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Recommendation

ITU-T Y.2346 (12/2023)

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

Next Generation Networks – Enhancements to NGN

Requirements and framework of service function orchestration based on service function chaining

ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	Y.100-Y.999
INTERNET PROTOCOL ASPECTS	Y.1000-Y.1999
NEXT GENERATION NETWORKS	Y.2000-Y.2999
Frameworks and functional architecture models	Y.2000-Y.2099
Quality of Service and performance	Y.2100-Y.2199
Service aspects: Service capabilities and service architecture	Y.2200-Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250-Y.2299
Enhancements to NGN	**Y.2300-Y.2399**
Network management	Y.2400-Y.2499
Computing power networks	Y.2500-Y.2599
Packet-based Networks	Y.2600-Y.2699
Security	Y.2700-Y.2799
Generalized mobility	Y.2800-Y.2899
Carrier grade open environment	Y.2900-Y.2999
FUTURE NETWORKS	Y.3000-Y.3499
CLOUD COMPUTING	Y.3500-Y.3599
BIG DATA	Y.3600-Y.3799
QUANTUM KEY DISTRIBUTION NETWORKS	Y.3800-Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	Y.4000-Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.2346

Requirements and framework of service function orchestration based on service function chaining

Summary

Recommendation ITU-T Y.2346 provides scenarios, requirements, and framework of service function orchestration based on service function chaining. Based on user requirements, service function orchestration can realize function services deployment and dynamically adjustment on demand, and based on resource situation, it can realize resource optimization and load balance of service functions.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T Y.2346	2023-12-14	13	11.1002/1000/15733

Keywords

Architecture, framework, service function chaining, service function orchestration.

* 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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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Table of Contents

Recommendation ITU-T Y.2346

Requirements and framework of service function orchestration based on service function chaining

1 Scope

This Recommendation provides scenarios, requirements, and framework of service function orchestration based on service function chaining.

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).*

[ITU-T Y.2501] Recommendation ITU-T Y.2501(2021), *Computing power network – Framework and architecture.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 service function [b-IETF RFC 7665]: A function that is responsible for the specific treatment of received packets. As a logical component, a service function can be realized as a virtual element or be embedded in a physical network element. One or more service functions can be involved in the delivery of added-value services. A non-exhaustive list of abstract service functions includes firewalls, wide area network (WAN) and application acceleration, deep packet inspection (DPI), lawful intercept (LI), server load balancing, and so on.

3.1.2 SFC (service function chaining) [b-IETF RFC 7665]: SFC is used to describe the definition and instantiation of an ordered list of instances of such service functions, and the subsequent "steering" of traffic flows through those service functions.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

ASP Application Service Provider

BSS Business Support System

CPE Customer Premise Equipment

CSP Cloud Service Provider

DDoS Distributed Denial of Service

ISP Internet Service Provider

MEC Mobile Edge Computing

OSS Operation Support System

SFC Service Function Chaining

VMS Virtual Management System

VNF Virtualized Network Function

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 Background and motivations

From the trend evolution of ubiquitously distributed cloud, edge and terminal, the new generation of network is transforming from the network infrastructure with information transmission as the core to the intelligent cloud network infrastructure with integrated computing, storage and network resources.

With the development of network and services, more and more value-added functions need to be deployed on demand. Originally, a variety of service functions could be deployed in the centralized cloud resource pool. With the development of mobile edge computing (MEC) technology, and the requirements of network performance such as network quality and request delay, as well as the increasing demand for flexible addition and reduction of service functions, operators will deploy service functions on the edge nodes. Service functions deployed in the edge nodes are connected in series to meet users' demand for flexible scheduling of service functions and to achieve response time minimization, resource optimization, and high network efficiency.

The existing service function chaining (SFC) is a set of virtualized network functions (VNFs) executed in a specific order to provide traffic flow control. By the use of SFC, cloud service providers (CSPs), application service providers (ASPs), and Internet service providers (ISPs) can offer personalized services to their customers more easily.

In [ITU-T Y.2323] and [ITU-T Y.2324], an NGN evolutional architecture with orchestration has been described thoroughly where the network resource could be optimized, and innovative services could be realized via a unified orchestration. In [ITU-T Y.2501], an NGN evolutional architecture can provide optimal scheduling of computing, storage, and network resources. As the number of service functions of an SFC grows, there are many challenges that should be addressed. Management of the SFCs manually will be a complex task, and the optimal placement of them will be hard. As a result, to overcome these challenges, the service function orchestration based on an SFC is required.

