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Software Defined Networking

A new paradigm for virtual, dynamic, flexible networking

IBM

Executive summary

Virtualization has been a boon to data center administrators as they strive to meet changing business needs with limited budgets. But as data centers grow, virtualized networks are hosting more physical and virtual devices in more complex configurations than ever before. Managing such a complex and fluid network configuration is a resource-intensive effort that is difficult to execute efficiently.

Much of the management challenge facing administrators today stems from the physical network architecture itself. Today's networks depend on IP addresses to identify and locate servers and applications. This approach was fine for static networks of physical devices, but is extremely labor-intensive for large virtual networks. Managing such complex and changeable environments using traditional means has become far too time-consuming and expensive to remain feasible, especially in the areas of VM connectivity, network configuration and virtual device mobility. The continuing expansion of large data centers is already beginning to outstrip the ability of administrators to efficiently manage these very large-scale networks.

To simplify the task of managing large, virtualized networks, administrators must be freed from the physical infrastructure concerns that increase management complexity.

Software Defined Networking

Software Defined Networking (SDN) is a new network paradigm that separates each network service from its point of attachment to the network, creating a far more dynamic, flexible, automated and manageable architecture. Administrators can easily move virtual resources throughout the network, create private virtual networks that meet specific performance and security needs, and a host of other high-value applications.

The key to SDN is an innovative approach to controlling how data flows through a network. In a traditional network, data flow is controlled by switches and routers. Each switch and router contains the following basic elements:

- Data plane: physically carries data packets from one port to another by following rules that are programmed into the device hardware. The data forwarding plane operates at the speed of the network (wire speed).
- Control plane: contains the logic that the device uses to program the data plane, so packets are forwarded correctly throughout the network.
- Management plane: lets an administrator log in to the device and configure it for basic activities. Most devices can be configured locally or through a network management tool.

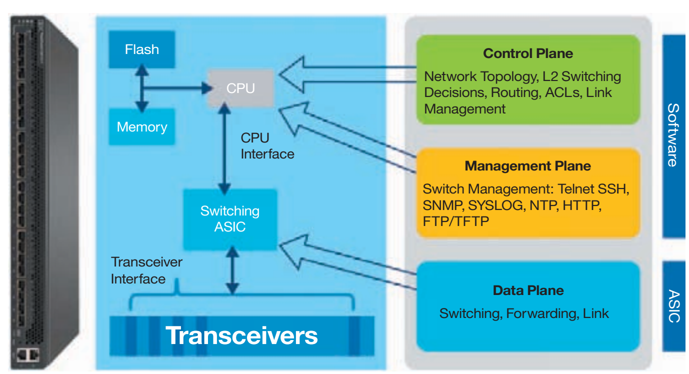

Figure 1: Traditional network switch architecture

Vendors use control plane software to optimize data flow to achieve high performance and a competitive advantage. The switch-based control plane paradigm gives network administrators very little opportunity to increase data flow efficiency across the network as a whole.

SDN abstracts flow control from individual devices to the network level. Network-wide data flow control gives administrators the power to define network flows that meet the connectivity requirements of end stations and address the specific needs of discrete user communities. For example, an administrator might select network bandwidth, path latency or other criteria as the optimal communication path for a specific data flow.

