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Recommendation

ITU-T Y.3656 (06/2023)

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

Big Data

Big data driven networking – mechanism of network service provisioning

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Recommendation ITU-T Y.3656

Big data driven networking – mechanism of network service provisioning

Summary

Compared with the traditional network, Recommendation ITU-T Y.3656 can provide better integration and more intelligent capabilities, such as the capabilities of self-optimization, self-configuration, and intelligent fault management, based on big data plane and its machine learning capabilities. This Recommendation can provide a significant enhancement to network service provisioning by using big data intelligence. This Recommendation specifies the network service provisioning mechanism in big data driven networking (bDDN).

History *

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T Y.3656	2023-06-22	13	11.1002/1000/15539

Keywords

Big data driven networking, mechanism, service provisioning.

* 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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NOTE

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1 Scope

This Recommendation specifies the mechanism of network service provisioning in big data driven networking (bDDN). This Recommendation includes:

- Overview of network service provisioning in bDDN;
- Functional entities of network service provisioning in bDDN;
- Mechanism of intelligent network resource scheduling and orchestration in bDDN;
- Mechanism of automatic service establishment and configuration in bDDN;
- Security considerations.

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.2704] Recommendation ITU-T Y.2704 (2010), *Security mechanisms and procedures for NGN*.

[ITU-T Y.3653] Recommendation ITU-T Y.3653 (2021), *Big data driven networking-Functional architecture.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 big data driven networking (bDDN) [b-ITU-T Y.3650]: Big data driven networking (bDDN) is a type of future network framework that collects big data from networks and applications, and generates big data intelligence based on the big data; it then provides big data intelligence to facilitate smarter and autonomous network management, operation, control, optimization and security, etc.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AR Augmented Reality

bDDN Big Data Driven Networking

BSS Business Support System

CPU	Central Processing Unit
eMBB	enhanced Mobile Broadband
IaaS	Infrastructure as a Service
mMTC	massive Machine Type Communication
NFV	Network Function Virtualization
OSS	Operating Support System
QoS	Quality of Service
SDN	Software Defined Networking
SLA	Service Level Agreement
uRLLC	ultra-Reliable Low-Latency Communication
VNF	Virtual Network Function
VR	Virtual Reality
WAN	Wide Area Network

5 Conventions

This Recommendation uses the following conventions:

In the body of this Recommendation and its annexes, the words 'should', and 'may' sometimes appear, in which case they are to be interpreted, respectively, as 'is recommended', and 'can optionally'.

6 Overview of network service provisioning in bDDN

6.1 Service characteristics in future networks

Compared with the traditional network, the future network will realize a very real "Internet of all things". In the future, the connection of the network will extend to the intelligent interconnection of things and people to things, so that communication technology can penetrate into a broader industry field. The future network will further develop richer and more diverse industry businesses, including telemedicine, vehicle networking, smart home, industrial control, environmental monitoring, etc., so as to promote the rapid growth of various industry applications. The future network service has the following characteristics:

Service diversity: The enhanced mobile broadband (eMBB) service focuses on services requiring high bandwidth, such as high-definition video, virtual reality (VR) / augmented reality (AR) services; ultra-reliable low-latency communication (uRLLC) service focuses on services sensitive to time delay and reliability, such as automatic driving, industrial control and telemedicine; massive machine-type communication (mMTC) service covers scenarios with high connection density, such as smart city and smart agriculture. These have completely different performance requirements for the network, and these diverse requirements are difficult to satisfy with a traditional network framework on the shared network infrastructure.

High performance: In the future, some service scenarios will often have high performance requirements. For example, VR/AR services have high performance requirements in terms of both bandwidth and delay. In the industry scenarios, end users are "machines", which are much more sensitive to the requirements of network performance than people. In a fully automatic driving scenario, if the data transmission delay and the reliability requirements are not satisfied, it will be difficult to truly realize a commercial use.

Rapid deployment: The deployment of a new service in a traditional network often takes several weeks or months, which makes it difficult to meet the needs of operators for rapid service deployment when providing services to industries.

Network slicing and security isolation: Network slicing is one of the key features of networking. The network provides different network slices for multiple tenants based on a set of shared network infrastructure. Each vertical industry customer will use the network in the form of sliced tenants, so the network slices providing services for tenants need to be safely isolated. This is very important to vertical industry. On the one hand, from the perspective of security, it is necessary to effectively isolate the data and information between tenants. On the other hand, from the perspective of reliability, network slicing and security isolation can prevent a network abnormality or failure of a tenant from affecting different tenants in the same network.

