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# SYSTEM TO ENABLE CONTRACT-LESS/AGREEMENT-LESS ROAMING ACROSS MOBILE OPERATORS

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## ABSTRACT

Mobile roaming is a service that allows mobile users to continue to use their mobile phones or other mobile devices to make and receive voice calls and text messages, browse the internet, and send and receive emails while visiting another geography where a home network connection does not exist. However, issues may arise for scenarios in which a visited network may not have a roaming agreement with a user's home network in a given country and/or an agreement may be cost prohibitive for the user to utilize. Presented herein are techniques to facilitate agreement-free or contract-less roaming across network operators using a priority list of predetermined Public Land Mobile Network (PLMN) based rules that can be defined through home operator preferences.

## DETAILED DESCRIPTION

Mobile roaming extends the coverage of a home operator's mobile services, allowing a mobile user to continue using their home operator phone number and data services within another country. The seamless extension of coverage is enabled by a wholesale roaming agreement between a mobile user's home operator and a visited mobile operator network. Such a roaming agreement typically addresses the technical and commercial components required to enable the service.

So what happens when you visit a country where there is no agreement of your home network with the operator in that country? Even if the operator is in the visiting country, the agreement also means the price/plan or QoS for roaming may not be the most optimized from the end-user perspective. Additionally, there may be other operators, not in agreement with home operator, but which may have a better plan or service.

There are several challenges that are to be addressed in order to facilitate agreement-free roaming, such as:

1. Providing for the selection of a preferred public land mobile network (PLMN);

2. Providing for the ability to pre-identify PLMNs in the destination or the path traveled by a device; and

3. Matching communication profiles / Home Location Register (HLR) templates and rate plans.

In order to address the above challenges, this proposal covers techniques involving: 1) providing agreement-free or contract-less roaming across operators; and 2) providing a priority list of predetermined PLMNs based on rules defined by home operator preferences. The techniques of this proposal may build upon the OpenRoaming™ Federation architecture, which provides authentication services for devices associated with participating Service Providers (SPs) or Identity Providers (IDPs) in order to authenticate devices across heterogeneous networks. Thus, techniques of this proposal provide a mechanism through which devices managed by a connectivity management platform or similar platform may roam across multiple service providers (SPs) that may participate in the OpenRoaming™ Federation.

Consider various existing features that may be realized via a connectivity management platform, such as Location-Based Service (LBS), which may provide for the ability to maintain a list of cell identifiers (IDs) and locations of all cell towers belonging to an operator. Additionally, Charging Data Records (CDRs) can be obtained from all operators to facilitate billing and invoicing by the connectivity management platform. Further, an SP can assign a communication plan (e.g., a rate plane + communication profile) to devices associated with the SP. It is assumed that the connectivity management platform can communicate/exchange information with an SP network (e.g., via an HLR, Home Subscriber Server (HSS), Short Message Service Center (SMSC), etc.) for adding, updating, managing, subscribers/devices for sending SMS and/or over-the-air (OTA) communications to devices. Further for techniques of this proposal, it is assumed that the operators are part of the OpenRoaming™ Federation, which allows for authentication of devices across visited and home networks.

Techniques herein seek to provide various new innovations to provide for the ability to build a priority list of PLMNs in the location outside of a home network of a

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device. In order to identify PLMNs outside of a home network of a device, it will be important to:

1. Have an ability to find the current location of the device. For example, as a device connects to a Cell Id, an authentication/authorization request is sent to a network Authentication, Authorization, and Accounting (AAA) service, which can also contain the location and Cell ID. Recall, the connectivity management platform maintains a list of all Cell IDs and their corresponding location.

2. Have the ability to obtain the destination location of a device as user input from UE/device. This is only required in case a device is switched off at one location and is switched on in another location.

3. Using the real-time location from (1) or destination location from (2), build the PLMN list.

4. Obtain operator indicators to determine whether (i) OpenRoaming is enabled for an operator and (ii) whether an operator wants to enable agreement-free roaming, and, based on determining (i) and (ii), (iii) determining rules settings for agreement-free roaming, such as determining a closest match to a UE/device active communication profile or defining a roaming communication profile and determining billing rules.

