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SOFTWARE-DEFINED NETWORKING AND OPENFLOW

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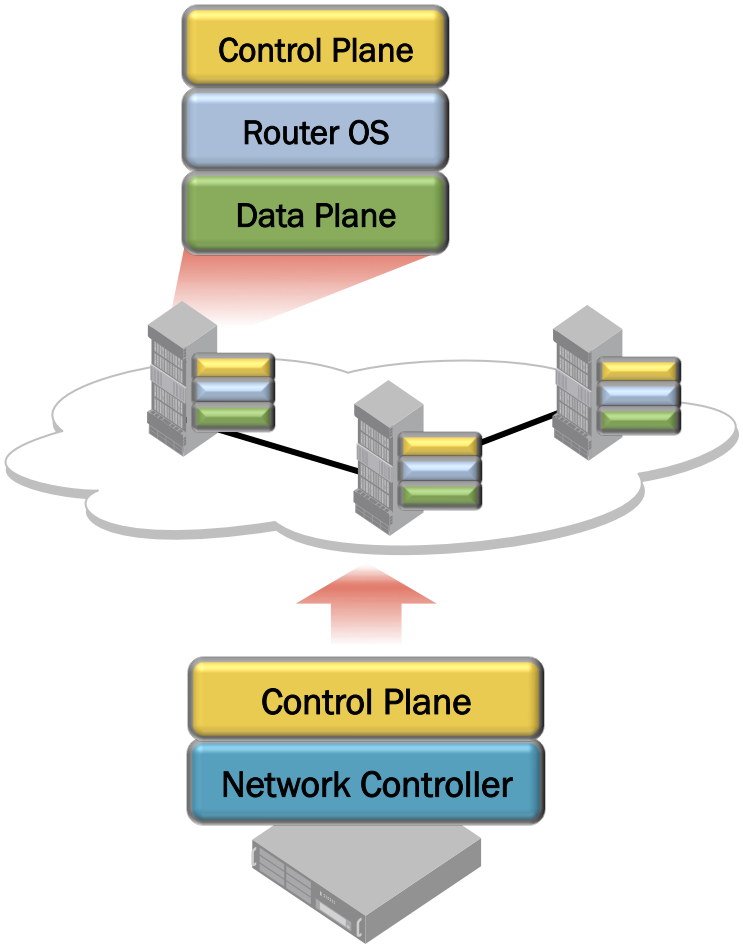
Software-Defined Networking (SDN): Fundamental Control Plane Paradigm Shift

- Decouples the integrated control plane in routers to improve network flexibility and manageability
- External controllers augment the control plane and make forwarding decisions for a set of flows
- A group of technologies that open the data, control, and management planes of the network through APIs



SDN Network Architecture: The Big Picture

Cloud-Optimized Network Stack	Key Benefits	Enabling Technologies
Cloud Management Layer	Automation and Orchestration	Cloud APIs: OpenStack, VMware, Microsoft, CloudStack
Services Layer	Personalization and Monetization	Programmatic Control: OpenFlow; OpenScript
Network Virtualization Layer	Flexibility and Efficient Asset Utilization	Overlay Networking: VXLAN, NVGRE, STT; MPLS
Network Fabric Layer	Reliability and Simplicity	Any-to-Any Connectivity: Ethernet Fabrics; IP Routing

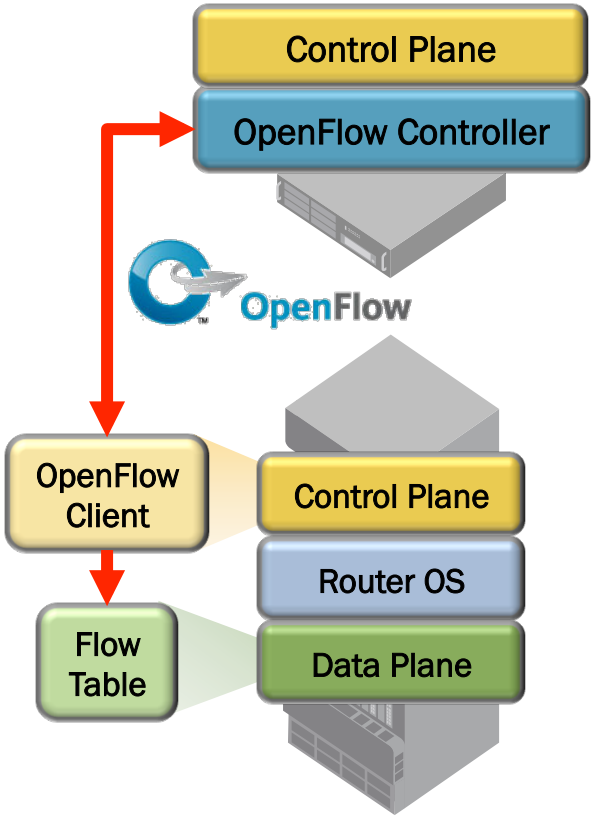
Who is behind OpenFlow: Open Networking Foundation (ONF)

