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Understanding Software-Defined Networks

IT organizations we surveyed believe this new approach to networking can reduce costs and improve network efficiency and security. So why have only **4%** of them implemented SDN? Maybe because **32%** cite "confusion" over vendor strategies as a barrier to adoption. In this report, we aim to cut through the confusion and help IT organizations develop an SDN strategy.

By Jim Metzler

Report ID: R5451012

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Jim Metzler
InformationWeek Reports

Jim Metzler has a broad background in the IT industry. This includes being a software engineer, an engineering manager for high-speed data services for a major network service provider, a product manager for network hardware, a network manager at two *Fortune* 500 companies and the principal of a consulting organization. In addition, he has created software tools for designing customer networks for a major network service provider and directed and performed market research at a major industry analyst firm.

Each year Jim publishes two e-books, one on application and service delivery and the other on cloud networking. He co-authored a book titled *Layer 3 Switching*, which is part of the Prentice Hall series in computer networking and distributed systems. He has a Ph.D. in mathematics from Boston University and is currently an independent industry analyst and consultant.

EXECUTIVE SUMMARY

Software-defined networking has the potential to fundamentally change the networking industry. Given that potential and the buzz that surrounds it, you might guess that SDN is a well-understood concept and has been deployed by a large number of IT organizations. The reality is that only a small percentage of IT organizations claim to be very familiar with SDN. In addition, our *InformationWeek* 2012 Software-Defined Networking Survey shows that only 4% of IT organizations have already implemented SDN and only another 5% of IT organizations are testing it. At present, SDN is only for early adopters.

It will be challenging for SDN to be broadly deployed in the near term in part because it's not a narrowly defined technology like TRILL or SPB. Rather, it's an approach to networking that focuses on centralizing control functionality and providing programmatic interfaces into a wide range of network equipment. It also requires an extensive ecosystem of vendors. The breadth of what is referred to as SDN is partially a result of the varying ways that it's possible to centralize control and provide programmatic interfaces into network elements.

This report aims to bring clarity to the nascent SDN market by outlining the major approaches to SDN. We dig into how these approaches are similar and where they differ, and we examine the benefits and drawbacks of each approach. The report also shares the results from the *InformationWeek* Software-Defined Networking Survey, which measures IT pros' familiarity with and attitudes toward SDN and OpenFlow, a new protocol closely associated with SDN. Finally, it provides guidance to help IT organizations develop a strategy for SDN.

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SYNOPSIS

RESEARCH

Survey Name *InformationWeek* 2012 Software-Defined Networking Survey

Survey Date July 2012

Region North America

Number of Respondents 250

Purpose To gauge awareness of and adoption plans for software-defined networking and OpenFlow technology.

Methodology *InformationWeek* surveyed 250 business technology decision-makers familiar with software-defined networking at North American organizations. The survey was conducted online, and respondents were recruited via an email invitation containing an embedded link to the survey. The email invitation was sent to qualified *InformationWeek* subscribers.

What Is Software-Defined Networking?

Software-defined networking is a new approach to networking that aims to make data networks more flexible, easier to operate and manage, and better able to respond to the changing demands of applications and network conditions.

According to *InformationWeek*'s 2012 Software-Defined Networking Survey, IT organizations believe SDN can help them overcome a number of challenges by improving network utilization and efficiency, increasing automation of common tasks, and improving security. SDN may also lower costs.

SDN also promotes the use of software interfaces to allow the development of third-party applications that can improve network services or provide new ones, and enable orchestration of resources across multiple devices, such as switches, routers, firewalls and load balancers.

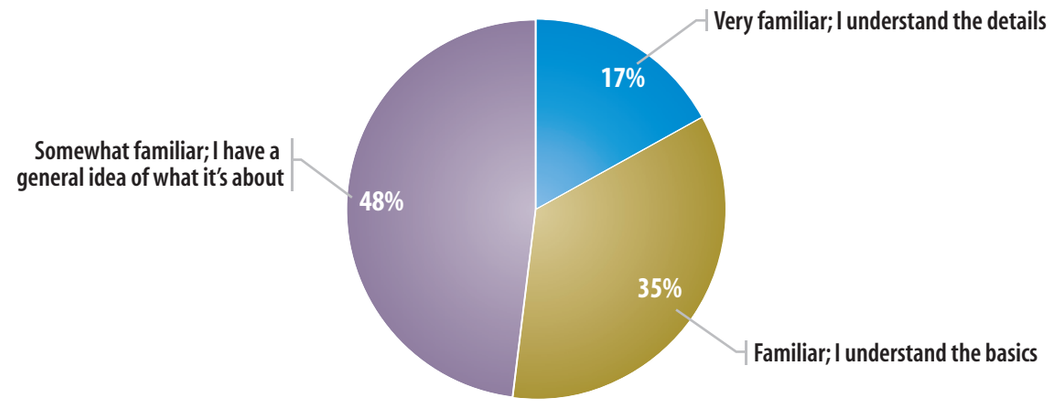
While SDN has received a lot of attention this year, IT pros are still trying to get their arms around the concept: Of the 250 respondents to our *InformationWeek* Software-Defined Networking Survey who express having some knowledge about SDN, 48% say they are only somewhat familiar with this new approach to networking (Figure 1).

