. The Script.txt file is updated with the details of the output parameter to be read from the Metrics.xml file and added to the result csv log file. In this case the Application throughput is to be logged for each simulation run.



```
Script.txt - Notepad
File Edit Format View Help
MENU NAME="Application_Metrics"
TABLE NAME="Application_Metrics"
SET A="Throughput (Mbps)" WHERE "Application Id"="1"
```

- runTest.py/runTest.bat is updated to pass the Y coordinate value during each iteration to generate Configuration file run simulation and update the result csv log.

The runTest.bat batch script modified for running simulations for different values of Y coordinates starting from 250 up to 400 in steps of 50 is shown below:



```
Solution1 - runTest.bat
runTest.bat
1 SET NETSIM_PATH="C:\\Users\\TETCOS\\Documents\\NetSim_12.2.26_64_pro_default\\bin\\bin_x64"
2 SET NETSIM_AUTO=1
3 IF NOT EXIST IOPATH mkdir IOPATH
4 IF NOT EXIST Data mkdir Data
5 Del /Q Data\\*.
6 Del /Q IOPATH\\*.
7
8 echo Y,THROUGHPUT(Mbps),>result.csv
9
10 FOR /L %%i IN (250,50,400) DO (
11     echo | set /p=%%i, >> result.csv
12     Del /F Configuration.netsim
13     Del /F IOPATH\\Configuration.netsim
14     Del /F IOPATH\\metrics.xml
15     ConfigWriter %%i
16     copy /Y configuration.netsim iopath\\configuration.netsim
17     "%NETSIM_PATH%\\NetSimcore" -apppath "%NETSIM_PATH%" -iopath "IOPATH" -license 5053@127.0.0.1
18     copy /y iopath\\metrics.xml metrics.xml
19     pause
20     IF EXIST metrics.xml (MetricsReader result.csv) else (echo | set /p=crash >> result.csv)
21     echo , >> result.csv
22     copy /Y configuration.netsim Data\\configuration %%i.netsim
23     copy /y metrics.xml Data\\metrics_%%i.xml
24     Del /Q Configuration.netsim
25     Del /Q metrics.xml
26 )
27
```

- NETSIM\_PATH variable is set to the path of NetSim 32-bit/64-bit binaries in the install directory or workspace in the system.
- A result.csv file is created and added with headings Y and Throughput(Mbps)
- For loop is set to iteratively run simulations for values starting from 250 to 400 in steps of 50.
- The value of the parameter Y in the current iteration is written to the result log file for analysis.
- The value of the parameter Y in the current iteration is passed as input to ConfigWriter executable to generate Configuration.netsim file for each simulation.
- NetSim simulation is run via CLI mode by passing the apppath, iopath and license server information

- Configuration file and Metrics file are copied and renamed appending the value of the parameter in the current iteration.

The runTest.py python script modified for running simulations for different values of Y coordinates starting from 250 up to 400 in steps of 50 is shown below:

```

1  import random
2  import shutil
3  import math
4  import sys
5  import os
6
7  #Set the path of NetSim Binaries to be used for simulation. Either 32 bit or 64 bit
8  NETSIM_PATH="C:\\Users\\TETCOS\\Documents\\NetSim_12.2.26_64_pro_default\\bin\\bin_x64"
9
10 #Set NETSIM_AUTO environment variable to avoid keyboard interrupt at the end of each simulation
11 os.environ['NETSIM_AUTO'] = '1'
12
13 #Create IOPATH directory to store the input Configuration.netsim file and the simulation output files
14 #during each iteration
15 if not os.path.exists('IOPATH'):
16     os.makedirs('IOPATH')
17
18 #Create Data directory to store the Configuration.netsim and the Metrics.xml files associated with each
19 #iteration
20 if not os.path.exists('Data'):
21     os.makedirs('Data')
22
23 #Clear the IOPATH folder if it has any files created during previous multi-parameter sweep runs
24 for root, dirs, files in os.walk('IOPATH'):
25     for file in files:
26         os.remove(os.path.join(root, file))

