HEAVY READING

White Paper

Communications in the New Era of Open

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Introduction

The new era of hyper-scale cloud networking and over-the-top (OTT) video applications are fueling tremendous growth and innovation across the communications industry, presenting an insurmountable challenge for the communications standardization status quo. In this software-driven era of communications, operators no longer have years to wait for standards to be ratified. Unable to stand still, they have been forced to bring proprietary advances to market – either self-developed or from their suppliers. But proprietary approaches create major challenges of their own: single vendor lock-in and inability to scale across vendors and domains.

Enter the new era of open, driven by open source development across both software and hardware. The open source model has moved from IT to communications and is helping operators bring their products and services to market faster than ever before while also achieving the interoperability and scalability that is critical.

This paper provides an in-depth analysis of the new openness in communications based on open source models for hardware and software. The paper charts the rise of open source, including looking at operator challenges today, the key benefits that open source brings and some of the most significant open source efforts currently underway. The paper concludes by presenting a roadmap from getting from the present mode of operation (PMO) to the future mode of operation (FMO).

Challenging the Standards Status Quo

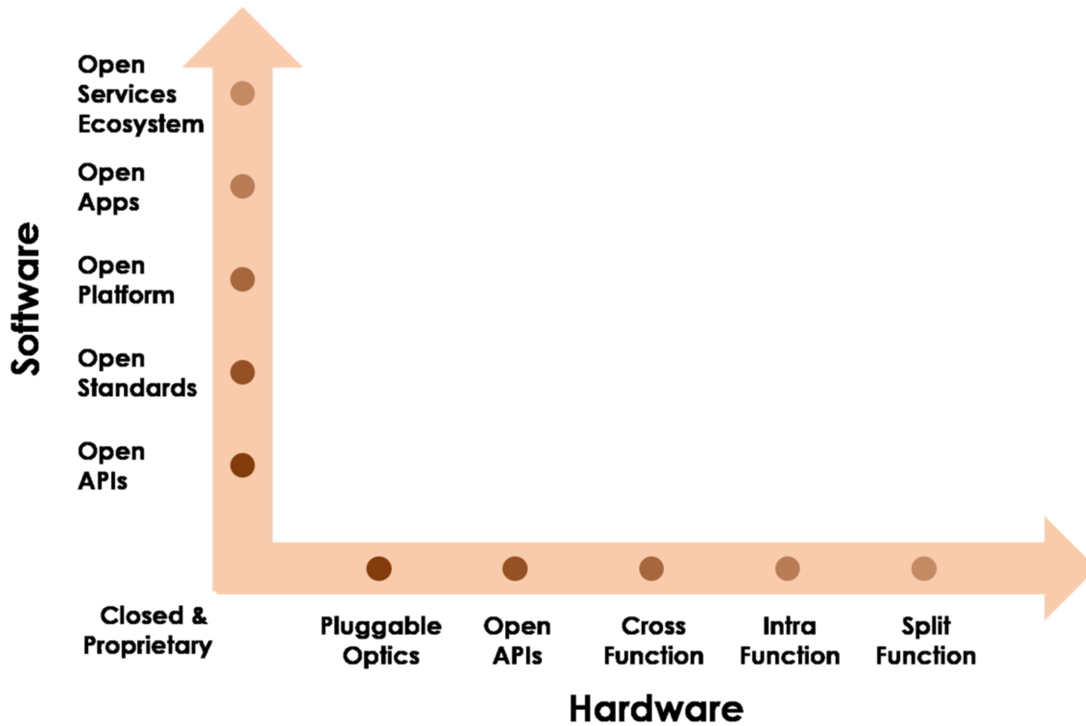
Standards bodies are the historical path for achieving interoperability among systems and avoiding vendor lock-in in telecom networks. Traditional standards bodies have had their proponents and detractors, but, up until the emergence of the cloud era, they remained the best available means for operators to achieve their network goals. The standards specification model began to break down in the cloud era for three primary reasons, as described below:

