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Service Function Chaining Use Cases
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Abstract

The delivery of value-added services relies on the invocation of advanced Service Functions in a sequential order. This mechanism is called Service Function Chaining (SFC). The set of involved Service Functions and their order depends on the service context.

This document presents a set of use cases of Service Function Chaining (SFC).

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1. Introduction

The delivery of value-added services relies on the invocation of various Service Functions (SFs). Indeed, the traffic is forwarded through a set of Network Elements embedding Service Functions, e.g.:

a. Direct a portion of the traffic to a Network Element for monitoring and charging purposes.

b. Before sending traffic to DC servers, steer the traffic to cross a load balancer to distribute the traffic load among several links, Network Elements, etc.

c. Mobile network operators split mobile broadband traffic and steer them along an offloading path.

d. Use a firewall to filter the traffic for IDS (Intrusion Detection System)/IPS (Intrusion Protection System).

e. Use a security gateway to encrypt/decrypt the traffic. SSL offloading function can also be enabled.

f. If the traffic has to traverse different networks supporting distinct address families, for example IPv4/IPv6, direct the traffic to a CGN (Carrier Grade NAT, [RFC6888][RFC6674]) or NAT64 [RFC6146].

g. Some internal service platforms rely on implicit service identification. Dedicated service functions are enabled to enrich (e.g., HTTP header enrichment) with the identity of the subscriber or the UE (User Equipment).

This document describes some use cases of Service Function Chaining (SFC).The overall SFC Framework is defined in [I-D.boucadair-service-chaining-framework].

For most of the use cases presented in this document,

o SFC are not per-subscriber. In other words, this document assumes per-subscriber SFCs are not instantiated in the network. Deployments cases that would require per-subscriber SFCs are out of scope.

o Instantiated SFC are driven by service creation and offering needs.

o The amount of instantiated SFCs can vary in time, service engineering objectives and service engineering choices.

o The amount of instantiated SFCs are policy-driven and are local to each administrative entity.

o The technical characterization of each Service Function is not frozen in time. A Service Function can be upgraded to support new features or disable an existing feature, etc.

- o Some stateful SFs (e.g., NAT or firewall) may need to treat both outgoing and incoming packets. The design of SF Maps must take into account such constraints, otherwise, the service may be disturbed. The set of SFs that need to be invoked for both direction is up to the responsibility of each administrative entity operating an SFC-enabled domain.

- o Some Service Functions may be in the same subnet; while others may not.

2. Terminology

This document makes use of the terms defined in [I-D.boucadair-service-chaining-framework].

Service Flow: packets/frames with specific service characteristics (e.g., packets matching a specific tuple of fields in the packet header and/or data) or determined by some service-inferred policies (such as access port and etc.).

3. Service Function Chaining Deployment Scenarios

Service Function Chains can be deployed in a diversity of scenarios such as broadband networks, mobile networks, and DC center. This section describes a set of scenarios for Service Function Chaining deployment.

3.1. Use Case of Service Function Chain in Broadband Network

In broadband networks, an operator may deploy value-added service nodes on POP (Point of Presence) site. These service nodes compose different Service Function Chains to deliver added-value services.

```
                  ------                                       ------
               //        \\  ********************           //        \\
    +----+    |            | * +---+            * +---+    |            |
    |CPE |--->+  Metro     +-->+BNG+>+-------+--->|CR +--->+ Internet   |
    +----+    |            | * +---+ |       ^  * +---+    |            |
               \\        //  *       v       |  *           \\        //
                  ------     *      ++-------++ *              ------
                             *      | Service | *
                             *      | Chain   | *
                             *      +---------+ *
                             ********************
                      Service Function Chain deployment position
```

Figure 1: An example of Service Function Chain in Broadband Networks

Figure 1 illustrates a possible deployment position for Service Function Chaining: between BNG and CR (Core Router). The Service Function Chain shown in Figure 1 may include several Service Functions to perform services such as DPI, NAT44, DS-Lite, NPTv6, Parental control, Firewall, load balancer, Cache, etc.

