

Draft new Recommendation ITU-T Y.3162 (ex. ITU-T Y.IMT-2020-EIL)

Evaluating intelligence capability for network slice management and orchestration in IMT-2020 network and beyond

Summary

As a novel technology of IMT-2020 network and beyond, network slicing allows the creation of multiple virtual networks on top of a shared physical infrastructure and meets diverse needs of users and applications. Meanwhile, Artificial Intelligence (AI) makes it intelligent especially by empowering network slice management and orchestration.

This Recommendation aims to evaluate the intelligence level for network slice management and orchestration in IMT-2020 network and beyond and mainly covers the following aspects: overview, intelligence level definition, evaluation methods, framework and procedures of intelligent network slice management and orchestration.

Keywords

Evaluation, intelligence level, network slicing

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Evaluating intelligence capability for network slice management and orchestration in IMT-2020 network and beyond

1. Scope

This Recommendation aims to evaluate the intelligence level for network slice management and orchestration in IMT-2020 network and beyond and mainly covers the following aspects:

- Overview of intelligent network slice management and orchestration
- Intelligence level definition of network slice management and orchestration
- Evaluation methods of network slice management and orchestration
- Framework and procedure for evaluating intelligence levels of each phases

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.3080] Recommendation ITU-T M.3080 (2021), *Framework of artificial intelligence enhanced telecom operation and management (AITOM)*

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

[ITU-T Y.3153] Recommendation ITU-T Y.3153 (2019), *Network slice orchestration and management for providing network services to 3rd party in the IMT-2020 network*

[ITU-T Y.3156] Recommendation ITU-T Y.3156 (2020), *Framework of network slicing with AI-assisted analysis in IMT-2020 networks*

[ITU-T Y.3173] Recommendation ITU-T Y.3173 (2020), *Framework for evaluating intelligence levels of future networks including IMT-2020*

3. Definitions

3.1. Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 IMT-2020 [ITU-T Y.3100]: Systems, system components, and related technologies that provide far more enhanced capabilities than those described in [b-ITU-R M.1645].

3.1.2 management [ITU-T Y.3100]: In the context of IMT-2020, the processes aiming at fulfillment, assurance, and billing of services, network functions, and resources in both physical and virtual infrastructure including compute, storage, and network resources.

3.1.3 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 infrastructure by optimization criteria.

3.1.4 network slice [ITU-T Y.3100]: A logical network that provides specific network capabilities and network characteristics.

3.1.5 network intelligence level [ITU-T Y.3173]: Level of application of automation capabilities including those enabled by the integration of artificial intelligence techniques in the network.

3.2. Terms defined in this Recommendation

This Recommendation defines the following terms:

None

4. Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

3GPP	3rd Generation Partnership Project
AI	Artificial Intelligence
M&O	Management & Orchestration
RAN	Radio Access Network
SLA	Service Level Agreement
SMOS	Slice Management and Orchestration System

5. Conventions

The keywords “is required to” indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this document is to be claimed.

The keywords “is recommended” indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

The keywords “can optionally” indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor’s implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

In the body of this document and its annexes, the words shall, shall not, should, and may sometimes appear, in which case they are to be interpreted, respectively, as is required to, is prohibited from, is recommended, and can optionally. The appearance of such phrases or keywords in an appendix or in material explicitly marked as informative are to be interpreted as having no normative intent.

6. Overview of intelligent network slice management and orchestration

6.1 Functional architecture of network slice management and orchestration

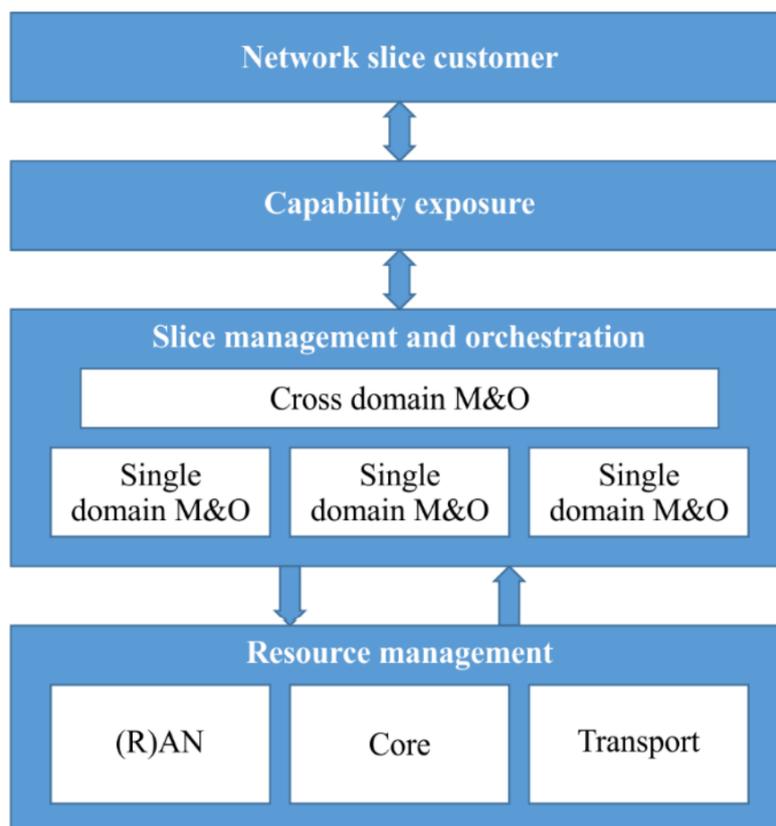


Figure 1 – Functional architecture of network slice management and orchestration [ITU-T Y.3153]

The network slice management and orchestration provides a complete set of network functions, which is required to support customer services over different network domains. The functional architecture consists of four entities described in [ITU-T Y.3153]: network slice customer, capability exposure, slice management and orchestration and resource management. Once capability exposure accepts a network slice requirement from a customer, then the requirement is sent to the slice management and orchestration to instantiate, modify or release a network slice instance. The responsibilities of resource management are to manage the life-cycle of required network functions and corresponding virtualized resources respectively.

6.2 Workflow of network slice management and orchestration

The workflow of network slice management and orchestration is summarized from [ITU-T Y.3153] and [b-3GPP TS28.530]. It consists of the following five phases.

- 1) **Preparation.** The main aim of this phase is to prepare a slice instance. It includes the following operations, like network slice design, network slice capacity planning, preparation of network environment, etc.
- 2) **Commissioning.** The main aim of this phase is to create a slice instance. It includes the following operations, like resource allocation and network configuration.
- 3) **Maintenance.** The main aim of this phase is to ensure that the network slice runs in a normal state. It includes the following operations, like function monitoring and resource modification.
- 4) **Optimization.** The main aim of this phase is to increase performance and efficiency of a network slice. It includes the following operations, like resource adjustment and network topology adjustment.
- 5) **Decommissioning.** The main aim of this phase is to terminate a slice instance. It includes the following operations, like releasing resources and configuration.

