**3GPP TSG-SA5 Meeting #158S5-247066**

Orlando, USA, 18 - 22 November 2024

**Source: Ericsson India Private Limited (TSDSI)**

**Title: ML-Knowledge-based Transfer Learning Evaluation**

**Document for: Approval**

**Agenda Item:** **FS\_AIML\_MGT\_Ph2**

# 1 Decision/action requested

***Request for approval***

# 2 References

[1] 3GPP TR 28.858 “Study on Artificial Intelligence / Machine Learning (AI/ML) management Phase 2”.

[2] 3GPP TS 28.105: Artificial Intelligence / Machine Learning (AI/ML) management".

# 3 Rationale

Knowledge sharing described in clause 5.1.1.4 is a valid use case in machine learning. However, the current description does not clearly differ between knowledge sharing and Transfer learning. There are indications about sharing knowledge and not models. More clarifications are needed to distinct between what is allowed to be shared and what is not. Further, there are new entities (see figure) for which their role and authority are not well defined.

Considering the complexity and sensitivity of data sharing, the proposed solution is still on very high level and further study is required.

This contribution proposes to update the evaluation to reflect that this use case is not ready to go to normative step and further study is required.

# 4 Detailed proposal

***First change***

### 5.1.1 ML-Knowledge-based Transfer Learning

#### 5.1.1.1 Description

It is known that existing ML capability can be leveraged in producing or improving new or other ML capability. Specifically, transfer learning allows knowledge contained in one or more ML models to be transferred to another ML model. Transfer learning relies on task and domain similarity to determine whether parts of a deployed ML model can be reused in another domain / task with some modifications.

In multi-vendor environments, aspects of transfer learning need to be supported in network management systems. However, as ML models are not expected to be multi-vendor objects, i.e. an ML model cannot be transferred directly from one function to another, the knowledge contained within the model, referred to as ML knowledge, should be transferred instead of the ML model itself.

ML knowledge represents the information gained through the training of an ML Model (e.g., experience that indicates the recommended outputs for a given set of input data). This information can various forms such as statistics (e.g., a distribution) or summaries (e.g. tables).

For example, knowledge contained in an ML model deployed to perform mobility optimization during the day can be leveraged to produce a new ML model to perform mobility optimization at night. As illustrated in Figure 5.1.1.1-1, the network or its management system needs to have the required management services to support ML Knowledge-basedTransfer Learning (MLKTL). ML Knowledge-based Transfer Learning refers toto the capability of enabling and managing the transfer learning between any two ML models or training functions.



**Figure 5.1.1.1-1: ML Knowledge-based Transfer Learning (MLKTL) flow between the source MLKTL
(which is the MnS producer with the pre-trained ML model), the peer MLKTL
(which is the MnS producer that shall train a new ML model) and the MLKTL MnS consumer
(which may be the operator or another management function that triggers or controls MLKTL)**

Note 1: The services between the source and peer for the transfer knowledge and triggering of learning is implementation specific and is not in scope of the current technical report.

Note 2: Transfer learning (including knowledge-based transfer learning) can be sensitive from a data exposure and privacy aspect. Knowledge-based transfer learning will not be triggered for non-authorized consumers, but the authorization of the consumers is not in scope of the current technical report.

#### 5.1.1.2 Use cases

##### 5.1.1.2.1 Discovering sharable Knowledge

For transfer learning, it is expected that the source ML Knowledge-based Transfer Learning (MLKTL) MnS producer shares its knowledge with the target ML training function, either through a single instance of knowledge transfer or through an interactive transfer learning process. The ML knowledge here represents any experiences or information gathered by the ML model within the MLKTL MnS producer through training, inference, updates, or testing. This knowledge can be in the form of data statistics, features of the underlying ML model, or the output of the ML model. The 3GPP management systems should provide mechanisms for an MnS consumer to discover this potentially shareable knowledge as well as the means for the MLKTL provider to share that knowledge with the MnS consumer.

##### 5.1.1.2.2 Knowledge sharing and transfer learning

Transfer learning may be triggered by an MnS consumer, either to fulfil its own learning needs or delegate the process to another ML training function. The model containing the knowledge may be an independent managed entity or it could be an attribute of a managed ML model or ML training function. In the latter case, MLKTL does not involve sharing the ML model itself or parts of it but would focus on enabling the sharing of the knowledge contained within the ML model or ML-enabled function.

