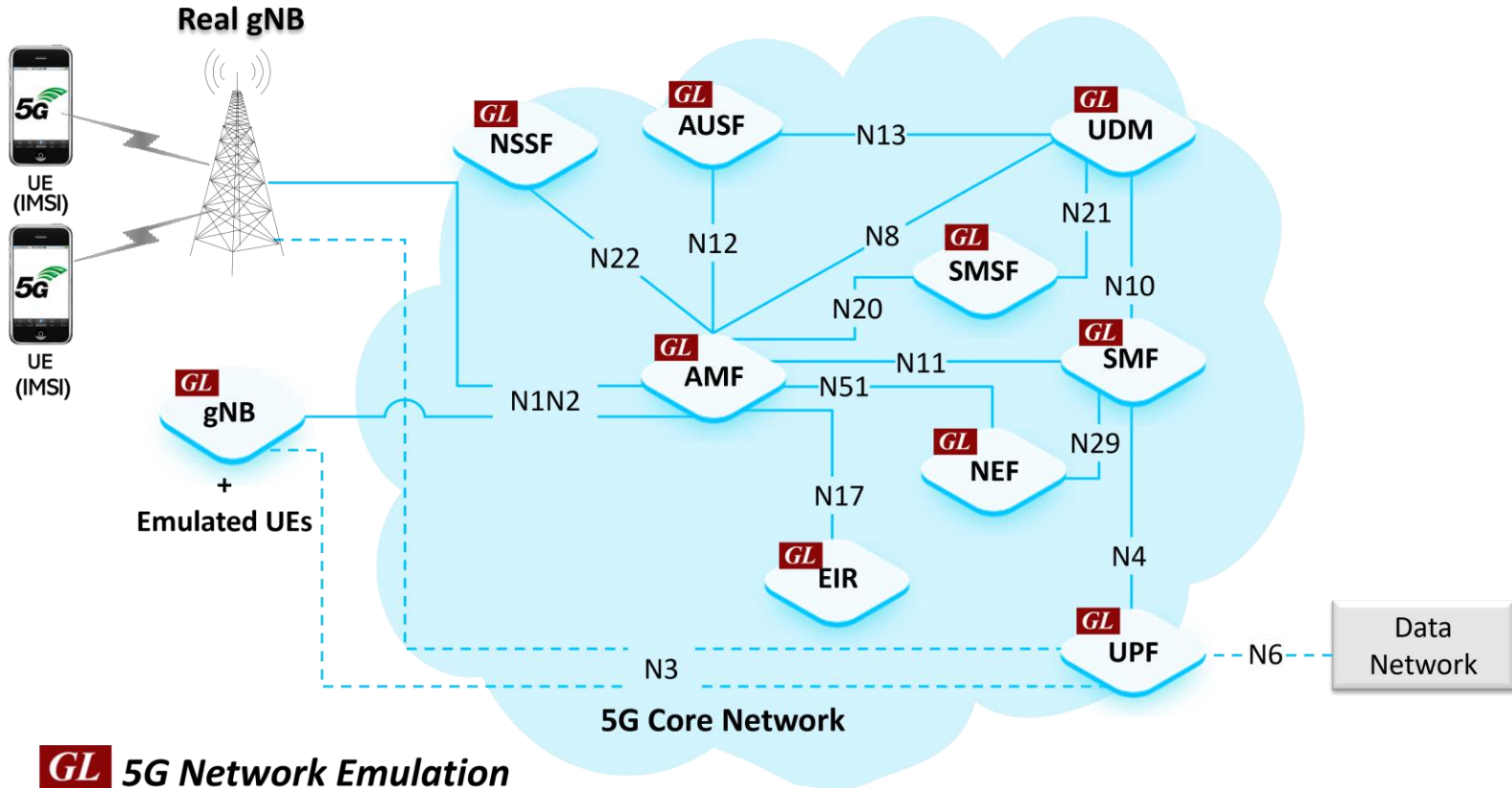

MAPS™ - 5G N4 Interface Emulator



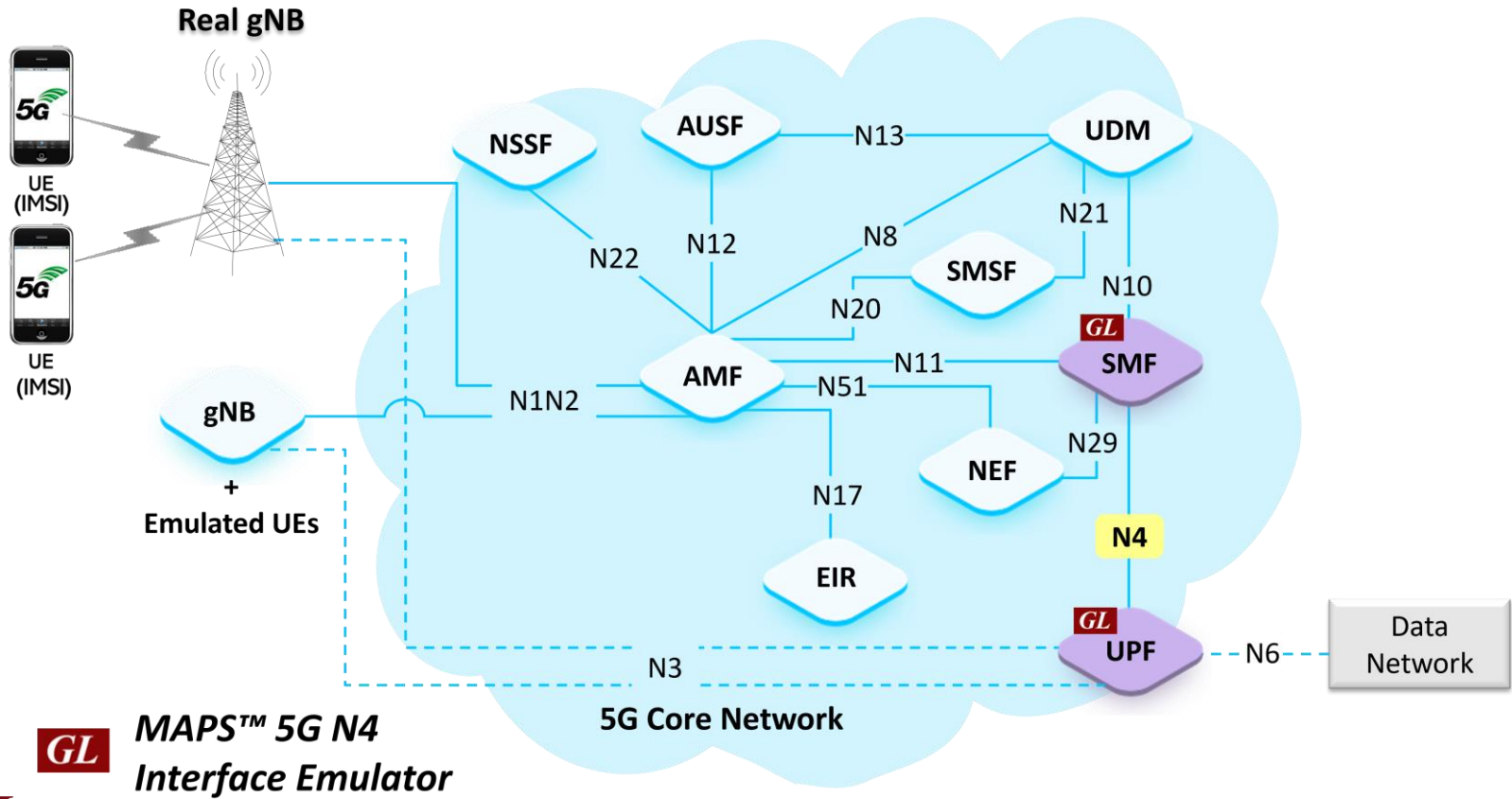
818 West Diamond Avenue - Third Floor, Gaithersburg, MD 20878
Phone: (301) 670-4784 Fax: (301) 670-9187 Email: info@gl.com
Website: <https://www.gl.com>