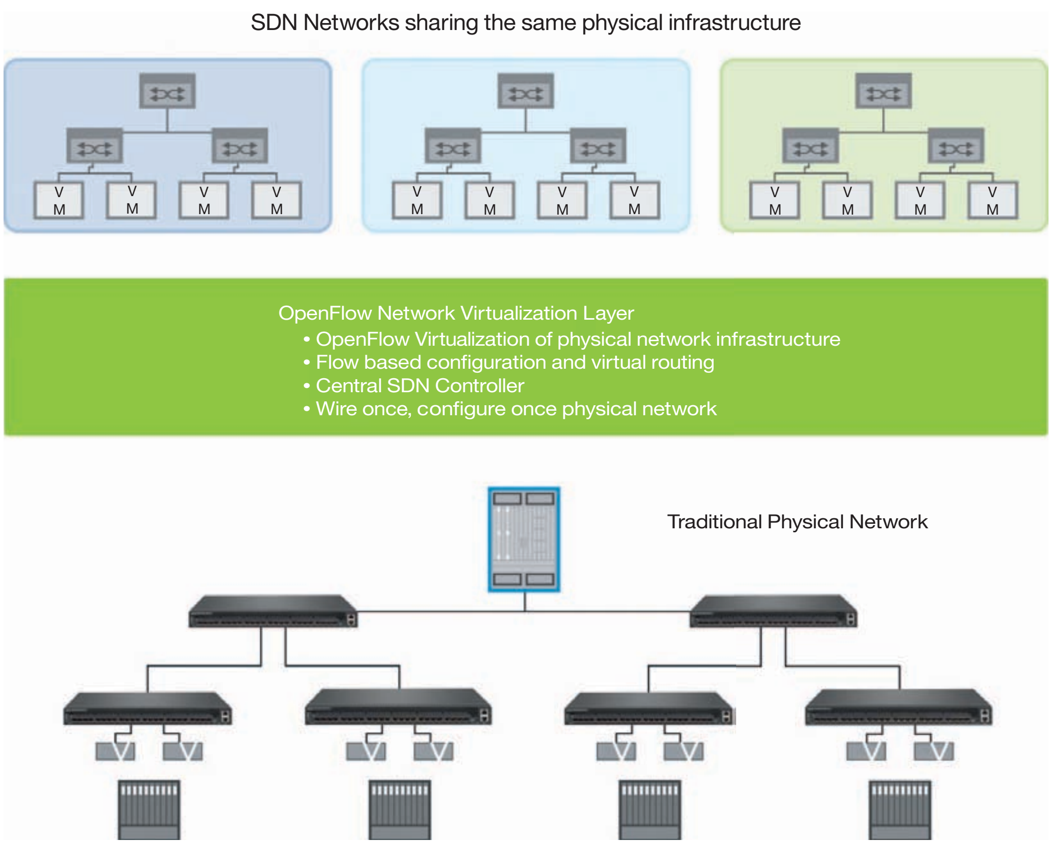

Figure 2: SDN Network Architecture

SDN network components and infrastructure

The SDN Controller implements the control plane and management plane functions of a traditional switch. It can be implemented as software running on a server or as a dedicated appliance. Logically centralized software within the SDN Controller manages end station connectivity and forwards packets through the network.

SDN can use an existing physical network infrastructure or a virtual overlay network to provide end station connectivity. In the overlay network model, a SDN Controller creates virtual connectivity between end stations by creating virtual L2 and or L3 networks, or through policy-based networking.

Programming individual network elements to provide end station connectivity as determined by the SDN Controller is another option for enabling SDN. The controller provides the virtual network abstraction so that the end stations are not exposed to physical network infrastructure. In contrast, traditional network elements are closed systems which do not provide the means for programming.

Implementing SDN through the OpenFlow standard

SDN is implemented through a protocol known as OpenFlow that lets administrators select the path through which data will flow through a network. Several major vendors such as IBM are implementing SDN through the OpenFlow standard.

OpenFlow provides software-based access to the flow tables that instruct switches and routers how to direct network traffic. Using these flow tables, administrators can quickly change the network layout and traffic flow. The OpenFlow specification is controlled and published by the nonprofit Open Network Foundation (ONF), which is led by a board of directors from seven companies that own and operate some of the largest networks in the world (Deutsche Telekom, Facebook, Google, Microsoft, Verizon, Yahoo and NTT). The ONF will license the trademark “OpenFlow Switching” to companies that adopt this standard.

Practical, profitable uses

The ability to control specific data flows means that data can be directed to move through the network more efficiently, using a path with more available bandwidth or fewer hops. In addition to routing traffic more efficiently, controlling data flow through SDN greatly simplifies the task of creating secure, private paths for specific data flows. The ability to rapidly scale secure network capacity for specific users and applications has a wide v ariety of useful, cost-saving applications.

