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SERIES M: TELECOMMUNICATION MANAGEMENT, INCLUDING TMN AND NETWORK MAINTENANCE

Telecommunications management network

Framework of artificial intelligence enhanced telecom operation and management (AITOM)

Recommendation ITU-T M.3080

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Recommendation ITU-T M.3080

Framework of artificial intelligence enhanced telecom operation and management (AITOM)

Summary

Recommendation ITU-T M.3080 provides a framework of artificial intelligence enhanced telecom operation and management (AITOM). It describes the functional framework of AITOM to support telecom operation management for efficiency improvement, quality assurance, cost management, and security assurance. It also describes artificial intelligence (AI) pipelines that combine some components to enable AI based applications.

This Recommendation also describes the relationship of the functional framework of AITOM with smart operations, management and maintenance (SOMM) presented in Recommendation ITU-T M.3041. General requirements of security are also described.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Keywords

AITOM, framework.

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1 Scope

This Recommendation provides a framework for artificial intelligence (AI) enhanced telecom operation and management (AITOM). It describes the functional framework of AITOM to support telecom operation management for efficiency improvement, quality assurance, cost management, and security assurance. It also describes the artificial intelligence (AI) pipeline which combines some components to enable AI based applications.

This Recommendation also describes the relationship of the functional framework of AITOM with smart operations, management and maintenance (SOMM). General requirements of security are also described.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T M.3010] Recommendation ITU-T M.3010 (2000), *Principles for a telecommunications management network.*

[ITU-T M.3016.2] Recommendation ITU-T M.3016.2 (2005), *Security for the management plane: Security services*.

[ITU-T M.3041] Recommendation ITU-T M.3041 (2020), *Framework of smart operation, management and maintenance.*

[ITU-T X.805] Recommendation ITU-T X.805 (2003), *Security architecture for systems providing end-to-end communications.*

[ITU-T X.1111] Recommendation ITU-T X.1111 (2007), *Framework of security technologies for home network.*

[ITU-T Y.3100] Recommendation ITU-T Y.3100 (2017), *Terms and definitions for IMT-2020 network.*

[ITU-T Y.3172] Recommendation ITU-T Y.3172 (2019), *Architectural framework for machine learning in future networks including IMT-2020.*

[ETSI GR ENI 004] European Telecommunication Standards Institute (2019), *Experiential Networked Intelligence (ENI); Terminology for Main Concepts in ENI.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 artificial intelligence (AI) [ETSI GR ENI 004]: Computerized system that uses cognition to understand information and solve problems.

NOTE 1 – ISO/IEC 2382-28 defines AI as "an interdisciplinary field, usually regarded as a branch of computer science, dealing with models and systems for the performance of functions generally associated with human intelligence, such as reasoning and learning".

NOTE 2 – In computer science AI research is defined as the study of "intelligent agents": any device that perceives its environment and takes actions to achieve its goals.

NOTE 3 – This includes pattern recognition, the application of machine learning and related techniques.

NOTE 4 – Artificial-intelligence is the whole idea and concept of machines being able to carry out tasks in a way that mimics human intelligence and would be considered "smart".

3.1.2 management function [ITU-T M.3010]: The smallest part of a business process (or management service) as perceived by the user of the process (or service).

3.1.3 management function set [ITU-T M.3010]: A grouping of management functions that contextually belong together.

3.1.4 machine learning (ML) [ITU-T Y.3172]: Processes that enable computational systems to understand data and gain knowledge from it without necessarily being explicitly programmed.

NOTE 1 – This definition is from [ETSI GR ENI 004].

NOTE 2 – Supervised machine learning and unsupervised machine learning are two examples of machine learning types.

3.1.5 machine learning model [ITU-T Y.3172]: Model created by applying machine learning techniques to data to learn from.

NOTE 1 – A machine learning model is used to generate predictions (e.g., regression, classification, clustering) on new (untrained) data.

NOTE 2 – A machine learning model may be encapsulated in a deployable fashion in the form of a software (e.g., virtual machine, container) or hardware component (e.g., IoT device).

NOTE 3 – Machine learning techniques include learning algorithms (e.g., learning the function that maps input data attributes to output data).

3.1.6 machine learning pipeline [ITU-T Y.3172]: A set of logical nodes, each with specific functionalities, that can be combined to form a machine learning application in a telecommunication network.

3.1.7 management service [ITU-T M.3010]: A management service is an offering fulfilling specific telecommunications management needs.

3.1.8 orchestration [ITU-T Y.3100]: In the context of IMT-2020, the processes aiming at the automated arrangement, coordination, instantiation and use of network functions and resources for both physical and virtual infrastructures by optimization criteria.

3.1.9 orchestrator [ITU-T Y.3100]: In the context of IMT-2020, an entity that fulfils orchestration functions.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 artificial intelligence capability set: A set of functions that are provided based on orchestrated artificial intelligence (AI) models to meet the requirement of some specific application scenarios.

NOTE 1 – Specific application scenarios are to realize quality assurance, efficiency improvement, cost management, security assurance and industry applications, which are used for telecom operation and management.

NOTE 2 – An AI capability can be generated through AI models orchestration based on the requirement of a specific application scenario.

NOTE 3 – These functions may, but do not have to, be used based on the requirements of specific application scenarios.

3.2.2 artificial intelligence engine: The realization and mechanization, in software or hardware, of one or more functions dedicated to performing a specific artificial intelligence (AI) task.

3.2.3 artificial intelligence model: The model created by applying artificial intelligence (AI) technology to data to learn from.

3.2.4 artificial intelligence pipeline: A set of logical nodes, each with specific functionalities, that can be combined to form an artificial intelligence (AI) application in systems of telecom operation and management.

3.2.5 artificial intelligence sandbox: An environment in which artificial intelligence (AI) models can be trained and tested, and their effects on the network are evaluated.

3.2.6 capability customization: Personalized capability, which does not exist in the capability directory, customized for external customers to meet their requirements.

3.2.7 common artificial intelligence model repository: The part of the archive that contains and manages the artificial intelligence (AI) models, constructed by general algorithms, such as classification algorithms, and is thus responsible for the storage and preservation of the AI models.

3.2.8 computing engine framework: A framework which provides an operation environment or coding resources in the context of artificial intelligence (AI)-based applications or developments.

3.2.9 customer-oriented marketplace: A collection of functional sets that exposes capability to external telecom customers, especially enterprises and industries. The exposed capability includes applications, service, data and artificial intelligence (AI) capability.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
AITOM	AI enhanced Telecom Operation and Management
APP	Application
B-OSF	Business management layer – Operations Systems Function
EMS	Element Management System
E-OSF	Element management layer – Operations Systems Function
MFS	Management Function Set
NFV	Network Function Virtualization

NMS Network Management System

N-OSF Network management layer – Operations Systems Function

OAM Operations, Administration and Maintenance

OS Operations System

OSF Operations Systems Function

PaaS Platform as a Service

SMF System Management Function

SOMM Smart Operation Maintenance and Management

S-OSF Service management layer – Operations Systems Function

TMN Telecommunications Management Network

VIM Virtual Infrastructure Management

5 Conventions

In this Recommendation, the keyword "should" indicates a requirement that is recommended but not absolutely required.