5G Network Diagram



GL 5G Network Emulation

MAPS™ 5G N4 Interface Emulator Architecture



GL MAPS™ 5G N4 Interface Emulator

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

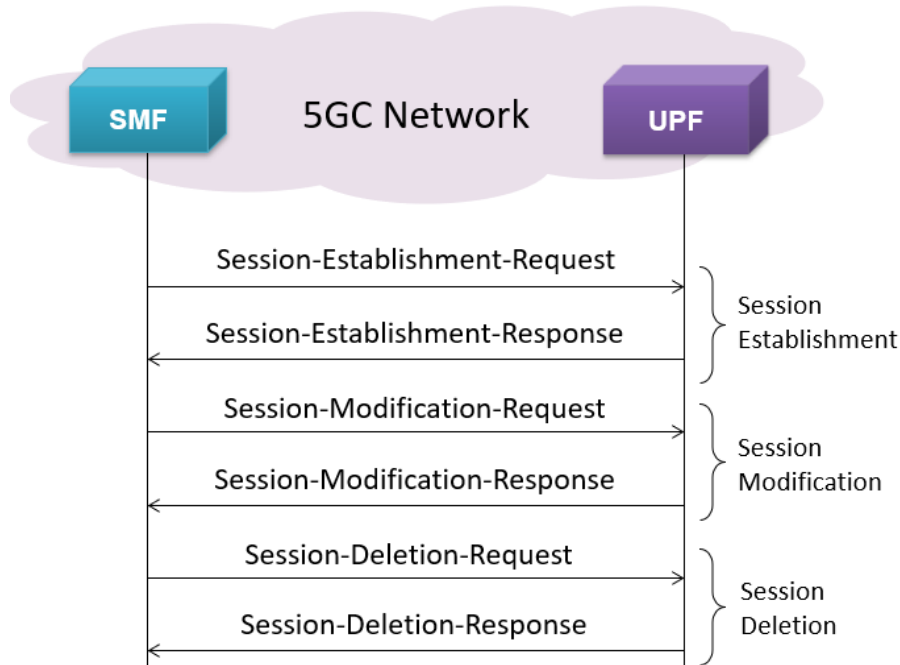
Protocol Stack Specification

PFCP
UDP
IP
L2
L1

Supported Protocols	Standard / Specification Used
N4 Interface	
N4 Interface (SMF - UPF)	TS29.244
PFCP	3GPP TS 23.501 [28] 3GPP TS 23.502 [29]
UDP	IETF RFC 768
IPv4	IETF RFC 791 [5] IETF RFC 2460 [6]

