Mobile Cloud Development with Software Defined 5G Networks using NFV (Network Function Virtualization Technologies)

Umair Shahid, Rafal Krenz,Ph.D
Poznan University of Technology,Poland

Abstract— 5G is the upcoming generation of telecommunication around 2020 with the promise of Heterogeneous Networks and mobile cloud computing. In previous networks cloud's are rather considered static mounted with racks, servers etc, but 5G brings the new concept of HetNets which means that micro, macro and pico cells will be integrated on one platform. This demands us to bring concept of "Mobile cloud" for data storage necessary to connect different types of heterogeneous data networks (e.g large mobile data centers in 5G) at the same time offers mobile data storage facility. It will be possible with the help of "Software Defined Networking" approach. This paper presents solution how to develop mobile cloud with SDN and NFV technologies.

Index Terms—5G, Hetrogenous networks, Ad Hoc network, Open flow, Open Stack, Cloud computing, Mobile network, NetFPGA.

1 Introduction

SDN (Software Defined Networking) presents solution for the deployment of mobile clouds in 5G networks. SDN is a new technology which helps to develop programmable network. SDN abstract control plane from data plane and allows to program control plane according to the needs, that's why researcher take advantage of this technology to program their own network..

Control Plane

It is the controlling part of OpenFlow switch where you can test your applications.

Data Plane

It deals with the data part of OpenFlow switch which is used to forward the traffic.

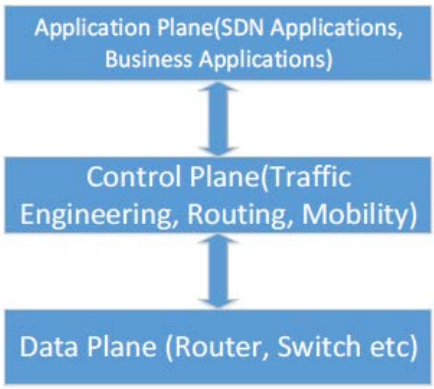

Fig 1: SDN Architecture

2 OpenFlow Concept

SDN technology provides "OpenFlow" concept which means that it provides an interface defined between control and forwarding layers of SDN architecture [5]. It is used to manage OpenFlow switch. It allows the network to be programmed according to organization's needs. It also describes message exchanges that take place between an OpenFlow controller and an OpenFlow switch [3].

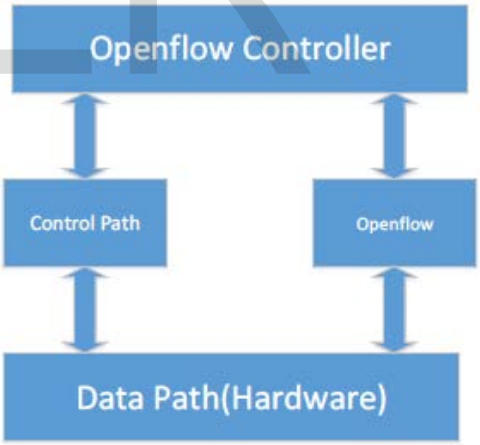

Fig 2: OpenFlow Communication

3 Mobile Cloud Deployment using SDN

a) Problem Statement

The problem is to provide cloud mobility among HetNets in 5G networks. When it comes to heterogeneous networks (HetNets) in 5G, the scenario is that we have macro, micro and pico cells and all of them has different density of users. On the basis of coverage areas these cells are divided among three major categories.

Macro cell: It provides the largest coverage areas and serves large number of users.

Micro cell: It provides limited area coverage comparison to macro cell like shopping mall, hotel etc.

Pico cell: It provides coverage in to extremely dense areas like trains, buses etc. It is also used to extend coverage.

The problem is to integrate these cells in to one processing unit which is able to handle demands on real time basis with low latency requirement.

We can take advantage of OpenFlow concept, NFV and cloud computing to build mobile clouds in 5G which can be easily assessable in terms of storage, data retrieval and other purposes.

4 Mobile Cloud Computing

Mobile cloud computing is a new platform where we can combine mobile devices and cloud computing to take advantage of mobility and computing resources of both of them [1]. In 5G mobile devices refer to UE's (User equipment) which could be any vehicle, mobile phone or sensor, actuator or any other device.

The new paradigm of telecom services is shifted from traditional sectorization of cells to densely populated mobile UE's. In previous telecom architectures when user moves away from cell center it experiences degraded signal and poor SNR values. Rather than this, If we deploy "Cloud RAN" (proposed by China Mobile)[4] and incorporate all resources in to one processing unit, it would be much easier and more efficient. There will be AP's (access points) which are connected to UE's and those AP's are then connected to C-RAN finally which is responsible to deliver all resources. The diagrammatic representation is as follows which is expected in 5G scenario where we move beyond the boundaries of sectorization and can be ubiquitous [2].

Now the question is how to challenge this problem?

The solution lies in the heart of SDN based technology which is OpenFlow. We need to deploy OpenFlow controllers in the heart of C-RAN [4] which could balance traffic load among VM's. OpenFlow controllers are linked via API's (Application Programmable Interface) which are programmable and can be modified according to the needs of the network [7].