So what is SDN? That depends on whom you ask. One approach to SDN would overturn the role that switches and other network devices play by turning them in fast but dumb (and inexpensive) machines to forward packets, while network intelligence would reside in a centralized controller. This approach threatens dominant networking vendors such as Cisco Systems, which commands high

Figure 1

Familiarity With Software-Defined Networking

How familiar are you with software-defined networking, or SDN?



Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012 R5451012/1

prices for network gear. Cisco and others are pushing back by proposing SDN models that allow for more automation and flexibility without doing away with the switch's prominent role in determining optimal network pathways.

However, one element that all the SDN approaches share is the ability to use programmatic interfaces, such as APIs. This programmatic interface allows for much more automation, which can simplify network operations, reduce the number of administrators required to manage devices and enable the creation of applications that provide new network features and functions.

This report outlines three approaches to SDN, explores their similarities and differences, and weighs the benefits and drawbacks of each approach. It provides guidance for IT organizations to develop an SDN strategy. It also examines the results from the *InformationWeek* Software-Defined Networking Survey, which measures IT pros' familiarity with and attitudes toward SDN and OpenFlow, a new protocol closely associated with SDN.

FAST FACT

33%

of respondents to our Software-Defined Networking Survey say they are familiar or very familiar with the OpenFlow protocol.

Impact Assessment: Software-Defined Networking

Impact to…	Benefit	Risk
IT Organization	○●●●● SDN has the potential to make networks more automated, which reduces management burdens and increases flexibility. Other benefits include the ability to implement new functionality more effectively and faster than is otherwise possible.	○●●●● At present, SDN is characterized by immature products and standards and only rudimentary interoperability. There is also a lack of applications that take advantage of SDN and gapping holes around how an SDN will be managed.
Business Organization	○●●●● If the adoption of SDN results in lower cost and a more agile IT function, the business organization wins.	○○●●● There is a risk that SDN will not add the promised value. If an SDN implementation does not work well, business projects may face IT-related delays.
Business Competitiveness	●●●●● In the mid- to long term, SDN should enable IT to align network resources with business goals. It holds the promise of a more agile, more automated and potentially more cost effective IT organization.	○○○●● If the implementation of SDN has technical issues, those could negatively impact the company's competitiveness. However, few IT organizations will risk running a business-critical application in the short term on an embryonic set of technologies and products, so significant disruption is unlikely.

Bottom Line: ○●●●●○○●●●

SDN promises to replace human interfaces into network elements with automated interfaces, which should streamline management and provide granular visibility and control. SDN also has the potential to open up networking to new applications that will further extend the value of the network infrastructure.

A Vision of Control

There are three general approaches to SDN. The approach that's probably most well known separates the forwarding and control planes that typically reside in a switch and moves the control plane to a separate device. This device, called a controller, calculates the best path through a network for particular workloads and programs the forwarding behavior of the switches (Figure 2). The controller can be an appliance, a virtual machine or a physical server.

A core concept of this approach to SDN is

Strategy: Inside OpenFlow

New software-defined networking technologies in general and OpenFlow in particular are poised to disrupt the way we manage load in highly virtualized data centers. In a world where for decades we've relied on Ethernet and TCP/IP standards—and where big vendors like Cisco and Juniper have made their fortunes based on intelligence in switches—that's a big deal.

Download

that the OpenFlow protocol is used between the network elements and an SDN controller to program the forwarding behavior of the switch. According to our survey, 33% of respondents say they are very familiar or familiar with the OpenFlow protocol, and another 38% say they are somewhat familiar (Figure 3). The controller also has a northbound API, which is an interface for applications that want to use OpenFlow data. A number of vendors have announced their intention to ship OpenFlow-enabled switches, including Brocade, Cisco, Extreme, Hewlett-Packard and Juniper.

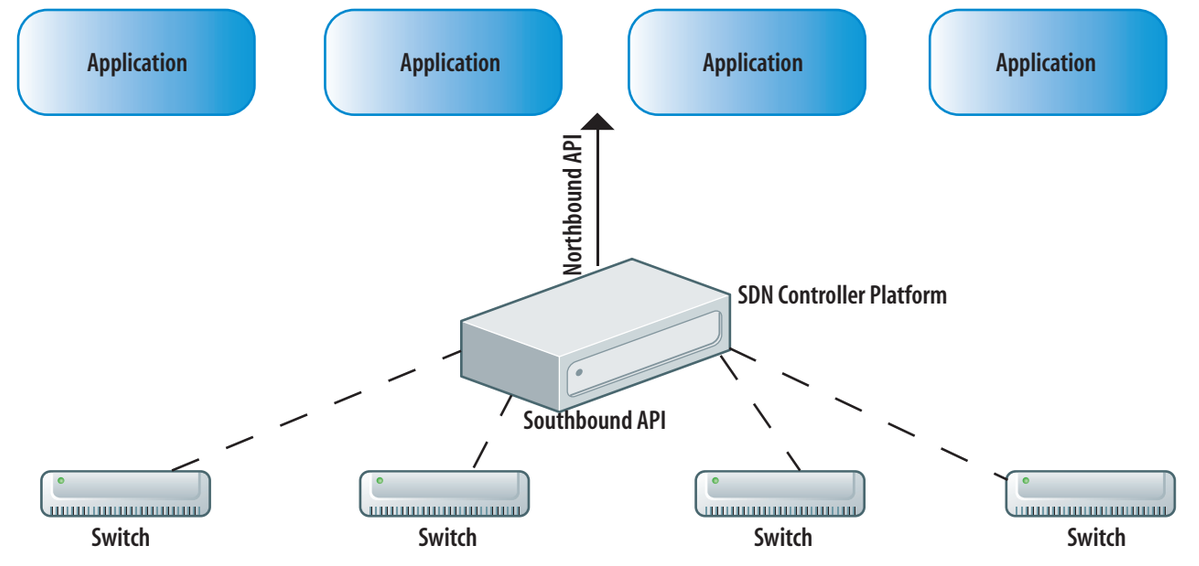
The Open Networking Foundation, a nonprofit group that oversees the development of the OpenFlow protocol, advocates a controller-based architecture using OpenFlow. ONF has more than 70 members, including service providers, some of the world's largest network device manufacturers and startups.

