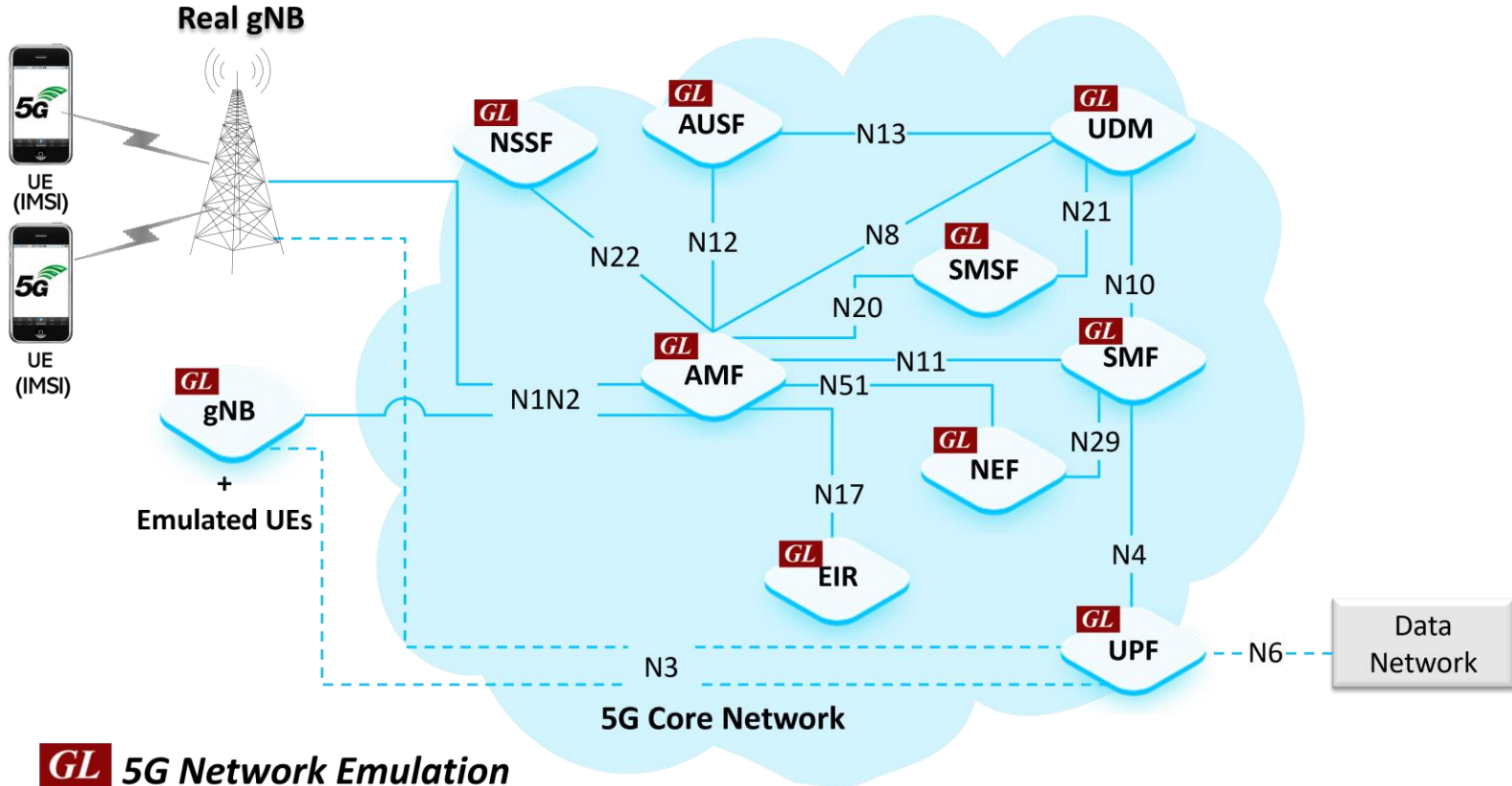

MAPS™ - 5G N4 Interface Emulator



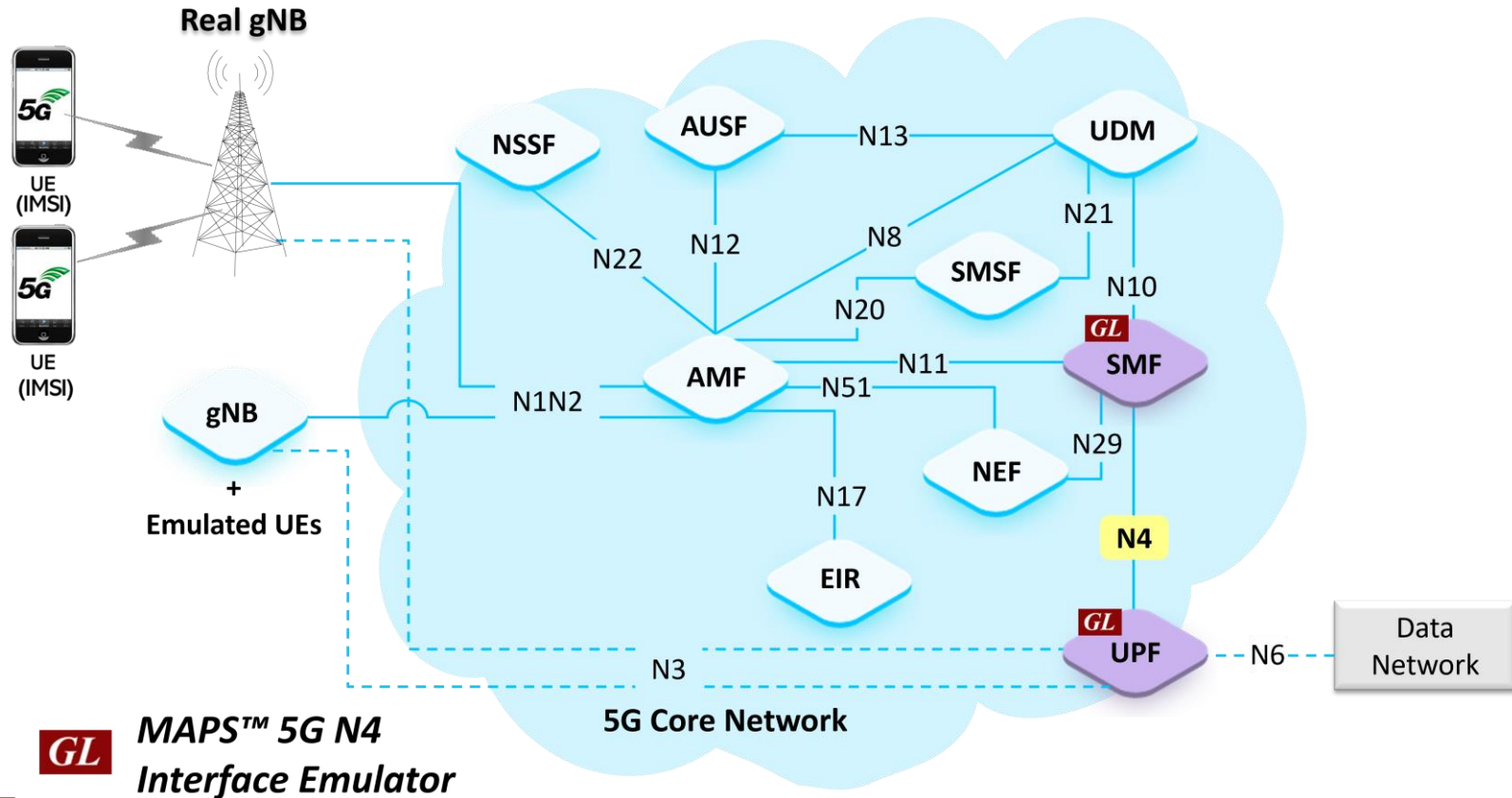
818 West Diamond Avenue - Third Floor, Gaithersburg, MD 20878
Phone: (301) 670-4784 Fax: (301) 670-9187 Email: info@gl.com
Website: <https://www.gl.com>

5G Network Diagram



GL 5G Network Emulation

MAPS™ 5G N4 Interface Emulator Architecture



Features

- Emulate Session Management Function (SMF) and User Plane Function (UPF) elements
- Supports 5G Control plane and User plane
- Supports Mobile Traffic type
- Supports Command Line Interface (CLI) through a client-server model, enabling users to control all features via Python APIs
- Generates and process PFCP (valid and invalid) messages
- Supports PDU Session Establishment, Modification, Release and Reporting of traffic data usage procedures
- Supports GTP Traffic (GTP User Plane Data), HTTP traffic generation capability

