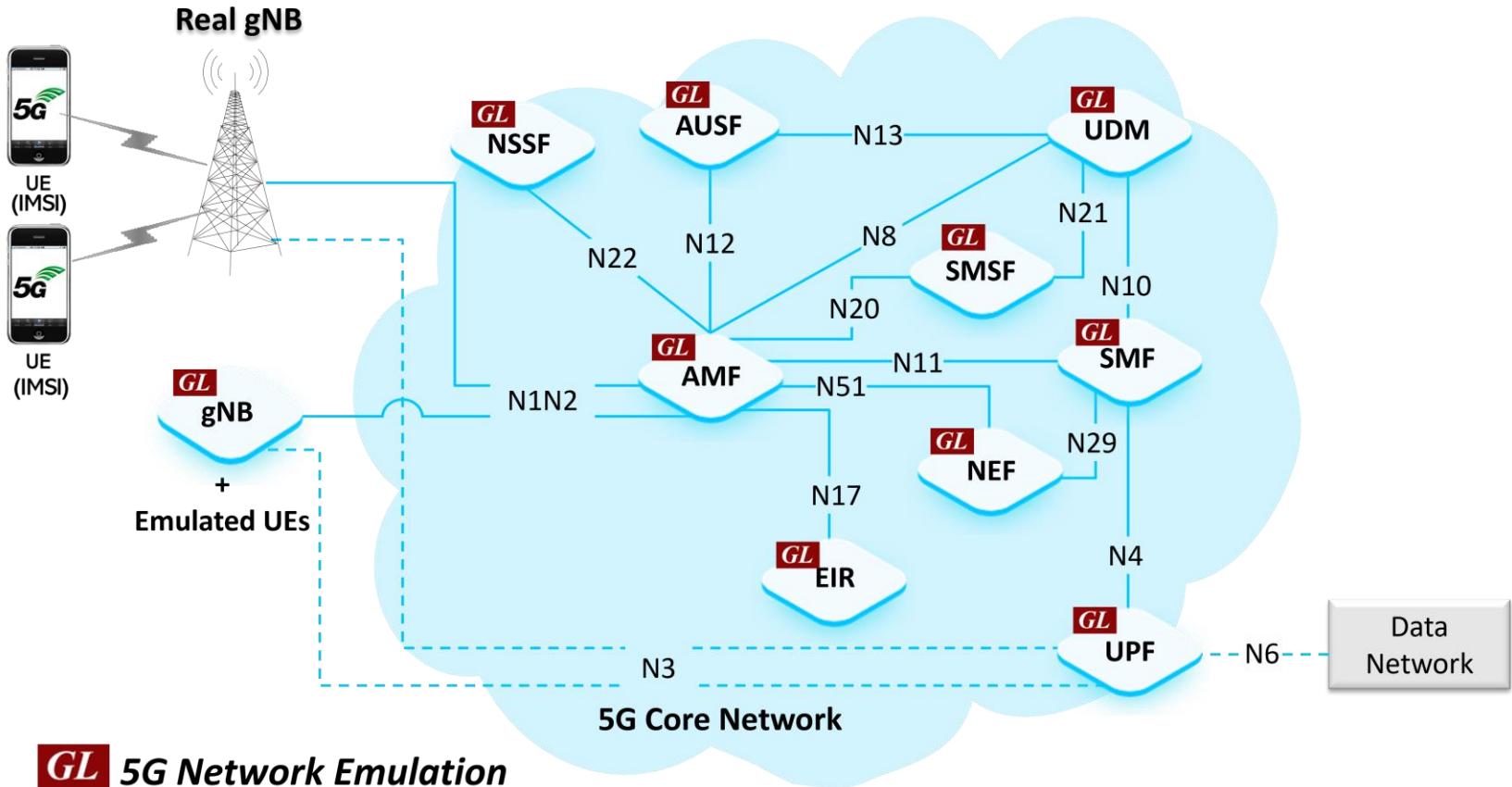

MAPS™ 5G N21 Interface Emulator



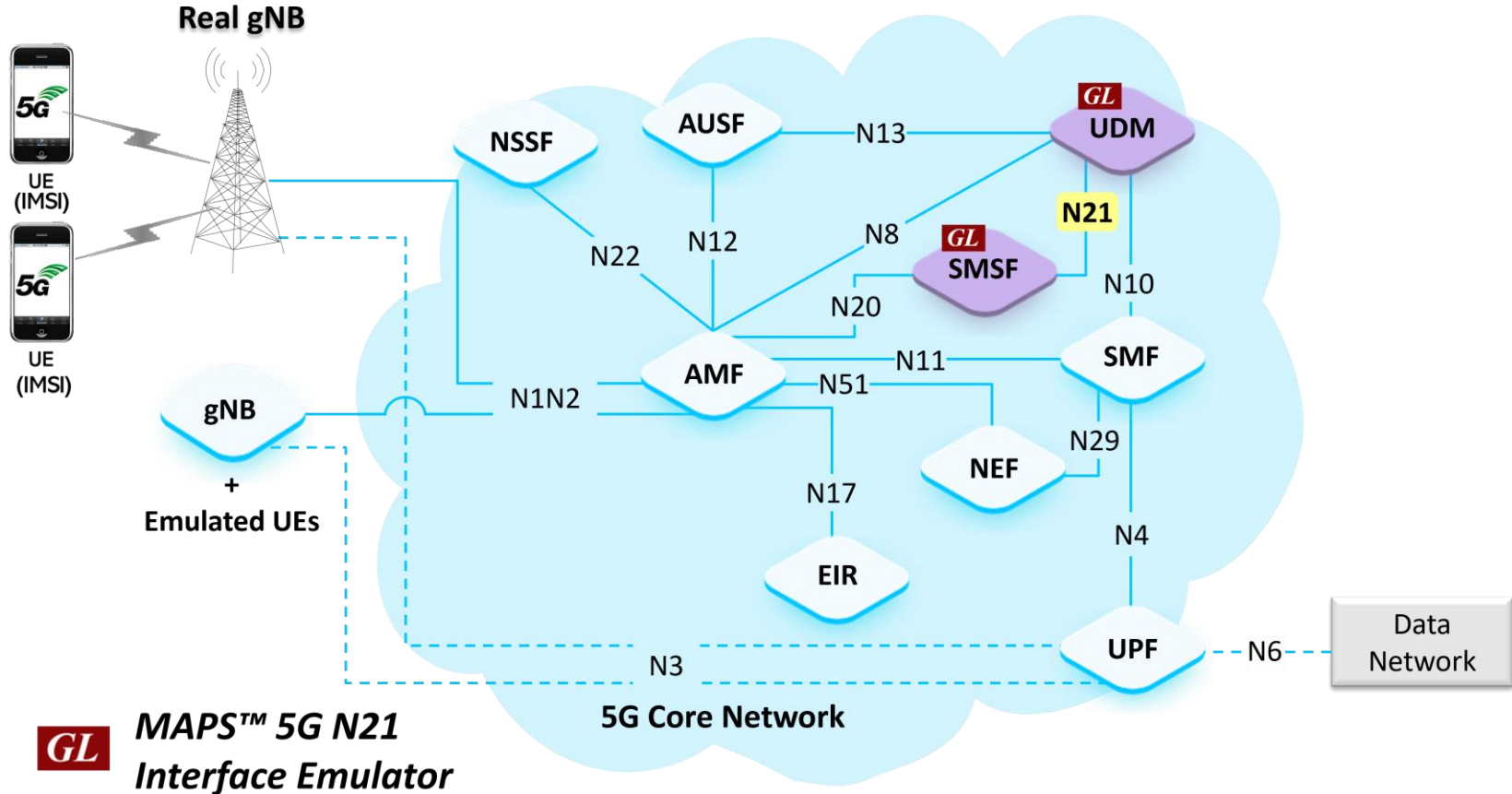
818 West Diamond Avenue - Third Floor, Gaithersburg, MD 20878
Phone: (301) 670-4784 Fax: (301) 670-9187 Email: info@gl.com
Website: <https://www.gl.com>

5G Network Diagram



GL 5G Network Emulation

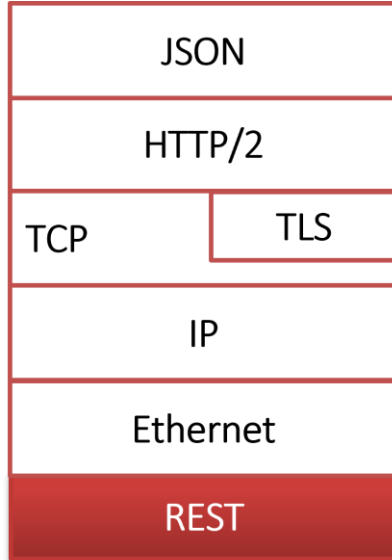
MAPS™ 5G N21 Interface



Main Features

- Emulate Short Message Service Function (SMSF) and Unified Data Management (UDM) elements
- Supports Nudm_SubscriberDataManagement Services (Get, Subscribe, ModifySubscription, Unsubscribe and Notification operations) and Nudm_UEContextManagement Services (SMSF Registration and Deregistration operations)
- Services use REST APIs based on HTTP and JSON data format
- Supports Command Line Interface (CLI) through a client-server model, enabling users to control all features via Python APIs
- Supports TLS and TCP transports
- Supports scripted call generation and automated call reception
- Supports customization of call flow and message templates using Script and Message Editor
- Ready-to-use scripts for quick testing
- Provides Call Statistics and Events Status

