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Recommendation

ITU-T Y.2344 (01/2024)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Next Generation Networks – Enhancements to NGN

Scenarios and requirements of intent-based network for network evolution

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Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

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Recommendation ITU-T Y.2344

Scenarios and requirements of intent-based network for network evolution

Summary

Recommendation ITU-T Y.2344 aims to provide the scenarios and requirements of intent-based network for network evolution.

The scope of this Recommendation includes:

- Scenarios and workflow of intent-based network for network evolution.
- Capability requirements of intent-based network for network evolution.
- General framework of intent-based network for network evolution.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T Y.2344	2024-01-13	13	11.1002/1000/15048

Keywords

Intent-based network, network evolution, requirements, scenarios.

* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

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Scenarios and requirements of intent-based network for network evolution

1 Scope

This Recommendation aims to provide the scenarios and requirements of intent-based network (IBN) for network evolution.

The scope of this Recommendation includes:

- Scenarios and workflow of IBN for network evolution.
- Capability requirements of IBN for network evolution.
- General framework of IBN for network evolution.

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 Y.2323] Recommendation ITU-T Y.2323 (2018), *Requirements and capabilities of orchestration in next generation network evolution*.

[ITU-T Y.2324] Recommendation ITU-T Y.2324 (2019), *Functional architecture of orchestration in next generation network evolution (NGNe)*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 application [b-ITU-T Y.101]: A structured set of capabilities, which provide value-added functionality supported by one or more services.

3.1.2 intent [b-IETF RFC 9315]: A set of operational goals (that a network should meet) and outcomes (that a network is supposed to deliver) defined in a declarative manner without specifying how to achieve or implement them.

3.1.3 media [b-ITU-T Y.2012]: One or more of audio, video, or data.

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 [b-ETSI GR ENI 004].

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

3.1.5 network intelligence capability enhancement (NICE) [b-ITU-T Y.2301]: An enhancement for NGNs supporting some intelligent capabilities for the provisioning of services according to requirements of users and application providers. These intelligent capabilities (termed as "NICE capabilities") enable operators to assign and dynamically adjust specific network resources based on the requirements, as well as support interfaces for users and applications enabling on-demand resource and service provision.

3.1.6 NGN [b-ITU-T Y.2001]: A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.

3.1.7 service [b-ITU-T Y.2091]: A set of functions and facilities offered to a user by a provider.

3.1.8 user [b-ITU-T Y.2201]: A user includes end user [b-ITU-T Y.2091], person, subscriber, system, equipment, terminal (e.g., FAX, PC), (functional) entity, process, application, provider, or corporate network.

3.1.9 intent-based network [b-IETF RFC 9315]: A network that can be managed using intent.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
CNF	Cloud native Network Function
E2E	End to End
IBN	Intent-Based Network
ID	Identity Document
IoT	Internet of Things
KPI	Key Performance Indicator
LAN	Local Area Network
MEC	Multiaccess Edge Compute
MR	Mixed Reality
NFV	Network Function Virtualization
NGNe	Next Generation Network evolution
NICE	Network Intelligence Capability Enhancement
QoS	Quality of Service
SDN	Software-Defined Networking
SLA	Service Level Agreement
VNF	Virtual Network Function
VR	Virtual Reality
WAN	Wide Area Network

5 Conventions

In this Recommendation:

The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation 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.

6 Overview of intent-based network

At present, the evolution of emerging technologies represented by cloud computing, big data, Internet of Things, artificial intelligence, etc. is surging, which has set off a storm of change in various industries. At the same time, under the dual drive of 'technology and demand', the network field is also undergoing a huge change which leads to network evolution. The data show that the base of IoT devices is growing rapidly in these years, and millions of new devices will be connected to the network in every second. At the same time, the cost of network management and maintenance for enterprises will be many times that of building the network. Furthermore, in terms of network security, it takes days or even months to discover a vulnerability. However, the current business requirements and network requirements seem to be standing on two opposite sides: on one hand, various network requirements are continuously put forward for business needs, and on the other hand, the network operation and maintenance personnel are exhausted by various operations in response to the demand.

Under this circumstance, in order to support business agility and to save costs, the network needs to evolve from a static system to a dynamic system that can meet business goals. The IBN emerges at the historic moment with the continuous development and maturity of SDN technology and artificial intelligence technology. IBN is a network that can be managed to achieve desired operational goals and outcomes without specifying network details. It defines intent and how to translate it into corresponding network strategies or configurations and send them to the network, and continuously monitor network status information to observe whether the user's intent is fulfilled or not. If the IBN detects that the intents are not realized, the system will retranslate the user's intents through artificial intelligence and automation technology to satisfy the user's intents to the greatest extent.

The implementation steps of the IBN are as follows: intent acquisition, intent translation and verification, strategy delivery and execution, optimization and adjustment and real-time results feedback. Among those steps, the acquisition and the translation of intent involves technologies such as natural language analysis and recognition and artificial intelligent strategy selection. The intent verification involves format verification methods and automated network verification, and the delivery and execution of the intent can be realized through varied network protocol, data plane programming language or other related technologies. The following figure illustrates the basic implementation process of the IBN.