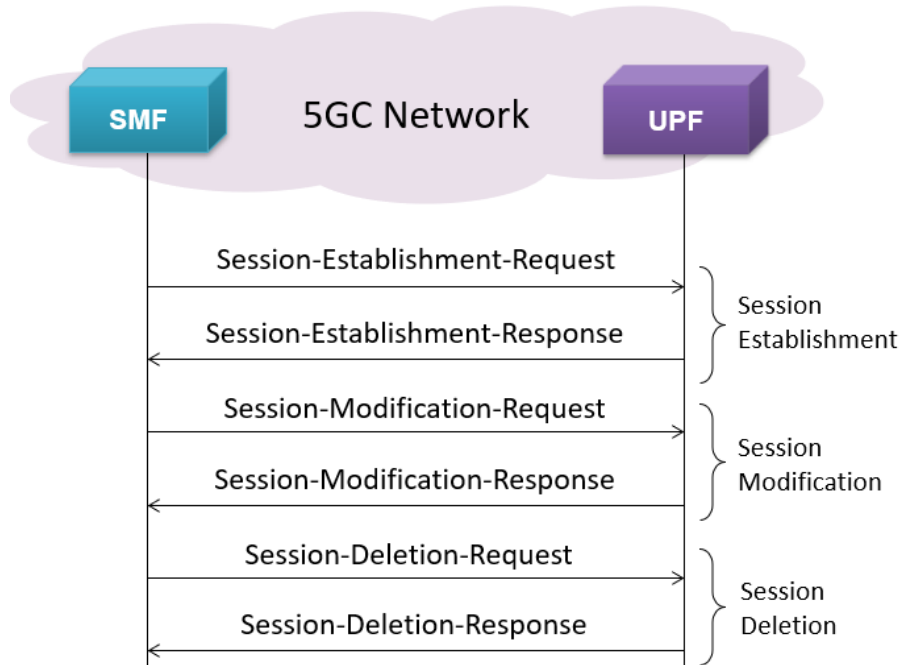
Protocol Stack Specification

PFCP
UDP
IP
L2
L1

Supported Protocols	Standard / Specification Used
N4 Interface	
N4 Interface (SMF - UPF)	TS29.244
PFCP	3GPP TS 23.501 (Release 17) 3GPP TS 23.502 (Release 17)
UDP	IETF RFC 768
IPv4	IETF RFC 791 [5] IETF RFC 2460 [6]

- PFCP entity supports IPv4 protocol

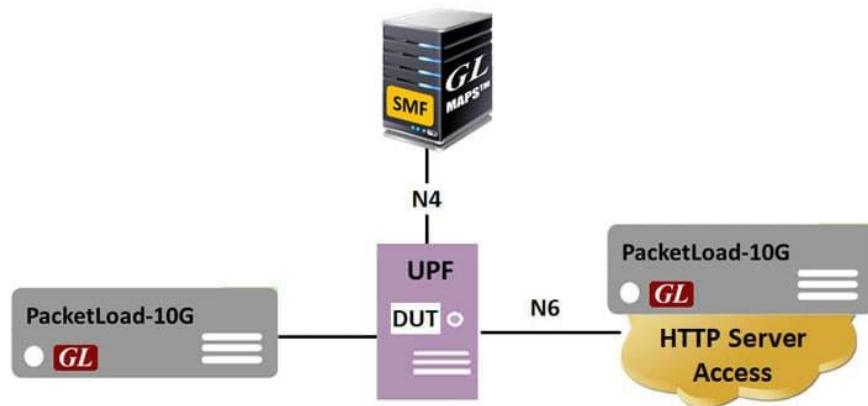
MAPS™ 5G Call Scenarios



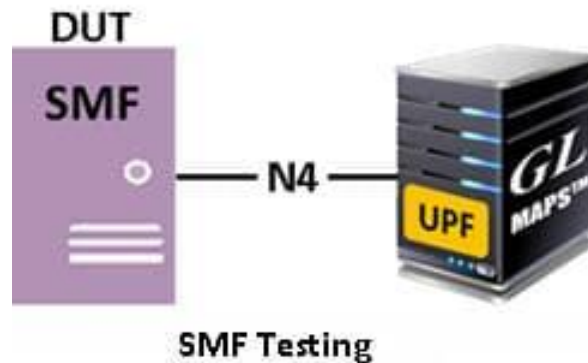
- PFCP Session Establishment Procedure
 - Session Establishment Request
 - Session Establishment Accept
- PFCP Session Modification Procedure
 - Session Modification Request
 - Session Modification Response
- PFCP Session Deletion Procedure
 - Session Deletion Request
 - Session Deletion Response

MAPS™ 5G N4 Single Interface Testing – Use Cases

UPF Testing



SMF Testing



- In SMF Testing, SMF node is the device under test and all the other nodes (AMF, UDM, UPF)UPF node interacting with the SMF node are emulated
- In UPF Testing, UPF node is the device under test and all the other nodes (gNodeB, SMF, Data Network) SMF node interacting with the UPF node are emulated

Testbed Configuration

GL MAPS SMF (N4 RELEASE17) - [Testbed Setup - TestBedDefault]

Configurations Emulator Reports Editor Debug Tools Windows Help

Config Value

SMF Parameters

- Adapter Index 0
- SMF 1
 - SMF IP Address 192.168.12.89
 - gNB Traffic IP Address 192.168.12.89
 - SMF Port 8805
 - PLMN Identities
 - Mobile Country Code 001
 - Mobile Network Code 001
 - UPF Configuration 1
 - UPF Configuration 1
 - UPF IP Address 192.168.12.35
 - UPF Port 8805
 - Local FTEID Allocation SMF
 - UPF Traffic IP Address 192.168.12.35
- Traffic
 - PacketLoad Traffic Type HTTP Traffic
 - PacketLoad Management IP Address 192.168.12.55
- DNN Configuration 3
 - DNN Configuration 1
 - DNN Name default
 - IPv4 Range
 - Start IP 192.168.121.1
 - End IP 192.168.140.250
 - IPv6 Range
 - DNN Configuration 2
 - DNN Configuration 3

☒ Enable

Start Edit

Initialisation Errors Error Events

Profile Configuration

GL MAPS SMF (N4 RELEASE17) - [Profile Editor - MobileIPCore]

Configurations Emulator Reports Editor Debug Tools Windows Help

Icons: Gear, Document, Cloud, Network, Folder, Key, Lock, Green G, Green P, Person, Document with X, Question Mark, Refresh

