

NetSim Multi-Parameter Sweeper MATLAB Script

Software: NetSim v13.2 (64 bit), [DOT NET CORE SDK 3.1](#), MATLAB (2022 or higher)

Project Download Link:

https://github.com/NetSim-TETCOS/Multi-Parameter_Sweeper_v13.2/archive/refs/heads/main.zip

Introduction

When users want to *sweep* one or more parameters, they change their values between simulation runs, and compare and analyse the performance metrics from each run. NetSim multi-parameter sweeper enables users to automate the sweep process.

Consider an example, where a user wishes to create and simulate a network scenario for all possible values of one or more parameters in combination and analyse a set of performance metrics across the simulation runs. This is extremely time consuming to do manually using the NetSim GUI.

The multi-parameter sweep program enables users to automate the sweep process across multiple input parameters, simulate each run, save each result, and compare specific output metrics via a spreadsheet software like MS Excel.

The sweep program runs NetSim via its CLI interface.

File Organization

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

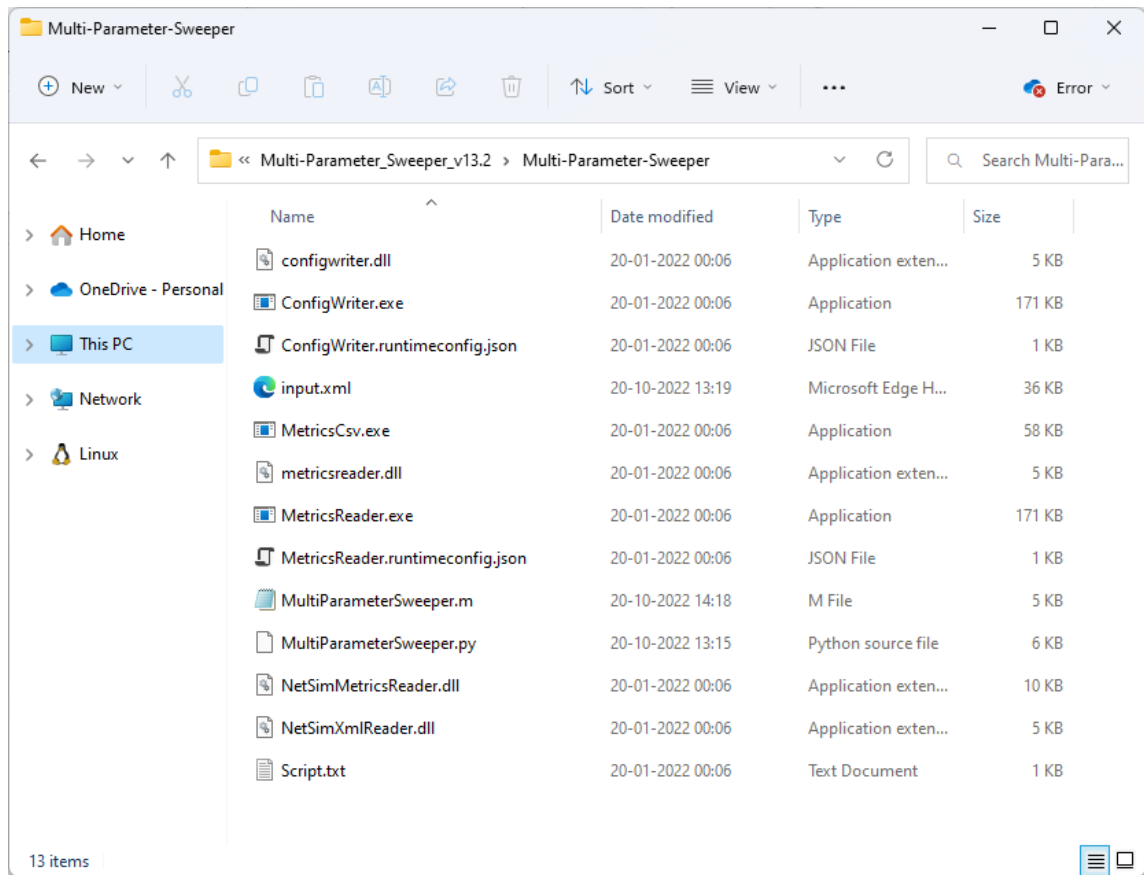


Figure 1: project directory consists of several binaries

1. **input.xml**: This file contains the base NetSim network configuration that is to be simulated. This file is created by copy pasting the Configuration.netsim file that can be obtained by saving a network configuration in NetSim and renaming it to input.xml.

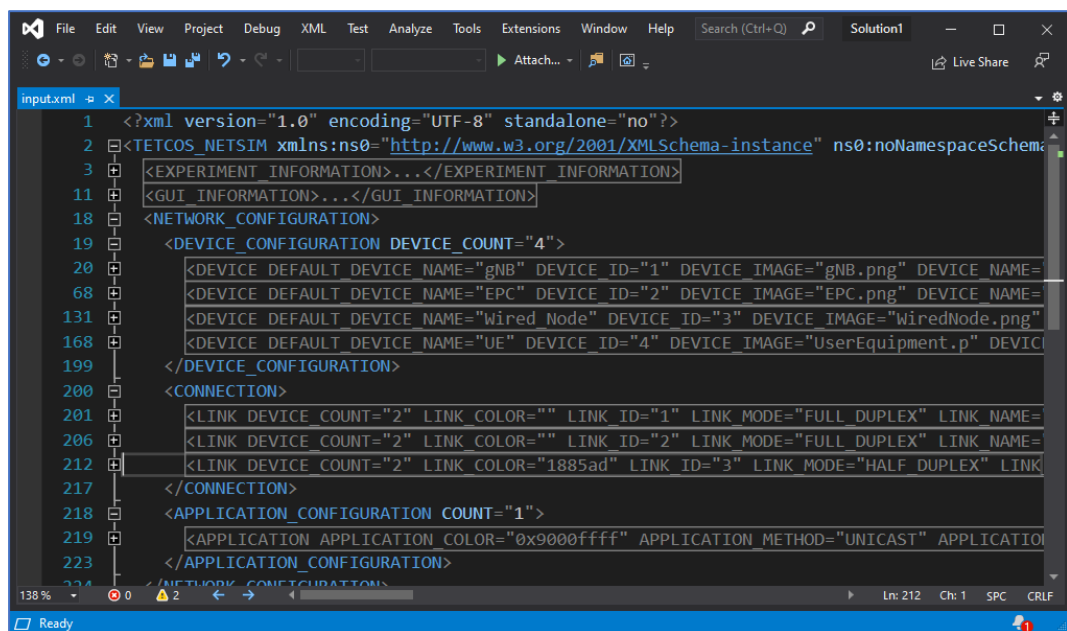


Figure 2: NetSim input Configuration.netsim file

- The values of parameters which are to be varied during each simulation run needs to be specified as {0}, {1}, {2}, etc. respectively.
- For Example, if the X and Y coordinates of a device is to be varied the values can be modified in the input.xml file as shown below:

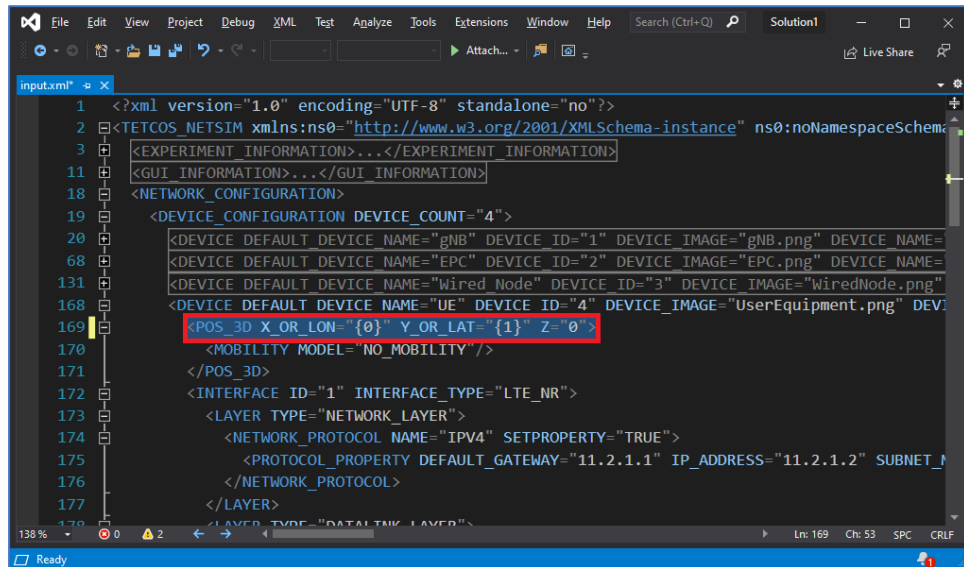


Figure 3: Modify X and Y coordinates in input input.xml file

2. **Script.txt:** This file should be updated with the parameter from the output metrics of NetSim that is to be logged at the end of each simulation run for the purpose of analysis.

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"/>
```

Figure 4: NetSim output Metrics.xml file

For Example, if the application throughput is to be logged for each simulation run then the script 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"
```

Figure 5: The application throughput is to be logged for each simulation modified in Script.txt

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. **MetricsCSV.exe**: This executable is used to convert the Metrics.xml file present in the output folder into a comma separated file, MetricsPrint.csv.

5. **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.

It uses 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.

6. **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.

7. **MultiParameterSweeper.m** uses MATLAB 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 can be configured to run multiple simulation iterations based on the number of parameters to be varied and the range of values of each parameter.
- NETSIM_PATH variable can be set to the path of NetSim 64-bit binaries (bin_x64) in the install directory or workspace which is to be used to run Simulations.
- LICENSE_ARG variable can be set to License server port and IP details in case of floating on premise licenses or the path of license file in case of node locked or cloud licenses.