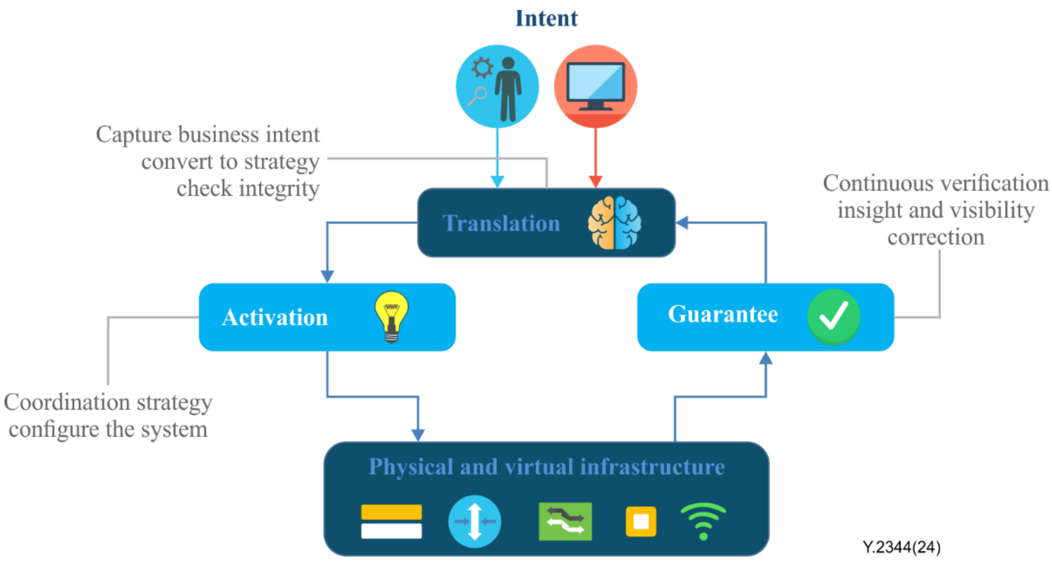


Figure 6-1 – Implementation process of the intent-based network

In [ITU-T Y.2323] and [ITU-T Y.2324], a network evolutional architecture with orchestration has been described thoroughly, where the network resource could be optimized and innovative services could be realized via an unified orchestration system. IBN would also depend on such infrastructure to implement its capabilities, and with some emerging technologies such as machine learning and artificial intelligent.

NOTE – This Recommendation is focusing on the adoption of the IBN in next-generation network evolution environment, and the related terminologies used in this Recommendation are aligned with ITU-T next generation network evolution (NGNe) Recommendations.

7 Framework of the intent-based network for network evolution

The framework of the IBN for network evolution includes three layers, the intent layer, control layer and network layer. Figure 7-1 illustrates the framework of the IBN.

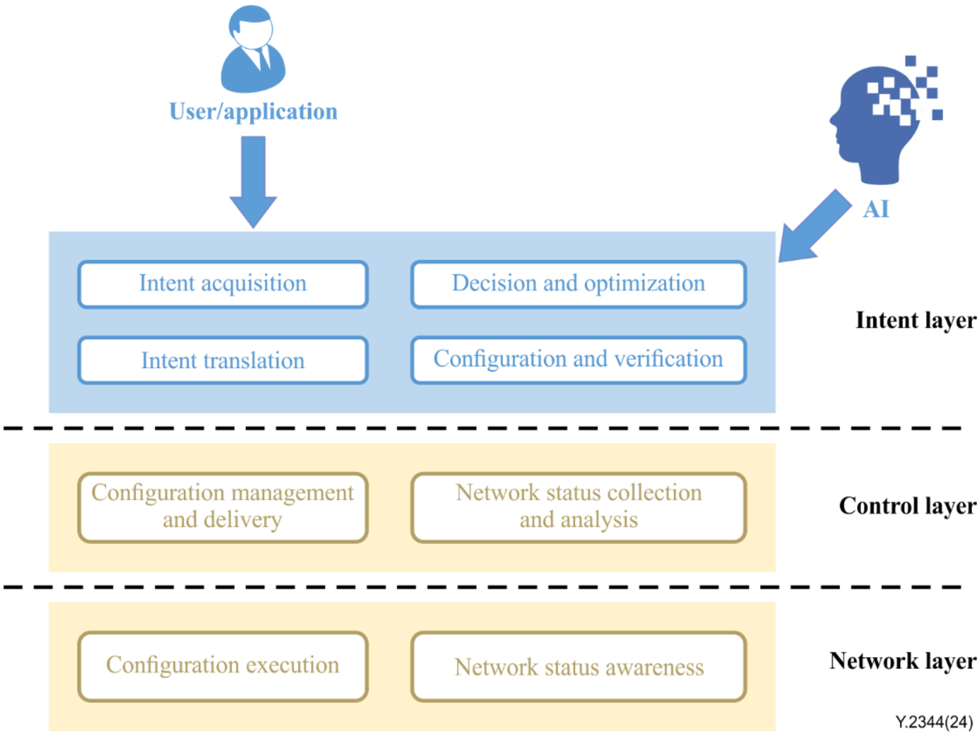


Figure 7-1 – Framework of the intent-based network

In the IBN, the intent could come from the network providers, users or services and applications. As a result, those different roles or identities require different levels of abstraction of their intents. In the context of this document, the word "user" represents all the individuals who put forward the demand, including the network providers, network administrators, network users and network services or applications. Furthermore, in the context of this document, the word "network instance" refers to an intent-based service of network slicing.

The IBN is able to configure all types of IBN instances. It translates intents from users' input, so as to obtain corresponding requirement information for the configuration of instance parameters, and creates network instances based on the requirement information of instance parameter configuration, and creates corresponding intent instances for users. IBN could also create associated relationships between the network instances and the intent instances. Therefore, it obtains the requirement information of instance parameter configuration based on the network instance and then operate the corresponding configuration of network instance.

In addition, the network instances are managed based on IBN during their full lifecycle. The IBN analyses natural language information from users' input to obtain corresponding network intent requirements. It creates network instances based on the requirement information of network intents and creates network intent instances in the instance repository based on the requirement information of network intents. Instance repository is used to store the intent instance. IBN could also provide the feedback of network status to users via the KPI monitoring interface and obtains updated information of users' inputted network intents or instructions for the network status information. When IBN obtaining the updated information, it creates a new network intent instance in the instance repository based on the updated information of network intent requirements and then replace the original network intent instance. Based on the network intent instance, IBN obtains the information or updated information of network intent requirements, and then predicts the network performance based on the collected real-time data of network status and the obtained information or updated information of network intent requirements. If it is predicted that the network performance will not satisfy the user's requirements, a modification policy of network instance configuration will be generated for changing the network instance. The term "policy" used here is aligned with NGNe related Recommendations.

The intent layer includes four key capabilities such as intent acquisition, intent translation, intent configuration and verification, decision and optimization. These capabilities cooperate with the configuration and distribution capabilities of the control layer, and the configuration execution and status awareness capabilities of the network layer to achieve a complete closed-loop operation process. In addition, AI will empower the intent layer, assist the modules in the intent layer and optimize the decision.

The intent layer is responsible for processing the user's intents. First of all, it obtains the user's intents and maps the intents with some reasonable network configurations or policies, then it verifies the enforceability of these configurations. After verifying that the corresponding policy could be implemented in the network, the intent layer will send the feedback information of successful verification to the users and next deliver the configuration to the control layer. As a consequence, the control layer will distribute the configuration to the network layer to complete the implementation of the intents and provide network state feedback information to the upper layers.

