COMCON: Use Cases for Virtual Future Networks

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***Abstract*— It is expected from a Future Internet that a multitude of networks will coexist and complement each other. Such environment allows to run specialized networks possibly provided by different operators to run in an isolated manner on the same infrastructure. Moreover, the infrastructure can evolve independently from network specific technologies. Network virtualization is considered as the key technology for future mobile and fixed Internet based networks supporting the establishment of such coexisting networks. It provides dynamic resource allocation and scalability on top of a substrate to reduce the time and overhead required to introduce new networks and services. The objective of the COMCON (COntrol and Management of COexisting Networks) project is to design novel control and management mechanisms that support the coexistence of networks in a future networking scenario and to illustrate the economic advantages. In this contribution, we present six use cases defined in COMCON, which serve as a guideline for our virtual network architecture.**

I. Introduction

In the Future Internet, a multitude of networks will coexist and complement each other. These coexisting networks allow specialization but require isolation of functionalities in order (a) to provide dependable and predictable networks (e.g., a banking network), (b) to allow different network technologies to run in parallel, but isolated from each other (e.g., coexistence of 3G and different beyond 3G mobile networks on the same physical infrastructure), and (c) to support network resource scalability to reduce the time and overhead required to introduce new services (e.g., to support the seamless transition from a limited liability beta service to a fully operational and resilient high-demand service). Each network should be able to run its own specialized protocols that may fundamentally differ from today's Internet Protocol (IP) stack. Network virtualization is considered to be a key technology to realize coexisting networks.

The objective of the COMCON project is to design novel control and management mechanisms that support the coexistence of networks in a future networking scenario and to illustrate the economic advantages. Virtualization technology is a key component that not only acts as an abstraction layer between services and infrastructure to facilitate innovation, but is also an integral part of the overall design to support the evolution and coexistence of different network architectures. Towards that goal, interfaces between functional roles in coexisting networks, realized by network virtualization, are specified. A provider- and operator-grade management and control functionality for coexisting virtual networks is built. It comprises of isolation, dynamic reassignment of resources, and efficient and effective monitoring of virtual networks. The requirements for the network reference architecture in the COMCON project is derived from a set of unique use cases. These use cases help to design, evaluate, and verify the reference architecture during the design process in an iterative way.

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II. Use Cases to Evaluate the Reference Architecture

Among others, we have defined the following use cases: Service Component Mobility, Service Broker, Beta Slice, Management Slice, Energy Efficiency, Resilience. We consider the last three use cases as cross sectional, as they are incorporated in the other use cases.

The *Service Component Mobility* use case considers dynamic migration of service components in a virtual network. Moving or reproducing virtualized components geographically closer to the user enables two kinds of improvements. On the one hand, the relocation of resources might improve the delay, jitter, and other quality of service parameters. The Quality of Experience (QoE) of the user increases accordingly. On the other hand, the relocation can optimize the utilization of network components. If the network is monitored and it is reported that the number of customers using the service from a distant location exceeds a certain threshold, the relocation may free capacity on long distant links, and is then of benefit also from a network cost perspective.

The *Service Broker* is realized as a network component, which knows about the user's needs and selects and bundles services from different providers. Thus, it is the ‘single interface‘ of the virtualized networks to the customer and chooses the virtual network configuration according to the user’s needs in terms of costs and network quality. In this use case, we consider a scenario, where the network virtualization is extended towards the end-customer. Different virtual network operators (VNOs) compete with their services and the end-customer is free to select a different VNO for each network service he wants to use. For example, he might want to watch IPTV using a video transfer service provided by one specific VNO. His VoIP services are delivered by another VNO, which has specialized on low-delay-connections with small bandwidth requirements. However, the peer-to-peer traffic is handled by a VNO that provides only best-effort data transfers with 90% availability, but charges on a cheap flat-rate basis.

