**SA WG2 Meeting # S2-20xxxxx**

**Source: Apple**

**Title: Solution for KI#8: UE Roaming Behaviour Analytics to improve roaming experience**

**Document for: Approval**

**Agenda Item: x.x**

**Work Item / Release: FS\_eNA\_ph2 / Rel-17**

*Abstract of the contribution: This contribution proposes a solution for Key Issue #8: UE data as input for analytics generation and for Key Issue #5: New types of outputs provided by NWDAF*

# 1. Introduction

An operator has roaming partners all over the world to ensure uninterrupted services. However, an operator may not have good insights on the user experience of its UEs when in roaming PLMNs and this is an important KPI. With the solution proposed, an operator may now have insights of user experience when the UE is in roaming networks. Sub-optimal experience of UEs in roaming PLMN may be due to:

- Roaming PLMN abnormal behaviour; and/or

- UE’s abnormal behaviour.

The proposed new inputs to analytics provide insights which can then be used to improve the user experience of UE in roaming PLMN.

This solution is proposed for Key Issue #8: Input from UE is collected at roaming PLMNs and used as input to NWDAF for analytics generation

# 2. Discussion

For variety of different reasons, the UE and/or the roaming PLMN may exhibit abnormal behaviour resulting in poor user experience. In other words, a roaming UE may not perform in a manner that is normally expected of the UE. Some examples of abnormal behaviour may include, but are not limited to, a delay in registering with a roaming PLMN, incorrect or sub-optimal radio access technology (RAT) selection, spending an abnormal amount of time camped on one RAT despite a second better RAT being available, selecting a PLMN that is not preferred by the home network carrier of the UE, call drops, call failures, data stalls, packet loss, baseband crashes, etc. Under conventional circumstances, the home PLMN may be unaware of the user experience of the UE when roaming. For example, the home PLMN may not receive an indication that the UE and/or the roaming PLMN exhibited abnormal behaviour. As a result, the home PLMN of the UE may be unable to identify why the UEs may not perform as expected when camped on the roaming PLMN.

|  |  |
| --- | --- |
| **Abnormal Behaviour** | **To derive analytics for:** |
| Registration | Delay in registering with roaming PLMN for NORMAL SERVICE |
| RAT selection  | Incorrect RAT selection (e.g. spending abnormally long time on UTRAN when E-UTRAN / NG-RAN was available) |
| PLMN selection | Registered on non-preferred PLMN  |
| Call statistics | Call drops and failures while roaming |
| Data stalls | Frequent data stalls and packet loss |
| Baseband crashes | How stable the UE performance is when roaming |

The home PLMN can provide the UE with information associated with interactions between the UE and the roaming PLMN. The UE collects information while roaming and provides the information to the NWDAF of the home PLMN. The information provided by the UE (and other UEs of the home PLMN) may provide the basis for the output generated by the NWDAF. The output may provide the operator with insight into the user experience and abnormal behaviour of their UEs when camped on the roaming PLMN, which may help the operator to initiate efforts to help improve the user experience by either letting the UE vendor make roaming enhancements in the UE software, or by negotiating better roaming agreements with the roaming PLMN operator.

# 3. Proposal

The following changes are proposed for TR 23.700-91.

**\* \* \* \* First Change (All new text) \* \* \* \***

## 6.X Solution #X: UE Roaming Behaviour Analytics to improve roaming experience

### 6.X.1 Description

#### 6.X.1.1 General

This solution is proposed to address:

- Key Issue #8: Input from UE is collected at roaming PLMNs and used as input to NWDAF for analytics generation.

NWDAF supporting UE roaming behaviour analytics shall be able to collect information from UE via NFs (e.g. AMF, PCF, SMF, etc), and to perform data analytics of abnormal behaviour of UE in a roaming PLMN.

The consumer of these analytics may indicate in the request the target of Analytics Reporting (single UE or a group of UEs) and the Analytics Filter Information containing parameters such as:

* Network Acquisition Parameter
* RAT Parameter
* Camped PLMN ID
* Voice Call parameter
* Data Stall parameter
* Baseband crashes
* Maximum number of results
* Target period indicating the time period over which the statistics are requested.
* Preferred level of accuracy of the analytics (low/high).