Furthermore, the intent layer also has the responsibility of verifying the effectiveness of the implemented strategies which have been generated by translating the intent, and the real-time feedback information of the global network state is required to be transmitted through the network layer and the control layer. The intent layer will repeatedly verify the effectiveness of all related strategies, to ensure that the user's intent is effectively processed and realized. In the IBN, the user's intent does not interact with the control layer directly but distributes and receives feedback information through the intent layer indirectly.

8 General requirements of intent-based network for network evolution

The intent layer of IBN is required to support the analysis of the user's intent, and formulate reasonable network strategies to distribute them to the control layer. The intent layer is required to connect with the control layer, so that the business requirements do not need to communicate with the control layer directly. The intent layer is required to obtain the real-time global network state information, and judge whether the intent is successfully realized based on the analysis results. The intent layer is also required to further consider and optimize the corresponding network configurations, including how to increase the network resources utilization rate and manage the whole network in a more efficient way.

The control layer of IBN is required to assist the intent layer to control and distribute the network configurations, and to collect or send feedback of the network status information in real time. The control layer is required to connect with the intent layer, and it is required to provide configuration distribution interface and information feedback interface to interact with the intent layer, in order to provide the ability of intelligent network to users through the intent layer. The control layer is also required to connect with the network layer, and it is required to support controlling and adjusting the network devices of the network layer to meet the intent of users.

The network layer of the IBN is required to receive and execute the network configuration commands from the control layer, and to collect the network status information. The network layer is required to support some specific capabilities, including the ability of configuration execution, QoS adjustment, traffic scheduling, performance monitoring and statistics, etc.

9 Capability requirements of intent-based network for network evolution

9.1 Capability requirements of intent layer

The intent layer is responsible for the detailed analysis of the user's intent, and generate reasonable strategies to distribute to the control layer. The intent layer is connected with the control layer, and in order to support the smooth operation of the intent layer, it is required to provide at least the following capability requirements:

- To analyse and translate the user's intent, including the detailed analysis of the user's intent, and verify the rationality.
- To report processing results to customers, including the intent processing results, the configuration execution results and network status changes.
- To configure or verify the user's intent, including configuration executable verification and validity verification.
- To store network status information and user's intent information.
- To exchange information and communicate with the control layer.

9.2 Capability requirements of the control layer

The control layer is responsible for assisting the intent layer to distribute the configuration, and collect and feedback the network status in real time. The control layer is required to support the following capability requirements but not limited to:

- It is required to provide a capability to control and distribute network configuration, including access control, bandwidth management, QoS level adjustments, security control, energy consumption control, etc., which can support the open interface with the intent layer, and make the configuration of the intent layer able to be distributed and adjusted smoothly.
- It is required to provide a capability to perceive the state information of the network from the network layer and feed back the status information to the intent layer.
- It is required to provide a capability to allocate and optimize network resources under different network environments such as NGNes, SDN enabled networks and NFV enabled networks.
- It is required to provide a capability to manage conflicts and maintain the configuration consistency among different layers, when any inconsistency in the strategies of different capabilities occurs.

9.3 Capability requirements of network layer

The network layer is responsible for performing the configuration execution, performance monitoring and statistics of the network layer. Therefore, the network layer is required to support at least the following capability requirements:

- To perform configuration execution. Through the control protocol between the control layer and the network forwarding device, the network layer receives the result of configuration control functions and performs configuration forwarding and processing, such as marking, packet loss and entering the QoS queue.
- To perform traffic scheduling. The network layer is required to complete the execution of the traffic scheduling strategy, support flow based programmable scheduling and realize the forwarding path scheduling of different flows through the output, push tag or pop tag and set field in the action operation of the flow table.
- To collect and report network status information. It is required to support the collection of network topology information, network traffic information and traffic path information.
- To exchange information and communicate with control layer.

10 Workflow of intent-based network

10.1 Intent instantiation

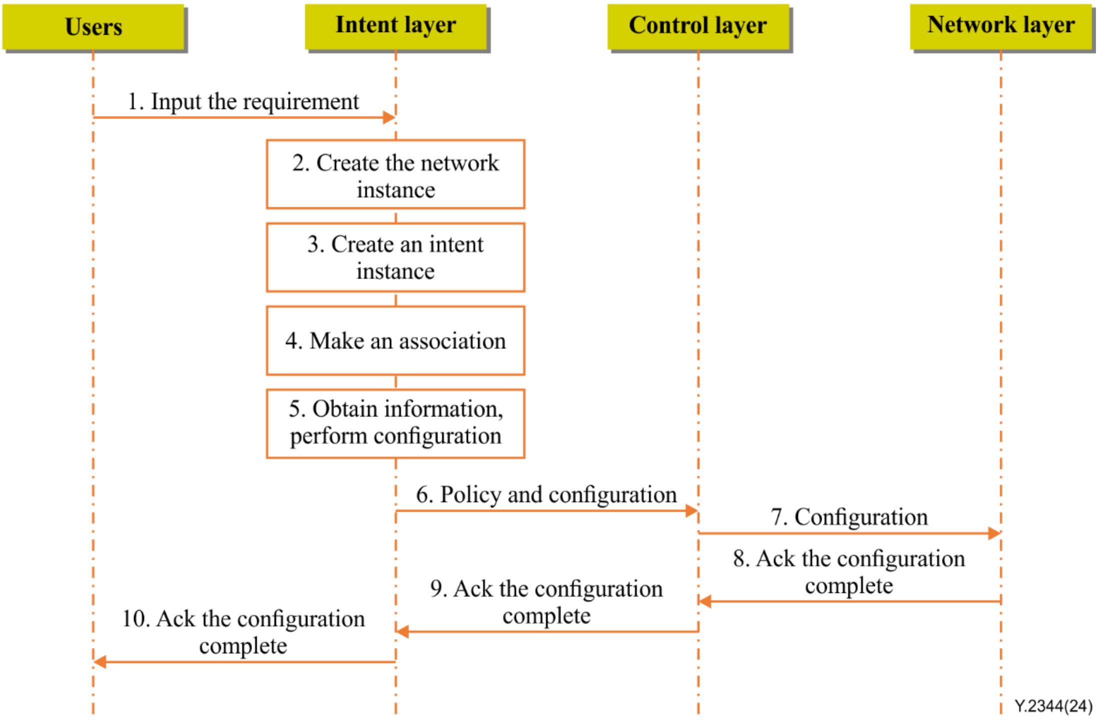


Figure 10-1 – Intent instantiation information flow

The main steps for intent instantiation are, in order:

1. Input the users' intent requirement information.

2. Translate the intent requirement information of users' input, obtain the corresponding business parameter configuration requirement information and create a network instance based on the requirement information of the network parameter configuration.

