NETWORK SERVICES CHAINING IN THE 5G VISION

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Among all the propositions for the future Internet, the fifth generation (5G) seems to be very well positioned for becoming a reality in the near future. The 5G network aims to converge mobile and fixed networks for supporting end-to-end applications and services. 5G will be resilient, secure, and available at all times. It is unthinkable to build such a convergent network without slicing at all levels: from the physical (slicing is enforced by the integration of several radio access technologies) to application levels. Slicing will be achieved thanks to service chaining: data processing will become a sequence of services, potentially managed by different stakeholders. This will require more collaboration between stakeholders and/or greater openness of the offered services.

There are a number of required 5G features that pose real challenges to network service chaining:

- 5G will count massive concurrent sessions, even in small cells, since mobile edge computing (MEC) is needed to be the running space for many applications with ultra-low latency requirements. Thus, services in 5G should be modular (which will increase the importance of approaches such as micro-services) and distributed in the heterogeneous network.
- 5G will build multi-operator heterogeneous scenarios, where management will be distributed. Therefore, management will be based on service chaining, including virtual network functions and external management applications. Two main scopes of management will be the separation between data storage and processing, and distributed management (e.g., operators' dashboards should be visible to other operators). Multi-technology and multi-operator scenarios bring important challenges to service chaining since concatenated services may be of different natures and have different scopes. An example of the latter is how to localize an error in one slice that spans different domains.
- Agile network operations of the radio are necessary in 5G, so radio access is mainly based on virtualizing and chaining the services (cloud radio access network [C-RAN], virtualized RAN, etc.). The slicing at the physical layer and at the service layer for RAN functions makes the integration more difficult. Moreover, automation in radio access services is necessary so that they may be self-managed and more dynamic (real-time management and control).
- 5G requires dynamicity, understood as the capacity of offering ad hoc solutions, some of them managed by the customer. This requires flexibility in service chaining, so new solutions must be provided. Fault, configuration, accounting, performance, and security management should be modular and open to core and/or access ad hoc services defined by customers (enterprises).

All these features will require the use of non-monolithic developments of service chaining, based more on reusable (micro-) services. Services will be much more abstract (developed in an out-of-context way) and service chains much more modular. In an all-layers slicing architecture such as 5G, service chain orchestration takes on significant importance. Orchestration must consider the service chain reliability, which is a challenging requirement due to multi-nature (different procedures and scopes) services.

Applicability of advanced service chains in 5G networks is presented in the articles of this Feature Topic. The authors' research shows foresight of networking into the future Internet for the readers.

The article "Network Service Chaining in the Fog and Cloud Computing for the 5G Environment: Data Management and Security Challenges" presents a novel architecture for providing cloud and fog facilities in 5G networks. The presented architecture makes use of advances in network functions virtualization and software defined networking (SDN) in order to provide access to data analytics and processing in case the end user is on the move. A similar approach is defended by Datsika *et al.* in the article "Software Defined Network Service Chaining for OTT Service Providers in 5G Networks," where the authors analyze the position of over-the-top (OTT) service providers in heterogeneous environments and propose prioritization of network service chaining for OTT applications based on SDN.

For their part, Qiu *et al.* present the problem of massive data collection with ultra-low latency and low energy consumption requirements in "A Lifetime-Enhanced Data Collecting Scheme for the Internet of Things," and propose a solution for improving routing decisions to data storage.

Edge computing is discussed in "Computing, Caching, and Communication at the Edge: The Cornerstone for Building a Versatile 5G Ecosystem," which deals with user-driven ad hoc solutions in the 5G edge and proposes that end users build virtual fogs for providing QoS/QoE requirements (e.g., latency) into the edge. Ultra-low latency is also a crucial aspect of providing edge computing, as shown in "Bringing Computation Closer toward the User Network: Is Edge Computing the Solution?," where research efforts and challenges of edge computing are analyzed together with the requirements of the network in order to provide the edge computing principles.

At a lower level, a solution for radio access in cognitive radio networks by using service chaining is demonstrated in "Cognitive Radio Network and Network Service Chaining toward 5G: Challenges and Requirements." Kakalou *et al.* discuss the deployment of cognitive radios into the 5G horizon.

In conclusion, the six articles in this Feature Topic give a spherical view of the challenges of service chaining in 5G networks for providing sliced networking at all levels.

BIOGRAPHIES

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