Multi-tenancy: secure infrastructure sharing

Multi-tenancy logically divides a hardware resource so that multiple users can securely share the same physical device, such as a server. SDN lets administrators expand this concept to the network, so traffic flows within multiple groups of users can safely share network resources. Users gain greater access to available bandwidth, and increased network utilization reduces costs. Multi-tenancy of the network is an important concept for cloud computing, in which different user communities share a common infrastructure.

Virtual overlay networks: private networks on a public infrastructure

Virtual overlay networks provide a single tenant with a private, secure virtual network. Virtual overlay networks expand on the concept of a VM, in which a physical server is divided into multiple logical servers. A virtual overlay network gives a user or user community not only a separate virtual server, but an entire private network that connects virtual compute and storage resources. Through SDN, administrators can easily maintain entire virtual networks with their associated compute and storage resources even when VMs are migrated to different hosts.

Load balancing: higher performance with no added investment

Load balancing distributes a server workload or network traffic to improve response times and resource utilization. Today, network load balancing is performed by dedicated hardware appliances and software. With SDN, administrators can implement load-balancing with an OpenFlow switch and a commodity server. This highly cost-effective solution lets administrators better control traffic flow throughout the network to improve network performance.

Virtualization: expanding virtualization to the network

Virtualization has become a ubiquitous technology in the data center by virtue of its ability to increase resource utilization, reduce costs and create a highly adaptable network environment. But as administrators strive to expand the benefits of server and storage virtualization to the network, they are limited by the physical network infrastructure itself. Networks can only support a finite number of virtual LANs (VLANS), and fixed router and switch configurations limit the flexibility of VM movement. A virtualized OpenFlow network removes these limitations, allowing administrators to create a flow-based virtual network abstraction that expands the benefits of virtualization to the network level.

IBM SDN LEADERSHIP

IBM was one of the inaugural members of the ONF, and the first vendor to adopt the OpenFlow 1.0 specification with advanced functionality in a 10 Gb Ethernet switch. In addition to its distinction as the first 10 Gb OpenFlow switch, the **IBM RackSwitch G8264** was honored with the TMC 2010 Communications Solutions Product of the Year award. This award acknowledges innovative products that facilitate voice, data and video communications. With a strong commitment to SDN, IBM will continue to innovate in OpenFlow switch development.

The **IBM Programmable Network Controller** (IBM PNC) is an OpenFlow-based SDN Controller that provides centralized control of network flows and unlimited virtual machine (VM) mobility—implemented in enterprise-class software. The controller software automatically and continuously discovers the OpenFlow network topology and maps physical and virtual traffic flows across any OpenFlow-based data center network environment. The IBM PNC helps provide a highly reliable, edge-to-edge system network fabric that can be defined for multi-tenant environments. Granular policy enforcements ensure secure isolation across multiple tenants. Administrators can also use the controller to attach policies that direct overall network operations, saving management time and helping to ensure that data center system and network deployments are aligned with business strategy.

Conclusion

The potential for SDN to ease management of virtualized networks, enable cloud computing, reduce costs and increase business agility has led networking vendors to embrace SDN and OpenFlow. With solutions such as the IBM Programmable Network Controller and the IBM RackSwitch G8264, administrators have a powerful new option for expanding the return on physical network investments, and providing the fast response to user needs that is critical to business success.

For more information

To learn more about the RackSwitch G8264, please contact your IBM representative or IBM Business Partner, or visit: **ibm.com**/systems/networking/switches/rack/g8264/index.html

To learn more about the IBM Programmable Network Controller, please contact your IBM representative or IBM Business Partner, or visit: **ibm.com**/systems/networking/software/pnc.html

For more information about the Open Network Foundation, visit: www.opennetworkingfoundation.org

For more information about the OpenFlow specification, visit: http://www.openflow.org/wp/ibm-switch

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