Icons: Folder, Save, Edit, Lightbulb, Question Mark

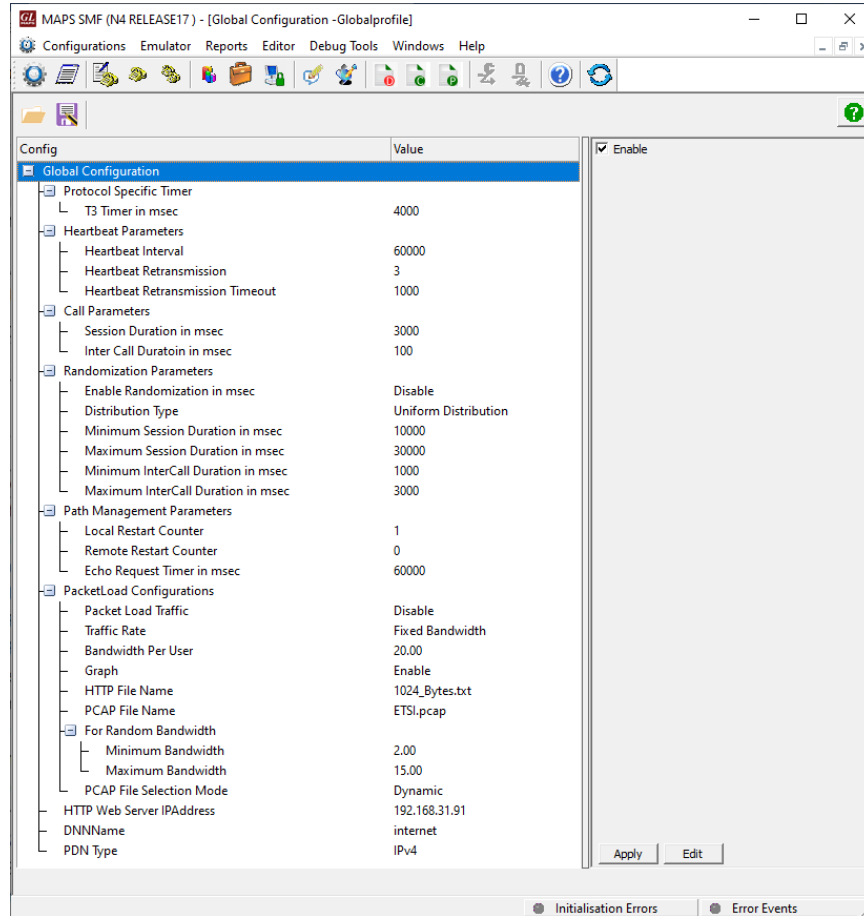
#	Profiles (Edit-F2)	Config	Value	<input checked="" type="checkbox"/> Enable
1	Profile	Profile		
		Traffic Parameters		
		Mobile Traffic Parameters		
		Udp Src Port	2152	
		Udp Dst Port	2152	
		HTTP Server IP Address	192.168.15.250	
		TCP port for HTTP	80	
		TCP Connection Identifier	1	
		Transmission Type	Once	
		Start File Count	3	
		Traffic File Name	img5a.flixcart.com	
		File Count For Concurrent Or S...	7	
		OS Socket	Enable	
		TxFile For Once Transmission F...	2	
		File Playback Count	6	
		TrafficType	HDTraffic	

Buttons: Insert, Delete, Clear

Buttons: Add, Insert, Delete, Properties

Buttons: Initialisation Errors, Error Events

Global Configuration



Incoming Call Handler Configuration

GL MAPS UPF (N4 RELEASE17) - [Incoming Call Handlers Configuration - default]

Configurations Emulator Reports Editor Debug Tools Windows Help

Message Name Script Name

Session Establishment Request	UPFSessionControl.gls
Association Setup Request	PFCPManagementHandler.gls
Heartbeat Request	PFCPManagementHandler.gls

