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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Next Generation Networks – Service aspects: Service capabilities and service architecture

Service function chaining in mobile networks

Recommendation ITU-T Y.2242

International Telecommunication Union

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Recommendation ITU-T Y.2242

Service function chaining in mobile networks

Summary

Recommendation ITU-T Y.2242 specifies a method of coordinating existing and ongoing works on service function chaining in mobile networks (specified in [IETF RFC 7665], [IETF RFC 8300] and [b-ONF TS-027]) by introducing a chain orchestrator as a new entity.

NOTE – [b-3GPP TS 23.203] is another well-known specification on service function chaining.

Recommendation ITU-T Y.2242 also covers the case when relevant network functions are virtualized.

Recommendation ITU-T Y.2242 aims to describe the requirements, architecture, functional entities, reference points and information flows of service function chaining in mobile networks.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2242	2018-12-14	13	11.1002/1000/13804

Keywords

Chain orchestrator, mobile network, service function chaining

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

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Service function chaining in mobile networks

1 Scope

This Recommendation specifies a method of coordinating existing and ongoing works on service function chaining in mobile networks (specified in [IETF RFC7665], [IETF RFC 8300] and [b-ONF TS-027]) by introducing a chain orchestrator as a new entity.

The Recommendation also covers the case when relevant network functions are virtualized.

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.2701] Recommendation ITU-T Y.2701 (2007), S*ecurity requirements for NGN release 1*.

[ITU-T Y.3150] Recommendation ITU-T Y.3150 (2018), *High-level technical characteristics of network softwarization for IMT-2020.*

[IETF RFC 7665] IETF RFC 7665 (2015), *Service function chaining (SFC) architecture*.

[IETF RFC 8300] IETF RFC 8300 (2018), *Network service header (NSH).*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 functional entity [b-ITU-T Y.2012]: An entity that comprises an indivisible set of specific functions. Functional entities are logical concepts, while groupings of functional entities are used to describe practical, physical implementations.

3.1.2 network softwarization [b-ITU-T Y.3100]: An overall approach for designing, implementing, deploying, managing and maintaining network equipment and/or network components by software programming.

NOTE – Network softwarization exploits the nature of software such as flexibility and rapidity all along the lifecycle of network equipment and/or components, for the sake of creating conditions that enable the re-design of network and services architectures, the optimization of costs and processes, self-management and bring added values in network infrastructures.

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

3.1.4 service function [b-ITU-T Y-Sup.41]: A function, specifically representing network service function, that is responsible for specific treatment of received packets other than the normal, standard functions of an IP router (e.g., IP forwarding and routing functions) on the network path between a source host and destination host.

3.1.5 service function chain [b-ITU-T Y-Sup.41]: A chain that defines an ordered set of abstract service functions and ordering constraints that must be applied to packets and/or frames and/or flows selected as a result of classification and/or policy.

3.1.6 service function chaining [b-ITU-T Y-Sup.41]: A mechanism of building service function chains and forwarding packets/frames/flows through them.

3.1.7 service function path [b-ITU-T Y-Sup.41]: A path that defines an ordered set of specific instantiations of service functions that packets and/or frames and/or flows must visit within a specific service function chain.

NOTE – A service function path is determined among the relevant service function paths within a specific service function chain, satisfying capacity and QoS requirements of service functions and their connecting links. There is typically a 1: n relationship between a service function chain and a service function path.

3.1.8 service routing [b-ITU-T Y.2085]: A unified service supporting platforms built on DSN. It supplies the service registration, publication, discovery, triggering and access mechanisms, and enhanced capabilities to optimize the service provision.

3.1.9 user plane [b-ITU-T Y.1714]: This refers to the set of traffic forwarding components through which traffic flows.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ACK Acknowledgement

APN Access Point Name

DPI Deep Packet Inspection

DSN Distributed Service Networking

IMT-2020 International Mobile Telecommunication 2020

IP Internet Protocol

IP-CAN Internet Protocol-Connectivity Access Network

NSH Network Service Header

OTT Over The Top

PDN Packet Data Network

SDN Software-Defined Network

SFC Service Function Chain

SFP Service Function Path

UE User Equipment

UP User Plane

UPF User Plane Function

URL Uniform Resource Locator

5 Convention

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 document is to be claimed.

