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# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document is to study the stage 2 and the stage 3 aspects for service requirements defined by SA WG1 under SA1 work item MINT (Minimization of Service Interruption), as specified in 3GPP TS 22.011 [2] and 3GPP TS 22.261 [3].

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.011: "Service accessibility".

[3] 3GPP TS 22.261: "Service requirements for the 5G system; Stage 1".

[4] 3GPP TS 23.501: "System architecture for the 5G System (5GS); Stage 2".

[5] 3GPP TS 32.101: "Telecommunication management; Principles and high level requirements".

[6] 3GPP TS 28.533: "Management and orchestration; Architecture framework".

[7] 3GPP TS 23.122: "Non-Access-Stratum functions related to Mobile Station (MS) in idle mode".

[8] 3GPP TS 23.502: "Procedures for the 5G System (5GS)".

[9] 3GPP TS 24.501: "Non-Access-Stratum (NAS) protocol for 5G System (5GS); Stage 3".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

**PLMN with Disaster Condition:** A PLMN to which a Disaster Condition applies.

**PLMN without Disaster Condition:** A PLMN to which no Disaster Condition applies.

For the purposes of the present document, the following terms and definitions given in 3GPP TS 22.261 [3] apply:

**Disaster Condition**

**Disaster Inbound Roamer**

**Disaster Roaming**

For the purposes of the present document, the following terms and definitions given in 3GPP TS 23.122 [7] apply:

**Allowable PLMN**

## 3.2 Symbols

void

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

# 4 Architectural Assumptions and Requirements

## 4.1 Architectural Assumptions

The following architectural assumptions apply:

- The PDU sessions of the UE can be transferred when a UE moves from a PLMN with Disaster Condition to a PLMN providing Disaster Roaming.

- In principle, the Disaster Inbound Roamers can receive the same services in a PLMN without Disaster Condition as non-disaster inbound roamers can receive in the PLMN without Disaster Condition, subject to agreement between HPLMN of the UE and the PLMN without Disaster Condition, regulations of the country, and constraints of the PLMN without Disaster Condition.

- The network functions except one or more RAN nodes of the PLMN with Disaster Condition can be assumed to be still operational. One or more RAN nodes of the PLMN with Disaster Condition are non-operational.

- Architecture defined in 3GPP TS 23.501 [4] is used as basis architecture for supporting minimization of service interruption.

## 4.2 Architectural Requirements

The system shall satisfy the stage-1 requirements in TS 22.261 [3] clause 6.31 and TS 22.011 [2] clause 3.2.2.

The solution shall enable a UE of a selected PLMN (HPLMN or VPLMN) with Disaster Condition, to select and register on another PLMN without Disaster Condition in UE's forbidden PLMN list when no other PLMN is available except for PLMNs in UE's forbidden PLMN list and the PLMN without Disaster Condition is able to accept Disaster Inbound Roamers from the PLMN with Disaster Condition.

If the UE, with HPLMN subscription, was informed by the HPLMN that it should apply Disaster Roaming when a Disaster Condition arises (in the HPLMN or a VPLMN), the solution shall enable a UE to detect that a Disaster Condition applies to PLMN D, where PLMN D is the UE's HPLMN or a PLMN not in the UE's forbidden PLMNs list, regardless of whether the UE is registered in PLMN D or not. When the UE detects that a Disaster Condition applies to PLMN D, the solution shall enable the UE to select and to register on another PLMN without Disaster Condition in the UE's forbidden PLMNs list when no other PLMN is available except for PLMNs in the UE's forbidden PLMNs list and the PLMN without Disaster Condition is able to accept Disaster Inbound Roamers from the PLMN with Disaster Condition.

# 5 Key Issues

## 5.1 Key Issue #1: Notification of Disaster Condition to the UE

### 5.1.1 Description

According to 3GPP TS 22.261 [3] clause 6.31.2.2:

*The 3GPP system shall enable UEs to obtain information that a Disaster Condition applies to a particular PLMN or PLMNs.*

*NOTE: If a UE has no coverage of its HPLMN, then obtains information that a Disaster Condition applies to the UE's HPLMN, the UE can register with a PLMN offering Disaster Roaming service.*

According to 3GPP TS 22.261 [3] clause 6.31.2.3:

*The 3GPP system shall provide means to enable that a Disaster Condition applies to UEs of a specific PLMN.*

When a Disaster Condition applies to a PLMN or PLMNs in an area, a UE is located in the area, and the PLMN is HPLMN of the UE or was selected by the UE, then the UE shall be able to obtain information that the Disaster Condition applies to the PLMN.

NOTE: The interactions between this Key Issue and the Key Issue #7 (Prevention of signalling overload in PLMNs without Disaster Condition) need to be considered, since preventing UEs from overloading the PLMNs without Disaster Condition could have an impact on how the UEs are notified that the Disaster Condition applies.

The following questions are expected to be studied within this Key Issue:

- How to deliver the information on the Disaster Condition of a PLMN in an area to the UE located in the area;

- Which network functions or entities are involved for the delivery of the information;

- Which PLMN(s) are responsible for the delivery of the information; and

- What kind of information should be delivered to the UE.

## 5.2 Key Issue #2: Notification of applicability on Disaster Condition to PLMNs without Disaster Condition

### 5.2.1 Description

According to 3GPP TS 22.261 [3] clause 6.31.2.2:

Subject to regulatory requirements or operator's policy, the 3GPP system shall support a PLMN operator to be made aware of the failure or recovery of other PLMN(s) in the same country when the Disaster Condition is applies, or when the Disaster Condition is not applicable.

The 3GPP system shall support means for a PLMN operator to be aware of the area where Disaster Condition applies.

When a Disaster Condition applies to a particular PLMN or PLMNs, the PLMN(s) without Disaster Condition in the same country shall be notified that Disaster Condition applies to PLMN(s) or Disaster Condition no longer applies. Also as per service requirement quoted above, the PLMN(s) in the same country can be made aware of the area where Disaster Condition applies.

The following questions are expected to be studied within this Key Issue:

- How to deliver the information on the Disaster Condition to the PLMNs without Disaster Condition;

- Who or which entity decides the Disaster Condition;

- How to provide information on the area where Disaster Condition applies; and

- What kind of information, if any, should be delivered to the PLMNs without Disaster Condition other than what is mentioned above.

NOTE: The interactions between this Key Issue and the Key Issue #8 (Prevention of signalling overload by returning UEs in PLMN previously with Disaster Condition) need to be considered, since preventing UEs from overloading a PLMN previously with Disaster Condition could have an impact on how the PLMNs without Disaster Condition are notified that the Disaster Condition no longer applies.

## 5.3 Key Issue #3: Indication of accessibility from other PLMNs without Disaster Condition to the UE

### 5.3.1 Description

According to 3GPP TS 22.261 [3] clause 6.31.2.3:

The 3GPP system shall be able to provide a resource efficient means for a PLMN to indicate to potential Disaster Inbound Roamers whether they can access the PLMN or not.

When a Disaster Condition applies to a particular PLMN or PLMNs, one or more PLMNs in the same country may be able to provide Disaster Roaming service to the UEs of a PLMN with Disaster Condition. In this case, the PLMN providing Disaster Roaming shall indicate that it can accommodate the Disaster Inbound Roamers from a PLMN with Disaster Condition.

The following questions are expected to be studied within this Key Issue:

- Which PLMN(s) are responsible for indicating their accesibility to Disaster Inbound Roamers;

- How other PLMN(s) than the PLMN with Disaster Condition indicate that they can accommodate Disaster Inbound Roamer; and

- What information can be provided to potential Disaster Inbound Roamers.

NOTE: The interactions between this Key Issue and the Key Issue #7 (Prevention of signalling overload in PLMNs without Disaster Condition) need to be considered, since preventing UEs from overloading a PLMN without Disaster Condition could have an impact on whether and how the PLMN indicates that it can accept Disaster Inbound Roamers.

## 5.4 Key Issue #4: Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition

### 5.4.1 Description

When the UE of a PLMN with Disaster Condition is notified of Disaster Condition, according to conclusion of the Key Issue #1, and the UE selects the other PLMN providing Disaster Roaming service, then the UE shall perform the registration procedure in order to be registered to the PLMN. It is unclear how the Disaster Roaming PLMN authenticates the UE and how to collect charging information when the Disaster Condition applies.

According to 3GPP TS 22.261 [3] clause 6.31.2.3:

3GPP system shall be able to collect charging information for a Disaster Inbound Roamer with information about the applied disaster condition

According to 3GPP TS 22.261 [3] clause 6.31.2.2:

The 3GPP system shall be able to support provision of service to Disaster Inbound Roamer only within the specific region where Disaster Condition applies.

As per this service requirement quoted, the Disaster Roaming PLMN shall be able to consider the area of service to Disaster Inbound Roamers that is limited to the region where Disaster Condition applies.

The following questions are expected to be studied within this Key Issue:

- How a registration procedure initiated by Inbound Disaster Roamer is performed;

- How to authenticate Inbound Disaster Roamer during the registration procedure;

- Which network functions or entities are involved for the registration procedure of Disaster Inbound Roamers;

- How a Disaster Roaming PLMN can limit the area of service to Inbound Disaster Roamers to the region where Disaster Condition applies;

- How and which function to collect charging information for a Disaster Inbound Roamer with information about the applied disaster condition; and

- What other information, if any, is needed to be transferred between the UE and the network during the initial registration procedure.

## 5.5 Key issue #5: PLMN selection when a "Disaster Condition" applies

### 5.5.1 Description

If the UE determines that a Disaster Condition applies as described in Key Issue #1 "Notification of Disaster Condition to the UE", then the PLMN selection procedure needs to be updated so the UE avoids selecting the PLMN with Disaster Condition.

If the UE determines that a Disaster Condition applies as described in Key Issue #1 "Notification of Disaster Condition to the UE", there is no available PLMN except for PLMNs in the list of "Forbidden PLMNs", and one or more available PLMNs indicate accessibility for the UE as described in Key Issue #3 "Indication of accessibility from other PLMNs without Disaster Condition to the UE", then the PLMN selection procedure needs to be updated so that the UE selects one of the PLMNs indicating accessibility for the UE.

In addition, if there are more than one PLMN indicating accessibility for the UE, then PLMN selection procedure needs to be updated for selecting one of those PLMNs.

According to 3GPP TS 22.261 [3] clause 6.31.2.3:

The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.

The following questions are expected to be studied within this key issue:

1) How the UE selects a PLMN if it is determined that a "Disaster Condition" applies;

a) If the UE determines that a Disaster Condition applies as described in Key Issue #1 "Notification of Disaster Condition to the UE", then how to update PLMN selection procedure so that the UE avoids selecting the PLMN with Disaster Condition.

b) If the UE determines that a Disaster Condition applies as described in Key Issue #1 "Notification of Disaster Condition to the UE", there is no available PLMN except for PLMNs in the list of "Forbidden PLMNs", and one or more available PLMNs indicate accessibility for the UE as described in Key Issue #3 "Indication of accessibility from other PLMNs without Disaster Condition to the UE", then how to update PLMN selection procedure so that the UE selects one of the PLMNs indicating accessibility for the UE.

c) if there are more than one PLMN indicating accessibility for the UE, then how to update PLMN selection procedure for selecting one of those PLMNs.

NOTE: The interaction between this Key Issue and Key Issue #7 (Prevention of signalling overload in PLMNs without Disaster Condition) should be considered, since preventing UEs from overloading a PLMN without Disaster Condition might have an impact on which PLMN the UEs should select.

2) How the UE handles the list of "forbidden PLMNs" when selecting a PLMN indicating accessibility for the UE in the bullet 1).

## 5.6 Key Issue #6: Notification that Disaster Condition is no longer applicable to the UEs

### 5.6.1 Description

According to 3GPP TS 22.261 [3] clause 6.31.2.2:

The 3GPP system shall be able to provide efficient means for a network to inform Disaster Inbound roamers that a Disaster Condition is no longer applicable.

According to 3GPP TS 22.261 [3] clause 6.31.2.3:

Disaster Inbound Roamers shall perform network reselection when a Disaster Condition has ended.

When a UE was camping on a PLMN offering Disaster Roaming service and was being served by the PLMN, the network can notify Disaster Inbound Roamers that Disaster Condition is no longer applicable. When a UE is notified that Disaster Condition is no longer applicable, the UE shall perform network reselection in order to return to its HPLMN in non-roaming scenario, or return to its previous registered VPLMN in roaming scenario.

The following questions are expected to be studied within this Key Issue:

- When and how to deliver the information that Disaster Condition is no longer applicable to Disaster Inbound Roamers;

- How to minimize interruption of the service receiving from Disaster Roaming PLMN (e.g. emergency service or high priority service) when the UE is notified that Disaster Condition is no longer applicable;

- How to remove the stored information on Disaster Condition from the UE's storage; and

- How Disaster Inbound Roamer UEs perform network selection when notified that Disaster Condition is no longer applicable.

NOTE: The interactions between this Key Issue and the Key Issue #8 (Prevention of signalling overload by returning UEs in PLMN previously with Disaster Condition) need to be considered, since preventing UEs from overloading the PLMN previously with Disaster Condition could have an impact on how the UEs are notified that the Disaster Condition is no longer applicable.

## 5.7 Key Issue #7: Prevention of signalling overload in PLMNs without Disaster Condition

### 5.7.1 Description

According to 3GPP TS 22.261 [3] clause 6.31.2.1:

*Subject to regulatory requirements or operator's policy, 3GPP system shall be able to enable a UE of a given PLMN to obtain connectivity service (e.g. voice call, mobile data service) from another PLMN for the area where a Disaster Condition applies.*

This means that when a Disaster Condition applies, all UEs of the PLMN with Disaster Condition that are located in the area where the Disaster Condition applies will look for another PLMN in that area and attempt to register on it to obtain service. This could cause a large number of UEs to migrate from the PLMN with Disaster Condition to another PLMN, and attempt registration at around the same time, leading to signalling overload in the other PLMN due to the massive influx of roamers. Consequently, mechanisms are needed to prevent signalling overload in the PLMNs without Disaster Condition. This is also reflected in the following service requirement of 3GPP TS 22.261 [3] clause 6.31.2.3:

The 3GPP system shall minimize congestion caused by Disaster Roaming.

These mechanisms should additionally take into account the fact that a new Accesss Identity (Access Identity 3) to be used by Disaster Inbound Roamers was introduced in 3GPP TS 22.261 [3] clause 6.22.2.2.

*Table 6.22.2.2-1: Access Identities*

|  |  |
| --- | --- |
| ***Access Identity number*** | ***UE configuration*** |
| *…* | *…* |
| *3* | *UE for which Disaster Condition applies (note 4)* |
| *…* | *…* |
| *(…)*  *NOTE 4: The configuration is valid for PLMNs that indicate to potential Disaster Inbound Roamers that the UEs can access the PLMN. See clause 6.31.* | |

The following questions are expected to be studied within this Key Issue:

- How to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition available in the area where the Disaster Condition applies, so as to share the load as evenly as possible between the PLMNs without Disaster Condition;

- How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;

- How to use new Access Identity 3 for the purpose of Disaster Inbound Roamer access control and signalling overload prevention in the PLMNs without Disaster Condition;

- How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion; and

- How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers.

## 5.8 Key Issue #8: Prevention of signalling overload by returning UEs in PLMN previously with Disaster Condition

### 5.8.1 Description

According to 3GPP TS 22.261 [3] clause 6.31.2.2:

*The 3GPP system shall be able to provide efficient means for a network to inform Disaster Inbound roamers that a Disaster Condition is no longer applicable.*

And according to 3GPP TS 22.261 [3] clause 6.31.2.3:

*Disaster Inbound Roamers shall perform network reselection when a Disaster Condition has ended.*

This means that when a Disaster Condition is no longer applicable, all UEs of the PLMN that was previously with Disaster Condition which are currently served by another PLMN and are currently in 5GMM-IDLE mode will perform PLMN reselection and return to the PLMN that was previously with Disaster Condition. These UEs will then attempt to register to obtain service. This could cause a large number of UEs to migrate from PLMNs without Disaster Condition back to the PLMN which was previously with Disaster Condition, and attempt registration at around the same time, leading to signalling overload in the PLMN previously with Disaster Condition due to the massive return of UEs. Consequently, means are needed to prevent signalling overload in the PLMN previously with Disaster Condition. This is also reflected in the following service requirement of 3GPP TS 22.261 [3] clause 6.31.2.3:

*The 3GPP system shall minimize congestion caused by Disaster Roaming.*

The following question is expected to be studied within this Key Issue:

- How to stagger the return of UEs to the PLMN previously with Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit.

## 5.9 Key Issue #9: Handling of Disaster inbound roaming PLMNs in Manual PLMN selection

### 5.9.1 Description

When a disaster happens, NW becomes unresponsive. As a normal reaction, when a network gets unresponsive, the user can immediately go for a manual PLMN selection.

There can be several PLMNs available in the area. So when the PLMNs are presented to the user, the PLMNs may be for example preferred PLMN, forbidden PLMNs etc. In the current implementation the UE can provide an indication to upper layers on what type of PLMN it is and the upper layers can take action on how they can be presented to the user.

If there are only forbidden PLMNs in the area, all the PLMNs will be displayed as forbidden PLMNs to the user which can be misleading and prevent user from selecting any of those PLMNs.

When the disaster condition happens, user will be denied service and the normal reaction can be to look for a the available networks and the PLMNs are presented to the user. As per the current design the PLMNs that support disaster roaming, which are mostly forbidden PLMNs, will be indicated as forbidden to the users.

This gives a wrong impression to the user that the PLMN is forbidden and will not be chosen by the user. So it is porposed to study the following items for manual PLMN selection

- During Manual PLMN selection, how the upper layers are informed that some of the forbidden PLMNs support disaster roaming.

- What additional information, if any, need to be sent to the upper layers when the PLMNs that support disaster roaming are sent to upper layers.

- Should the PLMN which is under disaster condition be sent to the upper layers if it becomes available?

# 6 Solutions

## 6.0 Mapping Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Key Issues | | | | | | | | |
| Solutions | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | X |  |  |  |  |  | X |  |  |
| 2 | X |  |  |  |  |  |  |  |  |
| 3 | X |  |  |  |  |  |  |  |  |
| 4 | X |  |  |  |  |  |  |  |  |
| 5 | X |  |  |  |  |  |  |  |  |
| 6 |  | X |  |  |  |  |  |  |  |
| 7 |  | X |  |  |  |  |  |  |  |
| 8 |  | X |  |  |  |  |  |  |  |
| 9 |  | X |  |  |  |  |  |  |  |
| 10 |  |  | X |  |  |  |  |  |  |
| 11 |  |  | X |  |  |  |  |  |  |
| 12 |  |  | X |  |  |  |  |  |  |
| 13 |  |  | X |  |  |  |  |  |  |
| 14 |  |  | X |  |  |  |  |  |  |
| 15 |  |  | X |  |  |  |  |  |  |
| 16 |  |  | X |  |  |  | X |  |  |
| 17 |  |  |  | X |  | X |  |  |  |
| 18 |  |  |  | X |  |  |  |  |  |
| 19 |  |  |  | X |  |  |  |  |  |
| 20 |  |  |  | X |  |  |  |  |  |
| 21 |  |  |  |  | X |  |  |  |  |
| 22 |  |  |  |  | X |  |  |  |  |
| 23 |  |  |  |  | X |  |  |  |  |
| 24 |  |  |  |  | X |  |  |  |  |
| 25 |  |  |  |  | X |  |  |  | X |
| 26 |  |  |  |  | X |  |  |  |  |
| 27 |  |  |  |  |  | X |  | X |  |
| 28 |  |  |  |  |  | X |  |  |  |
| 29 |  |  |  |  |  | X |  |  |  |
| 30 |  |  |  |  |  | X |  |  |  |
| 31 |  |  |  |  |  | X |  | X |  |
| 32 |  |  |  |  |  | X |  |  |  |
| 33 |  |  |  |  |  | X |  |  |  |
| 34 |  |  |  |  |  | X |  |  |  |
| 35 |  |  |  |  |  | X |  |  |  |
| 36 |  |  |  |  |  |  | X |  |  |
| 37 |  |  |  |  |  |  | X |  |  |
| 38 |  |  |  |  |  |  | X |  |  |
| 39 |  |  |  |  |  |  | X |  |  |
| 40 |  |  |  |  |  |  | X |  |  |
| 41 |  |  |  |  |  |  | X |  |  |
| 42 |  |  |  |  |  |  | X |  |  |
| 43 |  |  |  |  |  |  | X |  |  |
| 44 |  |  |  |  |  |  |  | X |  |
| 45 |  |  |  |  |  |  |  | **X** |  |
| 46 |  |  |  |  |  |  |  | **X** |  |
| 47 |  |  |  |  |  |  |  | **X** |  |
| 48 |  |  |  |  |  |  |  | **X** |  |
| 49 |  |  |  |  |  |  |  | **X** |  |
| 50 |  |  |  |  |  |  | **X** |  |  |
| 51 |  |  |  |  | **X** |  |  |  | **X** |
| 52 |  |  |  | **X** |  |  |  |  |  |
| 53 |  |  |  |  |  |  | **X** |  |  |
| 54 |  |  |  |  |  |  | **X** |  |  |
| 55 |  |  |  |  |  |  | **X** |  |  |
| 56 |  |  |  |  |  |  |  |  | **X** |
| 57 |  |  |  | **X** |  |  |  |  |  |
| 58 | **X** |  |  |  |  |  |  |  |  |
| 59 | **X** |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  | **X** |

## 6.1 Solution #1: Indicating to the UE, via non-3GPP access, the applicability of a disaster condition to the 3GPP access of the same PLMN

### 6.1.1 Description

#### 6.1.1.1 Introduction

This solution corresponds to KI#1 on Notification of Disaster Condition to the UE (see clause 5.1).

The solution also addresses one of the question in KI#7 on Prevention of signalling overload in PLMNs without Disaster Condition, in particular:

*- "How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit".*

#### 6.1.1.2 Detailed description

This solution is for a UE:

- that supports the non-3GPP access in addition to the 3GPP access;

- that supports NAS over the non-3GPP access;

- that supports connecting to N3WIF;

- that was registered to the same PLMN over 3GPP and non-3GPP access before (and when) the disaster condition occurred;

- that is in 5GMM-CONNECTED mode over the non-3GPP access; and

- that does not register to another PLMN over the 3GPP access while the disaster condition is ongoing.

Also, this solution is for a PLMN with a Disaster Condition (DC) and the PLMN:

- has N3IWF, and the AMF of the PLMN supports the N2 connection from the N3IWF; and

- for which the non-3GPP access network is not affected by the Disaster Condition.

The PLMN X experiences a disaster condition that impacts the 3GPP RAN. The serving AMF determines that a UE which is in 5GMM-CONNECTED mode over the non-3GPP access is within the area of the disaster condition.

The AMF makes this determination that the UE is within the area of the disaster condition based on the last registration area that was provided to the UE over the 3GPP access as follows:

- the UE is also registered to the same AMF (and PLMN) over the non-3GPP access and the UE is in 5GMM-CONNECTED mode over the non-3GPP access;

- the AMF determines that a disaster condition has occurred, where the disaster area is within, or overlaps with, the registration area that was last provided to the UE over the 3GPP access; and

- the last registration area that was provided to the UE over the 3GPP access UE has not changed.

The AMF notifies the UE with a NAS message, e.g. Configuration Update Command message, about a disaster condition has occurred for the 3GPP access. The AMF may provide a list of PLMNs, optionally in a prioritized order, that the UE can use to register on a target PLMN which does not have a disaster condition.

To avoid numerous simultaneous registration attempts on a target PLMN, the AMF may provide a "wait timer" that indicates a period during which the UE should wait before attempting to register on a target PLMN.

The AMF may also provide the UE with an "expected duration of disaster" that represents a time during which the disaster is expected to last and after which UE can attempt to return to PLMN that experienced a disaster condition over the 3GPP access.

NOTE: it is up to the AMF to use an "expected duration of disaster" timer as this timer may not always be accurate with respect to the time when the disaster condition actually ends.

When the UE receives a notification about the disaster condition, the UE, based on local policy, may decide to register to another PLMN (without a disaster condition) over the 3GPP access, or transfer its PDU session(s) from the 3GPP access to the non-3GPP access.

If the UE determines to register to a PLMN (without a disaster condition) over the 3GPP access, the UE uses the list of PLMN, if received from the network, to register on a target PLMN. Additionally, if a "wait timer" is received from the network, the UE starts a timer based on the received "wait timer" value and attempts to registers to a target PLMN (without a disaster condition) after this timer expires. Otherwise if no "wait timer" was received, the UE can immediately attempt to register on a target PLMN. If provided with an "expected duration of disaster" and the the indicated time elapses, the UE may then attempt to return (and register over the 3GPP access) to this PLMN if it is detected.

If the UE determines to not register with another PLMN (without a disaster condition) over the 3GPP access and decides to transfer its PDU session(s) from the 3GPP access to the non-3GPP access, the UE intiates the PDU session establishment procedure to transfer one or more PDU session from the 3GPP access to the non-3GPP access. The UE may deactivate the AS layer of its 3GPP access to save power resulting from any PLMN search on the 3GPP access.

### 6.1.2 Impacts on existing nodes and functionality

The following impacts can be identified:

- AMF

- Notifying the UE over the non-3GPP access about a disaster condition that has impacted the 3GPP access

- Optionally providing a list of target PLMNs to the UE

- Optionally providing a "wait timer" to stagger UE access to a target PLMN

- Optionally providing an "expected duration of disaster" representing the time that the disaster condition is expected to remain

- UE

- Handle of a notification over the non-3GPP access about a disaster condition that impacted the 3GPP access

- Optionally handling a list of PLMNs that the UE can use for registering in a PLMN without a disaster condition

- Optionally handling a "wait timer" to guard when the UE can attempt to register on a target PLMN without a disaster condition

- Optionally handling an "expected duration of disaster" timer to decide when to attempt to return to the PLMN that faced the disaster condition.

- Optionally deactivating the AS layer of the 3GPP access after being notified of a disaster condition that affects the 3GPP access.

## 6.2 Solution #2: Notification of Disaster Condition to the UE via Non-3GPP Access

### 6.2.1 Description

#### 6.2.1.1 Introduction

This solution addresses Key Issue #1: Notification of Disaster Condition to the UE in clause 5.1.

This solution is only applicable when the UE registers to 5G system via both 3GPP access and non-3GPP access.

#### 6.2.1.2 Detailed description

It is assumed that the disaster mainly hit the 3GPP access of a specific PLMN in a specific area. This solution provides methods to support the notification of Disaster Condition to the UE when the UE registers to 5G system via both 3GPP access and non-3GPP access.

The UE can register in the same PLMN or different PLMNs via 3GPP access and non-3GPP access. The UE can register to PLMN via untrusted non-3GPP access or trusted non-3GPP access. Therefore, there are total four scenarios illustrated as below.

**Scenario 1: UE registers in PLMN with Disaster Condition via both 3GPP access and untrusted non-3GPP access**



Figure 6.2.1.2-1. UE registers in PLMN with Disaster Condition via both 3GPP access and untrusted non-3GPP access

Figure 6.2.1.2-1 shows that the UE registers in the PLMN with Disaster Condition via both 3GPP access and untrusted non-3GPP access. The disaster mainly hit the 3GPP access, therefore the UE is only registers to the PLMN with Disaster Condition via untrusted non-3GPP access now.

When the PLMN with Disaster Condition notifies the UE of Disaster Condition via non-3GPP access, it is up to the UE whether select another PLMN without Disaster Condition via 3GPP access or just stay in the current PLMN with Disaster Condition via non-3GPP access.

**Scenario 2: UE registers in PLMN with Disaster Condition via both 3GPP access and trusted non-3GPP access**



Figure 6.2.1.2-2. UE registers in PLMN with Disaster Condition via both 3GPP access and trusted non-3GPP access

Figure 6.2.1.2-2 shows that the UE registers in the PLMN with Disaster Condition via both 3GPP access and trusted non-3GPP access. The disaster mainly hit the 3GPP access, therefore the UE is only registers to the PLMN with Disaster Condition via trusted non-3GPP access now.

When the PLMN with Disaster Condition notifies the UE of Disaster Condition via non-3GPP access, it is up to the UE whether select another PLMN without Disaster Condition via 3GPP access or just stay in the current PLMN with Disaster Condition via non-3GPP access.

**Scenario 3: UE registers in PLMN with Disaster Condition via 3GPP access and registers in PLMN without Disaster Condition via untrusted non-3GPP access**



Figure 6.2.1.2-3. UE registers in PLMN with Disaster Condition via 3GPP access and registers in PLMN without Disaster Condition via untrusted non-3GPP access

Figure 6.2.1.2-3 shows that the UE registers in the PLMN with Disaster Condition via 3GPP access and registers in the PLMN without Disaster Condition via untrusted non-3GPP access. The disaster mainly hit the 3GPP access or the whole PLMN with Disaster Condition, therefore the UE is only registers to the PLMN without Disaster Condition via untrusted non-3GPP access now. The PLMN with Disaster Condition and the PLMN without Disaster Condition are in the same country.

When the PLMN without Disaster Condition notifies the UE of Disaster Condition via non-3GPP access, it is up to the UE whether select one PLMN without Disaster Condition via 3GPP access or just stay in the current PLMN without Disaster Condition via non-3GPP access.

**Scenario 4: UE registers in PLMN with Disaster Condition via 3GPP access and registers in PLMN without Disaster Condition via trusted non-3GPP access**



Figure 6.2.1.2-4. UE registers in PLMN with Disaster Condition via 3GPP access and registers in PLMN without Disaster Condition via trusted non-3GPP access

Figure. 6.2.1.2-4 shows that the UE registers in the PLMN with Disaster Condition via 3GPP access and registers in the PLMN without Disaster Condition via trusted non-3GPP access. The disaster mainly hit the 3GPP access or the whole PLMN with Disaster Condition, therefore the UE is only registers to the PLMN without Disaster Condition via trusted non-3GPP access now. The PLMN with Disaster Condition and the PLMN without Disaster Condition are in the same country.

When the PLMN without Disaster Condition notifies the UE of Disaster Condition via non-3GPP access, it is up to the UE whether select one PLMN without Disaster Condition via 3GPP access or just stay in the current PLMN without Disaster Condition via non-3GPP access.

This solution proposes four different methods to notify the UE of Disaster Condition via non-3GPP access. The proposed methods apply for all four scenarios illustrated above.

Since the PLMN with Disaster Condition knows the disaster area and the PLMN without Disaster Condition is notified of the disaster area based on solution to KI#2: Notification of applicability on Disaster Condition to PLMNs without Disaster Condition, only UEs in the disaster area are notified of Disaster Condition.

**Method 1: AMF notifies the UE of Disaster Condition via non-3GPP access**



Figure 6.2.1.2-5. AMF notifies the UE of Disaster Condition via non-3GPP access

The UE is in 5GMM-CONNECTED mode over non-3GPP access.

**Option 1**: The AMF initiates the NAS transport procedure via non-3GPP access by sending the DL NAS TRANSPORT message to the UE, which includes an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list, etc.

NOTE 1: Which NF or how to trigger the AMF to initiate the NAS transport procedure is based on the solution to KI#2: Notification of applicability on Disaster Condition to PLMNs without Disaster Condition.

**Option 2**: The AMF initiates the generic UE configuration update procedure via non-3GPP access by sending the CONFIGURATION UPDATE COMMAND message to the UE, which includes an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list, etc.

When the UE is registered to PLMN with Disaster Condition via non-3GPP access, the AMF of PLMN with Disaster Condition sends an indication to the UE that Disaster Condition applies. When the UE is registered to PLMN without Disaster Condition via non-3GPP access, the AMF of PLMN without Disaster Condition sends PLMN ID(s) of PLMN(s) with Disaster Condition to the UE.

**Method 2: N3IWF notifies the UE of Disaster Condition via untrusted non-3GPP access**



Figure 6.2.1.2-6. The N3IWF notifies the UE of Disaster Condition via untrusted non-3GPP access

The UE is in 5GMM-CONNECTED mode over non-3GPP access.

1. The N3IWF sends INFORMATIONAL Request message to the UE. The INFORMATIONAL Request message includes an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list, etc.

When the UE is registered to PLMN with Disaster Condition via non-3GPP access, the N3IWF of PLMN with Disaster Condition sends an indication to the UE that Disaster Condition applies. When the UE is registered to PLMN without Disaster Condition via non-3GPP access, the N3IWF of PLMN without Disaster Condition sends PLMN ID(s) of PLMN(s) with Disaster Condition to the UE.

2. The UE sends an empty INFORMATIONAL Response message to the N3IWF to acknowledge the reception of the message.

**Method 3: TNGF notifies the UE of Disaster Condition via trusted non-3GPP access**



Figure 6.2.1.2-7. The TNGF notifies the UE of Disaster Condition via trusted non-3GPP access

The UE is in 5GMM-CONNECTED mode over non-3GPP access.

1. The TNGF sends INFORMATIONAL Request message to the UE. The INFORMATIONAL Request message includes an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list, etc.

When the UE is registered to PLMN with Disaster Condition via non-3GPP access, the TNGF of PLMN with Disaster Condition sends an indication to the UE that Disaster Condition applies. When the UE is registered to PLMN without Disaster Condition via non-3GPP access, the TNGF of PLMN without Disaster Condition sends PLMN ID(s) of PLMN(s) with Disaster Condition to the UE.