Scripts

UPFSessionControl.gls

☒ Sequence
☐ Random

Up
Down

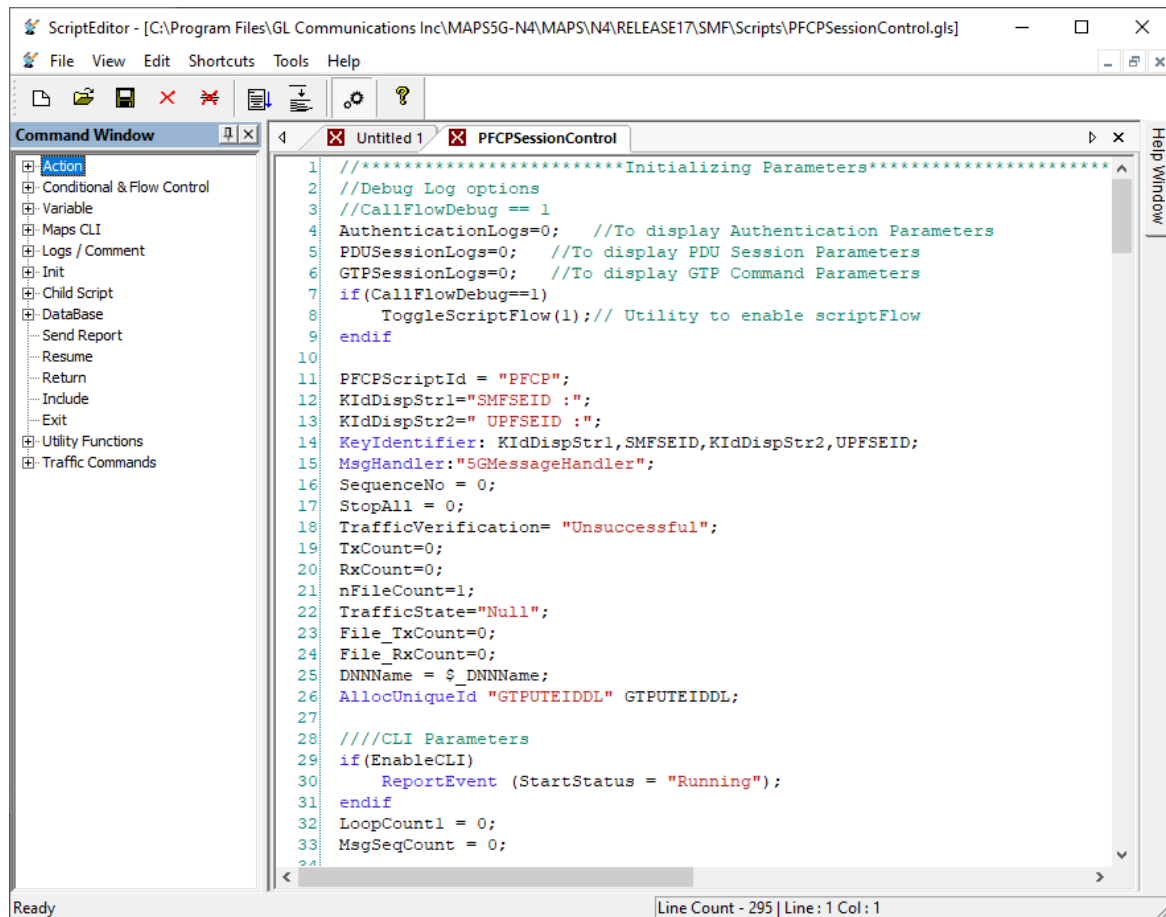
Add Delete

Add Delete

Apply Scripts Clear Scripts

Initialisation Errors Error Events

Script Editor



Message Editor

Message Editor - Untitled

File View Direction Tools Help

Frame No 1

PFCP

- S
 - Message Priority:
 - Version
 - Message Type
 - Length
 - Session Endpoint Identifier
 - Sequence Number
 - Message Priority
- InformationElements
 - Update PDR
 - Information Element Id

Session Modification Request = 52
 Session Establishment Request = 50
 Session Establishment Response = 51
 Session Modification Request = 52
 Session Modification Response = 53
 Session Deletion Request = 54
 Session Deletion Response = 55
 Session Report Request = 56
 Session Report Response = 57

```

===== PFCP Layer =====
0000 S = .....1 SEID field is present
0000 Message Priority: = .....1. Present
0000 Spare = ...000.. (0)
0000 Version = 001..... PFCP Version 1
0001 Message Type = 00110100 Session Modification Request
0002 Length = 44 (x002C)
0004 Session Endpoint Identifier = x0000000000000000
000C Sequence Number = 0 (x000000)
000F Spare = ....0000 (0)
000F Message Priority = 0000.... (0)
Update PDR =
0010 Information Element Id = x0009 Update PDR
0012 Length = 28 (x001C)
PDR ID =
Information Element Id = x0038 Packet Detection Rule ID
Length = 2 (x0002)
Rule ID = 0 (x0000)
PDI =
001A Information Element Id = x0002 PDI
001C Length = 18 (x0012)
Source Interface =
Information Element Id = x0014 Source Interface
Length = 1 (x0001)
Interface value = ....0000 Access
  
```

Ready NUM

MAPS™ 5G N4 Interface – Call Emulation

Call Generation

GL MAPS SMF (N4 RELEASE17) - [Call Generation -CallGenDefault]

Configurations Emulator Reports Editor Debug Tools Windows Help

Sr No	Script Name	Profile	Call Info	Script Exec...	Status	Events	Events Profile	Result	Total Iterati...	Completed Iterations
1	PFCPSessionControl.gls	Profile	SMFSEID :0x03, UPFSEID :0x0000000000002712	Start	SESSION-TERMINATED	None		Pass	1	1
2	PFCPSessionControl.gls			Start		None		Unknown	1	0
3	PFCPSessionControl.gls			Start						
4	PFCPSessionControl.gls			Start						

Add Delete Insert Refresh Start Start All Stop Stop All Abort Abort All

Save Column Width Show Latest

SMF UPF

Session Establishment Request 10:13:43.633000

Session Establishment Response 10:13:43.649000

Session Modification Request 10:13:43.649000

Session Modification Response 10:13:43.671000

Session Deletion Request 10:13:46.463000

Session Deletion Response 10:13:46.483000

Scripts Message Sequence Event Config Script Flow

Initialisation Errors

Call Reception

GL MAPS UPF (N4 RELEASE17) - [Call Reception]

