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Service Function discovery in fog environments  
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## Abstract

Service function chaining (SFC) allows the instantiation of an ordered set of service functions and subsequent "steering" of traffic through them. Service functions provide a specific treatment of received packets, therefore they need to be known so they can be used in a given service composition via SFC. This document discusses the need for service function discovery mechanisms and propose some solutions for sfc-aware nodes to discover available service functions in fog environments.

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## [1.](#) Introduction

Virtualization of functions provides operators with tools to deploy new services much faster, as compared to the traditional use of monolithic and tightly integrated dedicated machinery. As a natural next step, mobile network operators need to re-think how to evolve their existing network infrastructures and how to deploy new ones to address the challenges posed by the increasing customers' demands, as well as by the huge competition among operators. All these changes are triggering the need for a modification in the way operators and infrastructure providers operate their networks, as they need to significantly reduce the costs incurred in deploying a new service and operating it. Some of the mechanisms that are being considered and already adopted by operators include: sharing of network infrastructure to reduce costs, virtualization of core servers running in data centers as a way of supporting their load-aware elastic dimensioning, and dynamic energy policies to reduce the monthly electricity bill. However, this has proved to be tough to put in practice, and not enough. Indeed, it is not easy to deploy new mechanisms in a running operational network due to the high dependency on proprietary (and sometime obscure) protocols and interfaces, which are complex to manage and often require configuring multiple devices in a decentralized way.

Service Functions are widely deployed and essential in many networks. These Service Functions provide a range of features such as security, WAN acceleration, and server load balancing. Service Functions may

be instantiated at different points in the network infrastructure such as data center, the WAN, the RAN, and even on mobile nodes.

Service functions (SFs), also referred to as VNFs, or just functions, are hosted on compute, storage and networking resources. The hosting environment of a function is called Service Function Provider or NFVI-PoP (using ETSI NFV terminology).

With the arrival of virtualization, the deployment model for service function is evolving to one where the traffic is steered through the functions wherever they are deployed (functions do not need to be deployed in the traffic path anymore). For a given service, the abstracted view of the required service functions and the order in which they are to be applied is called a Service Function Chain (SFC). An SFC is instantiated through selection of specific service function instances on specific network nodes to form a service graph: this is called a Service Function Path (SFP). The service functions may be applied at any layer within the network protocol stack (network layer, transport layer, application layer, etc.).

A mobile terminal can benefit from using service function chaining at the edge/fog to enhance existing applications or to enable new ones. In order to do so, discovery of available service functions is required. This document focuses on this aspect.

## [2.](#) Terminology

The following terms used in this document are defined by the IETF in [\[RFC7665\]](#) and [\[RFC9015\]](#):

**Service Function (SF):** a function that is responsible for specific treatment of received packets (e.g., firewall, load balancer).

**Service Function Chain (SFC):** for a given service, the abstracted view of the required service functions and the order in which they are to be applied. This is somehow equivalent to the Network

Function Forwarding Graph (NF-FG) at ETSI.

Service Function Forwarder (SFF): A service function forwarder 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 SF.

SFI: SF instance.

Service Function Path (SFP): the selection of specific service function instances on specific network nodes to form a service graph through which an SFC is instantiated.

A Service Function Type (SFT) that is the category of Service Function that is provided (such as "firewall").

### [3.](#) Problem statement

[RFC7665] describes an architecture for the specification, creation, and ongoing maintenance of Service Function Chains (SFCs) in a network. It includes architectural concepts, principles, and components used in the construction of composite services through deployment of SFCs. In this architecture, a key element is the service function (SF), which is a function that is responsible for specific treatment of received packets (e.g., a firewall).

So far, how the SFs are discovered and composed has been out of the scope of discussions in IETF. There is however a need to define mechanisms that allow SF discovery in fog environments [[I-D.bernardos-sfc-fog-ran](#)]. Note that the mechanisms described in this document address fog environments. There are other mechanisms described, like [[RFC9015](#)], that cover generic SF discovery in more traditional environments. Some of the solutions described in the present document might be of applicable to other scenarios as well.