Protocol Stack



| Supported Protocols | Standard / Specification Used |
|-----------------------------------|---|
| N21 Interface | |
| N21 Interface (UDM-SMSF) | TS29.503 |
| JavaScript Object Notation (JSON) | IETF RFC 8259 |
| HTTP/2 | IETF RFC 7231 IETF RFC 7540/RFC 7541 |
| TLS | IETF RFC 8446 |
| TCP | IETF RFC 793 |
| IPv4 | IETF RFC 791 [5] IETF RFC 2460 [6] |

User Cases

- MAPS™ can emulate any one node (SMSF / UDM) or both nodes



Testbed Setup (UDM)

MAPS UDM (N21 RELEASE17)

Configurations Emulator Reports Editor Debug Tools Windows Help

Testbed Setup - TestBedDefault

| Config | Value |
|---------------------------------------|-------------------------------|
| UDM Configuration | |
| UDM | 1 |
| UDM 1 | |
| UDM IP Address | 192.168.12.89 |
| UDM Port | 6666 |
| URI Scheme | HTTP |
| UDM API Versions | |
| UE Authentication Service | v1 |
| Context Management Service | v1 |
| Subscriber Data Management Service | v2 |
| Event Exposure Service | v1 |
| Parameter Provision Service | v1 |
| NIDD Authorization Service | v2 |
| UE Simulation Parameters | |
| Type Of UE Simulation | Profiles |
| End User Configuration | UE_Profiles.xml |
| Auto Generated Users Info | |
| No Of Users To Be Simulated | 4000 |
| Starting IMSI | 001013012041631 |
| Auto Generated End User Configuration | AutoGeneratedUser_Profile.xml |

UDMIPAddress

Enter IP Address

192 . 168 . 12 . 89

Start Edit

Initialisation Errors Er

Testbed Setup (SMSF)

The screenshot displays the configuration interface for MAPS SMSF (N21 RELEASE17). The window title is "MAPS SMSF (N21 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 columns: "Config" and "Value". The "Config" column shows a hierarchical tree structure, and the "Value" column shows the corresponding values. A "Enable" checkbox is visible on the right side of the configuration table.

| Config | Value | Enable |
|-------------------------------------|-----------------|-------------------------------------|
| SMSF Configuration | | <input checked="" type="checkbox"/> |
| SMSF | 1 | |
| SMSF 1 | | |
| SMSF IP Address | 192.168.12.35 | |
| SMSF Server Port | 6666 | |
| URI Scheme | HTTP | |
| SMSF Client Name | SMSFClient1 | |
| UDM | 1 | |
| UDM 1 | | |
| UDM IP Address | 192.168.12.89 | |
| UDM Port | 6666 | |
| UDM API Versions | | |
| UE Authentication Service | v1 | |
| Context Management Service | v1 | |
| Subscriber Data Management Servi... | v2 | |
| Event Exposure Service | v1 | |
| Parameter Provision Service | v1 | |
| NIDD Authorization Service | v2 | |
| UE Simulation Parameters | | |
| Type Of UE Simulation | Profiles | |
| End User Configuration | UE_Profiles.xml | |
| Auto Generated Users Info | | |

Buttons: Start, Edit

Status: Initialisation Errors, Error Events

Profile Editor (UDM)

The screenshot displays the 'Profile Editor - UE_Profiles' window. The main area is divided into three panes:

- Profiles (Edit-F2):** A list of 21 profiles, each with a unique MSIN (e.g., MSIN3012041631).
- Config:** A tree view showing the configuration for the selected profile (MSIN3012041631). The configuration includes:
 - Subscriber Info
 - IMSI: 001013012041631
 - IMEI: 359877068325248
 - MSIN: 3012041631
 - HPLMN ID
 - MCC: 001
 - MNC: 01
 - NSSAI for HPLMN
 - GPSIs: 1
 - Internal GroupIds: 01030507-123-456-010203040506070809...
 - Authentication Parameters
 - Subscribed UE AMBR
 - RAT Restrictions: EUTRA
 - Forbidden Areas
 - Service Area Restriction
 - Core Network Type Restrictions: EPC
 - RAT or Frequency Selection Priority Index: 1
 - Subscribed Periodic Registration Timer: 300000
 - UE Usage Type: 1
 - MPS Priority: False
 - MCS Priority: False
 - Mico Mode Allowed: False
 - Active Time for PSM UEs: 100000
 - Service Gap Time: 10000
 - DL Buffering Suggested Packet Count: 1
 - SOR Information Expect Indicator: False
 - SOR AF Information Retrieval: False
- Enable:** A checkbox labeled 'Enable' which is checked.