"OpenFlow approach uses the concept of "Network Virtualization" to virtualized the underneath network so that user is unaware of lower layers of the network (no matter what physical hardware is used) at lower level. User has the virtualized feeling and is connected with the under lying network with API (Application Programmable Interface).This way, you can add multiple resource into a single resource and you are segmenting physical network in to logical segments" [3][5].

5 OpenStack

Although as stated above, It seems quite easy to say that we can face the challenge of mobile clouds and communication among them with the help of only OpenFlow but we should also keep in mind that there will be thousands of VM's, servers etc when it comes to real 5G network and this is not easy to manage by OpenFlow technology only. Therefore, OpenStack comes in and solve the problem.

"OpenStack is cloud computing software (Founded by NASA and RackSpace organization) which provides modular architecture and makes cloud computing more effective. The main problem in existing cloud computing network is its increasing number of virtual machines/virtual servers and hypervisors which is becoming problem for developers and programmers to manage. Therefore, OpenStack comes in and provide modular solution in form of compute, networking and storage. The most interesting thing that we can design our own API in C++/Python to connect with the user and user have the virtualized feeling for the underneath network. This way we can obtain flexibility and security as well [8]."

OpenStack has a modular architecture that currently has the following components [8]

- OpenStack Compute (Nova)- It is used for provisioning and managing large networks of virtual machines (VMs).
- OpenStack Object Storage (Swift) – It is used for storage system that provides support for both object storage and block storage.
- Image Service (Glance) – It is used for delivery service that provides discovery and registration for virtual disk images.
- Networking (Neutron/Quantum)- Neutron is a virtual network service for OpenStack. It was previously known as 'Quantum'. It basically provides "network connectivity as a service" between interface devices managed by other OpenStack services. Quantum controls network virtualization just like compute control server virtualization. Just like OpenStack Nova provides an API to dynamically request and configure virtual servers, Neutron provides an API to dynamically request and configure virtual networks. These networks connect "interfaces" from other OpenStack services (e.g., vNICs from Nova VMs). The Neutron API supports extensions to provide advanced network capabilities (e.g., QoS, ACLs, network monitoring, etc).

- DashBoard: It provides the graphical interface through which you can create, manage API and access different OpenStack services.

- OpenStack Identity Service (Keystone): This service is used for authentication and authorization request.

6 Solution

OpenStack could be one of the best solutions for cloudcomputing that could be used.However, there is one more effective solution better than OpenStack which is NetFPGA which is finally proposed in this paper with cloud computing. You can take the advantage of processing the packet rather than flows and monitor data rates as well. If we use NetFPGA with Openflow switches in Cloud computing in 5G networks it will bring state of art technology.

7 Mobile Cloud with OpenFlow switch and OpenFlow Controller

We can simply define NetFPGA as

- Networking Software running on a standard PC (OS:Linux).

- It is an open platform enabling researchers and instructors to build high-speed, hardware-accelerated networking systems.

- A line rate, flexible, open networking platform for teaching and research.

- It can process back to back packets, operate on packet headers (for switching, routing and firewall rules) and packet payload for intrusion prevention.

- You can program it in HDL (Verilog/VHDL).

- You can also implement "Cryptographic NIC" which means implement a network interface card (NIC) that encrypts upon transmission and decrypts upon reception. In this way you can make your network/cloud more secure.

NetFPGA is built on EDK(Embedded Development Kit) e.g Xilinx

8 Deployment of NetFPGA

NetFPGA can be easily deployed on a simple PC with LINUX operating system. We need to use mother board of the PC and put NetFPGA card in PCI slot and that's it!! It is really simple comparing to other NFV technologies.
NetFPGA platform consists of three parts: hardware, gateware, and software. The hardware is a PCI card that has the following core components: - Xilinx Virtex-II Pro 50 - 4x 1 Gbps Ethernet ports using a soft MAC core - Two parallel banks of 18 MBit Zero-bus turnaround (ZBT) SRAM - 64 MBytes DDR DRAM [5].

9 Working

After studying above mentioned different NFV technologies NetFPGA seems to be a more promising and ultimate solution for Mobile cloud development in 5G networks.

The need of NetFPGA is raised because it fulfills today's SDN requirement and provides the platform where we can program our network in HDL languages [6]. Not only this, but with the help of NetFPGA technology we can also provide more security to our network by introducing "Deep Packet Inspection" techniques where we need to look in to overall packet to detect various threats which ordinary IDS(Intrusion Detection Systems) or Anti Viruses can't do. Also the other advantage is that you don't need to buy license as you can program your own algorithm which is also cost effective and fast as well. 10G NetFPGA board is fast enough to check millions of packets in real time and able to handle them as well [6].

