SDN Integration and Management Solutions for Campus Network Enhanced Services

Jordi Ortiz
Dept. Information and Communications Engineering (DIIC)
University of Murcia (UM)
Murcia, Spain
jordi.ortiz@um.es

José Ignacio Aznar
Distributed Applications and Networks Area (DANA),
i2cat Foundation
Barcelona, Spain,
jose.aznar@i2cat.net

Alaitz Mendiola
Department of Communications Engineering
University of the Basque Country UPV/EHU
Bilbao, Spain
alaitz.mendiola@ehu.eus

Kostas Giotis
Network Management & Optimal Design Laboratory
(NETMODE)
National Technical University of Athens (NTUA)
Athens, Greece
coyiotis@netmode.ntua.gr

***Abstract*— the goal of this work is to present a case study demonstrator, presenting the field trial experience while extending network connectivity services in the campus, by enabling SDN-based equipment and coexisting with legacy hardware. The demonstrator aims to show the benefits of gradually adopting SDN technologies. This adoption will also improve and provide added value to traditional campus connectivity services. At the same time NOCs are able to make a better schedule of the network since more specific information about its usage is available.**

Keywords—Campus, SDN Network services, SDN and Legacy equipment.

I. Introduction

Campus environments (e.g. universities, research institutions, etc.) network services have been traditionally focused on provisioning best effort connectivity. In such environment, the network has been basically a kind of binary resource that simply worked or not.

Researchers and users of these campuses are in the need of requesting for improved connectivity services with a set of determined requirements that cannot be fulfilled by the Best Effort campuses production network. They are demanding novel capabilities (or old ones but not affordable by the legacy technology) and easier and faster provisioning mechanisms.

For instance, a researcher could be requesting for a Bandwidth on Demand (BoD) service to access a real time streaming resource, which cannot be recovered afterwards. Basically, in these cases, if the transmission fails, the content can never be recovered. Another example that could fit into this use case is what happens with the Large Hadron Collider (LHC)[1]. The LHC produces high amounts of data that cannot be processed in a single site and thus, it is disseminated across multiple processing centers[2]. It is clear that the bandwidth needs to be maintained to avoid data loss. Smaller examples of this particular use case can also be found around universities with small supercomputing centres deployed in their premises. Users that usually access these centres over the standard production network are keen on benefiting from special paths, guaranteed bandwidth, minimum delay and other network characteristics.

Main showstopper is that the new requirements to enhance current connectivity services' performance are handled by Campuses' NOCs and imply big amounts of man power investment, special treatment and manual configuration. The process of getting such enhanced services usually involves a lot of administrative and human interaction, which is further increased in the cases where the requirement involves carriers, NRENs and Network Service Providers (NSPs) in order to extend the connectivity beyond the campus. Additionally, the new features may influence the standard campus production traffic, so that NOCs are reluctant to introduce them.

Still, it would be desirable to have the means to obtain differentiated network services on demand and through fast simple allocation mechanisms, which should also be available to any user (usually researchers) in the campus. In addition, it must be taken into account the possibility that some users may request non-standard connectivity services that break with the TCP/IP paradigm and thus, cannot coexist with it.

One of these non-standard connectivity cases are Software Defined Network (SDN) enabled labs, which are already being deployed in many campuses. In many cases, these SDN labs need to extend their Points of Presence over the campus, and require the transparent transport of their communications over the production infrastructure. These labs do in many cases federate with other labs, which involve the carriers and NSPs in the equation of the non-standard connectivity. On the other hand, it has to be taken into account that the NOC has limited amount of resources and their reluctance to change hardware that is still operational, with maintenance contracts already paid. The separation of the production traffic from the research traffic needs to be done easily and probably using the actual equipment and available technologies while more advanced SDN equipment arrives to the campus core networks[4].

Considering both campuses' users and NOCs points of view in relation to the network connectivity services, one feasible possibility is to incrementally move from legacy to SDN virtualized environments, by introducing and running SDN equipment together with legacy equipment, and it will probably occur since a massive and at once replacement of existing hardware is not foreseen.

The goal of this work is to present a case study demonstrator, presenting the field trial experience by enabling SDN-based equipment to coexist with legacy hardware while extending network connectivity services in the campus. The demonstrator aims to show the benefits of gradually adopting SDN technologies to improve and add value to traditional connectivity services at the time NOCs are able to make a better schedule of the network since more specific information about its usage is available.

