Software-Defined Networking Primer + Deep Dive into Big Switch Networks

ISI’s Software-Defined Networking Primer + Deep Dive into Big Switch Networks:

In our view, software-defined networking (SDN), Hadoop (unstructured big data analytics) and cloud storage represent some of the biggest secular growth opportunities in enterprise infrastructure over the next several years. While still nascent, we have followed these trends extensively for over a year (e.g., multiple meetings with leading private companies, technical conferences, ISI-hosted investor meetings, our Enterprise Infrastructure Forum, etc.) to look for early signs of a meaningful impact to incumbent vendors in our coverage universe. In our view, business momentum as well as investor interest in SDN has grown faster than any other emerging enterprise technology we have seen in recent years (e.g., perhaps ~10% of IT buyers interested 1 year ago, ~1/3 interested 6 months ago, and over 50% today). We believe VMW’s purchase of private SDN company Nicira for ~$1.3bil has catalyzed interest and validated the strategic importance of SDN. We recently met again with the CEO, Co-founders and senior management of leading independent SDN company Big Switch Networks to gain additional perspective on trends in SDN and the company’s positioning.

As organizations have increasingly looked to wring maximum efficiency out of their IT assets, we believe over the last 5 years server virtualization has been the “go-to” technology for IT managers, often allowing compute utilization rates to increase from ~10% to ~50-75%. While compute and storage resources have been virtualized by most large organizations in recent years, networking constraints have tied workloads to the underlying physical network. This has been a significant barrier to workload mobility, scalability, multi-tenancy and greater automation. SDN technologies offer the ability to virtualize networking resources and help unlock the value of a completely virtualized infrastructure (e.g., compute, storage and networking with increased automation). In our view, industry interest in new SDN capabilities has shifted from 2nd gear to 5th gear almost overnight and we believe the market for SDN related technologies could reach ~$3bil over the next 5 years.

We came away positive from our meetings with Big Switch that the company’s vision of an open ecosystem is resonating well and gaining solid industry momentum. While founded a few years after Nicira, the company shares some of the same pedigree (e.g., key employees from VMW, CSCO, Arista, leading Stanford/UC Berkeley researchers, etc.) and we see it as the most attractive independent asset in the space today. We expect to see very significant partner and customer announcements in the coming months from the company and many pilots which turn into production customers over the next 1-2 years. We view the company as an attractive acquisition candidate for CTXS/CSCO/ORCL/MSFT/IBM and wouldn’t be surprised if it were to first obtain a large new round of financing following a ~$14mil Series A in Apr-11.

With the industry still at an early stage (e.g., sub-$10mil in revenue for both top vendors Nicira and Big Switch in CY12), we believe there are many different approaches and views on what constitutes SDN. While we expect a long-term headwind to networking incumbents (e.g., CSCO) from SDN, we continue to believe a meaningful impact to financial models is still at least ~1-2 years away. In this report, we aim to provide a brief primer on SDN encompassing some of the most frequently asked questions we hear from investors. We also include a more in-depth look at Big Switch Networks, the leading independent SDN company in our view.
What is Software-Defined Networking (SDN) and OpenFlow (OF)?

- In broad terms, SDN is a form of networking in which control over how data traffic is forwarded to its destination is separated from the switching hardware.

- A traditional switch consists of a data/forwarding plane and a control plane which an SDN architecture decouples.
  - The data or forwarding plane in a switch looks at a ‘forwarding table’ (which is set up by the control plane) and sends a packet to its destination based on information in the ‘forwarding table.’ The data plane requires very high throughput and sometimes uses custom silicon.
  - The control plane is responsible for creating the routing tables which determine how incoming packets are sent to their destination. It can also manage connections between switches, handle exceptions and define additional information such as quality of service for different packets.

- In an SDN architecture, control plane functions are separated from the physical switch and performed by an external controller (e.g., a standard server running SDN software). One key benefit is that the server platform used for the external controller can be significantly faster than the control plane hardware found in many routers (e.g., ~25-50x faster in the case of GOOG’s implementation).

