White Box Flavors in Carrier Networks

Victor Lopez[1], Oscar Gonzalez de Dios[1], Juan Pedro Fernandez-Palacios[1]
[1]*Telfonica gCTIO/I+D, Madrid, Spain*
victor.lopezalvarez@telefonica.com

Abstract: Disaggregation is a trend that is changing the way to architect and to operate networks. This paper presents the different disaggregation alternatives and which are the different elements in a white-box ecosystem.
OCIS codes: (060.4250) Networks; (060.4510) Optical Communications.

1. Introduction

The concept of "white-box" is not originally from the network area, but it comes from the IT world, where the hardware and switches were decoupled from the operating system that was installed on it. At that moment, different vendors can offer the software and the hardware that work together. The Open Compute Project (OCP) started in 2011 with the aim to create open hardware specifications for servers and later in 2013 they evolved this concept to the switches area. The Telecom Infra Project (TIP) [2] started in 2016 with the focus to deploy the concept of open hardware for the Telecommunications Operators (TELCOs) infrastructure.

In the early days of the telecommunications, the TELCOs used to do all the procedures to offer the phone service to the customer. These tasks started with the hardware definition, prototyping, manufacturing, testing, integrating as well as all the operational aspects, thus is, installation, commissioning, and maintenance. Little by little, different tasks were outsourced to companies specialized to carry out such functions. Nowadays, the vast majority of TELCOs purchase their network elements to systems integrators that define the hardware solution (switch, router, or transponder), purchase the components third parties and carries out the integration of the devices as well as the software to carry out the network element functions. Regarding the operational aspects, there are two flavors. There are vendors that perform the installation, commissioning, and maintenance, while there are others that rely on partners to do such activities. If we consider then the elements that compose a network element, we can identify the following roles and activities (Fig 1):

- Bare-metal. Hardware system formed with different components (chipset, memory, pluggables, etc.).
- Network Operating System. Software installed in the bare-metal to support the networking functionalities (L2, L3, etc.).
- Box System. This is a selection of a NOS and a Bare-metal.
- System integration. This is the process of testing and validating that the box system is performing as described in the specs.
- System maintenance. This is the process of installing, testing, repairing and decommissioning the box systems in the field.

If we consider that a network element is decoupled in hardware and software, then different roles appear in relation with the network operator. The two first roles are the bare-metal provider, which supply their hardware, and the NOS provider, which offers the operating system installable in the hardware. A mandatory requirement for those providers is that each component must be able to be deployed into a decoupled fashion with its counterpart. If either the hardware or the NOS limit the interoperability, the disaggregation of the solution does not offer any advantage. The TELCO requires a box system to perform the network function. Consequently, there must be a whitebox solution that combines hardware and software. The white-box provider role is a supplier who currently commercializes integrated products. If the NOS and the bare metal are open components that allow operating with third-party components, then the solution is an open whitebox or, simply, whitebox. On the other hand, if there are elements that are proprietary, this solution is known as a branded white-box or brite box. If we explore the idea of a whitebox in a production environment, it is required to have a whitebox integrator that deals with the system integration. The integrator works for the correct software and hardware integration, to be in charge of the L2/L3 support and maintenance services, and to participate in the certification activities, the integration with OSS/BSS, the training of operational teams, etc. The authors in [3] detail the ecosystem in more detail and outline a preliminary CapEx analysis comparing the emerging disaggregated approach to the currently deployed legacy aggregated solution.

Once we have introduced the concepts and roles for a disaggregated ecosystem, we analyze the white boxes in the optical domain.

