

PoC of DNS identifier

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Objective

- The numbering of Telecommunication IoT devices was mainly based on the “Recommendation E.164” in the past. And the mature and flourish development in the next generation of telecommunication and Internet technology brings the IoT application and devices rapidly advanced; however, telecom numbers and the management method of its numbers on the basis of “the principle of Recommendation E.164” lead to difficulties in managing and identifying billions of IoT devices.
- The research is based on the concept from the report of “5G Technology” which is published by ICANN, and we utilize DNS as IoT identifiers and design the Proof of Concept (PoC) , then manage the devices of IoT through the auto-allocation DNS identifiers from the customized program.
- We design two different empirical fields under network slicing environment of next generation telecommunication network, and the requirement of devices mobility, the same full domain names should be connected to different IP address and DNS for operation. Through full domain names, we can query IP address and connect to different application indicators as 5G IoT DNS identifier, and as the management method for 5G IoT.

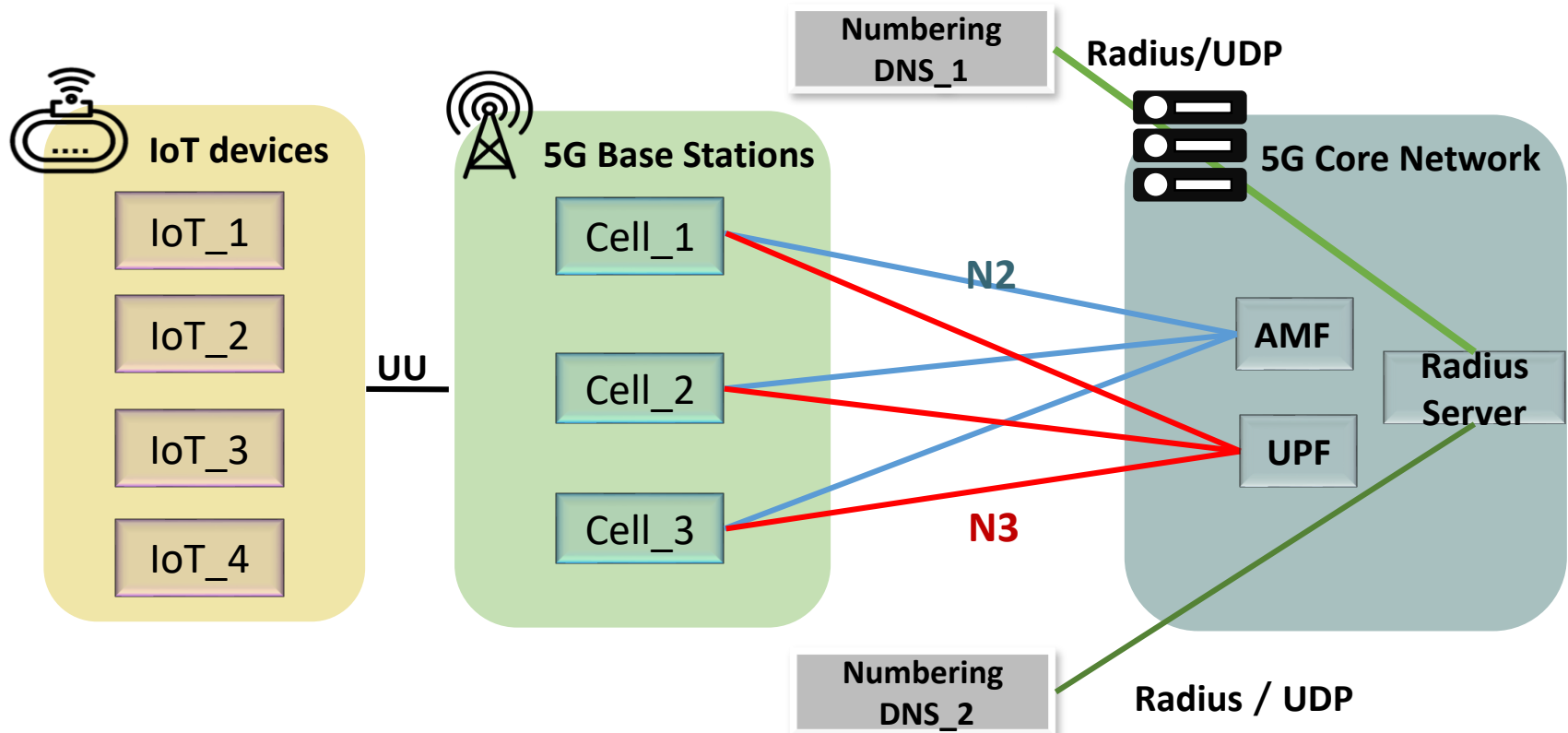
Key innovations

- Through the mechanism of DNS identifiers, the management of fixed and moving IoT devices under 5G is more efficient, and the IoT devices are improved their intuitive identifiability and managerial efficiency.
- In the context of 5G network slicing, Core Network (CN) sends APN, Cell ID, IMSI, MSISDN, IMEI, IP to Gn DNS to give identifiers on IoT devices according to Remote Authentication Dial-In User Service (RADIUS)

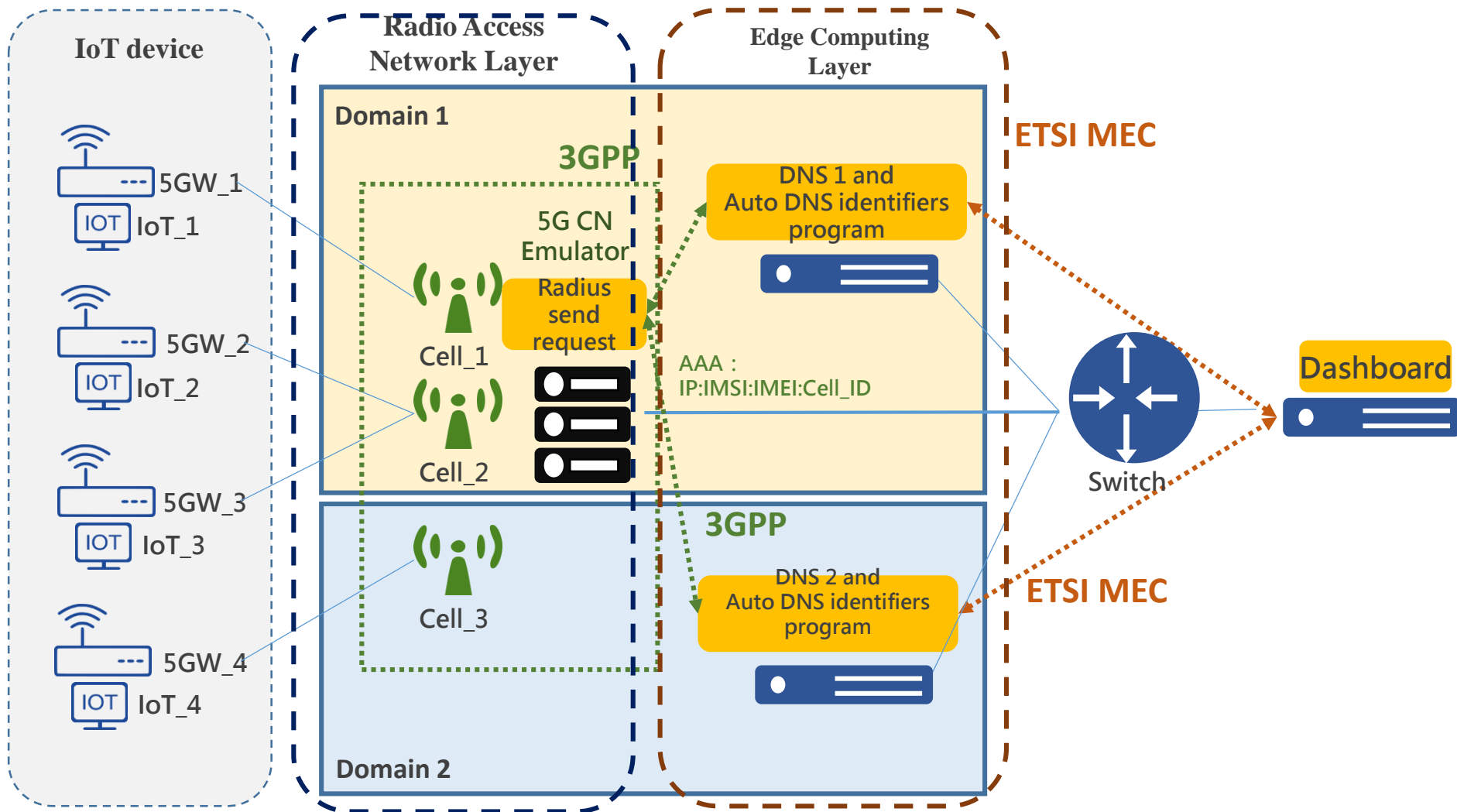
The Structure of PoC Experimental Platform

platform's fundamental settings

- Built in the Private Network
- SA WG2. Architecture that supported “3GPP Release 15”
- 5G Wireless Network Slicing for eMBB、URLLC、MIOT