6.3 Intelligent network slice management and orchestration

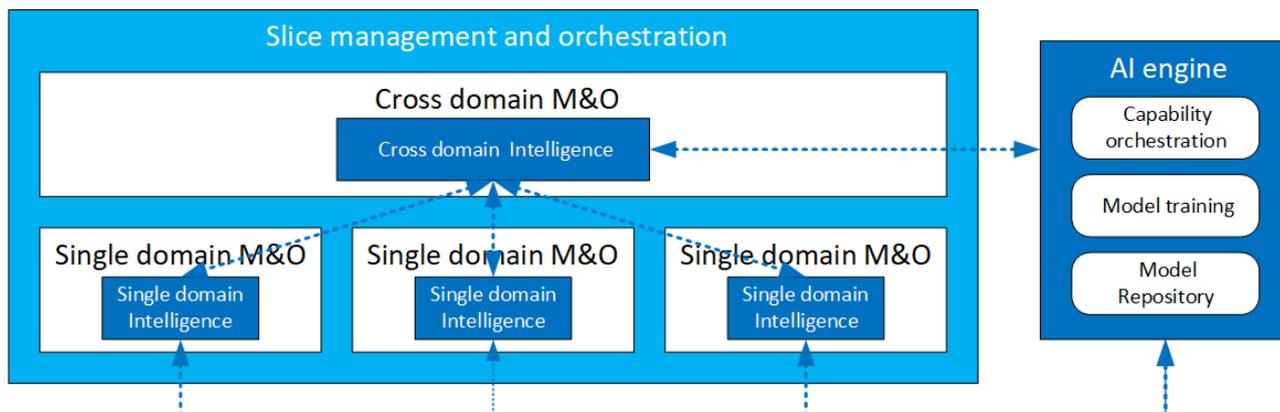


Figure 2 – Illustration for applying AI to network slice management and orchestration

Slice management and orchestration is the main part in which AI is deployed as shown in Figure 2. AI empowers slice management and orchestration and makes it intelligent. In detail, cross domain intelligence and single domain intelligence are achieved with AI engine, which is added to telecom operation and management [ITU-T M.3080] and will be an indispensable part of future network.

NOTE: AI engine: The realization and mechanization, in software or hardware, of one or more functions dedicated to performing a specific AI task.

The cross domain intelligence may include automatic translation of customers' intent and automatic creation of slice templates and the single domain intelligence may include network resource prediction and abnormal detection in a single domain.

Applying AI to network slice management and orchestration is manifold, which includes in particular the following aspects:

- Resource allocation: AI capabilities facilitate allocating resources to network slices to provide the required network slice performance and avoid SLA violation.
- Fault management: AI can automate the process of detecting, isolating and resolving faults for network slice and ensure its continuous and reliable operation by minimizing downtime.
- Security management: the AI-based attack detection enables faster attack identification, remediation and slice reconfiguration.
- Multi-objective optimization: the AI-based algorithms can be used for simultaneous optimization of multiple goals, for example, resource consumption, energy consumption.

7. Methods for evaluating intelligence levels of network slicing

7.1 Dimensions

Being consistent with [ITU-T Y.3173], this Recommendation makes use of the following five dimensions to evaluate intelligence levels of network slice management and orchestration, including demand mapping, data collection, analysis, decision, and action implementation. The explanations of dimensions can refer to [ITU-T Y.3173]. For each dimension, intelligence capability level is identified by human, human & Slice Management and Orchestration System (SMOS), and SMOS. Human represents all operations are performed by humans. SMOS represents all operations are performed by the system without human's intervention. Human & SMOS represents the hybrid operations.

7.2 Intelligence levels

Being consistent with [ITU-T Y.3173], this Recommendation makes use of six intelligence levels (i.e., L0-L5) to evaluate network slice management and orchestration. Intelligence levels and corresponding explanations are defined as follows.

- L0: Manual network operation. All operations of network slice management and orchestration are performed by humans.
- L1: Assisted network operation. Operations of data collection and action implementation are partly performed by humans & SMOS.
- L2: Preliminary intelligence. All operations of action implementation are performed by SMOS while operations of data collection and analysis are partly performed by humans & SMOS.
- L3: Intermediate intelligence. All operations of action implementation and data collection are performed by SMOS. Operations of analysis and decision are partly performed by humans & SMOS.
- L4: Advanced intelligence. All operations of action implementation, data collection, analysis and decision are performed by SMOS. Operations of demand mapping are partly performed by humans & SMOS.
- L5: Full intelligence. All operations of network slice management and orchestration are performed by SMOS automatically without human invention.

7.3 Basic method

As shown in Table 1, each intelligence level is determined with the following five widely applicable dimensions: demand mapping, data collection, analysis, decision, action implementation.

Table 1-Intelligence levels of network slice management and orchestration

Intelligence levels		Dimensions				
		Action implementation	Data collection	Analysis	Decision	Demand mapping
L0	Manual network operation	Human	Human	Human	Human	Human
L1	Assisted network operation	Human & SMOS	Human & SMOS	Human	Human	Human
L2	Preliminary intelligence	SMOS	Human & SMOS	Human	Human	Human
L3	Intermediate intelligence	SMOS	SMOS	Human & SMOS	Human	Human
L4	Advanced intelligence	SMOS	SMOS	SMOS	Human & SMOS	Human
L5	Full intelligence	SMOS	SMOS	SMOS	SMOS	SMOS

The above five dimensions are applicable to workflow intelligence level described in [ITU-T Y.3173] so they can be applied to workflow of network slice management and orchestration in order to determine the intelligence level of each phases, as shown in Figure 3. So, the intelligence level of the network slice management and orchestration is the lowest intelligence level among all phases.

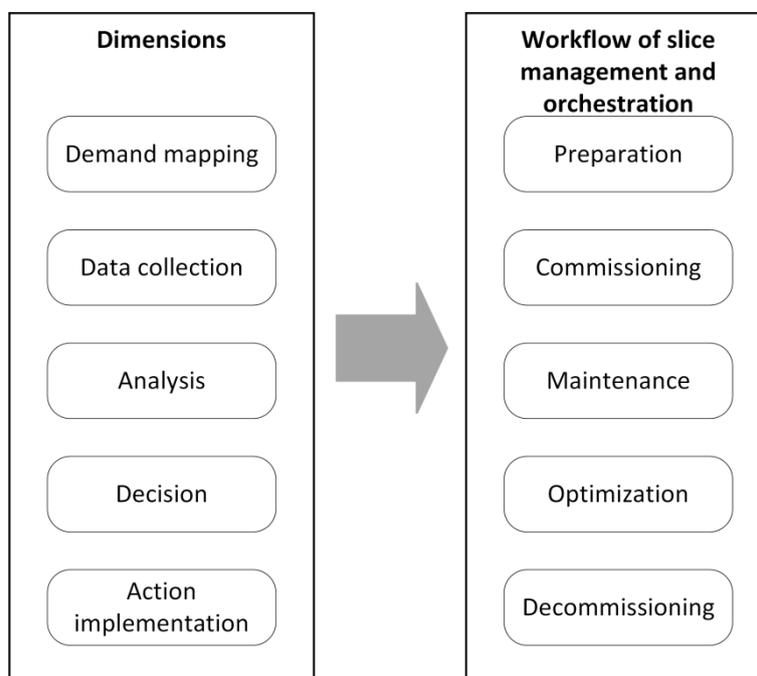


Figure 3 – Evaluating intelligence levels by dimensions

Each dimension in one phase is divided into tasks further, which represents more detailed operations in this dimension, since it is easier to infer the intelligence capability level of a task. For example, demand mapping of preparation phase is consisted of intent collection task and intent translation task. The intelligence capability level of the task is also identified by human, human & SMOS, and SMOS. Then, the intelligent capabilities of all tasks comprising a dimension are used to deduce the intelligence capability level of the dimension.