The 3GPP management system should provide mechanisms and services needed to realize the ML Knowledge-based transfer learning process. Specifically, the 3GPP management system should enable an MnS consumer to request and receive sharable knowledge as well as means for the producer of MLKTL to share the knowledge with the MnS consumer or a designated target ML training function. Similarly, the 3GPP management system should support MnS consumers in managing and controling the MLKTL process, including handling requests associated with knowledge transfer learning between two ML models directly or via a shared knowledge repository.

The two use cases should address the four scenarios illustrated below.

It should be note that, the use cases and requirements here focus on the required management capabilities the implementation of the knowledge transfer learning processes are implementation details that are out of the scope of the present document.

**Scenario 1 -** Interactions for ML-Knowledge-based Transfer Learning (MLKTL) to support training at the ML knowledge Transfer MnS consumer as peer - ML knowledge-based Transfer Learning MnS consumer obtains the ML knowledge which it then uses for training the new ML model based on knowledge received from the MLKTL source MnS producer.

**Scenario 2 -** interactions for ML-Knowledge-based Transfer Learning (MLKTL) to support training at the peer ML Knowledge-based Transfer Learning MnS producer triggered by the MLKTL Source - the ML Knowledge-based Transfer Learning MnS consumer acting as the MLKTL Source (the source of the ML knowledge) triggers the training at the ML knowledge-based Transfer MnS producer by providing the ML knowledge to be used for the training, the ML Knowledge-based Transfer Learning MnS consumer then undertakes the training.

**Scenario 3** - interactions for ML-Knowledge-based Transfer Learning (MLKTL) to support training at the Peer ML knowledge-based Transfer Learning MnS producer who is different from the ML knowledge-based Transfer Learning MnS consumer - the ML knowledge-based Transfer Learning MnS consumer triggers training at the MLKTL peer MnS producer. The MLKTL MnS consumer then obtains the ML knowledge from the MLKTL source MnS producer and then uses the knowledge for training the new ML model based on knowledge received from the MLKTL source MnS producer.

**Scenario 4 -** interactions for ML-Knowledge-based Transfer Learning (MLKTL) to support training at the Source ML knowledge Transfer MnS producer - the ML knowledge-based Transfer Learning MnS consumer triggers training at the MLKTL source MnS producer. The MLKTL MnS consumer then takes its available ML knowledge-based and uses the knowledge for training the new ML model based.

#### 5.1.1.3 Potential requirements

**REQ-MLKTL-1:** The 3GPP management systemshould have a capability to enable an authorized MnS consumer to discover available shared knowledge from a given MLKTL MnS producer according to a stated set of criteria.

**REQ-MLKTL-2:** The 3GPP management systemshould have a capability to enable an authorized MnS consumer to request a MLKTL MnS producer to provide some or all the available knowledge for sharing according to specified criteria.

**REQ-MLKTL-3:** The 3GPP management systemshould have a capability for an MLKTL MnS producer to report to an authorized MnS consumer on the available shared knowledge according to a Reporting Criteria specified in a request for information about the available Knowledge.

**REQ-MLKTL-4:** The 3GPP management systemshould have a capability enabling an authorized MnS consumer to request a MLKTL MnS producer to initiate and execute a transfer learning instance to a specified ML model or ML-enabled function.

**REQ-MLKTL-5:** The 3GPP management systemshould have a capability to enable an authorized MnS consumer (e.g. an operator or the function/entity that generated the request for available Knowledge) to manage or control the knowledge request or its information and subsequent process, e.g. to suspend, re-activate or cancel the ML Knowledge Request; or to adjust the description of the desired knowledge.

**REQ-MLKTL-6:** The 3GPP management systemshould have a capability to enable an authorized MnS consumer (e.g. an operator or the function/entity that generated the request for MLKTL) to manage or control a specific MLKTL Job, e.g. to start, suspend or restart the MLKTL Job; or to adjust the transfer learning conditions or characteristics (i.e. Modify MLKTL Job attributes).

