Hybrid-SDN for packet transport: The horizontal split

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ABSTRACT
Network operators are seeking for solutions to make their networks innovation-ready, as they intend to adapt transport networks more easily to continuously changing requirements. The emerging SDN concept and its related technologies are discussed widely in the industry as a promising tool-set in order to provide increased programmability for transport. However, the SDN concept itself, when applied to packet networks, creates a significant gap between traditional networking practice and solely centrally controlled SDN network.

This paper focuses on a Hybrid-SDN approach, which is able to narrow this gap via a more natural split of local and remote control functions. The described *horizontal split* keeps the impact on network design and operation less revolutionary and therefore such a Hybrid-SDN approach could provide a more realistic introduction of SDN in real transport network scenarios.
Keywords: SDN, Packet Transport, Horizontal-split, Transport programmability.

1. INTRODUCTION

Many emerging technologies have been appeared to challenge the fundamental concepts of current transport network architecture and design. They have been resulted in heavy discussions across the industry and showed that the need for a change is desired, but the direction of it is not yet concluded.

Taking a very high level view on networking, one can conclude, that (i) there is only a small set of carried protocols, namely IP and Ethernet; (ii) there is a small set of transport technologies: Optical, Ethernet and IP/MPLS however (iii) there is a large set of transport service implementations with several options and sub-variants.

Transport technologies are relatively mature and contain most features operators want (e.g., protocols, resiliency, autonomous operation, etc.). Major current headaches of network operators (like complexity, operation difficulties, etc.) are deeply associated with the multitude of service options, which are implemented in their transport edge nodes. These multitudes of service implementations make all networks somewhat unique and blocks fast innovation of offered services.

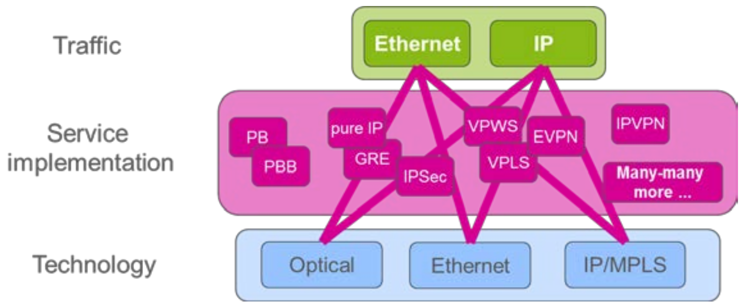

Figure 1. High level view on current networking practice

2. Hybrid-SDN concept

The concept to separate transport and service related nodal functions exists for several decades in the networking industry. This concept differentiates service un-aware transport nodes and service nodes, which are the only nodes to hold service states and require implementation of service related functions. Such separation is a future-proof concept and should be kept. Improvements should focus on service functions as they cause most of the challenges mentioned above and makes the introduction of a new services lengthy and costly, especially in multi-vendor networks.

A centralized control allows shorter service development cycle and quicker rollout of new control functionality [3] in comparison with a distributed service control e.g. based on MP-BGP. While in a distributed control plane changes must be made in several, already deployed control stacks, in case of a centralized controller the control function needs to be implemented and updated only once in the central stack. New approaches like SDN (and NFV) are built around this approach.

Some concepts of SDN [1] [2] have considered moving the whole control plane to a central entity called SDN controller. This is a significant disruption of packet networking and the Internet [5] – since they are based on distributed control architecture. Furthermore in packet transport networks not all control plane functions should be a target for centralization and further developments [6].

For packet networks a hybrid approach fits much better, where centralized and local control plane functions may coexists. ONF Hybrid working group has proposed a hybrid approach to partition the data-plane of a network node into disjoint subsets, where each such subset is controlled by a different control plane instance [4]. That has inevitably resulted in duplicated existence of the same control function and it has required creating methods to allow interaction between control plane instances. Such a split of the control plane may be appropriate e.g. in datacentre environment, but it can be noted rather odd for packet transport networks.

2.1 Horizontal split

In this paper we argue to split the control plane *horizontally*. In this arrangement transport related functions are implemented locally on the node, while service related functions are moved to a centralized SDN controller and no control plane functions are duplicated.