The Structure of PoC Experimental Platform



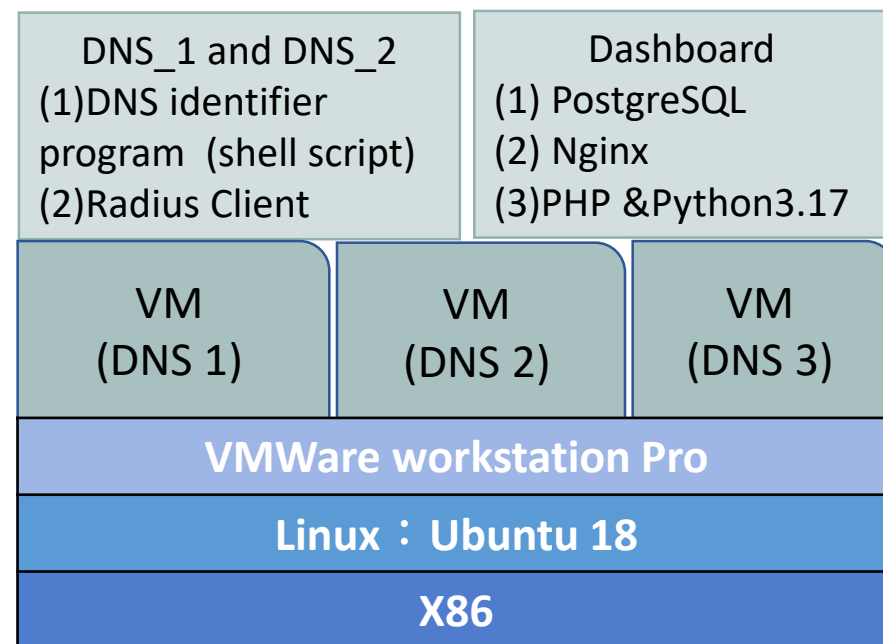
● : represented for VM

The Structure of PoC Experimental Platform and its Equipment

PoC platform's Equipment and its Specification

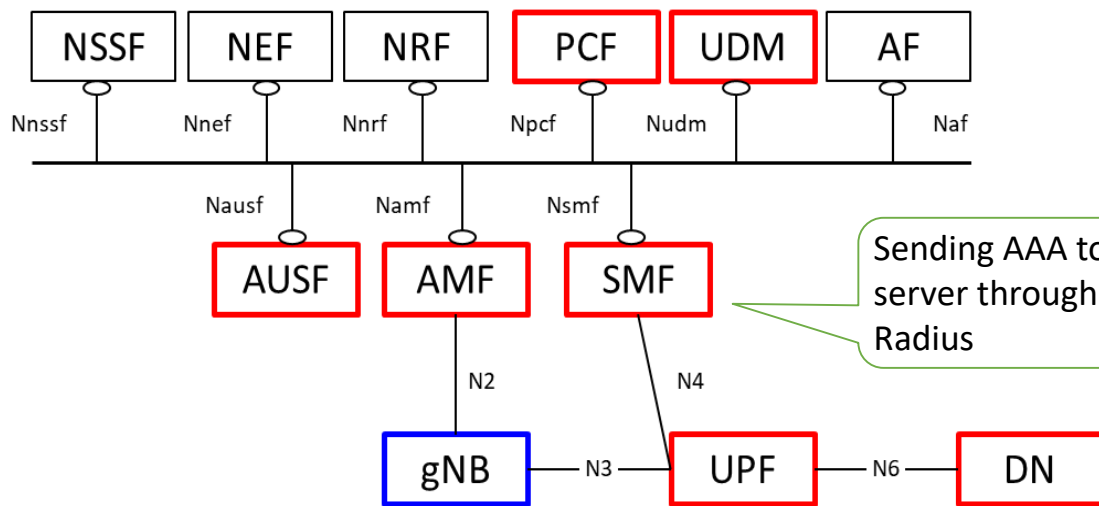
Equipment	Specification	Application
5G Gateway Radio Access Network Device	DTA1164W 5G SA/NSA Gateway*4	5G Router with 5G SIM
IPC Equipment	ADLINK MXE-211-M2G*4	Industrial Host PC in field experiment
5G Simulator Equipment	Amarisoft Classic Callbox*1	Simulator of gNB Based 5G R15 SA
Network Switch	Aruba 2930F-24G PoE+4SFP+ Swch*1	Providing 5G simulator, DNS, Dashboard Network Interface
MEC Server	ADLINK MECS-6110*3	Installed DNS and Dashboard System Software in field experiments

Applied Platform Structure



The Structure of the Function Elements of 5G Simulator

With the aim of verifying PoC, we adopted 3GPP R15 based 5G simulator to imitate the standard behavior of **gNB** and **5GC**. What interface among function elements adopted are listed below.



NSSF : Network Slice Selection Function

NEF : Network Exposure Function

NRF : Network Repository Function

PCF : Policy Control Function

UDM : Unified data management

AF : Application Function

AUSF : Authentication Server Function

AMF : Access Management Function

SMF : Session Management Function

gNB : Next Generation NodeB / Radio Access Network

UPF : User plane Function

DN : Data Network

Note: **Red squares and words** are the introduction of 5GC, and **blue squares and words** are the introduction of gNB.

The Initial Value of the Equipment's Parameter

	IoT_1	IoT_2	IoT_3	IoT_4
APN	internet1	internet2	internet3	internet4
IMEI	355979860003363	355979860003702	355979860003728	355979860003785
NSSAI	eMBB	eMBB	URLLC	MIOT
SST	1	1	2	3
Template	AR/VR 8K Videos	AR/VR 8K Videos	Factory Automatic Machines	Smart City Sensors
Throughput	1Gbps/1Gbps	1Gbps/1Gbps	500Mbps/500Mbps	1Mbps/1Mbps

Identifier mechanism

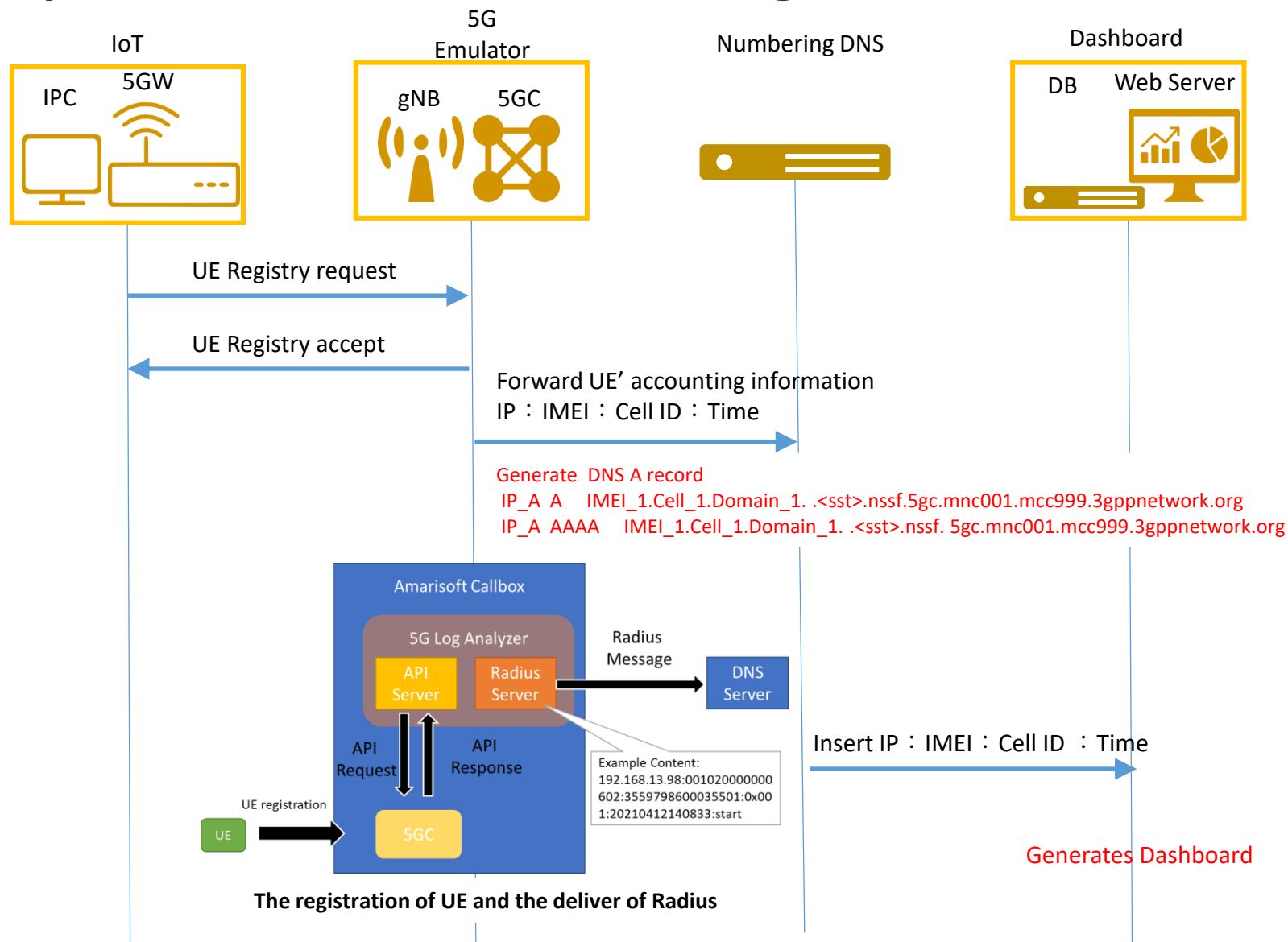
The experimental platform referred to “3GPP TS 23.003” , and the specifications of identifier proposed are below:

<IMEI>.<Cell_ID>.<Domain_ID>. <sst>.nssf.5gc.mnc<MNC>.mcc<MCC>.3gppnetwork.org

- According to “RFC952” , A “name” (Net, Host, Gateway, or Domain name) is a text string up to 24 characters drawn from the **alphabet** (A - Z) , **digits** (0 - 9) , minus sign (-) , and period (.) .
- According to “RFC1123”, host software MUST handle host names of up to 63 characters and SHOULD handle host names of up to 255 characters. Whenever a user inputs the identity of an Internet host, it SHOULD be possible to enter either (1) a host domain name or (2) an IP address in dotted-decimal (“#.#.#.#”) form.
 1. **IMEI** : Regarding the brand, model number, serial number and verification code of IoT, the numbering of IMEI device have uniqueness, which result in the uniqueness of the numbers that are generated form local host.
 2. **Cell_ID** : ID of the Base Station
 3. **Domain_ID** : geographical location
 4. **SST** : Slice / Service Type
 5. **MNC** : Mobile Network Code
 6. **MCC** : Mobile Country Code

Category	Terminal Layers of IoT	Radio Access Network Layer	Edge Computing Layer	Core Network Layer
Standard	GMSA TS.06 v18.2	3GPP TS29.061		3GPP TS 23.003
DNS identifier	IMEI	Cell_ID	Domain_ID	SST, MNC, MCC
	(equipment).	.(Cell).	.(area).	<sst>.nssf.5gc.mnc(mnc) .mcc(mcc).3gppnetwork.org
Example	355979860003363	Cell_1	Domain_1	<sst_1>.nssf.5gc.mnc001 .mcc999.3gppnetwork.org

Experimental Platform and Registration Process

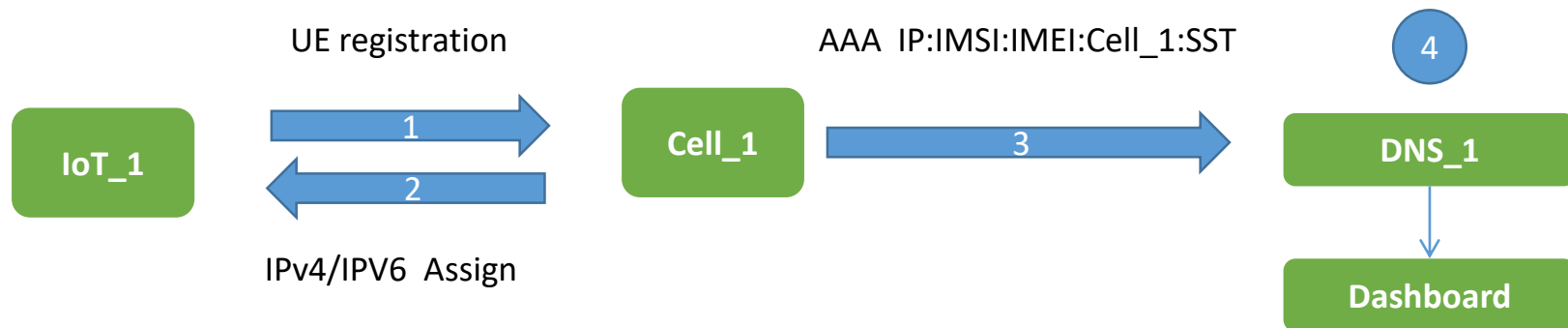


IoT End Device Registration for the Auto DNS Identifiers

4 Generate DNS A record

IP_A A IMEI_1.Cell_1.Domain_1. <sst>.nssf.5gc.mnc001.mcc999.3gppnetwork.org

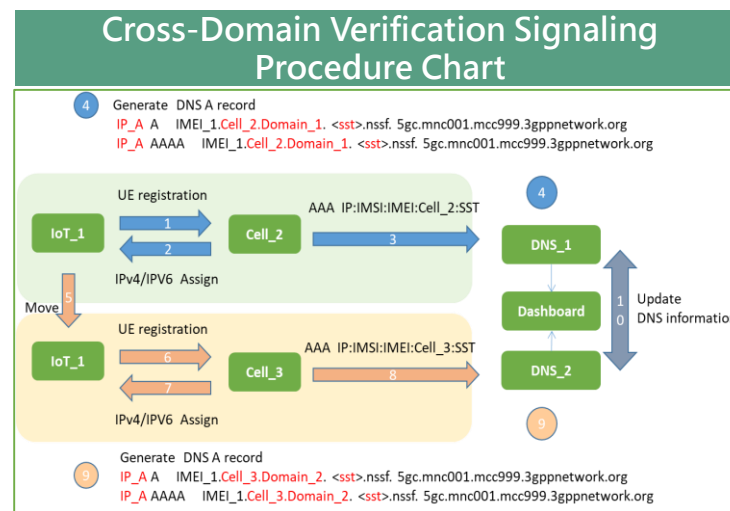
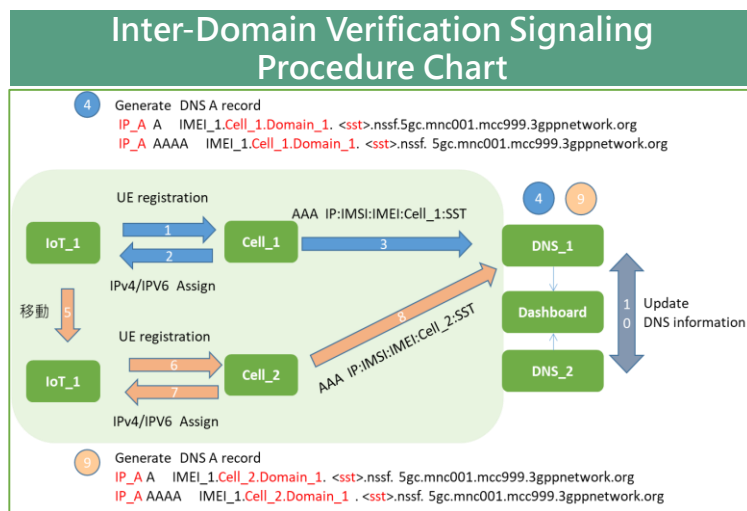
IP_A AAAA IMEI_1.Cell_1.Domain_1. <sst>.nssf.5gc.mnc001.mcc999.3gppnetwork.org



Testing the PoC of DNS Identifiers

the final result of PoC testing this year :

1. Fixed and moving IoT devices under 5G network can be efficiently managed through DNS identifiers mechanism.
2. A huge amounts of IoT devices under 5G network will be efficiently auto-allocated numbers by the DNS identifiers mechanism.



Verification items in scenarios

item	Inter-Domain	Cross-Domain
1	Edge computing on data switching of MEC and DNS	Edge computing on data switching of MEC and DNS
2	Simulation of switching of IoT and DNS of IPv4/IPv6	the simulation of switching of IoT and DNS of IPv4/IPv6
3	Auto DNS identifiers mechanism and its management	the mechanism of auto-allocation DNS identifiers and its management
4	the behavior of multiple devices registered DNS in the meantime	

