**3GPP TSG-SA2 Meeting #164 *S2-2407639r01***

**Maastricht, Netherlands, 19th Aug 2024 - 23rd Aug 2024**

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| *CR-Form-v12.3* |
| **CHANGE REQUEST** |
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|  | **23.288** | **CR** | **1126** | **rev** | **-** | **Current version:** | **18.6.0** |  |
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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:***  | General inference procedure for vertical federated learning  |
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| ***Source to WG:*** | OPPO, ETRI, China Telecom, Tencent, ICS |
| ***Source to TSG:*** | SA2 |
|  |  |
| ***Work item code:*** | AIML\_CN |  | ***Date:*** | 2024-07-31 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***Release:*** | Rel-19 |
|  | *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)* |
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| ***Reason for change:*** | Based on the conclusion captured in the TR 23.700-84 clause 8.2 P#2.4, this CR aims for specify the general inference procedure for vertical federated learning. The NWDAF contain AnLF is the consumer to request the VFL inference result to the VFL server. And the NWDAF contain AnLF based on the VFL inference result generate the analytics output and send the analytics output to the analytics consumer. |
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| ***Summary of change:*** | New clause 6.2X is added. The sub-clause 6.2X.1 and 6.2X.2 are added to specify the general inference procedure for vertical federated learning. |
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| ***Consequences if not approved:*** | Can not perform VFL inference if do not specify the VFL inference procedure. |
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| ***Clauses affected:*** | 6.2X (new), 6.2X.1 (new). 6.2X.2 (new) |
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|  | **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 ...  |
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| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

\* \* \* \* First change (all new)\* \* \* \*

## 6.2X Vertical Federated Learning

### 6.2X.1 General

This clause specifies how NWDAF(s) and AF(s) can leverage Vertical Federated Learning technique to perform VFL inference.

### 6.2X.2 Procedures

6.2X.2.X General inference procedure for vertical federated learning 

Figure 6.2X.2.X-1: General inference procedure for vertical federated learning

Editor's note: In case any of the Consumer, Server and clients are untrusted AF(s), how the NEF assists the VFL inference process, and whether the existing or new NEF service should be invoked are FFS.

0. Analytics consumer NF sends an Analytics request/subscribe (Analytics ID, Target of Analytics Reporting= UE IDs, Analytics Filter Information (e.g. Application ID, S-NSSAI, DNN, Application Server Address(es), Area of Interest, Analytics Reporting Information=Analytics target period)) to NWDAF containing AnLF by invoking a Nnwdaf\_AnalyticsInfo\_Request or a Nnwdaf\_AnalyticsSubscription\_Subscribe.

1a. If the NWDAF is the VFL server, the consumer (i.e NWDAF containing AnLF) sends a subscription request to VFL server NWDAF using Nnwdaf\_AnalyticsSubscription\_Subscribe including Analytics ID, Target of Analytics Reporting = UE IDs, Analytics Filter Information (e.g. Application ID, S-NSSAI, DNN, Application Server Address(es), Area of Interest, Analytics Reporting Information=Analytics target period).

 If the trused AF is the VFL server, the consumer (i.e NWDAF containing AnLF) sends a subscription request to VFL server AF using Naf\_EventExposure\_Subscribe including Event ID and Event Filter(s) associated with the Event ID.

1b. If the untrusted AF is the VFL server, the consumer (i.e NWDAF containing AnLF) sends a subscription request to VFL server AF via NEF using Nnef\_AnalyticsExposure\_Subscribe and Naf\_EventExposure\_Subscribe including Event ID and Event Filter(s) associated with the Event ID.

2. Based on the information received in the step 1, VFL server decides to iniate the VFL inference procedure with the VFL clients to generate more accurate analytics result. Before tha, the VFL server determines the VFL clients which participated in the VFL training process, based on the VFL model correlation ID. The VFL server may not select all VFL clients, e.g. depending on their contribution to the training result.

If the VFL server is the NWDAF or the trusted AF and the VFL client is the NWDAF, VFL server sends a Nnwdaf\_AnalyticsSubscription\_Subscribe to the VFL client NWDAF including the information received in the step 1 and the VFL model correlation ID to indicate the VFL client which previously well-trained VFL local model associated with this ID will be used.

If the VFL server is the NWDAF and the VFL client is the trusted AF, VFL server NWDAF sends a Naf\_EventExposure\_Subscribe to the VFL client AF including the information received in the step 1 and the VFL model correlation ID to indicate the VFL client which previously well-trained VFL local model associated with this ID will be used.

If the VFL server is the NWDAF and the VFL client is the untrusted AF, VFL server NWDAF sends a request to the VFL client AF using Nnef\_AnalyticsExposure\_Subscribe and Naf\_EventExposure\_Subscribe including the information received in the step 1 and the VFL model correlation ID to indicate the VFL client which previously well-trained VFL local model associated with this ID will be used.

If the VFL server is the untrusted AF, VFL server AF sends a request to the VFL client NWDAF using Nnef\_AnalyticsExposure\_Subscribe and Nnwdaf\_AnalyticsSubscription\_Subscribe including the information received in the step 1 and the VFL model correlation ID to indicate the VFL client which previously well-trained VFL local model associated with this ID will be used.

3. Each VFL Client collects its local data by using the current mechanism if the VFL Client has not 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.

5. Each VFL Client sends the intermediate local inference results and the VFL model correlation ID to the VFL server using the notify service operation corresponsing to the subscribe service operation used in the step 2. Optionally, one VFL client may send the local intermediate inference results to the other VFL client and let other VFL client send the aggregates local intermediate inference results to the VFL server.

Editor's note: Whether VFL client may also provide local intermediate inference results to other VFL client is FFS.

 The intermediate local inference 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 aggregates and generates the VFL inference results.

 For the case the untrusted AF is the VFL server, the NEF may wait to collect local intermediate inference result from each VFL client and send all collected local intermediate inference results to untrust AF in one notification.

6. The VFL Server aggregates all the intermediate local inference results to generate the VFL inference results based on the VFL model correlation ID.

7a. If step 1a performed, The VFL server sends Nnwdaf\_AnalyticsSubscription\_Notify or Naf\_EventExposure\_Notify to the consumer (i.e NWDAF containing AnLF) including the VFL inference results.

7b. If step 2a performed, The VFL server sends the notify to the consumer (i.e NWDAF containing AnLF) using Naf\_EventExposure\_Notify and Nnef\_AnalyticsExposure\_Notify including VFL inference results.

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\_Request response or Nnwdaf\_AnalyticsSubscription\_Notify, depending on the service used in step 0.

\* \* \* \* End of changes \* \* \* \*