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ITU-T Q Suppl. 77 (02/2024)

SERIES Q: Switching and signalling, and associated measurements and tests

Supplements to ITU-T Q-series Recommendations

Signalling requirements for parallel service function chaining packet processing

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Supplement 77 to ITU-T Q-series Recommendations

Signalling requirements for parallel service function chaining packet processing

Summary

Supplement 77 to ITU-T Q-series Recommendations describes the signalling requirements of parallel service function chaining (SFC) packet processing. This Supplement focuses on the signalling among the controller, classifier and service function forwarders.

History *

Edition	Recommendation	Approval	Study Group	Unique ID
1.0	ITU-T Q Suppl. 77	2024-02-07	11	11.1002/1000/15861

Keywords

Parallel SFC packet processing, signalling requirements.

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Signalling requirements for parallel service function chaining packet processing

1 Scope

The scope of this Supplement consists of:

– overview for parallel service function chaining (SFC) packet processing;

– interface reference model of parallel SFC packet processing;

– signalling procedure of parallel SFC packet processing;

– signalling requirements of parallel SFC packet processing.

2 References

None.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

3.1.1 service function [b-ITU-T Y.Suppl.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.

NOTE – The examples of service function are similar to, but not limited to that of a middlebox.

3.1.2 service function chain [b-ITU-T Y.Suppl.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.

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

3.1.4 service function path [b-ITU-T Y.Suppl.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.

3.2 Terms defined in this Supplement

This Supplement defines the following terms:

3.2.1 service index: A unique identification of a service function.

3.2.2 service path index: A unique identification of a service function path.

3.2.3 service function forwarder: A function used in service function chaining (SFC) which is responsible for forwarding traffic to one or more connected service functions according to information carried in the SFC encapsulation, as well as handling traffic coming back from the service function (SF).

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

CGN	Carrier Grade NAT
DPDK	Data Plane Development Kit
DPI	Deep Packet Inspection
NAT	Network Address Translation
NSH	Network Service Header
SF	Service Function
SFC	Service Function Chaining
SFF	Service Function Forwarder
SFP	Service Function Path
SPI	Service Path Index
VNF	Virtual Network Function

5 Conventions

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

6 Overview

6.1 Introduction to parallel SFC

To provide complex services, the concept of the service function chain is introduced, which is an ordered set of virtual network functions (VNFs) connected by logical links. However, the service function chaining (SFC) latency grows with the length of the chain, which could be unacceptable for some time sensitive applications. For example, applications, such as stock trading and self-driving, require ultra-low (a few microseconds) latency.

Several efforts have been proposed to address this problem. To achieve lower latency, most of the works choose to schedule traffic dynamically. Some efforts are devoted to enhance the performance of SFC by accelerating individual service functions (SFs) or packet delivery acceleration for example by employing data plane development kit (DPDK). However, the sequential composition of virtual network functions (VNFs) limits the performance ceiling of these works.

Some SFs have no relationship with each other and they could work in parallel. For example, in the service chain shown in Figure 6-1, the carrier grade NAT (CGN) SF only modifies the packet headers without modifying payloads. Therefore, as shown in Figure 6-2, the data packets could be sent into the CGN SF and the deep packet inspection (DPI) SF simultaneously. After processing by the CGN SF and the DPI SF, the data packets could be re-generated by combining the new packet header and new payload. In this way, the chain length is shortened and the latency is reduced by 25%.

As shown in Figure 6-1 and Figure 6-2, the SFC processing is fulfilled by the corporation of control plane and data plane. The controller plane, which includes the SFC controller, is responsible for calculating the service function path (SFP), generating the SFC mapping table and allocating the SFP information and SFC mapping table information to the data plane. The data plane which includes the classifier, service function forwarder (SFF) and SF, is responsible for generating the SFC packets and forwarding them based on the dedicated SFPs.