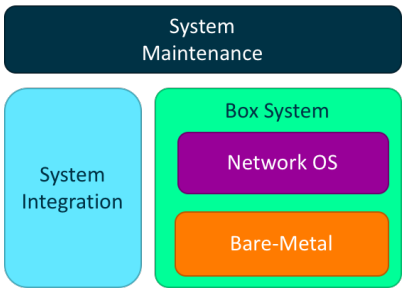

Fig. 1. Role in a whitebox ecosystem

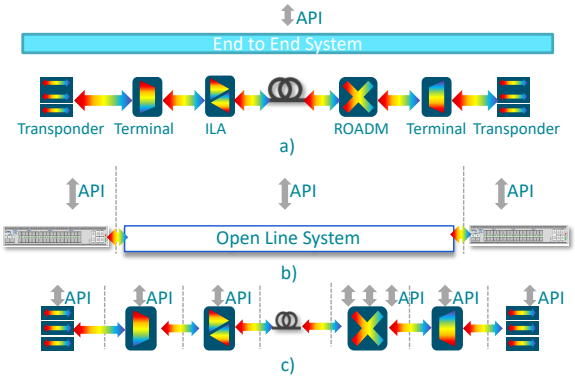

Fig. 2. Optical network architecture alternatives: a) Aggregated, b) Partially Disaggregated and c) Fully Disaggregated

2. Disaggregation in optical networks

Optical Transport DWDM networks for TELCOs are deployed on a regional basis. The reason for this approach is a combination of factors: legacy deployments, technology redundancy, different optical performance requirements (metro vs. long-haul), lack of interoperability and simply commercial reasons. These deployments include all system elements, the transponders that generate the optical signals, the line system in charge of amplification and lambda switching and also the network management system (NMS). The NMS is operated manually and, sometimes, is not integrated with other systems (e.g., OSS) through Application Programmable Interfaces (APIs).

When considering how disaggregation is applied to optical networking, three alternatives appear: aggregated (Fig 2a), partially disaggregated (Fig 2b) and fully disaggregated (Fig 2c). An aggregated architecture consists of a deployment where all components of the line system operate as an end-to-end entity. Therefore, there is no openness to the solution. A partially disaggregated scenario is composed of two main elements the Open Terminals (OT) and the Open Line System (OLS). The OTs are the transponders, while the OLS consists of the WSSs, wavelength multiplexors, optical amplifiers, etc. Finally, the fully disaggregated scenario decouples all elements in a line system and they operate as a stand-alone entity. The main driver for disaggregation in TELCOs is to reduce the cost of the technical solution. Most of the traffic in today's network is due to video content. Content Delivery Networks (CDNs) transmit their traffic closer to the end user to reduce TELCOs cost, so much CDN traffic is delivered from caches in the metro-regional networks, thus reducing the video traffic in the national backbones. According to [4], metro traffic is growing faster than the core traffic. Consequently, the investment of the network operators in the metro area will increase in this region.

Telefonica performed a data plane production validation of a partially disaggregated architecture in 2017. Such trial was done across three different live links in existing 10G/100G DWDM transmission network. The spanning distances for the tests were 1,070km, 630km, and 290km and connecting major network sites including Düsseldorf and Frankfurt. While interoperating with Telefónica's existing 10G/100G optical line system, the disaggregated transponders successfully demonstrated 100G transport across all three links, 150G across the 630km, and 200G across the 290km link. Similarly, authors in [5] demonstrated 100G DP-QPSK transmission over a 1030-km link from Boca Raton to Jacksonville using the HG-FEC line-side interoperability mode for 100G coherent DWDM transceivers. Based on the tests performed, we consider that the data plane is validated for scenarios bellow 1,000 km where most of CAPEX is expended.

Regarding whiteboxes for optical networks the reference project is TIP [2]. TIP has worked on two OTs: Voyager and Cassini. Voyager capacity is 800Gbps in a 1RU. It has 4x 200G 16QAM Line side, while it has 8x 100G QSFP28 clients. On the other hand, Cassini has a system throughput of 3.2 Tbps in a 1.5RU form factor. It has 16 100GbE QSFP28 ports, plus eight line-card slots which can provide additional 100GbE ports or coherent optics (ACO/DCO). OpenROADM initiative [6] defines a Multi-Source Agreement (MSA) which is not a white box approach, but it is a disaggregation architecture. It defines a multiwave interface between the ROADMs and a single wave interface from the transponders.