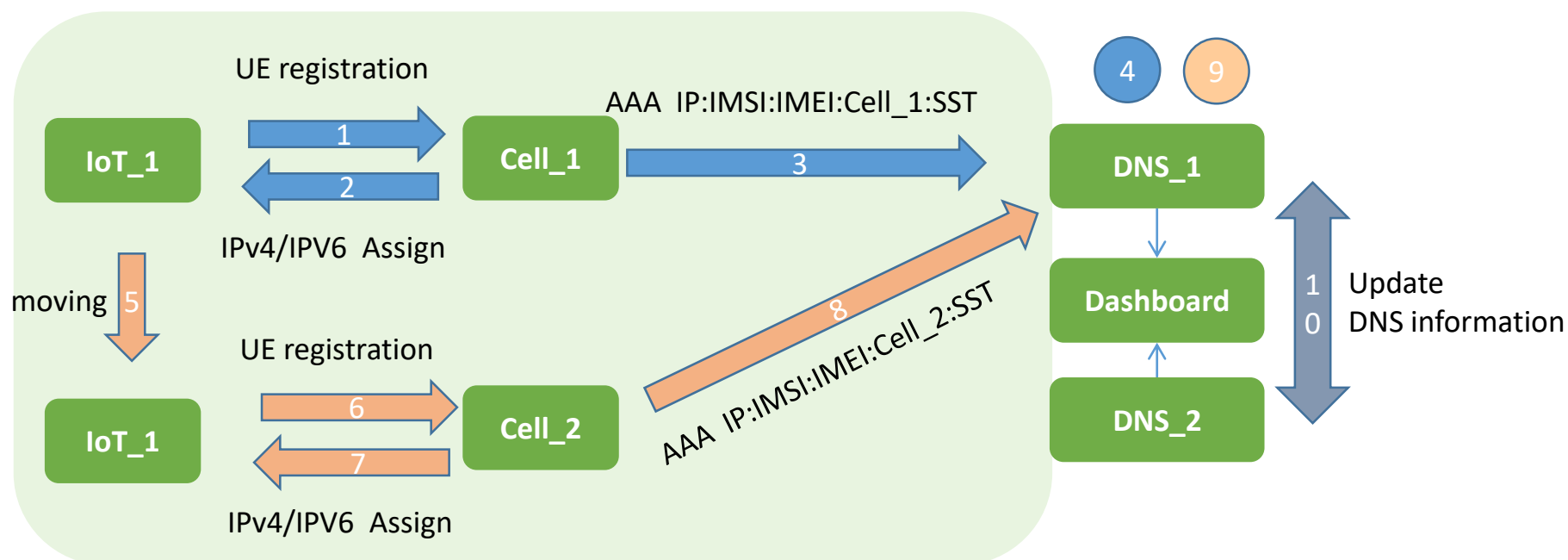
The Registration Process of IoT End Devices in Inter-Domain

From Cell_1 (Domain1) to Cell_2 (Domain1)

4 Generate DNS A record

IP_A A IMEI_1.Cell_1.Domain_1. <sst>.nssf.5gc.mnc001.mcc999.3gppnetwork.org

IP_A AAAA IMEI_1.Cell_1.Domain_1. <sst>.nssf.5gc.mnc001.mcc999.3gppnetwork.org



9 Generate DNS A record

IP_A A IMEI_1.Cell_2.Domain_1. <sst>.nssf.5gc.mnc001.mcc999.3gppnetwork.org

IP_A AAAA IMEI_1.Cell_2.Domain_1. <sst>.nssf.5gc.mnc001.mcc999.3gppnetwork.org

Inter-Domain's Test Steps

Step 1 to Step 4

(the demonstration of system operation)

Step	Procedure	Introduction of procedure
1	UE registration	IoT connects to Cell_1 and registered.
2	IPv4/IPv6 Assign	Callbox (MEC) assigns IP to IoT.
3	Send the registration information to DNS	Information like [IP:IMSI:IMEI:Cell_1:SS T] is sent to DNS.
4	Generate DNS A record	DNS auto-generates domain names and DNS A record through auto-allocation program.

```
[root@localhost RadiusApp]# python3 pyrad_server.py
10.10.11.2,10:10:11:2:200:ff:fe00:0,999010000000001,355979860003363,1,20210917134421,start,1
10.10.12.2,10:10:12:2:200:ff:fe00:0,999010000000002,355979860003702,1,20210917134431,start,1
10.10.13.2,10:10:13:2:200:ff:fe00:0,999010000000003,355979860003728,1,20210917134446,start,2
10.10.14.2,10:10:14:2:200:ff:fe00:0,999010000000004,355979860003785,1,20210917134456,start,3
```

Callbox

```
10.10.11.2,10:10:11:2:200:ff:fe00:0,999010000000001,355979860003363,1,20210917134421,start,1
10.10.12.2,10:10:12:2:200:ff:fe00:0,999010000000002,355979860003702,1,20210917134431,start,1
10.10.13.2,10:10:13:2:200:ff:fe00:0,999010000000003,355979860003728,1,20210917134446,start,2
10.10.14.2,10:10:14:2:200:ff:fe00:0,999010000000004,355979860003785,1,20210917134456,start,3
```

DNS

```
at nssf.5gc.mnc001.mcc999.3gppnetwork.org
#####
; BIND data file for local loopback interface
$TTL      604800
@         IN      SOA     localhost. root.localhost. (
                        2          ; Serial
                        604800     ; Refresh
                        86400      ; Retry
                        2419200    ; Expire
                        604800 )   ; Negative Cache TTL
;
ns        IN      NS      localhost.
ns        IN      A       127.0.0.1
ns        IN      AAAA    ::1
```

```
355979860003363.Cell_1.Domain_1.sst_1 IN      A       10.10.11.2
355979860003363.Cell_1.Domain_1.sst_1 IN      A       10:10:11:2:200:ff:fe00:0
355979860003702.Cell_1.Domain_1.sst_1 IN      A       10.10.12.2
355979860003702.Cell_1.Domain_1.sst_1 IN      A       10:10:12:2:200:ff:fe00:0
355979860003728.Cell_1.Domain_1.sst_2 IN      A       10.10.13.2
355979860003728.Cell_1.Domain_1.sst_2 IN      A       10:10:13:2:200:ff:fe00:0
355979860003785.Cell_1.Domain_1.sst_3 IN      A       10.10.14.2
355979860003785.Cell_1.Domain_1.sst_3 IN      A       10:10:14:2:200:ff:fe00:0
```

Inter-domain's test steps

Step	Procedure	Introduction of procedure
1	UE registration	IoT connects to Cell_1 and registered.
2	IPv4/IPv6 Assign	Callbox (MEC) assigns IP to IoT.
3	Send the registration information to DNS	Information like [IP:IMSI:IMEI:Cell_1:SST] is sent to DNS.
4	Generate DNS A record	DNS auto-generates domain names and DNS A record through auto-allocation program.

Dashboard

← → ↻ 不安全 | 192.168.0.44/index.html

財團法人電信技術中心 TELECOM TECHNOLOGY CENTER DNS1: DNS_1 CPU Usage: 0.9% Memory Usage: 22% Disk Space: 25%
 DNS2: DNS_2 CPU Usage: 0.9% Memory Usage: 22% Disk Space: 25%

Current State

History State

System Log

Domain 1		
Index	Cell	Online#
1	Cell_1	4
2	Cell_2	0

Domain 2		
Index	Cell	Online#
1	Cell_3	0

User Connection Status

Domain 1	Cell 1
<p>index: 1</p> <p>online</p> <p>Device_ID: Device_355979860003363</p> <p>IMEI: 355979860003363</p> <p>IPv4: 10.10.11.2</p> <p>IPv6: 10:10:11:2:200:ff:fe00:0</p> <p>FQDN: 355979860003363_Cell_1.Domain_1.sst_1.nssf.5g.c.mnc001.mcc999.3gppnetwork.org</p>	
<p>index: 2</p> <p>online</p> <p>Device_ID: Device_355979860003702</p> <p>IMEI: 355979860003702</p> <p>IPv4: 10.10.12.2</p> <p>IPv6: 10:10:12:2:200:ff:fe00:0</p> <p>FQDN: 355979860003702_Cell_1.Domain_1.sst_1.nssf.5g.c.mnc001.mcc999.3gppnetwork.org</p>	

Inter-domain's test

This chart shows some parameters that IoT register IP and auto-register DN.
(after step 1 to step 4)

	IoT_1	IoT_2	IoT_3	IoT_4	
APN	internet1	internet2	internet3	internet4	
IMEI	355979860003363	355979860003702	355979860003728	355979860003785	
NSSAI	eMBB	eMBB	URLLC	MIOT	
SST	1	1	2	3	
Template	AR/VR 8K Videos	AR/VR 8K Videos	Factory Automatic Machines	Smart City Sensors	
Throughput	1Gbps/1Gbps	1Gbps/1Gbps	500Mbps/500Mbps	1Mbps/1Mbps	
Step 1、2	Service IP IPv4 (DHCP)	10.10.11.2/24	10.10.12.2/24	10.10.13.2/24	10.10.14.2/24
	Service IP IPv6 (DHCP)	10:10:11.2::/80	10:10:12.2::/80	10:10:13.2::/80	10:10:14.2::/80
Step 3、4	DN	355979860003363.Cell_1.D omain_1.sst_1.nssf.5gc.mn c001.mcc999.3gppnetwork. org	355979860003702.Cell_1.D omain_1.sst_1.nssf.5gc.mn c001.mcc999.3gppnetwork. org	355979860003728.Cell_2.D omain_1.sst_2.nssf.5gc.mn c001.mcc999.3gppnetwork. org	355979860003785.Cell_1.D omain_1.sst_3.nssf.5gc.mn c001.mcc999.3gppnetwork. org

Inter-domain's test steps

Step 5 to step 9

(the demonstration of system operation)

Step	Procedure	Introduction of procedure
5	UE moving	It moves from Cell_1 to Cell_2, and it is still Domain_1.
6	UE registration	IoT connects to Cell_2 and registered.
7	IPv4/IPv6 Assign	Callbox (MEC) assigns IP to IoT, and it utilizes the original IP because it is still Domain_1.
8	Send the registration information to DNS	Information like [IP:IMSI:IMEI:Cell_1:SST] is sent to DNS by Callbox (MEC) .
9	Generate DNS A record	DNS auto-generates domain names and DNS A record through auto-allocation program.
10	Update the DNS and Dashboard	Dashboard accesses the latest DNS A record.