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

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

The keywords "is not recommended" indicate a requirement which is not recommended but which is not specifically prohibited. Thus, conformance with this specification can still be claimed even if this requirement is present.

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

6 Introduction

With the popularity of mobile devices and the rise of cloud-based over-the-top (OTT) services and content distribution, service provider networks need to transform their functionalities and capabilities. Service providers need networks to become more agile and efficient to address the challenges brought by the exponential growth of bandwidth, and also hope to open up new markets shared by innovative services and new business models. Network softwarization has become the technological choice for mobility, virtualization and cloud services [ITU-T Y.3150].

At present, the mobile network needs to provide users with personalized services, e.g., video optimization, web cache, HTTP header enhancement, network acceleration and load balancing. In the existing deployment of the mobile network, network topologies of network services are relatively static and they are not flexible to add or remove personalized services.

Service function chaining has been proposed to meet traffic handling needs of different users when service providers are in a network environment that combines the mobile and cloud networks [b-3GPP TS 23.203]. There is high demand in the mobile user access environment. A service function chaining system analyses different types of services and processes traffic sequentially. The system imposes a down flow control strategy for controlling the flow through a controller, and controls the service function chain (SFC) flow of various traffic streams. Service function chaining provides an elastic and automatic service deployment mechanism. Personalized services can be flexibly orchestrated into SFCs meeting the needs of different users. At the same time, service function chaining reduces deployment costs, increases network traffic processing capacity and improves the utilization rate of network resources.

The following items should be considered and included (although this list is not exhaustive):

– key functional requirements and management requirements of service function chaining in a mobile network;
– the architectural framework, key functionalities and reference points of service function chaining in the mobile network.

7 Requirements for service function chaining in a mobile network

Service function chaining in a mobile network will enable operators to orchestrate an SFC at a practical service level, manage each service function path (SFP) related to the SFC, define and enforce a service steering policy and charge a third party.

7.1 Requirements for orchestration of service function chains at a practical service level

The mobile network is required to have the capability to orchestrate and define an SFC that is an ordered set of service functions. Traffic flow must go through them according to traffic steering policies.

7.2 Requirements for definition and enforcement of a service function chaining policy

The mobile network is required to have the capability to define and modify a service function chaining policy that defines a way to steer traffic in service function chaining.

NOTE 1 – The SFC may contain third party service functions.

The mobile network is required to support a chaining policy that differentiates the treatment of traffic depending on sessions, direction of traffic and user equipment (UE).

NOTE 2 – A chaining policy contains the characteristic information of the SFC.

7.3 Requirements for management of service function chaining

The mobile network is required to have the capability to manage service function chaining.

Third parties can optionally create one or more logical SFCs to meet the needs of multiple service function flows.

The basic management functions of service function chaining are required to include creating, viewing, modifying and deleting SFCs.

1) Creating SFC: Specify the source address and destination address, and add predefined network function nodes sequentially.
2) Viewing SFC: Display the names, network function nodes, status (pending, approved, rejected or enabled), and running time of SFCs.
3) Modifying SFC: Modify a defined SFC, including increasing or deleting physical nodes in the chain or change the chain node order.
4) Deleting SFC: Delete a logical SFC.

The mobile network is recommended to have the capability to orchestrate service functions that are provided by a third party.

The mobile network is recommended to have the capability to expose management capability to the third party through a unified interface under the control of mobile network operators.

The third party can optionally orchestrate service functions (i.e., modifying or viewing existing SFCs).

7.4 Requirements for lifecycle management of a service function path

The mobile network is required to have the capability to create a SFP that is an ordered set of instantiated service functions, which a traffic flow must visit within a specific SFP (i.e., an SFP is an actual forwarding path as an instantiation of an SFC).

The mobile network is required to have the capability to monitor the current status of each SFP, and dynamically update the SFP based on certain policies.

