Background

Modern times have been defined by breakthroughs in information flow through computer networks, enabling countless innovations in any and all fields imaginable. Although the world is more connected than ever before, large-scale network infrastructure, such as is required by data centers or 5G mobile networks, remains underdeveloped and relatively slow, unreliable, and inflexible. In order to develop generalized network infrastructure which is more scalable, reliable, and low-cost, much work has been focused on developing architectures based on virtualized network functions (VNF), which are virtual machines running software which replace the functionality of hardware network nodes. Leveraging VNFs allows networks to be deployed more quickly and cheaply than using hardware.

I. Present Use of Network Function Virtualization (NFV)\(^1\)

Network functions (NFs), otherwise known as middleboxes, are “systems that examine and modify packets and flows in sophisticated ways: e.g. intrusion detection systems (IDSs), load balancers, caching proxies, etc.” (Gember-Jacobson 163, Khalid 239). As noted above, NFV refers to the process of replacing physical, hardware NFs with software equivalent systems which can run on a more generic computer. This technique is widely employed so as to allow networks to scale better and at a

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\(^1\) NFV—network function virtualization—and VNF—virtualized network functions—are very similar and can essentially be used in the same contexts and for the same purposes. The former refers to the concept of using the latter in an architecture.
lower cost than would be required to do so with physical NFs. (Open Networking Foundation 4-6).

II. Mobile Networks: 4G and 5G

One particular area where further work in NFV promises to bring great benefits is in improving mobile network architecture. (Qazi 348-9). 4G LTE architecture is structured around various of network devices, each of which manages different operations, but all of which share the same state of individual user devices. Ultimately, traffic originating from mobile devices is linked into standard IP networks (i.e., those used by the internet): the link from mobile network base stations to the IP network is called the Evolved Packet Core (EPC). However, the current EPC system is a prime point of inefficiency in matching the growing scalability demands of mobile networks. A significant improvement to this system, dubbed “PEPC,” has been proposed, which leverages the technique of “network slicing”: creating a single dedicated location for each user connection state, instead of sharing them (via duplication) between components, allowing multiple networks to run on one device (349)

Project Description

5G networks will require an entirely different framework of NFV than those presently used. The management of EPC in the current framework, in particular, is different than that of the proposed PEPC system which uses network slicing, enabling the scalability and reliability that 5G networks aim to achieve. In this project, I will investigate how to develop a stateful framework for VNFs. It’s important to point out that a full VNF system will be composed of two principal parts: a higher-order “control layer,” which manages individual VNFs, and the lower layer which consists of the individual VNFs, which are secluded from each other
and only interact in ways dictated by the control layer. I hope to investigate how to partition up responsibilities and logical roles between these individual functions, determine what state must be analyzed and kept between them, as well as implemented and evaluating strategies for ensuring reliability: for instance, if a single function crashes, how its neighbors/dependents are notified, and how they would recover from the crash.

Deliverables

- A theoretical programming model which is used to create generalized VNFs. In particular, this will extend beyond the current capability of VNFs in 4G networks, which has limited computation capability due to the limited logical model of the 4G network. In 5G, meanwhile, VNFs can perform essentially arbitrarily more general roles, above and beyond routing.

- An implementation of the programming model, including in particular an API which the control layer can use to manage all of its children VNFs, and an implementation of the communication protocol between the VNFs and their controller.

References