7 Scenarios

7.1 SFC solution based on service function orchestration

Taking security protection as an example, enterprise users need service functions of firewall and anti-distributed denial of service (DDoS) attacks, and operators are required to flexibly divert traffic to the corresponding security resource pool to realize providing these service functions on demand.

Taking the private line service scenario as another example, providers connect cloud resource pools through a network in which different service functions are deployed. Oriented by user service demand, serial service functions deployed in multi-clouds need to be provided through the network. However, the same service function may be deployed in different cloud resource pools. Therefore, it is necessary to realize service functions orchestrating based on SFC to solve the problems, such as how to select an appropriate resource pool, how to dynamically adjust service functions, how to realize service scheduling, and so on.

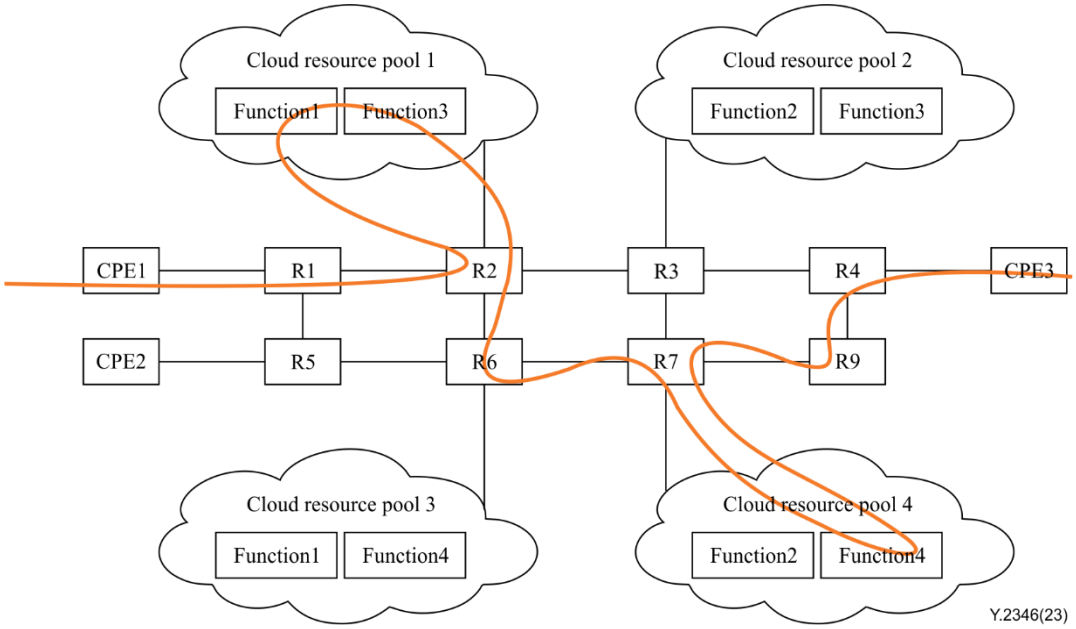

Figure 7-1 – SFC solution based on service function orchestration

When a user requests to establish a private connection from a customer premise equipment (CPE1) to CPE3 and access services Function1, Function3, and Function4, a service function chaining needs to be generated to connect these service functions in appropriate series. As shown in Figure7-1, Function1 is deployed in both cloud resource pool 1 and cloud resource pool 3, and Function3 is deployed in both cloud resource pool 1 and cloud resource pool 2. When network providers make decisions on which cloud resource pools need to be selected to provide service functions, it is necessary to consider network quality, delay and other factors in order to realize service function orchestration.

7.2 SFC solution based on performance request

In the video surveillance scenario, the traditional way is to capture various information through the video surveillance system and then send the information to the processing server for valuable information extraction. However, this method will transmit a large amount of video data from the video surveillance system to the processing server, which may increase the traffic load of the network and lead to high network delay. Combined with MEC technology, data analysis can be carried out directly on the MEC enabled node which is very close to the video surveillance system. At the same

time, combined with the scheduling of computing, storage, and network resources, when the service request increases sharply, it can be switched to other MEC enabled node to realize data analysis.