Note that there are alternatives to the use of OpenFlow as the communications protocol between a controller and network devices. In addition to Java, C, Python and REST APIs, this includes the Extensible Messaging and Presence Protocol, the Network Configuration Protocol and OpenStack from Rackspace and NASA. However, as our survey shows, OpenFlow is closely associated with SDN (Figure 4).

Figure 2

Decoupling of the Control and Forwarding Planes

Separation of the control and forwarding planes is commonly associated with a software-defined network.



Data: *InformationWeek Reports* R5450912/1

One of the implications of the ONF approach is the likelihood that switches and routers would become low-cost commodities, which could potentially cut costs for companies that adopt this approach. While vendors such as Cisco and HP have downplayed that notion, companies such as IBM, Dell and NEC are more supportive of it. One operation that

could migrate to a controller is functionality that negates the need for LAN switches to support the Spanning Tree Protocol, Dell executives responsible for SDN said in an interview. They also note that any control functionality that is related to some kind of policy and that requires taking an action based on what is inside the packet is also a candidate to move to a controller.

NEC and a startup called Big Switch Networks provide on their controllers functionality that eliminates the need for the Spanning Tree Protocol. Both companies have stated their intention to provide additional network services on their controllers over time.

The primary advantages of the ONF approach to SDN are that it is based on industry-standard protocols and has significant vendor support.

The disagreement on the relative role of the controller and the network elements between members of the same class of products is one of the many factors driving the confusion that surrounds SDN. Our survey respondents were somewhat evenly split on whether SDN would result in a dumbing down of switches and routers, with a third of the respondents indicating "don't know" (Figure 5).

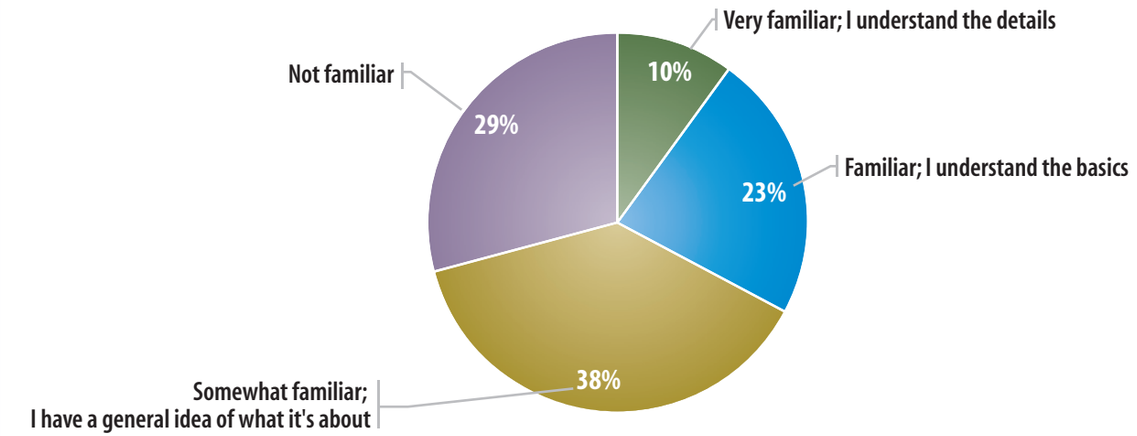
When evaluating SDN, IT organizations need to take a position on this issue. Is reducing the relative value of switches and routers a desired outcome of implementing an SDN? An acceptable outcome? An unacceptable outcome? The position that an IT organization takes will influence which vendors it should consider using and which ones it should avoid.

The primary advantages of the ONF approach to SDN are that it is based on industry-standard protocols and has significant vendor support and momentum. It may also reduce costs because switches would become

Figure 3

Familiarity With OpenFlow

How familiar are you with OpenFlow?



Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012 R5451012/14

single-function commodity devices.

However, one of the disadvantages of this approach is that vendors are just now in the early stages of implementing OpenFlow, which means interoperability among vendors isn't assured.