- ONF launched publicly in March, 2011
- The ONF defines OpenFlow and API specifications
- Founding members of ONF are network operators:

- Support from more than 70 major companies since the launch
- Recent interest from the IETF in provisioning protocols

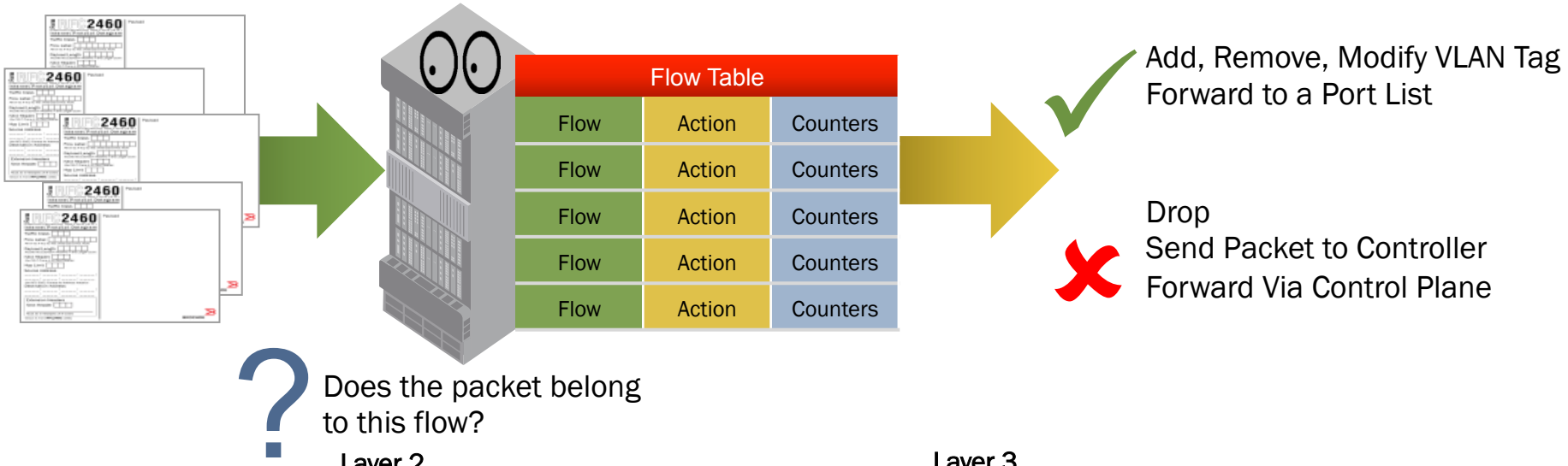
OpenFlow Overview

- Protocol that enables communication between an OpenFlow controller and an OpenFlow router
  - Control plane decisions for a defined set of flows are made by the controller, which typically runs on a server
  - Other control plane decisions and all data plane forwarding is still done by the router
- Router and controller communicate via the OpenFlow protocol, which defines messages
- Router maintains flow tables, which are maintained by the controller using APIs



OpenFlow Router Operation

- Flow table contains entries that define a flow based on the packet header
- Flows are sorted by priority as defined by the controller, highest priority flows match first