At the bottom of the interface, there are buttons for 'Insert', 'Delete', 'Clear', 'Add', 'Insert', 'Dele', and 'Properties'. The status bar at the very bottom shows 'Initialisation Errors', 'Error Events', and 'Captured Errors'.

Profile Editor (SMSF)

MAPS SMSF (N21 RELEASE17) - [Profile Editor -UE_Profiles*]

Configurations Emulator Reports Editor Debug Tools Windows Help

Profiles (Edit-F2)

| # | Profiles (Edit-F2) |
|----|--------------------|
| 1 | UEProfile0001 |
| 2 | UEProfile0002 |
| 3 | UEProfile0003 |
| 4 | UEProfile0004 |
| 5 | UEProfile0005 |
| 6 | UEProfile0006 |
| 7 | UEProfile0007 |
| 8 | UEProfile0008 |
| 9 | UEProfile0009 |
| 10 | UEProfile0010 |
| 11 | UEProfile0011 |
| 12 | UEProfile0012 |

Config Value

- UEProfile0001
 - Subscriber Info
 - SUPI 001013012041631
 - SMSF Client Name SMSFClient1
 - PLMN ID
 - MCC 001
 - MNC 01
 - UECM Service Request SMSF Registration Non 3GPP Access
 - SDM Service Request Get SMS-Mng-Data
 - SDM Subscription
 - Subscription Expires 2022-08-02T025:09:13.445Z
 - Immediate Report False

Enable

Add Insert

Properties

Insert Delete Clear

Initialisation Errors Error Events

Call Generation

The screenshot displays the GL MAPS SMSF (N21 RELEASE17) - [Call Generation - CallGenDefault] interface. The window title bar includes standard OS controls and a menu bar with options: Configurations, Emulator, Reports, Editor, Debug Tools, Windows, and Help. Below the menu bar is a toolbar with various icons for file operations and execution. A table at the top shows the execution status of a call.

| Sr No | Script Name | Profile | Call Info | Script Exec... | Status | Events | Events Profile | Result | Tot |
|-------|-----------------------|---------------|------------------------------|----------------|---|--------|----------------|--------|-----|
| 1 | Nudm_UECM_Control.gls | UEProfile0001 | SUPI : .imsi-001013012041631 | Start | SMSF Registration for 3GPP access is successful | None | | Pass | |

Below the table is a control bar with buttons: Add, Delete, Insert, Refresh, Start, Start All, Stop, Stop All, Abort, and Abort All. Below this is a sub-panel with a 'Save' button, a 'Column Width' slider, and a 'Show Latest' checkbox. The main area is divided into two parts: a message sequence diagram on the left and a log window on the right.

The message sequence diagram shows a sequence between SMSF and UDM. A PUT request is sent from SMSF to UDM with the URL: `PUT /nudm-uecm/v1/imsi-001013012041631/registrations/smsf-3gpp-access`. The request is received at UDM at 17:11:55.936000. A response of 200 OK is sent back from UDM to SMSF at 17:11:56.065000.

The log window on the right shows the following HTTP request and response:

```
PUT https://192.168.12.89:6666/nudm-uecm/v1/imsi-001013012041631/registration
content-type : application/json
accept : application/json,
application/problem+json
{
  "plmnId":{
    "mcc":"001",
    "mnc":"01"
  },
  "smsfInstanceId":"f39c418e-8f8f-4c0a-a435-2d4bc5703d32",
  "supportedFeatures":"0"
}
```

At the bottom of the interface, there are tabs for Scripts, Message Sequence, Event Config, and Script Flow. The Message Sequence tab is currently selected. Below the tabs are four status indicators: Initialisation Errors, Error Events, Captured Errors, and Link Status Up=0 Down.

