Mobile Network Sharing using OpenFlow

[Extended Abstract]

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***Abstract*— Seamless connectivity for data and broadband services in today's communication world is considered to be one of the most challenging tasks for operation and maintenance engineers and researchers. An aim of our ongoing research is to take a pragmatic approach to the "last mile" issue and provide a solution to improve resiliency and look at traffic prioritization primarily for 4G-LTE mobile networks. Towards this approach, we propose a solution for infrastructure sharing based on exploring OpenFlow as an architecture for e-Node B virtualization and backhaul infrastructure sharing. Through this work, we share our design and foreseen research.**

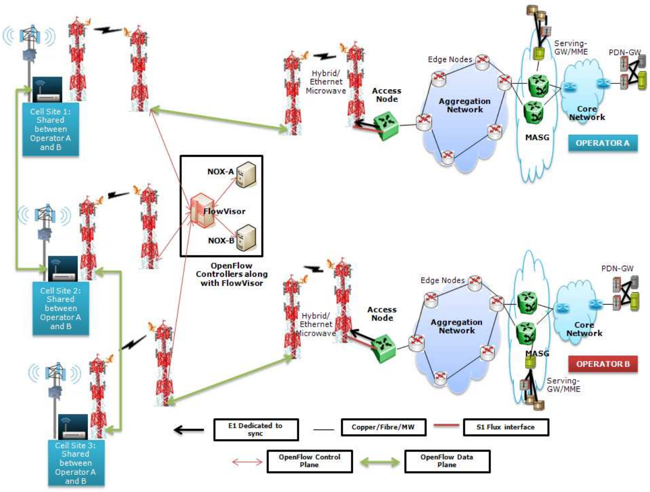
***Index Terms*— Backhaul Networks, e-Node B Virtualization, Infrastructure Sharing, 4G-LTE, Resiliency mechanisms.**

I. Introduction

Promoting network infrastructure sharing is a useful tool for regulators and policy makers to encourage mobile network deployment and coverage improvement in the un-served less populated areas. There are several ways that can be used to promote network sharing. As per [1], there are two architectures for network sharing that have been standardized. According to it, a network sharing architecture shall allow different core network operators to connect to a shared radio access network. The operators do not only share the radio network elements, but may also share the radio resources themselves. However, depending on the country, some limitations have to be considered regarding the level of sharing in particular for the spectrum, radio equipments. This limitation is explained by the fact that sharing of active mobile equipment may raise concerns about restricting competition between the sharing operators. Sharing active network infrastructure usually leads to mobile operators offering similar network coverage, quality and transmission speeds. Henceforth, a fundamental objective of resource sharing is to find a stable operating point based on certain fairness and efficiency criteria. There is a need to find a trade-off between simplicity of dynamic policies and flexibility of static policies. Now within this context, from a research perspective, we emphasize the way to evolve infrastructure sharing policies in order to enable "Service Differentiation", ex. service priorities, dynamic sharing policies between operators. The idea is to enable a mobile communication system that would facilitate two or more operators to share their access network extending to the backhaul till the core network. Hence, we propose our solution which is based on virtualization of e-Node Bs of operators within the LTE/EPC architecture, where more dynamicity and differentiation in access network sharing could be incorporated by OpenFlow [2] mechanisms, especially when the Telecom regulator imposes it. With OpenFlow, we seek to define how far it can be gone within the sharing scenarios based on the architecture of LTE/EPC defined in 3GPP, where the key lock is to open facilities to define flexible and extensible policies. Apart from using the infrastructure sharing to reduce cost or to increase coverage for customers, we exploit infrastructure sharing to the next level of using it for resiliency purpose in which the backhaul of the operators is shared. Current resiliency mechanisms are based on over-dimensioning and re-routing mechanisms that are mainly deployed on core networks but cost too much for being largely deployed till the last-mile backhaul compared to the probability of outage. Our solution paves a way for seamless connectivity even till the last mile without additional links.