2. The UE sends an empty INFORMATIONAL Response message to the TNGF to acknowledge the reception of the message.

**Method 4: TNAP advertises Disaster Condition to the UE**



Figure 6.2.1.2-8. The TNAP advertises Disaster Condition to the UE

1. The TNAP advertises an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list, etc to the UE by using the ANQP protocol.

When the UE is registered to PLMN with Disaster Condition via non-3GPP access, the TNAP of PLMN with Disaster Condition advertises an indication to the UE that Disaster Condition applies. When the UE is registered to PLMN without Disaster Condition via non-3GPP access, the TNAP of PLMN without Disaster Condition advertises PLMN ID(s) of PLMN(s) with Disaster Condition to the UE.

### 6.2.2 Impacts on existing nodes and functionality

UE:

- The UE supports handling of an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list, etc.

- Conditionally, the UE sends INFORMATIONAL Response message to N3IWF/TNGF which acknowledges the reception of an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list and etc.

AMF:

- Optionally, the AMF sends an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list and etc to the UE using DL NAS TRANSPORT message via NAS transport procedure.

- Optionally, the AMF sends an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list and etc to the UE using CONFIGURATION UPDATE COMMAND message via generic UE configuration update procedure.

N3IWF:

- Optionally, the N3IWF sends an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list and etc to the UE using INFORMATIONAL Request message.

TNGF:

- Optionally, the TNGF sends an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list and etc to the UE using INFORMATIONAL Request message.

TNAP:

- Optionally, the TNAP advertises an indication that Disaster Condition applies or the PLMN ID(s) of PLMN(s) with Disaster Condition, the recommended disaster roaming PLMN list and etc to the UE using ANQP protocol.

## 6.3 Solution #3: Notification of Disaster Condition to the UE by RAN sharing

### 6.3.1 Description

It is assumed that when a disaster condition applies, an NG-RAN node of a PLMN without a disaster condition becomes a shared RAN node between the PLMN without a disaster condition and a PLMN where a disaster condition applies. See Solution #9 for the details.

With the assumption above, since the UEs which were served by the PLMN where a disaster condition applies can register to the same PLMN through the shared RAN without any further changes, there is no need to notify the disaster condition to the UE. However, the UEs can recognize that a disaster condition applies to the current PLMN from the broadcast information, e.g. the barring information of the cell on which the UE is camping includes any information related to Access Identity 3.

NOTE 1: It is expected that the UE and the NG-RAN will be made capable of handling Access Identity 3 via conclusions for Key Issue #7.

NOTE 2: When a UE recognizes that a disaster condition applies to the current PLMN from the broadcast information, the UE considers itself configured with Access Identity 3.

### 6.3.2 Impacts on existing nodes and functionality

UE

The UE recognizes that a disaster condition applies to the current PLMN from barring information containing information related to a disaster condition (i.e. Access Identity 3).

NG-RAN

The NG-RAN should be enhanced to broadcast barring information related to Access Identity 3.

## 6.4 Solution #4: Disaster condition information delivered to UE via broadcast

### 6.4.1 Introduction

This paper proposes a solution for Key Issue#1:

Key Issue #1: Notification of Disaster Condition to the UE

In this solution, PLMN D is the PLMN with Disaster Condition and PLMN A is the PLMN without Disaster Condition.

This solution addresses how to notify Disaster Condition to the UE.

### 6.4.2 Detailed description

In this solution, it is assumed that PLMN A can obtain the Disaster Condition information based on the solution of KI#2. PLMN A broadcasts the Disaster Condition information in the area where the Disaster Condition applies when Disaster Condition starts in PLMN D.

The Disaster Condition information contains the indication that Disaster Condition applies to PLMN D, disaster area (e.g. TA list), and recommended PLMN(s). When the Disaster Condition happens to the current PLMN, the UE will perform the PLMN selection based on the recommended PLMN(s).

PLMN A may broadcast the Disaster Condition information by MIB, SIB1, or SIBx. If the information are broadcasted in SIBx rather than MIB or SIB1 (Considering that the Disaster Condition happens very infrequently, and scarcity of wireless resources), UE shall request the system information in SIBx on demand as specified in TS 38.331[13], clause 5.2.2.3, and the timing of requesting the Disaster Condition information in SIBx should be determined by UE.

A UE determines to request the Disaster Condition information in SIBx if the UE supports the MINT feature and there is no available PLMN except for PLMNs in the "Forbidden PLMN" data field in the UE.

If there is no assisted information (eg. the indication that Disaster Condition applies to PLMN D, disaster area (e.g. TA list), and recommended PLMN(s)) used for PLMN selection when Disaster Condition applies, UE should request randomly the system information in SIBx from the available PLMN(s) which are in the "Forbidden PLMN" data field.

NOTE: Extension of broadcast signalling is subject to agreement of RAN WGs.

### 6.4.3 Impacts on existing nodes and functionality

UE:

- support for receiving the Disaster Condition information via MIB, SIB, or SIBx;

- determine the timing of requesting the Disaster Condition information in SIBx on demand from the PLMN A;

RAN of PLMN A:

- support for providing the Disaster Condition information via broadcast.

## 6.5 Solution #5

### 6.5.1 Description

#### 6.5.1.1 Introduction

This solution addresses the following key issue:

Key Issue #1: Notification of Disaster Condition to the UE

#### 6.5.1.2 Detailed description

The UE determines that Disaster Condition applies for a PLMN (called PLMN D) when:

a) there is no available cell of PLMN D and broadcast signalling received via an available cell of another PLMN (called PLMN A) indicates that PLMN A can accept Disaster Inbound Roamers from PLMN D.

NOTE: Extension of broadcast signalling is subject to agreement of RAN WGs.

In order to enable UE's determination in case a the cell of PLMN A broadcasts that PLMN A can accept Disaster Inbound Roamers from PLMN D, based on solution selected for key issue #3.

UE's determination that the Disaster Condition applies for a PLMN is used in solutions for Key Issue #5.

### 6.5.2 Impacts on existing nodes and functionality

The UE is impacted with determination that Disaster Condition applies for a PLMN as described in clause 6.5.1.

Whether the NG-RAN of a PLMN without Disaster Condition is impacted with additional broadcast of indication that the PLMN without Disaster Condition can accept Disaster Inbound Roamers from a PLMN with Disaster Condition, depends on solution selected for key issue #3.

NOTE: If the indication that the PLMN without Disaster Condition can accept Disaster Inbound Roamers from a PLMN with Disaster Condition, is provided as part of a PWS message, the broadcast in the RAN of the PLMN without Disaster Condition can be done using existing PWS mechanisms.

## 6.6 Solution #6: O&M-based solution for Key Issue #2

### 6.6.1 Introduction

This solution addresses Key Issue #2: Notification of applicability on Disaster Condition to PLMNs without Disaster Condition in clause 5.2.

### 6.6.2 Solution description

The Disaster Condition caused RAN unavailability can be treated as a network fault. As per 3GPP TS 32.101 [5] for defining the legacy PLMN management functional architecture, the fault management is a basic management function provided by the PLMN NMS.

Furthermore, as per 3GPP TS 28.533 [6] for the SBA based NMS defined for 5GS, the network fault supervision service is also a basic management service provided by the PLMN NMS for the management of the 3GPP network.

The PLMN NMS can directly interface with different network elements within 3GPP network, including core network functions (e.g. AMF, SMF) and RAN nodes (e.g. gNB) via O&M operations. The required O&M operations may or may not be standardized, i.e. to use the proprietary implementation.

The O&M-based solution for each question within Key Issue #2 is described as below:

*"- How to deliver the information on the Disaster Condition to the PLMNs without Disaster Condition;"*

When the Disaster Condition applies to the UE's current seving PLMN, the Disaster Condition can be detected by serving PLMN NMS automatically or artificially. The serving PLMN NMS collects and stores the disaster PLMN ID (i.e. the current serving PLMN ID) and disaster area information. Hereafter, the serving PLMN NMS sends the disaster PLMN ID and disaster area information to other PLMN NMS without Disaster Condition which can provide the disaster roaming for the UE. The PLMN without Disaster Condition which can provide the disaster roaming for the UE is called Disaster Roaming PLMN and used hereafter. The Disaster Roaming PLMN NMS stores the received disaster PLMN ID and disaster area information and sends them to its core network functions (e.g. AMF) and RAN nodes (e.g. gNBs) based on the disaster area information, i.e. the core network functions and RAN nodes have overlapped serving area with the disaster area information.

NOTE: The communication between serving PLMN NMS and Disaster Roaming PLMN NMS, between Disaster Roaming PLMN NMS and Disaster Roaming PLMN core network functions and RAN nodes are implementation specific, e.g. via O&M operations.

*"- Who or which entity decides the Disaster Condition;"*

It is serving PLMN NMS to decide the Disaster Condition based on regulatory requirements or operator policy of the serving PLMN (i.e. the PLMN with Disaster Condition).

*"- How to provide information on the area where Disaster Condition applies."*

The serving PLMN NMS collects the disaster area information where Disaster Condition applies. The PLMN NMS can know this disaster area information based on O&M operations, e.g. by counting the number of fault gNBs due to Disaster Condition and then collecting the TAs corresponding their coverage area.

The end-to-end flow of O&M-based solution for KI#2 can be shown in Figure 6.6.2:



Figure 6.6.2: End-to-end flow of O&M-based solution for KI#2

### 6.6.3 Impacts on existing nodes and functionality

There is no impact on the UE.

NG-RAN of PLMN without Disaster Condition: To receive and store the disaster PLMN ID and disaster area information sent by the PLMN NMS via O&M operations.

AMF of PLMN without Disaster Condition: To receive and store the disaster PLMN ID and disaster area information sent by the PLMN NMS via O&M operations.

There are impacts on PLMN NMS but the required O&M operations may not to be standardized, i.e. by proprietary implementation.

## 6.7 Solution #7

### 6.7.1 Description

#### 6.7.1.1 Introduction

This solution addresses the following key issue:

Key Issue #2: Notification of applicability on Disaster Condition to PLMNs without Disaster Condition

This solution enables a PLMN (called PLMN A) without Disaster Condition to determine that Disaster Condition applies (or no longer applies) for another PLMN (called PLMN D) in an area, based on means out-of-scope of 3GPP.

PLMN A and PLMN D are in the same country.

#### 6.7.1.2 Detailed description

A PLMN (called PLMN A) without Disaster Condition which is in the same country as another PLMN (called PLMN D), is informed that Disaster Condition applies (or no longer applies) for PLMN D in an area based on means out-of-scope of 3GPP.

The decision on applicability (or applicability no longer) of the Disaster Condition for PLMN D is made by PLMN D, based on regulatory requirements or operator policy of PLMN D.

If PLMN A is informed that Disaster Condition applies for PLMN D in an area and PLMN A is able to accept Disaster Inbound Roamers from PLMN D in the area, then PLMN A adds using O&M the PLMN ID of PLMN D into the "disaster roaming PLMN list" configured in PLMN A's NG-RAN nodes serving the area.

If PLMN A is informed that Disaster Condition no longer applies for PLMN D in an area, then PLMN A removes using O&M the PLMN ID of PLMN D from the "disaster roaming PLMN list" configured in PLMN A's NG-RAN nodes serving the area.

### 6.7.2 Impacts on existing nodes and functionality

The NG-RAN of the PLMN without Disaster Condition is impacted with possibility to be configured with the "disaster roaming PLMN list as described in clause 6.7.1.

There are impacts on PLMN NMS but the required O&M operations may not to be standardized, i.e. by proprietary implementation.

## 6.8 Solution #8

### 6.8.1 Description

#### 6.8.1.1 Introduction

This solution addresses the following key issue:

Key Issue #2: Notification of applicability on Disaster Condition to PLMNs without Disaster Condition

This solution enables a PLMN (called PLMN A) without Disaster Condition to determine that Disaster Condition applies (or no longer applies) for another PLMN (called PLMN D) in an area, based on information received from the CBE (Cell Broadcast Entity). The CBE could be a CBE that is operated under responsibility of the regulator.

PLMN A and PLMN D are in the same country.

This solution requires deployment of CBE and CBC (and PWS-IWF) or CBCF.

#### 6.8.1.2 Detailed description

When PLMN D detects service interruptions and failures in PLMN D caused by a disaster, PLMN D informs the CBE using means out of scope of 3GPP.

If the CBE decides subject to regulatory requirements that the Disaster Condition applies for PLMN D and that UEs of PLMN D can use disaster roaming in another PLMN (called PLMN A) in the area, the CBE provides the CBC or the CBCF of PLMN A with a message (e.g. Disaster Roaming Command) with (updated) "disaster roaming PLMN and area list" containing PLMN D and the area. If the CBE provided a "disaster roaming PLMN and area list" previously, the CBE also indicates the previous "disaster roaming PLMN and area list" in the same message.

Upon receiving the message:

- if PLMN A is able to provide disaster roaming to UEs of PLMN D in the area as indicated in the (updated) "disaster roaming PLMN and area list", the CBC or the CBCF of PLMN A informs the CBE accordingly (e.g. by sending Disaster Roaming Command Ack) and provides the (updated) "disaster roaming PLMN and area list" to the AMF(s) of PLMN A which serve at least part of an area in the (updated) "disaster roaming PLMN and area list" or the previous "disaster roaming PLMN and area list", if received; or

- if PLMN A is unable to provide disaster roaming to UEs of PLMN D in the area as indicated in the (updated) "disaster roaming PLMN and area list", the CBC or the CBCF of PLMN A informs the CBE accordingly (e.g. by sending Disaster Roaming Command Reject).

When an AMF of PLMN A receives the "disaster roaming PLMN and area list" from the CBC (via the PWS-IWF) or the CBCF, the AMF removes the stored "disaster roaming PLMN and area list", if any, and if the AMF serves at least part of an area of the "disaster roaming PLMN and area list" provided by the CBC (via the PWS-IWF) or the CBCF, the AMF stores the "disaster roaming PLMN and area list".

When PLMN D resolves the service interruptions and failures in PLMN D caused by the disaster, PLMN D informs the CBE using means out of scope of 3GPP. If the CBE decides subject to regulatory requirements that the Disaster Condition no longer applies for PLMN D, the CBE provides the CBC or the CBCF with a message with an updated "disaster roaming PLMN and area list" not containing PLMN D and the area, and the previous "disaster roaming PLMN and area list".

Upon receiving the message, the CBC (via the PWS-IWF) or the CBCF provides the updated "disaster roaming PLMN and area list" to the AMF(s) of PLMN A which serve at least part of an area in the updated "disaster roaming PLMN and area list" or the previous "disaster roaming PLMN and area list".

When the AMF receives the "disaster roaming PLMN and area list" from the CBC (via the PWS-IWF) or the CBCF, the AMF removes the stored "disaster roaming PLMN and area list", if any, and if the AMF serves at least part of an area of the "disaster roaming PLMN and area list" provided by the CBC (via the PWS-IWF) or the CBCF, the AMF stores the "disaster roaming PLMN and area list".

Example flow can be found in figure 6.8.1.2-1.



Figure 6.8.1.2-1: CBE informing PLMN A without Disaster Condition with deployed CBCF that UEs of PLMN D with Disaster Condition can use disaster roaming in PLMN A

### 6.8.2 Impacts on existing nodes and functionality

The CBE is impacted with sending to the CBC or the CBCF a message (e.g. Disaster Roaming Command) with (updated) "disaster roaming PLMN and area list" and conditionally also the previous "disaster roaming PLMN and area list", as described in clause 6.8.1.

The CBC (and the PWS-IWF) or the CBCF are impacted with sending to impacted AMF(s) a message (e.g. Disaster Roaming Command) with (updated) "disaster roaming PLMN and area list" and conditionally also the previous "disaster roaming PLMN and area list", upon reception of the same from the CBE, as described in clause 6.8.1, and with providing CBE with rejection (e.g. Disaster Roaming Command Reject).

The AMF is impacted with managing the stored "disaster roaming PLMN and area list", upon reception of the "disaster roaming PLMN and area list" from the CBC (via the PWS-IWF) or CBCF, as described in clause 6.8.1.

## 6.9 Solution #9: Notification of applicability on Disaster Condition to PLMNs without Disaster Condition by RAN sharing

### 6.9.1 Description

When a government decides to initiate a disaster condition in an area for a PLMN (PLMNDC), an AMF of PLMNDC is informed that a disaster condition applies to PLMNDC associated with information on the disaster area.

NOTE 1: How the AMF of PLMNDC is informed by the government, is out of the scope of 3GPP.

After being informed, the AMF of PLMNDC notifies to NG-RAN nodes of a PLMN without disaster condition (PLMNNO DC) in the disaster area.

When a government decides to terminate a disaster condition, the AMF of PLMNDC is informed that a disaster condition no longer applies.

NOTE 2: How the AMF of PLMNDC is informed by the government, is out of the scope of 3GPP.

After being informed, the AMF of PLMNDC notifies to the NG-RAN nodes of PLMNNO DC that a disaster condition no longer applies.

In order to be able to exchange an NGAP message when a disaster condition applies or no longer applies, if PLMNNO DC has an SLA to support disaster condition applied to PLMNDC in an area, the NG Setup procedure is performed between all NG-RAN nodes of PLMNNO DC covering the area and AMF(s) of PLMNDC covering the area in advance. Neither the AMFs nor the NG-RAN nodes shall use the established N2 connection until a disaster condition applies.

### 6.9.2 Impacts on existing nodes and functionality

NG-RAN

- After the NG Setup with an AMF of a different PLMN, the NG-RAN node shall not use the N2 connection until being notified, by the AMF, that a disaster condition applies.

- The NG-RAN needs to be able to interpret the notification in NGAP that a disaster condition (no longer) applies.

AMF

- After the NG Setup with an NG-RAN node of a different PLMN, the AMF shall not use the N2 connection until a disaster condition applies.

- The AMF needs to be able to send the notification in NGAP that a disaster condition (no longer) applies.

## 6.10 Solution #10: Indication of accessibility from other PLMNs without Disaster Condition to the UE by RAN sharing

It is assumed that when a disaster condition applies, an NG-RAN node of a PLMN without a disaster condition becomes a shared RAN node between the PLMN without a disaster condition and a PLMN where a disaster condition applies. See Solution #9 for the details.

NOTE: The shared RAN node does not broadcast the same information which had been broadcast by the NG-RAN node of a PLMN with a disaster condition. As a result, several features such as CAG are not supported.

With the assumption above, since the UEs which were served by the PLMN where a disaster condition applies can register to the same PLMN through the shared RAN without any further changes, there is no need to newly indicate accessibility. In this case, the broadcast information from the shared RAN serves as an indication that the UE can access the cell.

### 6.10.2 Impacts on existing nodes and functionality

NG-RAN

Because the NG-RAN node is shared to a PLMN to which a disaster condition applies, there is a restriction in the number of networks that can be share the NG-RAN node.

NOTE: The maximum number of networks (i.e. PLMNs and NPNs) broadcast by a cell is 12 and 6 for an NR cell and an E-UTRA cell, respectively. For example, if a gNB is shared to three other PLMNs for handling of disaster condition according to Solution #9, the gNB can be shared to eight other networks.

## 6.11 Solution #11: DRS-supported PLMN list

### 6.11.1 Introduction

This is a solution for Key Issue#3, the principles are as follows:

Key Issue #3: Indication of accessibility from other PLMNs without Disaster Condition to the UE.

The basic idea of this solution is to configure UE with a Disaster Roaming Service (DRS)-supported PLMN list, the PLMN in the DRS-supported PLMN list is able to provide the Disaster Condition roaming service for the UE from the PLMN with Disaster Condition when the Disaster Condition happens.

### 6.11.2 Detailed description

For convenience on description, PLMN D is the PLMN with Disaster Condition and PLMN A is the PLMN without Disaster Condition.

To make this solution work, a DRS-supported PLMN list is proposed to be configured in the UE by the PLMN D before the Disaster Condition happens. The PLMN in the DRS-Supported PLMN list does not have the roaming agreements with the PLMN D but is able to provide the Disaster Condition roaming service for the UE when the Disaster Condition happens to PLMN D.

The determination of the DRS-Supported PLMN list can be based on:

- the indication of accessibility to Disaster Inbound Roamers from the PLMNs without Disaster Condition before Disaster Condition happens; or

- the agreements between PLMNs on the Disaster Condition handling.

The PLMN D can include the DRS-supported PLMN list in the following message before the Disaster Condition happens:

- REGISTRATION ACCEPT message; or

- CONFIGURATION UPDATE COMMAND message.

NOTE: The DRS-supported PLMN list may be provided by the PLMN D to the UE over non-3GPP access if any before the Disaster Condition happens.

The UE determines that PLMN A can accept "Disaster Inbound Roamers" from PLMN D if:

a) PLMN A is in the DRS-supported PLMN list; and

b) PLMN A's NG-RAN cell broadcasts "disaster roaming PLMN list" including PLMN ID of PLMN D (as defined in solution#13)

### 6.11.3 Impacts on existing nodes and functionality

UE:

- support for receiving DRS-supported PLMN list; and

- support for determining the accessibility of other PLMNs without Disaster Condition based on DRS-supported PLMN list.

UDM of HPLMN:

- support for providing DRS-supported PLMN list.

AMF of registered PLMN (with Disaster Condition):

- support for providing DRS-supported PLMN list.

## 6.12 Solution #12: Broadcast of disaster roaming indication

This solution addresses the Key Issue #3 "Indication of accessibility from other PLMNs without Disaster Condition to the UE".

### 6.12.1 Detailed description

In the description, PLMN D is subject to **d**isaster and PLMN A is **a**live and not subject to disaster.

PLMN A is informed of the disaster condition in PLMN D through any of the solutions for Key Issue #2. Once the PLMN A is prepared to accept inbound roamers from PLMN D, PLMN A shall update its broadcast information (System Information) to include an indication of "disaster roaming active" condition.

The design of the broadcast information shall take into account the following requirements:

1. During the PLMN search, a UE's first evaluation of suitability is based on the PLMN ID broadcast by the cell. If the PLMN ID is present in the list of forbiddden PLMNs or 5GS forbidden tracking areas for roaming, the UE will not read further system information from the cell and will consider the cell as not suitable. Hence an indication that a PLMN is providing disaster inbound roaming has to be included along with its PLMN ID information.

2. A UE that is a subscriber of PLMN B (another PLMN in the same area, but not subject to disaster) may also be performing a PLMN search due to a loss of coverage. In this case if the UE finds no cell of PLMN B but a cell of PLMN A which is broadcasting the "disaster roaming active" condition, this may lead to the UE assuming that PLMN B is experiencing a disaster condition. To avoid this ambiguity, it is necessary to include in the broadcast information the PLMN ID or a list of PLMN IDs that are subject to the disaster. This information may be broadcast along with the indication of "disaster roaming active" condition or in a separate System Information.

3. The SIB1 message is size constrained. Adding another list of PLMN IDs may not be scalable in some deployments (e.g., if there is already a high number of network sharing PLMNs). It is prefereable to have a new system information with PLMN IDs subject to disaster. This will also avoid impacts to PLMN A's own subscribers, who need not acquire this new information.

4. Broadcasting the "disaster roaming active condition" in SIB1 and not broadcasting in SIB X additional PLMN IDs for which disaster roaming is active indicates that disaster roaming is allowed for UEs from any PLMN. This is useful for the case where all PLMNs in the area, except PLMN A, are facing disaster condition.

#### 6.12.1.1 Broadcast Indication of Disaster Roaming condition

The PLMN A shall broadcast an indication that it is accepting UEs due to a disaster condition. The "disaster roaming active" condition is indicated as a single bit optional element in the *SIB1* of the cell*.*

The PLMN A shall broadcast the list of PLMN IDs which are not operational due to a disaster situation and whose subscribers or roaming UEs are allowed to attempt to roam into PLMN A. This information is broadcast in a new SIB type.

NOTE: Introduction of new information in SIB1, introduction of new SIB type and split of information between SIB1 and new SIB is subject to RAN2 agreement.

### 6.12.2 Impacts on existing nodes and functionality

NG-RAN: new fields in SIB1, new SIB X

UE: Cell selection and PLMN selection criteria

## 6.13 Solution #13

### 6.13.1 Description

#### 6.13.1.1 Introduction

This solution addresses the following key issue:

Key Issue #3: Indication of accessibility from other PLMNs without Disaster Condition to the UE

This solution is based on a cell of a PLMN without Disaster Condition broadcasting "disaster roaming PLMN list" indicating one or more PLMNs with Disaster Condition for which the PLMN without Disaster Condition is able to provide disaster roaming.

#### 6.13.1.2 Detailed description

When a PLMN without Disaster Condition (called PLMN A) is informed that Disaster Condition applies for another PLMN (called PLMN D) in an area and PLMN A is able to accept Disaster Inbound Roamers from PLMN D in the area, then PLMN A configures PLMN A's NG-RAN cells serving the area to broadcast "disaster roaming PLMN list" including PLMN ID of PLMN D.

NOTE 1: Extension of broadcast signalling is subject to agreement of RAN WGs.

Depending on solution selected for Key Issue #2, PLMN A's NG-RAN cells are configured for broadcasting "disaster roaming PLMN list" using O&M or by the AMFs of PLMN A.

A UE determines that PLMN A without Disaster Condition can accept Disaster Inbound Roamers from PLMN D with Disaster Condition if:

a) PLMN A's NG-RAN cell broadcasts "disaster roaming PLMN list" including PLMN ID of PLMN D;

b) PLMN A is in UE's list of forbidden PLMNs; and

NOTE 2: If PLMN A is not in UE's list of forbidden PLMNs, there is no need to determine that PLMN A can accept Disaster Inbound Roamers from PLMN D - the UE can select PLMN A and register in PLMN A using the legacy principles.

c) PLMN D is HPLMN of the UE or is not in UE's list of forbidden PLMNs.

UE's determination that PLMN A without Disaster Condition can accept Disaster Inbound Roamers from PLMN D with Disaster Condition is used in solutions for Key Issue #5.

### 6.13.2 Impacts on existing nodes and functionality

The UE is impacted with determination that the PLMN without Disaster Condition can accept Disaster Inbound Roamers from the PLMN with Disaster Condition as described in clause 6.13.1.

The NG-RAN of the PLMN without Disaster Condition is impacted with additional broadcast of "disaster roaming PLMN list as described in clause 6.13.1.

Whether the AMF of the PLMN without Disaster Condition is impacted with configuring NG-RAN of the PLMN without Disaster Condition to broadcast "disaster roaming PLMN list" depends on solution selected for Key Issue #2.

NOTE: If the NG-RAN of the PLMN without Disaster Condition is configured using O&M, the AMFs of the PLMN without Disaster Condition are not impacted.

## 6.14 Solution #14

### 6.14.1 Description

#### 6.14.1.1 Introduction

This solution addresses the following key issue:

Key Issue #3: Indication of accessibility from other PLMNs without Disaster Condition to the UE

This solution is based on a cell of a PLMN without Disaster Condition broadcasting a PWS message containing "disaster roaming PLMN list" indicating one or more PLMNs with Disaster Condition for which the PLMN without Disaster Condition is able to provide disaster roaming.

This solution requires deployment of PWS.

#### 6.14.1.2 Detailed description

When CBE is informed that Disaster Condition applies for a PLMN (called PLMN D) in an area and decides that a PLMN (called PLMN A) without Disaster Condition is to serve Disaster Inbound Roamers from PLMN D in the area and PLMN A is able to provide disaster roaming to UEs of PLMN D in the area, the CBE will trigger the CBCF/PWS-IWF to broadcast a PWS message in PLMN A. The PWS message will be composed as follows:

a) the Message Identifier is set to a newly reserved disaster-roaming-possible value; and

b) the content of the PWS message contains the "disaster roaming PLMN list", including PLMN ID of PLMN D.

A UE determines that PLMN A without Disaster Condition can accept Disaster Inbound Roamers from PLMN D with Disaster Condition if:

a) the UE receives a PWS message via PLMN A's NG-RAN cell and:

1) the Message Identifier of the PWS message is set to the disaster-roaming-possible value; and

2) the content of the PWS message contains the "disaster roaming PLMN list" including PLMN ID of PLMN D; and

b) PLMN A is in UE's list of forbidden PLMNs; and

NOTE: If PLMN A is not in UE's list of forbidden PLMNs, there is no need to determine that PLMN A can accept Disaster Inbound Roamers from PLMN D - the UE can select PLMN A and register in PLMN A using the legacy principles.

c) PLMN D is HPLMN of the UE or is not in UE's list of forbidden PLMNs.

### 6.14.2 Impacts on existing nodes and functionality

The UE is impacted with determination that the PLMN without Disaster Condition can accept Disaster Inbound Roamers from the PLMN with Disaster Condition as described in clause 6.14.1.

The CBE is impacted with composition of a PWS message of a particular Message Identifier and a particular content as described in clause 6.14.1.

NOTE: The CBCF/PWS-IWF, the AMF and the NG-RAN of the PLMN without Disaster Condition are not impacted as the PWS message is transported to the UE using existing PWS mechanisms.

## 6.15 Solution #15: List if PLMNs to be used while in Disaster condition

### 6.15.1 General

The solution aims to solve the below study items in key issue #3

- Which PLMN(s) are responsible for indicating their accesibility to Disaster Inbound Roamers;

- How other PLMN(s) than the PLMN with Disaster Condition indicate that they can accommodate Disaster Inbound Roamer; and

- What information can be provided to potential Disaster Inbound Roamers.

UE is provided with "List of PLMNs to be used while in Disaster condition". The list can be configured in the USIM or stored in the ME. List can also be dynamically updated via NAS signalling ( e.g when the UE is not in home country).

### 6.15.2 Solution description

When a disaster happens, the serving PLMN get unresponsive and so it is good to prepare the UE for disaster even before the disaster happens. So it is always better to provide the UE with the information that it can use to minimize the service interruption before the disaster happens in the form of a "List of PLMNs to be used while in Disaster condition". In reality the "List of PLMNs to be used while in Disaster condition" will contain the forbidden PLMNs which are forbidden in normal scenarios.

NOTE 1: It is FFS on how many PLMNs can be configured in the "List of PLMNs to be used while in Disaster condition" .

The list can be

a) Stored in the SIM card

b) Stored in the Non Volatile memory of the ME

c) Provided by NAS signalling messages.

Serving PLMN (HPLMN in most cases) can arrange the PLMNs in "List of PLMNs to be used while in Disaster condition" in the particular order so as to direct the UE to different PLMNs to avoid the overload on the network. In addition to the PLMN IDs of the PLMN, there can be a timer associated which indicates a 'minimum wait time' that the UE should wait to perform registration on the PLMN following a disaster condition.

The PLMNs that support disaster inbound roamers may indicate in the system information if they supports disaster inbound roaming.

NOTE 2: It is up to RAN2 to decide how the PLMN that supports disaster inbound roaming is indicated in the system information block.

If the UE gets an indication from a PLMN that it supports disaster inbound roaming and if the PLMN is also present in the "List of PLMNs to be used while in Disaster condition", then the UE can consider the PLMN for disaster inbound roaming.

### 6.15.3 Impacts on existing nodes and functionality

A new PLMN list is provided to the UE which is either pre-configured or provisioned via NAS signalling.

- UE needs to handle a new list which is "List of PLMNs to be used while in Disaster condition".

- AMF needs to provide the UE with a new list which is "List of PLMNs to be used while in Disaster condition"

- RAN needs to inform the UE whether it can accept inbound roamers.

## 6.16 Solution #16: Solution for indication of accessibility from other PLMNs without Disaster Condition to the UE and for prevention of signalling overload in PLMNs without Disaster Condition using Access Identities

### 6.16.1 Introduction

This is a solution for Key Issue #3 (Indication of accessibility from other PLMNs without Disaster Condition to the UE) and Key Issue #7 (Prevention of signalling overload in PLMNs without Disaster Condition).

The solution addresses all questions under Key Issue #3, as well as the first and third questions to be studied under Key Issue #7, namely:

- How to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition available in the area where the Disaster Condition applies, so as to share the load as evenly as possible between the PLMNs without Disaster Condition; and

- How to use new Access Identity 3 for the purpose of Disaster Inbound Roamer access control and signalling overload prevention in the PLMNs without Disaster Condition.

### 6.16.2 Detailed description

The UE can be provisioned with one or more Access Identities allocated for disaster roaming.

The Access Identities allocated for disaster roaming can be:

a) pre-configured in the ME;

b) pre-configured in the USIM;

c) sent to the UE by the network using the UE parameters update procedure (before a Disaster Condition applies); or

d) sent to the UE by the network using the steering of roaming procedure (before a Disaster Condition applies).

NOTE 1: The use of Access Identities other than Access Identity 3 for disaster roaming is subject to SA1 agreement.

Only the Access identities allocated for disaster roaming provisioned by the network are used by the UE, if both Access identities allocated for disaster roaming provisioned by the network and pre-configured Access identities allocated for disaster roaming are present. If no Access identities allocated for disaster roaming are provisioned by the network, and the UE has pre-configured Access identities allocated for disaster roaming in both the USIM and the ME, then only the pre-configured Access identities allocated for disaster roaming in the USIM are used.

Upon being notified that a Disaster Condition applies to the registered PLMN, the UE shall determine which Access Identity it shall use when performing an access attempt in a PLMN offering disaster roaming by applying a hash function to its IMSI.

NOTE 2: The output of the hash function maps to one of the Access Identities allocated for disaster roaming.

Upon being notified that a Disaster Condition applies, the PLMNs without Disaster Condition shall set the bit in the *uac-BarringForAccessIdentity* contained in "UAC barring parameter" in SIB for one or more of the Access Identities allocated for disaster roaming to zero.