Therefore, in this scenario, we may split these service functions into sub-service functions and select appropriate resource pools in combination with the computing, storage, and network resources to fulfil the orchestration of sub-service functions and generate a service function chaining to connect these sub-service functions in series.

As shown in Figure 7-2, when the user access Function1, and the service function can be split into sub-service functions Function1.1, Function1.2 and Function1.3, network providers deploy corresponding service functions in appropriate resource pools based on the computing and storage resources, and then connect them in series to generate service function chaining based on the performance request.

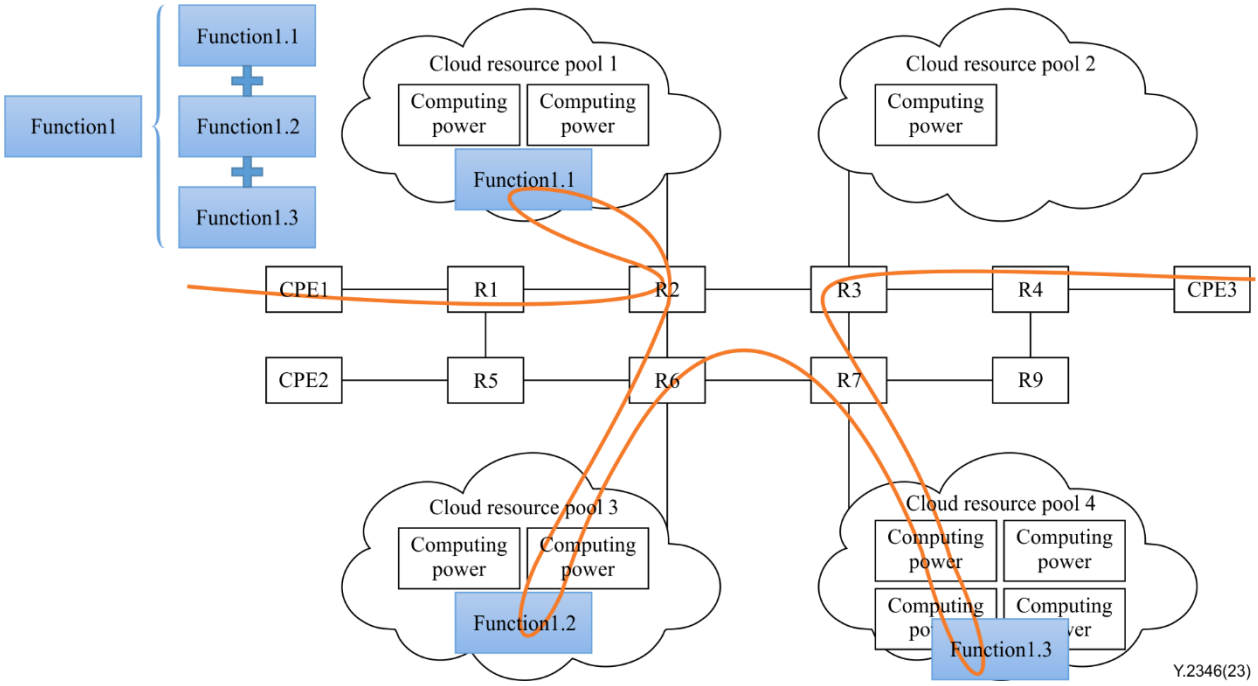

Figure 7-2 – SFC solution based on performance request

8 General framework of service function orchestration based on SFC

The framework of service function orchestration in a computing power network includes the service layer, service function orchestration layer, control layer and infrastructure layer. The service function orchestration framework is shown in Figure 8-1.