II. The Network in the Campus (NitC) Use Case

A. *Overall use case scenario*

Two main actors are considered in this scenario:

- The researcher (adopting the End-user role), is the actor that will produce knowledge and wealth by consuming the enhanced network service and/or by performing experiments with it. The researcher desires a way to reserve the resources and be sure that anyone else or any other technology interferes in the service.
- The NOC (adopting the campus NSP role), is in charge of the university's production network and the responsible of provisioning the network connectivity services.

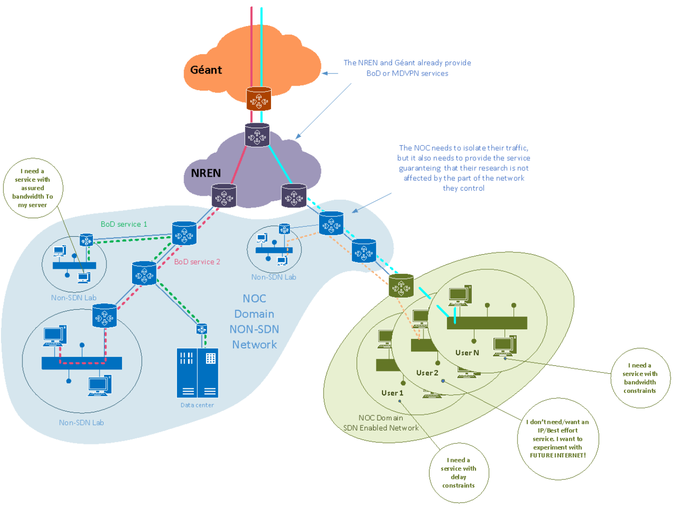


Figure 1 Network in the Campus scenario

The scenario, depicted in Figure 1, represents a campus network where SDN technologies have started to coexist with the legacy equipment , which occupies the vast majority of the deployment. In this scenario, the users that demand special and differentiated services are shown, together with the associated connectivity flows over the production network. The blue bubble represents this legacy equipment while the green bubble represents the new deployed SDN hardware. It is not expected to have the SDN hardware exposed to the NREN or the NSP, the most probable approach to be followed while deploying the new SDN equipment is to prioritize those centres with a high demand such as Computer Science faculties, Research centres within campuses or even the proper NOC building which in some cases is collocated in the same building with the other IT services of the campus.

B. *Storyboards*

In order to make clear the benefits that this use case brings to both actors, several storyboards are presented. These story boards identify concrete added value features while incorporating SDN technologies to provision improved connectivity services.

1) *Improved Layer 2 connectivity.*

The Improved Layer 2 connectivity storyboard involves a Network researcher in the field of Future Internet (FI). This user needs a connection between a wireless node deployed in the network lab of its faculty and a server deployed in another building of the same campus, the communication between both end points never leaves NOC's domain.

Researching FI topics has the drawback of breaking with all previously established network services, in particular the TCP/IP heap. Plain L2 connectivity is required but what is more relevant, no TCP/IP aware network element can interfere in this connection. Network connection redundancy is desirable and even more, some kind of control over the redundant connections would be much appreciated, at least to select the primary and backups paths. .

It would also be of interest to the researcher to obtain some extra information about the physical connection. Since this information could also be relevant for the interpretation of the results.

2) *NOC network and services enhanced management.*

The NOC is in charge of providing basic services to all the university users at a production level meanwhile having to cope with the special requests from researchers, faculty members and other power users.

Even if the proposed solution provides some mechanisms to allow these power users to have some automated resource requests, it is the NOC that finally must be able to control who, when and how will have access those resources.

In that sense, this storyboard represents how the NOC will be able to monitor the network and the reservations created by the users, the usage of such reservations and what is even more important, influence on the system to drive solutions or avoid upcoming problems thanks to the heuristic knowledge gained over years of service like for instance reallocating flows.

In addition to this daily maintenance, the NOC needs the means to define user profiles with their characteristics and capabilities as well as registering users enrolled in those profiles.