NOTE 3: For which Access Identities a PLMN without Disaster Condition sets the bit to zero in the *uac-BarringForAccessIdentity* contained in "UAC barring parameter" in SIB is up to operator policy and roaming agreements. How many bits the PLMN sets to zero can be commensurate to the capacity of the PLMN to accommodate Disaster Inbound roamers.

NOTE 4: An NG-RAN node can adjust the rate at which access attempts of Disaster Inbound Roamers are allowed during the access barring check with a granularity which depends on the number of Access Identities allocated for disaster roaming, e.g. if 4 Access Identities are allocated, the rate can be set with a granularity of 25%.

NOTE 5: The use of the bitmap in *uac-BarringForAccessIdentity* to indicate accessibility to the Disaster Inbound Roamers deviates from the existing semantic of uac-BarringForAccessIdentity and is subject to RAN2 agreement.

When performing disaster roaming PLMN selection, the UE shall not consider the PLMNs which have not set the bit in the *uac-BarringForAccessIdentity* contained in "UAC barring parameter" in SIB for the Access Identity which the UE has determined to use to zero as PLMN selection candidates. If after completing the procedure, the UE was unable to successfully register on a PLMN, the UE shall randomly select a PLMN among the available PLMNs which have set a bit to zero in the *uac-BarringForAccessIdentity* contained in "UAC barring parameter" in SIB for an Access Identity allocated for disaster roaming different from the Access Identity which the UE has determined to use.

### 6.16.3 Impacts on existing nodes and functionality

UE

- support for handling of Access Identities allocated for disaster roaming.

UDM of HPLMN

- optionally, support for providing Access Identities allocated for disaster roaming.

AMF of registered PLMN (with Disaster Condition)

- optionally, support for providing Access Identities allocated for disaster roaming.

RAN of PLMNs indicating that they can accept Disaster Inbound Roamers:

- support for determining for which Access Identities to set the bit to zero in the *uac-BarringForAccessIdentity* contained in "UAC barring parameter" in SIB.

## 6.17 Solution #17: Confining the service area of an inbound disaster roaming UE to the area of the disaster condition

### 6.17.1 Description

#### 6.17.1.1 Introduction

This solution corresponds to KI#4 on Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition (see clause 5.1), however the solution is specific to the following aspect of KI#4:

- *"How a Disaster Roaming PLMN can limit the area of service to Inbound Disaster Roamers to the region where Disaster Condition applies"*.

This solution also corresponds to KI#6 and in particular the following aspects of KI#6:

*- When and how to deliver the information that Disaster Condition is no longer applicable to Disaster Inbound Roamers;*

*- How Disaster Inbound Roamer UEs perform network selection when notified that Disaster Condition is no longer applicable.*

#### 6.17.1.2 Detailed description

This solution assumes that the AMF in the PLMN without a disaster condition knows the area of the disaster condition of the PLMN with the disaster condition. For example, this can be based on the solution for KI#2 and in particular on the solution for "*How to provide information on the area where Disaster Condition applies*".

When an inbound disaster roaming UE registers onto a PLMN without a disaster condition, the serving AMF may determine a registration area for the UE such that the 5GS tracking area list contains only those tracking area identities (TAIs) that overlap with the known area of the disaster condition.

The AMF also sends the Service area list IE to the UE such that the TAIs in the service area list are set to "allowed tracking areas" and shall only contain the TAIs of the PLMN that overlap with the known area of the disaster condition.

NOTE 1: how the AMF makes the determination of its TAIs which map to the area of disaster condition of another PLMN is implementation specific.

To enable a finer control of the area where the inbound disaster roaming UE can have service such that the area overlaps with the area of the disaster condition, the AMF may provide a list of cell identities to the UE. This list represents the list of (identifies of the) cell(s) that overlap with the area of the disaster condition and on which the UE can get normal service. Otherwise the UE will not get normal service if the UE is camped on any cell for which the cell identity is not part of this list.

NOTE 2: how the AMF makes the determination of which cells map to the area of disaster condition of another PLMN is implementation specific.

The UE may receive a list of cell identities from the AMF.

NOTE 3: the list of cell identities that is received from the AMF is not provided by the NAS to the AS layer in the UE.

When the UE receives a list of cell identities from the AMF, the NAS in the UE also receives the cell identity of the cell on which the UE is currently camped from the AS layer in the UE.

NOTE 4: the NAS receives the cell identity of the cell on which the UE is camped on from the AS layer in the UE using implementation specific means.

The UE verifies if the cell identity that is received from the AS layer is part of the list of cell identities that was received from the AMF. If yes, the UE remains in state 5GMM-REGISTERED.NORMAL-SERVICE. Otherwise, if the identity of the cell on which the UE is camped is not part of the received list, the UE determines that it cannot get normal service and enters 5GMM-REGISTERED.NON-ALLOWED-SERVICE state, and upon entering the 5GMM-REGISTERED.NON-ALLOWED-SERVICE state and the UE is in 5GMM-IDLE mode, the UE may trigger PLMN search to search for higher priority PLMN.

### 6.17.2 Impacts on existing nodes and functionality

The following impacts can be identified:

- AMF

- Optionally setting the 5GS tracking area list such that the contained TAIs are only those that overlap with the known area of the disaster condition of another PLMN

- Providing a service area list to the UE such that it contains only those TAIs that overlap with the known area of the disaster condition of another PLMN

- Optionally providing a list of cell identities represeting the cells on which the UE can get normal service.

- UE

- Optionally handling a list of cell identities and entering 5GMM-REGISTERED.NON-ALLOWED-SERVICE state if the UE camps on a cell for which the cell identity is not part of this list as described in 6.17.1.2

- Optionally triggering PLMN search upon entering the 5GMM-REGISTERED.NON-ALLOWED-SERVICE state.

## 6.18 Solution #18: Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition via shared RAN

### 6.18.1 Description

It is assumed that when a disaster condition applies, an NG-RAN node of a PLMN without a disaster condition becomes a shared RAN node between the PLMN without a disaster condition and a PLMN where a disaster condition applies. See Solution #9 for the details.

The UE can perform the registration procedure to the same PLMN using currently available means via the shared RAN and the 5GCN of the PLMN where a disaster condition applies. The area covered by the shared RAN can correspond to one or more presence reporting areas (PRAs). The PRA IDs assigned to the PRAs are preconfigured in the CHF, AMF, and PCF.

### 6.18.2 Impacts on existing nodes and functionality

NG-RAN

NG-RAN nodes in a PLMN without a disaster condition having N2 connection with AMF in a PLMN with disaster condition needs to support N3 connection with UPF in a PLMN with disaster condition.

UPF

UPF in a PLMN with disaster condition needs to support N3 connection with NG-RAN nodes in a PLMN without a disaster condition having N2 connection with AMF in a PLMN with disaster condition.

## 6.19 Solution #19

### 6.19.1 General

This a solution for the below study items listed in key issue #4

- How to authenticate Inbound Disaster Roamer during the registration procedure;

- How a Disaster Roaming PLMN can limit the area of service to Inbound Disaster Roamers to the region where Disaster Condition applies; and

When the UE has roamed into a PLMN that supports disaster roaming, it is important to consider that the PLMN is forbidden in normal scenarios and the UE would have been rejected by the network.

So it is important to let the Network know that the registration request is because of a disaster condition and not in any normal scenario because of the following 2 reason

a) A genuine UE that is performing disaster roaming can be accepted.

b) A UE that is not doing disaster roaming, but attempts registration on that PLMN needs to be rejected.

Also the disaster condition can be applicable only to a small region. So it is important to restrict the UE to that region for disaster roaming.

### 6.19.2 Solution description

To solve the problem the UE needs to differentiate the registration request due to disaster roaming and a normal registration request. So The UE needs to use a new registration request type in the registration request message. This will help the visiting NW to identify that the UE is performing a registration followed by disaster condition. On receiving the new registration request type in registration request message indicating 'disaster roaming', AMF of the visiting NW after verifying that the UE is coming from a disaster area (e.g based on the TA where the UE is located) shall send an indication to the AUSF of the HPLMN in the primary authentication that the registration is due to disaster roaming. AUSF may authenticate the UE using this information. If the Authentication is successful, the NW may accept the registration request from such a UE if the network supports disaster roaming in that area from the previously served PLMN of the UE. .

- The registration type is used by the UE only if it has detected a disaster condition and needs to move away from the serving PLMN.

NOTE: PLMN that supports disaster roaming can accept the registration request from the UE if the UE indicates that it is performing registration request due to a disaster condition and if the PLMN supports disaster roaming from the previously served PLMN of that UE in that area.

- Visiting NW can also assign the tracking areal list (TAI list) based on the area where the disaster has happened. This also has the advantage that the UE will perform a mobility and registration update procedure as soon as UE moves out of the area.

### 6.19.3 Impacts on existing nodes and functionality

A new registration type value will be used the UE so that the network needs to treat the registration as a registration due to disaster condition. Also the allocation of service area list and registration area list may also be impacted.

- UE needs to use a new registration type to indicate that it is performing registration due to disaster roaming.

- AMF of the PLMN providing disaster roaming needs to handle a new registration type from the UE.

- AUSF of the HPLMN may need to handle the authentication of the UE which is registering due to disaster condition.

## 6.20 Solution #20

### 6.20.1 Description

#### 6.20.1.1 Introduction

This solution addresses the following key issue:

Key Issue #4: Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition

This solution enables AUSF of the HPLMN of the UE to determine that the UE is requesting disaster roaming in a PLMN (called PLMN A) without Disaster Condition so that the AUSF starts authentication rather than rejecting the authentication due to PLMN A being a forbidden PLMN for the UE.

This solution also enables UDM of the HPLMN of the UE to determine that the UE is roaming using disaster roaming so that the UDM can provide the AMF with UE's subscription data applicable for disaster roaming.

#### 6.20.1.2 Detailed description

If the UE determined that Disaster Condition applies for a PLMN (called PLMN D), only PLMNs in the UE's list of forbidden PLMNs are available, and the UE selects a PLMN (called PLMN A) without Disaster Condition which accept Disaster Inbound Roamers from PLMN D, then the UE registers using a regular REGISTRATION REQUEST message sent in PLMN A.

NOTE: In this solution, whether the UE indicates that the registration is for disaster roaming depends on whether UE capabilities not available in Rel-16 UEs are needed for disaster roaming.

If the UE does not have 5G-GUTI for PLMN D and PLMN D is not UE's HPLMN, then the UE indicates PLMN D as the previously selected PLMN with Disaster Condition, in the REGISTRATION REQUEST message sent in PLMN A.

When a UE is registering via NG-RAN node of PLMN A to AMF of PLMN A and:

- PLMN ID of UE's 5G-GUTI;

- PLMN ID of UE's SUCI (if UE's 5G-GUTI is not provided); or

- previously selected PLMN with Disaster Condition indicated in the REGISTRATION REQUEST message (if UE's 5G-GUTI and UE's SUCI are not provided);

identifies a PLMN with Disaster Condition in the area served by NG-RAN node serving the UE (e.g. by PLMN ID being part of "disaster roaming PLMN list" provided by NG-RAN node serving the UE or PLMN ID and the area served by the RAN node serving the UE being in AMF's stored "disaster roaming PLMN and area list") then

a) the AMF determines the previously selected PLMN with Disaster Condition as:

1) PLMN ID of UE's 5G-GUTI;

2) PLMN ID of UE's SUCI (if UE's 5G-GUTI is not provided); or

3) previously selected PLMN with Disaster Condition indicated in the REGISTRATION REQUEST message (if UE's 5G-GUTI and UE's SUCI are not provided).

b) the AMF considers that the UE requests the disaster roaming and the AMF includes the "disaster roaming request" indication in a primary authentication related message (e.g. Nausf\_UEAuthentication\_Authenticate Request) sent towards the AUSF of the HPLMN of the UE. If the previously selected PLMN with Disaster Condition is not UE's HPLMN the AMF also includes the previously selected PLMN with Disaster Condition in the primary authentication related message.

If the AUSF of the HPLMN of the UE receives a primary authentication related message (e.g. Nausf\_UEAuthentication\_Authenticate Request) with the "disaster roaming request", the serving network name indicates a PLMN in which the UE is not allowed to roam in non-disaster condition and:

- the previously selected PLMN with Disaster Condition is not received; or

- the previously selected PLMN with Disaster Condition is received and the UE is allowed to roam in non-disaster condition in the previously selected PLMN with Disaster Condition;

then, the AUSF authenticates the UE (rather than rejecting the authentication) and if the primary authentication is successful, and the AUSF informs the UDM using Nudm\_UEAuthentication\_ResultConfirmation Request that the UE roams using disaster roaming.

If the primary authentication is successful, the AMF determines that the UE roams using disaster roaming.

If the UDM is informed that the UE roams using disaster roaming, when the AMF requests UE's subscription data, the UDM can provide the AMF with the UE's subscription data applicable for disaster roaming.

If the AMF is informed that the UE roams using disaster roaming, the AMF informs the SMF serving a PDU session established by the UE that the UE roams using disaster roaming. If the SMF is informed that the UE roams using disaster roaming, the SMF informs the CHF that the UE roams using disaster roaming. If the CHF is informed that the UE roams using disaster roaming, the CHF includes the information in CDRs.

### 6.20.2 Impacts on existing nodes and functionality

The UE is impacted with conditional indicating the previously selected PLMN with Disaster Condition, as described in clause 6.20.1.

The AMF of the PLMN without Disaster Condition is impacted by providing the AUSF of the HPLMN of the UE with the "disaster roaming request" and conditionally the previously selected PLMN with Disaster Condition, and by providing the SMF serving a PDU session of the UE with information that the UE roams using disaster roaming.

The SMF is impacted by providing the CHF with information that the UE roams using disaster roaming.

The CHF is impacted by including information that the UE roams using disaster roaming, in CDRs.

The AUSF of the HPLMN of the UE is impacted by performing the primary authentication if "disaster roaming request" is received, as described in clause 6.20.1 and providing information to the UDM, as described in clause 6.20.1.

The UDM of the HPLMN of the UE is impacted by providing the AMF of the PLMN without Disaster Condition with the UE's subscription data applicable for disaster roaming.

Whether the NG-RAN of the PLMN without Disaster Condition is impacted with providing the AMF of the PLMN without Disaster Condition with "disaster roaming PLMN list", depends on solution selected for key issue #3 and key issue #2.

NOTE: If the AMF of the PLMN without Disaster Condition is provided (via the CBCF/PWS-IWF) by the CBE with the "disaster roaming PLMN and area list", the NG-RAN of the PLMN without Disaster Condition is not impacted.

## 6.21 Solution #21: Solution for PLMN selection when a "Disaster Condition" applies

### 6.21.1 Introduction

This is a solution for Key Issue #5 (PLMN selection when a "Disaster Condition" applies).

### 6.21.2 Detailed description

The UE can be provisioned with disaster roaming assistance information, which the UE will use to select a PLMN upon being notified that a Disaster Condition applies to the registered PLMN.

The disaster roaming assistance information can be:

a) pre-configured in the ME;

b) pre-configured in the USIM;

c) sent to the UE by the network using the UE parameters update procedure (before a Disaster Condition applies);

d) sent to the UE by the network using the steering of roaming procedure (before a Disaster Condition applies); or

e) signalled to the UE by the PLMNs without Disaster Condition (when a Disaster Condition applies).

Only the disaster roaming assistance information provisioned by the network is used by the UE, if both a disaster roaming assistance information provisioned by the network and a pre-configured disaster roaming assistance information are present. If no disaster roaming assistance information is provisioned by the network, and the UE has a pre-configured disaster roaming assistance information in both the USIM and the ME, then only the pre-configured disaster roaming assistance information in the USIM is used.

The disaster roaming assistance information can consist of:

a) a prioritized list of PLMNs. In this case, the UE attempts registration on the available PLMNs from the list in priority order;

NOTE 1: The prioritized list of PLMN can be UE-specific, so as to direct a first group of UEs to PLMN 1, a second group of UEs to PLMN 2, and so on.

b) a weighted list of PLMNs. In this case, the UE performs a weighted random draw among the available PLMNs from the list; or

NOTE 2: The weight assigned to each PLMN can be commensurate to the size of the PLMN or the capacity of the PLMN to accommodate Disaster Inbound Roamers.

NOTE 3: Indication of the capacity of PLMNs without Disaster Condition to accept Disaster Inbound Roamers, pre-configured in the UE or provided to the UE using NAS signalling before the disaster, might not reflect the actual state after the disaster, since the disaster can also make some RAN nodes of PLMNs without Disaster Condition not operational.

c) an indication of the capacity of PLMNs without Disaster Condition to accept Disaster Inbound Roamers e.g broadcast by the PLMNs which indicate that they can accommodate Disaster Inbound Roamers. In this case, the UE performs a weighted random draw among the available PLMNs taking into account the capacity of each PLMN.

NOTE 4: The capacity of a PLMN without Disaster Condition to accept Disaster Inbound Roamers can be determined by the PLMN without Disaster Condition based on operator's policies e.g. the amount of resources allocated by the PLMN to serve Disaster Inbound Roamers.

NOTE 5: Extension of broadcast signalling is subject to agreement of RAN WGs.

If the UE is notified that a Disaster Condition applies to the registered PLMN, as specified in the solution(s) to Key Issue #1 (Notification of Disaster Condition to the UE):

a) the UE shall perform PLMN selection as specified in 3GPP TS 23.122 [7] clause 4.4.3.1.1 with the exceptions:

1) the UE shall not consider the PLMN with Disaster Condition as PLMN selection candidate unless the PLMN is available in satellite NG-RAN; and

NOTE 6: Input from SA3 is needed regarding potential security risks resulting from ignoring the HPLMN's coverage when the UE determines that the HPLMN is with Disaster Condition.

2) for bullets iv) and v) in 3GPP TS 23.122 [7] clause 4.4.3.1.1, the UE shall consider the available PLMNs which indicate that they can accommodate Disaster Inbound Roamers as determined in solution(s) to Key Issue #3 (Indication of accessibility from other PLMNs without Disaster Condition to the UE) as highest priority, even if the PLMNs are in the UE's "forbidden PLMNs" list. If more than one such PLMN is available, the order in which the UE attempts registration is based on:

i) disaster roaming assistance information, if provisioned to the UE; or

ii) UE implementation; and

NOTE 7: How the UE determines the order can be impacted by the solution(s) agreed for Key Issue #7 (Prevention of signalling overload in PLMNs without Disaster Condition). For instance the order could be randomized at the UE, to distribute the load between the available PLMNs.

b) if the UE was able to successfully register on a PLMN after performing bullet a) above, the procedure ends and the UE camps on the selected PLMN as specified in 3GPP TS 23.122 [7], with the following exceptions:

1) if the selected PLMN is in the UE's "forbidden PLMNs" list, the UE shall not remove the PLMN from the UE's "forbidden PLMNs" list;

2) if the selected PLMN is a VPLMN and:

i) the selected PLMN is in the UE's "forbidden PLMNs" list, the UE shall not perform higher priority PLMN search until the UE is notified that the Disaster Condition no longer applies as specified in solution(s) to Key Issue #6 (Notification that Disaster Condition is no longer applicable to the UEs); or

ii) the selected PLMN is not in the UE's "forbidden PLMNs" list, when performing higher priority PLMN search as specified in 3GPP TS 23.122 [7] clause 4.4.3.3.1, the UE shall not consider the PLMN with Disaster Condition as PLMN selection candidate unless the PLMN is available in satellite NG-RAN; and

3) if PLMN selection is subsequently triggered due to switch-on or recovery from lack of coverage, the UE shall:

i) not consider the PLMN with Disaster Condition as PLMN selection candidate unless the PLMN is available in satellite NG-RAN; and

ii) not consider an equivalent PLMN of the registered PLMN if the registered PLMN is in the UE's "forbidden PLMNs" list, the UE is registered to that PLMN for disaster roaming and the equivalent PLMN does not indicate that it can accommodate Disaster Inbound Roamers as determined in solution(s) to Key Issue #3 (Indication of accessibility from other PLMNs without Disaster Condition to the UE).

### 6.21.3 Impacts on existing nodes and functionality

UE

- support for performing existing PLMN selection procedures with the exceptions described in clause 6.21.2; and

- support for handling of disaster roaming assistance information.

UDM of HPLMN

- optionally, support for providing disaster roaming assistance information.

AMF of registered PLMN (with Disaster Condition)

- optionally, support for providing disaster roaming assistance information.

AMF of PLMNs indicating that they can accept Disaster Inbound Roamers:

- optionally, support for providing disaster roaming assistance information.

NG-RAN of PLMNs indicating that they can accept Disaster Inbound Roamers:

- optionally, support for providing disaster roaming assistance information.

## 6.22 Solution #22: Considerations for PLMN selection when a "Disaster Condition" applies

This solution addresses the Key Issue #5 "PLMN selection when a "Disaster Condition" applies".

### 6.22.1 Detailed description

The disaster condition on a HPLMN/EHPLMN or a preferred PLMN affects the UE behaviour in the PLMN search procedure.

#### 6.22.1.1 UE action for disaster roaming

System information broadcast in a PLMN informs UE whether disaster roaming is allowed and whether it is allowed for a specific (set of) PLMN(s) or all PLMNs .

While performing a PLMN search, if the available PLMN is in the forbidden PLMN list or in the list of "5GS forbidden tracking areas for roaming", a UE may select this PLMN temporarily ignoring its presence in the list of forbidden PLMNs or in the list of 5GS forbidden tracking areas for roaming, if it is:

1. either broadcasting "disaster roaming active" information in SIB1 and not broadcasting SIB X with the list of PLMN IDs for which disaster roaming is active

2. or broadcasting "disaster roaming active" information in SIB1 and broadcasting a PLMN ID that is either its HPLMN or any PLMN which is not in its forbidden PLMN list in SIB X.

NOTE: Introduction of new information in SIB1, introduction of new SIB type and split of information between SIB1 and new SIB is subject to RAN2 agreement.

If the UE, due to the indication of "disaster roaming active" condition, is registering to a PLMN which is listed in either the forbidden PLMN list or the list of "5GS forbidden tracking areas for roaming" and this PLMN accepts the registration, the UE shall not remove this PLMN from the forbidden PLMN list or from the list of " 5GS forbidden tracking areas for roaming".

If UE is camped on a PLMN indicating that it allows disaster roaming then the UE shall assume that the PLMNs which are listed in SIB as being not operational due to a disaster situation are not suitable/available and thus may skip "In VPLMN" background PLMN search for higher priority PLMNs (see 23.122 clause 4.4.3.3) if no other higher priority PLMNs are listed in the preferred PLMN lists for the current MCC.

### 6.22.2 Impacts on existing nodes and functionality

UE: UE actions for PLMN search and roaming during disaster condition

## 6.23 Solution #23

### 6.23.1 Description

#### 6.23.1.1 Introduction

This solution addresses the following key issue:

Key issue #5: PLMN selection when a "Disaster Condition" applies

The UE uses the determination that Disaster Condition applies for a PLMN (called PLMN D) as determined in a solution for Key Issue #1 and determination that another PLMN (called PLMN A) without Disaster Condition can accept Disaster Inbound Roamers from PLMN D with Disaster Condition as determined in a solution for Key Issue #3, to select PLMN A as the selected PLMN, despite PLMN A being in UE's list of forbidden PLMNs.

NOTE: If PLMN D needs to operate an NG-RAN cell for testing purposes, PLMN D can configure the NG-RAN cell to broadcast cellReservedForOperatorUse set to "reserved".

#### 6.23.1.2 Detailed description

The legacy principles for PLMN selection are extended as follows:

If:

- the UE determines that Disaster Condition applies for PLMN D as determined in a solution for Key Issue #1;

- the UE determines that PLMN A without Disaster Condition can accept Disaster Inbound Roamers from PLMN D with Disaster Condition as determined in a solution for Key Issue #3;

- PLMN D is UE's HPLMN or is not in UE's list of forbidden PLMNs; and

- PLMN A is in UE's list of forbidden PLMNs;

then:

- the UE shall consider PLMN A as an allowable PLMN.

- in automatic PLMN selection, the UE shall consider PLMN A for selection with the lowest priority. If there are several PLMNs A, the UE shall consider PLMNs A for selection in random order.

NOTE: If a non-forbidden PLMN is available in 3GPP access (terrestrial or satellite), the UE selects a non-forbidden PLMN in automatic PLMN selection.

If the UE determines that Disaster Condition applies for several PLMNs D, as determined in a solution for Key Issue #1 and:

- UE's RPLMN is one of those PLMNs D, the UE considers UE's RPLMN as the selected PLMN D; or

- UE's RPLMN is not one of those PLMNs D, the UE considers one of PLMNs D as the selected PLMN D based on the priority of the PLMNs as described in 3GPP TS 23.122 [7] clause 4.4.3;

and in automatic PLMN selection above the UE only considers PLMNs A without Disaster Condition which can accept Disaster Inbound Roamers from the selected PLMN D.

If the UE selects PLMN A in UE's list of forbidden PLMNs and the UE successfully registers in PLMN A, the UE does not remove PLMN A from UE's list of forbidden PLMNs.

### 6.23.2 Impacts on existing nodes and functionality

The UE is impacted with updated automatic PLMN selection as described in clause 6.23.1.

## 6.24 Solution #24

### 6.24.1 General

The solution aims at solving the below study item in the key issue #5

How the UE selects a PLMN if it is determined that a "Disaster Condition" applies;

a) If the UE determines that a "Disaster Condition" applies as described in Key Issue #1 "Notification of Disaster Condition to the UE", then how to update PLMN selection procedure so that the UE avoids selecting the PLMN with "Disaster Condition".

b) How the UE handles the list of "forbidden PLMNs" when selecting a PLMN indicating accessibility for the UE in the bullet a).

Once the UE detects "Disaster Condition" based on the solution for key issue #1, UE shall perform a PLMN selection and shall consider the list of "List of PLMNs to be used while in Disaster condition" in the PLMN selection. In the PLMN selection procedure, if the UE finds PLMN that is in the forbidden PLMN list, UE shall consider the forbidden PLMN also for PLMN selection if they are present in the "List of PLMNs to be used while in Disaster condition". Forbidden PLMNs shall be considered in the same order in which they are present in the "List of PLMNs to be used while in Disaster condition".

This is because the serving PLMN can arrange the PLMNs in a particular order to distribute the UEs so that all the UEs does not try to attempt registration on to the same PLMN for disaster roaming in case of a disaster condition and if these PLMNs are available. When the UEs are registering in a particular area (before the disaster has happened), AMF can assign the priority of the PLMNs in the order in "List of PLMNs to be used while in Disaster condition" e.g. If there are 2 PLMNs, PLMN\_1 and PLMN\_2 supporting disaster roaming in a particular area, then AMF can assign the list as {PLMN1, PLMN2} for UE\_1 and then {PLMN2, PLMN1} for UE\_2.

As long as the "Disaster Condition" is applicable, PLMNs in the forbidden list can be considered as available if they are present in the "List of PLMNs to be used while in Disaster condition" and if those PLMNs indicate that they support disaster roaming. Once the "Disaster Condition" is over, UE shall treat the PLMNs in the forbidden PLMN list as forbidden. Otherwise no need for any change for the forbidden PLMN list.

### 6.24.2 Solution description

Once the UE detects "Disaster Condition" based on the solution for key issue #1, UE performs PLMN selection as follows

- All the available PLMNs are sorted based on the PLMN selection algorithm defined in 3GPP TS 23.122 clause 4.4.3.1.1 with the following changes

a) UE arranges the available PLMNs in the order mentioned in i, ii, iii, iv in 4.4.3.1.1 based on the PLMN if they PLMNs fall in those categories.

b) Each PLMNs that is present in the "List of PLMNs to be used while in Disaster condition" and forbidden PLMNs list is considered in bullet v of 23.122 4.4.3.1.1 and is given lower priority than the PLMNs that are not in the forbidden PLMN list.For bullets v in 4.4.3.1.1, all the PLMNs that are present in the "List of PLMNs to be used while in Disaster condition" are sorted in the order in which they are present in "List of PLMNs to be used while in Disaster condition" if the PLMNs also indicate that they support disaster roaming. In normal scenario, these PLMNs are sorted in random order based on the signal strength. (bullets v in 23.122 4.4.3.1.1).

c) UE selects the PLMN which is highest priority after following the above procedure.

- If only forbidden PLMNs are available and if they are present in "List of PLMNs to be used while in Disaster condition" and if the PLMNs also indicate that they support disaster roaming, those PLMNs are selected in the order in which they are present in "List of PLMNs to be used while in Disaster condition"

### 6.24.3 Impacts on existing nodes and functionality

Changes needed in PLMN selection procedure defined in 3GPP TS 23.122 4.4.3.1.1

- UE needs to update its PLMN selection.

## 6.25 Solution #25

### 6.25.1 Introduction

This is a solution for Key Issue #5: PLMN selection when a "Disaster Condition" applies as specified in clause 5.5. Especially, this solution tries to resolve the following issues in the Key Issue #5:

- How the UE handles the list of "forbidden PLMNs" when selecting a PLMN indicating accessibility for the UE in the bullet 1).

This solution also tries to resolve the Key Issue #9: Handling of Disaster inbound roaming PLMNs in Manual PLMN selection, as specified in clause 5.9.

In this solution, it is assumed that the UE determines that the Disaster Condition applies to PLMN D (PLMN with Disaster Condition) based on the solution for Key Issue #1 "Notification of Disaster Condition to the UE", and the UE is notified that one or more PLMN A (PLMN without Disaster Condition) can accept Disaster Inbound Roamer from PLMN D based on the solution for Key Issue #3 " Indication of accessibility from other PLMNs without Disaster Condition to the UE".

### 6.25.2 Detailed description

When the UEis notified that Disaster Condition applies to the PLMN D, and the following conditions are met:

- the PLMN D is UE's HPLMN or is not in UE's list of forbidden PLMNs

- the PLMN A is available at the UE's location;

- the PLMN A can provide Disaster Roaming services to the Disaster Inbound Roamer from PLMN D; and

- the PLMN A is in UE's list of forbidden PLMNs,

then the UE shall add the PLMN A to the list of "alleviated forbidden PLMN" in the UE's storage. The UE shall delete the stored list if the USIM is removed or if the UE is switched off.

In automatic network selection mode, the UE shall consider a PLMN in the list of forbidden PLMN as allowable PLMN if the same entry exists in the list of alleviated forbidden PLMN. Otherwise, PLMNs in the list of forbidden PLMN shall not be considered as allowable PLMNs.

The priority of such PLMNs is the lowest in the order specified in clause 4.4.3.1.1 of 3GPP TS 23.122 [7]. This means:

i) either the HPLMN (if the EHPLMN list is not present or is empty) or the highest priority EHPLMN that is available (if the EHPLMN list is present) ;

ii) each PLMN/access technology combination in the "User Controlled PLMN Selector with Access Technology" data file in the SIM (in priority order);

iii) each PLMN/access technology combination in the "Operator Controlled PLMN Selector with Access Technology" data file in the SIM (in priority order) or stored in the ME (in priority order);

iv) other PLMN/access technology combinations with received high quality signal in random order;

v) other PLMN/access technology combinations in order of decreasing signal quality; and

vi) PLMN/access technology combinations in the list of alleviated forbidden PLMN.

In manual network selection mode, when NAS layer indicates the list of available PLMNs as candidate PLMNs to the upper layer, NAS layer shall indicate the PLMNs in the list of alleviated forbidden PLMN as available PLMNs not in the list of forbidden PLMN to the upper layer, only if there is no PLMN available other than those in the UE's list of forbidden PLMN. NAS layer may provide additional information that "a Disaster Condition applies to the PLMN with Disaster Condition."

If the PLMN A which was in the list of forbidden PLMNs is selected by the UE and the UE successfully registers in the PLMN A, the UE shall not remove PLMN A from the list of forbidden PLMNs.

When the UE is notified that Disaster Condition is no longer applicable based on the solution of Key Issue #6: Notification that Disaster Condition is no longer applicable to the UEs, the UE shall delete the stored list of alleviated forbidden PLMN, and apply normal network selection procedure as specified in 3GPP TS 23.122 [7].

### 6.25.3 Impacts on existing nodes and functionality

The UE is impacted with the introduction of the list of alleviated forbidden PLMN list and the update to the automatic network selection.

## 6.26 Solution #26: PLMN selection base on DRS-Supported PLMN list

### 6.26.1 Introduction

This solution addresses the Key issue #5: the PLMN selection when a "Disaster Condition" applies.

In the solution, PLMN D is the PLMN with Disaster Condition and PLMN A is the PLMN without Disaster Condition.

### 6.26.2 Detailed description

In this solution, it is assumed that the UE determines that the Disaster Condition applies to PLMN D based on the solution for Key Issue #1 "Notification of Disaster Condition to the UE".

If the UE has the information used for PLMN selection when a "Disaster Condition" applies and there is no available non-forbidden PLMN, the UE selects a PLMN without Disaster Condition based on the information.

This information contains Disaster Roaming service(DRS)-Supported PLMN list used for PLMN selection when a "Disaster Condition" applies. The PLMN in the DRS-Supported PLMN list does not have the roaming agreements with the PLMN D but is able to provide the Disaster Condition roaming service for the UE when the Disaster Condition happens to PLMN D. The UE may obtain these PLMN(s) in the following ways:

1) pre-configured by HPLMN;

2) broadcasted by PLMN A; or

NOTE: How the PLMN A delivers the DRS-Supported PLMN list is based on the solution for Key Issue #1 "Notification of Disaster Condition to the UE" or the solution for Key Issue #3: Indication of accessibility from other PLMNs without Disaster Condition to the UE.