- OpenFlow (OF) is an open protocol used by the external controller (i.e., server) to communicate with a physical and/or virtual switch in an SDN architecture. The protocol allows the controller to define how packets are forwarded.

Example of OpenFlow usage and an SDN architecture

- Switches need to be OpenFlow enabled to communicate with an OF controller. Vendors including Arista, BRCD, HPQ, JNPR, DELL and EXTR have all announced OF enabled switches. CSCO has announced that it will provide “proof-of-concept” OpenFlow v1.0 agents on the Catalyst 3750-X and 3560-X series switches, but we believe it has generally been slow to add OpenFlow support in its switches.

What are the primary benefits and motivations for deploying SDN and using the OpenFlow protocol?

- SDN aims to create a more dynamic and flexible network architecture capable of evolving quickly with changing business, end-user and market needs. Some of the key benefits outlined by the Open Networking Foundation (ONF) as well as leading industry participants include:
  - Ability to manage and control networking elements from a centralized point (e.g., “distribute what you must, centralize what you can”)

Source: Open Networking Foundation  
Source: Open Networking Foundation
Improved automation and management through the use of common application programming
interfaces (APIs) which help hide networking details from provisioning systems and applications

Ability to deliver new networking services without configuring individual devices or depending on
vendors to create new functionality

Programmability of the network infrastructure by the entire ecosystem (e.g., users, enterprises,
independent software vendors, etc.) allowing innovation from industry participants beyond the
equipment vendor

Ability to apply a wide variety of policies at the session, user, device and application levels which help
applications quickly adapt to the state of the network and user needs

Some of the anticipated benefits and use cases discussed by the ONF and top SDN vendors in different
environments include:

- In the datacenter, network virtualization can improve server utilization, help optimize bandwidth usage
  and provide tighter integration with storage
- In private or hybrid cloud environments, SDN helps allocate resources in a highly elastic manner (e.g.,
  rapid provisioning and scaling both up and down) which facilitates migrations to public cloud providers
- For carriers and service providers (SP), SDN helps deliver the scalability and automation needed to offer
  public cloud services (e.g., IT-as-a-Service). Centralized control and provisioning also help support multi-
  tenancy (e.g., when a single application or resource is serving multiple, separate customers)
- In the campus, SDN can help enforce policies consistently across both wired and wireless networks for a
  consistent and secure user experience. Automated control and provisioning helps support the
  convergence of data, voice and video with quality-of-service

What are the CapEx and OpEx savings?

- While we believe CapEx and OpEx savings from SDN will be material over time, we see increased flexibility and
  agility as the primary motivation among early adopters.

- We estimate a typical rack in a datacenter contains about $1mil worth of equipment with most of the cost going
to server hardware, followed by software (e.g., VMW, etc.) and then networking at ~10-15% of the cost of one
rack (i.e., ~$100-150k of networking equipment per rack).

- We believe SDN solutions such as those offered by Big Switch can improve resource utilization in the datacenter
by ~20% (e.g., 10 racks in the datacenter goes to 8 racks with SDN) resulting in a direct CapEx savings. Through
more efficient provisioning of bandwidth, oversubscription ratios can be reduced (e.g., aggregate bandwidth of
downstream links that are more in-line with bandwidth of upstream links).

- We believe OpEx savings can be substantial as well. For example, the number of troubleshooting service
requests (“tickets”) often go up ~5-6x following a company’s move from a traditional datacenter to a private
cloud. By offering greater programmability and automation, most of these tickets can be avoided.

What is network virtualization and what are the benefits and use cases?

- Network virtualization is perhaps the most important application for SDN. Nicira and Big Switch both highlight
network virtualization as the key application that they offer customers.

- Network virtualization enables:
  - 1) The creation of logically separate networks over a shared physical network infrastructure,
  - 2) Multiple virtual networks to coexist on the same physical network, and
  - 3) The aggregation of many network resources to appear as one large network element
• Greater utilization is a primary benefit of network virtualization as fewer compute resources are ‘stranded’ by applications that are tied to specific physical infrastructure. In one model, VM density per server rack can be increased by ~50% with network virtualization.