6.2 Overview of service provisioning in bDDN

Figure 6-1 shows service provisioning in bDDN. In order to meet the characteristics of services in the future network, bDDN uses the big data plane to realize intelligent resource orchestration, and realizes the rapid deployment of services through automatic full life cycle management of services. In bDDN, the application layer of the network plane is used to receive a customer's application request and provide network services. Then, the orchestration entity of the network plane is used to orchestrate and schedule the network resources according to the request of the application layer. bDDN can build multiple isolated virtual networks on the network infrastructure. By allocating different network resources and functional entities to different virtual networks, it can meet the differentiated requirements of bandwidth, delay, jitter and other quality of service (QoS) requirements in different service scenarios.

In order to achieve more flexible function deployment and service customization, network virtualization is the main trend of network architecture development. Network function virtualization (NFV) technology realizes network virtualization, which separates network functions from special hardware and virtualizes them into virtual network functions (VNFs). Under the constraints of network resources, virtual links between VNFs are deployed on the network physical infrastructure, providing end-to-end differentiated network function services. In the bDDN, NFV technology is used to realize the virtualization of network functions. The centralized control of the network is realized through the controller of the network plane, and intelligence is provided to the control plane and management plane through the big data plane.

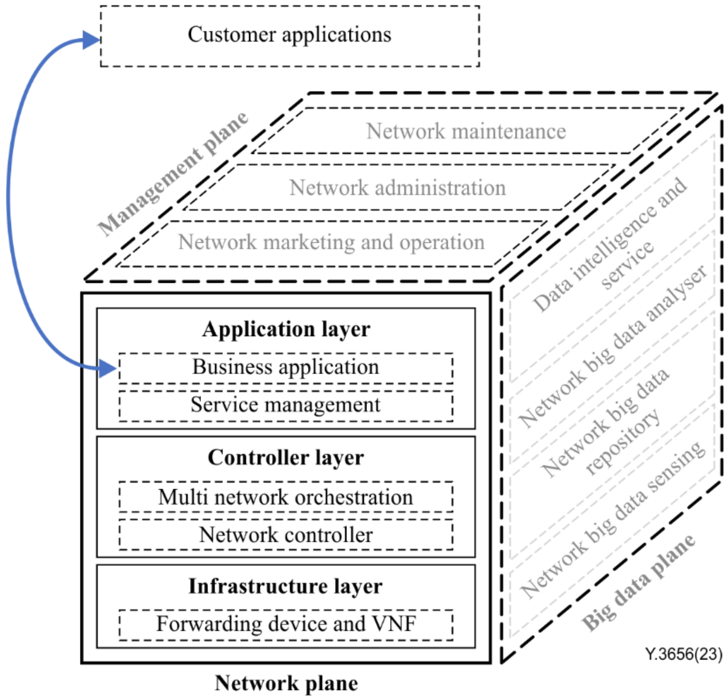

Figure 6-1 – Service provisioning in bDDN

The service management of the bDDN defines the workflow of service deployment, and then converts it into a standardized policy and sends it to the underlying network controller. According to the policy issued by the service management, the underlying network controller allocates and updates the network resources and network functions required by the service through the standardized interface. After the service deployment, the current network status is fed back to the big data plane. To improve the policy of network orchestration the bDDN makes use of the big data plane and management plane to continuously optimize the policy in the orchestration, so as to change the network orchestration from "automation" to "intelligence", and realize efficient, stable and rapid service deployment.

The service provisioning mechanism of bDDN is that bDDN uses the intelligence provided by the big data plane of bDDN to realize the automatic provisioning of network services and the automatic management of the whole life cycle of services. This mainly involves three aspects: functional entities of service provisioning, mechanisms of intelligent resource orchestration, and mechanisms of automatic establishment and configuration.

7 Functional entities of network service provisioning in bDDN

Figure 7-1 illustrates functional entities related to network service provisioning of bDDN. They can be divided into service provisioning functional entities and multi-domain resource orchestration functional entities.

