**3GPP TSG- Meeting #**

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| *CR-Form-v12.3* |
| **CHANGE REQUEST** |
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|  |  | **CR** |  | **rev** |  | **Current version:** |  |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* |
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| ***Proposed change affects:*** | UICC apps |  | ME |  | Radio Access Network |  | Core Network | **x** |

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| ***Title:***  |  |
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| ***Source to WG:*** |  |
| ***Source to TSG:*** | S2 |
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| ***Work item code:*** |  |  | ***Date:*** |  |
|  |  |  |  |  |
| ***Category:*** |  |  | ***Release:*** |  |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-17 (Release 17)Rel-18 (Release 18)Rel-19 (Release 19) Rel-20 (Release 20)* |
|  |  |
| ***Reason for change:*** | Some parameters as defined for the the analytics request (as defined in Clause 6.1.3 of TS 23.228) cannot be handled by the the NWDAF sending an inference request to the AF acting as VFL server.In SA2#167 the description of step 1 was made applicable only for AF as VFL server in, but the corresponding reply step 7 was not updated accordingly and the figure was also not updated.As an editorial issue, Figure 6.2H.2.3.2-1 is in a format which cannot be edited. |
|  |  |
| ***Summary of change:*** | Add parameters as defined for the the analytics request (as defined in Clause 6.1.3 of TS 23.228) that cannot be handled by the the NWDAF sending an inference request to the AF acting as VFL server.Step 7 only applies for AF as VFL server case.Figure is updated to show only service operations related to AF as server in steps 1 and 7.Figure 6.2H.2.3.2-1 is converted back to Visio. |
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| ***Consequences if not approved:*** | Not all analyitics requests can be fully supported via VFL with AF acting as VFL serverInternal contradictiuon between figure and desription related to steps 1 and 7. |
|  |  |
| ***Clauses affected:*** | 6.2H.2.3.2, 6.2H.2.4.1, 11.4.1, 11.4.2, 11.4.4, 11.4.5, 12.5.1, 12.5.2, 12.5.4, 12.5.5 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **x** |  Other core specifications  | TS/TR ... CR ...  |
| ***affected:*** |  | **x** |  Test specifications | TS/TR ... CR ...  |
| ***(show related CRs)*** |  | **x** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

1st change

##### 6.2H.2.3.2 Training Procedure for Vertical Federated Learning untrusted AF is acting as VFL server

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Figure 6.2H.2.3.2-1: Training procedure for Vertical Federated Learning when untrusted AF is acting as VFL server

0. [CONDITIONAL] Same as in step 0 in clause 6.2H.2.3.1, when the AF is the VFL Server, but AF is replaced with untrusted AF, and Nnef\_Training\_Subscribe offered by NEF is used.

 NEF forwards the subscription request to AF using Naf\_Training\_Subscribe.

 In addition:

- Either based on the information received or internal configuration, VFL server decides to initiate VFL training procedure, or

- case E) same as step 0d, but the Analytics consumer contacts the NWDAF containing AnLF that wants to perform inference and does not have a model, it discovers VLF Server from NRF that is a VFL Server, then request the VFL Server via NEF to perform inference. The VFL server may trigger VFL training if no corresponding VFL training has been performed.

1. Same as step 1 in Figure 6.2H.2.3.1-1.

Steps 2-7 are repeated until the training termination condition is reached.

2. To start VFL training, the VFL server do same as in step 2 in Figure 6.2H.2.3.1-1, using Nnef\_VFLTraining\_Subcribe.

2c. If a NWDAF VFL client is selected to aggregate the intermediate training results of other VFL clients, this NWDAF VFL client may send Nnwdaf\_VFLTraining\_Subscribe to other one or more indirect NWDAF VFL client as configured from which it desires to receive the client intermediate training results.

NOTE: To support the intermediate results sharing between VFL clients in step 2c, the VFL clients might be selected by NEF as described in clause 6.2H.2.1.2 and/or by using parameters available from preparation phase e.g. based on the VFL Interoperability Indicator and/or the parameters in VFL Interoperability Information (e.g. gradient dimension of local model, split point of the preconfigured initial model, etc.).

