OpenFlow: The next generation in networking interoperability

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Data centers host the computational power, storage, networking and applications that form the basis of any modern company. To reduce costs and increase the efficiency of this business-critical resource, IT organizations commonly implement new technologies and make fundamental architectural changes.

OpenFlow is an emerging technology with the potential to increase the value of data center services dramatically. Implementing OpenFlow can provide network administrators with greater control over their resources, integrated network and server management, and an open management interface for routers and switches.

Understanding OpenFlow

OpenFlow is an example of Software-Defined Networking (SDN), which provides an open, standards-based interface to control how data packets are forwarded through the network. The OpenFlow standard also provides a basic set of global management abstractions, which can be used to control features such as topology changes and packet filtering.

OpenFlow takes advantage of the fact that most modern Ethernet switches and routers contain flow tables, which run at line rate and are used to implement functions such as quality of service (QoS), security firewalls, and statistical analysis of data streams. OpenFlow standardizes a common set of functions that operate on these flows and will be extended in the future as the standard evolves.

An OpenFlow switch consists of three parts, as illustrated in *Figure 1:*

- **Flow Table**—Tells the switch how to process each data flow by associating an action with each flow table entry
- **Secure Channel**—Connects the switch to a remote control processor (called the Controller) so commands and packets can be sent between the controller and the switch
- **OpenFlow Protocol**—Provides an open, standardized interface for the controller to communicate with the switch

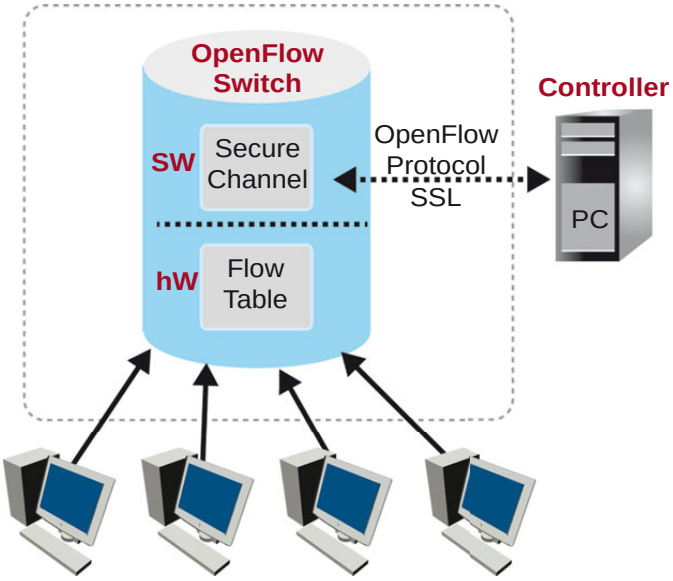

Figure 1. OpenFlow switch components

The OpenFlow Protocol allows entries in the Flow Table to be defined by a server external to the switch, which creates the potential to unify server and network device management. For example, a flow could be a TCP connection, all the packets from a particular MAC or IP address, or all packets with the same VLAN tag. Each flow table entry has a specific action associated with a particular flow, such as forwarding the flow to a given switch port (at line rate), encapsulating and forwarding the flow to a controller for processing, or dropping a flow's packets (for example, to help prevent denial of service attacks).

There are many applications for OpenFlow in modern networks. For example, a network administrator could create on-demand 'express lanes' for voice and data traffic that are time-sensitive. Software could also be used to combine several fiber optic links into a larger virtual pipe to handle a particularly heavy flow of traffic temporarily. When the data rush is over, the channels would automatically separate. Service providers could use OpenFlow to build a smarter planet by offering remote services such as home security or energy management. In cloud computing environments, OpenFlow improves scalability and enables resources to be shared efficiently among different services in response to the number of users.

The OpenFlow specification is controlled and published by a recently-formed, nonprofit industry trade organization called the Open Network Foundation (ONF), which will license the trademark "OpenFlow Switching" to companies who adopt this standard. The ONF is led by a board of directors from six companies that own and operate some of the largest networks in the world (Deutsche Telekom, Facebook, Google, Microsoft, Verizon, and Yahoo).