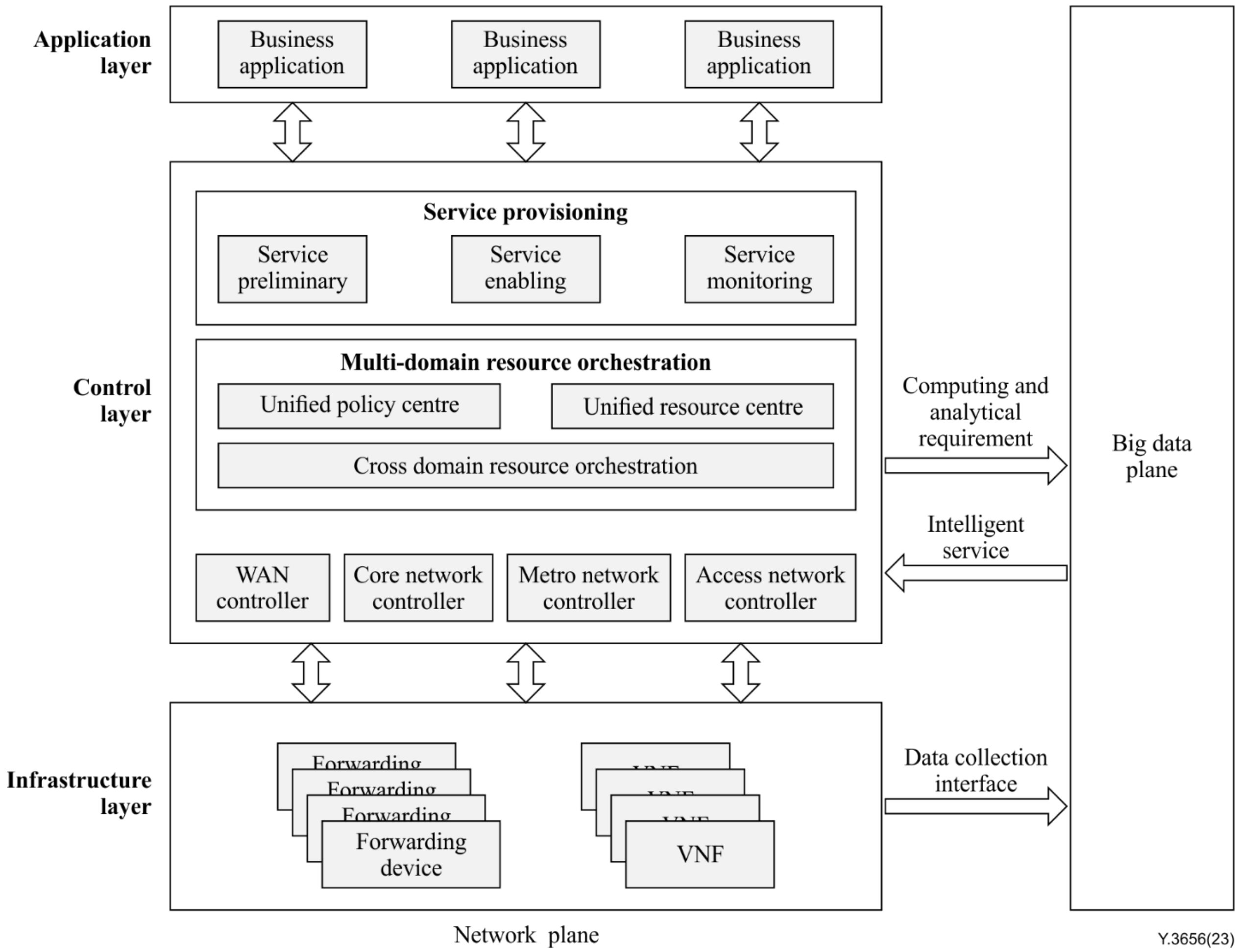

Figure 7-1 – Functional entities of network service provisioning

7.1 Service provisioning entity

Service provisioning functions consist of the components enabling bDDN network automatic management of the full life cycle of services. For this purpose, four functional entities are identified: The service preliminary entity, which handles the design, registration and verification of services. The service enabling entity is the functional block for network service deployment, configuration, start, termination, and resource allocation, etc. The service monitoring entity is responsible for monitoring the service execution environment and performance.

1) Service preliminary entity

The service preliminary entity is responsible for the design, definition of the service and development of the service provisioning procedure. It aims to facilitate the deployment and reuse of service provisioning, and automate the life cycle management of the service. The service preliminary entity can also easily add new functions, modify existing capabilities, and achieve continuous maintenance and improvement. Most of the automatic operation work of the network will be carried out on this entity.

2) Service enabling entity

It is responsible for the start, configuration, deployment and end of the service, and realizes the automatic management of the whole life cycle of the service. It will also realize service composition. Service composition is concerned with aggregating multiple services into a single composite service. The resulting composite services can be used as basic services in further service compositions or as complete applications to service consumers. The service enabling entity is concerned with the enabling of runtime service resources. Identification of the runtime resources allows service providers to describe service functionalities, publish service descriptions, and to find and bind available resources. However, the challenges are exacerbated by the heterogeneity of network technologies and functions, dynamic changing operating environments, e.g., fluctuating demand, mobility affecting core, transport, and access networks. The requirements for network service resource allocation are: i) Service conformance ensured by the integrity of heterogeneous resources; ii) adaptability to changing operation environments.

The service enabling entity also deals with the instantiation, life-cycle management and configuration of the services. In a network service domain, the services are built from constituting network functions, which are managed by different service providers. Configuration and monitoring therefore encompass broader orchestration, delegation of control and workflow management in accordance with network function providers.

