



Software-Defined Networking: Standardization for Cloud Computing's Second Wave

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As cloud computing's second wave begins to transform the networking industry, a snapshot of developments in software-defined networking standardization suggests how its components—devices, controllers, applications, service chains, network function virtualization, and interfaces—are maturing.

Cloud computing's first wave began with server centralization and virtualization—resulting in a paradigm shift that changed how data is stored and how software is used. The emerging second wave, *software-defined networking* (SDN), takes network centralization and virtualization, and especially network control, into the cloud.

After emerging in datacenters, SDN deployment has grown up into the networking-as-a-service (NaaS) model cloud service providers now offer to enterprise and residential subscribers. By centralizing control-plane software (the software controlling the part of the network that carries the signaling traffic responsible for routing) to the controller and its applications, and controlling the device data plane (the actual data-packet movement) remotely, devices can become simpler. Thus, SDN significantly reduces the administrators required and as a result reduces expenses, both capital and operational. SDN also enables fast service orchestration because the data plane is highly programmable from the remote control plane at controllers and applications. In general, SDN takes networking into the computing domain and will increasingly adopt the standardization practices common for computing and software.

NEED FOR STANDARDIZATION

However, in detaching the control plane to reside separately from the data plane, we must introduce new protocols between the two—namely, the southbound API between controllers and devices, and the northbound API between controllers and applications. Extending the control plane from controllers to applications, as with service chaining (SC), and the data plane from devices to network function virtualization (NFV) requires that newer mechanisms be added and that APIs be updated. To avoid fragmented markets, these southbound and northbound APIs need standardization as soon as possible. Multiple standards bodies are competing—or cooperating—for a piece of the action; these include the Open Networking Foundation (ONF), the Internet Engineering Task Force (IETF), the European Telecommunications Standards Institute (ETSI), and the International Telecommunication Union (ITU). ONF is taking the lead in growing the dominant OpenFlow protocol for

the southbound API: ONF-certified labs can help monitor how the defined standards are implemented on commercial products. However, the northbound, SC, and NFV APIs are still under development, although this is more likely taking place in open source software projects than in standards committees. For stable SDN growth in a unified market, where all devices, controllers, applications, service chains, and NFVs are highly interoperable, standardization is critical, along with associated test-lab facilities that enforce the standards.

IN THIS ISSUE

We focused our examination of SDN on its standardization and market maturity—for example by taking a look at ONF and what its certified test labs have accomplished so far. Rather than having an open call to solicit paper submissions, we invited ONF leaders as well as a number of selected scientists and practitioners from both industry and academia to contribute articles. After a rigorous peer-review process, we accepted six papers covering various SDN perspectives.

Evolution of SDN and OpenFlow

Many principles behind SDN and OpenFlow are not entirely new; the intellectual history of programmable networks that led to SDN is well documented. “SDN and OpenFlow Evolution: A Standards Perspective” by Jean Tourrilhes, Puneet Sharma, Sujata Banerjee, and Justin Pettit describes how the SDN framework and the OpenFlow protocol have evolved during ONF's standardization process. The Extensibility Working Group, whose activities have led to the evolution of the OpenFlow protocol, has been fundamentally driven by specific use cases. This is in line with ONF's desire to measure its success by SDN's market acceptance, which depends on business cases.

Open source standards testing program

Aligning economic, technological, and market drivers in the context of an open source standard like the OpenFlow network specification is challenging. “Aligning Technology and Market Drivers in an Open Source Standards Testing Program” by Rick Bauer, Ron Milford, and Li Zhen presents and analyzes ONF's testing program. The authors describe how the program was designed to leverage both collaboration and competition among participants; the “team of rivals” model ONF created was designed to develop consumer confidence, industry competition, and trustworthy product validation.

Service function chaining and network service headers

SC defines a new service deployment model promising topological independence and elastic scaling of services. “Service Function Chaining: Creating a Service Plane via Network Service Headers,” by Paul Quinn and Jim Guichard, presents NSH, a standard data-plane format that

creates a service plane for network SC. The authors outline how the NSH protocol, which was submitted in February 2014 to the IETF standard track, provides the required data-plane information needed to meet the promised goals.

Open source and network control planes

SDN is a promising innovation that aims to open interfaces of proprietary networking devices to improve orchestration, lower operating expenses, and enable innovation. In “When Open Source Meets Network Control Planes,” Christian Esteve Rothenberg, Roy Chua, Josh Bailey, Martin Winter, Carlos N.A. Corrêa, Sidney C. de Lucena, Marcos Rogério Salvador, and Thomas D. Nadeau discuss the role that open source plays in transforming SDN’s software and hardware in the networking landscape. The authors describe the RouteFlow project, which aims to combine open source IP routing stacks and OpenFlow networks, and they also share the operational experience of its use at a live Internet exchange.

Deploying software-defined networks

Many networks, especially enterprise networks, face challenges when migrating from traditional platforms to SDN. In “Software-Defined Networks: Incremental Deployment with Panopticon,” Marco Canini, Anja Feldmann, Dan Levin, Fabian Schaffert, and Stefan Schmid describe an incremental approach that combines traditional and SDN switches through interim hybrid networks. The authors claim that SDN benefits can extend—thanks to their Panopticon architecture—over an entire network, even when only a small fraction of the network is SDN-enabled.

Virtualizing network functions in home networks

Home networks are frequently based on relatively low-cost devices that are failure prone and thus require frequent use intervention. In “Virtualization of Home Network Gateways,” Marion Dillon and Timothy Winters present networks function virtualization, a new approach that aims to move the home network gateway to the cloud.

This first special issue of *Computer* devoted to SDN focuses on standardization. While we expect future issues will broaden this scope, we hope the articles included here will provide readers with a snapshot that suggests the prospects and many possibilities for this developing technology. ■

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