Software-defined networking as specified in [b-ITU-T Y.3300] is a mandatory technology for implementation of parallel SFC packet processing in this Supplement.

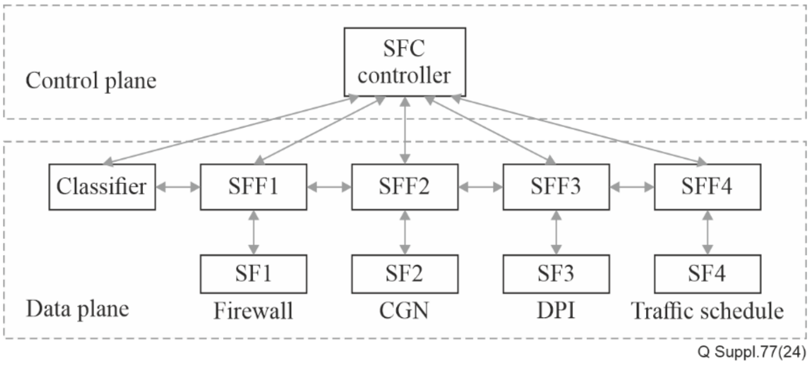

Figure 6-1 – An example of traditional sequential SFC

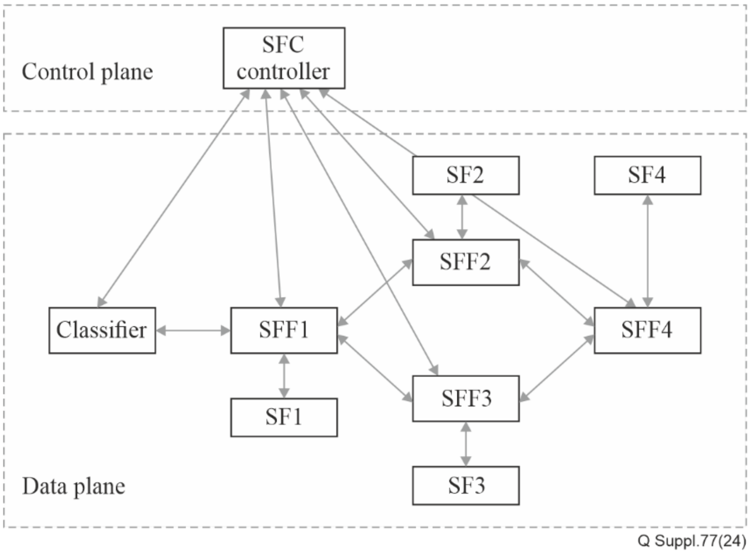

Figure 6-2 – An example of partial parallel SFC

6.2 Header classification in SFC

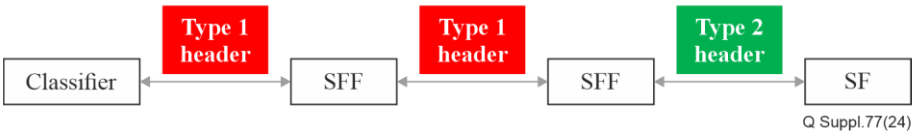

Figure 6-3 – Header classification in SFC

The packet headers used in the SFC could be classified into two types as shown in Figure 6-3. The Type 1 header is used for the packet transferred among classifier and SFFs. This is the SFC header for example the network service header (NSH). The Type 2 header is used for the packet transferred between SFF and SF. Its format could be the IP header, Ethernet header or another header other than SFC header. Its format depends on network protocols for the communication between SFF and SF.

7 Interface reference model of parallel SFC

The interface reference model of parallel SFC is shown in Figure 7-1.