3) Service monitoring entity

The service monitoring entity is the entity responsible for data collection and analysis. Its tasks include measuring and collecting of fault status, configuration information and other types of data from network elements and infrastructure. Through the analysis of the collected data, intelligent events are generated for other components by big data plane to complete the closed-loop control of services provisioning. It includes collectors for various data collection, analysers for evaluating data, and various micro-services for assisting data collection and analysis.

7.2 Multi-domain resource orchestration entity

The multi-domain resources orchestration entity is responsible for resource allocation and resource coordination of services across a domain. The multi-domain resources orchestration entity includes a unified resource centre, unified policy centre and resource orchestration entity.

1) Unified resource centre

The unified resource centre will unify management of the resource information in the domain and the relationship between resources and services.

2) Unified policy centre

The unified policy centre manages the corresponding policies of all services, including service resource policies, enabling policies, security policies, etc.

3) Cross domain resource orchestration entity

The cross domain resource orchestration entity is mainly responsible for cross-domain resource orchestration, including network connectivity resources, computing resources, etc. The cross domain resource orchestration entity will invoke the underlying internal resource orchestration entity to implement global resource scheduling.

8 Mechanisms of intelligent resource scheduling and orchestration in bDDN

8.1 Functional entities of resource orchestration in bDDN

The functional entities of resource orchestration for bDDN service across multiple administrative and technological domains are illustrated in Figure 8-1.

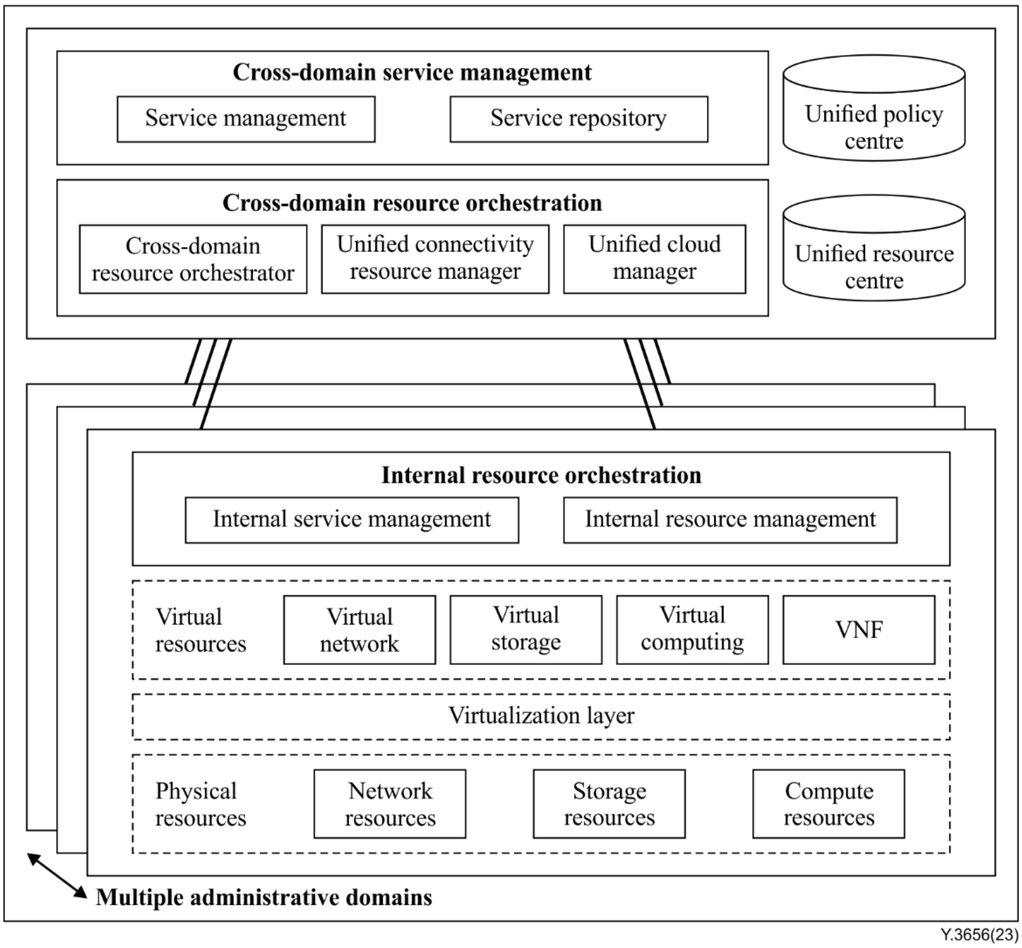

Figure 8-1 – **Functional entities of resource orchestration**

The functional entities of resource orchestration in bDDN includes three fundamental entities that are described below:

1) Cross-domain service management entity

The cross-domain service management entity is responsible for service management across the administrative domain with successfully admitted service requests. It consists of the following two main functional blocks:

- Service management block

  Service management handles incoming service requests from applications, e.g., service admission control and negotiation considering service aspects. It is also responsible for start and termination of a service.