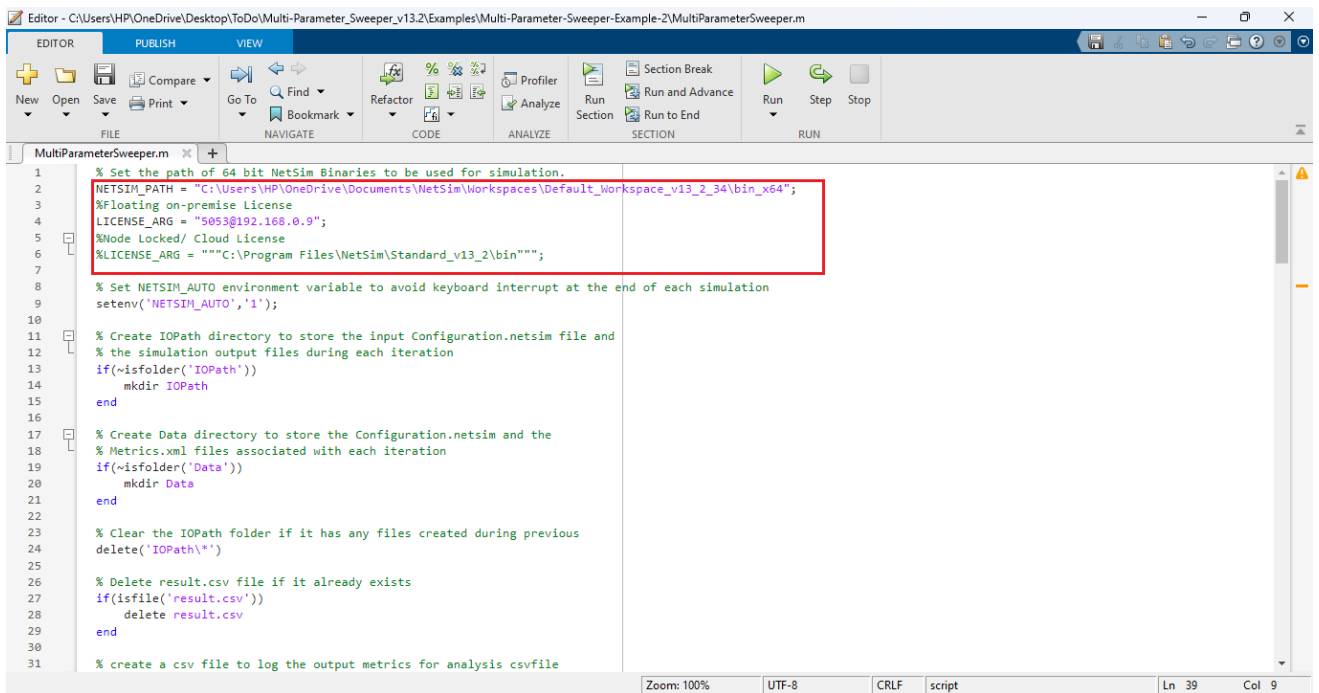


Figure 6: User need to set NetSim Path based on 64-bit

For example,

NETSIM_PATH

=

"C:\Users\HP\OneDrive\Documents\NetSim\Workspaces\Default_Workspace_v13_2_34\bin_x64";

Floating on-premise license (<port no>@<server ip address>):

LICENSE_ARG = "5053@192.168.0.9";

Node Locked or Cloud licenses (path of license file):

LICENSE_ARG = ""C:\Program Files\NetSim\Standard_v13_2\bin"";

- The MetricsCSV.exe will convert the Metrics.xml file inside the output folder into a csv file.

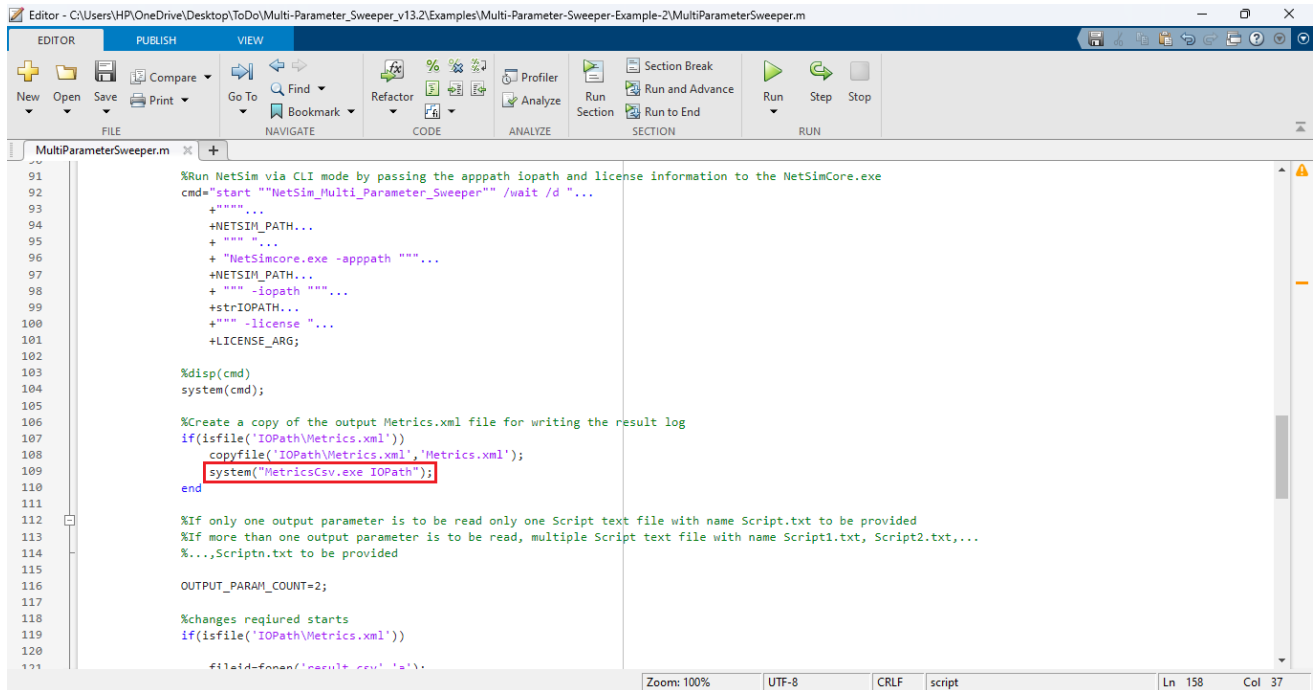


Figure 7: MetricsPrint.csv file will be created in the IOPATH and then copied into the respective output folder

8. Multi-Parameter Sweeping process can be started from MATLAB command line in the directory of the Multi-Parameter-Sweeping project as shown below:

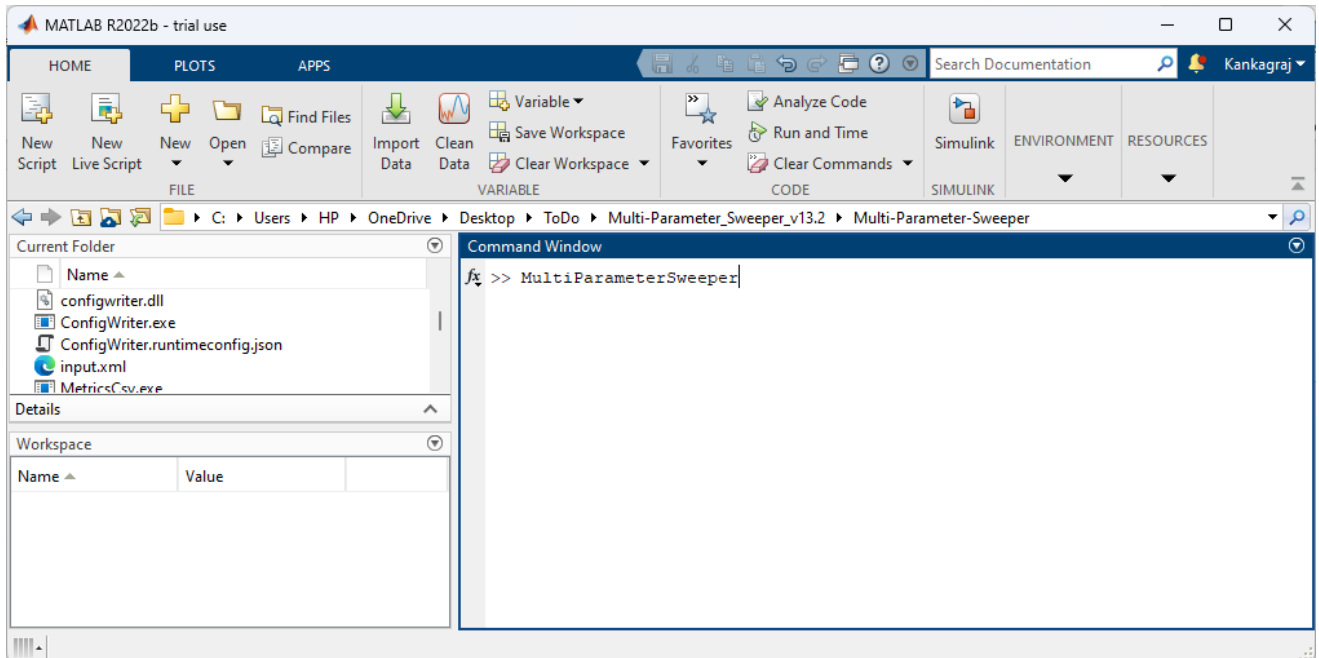


Figure 8: Running MATLAB script using cmd prompt

9. This starts the Multi-Parameter-Sweeping process which runs NetSim simulations iteratively for different values of Y parameter of UE.

