Chapter 17
Network Functions Virtualization:
Going beyond the Carrier Cloud

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ABSTRACT

Network Functions Virtualization (NFV) has emerged as a new paradigm for designing, deploying and operating network services. It is a natural evolution of the current trend of applying cloud technologies to Information Technology (IT) services, bringing them to network provider environments. While this is true for the most simple use cases, focused on the IT services network providers rely on, the nature of network services and the physical anchors of network themselves impose additional, unique requirements on the virtualization process in this environment. At the same time, NFV provides an opportunity to network providers, reducing operational costs and bringing the promise of dramatically easing the development of new services, reducing their time-to-market, and opening new possibilities for service provisioning. This chapter analyses these requirements and opportunities and the challenges NFV brings to network providers, and reviews the current state of the art in this new way of dealing with network services.

ENTER THE SOFTWARE-DEFINED ERA

The integration of Information Technologies and Communications, commonly referred as ICT, has been more a long-term goal than a reality for a long time. Roughly speaking, networking and computing knew an evolution at comparable pace till the global availability of the Internet and the almost pervasive application of its base protocols to any networking problem. Not surprisingly, the very success of these basic principles made the evolution of network technologies more and more difficult, precisely because they were the base for the radical changes that were taking place in the IT arena, around the ideas of Internet-based services and, most of all, the cloud.

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IT evolution and, in particular the evolution of Internet-based services, have been rooted on the successive revolutions in software development practices, and in more and more powerful abstractions easing the conception, creation and operation of these services. This software-based nature has allowed business actors in the IT services arena to become agile in terms of satisfying new requirements and deploying new solutions, best exemplified by the DevOps paradigm in Loukides (2012) a set of best practices gaining strong momentum in the IT industry, and focused on the tight communication (and even integration) of the activities related to development, operations, and quality assurance.

Network infrastructures, on the other side, became tied to their topologies and the requirements on using open, standardized interfaces among the different nodes in these topologies. While the development of network nodes became certainly software intensive, the evolution of network services was tied to longer innovation cycles, requiring the agreement on standards among node producers. What is more, the generalization of the network node as the basic functional unit implied an enormous degree of heterogeneity in network elements and their management procedures, what translated in additional problems for any attempt to make infrastructure evolution agile or able to satisfy evolving user requirements.

On the Internet arena we had on the one hand network service providers, dealing with highly-heterogeneous and difficult to evolve infrastructures, and unable to address in a timely manner specific user requirements or to cover long-tail demand at any reasonable cost, while on the other hand there were the IT service providers, much more agile, relying on an almost uniform infrastructure, and able to adapt and evolve their software at a much faster pace, therefore being able to increase their value while network infrastructures were becoming more and more ossified.

The advent of cloud computing was not only a forward step in IT service virtualization, as they did not need to be hosted at a physical infrastructure operated by the IT service provider anymore, but at the same time it implied some additional requirements on the network infrastructure that could not be solved by means of the usual techniques applied so far. These additional requirements on flexibility (the network had to adapt to the ever-changing cloud configuration) and abstraction (applications needed to interact with the network as a resource among others) brought the need for a different conceptual framework for networks, beyond the usual concepts so far. Furthermore, the idea of running IT services on virtualized infrastructures made some researchers think on the possibility of doing the same for the functions performed at the nodes of the network, what we will be refer in the following as network functions. These two orthogonal directions constituted the basis for the current trends in network "softwarisation".

Network softwarisation is a general term referring to all techniques oriented towards the application of two main and related principles:

- Providing a general interface for the provisioning, management, control and invocation of network resources, by means of software abstractions that hide complexity and deployment details of actual network infrastructures.
- Decoupling the different planes conforming the network, and using open interfaces between them, in order to make the supporting infrastructure as much regular and homogeneous as possible, and relying on software mechanisms to support specialized functionalities.

With this approach, network services are provided by a layered structure, grounded on general-purpose, homogenous hardware, with one or several software layers running on top of it and defining network behaviour and functionalities in general. Everything running on the network, from basic functionalities to user applications,