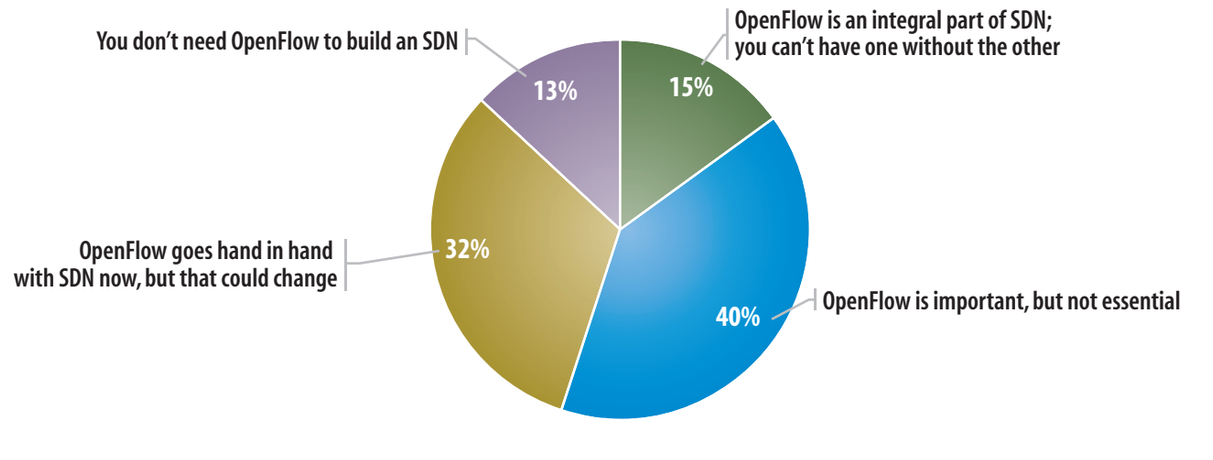
Another aspect of the lack of interoperability is that the northbound interface shown in Figure 2 is not standardized. This means that a company or vendor that writes an application to communicate with a controller has to ensure that the application works with APIs from myriad controller vendors. Note that the Open Network Foundation has recently announced an initiative intended to make it easier for application providers to use various APIs.

Other possible downsides include the fact that this approach would require companies to rearchitect their networks to incorporate the controller-based system. However, our survey shows that this may not be a significant barrier: Of those with or planning to have SDN in production, 48% say they are moderately willing to make significant changes to get SDN benefits, and another 40% are very or completely willing (Figure 6).

Figure 4

Attitude Toward OpenFlow

What is your attitude toward OpenFlow in regard to SDN?



Base: 178 respondents familiar with OpenFlow
R5451012/15
Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012

Competing Visions of SDN

As mentioned, while the ONF approach is most commonly associated with SDN, there are two other emerging visions for software-driven networks. The second approach also separates the control and forwarding planes, but it does so by leveraging a virtual switch such as Cisco's Nexus 1000V, VMware's DVS or IBM's DVS 5000v. In this approach, the virtual switch functions as a forwarding engine that's programmed by a device separate from the

virtual switch. This functionality is used as part of an overlay network that rides on top of the existing network infrastructure using protocols such as VXLAN or NVGRE.

This approach may appeal to existing customers of Cisco and VMware, of which there are significant numbers. However, it is only applicable for hypervisor-based virtual switches. In addition, support for functionality such as VXLAN and NVGRE is only now emerging.

The third approach uses direct programmatic interfaces via APIs into network devices, which are broadly defined to include devices that operate at Layers 2 through 7 of the OSI stack. In this case, the control and forwarding planes are not separated, nor is the control plane centralized.

Many network vendors, including Cisco, are adopting this approach. This summer, Cisco announced that as part of its SDN approach it will offer APIs into multiple platforms. (Part two of this report offers more details.) However, it is not a Cisco-only approach, as other vendors including Arista, Extreme Networks and Juniper Networks provide direct access to their platforms via APIs.

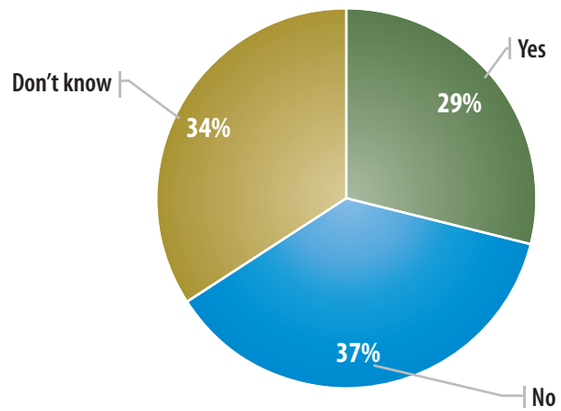
One advantage of this approach is that it enables very detailed access into, and control over, network devices. It also avoids the interoperability issues that are associated with the OpenFlow protocol. Because this approach does not rely on a centralized controller, it also avoids the availability and security issues that can be associated with a controller-based architecture (that is, if the controller dies, so does the ability to move traffic through the network).

On the downside, this approach is vendor-specific. In a multivendor network environment, it would result in "islands of control" whereby the operator would have differing

Figure 5

'Dumbing Down' of Switches and Routers?