- PFCP entity supports IPv4 protocol

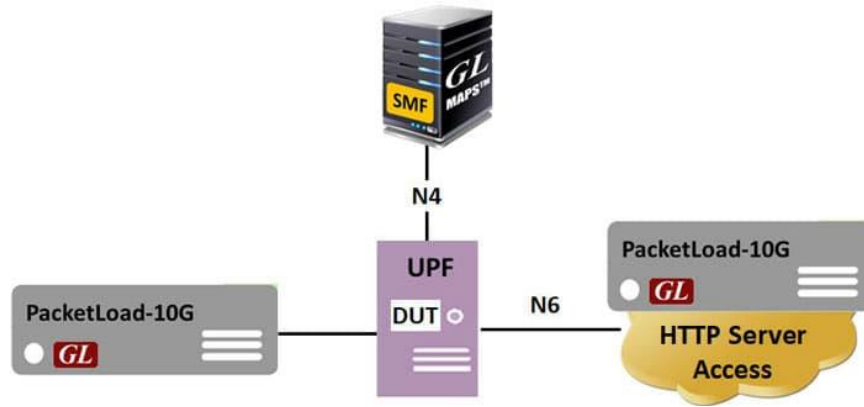
MAPS™ 5G Call Scenarios



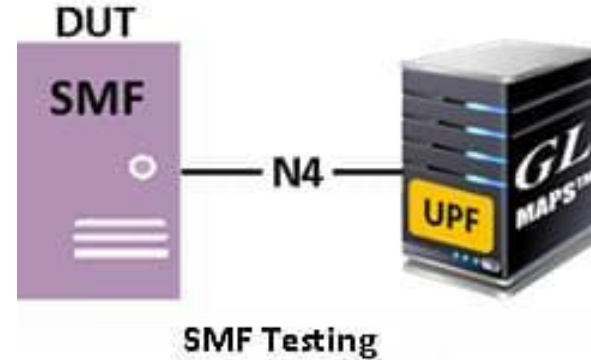
- PFCP Session Establishment Procedure
 - Session Establishment Request
 - Session Establishment Accept
- PFCP Session Modification Procedure
 - Session Modification Request
 - Session Modification Response
- PFCP Session Deletion Procedure
 - Session Deletion Request
 - Session Deletion Response

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

The screenshot displays the MAPS SMF (N4 RELEASE17) configuration interface. The window title is "MAPS SMF (N4 RELEASE17) - [Testbed Setup - TestBedDefault]". The menu bar includes "Configurations", "Emulator", "Reports", "Editor", "Debug Tools", "Windows", and "Help". The toolbar contains various icons for file operations and system functions.

The main configuration area is divided into two panes. The left pane shows a tree view of configuration parameters, and the right pane shows the values for the selected parameters. The "Enable" checkbox is checked.

Config	Value
SMF Parameters	
Adapter Index	0
SMF	1
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	Enable
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	

Buttons: Start, Edit

Status bar: Initialisation Errors, Error Events

Profile Configuration

The screenshot displays the 'Profile Editor - MobileIPCore' window. The interface includes a menu bar with 'Configurations', 'Emulator', 'Reports', 'Editor', 'Debug Tools', 'Windows', and 'Help'. A toolbar contains various icons for file operations and settings. The main workspace is divided into three panes:

- Profiles (Edit-F2):** A list with one entry: '1 Profile'.
- Config:** A tree view showing the configuration structure:
 - 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
 - Traffic Type: HDTraffic

- Value:** A pane on the right with a checked 'Enable' checkbox and buttons for 'Add', 'Insert', 'Delete', and 'Properties'.

At the bottom of the window, there are status bars for 'Initialisation Errors' and 'Error Events'. The bottom-left corner features the 'GL Communications' logo.

Global Configuration

Config	Value	Enable
Global Configuration		<input checked="" type="checkbox"/>
Protocol Specific Timer		
T3 Timer in msec	4000	
Heartbeat Parameters		
Heartbeat Interval	60000	
Heartbeat Retransmission	3	
Heartbeat Retransmission Timeout	1000	
Call Parameters		
Session Duration in msec	3000	
Inter Call Duratoin in msec	100	
Randomization Parameters		
Enable Randomization in msec	Disable	
Distribution Type	Uniform Distribution	
Minimum Session Duration in msec	10000	
Maximum Session Duration in msec	30000	
Minimum InterCall Duration in msec	1000	
Maximum InterCall Duration in msec	3000	
Path Management Parameters		
Local Restart Counter	1	
Remote Restart Counter	0	
Echo Request Timer in msec	60000	
PacketLoad Configurations		
Packet Load Traffic	Disable	
Traffic Rate	Fixed Bandwidth	
Bandwidth Per User	20.00	
Graph	Enable	
HTTP File Name	1024_Bytes.txt	
PCAP File Name	ETSI.pcap	
For Random Bandwidth		
Minimum Bandwidth	2.00	
Maximum Bandwidth	15.00	
PCAP File Selection Mode	Dynamic	
HTTP Web Server IPAddress	192.168.31.91	
DNName	internet	
PDN Type	IPv4	

