SDN: The Network Management Revival

This document describes the importance and the revival of advanced Network Management in the 2010's, and it tries to put today's buzz-words in perspective, relevant to network operators with the need to manage their transport networks.

Introduction

For many years network operators have relied on network management tools to manage their transport networks; however, a massive shift in end user expectations and the deployment of another transport platform has put operators in a challenging position. Network operators must figure out an effective way to provide end users with real-time control over their services.

To better understand the current state, challenges, and future developments of network management solutions, one must first look at the history behind the technology. This article will go back to the heydays, examine the subsequent decline and current revival of network management, taking a close look at the challenges that network operators face and concluding with how the industry is currently addressing these issues.

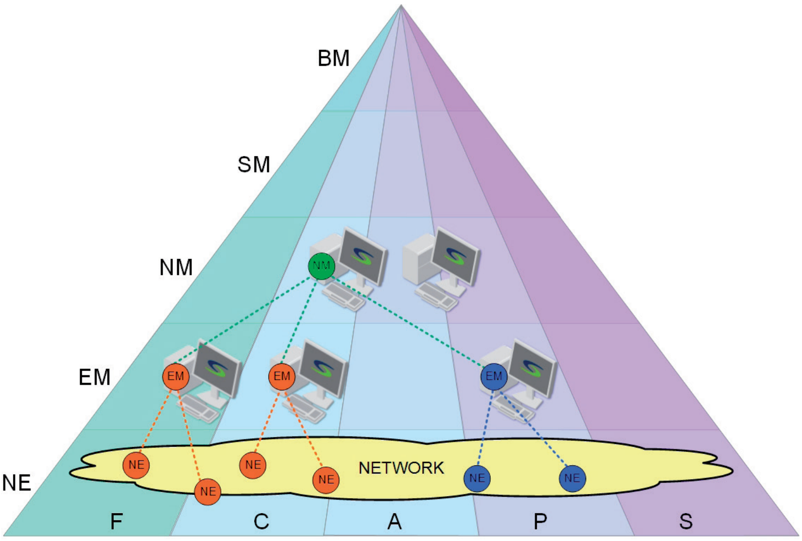

Figure 1: The ITU-T M.3000 TMN Reference Model

A Short History

With the introduction of SDH technology and the ITU's TMN management framework in the early 1990s, advanced network management applications were developed. However, the boost in the industry around network management resulted in an increasing focus on higher layer functions, such as performance and service management. Since these functions were less strictly coupled to specific network element types, parties outside of the traditional network elements vendors began offering solutions. Moreover, these higher layer functions proved to be better aligned to the needs of network operators in addition to being more profitable.

In general, the focus of vendors managing their own developed and manufactured equipment with comprehensive network management functions shifted again, and at the end of the 1990s — coinciding with the Internet bubble — a new hype was fueled.

Based on the assumption that customers would be willing to pay high fees for these value-added applications, most vendors changed their course in this direction. This effort was spearheaded by larger IT companies that didn't want to lose out on the opportunity. With the development effort now focused on dashboard GUIs that had a high sex appeal and integrating performance and service management information, any further development of end-to-end network management was put on hold.

With the Internet bubble burst, the telecommunications industry found itself in a situation where network operators were forced to focus on reducing capital expenses. Thus, they were not willing to invest anymore in costly higher layer management functions and started developing these type of applications in-house, mainly based on common information exchange and control interfaces (e.g., the command line (CLI) and the SNMP-protocol).

New Challenges

Now more than a decade later the challenges that network operators face have to do with being able to give their end users real-time control over their services. It is no longer a one-way direction of aggregated, time-delayed information from the network to information processing and presenting applications, but a bidirectional real-time exchange of information and commands required to monitor, provision and change services affecting all core systems and processes of the network operator. This challenge is often referred to within the industry as orchestration.