Call Reception

| Sr No | Script Name | Profile | Call Info | Script Execu... | Status | Events | Ev... | Results |
|-------|----------------------------------|---------|-----------------------------|-----------------|------------------------------------|--------|-------|---------|
| 1 | UDM_HTTP2_Connection_Monitor.gls | | UDM Server Clients : AMF | Stop | Monitoring HTTP2 Connection Status | None | | Unknown |
| 2 | Nudm_UECM_Control.gls | | SUPI : imsi-001013012041631 | Completed | SMSF Registration is updated | None | | Pass |

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

Save Column Width Show Latest

SMSF UDM

PUT /nudm-uecm/v1/imsi-001013012041631/registrations/smsf-3gpp-access 17:26:31.518000

200 17:26:31.519000

Find

Status: 3
:method : PUT
:path : /nudm-uecm/v1/imsi-001013012041631/registrations/smsf-3gpp-access
:scheme : http
:authority : 192.168.12.89:6666
content-type : application/json
accept : application/json,
application/problem+json
content-length : 115
{
 "plmnId": {
 "mcc": "001",
 "mnc": "01"
 },
 "smsfInstanceId": "5f5a7379-0609-4bf7-9a16-30b417ac8eab",
 "supportedFeatures": "0"
 }

Scripts **Message Sequence** Event Config Script Flow

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

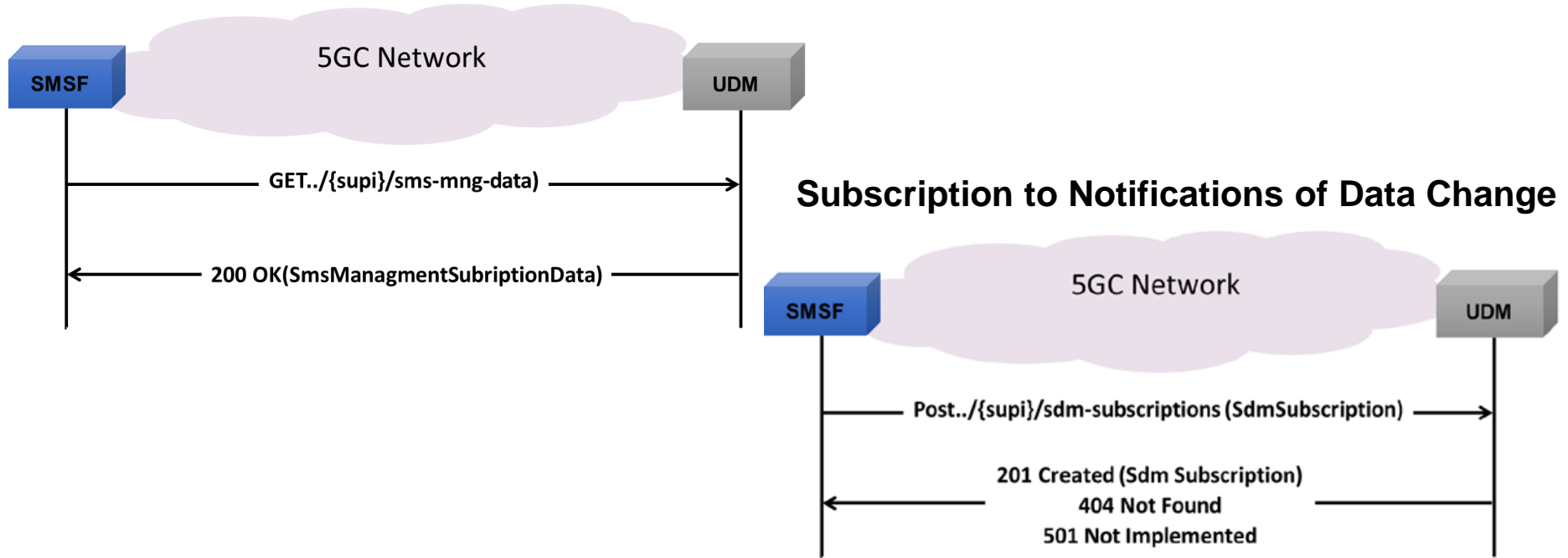
MAPS™ 5G N21 Interface Procedures

- **Nudm_SubscriberDataManagement Service**
 - SMS Management Subscription Data Retrieval
 - Subscription to Notifications of Data Change
 - Unsubscribe to notifications of data change
 - Modification of a subscription to notifications of data change
- **Nudm_UEContextManagement Service**
 - SMSF Registration for 3GPP Access
 - SMSF Registration for Non 3GPP Access
 - SMSF Deregistration for 3GPP Access
 - SMSF Deregistration for Non 3GPP Access