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

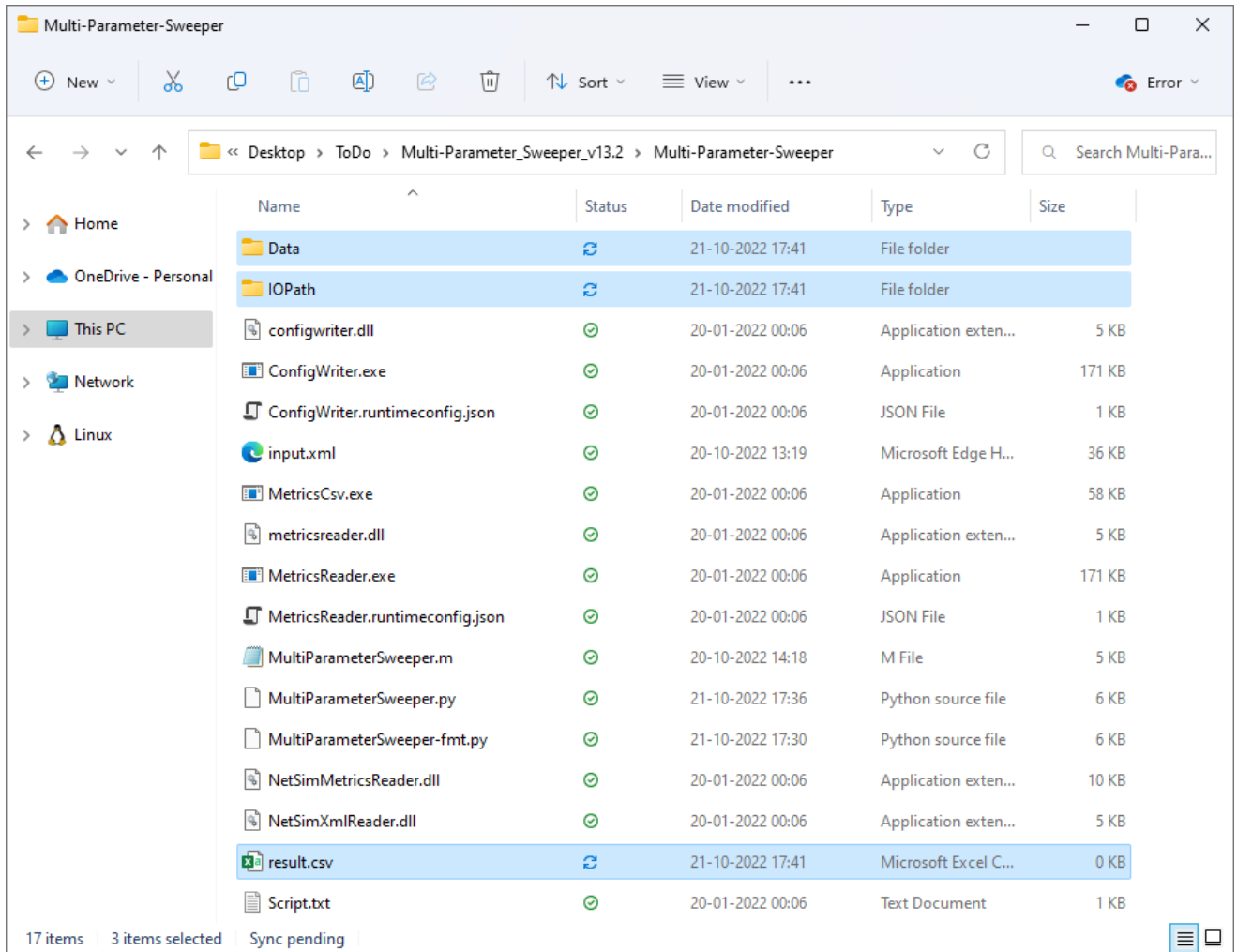


Figure 9: After Simulation Multi-Parameter-Sweeping folder contains output files like result.scv, Data etc

- **Data:** Contains multiple folders created based on date and time of simulation inside which multiple output folders corresponding to each simulation run, with its name including the value of the parameters in that iteration gets created.

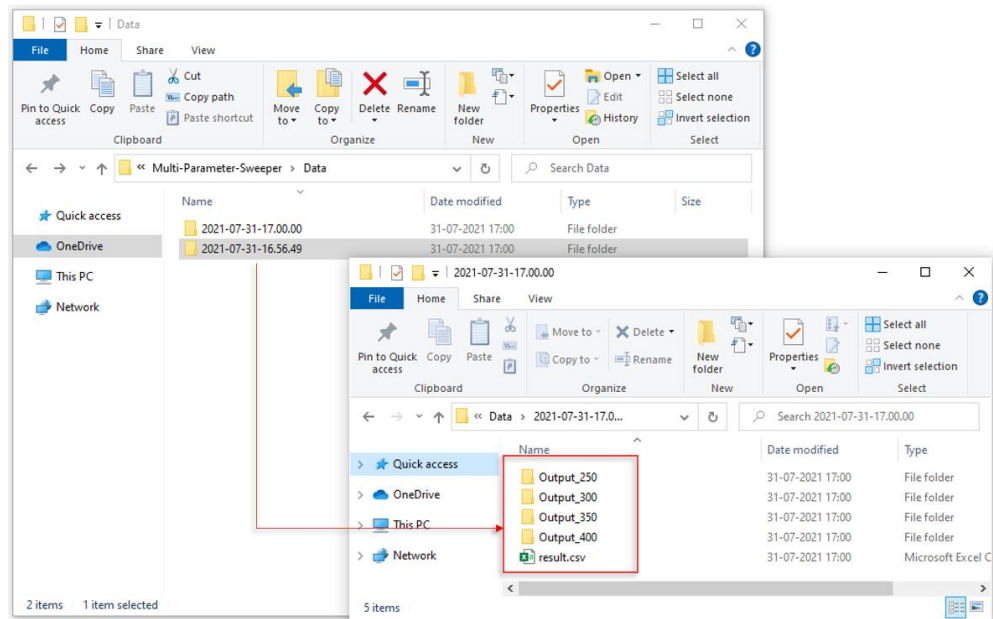


Figure 10: Based on values in the iteration, Output folder gets created in the Data directory inside a folder named as per date and time of simulation along with a copy of result.csv file.

- Each folder contains the all the output files associated with the simulation run.

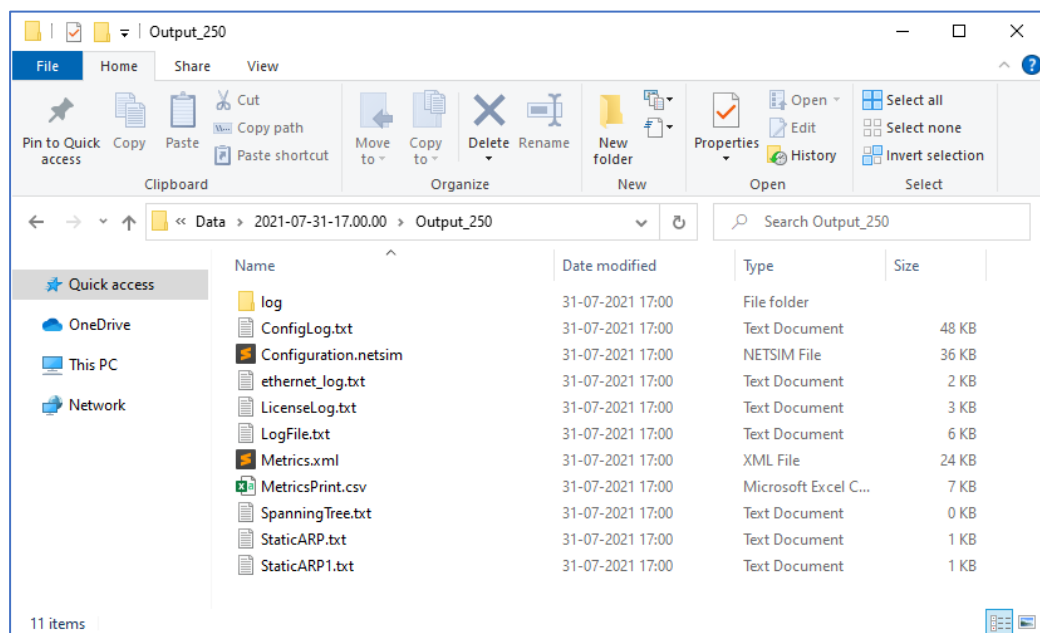


Figure 11: Each folder contains all the output files and the Metrics.xml file converted to MetricsPrint.csv file

Note: User should keep a back-up of the data folder to avoid data loss.

- **IO Path:** 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. The result.csv file will also be copied into the output folder after each simulation.

The screenshot shows a Microsoft Excel window titled 'result.csv'. The table has columns A through E. Column A contains values 1 through 8. Column B contains the text 'THROUGHPUT(Mbps)'. Column C contains numerical values: 250, 300, 350, 400, and then blank cells for rows 6 through 8. Column D contains throughput values: 4192.1856, 4192.1856, 2278.5344, 1352.7776, and then blank cells for rows 6 through 8. Column E is blank.

	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					

Figure 12: Iterated value and Throughput obtained listed in result.csv

Example 1: Modifying a single input parameter and logging a single output parameter

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

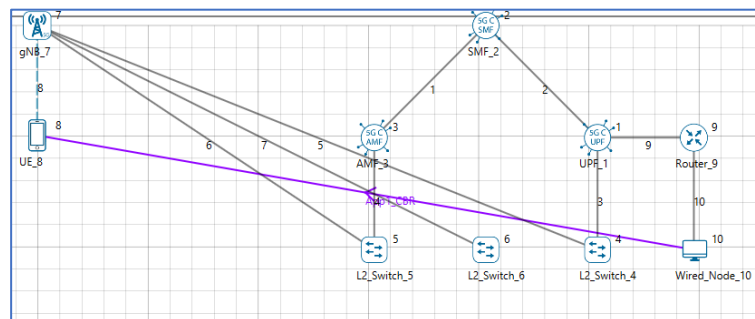


Figure 13: Network Topology

The network configuration has the initial distance between the gNB and UE as 50 meters with the gNB located at (500,0) and UE located at (500,500).

Multi-Parameter Sweeper is configured to run simulations for different distance between the gNB and UE by varying the UE Y coordinate value from 500 to 2000 in steps of 500 meters.

The network scenario is saved and the content of the Configuration.netsim file is copied to the Multi-Parameter-Sweeper directory and renamed as input.xml.

Refer to the Example 1 directory which is part of the project folder (Multi-Parameter-Sweeper_v13.1\Examples\Multi-Parameter-Sweeper-Example-1)