Consider an example architectural diagram, as shown below in Figure 1, which may be used to illustrate various components that may be involved in the generation of a PLMN priority list. As shown in Figure 1, the connectivity management platform can include a new Location Monitoring Engine and Location Storage along with a new Rating Definition Service and Rating Information Storage that can facilitate generating a PLMN priority list and updating one or more UE with the PLMN list.

Connectivity Management Platform

*Figure 1: Example PLMN Generation Architecture*

Figure 2, below, is an example sequence diagram illustrating example details associated with the interaction/operations among different components to generate the PLMN priority list and send the list to a UE that is associated with an operator that belongs to the OpenRoaming™ Federation.
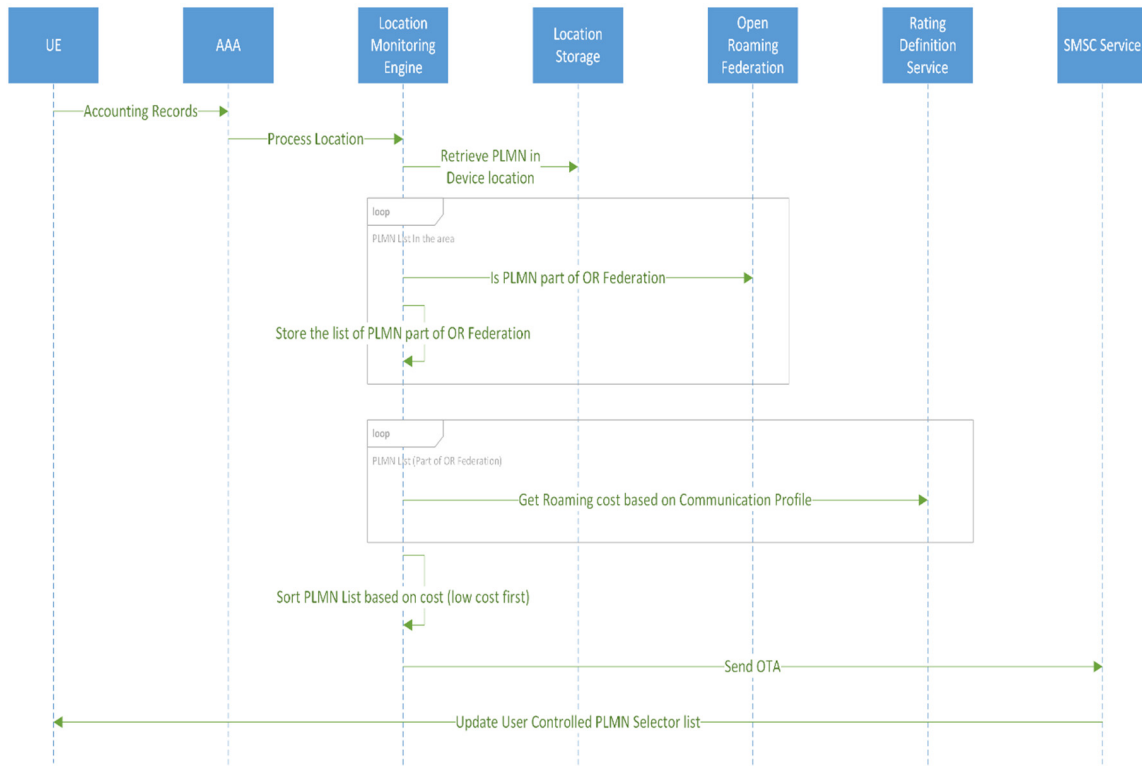
*Figure 2: Example PLMN List Generation Sequence Diagram*

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As shown in Figure 2, the UE, as part of establishing a data session, sends Accounting Records to the AAA service, which is part of the connectivity management platform. It is to be understood that other network elements may be involved in this interaction, but which are not shown for purposes of brevity only. Next, the AAA service forwards the record to the new Location Monitoring Engine.