3. Programmability in whitebox scenarios

Current NMS solutions shall evolve to or co-exist with the Optical SDN Controller (OSDNc), enabling network programmability through its North Bound Interface (NBI) while keeping the currently offered features for network creation, resources discovery and monitoring and service creation for L0-L1 layers. For the scenario of disaggregation, it is required that the OSDNc will support the disaggregated elements. To do so, the OSDNc will

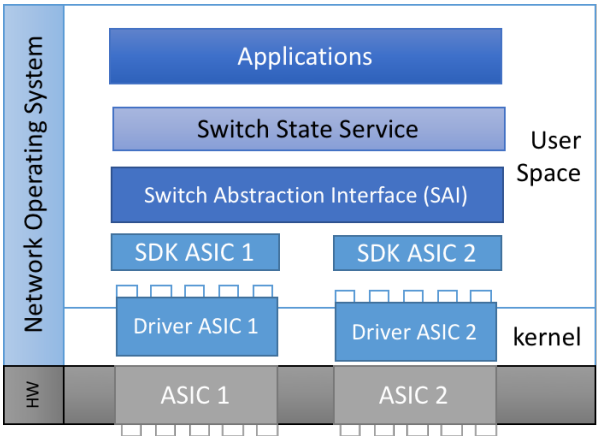

Fig. 3. SONIC NOS architecture

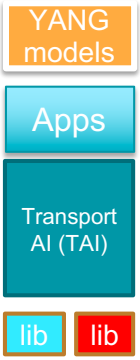

Fig. 4. Transport Abstraction Interface and its relation with the YANG models

support a network model in the NBI and a device model in the South Bound Interface (SBI). In our opinion, it is key that these interfaces are standard and not just open interfaces, so there is an interoperability between the OSDNc and the OSS, and the OSDNc to the disaggregated network elements. The interface definition is still open to debate, but currently, OpenConfig [6] and OpenROADM [7] initiatives are considered the most mature and promising solutions for both scenarios. OpenROADM goes in more detail for the line elements, but they must follow the OpenROADM MSA, while OpenConfig abstracts some elements without allowing a detailed configuration. Both models are capable to support the partially disaggregated scenario.

When considering the support of the models in a whitebox ecosystem, their support must be done at the NOS level. The Netconf agent is one of the applications in a NOS, for instance, SONIC [8] (Fig 3). The aim of the Switching Abstraction Interface (SAI) is to avoid direct integration between the ASIC manufacturers and the NOS provider. Similarly, the Transport Application Interface (TAI) defined within TIP [2] is in charge of the API to control the transponders in a vendor-independent fashion. TAI allows the NOS provider to request the transponder manufacturers a library that would enable the configuration of the parameters. Depending on the scenarios, the transponder can be configured in more detail. For metro scenarios, simplification and easy automation is the key to enable whitebox solutions.

4. Conclusions

White boxes ecosystem enables to decouple the hardware and operating system that is installed on it. The Telecom Infra Project is the fora where there is a definition of white boxes for optical networks. Even though there are advances in many aspects, there is still a lack of reference implementations with standard interfaces.

For network operators is not an easy task to decide, which model to follow. However, the most mature solution is the partially disaggregated, which would impact less in the operator processes, while providing a negotiation level for metro scenarios that is where TELCOs are investing most CAPEX.

Acknowledgments

This work was supported partially by the European Commission H2020-ICT-2016-2 METRO-HAUL project (G. A. 761727).

5. References

[1] Open Compute Project, https://www.opencompute.org/

[2] Telecom Infra Project, https://telecominfraproject.com

[3] E. Riccardi, et al., "An Operator view on the Introduction of White Boxes into Optical Networks," in JLT, vol. 36, no. 15, pp. 3062-3072, Aug.1, 2018.

[4] Cisco VNI, The Zettabyte Era: Trends and Analysis, Jun 2017.

[5] N. Garrafa, et al: Multi-Vendor 100G DP-QPSK Line-Side Interoperability Field Trial over 1030 km, in Proc. OFC, Mar 2017.

[6] OpenROADM http://openroadm.org

[7] OpenConfig http://www.openconfig.net/

[8] Software for Open Networking in the Cloud (SONiC) https://azure.github.io/SONiC/