- **Cloud and OTT require more flexibility in applications and networks**: Cloud resources are shared, flexible and accessed on demand. These attributes put tremendous strain on traditional communications networks, which were built to be fixed and static. Operators realized that the best way to address the challenges posed by cloud and OTT was to adopt cloud and OTT technologies and processes, including open source.
- **Mismatch between standards pace and innovation pace**: Innovation in the cloud era has accelerated. Networks need to adapt quickly to changing capacity and applications demands. To be more competitive, network operators must be able to introduce services to market rapidly, and quickly remove them if they don't succeed – like the Webscale Internet providers do. Traditional standards, however, move slowly, with new specifications developed over the course of years.
- **Historical standards do not always ensure efficient interoperability.** The end game for telecom standards is openness and interoperability, but the consensus driven standards process doesn't necessarily ensure interoperability among protocols and equipment. The IETF's GMPLS standard for multi-vendor and multi-layer control plane interoperability is just one prime example of this problem.

Degrees of Open in Software & Hardware

Systems are not simply open or closed. There are varying degrees of open, across both hardware and software. This section provides an overview of openness types and degrees. **Figure 1** illustrates degrees of open across two axes – a software openness axis and a hardware openness axis.

Figure 1: Degrees of Open Networking – Hardware & Software



Source: Heavy Reading

We further define and explain the benefits of each degree of openness across hardware and software below.

Definitions of Hardware Openness

Pluggable optics decouple the dense wavelength division multiplexing (DWDM) optics from the line card or system, allowing optics from one or more module vendors to be plugged into systems supplied by a different vendor. **Benefits:** Ability to buy transponders from lowest cost sources

Historically, all software changes to a system were made by the systems supplies themselves. Typically, these changes were tied to specific release dates. **Open application programming interfaces (APIs)** allow third-party developers (including operators) to program and make changes to systems. **Benefits:** Decouples software development from hardware development. Allows operators to customize systems to their specific requirements and to break away from rigid vendor development cycles.

In **cross-function** openness, a functional component from one vendor can interoperate with a different functional component supplied by a different vendor. For example, a transponder from Vendor A interoperates with a reconfigurable optical add-drop multiplexer (ROADM) from vendor B. This is a form of functional disaggregation. **Benefits:** Allows operator to pick best-of-breed and lowest cost options among multiple suppliers. Massive reduction in vendor lock-in.

Infra-function openness means data plane interoperability within a function. Interoperability between transponders from different vendors is one example. Interoperability between ROADMs from different suppliers is a second example. **Benefits:** Similar to above but with even greater flexibility: Allows operator to pick best-of-breed and lowest cost options among multiple suppliers. Massive reduction in vendor lock-in.

Split function openness means dividing a single function into distinct but interoperable "profiles," such as core, commodity and virtual. **Benefits:** Operators are able to best suit individual functions to application needs while maintaining full interoperability among the different profiles of each function.

Definitions of Software Openness

Open APIs appears on both axes because it involves software code acting on hardware that is built to accept open APIs. **Benefits:** Decouples software development from hardware development; allows operators to customize systems to their specific requirements and to break away from rigid vendor development cycles.

Standards can come from traditional consensus-driven bodies or, increasingly, **open standards** from open source communities in which participants from many companies contribute code. **Benefits:** The primary benefit is broad interoperability. Open source software has become popular due to greater speed of development.

Open platform means any software system that is based on open standards, such as open APIs. ON.Lab's ONOS and the OpenDayLight Project are two examples of open platforms. **Benefits:** Avoids vendor lock-in, reduces development costs and enables faster innovation for systems.

Open applications are software applications that are built from open APIs. **Benefits:** Avoids vendor lock-in, reduces development costs and enables faster innovation for applications.