3. Create an intent instance corresponding to the user.

4. Establish the corresponding relationship between the network instance and the intent instance.

5. Obtain network instance parameter configuration requirement information based on the network instance, and perform the corresponding network configuration.

6. Send the policy and configuration to the control layer.

7. Send the corresponding configuration to the network device.

8. Send the execution result to the control layer.

9. Send the execution result to the intent layer.

10. Send the execution result to users.

10.2 Update intent instance

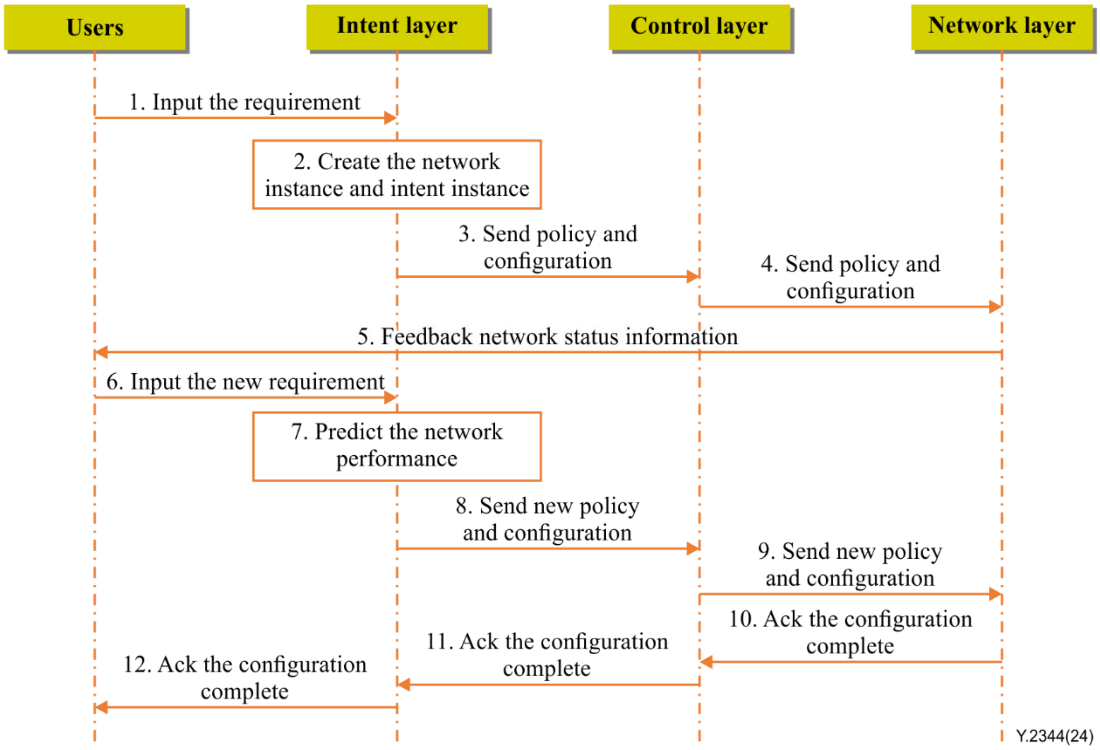


Figure 10-2 – Update intent instance information flow

The main steps for updating intent instance are as follows, in sequence:

1. Input the requirement to the intent layer.

2. Analyse the natural language information that has been input by users and obtain the corresponding network intent requirement information. A network instance is created based on the network intent requirement information, and a network intent instance is created in the instance depository based on the network intent requirement information.

3. Analyse users' requirements, and translate requirements into the network configuration and policy. The intent layer sends them to the control layer.

4. Send the related configuration to the network layer.

5. Feedback network status information to users through the related KPI monitoring interface.

6. The user inputs the new information. Obtain the network intent updating requirement information or receiving instructions of the network state information.

If the user inputs the intent updating information, a new network intent instance is created in the instance repository based on the updated information of the network intent requirement, and the original network intent instance is replaced.

7. According to the network intent instance, the network intent requirement information or the network intent requirement update information can be obtained. The network performance can be predicted based on the collected real-time network state data and the network intent requirement information or the network intent requirement update information. If the predicted network performance cannot meet the user's requirements, the network configuration modification policy is generated to change the network instances.

8. Analyse users' new requirements, and translates the new requirements into the network configuration and policy. The intent layer sends them to the control layer.

9. Send the policy and configuration to the network layer.

10. Send the execution result to the control layer.

11. Send the execution result to the intent layer.

12. Send the execution result to users.

11 Security considerations

The main aspects of security considerations of IBNs are aligned with those of NGNe and NICE. Furthermore, to consider the centralized structure of the IBN, it is required to support the following additional features:

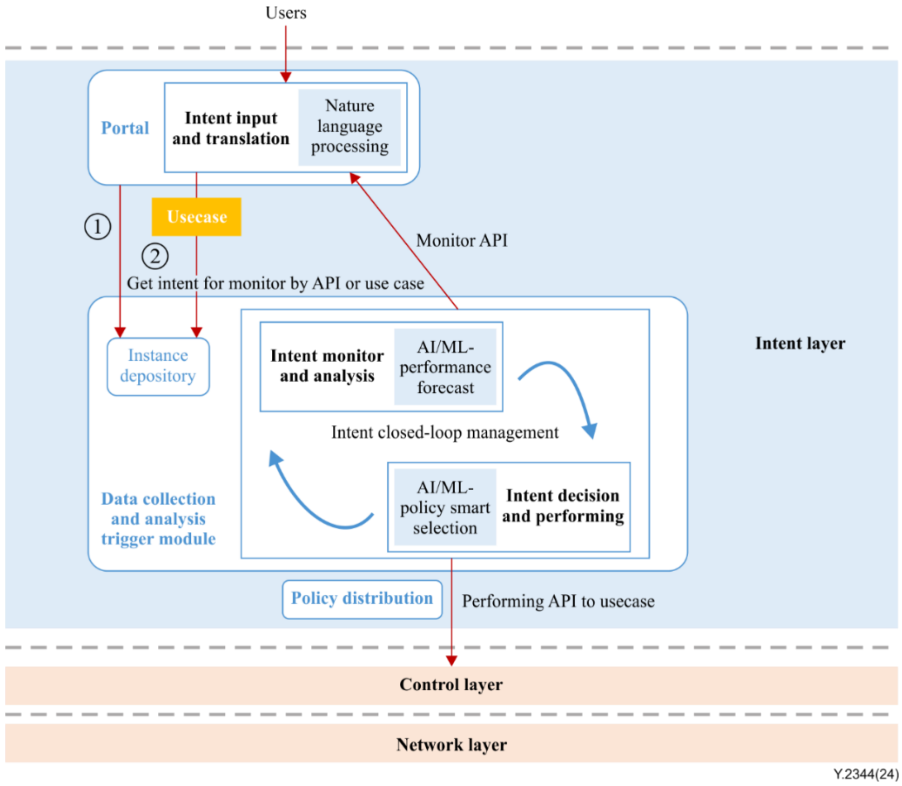
- Enhanced single point failure protection, because the input in the IBN could interact with the control layer and network layer, therefore any problems of IBN might become a widespread network failure which could affect millions of users.
- Secure mechanisms to ensure any configurations sent to the IBN could only be generated by authorized parties to prevent malicious attacks.
- Secure and detailed log analysis system to provide the history of all configurations and operations conducted by IBN in order to record and detect any unusual actions.

Annex A

Use cases of intent-based network

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

A.1 Guarantee scheme of E2E services support by IBN

Description	With the advancement of technology, the network is evolving in a more intelligent and understanding way. To ensure that the network can execute network policies according to the intent of users, real-time perception and interaction with upper-level users' intents are very important. The intent layer can be viewed as the intent orchestration layer. The intent layer is connected to the business layer, from which business information can be obtained for analysis and processing, and then the intent layer can deliver the network instructions to the network layer. This use case is oriented to the network configuration delivery scenario, and it provides an implementation solution to realize the end-to-end user intent guarantee, which can realize the perception interaction and guarantee of the upper-level user's intent. By introducing the intent instance ID and associating it with the network instance ID, it realizes the closed-loop monitoring and analysis of end-to-end business services. At the same time, it realizes the network status information and requirement interaction with end users and network operation and maintenance personnel through the KPI monitoring interface. By introducing an end-to-end user intent guarantee device, IBN integrates the existing network closed-loop monitoring system to realize the real-time perception, interaction and guarantee of users' intent.  **Figure A.1 – Use case of guarantee scheme of E2E services support by the IBN** The following three modules are involved: • User interaction module:

	The main function of this module is intent input and translation, which is used to analyse the natural language information input by users and obtain the corresponding network intent requirement information. A network instance is created based on the network intent requirement information, and a network intent instance is created in the instance depository based on the network intent requirement information. This module is used to obtain natural language information of users, analyse network intent requirements, select two kinds of intent instance creation interfaces according to business request, and deliver user intent to the data-collection and analysis event trigger module and create intent instances in the instance depository. It receives the network status information provided by the data-collection and analysis event trigger module through the KPI monitoring interface to obtain the update information of network intent requirement input by the user or the receiving instruction of the network status information. • Data-collection and analysis event trigger module: This module supports the intent closed-loop management function based on the intent instance, including: 1. Intent monitoring and analysis, which is based on real-time network status data and the user's latest network intent to realize the prediction of network performance. It is used to feedback network state information to users through the KPI monitoring interface, and obtain the update information of network intent requirement input by users or receive instructions for the network state information. Among them, a new network intent instance is created in the instance depository based on the updated information of the network intent requirement, and the original network intent instance is replaced. According to the network intent instance, the network intent requirement information or the network intent requirement update information is obtained. The network performance is predicted based on the collected real-time network state data and the network intent requirement information or the network intent requirement update information. 2. Intent decision and performing, which is used to determine if the predicted network performance cannot meet the user's requirements, the network configuration modification policy is generated to change the network instances. • Policy issuance and execution module: This module provides change strategy for business use cases, and the business use case invokes the strategy to change and issuance the related configuration.
Operational flows	The intent instance ID and network instance ID are associated to realize the closed-loop monitoring and analysis. At the same time, the KPI monitoring interface is used to realize the network status information interaction with end users and network operators. After obtaining the user's intent in the user interface, the system can create an intent instance. At the same time, according to the design and usage requirements of the business use case, the following two intent instance creation methods and processes can be enabled: A. Independent intent instance pattern • After translating the intent of users into the business parameters, the system creates the network instance. • Extract the network instance ID in the intent translation module. • Create an intent instance ID and associate it with the network instance ID. • Deliver the intent instance creation requirements to the instance depository to complete the creation of intent instance. • Data-collection and analysis event trigger module acquires the intent instances in the instance depository and monitors the intent. B. Business use case invocation pattern • After translating the intent of users into business parameters, create network instances through the business creation process, and the creation of intent instance is triggered at the same time, and the intent instance ID is generated for the business use case to invocate.