Overall, the intelligence levels of network slice management and orchestration are obtained by the following steps.

- 1) Determine tasks of dimensions. Each dimension of a given phase is divided into tasks with more specific operations.
- 2) Determine intelligence capability level of tasks. The intelligence capability level of a task is determined by the ratio of human's intervention.
- 3) Determine the intelligence capability level of a dimension. The intelligence capability of a given dimension is determined by the ratio of human's intervention in all tasks comprising the dimension.
- 4) Determine the intelligence level of a phase. The intelligence level of a given phase is determined by selecting the minimum intelligence capability level across all dimensions.
- 5) Determine the intelligence level of network slice management and orchestration. The overall intelligence level of network slice management and orchestration is determined by selecting the minimum intelligence level of all phases.

8. Framework and procedure for evaluating intelligence levels of each phase

8.1 Overview

Evaluating intelligence level of a phase in the workflow of network slice management of orchestration is mainly conducted as follows.

Firstly, tasks of each dimension for a given phase are determined. Table 2 summarizes tasks of each dimension for five phases of the network slice management and orchestration. Operations and descriptions of all tasks are detailed in the following sub-clauses.

Next, intelligence capability level of a task are determined, and then intelligence capability level of a dimension and intelligence level of a phase are determined, sequentially. The intelligence capability level of a task equals that of a dimension if there is only one task in a dimension. Otherwise, it is determined by the ratio of human's intervention in all tasks comprising the dimension. The intelligence level of a phase is finally determined by the minimum intelligence capability level across all dimensions. In summary, mapping relation is established between intelligence capability level of tasks and intelligence level of a phase.

Table 2-Tasks of network slice management and orchestration

Phases	Dimensions				
	Demanding mapping	Data collection	Analysis	Decision	Action implementation
Preparation	Task1: Intent collection Task2: Intent translation	Task1: Network resource collection	Task1: Network resource analysis Task2: Network slicing estimation	Task1: Network resource orchestration	Task1: Network slice template generation
Commissioning	Task1: Intent collection Task2: Intent translation	Task1: Network resource collection	Task1: Network capability analysis Task2: SLA analysis	Task1: Deployment strategy generation	Task1: Network slice creation and commissioning
Maintenance	Task1: Intent translation	Task1: Network slice state monitoring	Task1: Network slice state analysis	Task1: Maintenance strategy generation	Task1: Maintenance operation
Optimization	Task1: Intent translation	Task1: Network slice state monitoring	Task1: Network slice state prediction	Task1: Optimization strategy generation	Task1: Network slice optimization execution
Decommissioning	Task1: Intent translation	Task1: Network slice state monitoring	Task1: Network slice state analysis Task2: Network slice state prediction	Task1: Decommissioning strategy generation	Task1: Decommissioning execution

8.2 Grading method and procedure for preparation phase

8.2.1 Task

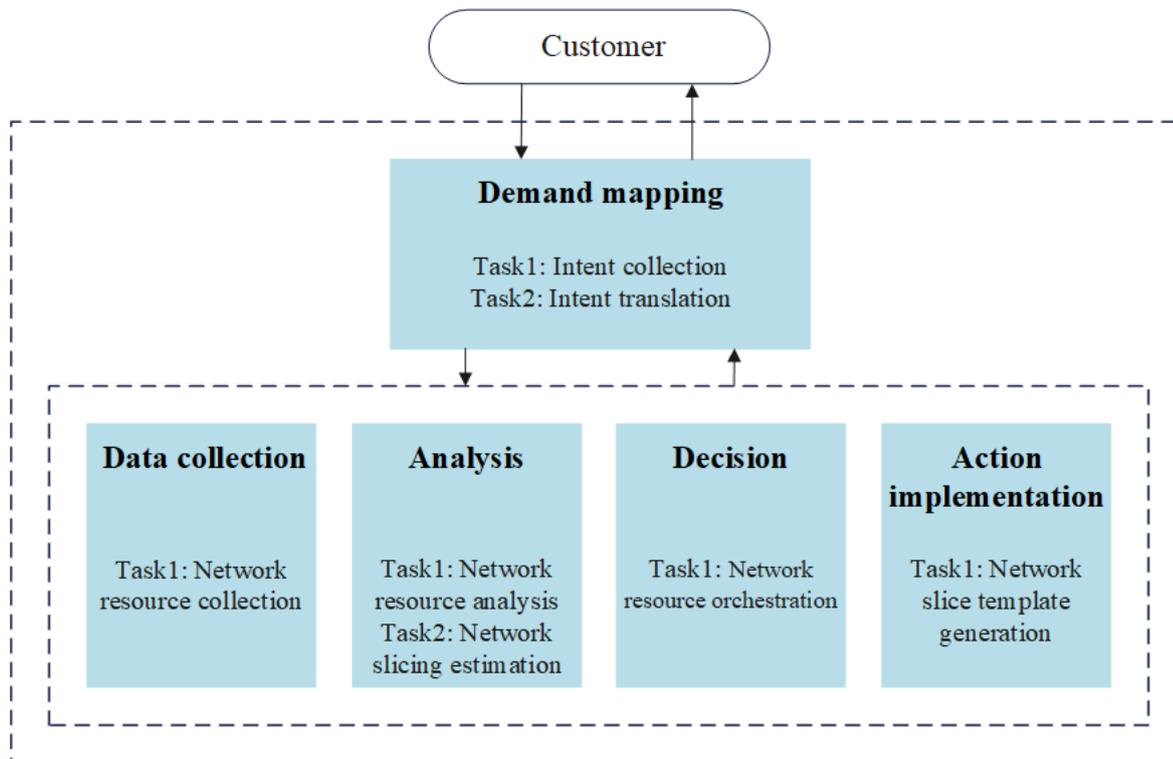


Figure 4 – Generic flow for preparation phase

The generic flow and tasks in dimensions for preparation phase are shown in Figure 4. The detailed description of tasks classified by dimensions is as follows.

- Tasks of demand mapping.
 - 1) Intent collection: Collect intent of customers to network slice in various application scenarios through comprehensive communication with them and finally form a intent set of network slice.
 - 2) Intent translation: Convert intent of customers for network slicing into requirements of network slice, including network slicing performance, network slicing function, customer's category, etc.
- Tasks of data collection.
 - 1) Network resource collection: Collect the information of network resources, network configuration, network operation in order to obtain the information of network infrastructure.
- Tasks of analysis.
 - 1) Network resource analysis: Make an analysis on the data of network resources and obtain network capabilities to support network slices.
 - 2) Network slicing estimation: Estimate the range of network slicing capabilities with customer's requirements and network resources.
- Tasks of decision.
 - 1) Network resource orchestration: Orchestrate the underlying network resources for different network slices and classify network slices.
- Tasks of action implementation.