6 Introduction

This Recommendation presents the functional framework of AI enhanced telecom operation and management (AITOM), which is used for supporting efficiency improvement, quality assurance, cost management, security assurance and industry application.

The objective of the AITOM framework is to introduce the AI engine and customer-oriented marketplace layer to enhance the intelligence of the telecom operation management system based on smart operation maintenance and management (SOMM). In addition, based on the definition of the AITOM framework, AI pipeline is also described.

More background about why artificial intelligence (AI) technology is introduced for telecom operation management systems and the characteristics of AITOM are described in Annex A.

7 General requirements of AITOM

To support telecom operation management for efficiency improvement, quality assurance, cost management, security assurance and industry application, AITOM may satisfy the following requirements:

– AITOM is compatible with SOMM standard.

– AITOM has stronger artificial intelligence (AI) capabilities to support intelligent telecom operation management.

– AITOM supports a data driven based framework, for example data sharing, data mining, data correlation, machine learning and other usage intents.

– AITOM supports an integrated framework, which can be applied for current and future networks. It can also support cross-domain management activities to fulfil end-to-end services for customers.

– AITOM supports agile telecom management where a new operation system can be deployed quickly with the open services and convergent data, along with the common infrastructure platform for OSs.

– AITOM supports the exposure of AI capabilities which can easily be exposed to any system within or out of AITOM. The systems out of AITOM refer to other industry systems, such as the financial industry, manufacturing industry, energy industry, etc.
– AITOM supports sandbox which supports the evaluation of AI pipeline.
– AITOM supports a security mechanism which guarantees AITOM operated in a safe way or environment.
– AITOM supports a closed-loop procedure of telecom operation management.

8 Functional framework of AITOM

8.1 Top views of AITOM

The framework of AITOM adds a new area (AI engine) and a new layer (customer-oriented marketplace layer) based on a top layered functional framework of SOMM. Figure 8-1 shows the relationship between the top layered functional frameworks of AITOM and SOMM.

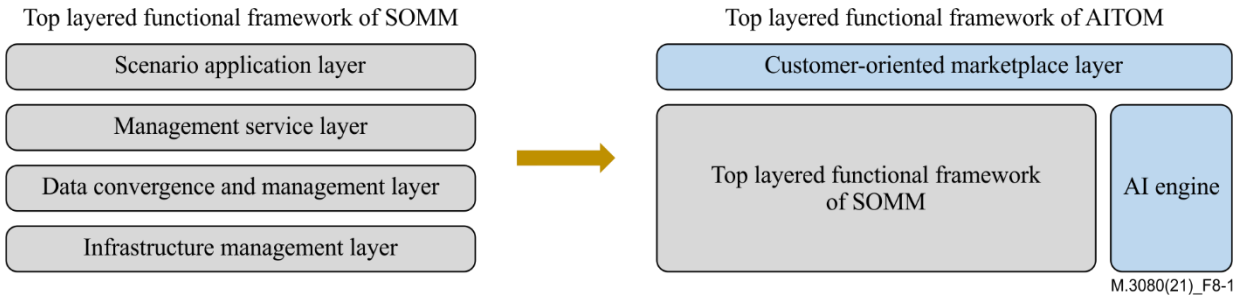

Figure 8-1 – Relationship between top layered functional frameworks of AITOM and SOMM

The framework of AITOM is compliant with the top layered functional framework of SOMM but enhances it. To make the layer structure, functionality, security and extendibility of SOMM clearer or more reasonable, an independent area which is called AI engine is added to the right side of SOMM framework to provide AI capabilities to internal layers. A new layer called the customer-oriented marketplace layer is added to the top of the SOMM framework to provide open capabilities for external customers.

The functional blocks contained in the AI engine and customer-oriented marketplace layer are defined respectively. A functional block chain called the AI pipeline is available based on the whole functional framework of AITOM, as shown in Figure 8-2.