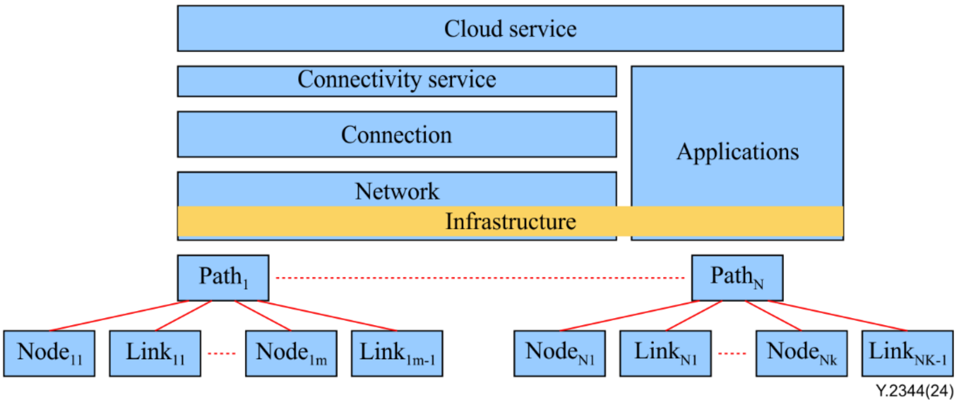
	• Network instances can use the instance depository open interface to create intent instances, and associate the intent instance ID with the network instance ID. • The data-collection and analysis event trigger module acquires the intent instances in the instance depository and monitors the intent. The above two intent realization methods can be selected by business use cases in the design state functional components. Complete the creation of the intent instance through one of the two intent instance creation methods and interfaces provided above (the design function component provides the selection function), bind the synchronously created network instance ID, and store it in the instance depository. The data-collection and analysis event trigger module retrieves the intent instance in the instance depository, and monitors the user's intent requirements based on the intent instance in synchronization with the existing network information. If the existing network performance cannot meet the user's intent, the business modification can be completed; at the same time network instance ID should be updated and the related parameters are synchronized. If the system needs to interact with the users, it can use the existing KPI monitoring interface. This use case provides two interfaces for the intent instance creation, which can realize intent instance creation and closed-loop operation independently, or integrate intent instances by business use cases for intent closed-loop monitoring. At the same time, this use case provides a method to guarantee the end-to-end user intent, which is used to realize the perceptual interaction and guarantee of the user's intent.

A.2 Business intent implementation method support by IBN

Description	Network technology makes it possible for users to differentiate SLA protection. At the same time, the closed-loop management function of IBN is suitable for various network scenarios. Therefore, Here provides an IBN implementation method for the network business.
Operational flows	The configuration device based on users' intent, mainly including the following modules: Intent requirement input and mapping module This is used to translate and process the intent requirement information of users' input, and obtain the corresponding business parameter configuration requirement information. Create a network instance based on the requirement information of the business parameter configuration, and create an intent instance corresponding to the user. The module is also used to monitor whether the user inputs new intent requirement information by using the intent instance. If so, the new intent requirement information is translated to obtain the corresponding new business parameter configuration requirement information. The module can send corresponding feedback information to users if the intent instance is used and the network state feedback information is used to judge that the network performance does not meet user needs or the network application cost changes. And the network state feedback information includes: real-time traffic, delay, jitter. Business isolation and intent instance module This is used to establish the corresponding relationship between the network instance and the intent instance. This module is also used to modify the business parameters corresponding to the network instance or replace the network instance according to the new business parameter configuration requirement information and the corresponding relationship. Intent configuration mapping and delivery module This is used to obtain business parameter configuration requirement information based on the network instance, and perform the corresponding business configuration.

	The main functionality of this module is to map network instance parameters to network configuration policies, generate network business configuration information and send the network business configuration information to the corresponding network system. The module is also used to obtain the configuration requirement information of the new business parameters based on the network instance and carry out the corresponding business configuration processing if the business parameters corresponding to the network instance are determined to be modified or the network instance is replaced. The module can monitor the running state of the network system and generate the network state feedback information corresponding to the intent requirement information. In general, the intent includes: individual user intent, service provider intent, network operator intent; intent requirement information including Network service quality requirements and basic network configuration information. Among them, the network quality of service requirements includes: network bandwidth, delay, reliability. The basic network configuration information includes: user location area information. Different elements of intent can be classified and mapped. Different element can be mapped to different intent instances. In the IBN, the intent layer can be connected to the upper system and send feedback in real time. When the requirements cannot be met, it will send feedback to the upper system and the staff will handle it.

A.3 Connectivity and cloud services support by IBN

Description	Recent developments in networking and services technologies increased number of choices for users and complexity of networks and services. In parallel to these developments, there has been substantial effort in the industry to enhance user experience with services. The enhancement of user experiences is tightly coupled with mapping of user intents to services by shielding customers from the complexity and by automating management processes. This use case describes user intents for wireless and wireline connectivity and cloud services, mapping user intents into all capabilities of connectivity and cloud services, and the design process. In this use case, services are modelled as connectivity services and cloud services as depicted in Figure A.2. Connectivity services are built over logical connections supported by network paths. The paths are formed of nodes such as switches and routers and physical links. Applications are built over infrastructure supporting both network and applications.  **Figure A.2 – Service modelling** This use case describes the process for mapping of user intents to services and designing services based on intents as shown in Figure A.3. The detailed description of the flow is provided in the following section.