- Service repository block

  bDDN collects service information and manages a global service repository. It also interacts with the operating/business support system (OSS/BSS) in order to collect application, policy and administrative information when handling service requests.

2) Cross-domain resource orchestration entity

The cross-domain resource orchestration entity decomposes a service request towards different administrative domains and decides on the combination of domains, including the cross-domain connectivity. It consists of the following three main functional blocks:

- cross-domain resource orchestrator

The cross-domain resource orchestrator is responsible for the cross-domain resource management, including start and termination of the service resource. The cross-domain resource orchestrator monitors, manages and controls the corresponding resources related to a service, while ensuring secure and trusted connectivity across administrative domains. It also serves as a manager among federated resources, carrying out domain specific resource allocation and re-adjustments to compensate potential performance degradation. When a cross-domain service is formed, the cross-domain resource orchestration achieves scalability by assigning a cross-domain resource orchestrator that is independent with domains.

- Unified cloud manager: the unified cloud manager performs computing, storage and other cloud resource allocation tasks with the help of a resource orchestrator. It also interprets and translates the performance capability description of heterogeneous cloud resources.
- Unified connectivity resource manager: the unified connectivity resource manager is responsible for establishment and management of connectivity across different administrative domains.

3) Internal resource orchestration entity

The internal resource orchestration entity interacts with the cross-domain resource orchestrator, allocating internal domain resources for establishing a cross domain federated resource. It also provides the corresponding life cycle management via the following functional blocks:

- Internal service management block

  The internal service management block analyses the resource request received from the cross-domain resource orchestrator and identifies the network functions. It also determines logical links characterized by bandwidth, delay, jitter, packet loss, etc. In return, it feeds the cross-domain resource orchestrator with service and performance capability information related to the underlying resources.
- Internal resource management block

  The internal resource management block identifies the appropriate network resource from an associated resource catalogue and forms a logical network resource graph. Such a graph is mapped to the underlying computing, storage and network resources corresponding to a specific technology. The internal resource management block is also responsible for the instantiation, enabling and management of the resource within the same administrative domain, and performing monitoring and modification related operations.

8.2 Cross-domain service resource orchestration mechanism

When a service request first arrives at the cross-domain service management entity, the service management block performs the admission control and negotiation with the requesting tenant considering the OSS/BSS policy and rules. It also analyses the service requirements selecting the appropriate domains before instantiating a cross-domain resource orchestrator for the new service. The service management block once authorized, programs the cross-domain resource orchestrator providing essential information related to the desired service type (e.g., SLA and policy).

Once the cross-domain resource orchestrator is initiated, the service management block provides the corresponding service decomposition details of the resource request. The cross-domain resource orchestrator relies on the unified cloud manager for guidance on interpreting the resource requirements related to VNFs. The cross-domain connectivity is established through the unified connectivity resource manager. Thereafter, the cross-domain resource orchestrator establishes a secure communication with each internal service management function in the relative administrative domain. It then provides service type specifics (e.g., SLA and policy) related to the corresponding service request. Each internal service management function in turn performs a mapping analysis to identify the network resources, i.e., network functions, value added service and connectivity, that correspond to certain technology sub-domains and then informs the internal resource management function. The internal resource management function selects the appropriate resource and creates the desired "service resource graph".

It then carries out the resource configuration towards the corresponding sub-domain by issuing a request towards the respective sub-domain network infrastructure and/or sub-domain specific network controller, which in turn needs to create the desired NFV, computing and connectivity resources. For the connectivity resource, the sub-domain network controller performs the necessary network configurations to establish the transport layer and related service chain.

A multi-domain service becomes operational when all domain-specific service resource and cross-domain connectivity are configured successfully. Once the resources are granted, an acknowledgement shall be returned to the tenant, also updating the service repository.

8.3 Policy based resource orchestration mechanism

In bDDN, more dynamics and autonomy are required. On the one hand, network elements have become more intelligent with flexible control and adaption. Such complexity in the network model and their possible compositions greatly increase uncertainty in network management strategies. On the other hand, new providers have emerged with increasingly open and horizontal network architectures, i.e., virtual mobile network operators, virtual network service providers, VNF providers, virtual infrastructure providers, alongside current service providers and network infrastructure providers.