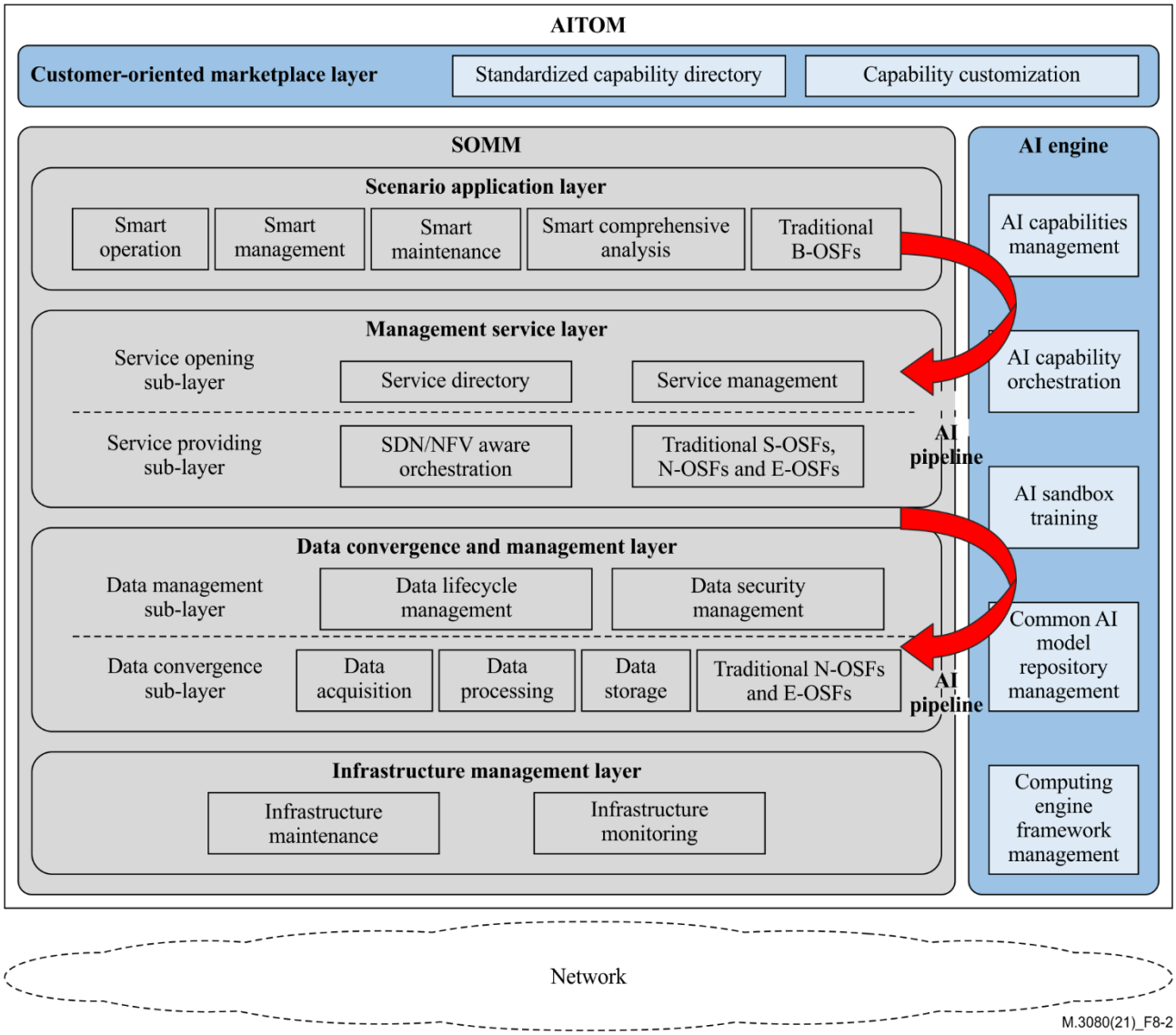

Figure 8-2 – Functional framework of AITOM

The customer-oriented marketplace layer aims for exposing the application, service, data and AI capability set of AITOM to external customers of telecom operators, especially for enterprise and industry customers. It has two functions, one of which is as a standardized capability directory and another is capability customization. The AI engine mainly provides AI capabilities to each layer of the SOMM functional framework, and has five functional blocks, which are AI capabilities management, AI capability orchestration, AI sandbox training, common AI model repository management and computing engine framework management. Each layer of the SOMM is the same as in [ITU-T M.3041]. The AI pipeline is a functional block chain, which is formed by some functional nodes of AITOM, including data collection, pre-processing, training or orchestration of the AI model, formulation or application of policy, and delivery of results. The underlay network provides data to data convergence and the management layer of SOMM in AITOM, but it is not included in the functional framework of AITOM.

The symbol of the AI pipeline in Figure 8-3, and also in Figure 8-2, refers to the symbol of the machine learning (ML) pipeline in [ITU-T Y.3172], which denotes a subset (including proper subset) of nodes in an AI pipeline.

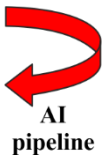

Figure 8-3 – Symbol of AI pipeline

8.2 AI engine

8.2.1 Introduction of the architecture of the AI engine within AITOM

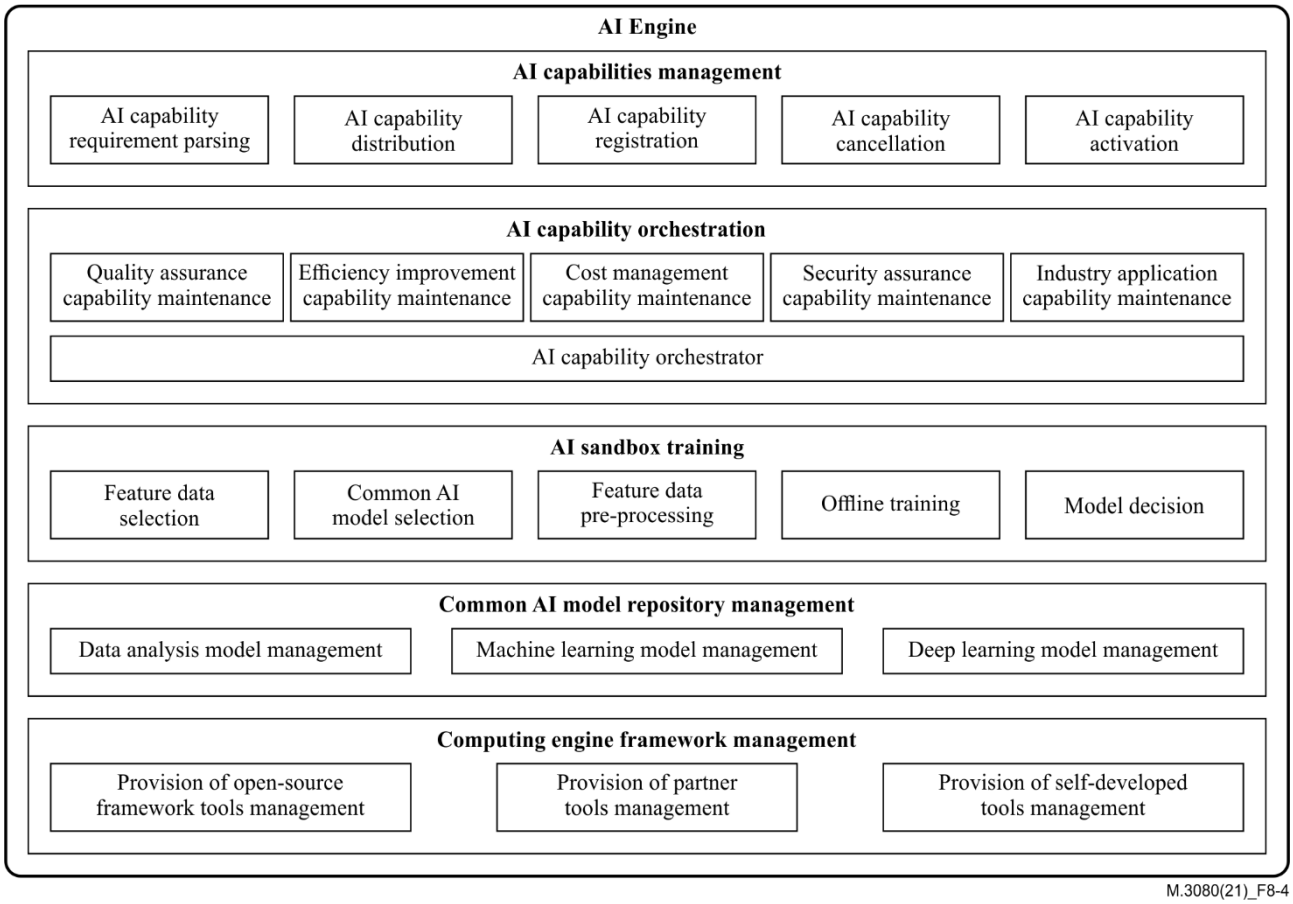

Figure 8-4 – Architecture of the AI engine within AITOM

Figure 8-4 shows more detailed functions of the AI engine. The computing engine framework provides a model framework and operation environment. The common AI model repository provides common AI models which are trained in an AI sandbox and orchestrated in AI capability orchestration. The trained AI models are transmitted from the AI sandbox to AI capability orchestration, and orchestrated AI capabilities are managed in AI capabilities management.