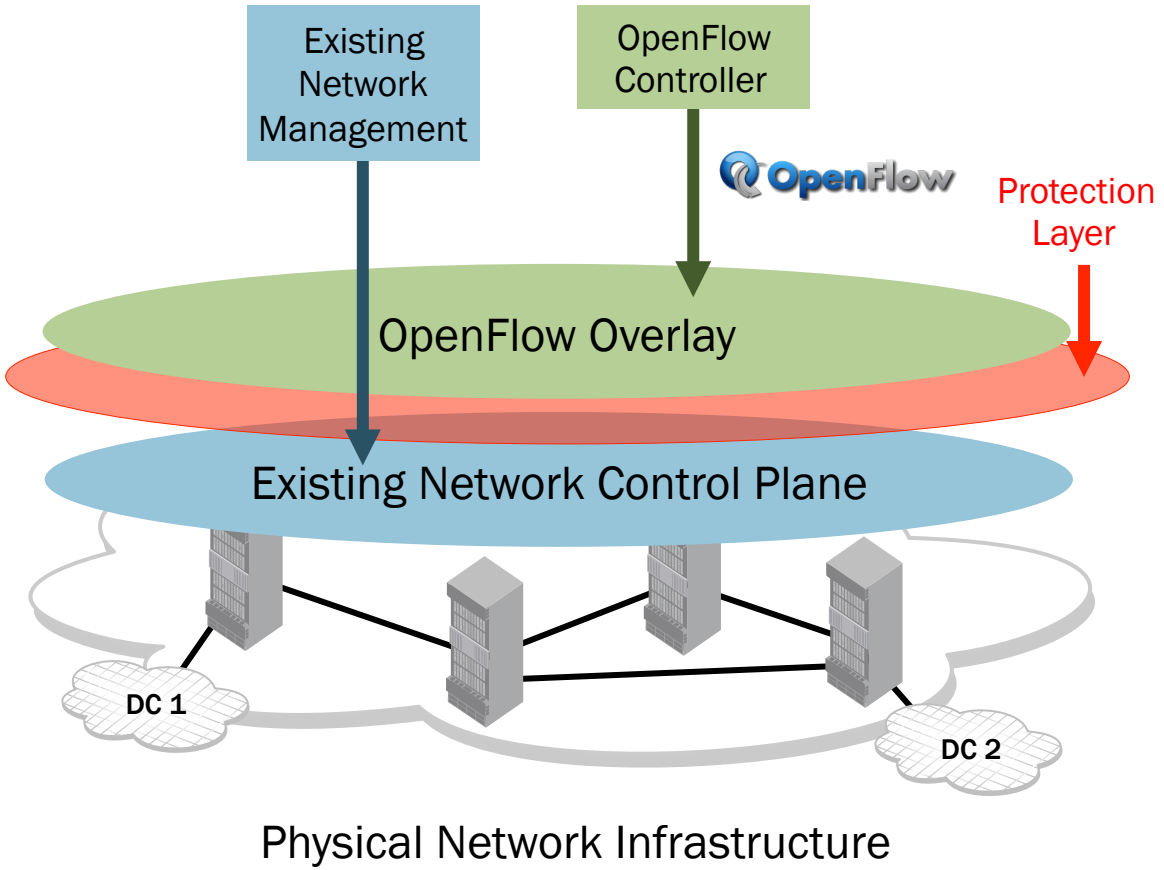
OpenFlow Applications: What can you do with OpenFlow?

- OpenFlow itself does not define or mandate any specific application, it's just an interface into the control plane
- Enables a large set of applications due to its flexibility to program the network based on any external criteria
  - Cost
  - Time of day
  - Latency
  - Security
  - Traffic policy
  - Load
- Ideal for automation in highly orchestrated environments where you want to precisely control network behavior