The unified policy centre is the entity of bDDN that is responsible for maintaining, distributing and operating various policy rules. It provides a logical centralized environment for creating and managing policies, including conditional rules. The functions of the unified policy centre include creating and verifying policies and rules, identifying overlaps, resolving conflicts, and deriving additional policies as needed. Policy is used to control, influence, and help ensure that operations meet objectives. Policy can support infrastructure, service and operation automation, security, etc.

Network service resource orchestration is driven by both fluctuation of resource utilization and diverse provider's objectives, which form a policy hierarchy according to the network hierarchy. The policy hierarchy and network hierarchy as shown in Figure 8-2:

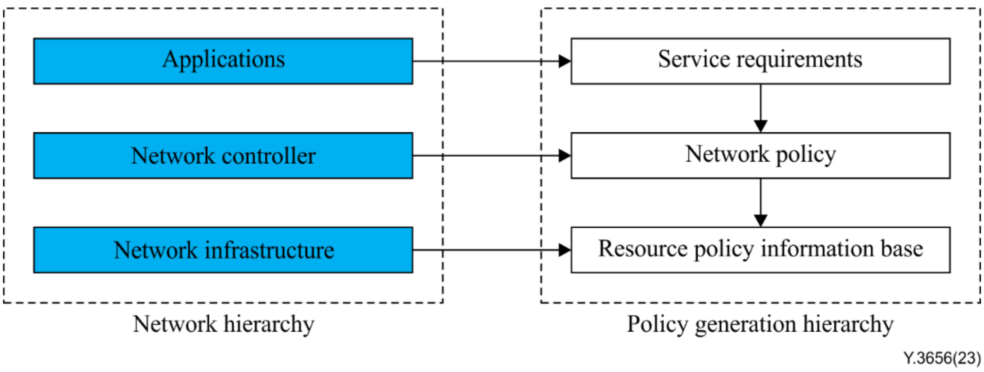

Figure 8-2 – Policy hierarchy and network hierarchy

As a result, while policy based autonomous network management is more relevant as an enabler for a future flexible network, it requires more autonomy in policy analysis and conflict resolution approaches. Figure 8-3 depicts the policy based resource orchestration mechanism for service provisioning. A policy based autonomous control procedure is realized in the framework.

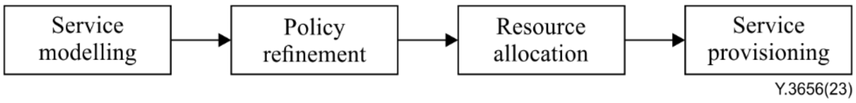

Figure 8-3 – Policy based resource orchestration mechanism for service provisioning

The mechanism allows service providers to provide formal service models at all levels of the policy hierarchy. Network services can then take advantage of the policy based autonomous composition and adaptation capability for self-adaption to changing demands and operation environments.

1) Service modelling

The service model management entity of big data plane establishes a formal abstraction service model in order to enable autonomous policy refinement and adaptation. The abstraction service model includes their respective entity models, policies and goals, conflicts and resolution strategies, among others. The policy hierarchy requires an abstraction model that can capture system and user behaviours, and facilitate autonomous policy refinement and adaptation. For this purpose, bDDN uses event calculus to create formal system models of each network layer, which support logical reasoning, i.e., deriving low-level policies required to fulfil a high-level goals, or identifying the causes to a conflicting state.

2) Policy refinement

The bDDN uses a logical reasoning approach for autonomous policy refinement and adaptation to cope with events in the policy hierarchy. Logical reasoning allows policy refinement and adaptation rules to contain only predicates for prerequisite and desirable system states, while intermediary operations and states are derived according to description logic semantics. Therefore, logic based policy approaches reduce the required knowledge about the managed systems and increase autonomy compared to static rule-based policy management.

There are two phases in this procedure. In the first phase, QoS-aware translation from the user's goals to resource requirements is required. Suitable resources are identified based on the facts in the resource centre. In the second phase, provisionally unavailable resources are recursively provisioned and additional service matching and optimization are applied. Matching of network services and resource objectives can be resolved. As a result, a set of resources are identified, which are used by the resource providers in their service provisioning procedures.

3) Resource allocation

In bDDN, the orchestration module in the network plane presented in [ITU-T Y.3653] schedules network resources according to the parsed modelling strategy, and provides customized network services on demand. The big data plane of bDDN brings great convenience for scheduling network resources when providing services. First, the big data plane can maintain a global network view and realize real-time and fine-grained data collection, providing sufficient network status data for machine learning. Second, the programmable network plane can carry out efficient network resource allocation and traffic scheduling, and realize the real-time distribution of optimization strategies by machine learning. The intelligent resource allocation of big data plane in bDDN mainly focuses on three aspects: network plane resource allocation, controller resource allocation and traffic scheduling.