8.2.2 AI capabilities management

AI capabilities management includes the following function set:

1) *AI capability requirements parsing* – A parsing function that parses the AI capability requirements from customer-oriented marketplace layer and other layers of AITOM, maps the requirements into an AI sandbox and AI capability orchestration, or transfers them to AI capability registration.

2) *AI capability distribution* – A distribution function that releases and distributes all AI capabilities from AI capability registration. The AI capabilities are open to the AITOM customer-oriented marketplace layer and other layer's OSs.

3) *AI capability registration* – A registration function that receives and registers the AI capabilities from AI capability orchestration, and establishes and maintains a directory for all the AI capabilities of AITOM.

4) *AI capability cancellation* – A cancellation function that cancels and updates AI capabilities from AI capability registration.

5) *AI capability activation* – A activation function that activates orchestrated AI capability and makes it in operated state after receiving requests from AI capabilities management.

8.2.3 AI capability orchestration

There are five classifications of AI capabilities included in AI capability orchestration: quality assurance capability, efficiency improvement capability, cost management capability, security assurance capability and industry application capability, which constitute the AI capability set. All of them need to be orchestrated by AI capability orchestrator and maintained in AI capability orchestration. The functions of maintenance include update and revision for AI capabilities. AI capability orchestration includes the following management function set:

1) *Quality assurance capability maintenance* – A management function that maintains the AI capability set of the telecom network based on quality assurance, provides accurate service quality experience, supports user experience optimization and improves the quality assurance efficiency of the telecom network fully.

   NOTE 1 – A typical AI capability set of quality assurance includes fault prediction, anomaly detection, and so on.

2) *Efficiency improvement capability maintenance* – A management function that maintains the AI capability set of efficiency improvement of the telecom network. This AI capability set provides continuous and high-quality efficiency operations via deep insight capability.

   NOTE 2 – This kind of AI capability set includes intelligent work-order processing, intelligent strategy, and so on.

3) *Cost management capability maintenance* – A management function that maintains the AI capability set of cost management. This kind of AI capability set is able to realize perceiving cost trend variation of the telecom network, support cost plan and optimization and improve cost management efficiency by intelligent resource optimization of the telecom network, capability management and performance optimization.

   NOTE 3 – This kind of AI capability includes cost analysis, cost decision, cost control, and so on.

4) *Security assurance capability maintenance* – A management function that maintains the AI capability set of security assurance. This kind of AI capability set is used for security assurance of AITOM.

5) *Industry application capability maintenance* – A management function that maintains the AI capability set of industry application for the telecom network and service. This kind of AI capability set is exposed to the capability marketplace and scenario application layer of AITOM.

   NOTE 4 – AITOM provides the capability to different industries like unmanned driving, intelligent city, and so on, via the telecom network and service, which is especially important in the 5G/IMT-2020 era.

6) *AI capability orchestrator* – A management function that manages the orchestration of AI pipeline. One or multiple AI models which are trained by AI sandbox are orchestrated here to satisfy the requirements of specific application scenarios. The orchestrated AI capability is registered to AI capabilities management.

8.2.4 AI sandbox training

AI sandbox training receives the requirements from AI capability requirement parsing. Based on the requirements, AI sandbox training selects the appropriate feature data and common AI model. After that, the model will be trained and tested by utilizing the AI pipeline so that the best model is selected and sent to the AI capability orchestrator for AI capability orchestration. These functions include:

1) *Feature data selection* – A selection function that selects relevant feature data based on the requirement of AI capability requirement parsing.

   NOTE 1 – The feature data is selected from work-order data, network service, and so on, if the requirement is intelligent fault-removing.

2) *Common AI model selection* – A selection function that selects an appropriate common data analysis or machine learning model for following analysis and training based on the requirement of AI capability requirement parsing and characteristics of feature data.

   NOTE 2 – Different common models are selected based on the data of different characteristics, for example, trajectory data and relevant model are used for network quality detection.

3) *Feature data pre-processing* – A data processing function that processes the historic feature data from data convergence and management layer, extracts and processes the features according to selected models by data analysis tools, based on AI capability requirements.

   NOTE 3 – Feature data pre-processing is different from data processing in the data convergence and management layer which handles raw data from networks, terminals and infrastructure, including raw data cleaning and tagging. It processes the feature data from data storage of the data convergence and management layer, including extracting feature vectors, converting type of feature vectors and standardizing feature vectors according to selected common AI models and business requirements of AI capability.

4) *Offline training* – A data training function that trains a model by utilizing fully historic data based on this function, and it does not affect, in real-time, the service rendered.

5) *Model decision* – A decision or choice function that selects the optimal trained model based on a judging rule of service requirements and accuracy. The selected model is provided to AI capability orchestration.

8.2.5 Common AI model repository management

This function defines different AI models which are service agnostic and includes three functions:

1) *Data analysis model management* – A management function that provides maintenance and operation of a common data analysis model. In order to abstract useful information and form a conclusion, the data is studied in detail and summarized. The general method is like a Pareto chart.

2) *Machine learning model management* – A management function that provides maintenance and operation of a machine learning algorithm. A typical machine learning model is like a decision tree or a support vector machine. From a learning method point of view, a machine learning algorithm consists of supervised learning, unsupervised learning, semi-supervised learning, ensemble learning, deep learning and reinforcement learning.

3) *Deep learning model management* – A management function that provides maintenance and operation of a deep learning algorithm. Deep learning is a kind of machine learning based on neural networks, which could be convolutional neural networks, recurrent neural networks and recursive neural networks.

NOTE 1 – The difference among AI, machine learning and deep learning is that the scope of AI is wider and could include machine learning, which is one of the AI methods. Deep learning is not an independent learning method here, and it would be seen as one specific technology to achieve machine learning.

NOTE 2 – The relationships between AI capability orchestration, AI sandbox training and common AI model repository management are that a trained AI model is set specific parameters in AI sandbox training based on common AI model in common AI model repository and selected feature data in it, and a specific AI capability is a set of orchestrated AI models in AI capability orchestration that can perform a specific AI application, such as intelligent fault location.

8.2.6 Computing engine framework management

All the AI models need to be operated with a computing engine framework. The functions of the computing engine framework include:

1) *Provision of open-source framework tools management* – A management function that provides the computing engine framework tools of open-source and supports the operation of data analysis, machine learning and deep learning algorithms.

   NOTE – Some open-source frameworks are TensorFlow, PyTorch and Scikit-learn.

2) *Provision of partner tools management* – A management function that provides computing engine framework tools from partners and support the operation of data analysis, machine learning and deep learning algorithms.

3) *Provision of self-developed tools management* – A management function that provides computing engine framework tools based on a self-developed framework and supports the operation of data analysis, machine learning and deep learning algorithms.