Network Virtualization

Hybrid Port Mode: OpenFlow Overlay

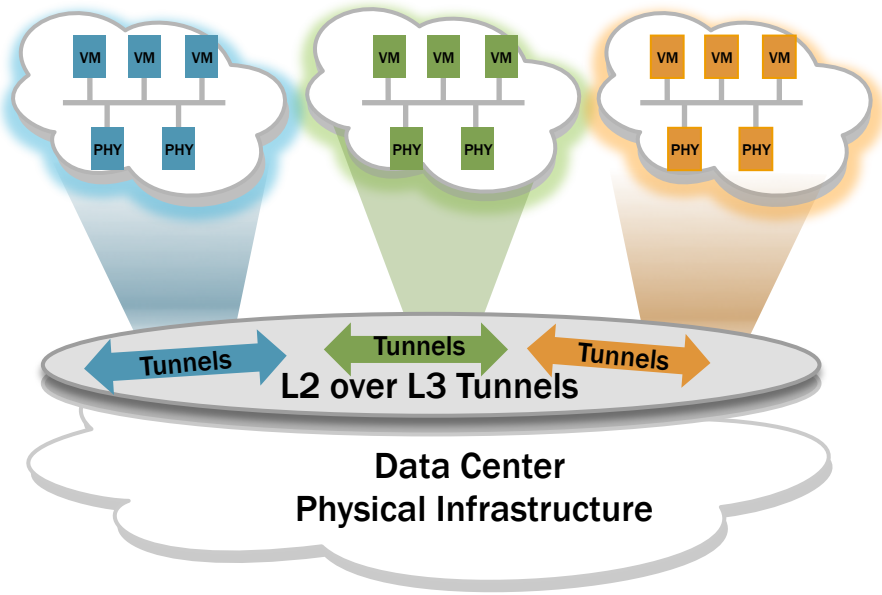
- OpenFlow used as an overlay in an existing network to add exception rules to create new services
- Hybrid port mode: OpenFlow does not affect other traffic on the same port, enforced in hardware
- Allows for OpenFlow service development without risk on top of the existing production network



Data Center Network Virtualization

Scalable Cloud Services

- vSwitches connect virtual machines, ToR switches connect physical machines
- Tunnels enable physical network abstraction
- SDN gateways enable scalable connectivity into the logical network
- Programmatic interface to server infrastructure with OpenFlow