Configurations Emulator Reports Editor Debug Tools Windows Help

Sr No	Script Name	Profile	Call Info	Script Execution	Status	Events	Events Profile	Results
1	UPF_HTTP2_Connection_Monitor.gls		UPF Server Clients : UPF,	Stop	Monitoring HTTP2 Connection Status	None		Unknown
2	NRF_ResourceMonitor.gls			Stop		None		Unknown
3	PFCPManagementHandler.gls		ConnectionID :1	Stop	Heartbeat Success	None		Pass
4	UPFSessionControl.gls		UEIPAddress :192.168.15.141.SMFSEID :0x000000...	Completed	Session Deletion Response Sent	None		Pass
5	UPFSessionControl.gls		UEIPAddress :192.168.15.142.SMFSEID :0x000000...	Completed	Session Deletion Response Sent	None		Pass

Stop Stop All Abort Abort All Show Records Select Active Call Auto Trash Trash Show Hidden Calls

Save Column Width Show Latest

SMF UPF

Session Establishment Request 10:13:43.640000

Session Establishment Response 10:13:43.641000

Session Modification Request 10:13:43.659000

Session Modification Response 10:13:43.659000

Session Deletion Request 10:13:46.473000

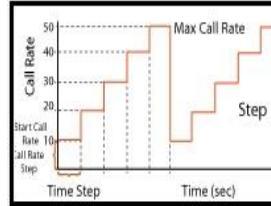
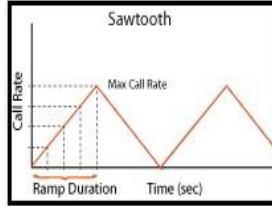
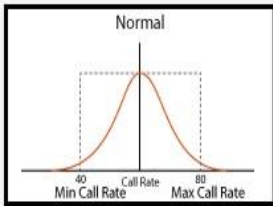
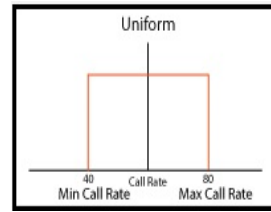
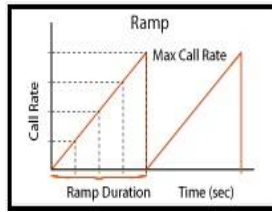
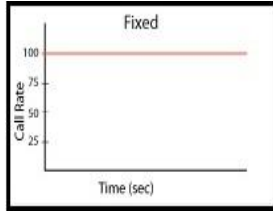
Session Deletion Response 10:13:46.473000

Scripts Message Sequence Event Config Script Flow

Initialisation Errors Error Events Captured Errors Link Status Up=0 Down=0

```
***** PFCP Layer *****
0000 S
0000 Message Priority:
0000 FO (Follow On)
0000 Spare
0000 Version
0001 Message Type
0002 Length
0004 Session Endpoint Identifier
000C Sequence Number
000F Spare
000F Message Priority
0010 Node ID
0010 Information Element Id
0012 Length
0014 Node ID Type
0014 Spare
0015 IPV4 Address
CP F-SEID
= .....1 SEID field is present
= .....1. Present
= .....0... Not Present
= .....00... (0)
= 001..... PFCP Version 1
= 00110010 Session Establishment Req
= 166 (x009C)
= x0000000000000000
= 0 (x0000000)
= .....0000 (0)
= 0000.... (0)
=
= x003C Node ID
= 5 (x0005)
= .....0000 IPV4 address
= 0000.... (0)
= 192.168.12.89 (x0A80C59)
=
```

Load Generation



MAPS SMF (N4 RELEASE17) - [Load Generation - LoadGenDefault]

Configurations Emulator Reports Editor Debug Tools Windows Help

Total Calls To Generate: 100 (* indicates no limit)

Max Active Calls: 100 ☐ Unique Distributions Per Script

☒ Multi Distributions Iteration: * (* indicates no limit)

Distributions	Description	Add
Uniform	MinCR=40, MaxCR=80, Duration=10.00	Remove
Fixed	Call Rate=150, Duration=10.00	Remove All
Normal	MinCR=40, MaxCR=80, Duration=10.00	Edit