Callbox

```
[root@localhost RadiusApp]#python3 pyrad_server.py
10.10.11.2,10:10:11:2:200:ff:fe00:0,999010000000001,355979860003363,2,20210917134928,start,1
10.10.12.2,10:10:12:2:200:ff:fe00:0,999010000000002,355979860003702,2,20210917134928,start,1
10.10.13.2,10:10:13:2:200:ff:fe00:0,999010000000003,355979860003728,2,20210917134928,start,2
10.10.14.2,10:10:14:2:200:ff:fe00:0,999010000000004,355979860003785,2,20210917134928,start,3
```

DNS

```

message : upload success } message : upload success
10.10.11.2,10:10:11:2:200:ff:fe00:0,999010000000001,355979860003363,2,20210917134928,start,1
10.10.12.2,10:10:12:2:200:ff:fe00:0,999010000000002,355979860003702,2,20210917134928,start,1
10.10.13.2,10:10:13:2:200:ff:fe00:0,999010000000003,355979860003728,2,20210917134928,start,2
10.10.14.2,10:10:14:2:200:ff:fe00:0,999010000000004,355979860003785,2,20210917134928,start,3
#####
cat 5gc.mnc001.mcc999.3gppnetwork.org
#####
; BIND data file for local loopback interface
$TTL      604800
@         IN      SOA     localhost. root.localhost. (
                                2          ; Serial
                                604800     ; Refresh
                                86400      ; Retry
                                2419200    ; Expire
                                604800    ) ; Negative Cache TTL
;
@         IN      NS     localhost.
ns        IN      A       127.0.0.1
ns        IN      AAAA    ::1

55979860003363.Cell_2.Domain_1.sst_1 IN      A       10.10.11.2
55979860003363.Cell_2.Domain_1.sst_1 IN      A       10:10:11:2:200:ff:fe00:0
55979860003702.Cell_2.Domain_1.sst_1 IN      A       10.10.12.2
55979860003702.Cell_2.Domain_1.sst_1 IN      A       10:10:12:2:200:ff:fe00:0
55979860003728.Cell_2.Domain_1.sst_2 IN      A       10.10.13.2
55979860003728.Cell_2.Domain_1.sst_2 IN      A       10:10:13:2:200:ff:fe00:0
55979860003785.Cell_2.Domain_1.sst_3 IN      A       10.10.14.2
55979860003785.Cell_2.Domain_1.sst_3 IN      A       10:10:14:2:200:ff:fe00:0

```

Inter-domain's test steps

Step	Procedure	Introduction of procedure
10	Update the DNS and Dashboard	Dashboard accesses the latest DNS A record.

Step 10 (the demonstration of system operation)

Dashboard

The screenshot displays the Dashboard interface with the following components:

- System Status:** CPU Usage: 0.9%, Memory Usage: 22%, Disk Space: 25%.
- Current State:**
 - 5G Core/MEC/Cell and IoT icons connected by a dashed line.
 - Domain1 Table:**

Index	Cell	Online#
1	Cell_1	0
2	Cell_2	4
 - User Connection Status Table:**

	Domain 1	Cell 2
index: 1	online	
Device_ID:	Device_355979860003363	
IMEI:	355979860003363	
IPv4:	10.10.11.2	
IPv6:	10:10:11:2:200:ff:fe00:0	
FQDN:	355979860003363.Cell_2.Domain_1.sst_1.nssf.5g.c.mnc001.mcc999.3gpnetwork.org	
index: 2	online	
Device_ID:	Device_355979860003702	
IMEI:	355979860003702	
IPv4:	10.10.12.2	
IPv6:	10:10:12:2:200:ff:fe00:0	
FQDN:	355979860003702.Cell_2.Domain_1.sst_1.nssf.5g.c.mnc001.mcc999.3gpnetwork.org	
- History State:** (Empty section)
- System Log:** (Empty section)
- Domain2 Table:**

Index	Cell	Online#
1	Cell_3	0

Inter-domain's test

This chart shows some parameters for step 6 to step 10

When the IoT end device (IoT_1) move from Cell_1 to Cell_2, DN will change the name of Cell, but APN and IP remain unchanged.

	IoT_1	IoT_2	IoT_3	IoT_4	
APN	internet1	internet2	internet3	internet4	
IMEI	355979860003363	355979860003702	355979860003728	355979860003785	
NSSAI	eMBB	eMBB	URLLC	MIOT	
SST	1	1	2	3	
Template	AR/VR 8K Videos	AR/VR 8K Videos	Factory Automatic Machines	Smart City Sensors	
Throughput	1Gbps/1Gbps	1Gbps/1Gbps	500Mbps/500Mbps	1Mbps/1Mbps	
Step 6 to 7	Service IP IPv4 (DHCP)	10.10.11.2/24	10.10.12.2/24	10.10.13.2/24	10.10.14.2/24
	Service IP IPv6 (DHCP)	10:10:11.2::/80	10:10:12.2::/80	10:10:13.2::/80	10:10:14.2::/80
Step 8 to 10	DN	355979860003363.Cell_2. Domain_1.sst_1.nssf.5gc.m nc001.mcc999.3gppnetwo rk.org	355979860003702.Cell_2. Domain_1.sst_1.nssf.5gc.m nc001.mcc999.3gppnetwo rk.org	355979860003728.Cell_2. Domain_1.sst_2.nssf.5gc.m nc001.mcc999.3gppnetwo rk.org	355979860003785.Cell_2. Domain_1.sst_3.nssf.5gc.m nc001.mcc999.3gppnetwo rk.org

Inter-domain's test steps

Check the Dashboard after the completion of the inter-domain test.

The dashboard displays system metrics and network status. The 'User Connection Status' table shows the following data:

Domain1		
Index	Cell	Online#
1	Cell_1	4
2	Cell_2	0

Domain2		
Index	Cell	Online#
1	Cell_3	0

The 'System Log' section shows the following log entry:

```

index: 1
online
Device_ID: Device_355979860003363
IMEI: 355979860003363
IPv4: 10.10.11.2
IPv6: 10:10:12:2:200:f:fe00:0
FQDN: 355979860003363.Cell_2.Domain_1.sst.5g.c.nmc001.mcc999.3gnetwork.org
  
```

A green callout box with the text "IoT moves from Cell_1 to cell_2" is overlaid on the dashboard, with a red arrow pointing from the 'Cell_1' entry in the 'User Connection Status' table to the 'Cell_2' entry.

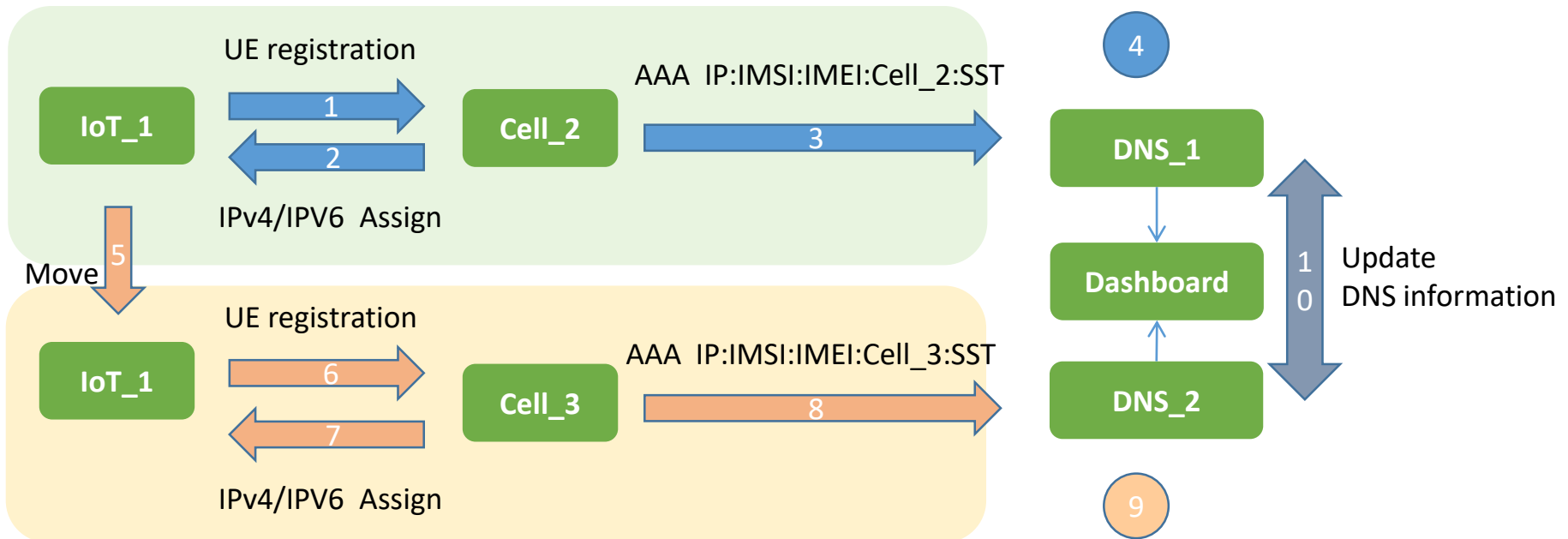
The Registration Process of IoT End Devices in Cross-Domain