MAPS™ 5G N21 Interface Procedures

Nudm_SubscriberDataManagement Service

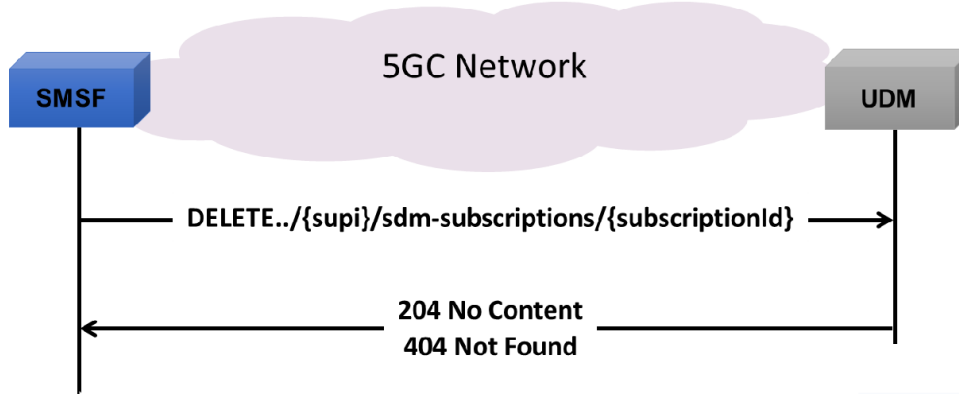
SMS Management Subscription Data Retrieval



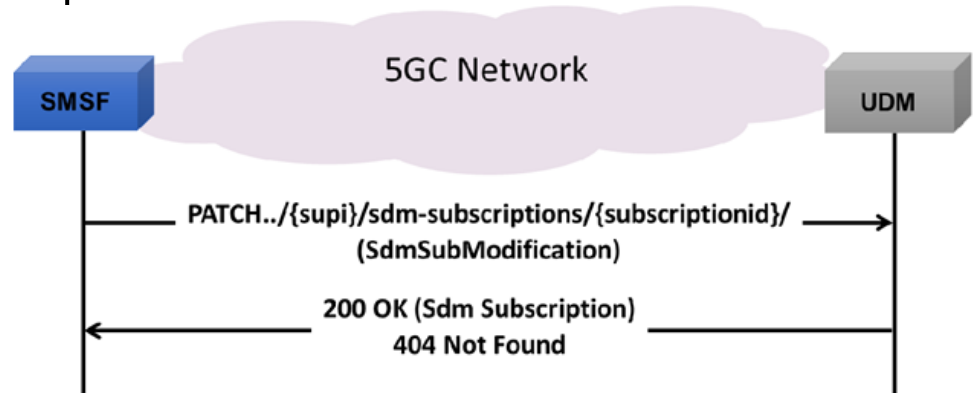
MAPS™ 5G N21 Interface Procedures (Contd.)

Nudm_SubscriberDataManagement Service

Unsubscribe to notifications of data change



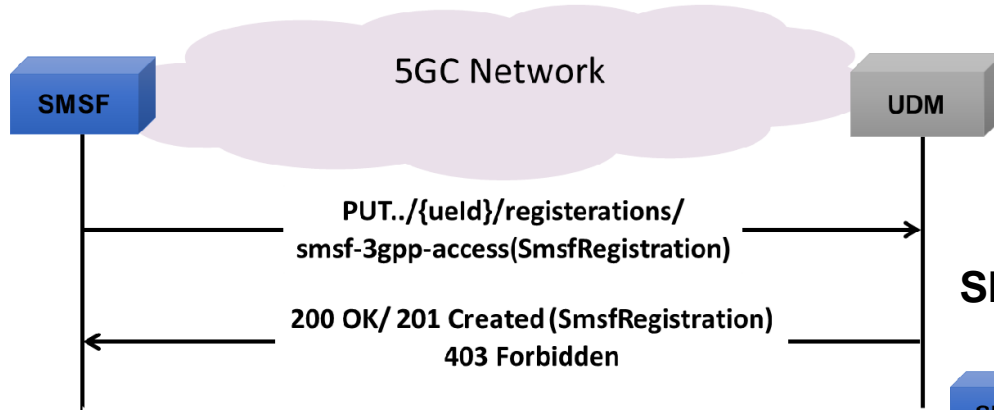
Modification of a subscription to notifications of data change



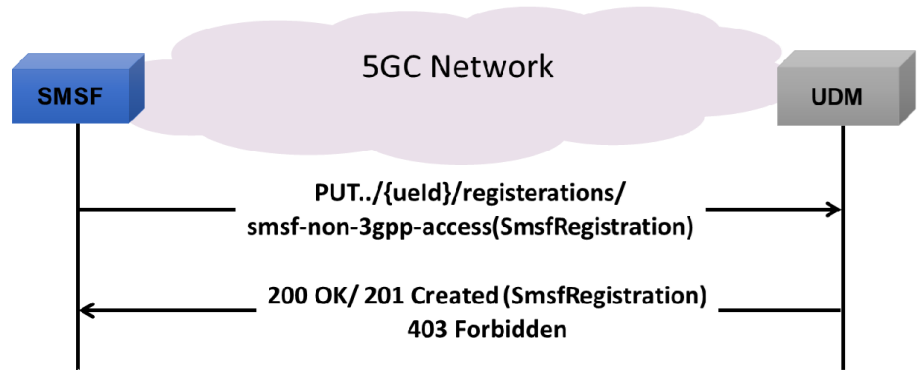
MAPS™ 5G N21 Interface Procedures (Contd.)

