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# MAPS™ - 5G N4 Interface Emulator

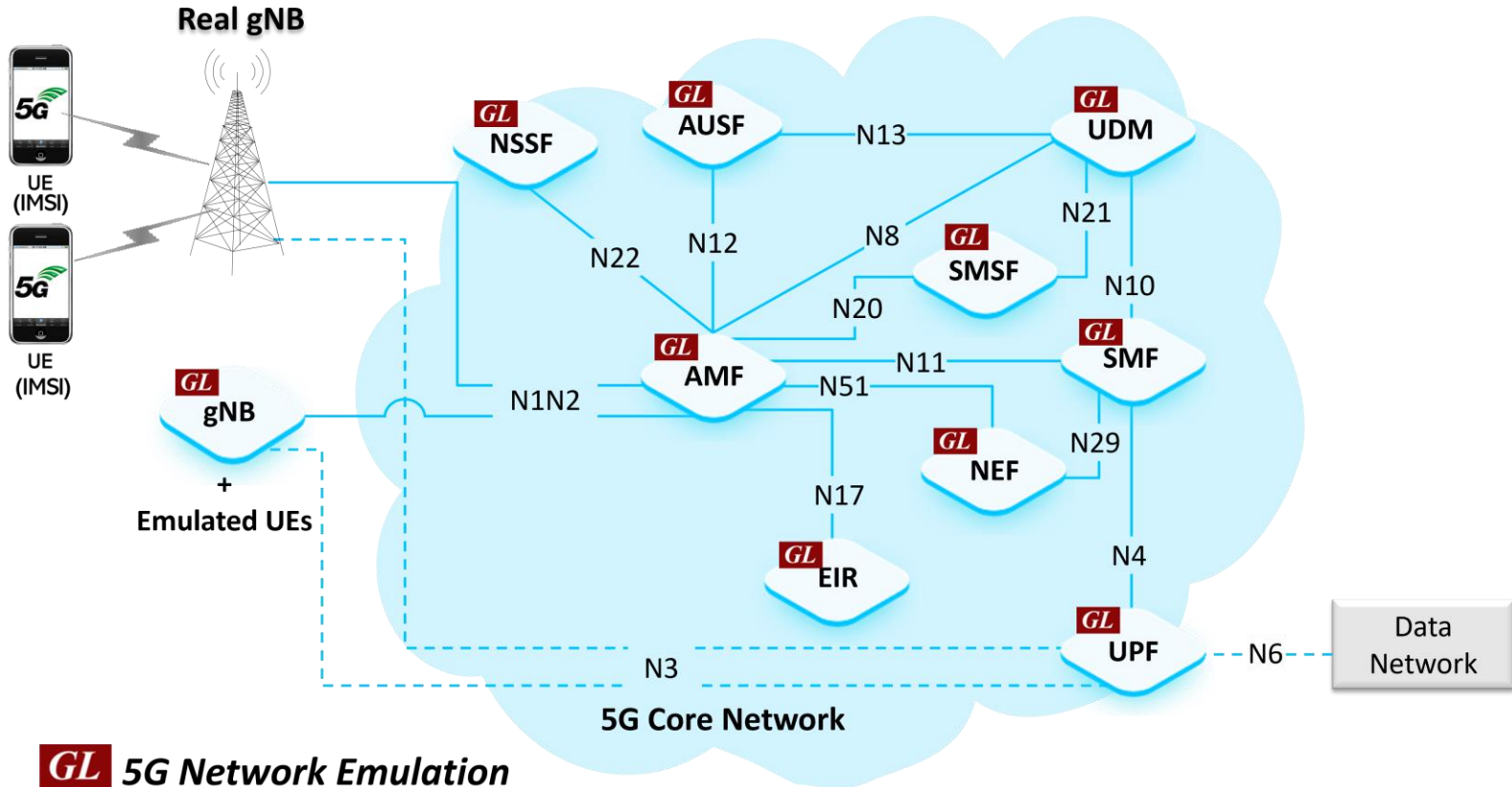
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