Automation Journey in Core and Metro Networks: an Operator View

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Abstract *We expose how moving from mono-vendor to multi-vendor optical transport networks raises challenges that can be solved leveraging on open source, open initiatives and standardization, and accelerate the deployment of automation solutions in current and future optical transport networks.*

Introduction

Network automation is an opportunity for business to offer seamless services for customers while crossing several infrastructures, to accelerate end-to-end service delivery from weeks to hours, etc. It holds the promise of simplifying and improving network operations, enabling fast adaptation to changes and accelerating innovation deployment. Automation however is still a challenge that carriers face in their multi-vendor networks context. In this respect, the introduction of more openness and interoperability as well as open source enablers are needed as discussed in the next sections.

Harmonizing multi-vendor contexts

Although operators have been asking for the interoperability of transmission systems for decades, we are forced to admit that this has never happened in the operational field. However, vendor lock-in is now an impediment to introduce automation across the network (where operators have to consider all systems together for economies of scale).

Current single vendor-based networks are managed with a proprietary Network Management System. Even if they expose nearly standardized interface, the used data models often remain proprietary. Support of standards is also incomplete and does not allow for field deployment. Therefore, automation based on these proprietary vendor interfaces raises multi-vendor integration challenges.

We do see in this automation process a clear trend for modularity where multiple applications dedicated to a single specialized task are or will be developed. Among these, we can highlight (multi-layer) path computation, capacity planning, design & feasibility check, Artificial Intelligence (AI) analytics...(Fig. 1.a). The network topology is the base requirement for these applications, but more than information about vertices and edges, additional technology-specific data is required.

Applications that consume the topology have their own input API or format. The proprietary interfaces or models require specific developments per vendor silo / network and adaption is necessary for each of these applications. This present scenario leads to expensive, complex, hard to maintain developments that even do not support multi-vendor use-cases.

To solve this issue, we have developed a mediation software tool which exposes to these different applications a fully usable standard topology model (Fig. 1.b). We made the decision to use the IETF model(s) because RFCs 8345[1] & 8795[2] are well known to our IP divisions which makes IP integration native and because the augmentation for Optical Impairment-Aware

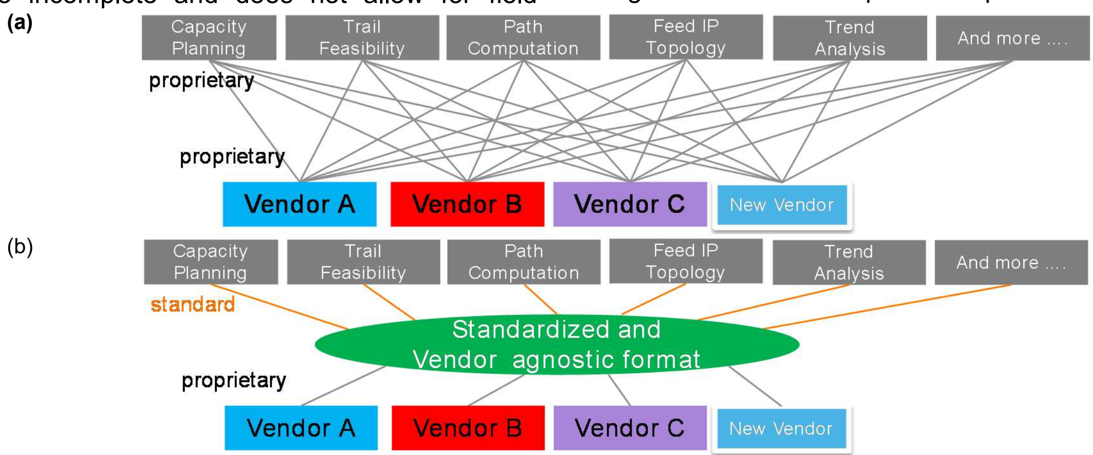

Fig. 1: (a) today's multiple applications with multiple vendor systems; (b) mediation tool mapping proprietary information onto standard format for applications