The Location Monitoring Engine is responsible for monitoring the location of the UE; generate the PLMN priority list, and updating the UE with the PLMN priority list, if needed. Next, the Location Monitoring Engine retrieves the list of PLMNs for the device location from the Location Storage. If the list of PLMNs for the device identifies that the home network (typically referred to as a Home PLMN (HPLMN)) is available in the surrounding area of the UE, further processing stops since it is safe to assume that the device can continue to connect to the home network. Otherwise, if the home network is not available in the area surrounding the UE, the processing continues, as discussed below. It should be noted that the Location Monitoring Engine will not process requests from UEs that are not associated with an operator that is part of the OpenRoaming™ Federation.

Next, the Location Monitoring Engine checks with the OpenRoaming™ Federation to filter the PLMNs that are part of the OpenRoaming™ Federation. This list will be used to generate the final PLMN priority list, which would be sent to the UE if it is near to a location that does not have access to the home network (e.g., if the UE is near a border of the home network).

Next, the Location Monitoring Engine retrieves the roaming Rate Plan from the Rating Definition Service. The Rating Definition Service uses the roaming Communication Profile associated with the device to determine a matching Rate Plan of the Visiting PLMN (VPLMN). The Location Monitoring Engine compares the Rate Plans of the different PLMNs and sorts them based on the cost (e.g., PLMN providing low-cost roaming is kept first). The sorted PLMN priority list can then be sent to the UE through the SMSC Service as OTA messages.

Figure 3, below, illustrates how the VPLMN connects to the HPLMN to authenticate the UE and allow the UE to attach to the PLMN. During operation, when the UE tries to attach to the PLMN that is set to the highest priority, the VPLMN's Mobility Management Entity (for a 4G/Long Term Evolution (LTE) implementation) or Access and

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Mobility Management Function (AMF) (for a 5G implementation) connects to the AAA service of the HPLMN for authentication through an access network (AN) connector. The AN connector at the VPLMN connects to an IDP connector of the HPLMN using a secure and authenticated tunnel.
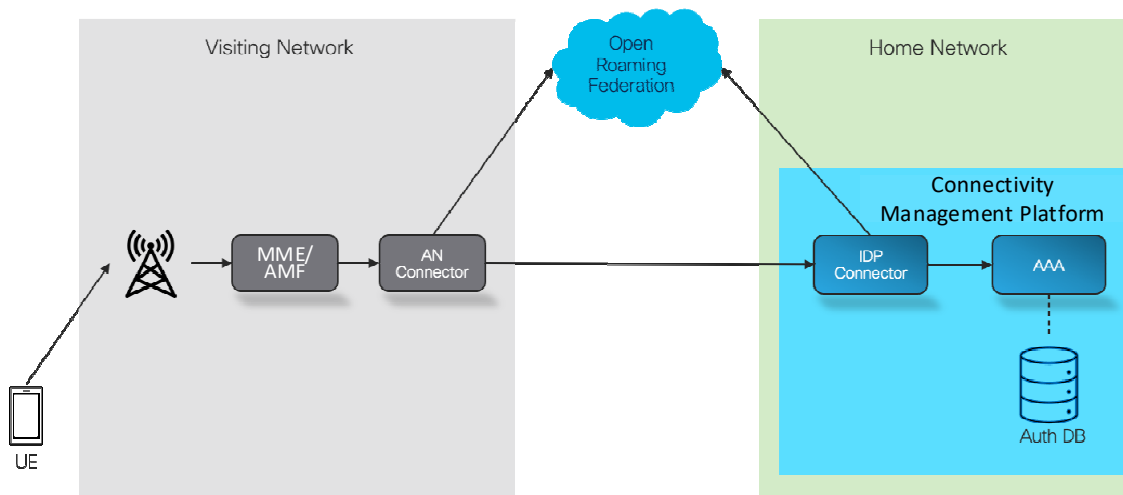


*Figure 3: Example UE Authentication Architecture*

Referring again to Figure 2, the Rating Definition Service will be responsible to identify the Roaming Rate Plan to be associated with a UE while the UE is roaming on a different VPLMN. In one instance, the following logic can be utilized to identify a Roaming Rate Plan for a given UE:

- Each operator will define one or more Roaming Rate Plans that can be used for other Operator's devices roaming in its network.