The IoT end device move from Domain_1 (cell_2) to Domain_2 (cell_3)

4 Generate DNS A record

IP_A A IMEI_1.Cell_2.Domain_1. <sst>.nssf. 5gc.mnc001.mcc999.3gppnetwork.org

IP_A AAAA IMEI_1.Cell_2.Domain_1. <sst>.nssf. 5gc.mnc001.mcc999.3gppnetwork.org



Cross-domain's test steps

Step 5 to step 9

(the demonstration of system operation)

CallBox

```
[root@localhost RadiusApp]# python3 pyrad_server.py
10.10.11.3,10:10:11:2:200:ff:fe00:0,999010000000001,355979860003363,3,20210917141322,start,1
10.10.12.3,10:10:12:2:200:ff:fe00:0,999010000000002,355979860003702,3,20210917141322,start,1
10.10.13.3,10:10:13:2:200:ff:fe00:0,999010000000003,355979860003728,3,20210917141322,start,2
10.10.14.3,10:10:14:2:200:ff:fe00:0,999010000000004,355979860003785,3,20210917141322,start,3
```

DNS

```
10.10.11.3,10:10:11:3:200:ff:fe00:0,999010000000005,355979860003363,3,20210917141322,start,1
10.10.12.3,10:10:12:3:200:ff:fe00:0,999010000000002,355979860003702,3,20210917141322,start,1
10.10.13.3,10:10:13:3:200:ff:fe00:0,999010000000003,355979860003728,3,20210917141322,start,2
10.10.14.3,10:10:14:3:200:ff:fe00:0,999010000000004,355979860003785,3,20210917141322,start,3
```

```
cat nssf.5gc.mnc001.mcc999.3gppnetwork.org
```

```
; BIND data file for local loopback interface
$TTL 604800
@      IN      SOA     localhost. root.localhost. (
                                2          ; Serial
                                604800     ; Refresh
                                86400      ; Retry
                                2419200    ; Expire
                                604800 )   ; Negative Cache TTL
;
@      IN      NS     localhost.
ns     IN      A       127.0.0.1
ns     IN      AAAA    ::1
```


```
355979860003363.Cell_3.Domain_2.sst_1 IN A 10.10.11.3
355979860003363.Cell_3.Domain_2.sst_1 IN A 10:10:11:3:200:ff:fe00:0
355979860003702.Cell_3.Domain_2.sst_1 IN A 10.10.12.3
355979860003702.Cell_3.Domain_2.sst_1 IN A 10:10:12:3:200:ff:fe00:0
355979860003728.Cell_3.Domain_2.sst_2 IN A 10.10.13.3
355979860003728.Cell_3.Domain_2.sst_2 IN A 10:10:13:3:200:ff:fe00:0
355979860003785.Cell_3.Domain_2.sst_3 IN A 10.10.14.3
355979860003785.Cell_3.Domain_2.sst_3 IN A 10:10:14:3:200:ff:fe00:0
```

Step	Procedure	Introduction of procedure
5	UE moving	It moves from Cell_2 to Cell_3, and it moves from Domain_1 to Domain_2 .
6	UE registration	IoT connects to Cell_3 and registers.
7	IPv4/IPv6 assign	Callbox (MEC) assigns IP to IoT
8	Send the registration information to DNS	Information like [IP:IMSI:IMEI:Cell_1:SST] is sent to DNS by Callbox (MEC) .
9	Generate DNS A record	DNS auto-generates domain names and DNS A/AAAA record through auto-allocation program.

Cross-domain's test steps

Step	Procedure	Introduction of procedure
10	Update the DNS and Dashboard	Dashboard accesses the latest DNS A/AAAA record.

Step 10 (the demonstration of system operation)



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TELECOM TECHNOLOGY CENTER

DNS ID: DNS_1
DNS ID: DNS_2

CPU Usage: 0.6%
CPU Usage: 0.6%


Memory Usage: 17%
Memory Usage: 17%

Disk Space: 25%
Disk Space: 25%

Current State

History State

System Log



5G Core/MEC/Cell ↔ IoT

Domain 1		
Index	Cell	Online#
1	Cell_1	0
2	Cell_2	0

User Connection Status	
Domain 2	Cell 3
<div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;"> <p>index: 1</p> <p>online</p> <p>Device ID: Device_355979860003363</p> <p>IMEI: 355979860003363</p> <p>IPv4: 10.10.11.3</p> <p>IPv6: 10:10:11:2:200:ff:fe00:0</p> <p>Slice ID: 1</p> <p>FQDN: 355979860003363.Cell_3.Domain_2.sst_1.nssf.5g.c.mnc001.mcc999.3gppnetwork.org</p> </div> <div style="border: 1px solid #ccc; padding: 5px;"> <p>index: 2</p> <p>online</p> <p>Device ID: Device_355979860003702</p> <p>IMEI: 355979860003702</p> <p>IPv4: 10.10.12.3</p> <p>IPv6: 10:10:12:2:200:ff:fe00:0</p> <p>Slice ID: 1</p> <p>FQDN: 355979860003702.Cell_3.Domain_2.sst_1.nssf.5g.c.mnc001.mcc999.3gppnetwork.org</p> </div>	

Domain2		
Index	Cell	Online#
1	Cell_3	4

10

Cross-domain's test

this chart shows some parameters for step 6 to step 10

When the IoT end device (IoT_1) moves from Cell_2 to Cell_3 and gets new IP through registration, DN will change the name of Cell.

	IoT_1	IoT_2	IoT_3	IoT_4
APN	internet1	internet2	internet3	internet4
IMEI	355979860003363	355979860003702	355979860003728	355979860003785
NSSAI	eMBB	eMBB	URLLC	MIOT
SST	1	1	2	3
Template	AR/VR 8K Videos	AR/VR 8K Videos	Factory Automatic Machines	Smart City Sensors
Throughput	1Gbps/1Gbps	1Gbps/1Gbps	500Mbps/500Mbps	1Mbps/1Mbps
Step 6、7	Service IP IPv4 (DHCP)	10.10.11.3/24	10.10.12.3/24	10.10.13.3/24
	Service IP IPv6 (DHCP)	10:10:11.3::/80	10:10:12.3::/80	10:10:13.3::/80
Step 8-10	DN	355979860003363.Cell_3.D omain_2.sst_1.nssf.5gc.mnc 001.mcc999.3gppnetwork.o rg	355979860003702.Cell_3.D omain_2.sst_1.nssf.5gc.mnc 001.mcc999.3gppnetwork.o rg	355979860003728.Cell_3.D omain_2.sst_2.nssf.5gc.mnc 001.mcc999.3gppnetwork.o rg
		355979860003785.Cell_3.D omain_2.sst_3.nssf.5gc.mnc 001.mcc999.3gppnetwork.o rg		

Cross-domain's test

Check the Dashboard after the completion of the cross-domain test

The image shows two screenshots of a dashboard interface, illustrating the state of a cross-domain test. The left screenshot shows the initial state where an IoT device is connected to Cell 2 in Domain 1. The right screenshot shows the final state where the IoT device has moved to Cell 3 in Domain 2.

Left Screenshot (Initial State):

- Current State:** Shows a diagram with '5G Core/MEC/Cell' and 'IoT' connected by a dashed arrow.
- Domain1 Table:**

Index	Cell	Online#
1	Cell_1	0
2	Cell_2	4
- User Connection Status:** Shows details for 'index: 1' and 'index: 2'. 'index: 1' is associated with Cell_2.