3) delivered by PLMN D with NAS or AS message before a "Disaster Condition" applies.

The UE selects a PLMN A among the available PLMNs under Disaster condition to obtain Disaster Roaming service. The available PLMNs under Disaster condition shall fulfill the following conditions:

a) PLMN A is in the DRS-supported PLMN list; and

b) There is an NG-RAN cell broadcasting PLMN ID of PLMN A.

When the UE in manual mode determines that the Disaster Condition applies to the PLMN D selected by the user based on the solution for Key Issue #1 "Notification of Disaster Condition to the UE", the UE can automatically select a PLMN which can provide Disaster Roaming service to the UE of PLMN D, and the UE can provide an indication to the upper layers that the UE has exited manual network selection mode.

If there are more than one available PLMN A, the UE can perform PLMN selection based on the following crierions:

a) the priority order of Disaster Roaming service(DRS)-Supported PLMN list, if any;

b) otherwise, select an available PLMN A randomly; or

c) UE implementation.

After the UE registers to the PLMN A, the UE shall still perform the higher priority PLMN search periodly as specified in 3GPP TS 23.122 [7] clause 4.4.3.3.1. Once the UE finds that the HPLMN or a higher priority PLMN becomes available, it shall perform PLMN selection as specified in 3GPP TS 23.122 [7] clause 4.4.3.1.1.

The UE shall not remove the PLMN from the list of "forbidden PLMNs" when selecting a PLMN indicating accessibility for the UE.

### 6.26.3 Impacts on existing nodes and functionality

UE:

- support for being pre-configuredthe DRS-Supported PLMN list by HPLMN; or

- support for obtaining the DRS-Supported PLMN list from the network;

- support for PLMN selection using DRS-Supported PLMN list.

RAN nodes of PLMN A:

- support for providing DRS-supported PLMN list.

AMF:

- support for providing DRS-supported PLMN list via NAS message.

## 6.27 Solution #27: Indicating to the UE, via non-3GPP access, the end of a disaster condition that was applicable to the 3GPP access of the same PLMN

### 6.27.1 Description

#### 6.27.1.1 Introduction

This solution corresponds to:

- KI#6 on Notification that Disaster Condition is no longer applicable to the UEs (see clause 5.6), and

- KI#8 on Prevention of signalling overload by returning UEs in PLMN previously with Disaster Condition (see clause 5.8)

#### 6.27.1.2 Detailed description

This solution is for a UE:

- that supports the non-3GPP access in addition to the 3GPP access;

- that supports NAS over the non-3GPP access;

- that supports connecting to N3WIF;

- that was registered to the same PLMN over 3GPP and non-3GPP access before (and when) the disaster condition occurred;

- that is in 5GMM-CONNECTED mode over the non-3GPP access; and

- that does not register to another PLMN over the 3GPP access while the disaster condition is ongoing.

Also, this solution is for a PLMN with a Disaster Condition (DC) and the PLMN:

- has N3IWF, and the AMF of the PLMN supports the N2 connection from the N3IWF; and

- for which the non-3GPP access network is not affected by the Disaster Condition.

Furthermore the UE was previously registered to the same PLMN over the 3GPP access for which a DC had previously occurred, and for which the UE had remained on the same PLMN over the non-3GPP access i.e. the UE did not register over the 3GPP access on another PLMN without a disaster condition.

The serving AMF determines that a UE which is in 5GMM-CONNECTED mode over the non-3GPP access is within the area where a previous disaster condition is no longer applicable to the 3GPP access.

The AMF notifies the UE with a NAS message, e.g. Configuration Update Command message that a disaster condition no longer applies to 3GPP access.

To avoid numerous simultaneous returns and consequently simultaneous registration attempts on the same PLMN over the 3GPP access, the AMF may provide a "wait timer" that indicates a period during which the UE should wait before attempting to return and register to the same PLMN over the 3GPP access.

When the UE receives, over the non-3GPP access, a notification that the disaster condition on the 3GPP access has ended, the UE removes the stored information about the disaster condition, if any. The UE returns to the same PLMN over the 3GPP access by performing a registration procedure with the same PLMN over the 3GPP access as follows:

- if the UE had disabled the lower layers of the 3GPP access, the UE shall enable the lower layers of the 3GPP access and peform a PLMN search

- if the UE received a "wait time" from the AMF, the UE starts a timer and registers to the PLMN over the 3GPP access after the timer expires. Otherwise, if no "wait time" was received, the UE attempts to register immediately over the 3GPP access to the same PLMN.

This same solution (as described above) can also be used in the case when, following a disaster condition, the UE registers over the non-3GPP access with another PLMN that is offering disaster roaming services.

In this case, the AMF of the PLMN that is offering disaster roaming service determines that the UE's previous PLMN no longer experiences a disaster condition. For a UE in 5GMM-CONNECTED mode over the non-3GPP access, the AMF informs the UE with a NAS message, sent over the non-3GPP access, that a disaster condition on a previous PLMN is no longer applicable.

Upon reception of this indication, over the non-3GPP access, that a disaster condition on a previous PLMN is no longer applicable, the UE performs PLMN search on the 3GPP access and attempts to register to the previous PLMN.

### 6.27.2 Impacts on existing nodes and functionality

The following impacts can be identified:

- AMF

- Notifying the UE, over the non-3GPP access, that a disaster condition related to the 3GPP access is no longer applicable

- Optionally providing a "wait timer" to stagger the return of UEs over the 3GPP access

- UE

- Handle of a notification, over the non-3GPP access, that a disaster condition related to the 3GPP access is no longer applicable

- Optionally handling a "wait timer" to guard when the UE can return to register on the same PLMN over the 3GPP access.

## 6.28 Solution #28: Solution for notification that Disaster Condition is no longer applicable to the UEs

### 6.28.1 Introduction

This is a solution for Key Issue #6 (Notification that Disaster Condition is no longer applicable to the UEs).

This solution can be used both over the 3GPP access and over the non-3GPP access of the PLMN without Disaster Condition (PLMN A).

### 6.28.2 Detailed description

Upon being notified that a Disaster Condition in PLMN D no longer applies, a PLMN without Disaster Condition (PLMN A) currently serving Disaster Inbound Roamers may perform one or more of the following:

a) over the 3GPP access, turn off the broadcast indication (e.g. in SIB) that a Disaster Condition in PLMN D applies;

NOTE 1: Extension of broadcast signalling is subject to agreement of RAN WGs.

NOTE 2: Dynamic update of broadcast signalling is subject to agreement of RAN WGs.

b) for the Disaster Inbound Roamers in 5GMM-CONNECTED mode, which previously selected PLMN D:

1) perform a generic UE configuration update procedure with an indication that the Disaster Condition in another PLMN no longer applies; or

2) perform a generic UE configuration update procedure with "re-registration requested", then reject the UE's registration request with 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies"; or

If a Disaster Inbound Roamer has an emergency PDU session or a high priority service, the AMF of PLMN A performs the handling above after release of the emergency PDU session or after the high priority service is finished.

c) for the Disaster Inbound Roamers in 5GMM-IDLE mode which previously selected PLMN D and which attempt to transition to 5GMM-CONNECTED mode by initiating a registration or service request procedure, reject the UE's request with 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies".

The AMF of PLMN A determines the previously selected PLMN of the Disaster Inbound roamers when the Disaster Inbound Roamers register on PLMN A, as specified in the solution(s) to Key Issue #4 (Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition).

Upon:

a) being notified by the lower layers that the indication (e.g. SIB flag) broadcast by PLMN A that a Disaster Condition applies in PLMN D has been turned off;

c) receiving a CONFIGURATION UPDATE COMMAND message with an indication that the Disaster Condition in another PLMN no longer applies; or

d) receiving a REGISTRATION REJECT or SERVICE REJECT message with 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies";

the UE shall remove the stored indication that a Disaster Condition applies to PLMN D, enter 5GMM-REGISTERED.PLMN-SEARCH and perform PLMN selection as specified in 3GPP TS 23.122 [7] clause 4.4.3.1.1.

### 6.28.3 Impacts on existing nodes and functionality

UE

- support for handling of the indication broadcast by PLMN A (e.g. SIB flag) that a Disaster Condition in PLMN D applies;

- support for CONFIGURATION UPDATE COMMAND message with an indication that the Disaster Condition in another PLMN no longer applies; and

- support for 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies".

AMF of registered PLMN (without Disaster Condition)

- optionally, support for CONFIGURATION UPDATE COMMAND message with an indication that the Disaster Condition in another PLMN no longer applies; and

- optionally, support for 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies ".

RAN of registered PLMN (without Disaster Condition)

- optionally, support for signalling the indication (e.g. SIB flag) that a Disaster Condition in PLMN D applies.

## 6.29 Solution #29: O&M-based solution for Key Issue #6

### 6.29.1 Introduction

This solution addresses Key Issue #6: Notification that Disaster Condition is no longer applicable to the UEs in clause 5.6.

### 6.29.2 Solution description

The Disaster Condition caused RAN unavailability can be treated as a network fault. As per 3GPP TS 32.101 [5] for defining the legacy PLMN management functional architecture, the fault management is a basic management function provided by the PLMN NMS.

Furthermore, as per 3GPP TS 28.533 [6] for the SBA based NMS defined for 5GS, the network fault supervision service is also a basic management service provided by the PLMN NMS for the management of the 3GPP network.

The PLMN NMS can directly interface with different network elements within 3GPP network, including core network functions (e.g. AMF, SMF) and RAN nodes (e.g. gNB) via O&M operations. The required O&M operations may or may not be standardized, i.e. to use the proprietary implementation.

The O&M-based solution for each question within Key Issue #6 is described as below:

When the Disaster Condition is no longer applicable to the serving PLMN, the serving PLMN NMS detects the fault recovery/correction via O&M operations, removes the stored disaster PLMN ID and disaster area information and then sends an indicaiton to other Disaster Roaming PLMN NMS to inform that the Disaster Condition is no longer applicable for it. The Disaster Roaming PLMN NMS removes the stored disaster PLMN ID and disaster area information and then sends an indicaiton to its AMFs which are providing the Disaster Roaming for the Disaster Inbound Roamers. The Disaster Roaming PLMN AMF removes the stored disaster PLMN ID and disaster area information if any, and informs the Disaster Inbound Roamers currently registered to it that the Disaster Condition is no longer applicable for its previous selected PLMN for which the Disaster Condition is no longer applicable over NAS.

The Disaster Roaming PLMN AMF determines the previous selected PLMN of the Disaster Inbound roamers when the Disaster Inbound Roamers register to the Disaster Roaming PLMN, as specified in the solution(s) to Key Issue #4 (Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition).

NOTE 1: The Disaster Roaming PLMN NMS can also send the indicaiton to its RAN nodes which are providing the Disaster Roaming for the Disaster Inbound Roamers and then the RAN node informs the Disaster Inbound Roamers that the Disaster Condition is no longer applicable for its previous selected PLMN for which the Disaster Condition is no longer applicable over radio interface. However this is not considered as an alternative in this solution.

*"- How to minimize interruption of the service receiving from Disaster Roaming PLMN (e.g. emergency service or high priority service) when the UE is notified that Disaster Condition is no longer applicable;"*

When the Disaster Roaming PLMN AMF was notified that the Disaster Condition is no longer applicable for Disaster Inbound Roamers, to minimize interruption of the service receiving from Disaster Roaming PLMN (e.g. emergency service or high priority service), the AMF handles as following:

(1) When the Disaster Inbound Roamer is current in the connected mode:

In this case, when the user-plane resources was established for the Disaster Inbound Roamer (i.e. the user data services are ongoing, including emergency service or high priority service), then after the completion of the ongoing user data services and before the release of the current N1 NAS signalling connection, the AMF initiates a network-initiated de-registration procedure by sending DEREGISTRATION REQUEST message with 5GMM cause #11 (PLMN not allowed) to the UE (i.e. Disaster Inbound Roamer). After completion of the network-initiated de-registration procedure, the AMF releases the current N1 NAS signalling connection to move the UE to the idle mode.

NOTE 2: The AMF can based on the existing mechanism to know the completion of the ongoing user data services, e.g. based on the N2 UE Context Release Request from RAN.

(2) When the Disaster Inbound Roamer is current in the idle mode:

The AMF defers the handling to the next time when the UE moves to the connected mode. When next time received a REGISTRATION REQUEST message or SERVICE REQUEST message from the UE, the AMF rejects it with 5GMM cause #11 (PLMN not allowed).

NOTE 3: There is another alternative for the AMF actively pages the UE to move to the connected mode and then initiate a network-initiated de-registration procedure by sending DEREGISTRATION REQUEST message with 5GMM cause #11 (PLMN not allowed) to the UE. However, this is not considered as an alternative in this solution due to it will consume a lot of radio resources considering due to paging.

*"- How to remove the stored information on Disaster Condition from the UE's storage;"*

Upon receipt of registration reject or service reject or de-registration request with 5GMM cause #11 (PLMN not allowed), if the UE currently is registered for the Disaster Roaming, then the UE knows the Disaster Condition is no longer applicable to its previous selected PLMN and then removes the stored information on Disaster Condition from the UE's storage.

*"- How Disaster Inbound Roamer UEs perform network selection when notified that Disaster Condition is no longer applicable."*

Upon receipt of registration reject or service reject or de-registration request with 5GMM cause #11 (PLMN not allowed), if the UE currently is registered for the Disaster Roaming, then the UE knows the Disaster Condition is no longer applicable to its previous selected PLMN and then performs the PLMN selection as legacy with the difference that to treat the previous selected PLMN as higher priority.

The end-to-end flow of O&M-based solution for KI#6 can be shown in Figure 6.29.2-1 for the UE in the connected mode and in Figure 6.29.2-2 for the UE in the idle mode:



Figure 6.29.2-1: End-to-end flow of O&M-based solution for KI#6, connected mode



Figure 6.29.2-2: End-to-end flow of O&M-based solution for KI#6, idle mode

### 6.29.3 Impacts on existing nodes and functionality

AMF:

- Based on the notification of PLMN NMS via O&M operations that the Disaster Condition is no longer applicable for Disaster Inbound Roamers, for the Disaster Inbound Roamer in the connected mode, the AMF initiates a network-initiated de-registration procedure by sending DEREGISTRATION REQUEST message with 5GMM cause #11 (PLMN not allowed) to the UE.

- Based on the notification of PLMN NMS via O&M operations that the Disaster Condition is no longer applicable for Disaster Inbound Roamers, for the Disaster Inbound Roamer in the idle mode, upon receipt of a REGISTRATION REQUEST message or SERVICE REQUEST message from the UE, the AMF rejects it with 5GMM cause #11 (PLMN not allowed).

UE:

- Upon receipt of registration reject or service reject or de-registration request with 5GMM cause #11 (PLMN not allowed), if the UE currently is registered for the Disaster Roaming, the UE removes the stored information on Disaster Condition from the UE's storage and performs the PLMN selection as legacy with the difference that to treat the previous serving PLMN as higher priority.

There are impacts on PLMN NMS but the required O&M operations may not to be standardized, i.e. by proprietary implementation.

## 6.30 Solution #30: UE-based solution for Key Issue #6

### 6.30.1 Introduction

This solution addresses Key Issue #6: Notification that Disaster Condition is no longer applicable to the UEs in clause 5.6.

### 6.30.2 Solution description

Disaster Roaming is still a roaming for the UE. In VPLMN, as per specified in 3GPP TS 23.122 [7], the UE shall periodically attempt to obtain service on its HPLMN (if the EHPLMN list is not present or is empty) or one of its EHPLMNs (if the EHPLMN list is present) or a higher priority PLMN/access technology combinations listed in "user controlled PLMN selector" or "operator controlled PLMN selector".

In non-roaming scenario, when Disaster Condition applies to the HPLMN, the UE (i.e. Disaster Inbound Roamer) registered in the Disaster Roaming PLMN shall also periodically attempt to obtain service on its HPLMN regardless of its HPLMN has recovered from the Disaster Condition or not. During the periodic scan, if its HPLMN is available (which clearly means Disaster Condition is no longer applicable), the UE shall selects its HPLMN; otherwise, the UE still stays at the current selected Disaster Roaming PLMN, i.e. the HPLMN is still under Disaster Condition.

In roaming scenario, when Disaster Condition applies to the current serving VPLMN, the UE (i.e. Disaster Inbound Roamer) registered in the Disaster Roaming PLMN shall also periodically attempt to obtain service on a higher priority VPLMN regardless of its previous serving VPLMN has recovered from the Disaster Condition or not. In roaming scenario, once the UE has registered to a VPLMN, normally, it means this VPLMN is the highest priority PLMN in the current area for the UE. Hence, during the periodic scan, if its previous serving VPLMN is available (which clearly means Disaster Condition is no longer applicable), the UE shall selects its previous serving VPLMN; otherwise, the UE still stays at the current selected Disaster Roaming PLMN, i.e. the previous serving VPLMN is still under Disaster Condition.

Such periodic scan is controlled by a timer T with the range 6 minutes to 8 hours and the default value 1 hour. If the default value applies, at worst it will defer the UE returning back to its previous serving PLMN for up to 1 hour after Disaster Condition is no longer applicable to its previous serving PLMN. Such deferring is acceptable as this is the worst case and also there is no stage 1 requirements to enforce the UE has to return back immediately once Disaster Condition is no longer applicable to its previous serving PLMN. Considering Disaster Condition can be applicable for long time, e.g. several hours, to avoid the UE frequently performing PLMN scan to drain the UE battery, the default value (i.e. 1 hour) is preferred to be used for T in such Disaster Roaming.

The UE based solution for each question within Key Issue #6 is described as below:

"- When and how to deliver the information that Disaster Condition is no longer applicable to Disaster Inbound Roamers;"

There is no need for the network to deliver the information that Disaster Condition is no longer applicable to Disaster Inbound Roamers, i.e. nothing needs to do at both the PLMN with Disaster Condition applied and also the Disaster Roaming PLMN.

"- How to minimize interruption of the service receiving from Disaster Roaming PLMN (e.g. emergency service or high priority service) when the UE is notified that Disaster Condition is no longer applicable;"

This question is not applicable as the periodic scan in VPLMN can only be perfomed by the UE at the idle mode.

"- How to remove the stored information on Disaster Condition from the UE's storage;"

During the periodic scan, if the UE finds its previous serving PLMN is available (which clearly means Disaster Condition is no longer applicable), then the UE removes the stored information on Disaster Condition from the UE's storage.

"- How Disaster Inbound Roamer UEs perform network selection when notified that Disaster Condition is no longer applicable."

The UE performs network selection as legacy periodic scan in VPLMN.

### 6.30.3 Impacts on existing nodes and functionality

UE:

- The default value (i.e. 1 hour) is preferred to be used for T in Disaster Roaming.

- The UE removes the stored information on Disaster Condition from the UE's storage when it finds its previous serving PLMN is available.

No impact on NG-RAN and core network functions.

## 6.31 Solution #31

### 6.31.1 Introduction

This is a solution for Key Issue #6: Notification that Disaster Condition is no longer applicable to the UEs, as specified in clause 5.6. This solution also tries to resolve the Key Issue #8: Prevention of signalling overload by returning UEs in PLMN previously with Disaster Condition, as specified in clause 5.8.

In this solution, it is assumed that the UE is successfully registered to a PLMN A (PLMN without Disaster Condition) based on the other key issues.

### 6.31.2 Detailed description

When the Disaster Condition is resolved and PLMN previously with Disaster Condition is restored and becomes available, PLMN A providing Disaster Roaming service are notified that Disaster Condition is no longer applicable.

While the UE is a Disaster Inbound Roamer and being served by PLMN A, the AMF may take the following behaviors in order to return the Disaster Inbound Roamers to the PLMN previously with Disaster Condition (PLMN D in this solution).

a) For dispersing the UE's transitions to the PLMN D, the AMF may apply the following behaviors only to part of the Disaster Inbound Roaming UEs at a time, i.e. based on the mod value of SUPI;

b) If the UE is in 5GMM-IDLE state, the AMF may:

- wait until the UE enters 5GMM-CONNECTED state, so that the PLMN A can stagger the return of UEs to the PLMN previously with Disaster Condition; or

- page the UE to request the establishment of a NAS signalling connection to the UE;

c) If the UE is in 5GMM-CONNECTED state, then

1) The AMF may send a CONFIGURATION UPDATE COMMAND message including the information of Disaster Condition (Disaster Condition is no longer applicable). After the completion of UE configuration update procedure, if the UE has ongoing services with high priority (e.g. UE using emergency PDU session, MPS/MCS UE or high priority UEs with AC11-15), then the UE waits until the ongoing services are finished. When the UE finishes the ongoing session or if the UE has no ongoing services with high priority, the UE shall request the UE-initiated deregistration request, and enter the 5GMM-DEREGISTERED.PLMN-SEARCH state in order to select the other PLMN, possibly the PLMN previously with Disaster Condition; or

NOTE: Which services are considered as "service with high priority" is upto the PLMN A's policy.

2) alternatively, the AMF may send DEREGISTRATION REQUEST with a new cause "Disaster Condition no longer applicable" in order to deregister the Disaster Inbound Roaming UEs directly. The UE shall enter the 5GMM-DEREGISTERED.PLMN-SEARCH state in order to select the other PLMN, possibly the PLMN previously with Disaster Condition;

When the UE is deregistered from the PLMN A after being notified that Disaster Condition is no longer applicable, the UE shall clear any information regarding Disaster Condition from its memory.

The information of Disaster Condition in the CONFIGURATION UPDATE COMMAND shall include the indication that the Disaster Condition is no longer applicable.

### 6.31.3 Impacts on existing nodes and functionality

The AMF is impacted to disperse the returning Inbound Roamers to the PLMN D, to initiate UE configuration update procedure to notify the UE the end of Disaster Condition, and to initiate deregistration procedure to the UE of Disaster Inound Roamer.

The UE is impacted to be deregistered from the PLMN A when the UE is notified that the Disaster Condition is no longer applicable.

## 6.32 Solution #32: The quick return to PLMN with Disaster Condition

### 6.32.1 Introduction

This is a solution for KI#6:

Key Issue #6: Notification that Disaster Condition is no longer applicable to the UEs.

In this solution, the UE has registered with a PLMN without Disaster Condition after Disaster Condition happened for Disaster Roaming service. The PLMN without Disaster Condition initiates the deregistration procedure for the Disaster Inbound Roamers when Disaster Condition is no longer applicable.

### 6.32.2 Detailed description

For convenience on description, PLMN D is the PLMN with Disaster Condition and PLMN A is the PLMN without Disaster Condition.

When it is notified that the Disaster Condition is no longer applicable in PLMN D:

- for the UEs in 5GMM-CONNECTED mode, the AMF of PLMN A initiates the deregistration procedure by sending a Deregistration Request message to the Disaster Inbound Roamer from PLMN D. The Deregistration Request message contains a cause value #XX "disaster condition in PLMN with disaster condition is resolved" or an existing 5GMM cause value (e.g., 5GMM cause #11 (PLMN not allowed)) to indicate that the Disaster Condition in PLMN D is no longer applicable. The Disaster Inbound Roamer performs the deregistration procedure as described in 3GPP TS 23.502 [8] and deletes the corresponding Disaster Condition parameters which include:

- the parameters provisioned to UE when Disaster Condition applies (e.g., assistant information indicated in Key Issue #2 and Key Issue #3);

- UE context in PLMN A (e.g., GUTI, Disaster Condition Areas, back-off timer, etc.,); and

- information for PLMN selection under Disaster Condition.

- for the UEs in 5GMM-IDLE mode, the PLMN A may page UE to enter 5GMM-CONNECTED and then perform deregistration procedure above.

If the Disaster Inbound Roamer has any ongoing emergency PDU session or high priority service, the AMF shall not initiate the deregistration procedure until the emergency PDU session is released and all the PDU sessions for the high priority services are released.

After the completion of the deregistration procedure, the Disaster Inbound Roamer performs the normal PLMN selection as specified in 3GPP TS 23.122 [7].

The Disaster Inbound Roamer may store the information on the previously registered PLMN identity (i.e., the PLMN identity of PLMN D) before the Disaster Condition started to assist the quick return to PLMN D.

### 6.32.3 Impacts on existing nodes and functionality

UE:

- support for 5GMM cause value #XX "disaster condition in PLMN with disaster condition is resolved";

- optionally, support for storing the information on the previously registered PLMN identity.

AMF of PLMN without Disaster Condition:

- support for 5GMM cause value #XX "disaster condition in PLMN with disaster condition is resolved".

## 6.33 Solution #33

### 6.33.1 Description

#### 6.33.1.1 Introduction

This solution addresses the following key issue:

Key Issue #6: Notification that Disaster Condition is no longer applicable to the UEs

This solution enables the AMF of a PLMN without Disaster Condition to inform the UE when the UE enters or is in the 5GMM-CONNECTED mode.

#### 6.33.1.2 Detailed description

If the AMF of a PLMN (called PLMN A) without Disaster Condition determined in key issue #4 that a UE roams using disaster roaming due to a previously selected PLMN with Disaster Condition (called PLMN D), then when the AMF determines that Disaster Condition no longer applies for PLMN D in the area served by NG-RAN node serving the UE:

- if the UE is in the 5GMM-CONNECTED mode in 3GPP access, the AMF triggers over 3GPP access the UE to perform mobility registration update and rejects the mobility registration update with an indication that Disaster Condition no longer applies for the other PLMN (e.g. a new 5GMM cause #YYY "Disaster Condition in other PLMN no longer applies"). The indication triggers the UE to remove stored determination that Disaster Condition applies for PLMN D.

- if the UE in the 5GMM-IDLE mode in 3GPP access attempts to move to 5GMM-CONNECTED mode in 3GPP access, the AMF rejects the initial NAS request with an indication that Disaster Condition no longer applies for the other PLMN (e.g. 5GMM cause #YYY "Disaster Condition in other PLMN no longer applies"). The indication triggers the UE to remove stored determination that Disaster Condition applies for PLMN D.

If the UE has an emergency PDU session or a high priority service, the AMF perform the handling above after release of the emergency PDU session or after the high priority service is finished.

If the UE removes stored determination that Disaster Condition applies for a higher priority PLMN, the UE enters the state 5GMM-REGISTERED.PLMN-SEARCH, perform PLMN selection and attempts to perform mobility registration update.

### 6.33.2 Impacts on existing nodes and functionality

The UE is impacted with processing of the new 5GMM cause #YYY "Disaster Condition in other PLMN no longer applies".

The AMF of the PLMN without Disaster Condition is impacted with sending the new 5GMM cause #YYY "Disaster Condition in other PLMN no longer applies".

Depending on solution for Key Issue #2, the NG-RAN of the PLMN without Disaster Condition is impacted with providing the AMF with the area served by the RAN node serving the UE or with the "disaster roaming PLMN list" of the NG-RAN node.

## 6.34 Solution #34

### 6.34.1 Description

#### 6.34.1.1 Introduction

This solution addresses the following key issue:

Key Issue #6: Notification that Disaster Condition is no longer applicable to the UEs

This solution enables the UE in 5GMM-IDLE mode to determine this on its own.

#### 6.34.1.2 Detailed description

The UE in 5GMM-IDLE removes the stored determination that Disaster Condition applies for a PLMN if a cell of the PLMN becomes available when the UE periodically attempts to obtain service on HPLMN, an EHPLMN or a higher priority PLMN/access technology combinations.

If the UE removes the stored determination that Disaster Condition applies for a higher priority PLMN, the UE enters the state 5GMM-REGISTERED.PLMN-SEARCH, perform PLMN selection and attempts to perform mobility registration update.

### 6.34.2 Impacts on existing nodes and functionality

The UE is impacted with:

- removal of the stored determination that Disaster Condition applies for a PLMN if a PLMN's cell becomes available when the UE periodically attempts to obtain service on HPLMN, an EHPLMN or a higher priority PLMN/access technology combinations.

- entering the state 5GMM-REGISTERED.PLMN-SEARCH, perform PLMN selection and attempts to perform mobility registration update, if the UE removes the stored determination that Disaster Condition applies for a higher priority PLMN.

## 6.35 Solution #35: Notification that Disaster Condition is no longer applicable to the UEs by stopping RAN sharing

### 6.35.1 Description

It is assumed that an NG-RAN node of a PLMN without a disaster condition stops being a shared RAN node when a disaster condition no longer applies. See Solution #9 for the details.

With the assumption above, the UEs can come back to the NG-RAN nodes of a PLMN to which a disaster condition had applied if the NG-RAN nodes of a PLMN without a disaster condition becomes not shared anymore. Therefore, there is no need to notify that disaster condition is no longer applicable to the UEs. However, the UE can recognize that a disaster condition no longer applies to the current PLMN from the broadcast information, e.g. the barring information of the cell on which the UE is camping does not include any information related to Access Identity 3.

NOTE: It is expected that the UE and the NG-RAN will be made capable of handling Access Identity 3 via conclusions for Key Issue #7.

If the NG-RAN node of a PLMN without a disaster condition stops being a shared RAN node, a UE in 5GMM-CONNECTED mode can no longer be served by the NG-RAN node, i.e. from the UE perspective the cell that used to serve the UE disappears. Then, the UE will camp on a cell of a PLMN where a disaster condition had applied and perform the registration procedure.

There is no disaster-related information stored in the UE. Thus, there is no need to remove the stored information on Disaster Condition from the UE's storage.

### 6.35.2 Impacts on existing nodes and functionality

UE

The UE recognizes that a disaster condition no longer applies to the current PLMN from the barring information.

NG-RAN

While NG-RAN without a disaster condition is shared, it needs to broadcast barring information related to Access Identity 3.

## 6.36 Solution #36

### 6.36.1 Introduction

This is a solution for Key Issue #7: Prevention of signalling overload in PLMNs without Disaster Condition as specified in clause 5.7.

In this solution, it is assumed that the UE selects a PLMN without Disaster Condition (PLMN A) providing Disaster Roaming services, based on the solutions of Key Issue #3 and #5. The UE can be already registered to the PLMN A or can be attempting initial registration to the PLMN A.

### 6.36.2 Detailed description

When the UE initiate one of the following 5GMM procedure to the PLMN providing Disaster Roaming services:

- initial registration procedure;

- registration procedure for mobility and periodic update procedure; or

- service request procedure,

the AMF may assess the level of congestion or signalling load created by the Disaster Inbound Roamers, and proceed with the congestion control mechanism for Disaster Inbound Roamer as follows.

a) AMF may reject the 5GMM request by sending reject message with the following information

1) 5GMM cause value indicating that the resources are not sufficient for the Disaster Inbound Roamers; and

2) value for back-off timer T3346;

b) If the UE receives a REJECT message with such information, the UE proceeds as follows:

1) the UE enters 5GMM-REGISTERED.PLMN-SEARCH, and looks for any other available PLMNs other than the serving PLMN. If there are one or more candidates in the UE's location, the UE performs PLMN selection to select any other available PLMN;

2) else, the UE runs timer T3346 with the received value, and do not attempt to initiate any 5GMM proecedure except the deregistration procedure until the timer T3346 is expired.

Any other aspects regarding the congestion control mechanism are same as described in 3GPP TS 24.501 [9].

### 6.36.3 Impacts on existing nodes and functionality

The UE is impacted with the new 5GMM cause value and the behaviour with it.

The AMF is impacted with the new 5GMM cause value, and determination of congestion.

## 6.37 Solution #37: Enabling a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion

### 6.37.1 Introduction

This is a solution for the following question of KI#7:

*- How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion;*

### 6.37.2 Detailed description

To prevent the subscribers of the PLMN with Disaster Condition (i.e. "PLMN D") perform registration to the PLMN without Disaster Condition (i.e. "PLMN A"), the RAN of PLMN A will block the UE's attempts based on the "RRC Establishment Cause" and a back-off time.

The above is achieved by the following steps of the registration procedure:

- When the UE tries to establish an RRC connection in PLMN A, it will use a new "Establishment Cause", e.g. "Inbound Disaster Roamer".

NOTE: Introduction of a new RRC Establishment Cause is subject to agreement of RAN WGs.

- the AMF has already reached a predefined threshold and has sent an "Overload Control" message to the RAN entities (i.e. gNBs). In this Overload Control message, the AMF has the option of informing the RAN entities that connection attempts from "Disaster Inbound Roamers" shall be blocked

- The RAN entities will then send an "RRC Connection Reject" message to the UE with a back-off itmer

- the RRC layer of the UE will inform the 5GMM layer of the back-off itmer

- the 5GMM layer of the UE will then stop attempting connection establishment for the duration of the back-off timer

- the UE will retry connection establishment for the registration once the back-off timer has expired

### 6.37.3 Impacts on existing nodes and functionality

AMF:

- Upon reaching a predefined threshold, the AMF sends an Overload Control to RAN

UE:

- Includes a new "Establishment Cause" in the RRC Connection Request message when it tries to establish a new connection to register in a new PLMN after it has been informed of a Disaster Condition in its HPLMN

RAN:

- Receives an Overload Control from the AMF for particular attempts that are triggered by UEs using a new "Establishment Cause" in the RRC Connection Request message.

## 6.38 Solution #38: Prevention of signalling overload via barring factor for Access Identity 3

### 6.38.1 Description

Within UAC-BarringInfoSet, an NG-RAN node can include barring factor for Access Identity 3.

During the access barring check, if the UE NAS layer provides Access Identity 3 to the UE RRC layer together with an access category, the UE RRC layer decides whether the access attempt is allowed or not based on the value of the barring factor for Access Identity 3 associated with the access category and a random number drawn if none of the bit(s) for other access identity(ies) in *uac-BarringForAccessIdentity* is set to zero.