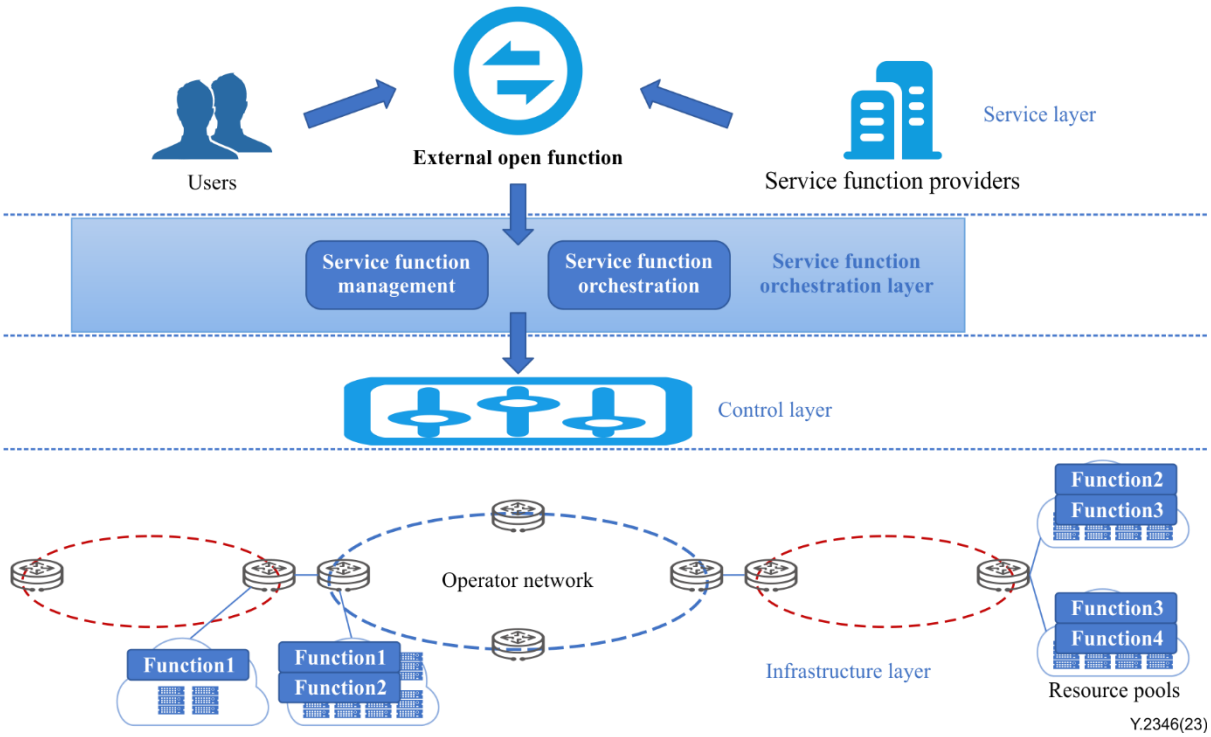

Figure 8-1 – Service function orchestration framework

Service layer: includes users, service function providers and openness function; specifically, users are individuals or enterprises who request service functions to be accessed based on their own requirements for service function sequence, network, computing and storage resources. Service function providers refer to providers who can provide service functions deployed in the operator's own resource pool or provided by a third-party cloud provider. Openness function is exposed to external parties to realize traffic statistics, billing, demonstration and other purposes.

Service function orchestration layer: responsible for service function orchestration, obtains service requirement information from users to achieve service function orchestration, and sends orchestration results to the control layer to generate SFC configuration based on the routing policies.

Control layer: collects network and cloud resource topology information, performs information announcements, makes routing decisions based on orchestration results from the service function orchestration layer, and sends the SFC configuration information to the infrastructure layer.

Infrastructure layer: includes network infrastructure and cloud infrastructure which provide service functions connected with the network infrastructure.

9 Requirements of service function orchestration based on SFC

9.1 Requirements of service function management

Service function management is required to support management features that include the following aspects:

– Service function registration, including the registration of deployed service functions;

– Service function deployment, including deploying new service functions based on service requests or other information;

– Service function optimization, to optimize the deployed service functions to achieve high network efficiency.

9.2 Requirements of service function orchestration

Service function orchestration is required to support orchestration features that include the following aspects:

– Service function splitting for service functions, reasonably splits them into appropriate sub-service functions which can be allocated to appropriate nodes for processing;

– Service function ordering based on the implementation mechanism of SFC, divides the service functions into serial processing mode, and parallel processing mode;

NOTE – Serial processing mode refers to accessing the service functions one by one in order. Parallel processing mode means that when service functions share no dependency, they can work in parallel.

Service function selection is based on user requirements and a comprehensive consideration of computing resources, storage resources, and network resources to select the appropriate resource pools.

10 Functional architecture of service function orchestration based on SFC

The functional architecture of service function orchestration based on SFC is depicted in Figure 10-1. It consists of four layers that provide the aforementioned functionalities by interacting with each other.