1) Network slice template generation: Generate generic network slice templates with different network slice capabilities. Besides, generate a specific network slice template for requirements of customer that cannot satisfied by the generic network slice template.

8.2.2 Grading method

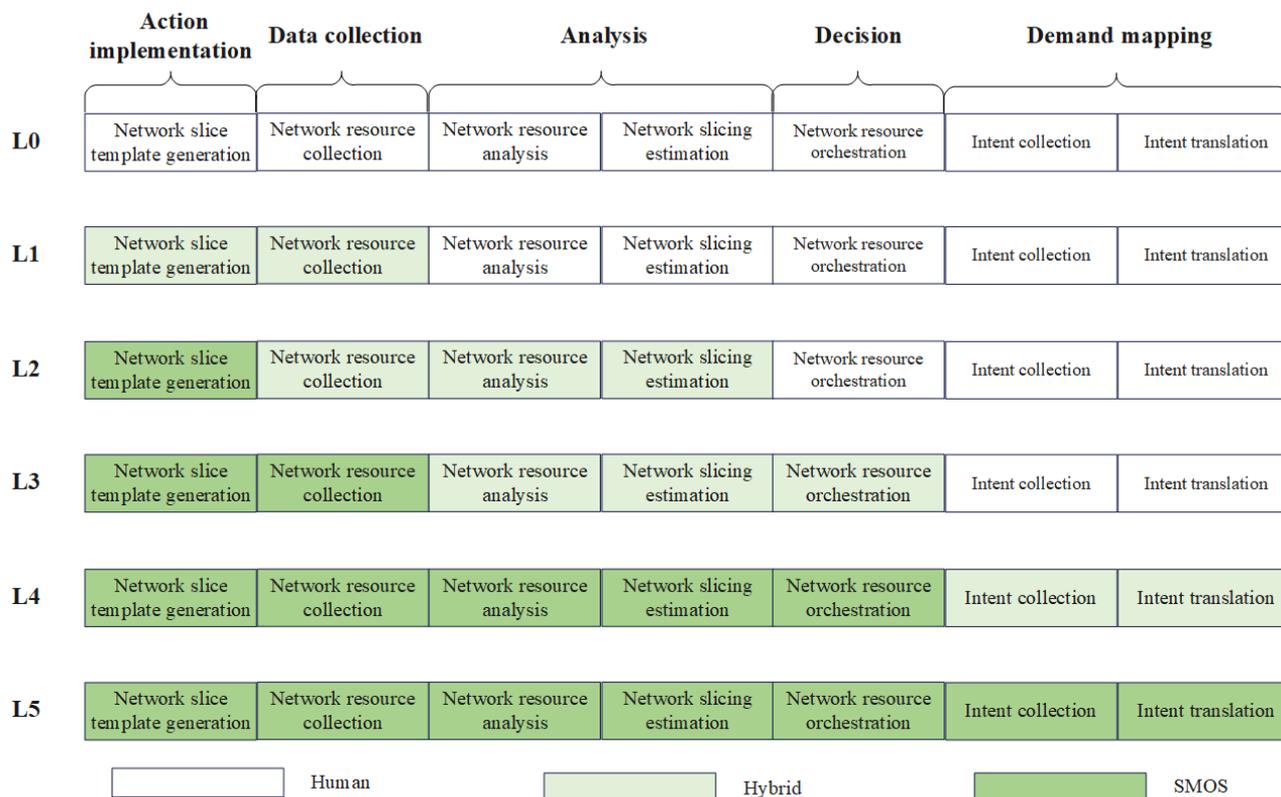


Figure 5 – Grading method for preparation phase

The general grading method for preparation phase, which is consistent with Table 1, is shown in Figure 5, and the detailed descriptions are as follows.

- L0 (Manual network operation): All tasks are performed by human.
- L1 (Assisted network operation): Network slice template generation task and network resource collection task are performed by human & SMOS while other tasks are performed by human.
- L2 (Preliminary intelligence): Network slice template generation task is fully performed by SMOS. Besides network resource collection task, network resource analysis task and network slicing estimation task are performed by human & SMOS. Other tasks are performed by human.
- L3 (Intermediate intelligence): Besides network slice template generation task, network resource collection task is fully performed by SMOS. Besides network resource analysis task, network slicing estimation task, network resource orchestration task is performed by human & SMOS. Other task are performed by human.
- L4 (Advanced intelligence): Intent collection tasks and intent translation tasks are performed by human & SMOS. Other tasks are fully performed by SMOS.
- L5 (Full intelligence): All tasks are fully performed by SMOS.

8.3 Grading method and procedure for commissioning phase

8.3.1 Task

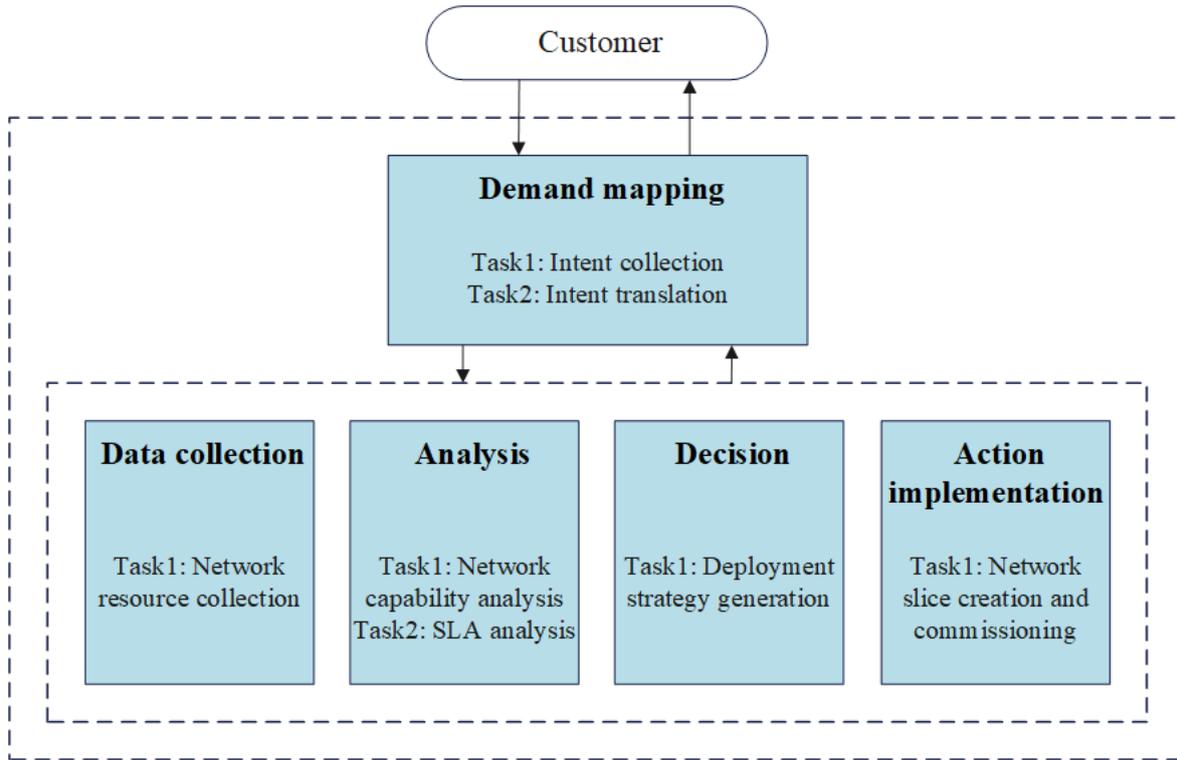


Figure 6 – Generic flow for commissioning phase

The generic flow and tasks in dimensions for commissioning phase are shown in Figure 6. The detailed description of tasks classified by dimensions is as follows.