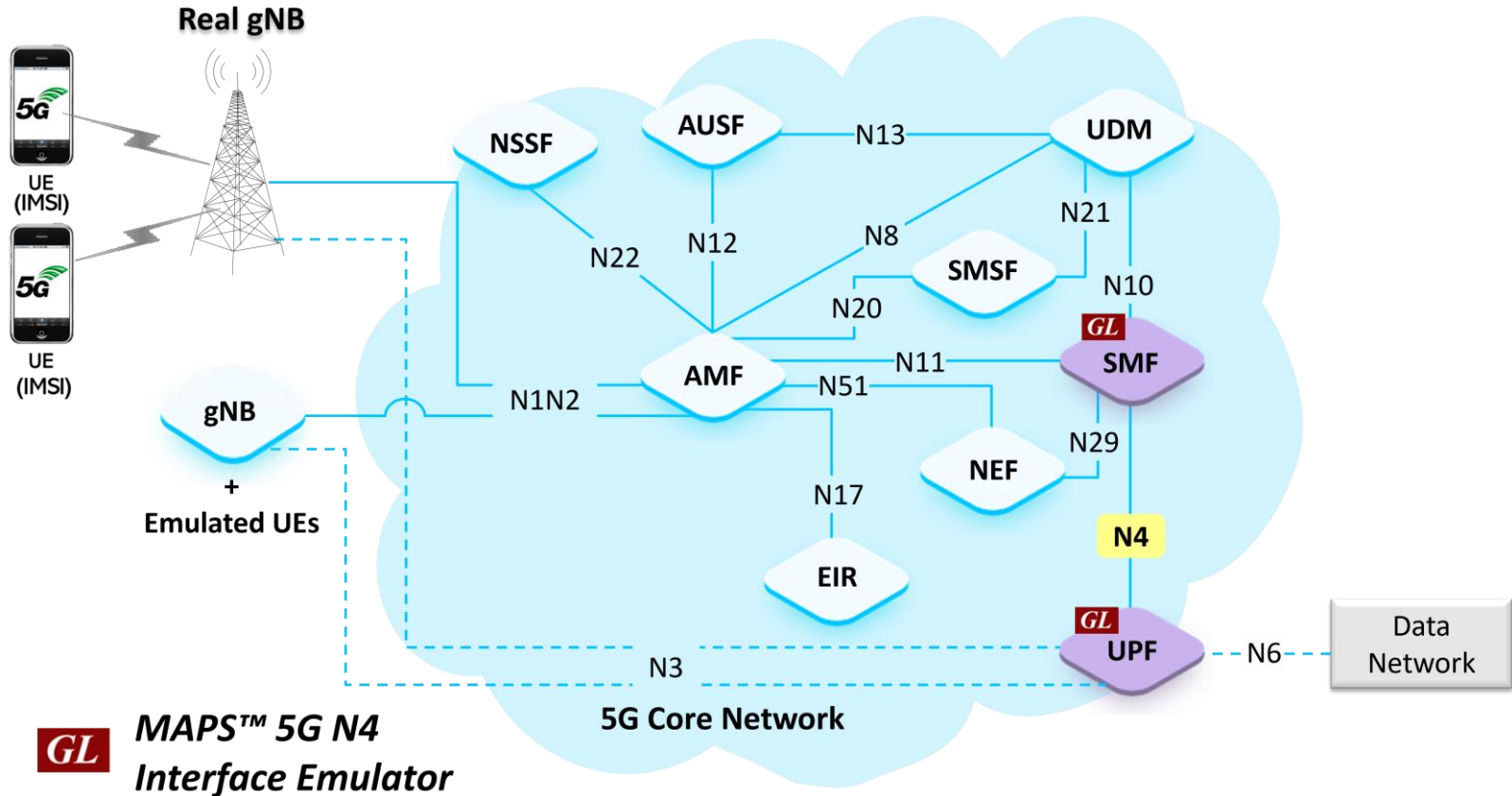
818 West Diamond Avenue - Third Floor, Gaithersburg, MD 20878  
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# 5G Network Diagram



