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Service Function Chaining Dataplane Elements in Mobile Networks
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Abstract

The evolution of the network towards 5G implies a challenge for the infrastructure. The targeted services and the full deployment of virtualization in all segments of the network will be possible and necessary to provide some traffic-specific services near the next generation base stations where the radio is processed. Thus, service function chains that currently reside in the infrastructure of the Network operator (like, e.g. the Expedited Packet Gateway(EPG)) will be extended to the radio access network (RAN).

In this draft we provide a non-exhaustive but representative list of service functions in 4G and 5G networks, and explore different scenarios for service-aware orchestration.

We base on the problem statement [[RFC7498](#)] and architecture framework [[RFC7665](#)] of the SFC working group, as well on the existing mobile networks use cases [[I-D.ietf-sfc-use-case-mobility](#)] and the requirement gathering process of the ITU-R IMT 2020 [[1](#)] and different initiatives in Europe [[2](#)], Korea [[3](#)] and China [[4](#)] to anticipate network elements that will be needed in 5G networks.

We then explore service-aware orchestration scenarios identifying where different network functions can be deployed in a fully virtualised future network, where both the core and the edge provide advanced virtualisation capabilities.

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1. Introduction

The evolution of the network towards 5G implies a challenge for the infrastructure. The targeted services and the full deployment of virtualization in all segments of the network will need service function chains that previously resided in the (local and remote) infrastructure of the Network operators to extend to the radio access network (RAN).

Existing mobile networks use cases presented to the working group and the requirement gathering process of the ITU-R IMT 2020 and different initiatives in Europe, Korea and China to anticipate network elements that will be needed in 5G networks allow us to define use cases for this next generation mobile networks. Once on the pillars of them will be service-aware orchestration. We present scenarios identifying where different network functions can be deployed in a fully virtualised future network, where both the core and the edge provide advanced virtualisation capabilities. These scenarios will allow us to derive Service Function Chaining (SFC)-specific requirements.

1.1. Terminology and abbreviations

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119](#) [[RFC2119](#)].

Much of the terminology used in this document has been defined by either the 3rd Generation Partnership Project (3GPP) or by activities related to 5G networks like IMT2020 in ITU-R. Some terms are defined here for convenience, in addition to those found in [RFC6459](#) [[RFC6459](#)].

UE	User equipment like tablets or smartphones
eNB	enhanced NodeB, radio access part of the LTE system
S-GW	Serving Gateway, primary function is user plane mobility
P-GW	Packet Gateway, actual service creation point, terminates 3GPP mobile network, interface to Packet Data Networks (PDN)
HSS	Home Subscriber Server (control plane element)
MME	Mobility Management Entity (control plane element)
GTP	GPRS (General Packet Radio Service) Tunnel Protocol
S-IP	Source IP address
D-IP	Destination IP address
IMSI	The International Mobile Subscriber Identity that identifies a mobile subscriber
(S)Gi	Egress termination point of the mobile network (SGi in case of LTE, Gi in case of UMTS/HSPA). The internal data structure of this interface is not standardized by 3GPP
PCRF	3GPP standardized Policy and Charging Rules Function
PCEF	Policy and Charging Enforcement Function
TDF	Traffic Detection Function
TSSF	Traffic Steering Support Function
IDS	Intrusion Detection System
FW	Firewall
ACL	Access Control List
PEP	Performance Enhancement Proxy
IMS	IP Multimedia Subsystem
LI	Legal Intercept

Table 1

1.2. General scope of mobile service chains

Current mobile access networks terminate at a mobile service creation point (called Packet Gateway) typically located at the edge of an operator IP backbone. Within the mobile network, the user payload is encapsulated in 3GPP specific tunnels terminating eventually at the P-GW. In many cases application-specific IP traffic is not directly exchanged between the original mobile network, more specific the P-GW, and an application platform, but will be forced to pass a set of service functions. Network operators use these service functions to differentiate their services.

In order to cope with the stringent requirements of 5G networks (cf. [Section 1.3](#)), we expect a new architecture to appear. This architecture will surely make extensive use of virtualisation up to the RAN. We also expect that IP packets will need to be processed much earlier than in the current 3GPP architecture. In this context,

it is foreseeable that Service Function Chaining will play a substantial role when managing the chains network traffic will traverse. We also expect new kinds of service functions specific to the radio access part to appear and that these new service functions will need to be managed by the SFC management infrastructure of the operator.

