**3GPP TSG- Meeting # *S2-2409828r02***

**Hyderabad, India, Oct 14 – 18, 2024 Revision of S2-2409416**

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| *CR-Form-v12.3* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  |  | **CR** | **1134** | **rev** | **5** | **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:*** | 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, Samsung | | | | | | | | | |
| ***Source to TSG:*** | SA2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** |  | | | | |  | ***Date:*** | | | 07 |
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| ***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 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 6.2G.2.X is added to specify the general training procedure for vertical federated learning between AF and NWDAFs.  Compared to the revision S2-2409416 in last meeting SA2#164, in TS23.288, VFL Registration and Discovery procedure in clause 6.2H.2.1 is already defined, hence, the related EN can be removed. | | | | | | | | |
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| ***Consequences if not approved:*** | | VFL training procedure not specified. | | | | | | | | |
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| ***Clauses affected:*** | | 6.2G.2.X (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:*** | | Comment for MCC: The following structure is intended: 6.2H Vertical Federated Learning6.2H.1 General6.2H.2 Procedures6.2H.2.1 Registration and Discovery Procedure for Vertical Federated Learning6.2H.2.2 Preparation Procedure for Vertical Federated Learning6.2H.2.3 Training Procedure for Vertical Federated Learning6.2H.2.3.1 Training Procedure for Vertical Federated Learning when untrusted AF is acting as VFL server6.2H.2.3.2 Training Procedure for Vertical Federated Learning when NWDAF is acting as VFL server6.2H.2.4 Inference Procedure for Vertical Federated Learning6.2H.2.4.1 Inference Procedure for Vertical Federated Learning when untrusted AF is acting as VFL server6.2H.2.4.2 Inference Procedure for Vertical Federated Learning NWDAF is acting as VFL server | | | | | | | | |
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| ***This CR's revision history:*** | |  | | | | | | | | |

>>>>BEGINNING OF CHANGES<<<<

#### 6.2H.2.3 Training Procedure for Vertical Federated Learning

##### 6.2H.2.3.1 Training procedure for Vertical Federated Learning when NWDAF is acting as VFL server

The figure 6.2H.2.3.1-1 below shows the training procedure for Vertical Federated Learning when NWDAF is acting as VFL server .

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Figure 6.2H.2.3.1-1Training procedure for Vertical Federated Learning when NWDAF is acting as VFL server

The VFL training procedure illustrated below is conducted after VFL preparation procedure.

Editor’s Note: It’s FFS to determine the VFL preparation procedure.

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: Whether and how to maintain a Vertical Federation Learning process including dynamical reselection, addition, or removal of VFL Client NWDAF(s) is FFS.

Editor's Note: When any of the VFL participants are untrusted AF(s),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: A possible need for a 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 sample/feature information is required to be provided in each training round or there is a session concept.

Editor´s Note: Whether and how to include interoperability information in the VFL training procedure is FFS.

Editor´s Note: It is FFS whether and how VFL server collects trained ML model from VFL clients after the VFL training process.

1. The NWDAF acting as VFL server determines the VFL clients that participate in VFL in the VFL clients discovery and preparation phase as described in the clause 6.2H.2.1 and clause 6.2H2.2.

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

The steps 2-6 are repeated until the training termination condition is reached.

2. To start VFL training, the VFL server allocates VFL Model correlation ID. The VFL server sends a request to start the VFL training containing the VFL Model correlation ID, an Analytics ID and sample IDs indication n to each of the selected VFL clients. When VFL server is NWDAF, it sends a Nnwdaf\_MLModelTraining\_Subscribe or Nnwdaf\_MLModelTrainingInfo\_Request to the selected NWDAF clients(s) and Naf\_VFLTraining\_Subscribe or Naf\_VFLTraining Info Request to the selected AF clients(s), which participate in the Federated learning to perform the local model training. The request includes VFL model correlation ID, sample IDs

If the VFL procedure continues in subsequent iterations, the VFL server sends a request for a new iteration containing the Server intermediate results to each of the VFL clients for next round of VFL training.

Editor´s Note: Additional Parameters to be provided in the request are FFS.

Editor´s Note: It is FFS whether and how the local ML model is obtained by VFL Client in VFL training process.

Editor’s Note: It is FFS which service is used between VFL server and VFL clients for VFL training.

3. [Optional] Each VFL client collects its local data by using the current mechanism if the VFL client has no local data already available..

4. During VFL training procedure, each VFL client further trains the local ML model(s) associated with the same VFL Model Correlation ID based on their own collected or available data and based on possible backward local ML model training information distributed by the VFL server in step 2, , and computes and reports the client intermediate training result of the local ML model to the VFL server.

Editor´s note: The following is ffs and may depend on the service design: When the clients reports the client intermediate training result, it also includes the corresponding VFL correlation ID.

The NWDAF acting as VFL Server and each NWDAF or AF acting as VFL Client, stores the latest information about their locally trained Models.

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

5. The VFL server may collect the local data and generate its own local server 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 the client intermediate training result received in step 4 and the label. The backward local ML model training information is used for updating 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 intermediate training result received from VFL clients and the label.

6. [Optional] The NWDAF acting as VFL server evaluates (e.g., based on the convergence of a loss function or loss value, the pre-set iteration number is reached) whether VFL Training process converged. If not, the NWDAF acting as a VFL Server determines another round of VFL training is required and repeats step 2. If yes, it determines the VFL Training is completed. In this case, the VFL Server terminates the current VFL training process via step 7.

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

Based on the consumer request, the VFL server sends VFL status report to the consumer..

Editor’s Note: The content of the VFL status report is FFS.

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.

Editor’s Note: the following is ffs.The VFL server determines with which VFL Client(s) to continue the VFL. The VFL server may provide to the VFL clients any sample ID(s) if changed

7. The VFL server sends VFL training termination message to VFL Client if it decides to terminate the VFL training process. The VFL Server and each VFL Client, stores the VFL model correlation ID and latest information related to their locally trained Models

NOTE: The VFL model correlation ID is later used for inference.

Editor’s Note: Whether VFL Training termination Flag in the termination message is required is FFS.

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 decision is made in step 6.

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

>>>>END OF CHANGES<<<<