Scripts

Scripts	Profile	Exclusive Profiles
PFCPSessionControl	Profile	

Add Delete

☐ Stop Time

Days: 0 Hours: 0 Minutes: 0

Start Time: 00:00:00.000

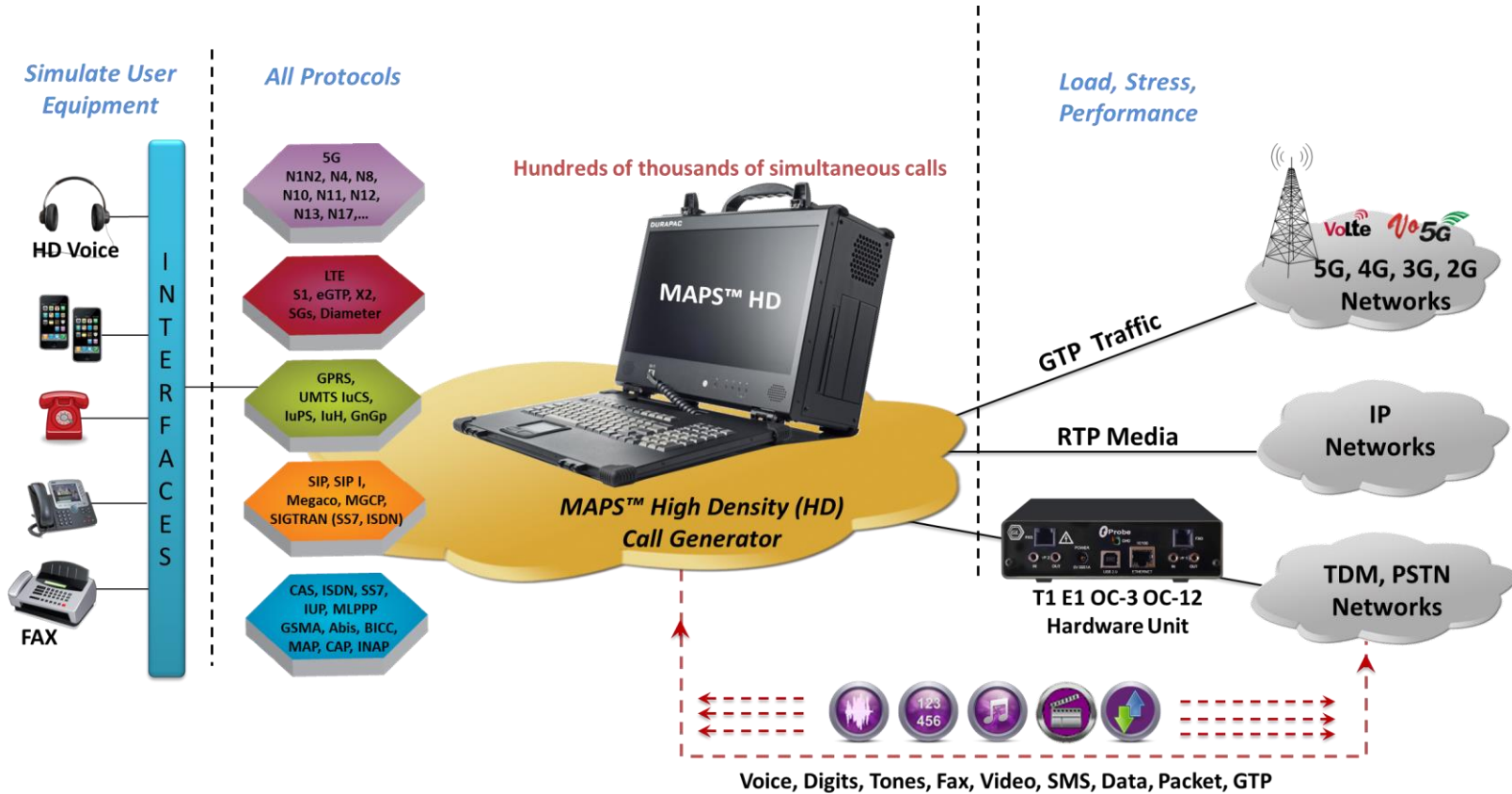
End Time: 00:00:00.000

Pause Start

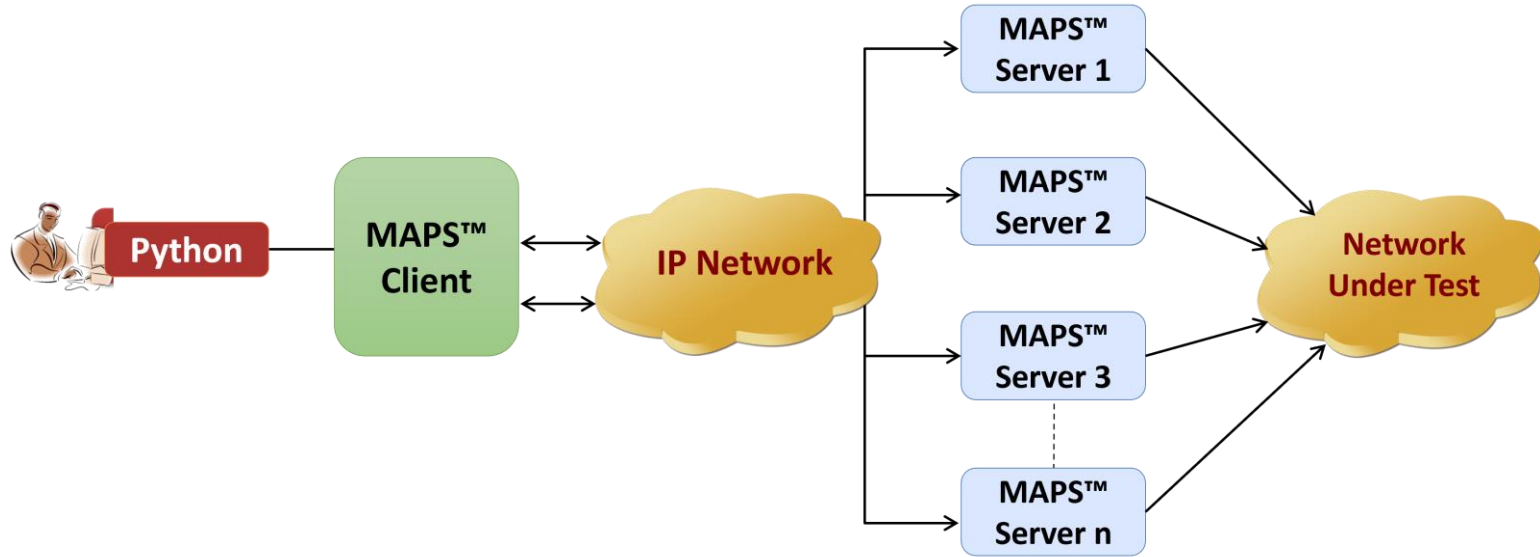
Initialisation Errors Error Events

- Stability/Stress and Performance testing using Load Generation
- Different types of Load patterns to distribute load
- User can load multiple patterns for selected script
- User configurable Test Duration, CPS, Maximum and Minimum Call Rate etc.

Traffic Emulation



MAPS™ API Architecture



- API wraps our proprietary scripting language in standard languages familiar to the user:
 - Python
- Clients and Servers support a “Many-to-Many” relationship, making it very easy for users to develop complex test cases involving multiple signaling protocols

Python Client and MAPS™ CLI Server

```
Python 3.7.5 Shell
File Edit Shell Debug Options Window Help
Python 3.7.5 (tags/v3.7.5:5c02a39a0b, Oct 15 2019, 00:11:34) [MSC v.1916 64 bit
(AMD64)] on win32
Type "help", "copyright", "credits" or "license()" for more information.
>>>
= RESTART: C:\Program Files\GL Communications Inc\MAPS5G-N4\MAPSCLI\PythonClient
\examples\UPF\N4_Recv_Call.py
N4 Server Connection...True
N4 Testbed Starting...True
N4 Loading Profile...True
UPF Waiting for N4 Session Call... UPF Waiting for Incoming handler.
wait_event == Session Establishment Request
Received Request = Session Establishment Request
Session Modification Response Sent
Call State = Session Modification Response Sent
Session Deletion Response Sent
Call State = Session Deletion Response Sent
Total Message Count : 6
N4 Call's LastMSGRCV :
Time Stamp      Route      Message
17:56:51.037    <-       Session Deletion Request

***** N4 Call Message Flow *****
      DUT(UPF)    <-->    CLI(SMF)

Time Stamp      Route      Message