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Topology[3] is the most mature model proposal for optical description. Thus the tool can be queried through a REST API and provides in response a topology in an encoded JSON format following IETF models (agnostic to vendors' implementation). This greatly simplifies the relation with applications because all the burden of vendors' adaptation is handled in one place.
Identification of gaps, improvements or inconsistencies in the standard is also eased due to this central positioning and promotes direct feedback to the standards bodies.
The tool might be seen as a subset of an SDN Controller dedicated to topology. Therefore without having to deploy a complete SDN solution, primary use-cases were addressed:

- Exposure of photonic topology including SRGs for IP/Optical path diversity computation is achieved;
- Interconnection with GNPy[4] in a complete workflow was also carried out, allowing the evaluation of photonic design performance of already deployed networks and the verification of the feasibility of the new optical paths;
- The capacity on the photonic pipes is also advertised for use by the capacity management / planning tool.

For this, GNPy, as a consuming application, was a great help to identify gaps and have models really capable to support our use cases.

Automating partially disaggregated networks

While the first section presented a way to interface with single vendor solutions with a unified access, one of the main coming automation use case is to handle networks hosting third party transponders. This partial disaggregation (Fig. 2), separating the optical line system (OLS) from terminals, is motivated by several reasons. For example, the life cycle of transponders is shorter than the line's one, and they represent the most of the cost of WDM networks. The capability to support multiple generations of transponders is expected to help introducing new vendors, favoring competition and protecting against industrial hazard.

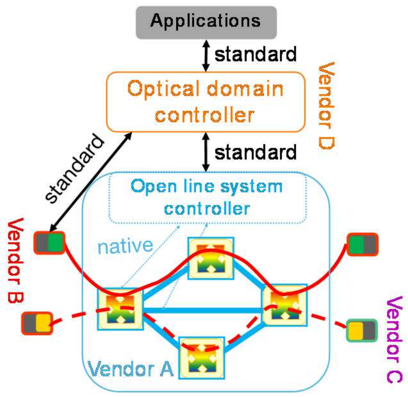

Fig. 2: Partial disaggregation simplified architecture: terminals may not be provided by the same vendor (B, C) as OLS(s) (vendor A) and optical domain controller (vendor D). It is expected to control terminals and one or multiple OLSs with standard interfaces relying on the native OLS controller.

Partial disaggregation raises challenges because optical systems require coordination between OLS and transponders and this is usually provided as a "turn-key" solution. The main issues are to discover relevant information on the third party transponders, to be capable of configuring them, to perform multi-vendor path computation, to extract topology and inventory across vendors and to make diagnosis and health assurance across vendors. Most of the challenges lies in the exposed models and their level of openness. International cooperation in standardization and open source appear as key to solve this challenge. For example the open source GNPy tool can play a reference role in identifying a minimum set of parameters that are needed for computing performances across vendors. Similarly, demos[5] are powerful means to identify gaps in the state of the art equipment, standards and protocols. Then these must be brought into standardization bodies and open initiatives such as IETF CCAMP[1], ONF T-API[6], OpenROADM[7] and OpenConfig[8]. All these groups work towards openness, interoperability and provide complementary models. In this respect, initiatives as MUST[9] can provide guidance and use cases specifications shared by groups of operators, and can accelerate convergence towards operators' needs.

Cross-layer, cross-domain automation

The recent breakthrough of 400G-OpenZR+ holds the promise of IP Optical convergence that has been long expected, because for the first time grey and colored 400G optics can be plugged indifferently on IP routers with the same port density, making the solution economically attractive[10]. This use case however raises the additional question of multi-layer control coordination, since WDM interfaces directly plugged into IP routers are expected to be configured and controlled at the same time by the IP network, while integrated to an OLS. Again, in this context, it is advisable that the coordination of the layers shall not be made in a proprietary way and that the end to end automation process remains generic. Decoupling operator's information system applications from specific per-vendor or per-layer domain is important to accelerate deployments and not to be locked. The open network automation platform ONAP[11] is a network infrastructures and services automation platform that exactly provides the framework to have this openness and decoupling, enabling at the same time the generic orchestration and abstraction of several layers or domains including the case of multiple per vendor domains.