8.3 Customer-oriented marketplace layer

The customer-oriented marketplace layer has two functions, including:

1) *Standardized capability directory* – A storage function that builds and maintains a directory for standardized capability of AITOM to external customer.

2) *Capability customization* – A storage function that customizes and maintains the personalized capability in case standardized capability cannot satisfy the requirement of external customers.

NOTE – The management service layer in SOMM architecture, which is proposed in [ITU-T M.3041], includes service exposure of every layer of AITOM. It is not recommended to do an additional definition for this aspect.

8.4 Sub-functions in SOMM

8.4.1 Scenario application layer

Reusing [ITU-T M.3041]. This layer includes the typical and emerging operation maintenance scenarios which includes smart operation, smart management, smart maintenance, smart comprehensive analysis and traditional business-level operations, administration and maintenance (OAM).

8.4.2 Management service layer

Reusing [ITU-T M.3041]. This layer incorporates the capability of fundamental functions of OSs which can be packaged as different services to be opened to the scenario application layer.

8.4.3 Data convergence and management layer

Reusing [ITU-T M.3041], this layer provides the capability of data-driven ability and converges the mass of data from different OSs to a unified data model, supporting data sharing, data mining, data correlation, machine learning and other usage intents.

8.4.4 Infrastructure management layer

Reusing [ITU-T M.3041], this layer is the operational foundations. The infrastructure could possibly be based on physical servers or the cloud, and platform as a service (PaaS) components providing IT services.

9 AI pipeline within AITOM

9.1 Introduction of AI pipeline within AITOM

[ITU-T Y.3172] describes ML pipeline, which is referred to by the AI pipeline. The steps of AI sandbox training and AI capability orchestration refer to the ML pipeline operation and training of ML models after orchestration. But the AI pipeline differs from the ML pipeline. The ML pipeline is used for the network layer, while the AI pipeline is used for the management layer, which has a higher position as shown in Figure 8-2. In addition, ML related models are only part of the AI models.

The AI pipeline has two states, one is a development state and the other is an operation state. It could be used for AI sandbox training and AI capability orchestration of a specific application for offline data in the development state, then used for AI capability operation for online data in the operation state.

In the development state, the AI model is trained in an AI sandbox and provided to an AI capability orchestrator based on the AI capability requirements from AI capability requirement parsing, and the orchestrated AI capability will be activated and operated in the operation state.

In the operation state, the AI capability orchestrated by the development state is activated and operated based on the AI capability requirements from AI capability requirement parsing. The capability quality could be improved by new data based on online retraining or incremental retraining.

NOTE – Regarding contents of development state and operation state refer to the clause 9 of [ITU-T M.3041].

9.2 AI pipeline in the development state

The AI pipeline has three parts in the development state: the process of AI capability requirement parsing, the process of AI sandbox training and the process of AI capability orchestration. The overall process of the AI pipeline in the development state is as shown in Figure 9-1.

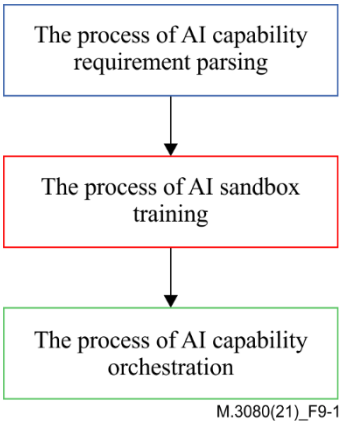

Figure 9-1 – Process of AI pipeline in the development state

1) In the process of AI capability requirement parsing, the AI sandbox training and AI capability orchestrator receives the requests from AI capability requirement parsing at the same time and does the relevant processing, as shown in Figure 9-2.

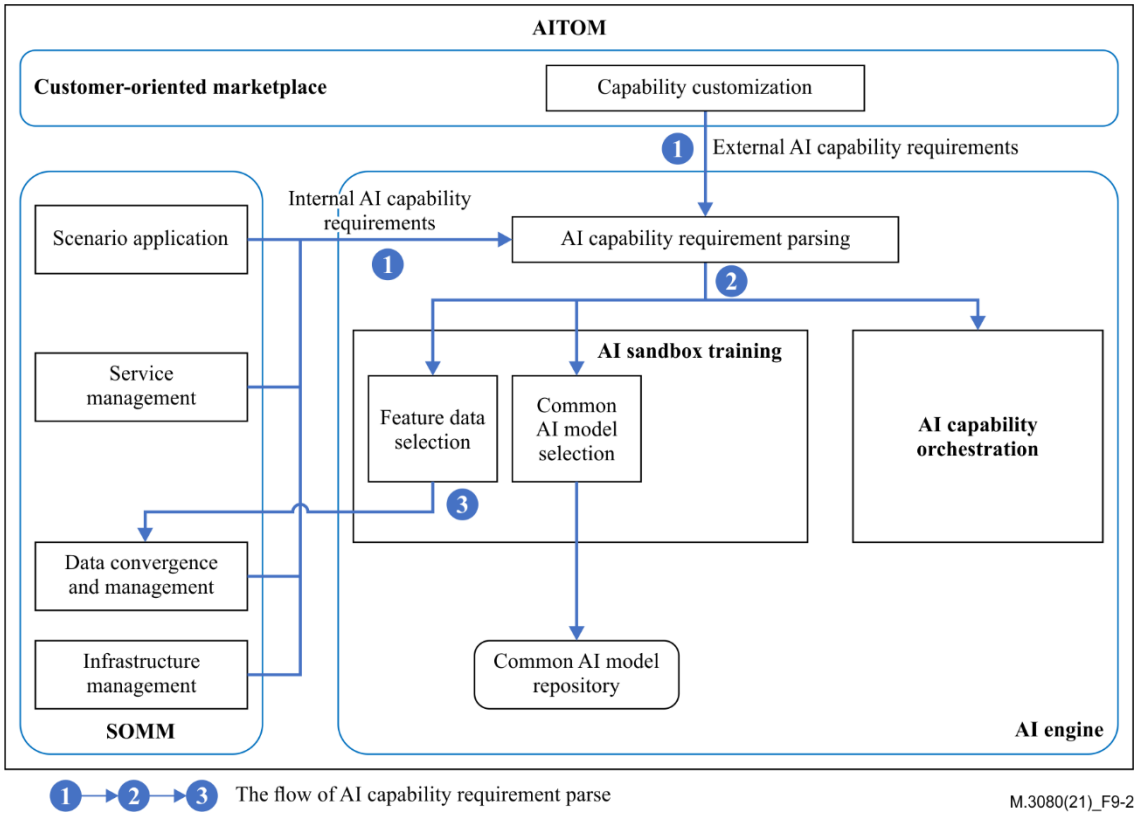

Figure 9-2 – AI capability requirement parsing within AITOM in development state

The detailed interaction procedures shown in Figure 9-2 are described below:

– As the requestors of AI capability, one or multiple layers for customer-oriented capability marketplace, scenario application, service management, data convergence and management, and infrastructure management provide the requirements.