3. [Optional] Same as step 3 in Figure 6.2H.2.3.1-1.

4. Same as step 4 in Figure 6.2H.2.3.1-1.

5. Same as step 5 in Figure 6.2H.2.3.1-1.

5a. A NWDAF VFL client sends a Nnwdaf\_VFLTraining\_Notify.

5b. For an untrusted AF acting as VFL server, the NEF converts any internal identifiers to external identifiers, provides the external NWDAF ID and sends a Nnef\_VFLTrainingNotify to the VFL server.

5c-5d. The NWDAF VFL clients share the client intermediate training results with the NWDAF VFL client from which it received subscription request in step 2c. This NWDAF VFL client aggregates the received client intermediate training results from the NWDAF VFL clients, performs local computation using the aggregated intermediate inference results, then sends one notification to the NEF by including its client intermediate training result.

6. [Optional] Same as step 6 in Figure 6.2H.2.3.1-1.

7a. Same as step 7a in Figure 6.2H.2.3.1-1.

7b-g. Same as in steps 7b-e in clause 6.2H.2.3.1, when the AF is the VFL Server, but AF is replaced with untrusted AF, and Nnef\_Training\_Notify offered by NEF is used. NEF forwards the subscription request to AF using Naf\_Training\_Notify. The AF stores the External NWDAF IDs together with the NEF and VFL correlation ID, to be able to use this e.g. for Inference later.

8. Same as step 8 of Figure 6.2H.2.3.1-1. However, sub steps in that figure are not applicable.

8a. For each NWDAF VFL client, the untrusted AF as VFL server sends a Nnef\_VFLTraining Unsubscribe to the NEF handling that AF. The untrusted AF identifies the VFL client using the external NWDAF ID assigned in the discovery procedure (see clause 6.2H.2.1.1).

8b. The NEF sends an Nnwdaf\_VFLTraining\_Unsubscribe to the NWDAF VFL client indicated by the received external NWDAF ID.

8c. An NWDAF VFL client may send Nnwdaf\_VFLTraining\_Unsubscribe to other one or more NWDAF VFL clients in step 2c.

9. Same as step 9 of Figure 6.2H.2.3.1-1.

2nd change

##### 6.2H.2.4.1 Inference procedure for vertical federated learning when NWDAF or Trusted AF is acting as VFL server



Figure 6.2H.2.4.2-1: Inference procedure for vertical federated learning when NWDAF or Trusted AF is acting as VFL server

The inference procedure when trusted AF is acting as VFL server may be triggered by a request or subscription from a 5GC consumer NF or internal service logic of the AF acting as VFL server. If triggered by internal service logic of the AF acting as VFL server, the steps 0, 1,7 and 8 are skipped.

0. The analytics consumer NF sends an Analytics request/subscribe (Analytics ID, Target of Analytics Reporting= e.g. UE IDs and optionally both Analytics Reporting Information=Analytics target period and Analytics Filter, Analytics Accuracy Request if the analytics consumer NF requests Analytics Accuracy Monitoring) to NWDAF containing AnLF by invoking a Nnwdaf\_AnalyticsInfo\_Request or a Nnwdaf\_AnalyticsSubscription\_Subscribe., providing parameters as defined in clause 6.1.3.

1. If the NWDAF containing AnLF can be the VFL server to generate the VFL inference results for the requested analytics ID, then step 1 is skipped.

 If the NWDAF containing AnLF cannot generate the analytics output, the NWDAF containing AnLF determines the VFL Server AF for the requested analytics.

 If the VFL server is trusted AF, the NWDAF containing AnLF sends a request to trusted AF VFL server using Naf\_Inference\_subscribe/request including Analytics ID, Target of Analytics Reporting = e.g. UE IDs and optionally Analytics Reporting Information with parameters as defined Clause 6.1.3, e.g Analytics target period, Analytics Filter and Analytics Accuracy Request.

2. Based on the information received in the step 0 or 1, VFL server decides to initiate the VFL inference procedure with the VFL clients. Before the VFL server initiate the VFL inference procedure, the VFL server may initiate the VFL training procedure if no VFL model is already trained as described in the clause 6.2H.2.3 based on the information received in the step 0 or 1 or VFL server local configuration. VFL Server selects clients(s) using information stored in the VFL training process. The VFL server may select some or no clients, e.g. depending on the accuracy of the VFL model, the contribution to the training result and the current status of the VFL clients.