Now let's understand how it works,

We are using NetFPGA instead of OpenFlow controller. Previously (as stated in this paper) in OpenFlow technology there are two components

1) OpenFlow Switch 2) OpenFlow Controller

So packets are forwarded by OpenFlow Switch and those packets which are not indentified by OpenFlow Switch forwarded to OpenFlow controller, which is responsible for taking routing decisions. But in this case packets are "flows" rather than "processes" which means that If we "process" the packet instead of "flows" [6] we can monitor its line rate, data rate and several other parameters. And this can be done by putting NetFPGA controller instead of OpenFlow Controller as shown in the following figure.
In the existing OpenFlow setup all the packets "flow" through OpenFlow switch which register flow entries. In this way we can have two major problems.

1) The system is congesting and time consuming. Also, not an intelligent approach.

2) When the switch starts it sends packets to all ports (as a learning switch) to register the entries which is not only time consuming but may also cause collision.

As shown in the following diagrams to better understand that packets usually route through OpenFlow switch which has flow entries in some cases If it doesn't find any flow entry it goes to the controller to make the decision. But when we place NetFPGA in this existing set up you can see in the following diagram that packet goes to NetFPGA for "processing" rather than OpenFlow controller for "flows". We can define line rate in this situation and let NetFPGA take the decision about the processing of the packet. So here the answer is, as we have taken the packet which means we can make packet more secure by encrypting it in (header etc..) This way we can ensure more secure packets which in other words means more cloud security. Also, you can do it in real time with speed. In this way we have performance, reliability, scalability [6].

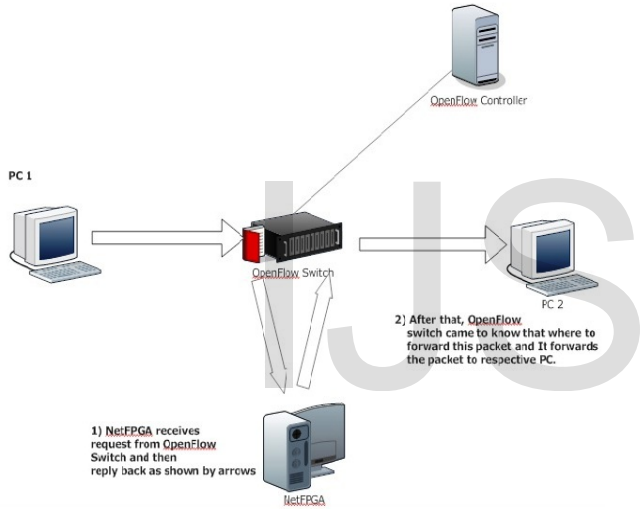

Fig 3: NetFPGA Deployment with OpenFlow switch

10 NetFPGA in context of 5G networks

Finally, we have come to the stage where we should start talking about that how to use NetFPGA in 5G networks and take benefits of ubiquitous cloud computing in C-RAN environment. As already mentioned in this paper the new era of telecommunication requires C-RAN [4][7] and all the base band processing in to one centralized controller which is the pool of resources and if we are talking about mobility then all mobile UE's(like cell phones, vehicles etc.) must take resources from this pool. This way we can develop mobile cloud computing scenario empowered by SDN with NetFPGA.

We use NetFPGA in C-RAN as a centralized controller by taking advantage of its fast processing (as it process billions of packets, mentioned previously). We incorporate all resources in to one entity and with the help of SDN we abstract physical underneath infrastructure from upper layer which is the processing unit and deploy NetFPGA in the heart of C-RAN.This way UE's can be free from processing load and their battery time could be increased and this load is shifted to NetFPGA which is specifically designed to meet this challenge.

11 CONCLUSION

In this research paper after investigating all NFV technologies we have come to conclusion that NetFPGA in C-RAN deployment will be the most cutting edge, state of art, cheap, easily deployable and most promising solution among different SDN technologies so this idea is proposed. We can program our entire mobile network in NetFPGA and deploy all computing features in that.

References

[1] T.D.Hoang , Chonho Lee, N.Dusit , and W.Ping,"A Survey of Mobile Cloud Computing: Architecture, Applications, and Approaches", Wireless Communications and Mobile Computing – Wiley.

[2] HUAWEI WHITE PAPER April 2015,"5G: New Air interface and radio Virtualization".

[3] J.Raj Jain and P. Subharthi , "Network Virtualization and Software Defined Networking for Cloud Computing: A survey". Cloud Networking and Communication.

[4] L.Chin, H.Jinri , D.Ran , C.Chufeng,J.J.Jesse and L.Lei ," Recent Progress on C-RAN Centralization and Cloudification", accepted July 14, 2014, published August 22, 2014, date of current version September 19, 2014. IEEE Access,Special section on recent advances in Cloud radio and access networks.

[5] N.Jad,E.David,C.G.Adam,A.Guido,M.Nick," Implementing an OpenFlow Switch on the NetFPGA platform".

[6]M.Nick,A.Tom,B.Hari,P.Guru,P.Larry,R.Jennifer,S.Scott,T.Jonathan" OpenFlow: Enabling Innovation in Campus Networks".

[7]Y.Mao,L.Yong,J.Depeng,S.Li,M.Shaowu,Z.Lieguang."OpenRAN: A Software-defined RAN Architecture Via Virtualization".

[8]www.openstack.org