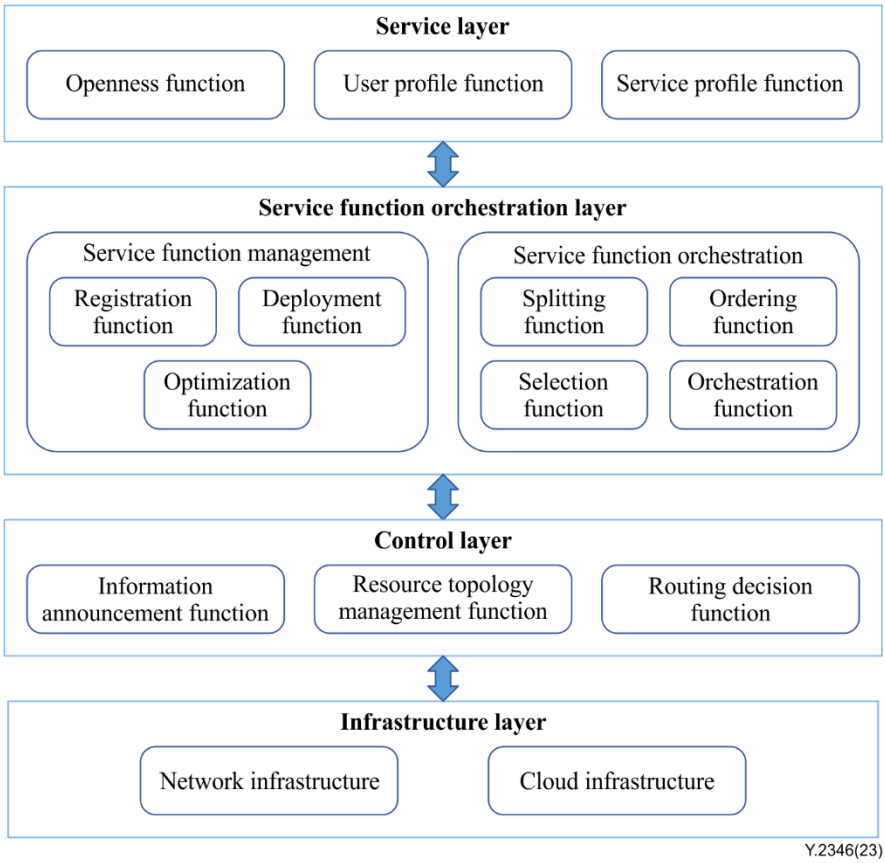

Figure 10-1 – Functional architecture of service function orchestration based on SFC

10.1 Service layer

Service layer is responsible for managing user and service information, which is used to receive service function orchestration requirements, send service requirement information to the service function orchestration layer, and expose it to the external parties.

Service layer has three basic functions: user profile function, service profile function, and openness function.

– **User profile function**: responsible for user information management, including users who request services, enterprise users and individual users who provide service functions, and the administrator (operation and maintenance, management, etc.) to implement authentication, authorization, and permission management. After authentication and authorization, users can initiate service requests and the service providers can provide service functions.

– **Service profile function**: to obtain service requirement information from users, including service functions to be accessed, requirements for network resources, computing resources, and storage resources, and send the information to the service function orchestration layer.

– **Openness function**: expose to external parties to realize billing, demonstration, and other purposes. For the service transaction process, the openness function receives the service function orchestration results from the service function orchestration layer and sends the relevant information to the traffic statistics function and operator operation support system (OSS) / business support system (BSS), generates bills through the billing function, and sends it to the user profile function to confirm the relevant billing information. For data demonstration purpose, this function supports open application programming interface (API) for providing relevant data to a third party for demonstration.

10.2 Service function orchestration layer

Service function orchestration layer is responsible for service function orchestration, selection, and management.

The service function orchestration layer has seven basic functions: registration function, deployment function, optimization function, splitting function, ordering function, selection function, and orchestration function.

– **Registration function**: the function is responsible for registration of the service functions, identifying their locations and resource status.

– **Deployment function**: analysing the information from the user profile function and service profile function in order to meet service requests. The function is recommended to select the appropriate edge nodes to deploy service functions based on the user requests for frequently accessed services.

– **Optimization function**: from the perspective of network efficiency, the function enables the service functions which has not been accessed for a long time to be in sleep mode. For frequently selected service functions, the mechanism is recommended to set to reduce the problem of the increased fault rate caused by the long-time work.

