**3GPP TSG-SA2 Meeting #164 *S2-2409134***

**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** | **1134** | **rev** | **2** | **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 training procedure for Vertical Federated Learning between NWDAF(s) and AF(s) | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | China Mobile, CATT, ZTE, OPPO, China Telecom, ETRI, Huawei, Nokia, Futurewei | | | | | | | | | |
| ***Source to TSG:*** | SA2 | | | | | | | | | |
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| ***Work item code:*** | AIML\_CN | | | | |  | ***Date:*** | | | 2024-08-07 |
|  |  | | | |  | |  | | |  |
| ***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 can be 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 conclusions for KI#2: 5GC Support for Vertical Federated Learning in clause 8.2 of TR23.700-84, this CR aims to specify the general training procedure for vertical federated learning between AF(s) and NWDAF(s). | | | | | | | | |
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| ***Summary of change:*** | | New clause 6.2X is added to specify the general training procedure for vertical federated learning between AF and NWDAFs. | | | | | | | | |
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| ***Consequences if not approved:*** | | VFL training procedure not specified. | | | | | | | | |
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| ***Clauses affected:*** | | 6.2X.Y.Z (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 ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

>>>>BEGINNING OF CHANGES<<<<

### 6.2X.Y.Z General training procedure for Vertical Federated Learning

Editor’s Note: Whether one general procedure or two separate procedures for NWDAF/AF as server will be discussed and decided in future meeting when the procedures are stable.

The figure 6.2X.Y.Z-1 below shows general training procedure for Vertical Federated Learning.



Figure 6.2X.Y.Z-1: General training procedure for VFL

This below procedure aims for NWDAF based Vertical Federated Learning.

Editor’s Note: Further extensions are needed to show the interaction between consumer and VFL server. For example, how the consumer (i.e., NWDAF containing AnLF) sends a subscription request to VFL server.

Editor’s Note: How the VFL server and client register to the network, how to discover VFL server or VFL client is FFS.

Editor’s Note: How to maintain a Vertical Federation Learning process including dynamical reselection, addition, or removal of VFL Client NWDAF(s) is FFS.

Editor's Note: Further extensions are needed to show when any of the VFL participants are untrusted AF(s). In this case the procedure below will contain a NEF, and how the NEF assists the VFL training process as well as whether the service operations going via NEF is using the existing or new service operation are FFS.

Editor’s Note: The details of the services in the procedure and whether VFL Training Start Flag is needed are FFS.

Editor’s Note: The process of sample exchange between VFL server and VFL client is FFS. The process may be determined after agreement on sample and/or feature alignment.

Editor’s Note: Whether and how to exchange feature between VFL server and VFL client is for FFS. The process may be determined after agreement on sample and/or feature alignment.

Editor’s Note: It is FFS whether model correlation ID and sample/feature information is required to be provided in each training round or there is a session concept.

0. The NWDAF acting as VFL Server and the respective NWDAFs or AFs acting as VFL Clients completed the VFL Training Preparation procedure.

1. VFL server selects the VFL clients that participate in VFL as described in the clause X.

NOTE: VFL Server determines to perform VFL training based on the operator’s policy.

Steps 2 to 5 are executed separately for each VFL client.

2. To start VFL training, VFL server sends a request to the selected VFL clients with VFL Model correlation ID.

NOTE: The local ML model used in the VFL Server and Clients is already determined based on local configuration.

3. [Optional] Each VFL client collects its local data by using the current mechanism if the VFL client has not local data available already.

4. During VFL training procedure, each VFL client further trains the local ML model based on its own data, and reports the local ML model training information (e.g. intermediate training result) to the VFL server. The report also includes VFL Model correlation ID.

Editor’s Note: What parameter contains in local ML model training information is FFS.

Editor’s Note: The details on whether and how to support that VFL clients provide intermediate results to other VFL clients is FFS.

5. The VFL server may collect the local data and generate its own local the intermediate training result. The NWDAF acting as VFL Server computes the backward local ML model training information (e.g. gradient information or loss information) based on all the local ML model training information and label. The backward local ML model training information is used for updating its own local model and the models of VFL clients. Different backward local ML model training information may be computed for different VFL clients, respectively.

The VFL server may also compute the global ML model metric (e.g. ML model accuracy) based on all the local ML model training information and the label.

Editor’s Note: Whether weight of feature is computed by VFL server is FFS.

6. [Optional] The NWDAF acting as VFL server evaluates (e.g., based on the convergence of a loss function or loss value) whether the performance of VFL Training process is adequate. If not, the NWDAF acting as a VFL Server determines another round of joint VFL training is required, if yes, it determines the VFL Training is completed. In this case, the VFL Server terminates the current VFL training process. The VFL server sends VFL training termination message including VFL Model Correlation ID and VFL Training Concluded Flag to VFL Client if it decides to terminate the VFL training process.

The VFL training termination decision may be also made as follows:

Based on the consumer request, the VFL server sends VFL status report to update the ML model metric to the consumer.

The consumer decides whether the current model can fulfil the requirement, e.g. ML model metric is satisfactory for the consumer and determines to stop or continue the training process. The consumer continues the training process or stops the training process.

Based on the subscription request sent from the consumer, the VFL server updates or terminates the current VFL training process.

If the VFL server received a request from consumer or decide to stop the Federated Training process, steps 7 and 8 are skipped.

7. If the VFL procedure continues, VFL server sends the backward local ML model training information (e.g. gradient information, loss information) to the VFL clients for next round of VFL together with VFL Model Correlation ID.

8. Each VFL client computes gradient of its local model and updates its local ML model based on backward local ML model training information distributed by the VFL server at step 7. The NWDAF acting as VFL Server and each NWDAF or AF acting as VFL Client, stores the latest information about their locally trained Models associated with the VFL Model correlation ID.

Editor’s Note: It is FFS whether model storage after each training round is required.

Editor’s Note: Possible procedures to be executed at the end of the VFL training (to terminate a training session and to store/handle trained models) are FFS.

The steps 4-8 should be repeated until the training termination condition (e.g. pre-set number of iterations) is reached.

NOTE 1: If untrusted AF is involved in VFL Clients, the message between VFL Server and the untrusted AF is via NEF.

NOTE 2: After VFL model training is terminated, VFL server may collect trained ML model from VFL clients. This aims to support VFL model inference with participants that have not involved in VFL model training procedure.

>>>>END OF CHANGES<<<<