- Tasks of demand mapping.
 - 1) Intent collection: Collect specific requirements of customers for network slicing.
 - 2) Intent translation: Select a suitable network slice template for the requirements of customers.
- Tasks of data collection.
 - 1) Network resource collection: Collect the data of network resources status, network configuration and network operation, etc.
- Tasks of analysis.
 - 1) Network capability analysis: Make a comprehensive analysis with current network resource information and obtain the network capabilities.
 - 2) SLA analysis: Compare SLA requirements of network slices to network capabilities and analyze the possibility to create a network slice with the selected network slice template.
- Tasks of decision.
 - 1) Deployment strategy generation: Generate a deployment strategy with the above analysis results.
- Tasks of action implementation.
 - 1) Network slice creation and commissioning: Create a new network slice with the selected network slice template and deploy it for customers with specified strategy.

8.3.2 Grading method

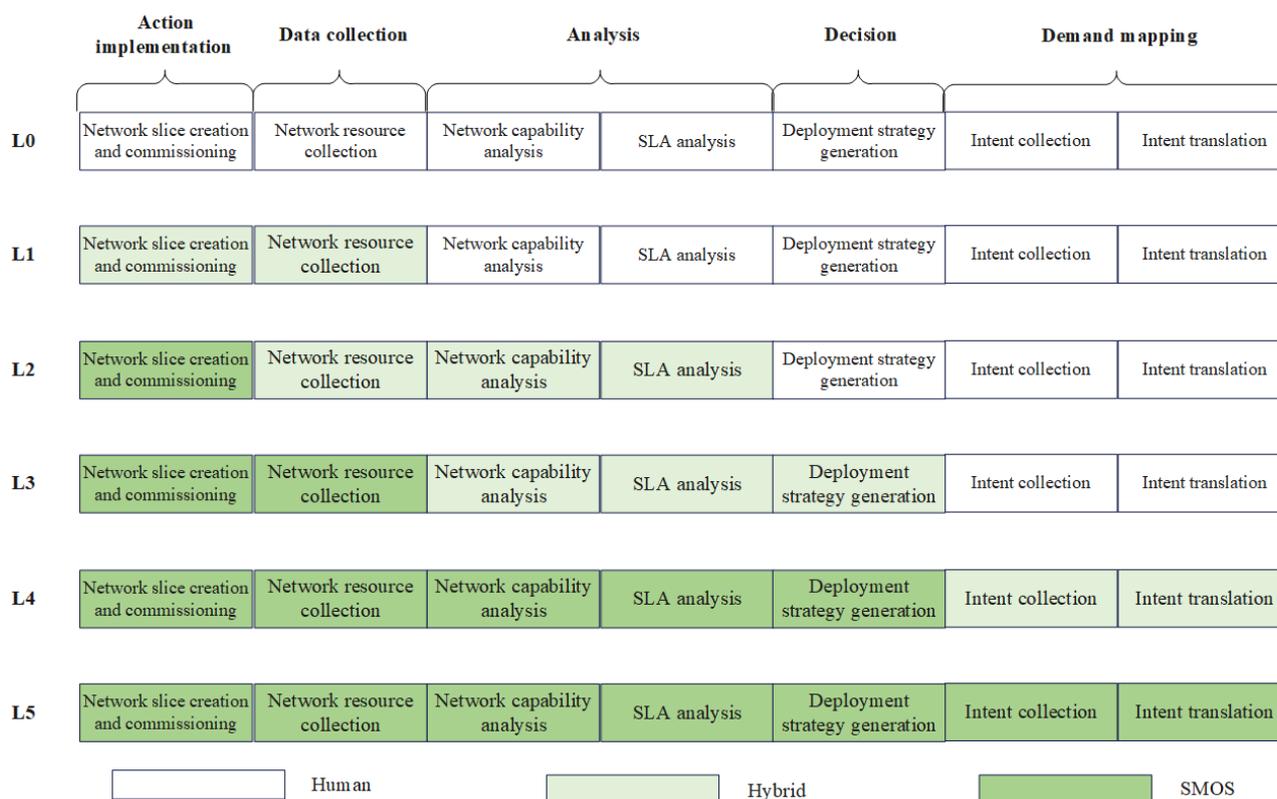


Figure 7 – Grading method for commissioning phase

The general grading method for commissioning phase, which is consistent with Table 1, is shown in Figure 7, and the detailed descriptions are as follows.

- L0 (Manual network operation): All tasks are performed by human.
- L1 (Assisted network operation): Network slice creation and commissioning task and network resource collection task are performed by human & SMOS while other tasks are performed by human.
- L2 (Preliminary intelligence): Network slice creation and commissioning task is fully performed by SMOS. Besides network resource collection task, network capability analysis task and SLA analysis task are performed by human & SMOS. Other tasks are performed by human.
- L3 (Intermediate intelligence): Besides Network slice creation and commissioning task, network resource collection task is fully performed by SMOS. Besides network capability analysis task and SLA analysis task, deployment strategy generation task is performed by human & SMOS. Other tasks are performed by human.
- L4 (Advanced intelligence): Intent collection tasks and intent translation tasks are performed by human & SMOS. Other tasks are fully performed by SMOS.
- L5 (Full intelligence): All tasks are fully performed by SMOS.