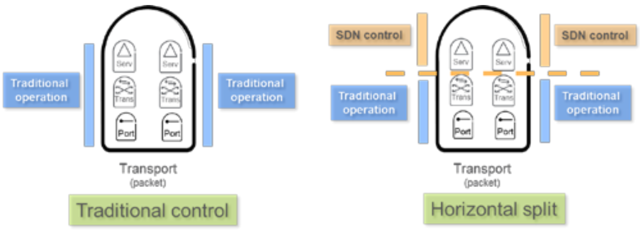

Figure 2. Control Plane: Concept of Horizontal split for Hybrid-SDN

2.2 Building nodes

Major entities that configure the node forwarding behaviours are management, local protocols and SDN controller. Possible distribution options of control functions among these major systems are shown in Figure 3.

The left side of the diagram shows the traditional way to build packet nodes. Nodal functions are implemented locally and controlled by protocols running on the node. The right side of the diagram shows fully SDN controlled nodes, where all control functions executed by the SDN controller. Hybrid-SDN nodes following the *horizontal split* method are in the middle, where some functions are local and protocol driven and some others are remotely controlled.

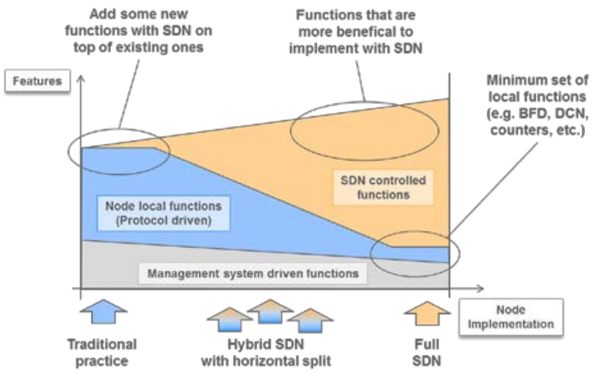

Figure 3. Node control alternatives at-a-glance

It is worth highlighting some special segments of the diagram. First, there is always a minimum set of transport related functions what must be implemented locally on the node (e.g. BFD, DCN, counters) even in the case of full SDN control. Second, some functions may be too complex to implement by a distributed control plane and networks with SDN control can provide more features than traditional ones. Hence, the SDN controller is a good candidate e.g. for implementing control plane for traffic engineering or new services, whereas the already implemented node local functions may remain in the node. A motivation to move node local function to the SDN controller can be if e.g. interactions are needed between multiple features. It is simpler to achieve those interactions when the functions reside close to each other in the SDN controller. And finally, even for feature rich nodes it might be useful to add SDN controlled functions (e.g. to provide centralized path computation entity (PCE) for segment routing (SR) based TE tunnels, etc.).

3. Details of horizontal split approach

The previously described Hybrid-SDN approach allows many possible *horizontal splits* of functions between the controller and the nodes. Such a decision - on where to split the control plane - can be network operator specific and may depend on several aspects (e.g. available feature set of nodes, operational preferences, etc.) [7].

3.1 Functional blocks and the split

During the analysis to find an optimal split three group of nodal features were distinguished. The first group is Basic Transport that maintains shortest path connectivity over the packet network. The second group called Advanced Transport provisions Traffic Engineering (TE) paths and Multi-Domain capabilities for enhanced scalability. The third group, Service Control, implements the traditional transport virtualization namely the transport service including adaptation to transport network technology (VPN labels, VxLAN, GRE, etc.).

In order to find an optimal split there are three major factors to consider: (1) minimizing the node local control plane protocols; (2) shorten the time-to-market for services by centralizing service control plane and (3) allowing re-use of operation and maintenance related experience of network operators. These requirements can be best fulfilled by the result shown on Figure 4.

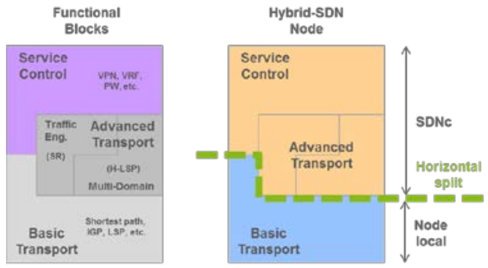

Figure 4. Horizontal split and the functional blocks.