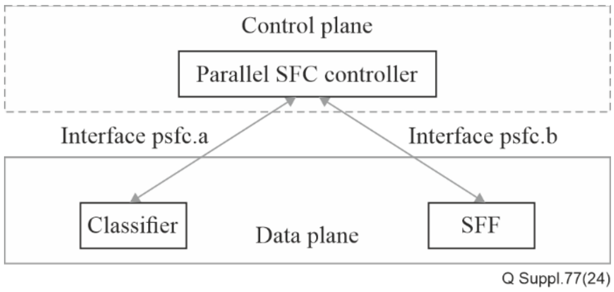

Figure 7-1 – The interface reference model of parallel SFC

The interface pSFC.a is between the parallel SFC controller and classifier to exchange the SFP information and the corresponding SFC mapping table information, as shown in Table 7-1.

The interface pSFC.b is between the parallel SFC controller and SFF to exchange the SFC mapping table information.

Table 7-1 – The SFC mapping table

SPI	SID	SFF	SF	REP	TN
m	255	SFF1	SF1	0	1
m	254	SFF2	SF2	0	N
m	254	SFF3	SF3	0	N
m	...	...	...	...	...
m	254	SFFx	SF(N+1)	0	N
m	253	SFFy	SF(N+2)	1	1
m	...	...	...	...	...

The SFC mapping table includes the service path index (SPI), sequence ID (SID), service function (SF), repackage operation (REP) and total number of packets to be repacked (TN).

The interface between classifier and the SFF, and the interface between different SFFs are defined in IETF and they are out of the scope of this Supplement.

8 Signalling procedure of parallel SFC

Figure 8-1 presents the signalling procedure of parallel SFC.

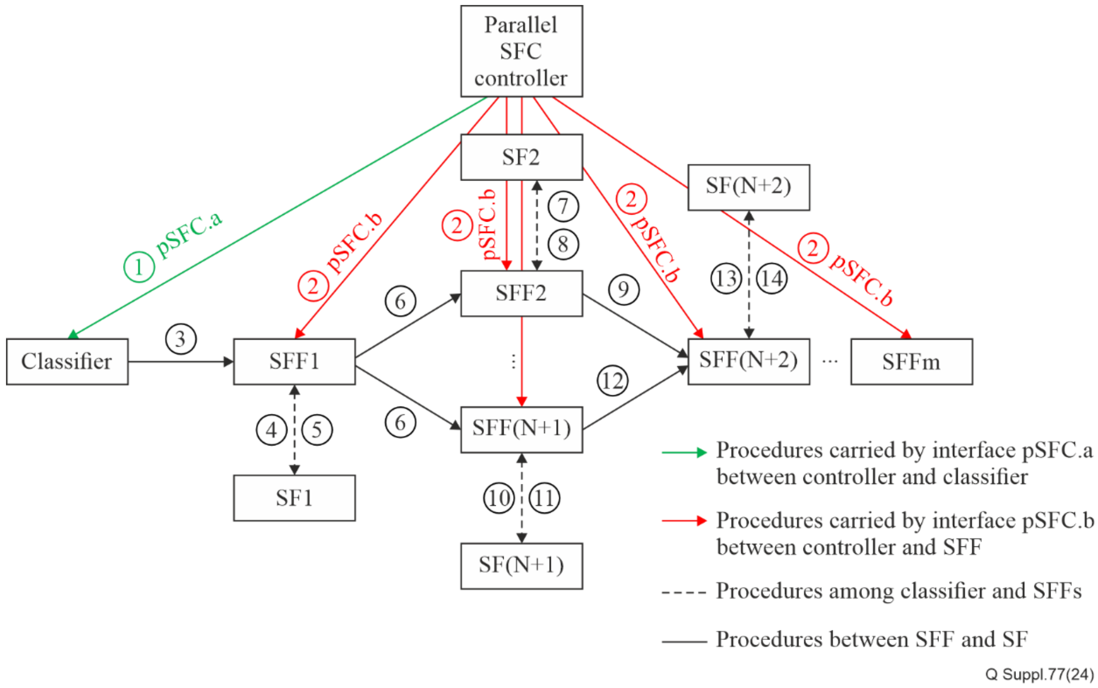

Figure 8-1 – Signalling procedure of parallel SFC

Step 1: The parallel SFC controller sends a dedicated SFP (SPI=m) and the SFC mapping table to the classifier through interface pSFC.a.