8.4 Grading method and procedure for maintenance phase

8.4.1 Task

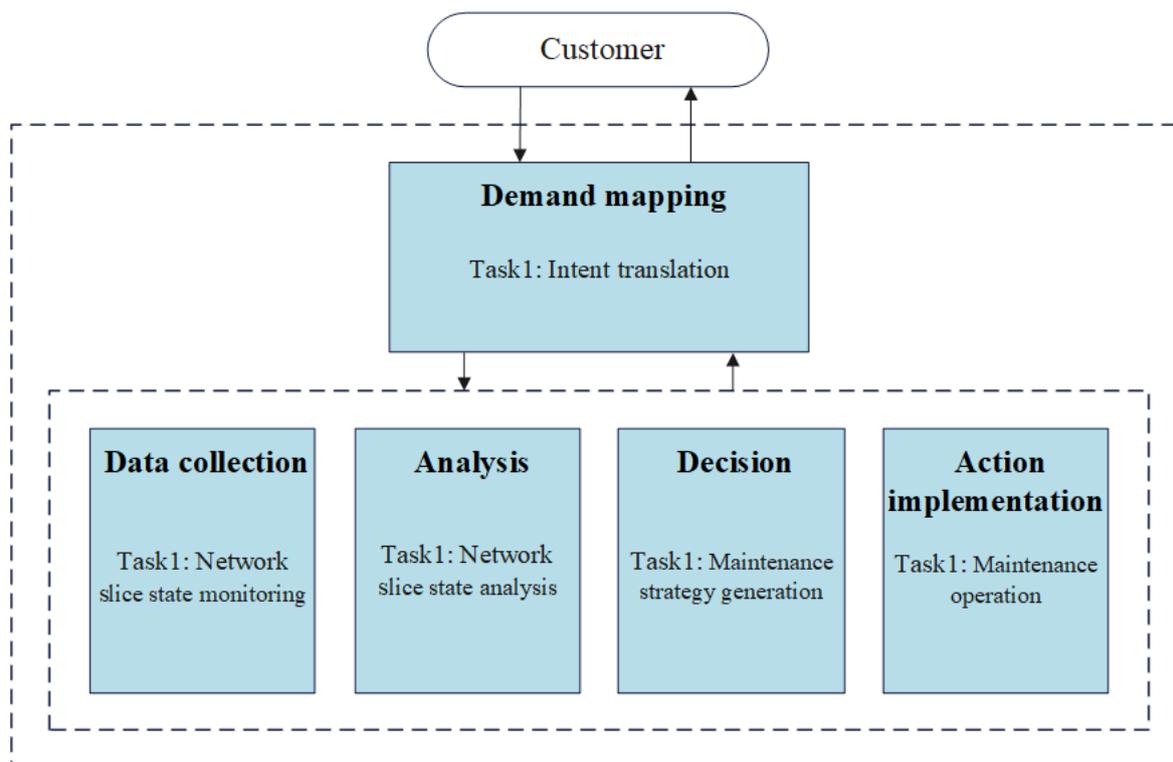


Figure 8 – Generic flow for maintenance phase

The generic flow and tasks in dimensions for maintenance phase are shown in Figure 8. The detailed description of tasks classified by dimensions is as follows.

- Tasks of demand mapping.
 - 1) Intent translation: Convert requirements of SLA into requirements of network slice maintenance.
- Tasks of data collection.
 - 1) Network slice state monitoring: Monitor running state of network slice and network infrastructure, and collect their running data, including network slice configuration, slice topology, network slice performance, network configuration, network topology, network performance, etc.
- Tasks of analysis.
 - 1) Network slice state analysis: Analyze on data of network slice and network infrastructure and judge whether they meet the requirements of network slice maintenance. Besides, this task include recognition of abnormal behavior or failure of the network slices and network infrastructure.
- Tasks of decision.
 - 1) Maintenance strategy generation: Generate maintenance strategy according to requirements of network slice maintenance and running state of network slices and network infrastructure. Especially, generate fixing solution for any failure.
- Tasks of action implementation.
 - 1) Maintenance operation: Execute maintenance operations with generated strategy including trouble shooting if an error occurred.

8.4.2 Grading method



Figure 9 – Grading method for maintenance phase

The general grading method for maintenance phase, which is consistent with Table 1, is shown in Figure 9, and the detailed descriptions are as follows.

- L0 (Manual network operation): All tasks are performed by human.
- L1 (Assisted network operation): Maintenance operation task and network slice state monitoring task are performed by human & SMOS while other tasks are performed by human.
- L2 (Preliminary intelligence): Maintenance operation task is fully performed by SMOS. Besides network slice state monitoring task, network slice state analysis task is performed by human & SMOS. Other tasks are performed by human.
- L3 (Intermediate intelligence): Besides maintenance operation task, network slice state monitoring task is fully performed by SMOS. Besides network slice state analysis task, maintenance strategy generation task is performed by human & SMOS. Other task are performed by human.
- L4 (Advanced intelligence): Intent translation task is performed human & SMOS. Other tasks are fully performed by SMOS.
- L5 (Full intelligence): All tasks are fully performed by SMOS.

8.5 Grading method and procedure for optimization phase

8.5.1 Task

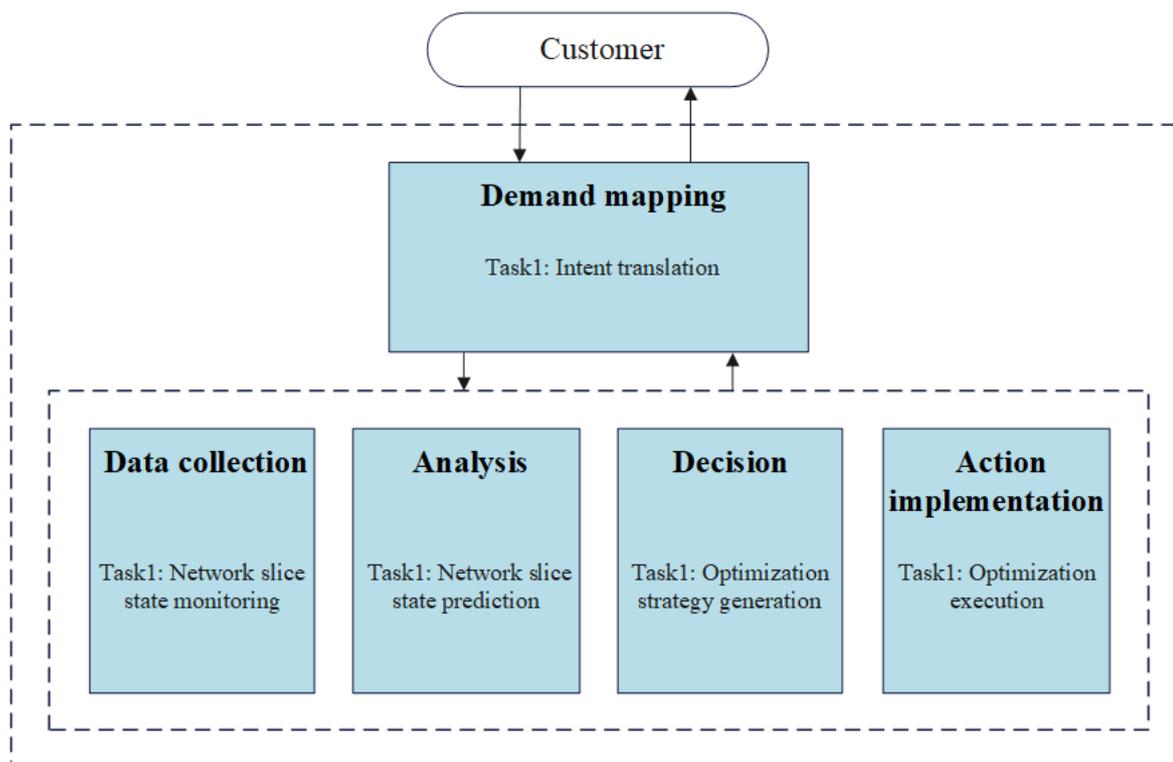


Figure 10 – Generic flow for optimization phase

The generic flow and tasks in dimensions for optimization phase is shown in Figure 10. The detailed description of tasks classified by dimensions is as follows.