The mobile network is required to have the capability to remove any existing SFP.

7.5 Requirements for reliability, flexibility and scalability of service function chaining

The mobile network is required to have the capability for redundancy, fault tolerance and restoration capacity for service function chaining.

The mobile network is required to have the flexibility to enhance service performance and scalability for service function chaining.

8 Architecture, functional entities and reference points for service function chaining in a mobile network

8.1 Architecture

Service function chaining in a mobile network includes two functional areas: a management and control area and a data-forwarding area.

The management and control area provides the following functions:

– Policy control of traffic steering: defines and updates a traffic steering policy per UE or per flow.

– Traffic classifier: classifies the traffic based on steering policy and assist the management and control area to realize traffic forwarding or routing based on a pre-defined SFP.

– Chain orchestrator: defines and updates an SFC.

– Controller function: defines and updates the routing/switching rules of SFCs, and monitor the availability of each SFC.

  A service function chaining rule is determined among the relevant service function chaining rules within a specific service function chaining policy, defining a way to steer traffic in service function chaining (i.e., A service function chaining rule is a part of a service function chaining policy).

The data-forwarding area provides the following functions:

– service routing/switching function: performs traffic routing/switching based on service function chaining policies;

– service functions: value-added service functions provided by operators or a third party, e.g., video optimizer, uniform resource locator (URL) filter and firewall.

NOTE – Service functions can be virtualized [b-ITU-T Y.3011].

See Figure 1.

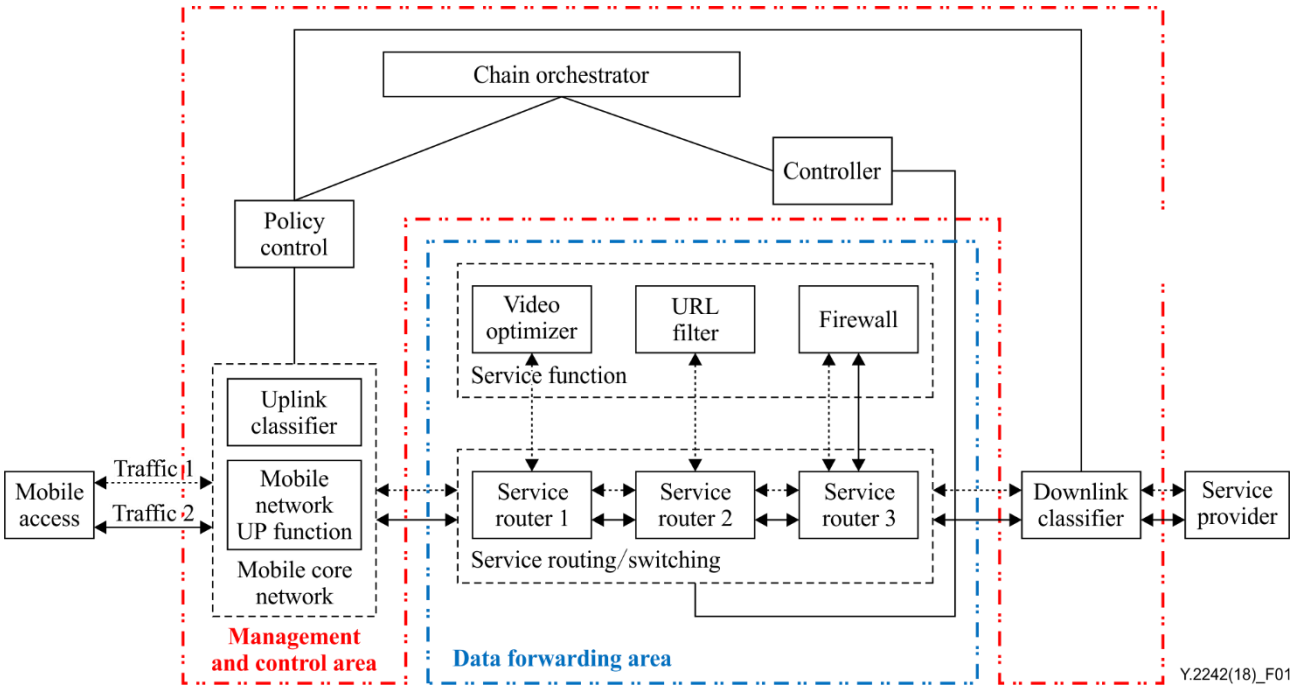

Figure 1 – Network architecture for service function chaining in a mobile network