1.3. Requirements for 5G networks

As set forth by the 5G Infrastructure Public Private Partnership (5GPPP) [5], the evolution of the infrastructure towards 5G should enable the following features in the mobile environment:

- o Providing 1000 times higher wireless area capacity
- o Saving up to 90% of energy per service provided
- o Reducing the average service creation time cycle from 90 hours to 90 minutes
- o Facilitating very dense deployments of wireless communication links to connect over 7 trillion wireless devices serving over 7 billion people

1.3.1. Evolution of the end-to-end carrier network

[SFC-Mobile-UC] presents the structure of end-to-end carrier networks and focused on the Service Function Chaining use cases for mobile carrier networks, such as current 3GPP- based networks. We recognise that other types of carrier networks that are currently deployed share similarities in the structure of the access networks and the service functions with mobile networks. The evolution towards 5G networks will make the distinction between these different types of networks blur and eventually disappear.

5G networks are expected to massively deploy virtualisation technologies from the radio elements to the core of the network. The four building blocks of the RAN, i.e. i) spectrum allocation or physical layer (PHY), ii) Medium Access Control (MAC), iii) Radio Link Control (RLC) and iv) Packet Data Convergence, are candidates for virtualisation.

2. Mobile network overview

[SFC-Mobile-UC] provides an overview of mobile networks up to LTE (Long Term Evolution) networks. As the specifications mature, we will provide the updates to the LTE architecture.

2.1.1. Classification schemes for 5G networks

TBD: We expect classification schemes for 5G networks to evolve as the standards appear.

2.2. Control plane considerations

TBD: We expect the RRC to be integrated with the SFC Control plane in 5G.

2.3. Operator requirements

4G mobile operators use service function chains to enable and optimize service delivery, offer network related customer services, optimize network behavior or protect networks against attacks and ensure privacy. Service function chains are essential to their business. Without these, mobile operators are not able to deliver the necessary and contracted Quality of Experience (QoE) or even certain products to their customers.

Operators are forced to high efficiency with respect to cost and resources in deployment and operation to offer affordable services to their customers and, as we discussed in [Section 1.3](#), the 5G Infrastructure Private-Public Partnership [6] has identified a set of additional requirements as the key differentiators for future networks. To meet these additional requirements, operators will need to make an extensive use of service chains and to extend their scope to functions in the Radio Access Network.

3. New concepts for virtualised mobile networks

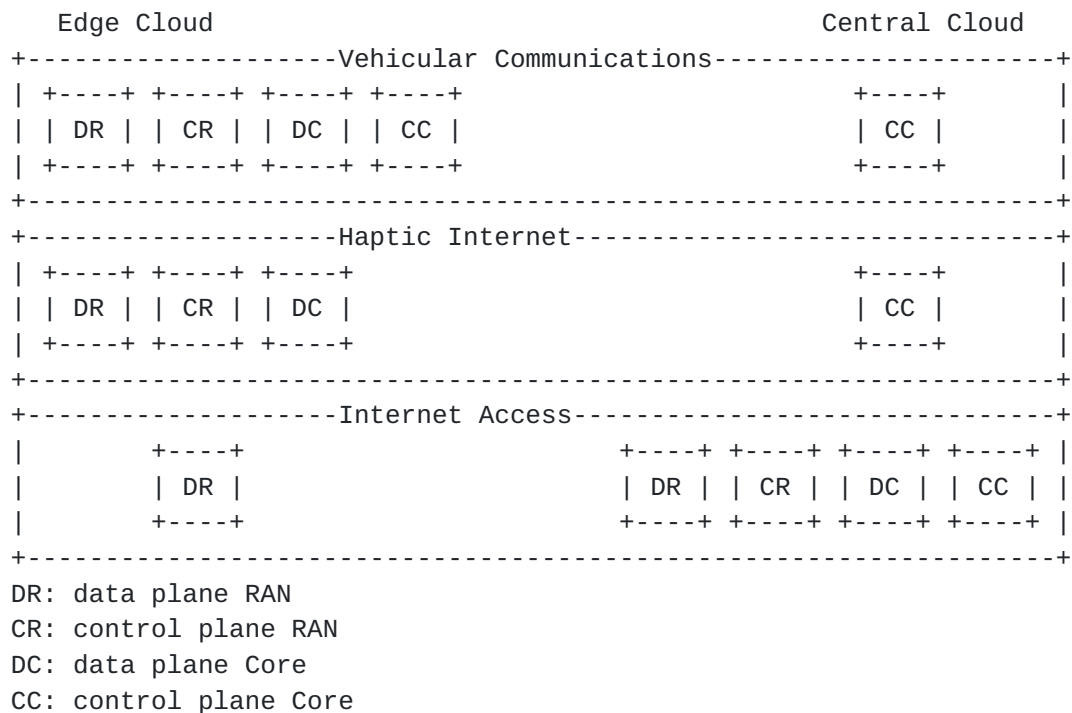
Virtualisation and softwarization will be among the key technology introduced in the design of future 5G Network architecture. They allow to decouple the binding between hardware and software components in a flexible way. While used in conjunction with SFC, future mobile network may support the dynamical allocation of Network Functions (NFs) in network nodes and their orchestration according to the requirements of the implemented service. These concepts will be the building blocks of the future 5G architecture. Current efforts in the definition of SFC mostly focus on Core Network functions. We believe that the cloudification of RAN functions will increase the flexibility needed to support very demanding and heterogeneous services envisioned by future 5G Networks, and hence the definition of the SFC Dataplane elements must also take into account functions once considered monolithically embedded in the eNB. In the next sections, we present some technical solutions that leverage on these novel concepts.