IBM offers first OpenFlow 10 GbE switch

IBM® is pleased to be one of the inaugural members of the ONF, and the first to adopt OpenFlow in a 10 Gigabit Ethernet (GbE) switch. Attendees of the Interop 2011 trade show in Las Vegas, Nevada, had the opportunity to view two demonstrations of the IBM BNT® RackSwitch G8264 *(Figure 2)* running OpenFlow environments.

Figure 2. IBM BNT RackSwitch G8264

In the NEC booth, the IBM BNT RackSwitch G8264, a 10/40 GbE switch, ran an OpenFlow environment to an NEC OpenFlow Controller. NEC, an active participant in OpenFlow development, currently offers OpenFlow-enabled Gigabit Ethernet switches.

The IBM and NEC architecture *(Figure 3)* demonstrated several unique performance attributes:

- A highly scalable terminal-owning region (TOR) interconnectivity architecture (scales to east-west traffic)
- Control on the bisection bandwidth/oversubscription ratio
- Use of intelligent flow-based multipath for active load balancing
- Fast failover in case of port or switch failure (high path availability)
- Ease of manageability using Controller and PF Management Console

The NEC programmable flow controller contributed several distinctive features:

- Creating multiple virtual networks on one multivendor infrastructure
- Creating intelligent flow filtering and routing
- Flow monitoring

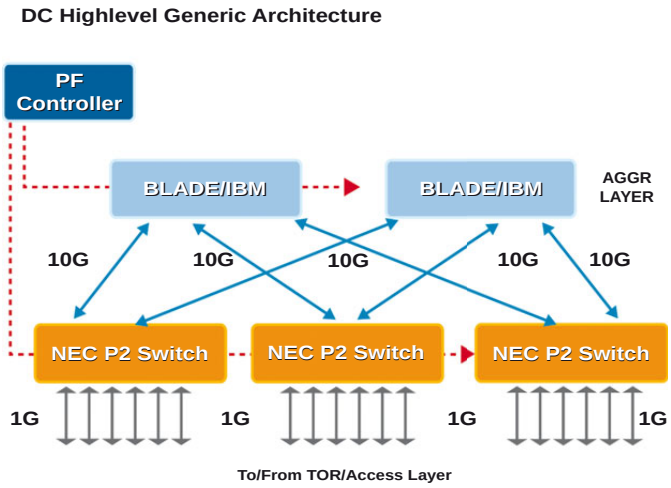

Figure 3. IBM and NEC switching architecture for OpenFlow

IBM also demonstrated the IBM BNT RackSwitch G8264 in the InteropNet OpenFlow Lab. The InteropNet OpenFlow Lab was created to educate Interop attendees on the principles, functions, and features of OpenFlow, and to demonstrate OpenFlow in different scenarios.

During the presentation, network experts working on the OpenFlow standard used OpenFlow to demonstrate the following points:

- How to extend a single management domain across a physical and virtual switch infrastructure made up of devices from a variety of vendors
- How to provide unique load-balancing functionality
- How to create an intelligent network-based QoS for voice over IP (VoIP) in a converged network

Industry-leading performance

In a recent independent performance test conducted by the Tolly Group, the IBM BNT RackSwitch G8264 demonstrated up to 100 times the packet buffering capacity and up to 70 percent less energy consumption than competitive switches, while maintaining full line rate and providing 160 Gbits/second more capacity than any other switch tested (http://www.tolly.com/DocDetail.aspx?DocNumber=211108).

Open standards support

OpenFlow complements IBM's long-standing commitment to open industry standards, which offer a choice of solutions that best fit user needs. NEC is actively driving OpenFlow for cloud computing applications in order to reduce IT and network infrastructure management complexity and to improve QoS for cloud applications.

For more information on OpenFlow, visit www.opennetworkingfoundation.org , or see the following articles:

- *Open Networking Foundation Pursues New Standards* http://www.nytimes.com/2011/03/22/technology/internet/22internet.html?_r=1&ref=technology
- *How Software Will Redefine Networking* http://gigaom.com/2011/03/21/open-networking-foundatio/
- *Tech Titans Back OpenFlow Networking Standard* http://www.datacenterknowledge.com/archives/2011/03/22/tech-titans-back-openflow-networking-standard/

For more information

For more information about the IBM BNT RackSwitch 8264 Ethernet switch, visit ibm.com/systems/x/options/networking/bnt8264/

To learn more about OpenFlow, contact your IBM marketing representative or IBM Business Partner, or visit http://www.opennetworkingfoundation.org

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