 When no VFL Clients are selected, the VFL server may generates the VFL inference results based only on its local trained ML model associated with the determined VFL correlation ID, skipping the steps 2 - 6 (and 7 if step 1 was also skipped).

NOTE 1: If the server does not select VFL clients for all features, it can internally store information about the features considered when deriving the analytics results together with a timestamp to identify the analytics results, to enable to subsequently trace the origin of analytics results and to interpret possible feedback on analytics accuracy.

 When a VFL client is not available for inference, e.g. depending on the contribution to the training result, the accuracy of the VFL model, the contribution to the training result and the current status of the VFL clients, the VFL server may select another available VFL client with a well-trained model not yet selected for inference, from the original training process, or the VFL server may select a new VFL client and start a new training procedure.

 VFL server NWDAF or trusted AF determines and sends a VFL Inference request/subscription to each VFL client including the Target of VFL inference = e.g. UE IDs, VFL correlation ID to indicate the VFL client which previously well-trained VFL local model associated with this ID will be used and optionally VFL inference filter, Data time window, Time when intermediate local result is needed, Dataset Statistical Properties, Analytics Metadata Request, as defined in clause 6.2H.2.4.3.

2a. For each NWDAF VFL client, the VFL Server NWDAF or trusted AF sends an Nnwdaf\_VFLInference\_Subscribe or Nnwdaf\_VFLInference\_Request to the VFL client.

2b. For each trusted AF VFL client, the VFL Server NWDAF sends an Naf\_VFLInference\_Subscribe or Naf\_VFLInference\_Request to the VFL client.

2c. For each untrusted AF VFL client, the VFL Server NWDAF sends an Nnef\_VFLInference\_Subscribe or Nnef\_VFLInference\_Request to the NEF serving the AF.

2d. For each untrusted AF VFL client, the NEF converts any internal identifiers to external identifiers and sends an Naf\_VFLInference\_Subscribe or Naf\_VFLInference\_Request to the untrusted AF VFL client.

NOTE 2: For the trusted AF is acting as VFL server, the VFL client can only be the NWDAF.

3. Each VFL Client collects its local data by using mechanism as specified in clause 6.2 and considering a possibly received data time window to ensure that different VFL clients use the inference data collected in the same time period if the VFL Client does not have local data available already.

4. Based on the VFL correlation ID, each VFL Client determines the VFL local model to generate the intermediate local inference results.

NOTE 3: In this Release, it is assumed that local intermediate inference is shared between VFL server and VFL client.

5. VFL Client sends the client intermediate local results to the VFL server. If requested in step 2, it includes Analytics Metadata, as defined in clause 6.2H.2.4.3. Alternatively, the VFL client may report their status and other cause value for rejecting the VFL inference process (e.g. overload, target UE moved out of NWDAF serving area) in the VFL inference response service.

 The intermediate local results, which are sent from the VFL Client to the VFL Server during the VFL inference process, are the information for the VFL Server to combine and generate the VFL inference results.

 If the VFL server used an inference subscription in step 2, step 5 may be repeated.

5a. Each NWDAF VFL client sends an Nnwdaf\_VFLInference\_Notify or Nnwdaf\_VFLInference\_Request response to the VFL Server NWDAF or trusted AF.

5b. Each trusted AF VFL client sends a Naf\_VFLInference\_Notify or Naf\_VFLInference\_Request response to the VFL Server NWDAF.

5c. Each untrusted AF VFL client sends a Naf\_VFLInference\_Notify or Naf\_VFLInference\_Request response to the NEF.

5d. For each untrusted AF VFL client, the NEF converts any external to internal identifiers and sends an Nnef\_VFLInference\_Notify or Nnef\_VFLInference\_Request response to the NWDAF VFL server.

6. The VFL server may collect its local data and generate the intermediate local inference results. When the VFL Server selected VFL clients to participate in the VFL Inference process, it combines all the intermediate local results to generate the combined inference results based on the VFL correlation ID. The VFL server takes into account the participation of each VFL client during the ML training process and the importance of the intermediate local results when it generates the combined inference results.