**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

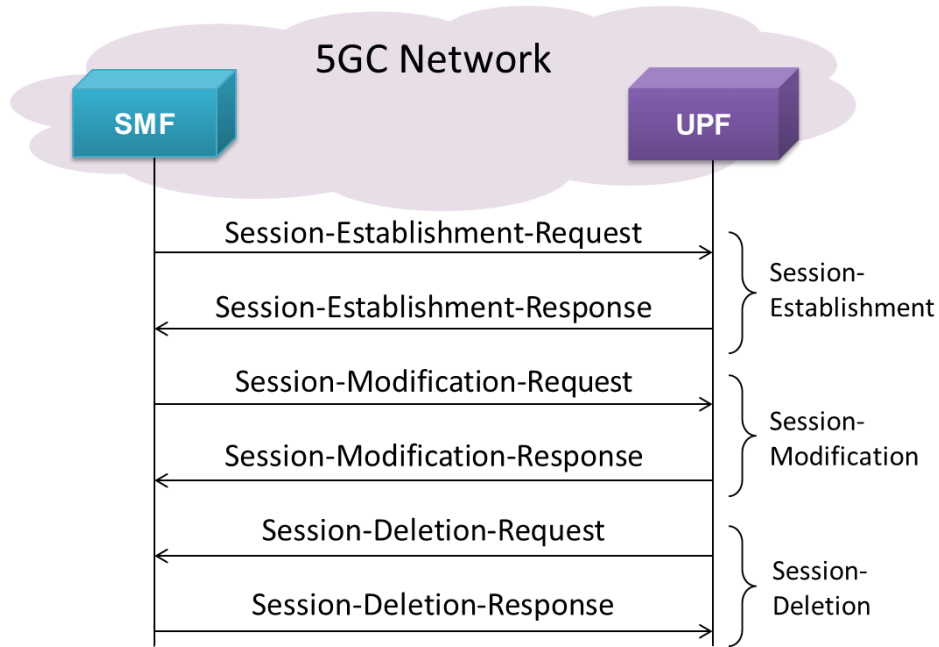
# Protocol Stack Specification

PFCP
UDP
IP
L2
L1

Supported Protocols	Standard / Specification Used
<b>N4 Interface</b>	
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

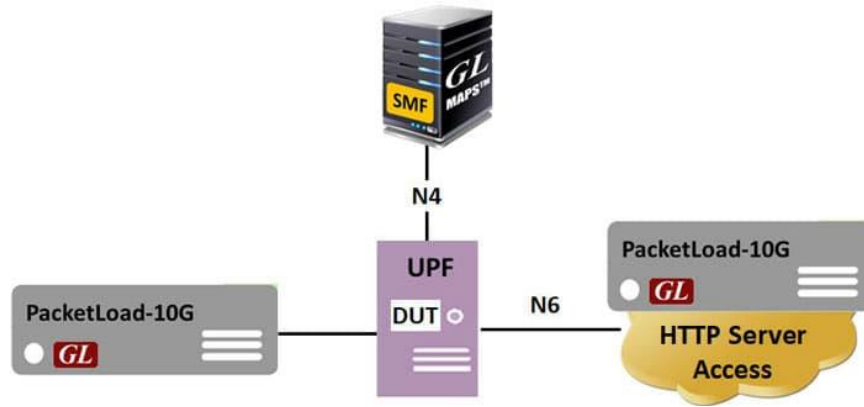
# MAPS™ 5G Call Scenarios



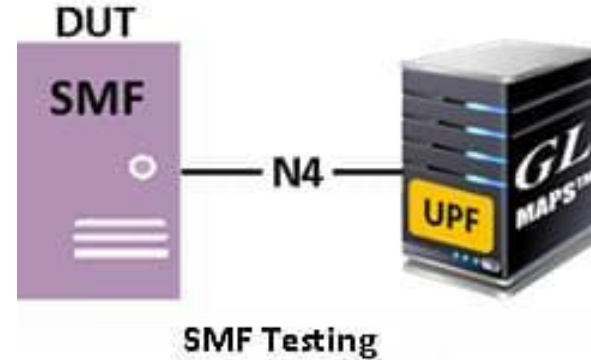
- PFCP Session Establishment Procedure
  - Session Establishment Request
  - Session Establishment Accept
- PFCP Session Modification Procedure
  - Session Modification Request
  - Session Modification Response
- PFCP Session Deletion Procedure
  - Session Deletion Request
  - Session Deletion Response