3.2. Use Case of Service Function Chain in Mobile Core Network (a.k.a., Gi-LAN)

Gi interface is a reference point between the GGSN (Gateway GPRS Support Node) and an external PDN (Packet Domain Network) [RFC6459]. In 4G networks, this reference point is called SGi. The following notes are made:

- o There is no standard specification of such reference points (i.e., Gi and SGi) in term of Service Functions to be located in that segment.

- o Several (S)Gi Interfaces can be deployed within the same PLMN (Public Land Mobile Network); this depends on the number of PDNs and other factors

Traffic is directed to/from Internet traversing one or more Service Functions. Note, these Service Functions are called "enablers" by some operators.

Plenty of Service Functions are enabled in that segment. Some of these functions are co-located on the same device while other standalone boxes can be deployed to provide some other Service Functions. The number of these SFs is still growing due to the deployment of new value-added services. Some of these functions are not needed to be invoked for all services/UEs, e.g.,:

- o TCP optimization function only for TCP flows

- o HTTP header enrichment only of HTTP traffic

- o Video optimization function for video flows

- o IPv6 firewall + NAT64 function for outgoing IPv6 packets

- o IPv4 firewall + NAT64 function for incoming IPv4 packets

- o Etc.

Figure 2 illustrates a use case of Gi Interface scenario. Figure 2 involves many Service Functions that are enabled in the Gi Interface: WAP GW, TCP Optimizer, Video Optimizer, Content Caching, FW, NAT (44,

64), etc. This list is not exhaustive but it is provided for illustration purposes.

```
               ***********************************
               *       1     +------+            *
               *  +--------->+WAP GW+----------+ *        ------
               *  |          +------+          | *     //        \\
   +----+    +---+| +---------+  +-----+       v *    |            |
   |GGSN+--->|DPI|+>+Optimizer+->|Cache+       +----->+  Internet  |
   +----+    +---+| +---------+  +--+--+       ^ *    |            |
               *  |                 |2         | *     \\        //
               *  |                 v          | *        ------
               *  |     3      +-----+  +----+ | *
               *  +----------->+Gi FW+->|NAT +-+ *
               *               +-----+  +----+   *
               ***********************************
```

Figure 2: An example of Service Function Chain scenario in the Gi Interface

For example, the traffic from GGSN/PGW to Internet can be categorized and directed into the following Service Function Chains by DPI:

- o Chain 1: WAP GW. DPI performs traffic classification function, recognizes WAP protocol traffic, and directs these traffic to the WAP GW through Service Function Chain 1.
- o Chain 2: Optimizer + cache + Firewall + NAT. DPI recognizes and directs the HTTP traffic to the Optimizer, Cache, Firewall and NAT in order, to perform HTTP video optimization, HTTP content cache, firewall and NAT function, respectively.
- o Chain 3: Firewall +NAT. For other traffic to the Internet, DPI directs these traffic by Service Function Chain 3, the traffic would travel the firewall and NAT in order.

Access to internal services is subject to dedicated policies. For example, a dedicated function to update HTTP flow with a UE identifier may be needed to avoid explicit identification when accessing some service platforms operated by the mobile operator.

```
                                                ------
                                             //        \\
   +----+    +-----------------------+      |  Internal  |
   |GGSN+--->|HTTP Header Enrichment |----->+  Service   |
   +----+    +-----------------------+      |  Network   |
                                             \\        //
                                                ------
```

Figure 3: HTTP Header Enrichment

Figure 3 illustrates a use case of HHE (HTTP Header Enrichment). The HHE SF is able to inject the UE identifier to Internal Service Network for identification purpose.

Note, some mobile networks rely on regional-based service platforms (including interconnection links); while some of service functions are serviced in a centralized fashion.

```
   +----+  +---+|  +---------+
   |GGSN+->|DPI|+->+Optimizer+-+
   +----+  +---+|  +---------+ |      ------                         ------
                               |   //        \\                    //        \\
   +----+  +---+|  +---------+ |  |            |  +-----+  +---+  |
|
   |GGSN+->|DPI|+->+Optimizer+-+->+  Regional  |->+Gi FW+->+NAT+->+  Internet
|
   +----+  +---+|  +---------+ |  |  Network   |  +-----+  +---+  |
|
                               |   \\        //                    \\        //
                               |      ------                         ------
           ...       ...      -+
```

Figure 4: Cross-region services

Figure 4 illustrates a use case of cross-region services, in which the functions that consist of the SFC are located at different regions and flows cross a regional network to go through the Service Function Chains.