– **Splitting function**: the function can split the service functions into several sub-service functions according to the service type that has been stored in the resource pool or according to the service task quantity, and stores and records its functional information including the order of service functions, service function characteristics and requirements for service functions and sub-service functions.

– **Ordering function**: the function is responsible for service functions and sub-service functions to realize ordering. Ordering is the index that indicates the sequence of each service function of an SFC, indicating whether a serial processing mode or a parallel processing mode is applied. And for serial processing mode, the pre-order relationship is required to be indicated. For parallel processing mode, there is no relevant pre-order relationship.

– **Selection function**: the function is responsible for resource pool selections for each service function and each sub-service function. The network requirements, computing resources and order sequences need to be considered at the same time, including bandwidth, delay, jitter, the load ratio of resource pools, computation requirements and so on.

– **Orchestration function**: the function realizes service function orchestration based on the results of service function splitting function, service function ordering function and service function selection function. For a parallel processing mode, it is required to be consolidated on the specified node.

10.3 Control layer

The control layer collects resource information from the infrastructure layer and sends service function information to the service function orchestration layer for service function registration. The control layer receives the orchestration results from the service function orchestration function, making routing decisions, and sends the corresponding SFC configuration to the infrastructure layer.

The control layer has three basic functions: information announcement function, resource topology management function, and routing decision function.

– **Resource topology management function**: The function obtains network and cloud resource information from the infrastructure layer, abstracts the network topology, and is able to manage the lifecycle of the topology. In addition, it could obtain information on various hardware computing resources in the cloud infrastructure (including processors, memory, storage, etc.) and virtual systems such as virtual machines and containers after the virtualization of hardware computing resources, in order to provide service deployment environments for service functions.

– **Information announcement function**: The function confirms service function information of cloud infrastructure in the infrastructure layer based on the orchestration results from the service orchestration layer and announces it in the network topology.

– **Routing decision function**: The function performs route calculation and route selection, and sends the SFC configuration results to the infrastructure layer according to the synchronized information in the network.

10.4 Infrastructure layer

The infrastructure layer sends the resource information to the control layer and executes the corresponding SFC configuration based on the results of the control layer.

Infrastructure layer includes network infrastructure and cloud infrastructure which provide service functions and establishes the network connection.

– **Network infrastructure**: Network devices and the network topologies which provide forwarding capabilities for data packets, based on routers, switches and so on.

– **Cloud infrastructure**: Resource pools that provide deployment environments for service functions, the hardware of which is a server or server cluster consisting of processors, memory, storage, and so on, and the software of which is a generic or dedicated system such as virtual management system (VMS), container and so on.