NOTE: The change in the UAC-BarringInfoSet proposed in this solution is subject to RAN2 agreement.

The 5GSM level congestion can be prevented by properly setting the values of the barring factor for Access Identity 3 each of which is associated with an access category. For example, if access attempts of disaster inbound roamers related to DNN X should be reduced, the barring factor for Access Identity 3 associated with an operator-defined access category for DNN X can be adjusted.

### 6.38.2 Impacts on existing nodes and functionality

UE

- The UE needs to be able to read information related to Access identity 3 in the barring information including barring factor for Access Identity 3.

- The UE needs to determine whether an access attempt associated with Access Identity 3 is allowed based on the value of the barring factor for Access Identity 3

NG-RAN

- The NG-RAN node needs to be able to include information related to Access Identity 3 in the barring information including barring factor for Access Identity 3.

## 6.39 Solution #39: Solution for prevention of signalling overload in PLMNs without Disaster Condition by providing disaster roaming assistance information to distribute roamers, and congestion mitigation

### 6.39.1 Introduction

This is a solution for Key Issue #7 (Prevention of signalling overload in PLMNs without Disaster Condition).

The solution addresses the first, second and fourth questions to be studied under Key Issue #7, namely:

- How to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition available in the area where the Disaster Condition applies, so as to share the load as evenly as possible between the PLMNs without Disaster Condition;

- How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit; and

- How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion.

The solution assumes that PLMNs without Disaster Condition which indicate that they can accept Disaster Inbound Roamers will accept Disaster Inbound Roamers from any PLMN with Disaster Condition, up until the point when they reach a congestion situation.

### 6.39.2 Detailed description

#### 6.39.2.1 Distribution of subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition

The UE can be provisioned with disaster roaming assistance information, which the UE will use to select a PLMN upon being notified that a Disaster Condition applies to the registered PLMN.

The disaster roaming assistance information can be:

a) pre-configured in the ME;

b) pre-configured in the USIM;

c) sent to the UE by the network using the UE parameters update procedure (before a Disaster Condition applies);

d) sent to the UE by the network using the steering of roaming procedure (before a Disaster Condition applies); or

e) signalled to the UE by the PLMNs without Disaster Condition (when a Disaster Condition applies).

Only the disaster roaming assistance information provisioned by the network is used by the UE, if both a disaster roaming assistance information provisioned by the network and a pre-configured disaster roaming assistance information are present. If no disaster roaming assistance information is provisioned by the network, and the UE has a pre-configured disaster roaming assistance information in both the USIM and the ME, then only the pre-configured disaster roaming assistance information in the USIM is used.

The disaster roaming assistance information can consist of:

a) a prioritized list of PLMNs. In this case, the UE attempts registration on the available PLMNs from the list in priority order;

NOTE 1: The prioritized list of PLMN can be UE-specific, so as to direct a first group of UEs to PLMN 1, a second group of UEs to PLMN 2, and so on.

b) a weighted list of PLMNs. In this case, the UE performs a weighted random draw among the available PLMNs from the list; or

NOTE 2: The weight assigned to each PLMN can be commensurate to the size of the PLMN or the capacity of the PLMN to accommodate Disaster Inbound Roamers.

c) an indication of the capacity of PLMNs without Disaster to accept Disaster Inbound Roamers e.g broadcast by the PLMNs which indicate that they can accommodate Disaster Inbound Roamers. In this case, the UE performs a weighted random draw among the available PLMNs taking into account the capacity of each PLMN.

NOTE 3: The capacity of a PLMN without Disaster Condition to accept Disaster Inbound Roamers can be determined by the PLMN without Disaster Condition based on operator's policies e.g. the amount of resources allocated by the PLMN to serve Disaster Inbound Roamers.

NOTE 4: Extension of broadcast signalling is subject to agreement of RAN WGs.

#### 6.39.2.2 Staggering of arrival of Disaster Inbound Roamers

The UE can be provisioned with a disaster roaming wait range, which the UE will use to determine how long to wait before initiating registration on the selected PLMN after performing a PLMN selection triggered by a notification that a Disaster Condition applies to the registered PLMN.

The disaster roaming wait range is set according to operator's policies and can be:

a) pre-configured in the ME;

b) pre-configured in the USIM;

c) sent to the UE by the network using the UE parameters update procedure (before a Disaster Condition applies); or

d) sent to the UE by the network using the steering of roaming procedure (before a Disaster Condition applies).

Only the disaster roaming wait range value provisioned by the network is used by the UE, if both a disaster roaming wait range value provisioned by the network and a pre-configured disaster roaming wait range value are present. If no disaster roaming wait range value is provisioned by the network, and the UE has a pre-configured disaster roaming wait range value in both the USIM and the ME, then only the pre-configured disaster roaming wait range value in the USIM is used.

Upon selecting a candidate PLMN following a notification that a Disaster Condition applies to the registered PLMN, the UE shall generate a random number within the disaster roaming wait range by applying a hash function to its IMSI and start a timer set to the generated random number. While the timer is running, the UE shall not initiate registration. Upon expiration of the timer, the UE shall initiate registration on the selected PLMN. If no disaster roaming wait range is provisioned to the UE, the UE shall use a default disaster roaming wait range. The default disaster roaming wait range is [0 – 5 min].

#### 6.39.2.3 Congestion mitigation in PLMNs without Disaster Condition

Upon encountering congestion due to the arrival of Disaster Inbound Roamers, a PLMN without Disaster Condition indicating that it can accommodate Disaster Inbound Roamers may perform one or more of the following:

a) turn off the indication (e.g. SIB flag) that the PLMN can accommodate Disaster Inbound Roamers, so as to prevent new roamers from considering the PLMN as PLMN selection candidate;

NOTE 1: Extension of broadcast signalling is subject to agreement of RAN WGs.

b) reject the Disaster Inbound Roamers' registration or service requests with 5GMM cause #22 "congestion" and back-off timer T3346; or

c) reject the Disaster Inbound Roamers' registration or service requests with 5GMM cause #YYY "disaster inbound roamers not allowed".

Upon receiving a REGISTRATION REJECT or SERVICE REJECT with 5GMM cause #YYY "disaster inbound roamers not allowed", the UE shall perform PLMN selection as specified in the solution(s) for Key Issue #5 (PLMN selection when a "Disaster Condition" applies) with the addition that the UE shall not consider the selected PLMN as candidate for PLMN selection.

The UE should maintain a list of PLMNs where 5GMM cause # YYY "disaster inbound roamers not allowed" was received:

- upon receiving 5GMM cause # YYY "disaster inbound roamers not allowed", the UE should add the identity of the PLMN to the list of PLMNs where 5GMM cause # YYY "disaster inbound roamers not allowed" was received and should start timer TX if timer TX is not already running. The number of PLMNs that the UE can store where 5GMM cause # YYY "disaster inbound roamers not allowed" was received is implementation specific, but it shall be at least one. The value of timer TX is UE implementation specific;

- in automatic PLMN selection the UE shall not consider PLMNs where 5GMM cause # YYY "disaster inbound roamers not allowed" was received as PLMN selection candidates, unless no other PLMN is available; and

- the UE shall delete stored information on PLMNs where 5GMM cause # YYY "disaster inbound roamers not allowed" was received when the USIM is removed, timer TX expires or the UE is notified that the Disaster Condition no longer applies as specified in solution(s) to Key Issue #6 (Notification that Disaster Condition is no longer applicable to the UEs).

NOTE 2: Using 5GMM cause #YYY rather than 5GMM cause #22 triggers the UE to not consider the selected PLMN as candidate for PLMN selection until the USIM is removed, timer TX expires or the UE is notified that the Disaster Condition no longer applies, which avoids repeated rejections in case e.g. the PLMN sending the reject is the only available PLMN in the area.

### 6.39.3 Impacts on existing nodes and functionality

UE

- support for handling of disaster roaming assistance information;

- support for handling of disaster roaming wait range; and

- support for 5GMM cause #YYY "disaster inbound roamers not allowed".

UDM of HPLMN

- optionally, support for providing disaster roaming assistance information; and

- optionally, support for providing disaster roaming wait range.

AMF of registered PLMN (with Disaster Condition)

- optionally, support for providing disaster roaming assistance information; and

- optionally, support for providing disaster roaming wait range.

AMF of PLMNs indicating that they can accept Disaster Inbound Roamers:

- optionally, support for providing disaster roaming assistance information; and

- optionally, support for 5GMM cause #YYY "disaster inbound roamers not allowed".

## 6.40 Solution #40: Enhancements to UAC barring information to prevent congestion in disaster roaming PLMN

This solution addresses the Key Issue #7 "Prevention of signalling overload in PLMNs without Disaster Condition".

### 6.40.1 Detailed description

It is important for the PLMN providing disaster roaming to avoid degradation of service levels to its own subscribers due to the activities of incoming UEs. For this reason, the network needs a method by which it can set differential access barring levels for own subscribers and disaster roamers.

The usage of new Access Identity 3 allows network to differentiate inbound roamers from own subscribers. But this alone would not be useful to mitigate congestion caused by a sudden inflow of inbound roamers.

A new offset value is introduced to the unified access control barring information. A UE which is registered or attempting registration in a PLMN which is on the forbidden PLMN list or on the list of "forbidden tracking areas for roaming", but which is broadcasting "disaster roaming active", shall apply a uac-DisasterOffsetToBarringFactor to the uac-BarringFactor.

The uac-DisasterOffsetToBarringFactor indicates to the disaster roaming UEs the offset value by which the BarringFactor must be reduced when evaluating the access barring condition for that access category. The uac-DisasterOffsetToBarringFactor is set per access category.

The uac-DisasterOffsetToBarringFactor is defined as a range of s5 till s95 in steps of 5.

A disaster roaming UE computes the uac-BarringFactor for its access category as

uac-BarringFactor = max (p00, (uac-BarringFactor - uac-DisasterOffsetToBarringFactor))

NOTE: The addition of a new parameter to UAC Barring information is subject to RAN2 agreement.

### 6.40.2 Impacts on existing nodes and functionality

Unified access control: definition of a new offset for BarringFactor

## 6.41 Recommended PLMN without Disaster Condition

### 6.41.1 Introduction

This is a solution for the following question of KI#7, the principles are as follows:

*- How to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition available in the area where the Disaster Condition applies, so as to share the load as evenly as possible between the PLMNs* *without Disaster Condition;*

This solution proposes to configure different UEs with a different recommended PLMN list for supporting Disaster Condition roaming service.

### 6.41.2 Detailed description

To distribute the subscribers of the PLMN with Disaster Condition to the PLMNs without Disaster Condition available in the area where the Disaster Condition happens, the PLMN with Disaster Condition will provide UE a recommended PLMN list with priority order before the Disaster Condition happens. Different UEs will be provided with the different recommended PLMN list. When the Disaster Condition happens to the current PLMN, the UEs will perform the PLMN selection with the PLMN in the recommended PLMN list based on the priority order and register to the recommended PLMN for Disaster Condition roaming service.

If all of those PLMNs in the recommended PLMN list are not available, the UE will switch to limited service state.

NOTE 1: The recommended PLMN list may be provided to the UE over non-3GPP access if any before the Disaster Condition happens.

As for how to determine the recommended PLMN list, it can be based on the following information:

- the agreements with PLMNs without Disaster Condition. For example, based on the agreements with PLMNs without Disaster Condition the UEs in one area will be accessed to PLMN#1, while the UEs in another area will be accessed to PLMN#2.

NOTE 2: How to determine the recommended PLMN list is out of the scope.

### 6.41.3 Impacts on existing nodes and functionality

UE:

- support for PLMN selection with the recommended PLMN list;

UDM of HPLMN:

- support for providing recommended PLMN list.

AMF of registered PLMN (with Disaster Condition):

- support for providing recommended PLMN list;

## 6.42 Solution #42

### 6.42.1 Description

#### 6.42.1.1 Introduction

This solution addresses the following key issue:

Key Issue #7: Prevention of signalling overload in PLMNs without Disaster Condition

and the following questions of the key issue:

*- How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;*

*- How to use new Access Identity 3 for the purpose of Disaster Inbound Roamer access control and signalling overload prevention in the PLMNs without Disaster Condition;*

*- How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion.*

This solution is based on extension of unified access control and on usage of existing congestion control mechanisms of core network.

#### 6.42.1.2 Detailed description

When the UE selects a PLMN in the UE's forbidden PLMN list according to a solution for Key Issue #5, the UE considers itself being configured with the access identity 3.

Furthermore, a new access category X (= MO\_Disaster\_Roaming) will be specified.

NOTE 1: pecification of a new access category requires SA1 agreement.

The UE will consider that an access attempt is of the access category X (= MO\_Disaster\_Roaming), if the access attempt is triggered by registration in a solution for Key Issue #4 and the registration is an initial registration or the first mobility registration update in the PLMN in the UE's forbidden PLMN list selected according to a solution for Key Issue #5.

In order to supress some registrations (an initial registration or the first mobility registration update in the PLMN in the UE's forbidden PLMN list selected according to a solution for Key Issue #5) in a solution for Key Issue #4, the NG-RAN node of the PLMN without Disaster Condition and offering disaster roaming will broadcast UAC-BarringInfoSet for the access category X (= MO\_Disaster\_Roaming):

- with uac-BarringFactor derived from the intended supression rate; and

NOTE 2: uac-BarringFactor in UAC-BarringInfoSet for access category X (= MO\_Disaster\_Roaming) can be lower than uac-BarringFactor in UAC-BarringInfoSet for the access category 3 (= MO\_sig).

- without indicating that access attempt is allowed for access identity 3.

NOTE 3: For an access category other than the access category X, access attempts from disaster inbound roamers and access attempts from non-disaster inbound roamers are subject to the same barring factor.

Additionally, the AMF of the PLMN providing the disaster roaming control can use the existing congestion control mechanisms (e.g. NAS level mobility management congestion control).

### 6.42.2 Impacts on existing nodes and functionality

The UE is impacted with determination of the access identity 3 and the new access category X (= MO\_Disaster\_Roaming), as specified in clause 6.42.1.2.

The NG-RAN of the PLMN without Disaster Condition is impacted with broadcast of barring rates for the new access category X, as specified in clause 6.42.1.2.

## 6.43 Solution #43: List if PLMNs to be used while in Disaster condition

### 6.43.1 General

This solution aims at solving the below study items in key issue #7

a) How to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition available in the area where the Disaster Condition applies, so as to share the load as evenly as possible between the PLMNs without Disaster Condition;

b) How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;

UE is provided with "List of PLMNs to be used while in Disaster condition". The order in which the PLMNs are arranged in the list by the HPLMN (or serving PLMN) is the order in which the UE shall prioritize the forbidden PLMNs during PLMN selection. Also the list is populated with a minium wait time per PLMN which will help to reduce the signalling overload on the network following the mass migration.

### 6.43.2 Solution description

When a disaster happens, the network will become unresponsive. So it is good to prepare the UE for disaster even before the disaster happens. So it is always better to provide the UE with the information that it can use to minimize the service interruption before the disaster happens in the form of a "List of PLMNs to be used while in Disaster condition".The list can be

a) Stored in the SIM card

b) Stored in the Non Volatile memory of the ME

c) Provided by NAS signalling messages via 3GPP or non-3GPP access.

Serving PLMN can arrange the PLMNs in "List of PLMNs to be used while in Disaster condition" in the particular order so as to direct the UE to different PLMNs to avoid the overload on the network.

PLMNs in "List of PLMNs to be used while in Disaster condition" are arranged in a particular order by the serving PLMN. Serving PLMN knows exactly how many PLMNs are there in an area before hand and so when assigning the "List of PLMNs to be used while in Disaster condition", it provides the UE with a priority order.

For example, consider the scenario where PLMN DC is the PLMN that is in disaster condition. PLMN NDC\_1 and PLMN NDC\_2 are the 2 PLMNs that are Not in Disaster condition and have coverage in the area where the disaster happened.

For UE1, PLMN DC can assign "List of PLMNs to be used while in Disaster condition" as {PLMN NDC\_1, PLMN NDC\_2} and for UE2, PLMN DC can assign the "List of PLMNs to be used while in Disaster condition". As {PLMN NDC\_2, PLMN NDC\_1}. If both the PLMNs NDC\_1 and PLMN NDC\_2 are available for the UEs, they need to give priority to the order in which the PLMNs are populated in "List of PLMNs to be used while in Disaster condition".

So in this case UE1 will go to PLMN NDC1 and UE2 will go to PLMN NDC2. The serving PLMN can thus equally distribute

In addition to the PLMN IDs of the PLMN, there can be a timer associated which indicates a 'minimum wait time' that the UE should wait to perform registration on the PLMN following a disaster condition.

Each of the entry of PLMN in "List of PLMNs to be used while in Disaster condition" is also associated with a 'minimum wait time' timer which is used to control the registration attempt. UE shall not perform a registration until the 'minimum wait time' timer has expired. This will also give the NW a chance to provide service to the UEs based on its priority. For a high priority device the value of the minimum wait time can be set to a very low value.

Right now in NAS, a random timer value is used in some situations, advantages of have a 'minimum wait time' value is that the registration of the UEs can be arranged in a more controlled way. Some UEs can also be given priority.

It can also be that the UE can have a random timer started after the minimum wait time is over which will also ensure less signalling load on the network.

AMF knows the number of UEs registering in a particular area. So AMF can assign the minimum wait time via NAS signalling so as to distribute the UEs registration in case of a disaster. E.g the first 20 UEs can be assigned a minimum wait time of 5 seconds, next 20 UEs a minimum wait time of 10 seconds and so on.

### 6.43.3 Impacts on existing nodes and functionality

Impacts on the PLMN selection functionality and also the timing of the registration update procedure once the disaster has happened.

- UE needs to handle the minimum wait time to control the timing of registration update procedure.

- AMF needs to provide UE with the minimum wait time.

## 6.44 Solution #44: Staggering of returning UEs trying to register in the PLMN previously with Disaster Condition

### 6.44.1 Introduction

This is a solution for the following question of KI#8:

*- How to stagger the return of UEs to the PLMN previously with Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;*

### 6.44.2 Detailed description

To distribute and stagger the return of the subscribers of the PLMN with Disaster Condition (i.e. "PLMN D"), the "PLMN D" will provide the UE with a specific timer which, along with other parameters, will result into a "Window of Time" over which the UE is allowed to make registration attempts in "PLMN A".

The above is achieved by the following steps of the registration procedure:

- the UE will inform the AMF of PLMN D that it supports MINT in the Registration Request Message

- the AMF then sends a specific timer, called T35yy, to the UE in the Registration Accept.

- the UE will insert timer T35yy, along with its unique ID, e.g. SUPI/PEI, into an algorithm

- the result of this operation will be a series of "Window of Time", defned by an Initial Start Time, an Initial Stop Time, and a "Wait Time" between consecutive (Window of Time) windows

- the UE is then only allowed to perform registration attempts, when returning to the PLMN D during an occurrence of the window(s) of time, where the first occurrence of the window of time is from Initial Start Time to Initial Stop Time, the second occurrence of window of time is from (Initial Stop Time + Wait Time) to (Initial Stop Time + Wait Time + the window duration), and so on

### 6.44.3 Impacts on existing nodes and functionality

AMF:

- Upon receipt of the Registration Request message, with the UE's indication of support of the MINT feature, the AMF sends a new information element that contains a new timer, called T35yy, to the UE in Registraion Accept message

UE:

- Includes the support of MINT in its 5GMM capability IE

- Upon reception of the new timer T35yy in Registration Accept message, it calculates the "Window of Time" as well as the wait time

## 6.45 Solution #45: Prevention of signalling overload by returning UEs

### 6.45.1 Description

Any existing mechanisms used in the NG-RAN (e.g. UAC) and the 5GCN (NAS-level congestion control) can be used.

### 6.45.2 Impacts on existing nodes and functionality

None

## 6.46 Solution #46: Solution for prevention of signalling overload by returning UEs in PLMN previously with Disaster Condition

### 6.46.1 Introduction

This is a solution for Key Issue #8 (Prevention of signalling overload by returning UEs in PLMN previously with Disaster Condition).

This solution can be used both over the 3GPP access and over the non-3GPP access of the PLMN without Disaster Condition (PLMN A).

### 6.46.2 Detailed description

Upon being notified that a Disaster Condition in PLMN D no longer applies, a PLMN without Disaster Condition (PLMN A) currently serving Disaster Inbound Roamers may perform one or more of the following:

a) over the 3GPP access, wait for an implementation specific amount of time before turning off the indication (e.g. SIB flag) that a Disaster Condition in PLMN D applies; or

NOTE 1: Waiting for an implementation specific amount of time ensures that Disaster Inbound Roamers camping on PLMN 1 are notified that the Disaster Condition no longer applies at a time different from the time when Disaster Inbound Roamers camping on PLMN 2 are notified, thereby spreading out in time the return of Disaster Inbound Roamers to the PLMN previously with Disaster Condition.

NOTE 2: Extension of broadcast signalling is subject to agreement of RAN WGs.

NOTE 3: Input from SA1 is needed on whether delaying turning off the indication (e.g. SIB flag) that a Disaster Condition in PLMN D applies conflicts with regulatory requirements.

b) for the Disaster Inbound Roamers in 5GMM-CONNECTED mode, which previously selected PLMN D:

1) perform a generic UE configuration update procedure with an indication that the Disaster Condition in another PLMN no longer applies; or

2) perform a generic UE configuration update procedure with "re-registration requested", then reject the UE's registration request with 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies";

For both 1) and 2), the time when the procedure is triggered for each UE should be randomized.

NOTE 4: Randomizing the time when the procedure is triggered for each UE ensures that Disaster Inbound Roamers served by a given PLMN are notified that the Disaster Condition no longer applies at different times and thus return to the PLMN previously with Disaster Condition at different times.

NOTE 5: It is assumed that the AMF of PLMN A determines the previously selected PLMN of the Disaster Inbound roamers when the Disaster Inbound Roamers register on PLMN A, as specified in the solution(s) to Key Issue #4 (Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition).

The UE can be provisioned with a disaster return wait range, which the UE will use to determine how long to wait before initiating registration on the PLMN selected after being notified that a Disaster Condition no longer applies.

The disaster return wait range is set according to operator's policies and can be:

a) pre-configured in the ME;

b) pre-configured in the USIM;

c) sent to the UE by the network using the UE parameters update procedure (before a Disaster Condition applies);

d) sent to the UE by the network using the steering of roaming procedure (before a Disaster Condition applies); or

e) sent to the UE by the PLMN without Disaster Condition in a CONFIGURATION UPDATE COMMAND message with an indication that the Disaster Condition in another PLMN no longer applies or a REGISTRATION REJECT message with new 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies".

Only the disaster return wait range value n provisioned by the network is used by the UE, if both a disaster return wait range value provisioned by the network and a pre-configured disaster return wait range value are present. If no disaster return wait range value is provisioned by the network, and the UE has a pre-configured disaster return wait range value in both the USIM and the ME, then only the pre-configured disaster return wait range value in the USIM is used.

Upon being notified that a Disaster Condition no longer applies (either by detecting that the serving PLMN has turned off the indication that a Disaster Condition in PLMN D applies, receiving a CONFIGURATION UPDATE COMMAND message with an indication that the Disaster Condition in another PLMN no longer applies, or receiving a REGISTRATION REJECT message with 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies"), the UE shall enter 5GMM-REGISTERED.PLMN-SEARCH and perform PLMN selection as specified in 3GPP TS 23.122 [7] clause 4.4.3.1.1. Upon selecting a PLMN, the UE shall generate a random number within the disaster return wait range by applying a hash function to its IMSI and start a timer set to the generated random number. While the timer is running, the UE shall not initiate registration. Upon expiration of the timer, the UE shall initiate registration on the selected PLMN. If no disaster return wait range is provisioned to the UE, the UE shall use a default disaster return wait range. The default disaster return wait range is [0 – 5 min]

### 6.46.3 Impacts on existing nodes and functionality

UE

- support for handling of the indication broadcast by PLMN A (e.g. SIB flag) that a Disaster Condition in PLMN D applies;

- support for CONFIGURATION UPDATE COMMAND message with an indication that the Disaster Condition in another PLMN no longer applies;

- support for 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies"; and

- support for handling of disaster return wait range.

UDM of HPLMN

- optionally, support for providing disaster return wait range.

AMF of registered PLMN (without Disaster Condition)

- optionally, support for providing disaster return wait range;

- optionally, support for CONFIGURATION UPDATE COMMAND message with an indication that the Disaster Condition in another PLMN no longer applies; and

- optionally, support for 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies".

RAN of registered PLMN (without Disaster Condition)

- optionally, support for waiting for a randomized amount of time before turning off the indication (e.g. SIB flag) that a Disaster Condition in PLMN D applies.

## 6.47 Solution #47: Network controlled return of UEs at the end of disaster condition

At the end of disaster condition, a coordinated action to return roaming UEs to their own PLMN is required to avoid an exodus in the reverse direction. This solution addresses the Key Issue #8 "Prevention of signalling overload by returning UEs in PLMN previously with Disaster Condition".

### 6.47.1 Detailed description

In the description, PLMN D is subject to **d**isaster and PLMN A is **a**live and not subject to disaster.

PLMN A providing disaster roaming services is informed of the end of disaster condition in PLMN D though any of the solutions for Key Issue #6. This may also include a start time at which to start returning the UEs.

#### 6.47.1.1 Staggered return of UEs controlled by AMF

In order to have a controlled return of the disaster roamers at the start time indicated by the PLMN D, the time period for which PLMN A keeps the broadcast indication active and the time period for which it accepts registration requests by inbound roamers need to be different. This is illustrated in the figure below.



Figure 6.47.1.1-1 Actions by disaster roaming PLMNs during various phases

Once it is determined that UEs can start to return to PLMN D, the AMF in PLMN A enters a 'winding down' phase for disaster roaming. The duration of this phase is chosen by the networks such that it is larger than the periodic registration timers configured for disaster roamer UEs. The PLMN A keeps the broadcast indication of "disaster roaming active" in this phase.

Starting from 'winding down' phase, the AMF:

- responds to perioidic and mobility registration update requests from disaster roaming UEs with a Registration Reject message with a reject cause which is applicable to the normal roaming agreement for this subscriber (e.g. 5GMM cause #11 "PLMN not allowed" or #13 "Roaming not allowed in this tracking area"). On receipt of this reject cause the UE will perform PLMN search and find a suitable cell of PLMN D.

- responds to an initial registration attempt from disaster inbound roamers starting from the 'winding down' phase with a Registration Reject message according to its normal roaming policies.

- for a UE in CM-CONNECTED state, if the UE has PDU sessions established and AMF, based on local configurations, determines that transfer of PDU Sessions from PLMN A to PLMN D is possible, sends a Configuration Update Command including the configuration update indication IE with Registration Requested but set to "Registration Required". The subsequent Registration Request by the UE is rejected with 5GMM cause #13. On receipt of this reject cause the UE will perform PLMN search and find a suitable cell of PLMN D.

- for a UE in CM-CONNECTED state, if the UE does not have any PDU sessions established or the AMF, based on local configurations, determines that transfer of PDU Sessions from PLMN A to PLMN D is not possible, sends a Deregistration Request with a reject casue which is applicable to the normal roaming agreement for this subscriber (e.g. with detach type = "re-registration not required" and 5GMM cause #11 "PLMN not allowed" or #13 "Roaming not allowed in this tracking area"). The AMF also considers the ongoing services for deciding when to trigger the Deregistration procedure to minimize interruption to the UEs. For example the AMF shall not interrupt an ongoing IMS emergency session, and it should not interrupt an ongoing IMS VoNR call, if possible. AMF may also decide not to trigger Deregistration for a UE that has any active persistant bearer. On receipt of this Deregistration message, the UE shall perform a PLMN search.

The above steps ensure that all disaster roamers that go into CM-CONNECTED during the winding down phase are gracefully returned. The CM-IDLE roamers are unaffected since the broadcast indication is not changed. At the end of the 'winding down' phase, the PLMN A stops the broadcast indication of "disaster roaming active" condition. This step begins to return all Idle mode roamers to their own PLMN.

#### 6.47.1.2 Randomized return of UEs

The recovered PLMNs are assumed to be able to handle a percentage of returning UEs without a problem.

In this approach, the PLMN D indicates that a certain percentage of UEs can return at a specific time and the remaining UEs shall randomize their return time to PLMN D.

The AMF in PLMN A sends a "UE Configuration Update" message to the disaster roaming UEs. In this message, the AMF indicates a timer T1 with a value such that it does not expire before the start time indicated by PLMN D and a value 'n' (0 < n <1) corresponding to the percentage of UEs that can be accepted at expiry of timer T1.

On reception of the message, UE shall draw a random number 'x' distributed in the range [0 < x <1]. If x<=n, UE shall start the return to PLMN timer with value T1. If x>n, the UE shall start a timer with value (1+x) \* T1.

### 6.47.2 Impacts on existing nodes and functionality

AMF: Implement a "winding down" phase where CM-Connected UEs are returned, while keeping the broadcast indication for "disaster roaming" active.

UE: Accept a UE configuration update with an indication of a timer value and a barring factor to compute the local back-off timer before leaving disaster roaming PLMN.

## 6.48 Solution #48

### 6.48.1 Description

#### 6.48.1.1 Introduction

This solution addresses the following key issue:

Key Issue #8: Prevention of signalling overload by returning UEs in PLMN previously with Disaster ConditionThis solution is based on usage of existing unified access control.

#### 6.48.1.2 Detailed description

RAN cells of the PLMN previously with Disaster Condition can control access of returning UEs using the existing unified access control, by setting up UAC parameters for access category 3 (= MO\_sig).

### 6.48.2 Impacts on existing nodes and functionality

None.

## 6.49 Solution #49: Minimum wait timer

### 6.49.1 Solution description

This solution aims at solving the below study item

- How to stagger the return of UEs to the PLMN previously with Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit.

UE is provided with "List of PLMNs to be used while in Disaster condition". Also the list is populated with a minium wait time per PLMN which will help to reduce the signalling overload on the network following the mass migration. So when the UE returns to the HPLMN ( or previously served PLMN) UE can use the same timer and wait for the minimum wait time before initiating registration attempt in the previous PLMN.

### 6.49.2 Solution description

When a disaster happens, the network will become unresponsive. So it is good to prepare the UE for disaster even before the disaster happens.

In addition to the PLMN IDs of the PLMN, there will be a timer associated which indicates a 'minimum wait time' that the UE should wait to perform registration on the PLMN following a disaster condition.

Each of the entry of PLMN in "List of PLMNs to be used while in Disaster condition" is also associated with a 'minimum wait time' timer which is used to control the registration attempt. After moving back to the previously served PLMN from the VPLMN, UE shall not perform a registration until the 'minimum wait time' timer has expired. This will also give the NW a chance to provide service to the UEs based on its priority. For a high priority device the value of the minimum wait time can be set to a very low value.

It can also be a common timer for all PLMNs in the "List of PLMNs to be used while in Disaster condition" and the same timer can be used for re-registration at the previously served PLMN.

Right now in NAS, a random timer value is used in some situations, advantages of have a 'minimum wait time' value is that the registration of the UEs can be arranged in a more controlled way. Some UEs can also be given priority.

It can also be that the UE can have a random timer started after the minimum wait time is over which will also ensure less signalling load on the network.

### 6.49.3 Impacts on existing nodes and functionality

Timer value provided to the UE which is used as a minimum wait time for performing registration on moving back to the previously served PLMN.

- UE needs to handle the minimum wait timer to control the timing of the registration procedure.

- AMF needs to provide a minimum wait time to the UE.

## 6.50 Solution #50: Providing information to the RAN of PLMN A

### 6.50.1 Introduction

This is a solution for the following question of KI#7:

*-* "How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers".

In this solution, PLMN D is the PLMN with Disaster Condition and PLMN A is the PLMN that accepts inbound disaster roamers.

This solution assumes that

- the UE has been informed of the Disaster Condition in PLMN D

- the UE is about to register in PLMN A

### 6.50.2 Detailed description

The UE will provide the RAN of PLMN A with information to select proper AMF.

The above is achieved by the following steps below:

- during the RRC Connection Establishment in PLMN A, the UE will send to the RAN of PLMN A, an indication that it is an "Inbound Roamer" due to "Disaster Condition". This new information is sent, in addition to the GUAMI and 5G-S-TMSI of the UE

- The RAN will then use these parameters in order to select a special AMF that the PLMN A has designated for Disaster Inbound Roamers

- In order to spread the inbound (disaster) roamers, the RAN nodes should be configured by the operator to choose different AMF entities. This choice could be based on the geographic area and/or a priority order.

NOTE: Whether the addition of the parameter to the RRC message is a feasible solution is left for the RAN WGs to decide.

### 6.50.3 Impacts on existing nodes and functionality

UE:

- Needs to include a new indicaiton that the UE is a Diaster Inbound Roamer during the RRC Connection establishment

## 6.51 Solution #51: PLMN selection when shared RAN is available in case of disaster condition

### 6.51.1 Description

It is assumed that when a disaster condition applies, an NG-RAN node of a PLMN without a disaster condition becomes a shared RAN node between the PLMN without a disaster condition and a PLMN where a disaster condition applies. See Solution #9 for the details.

After a disaster condition applies, a UE can perform PLMN selection (either automatic or manual) as-is. As a result, the UE will select the same PLMN.

### 6.51.2 Impacts on existing nodes and functionality

None.

