**SA WG2 Meeting #165 S2-2410279**

**14 - 18 October, 2024, Hyderabad, India**

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| *CR-Form-v12.3* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  |  | **CR** | **1161** | **rev** | **1** | **Current version:** |  |  |
|  | | | | | | | | |
| *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:*** | High-level description for Vertical Federated Learning when AF is as Server. | | | | | | | | | |
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| ***Source to WG:*** | KDDI | | | | | | | | | |
| ***Source to TSG:*** | SA2 | | | | | | | | | |
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| ***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 high-level functionality for vertical federated learning between AF and NWDAF(s) when AF is VFL server. | | | | | | | | |
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| ***Summary of change:*** | | 5.4 is modified to specify the high-level functionality for vertical federated learning between AF and NWDAFs when AF is VFL server. | | | | | | | | |
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| ***Consequences if not approved:*** | | VFL functionality when AF is VFL server is not specified. | | | | | | | | |
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| ***Clauses affected:*** | | 5.4 | | | | | | | | |
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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<<<<

5.4 Vertical Federated Learning (VFL)

Vertical Federated learning is a machine learning technique without exchanging/sharing local data set, while maintaining some level of coordination amongst VFL participants, when training and inference are performed on local ML Models, wherein the local data set in different VFL Participant for local model training have different feature spaces for the same samples (e.g. UE IDs). Vertical Federated Learning may involve multiple NWDAFs and AF.

For Vertical Federated Learning, there may be one NWDAF or one AF acting as a VFL server and one or multiple NWDAF(s) and/or one or multiple AF(s) acting as VFL Client(s). Vertical Federated Learning is available among NWDAFs within a single PLMN or between an AF and NWDAF(s) in a single PLMN.

The main functionalities of VFL server and VFL client include:

**VFL server:**

- An NWDAF acting as VFL server discovers and selects VFL client(s) (NWDAF(s) and/or AF(s)) to participate in a VFL procedure.

- A trusted AF acting as VFL server discovers and selects VFL client(s) (NWDAF(s)) to participate in a VFL procedure.

- When an untrusted AF is acting as VFL server, NEF discovers and selects VFL client NWDAFs based on selection criteria that the AF provides or pre-configured in NEF, and hides detailed information about the NWDAFs from the AF. The VFL client NWDAF can be pre-configurated in untrusted AF acting as VFL server.

- requests VFL clients to do local ML model training for an Analytic ID, it assigns VFL model correlation ID, and it requests to report intermediate results.

- When untrusted AF is acting as VFL server, NEF translates internal IDs and external IDs (e.g., SUPI and GPSI, Analytics ID and AF internal ID) and forwards intermediate results from/to NWDAF to/from AF. The untrusted AF determines samples that will used in the VFL process based on negotiation between NWDAF(s) acting as VFL client and the untrusted AF via NEF.

- aggregates intermediate results from VFL client(s) and computes intermediate training results (e.g. gradient information, loss information) for updating its own local ML Model and the ML Models of VFL clients during the VFL training process and sends the intermediate training results towards VFL clients involved in the joint VFL training process. In case multiple NWDAFs are acting as VFL client and the untrusted AF is acting as VFL server, the untrusted AF sends and receives different message for each NWDAF.

- It initiates the VFL inference process using VFL model correlation ID and requests the VFL clients to determine local inference results.

- It aggregates local inference result from VFL clients and generates the final VFL inference result.

- If the VFL Server is NWDAF, it may send the final VFL inference result to the consumer.

**VFL client:**

- locally trains ML Model with the available local data set, which includes the data that may not be allowed to be shared with other VFL clients due to e.g. data privacy, data security, data access rights.

- computes the intermediate results for their local ML Models involved in the VFL training and provide reports with the intermediate results to the AF or NWDAF acting as VFL server.

- performs inference based on the local model and local data and provides inference results to VFL server.

Editor's note: Details regarding Sample alignment and features alignment functionality or whether the functionality needs to be specified are FFS.

Editor's note: Accuracy monitoring in VFL when VFL server is NWDAF is FFS.

Editor's note: For an NWDAF impacts of the split into AnLF and MTLF are FFS.

>>>>END OF CHANGES<<<<