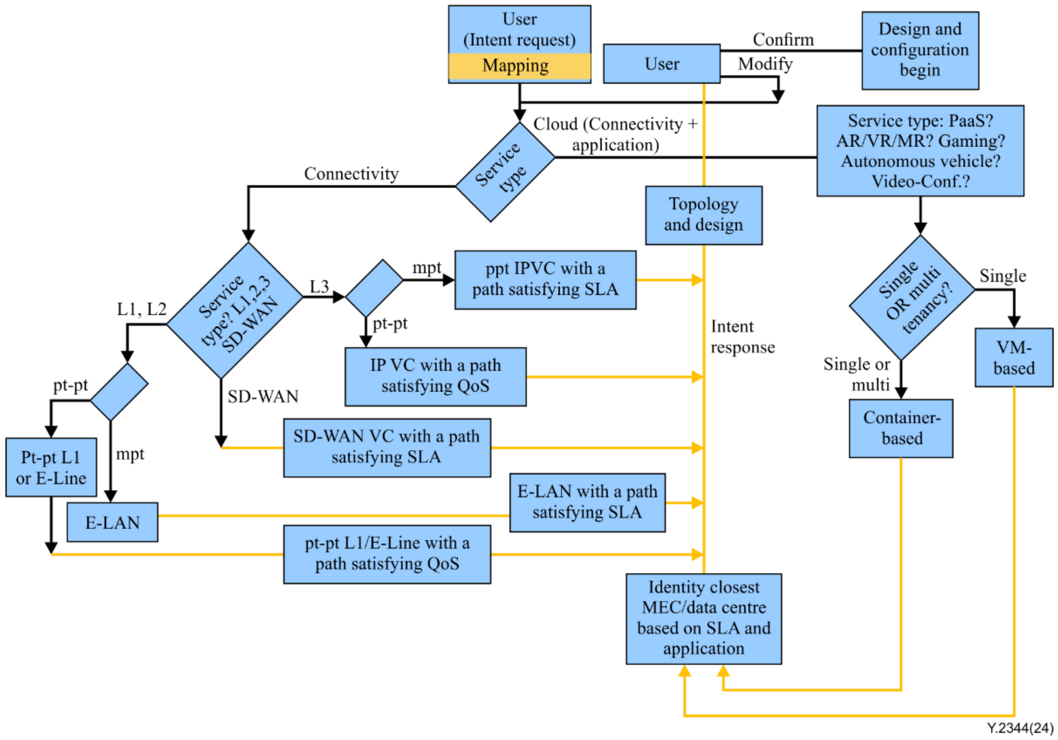
<table>
<tr><td></td><td>


Figure A.3 – A process for mapping user intents to services
</td></tr>
<tr><td>Operational flows</td><td>
1. User inputs for intent identification
We can identify user intents as below:
a. Service type = {connectivity ∩ application ∩ (connectivity and application)}
b. Location-Connectivity = {location (s) requiring WAN connectivity ∩ location (s) requiring LAN connectivity ∩ (location (s) requiring LAN and WAN connectivity)}
c. Location type= {(number of locations ≤ 2) ∩ (number of locations > 2)} U {(location type is commercial building) ∩ (location type is campus) ∩ (location type is stadium) ∩ (location type is factory) ∩ (location type is mobile)}
d. Security= {high security ∩ (medium to low security)}
e. Availability = {high availability ∩ (medium to low availability)}
f. Service level agreement (SLA) = {(SLA with delay, jitter and loss constraints) ∩ Best Effort}
g. Application name
h. Application tenancy = {single or multi-tenancy}
i. Network slicing = {Yes or No}
j. Elasticity = {Yes or No}
k. Billing = {usage-based ∩ fixed ∩ per-transaction}
From above, the complete user intent can be expressed as:
User intent = {Service type U Location-connectivity U Location type U Security U Availability U SLA U Application name
U Application tenancy U Network slicing U Elasticity U Billing}
where U represents "AND" function and ∩ represents "OR" function.
2. Connectivity service design choices based on intent
The next step is to map the user intent to connectivity services and cloud services consisting of connectivity and applications.
As an example, Table A.1 maps some of the user intents into connectivity services. The user intents in Table A.1 are:
High security
</td></tr>
</table>

High availability

a. Best effort
b. SLA
c. Service type = connectivity
d. Location type-Commercial building
e. Location connectivity – LAN connectivity
f. Elasticity
g. Network slicing

These intents are mapped into the following connectivity services in Table A.1:

a. SD-LAN (software-defined LAN)
b. LAN-wired
c. LAN-wireless
d. LAN-Wi-Fi

In order to map intents to connectivity services, for a given intent, each option is ranked as the first, second or third choice. For example, SD-LAN can be considered the first choice for a high security and SLA compliant LAN connectivity services. All services can support elasticity or network slicing.

Table A.1 – An example mapping of user intents to connectivity services

Connectivity service	User intents				
	High security	High availability	Best effort	SLA	Location type-commercial building/w LAN connectivity
SD-LAN	1st choice	1st choice with redundant path	N/A	N/A	1st choice
LAN-wired	2nd choice	1st choice with redundant path	N/A	N/A	2nd choice
LAN-wireless	2nd choice	2nd choice	N/A	N/A	2nd choice
LAN-Wi-Fi	3rd choice	2nd choice	N/A	N/A	3rd choice

3. Cloud service design choices based on intent

A cloud service has both connectivity and application components. Table A.2 provides an example of mapping applications to cloud services. An application name along with SLA in addition to user intents for connectivity services are considered the user intents for cloud services in this example.

For example, an AR/VR/MR (augmented reality/virtual reality/mixed reality) cloud service requiring high security and availability with tight SLAs for applications could choose network slicing that does not use Internet for connectivity.

Table A.2 – An example mapping of user intents to cloud services

Cloud Services	AR/VR/MR		Gaming		Video conferencing	
	Best effort	Support SLA	Best effort	Support SLA	Best effort	Support SLA
Connectivity (non-Internet)+ Application	2nd choice	2nd choice	2nd choice	2nd choice	2nd choice	2nd choice
Network slicing+ Application+ Non-Internet for connectivity	3rd choice	1st choice	3rd choice	1st choice	3rd choice	1st choice
Connectivity (Internet)+ Application	1st choice	3rd choice	1st choice	3rd choice	1st choice	3rd choice

4. Service design process

The process for mapping of user intents to services and designing services based on intents is depicted in Figure A.3. The intents entered from a user portal or a user interface application programming interface (API) are mapped to a service type

	(i.e., connectivity service or cloud service). With intents additional to those described in Section 1, a connectivity service or a cloud service is identified. The service is designed. The service topology is passed to the user for feedback. If the user intent is not met, the process is repeated. The intended connectivity service, based on inputs in Section 1, is identified as LAN, L1, L2, L3 or SD-WAN. Depending on connection type and locations, it could be a point-to-point or a multipoint connectivity service. The next step is to determine quality of service (QoS) constraints from the intended SLA and identify connectivity paths accordingly. If the intended service is a cloud service, its connectivity segment can be determined as above. Its application segment is determined based on an application name, whether it is VNF (virtual network function) or CNF (cloud native network function), whether it is for single tenant or multitenants, etc. In order to satisfy the QoS for applications, the applications may be located at a data centre or a multi-access edge compute (MEC) location closest to the customer. At the end, connectivity and application segments of the intended service is combined and presented to the customer for feedback. The process is repeated as needed.

Appendix I

Typical scenarios of intent-based network for network evolution

(This appendix does not form an integral part of this Recommendation.)

I.1 Scenarios for online shopping

Since the network provider is responsible for facilitating high-quality traffic for online shopping services, it will provide reliable service guarantees during certain traffic peak periods, which requires the real-time monitoring of network status through the intent-based network (IBN), prediction of the future state of the network and timely adjustments of network resources such as bandwidth. Figure I.1 illustrates the basic idea of this scenario.