Note: the MLKTL Job represents the process of knowledge-based transfer learning.

**REQ-MLKTL-7:** The 3GPP management systemshould have a capability to enable an ML model to register available knowledge to a shared knowledge repository, e.g. through a ML Knowledge Registration process.

**REQ-MLKTL-8:** The 3GPP management systemshould have a capability to enable a Knowledge Repository to act as the MLKTL MnS producer, allowing an authorized MnS consumer to request the shared knowledge repository to provide information on the available knowledge according to specified criteria.

**REQ-MLKTL-9:** The 3GPP management systemshould have a capability to enable Knowledge Repository to act as the MLKTL MnS producer allowing an authorized MnS consumer to request the Knowledge Repository to provide some or all the knowledge available for sharing based on specific criteria.

**REQ-MLKTL-10:** The 3GPP management systemshould have a capability to enabe Knowledge Repository to act as the MLKTL MnS producer allowing an authorized MnS consumer (e.g. an operator or the function/entity that generated the ML Knowledge Request) to manage the request, e.g. to suspend, re-activate or cancel the ML Knowledge Request ; or to adjust the description of the desired knowledge.

**REQ-MLKTL-11:** The 3GPP management systemshould have a capability to enable Knowledge Repository to act as the MLKTL MnS producer allowing an authorized MnS consumer (e.g. an operator) to manage or control a specific MLKTL Job, e.g. to start, suspend or restart the MLKTL Job; or to adjust the transfer learning conditions or characteristics.

#### 5.1.1.4 Possible solutions

Discovering sharable Knowledge

To discover sharable knowledge:

- The MnS consumer may send a request to the MLKTL MnS producer to provide information on the available sharable knowledge. In other words, the MLKTL MnS producer receives a request to report on the available sharable knowledge.

- The request may be generic or may state a set of criteria which the knowledge should fulfil.

- The request may be referred to as MLKnowledgeInfoRequest.

- The MLKnowledgeInfoRequest must have informational description (Metadata description) of the task and domain related to the required knowledge or given a network problem.

- An ML model or a function containing an ML model may register its available knowledge to a shared knowledge repository, e.g. through a MLKnowledgeRegistration process.

- The MLKnowledgeRegistration must contain informational description (Metadata description) of the task and domain related to the registered knowledge or suitable network problem.

Knowledge sharing and transfer learning

To share knowledge:

- Introduce an IOC for an ML Knowledge request. The MnS consumer may send a request to the MLKTL MnS producer to share a specific kind of knowledge. i.e. the MLKLT MnS producer receives a request to provide sharable knowledge, The request may be referred to as MLKnowledgeRequest.

- Introduce an IOC for an ML Knowledge-based transfer learning process or job which is instantiated for any request for transfer learning or ML knowledge-based transfer. The MLKTL MnS producer instantiates a MLknowledge-based transfer learning process. The process may be referred to as MLKTLJob.

- The MLKTLJob is responsible for adapting the required knowledge into a shareable format with the MLKTL consumer.

- MLKTLJob may be a continuous process where knowledge is shared with the MLKTL consumer frequently to account for updates in the knowledge.

NOTE: It may also be the case that the consumer directly instantiates the MLKTLJob without a separate request.

#### 5.1.1.5 Evaluation

The use case has provided requirements and solutions for knowledge-based transfer learning as a subset of transfer learning and a means for achieving the same outcomes as transfer learning (i.e. reusing an existing model to create a new model) but without need to exchange ML models.

The solution described in clause 5.1.1.4 proposes simple information objects that can enable ML functions to exchange their knowledge to be used towards transfer learning while ensuring that vendor specific aspects of the ML models are not exposed. Therefore, the solution described in clause 5.1.1.4 is a feasible solution before further development in the normative specifications.

Note 1: The normative solution shall not include specification of services between the source and peer for the transfer knowledge and triggering of learning.

Note 2: Transfer learning (including knowledge-based transfer learning) can be sensitive from a data exposure and privacy aspect. The normative work should describe interaction for authenticated and authorized consumers to ensure that knowledge-based transfer learning will not be triggered for non-authenticated or non-authorized consumers. The authentication and authorization process is not in the scope of this particular use case and is referred to existing procedures.

***End of changes***