## 6.52 Solution #52: New solution to KI#4: Using the existing mobility restriction list to confine the UE service area in disaster roaming PLMN to the area of the disaster condition

### 6.52.1 Description

#### 6.52.1.1 Introduction

This solution corresponds to KI#4 on Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition (see clause 5.1), however the solution is specific to the following aspect of KI#4:

- "How a Disaster Roaming PLMN can limit the area of service to Inbound Disaster Roamers to the region where Disaster Condition applies".

#### 6.52.1.2 Detailed description

This solution assumes that the AMF in the PLMN without a disaster condition knows the area of the disaster condition of the PLMN with the disaster condition. For example, this can be based on the solution for KI#2 and in particular on the solution for "*How to provide information on the area where Disaster Condition applies"*.

Currently, the AMF provides a mobility restriction list to the RAN, where the list can indicate any mobility restrictions for the UE as described in 3GPP TS 23.501 [4]:

*"For a UE in CM-CONNECTED state the AMF shall indicate the Service Area Restrictions of this UE to the RAN, using a Mobility Restriction List.*

*…[skip]…*

*The RAN uses the Service Area Restrictions for target cell selection in Xn and N2 based handover."*

This **existing** function should be used to ensure that the UE's service area is confined to the area of the disaster condition. As such, the AMF determines, based on implementation methods (e.g. based on solutions for KI#2), the cells where the UE can get service and provide the TACs of these cells to the RAN. These TACs are indicated to be "Allowed TACs" as part of the Mobility Restriction List IE that is defined in 3GPP TS 38.413.

Futhermore, the since there is no control on the UE services area in EPC, it is required to make EPC a core network that is not allowed for the UE during disaster roaming service. Again, this is an **existing** function as described in clause 5.3.4.1.1 of 3GPP TS 23.501 [4]:

"*- Core Network type restriction:*

*Defines whether UE is allowed to connect to 5GC only, EPC only, both 5GC and EPC for this PLMN. The Core Network type restriction when received applies in the PLMN either to both 3GPP and non-3GPP Access Types or to non-3GPP Access Type only."*

The AMF should indicate it to the RAN to avoid handover to EPC where requirements about service area confinement cannot be met. The AMF indicates that EPC is not allowed for the UE in the "Core Network Type Restriction" component of the Mobility Restriction List IE that is defined in 3GPP TS 38.413.

### 6.52.2 Impacts on existing nodes and functionality

AMF: needs to set up the mobility restrictions according to the disaster area (even though it does not have impact on N2 and on RAN).

However the allowed TACs that are provided to the RAN in the mobility restriction list should correspond to the TACs of the cells that overlap with the area of the disaster condition.

The AMF also indicates that EPC is not an allowed core network.

## 6.53 Solution #53: Staggering of UEs trying to register in the PLMN without Disaster Condition

### 6.53.1 Introduction

This is a solution for the following question of KI#7:

*- How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;*

### 6.53.2 Detailed description

To distribute and stagger the arrival of the subscribers of the PLMN with Disaster Condition (i.e. "PLMN D") to the PLMN(s) without Disaster Condition (i.e. "PLMN A") available in the area where the Disaster Condition happens, the "PLMN D" will provide the UE with a specific timer which, along with other parameters, will result into a "Window of Time" over which the UE is allowed to make registration attempts in "PLMN A".

The above is achieved by the following steps of the registration procedure:

- the UE will inform the AMF of PLMN D that it supports MINT in the Registration Request Message

- the AMF then sends a specific timer, called T35xx, to the UE in the Registration Accept Message along with a list of PLMN(s) that the UE may try to register on in case a Disaster Condition applies.

- in case there is more than one PLMN in the list provided by the AMF, the AMF provides either a priority order for the PLMNs or different timers for diferent PLMNs in the Registration Accept Message

- the UE will insert timer T35xx, along with its unique ID, e.g. SUPI/PEI, into an algorithm

- the result of this operation will be a series of "Window of Time", defined by an Initial Start Time and an Initial Stop time, and a "Wait Time" between consecutive (Window of Time) windows

- the UE is then only allowed to perform registration attempts in the PLMN A during an occurrence of the window(s) of time, where the first occurrence of the window of time is from Initial Start Time to Initial Stop Time, the second occurrence of window of time is from (Initial Stop Time + Wait Time) to (Initial Stop Time + Wait Time + the window duration), and so on

NOTE: How the network can determine the value of the specific timer before a Disaster Condition applies is FFS.

### 6.53.3 Impacts on existing nodes and functionality

AMF:

- Upon receipt of the Registration Request message, with the UE's indication of support of the MINT feature, the AMF sends a new information element that contains a new timer, called T35xx, to the UE in Registraion Accept message

UE:

- Includes the support of MINT in its 5GMM capability IE

- Upon reception of the new timer T35xx in Registration Accept message, it calculates the "Window of Time" as well as the wait time

## 6.54 Solution #54: Preventing 5GSM-level congestion on a PLMN without a disaster condition

### 6.54.1 Description

#### 6.54.1.1 Introduction

This solution corresponds to KI#7 on Prevention of signalling overload in PLMNs without Disaster Condition, however the solution focuses on prevention of 5GSM signalling overload for which the following is listed as a question to be answered in KI#7:

*How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers.*

#### 6.54.1.2 Detailed description

This solution provides a different method to address congestion control compared to existing mechanisms that are reactive and may lead to cases in which certain UEs have more PDU sessions established while others may have much less or no PDU session established. This solution differs from existing mechanism by:

a) making the 5GSM load control mechanism proactive;

b) ensuring that all UEs can request a similar number of PDU sessions (instead of certain number UEs requesting much more PDU sessions prior to other UEs);

c) still permitting UEs to send 5GSM messages for established PDU sessions e.g. to perform PDU session modification, which would not be possible if existing 5GSM BO mechanisms are used as they would prohibit PDU session modification.

The solution aims to enable a PLMN without a disaster condition to control the level of 5GSM signalling that can be generated by disaster inbound roamer UEs which may request the establishment of more than one PDU session following their registration with the PLMN. The UEs may request more than one PDU session within short periods of time and this can suddenly increase the load on the SMFs. Other UEs that request one PDU session may not be successful due to congestion caused by requests for multiple PDU sessions (by other UEs) which have congested the SMF(s).

Without a method to evenly and proactively control and prevent congestion on the 5GSM level, the SMFs in the PLMN may quickly be congested as a result of the new multiple requests that can be made by each disaster inbound roamer, which are in addition to requests from non-roaming UEs. Any SMF congestion would potentially not enable non-roaming UEs, or more/other subsequent disaster inbound roamer UEs to establish a new PDU session let alone more sessions.

To proactively prevent 5GSM congestion, to spread the 5GSM signalling load over time, and to also ensure that most of the UE can (with a higher chance) establish at least one PDU session in the PLMN without a disaster condition, the AMF may (as part of the registration procedure) indicate a limit on the number of PDU sessions that a UE can request. This may be done when such congestion control mechanism is activated at the AMF e.g. configured by OAM.

The limit represents a maximum number of PDU sessions that the UE can request to establish, where:

- this limitation may only be applicable for a specific period of time, if a timer is provided by the AMF, or

- this limitation remains until the network explicitly indicates otherwise.

NOTE 1: how the AMF determines this number is implementation specific e.g. as configured by OAM. However, the AMF is not actively engaged in determining load conditions in the SMFs in order to set this number.

The AMF may send a NAS message to modify this number based on local policies or e.g. as configured by OAM.

If (during the registration procedure) a disaster inbound roamer UE receives a limit on the number of PDU session that can be requested, then the UE shall not request the establishment of additional PDU sessions when the number of PDU session that the UE has established is equal to this indicated maximum limit.

NOTE 2: when the maximum number of PDU session is reached, new requests from upper layers does not lead to any sort of re-prioritization of established PDU sessions compared to new requests. As such, upper layer requests for new PDU sessions are not to be handled.

NOTE 3: receiving a limit on the number of PDU session from the network cannot be used by the UE to perform PLMN reselection.

If the UE additionally receives a timer value with this limit, the UE starts a timer with the indicated value and UE enforces this limitation for the duration of the timer. Otherwise, if no timer value is received, the UE applies this limitation until explicitly told otherwise by the AMF.

### 6.54.2 Impacts on existing nodes and functionality

The following impacts can be identified:

- AMF

- Optionally providing a maximum number of PDU sessions that a UE can establish after registration or modify the restriction

- Optionally providing a timer value representing the period of time during which a restriction on the number of PDU session can apply

- UE

- Optionally handle an indicated restriction on the total number of PDU session that the UE can request, and enforce the restriction accordingly

- Optionally enforce the restriction for a specific period of time only, if such timer value is provided

## 6.55 Solution #55

### 6.55.1 Description

#### 6.55.1.1 Introduction

This solution addresses the following key issue:

Key Issue #7: Prevention of signalling overload in PLMNs without Disaster Condition

and the following questions of the key issue:

*- How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers.*

#### 6.55.1.2 Detailed description

The following existing mechanism specified in 3GPP TS 24.501 [9] can be used:

- DNN based congestion control, triggered by the AMF or by the SMF (see 3GPP TS 24.501 [9] clause 5.3.10 and clause 6.2.7).

- S-NSSAI only or S-NSSAI and DNN based congestion control, triggered by the AMF or by the SMF (see 3GPP TS 24.501 [9] clause 5.3.11 and clause 6.2.8).

The network triggers those mechanisms towards a particular UE so if required by operator policy, the network can trigger one or more of them towards a Disaster Inbound Roamer.

### 6.55.2 Impacts on existing nodes and functionality

Depending on the selected mechanism, the SMF or the AMF is impacted with an additional trigger of the existing mechanism.

## 6.56 Solution #56: Solution for manual PLMN selection when a "Disaster Condition" applies

### 6.56.1 Introduction

This is a solution for Key Issue #9 (Handling of Disaster inbound roaming PLMNs in Manual PLMN selection).

### 6.56.2 Detailed description

The UE shall perform PLMN selection as specified in 3GPP TS 23.122 [7] clause 4.4.3.1.2, with the following addition:

a) if all of the available PLMNs are in the UE's "forbidden PLMNs" list, the UE may indicate whether the available PLMNs can accommodate Disaster Inbound Roamers; and

b) once the MS has registered on a PLMN without Disaster Condition as determined in solution(s) to Key Issue #4 (Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition) and the PLMN without Disaster Condition is selected by the user, before the MS is notified that the Disaster Condition no longer applies as specified in solution(s) to Key Issue #6 (Notification that Disaster Condition is no longer applicable to the UEs), the MS shall not automatically register on a different PLMN unless the new PLMN is declared as an equivalent PLMN by the registered PLMN and the new PLMN can accommodate Disaster Inbound Roamers as determined in solution(s) to Key Issue #3 (Indication of accessibility from other PLMNs without Disaster Condition to the UE).

### 6.56.3 Impacts on existing nodes and functionality

UE

- optionally, support for indicating that a PLMN available for manual selection can accommodate Disaster Inbound Roamers.

## 6.57 Solution #57: Registration to PLMN providing Disaster Roaming service and to PLMN with Disaster Condition when no roaming interfaces are in place

### 6.57.1 Description

#### 6.57.1.1 Introduction

This solution is Key Issue #4 "Registration to the roaming PLMN without Disaster Condition in case of Disaster Condition".

This solution targets the scenario where there are no roaming interfaces in place between the PLMN without Disaster Condition (PLMN A) and the PLMN with Disaster Condition (PLMN D).

The following are the main features of the solution:

- PLMN A is aware that disaster happened in PLMN D and configured to accept registration requests from disaster inbound roamers from PLMN D without primary network authentication.

- PLMN D allows connectivity service to the disaster inbound roamers only to restricted destinations, e.g. PLMN D (or an N3IWF in PLMN D).

- The UE is informed correspondingly, so that the UE initiates registration with PLMN D via the N3IWF.

- The SMF/UPF may monitor the UP traffic to determine whether the registration with PLMN D is successful. If it is determined that the registration is not successful, the AMF initiates UE deregistration procedure.

#### 6.57.1.2 Detailed solution description



Figure 6.57.1.2-1: UE registering with PLMN D via N3IWF using connectivity provided from PLMN A

The steps of the solution are as follows:

1. The UE applies the network selection procedure for disaster condition, e.g. as described in other Key Issues. As a result, the UE selects to camp on a cell from PLMN A.

2. The UE initiates registration procedure with PLMN A. The UE indicates in the RRC signalling or in the NAS REGISTRATION REQUEST message that the registration is due to disaster conditions. The NAS REGISTRATION REQUEST message includes the UE's subscription concealed identifier (SUCI), which is based on the HPLMN SUPI. If PLMN D is not the HPLMN, the UE includes the identity of PLMN D in the message.

3. The AMF determines that the registration is by the UE from PLMN D and is due to disaster conditions in PLMN D. Since the AMF cannot communicate with PLMN D due to missing roaming agreements, the AMF determines to apply:

a) a registration without performing the primary authentication procedure PLMN A applies unauthenticated registration which is similar to Emergency registration with no USIM. The AMF may request the PEI of the UE; or

b) a local registration, which requires the AMF having local configuration data applicable for disaster conditions (e.g the configuration data may be configured from the OAM). The AMF performs a NAS security mode command (SMC) procedure and the UE transmits, in a secure way, its subscriber permanent identifier (SUPI) to the AMF, where it is stored to be used for signalling exchange with the SMF for e.g. charging purposes.

NOTE 1: The end-to-end details of security protocol for the NAS message exchange during the registration is to be determined by SA3. Potential security risks resulting from accepting registration requests from the disaster inbound roamers from PLMN D without primary network authentication are to be checked by SA3.

4. The AMF sends REGISTRATION ACCEPT message to the UE including an allowed NSSAI having a single S-NSSAI identifying a network slice that provides disaster condition services in PLMN A. The AMF indicates also to the UE that only a single PDU session is allowed which can be used for communication with destination addresses.

NOTE 2: The UE is supposed to establish PDU session with an N3IWF in PLMN D.

5. The UE sends a UL NAS TRANSPORT message containing a PDU SESSION ESTABLISHMENT REQUEST message to the AMF. The AMF selects an SMF (e.g. by applying the disaster configuration data) and sends an Nsmf\_PDUSession\_CreateSMContext request to SMF requesting to establish a PDU session for the UE. The AMF may indicate that the requested PDU session is due to disaster condition and also to include PLMN A ID from the SUCI from step 2.

6. Based on the local configuration data for disaster in the SMF and the additional indication from the AMF:

a) The SMF decides to apply restricted data connectivity for the requested PDU session so that communication with destination addresses in PLMN D is only supported. The SMF restricts the bit rate of the PDU sessions and configures the UPF to perform deep packet inspection (DPI) to determine if the UE has successfully registered to PLMN D via the N3IWF.

b) If the local registration is performed so the AMF stores the UE's SUPI and also transmits to the SMF, the SMF uses the SUPI as a key in the signalling exchange with the charging function (CHF) and to generate charging data records (CDRs) for this UE.

NOTE 3: SA5 needs to be consulted for the whether charging based on PEI or SUCI can be performed for an unauthenticated UE of PLMN D while roaming in PLMN A.

7. The SMF sends a PDU SESSION ESTABLISHMENT ACCEPT message to the UE. This message indicates that data connectivity over the PDU session is limited to destination address of the N3IWF in PLMN D. The UE triggers registration to PLMN D via the N3IWF.

8. – 9. The UE performs 5G registration via untrusted non-3GPP access via the N3IWF with PLMN D.

10. The UPF determines whether the UE has successfully registered to PLMN D via the N3IWF, e.g. by performing deep-packet inspection (DPI) and analysing the traffic exchange via the PDU session. The UPF informs the SMF with the result and the SMF forwards this information to the AMF. The SMF decides to increase the bit rate of the PDU session.

11. The AMF verifies whether the UE has successfully registered with PLMN D or the UE has registered to PLMN A in an attempt to misuse PLMN A. In the latter case, the AMF initiates deregistration procedure.

The SMF in PLMN A may collect offline charging data for the disaster inbound roamers using the PLMN D ID as key. PLMN D may also collect charging data for the UE.

NOTE 4: Charging record is collected for all inbound disaster roamers as a group and not individually.

### 6.57.2 Impacts on existing nodes and functionality

Impacts to AMF:

- Allowing unauthenticated registration for restricted service for disaster condition; and

- initiating deregistration if the UE does not successfully register with PLMN D.

Impacts to SMF:

- Establishing a PDU session for restricted connectivity to PLMN D; and

- configuring the UPF to monitor if the UE misbehaves.

Impacts to CHF:

- Collecting the charging information in PLMN A if the UE is not authenticated.

Impacts to UE:

- After receiving an indication that the registration and PDU sessions are limited to destination to PLMN D, the UE triggers registration to PLMN D via the N3IWF.

## 6.58 Solution #58: Transitioning to Connected Mode over non-3GPP access by a UE in Idle Mode

### 6.58.1 Introduction

This is a solution for the following question of KI#1:

*- How to deliver the information on the Disaster Condition of a PLMN in an area to the UE located in the area*

In this solution, PLMN D is the PLMN with Disaster Condition and PLMN A is the PLMN that accepts inbound disaster roamers.

This solution assumes that

- the UE is registered in the PLMN D over both 3GPP and non-3GPP Accesses

- the UE is in 5GMM-IDLE Mode in non-3GPP access

### 6.58.2 Detailed description

Since there is no mechanism defined for "Paging" over the non-3GPP Access, the network (i.e. the AMF) has no means to contact the UE, when it is in 5GMM-IDLE Mode, in order to deliver the information on a possible disaster condition. Therefore, the UE needs to transition to 5GMM-CONNECTED Mode in order for the network to communicate with it.

The above is achieved by the following steps below:

- when the UE detects that there is an issue with the 3GPP Access (e.g. it cannot decode any SIB from the 3GPP RAN, it cannot find a suitable cell, RRC Connection failure, loss of signal in the current cell, etc.), it will transition to 5GMM-CONNECTED Mode, over the non-3GPP access

- the AMF will inform the UE of possible disaster condition in PLMN D when the UE is in 5GMM-CONNECTED Mode over non-3GPP access

### 6.58.3 Impacts on existing nodes and functionality

UE:

- Transitions from 5GMM-IDLE to 5GMM\_CONNECTED Mode, over the non-3GPP access, when it detects certain failure in the 3GPP access.

AMF:

- Needs to inform the UE of possible disaster condition in PLMN D when the UE is in 5GMM-CONNECTED Mode over non-3GPP access

## 6.59 Solution #59

### 6.59.1 Description

#### 6.59.1.1 Introduction

This solution addresses the following key issue:

Key Issue #1: Notification of Disaster Condition to the UE

#### 6.59.1.2 Detailed description

Before disaster condition occurs, the UE would have performed registration procedure to receive normal services in its HPLMN or a VPLMN. The UDM via the AMF informs the UE whether it is allowed, or not allowed, to receive disaster inbound roaming services using the UE parameters update via UDM control plane procedure. This indication may be e.g. "UE is not allowed to receive Disaster Inbound Roaming service" or "UE is allowed to receive Disaster Inbound Roaming service".

NOTE 1: the AMF of the serving PLMN does not change this indication that is received from the UDM but simply forwards the value of this indication using an appropriate IE of the NAS message, as specified for the UE parameters update via UDM control plane procedure in 3GPP TS 23.502 [8].

The UDM stores this new indication in the subscription information and provides it to the AMF as specified for the UE parameters update via UDM control plane procedure in 3GPP TS 23.502 [8].

The AMF provides this indication as received from UDM, as specified for the UE parameters update via UDM control plane procedure in 3GPP TS 23.502 [8].

NOTE 2: the expectation of this solution is that a UE which receives the "UE is not allowed to receive Disaster Inbound Roaming service" would be that the UE does not use disaster roaming service for the entire duration of the disaster condition.

The UE determines that disaster roaming service can be used when:

a) The UE is notified about a disaster condition (e.g. as described in any of the solutions from KI#1); and

b) HPLMN has not configured the UE before the disaster condition with "UE is not allowed to receive Disaster Inbound Roaming service".

### 6.59.2 Impacts on existing nodes and functionality

The UE is impacted with determination whether it can use disaster roaming services based on a received indication.

The UDM is impacted to store the subscription information on whether or not the UE can use disaster roaming services, and provides that to the UE via the AMF using the UE parameters update via UDM control plane procedure in 3GPP TS 23.502 [8].

## 6.60 Solution #60: Manual PLMN selection during disaster condition

When the disaster condition happens, user will be denied service and the normal reaction can be to look for a the available networks and the PLMNs are presented to the usre. As per the current design the PLMNs that support disaster roaming, which are mostly forbidden PLMNs, will be indicated as forbidden to the users.

This gives a wrong impression to the user that the PLMN is forbidden and will not be chosen by the user. So it is porposed to study the following items for manual PLMN selection

- During Manual PLMN selection, how the upper layers are informed that some of the forbidden PLMNs support disaster roaming.

- What additional information need to be sent to the upper layers when the PLMNs that support disaster roaming are sent to upper layers.

- Should the PLMN which is under disaster condition be sent to the upper layers if it becomes available?

### 6.60.1 Solution description

To solve the key issues described in the above section, when the user performs a manual PLMN selection,

if the UE finds PLMNs that support disaster roaming and only forbidden PLMNs are available, the UE shall send an indication along with the PLMN ID that the PLMN supports disaster roaming to the upper layers. This will help the user understand that such a PLMN can actually provide service and can be selected.

### 6.60.3 Impacts on existing nodes and functionality

None.

# 7 Evaluations

## 7.1 Evaluation on solutions of Key Issue #1

Solution #1 provides a solution for key issue #1 when:

a) the UE is in coverage of a non-3GPP access;

b) the UE is registered to the same AMF over 3GPP and non-3GPP access when the Disaster Condition occurs; and

c) the UE is in 5GMM-CONNECTED mode over the non-3GPP access when the Disaster Condition occurs.

Solution #1 does not change the existing UE behaviour when the UE is out-of-coverage of serving PLMN in 3GPP access and Disaster Condition does not apply to the serving PLMN.

Solution #2 provides a solution for key issue #1:

a) using method 1 when:

1) the UE is in coverage of a non-3GPP access; and

2) the UE is in 5GMM-CONNECTED mode over non-3GPP access when the Disaster Condition occurs;

b) using method 2 when:

1) the UE is in coverage of a untrusted non-3GPP access; and

2) the UE is in 5GMM-CONNECTED mode over untrusted non-3GPP access when the Disaster Condition occurs;

c) using method 3 when:

1) the UE is in coverage of a trusted non-3GPP access; and

2) the UE is in 5GMM-CONNECTED mode over trusted non-3GPP access when the Disaster Condition occurs; and

d) using method 4 when the UE is in coverage of a trusted non-3GPP access.

Solution #2 does not change the existing UE behaviour when the UE is out-of-coverage of serving PLMN in 3GPP access and Disaster Condition does not apply to the serving PLMN.

Solution #3 (which references Solution#9 for details):

a) does not provide a solution for key issue #1 when the RAN node of PLMN without Disaster Condition is shared by maximum number of PLMNs when the Disaster Condition start applying for a PLMN;

b) PLMN without Disaster Condition needs to understand core network deployment of PLMN where the Disaster Condition might happen in future, and PLMN with Disaster Condition needs to understand RAN deployment of PLMN without Disaster Condition, as:

1) to setup the N2 connection to appropriate AMF, NG-RAN node of PLMN without Disaster Condition needs to know AMF(s) of PLMN where the Disaster Condition might happen in future serving the area of the NG-RAN node - see the clause 6.9.1 stating "*In order to be able to exchange an NGAP message when a disaster condition applies or no longer applies, if PLMNNO DC has an SLA to support disaster condition applied to PLMNDC in an area, the NG Setup procedure is performed between all NG-RAN nodes of PLMNNO DC covering the area and AMF(s) of PLMNDC covering the area in advance.*"; and

2) to trigger appropriate RAN nodes to become shared RAN nodes, AMF of PLMN with Disaster Condition needs to know which area the RAN nodes of PLMN without Disaster Condition serve - see the clause 6.9.1 stating "*After being informed, the AMF of PLMNDC notifies to NG-RAN nodes of a PLMN without disaster condition (PLMNNO DC) in the disaster area.*";

c) works only when the UE is in coverage of a NG-RAN cell of a PLMN without Disaster Condition which can be shared by the PLMN with Disaster Condition.

Solution #3 does not change the existing UE behaviour when the UE is out-of-coverage of serving PLMN in 3GPP access and Disaster Condition does not apply to the serving PLMN.

Solution#4 works only when the UE is in coverage of a NG-RAN cell of a PLMN without Disaster Condition.

Solution #4 does not change the existing UE behaviour when the UE is out-of-coverage of serving PLMN in 3GPP access and Disaster Condition does not apply to the serving PLMN.

Solution#5 works only when the UE is in coverage of a NG-RAN cell of a PLMN without Disaster Condition which is willing to provide disaster roaming to UEs of PLMN with Disaster Condition.

Solution #5 does not change the existing UE behaviour when the UE is out-of-coverage of serving PLMN in 3GPP access and Disaster Condition does not apply to the serving PLMN.

Solution #58 provides a solution for key issue #1 when:

a) the UE is in coverage of a non-3GPP access;

b) the UE is registered to the same AMF over 3GPP and non-3GPP access when the Disaster Condition occurs; and

c) the UE is in 5GMM-IDLE mode over the non-3GPP access when the Disaster Condition occurs.

Solution #58 requires the UE to perform actions when the UE is out-of-coverage of serving PLMN in 3GPP access, regardless whether the Disaster Condition applies to the serving PLMN. Thus, Solution #58 changes the existing UE behaviour also when the UE is out-of-coverage of the serving PLMN in 3GPP access and Disaster Condition does not apply to the serving PLMN. The additional UE handling performed when the UE is out-of-coverage of the serving PLMN in 3GPP access and Disaster Condition does not apply to the serving PLMN, wastes UE's battery power and generates unnecessary load on the network over non-3GPP access.

Solution #59 does not describe how to deliver the information on the Disaster Condition of a PLMN in an area, to the UE located in the area. Solution #59 expects re-use of other solution for key issue #1.

NOTE: Solution #59 enables HPLMN to configure the UE to restrict usage of disaster roaming.

Solution #4 broadcasts more broadcast information (indication that Disaster Condition applies to PLMN D, disaster area (e.g. TA list), and recommended PLMN(s)) than solution #5 broadcasts (PLMN A can accept Disaster Inbound Roamers from PLMN D). Information broadcast in solution#5 is sufficient to enable the UE to select a PLMN providing Disaster Roaming when a Disaster Condition applies in a PLMN with Disaster Condition.

Given that the Disaster Condition impacts 3GPP access only (as "*The network functions except one or more RAN nodes of the PLMN with Disaster Condition can be assumed to be still operational. One or more RAN nodes of the PLMN with Disaster Condition are non-operational.*."), UEs impacted by the Disaster Condition support 3GPP access and can but do not have to support non-3GPP access. Thus, informing the UE about Disaster Condition being applicable to a PLMN:

- via 3GPP access will enable **all UEs impacted by the Disaster Condition** to determine that Disaster Condition applies, subject to availabity of coverage of a PLMN in 3GPP access; and

- via non-3GPP access will enable **a subset of UEs impacted by the Disaster Condition** **only** (i.e. UEs supporting 3GPP access and non-3GPP access only) to determine that Disaster Condition applies, subject to availabity of non-3GPP access and availablity of a network support for non-3GPP access.

Given that:

- the RAN sharing based approach requires that PLMN without Disaster Condition understands core network deployment of PLMN where the Disaster Condition might happen in future, and PLMN with Disaster Condition understands RAN deployment of PLMN without Disaster Condition; and

- the disaster roaming use case addresses PLMNs not normally cooperating (PLMN without Disaster Condition in the list of forbidden PLMNs of the UE of PLMN with Disaster Condition);

it is not reasonable to expect such deployment information sharing, and updates of configuration of the network nodes, between the involved PLMNs, solely for disaster roaming functionality.

## 7.2 Evaluation on solutions of Key Issue #2

All solutions for KI#2 have no UE impact.

Except Solution #8, all other solutions have RAN impact.

Except Solution #7, all other solutions have CN impact.

Solution #6 relies on O&M operations which need not to be standardized, i.e. by proprietary implementation. The required RAN impacts and CN impacts can also be implemented via the O&M operations. This solution involves CT1 and RAN2 but the main required work is just to document that disaster condition notification is performed via O&M operations.

Solution #7 uses means out-of-scope of 3GPP for disaster condition notification between PLMN D and PLMN A and uses O&M operations within PLMN A to configure PLMN A's NG-RAN nodes. Hence, the required RAN impacts can be implemented via the O&M operations and if the O&M operations needs to be standardized, then SA5 needs to be involved.

Solution #8 requires deployment of CBE and CBC (and PWS-IWF) or CBCF while these network entities or NFs are originally deployed for CBS/PWS which is an optional feature for an operator. Hence, for a regulator or an operator which has not deployed the CBE and CBC (and PWS-IWF) or CBCF for CBS/PWS, then it will be a big CAPEX to implement Solution#8 for MINT. This solution involves CT1 to specify stage 2 message flow and parameters between CBE and CBC (and PWS-IWF) or CBCF, and between CBC (and PWS-IWF) or CBCF and AMF for "disaster roaming PLMN and area list" handling. This solution also involves CT4 to specify stage 3 SBI service operations related to "disaster roaming PLMN and area list" handling.

Solution #9 relies on the RAN sharing between PLMN D and PLMN A and the UE is still served by the same PLMN D via the shared RAN of PLMN A. Solution #9 further requires the setup of N2 connection between NG-RAN nodes of PLMN A and one or more AMFs of PLMN D in advance before disaster condition applies to PLMN D in an area which may waste NGAP resources. This solution involves RAN3 to setup N2 connection between the AMF of the PLMN D and the NG-RAN of PLMN A for disaster condition notification. There is no CT1 involvement as how the AMF of PLMN D is notified for disaster condition is out of the scope of 3GPP.

## 7.3 Evaluation on solutions of Key Issue #3

The solutions for this key issue can be classified into 5 categories as below:

Category A: Pre-provisioned information before disaster condition

Solution #11 proposes Disaster Roaming Service (DRS)-supported PLMN list. This is a list of PLMNs where disaster roaming is allowed for the UE. The list is provisioned and kept up-to-date by a PLMN (say PLMN D), before disaster occurs, using NAS signalling. If the list does not contain all the forbidden PLMNs in the country of the serving PLMN, there is no guarantee that a PLMN in the DRS-supported PLMN list will actually provide the disaster roaming service when the disaster condition starts applying for the serving PLMN. Solution#11 also requires that NG-RAN cell of PLMN that provides disaster roaming shall broadcast the list of PLMNs for which disaster roaming is offered (similar to Solution #13). The UE determines the accessibility of the PLMN without Disaster Condition based on a combination of broadcast information (list of PLMNs) and Disaster Roaming Service (DRS)-supported PLMN list provided to UE in security protected signalling. This solution requires that PLMN with Disaster Condition performs notification of applicability of Disaster Condition and of disaster area to one or more PLMNs which have been configured in DRS-supported PLMN list of at least one UE of PLMN with Disaster Condition located in the disaster area and that at least one of those PLMNs having at least one functioning NG-RAN node offer disaster roaming to the UEs of PLMN with Disaster Condition. Sol#11 also enables PLMN D to provide the UE with the DRS-supported PLMN list over non-3GPP access at time of Disaster Condition applying to PLMN D. However, this is limited to scenarios for example, when the UE supports non-3GPP access and is in coverage of a non-3GPP access.

Solution #15 introduces "List of PLMNs to be used in disaster condition" to be provisioned by the serving PLMN prior to a disaster condition. The pre-provisioning can be in the USIM, stored in the ME or provided over NAS signalling. UE relies on indication from system information for identifying whether a PLMN offers disaster roaming, which are always sent without ciphering or integrity protection. This solution requires that PLMN with Disaster Condition performs notification of applicability of Disaster Condition and of disaster area to all PLMNs which has been configured in "List of PLMNs to be used in disaster condition" of at least one UE of PLMN with Disaster Condition located in the disaster area and that all those PLMNs having at least one functioning NG-RAN node in the disaster area offer disaster roaming to the UEs in disaster area. The provisioning of "List of PLMNs to be used in disaster condition" is performed using NAS signalling, which can be integrity protected if the authentication has been successful.

The "List of PLMNs to be used in disaster condition" applicable to the UE can also be provided by a PLMN without Disaster Condition, during a rejected registration in that PLMN but only if the following conditions are satisfied:

i) PLMN with Disaster Condition provides the "List of PLMNs to be used in disaster condition" to the PLMNs without Disaster Condition,

ii) the PLMNs without Disaster Condition provide the "List of PLMNs to be used in disaster condition" to the UE without changes,

iii) the UE selects and attempts to register in the PLMN without Disaster Condition (i.e. manual PLMN selection is used, the PLMN without Disaster Condition is not in the UE's list of forbidden PLMNs or the PLMN without Disaster Condition is in UE's "List of PLMNs to be used in disaster condition"),

iv) the UE is successfully authenticated in the PLMN without Disaster Condition and

v) the PLMN without Disaster Condition activates integrity protection of the NAS messages.

In these two solutions, UE makes use of a pre-provisioned list of PLMNs to (prioritise and) select a PLMN offering disaster roaming. The pre-provisioned list can also be provisioned over NAS signalling. It is possible in certain scenarios that all PLMNs in the pre-provisioned list are damaged by the same disaster - in such a case, even if PLMN D negotiates after disaster with another PLMN to provide the disaster roaming (called PLMN Az) to UEs of PLMN D, the UEs of PLMN D will be unable to select PLMN Az. If the list contains all forbidden PLMNs in the country of the serving PLMN, the list can be long.