• Some of the key use cases for network virtualization include:
  o 1) Creation of network overlays which allow packets to be encapsulated across multiple vSwitches that reside on servers in the datacenter. These vSwitches forward packets on top of the physical networking infrastructure and are directed by a network controller which talks to the vSwitch using OpenFlow, and
  o 2) Movement of entire workloads (e.g., applications with associated data) within and across datacenters

A Closer Look at Big Switch Networks, the leading independent company in software-defined networking

• Following VMW’s acquisition of Nicira, we view Big Switch as the leading independent company addressing opportunities in software-defined networking.

• Big Switch offers a scalable SDN platform, network virtualization and additional applications that leverage an SDN architecture with support for both virtual and physical infrastructure.

• While Nicira was founded in 2007 several years before Big Switch was founded in 2010, both share some of the same pedigree (e.g., top OpenFlow and networking researchers from Stanford and U.C. Berkeley, former employees of CSCO, VMW and Arista, etc.).

• Big Switch is currently at close to 50 employees while Nicira was at around 100 employees when it was acquired. The company was founded by its CEO Guido Appenzeller (formerly head of the Clean Slate Lab at Stanford and leader of the team that created OpenFlow 1.0) and Kyle Forster (formerly in CSCO’s wireless networking division).

• We believe both Big Switch and Nicira will each generate under $10mil in revenue in CY12.

• Big Switch has been in production beta deployments since 2011 and started generating product revenue in 2012. The company’s largest trial as of late 2011 had been with 5,000 hosts and we believe current trials are significantly larger.

• Big Switch is funded by Index Ventures, Khosla Ventures and Morgenthaler Ventures. We expect the company to raise a large 2nd round of funding in the near future with Nicira’s recent acquisition likely helping significantly increase its valuation. We also believe Big Switch could ultimately be an acquisition target for CTXS/CSCO/ORCL/MSFT/IBM.

• In our view, Big Switch is taking the most open approach to software-defined networking relative to CSCO (most closed with its SDN spin-out Insieme developing solutions closely tied to CSCO products) and Nicira, which includes some proprietary elements in its Network Virtualization Platform (NVP).
  o Big Switch’s OpenFlow controller, Floodlight, is open-source under an Apache license and available to the networking ecosystem to build applications on
  o We believe Floodlight is becoming the dominant controller for OpenFlow-based SDN networks with the most applications written for it

• Big Switch’s solutions are interoperable with switches from Arista, BRCD, DELL, EXTR, HPQ, JNPR and IBM. We expect significant partnership announcements that may help provide an alternative to more closed solutions from CSCO and VMW.
- Big Switch's solutions are interoperable with the VMWare ESX, Red Hat KVM (Kernel-based Virtual Machine), Microsoft Hyper-V and Citrix Xen hypervisors. We believe broad support from multiple switch vendors and hypervisors is helping Big Switch establish a leading ecosystem for SDN solutions.

- Big Switch also has a commercial version of the Floodlight controller which we believe is in use by over 15 companies in the Fortune 500 and has over 6,000 downloads. In our view, this suggests solid early traction among enterprises and bodes well for future revenue opportunities.

- We believe Big Switch's differentiation centers around several key elements:
  - Support for physical plus virtual environments: Big Switch applies the same methodologies and approaches to physical switches as it does to virtual switches. This makes it possible for 'bare metal' servers connected to physical switches to benefit from an SDN architecture.
  - Integration with existing networks: Along with OpenFlow, Big Switch supports other traditional networking standards (e.g., BGP, VLAN, CAPWAP, etc.) enabling a smoother integration with existing networks.
  - Solutions that help abstract complexity of the underlying network infrastructure and make the network easier to configure/manage through applications such as network virtualization.
  - An application platform that is open to 3rd parties across the ecosystem (e.g., switching vendors, enterprise users, independent software vendor vendors, etc.). We believe this is attracting support from customers who want to use Big Switch APIs to build their own applications internally. Big Switch currently has 5 of its own applications in engineering development and 15 more in the pipeline.