Furthermore, the cost reductions network operators had to implement to fulfill the ever-increasing bandwidth needs, resulted in a revolutionary change of the transmission platform. The SDH network, with its advanced network management, was no longer the platform to grow on; Carrier Ethernet took over. While the maturity of Carrier Ethernet's network management compared to that of SDH lags behind, the complexity of Carrier Ethernet technology has surpassed that of SDH.

The enormous complexity and scope involved with solving orchestration and Carrier Ethernet network management challenges can only be handled by an architecture that is independent of individual vendors, technology and products, thus requiring standardization that transcends existing network management standards.

Initiatives in the different disciplines result in a staggering rate of developments that are relevant to this required standardization, such as SOA, OpenFlow, SDN, Netconf, NFV.

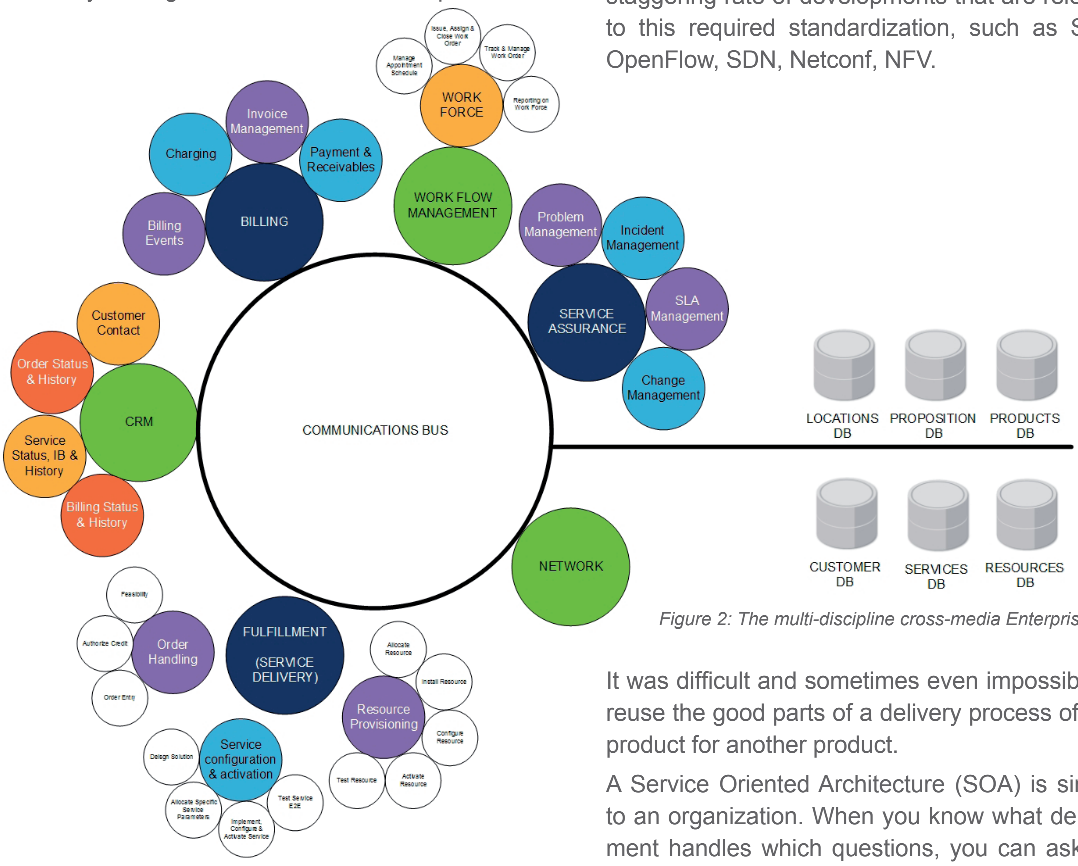

Figure 2: The multi-discipline cross-media Enterprise interaction to be facilitated

Service Oriented Architecture (SOA)

With orchestration, the network operator is faced to link all its core systems and processes together without getting stuck in rigid monolithic implementations.