- Network resource allocation

  The network resource allocation of bDDN is to maximize the resource utilization and scheduling efficiency of the network under the conditions of the service level agreement (SLA). In the network plane, network virtualization can realize the isolation of network resources, so that several user services can share a physical network. The allocation of network resources in the network plane is equal to resources allocated from the physical network to the virtual network according to the user's service requirements for topology, bandwidth, central processing unit (CPU), etc.

- Controller resources allocation

  Controller resources allocation is mainly to schedule the resources for the network controller from a higher level, so as to provide more efficient and stable control capability for the network plane. The controller needs to handle the control traffic of all devices connected to it, and needs to allocate appropriate computing resources and bandwidth resources to the controller.

  The distance between the controller and the network plane equipment will also affect the service processing efficiency. Therefore, the deployment of the controller should not only consider the load capacity of the controller itself, but also reasonably deploy the controller according to the equipment location and traffic of the network plane.

- Traffic scheduling

  Traffic scheduling based on big data plane mainly plans the traffic path by setting an optimized routing strategy to achieve lower end-to-end delays, load balancing or to maximize the utilization of network resources. The traffic scheduling algorithm in bDDN can be fully trained through the data collected by the controller to realize traffic prediction and routing optimization, and realize real-time and dynamic traffic scheduling.

9 Mechanism of automatic service establishment and configuration in bDDN

9.1 Automatic control loop of service provisioning

The bDDN enables the user to dynamically and on demand, create, modify and terminate services via the user's portals or applications. This is analogous to cloud-based services, such as infrastructure as a service (IaaS), where users can dynamically create, modify or terminate computing and storage resources. In summary, the goal of the service provisioning in bDDN, based on network as a service principle, is to enable agile service delivered across network domains.

The automatic provisioning capability of service is completed by the collaboration of several different components. The service preliminary entity is responsible for service design and testing. The service enabling entity is responsible for the configuration, deployment and enabling service. The service monitoring entity is responsible for monitoring, collecting and analysing the data of performance and failure. The service automatic control entity is used to control the whole service life cycle itself. The functional block is shown in Figure 9-1.

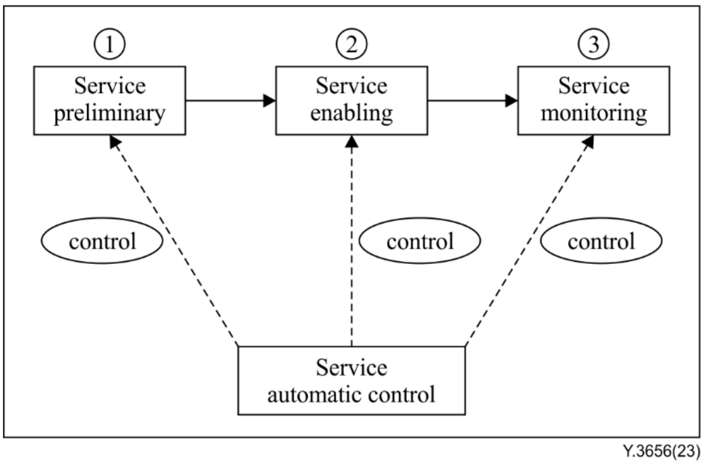

Figure 9-1 – Automatic control loop of service provisioning

Services in the bDDN rely on coordinated orchestration of distributed capabilities across potentially many networks and many domains to enable end-to-end management. Such orchestration is executed for the entire service lifecycle where each functional area of the lifecycle is further streamlined and automated, from service definition to service fulfilment, control, assurance, and billing.

9.2 Procedure of service provisioning in bDDN

In bDDN, the service is across many network domains from one or more network operators. These network domains may be operated by communications service providers, data centre operators, enterprises, wireless network operators, virtual network operators, or content providers. The service management encompasses all network domains that require coordinated end-to-end management and control to deliver service. Within each provider domain, the network infrastructure may be implemented with traditional wide area network (WAN) technologies, as well as network function virtualization (NFV) and/or other technologies.

Cross domain service provisioning involves service design procedure, service deployment procedure, online configuration procedure, closed-loop control, and so on. It needs to realize end-to-end resource orchestration and full life cycle automation and intelligent management. bDDN divides service provisioning into two stages: a preliminary stage and a provisioning stage. The preliminary stage completes the offline design of the network service model, and distributes the service model to the provisioning stage. The provisioning stage completes the resource scheduling of each domain, the enabling of service, including the interaction with the controller, and the automatic deployment of service. As shown in Figure 9-1, step 1 is the preliminary state, and steps 2 and 3 are the provisioning stage. All the steps 1, 2 and 3 are controlled by the service automatic control entity. bDDN will update the status data of service resources to the unified resource pool in real time. At the same time, the system starts to collect the performance and fault data of the service, and matchs the operation and maintenance strategy, so as to realize the automatic and intelligent network operation and maintenance. The service provisioning procedure is shown in Figure 9-2.