- Big Switch’s controller platform is based on the open source Floodlight controller and is helping build a strong ecosystem. The commercial controller will maintain API compatibility with Floodlight and key functionality from the commercial controller (e.g., enterprise-oriented features for scale-out, manageability, high-availability, etc.) will be migrated to the Floodlight open source project over time. In the diagram below, Big Switch will participate in the controller platform and the applications that are built on top of it. In many cases, Big Switch will help partners build their own applications using Big Switch’s commercial controller.

![Controller Platform Diagram]

- In particular, we believe Big Switch’s support for both physical as well as virtual switches will be critical as companies try to move from pilot programs to real-world production environments which are more complex. Without support for physical network infrastructure, many existing network elements (e.g., L4-7 devices such as...
security devices which don’t have hypervisors in front of them, existing monitoring/debugging devices, etc.) become ‘stranded’ or difficult to use.

- Key applications we expect Big Switch or its partners to sell along with the commercial version of its controller include:
  - Network virtualization (both overlay and physically integrated approaches) that helps enable ~20-50% more VMs per rack,
  - Network analysis for use in network deployment, monitoring and troubleshooting/debugging the network more efficiently,
  - Cloud security and L4-7 applications built by partners on top of Big Switch’s platform
Our “Four-Legged Stool” Analogy of Enterprise Infrastructure

We created the genesis of the “Four-Legged Stool” (“FLS”) analogy of enterprise infrastructure back in the summer of 2009 (originally dubbed the “Three-Legged Stool”) to assist the investment community by providing a simple representation of the required components used in the creation of a next-generation datacenter. Since then, the FLS has evolved to include a separate “security leg” and is widely used as an investment and competitive framework by investors as well as corporations. Specifically, the “Four-Legged Stool” is a tool used to map and organize the strengths and weaknesses of respective product silos of the large mature information technology (IT) companies (e.g., IBM, Hewlett-Packard, Cisco, Oracle, DELL and Huawei). The following are the key components of our “Four-Legged Stool” analogy:

- **Leg 1 (Enterprise Storage):** enterprise storage product portfolio aimed at the retention and analysis of corporate data (e.g., SAN or storage area networks, NAS or network attached storage, flash memory arrays, disk arrays, tape libraries, de-dupe, etc.)
- **Leg 2 (Networking/Telecom Equipment):** connectivity within, to and from the datacenter is established with networking/telecom equipment (e.g., routers, switches) which basically provides the “plumbing” responsible for transporting data from one location to another
- **Leg 3 (Servers):** data in the form of binary code (e.g., 1s and 0s) requires “computational horsepower” in order to be processed; primarily occurring in the computing elements of the network (i.e., servers)
- **Leg 4 (Security):** as corporate networks become more virtual (or hybrid) in nature, the importance of enhanced security features has grown rapidly and is near the top of most IT spending priority lists (e.g., authentication, threat protection, network forensics, etc.)
- **Stool (Software & IT Services):** intelligence or “glue” (i.e., software and IT services) is required to seamlessly integrate all disparate legs and create one unified “stool” or network aimed at increasing efficiency and productivity (e.g., virtualization, operating systems, middleware, applications, etc.)

ISI Group’s “Four-Legged Stool” Analogy of Enterprise Infrastructure

*Source: company reports and ISI Group estimates.*
Total Addressable Market (TAM) of the “Four-Legged Stool”

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<td>IT Services</td>
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<tr>
<td><strong>Total</strong></td>
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Source: company reports and ISI Group estimates.

Top Acquisition Candidates within the “Four-Legged Stool”

Source: company reports and ISI Group estimates.
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ISI RATING SYSTEM: Based on stock’s 12-month risk adjusted total return; ETR = total expected return (stock price appreciation/depreciation + dividend yield)

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ISI has assigned a rating of BUY to 47% of the securities rated as of 6/30/12.
ISI has assigned a rating of HOLD to 50% of the securities rated as of 6/30/12.
ISI has assigned a rating of SELL to 3% of the securities rated as of 6/30/12.

Due to rounding the above numbers may add up to more/less than 100%.

RISK RATING:
30% based on stock price volatility, 30% on EPS volatility, 30% on debt rating & 10% on mkt cap.