Solution #16: Pre-provisioned disaster roaming access identities

This solution addresses whole of KI#3 and part of KI#7. The solution proposes use of new access identities (in addition to Access Identity 3) provisioned by the network to be used by the UEs at the time of disaster roaming. The PLMNs offering disaster roaming for a certain access identity is required to set the corresponding bit in *uac-BarringForAccessIdentity* to indicate that a UE that has chosen that access identity is allowed to select the PLMN. The information is provided by HPLMN, so when the UE roams, the HPLMN needs to provide the access identities appropriate for the visited country. Solution requires a PLMN offering disaster roaming to accept disaster inbound roamers which use access identity for which the bit in the uac-BarringForAccessIdentity is set to zero, from any PLMN with disaster condition in a given disaster area. Setting a bit corresponding to an access identity to zero implies that network can provide access without subject to barringFactor to UEs using that Access Identity.

Category B: System information broadcast at the time of disaster condition

Sol#13 identifies the information to be broadcast by the PLMN offering disaster roaming (a disaster roaming PLMN List). This solution requires that PLMN with Disaster Condition performs notification of applicability of Disaster Condition and of disaster area to one or more PLMNs which can provide disaster roaming in the area, those PLMNs being selected by the PLMN with Disaster Conditon, and that at least one of those PLMNs having at least one functioning NG-RAN node in the disaster area offering disaster roaming to the UEs in disaster area.

Sol#12 proposes similar information as in Sol#13 and additionally proposes a split of the information in various SIB messages. This solution requires that PLMN with Disaster Condition performs notification of applicability of Disaster Condition and of disaster area to one or more PLMNs which can provide disaster roaming in the area, those PLMNs being selected by the PLMN with Disaster Conditon, and that at least one of those PLMNs having at least one NG-RAN node in the disaster area offering disaster roaming to the UEs in disaster area.

These solutions are similar in content of broadcast information they are proposing. Sol#12 had additional analysis on how the information could be split in various SIB messages to limit the impact from new system information broadcast to disaster roamers. For PLMN selection, UE relies on information from system information messages which are always sent without ciphering or integrity protection.

Category C: PWS broadcast at the time of disaster condition

Sol#14 proposes a new PWS message in the PLMN providing disaster roaming to inform UEs. The PWS message indicates a list of PLMNs for which disaster roaming is offered. This solution requires that PLMN with Disaster Condition performs notification of applicability of Disaster Condition and of disaster area to CBE and CBE notifies one or more PLMNs which can provide disaster roaming in the area, those PLMNs being selected by CBE, and that at least one of those PLMNs having at least one NG-RAN node in the disaster area offering disaster roaming to the UEs in disaster area. The PWS SIB broadcast has to continue for the duration the PLMN is offering disaster roaming. This implies that all UEs (own subscribers and non-disaster roamers) are required to read the PWS SIB, which is an existing requirement.

Category D: Dynamic sharing of RAN

Sol#10: proposes the concept of dynamic shared RAN. In this solution, UE finds the PLMN it is interested in (HPLMN or VPLMN) as one of the shared PLMNs in another cell. This solution requires that all PLMNs have a redundant N2 and N3 link with another NG-RAN node providing overlapping coverage in areas where disaster roaming service has to be offered. This implies the following:

- NG-RAN node of PLMN without Disaster Condition needs to know AMF(s), of PLMN where the Disaster Condition might happen in future, serving the area of the NG-RAN node to setup the N2 connection to appropriate AMF.

- AMF of PLMN with Disaster Condition needs to know which area the RAN nodes, of PLMN without Disaster Condition, serve to trigger appropriate RAN nodes to become shared RAN nodes Category E: Provisioning of information over non-3GPP AN at the time of disaster

Parts of solution#11, solution#1 and solution#2 (Methods 1, 2 and 3) address Key Issue#3 in a similar way. These solutions propose that a list of PLMNs which provide disaster roaming can be provided over non-3GPP access network by the PLMN with disaster condition or the PLMN without disaster condition at the time of disaster. However, this is limited to scenarios, for example, when the UE and the PLMN support non-3GPP access and UE is in 5GMM-CONNECTED mode over non-3GPP access. Furthermore, if the PLMN without Disaster Condition provides the list of PLMNs which provide disaster roaming, it requires that:

i) PLMN with Disaster Condition provides the "List of PLMNs to be used in disaster condition" to the PLMNs without Disaster Condition; and

ii) the PLMNs without Disaster Condition provide the "List of PLMNs to be used in disaster condition" to the UE without changes.

Additionally solution#2 Method 4 specifies a way in which TNAP of PLMN with disaster condition or PLMN without disaster condition informs UE about the PLMN(s) that provide disaster roaming. This is applicable in cases where UE is in coverage of an AP that supports ANQP. The advertise messages may not be ciphered or may not be integrity protected if the UE receives this in pre-associated state. Furthermore, if the PLMN without Disaster Condition provides the list of PLMNs which provide disaster roaming, it requires that:

i) PLMN with Disaster Condition provides the "List of PLMNs to be used in disaster condition" to the PLMNs without Disaster Condition; and

ii) the PLMNs without Disaster Condition provide the "List of PLMNs to be used in disaster condition" to the UE without changes.

**Observation 1:**

Category A solutions depend on UEs being pre-configured with information required for disaster roaming (List of PLMNs for disaster roaming in Solution#11 and Solution#15 / Access Identities allocated for disaster roaming in Solution#16). This category of solutions enables the HPLMN, based on subscription, to configure UEs to perform disaster roaming following a disaster condition.

**Observation 2:**

Category B solutions depend only on SIB broadcast messages for informing UEs about PLMNs offering disaster roaming. This category of solutions offer more flexibility to the PLMNs to react according to the current disaster situation than Category A solutions where each UE has to be provided updated configurations.

**Observation 3:**

Category C solution is limited by support of PWS functionality in both PLMN and UE.

**Observation 4:**

Category D solution requires that AMF in PLMNs create, test and maintain redundant N2 and N3 links with at least one another NG-RAN node providing overlapping coverage.

**Observation 5:**

Category E solutions apply to networks and UEs that support non-3GPP access.

## 7.4 Evaluation on solutions of Key Issue #4

This clause presents an evaluation of the solutions that address only the following specific aspect of KI#4:

*- How a Disaster Roaming PLMN can limit the area of service to Inbound Disaster Roamers to the region where Disaster Condition applies*

Both solutions #19 and 17# have a common solution which reuses existing mechanims to confine the UE to a certain area by determining a UE registration area such that it corresponds to the area of the disaster condition. The solutions require that the AMF determines the registration area for a UE based on the area of the disaster condtion.

Solution #17 also provides the AMF with the option to use the service area list that can be used in the case when the registration area contains TAIs that are more than the TAIs of the area that is considered to correspond to the area of the disaster condition. Again this does not have new impacts to the AMF or the UE, noting that the AMF only needs to determine the service area restriction based on the area of the disaster condition. This implies that the UE will not be able to get service when the UE is in a non-allowed area.

Solution #17 enables further provides the AMF with the option to have finer control and determination of the area where the UE can get disaster roaming service by defining a service area based on a set of cells. This requires the AMF to provide a set of cell identities where this set would correspond to the area with the disaster condition. The UE which receives this information is also required to determine whether it should be in state 5GMM-REGISTERED.NORMAL-SERVICE or 5GMM-REGISTERED.NON-ALLOWED-SERVICE. The determination in the UE is based a check of the cell identity on which the UE is camped, where the UE gets this information from the AS layer by implementation specific means.

Solution #17 enables the UE to optionally perform PLMN search when the UE enters 5GMM-REGISTERED.NON-ALLOWED-SERVICE based on check of the cell identity on which the UE is camped and is in 5GMM-IDLE mode. If the UE does not perform PLMN search in this situation, the UE will not be able to get service. If the UE is in 5GMM-CONNECTED mode after the UE enters 5GMM-REGISTERED.NON-ALLOWED-SERVICE based on check of the cell identity on which the UE is camped, the UE will not be able to get service.

The use of the service area restriction based on TAIs, as described above for solution #17, can lead to cases in which the UE may move into a non-allowed area that is considered to be non-allowed because of the serving PLMN's service area restrictions that are not related to confining the UE's service area during disaster roaming. In this case, the UE that implements PLMN search after entering 5GMM-REGISTERED.NON-ALLOWED-SERVICE, and is in 5GMM-IDLE mode, can lead to unnecessary PLMN search as the UE would still be in an area that corresponds to the disaster area. If this happens, then increased UE power consumption would occur from this unnecessary PLMN search.

While solutions #17 and #19 relate to the determination of the registration area, etc, which is relevant to the AMF and the UE, solution #52 is relevant to the AMF and the RAN and as such is independent of, and complementary to, solutions #17 and #19.

Solution #52 requires the AMF to use the existing mobility restriction list and to set the contents of the service area (e.g. allowed area) such that it corresponds to the area of the disaster condition and to indicate that EPS is not allowed as a core network for the UE. Other than this, solution #52 does not introduce any new impacts on the N2 protocol interface.

Solutions #18 #20, #57 do not address this aspect.

This clause presents an evaluation of the solutions that address only the following specific aspects of KI#4.

*- How a registration procedure initiated by Inbound Disaster Roamer is performed;*

*- What other information, if any, is needed to be transferred between the UE and the network during the initial registration procedure.Solutions #18, #19, #20 and #57 tries to solve the above issues identified in KI#4*

Solution #18 assumes that when a disaster condition applies, an NG-RAN node of a PLMN without disater condition becomes a shared RAN between PLMN without a disaster condition and a PLMN where a disaster condition applies. With this assumption, there is no need to change the registration procedure in the UE and in the network.

Solution #19 proposes the usage of a new registration type when the UE performs a registration update procedure in the PLMN that supports disaster roaming following a disaster condition in the previously severd PLMN. The new registration type will help the AMF to identify the UE that is performing registration procedure for disaster roaming.

Solution #20 proposes that when the UE performs a registration procedure for disaster roaming, if the UE includes 5G-GUTI in the REGISTRATION REQUEST message and does not indicate the PLMN with Disaster Condition in the REGISTRATION REQUEST message, the network uses the PLMN ID in the UE's 5G-GUTI to determine the PLMN that was serving the UE which had disaster condition. If UE does not have a 5G-GUTI assigned by the PLMN with disaster condition, and the PLMN with disaster condition is not the HPLMN or the PLMN with disaster condition is HPLMN and the UE does not provide SUCI, then the UE indicates the PLMN with disaster condition in the REGISTRATION REQUEST message. Indication of the PLMN with disaster condition in the REGISTRATION REQUEST message (when the UE does not have a 5G-GUTI assigned by the PLMN with disaster condition, and the PLMN with disaster condition is not the HPLMN or the PLMN with disaster condition is HPLMN and the UE does not provide SUCI) will help the AMF to identify the PLMN with Disaster Condition that would have served UE if the disaster condition had not happened. This helps the AMF to decide on whether to provide disaster roaming service to the UE. AMF also checks whether the TA where the UE is registering is part of the disaster area of the UE's PLMN with disaster condition. If AMF determines that the PLMN with Disaster Condition in the registration request, SUCI or 5G-GUTI identify a PLMN with disaster condition and the TA is part of disaster area of the PLMN with disaster condition, then AMF handles the registration request.

Solution #57 proposes the usage of a new registration type in the registration request message which is similar to #19.This solution also proposes the usage of new indication in RRC signalling that caries the registration request to indicate that the RRC signalling is due to disaster roaming. This solution also proposes the usage of the PLMN ID in the 5G-GUTI by the network to determine the PLMN that had disaster condition. If the PLMN that went into disaster is not the HPLMN of the UE, then this solution proposes to include the identity of PLMN that went into disaster condition in the registration request towards the network.

Observation 1: Solution #19 and solution #57 proposes the usage of a new registration type in the registration request message sent by the UE to the network trying to register for disater roaming. This new indication will help the network to identify the that the UE's registration request is for disaster roaming. This indication is also helpful for the network in identifying the UEs that support the MINT functionality thereby providing service to those UEs. This solution does not provide the network with enough information about the PLMN that has gone into disaster condition.

Observation 2: Solution #20 and solution #57 proposes the ways for the network (during registration update procedure for disaster roaming) to get information on the PLMN that was serving the UE or the PLMN that would have served the UE if the disaster condition had not happened. This information is useful for the network to determine whether disaster roaming service needs to be provided to the UE.Solution #20 also adds an additional check to see if the UE is registering in a TA which is part of the disaster area of the PLMN indicated by the UE This solution for some cases ( when the UE is registered on a PLMN and has a valid 5G-GUTI) does not differentiate whether the registration update request from a UE is due to disaster roaming or if the registration request is from a legacy UE.

## 7.5 Evaluation on solutions of Key Issue #5

Solution #21:

- the solution refers to solutions of KI#3 for discovery of PLMNs offering disaster roaming.

- prohibits the UE in automatic selection to select available PLMN D when the UE is informed that Disaster Condition applies for PLMN D, with exception of the PLMN D being available in satellite access. If the UE is located at the border of disaster area, this prevents the UE from selecting and camping on PLMN D on PLMN D's cells located outside of the disaster area. Furthermore, this violates 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- specifies that in automatic selection the UE considers PLMNs offering disaster roaming in bullet iv and v of 3GPP TS 23.122 [7] clause 4.4.3.1.1, i.e. with higher priority that any non-forbidden PLMN in bullet iv and v of 3GPP TS 23.122 [7] clause 4.4.3.1.1. This violates 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- if there are several PLMNs offering disaster roaming, they are ordered in automatic selection based on disaster roaming assistance information, if provisioned in the UE, or UE implementation.

- if the selected PLMN is in the UE's "forbidden PLMNs" list, the UE does not remove the PLMN from the UE's "forbidden PLMNs" list.- describes solution only when the PLMN with Disaster Condition is UE's RPLMN.

Solution #22:

- the solution does not refer to solutions of KI#3 for discovery of PLMNs offering disaster roaming. Instead, the solution enables selection of PLMN A offering disaster roaming to a UEs of PLMN D with Disaster Condition broadcasts a list of PLMNs D for which the broadcasting PLMN A offers disaster roaming. Such handling has characteristics similar to characteristics of solutions #12 identified in evaluation of KI#3.

- enables the UE in automatic selection to select available PLMN D when the UE is informed that Disaster Condition applies for PLMN D. If the UE is located at the border of disaster area, this enables the UE to select and camp on PLMN D on PLMN D's cells located outside of the disaster area. Furthermore, this is aligned with 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- does not specify priority of PLMNs offering disaster roaming in automatic selection, in relation to the bullets of 3GPP TS 23.122 [7] clause 4.4.3.1.1

- does not specify ordering in automatic selection when there are several PLMNs offering disaster roaming.

- if the selected PLMN is in the UE's "forbidden PLMNs" list, the UE does not remove the PLMN from the UE's "forbidden PLMNs" list.

- describes solution without restriction to the PLMN with Disaster Condition being UE's RPLMN but does not specify how to select PLMN with Disaster Condition when the UE does not have RPLMN or UE's RPLMN is not available, there is no available non-forbidden PLMN and there are several non-forbidden PLMNs with Disaster Condition.

Solution #23:

- the solution refers to solutions of KI#3 for discovery of PLMNs offering disaster roaming.

- enables the UE in automatic selection to select available PLMN D when the UE is informed that Disaster Condition applies for PLMN D. If the UE is located at the border of disaster area, this enables the UE to select and camp on PLMN D on PLMN D's cells located outside of the disaster area. Furthermore, this is aligned with 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- specifies that the UE in automatic selection considers PLMNs offering disaster roaming with lowest priority. This is aligned with 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- if there are several PLMNs offering disaster roaming, they are ordered in automatic selection in random order.

- if the selected PLMN is in the UE's "forbidden PLMNs" list, the UE does not remove the PLMN from the UE's "forbidden PLMNs" list.

- describes solution without restriction to the PLMN with Disaster Condition being UE's RPLMN and specifies how to select PLMN with Disaster Condition when the UE does not have RPLMN or UE's RPLMN is not available, there is no available non-forbidden PLMN and there are several non-forbidden PLMNs with Disaster Condition.

Solution #24:

- the solution does not refer to solutions of KI#3 for discovery of PLMNs offering disaster roaming. Instead, the solution enables selection of PLMN A broadcasting support of disaster roaming when the PLMN A is in UE's "List of PLMNs to be used while in Disaster condition". Such handling has characteristics similar to characteristics of solution #15 identified in evaluation of KI#3.

- enables the UE in automatic selection to select available PLMN D when the UE is informed that Disaster Condition applies for PLMN D. If the UE is located at the border of disaster area, this enables the UE to select and camp on PLMN D on PLMN D's cells located outside of the disaster area. Furthermore, this is aligned with 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- specifies that the UE in automatic selection considers PLMNs offering disaster roaming in bullet v of 3GPP TS 23.122 [7] clause 4.4.3.1.1, with lower priority that any non-forbidden PLMN in bullet v of 3GPP TS 23.122 [7] clause 4.4.3.1.1. This is aligned with 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- if there are several PLMNs offering disaster roaming, they are ordered in automatic selection based on UE's "List of PLMNs to be used while in Disaster condition".

- if the selected PLMN is in the UE's "forbidden PLMNs" list, the UE does not remove the PLMN from the UE's "forbidden PLMNs" list.

- describes solution only when the PLMN with Disaster Condition is UE's RPLMN.

Solution #25:

- the solution refers to solutions of KI#3 for discovery of PLMNs offering disaster roaming.

- prohibits the UE in automatic selection to select available PLMN D when the UE is informed that Disaster Condition applies for PLMN D. If the UE is located at the border of disaster area, this prevents the UE from selecting and camping on PLMN D on PLMN D's cells located outside of the disaster area. Furthermore, this violates 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- specifies that the UE in automatic selection considers PLMNs offering disaster roaming in bullet vi of 3GPP TS 23.122 [7] clause 4.4.3.1.1. This is aligned with 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- does not specify ordering in automatic selection when there are several PLMNs offering disaster roaming.

- if the selected PLMN is in the UE's "forbidden PLMNs" list, the UE does not remove the PLMN from the UE's "forbidden PLMNs" list.

- describes solution without restriction to the PLMN with Disaster Condition being UE's RPLMN but does not specify how to select PLMN with Disaster Condition when the UE does not have RPLMN or UE's RPLMN is not available, there is no available non-forbidden PLMN and there are several non-forbidden PLMNs with Disaster Condition.

Solution #26:

- the solution does not refer to solutions of KI#3 for discovery of PLMNs offering disaster roaming. Instead, the solution enables selection of PLMN A broadcasting support of disaster roaming when the PLMN A is in UE's DRS-supported PLMN list. Such handling has characteristics similar to characteristics of solution #11 identified in evaluation of KI#3.

- enables the UE in automatic selection to select available PLMN D when the UE is informed that Disaster Condition applies for PLMN D. If the UE is located at the border of disaster area, this enables the UE to select and camp on PLMN D on PLMN D's cells located outside of the disaster area. Furthermore, this is aligned with 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- specifies that the UE in automatic selection considers PLMNs offering disaster roaming for selection only when no non-forbidden PLMNs are available. This is aligned with 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- if there are several PLMNs offering disaster roaming, they are ordered in automatic selection based on UE's DRS-supported PLMN list, if available, random order or UE implementation.

- if the selected PLMN is in the UE's "forbidden PLMNs" list, the UE does not remove the PLMN from the UE's "forbidden PLMNs" list.

- does not state whether the solution restricts to the PLMN with Disaster Condition being UE's RPLMN or not.

Solution #51:

- the solution does not refer to solutions of KI#3 for discovery of PLMNs offering disaster roaming. Instead, the solution expects RAN of PLMN A to be shared by PLMN D. Such handling has characteristics similar to characteristics of solution #10 identified in evaluation of KI#3.

- enables the UE in automatic selection to select available PLMN D when the UE is informed that Disaster Condition applies for PLMN D. This enables the UE from selecting and camping on PLMN D on PLMN D's cells. Furthermore, this is aligned with 3GPP TS 22.261 [3] statement "*The 3GPP system shall be able to provide means to enable a UE to access PLMNs in a forbidden PLMN list if a Disaster condition applies and no other PLMN is available except for PLMNs in the forbidden PLMN list.*".

- expects the UE in automatic selection to select PLMN D on shared RAN of PLMN A.

- the UE continues sees PLMN D as the most prioritized available PLMN.

- the selected PLMN is never in the UE's "forbidden PLMNs" list.

- describes solution without restriction to the PLMN with Disaster Condition being UE's RPLMN and specifies how to select PLMN with Disaster Condition when the UE does not have RPLMN or UE's RPLMN is not available, there is no available non-forbidden PLMN and there are several non-forbidden PLMNs with Disaster Condition.

## 7.6 Evaluation on solutions of Key Issue #6

All solutions for KI#6 have UE impact.

Except Solution #28, #33 and #35, all other solutions for KI#6 have no RAN impact, Solution #33 has possible RAN impact based on solution for KI#2.

Except Solution #30, #34 and #35, all other solutions for KI#6 have CN impact.

Solution #27 requires the UE to register to a PLMN over non-3GPP access. The registered PLMN over non-3GPP access can be the same PLMN as or different PLMN from the PLMN with Disaster Condition. Solution #27 further assumes that the non-3GPP access network is not affected by the Disaster Condition for the case that the UE remains registered to the PLMN with Disaster Condition over the non-3GPP access. Also for the case when the UE does not register to another PLMN offering disaster service over the 3GPP access, the solution requires the UE to enable the lower layers of the 3GPP access if the UE had disabled the lower layers of the 3GPP access, where the disabling of the lower layers of the 3GPP access was optional for the UE.

Solution #28 provides two ways for disaster no longer applicable notification to the UEs: (1) RRC based notification and (2) NAS based notification. RRC based notification requires a new broadcast indication (e.g. in SIB) to indicate that a Disaster Condition in PLMN D applies or not. NAS based notification requires a new NAS indication (e.g. a new 5GMM cause value "disaster condition in other PLMN no longer applies") to the UE. NAS based notification can be performed over both the 3GPP access and over the non-3GPP access of PLMN A. There is no paging for NAS based notification for UEs in idle mode. Based on this new indication, the UE still stays in the registered state when performing PLMN selection for return back. RRC based notification only involves RAN2 while NAS based notification only involves CT1.

Solution #29 proivdes one way for disaster no longer applicable notification to the UEs, i.e. NAS based notification. This solution reuses the existing handling for the case when the UE is accessing a forbidden PLMN, i.e. the network provides an existing 5GMM cause value #11 (PLMN not allowed) as an indication that a Disaster Condition in PLMN D is no longer applicable. There is no paging for UEs in idle mode. As per existing UE handling, the UE will enter the deregistered state when performing PLMN selection for return back. No new indication is required for Solution #29.

Solution #30 and Solution #34 rely on UE performing the periodic PLMN scan in VPLMN which is an existing mechanism for the roaming. There is no need for the network to provide an indication that a Disaster Condition in PLMN D is no longer applicable as the UE can detect this by performing PLMN scan. However, these solutions cannot guarantee the UE can detect the Disaster Condition in PLMN D is no longer applicable in time and hence the UE cannot return back to PLMN D quickly after the Disaster Condition is no longer applicable. There is no impact on both NG-RAN and 5GCN of PLMN A.

Solution #31 provides one way for disaster no longer applicable notification to the UEs, i.e. NAS based notification. This solution requires a new NAS indication (e.g. a new 5GMM cause value "Disaster Condition no longer applicable") to the UE. For UEs in idle mode, the network either pages the UE or waits until the UE enters 5GMM-CONNECTED state. Based on this new indication, the UE will enter the deregistered state when performing PLMN selection for return back.

Solution #32 provides one way for disaster no longer applicable notification to the UEs, i.e. NAS based notification. This solution requires a new NAS indication (e.g. a new 5GMM cause value "Disaster Condition no longer applicable") to the UE. For UEs in idle mode, the network needs to page the UE. Based on this new indication, the UE will enter the deregistered state when performing PLMN selection for return back.

Solution #33 provides one way for disaster no longer applicable notification to the UEs, i.e. NAS based notification. This solution requires a new NAS indication (e.g. a new 5GMM cause value "Disaster Condition in other PLMN no longer applies") to the UE. There is no paging for NAS based notification for UEs in idle mode. Based on this new indication, the UE still stays in the registered state when performing PLMN selection for return back.

Solution #35 relies on the RAN sharing between PLMN D and PLMN A and the UE is still served by the same PLMN D via the shared RAN of PLMN A. For disaster no longer applicable notification to the UEs, Solution #35 relies on the shared RAN to stop broadcast barring information related to Access Identity 3. This solution only involves RAN2 and no new work to be done in CT1.

Solutions #28, #30, #34, #35 provide solution for a UE in 5GMM-IDLE mode over 3GPP access.

Solutions #28, #29, #31, #32, #33 provide solution for a UE transiting from 5GMM-IDLE mode to 5GMM-CONNECTED mode over 3GPP access.

Solutions #28, #29, #31, #32 #33, #35 provide solution for a UE in 5GMM-CONNECTED mode over 3GPP access.

Solution #27 provides solution for a UE not registered over 3GPP access for duration of the Disaster Condition of the PLMN with Disaster Condition.

Solutions #28, #30, #33, #34, #35 enable preserving PDU sessions of the UE when moving from the PLMN providing disaster roaming to the PLMN previously with Disaster Condition, subject to agreement between the PLMN providing Disaster Roaming and the PLMN previously with Disaster Condition.

Solutions #29, #31, #32 do not enable preserving PDU sessions of the UE when moving from the PLMN providing disaster roaming to the PLMN previously with Disaster Condition.

Solution #27 does not state whether it enables or not preserving PDU sessions of the UE when moving from the PLMN providing disaster roaming to the PLMN previously with Disaster Condition, subject to agreement between the PLMN providing Disaster Roaming and the PLMN previously with Disaster Condition.

## 7.7 Evaluation on solutions of Key Issue #7

**Solution #1:**

a) only addresses the following question of Key Issue #7:

*How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit*

b) provides a solution for the question above of Key Issue#7 if all of the following conditions are met:

1) the UE:

i) supports the non-3GPP access in addition to the 3GPP access;

ii) supports connecting to N3WIF;

iii) was registered to the same PLMN over 3GPP and non-3GPP access before (and when) the disaster condition occurred; and

iv) is in 5GMM-CONNECTED mode over the non-3GPP access; and

2) the PLMN with Disaster Condition:

i) has N3IWF; and

ii) has a non-3GPP access network which is not affected by the Disaster Condition.

As such, Solution #1 cannot be the only solution to progress to normative phase and other solutions also need to be specified for fully address Key Issue #7;

c) enables the network to provide the UE with an "expected duration of disaster" timer. This timer may not always be accurate with respect to the time when the disaster condition actually ends;

d) enables the network to provide the UE with a list of PLMNs, optionally prioritized, for disaster roaming, which is similar to what is proposed in Solutions #39, #41 and #43; and

e) relies on providing a "wait timer" to the UE to stagger the arrival of UEs in the PLMNs without Disaster Condition, which is similar to what is proposed in Solutions #39, #43 and #53.

**Solution #16:**

a) only addresses the following questions of Key Issue #7:

*How to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition available in the area where the Disaster Condition applies, so as to share the load as evenly as possible between the PLMNs without Disaster Condition; and*

*How to use new Access Identity 3 for the purpose of Disaster Inbound Roamer access control and signalling overload prevention in the PLMNs without Disaster Condition;*

As such, Solution #16 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions; and

b) enables pre-configuration in the UE, or provisioning of the UE over NAS signalling, with the information required to distribute the UEs between the PLMNs which can accommodate Disaster Inbound Roamers;

c) makes use of existing SIB parameters;

d) requires SA1 agreement to allocate new Access Identity values for disaster roaming; and

e) requires RAN2 agreement to update the semantics of uac-BarringForAccessIdentity.

**Solution #36:**

a) only addresses the following question of Key Issue #7:

*How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion;*

As such, Solution #36 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions; andb) relies on rejecting Disaster Inbound Roamers with a new 5GMM cause value indicating that the resources are not sufficient for the Disaster Inbound Roamers that triggers the UE to look for another PLMN, which is similar to what is proposed in Solution #39.

**Solution #37:**

a) only addresses the following question of Key Issue #7:

*How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion;*

As such, Solution #37 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions;

b) requires RAN2 agreement to create a new RRC establishment cause; and

c) does not enable the UE to know that the rejection is due to congestion caused by the arrival of Disaster Inbound Roamers.

**Solution #38:**

a) only addresses the following questions of Key Issue #7:

*How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;*

*How to use new Access Identity 3 for the purpose of Disaster Inbound Roamer access control and signalling overload prevention in the PLMNs without Disaster Condition;*

*How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion; and*

*How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers.*

As such, Solution #38 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions;

b) proposes to change the way that barring is applied for Access Identities, by associating a barring factor with Access Identity 3, whereas per current RAN2 specifications, barring factors are only associated with Access Categories. This requires RAN2 agreement.

**Solution #39:**

a) only addresses the following questions of Key Issue #7:

*How to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition available in the area where the Disaster Condition applies, so as to share the load as evenly as possible between the PLMNs without Disaster Condition;*

*How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit; and*

*How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion.*

As such, Solution #39 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions;

b) enables the network to provide the UE with a prioritized or weighted list of PLMNs for disaster roaming, which is similar to what is proposed in Solutions #1, #41 and #43;

c) relies on providing a "disaster roaming wait range" to the UE to stagger the arrival of UEs in the PLMNs without Disaster Condition, which is similar to what is proposed in Solutions #1, #43 and #53;

d) proposes a new 5GMM cause value that can be used by the PLMNs without disaster when they encounter congestion due to the arrival of Disaster Inbound Roamers and that trigger the UE to look for another PLMN, which is similar to what is proposed in Solution #36; and

e) proposes the use of a broadcast indicator to indicate that the PLMN can accommodate / no longer accommodate Disaster Inbound Roamers, which requires feedback from RAN2 and SA3.

**Solution #40:**

a) only addresses the following questions of Key Issue #7:

*How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;*

*How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion; and*

*How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers.*

As such, Solution #40 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions; and

b) proposes to change the way that barring is applied for Access Identities, by introducing a new offset value to the unified access control barring information. This requires RAN2 agreement. This solution enables the disaster roaming PLMN to setup stricter barring factor only affecting Disaster Inbound Roamer UE for any access category it may use while in that PLMN.

**Solution #41:**

a) only addresses the following question of Key Issue #7:

*How to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition available in the area where the Disaster Condition applies, so as to share the load as evenly as possible between the PLMNs without Disaster Condition;*

As such, Solution #41 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions; and

b) enables the network to provide the UE with a prioritized list of recommended PLMNs for disaster roaming, which is similar to what is proposed in Solutions #1, #39 and #43.

**Solution #42:**

a) only addresses the following question of Key Issue #7:

*How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;*

*How to use new Access Identity 3 for the purpose of Disaster Inbound Roamer access control and signalling overload prevention in the PLMNs without Disaster Condition; and*

*How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion.*

As such, Solution #42 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions; and

b) relies on the creation of a new Access Category, which is subject to SA1 agreement. Additionally, for an Access Category other than the Access Category X, access attempts from Disaster Inbound Roamers and access attempts from non-Disaster Inbound Roamers are subject to the same barring factor.

**Solution #43:**

a) only addresses the following question of Key Issue #7:

*How to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition available in the area where the Disaster Condition applies, so as to share the load as evenly as possible between the PLMNs without Disaster Condition;*

*How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;*

As such, Solution #43 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions;

b) enables the network to provide the UE with a prioritized list of PLMNs for disaster roaming, which is similar to what is proposed in Solutions #1, #39 and #41; and

c) relies on providing a "minimum wait time" to the UE to stagger the arrival of UEs in the PLMNs without Disaster Condition, which is similar to what is proposed in Solutions #1, #39 and #53.

**Solution #53:**

a) only addresses the following question of Key Issue #7:

*How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit;*

As such, Solution #53 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions; and

b) enables configuring the UE (before the Disaster Condition occurs) with a timer, which the UE will use along with its unique ID (e.g. SUPI/PEI) to compute a series of windows of time during which the UE is allowed to attempt registration upon arriving in the PLMN previously with Disaster Condition, hence relies on putting restrictions on the time when the UE can initiate registration as well as reattempt registration in the PLMN without Disaster Condition, which is similar to what is proposed in Solutions #1, #39 and #43.

**Solution #54:**

a) only addresses the following question of Key Issue #7:

*How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers;*

As such, Solution #54 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions; and

b) enables a PLMN offering disaster roaming to indicate to a Disaster Inbound Roamer, during the registration procedure, a maximum number of PDU sessions which the UE is allowed to request to establish, and to optionally provide a timer during which this maximum number is applicable. The PLMN can also either modify this number or remove any limitation.

**Solution #55:**

a) only addresses the following question of Key Issue #7:

*How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers;*

As such, Solution #55 is not sufficient to fully address Key Issue #7 and must be supplemented by other solutions addressing the remaining questions; and

b) does not specify any new mechanism and instead proposes that existing mechanisms (DNN based congestion control triggered by the AMF or by the SMF, and S-NSSAI only or S-NSSAI and DNN based congestion control triggered by the AMF or by the SMF) are sufficient. The network triggers those mechanisms towards a particular UE so if required by operator policy, the network can trigger one or more of them towards a Disaster Inbound Roamer.