 The VFL server may compute the VFL accuracy based on all the intermediate local results received from VFL clients and the label, if it receives Analytics accuracy request in step 0. The server also aggregates possibly received analytics metadata.

7. If step 1 was executed, the trusted AF as VFL server sends Naf\_Inference\_Response/Notify to the consumer (i.e. NWDAF containing AnLF) including the inference results, optionally, accuracy information, Validity period, Confidence, Analytics Metadata Information (see Clause 6.1.3 for explamtations of those paramerters ).

NOTE 4: If the AF VFL server is no longer able to continue a inference subscription, it can send a termination request to the NWDAF containing AnLF. If the AF VFL server is nt able to provide analytics in the requested time, it may provide a Revised waiting time.

8. The NWDAF containing AnLF provides the analytics output to the analytics consumer NF based on the VFL inference results by means of either Nnwdaf\_AnalyticsInfo\_Response or Nnwdaf\_AnalyticsSubscription\_Notify, depending on the service used in step 0.

 The NWDAF containing AnLF may provide VFL accuracy if the consumer NF provides Analytics Accuracy request in step 0.

NOTE 5: There may be some time delay between the time when the AnLF provides the analytics output to consumer NF and the time when the AnLF provides VFL accuracy, as the labels are collected after making predictions. The analytics result and VFL accuracy may be send in different response messages.

3rd change: Naf\_Inference Service

### 11.4.1 General

**Service Description:** This service is provided by AF acting as VFL server and enables an NWDAF or an NEF acting on its behalf as consumer to request or subscribe/unsubscribe for a VFL inference.

4th change

### 11.4.2 Naf\_Inference\_Subscribe service operation

**Service operation name:** Naf\_Inference\_Subscribe

**Description:** Subscribe to VFL inference.

**Inputs, Required:**

 For new subscription:

- Notification Target Address (+ Notification Correlation ID).

- Analytics ID.

- Target of Analytics Reporting.

 When updating a subscription:

- Subscription Correlation ID.

**Inputs, Optional:**

- Analytics Reporting Information (see Clause 6.1.3 for explanation of parameters):

- Event Reporting parameters defined in Table 4.15.1-1 of TS 23.502 [3]

- Reporting Thresholds

- Analytics target period

- Data time window

- Preferred level of accuracy of the analytics

- Preferred level of accuracy per analytics subset

- Dataset Statistical Properties

- Time when analytics information is needed

- Maximum number of objects requested

- Preferred granularity of location information

- Spatial granularity size

- Temporal granularity size

- Preferred orientation of location information

- Preferred order of results

- Output strategy

- Analytics Metadata Request

- Analytics Accuracy Request information

- Analytics Filter.

**Outputs Required:** When the subscription is accepted: Subscription Correlation ID (required for management of this subscription). When the subscription is not accepted, an error response.

**Outputs, Optional:** First corresponding inference report is included, if available and if analytics consumer requested immediate reporting (see clause 4.15.1 of TS 23.502 [3])..

5th change

### 11.4.4 Naf\_Inference\_Notify service operation

**Service operation name:** Naf\_Inference\_Notify

**Description:** Notify VFL inference result.

**Inputs, Required:**

- Notification Correlation Information.

**Inputs, Optional:**

- inference results:

- Set of the tuple (Analytics ID, Analytics specific parameters): this parameter shall be present if output analytics are reported

- Validity period

- Confidence

- Analytics Metadata Information

- Analytics Accuracy Information

- Revised waiting time.

 - Termination Request: this parameter indicates that AF requests to terminate the inference subscription, i.e. AF will not provide further notifications related to this subscription, with cause value.

**Outputs, Required:** Operation execution result indication.

**Outputs, Optional:** None.

6th change

### 11.4.5 Naf\_Inference\_Request service operation

**Service operation name:** Naf\_Inference\_Request

**Description:** The consumer requests the AF to perform a one-time VFL inference.

**Inputs, Required:**

- Analytics ID.

- Target of Analytics Reporting.