The monolithic implementations seen in the past, characterized by their end-to-end process and network communication defined as a whole in low-level instructions, worked well when launching a single product, but tended to become unmanageable over time when modifications had to be made to products and new products needed to be launched.

It was difficult and sometimes even impossible to reuse the good parts of a delivery process of one product for another product.

A Service Oriented Architecture (SOA) is similar to an organization. When you know what department handles which questions, you can ask the right department the right question and you will get a proper answer. You do not have to know how a department functions to be able to request an answer. Similarly, within a SOA services can be provided to whoever is entitled to request them. It is necessary to know which SOA service providers are relevant to you and what you can ask them. Once an SOA service provider can provide a list of services that are available , what they expect as input and in what format, and identify how they will send their output, a key cornerstone has been laid on the road to become independent of vendor, technology or product specific implementations.

Another advantage of this approach is that it will help you to become better prepared for inevitable changes through the lifetime of a service. It can be expected that with every new version of a service, new functionality will become available and that might have an impact on the format of a request for existing functionality. When service providers and consumers can dynamically act on the lifecycle events of a service, the chance that applications become outdated and need continuous maintenance is reduced.

Figure 3: Reusable standard building blocks (services)

In this way a SOA enables organizations to build new functionalities by reusing functions that are made available by network management applications, billing applications, or other applications that act as service providers. Rather than rely on monolithic holistic constructions, where over time fewer and fewer people fully understand what influence a change can have due to abstract dependencies, the SOA approach is to regain a clear overview of relations and dependencies of separate cross-domain actors. For proven functionalities, it is important to understand the effect of instructions given to a black-box, not to understand the inside of the black-box.

Software Defined Networking (SDN)

The contemporary view of consumers and businesses is to be able to order services on the fly, online, without having to wait hours, days, or weeks. This is the key value and strength on which cloud-based services thrive. Some cloud-based services are regarded as a threat to higher margin telecom operators' services. Over the last five years, telecom operators have lost revenue and live in fear of being degraded to providers of mere connectivity, the so-called "dumb-pipe." To counteract the threat of the cloud, telecom operators are giving their customers more and more insight into how their individual services are performing and are working toward giving customers the power of influence over some of the key aspects of the service.

The OpenFlow initiative of McKeown et al in 2008 [1] started researchers down a path to find the means to experiment with new ideas for evolved switching and routing protocols on existing real life and real scale (campus) networks without the risk of affecting the rest of the users.

To do so they required a virtualized part of the infrastructure. Within that virtual network, they did not want the physical switch/router to decide on what grounds frames or packets were moved around. Instead, they wanted to communicate this through use of their own developed control algorithms. The protocol in between the physical infrastructure (data-plane) and the remote controller (control-plane) was named OpenFlow.

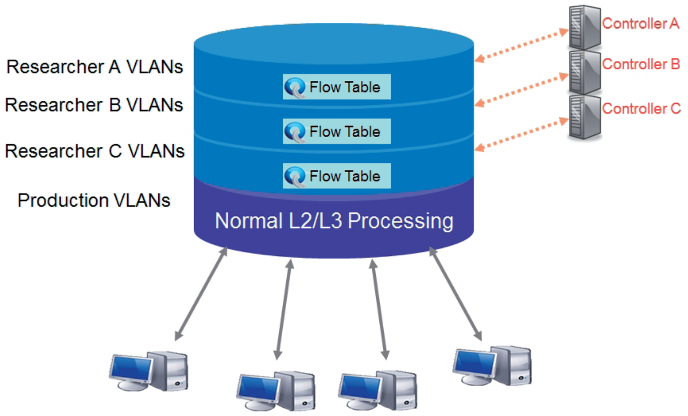

Figure 4: OpenFlow's Aim

Those involved in this early initiative soon realized that the initiative was in fact an element of a much bigger concept: the concept of opening up the dominantly vertical integrated, closed, proprietary and slowly innovating networking industry. The goal was to empower network owners/operators, increase the pace of innovation, diversify the supply chain and build a robust foundation. This concept, called Software Defined Networking, relies upon hardware in the network to interact with different or multiple control planes via open interfaces, with the control planes providing services to a variety of applications via open interfaces.