```

- NETSIM\_PATH variable is set to the path of NetSim 32-bit/64-bit binaries in the install directory or workspace in the system.

```

26 #Clear the Data folder if it has any files created during previous multi-parameter sweep runs
27 for root, dirs, files in os.walk('Data'):
28     for file in files:
29         os.remove(os.path.join(root, file))
30
31 #Delete result.csv file if it already exists
32 if os.path.isfile("result.csv"):
33     os.remove("result.csv")
34
35 #create a csv file to log the output metrics for analysis
36 csvfile = open("result.csv", 'w')
37
38 #Add headings to the CSV file
39 csvfile.write('Y,THROUGHPUT(Mbps),')
40 csvfile.close()
41
42 #Iterate based on the number of time simulation needs to be run and the input parameter range
43 for i in range(250, 401, 50):
44     if os.path.isfile("Configuration.netsim"):
45         os.remove("Configuration.netsim")
46
47     if os.path.isfile("IOPATH\\Configuration.netsim"):
48         os.remove("IOPATH\\Configuration.netsim")
49
50     if os.path.isfile("IOPATH\\Metrics.xml"):
51         os.remove("IOPATH\\Metrics.xml")
52

```

- A result.csv file is created and added with headings Y and Throughput(Mbps)



- For loop is set to iteratively run simulations for values starting from 250 to 400 in steps of 50.

```

54 #Call ConfigWriter.exe with arguments as per the number of variable parameters in the input.xml file
55 cmd='ConfigWriter.exe '+str(i)
56 print(cmd)
57 os.system(cmd)
58
59 #Copy the Configuration.netsim file generated by ConfigWriter.exe to IOPath directory
60 if(os.path.isfile("Configuration.netsim")):
61     shutil.copy("Configuration.netsim", "IOPath\\Configuration.netsim")
62
63 #Run NetSim via CLI mode by passing the apppath iopath and license information to the NetSimCore.exe
64 cmd=NETSIM_PATH+"\\NetSimcore.exe -apppath "+NETSIM_PATH+" -iopath IOPath -license 5053@127.0.0.1"
65 os.system(cmd)
66 #print(cmd)
67
68 #Create a copy of the output Metrics.xml file for writing the result log
69 if(os.path.isfile("IOPath\\Metrics.xml")):
70     shutil.copy("IOPath\\Metrics.xml", "Metrics.xml")
71
72 #Write the value of the variable parameter in the current iteration to the result log
73 csvfile = open("result.csv", 'a')
74 if(os.path.isfile("Metrics.xml")):
75     csvfile.write('\\n'+str(i)+'+')
76     csvfile.close()
77 #Call the MetricsReader.exe passing the name of the output log file for updating the log based
78     on script.txt
79     os.system("MetricsReader.exe result.csv")

```

- The value of the parameter Y in the current iteration is passed as input to ConfigWriter executable to generate Configuration.netsim file for each simulation.
- NetSim simulation is run via CLI mode by passing the apppath, iopath and license server information.
- The value of the parameter Y in the current iteration is written to the result log file for analysis.

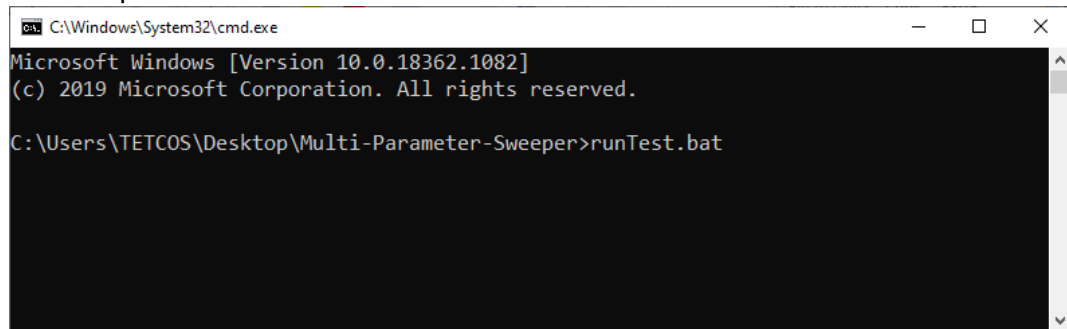
```

78     on script.txt
79     os.system("MetricsReader.exe result.csv")
80
81 else:
82     #Update the output Metric as crash if Metrics.xml file is missing
83     csvfile.write('\\n'+str(i)+'+'+crash'+','')
84     csvfile.close()
85
86 #Create a copy of the Configuration.netsim file appending the value of the variable parameters used
87     in the current iteration
88     if(os.path.isfile("Configuration.netsim")):
89         shutil.copy("Configuration.netsim", "Data\\configuration_"+str(i)+".netsim")
90
91 #Create a copy of the Metrics.xml file appending the value of the variable parameters used in the
92     current iteration
93     if(os.path.isfile("Metrics.xml")):
94         shutil.copy("Metrics.xml", "Data\\metrics_"+str(i)+".xml")
95
96 #Delete Configuration.netsim file created during the last iteration
97 if(os.path.isfile("Configuration.netsim")):
98     os.remove("Configuration.netsim")
99
100 #Delete Metrics.xml file created during the last iteration
    if(os.path.isfile("Metrics.xml")):
        os.remove("Metrics.xml")