Do you believe that SDN will relegate switches and routers to being just relatively dumb forwarding engines?



Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012 R5451012/12

levels of control of the network equipment based on the provider of that equipment.

Drivers of SDN Deployment

Other than a few research-oriented organizations, no IT department wants to implement an SDN. What IT wants to do is to solve one or more problems and/or find new ways to add value to the business. If it perceives that SDN is the best way to resolve those problems and add new value, then implementing SDN makes sense.

That's the attitude of an infrastructure portfolio architect for a multinational professional services organization who took part in the survey. "There is confusion about what SDN is and what it means to the business," he says. "If I were to go to a business-unit manager and say that I need $3 million to implement OpenFlow and that will allow me to centralize the control plane of my network, they would kick me out of their office."

In other words, it only makes sense to implement SDN if it results in a measurable and significant improvement of the IT infrastructure and operations. "If I go to management with a plan to implement SDN and reduce the number of network administrators from 20 to 10 and to reduce provisioning time from two weeks to four days, they will at least listen to me," says the infrastructure architect.

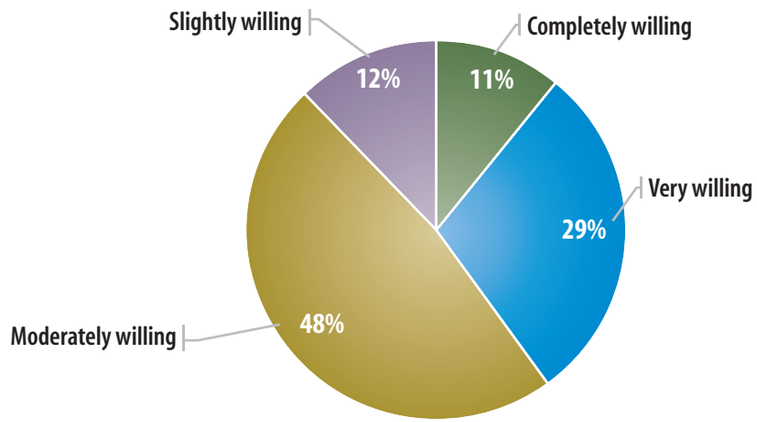
Those anticipated improvements are reflected in our survey. We asked respondents with or planning to have SDN in production to choose the top three challenges that SDN would mitigate. At the top of the list was improving network utilization and efficiency, closely followed by automation of provisioning and management (Figure 7). Improved security was third.

Overall, we believe SDN offers three basic

Figure 6

Willingness to Make Architectural Changes for SDN

How willing are you to make significant architectural changes to your production networks in order to achieve the promised benefits of SDN?



Base: 116 respondents at organizations with, or planning to have, SDN in production R5451012/5
Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012

value propositions for IT:

1. It defines business logic that the infrastructure responds to throughout Layers 2 through 7. For example, a network service provider could use SDN to align its L2 to L7 devices to support a service-level agreement for a given customer and a given application.

2. It lets the network be aware of the needs of the applications and compute resources and dynamically provide the required network resources.

3. It provides better control, management and security of the infrastructure by automating tasks such as configuration management.

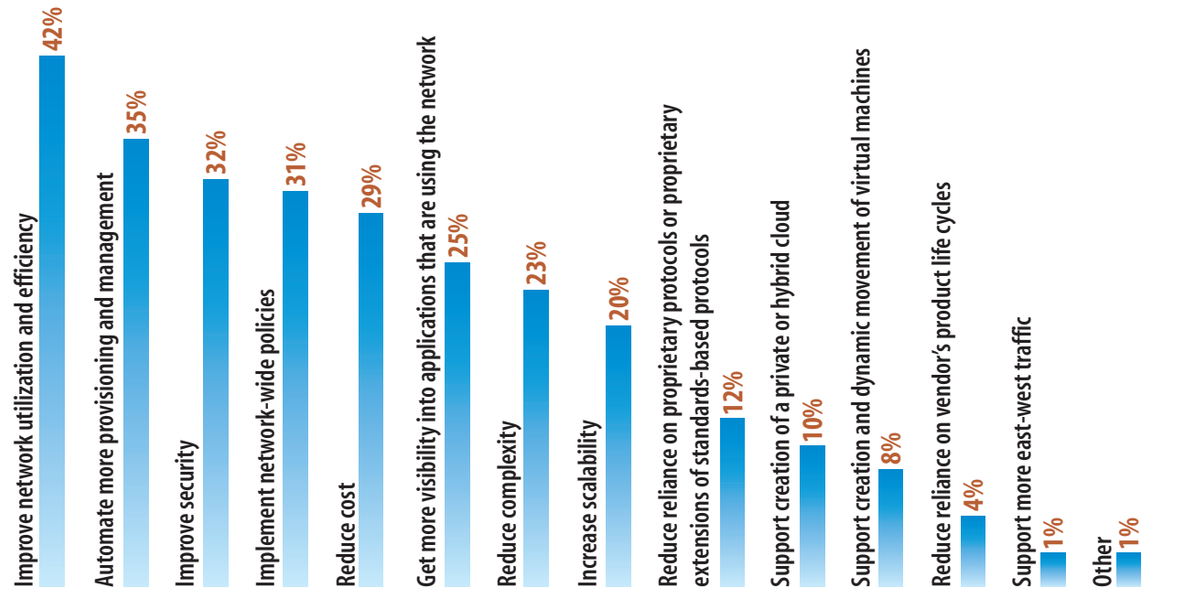
These value propositions overlap somewhat and are listed in descending order from strategic to tactical. Value propositions 1 and 2 will have traction in the near term with sophisticated organizations such as hyperscale data centers, public cloud providers and network services providers. These value propositions will also have some traction in the near term among some enterprise IT organizations, primarily enterprises such as financial institutions that recognize that the IT function impacts revenue in a way that is very direct and measurable. Value proposition 3 should appeal to all types of organizations.