**Inputs, Optional:**

- Analytics Reporting Information (see Clause 6.1.3 for explanation of parameters):

- Reporting Thresholds

- Analytics target period

- Data time window

- Preferred level of accuracy of the analytics

- Preferred level of accuracy per analytics subset

- Dataset Statistical Properties

- Time when analytics information is needed

- Maximum number of objects requested

- Preferred granularity of location information

- Spatial granularity size

- Temporal granularity size

- Preferred orientation of location information

- Preferred order of results

- Output strategy

- Analytics Metadata Request

- Analytics Accuracy Request information

- Analytics Filter.

**Outputs, Required:** If the request is accepted, then VFL inference results. When the request is not accepted, an error response.

**Outputs, Optional:**

- Validity period.

- Confidence.

- Analytics Metadata Information.

- Analytics Accuracy Information.

7th change: Nnef\_Inference Service

### 12.5.1 General

**Service Description:** This service is provided by an NEF on behalf of an AF acting as VFL server and enables an NWDAF as consumer to request or subscribe/unsubscribe for a VFL inference.

8th change

### 12.5.2 Nnef\_Inference\_Subscribe service operation

**Service operation name:** Nnef\_Inference\_Subscribe

**Description:** Subscribe to VFL inference.

**Inputs, Required:**

 For new subscription:

- Notification Target Address (+ Notification Correlation ID).

- Analytics ID.

- Target of Analytics Reporting.

 When updating a subscription:

- Subscription Correlation ID.

**Inputs, Optional:**

- Analytics Reporting Information (see Clause 6.1.3 for explanation of parameters):- Event Reporting parameters defined in Table 4.15.1-1 of TS 23.502 [3]

- Reporting Thresholds

- Analytics target period

- Data time window

- Preferred level of accuracy of the analytics

- Preferred level of accuracy per analytics subset

- Dataset Statistical Properties

- Time when analytics information is needed

- Maximum number of objects requested

- Preferred granularity of location information

- Spatial granularity size

- Temporal granularity size

- Preferred orientation of location information

- Preferred order of results

- Output strategy

- Analytics Metadata Request

- Analytics Accuracy Request information

- Analytics Filter.

**Outputs Required:** When the subscription is accepted: Subscription Correlation ID (required for management of this subscription). When the subscription is not accepted, an error response.

**Outputs, Optional:** First corresponding inference report is included, if available and if analytics consumer requested immediate reporting (see clause 4.15.1 of TS 23.502 [3]).

9th change

### 12.5.4 Nnef\_Inference\_Notify service operation

**Inputs, Required:**

- Notification Correlation Information.

**Inputs, Optional:**

- VFL inference results:

- Set of the tuple (Analytics ID, Analytics specific parameters): this parameter shall be present if output analytics are reported.

- Validity period.

- Confidence

- Analytics Metadata Information.

- Analytics Accuracy Information.

- Revised waiting time.

 - Termination Request: this parameter indicates that AF requests to terminate the inference subscription, i.e. AF will not provide further notifications related to this subscription, with cause value.**Outputs, Required:** Operation execution result indication.

**Outputs, Optional:** None.

10th change

### 12.5.5 Nnef\_Inference\_Request service operation

**Service operation name:** Nnef\_Inference\_Request

**Description:** The consumer requests the VFL server to perform a one-time VFL inference.

**Inputs, Required:**

- Analytics ID.

- Target of Analytics Reporting.

**Inputs, Optional:**

- Analytics Reporting Information (see Clause 6.1.3 for explanation of parameters):

- Reporting Thresholds

- Analytics target period

- Data time window

- Preferred level of accuracy of the analytics

- Preferred level of accuracy per analytics subset

- Dataset Statistical Properties

- Time when analytics information is needed

- Maximum number of objects requested

- Preferred granularity of location information

- Spatial granularity size

- Temporal granularity size

- Preferred orientation of location information

- Preferred order of results

- Output strategy

- Analytics Metadata Request

- Analytics Accuracy Request information

- Analytics Filter.

**Outputs, Required:** If the request is accepted, then VFL inference results. When the request is not accepted, an error response.

**Outputs, Optional:**

- Validity period.

- Confidence.

- Analytics Metadata Information.

- Analytics Accuracy Information.

End of changes