Step 2: The parallel SFC controller sends the SFC mapping table to each SFF through interface pSFC.b.

NOTE 1 – In this case, data packets should be processed in parallel from SF2 to SF(N+1) after being processed in SF1 and then should be processed in SF(N+2).

Step 3: The classifier takes the following actions:

1) It packs the data packets with SFC header.

2) It checks the SFC mapping table with SID=255 and finds out the related SF is SF1.

3) It sends the messages to the SF1 related SFF(SFF1).

Step 4: The SFF1 takes the following actions:

1) It receives the message and reads out the SID=255 from the Type 1 header, checks the mapping table of SPI and finds out the SF1(SID=255).

2) It reads the REP=0 from the Type 1 header and finds out there is no need to pack the data packets processed by the former SF.

3) It strips the Type 1 header, and sends the payload packed by Type 2 header to the SF1.

Step 5: The SF1 receives the message, strips the Type 2 header, processes the payload, repacks the processed payload with Type 2 header and sends it back to the SFF1.

Step 6: The SFF1 takes the following actions:

1) It receives the message from SF1 and strips the Type 2 header.

2) It repacks it with the Type 1 header and decreases the SID by 1.

3) It checks the SFC mapping table with SID=254 and finds out there are N SFs in the table that should be processed in parallel.

4) It copies the packed messages for N-1 times and sends these N packed messages to the nodes from SFF2 to SFF(N+1) separately.

NOTE 2 – The actions of the parallel processing mode from SF2 to SF(N+1) are the same. In these following steps, SF2 is taken as an example.

Step 7: The SFF2 takes the following actions:

1) It receives the message, reads out SID=254 from the Type 1 header, and checks the mapping table of SPI and find out the SF2(SID=254).
2) It reads the REP=0 from the Type 1 header and finds out there is no need to pack the data packets processed by the former SF.
3) It strips the Type1 header and sends the payload packed by Type 2 header to the SF2.

Step 8: The SF2 receives the messages, strips the Type 2 header, processes the payload, repacks the processed payload with Type 2 header and sends it back to the SFF2.

Step 9: The SFF2 takes the following actions:

1) It receives the message from SF2 and strips the Type 2 header.
2) It repacks the payload with the Type 1 header and decreases the SID by 1.
3) It checks mapping table with SID=253 and finds out the SF(N+2).
4) It sends messages to SFF(N+2).

Step 10 to Step 12 for SF(N+1) are similar to the Step 7 to Step 9.

Step 13: SFF(N+2) takes the following actions:

1) It receives the message, reads out SID=253 and checks the mapping table to find out SF(N+2).
2) It reads the REP=1 from the mapping table and finds out there is a need to pack the data packets processed by the former parallel SFs.
3) It reads the TN=N from the mapping table and finds out that N data packets should be repacked from the former SFs.
4) It repacks all the received data packets into one data packet after stripping their Type 1 header.
5) It repacks this data packet with Type 2 header and sends it to the SF(N+2).

Step 14: SF(N+2) receives the messages, strips the Type 2 header, processes the payload, repacks the processed payload with Type 2 header and sends it back to the SFF(N+1).

9 Signalling requirements of parallel SFC

9.1 Overview

The signalling messages are exchanged over the various interfaces for hierarchical network slicing service. The signalling messages may be extensible markup language (XML)-based messages over (or carried by) transmission control protocol (TCP), user datagram protocol (UDP), stream control transmission protocol (SCTP), transport layer security (TLS), etc. All of the messages consist of the message header and the message body.

The message format is described in Figure 9-1.