Another key factor for these users and the NOC itself is the ability of the system to administrate the resources in a human friendly way. It is not expected that any user knows to which L2 switch and which port his laptop is connected and in many cases even what is a L2 switch. The system has to provide the means to translate what a user really knows (e.g. the socket in my office labeled with the number 38) with what the network needs to provide a service (e.g. the L2 switch in the third floor of mathematics faculty port 17).

3) Warranted QoS connectivity service.

With this storyboard two objectives are accomplished, on the one hand we introduce the QoS service and on the other hand we introduce a non-technical user.

In this case a mathematic researcher who has just discovered a new way to demonstrate an up to now undemonstrated theorem wants to share his discovery with the scientific community. In order to do that he will provide a live HD presentation through a multimedia services provider such as YouTube. To be able to stream Full HD (1080p) 30fps video with commercial products (H.264/AVC), a minimum of 20 Mb/s (up to 200) is needed.

So the researcher in this case desires not only an assured bandwidth on the campus network but also on the peering with the outside world which means doing reservations also on the uplink of the University.

III. Demonstrator Set Up

A. Demonstrator

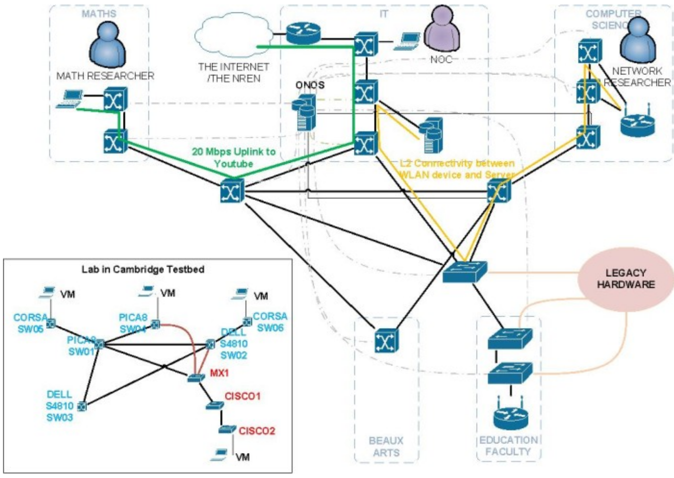
During the design phases of the use case and only after having designed the story boards and having the positive feedback from our Universities NOCs, we defined what would be our ideal and minimal deployment to showcase such a system. The result is shown in , which depicts where the users related to the aforementioned story boards are situated in the network architecture resembling a campus network spread over 5 different buildings. In this minimal deployment there is also some legacy equipment, which allows the demonstration of the solution regarding the communication and interaction of the two different network devices. On the bottom left corner there is a mapping with the actual deployment in the testbed provided by the Cambridge Lab of Géant[3].

B. Testing requirements

Up to 13 high level requirements were identified related to this Use case, some of them split in more definite sub-requirements which rise this value in not less than 30 sub-requirements. Among them it is worth to mention the most relevant ones that in authors' opinion assess the value of leveraging SDN-based technologies to accomplish the objectives of the proposes storyboard scenarios:

- Traffic Isolation: Research traffic must be isolated from production traffic, and the other way around. It is fundamental to maintain the production services while providing the researchers with extended functionalities. At the same time, researchers working with innovative network architectures desire isolation from ossified network architectures.

Figure 2 Testbed designed and demonstrator



- Accommodate Legacy Equipment: The coexistence of legacy and SDN equipment is fundamental for a smooth adoption of the SDN and all the implicit benefits.
- Rate Limiting: In some scenarios assured bandwidth is desired and is understandable but also network restrictions can be a key functionality. Some researchers are in the need of constraining the offered service to emulate congestion or future shortages.
- L2 Connectivity: Offering raw connectivity to network researchers is a service already offered but often restricted to the manpower available to the NOC.

C. Conclusions

The proposal presented is intended to be a step forward in the provision of networking services within the educational communities, in particular universities. The inclusion of the user as part of the system will provide with a rich experience, while at the same time will discharge of administrative and repetitive work to the NOC.

With our demonstrator we aim to show how such a system should look alike and how (and in the case of legacy hardware up to which point) the aforementioned story boards can be implemented on the campus networks in order to be able to convince real NOCs to try the system in their environments. The adoption of SDN-based technologies is a key enabler to this target.

Acknowledgment

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