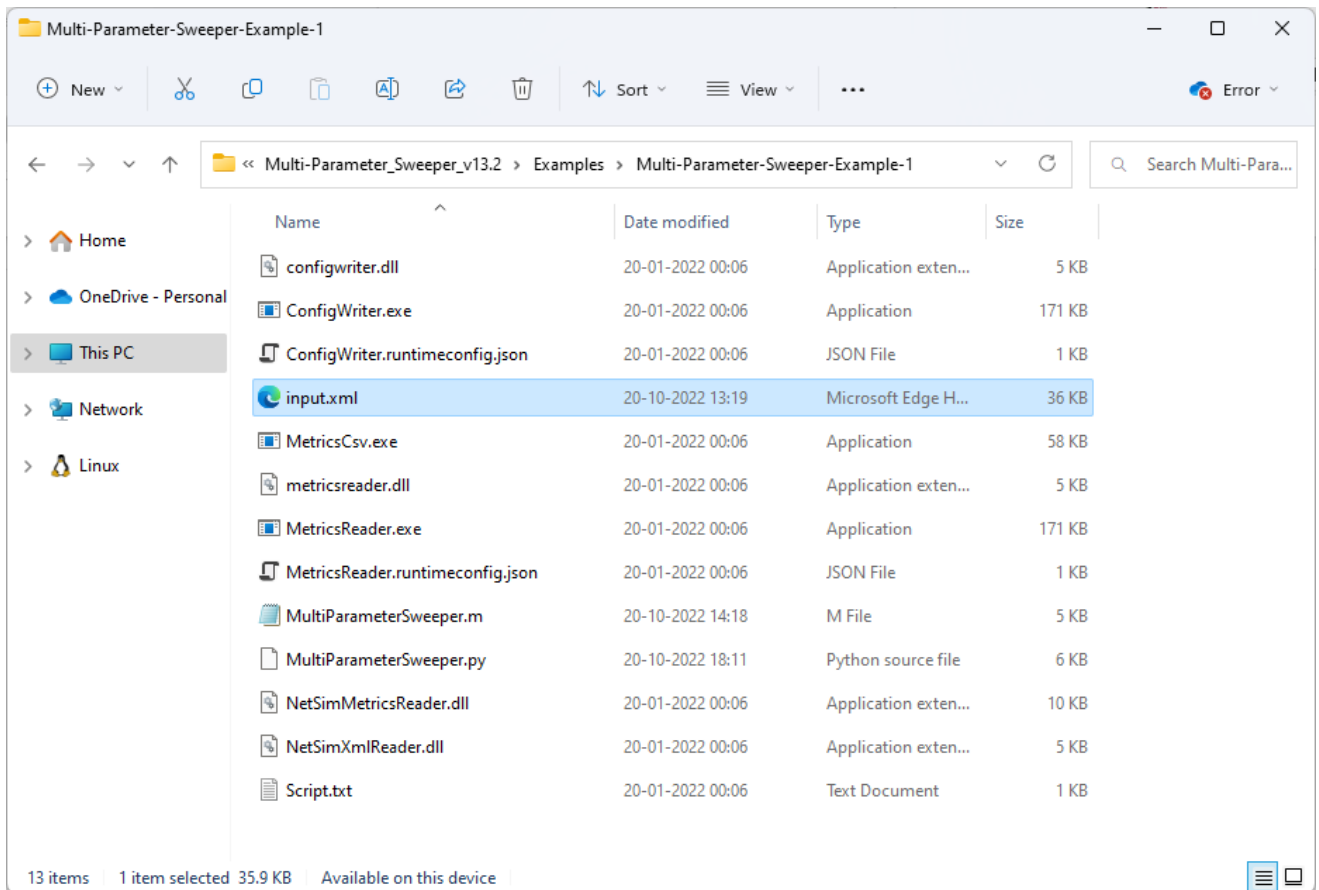


Figure 14: Renamed Configuration.netsim to input.xml and pasted in Multi-Parameter-Sweeper directory

1. 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:

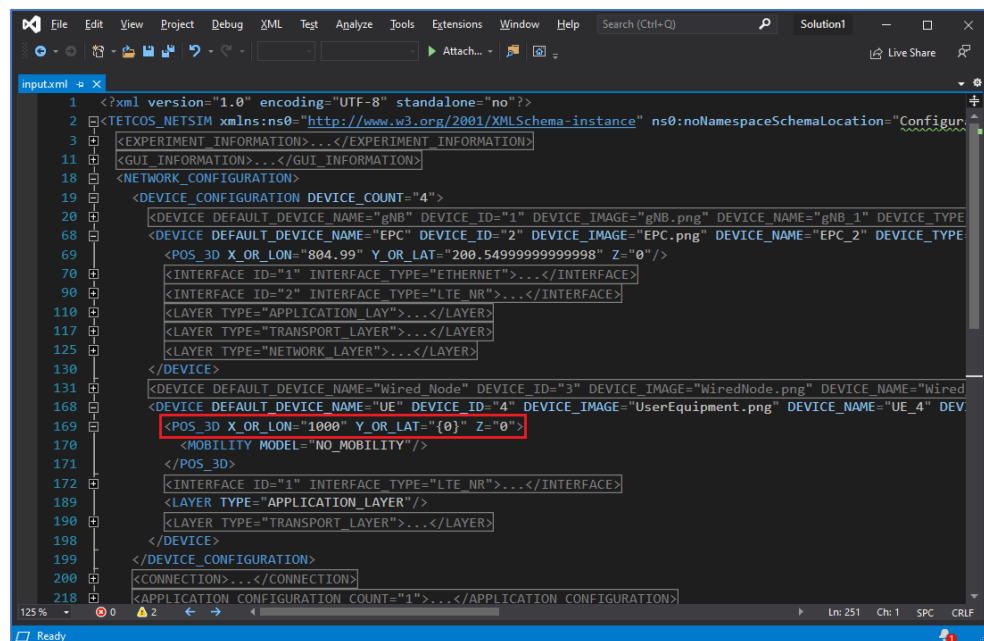


Figure 15: Modified Y coordinate of UE in input.xml

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.

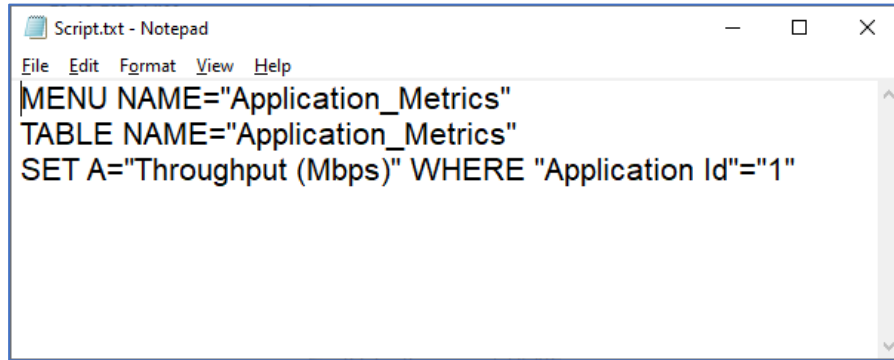


Figure 16: The application throughput is to be logged for each simulation modified in Script.txt

3. MultiParameterSweeper.m is updated to pass the Y coordinate value during each iteration to generate Configuration file run simulation and update the result csv log.

The MultiParameterSweeper.bat batch script modified for running simulations for different values of Y coordinates starting from 500 up to 2000 in steps of 500 is shown below:

- A result.csv file is created and added with headings Y and Throughput (Mbps).
- A MetricsPrint.csv is created inside every output folder.
- For loop is set to iteratively run simulations for values starting from 500 to 2000 in steps of 500.
- 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 MultiParameterSweeper.m MATLAB script modified for running simulations for different values of Y coordinates starting from 500 up to 2000 in steps of 500 is shown below:

- For loop is set to iteratively run simulations for values starting from 500 to 2000 in steps of 500.
- 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.

```

94 %changes required starts
95 if(isfile('IOPATH\Metrics.xml'))
96
97     fileid=fopen('result.csv','a');
98     if(fileid)
99         fprintf(fileid,'\n%d',i);
100     fclose(fileid);
101 end
102 if(OUTPUT_PARAM_COUNT==1)
103     system('MetricsReader.exe result.csv');
104 else
105     for n = 1 : OUTPUT_PARAM_COUNT
106         filename='Script'+string(n)+'.txt';
107         movefile(filename,'Script.txt');
108         system('MetricsReader.exe result.csv');
109         fileid=fopen('result.csv','a');
110         if(fileid)
111             fprintf(fileid,'\n');
112             fclose(fileid);
113         end
114         movefile('Script.txt',filename);
115     end
116 else
117 %Update the output Metric as crash if Metrics.xml file is missing
118 fileid=fopen('result.csv','a');
119 if(fileid)
120     fprintf(fileid,'\n%d,crash',i);
121     fclose(fileid);
122 end
123 end
124
125 % Name of the Output folder to which the result will be saved
126 OUTPUT_PATH = 'Data/'+today+'Output_'+string(i);
127

```

Figure 19: Modify parameters in MultiParameterSweeper.m

- The value of the parameter Y in the current iteration is written to the result log file for analysis.
 - Configuration file and Metrics file are copied and renamed appending the value of the parameter in the current iteration.
4. Multi-Parameter Sweeping process can be started from MATLAB command line in the directory of the Multi-Parameter-Sweeping project as shown below:

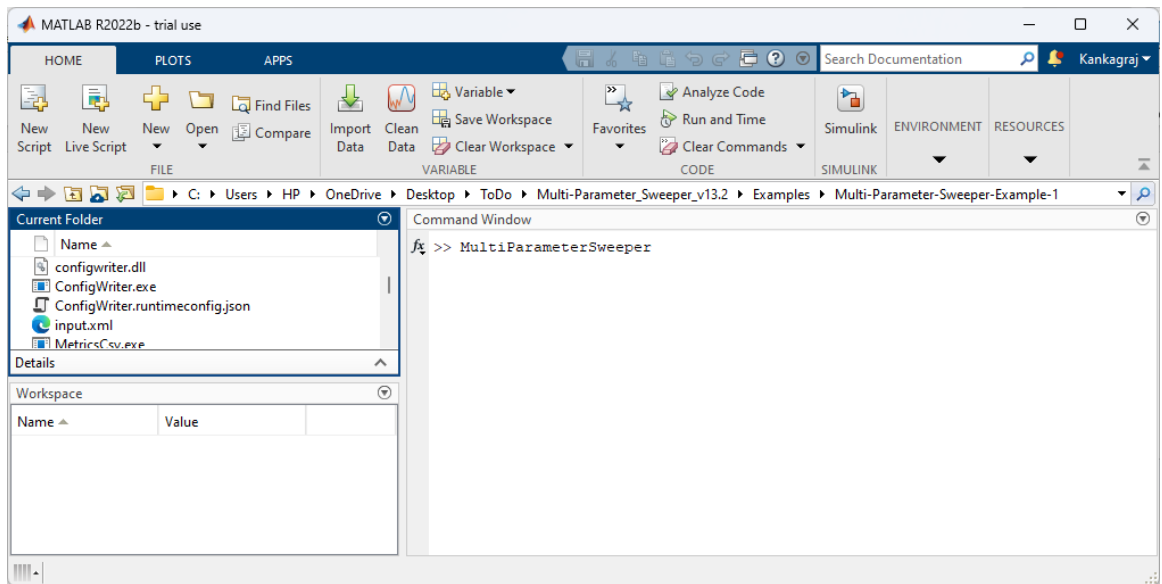


Figure 20: Running MATLAB script using cmd prompt

This starts the Multi-Parameter-Sweeping process which runs NetSim 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:

