3GPP TSG-SA WG2#161 S2-2405338

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**Source:** **KDDI**

**Title: KI#2: New Solution for support Vertical Federated Learning model training and inference between NWDAF and AF**

**Document for: Discussion/Approval**

**Agenda Item: 19.15**

**Work Item / Release: FS\_AIML\_CN / Rel-19**

*Abstract of the contribution:* This contribution is resubmission of solution for Key Issue #2 and use case#5 to study supporting Vertical Federated Learning in 5GS in TS 23.700-81.

# Discussion

## 1.1 General

KI#2 was approved to study supporting VFL with 5GC and/or AF in TR 23.700-84. As indicated in KI#2: 5GC Support for Vertical Federated Learning, the following aspects need to be studied:

* *Whether and how ML Model training and/or inference related procedures need to be enhanced to support VFL*
* *Whether and how to provide ML Models to the participants in the VFL training process.*

Use case #5 was approved in TR 23.700-84, and this focus on a use case of VFL involving NWDAF and AF, including

*Two scenarios are identified in this case:*

*Scenario 1: NWDAF initiates VFL training process.*

*Scenario 2: AF initiates VFL training process.*

This pCR support both two Scenarios.

## 1.2 Discussion on scenario of inference for VFL

The inference for VFL is also distributed inference, where multiple NFs are involved. As indicated in use case #5,

*Additionally, since the inference for VFL is also a distributed inference, no raw data will be shared in the inference as well as in the training. Each entity uses local data to do the inference. And the output will be gathered to get the final result.*

Considering the distributed inference nature, the inference procedure involves multiple NF instances. Therefore, the inference for VFL can be categorized into two cases, in terms of the difference between the NF instances that participate in the inference and training.

* Case 1: The set of NF instances that participate in the inference for VFL (i.e., AF(s) and NWDAF(s)) is same as that participated in the VFL model training. Namely, all the NF instances participate in both VFL model training and inference.
* Case 2: The set of NFs that participate in the inference for VFL is different from the set of NFs that participated in the VFL model training. Namely, some of the NFs participate in either of VFL model training or inference.

Revisiting the discussion that NWDAF containing MTLF and NWDAF containing AnLF are separately specified, the ML model training capability and inference capability can be supported by different instance. Therefore, Case 2 shall be supported in Rel-19.

To support Case 2, the ML model that will be used in the VFL participants (e.g., ML model that is trained using VFL model training) should be **aligned** among participants.

**Observation: *ML model alignment between NWDAF and AF should be supported in both VFL model training and inference.***

# 2. Text proposal

It is proposed to agree the following changes in TR 23.700-84:

>>>>BEGINNING OF CHANGES<<<<

## 6.0 Mapping of Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues and Use Cases

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Key Issues | | | | Use cases (optional) | | | | | |
| Solutions | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 5 | 6 |
| #X |  | X |  |  |  |  |  |  | X |  |

>>>>BEGINNING OF CHANGES (all new text)<<<<

## 6.X Solution #X: VFL inference procedure between NWDAF and AF

### 6.X.1 Description

This solution is proposed for KI#2 and Scenario 2 (i.e., AF initiated Scenario) of use case#5 to support the VFL inference procedure between NWDAF and AF. In the VFL model inference, the ML models are aligned, "VFL Passive Participant" NF(s), i.e., NWDAF, send intermediate results to "VFL Active Participant" NF, i.e., AF.

Note: The VFL model training is out of scope of this solution and focuses on VFL inference.

Considering the distributed inference nature, the inference procedure involves multiple NF instances. Therefore, the inference for VFL can be categorized into two cases, in terms of the difference between the NF instances that participate in the inference and training.

* Case 1: The set of NF instances that participate in the inference for VFL (i.e., AF(s) and NWDAF(s)) is same as that participated in the VFL model training. Namely, all the NF instances participate in both VFL model training and inference.
* Case 2: The set of NFs that participate in the inference for VFL is different from the set of NFs that participated in the VFL model training. Namely, some of the NFs participate in either of VFL model training or inference.

Revisiting the discussion that NWDAF containing MTLF and NWDAF containing AnLF are separately specified, the ML model training capability and inference capability can be supported by different instance. Therefore, Case 2 shall be supported in Rel-19.

To support Case 2, the ML model that will be used in the VFL participants (e.g., ML model that is trained using VFL model training) should be aligned among participants.

### 6.X.2 Procedures



Figure. 6.x.2 VFL model inference on AF initiated scenario.

This section describes the AF initiated VFL inference procedure to use ML model that trained in the VFL model training procedure. This procedure supports the two cases: case 1) the AF was involved in the VFL model training procedure, and case 2) AF was not involved in the VFL model training procedure. In case 1, the AF has a ML model to be used in the VFL inference. On the other hand, in case 2, the AF may not have or not able to identify a ML model to be used in the VFL inference.

Editor's Note: Whether during this inference the NWDAF support both AnLF and MTLF is FFS.

The AF subscribes VFL inference for the NWDAF, and then the NWDAF determines to provides analytics using VFL inference for privacy reason. In case 2, the NWDAF provides an ML model or its identifier that will used in the AF if needed. The NWDAF sends the intermediate results the AF.

1. The AF subscribes subscription in Nnwdaf\_VFL\_inference\_service (new), via NEF if the AF is untrusted. The subscription request includes ML Correlation ID for VFL, if the AF was involved in the VFL model training procedure (case 1), VFL capability indicator that indicates the capability of AF to perform the ML model inference, and sample alignment information, e.g., UE ID. NWDAF determines to use VFL model inference based on the operator policy, Analytic ID, Service Area/DNAI, and/or UE ID because data that cannot be obtained/exposed directly from data producer NF (e.g., for privacy reasons).

Editor's Note: Whether additional information is needed in Step 1 is FFS.

2. The ML model alignment is conducted between NWDAF and AF(s) if needed. For example, NWDAF may notify the appropriate ML model ID or notify the ML model.

Editor's Note: Whether the ML model transfer is needed is ffs. This depends on whether the ML model is assumed to be preconfigured or not.

3. [Optional] Each NF collects its local data associated with the sample alignment information shared in step 1 using the mechanism in clause 6.2 of TS23.288[5] if the NF does not have local data available already.

4. NWDAF calculates the intermediate results based on that sample alignment information and reports the intermediate results to AF invoking Nnwdaf\_VFL\_inference\_service\_Notify (new) in clause 6.1 of TS23.288[5]. The notification shall include ML Correlation ID for VFL, sample alignment information, and intermediate results.

Editor's Note: Whether new service is needed is ffs.

### 6.X.3 Impacts on Existing Nodes and Functionality

For AF:

- support to request the intermediate results of local ML models from NWDAF (s)

-support to align the ML model between NWDAF.

For NWDAF:

- support to compute the intermediate results, report the intermediate results to the AF.

>>>>END OF CHANGES<<<<