In addition to reducing costs and automating management and security policy enforcement, other enterprise-specific applications that SDN will enable, potentially better than they could be performed otherwise, include:

Figure 7

LAN Challenges Mitigated by SDN

Which of the following data center LAN challenges do you believe SDN can be most helpful in overcoming?



Note: Three responses allowed R5451012/6
Base: 116 respondents at organizations with, or planning to have, SDN in production
Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012

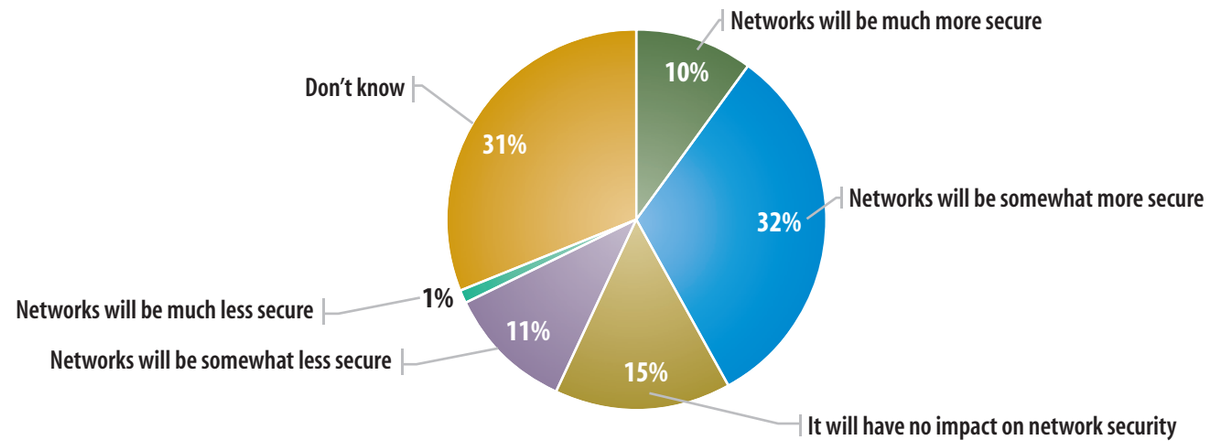
> Network virtualization
> Load balancing
> Firewalls
> Distributed denial of service prevention
> Traffic engineering
> Disaster recovery
> Application acceleration via techniques such as SSL offload
> Web optimization
> Network analysis whereby management data is filtered from network elements and sent to a central site for analysis

In the near term, SDN applications will come primarily from current infrastructure players. Extreme Networks, for example, has announced an identity management application for SDN. Big Switch offers both a network virtualization and network analysis application. Radware has announced an anti-DOS application and an application that enables the creation of an application delivery controller fabric. While infrastructure players will likely continue to develop SDN applications, one of the great promises of SDN is that developer communities will create a wide range of applications that can take advantage of the access to granular network data that it will provide.

Figure 8

Impact of SDN on Network Security

What impact will SDN have on network security?



Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012 R5451012/9

SDN and Security

Security is always a key factor for IT organizations to evaluate when considering a new technology, and SDN is no exception. According to our survey, only 12% of respondents think implementing SDN will make networks less secure (Figure 8). However, 31% say they just don't know, a result that highlights the confusion in the market about SDN.