11 Workflow of service function orchestration based on SFC

11.1 Procedure for implementation of service function chaining

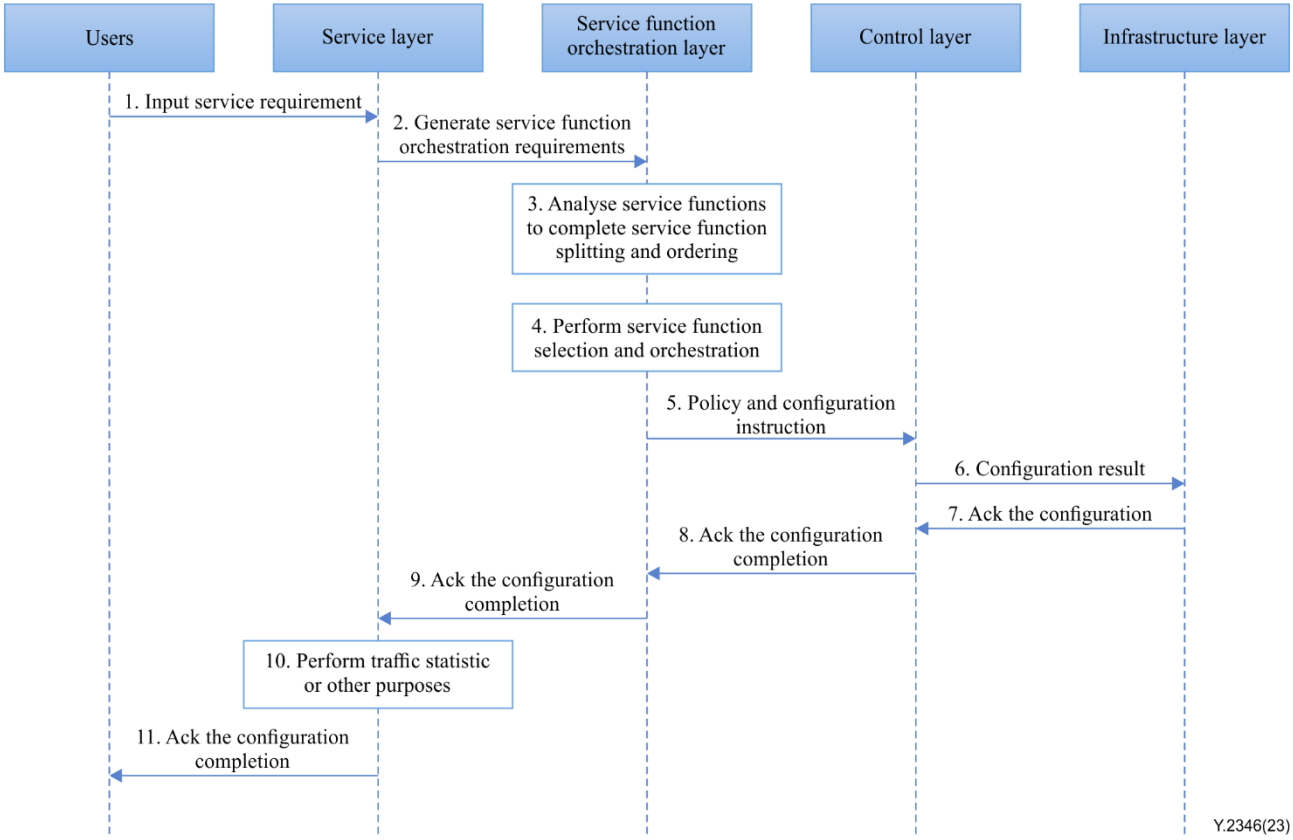

Figure 11-1 – Information flow of an implementation of service function chaining

The main steps for the implementation of service function chaining procedure are as follows by sequence:

1. Users input the users' service requirement information;

2. Service layer receives the service requirement information including service functions to be accessed, requirements for network, computing and storage resources;

3. Service function orchestration layer analyses service functions, to split some service functions into several sub-service functions and to make the service functions and sub-service functions have appropriate order;

4. Based on service requirements for network, computing, and storage resources and service function ordering results, the service function orchestration layer selects the appropriate resource pools for each service functions and sub-service functions, and performs the service function orchestration;