Nudm_UEContextManagement Service

SMSF Registration for 3GPP Access



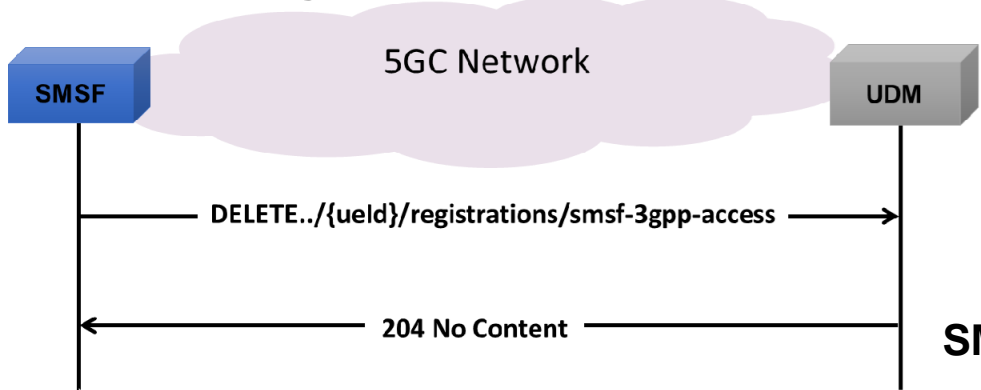
SMSF Registration for Non 3GPP Access



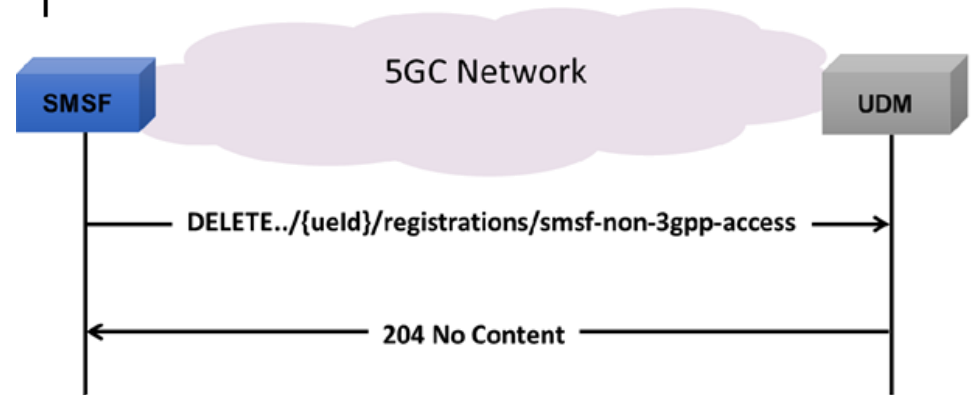
MAPS™ 5G N21 Interface Procedures (Contd.)