Incoming Call Handler Configuration

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

Configurations Emulator Reports Editor Debug Tools Windows Help

Message Name Script Name

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

```
ScriptEditor - [C:\Program Files\GL Communications Inc\MAPS5G-N4\MAPS\N4\RELEASE17\SMF\Scripts\PFCPSessionControl.gls]
File View Edit Shortcuts Tools Help
Command Window
+ Action
+ Conditional & Flow Control
+ Variable
+ Maps CLI
+ Logs / Comment
+ Init
+ Child Script
+ DataBase
+ Send Report
+ Resume
+ Return
+ Include
+ Exit
+ Utility Functions
+ Traffic Commands
1 //*****Initializing Parameters*****
2 //Debug Log options
3 //CallFlowDebug == 1
4 AuthenticationLogs=0; //To display Authentication Parameters
5 PDUSessionLogs=0; //To display PDU Session Parameters
6 GTPSessionLogs=0; //To display GTP Command Parameters
7 if(CallFlowDebug==1)
8     ToggleScriptFlow(1); // Utility to enable scriptFlow
9 endif
10
11 PFCPScriptId = "PFCP";
12 KidDispStr1="SMFSEID ";
13 KidDispStr2=" UPFSEID ";
14 KeyIdentifier: KidDispStr1,SMFSEID,KidDispStr2,UPFSEID;
15 MsgHandler:"SGMessageHandler";
16 SequenceNo = 0;
17 StopAll = 0;
18 TrafficVerification= "Unsuccessful";
19 TxCount=0;
20 RxCount=0;
21 nFileCount=1;
22 TrafficState="Null";
23 File_TxCount=0;
24 File_RxCount=0;
25 DNNName = $ DNNName;
26 AllocUniqueId "GTPUTEIDDL" GTPUTEIDDL;
27
28 ////CLI Parameters
29 if(EnableCLI)
30     ReportEvent (StartStatus = "Running");
31 endif
32 LoopCount1 = 0;
33 MsgSeqCount = 0;
```

Ready | Line Count - 295 | Line: 1 Col: 1

Message Editor

The screenshot shows the Message Editor application window titled "Message Editor - Untitled". The interface includes a menu bar (File, View, Direction, Tools, Help) and a toolbar with icons for help, save, and close. The main area is divided into three sections:

- Frame No.:** A table with one row containing the number "1".
- Tree View:** A hierarchical tree structure for a PFCP message:
 - PFPC
 - S
 - Message Priority:
 - Version
 - Message Type
 - Length
 - Session Endpoint Identifier
 - Sequence Number
 - Message Priority
 - InformationElements
 - Update PDR
 - Information Element Id
- Hex Dump:** A detailed view of the message content, showing hexadecimal values and their corresponding field names and values. The dump is as follows:

```
===== 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
```

MAPS™ 5G N4 Interface – Call Emulation

Call Generation

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						

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

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

● Initialisation E

Call Reception

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 : JPF.	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 ..0x00000...	Completed	Session Deletion Response Sent	None		Pass
5	UPFSessionControl.gls		UEIPAddress :.192.168.15.142.SMFSEID ..0x00000...	Completed	Session Deletion Response Sent	None		Pass