#### [3.1.](#) Discovery of SF in a multi-provider fog/edge environment

The need to provide networking, computing, and storage capabilities

closer to the users has recently emerged, due to the demands from 5G applications of very low latency, leading to what is known today as the concept of intelligent edge. ETSI has been the first to address this need recently by developing the framework of mobile edge computing (MEC). Such an intelligent edge could not be envisaged without virtualization. Beyond applications, it raises a clear opportunity for networking functions to execute at the edge benefiting from inherent low latencies. Being in close proximity to the access, the edge becomes an attractive place for hosting different functions, saving bandwidth in their respective domains and offering local breakout options where required. Whilst it is appreciated the particular challenge for the intelligent edge concept in dealing with mobile users, the edge virtualization substrate has been largely assumed to be fixed or stationary. Although little developed, the intelligent edge concept is being extended further to scenarios where for example the edge computing substrate is on the move, e.g., on-board a car or a train, or that it is distributed further down the edge, even integrating resources from different stakeholders, into what is known as the fog.

Service composition is a powerful tool which can provide significant benefits when applied in a softwarized network environment. While it is being explored in the core part of networks to compose services using DPIs (Deep Packet Inspections), firewalls, parental control, video accelerators, etc., its applicability to the RAN (Radio Access Network), and in particular to the edge and the fog, has not been explored yet.

Running functions (standalone functions or service function chains) at the edge of the network has clear advantages. For example, it enables offloading functions from the end-user terminal so that it can become more efficient in terms of cost and energy consumption.

A mobile terminal can benefit from using service function chaining at the edge/fog to enhance existing applications or to enable new ones. Some examples of such applications are: privacy enhancement by local anchoring, opportunistic local breakout, assisted encryption, video transcoding, personal firewalling, etc. The mobile terminal might look for function hosting opportunities at the edge for various reasons such as:

- o to increase battery life in critical situations by offloading

energy demanding operations (e.g., video transcoding, augmented reality) to the edge/cloud;

- o to reduce communications latency (e.g., by using local breakout at the edge for selected applications demanding low latency);
- o to enable new functions (e.g., privacy improvements, personal firewalling) which demand additional intelligence/resources at the network;
- o to benefit from context information available at the edge (e.g., enrich networking decisions by executing functions at the edge using RAN information);

Several key challenges need to be addressed to enable controlled service function chaining for a mobile terminal, and one of them is the discovery of the functions available for use at the Fog/Edge/Cloud.

#### 4. Network-based SF discovery

In this section we describe several mechanisms for a mobile SFC-aware node to discover what SFs are available in the network. Different alternatives (protocol containers) are considered to enable the mobile node to obtain the following information per SF available:

- o Service Function Type, identifying the category of SF provided.
- o SFC-aware: Yes/No. Indicates if the SF is SFC-aware.
- o Route Distinguisher (RD): IP address indicating the location of the SF(I).
- o Pricing/costs details.
- o Migration capabilities of the SF: whether a given function can be moved to another provider (potentially including information about compatible providers topologically close).
- o Mobility of the device hosting the SF, with e.g. the following sub-options:

Level: no, low, high; or a corresponding scale (e.g., 1 to 10).

Current geographical area (e.g., GPS coordinates, post code).

Target moving area (e.g., GPS coordinates, post code).

- o Power source of the device hosting the SF, with e.g. the following sub-options:

Battery: Yes/No. If Yes, the following sub-options could be defined:

Capacity of the battery (e.g., mmWh).

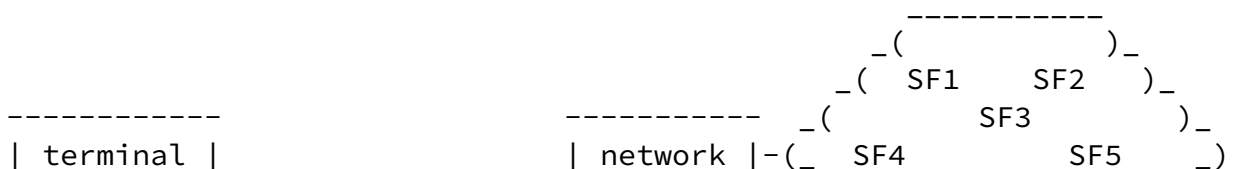
Charge status (e.g., %).

Lifetime (e.g., minutes).