- Tasks of demand mapping.
 - 1) Intent translation: Convert requirements of SLA into requirements of network slice optimization.
- Tasks of data collection.
 - 1) Network slice state monitoring: Monitor running state of network slice and network infrastructure, and collect their running data, including network slice configuration, network slice topology, network slice performance, network configuration, network topology, network performance, etc.
- Tasks of analysis.
 - 1) Network slice state prediction: Analyze on running data of network slice and network infrastructure and make prediction for future performance of network slice.
- Tasks of decision.
 - 1) Optimization strategy generation: Generate optimization strategy for network slices according to the prediction for network slices.
- Tasks of action implementation.
 - 1) Optimization execution: Implement optimization strategy for network slices, in order to guarantee SLA requirements all the time.

8.5.2 Grading method

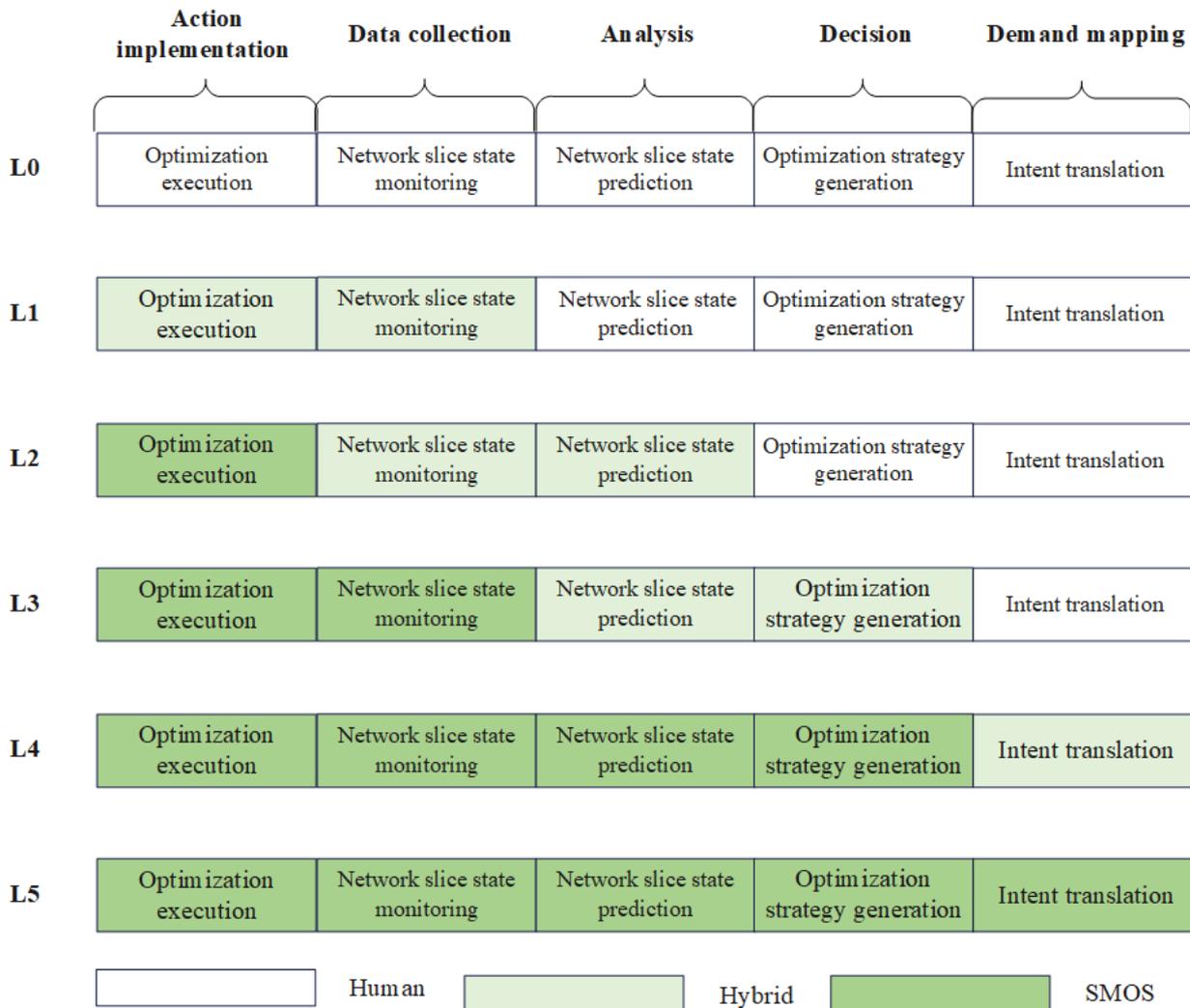


Figure 11 – Grading method for optimization phase

The general grading method for optimization phase, which is consistent with Table 1, is shown in Figure 11, and the detailed descriptions are as follows.

- L0 (Manual network operation): All tasks are performed by human.
- L1 (Assisted network operation): Optimization execution task and network slice state monitoring task are performed by human & SMOS while other tasks are performed by human.
- L2 (Preliminary intelligence): Optimization execution task is fully performed by SMOS. Besides network slice state monitoring task, network slice state prediction task is performed by human & SMOS. Other tasks are performed by human.
- L3 (Intermediate intelligence): Besides optimization execution task, network slice state monitoring task is fully performed by SMOS. Besides network slice state prediction task, optimization strategy generation task is performed by human & SMOS. Other task are performed by human.
- L4 (Advanced intelligence): Intent translation task is performed human & SMOS. Other tasks are fully performed by SMOS.
- L5 (Full intelligence): All tasks are fully performed by SMOS.