Show Records
 Select Active Call
 Auto Trash
 Show Hidden Calls

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

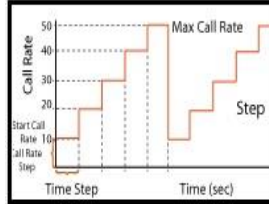
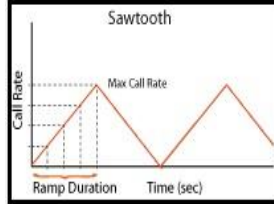
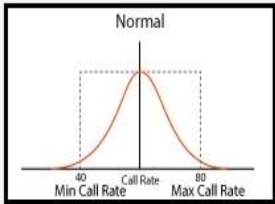
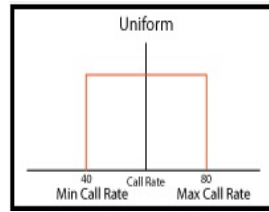
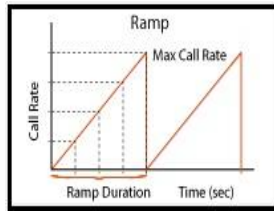
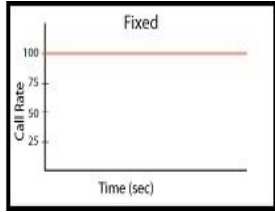
← Session Deletion Response 10:13:46.473000

```

Find
----- PFPC 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
                    
```