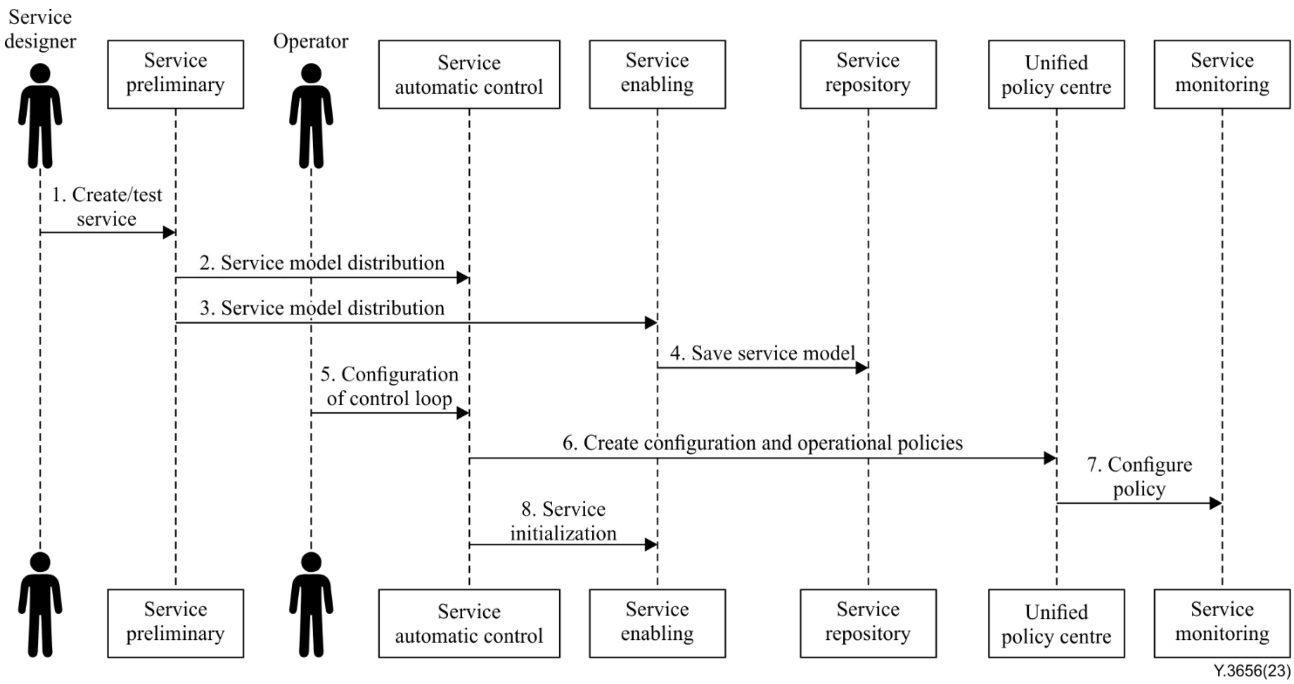

Figure 9-2 – Procedure of bDDN service provisioning

1. In service the preliminary stage, the service designer creates/tests the service, and loads resources.

2. Then, the service preliminary entity distributes the service model to the service automatic control module.
3. Meantime the service preliminary entity distributes the service model to the service enabling entity.
4. The service enabling entity is mainly responsible for service provisioning and management. It accepts and parses the service model from the service preliminary entity, and it saves the service information to the service repository database, including the related resource information.
5. The operator configures the control flow and parameters for service provisioning. This flow will automatically guide the service to realize the automatic configuration and provisioning.
6. The service automatic control entity creates the configuration and operational policy in the unified policy centre. This policy will be used in resource orchestration and monitoring of the service.
7. The service monitoring entity will monitor the real time status of service resource after service enabling.
8. The service monitoring entity of bDDN starts to collect the performance and fault data of the service resources, and bDDN provides the ability of big data analysis and closed-loop operation. bDDN adjusts the resources of the service in real time according to the dynamic usage of service resources.

10 Security considerations

When applying network service provisioning in bDDN, security best practices should be adopted such as authentication, authorization and access control and described in [ITU-T Y.2704].

In the meantime, operations related to network resources should have multiple reliability guaranteeing measures in order to avoid incorrect operation of network resources and causing the degrading of network performance.

Bibliography

[b-ITU-T Y.3650] Recommendation ITU-T Y.3650 (2018), *Framework of big-data-driven networking*

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