There are two service chain routing specifications. The first uses a software-defined network (SDN) OpenFlow [b-ONF TR-027] to configure an SDN switch or a router to achieve traffic routing based on chain information. The second uses a network service header (NSH) [IETF RFC 7665], [IETF RFC 8300] that includes SFP information to achieve traffic routing by enhancing the switch or router to support NSH processing.

There are two kinds of service routing mechanism to be used according to each specification mentioned in the previous paragraph. If NSH is used to realize service routing, it can carry policy information from an uplink classifier to a downlink classifier. In this case, no interface between a policy control and the downlink classifier is needed. If SDN technology is used to realize the service routing, an interface between the policy control and the downlink classifier is needed, which allows the downlink classifier to obtain the service routing policy for downstream traffic.

8.2 Functional entities

8.2.1 Chain orchestrator

– To create an SFC, a chain orchestrator:
  - performs the orchestration of services functions: designs which service functions are included in an SFC, while defining the sequence of the service functions in the SFC if the SFC contains more than one service function;
  - assigns a chain identifier to the designed chain;
  - requests a controller to create, update, delete or monitor SFPs by transferring chain information to the controller to manage SFPs after creating the SFC;
  - sends SFC information created by the chain orchestrator to a policy control and sends a request to the policy control to create a new chain policy with chain rules that can include the identifier of the SFC.

– To update an SFC, a chain orchestrator:
  - gathers SFP status information from the controller when the SFC requires updating or deletion, and modifies or deletes the SFC based on the status of the existing SFC;

- designs which service functions are included in the updated SFC, while defining the sequence of service functions in the updated SFC if the SFC contains more than one service function;
- assigns a new chain identifier to the updated chain;
- requests a controller to update, delete or monitor SFPs by transferring the updated chain information to the controller to manage new SFPs after the SFC is updated;
- sends an updated request to policy control to update a chain policy.

8.2.2 Policy control function

The policy control function:

– obtains the current status, time information, UE network information and some other related information about the SFC;

– creates, updates or deletes a chain policy according to the information obtained in the previous entry;

– transfers the chain policy to an uplink classifier or a downlink classifier to enforce the chain policy and steer the traffic;

– transfers the updated chain policy to the classifiers to let them update the path;

– defines and updates load balancing and optimization rules for the SFC (e.g., an instruction for bypassing the service function when it is unavailable in the SFC).

8.2.3 Controller

The policy controller:

– monitors routers, switches and network service servers connected with routers or switches under automatic control;

– enables SFPs based on chain information.

8.2.4 Classifier

The classifier:

– obtains the chain policy from the policy control function;

– (an uplink classifier) receives chain policies created by the policy control and transfers the policies to a mobile network user plane (UP) function;

– (an uplink classifier) provides SFC-related information to a downlink classifier by adding the information to an upstream flow or providing the information to the policy control that transfers the information to the downlink classifier;

– (a downlink classifier) receives a downstream flow, applies the SFC rule to the flow to steer the flow going through the related service functions, and receives the SFC rule from the policy control function or the uplink classifier.

NOTE – Classifiers can be deployed either in an International Mobile Telecommunication 2020 (IMT-2020) advanced packet data network (PDN) gateway or IMT-2020 network user plane function (UPF) or outside PDN gateway.

8.2.5 Mobile network user plane function

The mobile network UPF:

– identifies a data flow to be processed and routes the flow in mobile core networks to a corresponding SFC according to the SFC rule information in the chain policy.

8.3 Reference points

See Figure 2.