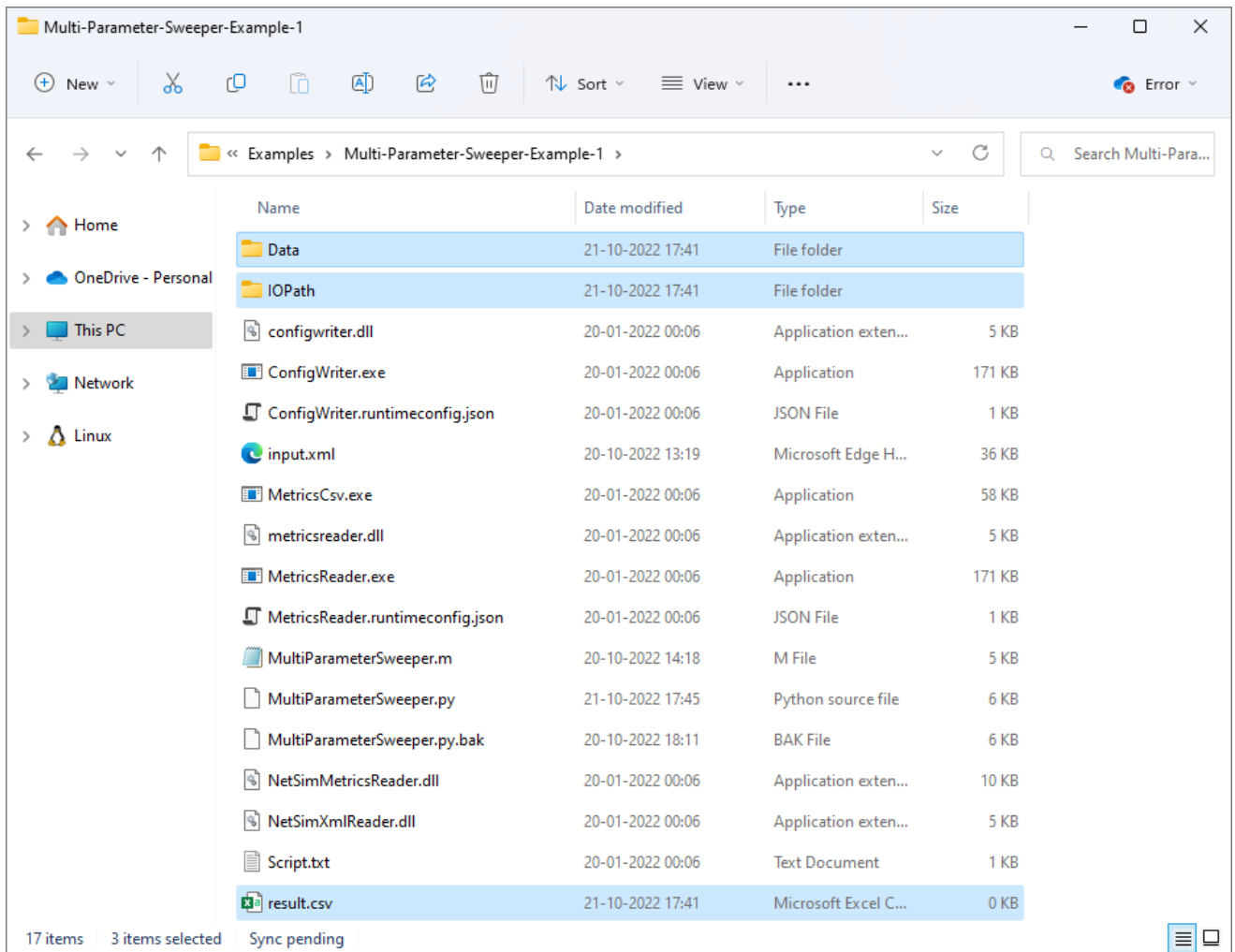


Figure 21: After Simulation Multi-Parameter-Sweeping folder contains output files like result.csv, Data etc

- **Data:** Contains multiple folders corresponding to each simulation run, with its name including the value of the parameters in that iteration. The output folders will be created inside folder with name in the format Year-Month-Day-Hours-Minutes-Seconds.

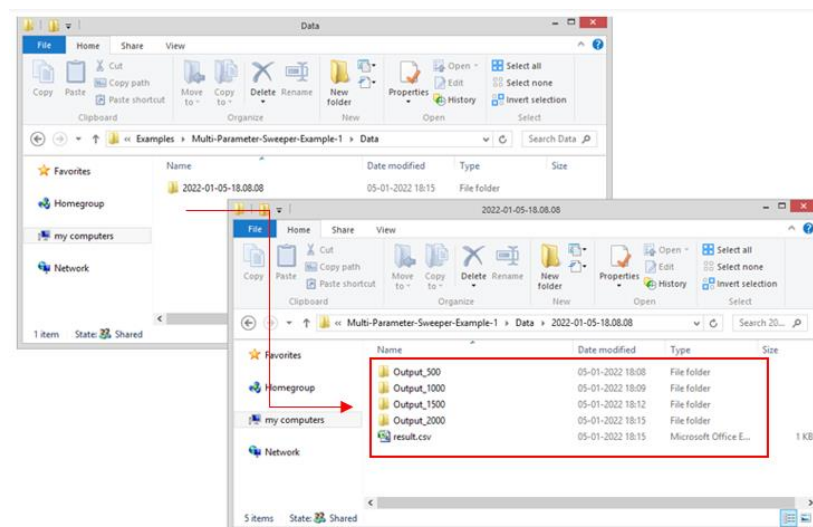


Figure 22: Based on distance Configuration.netsim files created in output folder

- Each folder contains the all the output files associated with the simulation run.

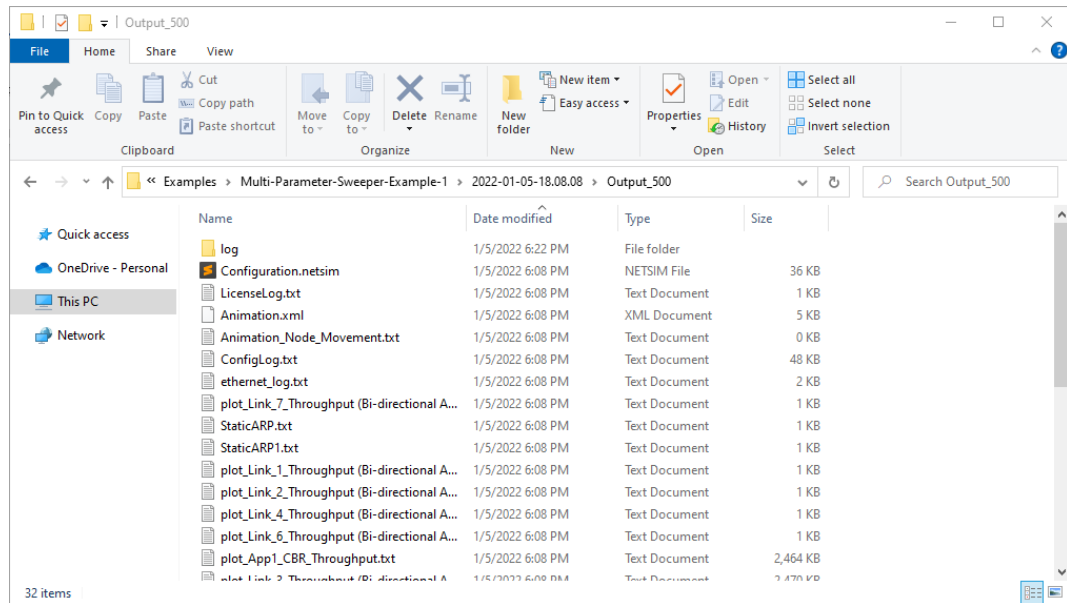


Figure 23: Each folder contains the all the output files

- **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.

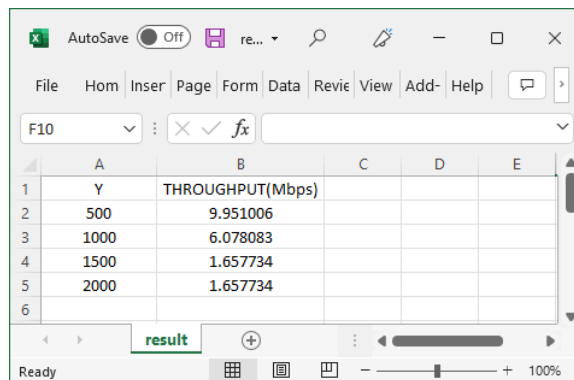


Figure 24: Distance Vs. Throughput obtained in result.csv

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},...{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.

To log multiple parameters, multiple script files can be used. If n output parameters are to be logged, then there can be script1.txt, script2.txt, script.txt in the sweeper folder.

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

Name	Date modified	Type	Size
Data	21-10-2022 17:16	File folder	
IOPath	21-10-2022 17:17	File folder	
configwriter.dll	20-01-2022 00:06	Application exten...	5 KB
ConfigWriter.exe	20-01-2022 00:06	Application	171 KB
ConfigWriter.runtimeconfig.json	20-01-2022 00:06	JSON File	1 KB
input.xml	20-10-2022 18:40	Microsoft Edge H...	37 KB
MetricsCsv.exe	20-01-2022 00:06	Application	58 KB
metricsreader.dll	20-01-2022 00:06	Application exten...	5 KB
MetricsReader.exe	20-01-2022 00:06	Application	171 KB
MetricsReader.runtimeconfig.json	20-01-2022 00:06	JSON File	1 KB
MultiParameterSweeper.m	21-10-2022 17:16	M File	7 KB
MultiParameterSweeper.py	21-10-2022 17:45	Python source file	8 KB
NetSimMetricsReader.dll	20-01-2022 00:06	Application exten...	10 KB
NetSimXmlReader.dll	20-01-2022 00:06	Application exten...	5 KB
result.csv	21-10-2022 17:18	Microsoft Excel C...	1 KB
Script1.txt	20-01-2022 00:06	Text Document	1 KB
Script2.txt	20-01-2022 00:06	Text Document	1 KB

Figure 25: Multiple output parameters

Example 2: Modifying multiple input parameters and logging multiple output parameter

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

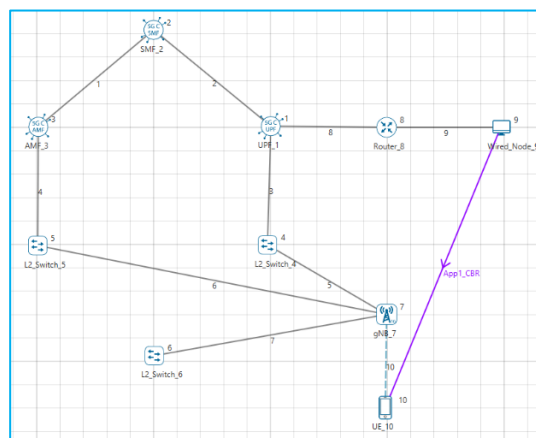


Figure 26: Network Scenario

2. Properties configured in the LTE_NR interface of the gNB is shown in the table below:

Interface(5G_RAN) Properties	
Tx_Power(dBM)	40
Tx_Antenna_Count	8
Rx_Antenna_Count	4
CA_Type	Single Band
CA_Configuration	n78
CA_Count	1
Numerology	0
Channel Bandwidth (MHz)	10
PRB Count	52
MCS Table	QAM64
CQI Table	Table 1
X_Overhead	XOH0
DL UL Ratio	4:1
Outdoor Scenario	Rural Macro
LOS Mode	Standard
Wireless Link Properties	
Channel Characteristics	No_Pathloss
Wired Link Properties	
Link Speed (Mbps)	10000
BER	0
Propagation Delay (μ s)	0
Application Properties	
Packet Size (Byte)	1460
Inter Arrival Time (μ s)	166
Generation Rate (Mbps)	100
Transport Control	UDP
Start Time (s)	1
QoS	BE
Simulation Parameters	
Simulation Time (s)	1.1

Table 1: gNB Properties

3. Traffic is generated at a rate of 70 Mbps and upon running simulation, the throughput achieved is 59.95 Mbps.
4. We now find the max throughput for each possible bandwidth; Tx Antenna count and Rx Antenna count combination varying the generation rate based accordingly.
5. Two more parameters to be taken care include, the PRB Count and Guard Band (KHz) which vary with respect to the bandwidth.