In an **open services ecosystem**, the concept of software openness is extended to a full service. Well-known examples are the Apple App Store and Amazon Web Services. **Benefits:** Presents the widest choice of applications and services for participants and for their customers.

Rise of Open Source

Open source has risen as a means of achieving standardization goals of global connectivity, openness and efficiency much faster than the historical standards process and in a way that is ultimately much more open. The rise of open source within communications coincides with the migration from hardware-centric architectures of the past to new software-centric architectures – notably, software-defined networking (SDN) and network functions virtualization (NFV). This is no coincidence.

While hardware development is governed by hardware specifications and interfaces, software is written in code. Thus, code-based development (such as open source) is rising in the era of SDN and NFV.

One of the key success metrics for network operators today is "service velocity," or the speed with which services can be developed and introduced to the market to generate revenue. A key component to achieving service velocity is how quickly standards can be developed from which operators can build their networks and their services. In this respect, open source clearly shines when compared to traditional consensus-driven standards development.

Figure 2 compares development time for several significant traditional standards to development times for some recent open standards. As shown, the difference is a measurement in years (traditional) versus measurement in months (open source).

Figure 2: Traditional vs. Open Source Standards – Speed of Development

Traditional		
Standard	Body	Length
100GE	IEEE	29 months
OTU4	ITU-T	31 months
GMPLS	IETF	39 months
NETCONF	IETF	40 months

Open Source		
Standard	Body	Length
ODL Hydrogen Release	OpenDaylight Foundation	12 months
OpenStack Austin Release	OpenStack Foundation	4 months
OpenFlow 1.2 Release	ONF	12 months

Source: Heavy Reading, 2016

The power shift within the communications industry from traditional standards bodies to open source development is not hype and speculation. While still early on, the shift to open source is already measurable. In 2015, Heavy Reading asked 459 telecom industry professionals globally to assess how the importance of various industry standards bodies has changed over the past two years. The top five gainers and top five losers are shown in **Figure 3**.

Figure 3: Operator Views on Rising & Falling Standards Organizations

Who's Hot	
Organization	Biggest % increase in importance
OPNFV	1
ONF	2
OpenDaylight	3
ETSI	4
IETF	5

Who's Not	
Organization	Biggest % decrease in importance
ATIS	1
TIA	1
ITU	3
ANSI	4
TM Forum	5

Source: Heavy Reading, 2015; N=459

Of the top five gainers, the top three – OPNFV, ONF and OpenDaylight – are all based in open source, and all five are heavily involved in SDN and NFV. The top five decliners, meanwhile, contains some of the most prominent traditional standards groups of past decades, including the ITU, ANSI and the TM Forum.

Our point in highlighting these survey findings is not to assert that traditional standards bodies are now irrelevant, but that the open source standardization process is quickly rising to share equal footing in many cases, even today.

Key Operator Benefits of Open Source

Key benefits that network operators can take advantage of in adopting open source development models are:

- **Faster time to market:** Suppliers and operators achieve faster time to market for new products, services and network functions by using and building upon base code that has been developed by many other open source project members with like interests.
- **Faster time to interoperability:** The ability to reach agreement in months rather than in years results in a faster path to interoperability versus the traditional standards approach. Interoperability means that projects can move from niche status to wide-scale deployment much more quickly. Interoperability eliminates vendor lock-in, and most large operators require multiple vendors per domain in order to roll out services in scale.
- **Community of idea sharing:** The "community" part of an open source community enables suppliers and operators to benefit from the ideas and contributions of individuals outside their company walls and even outside the telecommunications industry.
- **Reduced costs of development:** Finally, the use of open source base code reduces the overall cost of software development for suppliers and operators.
- **Modularity:** Open software creates software component modularity; open hardware creates hardware component modularity. In either case, modularity provides increased flexibility and scalability for operators while allowing them to better customize functions to their needs and reduce costs by getting only what they need, when they need it.

Industry Examples of Open Source Networking

The real litmus test for open source is how quickly commercial services and applications can be rolled out in the era of SDN and open source development.