– AI capability requirement parsing analyses the requirements of AI capability and decomposes the requirements of data and model respectively. These requirements are transmitted to AI sandbox training and AI capability orchestration.

– The AI sandbox training selects feature data from the data convergence and management layer and a model from the common AI model repository management based on the AI capability requirements parsed by AI capability requirement parsing.

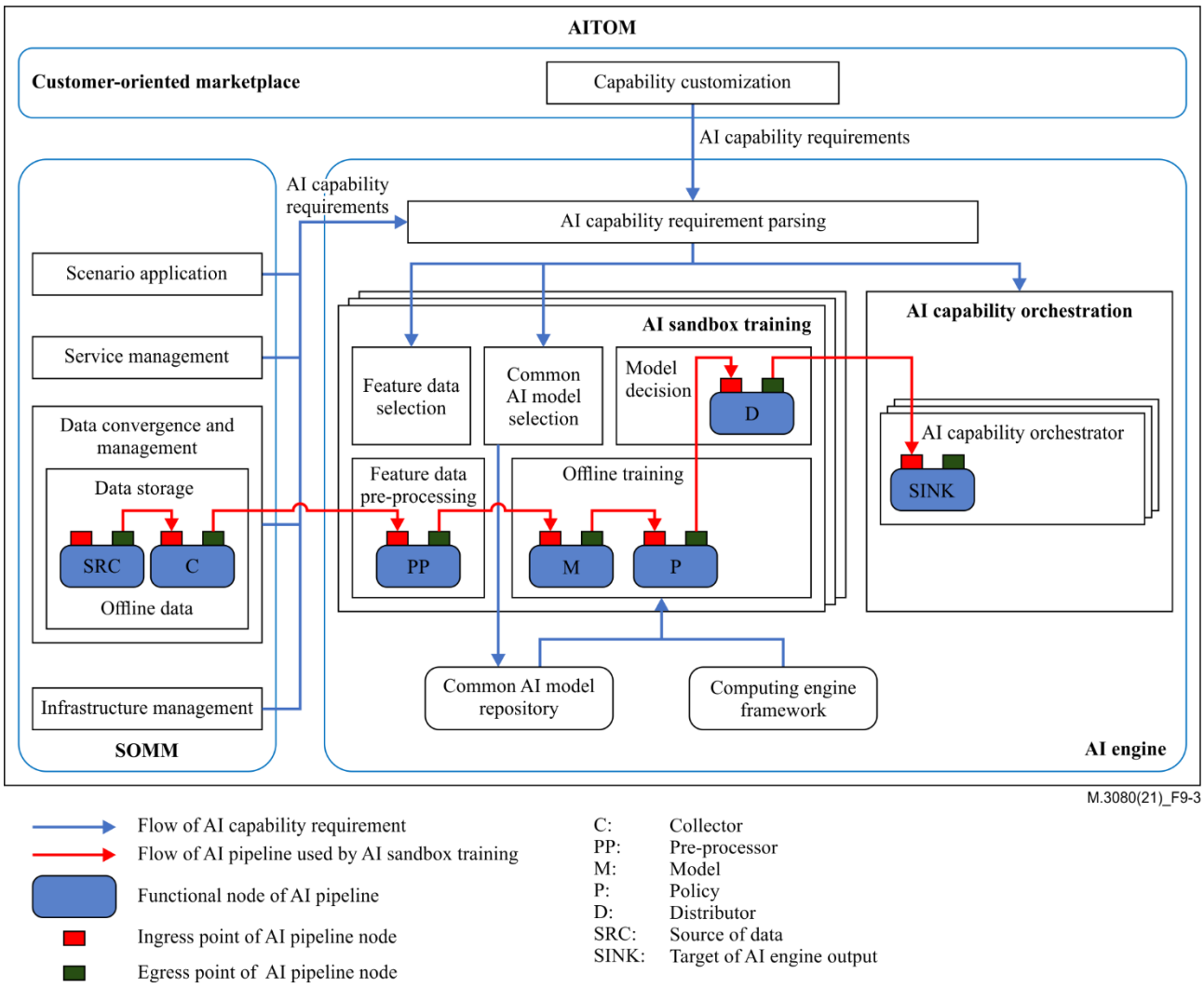

Figure 9-3 – AI capability requirement parsing and AI sandbox training within AITOM in the development state

2) In the process of AI sandbox training, the AI sandbox training generates a single model with specific parameters after training when the AI pipeline is available in the development state. The symbols used for the AI pipeline in Figure 9-3 include the functional block of the AI pipeline, and the ingress point and egress point of the AI pipeline node, whose whole shape is shown in Figure 9-4, which refers to [ITU-T Y.3172].

Figure 9-4 – Symbol used to denote a node with its service egress and ingress points for AI pipeline

Within the AI sandbox training, the detailed procedure and functional nodes which is also called the AI pipeline for AI sandbox training are described below. The flow of the AI pipeline used by AI sandbox training is as shown in Figure 9-3.

– *SRC (source of data)* – This node is the source of data provided by data convergence and management layer from the underlay network or service system used by AITOM, which acts as a data source of AITOM.

– *C (collection)* – This node collects the data in the data convergence and management layer and provides the data to the AI sandbox according to selected feature data.

– *PP (pre-processor)* – This node pre-processes the feature data in AI sandbox training according to data analysis model and features are extracted. In this way, the training data and test data sets are formed.

– *M (machine learning model)* – This node trains AI models in AI sandbox training by utilizing feature data. A new model is formed with specific parameters by adopting offline data.

– *P (Policy)* – This node generates the policy based on policy rules defined by humans or by self-learning.

– *D (Distributor)* – This node identifies application objects and distributes a trained AI model to the AI capability orchestrator of AI capability orchestration.

– *SINK (applied object)* – This node is the object served by the trained AI model. It is served as the input module of AI capability orchestrator.

NOTE – The AI sandbox training provides a single AI model, which is different to the common AI model, and the parameters of the provided model are clearly set after training.

