The Journey towards virtual Evolved Packet Core (vEPC) Transformation via Network Function Virtualization

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Abstract - As mobile networks have evolved from 2G to 4G, they've also grown in size and complexity with more network elements, more vendors and more protocols to be managed. The paperdiscusses and provides a smarter path to network transformation by adding scale and new capabilities but with reduced complexity and cost. With vEPC solution based on OPNFV solutions leveraging the NFV infrastructure, VIM software, orchestration and SDN capabilities mobile network operators can quickly build out their networks using a single, virtualized, cloud-based and feature-rich high-performance platform.

***Keywords:* NFV, VIM, vEPC, SDN, OPNFV**

I. Introduction

The concept of Network Function Virtualization originated from the requirement of telecommunication service providers worldwide, to accelerate deployment of new network services and to support their revenue and future growth objectives. Present day telecommunication networks are over populated with a large and increasing variety of proprietary hardware appliances. Therefore, to launch a new network service, it often requires introduction of yet another variety of proprietary hardware requiring to find the space and power to accommodate these arrangements, which is becoming increasingly difficult. This is further compounded by the increasing costs of energy, capital investment, requirement of huge technical manpower etc. The variety of skills necessary to design, integrate and operate increasingly complex hardware-based appliances, poses real challenge to both developer and the network operator. Moreover, hardware-based appliances rapidly reach end of life and other cost oriented issues result in little or no revenue benefit. These constraints/limitations of hardware-based appliances (e.g. Routers, firewalls etc) led them to think beyond traditional network system and thereby, resulting into development of various IT virtualization technologies, their standards & incorporation of the same into their networks. To accelerate progress towards this common goal, service providers world-over came together to work it out with different standardization bodies such as the European Telecommunications Standards Institute (ETSI). The ETSI Industry Specification Group for Network Functions Virtualization (ETSI ISG NFV) is the lead group responsible for the development of requirements, architecture and other concerned issues for virtualization of various functions within telecommunication networks. NFV is a new way to design, deploy, and manage networking services by decoupling the physical network equipment's from the functions that run on them, which replaces hardware centric, dedicated network devices with software running on general-purpose CPUs or virtual machines, operating on standard servers. By decoupling Network Functions (NFs) from the physical devices on which they run, NFV has the potential to lead to significant reductions in Operating Expenses (OPEX) and Capital Expenses (CAPEX) and will facilitate the deployment of new services with increased agility and faster time-to-value. The concept of NFV is quite recent, though it is based on technologies that have proven their validity in IT sector, and is a result of careful experimenting and evaluation by players in the industry and academy in the recent years.

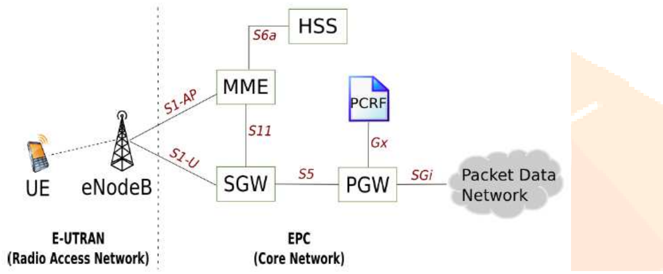
II. Background and Related Work

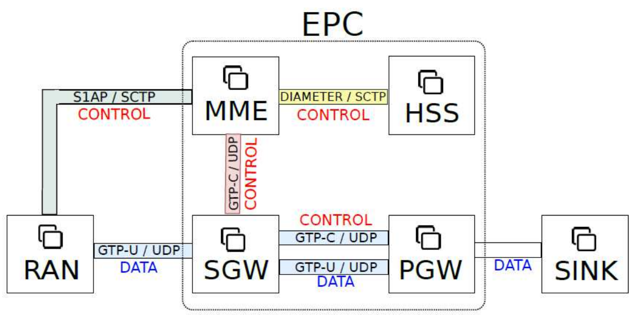
Communication service providers are looking for ways to increase capacity, coverage and at the same time to ensure the businesses KPIs were met. CSP's were also demanding a better environment for innovations which in turns accelerate the introduction of new services at a lower total cost of ownership and creation of virtual networks elements and those operations can be deployed quickly and effortlessly. Furthermore, the following are the high-level challenges that need to be taken into account when defining the specific solution for virtualizing Evolved Packet Core are defined as follows:

- Resource Scaling
- Service Awareness
- Virtualization transparency to services, network control and management
- State maintenance
- Monitoring/fault-detection/diagnosis/recovery
- Service Availability

The proposed NFV solution of virtualizing evolved packet core aims at reducing the network complexity and related operational issues by leveraging standard IP virtualization technologies to consolidate different types of network equipment onto industry standard high volume servers, switched and storage, located in NFVI-PoPs – such consolidation of hardware is expected to reduce the total cost of ownership. Flexible allocation of Network Functions on such hardware resource pool could highly improve network usage efficiency in a day-to-day network operation. This also helps to accommodate increased demand for particular services like voice without fully relying on the call restriction control mechanisms in a large-scale natural disaster scenario. HPE vEPC solution promotes an open ecosystem and is in full alignment with the ETSI NVF use case #5 -Virtualization of Mobile Core Networks and IMS.