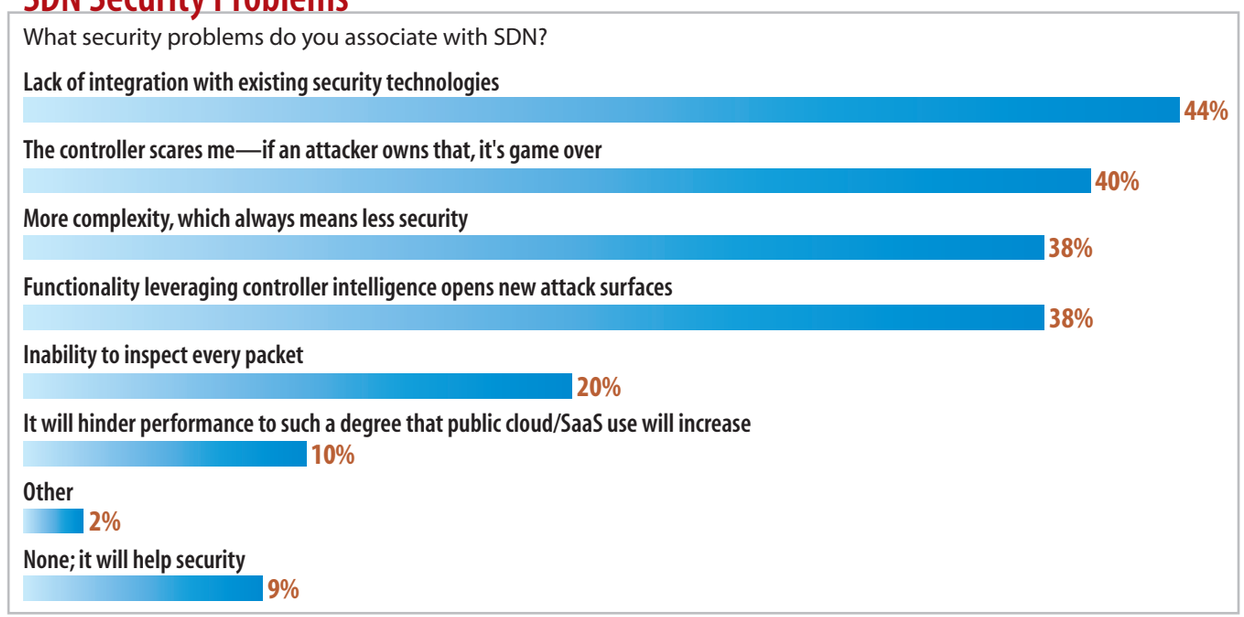
IT organizations do recognize that SDN has security risks. Some of these challenges, like the lack of integration with existing security

technologies, are to be expected when implementing any new technology (Figure 9).

Some other challenges, such as the concerns over the vulnerability of the controller, are unique to SDN. For instance, if hackers were to gain access to the SDN controller, they would have the power to inflict significant harm. The counterargument is that it's often easier to protect one central device than it is to protect hundreds or thousands of decentralized devices.

Survey respondents do see the potential for SDN to benefit network security. The most anticipated benefit is that SDN will make it easier to apply a unified security policy (Figure 10). The bottom line is that any IT organization that is evaluating SDN needs to address security issues from the outset.

Figure 9



Note: Multiple responses allowed R5451012/11
Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012

Be Clear About SDN Objectives

When discussing SDN, it's common for the trade press and industry analysts to talk about its ability to better support the adoption of private and/or hybrid cloud computing. However, as Figure 7 shows, that capability isn't a strong driver of enterprise adoption of SDN.

It is common, however, to have technology adoption driven by different factors at different points in the adoption cycle. For example, the initial driver of server virtualization was cost savings. However, once IT organizations began to implement server virtualization, most of them found the agility that virtualized servers provide became as important as the cost savings. In similar fashion, IT organizations may well implement a software-defined network initially for cost savings or added security and later expand that implementation

because it provides other capabilities.

This example demonstrates that any IT organization considering SDN needs to be clear about the value proposition of the technology and how that value proposition might change over time.

IT organizations also need to identify how deploying SDN fits in with other IT initiatives. As the infrastructure architect notes, "No CIO is going to fund an investment in SDN without understanding how that fits into their cloud strategy."

In another example, many IT organizations are in the process of flattening their data center LANs. As part of that activity, most are evaluating the viability of eliminating Spanning Tree Protocol. One way to do that is to implement a protocol such as Transparent Interconnection of Lots of Links or Shortest Path Bridging. However, as previously mentioned, it's also possible to eliminate STP by implementing an SDN controller that supports the appropriate functionality.

The upshot is that an IT organization must set realistic expectations with management