17:56:39.764    <-       Session Establishment Request
17:56:40.890    ->       Session Establishment Response
17:56:40.905    <-       Session Modification Request
17:56:41.001    ->       Session Modification Response
17:56:51.037    <-       Session Deletion Request
17:56:51.079    ->       Session Deletion Response
N4 Script Stopping...True
N4 Server Disconnecting...True
>>> |
```

```
MapsCLI UPF (N4 RELEASE17)
File Edit View
View Latest Command
1:: 2024-1-16 17:56:29.369000 : Start "TestBedDefault.xml";
1:: 2024-1-16 17:56:29.700000 : LoadProfile "MobileIPCore.json"
1:: 2024-1-16 17:56:29.811000 : IncomingCallHandler # "Session Establishment Request"="UPFSessionControl.gls","IsApiClient"="True";
1:: 2024-1-16 17:56:40.887000 : UserEvent 200001 "SendSessionEstablishmentResponse";
1:: 2024-1-16 17:56:40.999000 : UserEvent 200001 "SendSessionModificationResponse";
1:: 2024-1-16 17:56:41.109000 : UserEvent 200001 "GetCallStatus";
1:: 2024-1-16 17:56:51.075000 : UserEvent 200001 "SendSessionDeletionResponse";
1:: 2024-1-16 17:56:51.184000 : UserEvent 200001 "GetCallStatus";
1:: 2024-1-16 17:56:52.397000 : UserEvent 200001 "GetMessageCount";
1:: 2024-1-16 17:56:52.505000 : UserEvent 200001 "GetLastReceivedMessage";
1:: 2024-1-16 17:56:52.612000 : UserEvent 200001 "GetMessageInfo" # "Index"=0;
1:: 2024-1-16 17:56:52.723000 : UserEvent 200001 "GetMessageInfo" # "Index"=1;
1:: 2024-1-16 17:56:52.833000 : UserEvent 200001 "GetMessageInfo" # "Index"=2;
1:: 2024-1-16 17:56:52.943000 : UserEvent 200001 "GetMessageInfo" # "Index"=3;
1:: 2024-1-16 17:56:53.055000 : UserEvent 200001 "GetMessageInfo" # "Index"=4;
1:: 2024-1-16 17:56:53.151000 : UserEvent 200001 "GetMessageInfo" # "Index"=5;
1:: 2024-1-16 17:56:53.261000 : StopScript 200001;
ServerLog:errCode = 0,errString = connection has been gracefully closed for ClientId =1
NUM SCRL
```

Thank you