II. Infrastructure Sharing Strategies

Our primary solution focuses on the access network sharing extending to the backhaul where the resources from the e-Node Bs until the mobile core network are shared and controlled by operators who have concluded on a sharing agreement. Current access network sharing techniques are based on VLANs, a common network slicing technique. However, from our research results, we could not be convinced with the advantages that VLANs are offering at the moment. We exploit the capability of FlowVisor [3] based virtualization for virtualizing LTE/EPC architecture because it gives the possibility to slice or virtualize bandwidth, traffic, topology of any given network. As a first step, we have elaborated our proposal by considering a scenario where the physical equipment, i.e. e-Node B is sliced into two. By this, it is implied that it enforces a policy where there are only two operators who share the same network resources. This is depicted in the Fig. 1. According to this, the entire cellular network resource is divided into two slices by the FlowVisor policy; one for operator A and one for operator B. Each operator operates and controls its own controller(s). Thus, FlowVisor policy slices the network so that operator A's sees traffic from users that have opted-in to his slice. After virtualization, each operator will be able to share sufficient amount of its own resource with the other operator(s) who is sharing the infrastructure for the purpose of load sharing as well as to tackle network failure situations of their own network.



The second part of the research is to extend further and find solutions as an alternative to resiliency mechanisms. As a matter of fact, every operator establishes their own set of different resiliency mechanism at every relevant layer (namely datalink, transport, logical IP) of the network to protect the network from failures. However, the existing resiliency mechanisms adapted by operators still prove to have their own downtimes [4] and hence this led to the primary consideration to share the backhaul infrastructure with the other operators under network failure conditions. When two operators share their network including sharing their backhaul infrastructure and if either one of the operator's link fail, there is no mechanism that defines how the traffic density has to be re-routed via the other operators available link based on transmission metrics, yet with meaningful energy savings. The preliminary pre-requisite for backhaul sharing is the ability of the e-Node B to route the traffic via another operator backhaul, thus sharing of backhaul infrastructure and the availability of the network is increased. Such mechanisms allow for quick network failover, so they increase its availability to the end users. Our scenarios for backhaul sharing essentially require that the e-Node B is announced about a fault in a link on its own backhaul network that is detected by the OpenFlow controller and automatically route the traffic towards another operator backhaul network with whom the sharing agreement is signed.

The main advantages of this solution are:

• Cost reduction: If there are two operators (as in our case) decide to share the cost for deploying the network infrastructure, CAPEX will be greatly reduced for each of them individually [4].

• Efficient resource utilization: The operators get to optimize their traffic according to the available bandwidth. With our solution we could achieve more optimized use of the available bandwidth according to need of the applications.

• Technically simple solution: Since, the operators do not have to modify the e-Node Bs, it allows for more simplified modification at any time just in the controllers.

• The operators have the liberty to choose to prioritize the type of traffic that he would want to flow in the sharing backhaul bandwidth. Even better is, the operator can nonetheless care about the traffic priorities and just re-route a part of its own traffic in the shared bandwidth.

III. COMPLEXITIES INVLOVED AND FUTURE WORK

As a primary step, we evaluated the performance of OpenFlow protocol with the standard VLAN technology to see the throughput performance. We noticed that OpenFlow gives much higher throughput performance compared to the existing VLANs. We also experimented on FlowVisor's property to isolate network resources. All these lead to the conclusion that OpenFlow is an enabler to network virtualization and service virtualization programmability within the context of mobile network architecture enabling shared network access. Network & service virtualization for increasing the ARPU while cutting down CapEx, OpEx can increase revenue opportunities for network service providers. With backhaul infrastructure sharing, the cost reductions will lead to a reduction of business risk for the involved operators. The cost and energy reduction in this scenario is of a similar magnitude, since more traffic can be served with the same equipment before additional sites are needed. With all these in mind, backhaul infrastructure sharing could be one of the problem solvers to tackle the issue of restoring network failures or undermining peak traffic problems). However, at this level, there are legitimate questions to ask about the performance, reliability and scalability of a controller that dynamically adds and removes flows as the number of e-Nodes could increase for a particular operator. Considering network failure conditions, questions like how OpenFlow takes care of detecting a link failure and re-routing within an OpenFlow network still arise and lead to further research. Nonetheless, if we are successful in deploying OpenFlow networks in the existing mobile network infrastructure, it will lead to a new generation of control software, allowing operators to re-use controllers, enabling more savings in cost and energy.

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