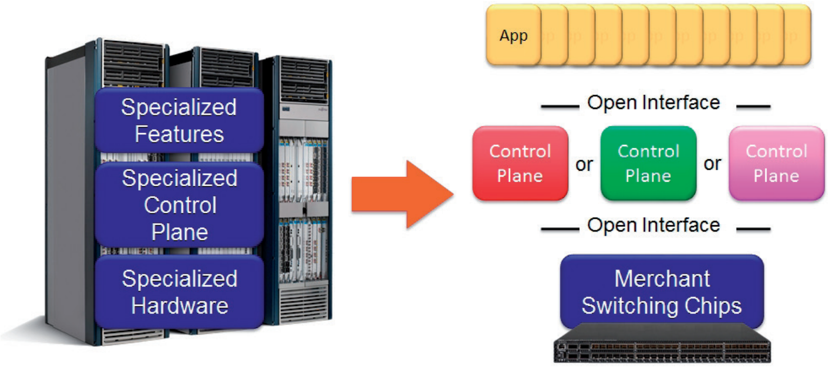

Figure 5: A horizontal layered open network architecture

SOA and SDN both find themselves in a universal approach of fighting verticalization and increasing the pace of innovation and development. This enables everybody to contribute, without having to understand the whole monolith; instead they can focus on the problem at hand. Thus, Software Defined Networking is an umbrella concept that will affect all areas of the telecommunications industry. It's difficult to find one common definition for SDN, let alone implementations. It is more like the path to an ideal that is commonly accepted.

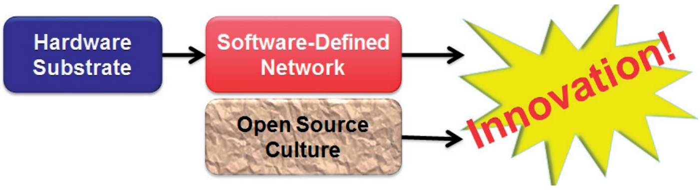

Figure 6: SDN, an Innovation enabler

Network Function Virtualization (NFV)

While SDN is not really tangible and resulted in a big hype, where everybody in the industry started to use the term for marketing their products, a collective of telecom operators started the initiative [3] by clearly defining how SDN would be relevant in the short term. They began by expressing that they see NFV as highly complementary to SDN, but that NFV does not require SDN, and that its main focus is to reduce CAPEX, OPEX, space and power consumption. The way to achieve this is by transforming specialized functionality nowadays running on specialized hardware to software processes that can run on industry standard server hardware.

In general the first logical step for operators is to go for the low hanging fruit on the way to the larger ideal.

It should be noted that this approach is not new and finds its first implementations well before the concepts of SDN and NFV were invented; for instance the soft-switch, which took over from the big, dedicated hardware based, telephony switches.

Three main applications are regarded as the first wave of dedicated hardware that is going to be transformed to virtualized functions:

- the Broadband Remote Access Server (BRAS),
- the router (CPE) at customer premises and
- the Session Border Controller (SBC).

The goal of the NFV initiative, like OpenFlow, proliferates SDN, but unlike OpenFlow is not initially focused on virtualizing the network (layers 1 to 4 of the OSI model), but on virtualizing functions (layer 7 applications in the OSI model).