5. Service function orchestration layer sends the policy and configuration instruction to the control layer;

6. Control layer sends the corresponding configuration result to the infrastructure layer;

7. Infrastructure layer sends the execution result to the control layer;

8. Control layer sends the execution result to the service function orchestration layer;

9. Service function orchestration layer sends the execution result to the service layer;

10. Service layer sends the execution result to external parties to realize billing, demonstration, and other purposes;

11. Service layer sends the execution result to users.

11.2 Procedure for service function orchestration

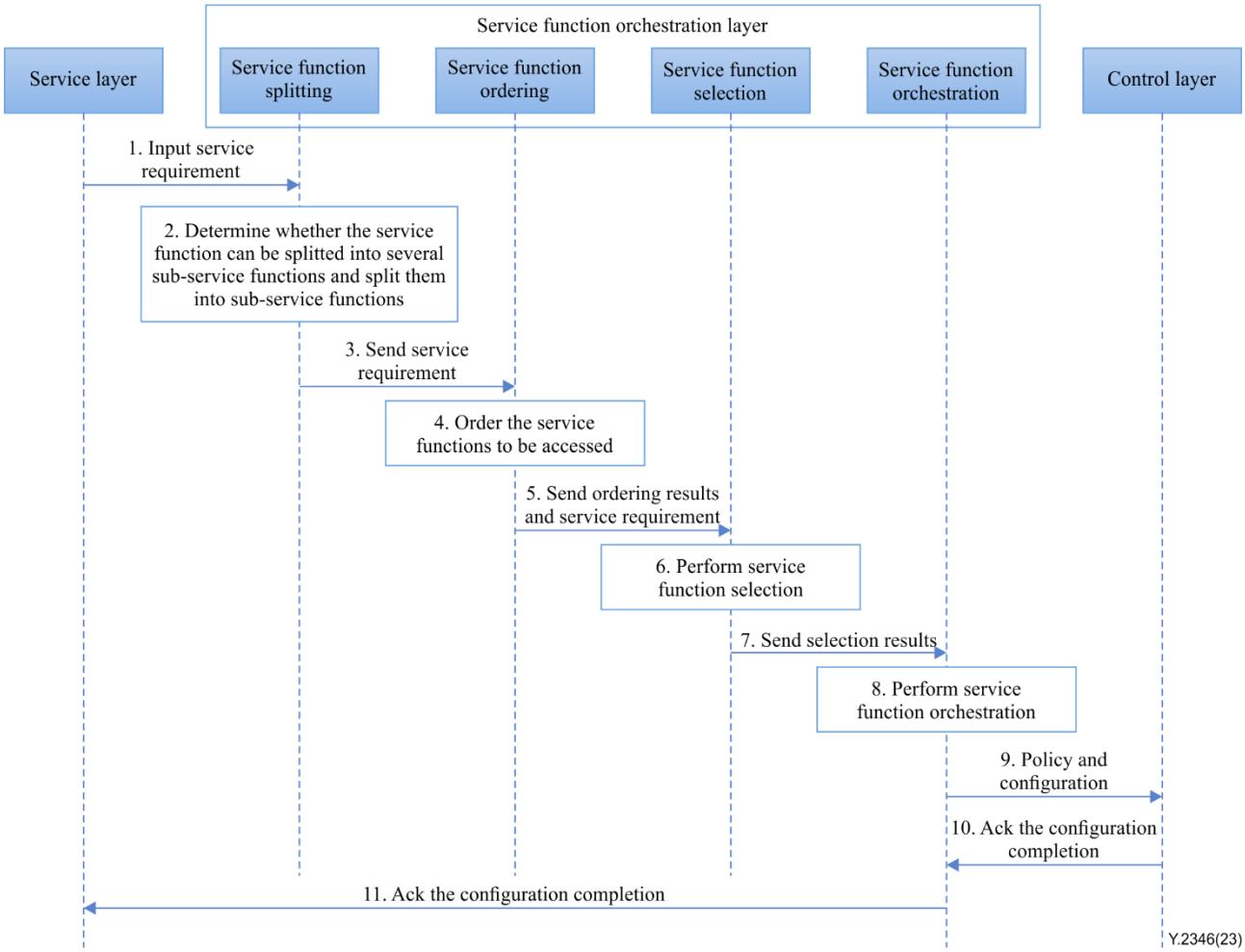

Figure 11-2 – Information flow of service function orchestration

The main steps for the service function orchestration procedure are as follows by sequence:

1. Service layer sends the service requirement information including service functions to be accessed, requirements for network, computing, and storage resources to the service splitting function in the service function orchestration layer;

2. Splitting function determines whether the service function can be split and splits them into several sub-service functions according to the service type which has been stored in the resource pool, or according to the service task quantity;

3. Splitting function sends the information of service functions and sub-service functions, and requirements for network, computing and storage resources together to the ordering function in the service function orchestration layer;

4. Ordering function makes the service functions and sub-service functions have appropriate order, indicating whether serial processing mode and parallel processing mode is applied; especially for serial processing mode, the pre-order relationship is required to be indicated;

5. Ordering function sends the ordering results to the selection function in the service function orchestration layer;

6. Selection function selects the appropriate resource pools for each service function and each sub-service function based on the order sequences and requirements for network, computing and storage resources;

7. Selection function sends the selection results to the orchestration function in the service function orchestration layer;

8. Orchestration function realizes the service function orchestration based on the results, and for parallel processing mode it is required to be consolidated on the specified node;

9. Orchestration function in the service function orchestration layer sends the policy and configuration instruction to the control layer;

10. As described in clause 11.1, the control layer sends the corresponding configuration result to the infrastructure layer, and the infrastructure layer sends the execution result to the control layer; Therefore, the control layer sends the execution result to the orchestration function in the service function orchestration layer;

11. Orchestration function in the service function orchestration layer sends the execution result to the service layer to realize billing, demonstration, and other purposes.

12 Security considerations

The security considerations for a functional architecture of service function orchestration based on SFC are aligned with [ITU-T Y.2324] and [ITU-T Y.2501].

Bibliography

[b-IETF RFC 7665] IETF RFC 7665 (2015), *Service Function Chaining (SFC) Architecture*. <https://datatracker.ietf.org/doc/html/rfc7665>

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