Service Control and Advanced Transport related functions are moved to the SDN controller and all forwarding related parameters are centrally calculated, optimized and downloaded to the physical node. Only Basic Transport functions reside on the physical node requiring a single routing protocol (IGP) to be implemented for shortest path calculations. Forwarding Information Base (FIB) entries are created by combining the information provided by the central Service Control and Advanced Transport functions and by the local Basic Transport.

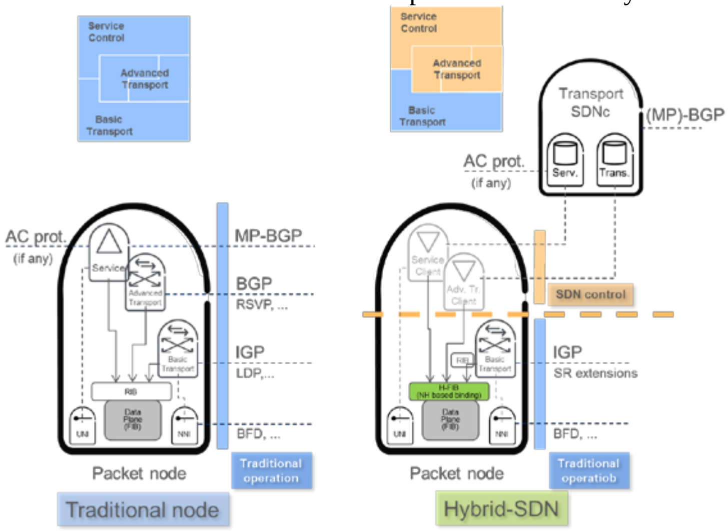

Figure 5. Implementation of proposed horizontal split.

3.2 Creating FIB entries

The information elements - provided by the control plane functions - contain a *next-hop ID* to allow their correlation and combination by the H-FIB manager. This H-FIB manager provides a hierarchical FIB model based API to local and central control entities. The next-hop ID can be an IP address, a path-ID or an MPLS label depending on the network scenario.

Figure 6 shows an example for the creation of a FIB entry in a network scenario where IP VPN service is provided with TE over a single domain MPLS network. Service control and advanced transport functions are integrated in a single SDN controller entity in this example. The outermost label of the segment routing TE label stack is used as next-hop ID to create the necessary binding between the remote (VPN + TE tunnel) and local

(IGP) information. The second FIB entry in the figure represents a pre-installed backup route that is provided e.g. by the IGP in case of the failure of the primary outgoing interface.

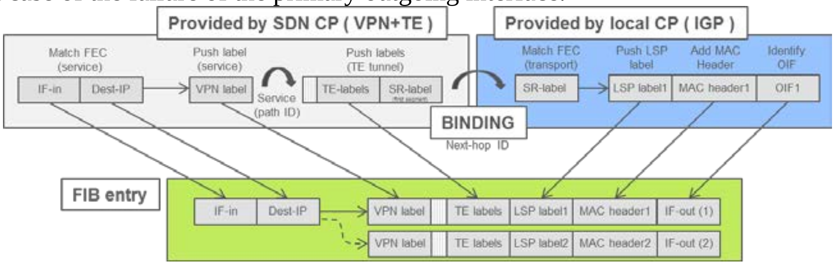

Figure 6. FIB creation example (IPVPN with TE over MPLS)

3.3 NBI to SDN controller

North Bound Interfaces (NBI) between the node and the SDN controller have to be implemented also on the physical node. Protocols (like Openflow, SNMP, NETConf, etc.) are needed for bidirectional communication with the SDN controller. The complete list of protocols is implementation specific and also depends on the actual network scenario.

4. CONCLUSIONS

There are big expectations on SDN technology to significantly improve the innovation potential, service velocity and the programmability of current networks. However, its wide spread implementation in real transport networks cannot be expected without incorporating the experience of many decades the industry has spent to evolve current best practices in networking, especially in packet networks.

This paper has focused on splitting the control plane when SDN and traditional network practices are combined. It has proposed a *horizontal split* of the control plane in order to mitigate required changes, whereas fully reaping the benefits provided by SDN technology. This is achieved by leaving basic transport functions locally on network nodes and moving all more complex service control and advanced transport related functions to the SDN controller(s). Such a *horizontal split* allows operators to keep a significant part of their backbone design and operational practices; and concentrate on the real problem what they have, namely how to enhance and adapt their provided services to meet future challenges.

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