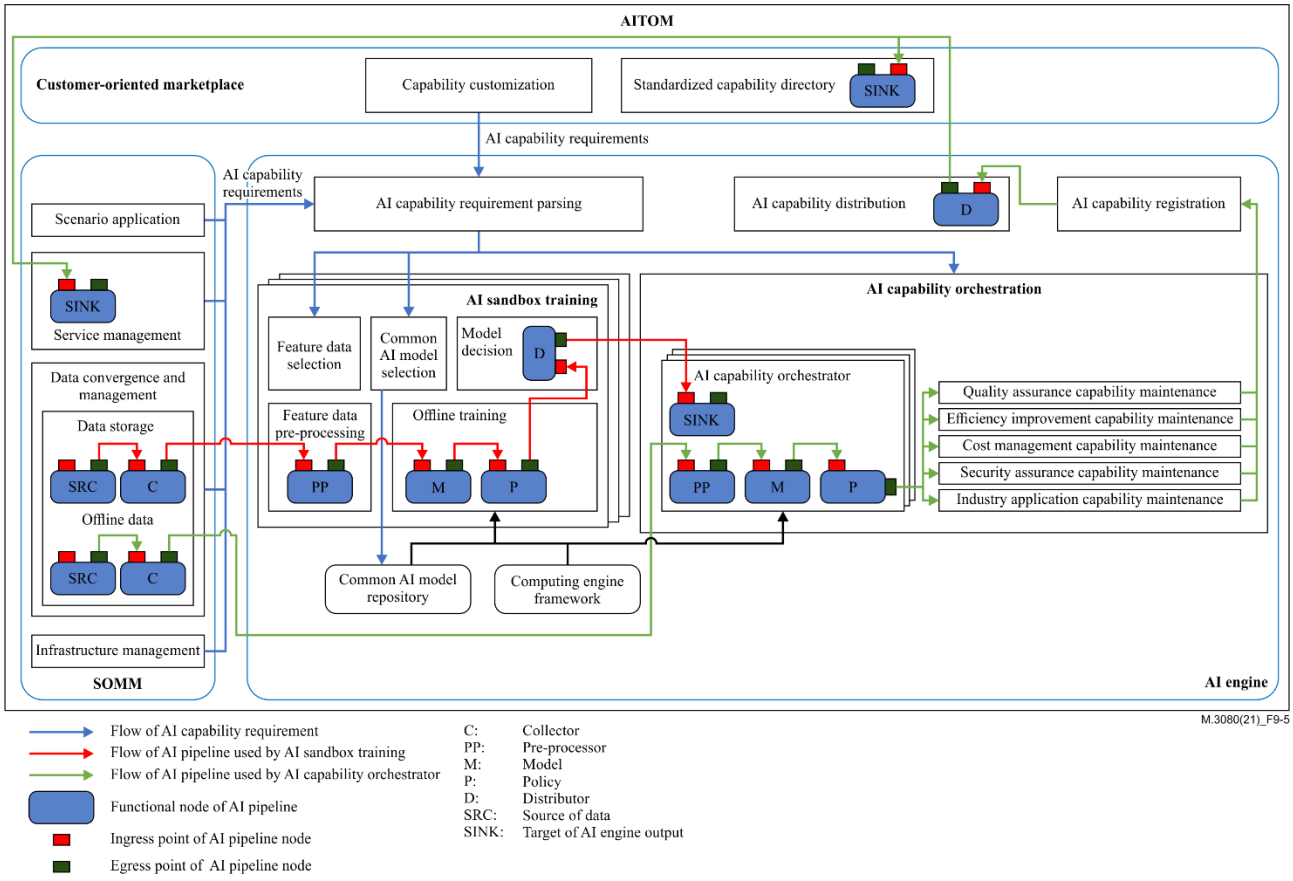

Figure 9-5 – Overall AI pipeline within AITOM in development state

3) In the process of AI capability orchestration, AI sandbox training provides a trained model to the AI capability orchestrator, which integrates multiple AI pipelines based on requirements of specific applications and forms a specific AI capability.

Within the AI capability orchestrator, the detailed procedure and functional nodes also called AI pipeline for AI capability orchestration are described below. The flow of AI pipeline used by the AI capability orchestrator is shown in Figure 9-5.

– *SRC (source of data)* – This node is the source of data provided by the data convergence and management layer from the underlay network or service system used by AITOM, which acts as the data source of AITOM.

– *C (collection)* – This node collects the data in the data convergence and management layer and provides the data to the AI capability orchestrator according to the selected feature data.

– *PP (pre-processor)* – This node pre-processes the feature data by data analysis model and features are extracted in the AI capability orchestrator. In this way, the training data and test data sets are formed.

– *M (machine learning model)* – This node combines the multiple AI models provided by the AI sandbox training according to the AI capability requirements and the test data is used for updating parameters of the model to improve quality.

– *P (Policy)* – This node combines multiple policies provided by the AI sandbox training and the test data is used for updating parameters of the model to improve quality.

– *D (Distributor)* – This node identifies the application object and distributes the orchestrated AI capability to the modules of the specific AI application capability maintenance. In addition, a specific AI capability is published to the application object by AI capability registration and distribution.

– *SINK (applied object)* – This node is the applied object for AI capability, which includes the standardized capability directory of the customer-oriented marketplace and service directory of the service management layer.

4) The AI capability orchestrator continues to train and optimize the models based on the trained AI model and stops such procedures until the model can satisfy the requirement of the AI capability.

Then the development state of the AI pipeline is stopped, and it then enters into the operation state.