- These Roaming Rate Plans will be mapped to one or more Communication Profiles defined by the Operator.

- The Rating Definition Service compares these Communication Profiles with the Communication Profile (defined by an HPLMN) already associated with the UE and identifies the Communication Profile that closely matches the UE's Communication Profile. Details on how the Communication Plans are compared is described in further detail, below.

- The Rating Definition Service then selects the Roaming Rate Plan associated with the closest matching Communication Profile and provides this information to the Location Monitoring Engine.

Consider various operations that may be performed via the connectivity management platform to identify a matching roaming Communication Profile for a given UE. Generally, the connectivity management platform may support three basic types of wireless services: data, SMS (e.g., text messages), and voice. It is to be understood that other services may be supported on a case-by-case basis. The services available to each of a given UE can be defined in a Communication Profile associated with each UE, which may identify any combination of the following services:

1. 5G Data
2. LTE Data
3. VoLTE (Voice over LTE)
4. GPRS (General Packet Radio Service)
5. SMS:
   a. MO (Mobile Originated)
   b. MT (Mobile Terminated)
6. Voice
   a. MO
   b. MT
7. International Voice
8. International SMS

During operation, the Rating Definition Service will match the services enabled for the device on the home network (HPLMN) with different roaming Communication Profiles defined by the roaming Operator (VPLMN) to determine the most suitable Communication Profile. In one instance, weighted scoring can be used to find a matching Communication Profile for a given UE, as explained in further detail below. Key services that have the same setting in the two Communication Profiles being compared can be given a different weightage, as shown below in TABLE 1.

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**TABLE 1: Example Service Weightage**

| Service | Weightage |
|---|---|
| Voice MO | 15 |
| Voice MT | 15 |
| SMS MO | 10 |
| SMS MT | 10 |
| International Voice | 2 |
| International SMS | 2 |
| 5G Data | 4 |
| LTE Data | 6 |
| VoLTE | 6 |
| GPRS | 8 |

During operation, a final score for determining a best matching Communication Profile can be computed by adding weightages of matching services. The Communication Profile with the maximum score can be chosen as the most suitable Communication Profile for a given UE. An example score calculation for determining a most suitable Communication profile for given UE is shown below in TABLE 2.

**TABLE 2: Example Communication Profile Score Calculations**

| | Enabled? | Enabled? | Score | Enabled? | Score | Enabled | Score |
|---|---|---|---|---|---|---|---|
| | Communication Profile - Home (HPLMN) | Communication Profile 1 - Roaming (VPLMN) | | Communication Profile 2 - Roaming (VPLMN) | | Communication Profile 3 - Roaming (VPLMN) | |
| Voice MO | N | Y | 0 | N | 15 | N | 15 |
| Voice MT | Y | Y | 15 | Y | 15 | N | 0 |
| SMS MO | N | Y | 0 | Y | 0 | N | 10 |
| SMS MT | Y | Y | 10 | Y | 10 | N | 0 |
| International Voice | N | N | 2 | N | 2 | Y | 0 |
| International SMS | N | N | 2 | Y | 0 | N | 2 |
| 5G Data | N | N | 4 | Y | 0 | Y | 0 |
| LTE Data | Y | N | 0 | Y | 6 | Y | 6 |
| VoLTE | N | N | 6 | N | 6 | Y | 0 |
| GPRS | Y | N | 0 | Y | 8 | Y | 8 |
| **Total Score** | | | 39 | | 62 | | 41 |

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As shown in TABLE 2, the weightage score of 'Communication Profile 2 – Roaming (VPLMN)' is higher than that of other Communication Profiles, which means that this profile is the best matching (most suitable) Communication Profile that can be used for the UE while roaming on the VPLMN.

In summary, techniques herein involve providing a priority list of predetermined PLMNs based on rules defined by home operator preferences to facilitate agreement-free or contract-less roaming across operators. Thus, techniques of this proposal provide a mechanism through which devices managed by a connectivity management platform across multiple SPs that may participate in the OpenRoaming™ Federation may roam across visited networks through agreement-free or contact-less roaming across operators.