```

- Configuration file and Metrics file are copied and renamed appending the value of the parameter in the current iteration.
4. Multi-Parameter Sweeping process is started by opening command prompt in the directory of the Multi-Parameter-Sweeping project and starting the batch script or the python script as shown below:

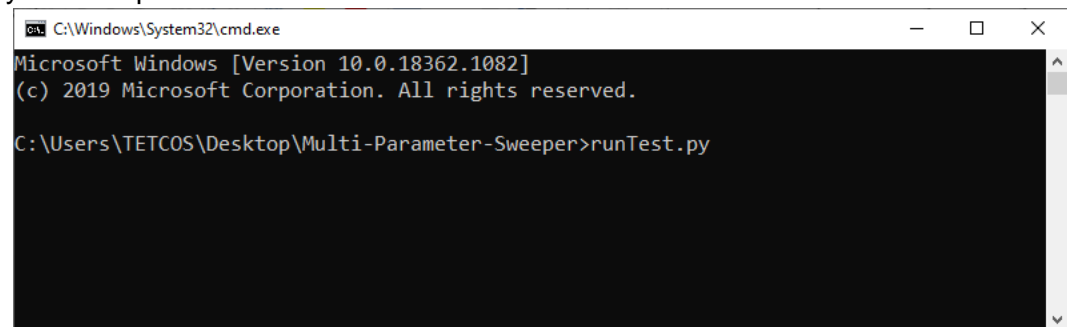
Batch Script:



```
C:\Windows\System32\cmd.exe
Microsoft Windows [Version 10.0.18362.1082]
(c) 2019 Microsoft Corporation. All rights reserved.

C:\Users\TETC0S\Desktop\Multi-Parameter-Sweeper>runTest.bat
```

Python Script:

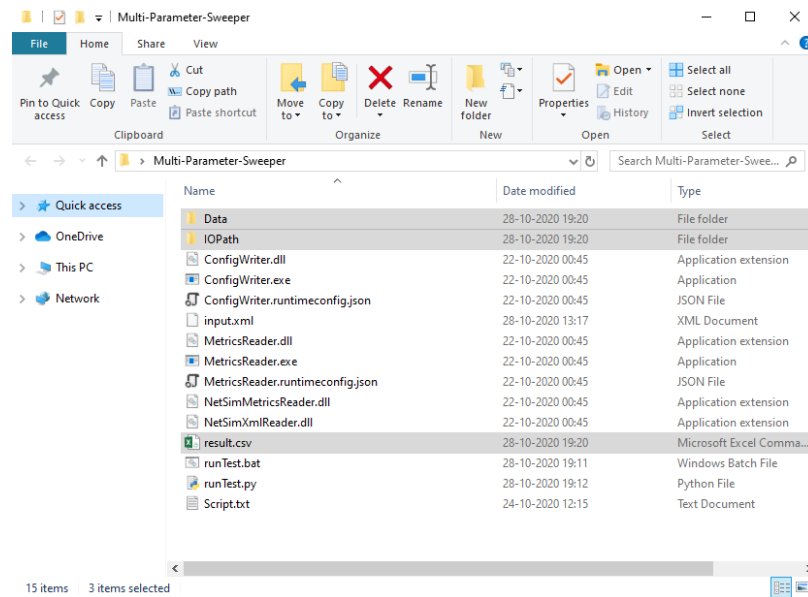


```
C:\Windows\System32\cmd.exe
Microsoft Windows [Version 10.0.18362.1082]
(c) 2019 Microsoft Corporation. All rights reserved.

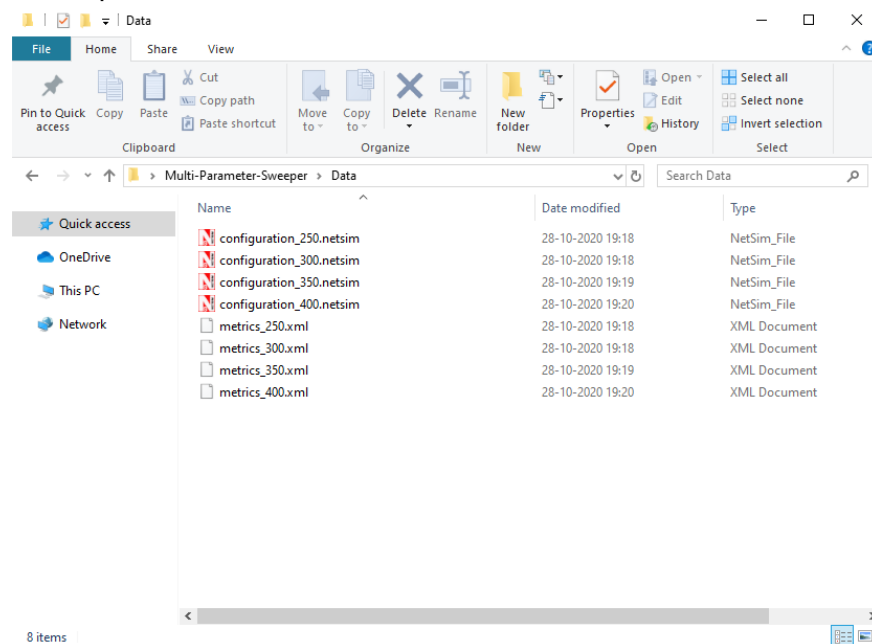
C:\Users\TETC0S\Desktop\Multi-Parameter-Sweeper>runTest.py
```