3.3. Use Case for Distributed Service Function Chain

Besides the deployment use cases listed above, a Service Function Chain is not necessarily implemented in a single location but can also be distributed crossing several portions of the network (e.g., data centers) or even using a Service Function that is located at an network element close to the customer (e.g. certain security functions).

Multiple SFC-enabled domains can be enabled in the same administrative domain.

3.4. Use Case of Service Function Chain in Data Center

In DC (Data Center), like in broadband and mobile networks, Service Function Chains may also be deployed to provide added-value services.

Figure 5 illustrates a possible scenario for Service Function Chain in Data Center: SFs are located between the DC Router (access router) and the Servers. From Servers to Internet, there are multiple Service Functions such as IDS/IPS, FW, NAT lined up and a monolithic SFC created for all incoming traffic.

```
   ***********************************************
   * +------+                                    *
   * |Server+-+                                  *
   * +------+ |                                  *            ------
   *          |                                  *         //        \\
   * +------+ |  +-------+   +--+   +---+   +---------+   |          |
   * |Server+-+->|IDS/IPS+-->|FW+-->|NAT+-->|DC Router|-->+  Internet  |
   * +------+ |  +-------+   +--+   +---+   +---------+   |          |
   *          |                                  *         \\        //
   *          |                                  *            ------
   *   ...   -+                                  *
   *                                             *
   *   ...                                       *
   *                                             *
   *                     DC                      *
   ***********************************************
```

Figure 5: Service Function Chain in Data Center

4. Use Cases of Service Function Chaining Technical Scenario

There are several possible cases for the steering of traffic according to service characteristics due to specific requirements from operators and service providers.

4.1. General Use Case for Service Function Chaining

The traffic in a network is usually forwarded based on destination IP or MAC addresses. In an operator's network, some Service Functions are implemented, where traffic is steered through these Service Functions in a certain sequence according to service characteristics and objectives.

```
                                          +--------------------------+
                                          |Service Function Chaining|
                             +----------->|            A             |
                             |            +--------------------------+
           +------------+    |
           |Service      |    |
   ------->|Classifier  |--->|
           +------------+    |
                             |            +--------------------------+
                             |            |Service Function Chaining|
                             +----------->|            B             |
```

```
                                  +-------------------------+
```

Figure 6: General Service Function Chain

Traffic enters a SFC-enabled domain in a service classifier, which identifies traffic and classifies it into service flows. Service flows are forwarded on a per SF Map basis.

4.2. Use Case for Service Function Chain with NAT Function

Due to IPv4 address exhaustion, more and more operators have deployed or are about to deploy IPv6 transition technologies such as NAT64 [RFC6146]. The traffic traversing a NAT64 function may go through different types of IP address domains. One key feature of this scenario is that characteristics of packets before and after processed by the service processing function are different, e.g., from IPv6 to IPv4. The unpredictability of processed packets, due to the algorithm in the Service Function, brings difficulties in steering the traffic.

A variety of hosts can be connected to the same network: IPv4-only, dual-stack, and IPv6-only. A differentiated forwarding path can be envisaged for each of these hosts. In particular, DS hosts should not be provided with a DNS64, and as such there traffic should not be delivered to a NAT64 device. Means to guide such differentiated path can be implemented at the host side; but may also be enabled in the network side as well.

```
     +---------+       +----------+       +----------+
     |         |       |          |       |          |
---->+ SF C    +------->+ SF NAT  +------->+ SF E     +-->
     |         |       |          |       |          |
     +---------+       +----------+       +----------+
```

Figure 7: Service Function Chain with NAT64 function

Figure 7 shows a specific example of Service Function Chain with NAT function. Service flow1 is processed by SF(Service Function) C, NAT and E sequentially. In this example, the SF NAT performs NAT64. As a result, packets after processing by the SF NAT are in IPv4, which is a different version of IP header from the packets before processing. Service Function Chaining in this scenario should be able to identify the flow even if it is changed after processed by Service Functions.