9.3 AI pipeline in the operation state

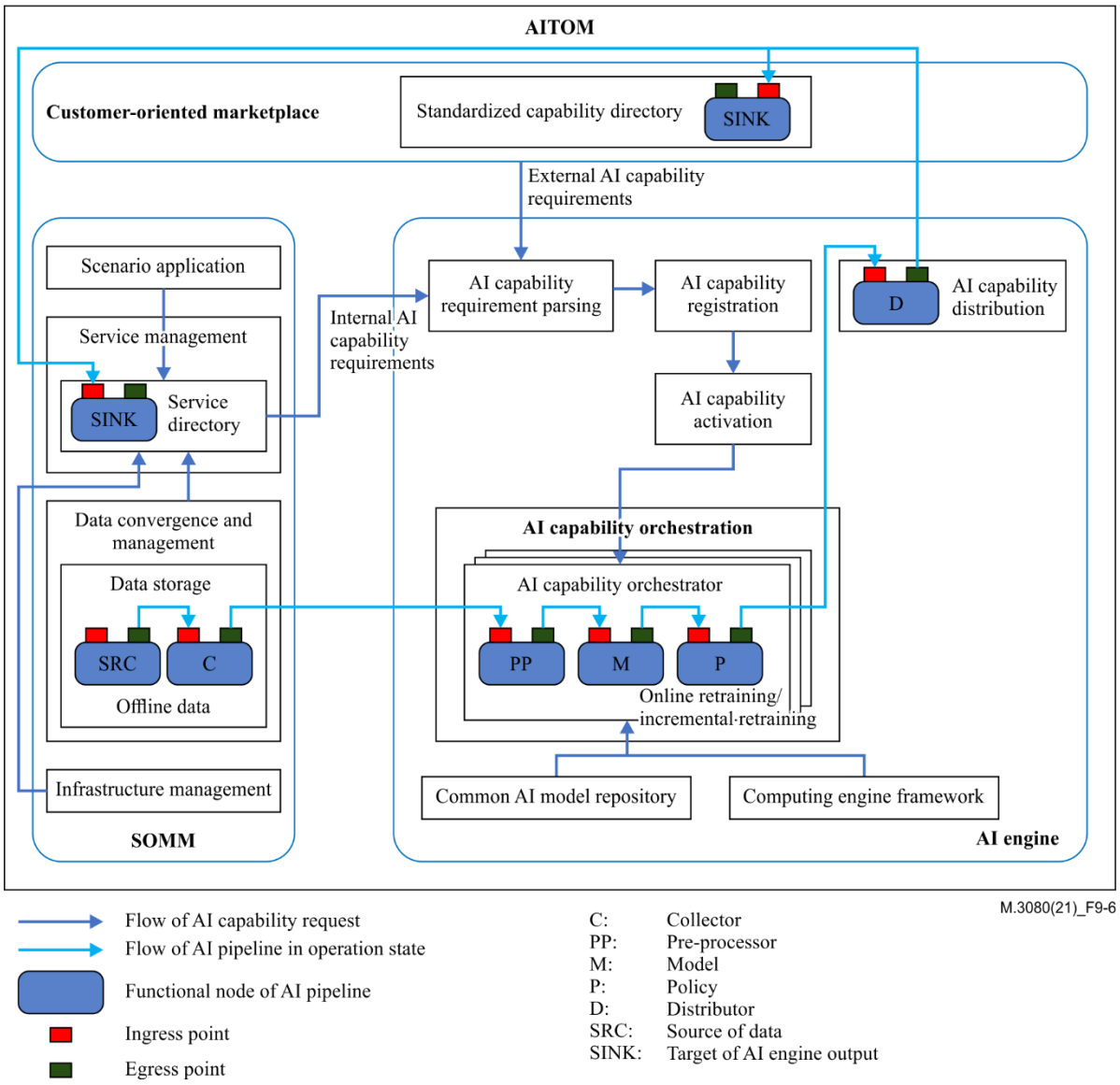

Figure 9-6 – AI pipeline within AITOM in the operation state

When the AI pipeline within the AITOM is in the operation state, the external customers and the different layers of the AITOM send the requirements of the AI capability by the customer-oriented marketplace or service management layer. Then the module of the AI capability requirement parsing analyses the requirements, maps it into the AI capability and transfers the mapped AI capability to the AI capability register. The AI capability registration module searches the mapped AI capability and activates the AI capability for AI capability orchestration. The functional nodes and the flow of AI pipeline in development state, as shown in Figure 9-6, are described below:

– *SRC (source of data)* – This node is the source of data out of AITOM provided by data convergence and management from the underlay network or service system used by AITOM. Differing from the development state, the data here is from the real-time online system.

– *C (collection)* – This node collects data from the SRC nodes in the data convergence and management layer and provides the data to the specific AI application.

– *PP (pre-processor)* – This node pre-processes the feature data and uses them for the learning and decision of the model.

– *M (model)* – This node orchestrates the model with the AI capability orchestrator of AI capability orchestration, including multiple AI models provided by the AI sandbox to satisfy the requirements of the specific application. The online retraining or incremental retraining are used for improving the model quality.

– *P (Policy)* – This node orchestrates the policy with the AI capability orchestrator of AI capability orchestration, including multiple AI policies provided by the AI sandbox training to satisfy the requirements of the specific application. The online data or incremental data are used for improving the model quality.

– *D (Distributor)* – This node identifies the application object and distributes operated results from AI capability requestors to the standardized capability directory via AI capability distribution.

– *SINK (applied object)* – This node is the AI capability requestors which receives the output from the AI capability distribution module.

NOTE 1 – Online retraining is a kind of training where real-time data is used to retrain the existing model to improve the model quality. Initially, offline data is used for initializing model parameters which are updated based on real-time data later.

NOTE 2 – Incremental retraining is the same as online retraining, and the existing model is retrained, and the parameters are updated to improve the model quality by periodically updating the training data. The difference with online retraining is that its new training data is not updated in real time but in a periodic way.

10 Security requirements for AITOM

AITOM should be operated in a safe way or environment, which is a general requirement. In this sense, the following aspects should be supported:

Data integrity: Data integrity ensures the correctness or accuracy of data. The data is protected against unauthorized modification, deletion, creation, and replication and provides an indication of these unauthorized activities. See clause 8.1.2 of [ITU-T X.1111].

Communication flow security: Communication flow security ensures that information flows only between the authorized end points (the information is not diverted or intercepted as it flows between these end points). See clause 8.1.6 of [ITU-T X.1111].

Availability: The availability ensures that there is no denial of authorized access to network elements, stored information, information flows, services and applications due to events impacting the network. Disaster recovery solutions are included in this category. See clause 6.7 of [ITU-T X.805].

Security protection of AI system and network: It includes data security management, access security control and user security isolation.

More security requirements can be found in [ITU-T M.3016.2], including authentication, access control, non-repudiation, audit trail, alarm reporting and packet inspection.

Annex A

The background and main characteristics of the AITOM framework

(This annex forms an integral part of this Recommendation.)

With the continuous evolution of the network and the arrival of the 5G/IMT-2020 era, the network of the operators is more complex, the business demands are more diversified, and the management of the telecommunication operation is more complex. It is necessary to introduce artificial intelligence (AI) technology to strengthen the intelligence and automation of the telecom operation management system.

Introducing AI technology would have a big impact to the existing framework of the operation and management system. It needs to introduce some new functionalities related to AI, such as for example AI model management, data collection, data management, policy, and so on. It is necessary to design a closed-loop procedure on how to do operation and management based on an enhanced framework, in order to obtain full guidance on how to use AI for telecom operation and management.

The main characteristics of the AITOM framework can be described as follows:

– Intelligent: Compared with SOMM, AITOM is more intelligent due to strong AI capability.

– Automaticity: By utilizing AI pipeline orchestration, AITOM is able to realize automatic network management or service provision. Many closed-loop control procedures, service provisions or openings are supported.

– Data driven: As for SOMM, the AITOM framework converges masses of data from different OSs to a unified data model, supporting data sharing, data mining, data correlation, machine learning and other usage intents. More detailed data processing functions related to AI, such as feature engineering are supported.

– Integrated: As for SOMM, the AITOM framework can be applied for current and future networks. It can also support cross-domain management activities to fulfil end-to-end services for customers.

– Agile: As for SOMM, the AITOM framework is a service-oriented framework in which each operations systems function (OSF) is packaged as a service to be opened. A new OS can be deployed quickly with these open services and convergent data, along with the common infrastructure platform for OSs.

– Capability-exposed: With the customer-oriented marketplace layer, the application, service, data and AI capability set of AITOM are easily exposed to any system outside of AITOM.

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