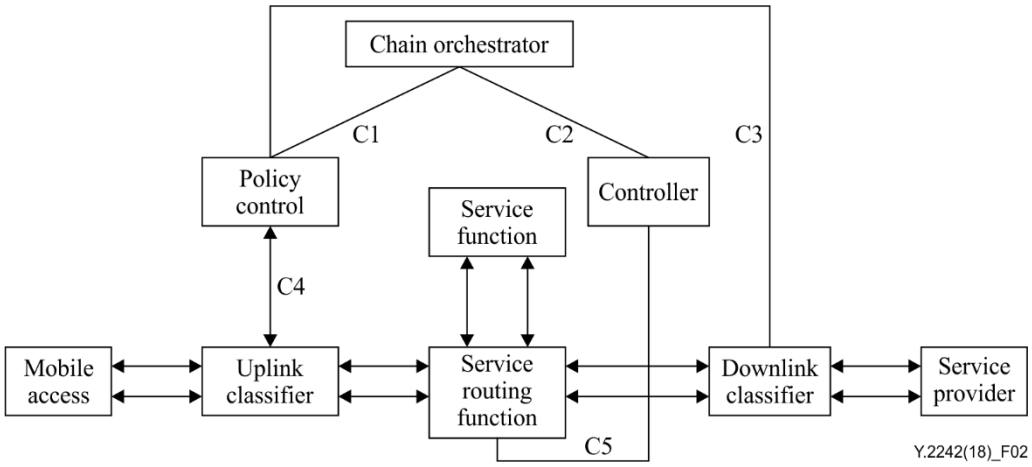

Figure 2 – Reference points of service function chaining in a mobile network

8.3.1 Reference point C1

A policy control function interacts with a chain orchestrator via the reference point C1 to get the SFC information created by the chain orchestrator and sends the response to the chain orchestrator.

8.3.2 Reference point C2

A controller interacts with the chain orchestrator via the reference point C2 to get the SFC information created by the chain orchestrator to enable a SFP and sends the response to the chain orchestrator.

8.3.3 Reference point C3

A downlink classifier interacts with the policy control function via the reference point C3 to receive the chain rules from the policy control function or transferred by way of the policy control function from an uplink classifier, and sends the response to the policy control function, then applies a service chain rule to the flow.

8.3.4 Reference point C4

The uplink classifier interacts with the policy control function via the reference point C4 to receive the chain rules created by the policy control function and provides the chain-related information to the policy control function, which transfers the information to the downlink classifier.

8.3.5 Reference point C5

The controller interacts with service routing functions to send the SFP information to enable the SFP, and get the information of switches or /routers under the control of the controller.

9 Information flows for service function chaining in mobile network

9.1 Creation of a new chain

See Figure 3.