Figure 1 shows the generic mechanism for SF discovery, with network support. In this scenario, SFs (which might belong to different administrative domains) are previously registered at the network, which can then reply to requests sent from mobile nodes that have just attached to the network. A request might optionally include the SFs of interest for the terminal, instead of a request for all known SFs.

The network might also send periodic advertisements in addition to responses to solicited requests. These responses/advertisements include the information about known SFs (or only about the ones queried by the terminal), which can then be used by the terminal to decide whether to use (some of) them in a certain SFC. How the

mobile terminal then configures this SFC is not covered in this document.



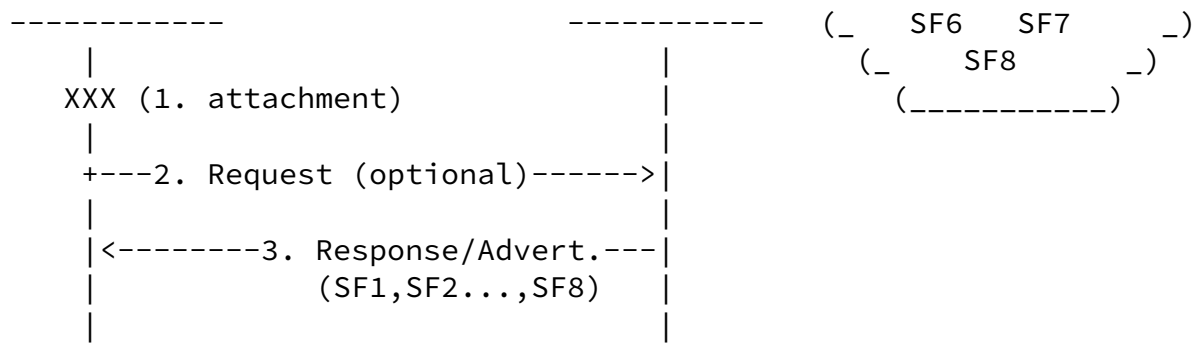


Figure 1: SF (network) discovery

In addition to the discovery of SFs at the infrastructure, mobile terminals can also host SF(I)s, and therefore they also need to be discovered. A similar approach can be followed, as shown in Figure 2.

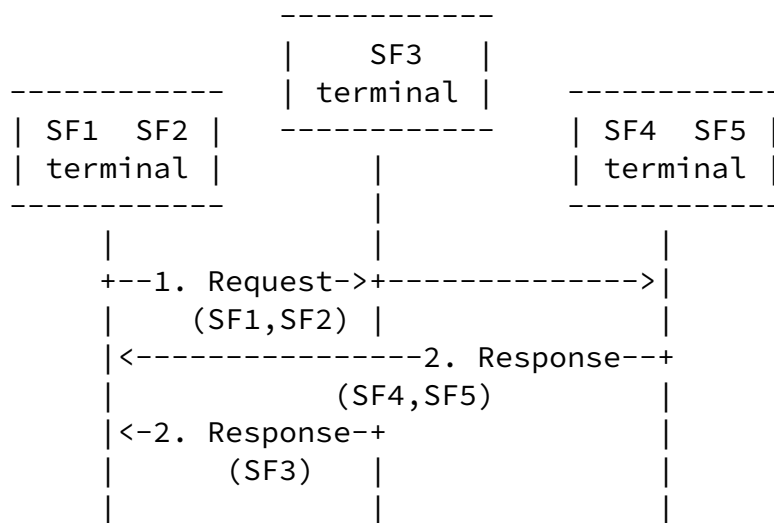


Figure 2: SF (mobiles) discovery

SFs might belong to different administrative domains. This might require the use of additional security and authentication mechanisms. Policies can be used (both in single and multi-domain scenarios) to adapt/limit the type and number of SFs that are advertised, depending on the relationship of the requester and the advertiser.

Next sections describe different protocol alternatives for this SF



discovery in fog environments.

#### [4.1.](#) ICMPv6-based SF discovery

TBD.

#### [4.2.](#) DHCPv6-based SF discovery

TBD.

#### [5.](#) IANA Considerations

N/A.

#### [6.](#) Security Considerations

TBD.

#### [7.](#) Acknowledgments

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