- AT&T has been very public in publishing its plans and timelines for its aggressive virtualization and SDN rollouts and provides a good example of service velocity in action. AT&T doubled the amount of open source code in its network in 2015 from 5 to 10 percent. Important open source initiatives supported by AT&T include OPNFV, OpenDaylight, Open Contrail, ON.Lab, the Open Container Initiative, Cloud Native Computing Foundation and Open Compute Project, among many others. In 2015, AT&T targeted to virtualize 5 percent of its network. The operator slightly exceeded that goal, achieving 5.7 percent, and now aims for 30 percent virtualization in 2016. AT&T remains committed to virtualize 75 percent of its network by 2020.

- Level 3 provides another example of SDN-based service velocity in action. Level 3 currently has 75,000 software controlled elements in its network serving more than 1,500 customers. Services based on software control include Dynamic Capacity and Adaptive Network Control across its North America and EMEA footprint. In progress for 2016, are rolling out software based control in Level 3's Latin America region, rolling out Adaptive Network Control for Level 3's Cloud Connect services and piloting Dynamic Connections for Level 3 Cloud Connect Services. In 2017, Level 3 is working to commercialize its first SD-WAN services.

Network Transition From PMO to FMO

This section discusses key aspects of a well-designed open network and things customers should look for when evaluating an open network solution. Heavy Reading research shows that operators see three primary technical challenges standing in the way of wide scale adoption of SDN. The challenges are:

- Compatibility of SDN solutions with their installed base of equipment
- Lack of standardization
- Integration of SDN hardware and software components

These three challenges are inter-related and must be resolved for wide scale adoption to occur. The good news is that progress is made on all of these fronts.

Compatibility With Existing Networks & Systems

While there are some greenfield SDN deployments, the reality for the vast majority of network operators globally is that integration and coexistence with existing networks and systems is essential for wide-scale adoption.

In this context, the best suppliers will present a hybrid and phased approach from PMO to FMO in which the legacy and new SDN-based systems will coexist with a level of compatibility between them.

OSS/BSS integration is an essential component of the hybrid network phase. From Heavy Reading SDN operator surveys, we know that operators are using "lightweight" OSS for tests and trials, but that for wide-scale commercial deployments they plan to make significant changes to their OSS structure while also re-using as much as possible. Few operators are planning complete overhauls.

Standardization

The open source projects highlighted in this paper, along with others, are providing the means to interoperability and scale at the speed that is required today.

Much of the discussion in open source development to date has focused on software; however, as we have shown in this paper, hardware has a critical role to play in the phased migration from legacy to new. Specifically, modular hardware architectures allow hardware components to be swapped out in steps, over time, as the operators' hardware and software requirements change – including moving from proprietary hardware blades initially to generic hardware blades later for certain functions.

Integration of SDN Components

Above, we discussed compatibility of new systems with the existing installed base. In addition, integration of SDN hardware and software components with each other is a requirement. Several leading operators use a building blocks or "Legos" analogy to describe the appeal of SDN and NFV – meaning that operators can take individual hardware and software building blocks to create services that fit their needs and their customers' needs.

For this model to work, however, the building blocks must be able to fit together without complex additions of scripts and code. Standardization (including open source development described in this paper, as well as others) is the key to successful integration on a large scale.

Conclusions

Hyper-scale cloud networking and OTT applications have placed a tremendous strain on the old model of communications operation and standardization. Open source development – which itself comes from the world of IT software – presents a promising new path for operators, one that combines key interoperability benefits of traditional standards bodies with the speed and scale of cloud.

Successful operators will engage in open source development, migrate to open systems and choose hardware and software suppliers that are truly committed to these principles.