#### 6.X.1.2 Input data

The information collected via 5GC NFs for UE roaming behaviour analytics is defined in Table 6.X.1.2-1.

Table 6.X.1.2-1: Input Data related to for UE roaming behaviour analytics

|  |  |  |
| --- | --- | --- |
| Information | Source | Description |
| Network Acquisition Parameter | UE via SMF, AMF | Time taken by the UE to register in the roaming PLMN |
| RAT Parameter | SMF, AMF | Incorrect or sub-optimal RAT selection by UE in roaming PLMN  |
| PLMN ID | SMF, AMF | Registered Roaming PLMN ID |
| Voice call statistics | SMF, AMF | Voice call drops and call failures in roaming PLMN |
| Data stalls | SMF, AMF | Data stalls and packet loss in roaming PLMN |
| Baseband crashes | SMF, AMF | Number of UE baseband crashes in roaming PLMN |
| UE identification | AMF | TAC, IMEI, GUTI, etc. |

#### 6.X.1.3 Output Analytics

The NWDAF supporting UE roaming behaviour analytics shall be able to provide analytics to consumer NFs or AFs.

With this analytics information, the home PLMN has the visibility of UE behaviour in roaming PLMNs. This analytics information can be used to improve the user experience of UE in roaming PLMNs.

UE abnormal behaviour in roaming PLMN statistics information is defined in Table 6.X.1.3-1.

Table 6.X.1.3-1: UE abnormal behavior in roaming PLMN statistics

|  |  |
| --- | --- |
| Information | Description |
| Network Acquisition Time | Identification of abnormality related to delay in registration |
| In Service / Out of Service | Identification of abnormality related to no network coverage |
| RAT Distribution | Identification of abnormality related to incorrect or sub-optimal RAT Retainability |
| PLMN ID Distribution | Identification of abnormality related to non-operator preferred PLMN selection |
| Call Failure / Drops | Statistics related voice call user experience  |
| Packet Loss / Data Stalls | Statistics related packet drop user experience  |
| Baseband Stability | Identification of abnormality related to baseband stability |
| Time slot entry (1..max) | List of time slots during the analytics target period |
| > Time slot start | Time slot start within the analytics target period |
| > Duration | Duration of the time slot (average and variance) |

#### 6.X.1.4 UE warm-up

The UE is configured when registered in home PLMN for UE roaming behaviour analytics. This involves the network indicating the parameters to UE which need to be monitored to understand the user experience of UE in a roaming PLMN. These parameters are configurable and can be modified by the network. These parameters are configured via "Operator-defined parameters" and URSP rules.

#### 6.X.1.4.1 Operator-defined Parameters

"Operator-defined parameters" are provisioned from PCF (via AMF) to UE in home PLMN via UE Configuration Update procedure. The "Operator-defined parameters" indicate to the UE which parameters to report periodically or save when the UE is in a roaming PLMN.

#### 6.X.1.4.1.1 Operator-defined Parameters for UE Reporting Analytics data while in home PLMN after returning back from roaming PLMN

This configuration can be applied to the UE when the home PLMN provisions the UE to send the report while registered in the home PLMN after returning back from the roaming PLMN.

Table 6.X.1.4.1.1-1: Operator-defined Parameters

|  |  |
| --- | --- |
| UE Configuration | Purpose |
| Network Acquisition | UE to report time registered in roaming PLMN |
| RAT  | UE to report camped RAT |
| PLMN | UE to report camped PLMN |
| Voice call statistics | UE to report number of call drops and call failures |
| Data stalls | UE to report frequent data stalls and packet loss |
| Baseband crashes | UE to report number of baseband crashes |
| Reporting Location  | Indicate to UE that reporting shall be performed from home PLMN |
| Max Allowed Memory | 1024/2048 bytes - predetermined maximum number of bytes allocated for this purpose |
| Periodicity (applicable only in roaming scenarios) | Indicate to UE about periodic saving (e.g. 24 hrs) time |

NOTE 1: When the UE returns to the home PLMN, some of the collected information may have been purged prior to reporting the information to the NWDAF. For example, the UE may collect, store and purge the collected information on a first in/first out basis (e.g., when the storage capacity is full, the earliest collected data may be purged).