Right Screenshot (Final State):

- Current State:** Shows a diagram with '5G Core/MEC/Cell' and 'IoT' connected by a dashed arrow.
- Domain1 Table:**

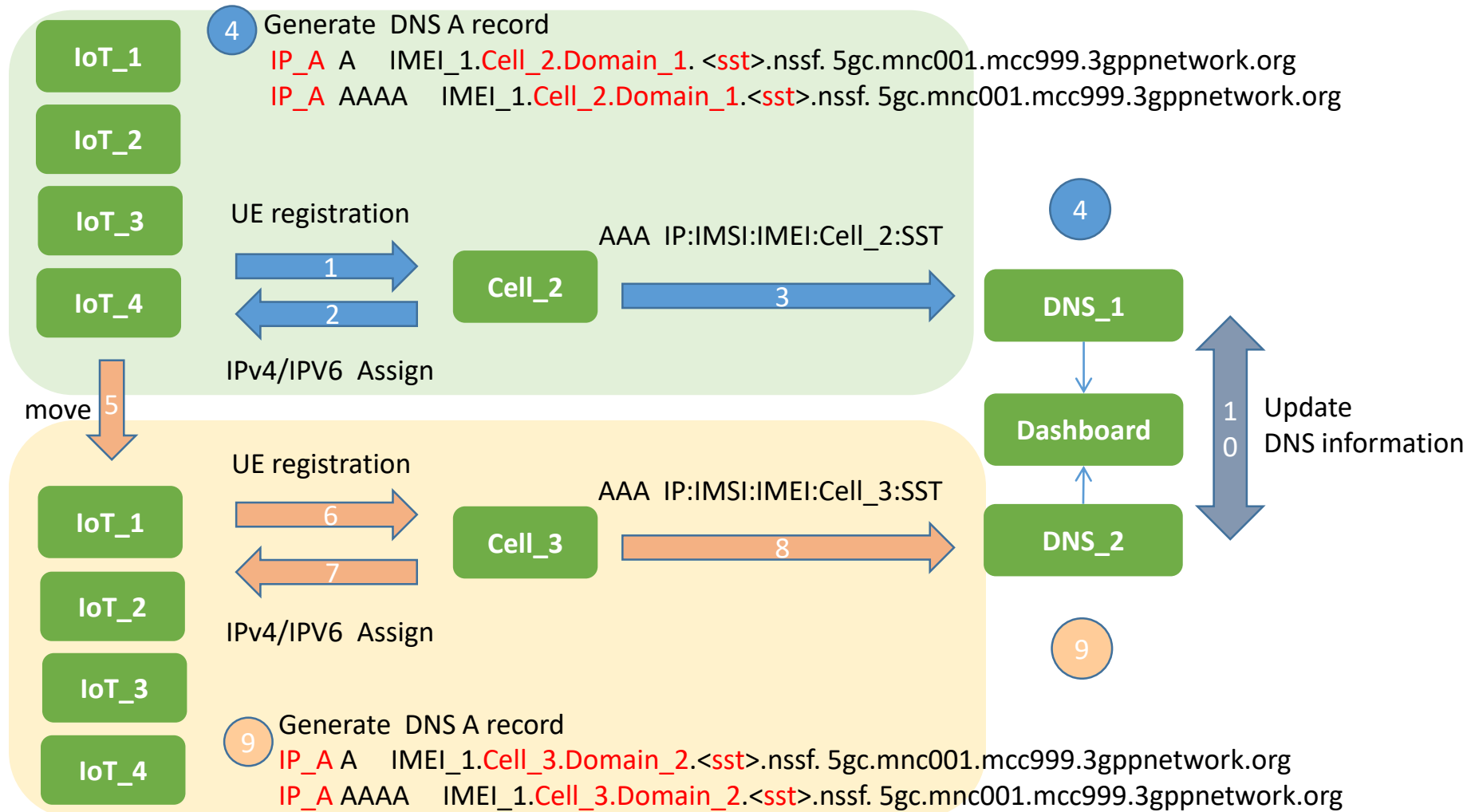
Index	Cell	Online#
1	Cell_1	0
2	Cell_2	0
- Domain2 Table:**

Index	Cell	Online#
1	Cell_3	4
- User Connection Status:** Shows details for 'index: 1' and 'index: 2'. 'index: 1' is now associated with Cell_3 in Domain 2.

IoT moves from Cell_2 to Cell_3

Scenario 1: Large amounts of IoT devices are given identifiers automatically

Four sets of IoT equipment are used in 20 minutes and move among different Cells and Domains



Scenario 1: Testing large amounts of IoT devices are given identifiers automatically

Identify the status of DN after the movement of IoT device through log

The screenshot displays a system log interface with the following components:

- System Status:** DNS ID: DNS_1, CPU Usage: 0.6%, Memory Usage: 18%, Disk Space: 25%.
- Navigation:** DNS Call Flow, System Log, Date range: 2021/09/23 上午07:13 to 2021/09/25 上午07:13, Search icon, download link, and refresh icon.
- Log Table:**

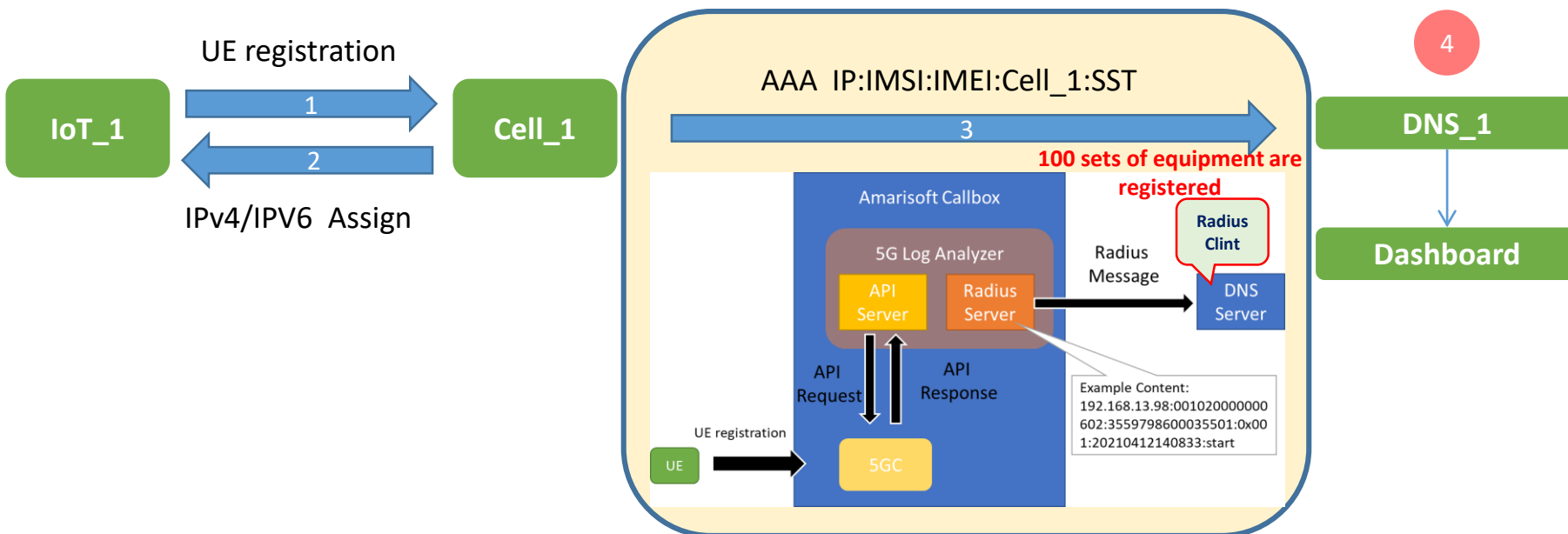
Time	Event	Payload
24 07:11:56	Temp_Meter_234567810003320 is attached on Cell_1 with FQDN 234567810003320.Cell_1.Domain_1.sst_3.nssf.5gc.mnc001.mcc	
24 07:11:56	Smart_Parking_123456780003320 is attached on Cell_2 with FQDN 123456780003320.Cell_2.Domain_1.sst_3.nssf.5gc.mnc001.mcc	
24 07:11:56	Smart_Parking_723456780003320 is attached on Cell_3 with FQDN 723456780003320.Cell_3.Domain_2.sst_3.nssf.5gc.mnc001.mcc	
24 07:23:12	Device_355979860003363 is attached on Cell_1 with FQDN 355979860003363.Cell_1.Domain_1.sst_1.nssf.5gc.mnc001.mcc	
24 07:23:12	Device_355979860003702 is attached on Cell_2 with FQDN 355979860003702.Cell_2.Domain_1.sst_1.nssf.5gc.mnc001.mcc	
24 07:23:12	Device_355979860003728 is attached on Cell_3 with FQDN 355979860003728.Cell_3.Domain_2.sst_2.nssf.5gc.mnc001.mcc	
24 07:23:12	Device_355979860003785 is attached on Cell_1 with FQDN 355979860003785.Cell_1.Domain_1.sst_3.nssf.5gc.mnc001.mcc	
24 07:23:23	Device_355979860003363 is attached on Cell_2 with FQDN 355979860003363.Cell_2.Domain_1.sst_1.nssf.5gc.mnc001.mcc	
24 07:23:23	Device_355979860003702 is attached on Cell_3 with FQDN 355979860003702.Cell_3.Domain_2.sst_1.nssf.5gc.mnc001.mcc	
24 07:23:23	Device_355979860003728 is attached on Cell_2 with FQDN 355979860003728.Cell_2.Domain_1.sst_2.nssf.5gc.mnc001.mcc	
24 07:23:23	Device_355979860003785 is attached on Cell_2 with FQDN 355979860003785.Cell_2.Domain_1.sst_3.nssf.5gc.mnc001.mcc	
24 07:23:34	Device_355979860003363 is attached on Cell_3 with FQDN 355979860003363.Cell_3.Domain_2.sst_1.nssf.5gc.mnc001.mcc	
24 07:23:34	Device_355979860003702 is attached on Cell_2 with FQDN 355979860003702.Cell_2.Domain_1.sst_1.nssf.5gc.mnc001.mcc	
24 07:23:34	Device_355979860003728 is attached on Cell_3 with FQDN 355979860003728.Cell_3.Domain_2.sst_2.nssf.5gc.mnc001.mcc	
24 07:23:34	Device_355979860003785 is attached on Cell_1 with FQDN 355979860003785.Cell_1.Domain_1.sst_3.nssf.5gc.mnc001.mcc	
24 07:23:45	Device_355979860003363 is attached on Cell_2 with FQDN 355979860003363.Cell_2.Domain_1.sst_1.nssf.5gc.mnc001.mcc	
24 07:23:45	Device_355979860003702 is attached on Cell_1 with FQDN 355979860003702.Cell_1.Domain_1.sst_1.nssf.5gc.mnc001.mcc	
24 07:23:45	Device_355979860003728 is attached on Cell_2 with FQDN 355979860003728.Cell_2.Domain_1.sst_2.nssf.5gc.mnc001.mcc	
- Callout:** A teal box labeled "Moving track of IoT" highlights the log entries for Smart_Parking_723456780003320 and Device_355979860003785.
- Navigation:** Page numbers 1, 4, 5, 6, 7, 8 are visible at the bottom.