4.3. Use Case for Multiple Underlay Networks

Operators may need to deploy their networks with various types of underlay technologies. Therefore, Service Function Chaining needs to support different types of underlay networks.

```
      +---------+         +----------+       +----------+
      |         |         |          |       |          |
   -->+ SF A    |         | SF B     |       | SF C     +-->
      |         |         |          |       |          |
      +----+----+         +---+-+----+       +-----+----+
           |                  ^ |                  ^
           |      ------      | |      ------      |
           |   //        \\   | |   //        \\   |
           |  |  Ethernet  |  | v  |            |  |
           +->+  network   +->+ +->+ IP network +->+
              |            |       |            |
               \\        //         \\        //
                  ------               ------
```

Figure 8: multiple underlay networks: Ethernet and IP

Figure 8 illustrates an example of Ethernet and IP network, very common and easy for deployment based on existing network status, as underlay networks. SF(Service Functions) A, B and C locate in Ethernet and IP networks respectively. To build a Service Function Chain of SF A, B and C, Service Function Chaining needs to support steering traffic across Ethernet and IP underlay networks.

4.4. Use Case of Service Path Forking

To enable service or content awareness, operators need DPI functions to look into packets. When a DPI function is part of a Service Function Chain, packets processed by the DPI function may be directed to different paths according to result of DPI processing. That means a forking service path.

```
        +---------+        +----------+        +----------+
        |         |        |          |        |          |
   ---->| Firewall+------->+  DPI     +------->+anti-virus|--->
        |         |        |          |        |          |
        +---------+        +-----+----+        +----------+
                                 |
                                 |
                                 V
                           +-----+----+
                           |          |
                           | Parental |
                           | control  |
                           +-----+----+
```

```
                                 |
                                 |
                                 V
```

Figure 9: a forking service path

Figure 9 shows the use case of a forking service path. Traffic first goes through a firewall and then arrives at DPI function which discerns virus risk. If a certain pre-configured pattern is matched, the traffic is directed to an anti-virus function.

Such DPI function may fork out more than one path.

4.5. Use Case of Multiple Service Paths Share one Service Function

Some carrier grade hardware box or Service Functions running on high performance servers can be shared to support multiple Service Function Chains. Following is an example.

```
    SFC1    +----------+        +---------+
    ------->+----------+------->+---------+--->
    SFC2    |Firewall |        |Video    |
    ------->+-->+     |        |Opt      |
            +---|-----+        +---------+
                |
                v
            +---+-----+
            |   |     |
            |Parental |
            |Control  |
            +---+-----+
                |
                v
```

Figure 10: Two Service Function Chains share one Service Function

In Figure 10, there are three Service Functions, firewall, VideoOpt and Parental Control, and two Service Functions Chains SFC1 and SFC2. SFC1 serves broadband user group1 which subscribes to secure web surfing and Internet video optimization, while SFC2 serves broadband user group2 which subscribes to secure web surfing with parental control. SF Firewall is shared by both Service Function Chains.

4.6. Use Case of Service Layer Traffic Optimization

In Figure 11, one SF has two instances SF_A1 and SF_A2 on different networking paths. When data traffic hits the first SF_0, it will be forwarded to SF_A1 or SF_A2 depending on the traffic load on different paths. Such service layer traffic optimization is the essential requirement for many computing-intensive service process functions.

```
                         +----------+
                         |          |
                   +-----+  SF_A1   +---------+
                  /      |          |          \
   +-------+     /       +----------+           \
   | SF0   |____/                                \______
   |       |    \                                /
   +-------+     \       +----------+           /
                  \      |          |          /
                   +-----+  SF_A2   +---------+
                         |          |
                         +----------+
```

Figure 11: service layer traffic optimization

5. Security Considerations

This document does not define an architecture nor a protocol. It focuses on listing use cases and typical service function examples. Some of these functions are security-related.

SFC-related security considerations are discussed in [I-D.boucadair-service-chaining-framework].

6. Acknowledgements

N/A.

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