The *Beta Slice* enables the creation and testing of new services without the additional cost of setting up a specialized test bed. Often the evaluation of new services in a specialized test bed environment is too expensive. Hence, the new service is never implemented. The Beta Slice is a special purpose virtual network to solve this problem. A new service is launched within a small dedicated virtual network, which restricts the access to a small group of initial users. After the service has been tested successfully, the virtual network can be extended progressively to a full operational network. This way, roll-out costs are decreased and expenditures for test bed evaluation are saved. Another aspect is that the time-to-market of the new service may be significantly decreased.

The *Management Slice* use case defines a special virtual network for monitoring and control. We consider virtual networks in which the operator has no direct access to the physical resources his networks are deployed on. Therefore, it is necessary to provide him with access to monitoring data and control mechanism for his own virtual network. From our point of view this can be achieved by creating a virtual network dedicated to this purpose. In this virtual network, operators are able to access monitoring data of the physical resources. Based on this information they can manage their network and request further resources if necessary.

Virtual Networks can enable energy efficiency on the physical layer. In our *Energy Efficiency* use case we are looking into mechanisms and algorithms to optimize the power consumption of the physical substrate by consolidating resources. There are many ways in which energy cost can be minimized. One possibility is to allow the relocation of virtual nodes onto less used nodes on the same physical resources. Hence, freed resources can be shut down.

The *Resilience* use case considers how virtual networks can be deployed on separate physical resources. The main challenge is the mapping between physical and virtual links. This mapping has to guarantee that the resilient links are covered by physical protection without revealing the topology of the substrate. This resource allocation has to be communicated during the setup of the virtual network and maintained during its life cycle. For this purpose, a flexible and accurate meta-description language has to be designed.

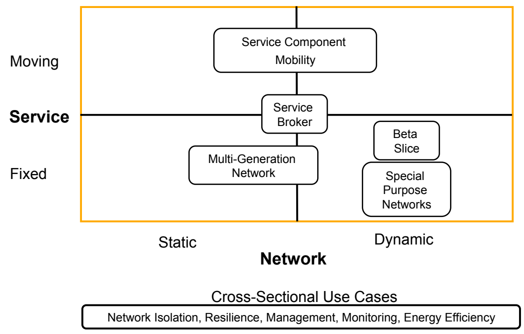

Fig. 1. Clustering of Use Cases

III. Use Case Clustering

Figure 1 depicts how the use cases differ according to service mobility and network dynamics. The Beta Slice is a good example for a use case, which changes the network size rapidly but does not vary in terms of the service delivery. In contrast, the Service Component Mobility use case is very dynamic in terms of service delivery. The numbers of users is expected to vary over time, but the mean value is considered to be only changing slightly. The Service Broker use case is somewhere in-between. The number of networks attached to the user as well as the the service delivery will change from time to time but not completely.

IV. Functional Roles of a Virtual Infrastructure

We consider network virtualization to be the enabler for our use cases, which require the isolation of parallel running networks and separation of the network logic from the hardware it runs on. In a virtual network environment the tasks to operate a network are the same as in a scenario without virtualization, but it is no longer necessary, that one single company is owning, operating, and managing the physical hardware and the network on top. Hence, we do not consider a classical role model. Instead, we characterize roles according to their functional aspects.

Basically, there are five different roles. 1) The physical infrastructure provider (PIP) owns and operates the hardware and offers virtualized resources. 2) Virtual network providers (VNPs) gather these virtual resources and constructs virtual networks. 3) A virtual network operator (VNO) requests networks with special requirements, e.g. setting up a service level agreement (SLA), and brings them to life, i.e. he installs the protocols on the hosts and controls the network. At the edges of the network, 4) end-customers (EC) and 5) application service providers (ASP) request and offer services, which are delivered in high quality by the virtualized networks.

V. Conclusion and Outlook

Based on these and other defined use cases, the COMCON project will design novel control and management mechanisms for coexisting virtualized networks. We show initial project results derived from the evaluation of the use cases. Moreover, potential business impact will be illustrated.