Scenario 2: Testing large amounts of IoT devices are given identifiers automatically

Register large amounts of IoT devices and then generate Radius record that will be sent to DNS server.

- 4 Generate DNS A record
- ```
IP_A A IMEI_1.Cell_1.Domain_1. <sst>.nssf. 5gc.mnc001.mcc999.3gppnetwork.org
IP_A AAAA IMEI_1.Cell_1.Domain_1. <sst>.nssf. 5gc.mnc001.mcc999.3gppnetwork.org
```

generating corresponding DNS record



# Scenario 2:

## Testing large amounts of IoT devices are given identifiers automatically

| Name                 | IP_CAM                                 | Power_Meter                       | Temp_Meter                        | Smart_Parking                     | Smart_Lamps                       |
|----------------------|----------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| APN/DNN              | IP_CAM                                 | Power_Meter                       | Temp_Meter                        | Smart_Parking                     | Smart_Lamps                       |
| TAC<br>(IMEI 8 code) | 45678123                               | 34567812                          | 23456781                          | 12345678                          | 72345678                          |
| NSSAI                | eMBB                                   | MIOT                              |                                   |                                   |                                   |
| SST                  | 1                                      | 3                                 |                                   |                                   |                                   |
| Template             | High quality Video                     | Smart City sensor                 |                                   |                                   |                                   |
| Throughput           | 100Mbps/100Mbps                        | 1Mbps/1Mbps                       |                                   |                                   |                                   |
| Zone                 | nssf.5gc.mnc001.mcc999.3gppnetwork.org |                                   |                                   |                                   |                                   |
| Service IP<br>IPv4   | 10.100.11.0/24                         | 10.100.12.0/24                    | 10.100.13.0/24                    | 10.100.14.0/24                    | 10.100.15.0/124                   |
| Service IP<br>IPv6   | 10::100:11:(1-254):200:ff:fe00:00      | 10::100:12:(1-254):200:ff:fe00:00 | 10::100:13:(1-254):200:ff:fe00:00 | 10::100:14:(1-254):200:ff:fe00:00 | 10::100:15:(1-254):200:ff:fe00:00 |

# Scenario 2: Testing large amounts of IoT devices are given identifiers automatically

## Dashboard

System Metrics: CPU Usage: 0.6%, Memory Usage: 18%, Disk Space: 25%

Current State: 5G CoreMECCell connected to IoT.

| Domain1 |        |         |
|---------|--------|---------|
| Index   | Cell   | Online# |
| 1       | Cell_1 | 29      |
| 2       | Cell_2 | 31      |

| Domain2 |        |         |
|---------|--------|---------|
| Index   | Cell   | Online# |
| 1       | Cell_3 | 40      |

User Connection Status (Domain 1, Cell 1):

```

index: 1
online
Device ID: Smart_Parking_723456780003362
IMEI: 723456780003362
IPv4: 10.100.15.2
IPv6: 10:10:15:2:200::ff:fe00:0
Slice ID: 3
FQDN: 723456780003362.Cell_1.Domain_1.sst_3.nssf.5gc.mnc01.mcc999.3gppnetwork.org

```

User Connection Status (Domain 1, Cell 2):

```

index: 2
online
Device ID: Power_meter_345678120003363
IMEI: 345678120003363
IPv4: 10.100.12.3
IPv6: 10:10:12:3:200::ff:fe00:0
Slice ID: 3
FQDN: 345678120003363.Cell_1.Domain_1.sst_3.nssf.5gc.mnc01.mcc999.3gppnetwork.org

```

System Log: 2021/09/23 上午 07:13

| Time          | Payload                                                                                                              |
|---------------|----------------------------------------------------------------------------------------------------------------------|
| 3-24 07:11:54 | Power_meter_345678120003316 is attached on Cell_3 with FQDN 345678120003316.Cell_3.Domain_2.sst_3.nssf.5gc.mnc001.   |
| 3-24 07:11:54 | Temp_Meter_234567810003316 is attached on Cell_1 with FQDN 234567810003316.Cell_1.Domain_1.sst_3.nssf.5gc.mnc001.    |
| 3-24 07:11:54 | Smart_Parking_123456780003316 is attached on Cell_2 with FQDN 123456780003316.Cell_2.Domain_1.sst_3.nssf.5gc.mnc001. |
| 3-24 07:11:54 | Smart_Parking_723456780003316 is attached on Cell_2 with FQDN 723456780003316.Cell_3.Domain_2.sst_3.nssf.5gc.mnc001. |
| 3-24 07:11:54 | IP_CAM_456781230003317 is attached on Cell_2 with FQDN 456781230003317.Cell_2.Domain_1.sst_1.nssf.5gc.mnc001.m       |
| 3-24 07:11:54 | Power_meter_345678120003317 is attached on Cell_3 with FQDN 345678120003317.Cell_3.Domain_2.sst_3.nssf.5gc.mnc001.   |
| 3-24 07:11:54 | Temp_Meter_234567810003317 is attached on Cell_1 with FQDN 234567810003317.Cell_1.Domain_1.sst_3.nssf.5gc.mnc001.    |
| 3-24 07:11:54 | Smart_Parking_123456780003317 is attached on Cell_2 with FQDN 123456780003317.Cell_2.Domain_1.sst_3.nssf.5gc.mnc001. |
| 3-24 07:11:54 | Smart_Parking_723456780003317 is attached on Cell_3 with FQDN 723456780003317.Cell_3.Domain_2.sst_3.nssf.5gc.mnc001. |
| 3-24 07:11:55 | IP_CAM_456781230003318 is attached on Cell_2 with FQDN 456781230003318.Cell_2.Domain_1.sst_1.nssf.5gc.mnc001.m       |
| 3-24 07:11:55 | Power_meter_345678120003318 is attached on Cell_3 with FQDN 345678120003318.Cell_3.Domain_2.sst_3.nssf.5gc.mnc001.   |
| 3-24 07:11:55 | Temp_Meter_234567810003318 is attached on Cell_1 with FQDN 234567810003318.Cell_1.Domain_1.sst_3.nssf.5gc.mnc001.    |
| 3-24 07:11:55 | Smart_Parking_123456780003318 is attached on Cell_3 with FQDN 123456780003318.Cell_3.Domain_2.sst_3.nssf.5gc.mnc001. |
| 3-24 07:11:55 | IP_CAM_456781230003319 is attached on Cell_2 with FQDN 456781230003319.Cell_2.Domain_1.sst_1.nssf.5gc.mnc001.m       |
| 3-24 07:11:55 | Power_meter_345678120003319 is attached on Cell_3 with FQDN 345678120003319.Cell_3.Domain_2.sst_3.nssf.5gc.mnc001.   |
| 3-24 07:11:55 | Temp_Meter_234567810003319 is attached on Cell_1 with FQDN 234567810003319.Cell_1.Domain_1.sst_3.nssf.5gc.mnc001.    |
| 3-24 07:11:55 | Smart_Parking_123456780003319 is attached on Cell_2 with FQDN 123456780003319.Cell_2.Domain_1.sst_3.nssf.5gc.mnc001. |
| 3-24 07:11:56 | Smart_Parking_723456780003319 is attached on Cell_3 with FQDN 723456780003319.Cell_3.Domain_2.sst_3.nssf.5gc.mnc001. |

Use program to simulate 100 fixed IoT devices in 3 Cells

The detailed description of fixed IoT devices

<DNN>\_<IMEI> are the IMEI identifier of IoT, and these logs are different IoT devices registered in 3 different Cells.

# Summary

- This Project was funded by MOTC .
- Through the mechanism of DNS identifiers, the management of fixed and moving IoT devices under 5G is more efficient, and the IoT devices are able to be given identifiers under 5G efficiently.
- The PoC of the research based on the context above verify the mechanism and methods of auto DNS identifiers, which can apply to the latest 5G slicing network context and manage the IoT devices efficiently.
- In the next phase of the research, we plan to do the Proof of Service ( PoS ) on the real 5G network context.

# Research Partners







# Thank you

If you have questions or feedbacks,  
you can send them via email.

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