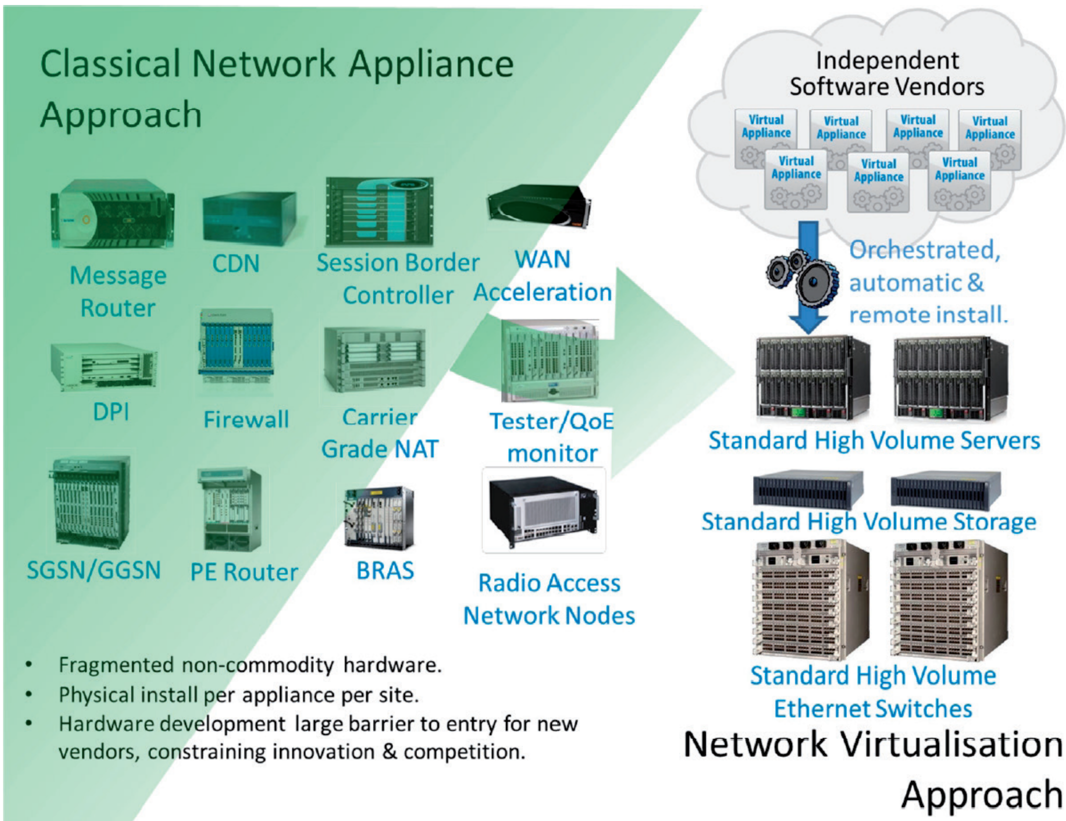

Figure 7: NFV's core Aim

Bidirectional North Bound Interfaces (NBI)

Whichever approach is followed, there will be a need for a network controller. The network controller must interface with the Operational Support Systems (OSS) of the network owner/operator. This interface, the NBI, must accommodate not only for presenting information from the network, such as alarms and performance statistics, but it must also support the capability for the controller to receive instructions from the OSS and inform the OSS of the results in an asynchronous way (unsolicited).

In Figure 8, a simplified eTOM structure is shown, with the positioning of the often under one nominator mentioned OSS and BSS systems, the Customer Portal through which the customer is able to control his services in the network, and the northbound Interface through which the OSS will be able to communicate with and command the network.

Figure 8, Bringing it all into the context again of the telecom operators environment, with the eTOM reference model.

To be able to come closer to our ideals (SDN and SOA), this interface must conform to the current standards and best practices to be able to interact with a variety of systems that require the network controller to service them, i.e., XML based RESTful and SOAP. Naturally the proven SNMP alarm forwarding functionality on the NBI must remain as well.

A big challenge for network operators is the concurrent interaction of multiple network controllers with the OSS. In an ideal world, one network controller could manage the whole network, independent of whatever network elements from various vendors are being used, so that the OSS is only required to understand the semantics of that single network controller. In reality there will be a collective of multi-vendor network controllers forming the network management layers. So far, there is no initiative underway to develop a standardized set of instructions and associated formats. Most of the larger vendors still strive for their hegemony.