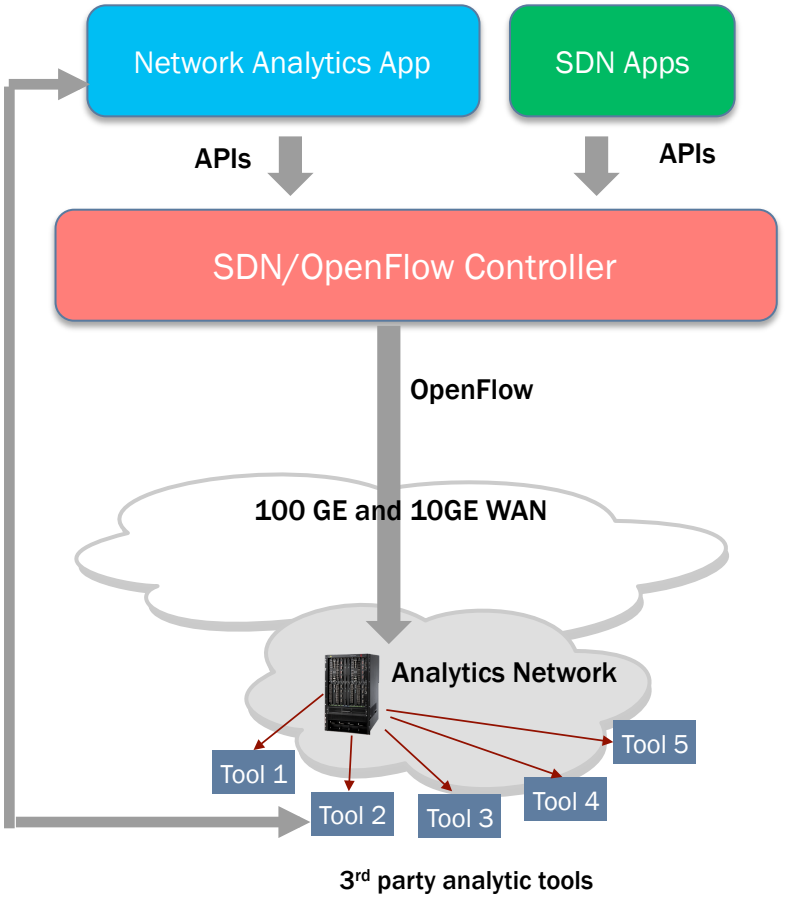


Data Center With 1000s of Virtual and Physical Servers

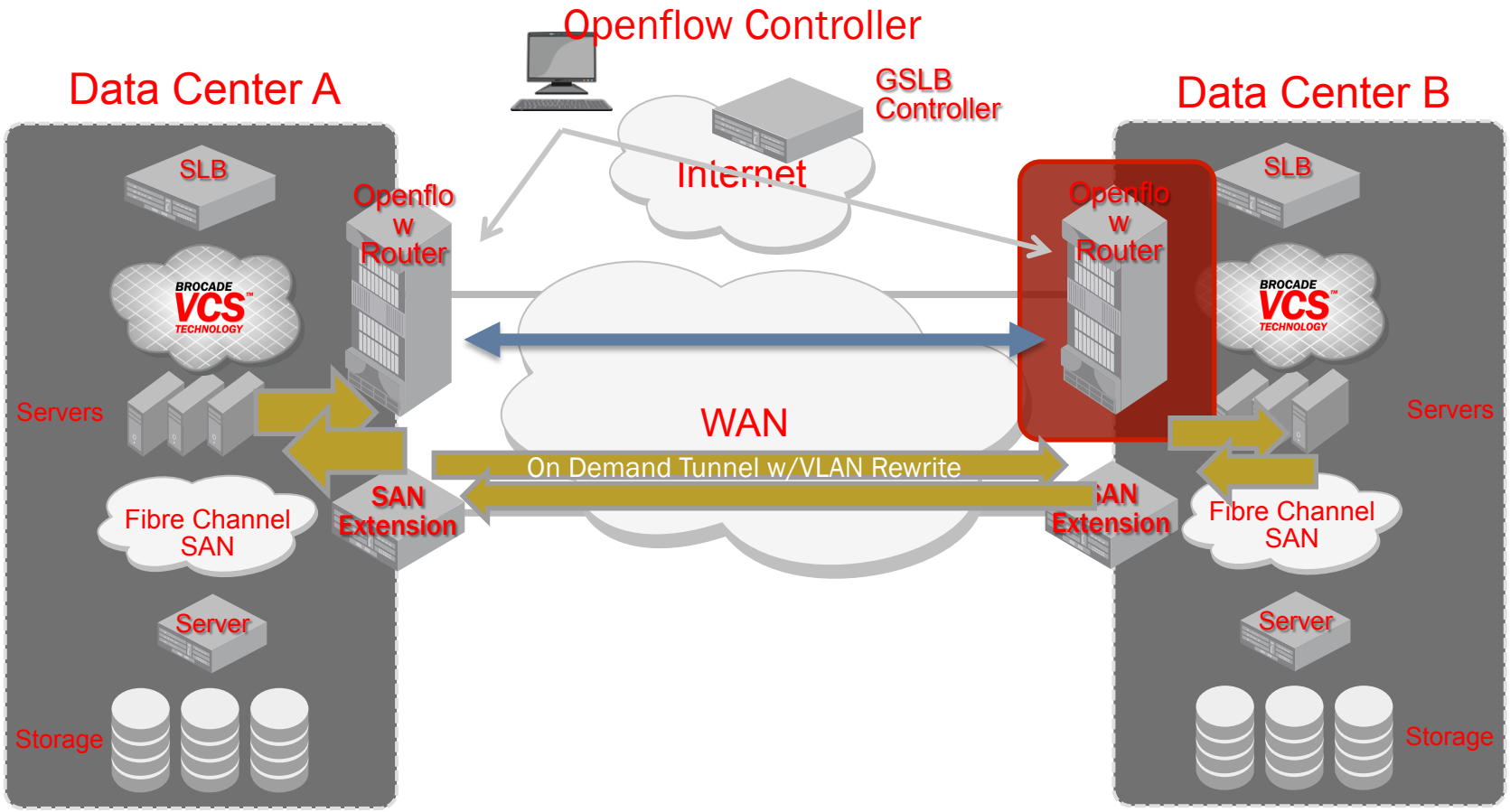
Network Analytics Application and SDN Controller