Input Variables	Value Range
Channel Bandwidth (MHz)	10,15,20,25,30,40,50
Tx_Antenna_Count	1,2,4,8,16,32,64,128
Rx_Antenna_Count	1,2,4,8,16
PRB Count	52,79,106,133,160,216,270
Guard Band (KHz)	312.5,382.5,452.5,522.5,592.5,552.5,692.5
Reference Inter Arrival Time (Microseconds)	166
Reference Bandwidth	10
Reference DL MIMO Layer Count	2

Table 2: Input variable values

6. Inter Arrival Time for each case is calculated based on the Reference IAT Bandwidth and DL MIMO Layer Count as shown below:

$$Inter\ Arrival\ Time\ (Micro\ Seconds) = \frac{Ref\ IAT}{\left(\frac{Curr\ BW}{Ref\ BW}\right) * \left(\frac{Curr\ DL\ MIMO\ Count}{Ref\ DL\ MIMO\ Count}\right)}$$

For E.g. In case of Bandwidth of 20 MHz and DL MIMO Count of 4 inter arrival time is

$$Inter\ Arrival\ Time\ (Micro\ Seconds) = \frac{166}{\left(\frac{20}{10}\right) * \left(\frac{4}{2}\right)} = 41.5\ Mbps$$

7. The network scenario is saved and the content of the Configuration.netsim file is copied to the Multi-Parameter-Sweeper directory and renamed as input.xml.
8. Refer to the Example 2 directory which is part of the project folder (Multi-Parameter-Sweeper_v13.1\Examples\Multi-Parameter-Sweeper-Example-2).

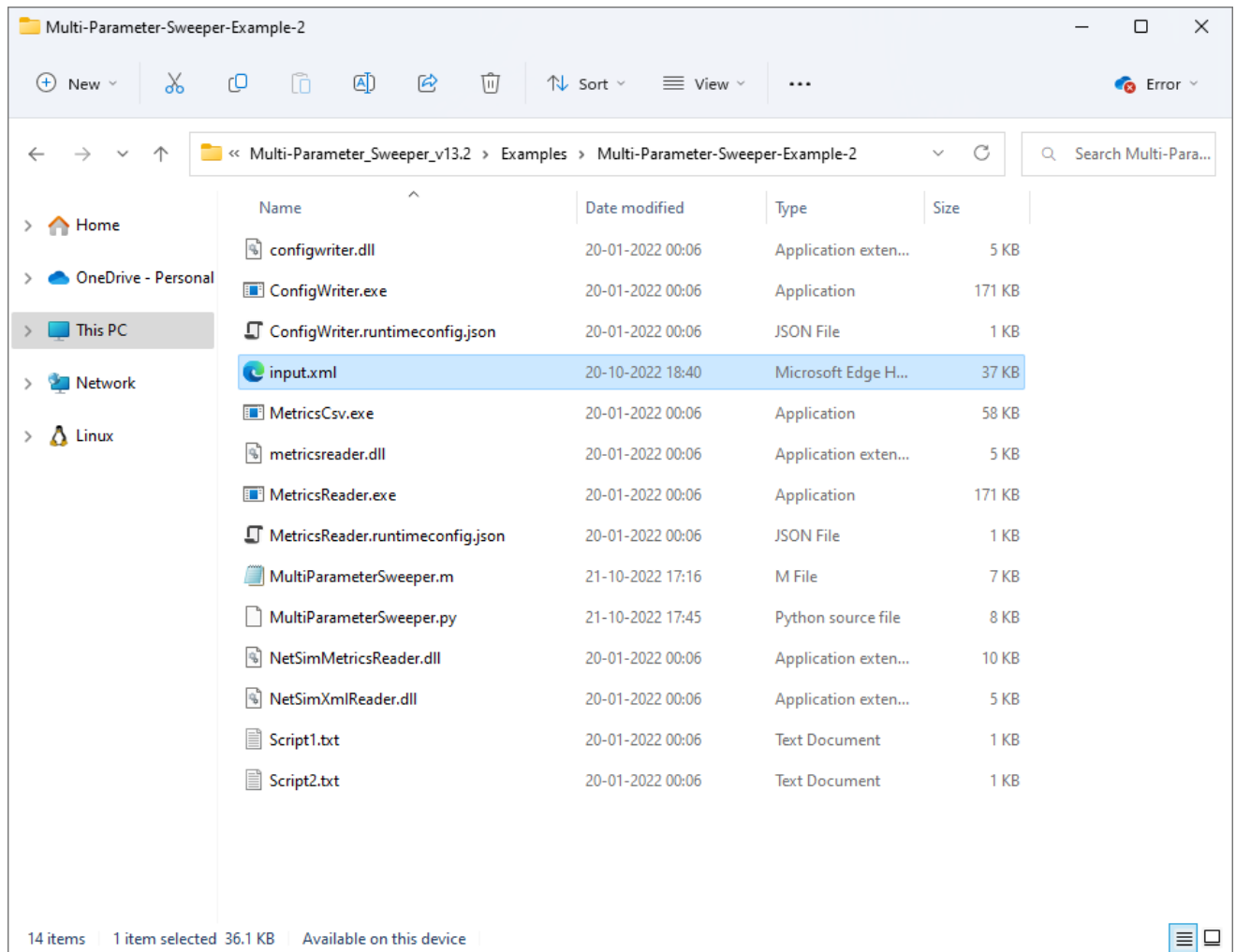


Figure 27: Renamed Configuration.netsim to input.xml and pasted in Multi-Parameter-Sweeper directory

9. In the Input.xml file the value of the input variables are modified as shown in the table below:

Input Variables	
Channel Bandwidth (MHz)	{0}
Tx Antenna Count	{1}
Rx Antenna Count	{2}
Inter Arrival Time (Microseconds)	{3}
PRB Count	{4}
Guard Band (KHz)	{5}

Table 3: Variables are modified to the input.xml file

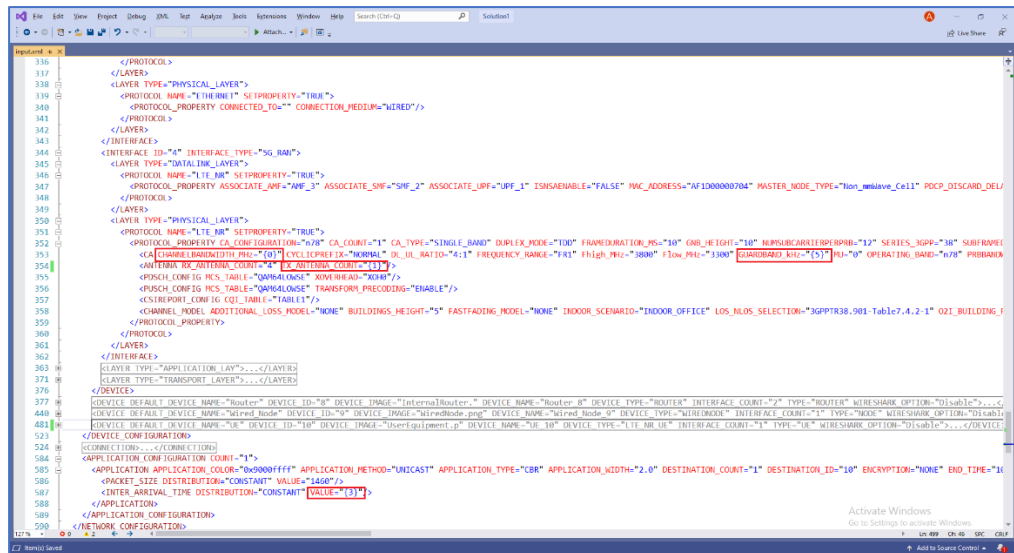


Figure 28: The above table 3 Variables are modified in input.xml file

10. The MATLAB script MultiParameterSweeper.m is modified to run simulation for all possible combinations of Bandwidth and Tx Antenna Count and Rx Antenna Count with the respective values of Guard Band, PRB Count and the IAT that is calculated.