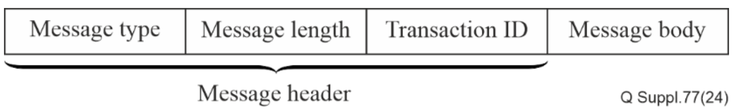

Figure 9-1 – Message composition

The message header field contains the following information:

– Message type: uniquely specifies the type of message.
– Message length: specifies the length of the message body.
– Message transaction ID: generated by the sender of the message. If there is a response message for the request message, the transaction IDs of the request and response messages are the same.
– The message body field contains the message contents which are described in clauses 9.2 and 9.3 based on different types of interfaces.

Table 9-1 – Relationships among interfaces, messages and steps

Interface	Message	Step
pSFC.a	SFP-allocation	1
	SFP-allocation-response	
pSFC.b	SFP-MT-allocation	2
	SFP-MT-allocation-response	

Table 9-1 gives the relationships among interfaces, messages and related steps of the signalling procedure specified in clause 8.

9.2 Signalling requirements of interface pSFC.a

The SFP allocation message is defined as the SFP-Allocation message.

The SFP-Allocation message, indicated by the message type in the message header field, is sent by the controller to the classifier in order to transfer the information of a dedicated SFP and the corresponding SFC mapping table information.

Message format:

```
< SFP-Allocation-Message> ::= < Message Header >
    { SFP-Identifier}
    {SFC-Mapping-Table}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

1 `SFP-Identifier` uniquely specifies the SFP identifier. The form of the identifier is not specified in this Supplement. It could be a number or character string.

2 `SFC-Mapping-Table` uniquely specifies the SFP mapping table as shown in Table 7-1.

The SFP allocation response message is defined as the SFP-Allocation-Response message.

The SFP-Allocation-Response message, indicated by the message type in the message header field, is sent by the classifier to the controller in order to acknowledge the controller that the SFP information and SFC mapping table information are correctly received or not.

Message format:

```
< SFP- Allocation-Response-Message> ::= < Message Header >
    { SFP-Identifier }
    { SFC-Mapping-Table-Confirmation}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

1 `SFP-Identifier` uniquely specifies the SFP identifier. It could be a number or character string.

2 `SFC-Mapping-Table-Confirmation` uniquely specifies whether the SFC mapping table as shown in Table 7-1 is correctly received or not. When this field=1, it means the SFC mapping table is correctly received. When this field=0, it means the SFC mapping table is not correctly received.

9.3 Signalling requirements of interface pSFC.b

The SFC mapping table allocation message is defined as the SFC-MT-Allocation message.

The SFC-MT-Allocation message, indicated by the message type in the message header field, is sent by the controller to the SFF in order to transfer the SFC mapping table information.

Message format:

```
< SFC-MT-Allocation-Message> ::= < Message Header >
    { SFC-Mapping-Table}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

1 `SFC-Mapping-Table` uniquely specifies the SFP mapping table as shown in Table 7-1.

The SFC mapping table allocation response message is defined as the SFC-MT-Allocation-Response message.

The SFC-MT-Allocation-Response message, indicated by the message type in the message header field, is sent by the classifier and SFF to the controller in order to acknowledge the controller the SFC mapping table is correctly received or not.

Message format:

```
< SFC-MT-Allocation-Message> ::= < Message Header >
    { SFC-Mapping-Table-Confirmation}
```

Meanings and explanations:

The detailed information indicates but is not limited to:

1 `SFC-Mapping-Table-Confirmation` uniquely specifies whether the SFC mapping table as shown in Table 7-1 is correctly received or not. When this field=1, it means the SFC mapping table is correctly received. When this field=0, it means the SFC mapping table is not correctly received.

Bibliography

[b-ITU-T Y.3300] Recommendation ITU-T Y.3300 (2014), *Framework of software-defined networking.*

[b-ITU-T Y.Suppl.41] Supplement 41 to ITU-T Y-series Recommendations (2016), *Deployment models of service function chaining*.

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