For selecting open systems, Heavy Reading offers the following checklist:

- A modular, scalable open architecture platform that allows operators to pick and choose the appropriate functions for their unique needs
- Open APIs, including REST and YANG, for easy interoperability for service, devices and network models
- Based on open-source components and are upstream to open-source projects
- Preserves investment in legacy equipment by enabling migration path from legacy/proprietary to open products that interoperate

Choosing the right supplier partners is also essential. Heavy Reading offers the following checklist for evaluating potential partners:

- Engaged and active participant in the relevant open forums and projects
- Adopts agile development internally to deliver customer requirements via accelerated roadmap development
- Recognizes that the customers' needs and ultimate solution are unique (competitive and differentiated)
- Supports moving to open technologies at the customer's own pace and integrates with existing unique systems and processes
- Offers a range of services that support customers' specific implementation

Appendix: Important Open Initiatives

This Appendix describes some major open source software and hardware projects that are helping redefine communications.

ON.Lab ONOS

Key Benefit: Applying SDN and virtualization technologies and principles to build an open source network operating system specifically for network operators.

In 2015, AT&T and Open Networking Lab (ON.Lab) launched an effort to re-design the traditional telco central office using SDN, NFV and cloud software technologies combined with commodity hardware. The goals are to lower central office capex and opex and enable rapid services creation. The collaboration is called Central Office Re-architected as a Data center, or CORD. The universe of CORD use cases has expanded greatly. Enterprise CORD (E-CORD), M-CORD (the mobile version of CORD) and the Enhanced Control, Orchestration, Management & Policy (ECOMP) initiative have all been added.

OpenDaylight

Key Benefit: Rapidly innovate on interoperable, standardized SDN controllers across many SDN applications.

The OpenDaylight Project is a collaborative, open source software project hosted by the Linux Foundation with a mission to accelerate the adoption of SDN and NFV. OpenDaylight is the most known and mature of the open controller platforms and has broad service provider and vendor support today, based on Heavy Reading survey data. ODL stands out for its ability to control both greenfield (OpenFlow-based) devices as well as legacy devices using other protocols, including PCEP, BGP, NETCONF and others. Separate releases address service provider and enterprise applications.

Open ROADM

Key Benefit: Speed innovation and increase vendor competition specifically at the photonic layer.

Spear-headed by AT&T and launched publicly in March 2016, the Open ROADM MSA defines interoperability specifications for ROADMs, including the ROADM optical switches, the transponders and the pluggable optics. Specifications consist of optical interoperability, as well as Yang data models. The goals of the MSA are twofold. One goal is to disaggregate and open up traditional proprietary ROADM systems by building ROADMs to a common hardware spec – essentially a "white box" ROADM. The other goal is to create centralized SDN control and software automation of traditionally fixed ROADM networks. Initial Open ROADM MSA members are operators AT&T and SK Telecom (South Korea) and optical suppliers Ciena, Fujitsu and Nokia (formerly Alcatel-Lucent).

Telecom Infra Project (TIP)

Key Benefit: Drastically reduce the costs of network hardware by applying open source principles to hardware development.

In February 2016, Facebook, along with a group of 17 initial partners, announced the Telecom Infra Project (TIP). Based on the model of the successful OCP, TIP's mission is to redesign networking hardware and software technology specifically for telecom networks. Operator partners include Deutsche Telekom (Germany), BT subsidiary EE (U.K.), Globe Telecom (the Philippines), Equinix (U.S.) and SK Telecom (South Korea). Technology supplier partners include Intel, Nokia and Radisys.

Apache Hadoop

Key Benefit: Building carrier-class reliability in highly distributed network architectures.

Apache Hadoop is an open-source software framework that allows for the distributed processing of large data sets across clusters of computers using simple programming models. It is designed to scale up from single servers to thousands of machines, each offering local computation and storage. Rather than rely on hardware to deliver high availability, the library is designed to detect and handle failures at the application layer, so delivering a highly-available service on top of a cluster of computers, each of which may be prone to failures. Hadoop is distributed under the Apache License 2.0.