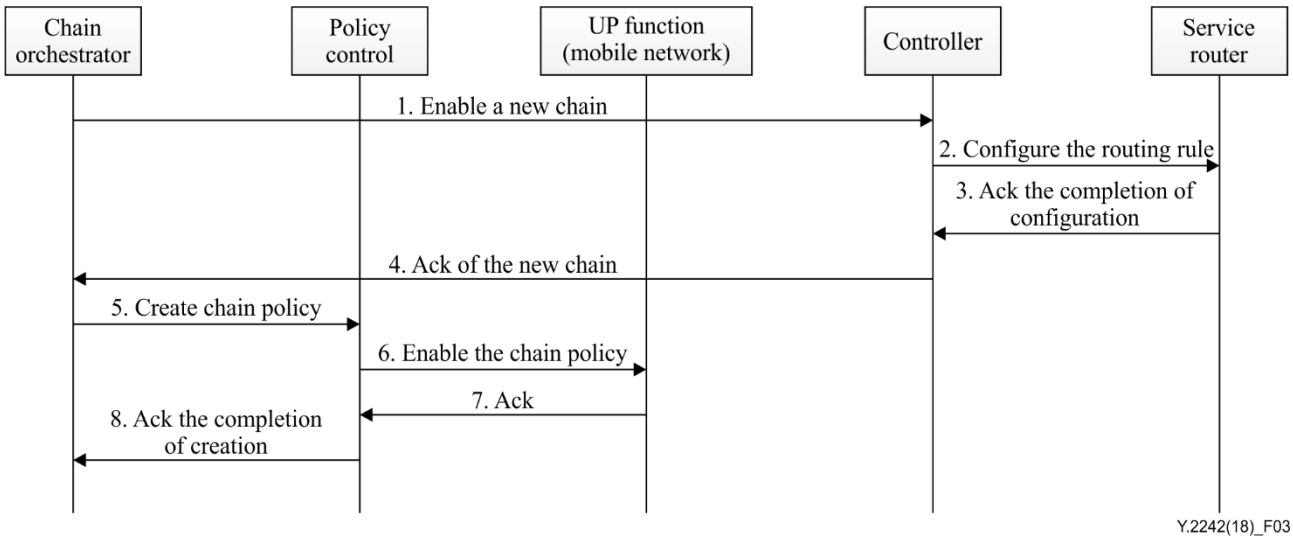

Figure 3 – Creation of a new chain

The main steps for a new SFC are as follows.

1 A chain orchestration creates a new SFC and asks a controller to enable a new SFP(s).

The creation of the SFC will include the following features.

– The service functions that are included in the SFC.

– The routing order in the service function, if the SFC is composed of more than one service function.

2 The controller configures the related service routers with the forwarding rules.

3 Service routers reply to the controller with an acknowledgement (ACK) completion.

4 The controller replies to the chain orchestration with an ACK completion.

5 After the creation of the new SFC, the chain orchestration sends a request to a policy control function to create a new chain policy with chain rules. Chain rules can include the identifier of a traffic flow, service characteristics, the identifier of Internet protocol-connectivity access network (IP-CAN) connectivity, the SFC identifier and the permission status plus whether it enables the deep packet inspection (DPI) of the downlink classifier or directly includes traffic match information (e.g., IP five tuples). The traffic identifier can be derived from the traffic match information in a mobile UP function.

Service characteristics can be application layer match information (e.g., URL). The IP-CAN connectivity identifier can be access point name (APN) information in IMT-2020 networks, which can be preconfigured. The identifier of the SFC is used to steer the matched traffic along the SFP.

6 The policy control notifies the mobile UP function of the new chain policy for the target flows. When the traffic flow comes into the mobile UP function, the mobile UP function detects and matches it with the service chain rules and steers the traffic along the corresponding SFP.

7 The mobile UP function replies to the policy control with an ACK completion.

8 The policy control replies to the chain orchestration with an ACK completion.

9.2 Update a chain

See Figure 4.