NOTE 2: The UE may purge information related to the less critical parameters from the operator perspective (e.g. baseband crashes).

#### 6.X.1.4.2 URSP rules

The URSP rules include information that is to be used for the reporting of UE analytics data collected in a roaming PLMN.

#### 6.X.1.4.2.1 URSP rules based on a new DNN

The structure for URSP rules based on a new DNN is defined in Table 6.X.1.4.1.2-1:

Table 6.X.1.4.1.2-1: URSP rules based on a new DNN

|  |  |
| --- | --- |
| Information Name | Description |
| DNN | A specific DNN may be defined by the home PLMN for sending analytics information collected by UE |
| Non-Seamless Offload indication | The non-seamless offload indication may indicate to the UE that the information collected by the UE when roaming may be offloaded on a non-3GPP access |
| Access Type preference | The access type preference indication may indicate to the UE the preferred access type (e.g., non-3GPP, multi-access, etc.) when the UE establishes a PDU session to deliver the information collected by the UE while roaming |
| Location Criteria | The location criteria indication may indicate location where analytics information may be collected by roaming UEs. The URSP rules are not considered valid if UE location does not match the location criteria. The location criteria may be specified in terms of Mobile Country Code (MCC) identifier, Tracking Area Identifier(s), global cell identifier(s), or latitude and longitude. |

#### 6.X.1.4.2.2 URSP rules based on an existing DNN and Domain descriptors

The structure for URSP rules based on an existing DNN and Domain descriptors is defined in Table 6.X.1.4.2.2-1:

Table 6.X.1.4.2.2-1: URSP based on based on an existing DNN and Domain descriptors

|  |  |
| --- | --- |
| Information Name | Description |
| Domain descriptors | The existing DNN with domain descriptor (i.e. FQDN) may be defined by the home PLMN for sending analytics information collected by roaming UEs |
| Non-Seamless Offload indication | The non-seamless offload indication may indicate to the UE that the information collected by the UE when roaming may be offloaded on a non-3GPP access |
| Access Type preference | The access type preference indication may indicate to the UE the preferred access type (e.g., non-3GPP, multi-access, etc.) when the UE establishes a PDU session to deliver the information collected by the UE while roaming |
| Location Criteria | The location criteria indication may indicate location where analytics information may be collected by roaming UEs. The URSP rule are not considered valid if UE location does not match the location criteria. The location criteria may be specified in terms of Mobile Country Code (MCC) identifier, Tracking Area Identifier(s), global cell identifier(s), or latitude and longitude. |

#### 6.X.1.4.2.3 URSP rules based on a dedicated Network Slice

The structure for URSP rules based on a dedicated network slice is defined in Table 6.X.1.4.2.3-1:

Table 6.X.1.4.2.3-1: URSP based on based on a dedicated Network Slice

|  |  |
| --- | --- |
| Information Name | Description |
| DNN | A specific DNN may be defined by the home PLMN for sending analytics information collected by UE |
| Non-Seamless Offload indication | The non-seamless offload indication may indicate to the UE that the information collected by the UE when roaming may be offloaded on a non-3GPP access |
| Access Type preference | The access type preference indication may indicate to the UE the preferred access type (e.g., non-3GPP, multi-access, etc.) when the UE establishes a PDU session to deliver the information collected by the UE while roaming |
| Location Criteria | The location criteria indication may indicate location where analytics information may be collected by roaming UEs. The URSP rule is not considered valid if UE location does not match the location criteria. The location criteria may be specified in terms of Mobile Country Code (MCC) identifier, Tracking Area Identifier(s), global cell identifier(s), or latitude and longitude. |
| Network Slice Selection | The network slice selection indication may include an S-NSSAI dedicated for sending analytics information collected by roaming UEs. |

#### 6.X.1.5 Architecture

#### 6.X.1.5.1 Architecture - UE Reports Analytics data in Home PLMN network after returning back from roaming PLMN

#### A close up of a map  Description automatically generated

Figure 6.X.1.5.1-1: UE Reports Analytics data at Home Location network after returning back from Roaming Location

#### 6.X.1.6 Procedures

#### 6.X.1.6.1 Procedures for UE warm-up in Home PLMN



Figure 6.X.1.6.1-1: Procedure for UE warm-up in home PLMN

1. UE sends initial registration request to AMF.

2. AMF decides to establish AM Policy Association with the PCF. AMF requests the PCF to provision URSP rules for the UE. The AMF sends Npcf\_AMPolicyControl\_Create to the PCF to establish an AM policy control association with the PCF.