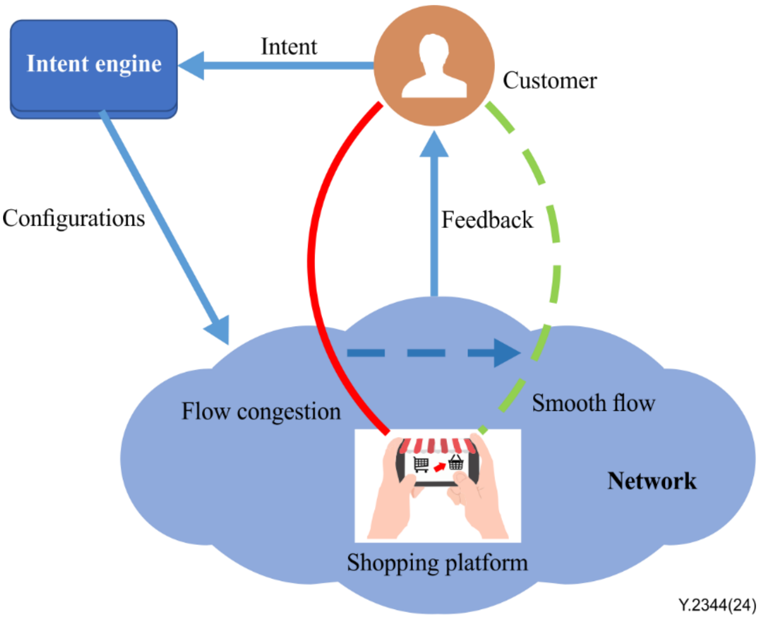


Figure I.1 – Example of online shopping scenario of IBN

In this scenario, the execution process of the IBN is as follows:

- Intent acquisition: The customers raise the intent to have a high-quality service during certain traffic peak periods, in order to guarantee the connection speed of some e-shopping applications.
- Translation and verification: Through the translation module of IBN, customer's intents are converted into specific network requirements, including bandwidth, delay and jitter. After translation, the network requirements need to be verified according to the availability of the network resource.
- Delivery and execution: After receiving and calculating the network status information, including the bandwidth, delay and jitter of each link of the network, the traffic path information will be sent to network controllers and network devices. Different paths will be selected under different traffic conditions.
- Optimization and adjustment: The system collects the network status information in real time. When the network status changes and it fails to mee' the customer's service requirements, the system will recalculate the traffic path, predict the network status after the flow adjustment. Then the new path and the relevant traffic configurations will be delivered to the controllers and network devices.

- Results feedback: The network will send the feedback to the control element of IBN based on the results of the intent execution, such as whether the network status meet the requirements of the customer after the strategy is executed.

For example, during the shopping festival, the network needs to enable a large number of customers to access the website through the shopping platform at the same time, and provides reliable network service during the peak traffic period for e-shopping customers by reserving bandwidth and expanding network capacity in advance. In order to meet the requests of customers to access the shopping platform smoothly, the IBN will provide more network resources to the links between customers and shopping platform during shopping festivals. In addition, the intent-Based Network will monitor the status of the network in real time. As shown in Figure I.1, if the flow congestion occurs, the intent-based network will make strategies to change the links between customers and shopping platform, based on the overall monitoring information of the network. According to the strategy made by the IBN, it will send the network configurations to the corresponding network equipment. Finally, the IBN will utilize the feedback based on the results of the intent execution, to further optimize its strategy with the assistant of AI engine.

I.2 Scenarios for the data centre

Nowadays, there exist a large number of important services and key data in the data centre. Therefore, network failures in the data centre will have a severe impact on services and related users. However, by adopting the IBN, the data centre can use the fault information and alarm information to predict potential failures and provide early warning to the administrator. Figure I.2 illustrates the basic idea of this scenario.

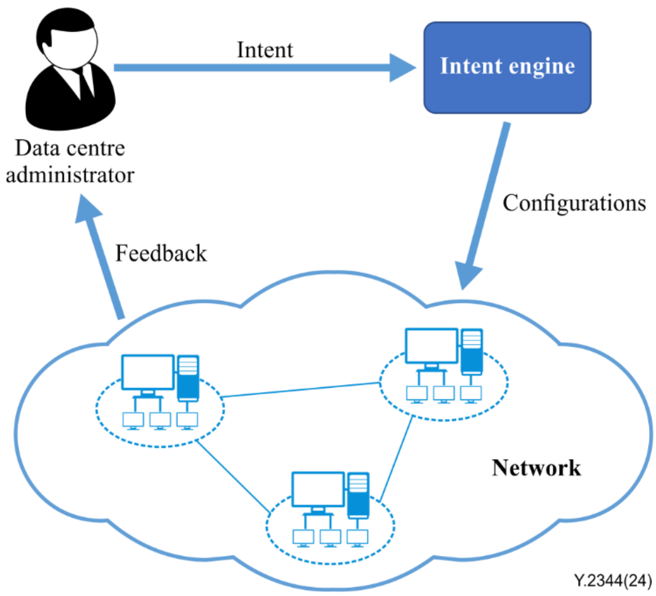


Figure I.2 – Example of data centre scenario of IBN

In this scenario, the execution process of the IBN is as follows:

- Intent acquisition: The data centre administrator first input the service requirements of the data centre into the relevant system of the IBN.
- Translation and verification: The translation module of IBN converts the service requirements into specific data centre requirements, including link availabilities, service availabilities and hardware availabilities.
- Delivery and execution: According to the data centre requirements which were translated from the intent of the data centre administrator, the IBN sends appropriate configurations to the relevant devices in the data centre and executes those commands.

- Optimization and adjustment: When a possible failure occurs or the IBN predicts such failure will occur, it can use related AI algorithms to give an early warning to the administrator and initiate an optimize plan.
- Results feedback: The network provides feedback on the results of the intent execution, generates the operation log and sends the results to administrator.
- For example: Network maintenance services of the data centre include alarm fault diagnosis and the early warning. By adopting the IBN, the network maintenance services process of the data centre is shown in Figure I.2. First of all, the network administrator raises its data centre intent. After obtaining the intent, the intent translation module of the IBN will have a certain understanding of the entire network based on the monitoring information of the network in the data centre, and then makes corresponding strategies by obtaining comprehensive network and service information. Then the faulty equipment can be accurately located based on the overall monitoring information of the network. Next, the intent execution module will deliver the corresponding configuration commands to the device according to the strategies such as calculating the flow of a path and perform automatic troubleshooting based on the location of the faulty equipment. Finally, the IBN will collect feedback of the results of the intent execution to confirm whether the intent of the administrator has already been achieved and further optimize its strategy with the assistant of AI engine.

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