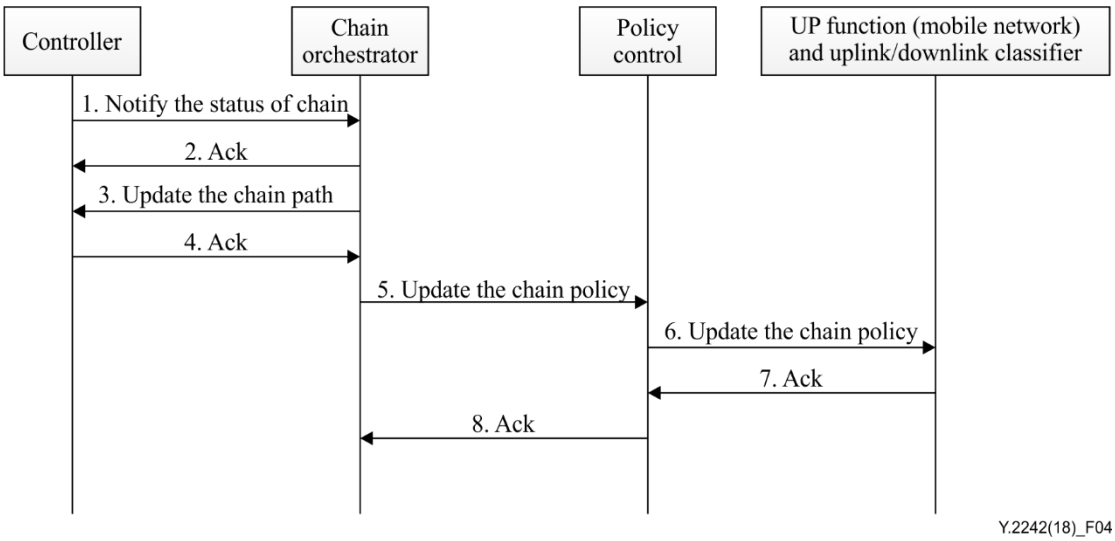

Figure 4 – Update chain policy

The main steps for updating an SFC are as follows.

1 A controller collects the status of an SFC. If there is a problem, the controller notifies a chain orchestrator with the status of the SFC.

2 The chain orchestrator replies to the controller with an ACK completion.

3 The chain orchestrator decides to update the SFC or SFP based on the status of the existing SFC or SFP, and send an update request to the controller.

The modification of the SFC or SFP will include the following features:

– The service functions that are included in the SFC or SFP.

– The routing order in the service function, if the SFC or SFPs is/are composed of more than one service function.

4 The controller replies to the orchestrator with an ACK completion after the controller finishes updating the SFC or SFPs.

5 The chain orchestrator sends an update request to a policy control function. The policy control updates a chain policy based on one or more pieces of information (i.e., current status, time information, UE network information or other related information about the existing SFC) it obtains.

Status information may include SFC availability information, availability information of the value-added service functions in SFC, manageable flow size and latency of the value-added service functions in SFC.

The UE network information may include UE location information and flow destination.

When obtaining status information, the policy control first sends the subscription of the SFC status information for status monitoring. The status information of the current SFC will then be sent to the policy control.

When updating a chain policy, there are several possibilities for the update, as follows.

– For a chain policy based on status and time information, the policy control updates the chain policy according to the flow status in a different time period.

– For a chain policy based on status and UE network information, the policy control updates the chain policy according to different location of the UE and flow destination.

– For a chain policy based on time and UE network information, the policy control updates the chain policy according to the location of the UE in a different time period and the flow destination.

– For a chain policy based on status, time and UE network information, the policy control updates the chain policy according to the different location of the UE in a different time period and the different flow destination.

6 A mobile UP function updates a routing rule or path based on the updated chain policy from the policy control function.

After getting the chain policy, the classifier will find the pending flow based on the service chain rule information in the policy, and then guide the pending flow to the corresponding SFC.

The service chain rule information will include one or more of the following information types:

– user flow identifier;

– service characteristics;

– downlink DPI status (whether started);

– SFC identifier.

For an uplink flow, the service chain rule information will first classify the uplink information and select an SFC identifier for the flow, then append the selected SFC information on the flow and guide the flow to the corresponding SFC.

Based on the uplink flow information, the classifier will, as a preliminary, determine and retain the downlink flow characteristic and the SFC identifier.

For a downlink flow, if DPI is needed, the classifier will first detect the downlink flow, determine the flow characteristic and then map the detection result with the rule information or selected characteristic according to the rule information. Then the classifier will select the SFC identifier based on the preliminarily determined flow characteristic from the uplink flow information and the determined downlink flow characteristic after DPI, and guide the flow to the corresponding SFC based on the identifier. If DPI is not needed, the classifier will select and append the SFC identifier based on the preliminarily determined flow characteristic and SFC identifier from the uplink flow, then guide the downlink flow to the corresponding SFC based on the identifier.

After the flow has been handled by all the value-added service functions, the SFC identifier will be deleted by the classifier.

7 The mobile UP function replies to the policy control function with an ACK completion.

8 The policy control function replies to the policy chain orchestrator with an ACK completion.

10 Security considerations

This Recommendation is recognized as an enhancement of IP-based mobile networks. Thus, it is assumed that security considerations in general are based on the security of IP-based networks, which are required to follow the security considerations specified in clauses 7 and 8 of [ITU-T Y.2701].

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