3. PCF responds to the Npcf\_AMPolicyControl\_Create service operation with Npcf\_AMPolicyControl\_Response. The PCF provides the URSP rules.

4. The AMF sends the URSP rules to the UE in Registration Accept.

5. The AMF requests the PCF to provision "Operator-defined Parameters" for the UE. The AMF sends Npcf\_AMPolicyControl\_Create to the PCF to establish an AM policy control association with the PCF.

6. PCF responds to the Npcf\_AMPolicyControl\_Create service operation with Npcf\_AMPolicyControl\_Response. The PCF provides "Operator-defined Parameters".

7. The AMF sends the "Operator-defined Parameters" in a UE Configuration Update Command message.

8. UE acknowledges the receipt of the "Operator-defined Parameters" in a Configuration Update Complete message.

#### 6.X.1.6.2 Procedures for sending UE analytics data in home PLMN after returning back from a roaming PLMN via NAS



Figure 6.X.1.6.2-1: Procedure for sending UE analytics data in home PLMN after returning back from roaming PLMN via NAS

1. Procedures in clause 6.X.1.6.1 are executed.

2-3. UE registers in a roaming PLMN and established PDU sessions.

4-5. UE collects the provisioned parameters required for UE roaming behaviour analytics and saves them in non-volatile memory.

6-7. UE returns to and registers with home PLMN.

8. UE roaming behaviour analytics input data is sent to SMF via an UL NAS transport message included in Additional Information IE as described in TS 24.501 clauses 8.2.10.1 and 9.11.2.1.

9. The SMF sends the UE roaming behaviour analytics input data to NWDAF as described in procedure 6.X.1.6.4

#### 6.X.1.6.3 Procedures for sending UE analytics data in home PLMN after returning back from a roaming PLMN via user plane



Figure 6.X.1.6.3-1: Procedure for sending UE analytics data in home PLMN after returning back from roaming PLMN via user plane

1. Procedures in clause 6.X.1.6.1 are executed.

2-3. UE registers in a roaming PLMN and established PDU sessions.

4-5. UE collects the provisioned parameters required for UE roaming behaviour analytics and saves them in non-volatile memory.

6-7. UE returns to and registers with home PLMN.

8-10. UE establishes a PDU session based on provisioned URSP rules and sends UE roaming behaviour analytics input data to NWDAF.

#### 6.X.1.6.4 Procedures for NWDAF providing UE roaming behaviour analytics output to Consumer NF



Figure 6.X.1.6.4-1: Procedure for NWDAF providing Roaming location analytics output to Consumer NF

1. Consumer NF sends an Analytics subscribe (Analytics ID = UE Roaming Behaviour Analytics, Target of Analytics Reporting = UE ID, Analytics Filter information to NWDAF by invoking a Nnwdaf\_AnalyticsSubscription\_Subscribe).

2. NWDAF subscribes the network data from 5GC NF (SMF/UPF) by invoking Nnf\_EventExposure\_Subscribe/Notify service operation.

3. The NWDAF derives the subscribed the UE roaming behaviour analytics.

4. The NWDAF provides the UE roaming behaviour analytics to the consumer NF by means of Nnwdaf\_AnalyticsSubscription\_Notify.

NOTE: The call flow only shows a subscription-notify model for the interaction of NWDAF and consumer NF for simplicity instead of both request-response model and subscription-notification model as defined in clause 6.1, TS 23.288 [5].

### 6.X.2 Impacts

### 6.X.3 Solution evaluation

**\* \* \* \* End of Changes \* \* \* \***