# 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 shows the MAPS SMF (N4 RELEASE17) configuration window. The title bar reads "GL 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 area is divided into a tree view on the left and a table on the right. The tree view shows a hierarchy of configuration parameters under "SMF Parameters" and "DNN Configuration". The table lists the values for these parameters. A "Start" button is visible at the bottom right of the configuration area.

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	



# Profile Configuration

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

Configurations Emulator Reports Editor Debug Tools Windows Help

Profiles (Edit-F2)

#	Profiles (Edit-F2)
1	Profile

Config

- 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

Enable

Add Insert Delete

Properties

Initialisation Errors Error Events

# Global Configuration

The screenshot shows the 'Global Configuration' window in the MAPS SMF (N4 RELEASE17) application. The window title is 'MAPS SMF (N4 RELEASE17) - [Global Configuration - Globalprofile]'. 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 area is divided into three sections: a tree view on the left, a table in the center, and a control panel on the right.

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	

At the bottom right of the configuration table, there are 'Apply' and 'Edit' buttons. At the bottom of the window, there are two status indicators: 'Initialisation Errors' and 'Error Events'.

# 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
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

The screenshot shows the Script Editor application window. The title bar reads "ScriptEditor - [C:\Program Files\GL Communications Inc\MAPS5G-N4\MAPS\N4\RELEASE17\SMF\Scripts\PFCPSessionControl.gls]". The menu bar includes "File", "View", "Edit", "Shortcuts", "Tools", and "Help". The toolbar contains icons for file operations and settings. The Command Window on the left lists various actions like "Action", "Conditional & Flow Control", "Variable", "Maps CLI", "Logs / Comment", "Init", "Child Script", "DataBase", "Send Report", "Resume", "Return", "Include", "Exit", "Utility Functions", and "Traffic Commands". The main editor area shows a script with the following content:

```
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;
```

The status bar at the bottom indicates "Ready" and "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:

- Left Panel:** A table with "Frame No." and "1".
- Tree View:** A hierarchical tree structure under "PFCP".
  - S
  - Message Priority:
  - Version
  - Message Type
  - Length
  - Session Endpoint Identifier
  - Sequence Number
  - Message Priority
  - InformationElements
    - Update PDR
      - Information Element Id

- Right Panel:** A dropdown menu showing a list of message types:
- 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

The main area displays a hex dump of the message content:

```
===== 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]

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						

Message Sequence Diagram (SMF vs UPF):

- SMF → UPF: Session Establishment Request (10:13:43.633000)
- UPF → SMF: Session Establishment Response (10:13:43.649000)
- SMF → UPF: Session Modification Request (10:13:43.649000)
- UPF → SMF: Session Modification Response (10:13:43.671000)
- SMF → UPF: Session Deletion Request (10:13:46.463000)
- UPF → SMF: Session Deletion Response (10:13:46.483000)

## Call Reception

MAPS UPF (N4 RELEASE17) - [Call Reception]

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

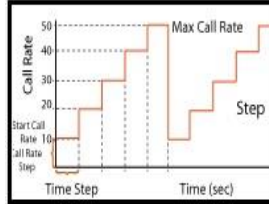
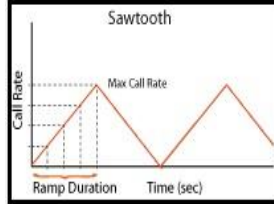
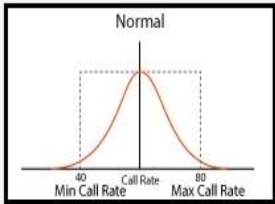
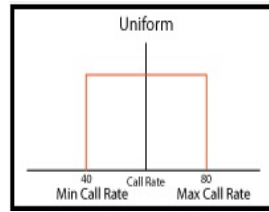
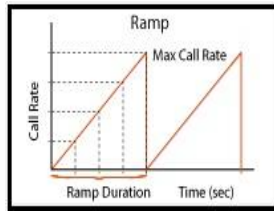
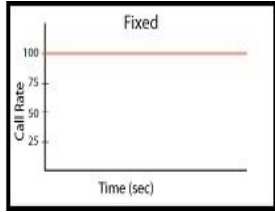
Message Sequence Diagram (SMF vs UPF):

- SMF → UPF: Session Establishment Request (10:13:43.640000)
- UPF → SMF: Session Establishment Response (10:13:43.641000)
- SMF → UPF: Session Modification Request (10:13:43.659000)
- UPF → SMF: Session Modification Response (10:13:43.659000)
- SMF → UPF: Session Deletion Request (10:13:46.473000)
- UPF → SMF: Session Deletion Response (10:13:46.473000)

Log Output:

```
----- 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
```

# 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

Pause

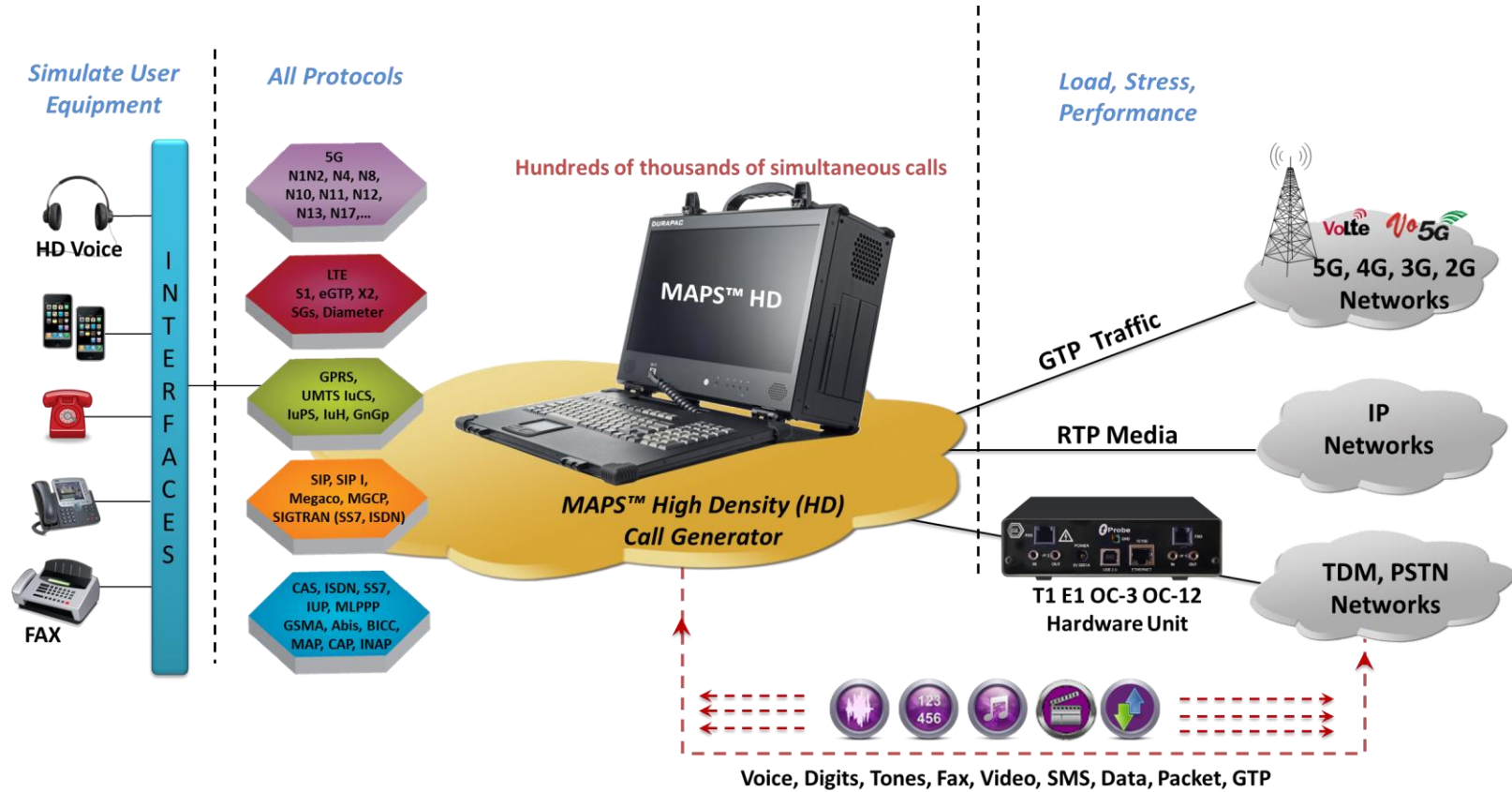
Start

Initialisation Errors

Error Events

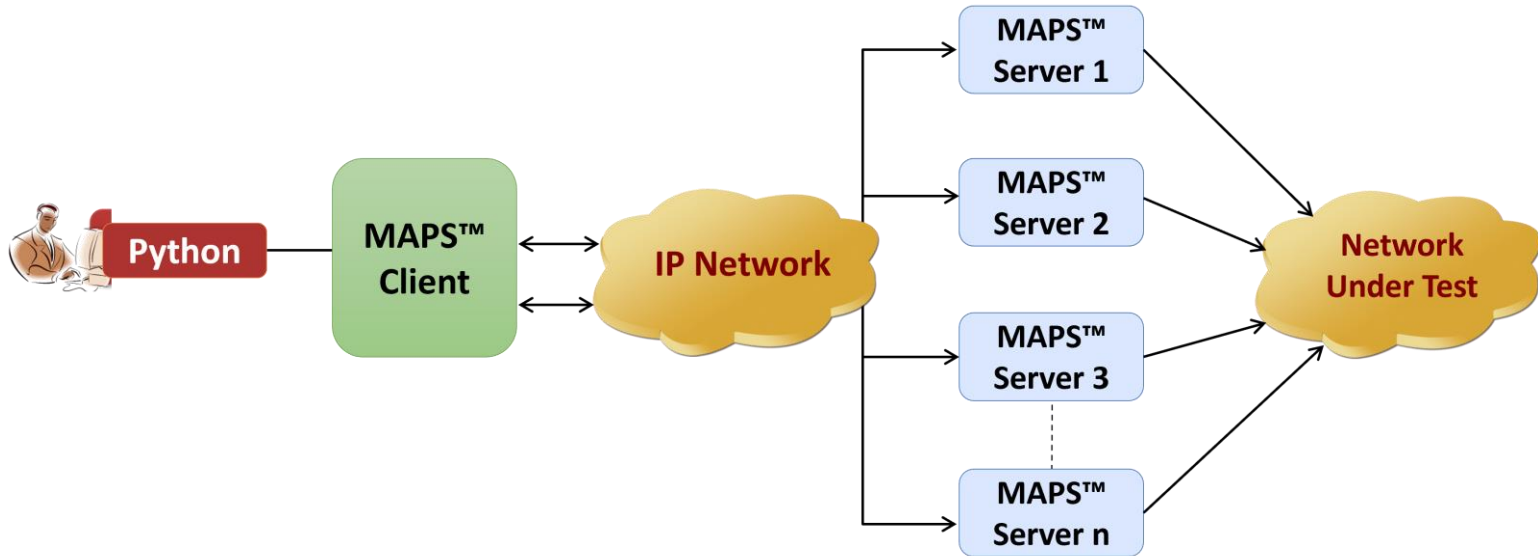
- Stability/Stress and Performance testing using Load Generation
- Different types of Load patterns to distribute load
- User can load multiple patterns for selected script
- User configurable Test Duration, CPS, Maximum and Minimum Call Rate etc.

# 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
>>> |
```

```
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**