communication protocol stacks prescribed by 3GPP are used across the implemented system. We have modified the formats of the S1AP and diameter protocols slightly for ease of implementation; the rest of our implementation faithfully follows the standards each of the EPC components (MME, SGW, PGW, HSS) isimplemented as a multi-threaded server that services requests(e.g., UE attach request) from the downstream nodes and sendsresponses back. Note that every component acts as a server tothe downstream node, and as a client to the upstream nodein the chain of VNF components traversed by a request. TheMME application module uses a multi-threaded SCTP server to handle requests from the downstream eNodeB. For ease of implementation, we did not use the multi-streaming feature ofSCTP. The EPC gateways are built around a multi-threadedUDP server, because the protocol stack of the gateways usesUDP to communicate with the other components. Below, we elaborate on our multi-threaded server architecture.





To leverage cloud competences the functional software must be on-boarded, managed, orchestrated and optimized within the cloud network, here in this solution we use Commercial Off-The-Shelf (COTS) platform to onboard and manage its virtualized applications and this has been expanded to support greater network control, broader open industry standard technologies, and virtualized network functions. The proposed solution also aims to deliver highly automated, programmable and responsive networks in support for telecommunications applications for the cloud epoch. Finally the solution includes a single orchestration engine based upon Heat Orchestration Template (HOT) to deploy/manage the complete life-cycle of vEPC functions and bring together the assurance and fulfillment capabilities that our Communications Service Provider's customers are seeking

III. Features and Requirements

The core network functions of the EPC (MME, HSS, SGW and PGW) are built as software modules, and are run on VMs hosted on a private cloud. Much like in the case of the SDN-based EPC, we also built a RAN-simulator module that combines the functionalities of the UE and eNodeB into a single logical entity for the purpose of generating traffic to our EPC. A separate sink module is used to receive the generated traffic from the RAN and send back downlink traffic. We use tun devices to perform GTP encapsulations and decapsulations of TCP traffic at the source and sink. MySQL is used for database operations by the HSS entity. Standard

IV. Proposed Model

For the first phase of implementation of vEPC, we aim to provide both best-in-breed and best-in-suite solution where we have with technically verified VNFs like HSS, AAA, OCS and PCRF along with the Mobile content cloud (MCC) and Mobile Management Entity (MME). We were successfully able to exhibited interoperability between VNF vendors and also have documented many setup & config details required to make solution work. Re-usable solution, collaterals& tools were developed for integrating HOT which automated deployment of vEPC stack in support of a use case solution; not a one-off effort.

The overall design of the system is based on client-server paradigm, where the server is multithreaded to satisfy concurrent client requests. This effectively captures all necessary functionalities involved in a typical EPC. Standard communication protocol stacks prescribed by 3G Partnership Project (3GPP) are used across the implemented system, as shown in figure 1. We have modified the formats of the S1AP and diameter protocols slightly for ease of implementation; the rest of our implementation faithfully follows the standards. Each of the EPC components (MME,SGW, PGW, HSS) are implemented as multithreaded servers that service requests (e.g., UE attach request) from the downstream nodes and send responses back. Note that every component acts as a server to the downstream node, and as a client to the upstream node in the chain of VNF components traversed by a request. The MME application module employs Stream Control Transmission Protocol (SCTP) for its communication with eNodeB and HSS. For ease of implementation, we did not use the multi-streaming feature of SCTP. The EPC gateways are built around a multithreaded UDP server, because the protocol stack of the gateways uses UDP to communicate with the other components. Below, we elaborate on our multithreaded server architectures

V. Conclusion

The proposed virtualized Evolved Packet Core (vEPC) solution automates the authentication and management of subscribers and the services they access, as well as the creation of and connectivity to services within the operator's network and to the wider Internet on a massive scale, with the quality and performance subscribers demand. The discussed vEPC solution leverages a software base that has been proven in the networks of the world's largest mobile network operators. Possible advantages of the virtualization of mobile core network would include the following:

- Improved network usage efficiency due to flexible allocation of different Network Functions on such hardware resource pool.
- Higher service availability and resiliency provided to end users/customers by dynamic network reconfigurations inherent to virtualization technology.
- Elasticity: Capacity dedicated to each Network function can be dynamically modified according to actual load on the network, this increasingly scalability.
- Topology reconfiguration: Network topology can be dynamically reconfigured to optimize performances.

As next steps we would like to extend the work on the following

- vEPC VNF Lifecycle Management using NFV Director
- E2E service with Service Chaining
- vEPC VM auto scaling based on resource in SR-IOV network.
- Reliability (Host level and VM level)
- Flexible Service Chaining Policy Definition

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