8.6 Grading method and procedure for decommissioning phase

8.6.1 Task

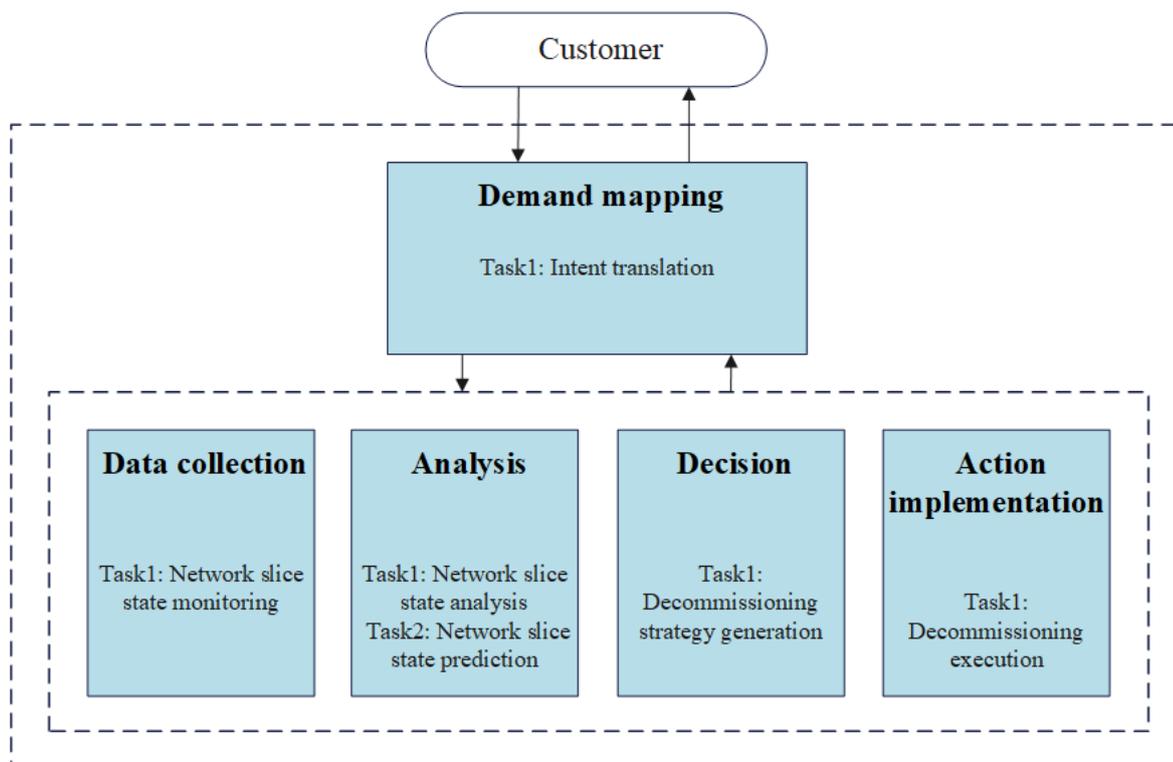


Figure 12 – Generic flow for decommissioning phase

The generic flow and tasks in dimensions for decommissioning phase are shown in Figure 12. The detailed description of tasks classified by dimensions is as follows.

- Tasks of demand mapping.
 - 1) Intent translation: Convert requests of decommissioning from customers for unused network slice or from system for inactive network slice into decommissioning requirements.
- Tasks of data collection.
 - 1) Network slice state monitoring: Monitor running state of network slice and collect data including operation and service data.
- Tasks of analysis.
 - 1) Network slice state analysis: Analyze on the data to find inactive network slice.
 - 2) Network slice state prediction: Make a prediction for the trend of network slice usage.
- Tasks of decision.
 - 1) Decommissioning strategy generation: Determine the network slice that will be decommissioned and generate corresponding decommissioning strategy.
- Tasks of action implementation.
 - 1) Decommissioning execution: Execute decommissioning command for selected network slice with the strategy.

8.6.2 Grading method

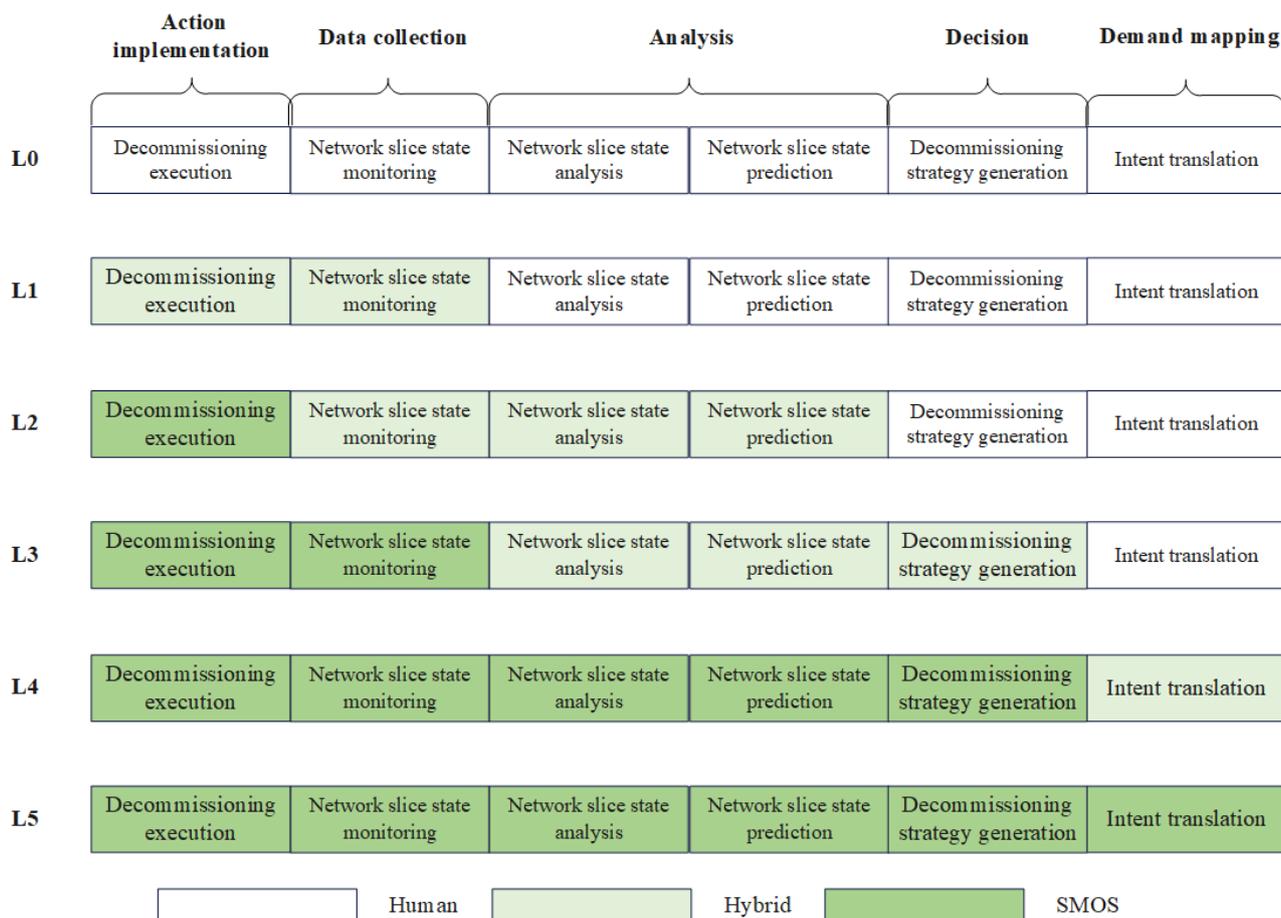


Figure 13 – Grading method for decommissioning phase

The general grading method for decommissioning phase, which is consistent with Table 1, is shown in Figure 13, and the detailed descriptions are as follows.

- L0 (Manual network operation): All tasks are performed by human.
- L1 (Assisted network operation): Decommissioning execution task and network slice state monitoring task are performed by human & SMOS while other tasks are performed by human.
- L2 (Preliminary intelligence): Decommissioning execution task is fully performed by SMOS. Besides network slice state monitoring task, network slice state analysis task and network slice state prediction task are performed by human & SMOS. Other tasks are performed by human.
- L3 (Intermediate intelligence): Besides decommissioning execution task, network slice state monitoring task is fully performed by SMOS. Besides network slice state analysis task and network slice state prediction task, decommissioning strategy task is performed by human & SMOS. Other task are performed by human.
- L4 (Advanced intelligence): Intent translation task is performed human & SMOS. Other tasks are fully performed by SMOS.
- L5 (Full intelligence): All tasks are performed by SMOS.

9. Security considerations

This Recommendation describes the methods to evaluate intelligence levels of network slice management and orchestration. Thus, the security considerations in [ITU-T Y.3156] and [ITU-T Y.3173] are applicable to this Recommendation.

Bibliography

- [b-ITU-R M.1645] Recommendation ITU-R M.1645 (2003), Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000.
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