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

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
PFCPSessionControl	Profile

Stop Time: Days 0 Hours 0 Minutes 0

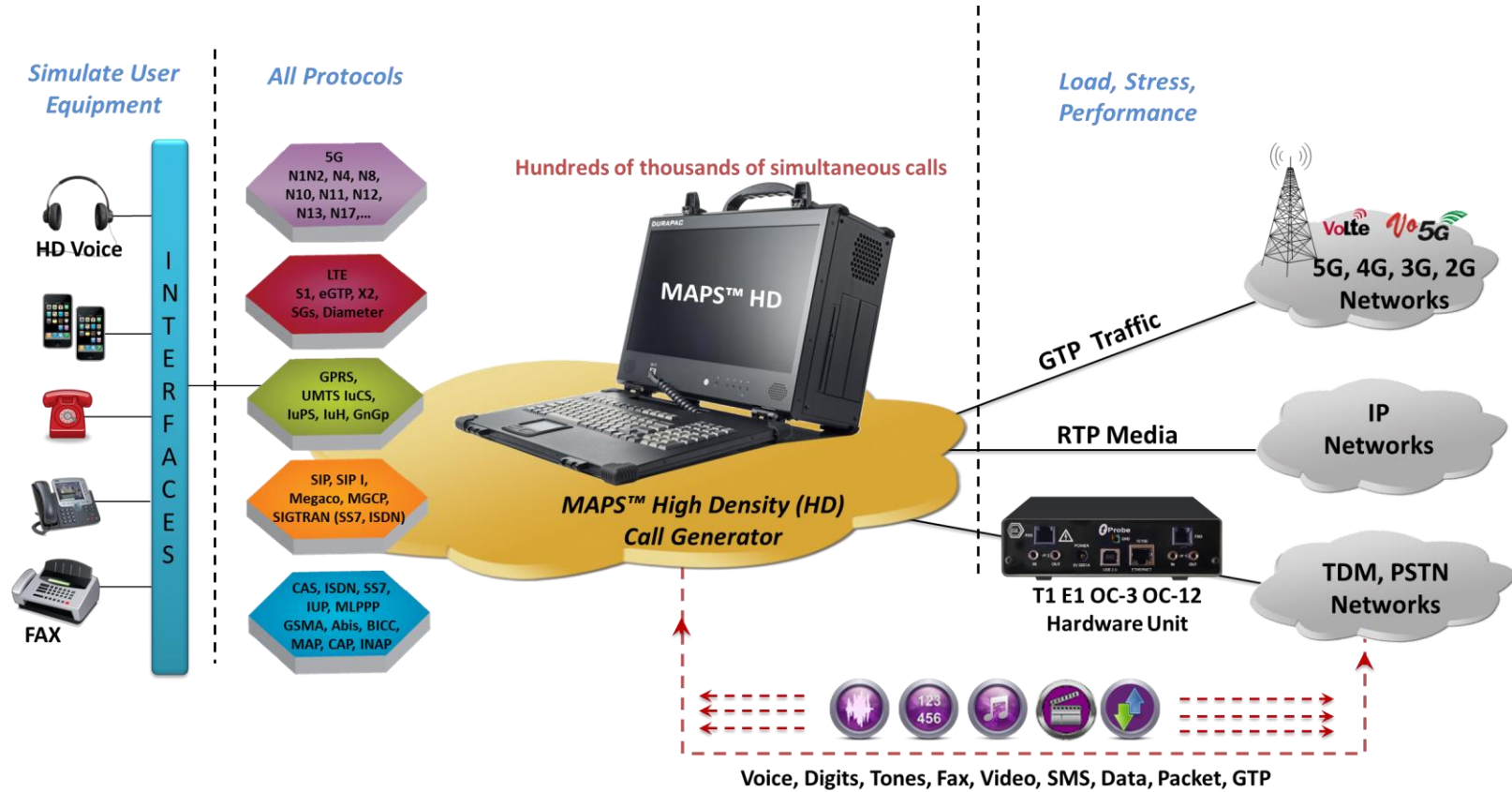
Start Time: 00:00:00.000

End Time: 00:00:00.000

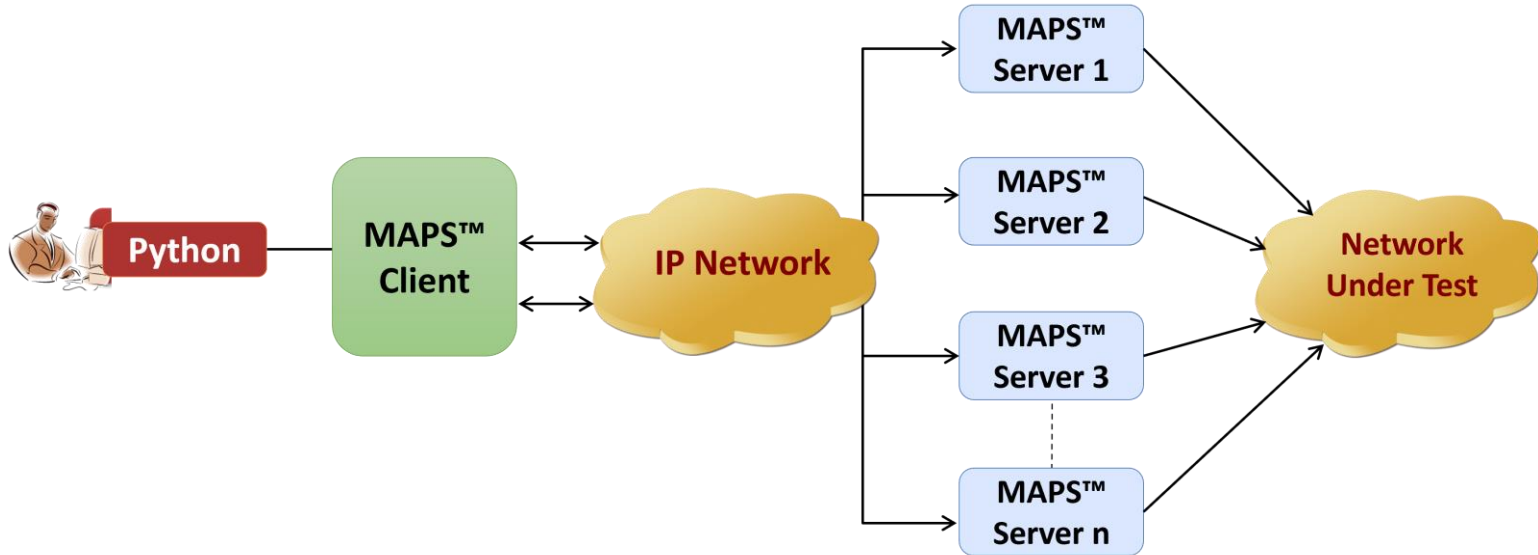
Initialisation Errors Error Events

- 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
>>> |
```

```
CLI 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