**Summary:**

The following key points can be observed from the evaluation above:

**Observation 1:** None of the solutions address all questions of Key Issue #7, which suggests that it will be necessary to combine components from different solutions for normative work.

**Observation 2:** One solution (Solution #1) relies on the use of non-3GPP access in specific conditions. It is not sufficient to address Key Issue #7 in all cases, but it could co-exist with solutions based on the use of 3GPP access.

**Observation 3:** Four solutions (Solutions #1, #39, #41 and #43) rely on the use of a prioritized list of PLMNs provided to the UE to distribute the subscribers of the PLMN with Disaster Condition between the PLMNs without Disaster Condition. When the disaster condition happens the congestion situation may be changing dynamically. A finer adjustment by the PLMNs offering disaster roaming is not possible when this information is pre-provisioned. The pre-configured distribution among various PLMNs achieves the intended distribution only if all these are available in the disaster area. It requires the operator to create, maintain up-to-date and provision such information to all subscribers and roamers. The pre-configured information cannot apply to roamers who has not registered with the PLMN with disaster condition earlier.

**Observation 4:** Four solutions (Solutions #1, #39, #43 and #53) rely on putting restrictions on the time when the UE can initiate registration on the PLMN without Disaster Condition to stagger the arrival of UEs in the PLMNs without Disaster Condition. The specific methods proposed in each of these solutions can be compared as follows:

a) As compared to only providing a "wait timer" (as in Solution #1), a timer used to compute a series of windows of time (as in Solution #53) or a "minimum wait time" (as in Solution #43), providing a range and having the UE draw a random value within that range (as in Solution #39 has the advantage of providing an upper bound for the wait time, thereby limiting the service interruption;

b) As compared to only providing a "wait timer" (as in Solution #1), providing a timer which the UE uses to compute a randomized series of windows (as in Solution #53) or providing a range and having the UE draw a random value within that range (as in Solution #39) has the advantage of removing the need for the network to allocate different "wait timer" values to different UEs to achieve spreading out the registration attempts over time, since the randomization of the registration time is done at the UE;

c) As compared to providing a "wait timer" (as in Solution #1) or a "minimum wait time" (as in Solution #43) or providing a range and having the UE draw a random value within that range (as in Solution #39), providing a timer which the UE uses to compute a randomized series of windows (as in Solution #53) has the advantage of enforcing back-off of the UE in case the UE was unable to register during a window of time, and retry of the UE during the next occurrence of the window of time;

d) Configuring the UE with "wait timer" before the Disaster Condition (as in Solution #1) or providing a timer which the UE uses to compute a randomized series of windows (as in Solution #53) makes it less flexible for networks to adapt to actual congestion situation at the time of arrival of roamers. For example, if the affected area/number of UEs is small, the PLMN without Disaster Condition would not be able to reduce the minimum wait duration or the time between the consecutive windows for registration; and

e) As compared to providing a "wait timer" (as in Solution #1), providing a "minimum wait time" (as in Solution #43), providing a range and having the UE draw a random value within that range (as in Solution #39) or providing a timer which the UE uses to compute a randomized series of windows (as in Solution #53), using UAC and NAS-level congestion control has the advantage that restrictions are put on the time when the UE can initiate registration only in case of actual congestion, which avoids delay in registration when there is no congestion.

**Observation 5:** Two solutions (Solutions #36 and #39) rely on the use of new 5GMM cause value indicating that the resources are not sufficient for the Disaster Inbound Roamers and which triggers the UE to look for another PLMN. This could result into a UE trying in sequence to register with all PLMNs offering Disaster Roaming to the UE and getting rejected in all those PLMNs.

**Observation 6:** Three solutions (Solutions #38, #40 and #42) build on top of Unified access control concept which was introduced in 5GS with an intention to avoid diverse Reject with back-off timer (RRC, NAS) mechanisms and provide a unified access control framework.

**Observation 7:** Solutions #38, #54 and #55 address the 5GSM congestion aspect of Key issue #7. The specific methods proposed in each of these solutions can be compared as follows:

a) Solution #38 does not introduce any new mechanism to handle 5GSM load from Disaster Inbound Roamers, but assumes that access-stratum level and 5GMM-level congestion control mechanisms are sufficient in addition to existing 5GSM congestion control mechanisms;

b) Solution #54 is based on providing the AMFs with an optional maximum limit of PDU sessions and an optional time that are provided to Inbound disaster roamers at registration. O&M is given as an example of how the values are determined. Once the maximum number of PDU sessions is reached, new requests from upper layers does not lead to any sort of re-prioritization of established PDU sessions compared to new requests. As such, upper layer requests for new PDU sessions are not to be handled. Additionally, receiving a limit on the number of PDU session from the network cannot be used by the UE as a trigger to perform PLMN reselection. The PLMN can also either modify this number or remove any limitation. Solution #54 is optional for the network to use and implement, but needs to be mandatory for the UE to implement. Solution #54 prevents Disaster Inbound Roamers to establish more than a certain minimum number of PDU sessions which can reduce 5GSM signalling generated by Disaster Inbound Roamers; and

c) Solution #55 proposes that the UE property of being a Disaster Inbound Roamer can be taken into account at evaluation of congestion control when using existing 5GSM congestion control mechanisms. If network knowledge of Disaster Inbound Roamers is added as part of solutions to other Key issues, the use of such knowledge in existing 5GSM congestion control may even be solved by implementation. The solution states that the network can use this method based on operator policy. If some Disaster Inbound Roamers request a high number of PDU sessions in a short period of time, action needs to be taken by the network to apply existing mechanisms in order to prevent a situation where other Disaster Inbound Roamers cannot establish any PDU session.

### 7.7.1 Evaluation of solutions using UAC after selecting a PLMN without disaster condition

Solutions #38, #40, and #42 are evaluated. See the table below.

Table 7.7.1-1: Evaluation of solutions using UAC after selecting a PLMN without disaster condition

|  |  |  |  |
| --- | --- | --- | --- |
|  | Solution #38 | Solution #40 | Solution #42 |
| Questions addressed by the solution | How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit  How to use new Access Identity 3 for the purpose of Disaster Inbound Roamer access control and signalling overload prevention in the PLMNs without Disaster Condition  How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion.  How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers. | How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit  How to use new Access Identity 3 for the purpose of Disaster Inbound Roamer access control and signalling overload prevention in the PLMNs without Disaster Condition  How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion.  How to enable a PLMN without Disaster Condition to efficiently prevent congestion on the 5GSM level that can be caused by 5GSM signalling generated by Disaster Inbound Roamers. | How to stagger the arrival of UEs in the PLMNs without Disaster Condition, so as to spread out registration attempts over time and keep the number of UEs attempting to register simultaneously within a manageable limit  How to use new Access Identity 3 for the purpose of Disaster Inbound Roamer access control and signalling overload prevention in the PLMNs without Disaster Condition  How to enable a PLMN without Disaster Condition to efficiently prevent Disaster Inbound Roamers from attempting registration on the PLMN when the PLMN can no longer accept Disaster Inbound Roamers due to congestion. |
| Impacts to UAC in addition to AI 3 | *UAC-BarringInfoSet* needs to include a new barring factor for AI 3.  For an access attempt with an AC and one or more AIs including AI 3, the barring rate is determined based on the barring factor for AI 3. | A new offset value for each of ACs needs to be defined in the barring information.  For an access attempt with an AC and one or more AIs including AI 3, the barring rate is determined base on the barring factor for the AC and the offset value for the AC. | A new AC (= MO\_Disaster\_ Roaming), namely AC X, needs to be defined.  AC X is applied to an access attempt which is cuased by the first registration to the PLMN without disaster condition. |
| Distinction between access attempts made by DIRs and non-DIRs after registration by DIRs | Distinction can be achieved | Distinction can be achieved | Distinction cannot be achieved. |

## 7.8 Evaluation on solutions of Key Issue #8

**Solution #27:**

a) provides a solution for Key Issue#8 if all of the following conditions are met:

1) the UE:

i) supports the non-3GPP access in addition to the 3GPP access;

ii) supports connecting to N3WIF; and

iii) is in 5GMM-CONNECTED mode over the non-3GPP access; and

2) the PLMN with Disaster Condition or a PLMN offering disaster roaming has N3WIF;

As such, Solution #27 cannot be the only solution to progress to normative phase and other solutions also need to be specified for fully address Key Issue #7; and

b) enables providing a "wait timer" to the UE to stagger the return of UEs to the PLMN previously with Disaster Condition, hence relies on putting restrictions on the time when the UE can initiate registration on the PLMN previously with Disaster Condition, which is similar to what is proposed in Solutions #44, #45, #46, #47 and #49.

**Solution #31:**

a) relies on the AMF's notifying only part of the Disaster Inbound Roamers at a time that the Disaster Condition is no longer applicable, e.g. based on the mod value of SUPI, to stagger the return of UEs to the PLMN previously with Disaster Condition;b) requires paging the UEs that are in 5GMM-IDLE mode to bring them to 5GMM-CONNECTED mode and notify them that the Disaster Condition has ended over NAS signalling, which is costly in terms of dedicated signalling;

c) for the UEs in 5GMM-CONNECTED mode, the AMF either sends a CONFIGURATION UPDATE COMMAND message including the information that the Disaster Condition is no longer applicable or sends a DEREGISTRATION REQUEST message with a new 5GMM cause value; and

d) requires the UE to de-register from the PLMN without Disaster Condition before returning to the PLMN previously with Disaster Condition, which prevents the UE from attempting to transfer ongoing PDU sessions.

**Solution #44:**

a) enables configuring the UE (before the Disaster Condition occurs) with a timer, which the UE will use, along with a unique ID (e.g. the UE's SUPI/PEI), to compute a series of windows of time during which the UE is allowed to attempt registration upon returning to the PLMN previously with Disaster Condition, hence relies on putting restrictions on the time when the UE can initiate registration on the PLMN previously with Disaster Condition. This solution is similar to what is proposed in Solutions #27, #45, #46, #47 and #49, but differs from all of them in the way the "windows of time" are calculated as it depends on not only a timer but also UE's unique ID, hence staggering the UEs and spreading the registration attempts even more.

**Solution #45:**

a) does not specify any new mechanism and instead proposes that existing mechanism (e.g. UAC, NAS-level congestion control) are sufficient; and

b) Through the use of UAC and NAS-level congestion control, can also put restrictions on the time when the UE can initiate registration on the PLMN previously with Disaster Condition, which is similar to what is proposed in Solutions #27, #44, #46, #47 and #49.

**Solution #46:**

a) enables the network to optionally wait for an implementation specific amount of time before turning off a broadcast indication that the Disaster Condition applies. This requires RAN2 and SA3's feedback;

b) enables the network to randomize the times when the UEs in 5GMM-CONNECTED are notified that the Disaster Condition no longer applies (via a generic UE configuration update procedure with an indication that the Disaster Condition in another PLMN no longer applies, or via a generic UE configuration update procedure with "re-registration requested" followed by a reject of the UE's registration request with 5GMM cause #ZZZ "disaster condition in other PLMN no longer applies"); and

c) enables the network to configure the UE with a "disaster return wait range" from which the UE draws a random wait time which determines how long the UE has to wait before registering upon returning to the PLMN previously with Disaster Condition, hence relies on putting restrictions on the time when the UE can initiate registration on the PLMN previously with Disaster Condition, which is similar to what is proposed in Solutions #27, #44, #45, #47 and #49.

**Solution #47:**

a) enables the AMF to stagger return of UEs by rejecting the registration requests from Disaster Inbound Roamers when the Disaster Condition no longer applies, while continuing to broadcast the indication that a Disaster Condition applies for a time T after that point;

b) for the UEs in 5GMM-CONNECTED mode:

1) if the UE has ongoing PDU sessions which can be transferred to the PLMN previously with Disaster Condition, the AMF initiates a generic UE configuration update procedure with "re-registration requested" followed by a reject of the UE's registration request with with 5GMM cause #13 to trigger the UE to perform PLMN selection; and

2) if the UE does not have any ongoing PDU session or the UE has ongoing PDU sessions which cannot be transferred to the PLMN previously with Disaster Condition, the AMF performs a network-initiated de-registration procedure with 5GMM cause #11 or #13 to trigger the UE to de-register and then perform PLMN selection; and

c) enables the PLMN without Disaster Condition to configure the Disaster Inbound Roamers with a timer T1 and a factor n which the UE will use to determine how long the UE has to wait before registering upon returning to the PLMN previously with Disaster Condition, with the maximum wait time being 2 \* T1, hence relies on putting restrictions on the time when the UE can initiate registration on the PLMN previously with Disaster Condition, which is similar to what is proposed in Solutions #27, #44, #45, #46 and #49.

**Solution #48:**

a) does not specify any new mechanism and instead proposes that RAN cells of the PLMN previously with Disaster Condition can control access of returning UEs using the existing unified access control, by setting up UAC parameters for access category 3 (= MO\_sig).

**Solution #49:**

a) enables the network to provision the UE with a minimum wait time per PLMN offering Disaster Roaming, hence relies on putting restrictions on the time when the UE can initiate registration on the PLMN previously with Disaster Condition, which is similar to what is proposed in Solutions #27, #44, #45, #46 and #47. In this solution, once the minimum wait time is over, UE can use a random timer to trigger a registration update request.

**Summary:**

The following key points can be observed from the evaluation above:

**Observation 1:** One solution (Solution #27) relies on the use of non-3GPP access in specific conditions. It is not sufficient to address Key Issue #7 in all cases, but it could co-exist with solutions based on the use of 3GPP access.

**Observation 2:** Six solutions (Solutions #27, #44, #45, #46, #47 and #49) rely on putting restrictions on the time when the UE can initiate registration on the PLMN previously with Disaster Condition to stagger the return of UEs in the PLMNs previously with Disaster Condition. Solution #46 additionally proposes to have a wait time that runs at the network side before the network turns off the indication that a Disaster Condition applies, to further stagger the return of the UEs in 5GMM-IDLE mode and Solution #44 uses, in addition to a timer, UE's unique ID for the calculation of windows of time when the UE is allowed to attempt registration. Similar to Solution #44, Solution #46 also uses a unique ID by applying a hash function to the UE's IMSI number. The specific method proposed in each of these solutions can be compared as follows:

a) As compared to only providing a "wait timer" (as in Solution #27), a timer used to compute a series of windows of time (as in Solution #44) or a "minimum wait time" (as in Solution #49), providing a range and having the UE draw a random value within that range (as in Solution #46), or providing a timer T1 and a factor n (as in Solution #47) has the advantage of providing an upper bound for the wait time, thereby limiting the service interruption;

b) As compared to only providing a "wait timer" (as in Solution #27), providing a timer which the UE uses along with its unique ID to compute a randomized series of windows (as in Solution #44) , providing a range and having the UE draw a random value within that range (as in Solution #46) or providing a timer T1 and a factor n (as in Solution #47) has the advantage of removing the need for the network to allocate different "wait timer" values to different UEs to achieve spreading out the registration attempts over time, since the randomization of the registration time is done at the UE;

c) As compared to providing a "wait timer" (as in Solution #27) or a "minimum wait time" (as in Solution #49), providing a range and having the UE draw a random value within that range (as in Solution #46) or providing a timer T1 and a factor n (as in Solution #47), providing a timer which the UE uses, along with its unique ID, to compute a randomized series of windows (as in Solution #44) has the advantage of enforcing back-off of the UE in case the UE was unable to register during a window of time, and retry of the UE during the next occurrence of the window of time;

d) Configuring the UE with "wait timer" before the Disaster Condition (as in Solution #49) makes it less flexible for networks to adapt to actual congestion situation at the time of return. For example, if the affected area/number of UEs is small, the PLMN with Disaster Condition would not be able to reduce the minimum wait duration or the time between the consecutive windows for registration; and

**Observation 3:** Two solutions (Solutions #45 and #48) propose that using existing mechanisms (UAC, NAS-level congestion control) are sufficient to to address Key Issue #8 via the use of a specific barring factor for Access Category 3 (MO\_sig) which will be used by UEs to register on the PLMN previously with Disaster Condition and the use of reject with back-off timer in case of congestion.

**Observation 4:** Two solutions (Solutions #31 and #46) propose to use a new 5GMM cause value to notify the Disaster Inbound Roamers that the Disaster Condition no longer applies.

**Observation 5:** Two solutions (Solution #46 and Solution #47) propose the return of UEs under network control. Solution #46 achieves this by randomizing the time at which UEs in 5GMM\_CONNECTED mode are notified that Disaster Condition no longer applies. Solution #47 staggers the return of UEs by prioritizing returning 5GMM\_CONNECTED mode UEs before returning the remaining UEs that are in IDLE mode.

## 7.9 Evaluation on solutions of Key Issue #9

Solutions #51, #56 and #60 and part of solution #25 aim at solving the key issue #9.

Solution #56 and #60 proposes that if during manual PLMN selection, all the available PLMNs are forbidden PLMNs and there are PLMNs that supports disaster roaming, then the UE may indicate to upper layers that the PLMN support disaster roaming.

Solution #56 also proposes that during manual PLMN selection, once the MS has registered on a PLMN without Disaster Condition which is selected by the user, before the MS is notified that the Disaster Condition no longer applies, the MS shall not automatically register on a different PLMN unless the new PLMN is declared as an equivalent PLMN by the registered PLMN and the new PLMN can accommodate Disaster Inbound Roamers.

Solution #25 proposes that if during manual PLMN selection, all the available PLMNs are forbidden PLMNs and if there are PLMNs that supports disaster roaming, then the NAS layer provides information about the PLMNs that support disaster roaming as not in the list of forbidden PLMNs to the upper layer. In addition to this, Solution #25 also proposes that in manual PLMN selection, the NAS layer may also provide information that the PLMN that is in disaster condition has a disaster condition.

However, in rel-17, the assumption is that the disaster condition is due to the unavailability of RAN. In that case the PLMN that is in disaster condition will not be available for PLMN selection. If that PLMN is available, it can be safely assumed that the disaster condition is over and so no need to send any indication.

Solution #51 proposes that no changes are needed if the RAN is shared between the PLMN that is in disaster condition and PLMN that supports disaster roaming.

# 8 Conclusions

## 8.1 Conclusions on Key Issue #1

The solution #3 is not progressed in the normative phase of FS\_MINT-CT.

A solution:

- which informs the UE about Disaster Condition over 3GPP access; and

- with minimal information broadcast over 3GPP access of a PLMN offering disaster roaming to UEs of a PLMN with Disaster Condition, sufficient to enable the UEs to determine that a Disaster Condition applies to the PLMN with Disaster Condition;

shall be progressed in normative phase.

Solutions which inform the UE about Disaster Condition over non-3GPP access are not progressed in the normative phase of FS\_MINT-CT in Release 17.

In the area where a PLMN can provide normal services to a UE, this PLMN is not considered as a PLMN with Disaster Condition in that area for that UE.

If a UE can get service from the PLMN with Disaster Condition over non-3GPP access, the UE is not eligible for disaster roaming service.

No further enhancement is needed for handling security risks resulting from using broadcast signalling to convey information related to disaster roaming.

## 8.2 Conclusions on Key Issue #2

The solution #9 is not progressed in the normative phase of FS\_MINT-CT.

The notification between the PLMN with Disaster Condition and PLMN without Disaster Condition is out of 3GPP scope.

NOTE: The information that has been listed in SA1 requirements will need to be exchanged for the feature to work.

Roaming agreements for the disaster roaming between PLMN with Disaster Condition and PLMN providing disaster roaming is out of scope of 3GPP.

## 8.3 Conclusions on Key Issue #3

For Key Issue#3, the following aspects are concluded.

- The solution #10 is not progressed in the normative phase of FS\_MINT-CT.

- The UE shall perform disaster roaming only if HPLMN has configured the UE with a 'list of PLMN(s) to be used in disaster condition' with at least one entry in it. The list is either pre-configured in the USIM or provided by the HPLMN following a successful registration procedure.

- The UE shall not perform disaster roaming if HPLMN has not configured the UE with a 'list of PLMN(s) to be used in disaster condition' or the number of elements in the list is zero.

- While roaming, the Registered PLMN may provide the 'list of PLMN(s) to be used in disaster condition' after a successful registration procedure. The UE shall ignore this information if 'list of PLMN(s) to be used in disaster condition' is empty .

- Registered PLMN(s) may provision 'list of PLMN(s) to be used in disaster condition' over non-3GPP access before a disaster condition.

- PLMN offering disaster roaming shall indicate accessibility for disaster roamers through SIB messages. The indication may contain the list of PLMN(s) with Disaster condition for which disaster roaming is offered.

- The solution #14 is not progressed in the normative phase of FS\_MINT-CT.

- UE of PLMN D with Disaster Condition shall determine that PLMN A offers disaster roaming when PLMN A's NG-RAN cell broadcasts PLMN ID of PLMN D in the list of PLMN(s) with Disaster Condition for which disaster roaming is offered by PLMN A. For PLMN selection, the UE shall prioritize the determined PLMNs offering the disaster roaming which are also included in UE's 'list of PLMN(s) to be used in disaster condition', above the determined PLMNs offering the disaster roaming which are not included in UE's 'list of PLMN(s) to be used in disaster condition'. If the 'list of PLMN(s) to be used in disaster condition' is non-empty and there are no determined PLMNs offering the disaster roaming which are also included in UE's 'list of PLMN(s) to be used in disaster condition', the UE shall perform disaster roaming in a PLMN determined as per the conclusion of KI#5 offering the disaster roaming which is not included in UE's 'list of PLMN(s) to be used in disaster condition'.

NOTE: the design of the SIB messages is defined by RAN WG2.

If a UE can get service from the PLMN with Disaster Condition over non-3GPP access, the UE is not eligible for disaster roaming service.

No further enhancement is needed for handling security risks resulting from using broadcast signalling to convey information related to disaster roaming.

## 8.4 Conclusions on Key Issue #4

The solution #18 is not progressed in the normative phase of FS\_MINT-CT.

The higher priority PLMN search can be modified under the Disaster Condition.

The AMF of PLMN providing disaster roaming should be able to distinguish the registration request from the normal UEs and the registration request for the disaster roaming.

With regards to the following aspect from KI#4:

*- How a Disaster Roaming PLMN can limit the area of service to Inbound Disaster Roamers to the region where Disaster Condition applies*;

the following interim conclusions are made for the normative phase:

- The AMF in the PLMN offering disaster roaming service determines a registration area for the UE such that the 5GS tracking area list contains only those tracking area identities (TAIs) that overlap with the area of the disaster condition.

- The AMF in the PLMN offering disaster roaming service provides the mobility restriction list to the RAN with the service area information set to the area that corresponds with the area of the disaster condition, and also indicating that EPC is not an allowed core network.

The following conclusions are reached for other aspects:

- When the UE performs a registration procedure due to disaster roaming in a PLMN which supports disaster roaming, UE will indicate a new registration type in the REGISTRATION REQUEST message to differentiate between normal registration and registration due to disaster roaming.

- If the UE does not have a valid 5G-GUTI assigned by the PLMN with disaster condition and:

- the PLMN with Disaster Condition is not HPLMN of the UE; or

- the PLMN with Disaster Condition is HPLMN of the UE and the UE does not provide SUCI;

in addition to the new registration type, the UE also indicates the PLMN with Disaster Condition in the registration request.

- Upon receiving REGISTRATION REQUEST message with a new registration type for disaster roaming, AMF of PLMN providing disaster roaming:

- checks that the UE's PLMN with Disaster Condition which is determined from the PLMN with Disaster Condition indicated in the registration request, SUCI or 5G-GUTI, provided by the UE, is a PLMN with Disaster Condition for which the PLMN of the AMF provides disaster roaming; and

- checks that the UE is registering in a TA which is part of the disaster area of the UE's PLMN with Disaster Condition.

If both the above checks are successful PLMN A handles the request further, otherwise PLMN A rejects the request.

## 8.5 Conclusions on Key Issue #5

The solution #51 is not progressed in the normative phase of FS\_MINT-CT.

The higher priority PLMN search can be modified under the Disaster Condition.

The following will be progressed in the normative phase of FS\_MINT-CT:

1) concluded solution of KI#3 shall be used for discovery of PLMNs offering disaster roaming.

2) the solution shall enable the UE in automatic selection to select available PLMN D even if the UE is informed that Disaster Condition applies for PLMN D.

3) the UE in automatic selection shall consider PLMNs offering disaster roaming in automatic selection in bullet vi of 3GPP TS 23.122 [7] clause 4.4.3.1.1.

4) if there are several PLMNs offering disaster roaming, they shall be ordered according to the information configured by PLMN D, if available, or in random order.

5) the PLMN providing disaster roaming shall not be removed from the list of forbidden PLMNs.

6) when UE's RPLMN is not available, there is no available non-forbidden PLMN, no PLMN offers disaster roaming to UEs of UE's RPLMN, and an available PLMN offers disaster roaming to UEs of a non-forbidden PLMN with Disaster Condition, the UE shall select the PLMN offering disaster roaming to UEs of the non-forbidden PLMN with Disaster Condition. If there are several non-forbidden PLMNs with Disaster Condition, the UE shall consider the PLMN with Disaster Condition based on the priority of the PLMNs as described in 3GPP TS 23.122 [7] clause 4.4.3.

7) in automatic network selection mode, reselection to an EPLMN is allowed only if the EPLMN can provide the UE with disaster roaming as determined according to the conclusions of KI#3 as specified in clause 8.3.

NOTE: Aspects of leaving manual selection in solution #26 can be studied in normative phase.

For automatic selection, access to CAG cell of a PLMN for which the UE is not configured is not allowed.

If a UE can get service from the PLMN with Disaster Condition over non-3GPP access, the UE is not eligible for disaster roaming service.

No further enhancement is needed for handling security risks resulting from using broadcast signalling to convey information related to disaster roaming.

## 8.6 Conclusions on Key Issue #6

The solution #35 is not progressed in the normative phase of FS\_MINT-CT.

The higher priority PLMN search can be modified under the Disaster Condition.

Solution #30 and #34 will be progressed to normative work to enable the UE to detect that Disaster Condition in PLMN D is no longer applicable without network notification and then to perform the PLMN selection, e.g. in order to return to PLMN D. This is treated as a pure UE based solution for Key Issue #6.

NOTE 1: Conclusions for network based solutions will be decided during the normative phase.

NOTE 2: Impacts due to SA1 LS response (C1-213550) will be determined during the normative phase.

The solutions utilizing 3GPP access based approach will be the basis solutions for the Key Issue #6 on the notification that Disaster Condition is no longer applicable to the UEs.

No further enhancement is needed for handling security risks resulting from using broadcast signalling to convey information related to disaster roaming.

## 8.7 Conclusions on Key Issue #7

It is proposed to adopt the following conclusion principles:

- none of the solutions in the present specification fully address Key Issue #7, as a result it will be necessary to combine components from different solutions for normative work;

- the non-3GPP access (of the PLMN with Disaster Condition, or of a PLMN without Disaster Condition), if available, can optionally be used to provide information on the Disaster Condition;

- the network can optionally provision the UE with a prioritized list of PLMNs for disaster roaming;

NOTE 1: Whether the prioritized list of PLMNs for disaster roaming is pre-configured in the UE and/or signalled to the UE will be decided during the normative phase.

- the network can optionally put restrictions on the time when the UE can initiate the registration procedure upon arriving in the PLMN without Disaster Condition; and

NOTE 2: Whether these restrictions are signalled, pre-configured, or computed at the UE (possibly based on signalled or pre-configured parameters) will be decided during the normative phase.

- for mitigating congestion on the 5GMM layer, enhancements to existing mechanisms for congestion/overload mitigation (NAS level congestion control, RAN overload control, UAC) can be considered in normative phase as long as they are optional to support for the UE and the network.

- Among Solutions #38, #40, and #42 which address UAC after selecting a PLMN without disaster condition, Solution #42 will not not be progressed in the normative phase.

The existing mechanisms available at the AMF and the SMF for mitigation of overload/congestion are used for 5GSM layer congestion mitigation during the disaster roaming service.

No further enhancement is needed for handling security risks resulting from using broadcast signalling to convey information related to disaster roaming.

## 8.8 Conclusions on Key Issue #8

It is proposed to adopt the following conclusion principles:

- the non-3GPP access (of the PLMN with Disaster Condition, or of a PLMN without Disaster Condition), if available, can optionally be used to provide information on the Disaster Condition;

- the network can optionally put restrictions on the time when the UE can initiate the registration procedure upon returning to the PLMN previously with Disaster Condition;

NOTE: Whether these restrictions are signalled, pre-configured, or computed at the UE (possibly based on signalled or pre-configured parameters) will be decided during the normative phase.

- a PLMN providing disaster roaming can optionally page Disaster Inbound Roamers to trigger their return to the PLMN previously with Disaster Condition. Whether and how long the PLMN waits before paging the Disaster Inbound Roamers upon being notified that a Disaster Condition no longer applies is up to operator's policy; and

- A PLMN providing disaster roaming can optionally trigger Disaster Inbound Roamers to return to the PLMN previously with Disaster Condition when the Disaster Inbound Roamers attempt to transit to 5GMM-CONNECTED mode.

No further enhancement is needed for handling security risks resulting from using broadcast signalling to convey information related to disaster roaming.

## 8.9 Conclusions on Key Issue #9

It is concluded that:

- The solution #51 is not progressed in the normative phase of FS\_MINT-CT.

- The PLMN providing disaster roaming shall not be removed from the list of forbidden PLMNs.

- for manual network selection if only forbidden PLMNs are available and UE detects that some of those forbidden PLMNs support disaster roaming, then the UE may send an indication to the upper layers that those PLMNs support disaster roaming.

- in manual network selection mode, reselection to an EPLMN is allowed only if the EPLMN can provide the UE with disaster roaming as determined according to the conclusions of KI#3 as specified in clause 8.3.

For manual selection, access to CAG cell of a PLMN for which the UE is not configured is allowed only when the CAG cell indicates that manual selection is possible.

If a UE can get service from the PLMN with Disaster Condition over non-3GPP access, the UE is not eligible for disaster roaming service.

Annex A (informative):  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2010-11 | CT1#127e | C1-207563 |  |  |  | Draft skeleton provided in C1-207563 by the rapporteur. | 0.0.0 |
| 2020-11 | CT1#127e |  |  |  |  | Implementing the following p-CR agreed by CT1: C1-207564, C1-207630, C1-207646, C1-207647, C1-207648,  C1-207649, C1-207650, C1-207684, C1-207685 | 0.1.0 |
| 2021-01 | CT1#127bis-e |  |  |  |  | Implementing the following p-CR agreed by CT1: C1-210167, C1-210319, C1-210359, C1-210365, C1-210368,  C1-210370, C1-210371, C1-210372, C1-210373, C1-210413,  C1-210424  C1-210309, C1-210308, C1-210346, C1-210325, C1-210393,  C1-210357, C1-210394, C1-210395, C1-210423, C1-210344,  C1-210374, C1-210350, C1-210396, C1-210403, C1-210425,  C1-210337, C1-210307, C1-210334, C1-210426, C1-210409,  C1-210335, C1-210351, C1-210404, C1-210427, C1-210415,  C1-210326, C1-210304, C1-210342, C1-210363, C1-210364,  C1-210367, C1-210391, C1-210405, C1-210432, C1-210225,  C1-210312, C1-210329, C1-210336, C1-210352, C1-210375,  C1-210414, C1-210428, C1-210315, C1-210328, C1-210340,  C1-210353, C1-210407, C1-210429 | 0.2.0 |
| 2021-03 | CT1#128e |  |  |  |  | Implementing the following p-CR agreed by CT1: C1-210779, C1-210921, C1-211177, C1-211243, C1-211245,  C1-211321, C1-211331, C1-211352, C1-211371, C1-211382,  C1-211494,  C1-210726, C1-210727, C1-210875, C1-210885, C1-210945,  C1-211084, C1-211267, C1-211318, C1-211319, C1-211323,  C1-211327, C1-211328, C1-211329, C1-211330, C1-211335,  C1-211343, C1-211373, C1-211374, C1-211410, C1-211449,  C1-211450, C1-211479, C1-211485, C1-211487, C1-211488,  C1-211490, C1-211491, C1-211492, C1-211493  C1-211310, C1-211447, C1-211448 | 0.3.0 |
| 2021-03 | CT#91e | CP-210174 |  |  |  | Presentation to TSG CT for information | 1.0.0 |
| 2021-04 | CT1#129e |  |  |  |  | Implementing the following p-CR agreed by CT1: C1-212113, C1-212138, C1-212139, C1-212404, C1-212453,  C1-212471, C1-212492, C1-212493, C1-212516, C1-212526,  C1-212527, C1-212543,  C1-212071, C1-212109, C1-212432, C1-212447, C1-212450,  C1-212518, C1-212545, C1-212567, C1-212570, C1-212595 | 1.1.0 |
| 2021-06 | CT1#130e |  |  |  |  | Implementing the following p-CR agreed by CT1: C1-212921, C1-212922, C1-213025, C1-213233, C1-213268,  C1-213282, C1-213409, C1-213435, C1-213524, C1-213525,  C1-213713, C1-213826, C1-213852, C1-213867, C1-213879,  C1-213892, C1-213924, C1-213925, C1-213926, C1-213927,  C1-213963 | 1.2.0 |
| 2021-06 | CT#92e | CP-211122 |  |  |  | Version created for approval | 2.0.0 |
| 2021-06 | CT#92e |  |  |  |  | Version 17.0.0 created after approval of v2.0.0 | 17.0.0 |
| 2021-09 | CT#93e | CP-212144 | 0001 | - | F | Clean-up of TR 24.811 | 17.1.0 |