This starts the Multi-Parameter-Sweeping process starts and run simulations iteratively for different values of Y parameter of UE.

At the end of the process the Multi-Parameter-Sweeping folder will have the following file and folders created:



- **Data:** The Data directory contains the Configuration.netsim and the Metrics.xml files associated with each simulation run, renamed including the value of the parameter in the file name.



- **IOPath:** Used for storing the Configuration.netsim file and the simulation files generated during each simulation run.
- **Result.csv:** This is the output log which contains the parameter varied during each simulation run and the output parameter associated with each run.

	A	B	C	D	E
1	Y	THROUGHPUT(Mbps)			
2		250	4192.1856		
3		300	4192.1856		
4		350	2278.5344		
5		400	1352.7776		
6					
7					
8					

### Varying multiple network parameters:

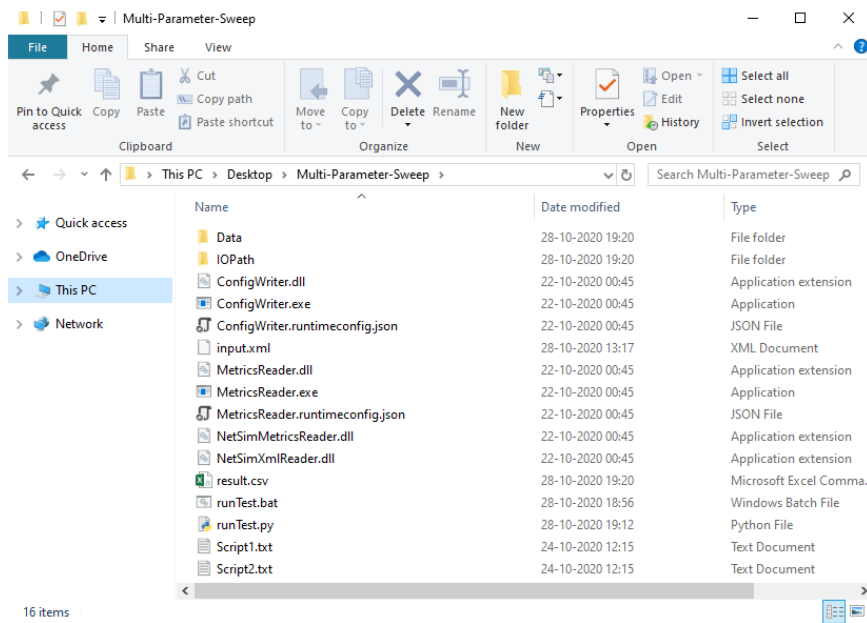
In order to vary multiple network parameters during the multi-parameter sweep process each parameter in the input.xml file can be modified as  $\{0\}, \{1\}, \{2\}, \{3\}, \dots, \{n\}$  respectively.

### Logging multiple output parameters:

Each output parameter that is to be logged should be part of the Script.txt file. However, the Script.txt file should contain only the details of one output parameter during the call to MetricsReader.exe.

In order to log multiple parameter, MetricsReader.exe can be called multiple times with Script.txt file having information about different parameter during each call.

For Example, there can be two Script files as shown below:



During each call to MetricsReader each of the Script files (Script1.txt and Script2.txt) can be renamed to Script.txt and renamed back.