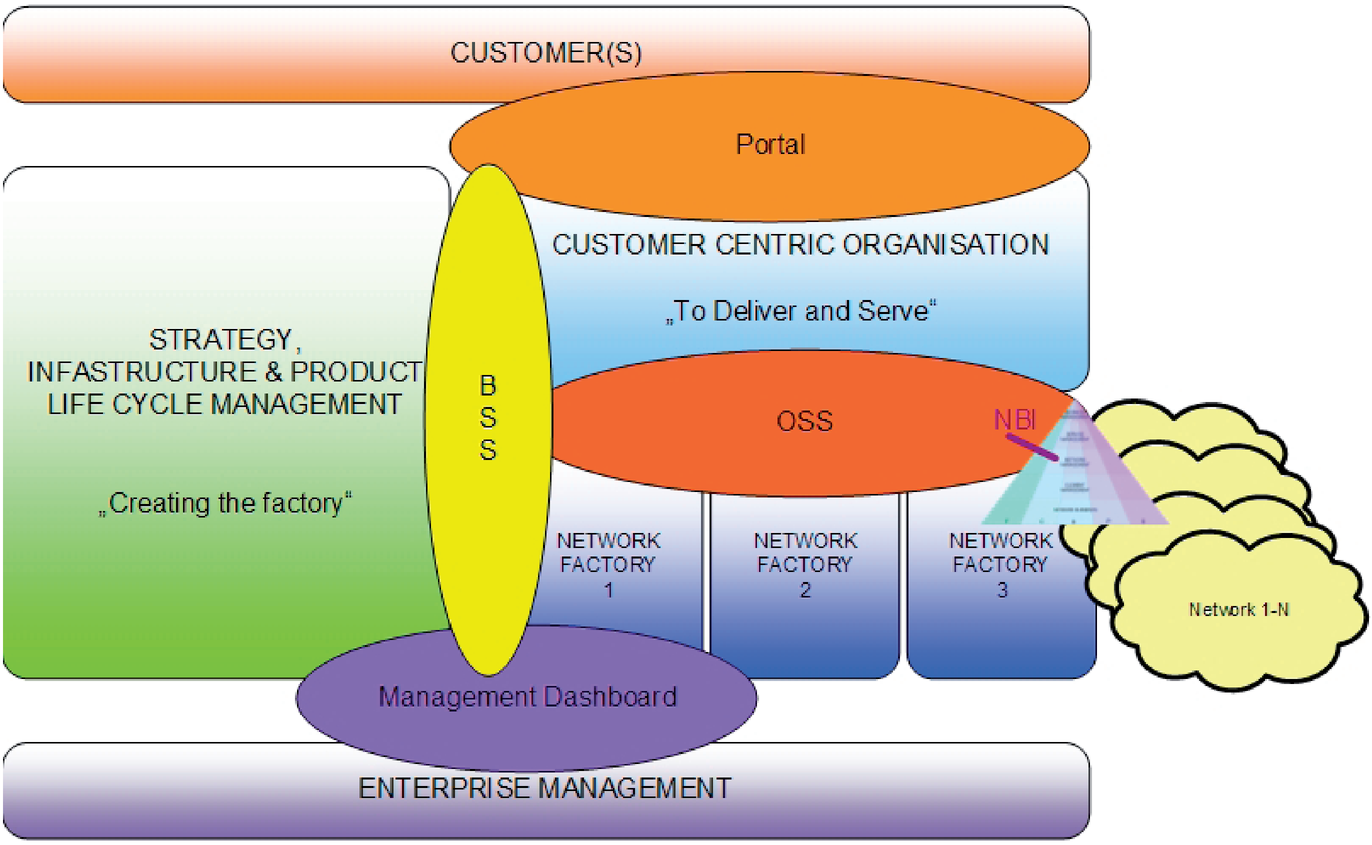

Figure 8: Bringing it all into the context again of the telecom operators environment, with the eTOM reference model

Communication With the Network: OpenFlow and NETCONF

One debate that hasn't been settled is what type of protocol to use to interface the network management layer (e.g., network controllers) with the network elements. Although OpenFlow has been discussed in the academic world as the preferred protocol to program the forwarding plane of a network element and moving the control plane out of the network element (NE), thus removing the need for further configuration of the NE, telecom operators want to focus on the low hanging fruit first and stay away from enabling even more complexity in their domain of responsibility. From their perspective, the need for configuration of the NE will remain, and to become vendor independent (one of the main goals of SDN) a standardized way of configuring NEs is a constraint that has to be met.