3.1. Service-aware orchestration

The current 3GPP LTE Mobile Network architecture offers a low flexibility. Even by applying SFC techniques, specific network functions are executed in well-defined units (e.g., eNB and P-GW functions are carried out in dedicated hardware). Moreover, those network equipment are usually physically located in precise locations. This static approach burdens the flexibility needed by future 5G Networks.

Softwarization and Virtualisation techniques allow for the flexible deployment of functions in the network. Therefore, the placement and execution of network functions should not be driven by topological constraints, but rather on QoS ones such as the specific requirements of the implemented service (e.g., latency, bandwidth and reliability, among others), the radio characteristics and the transport network capacity.

This approach enables the concurrent execution of different instantiations of the protocol stack in the same network infrastructure, as envisioned by the network slicing concepts. SFC is set to be a fundamental technology in this framework, allowing the dynamic deployment of different chains across many network slices spanning different cloud infrastructure arrangements. Hence, network functions can be physically located into different zones of the network: near the transmission point (edge cloud) or in centralised data centers (central cloud). The choice on the orchestration of such network functions will hence happen on a per-service basis.



Source [[SFC-Mobile-UC](#)]

Figure 2: Service-aware orchestration of network functions.

In order to achieve a service aware orchestration described above, there are some challenges that need to be addressed. They are illustrated by the following examples :

- o Vehicular communications need low latency and sessionless connectivity. Therefore, almost all the NFs belonging to this service should be located close to the transmission point, including those traditionally located in the core network;
- o Haptic Internet applications require both low latency and session continuity. Therefore, most of the network functions should be located close to the transmission point, but some control plane ones should be located in the core network;
- o Internet access users do not usually have strict latency requirements. Thus, the network functions related to them may be located in the core network, efficiently exploiting the multiplexing gain enabled by this kind of deployment.

3.2. Combining Access and Core

Traditional architectures force a fixed topological relation between network functions, while in a virtualised architecture, as the one proposed above, these constraints are relaxed. This difference is especially highlighted for access and core network functions. While in a traditional architecture, these functions are usually executed in different parts of the network (e.g., the scheduler in the base station and a firewall in the centre of the network), a virtualised architecture blends the boundaries between access and core functions: their final location is decided on a functional basis.

For instance, services with strict latency requirements may be located close to the transmission points, while services that can exploit centralisation may be located in the core data centre. The application of this concept may end up with access and core functions sharing the same network location. This fact enables possible improvements, as detailed in the following example. Currently, mobility and scheduling decisions are taken separately. The mobility-related network functions are traditionally located in the core network and their decisions are taken before scheduling ones, which are taken subsequently, in the access network. It is important to note that a decision about mobility cannot be modified at the scheduling level. With a fully virtualised architecture, the mobility and scheduler network functions may be co-located in the same network node, enabling a possible joint-optimisation between mobility and scheduling.

However, this is only one example of possible optimisations that can be achieved using this kind of approach. The proposed approach reduces high latencies introduced by the traditionally separated deployment of access and core domains. Therefore, further optimisation may be introduced as the impact of signalling protocols is reduced. SFC is expected to play a fundamental role in this picture, allowing the flexible chaining of network functions.

4. Security Considerations

Organizational security policies must apply to ensure the integrity of the SFC environment.

SFC will very likely handle user traffic and user specific information in greater detail than the current service environments do today. This is reflected in the considerations of carrying more metadata through the service chains and the control systems of the service chains. This metadata will contain sensitive information about the user and the environment in which the user is situated. This will require proper considerations in the design, implementation

and operations of such environments to preserve the privacy of the user and also the integrity of the provided metadata.

5. IANA Considerations

This document has no actions for IANA.

6. Acknowledgements

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