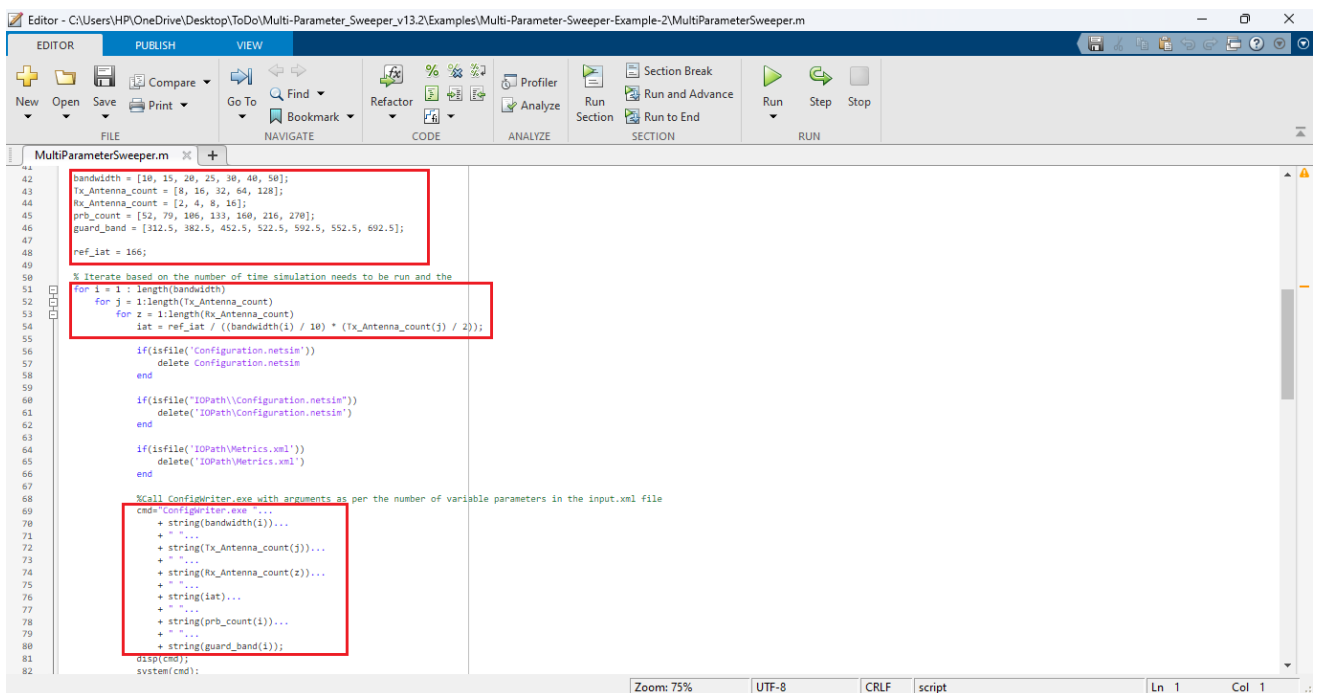


Figure 29: Modified MultiParameterSweeper.m based on input parameter

11. Multiple parameters are read from the Metrics.xml file and logged in the results.csv file along with the input parameters such as CHANNELBANDWIDTH_MHz, TX_ANTENNA_COUNT, RX_ANTENNA_COUNT, INTER_ARRIVAL_TIME (micro sec).

Output Parameters

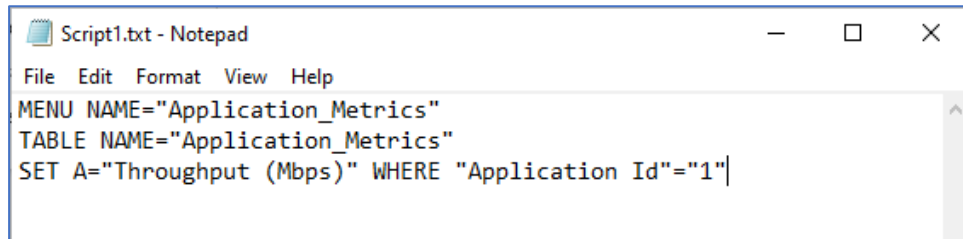
Throughput (Mbps)

Data Packets transmitted

Table 4: User need to modify these two parameters in Script files

- Two script text files namely Script1.txt and Script2.txt are created with information to read each of the parameters from the Metrics.xml file. The variable OUTPUT_PARAM_COUNT is set to 2 as per the number of Script files.

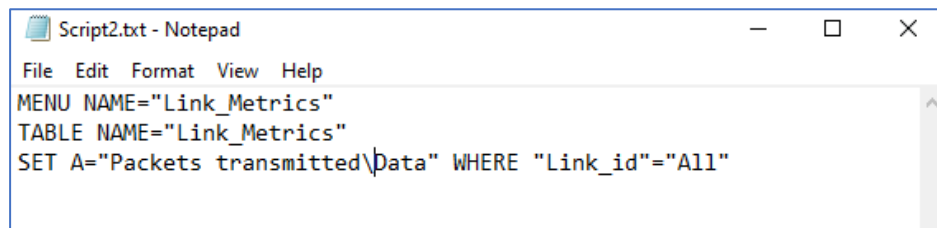
Script1.txt



```
Script1.txt - Notepad
File Edit Format View Help
MENU NAME="Application_Metrics"
TABLE NAME="Application_Metrics"
SET A="Throughput (Mbps)" WHERE "Application Id"="1"
```

Figure 30: The application throughput is to be logged for each simulation modified in Script1.txt

Script2.txt



```
Script2.txt - Notepad
File Edit Format View Help
MENU NAME="Link_Metrics"
TABLE NAME="Link_Metrics"
SET A="Packets transmitted\Data" WHERE "Link_id"="All"
```

Figure 31: The Data Packets transmitted is to be logged for each simulation modified in Script2.txt

- In the MATLAB script MultiParameterSweeper.m, MetricsReader is called to log each parameter specified in the script text files separating the entries with a comma (","). If simulation crashes, without generating the output Metrics.xml, then "crash" message is written to the log for each output parameter. The input parameters that were varied during each simulation run are also logged in the results.csv file.

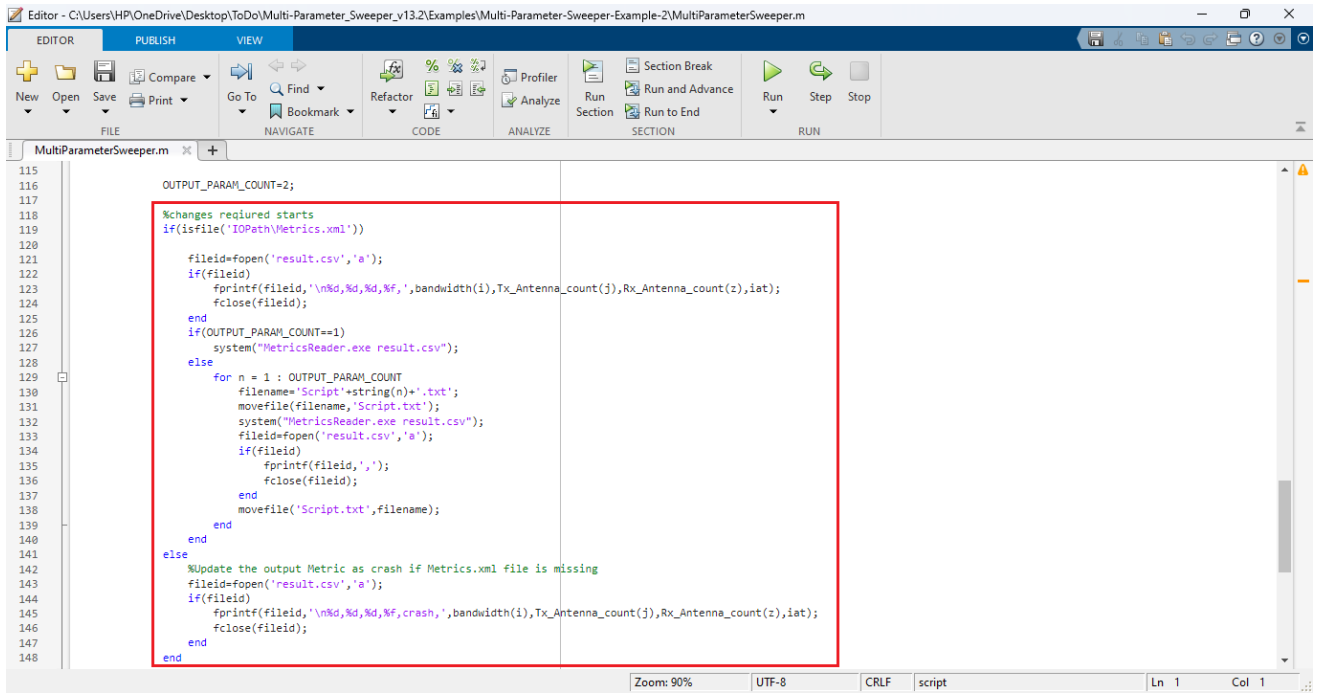


Figure 32: Modify MATLAB script MultiParameterSweeper.m file

14. The simulation Configuration file and all the output files associated with each simulation run is saved to folders with name including the bandwidth and DL MIMO count values that were used during each simulation run.

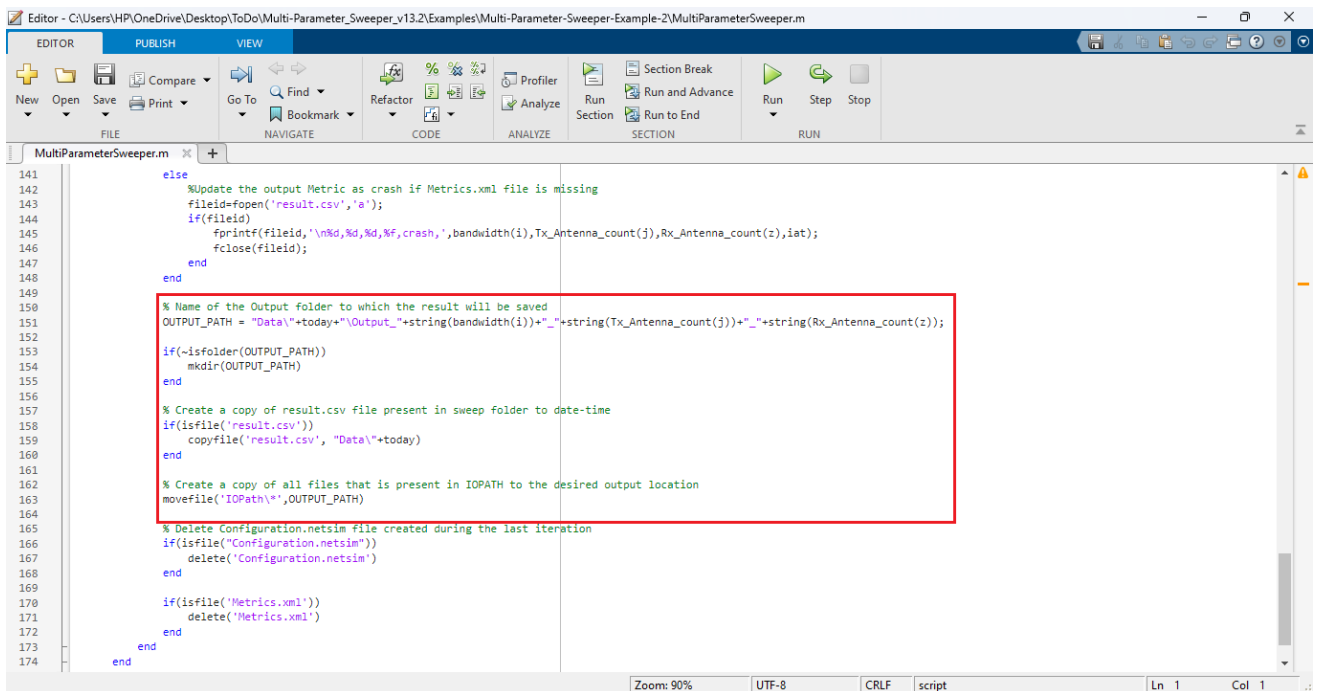


Figure 33: Modify MATLAB script MultiParameterSweeper.m file

15. Multi-Parameter Sweeping process can be started from MATLAB command line in the directory of the Multi-Parameter-Sweeping project as shown below:

MATLAB Script:

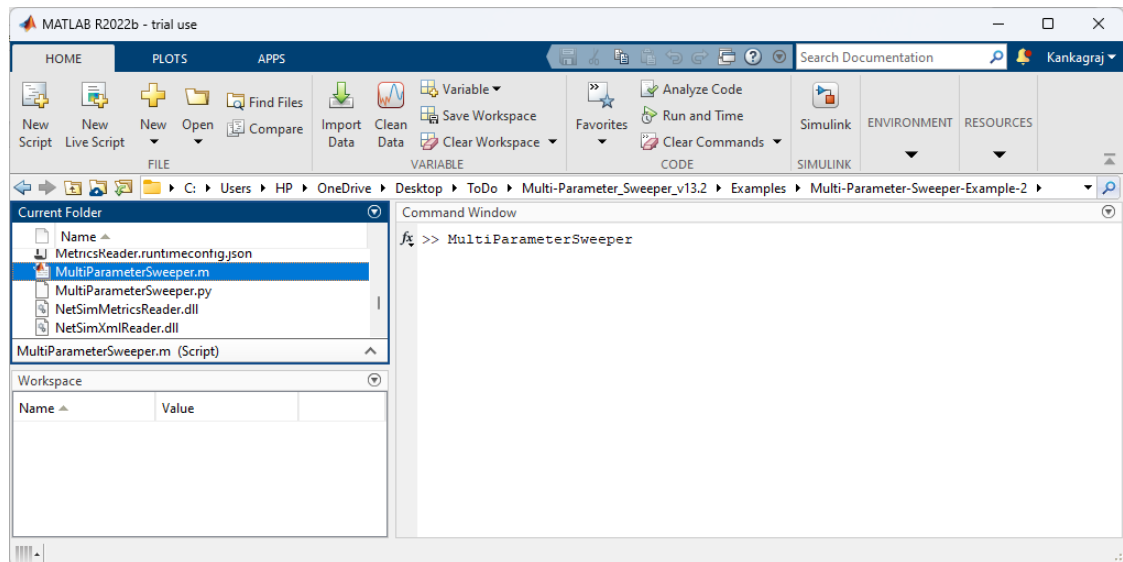


Figure 34: Running MATLAB Script using cmd Prompt

This starts the Multi-Parameter-Sweeping process which runs NetSim simulations iteratively for different combinations of input parameters.

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

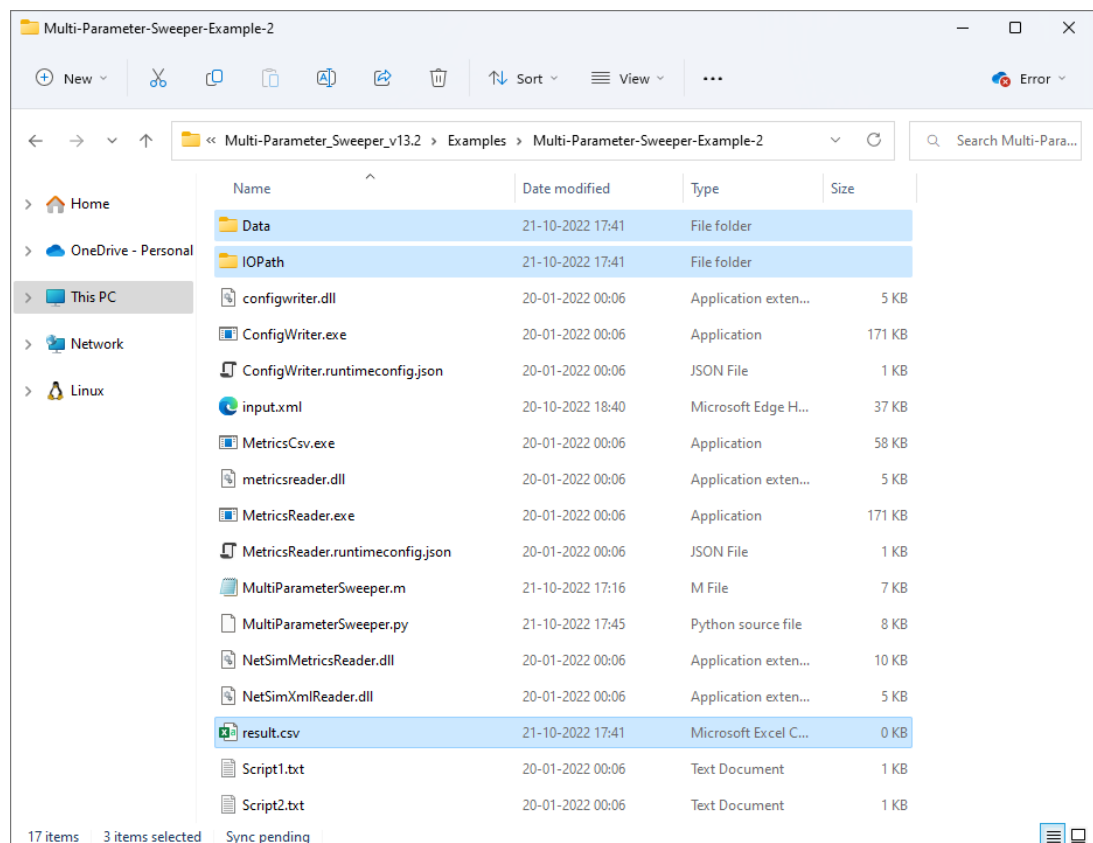


Figure 35: After Simulation Multi-Parameter-Sweeping folder contains output files like result.csv, Data etc

16. **Data:** The Data directory contains multiple output folders with the output files associated with each simulation run.

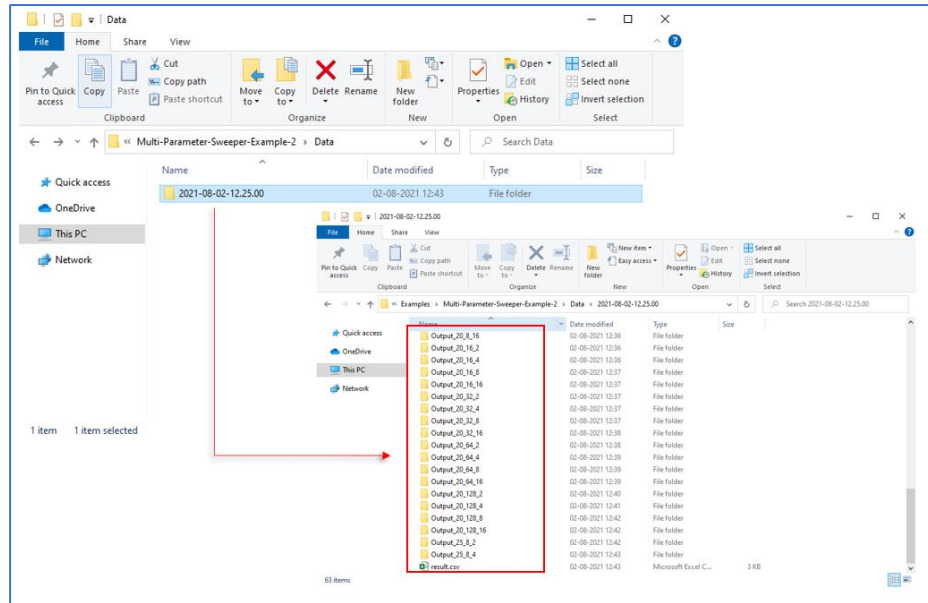


Figure 36: Based on input parameter Configuration.netsim and other files created in output folder

17. **IOPath:** Used for storing the Configuration.netsim file and the simulation files generated during each simulation run.
18. **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	F	G	H	I
1	CHANNELBANDWIDTH_MHz	TX_ANTENNA_COUNT	RX_ANTENNA_COUNT	INTER_ARRIVAL_TIME[microsec]	THROUGHPUT[Mbps]	Data Packets transmitted			
2	10	8	2	41.5	41.049891	40294			
3	10	8	4	41.5	80.560145	44129			
4	10	8	8	41.5	80.560145	43579			
5	10	8	16	41.5	80.560145	43579			
6	10	16	2	20.75	41.049891	40294			
7	10	16	4	20.75	80.560145	44129			
8	10	16	8	20.75	80.560145	43579			
9	10	16	16	20.75	80.560145	43579			
10	10	32	2	10.375	41.049891	40294			
11	10	32	4	10.375	80.560145	44129			
12	10	32	8	10.375	80.560145	43579			
13	10	32	16	10.375	80.560145	43579			
14	10	64	2	5.1875	41.049891	40294			
15	10	64	4	5.1875	80.560145	44129			
16	10	64	8	5.1875	80.560145	43579			
17	10	64	16	5.1875	80.560145	43579			
18	10	128	2	2.59375	41.049891	40294			
19	10	128	4	2.59375	80.560145	44129			
20	10	128	8	2.59375	80.560145	43579			
21	10	128	16	2.59375	80.560145	43579			
22	15	8	2	27.66666667	62.519855	42616			
23	15	8	4	27.66666667	80.560145	43761			
24	15	8	8	27.66666667	80.560145	43579			
25	15	8	16	27.66666667	80.560145	43579			
26	15	16	2	13.83333333	62.519855	42616			
27	15	16	4	13.83333333	80.560145	43761			
28	15	16	8	13.83333333	80.560145	43579			
29	15	16	16	13.83333333	80.560145	43579			
30	15	32	2	6.916666667	62.519855	42616			
31	15	32	4	6.916666667	80.560145	43761			
32	15	32	8	6.916666667	80.560145	43579			
33	15	32	16	6.916666667	80.560145	43579			
34	15	64	2	3.458333333	62.519855	42616			
35	15	64	4	3.458333333	80.560145	43761			
36	15	64	8	3.458333333	80.560145	43579			
37	15	64	16	3.458333333	80.560145	43579			
38	15	128	2	1.729166667	62.519855	42616			

Figure 37: Based on script result stored in result.csv file