So far, there is a relatively well adhered to standard in place for retrieving alarm information: SNMP. However, it has some significant drawbacks for configuring equipment. The same goes for the ubiquitous CLI. NETCONF is an IETF standard defining the standardized API to NEs for network configuration, tackling the traditional drawbacks (e.g., the absence of an API, human readable and meaningful structure, separation of configuration and state data, connection oriented sessions with message sequence numbers, playback of event notifications, rollback and commit mechanisms).

Carrier Ethernet Network Management

Given the context of network management, it's clear that a lot is going on and is required to be able to let the network react dynamically to end users' demands.

However, one key aspect has not been touched on yet, and that is the fact that the network has become far more complex than it was before the introduction of Ethernet as the dominant transport layer. On the other hand, the same advanced network management capabilities as there were for SDH are not yet available for Ethernet. With the evolved standards of the Metro Ethernet Forum, the Carrier Ethernet Network is now capable of functionality that is at least similar to the monitoring and resiliency functionalities of SDH, but the use is complex and so far only poorly supported by networking management. The main goal for vendors is to hide this complexity from the operator by advanced network management applications. Instead of having each operator implement complex interactions to the network, the SOA approach will let vendors take care of this by providing a clear set of services that their OSS can request from the network management applications.

Summary

After a booming period in the early 1990s for network management applications and just before the burst of the Internet bubble, advanced developments on end-to-end management of SDH networks came to a standstill. It took more than 15 years and new concepts and technology across multiple disciplines to be created and deployed to bring network management back to the center of the field. It is clear now that the ideal, SDN, can be achieved gradually through hard work and many iterations, despite what all current hype may let us believe.

Attributions:

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Figure 4,6: Nick McKeown, Stanford University, Infocom Keynote Talk "Software Defined Networks", April 2009, Rio de Janeiro, Brazil
Figure 5: Nick McKeown, Stanford University, Open Networking Summit, „Making SDNs Work", April 2012
Figure 7: NFV Whitepaper presentation, "SDN and OpenFlow World Congress", October 22-24, 2012, Darmstadt-Germany.

References and further reading

[1] „OpenFlow: Enabling Innovation in Campus Networks", McKeown et al, ACM SIGCOMM Computer Communications Review, Volume 38, nr.2, April 2008 (http://ccr.sigcomm.org/online/files/p69-v38n2n-mckeown.pdf)
[2] „Nick McKeown: a selection of recent talks", http://yuba.stanford.edu/~nickm/talks/
[3] „Network Functions Virtualisation – Introductory Whitepaper", October 2012, http://portal.etsi.org/NFV/NFV_White_Paper.pdf
[4] „Reference Model for Service Oriented Architecture 1.0", OASIS standard, October 2006, http://docs.oasis-open.org/soa-rm/v1.0/soa-rm.pdf

About Albis Technologies

As a leading provider of access solutions for Ethernet and Carrier Ethernet transport, Albis Technologies supports a wide range of applications including business access (TDM and Carrier Ethernet), mobile backhaul, wholesale, and utilities and infrastructure. Its ULAF+platform has been deployed by a large number of operators and utilities around the world, including many Tier 1 companies. Albis Technologies (http://www.albistechnologies.com/en/access-solutions/access-home.php) is headquartered in Switzerland and focuses on partnerships and customer satisfaction.

MetroIntegrator is Albis Technologies newest member of the management product line and allows operators to run advanced network management applications from within their standard browsers. MetroIntegrator enables operators to prepare for SDN based automation and enhanced service management.

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