Moving towards full disaggregation

Partial disaggregation relies on the concept of OLS, which still needs to be managed through specific domain controllers. Some operators are willing to further simplify the management / control architecture and extend the interoperability to ROADMs, to add flexibility and let the competition act. The direct control of devices through standardized APIs based on Netconf and open standards avoids deploying as many optical domain controllers as systems from different vendors installed in the network.

In this scope, OpenROADM adds an additional level of disaggregation to address this challenge, separating add/drop blocks ("srgs") from line blocks ("degrees"). Pushing disaggregation one step further, down to the component level (WSS, amplifiers, couplers…) has not been considered, to avoid introducing unneeded complexity that would imply operators to play the role of system manufacturers. Proposed device model is shared between the different vendors for the Southbound API, moving from distributed proprietary control functions to an open centralized control.

TransportPCE offers a reference implementation for the control of open optical infrastructures based on OpenROADM[12]. The same code is used to control any systems that respect this standard. The introduction of new equipment in the network does not imply to redevelop applications. Leveraging on standard APIs and optical specifications, ROADMs and transponders from different vendors can be mixed in the same network[13]. Openness helps accelerating the development of applications while interoperability limits the development efforts.

As an OpenDaylight project, TransportPCE is available to all operators willing to control their optical infrastructure. The development effort is shared through different companies: any contributions to the code are welcome, and can be easily integrated thanks to the complete CI/CD chain used to check that new contributions do not bring regressions to the existing code[14].

Anticipating the introduction of higher rates, beyond 100 Gbps (B100G), which brings its challenges considering interoperability, TransportPCE provides an interconnection of the path calculation engine with GNPy to address impairment-aware path calculation[15]. Again, rather than re-developing complex algorithms to perform this task, this feature will be available as soon as the OpenROADM B100G specifications will be integrated in GNPy catalogs (equipment performance database).

Last, thanks to its open northbound interfaces, TransportPCE has been integrated to the ONAP platform to address cross-domains and cross-carriers use cases such as Multi-Domain Optical Network Services "MDONS"[16].

From vendor-centric to data-centric control

The multi-vendor interoperability raises challenges related to the specificity of each vendor to design and manufacture its equipment. This concerns the accuracy of failure prediction/detection and the quality of transmission (QoT) computation. The use of Machine Learning (ML) techniques is opening new opportunities to address this issues and moves from a vendor-centric to a data-centric control/management systems. In fact, the ML-based solutions are able to learn the behaviour of different equipment and then detect/predict faults and locate them[17]. By differentiating between a failure and a normal system fluctuation, ML-base solution will be able to achieve low false positive and false negative rates in additional to locating faults and identifying their root-cause[18]. Moreover, ML-based solutions could reduce the uncertainty in the values of key parameters used to compute the QoT; in other words, reduce the difference between the theoretical and the actual values of critical optical parameters, like amplifier noise figure and input power[19]. The accurate calculation of the QoT reduces additional margins due to missing or inaccurate equipment parameters. The use of ML-based solutions must overcome a set of challenges related firstly to the requirement of standardized datasets and data labels as well as a streaming telemetry protocol to efficiently extract real-time data from equipment. Secondly, ML based-solution are typically designed in an ideal scenario which makes challenging the transition to a real-world context with many conflicting and complex functions. Thirdly, ML-models are difficult to generalize to different contexts and the transfer of knowledge without performing the training process is far from being achieved.

Conclusion

Automation is at stake for operators, to continue operating more and more complex and numerous network infrastructures. Decoupling information system applications from network specificities appears as a must to cope with multi-vendor domains, multi-layer use cases and, in general, to avoid per-vendor specific silos, that prevent from fast deployments. In this respect open source and open, interoperable models are cornerstones, applicable immediately to the traditionally vendor-locked optical transport.

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