SDN Approach to Network Analytics

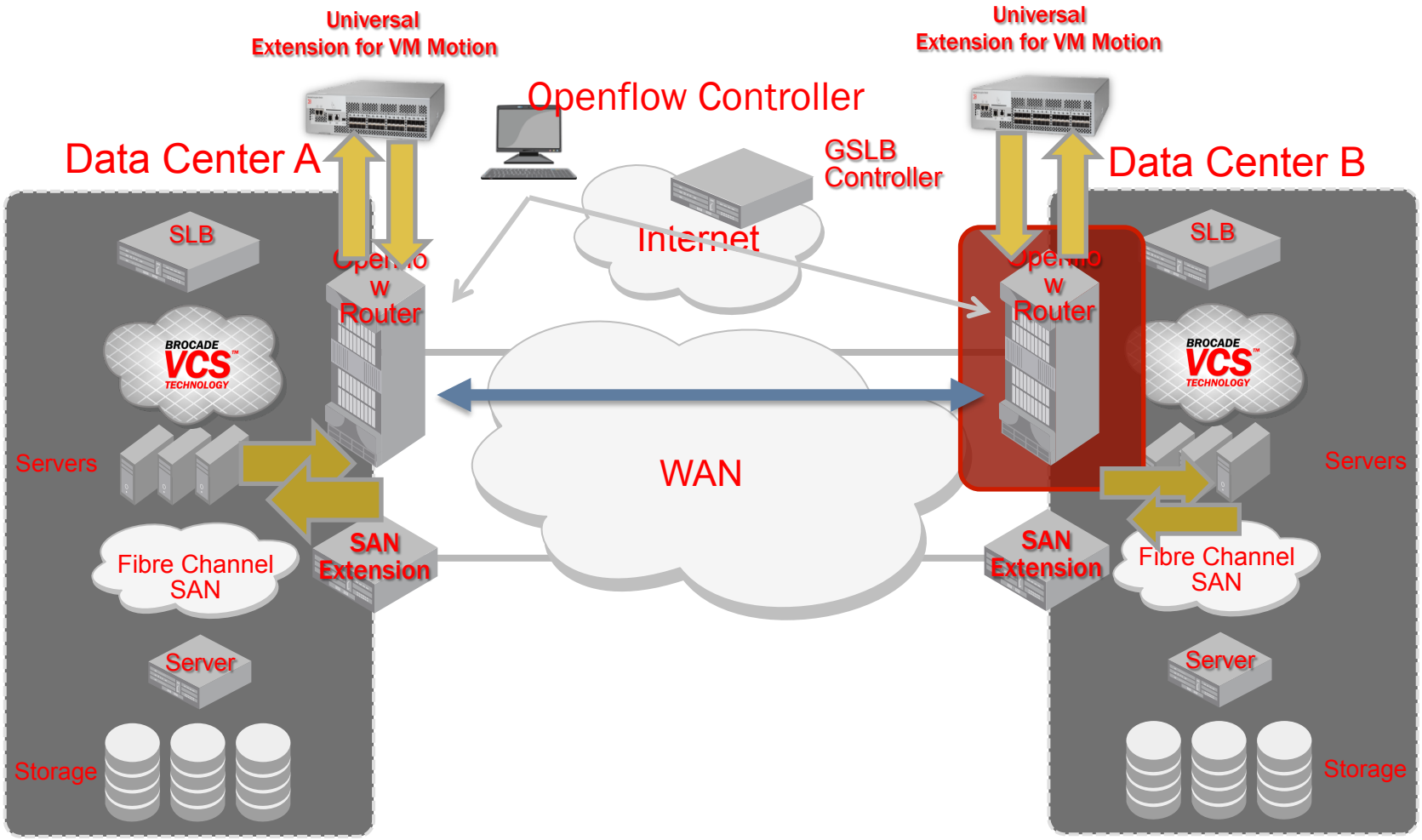
- SDN/OpenFlow Controller uses north bound APIs for application development
- SDN/OF Controller provisions network using OpenFlow
- OpenFlow to networks
  - For traffic replication from WAN to Analytics Network
  - For traffic replication from Analytics Network to Analytic tools
- Analytic tools provide for reporting and analytics



Extending Clouds Across Data Centers



Extending Clouds Across Data Centers, contd



Where is the ONF and OpenFlow headed?

- OpenFlow 1.3 received preliminary approval in April
  - Post review approval in June, and work on 1.3.1 (clean up)
  - 1.4 was originally planned for late summer, but delayed
- ONF would like to see more adoption of 1.3
  - Stabilize the specification at a good version
  - Go back to original approach of OpenFlow 1.0 which requires working code before a new feature is standardized
- Need open reference implementations to help promote adoption and testing
- Forwarding Abstractions Working Group (FAWG) is working to make OpenFlow support on more hardware platforms easier

Further Information

- Open Networking Foundation
  https://www.opennetworking.org/index.php
- Intro to OpenFlow
  https://www.opennetworking.org/standards/intro-to-openflow
- Brocade OpenFlow Page
  http://www.brocade.com/launch/sdn/openflow.html

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Questions?