Nudm_UEContextManagement Service

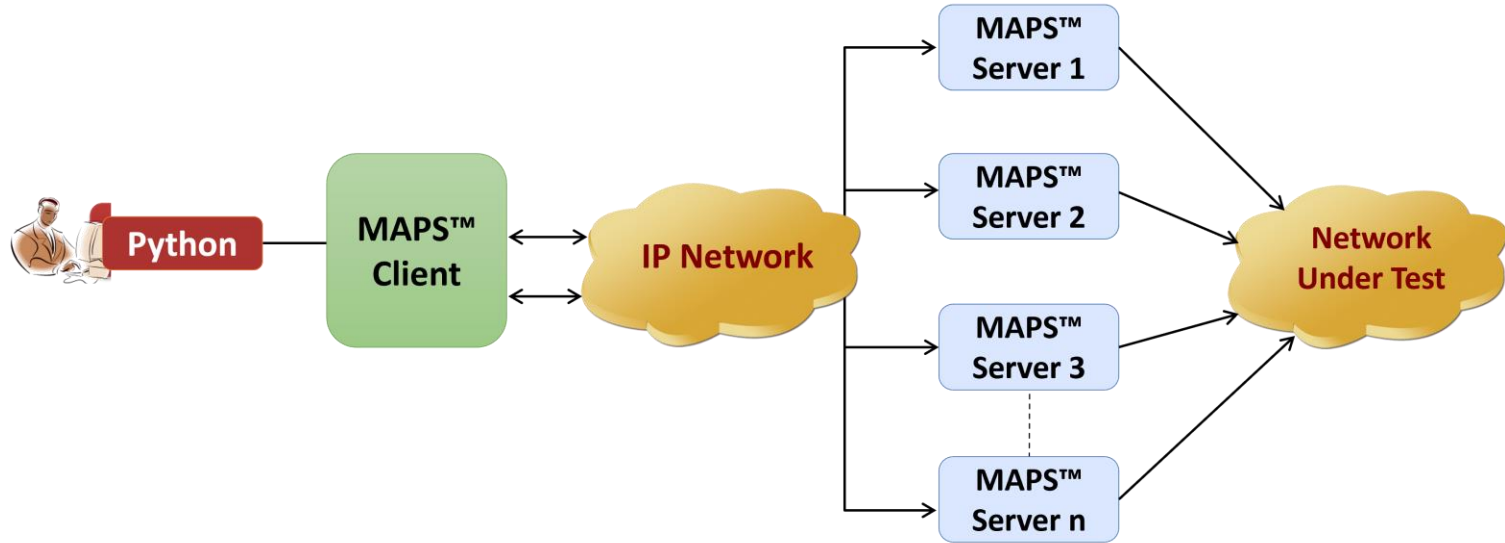
SMSF Deregistration for 3GPP Access



SMSF Deregistration for Non 3GPP Access



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-N21\MAPSCLI\PythonClient\examples\SMSF\N21_PlaceCall.py
N21 Server Connection... True
N21 Testbed Starting ... True
N21 Profile Loading... True
N21 Nudm_UECM_Control.gls Script Started... ProfileLoadStatus == Profile loaded
Starting N21 script True
Call Initiation Status ... SMSF_Registration_3GPPAccess :
True
Call Response Status... SMSF Registration for 3GPP access is successful
ResponseStatus = SMSF Registration for 3GPP access is successful
3gpp or non 3gpp
N21 MsgCount: 2
***** N21 Message Flow *****
Time Stamp          Route          Message
12:55:22.073        ->             PUT - /nudm-uecm/v1/imsi-001013012041631/registrations/smsf-3gpp-access
12:55:22.073        ->             PUT - /nudm-uecm/v1/imsi-001013012041631/registrations/smsf-3gpp-access
{"plmnId":{"mcc":"001","mnc":"01"},"smsfInstanceId":"6a8aaef4-0173-4f31-b8fd-5de79f94b658","supportedFeatures":"0"}
12:55:22.092        <-            200
12:55:22.092        <-            200
{"plmnId":{"mcc":"001","mnc":"01"},"smsfInstanceId":"6a8aaef4-0173-4f31-b8fd-5de79f94b658","supportedFeatures":"0"}
Stopping Script... True
N21 Server Disconnecting... True
>>>
```

```
CLI MapsCLI SMSF (N21 RELEASE17)
File Edit View
View Latest Command
1:: 2024-1-22 12:56:57.486000 : Start "TestBedDefault.xml" # "_TypeOfUESimulation"="XML", "_DefaultProfile"="UE_Profiles.xml";
1:: 2024-1-22 12:57:00.213000 : LoadProfile "UE_Profiles.xml"
1:: 2024-1-22 12:57:02.413000 : StartScript 1 "Nudm_UECM_Control.gls" "UEProfile0001" 1 # "IMSI"=(binarystring)001013012041631,"AccessType"="3GPP_ACCESS","CallFlowDebug"=1,"EnableCLI"=1;
1:: 2024-1-22 12:57:02.637000 : UserEvent 1 "Nudm_UECM_3gppSmsRegistration_Request";
1:: 2024-1-22 12:57:03.287000 : UserEvent 1 "GetCallStatus";
1:: 2024-1-22 12:57:04.385000 : UserEvent 1 "GetMessageCount";
1:: 2024-1-22 12:57:06.565000 : UserEvent 1 "GetMessageInfo" # "Index"=0;
1:: 2024-1-22 12:57:08.643000 : UserEvent 1 "GetMessageInfo" # "Index"=1;
1:: 2024-1-22 12:57:08.754000 : StopScript 1;
ServerLoggerCode = 0,errString = connection has been gracefully closed for ClientId =1
```

Thank you