FAST FACT

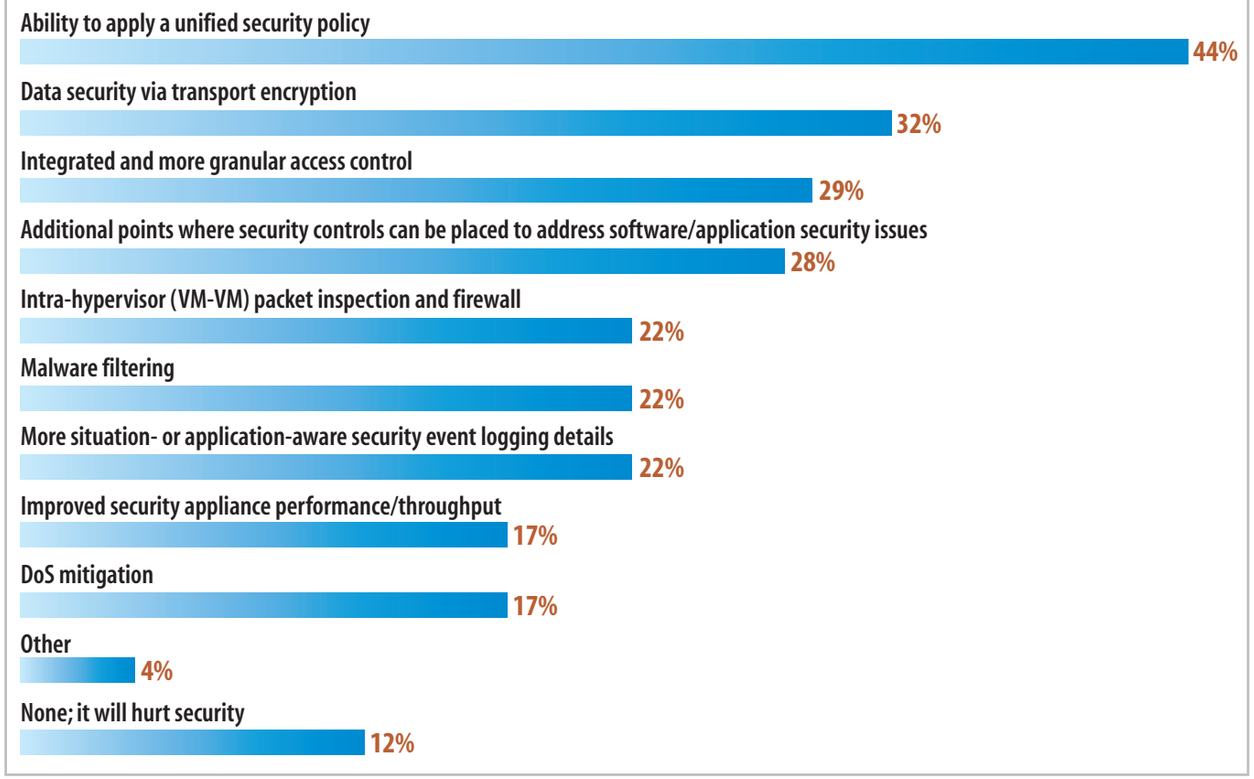
12%

of respondents think implementing SDN will make networks less secure; 31% say they just don't know.

Figure 10

SDN Security Benefits

What are the security benefits of SDN?



Note: Multiple responses allowed R5451012/10

Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012

about the benefits of SDN, how those benefits might evolve over time, and how SDN will complement or support other major IT projects and goals.

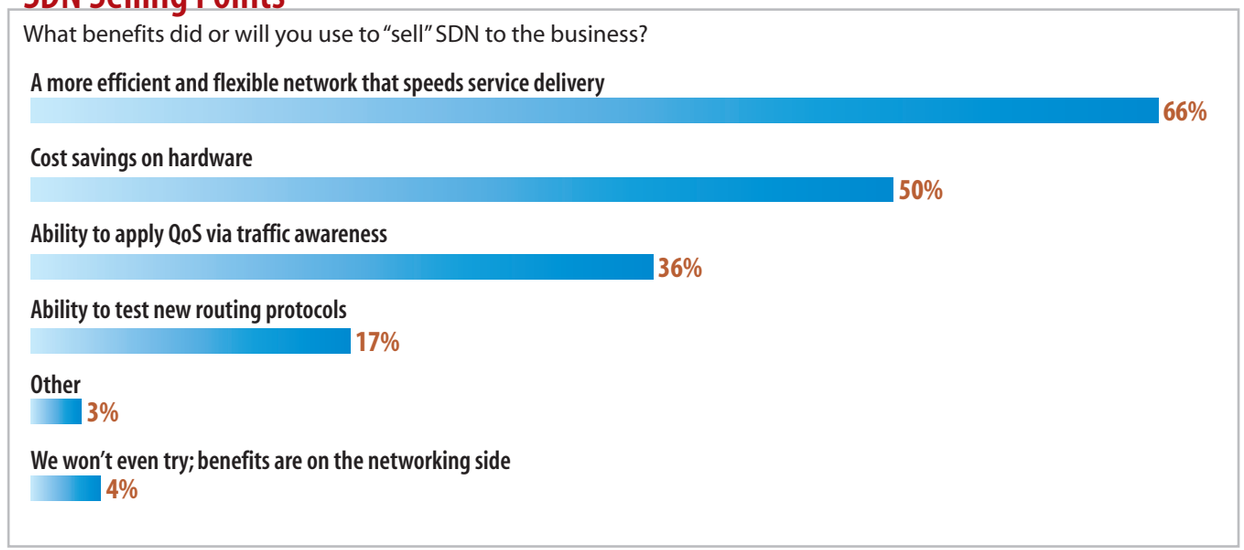
Money Matters

Given that IT believes the primary benefits of SDN relative to the data center are reducing cost and automating management and security policy enforcement, it's not surprising that those tend to be the selling points used by IT organizations that have implemented SDN or intend to implement it (Figure 11).

However, it's not clear that the expected cost savings anticipated with a controller-based SDN model will appear. IT anticipates those savings in large part because dumbed-down switches will be cheaper than conventional switches. But given the current state of the market, the deployment of SDN won't result in any dumbing down of switches and routers for at least the next two years. That follows in part because it will take a new generation of merchant silicon to build fully functional, highly scalable OpenFlow-enabled devices.

Figure 11

SDN Selling Points



Note: Multiple responses allowed
R5451012/7
Base: 116 respondents at organizations with, or planning to have, SDN in production
Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012

And even if fully functional OpenFlow devices were available, the vast majority of IT organizations would adopt them over time and most likely would implement them only in part of their infrastructure. That's because IT organizations seldom swap out one infrastructure for another in a single move, particularly with a new technology.

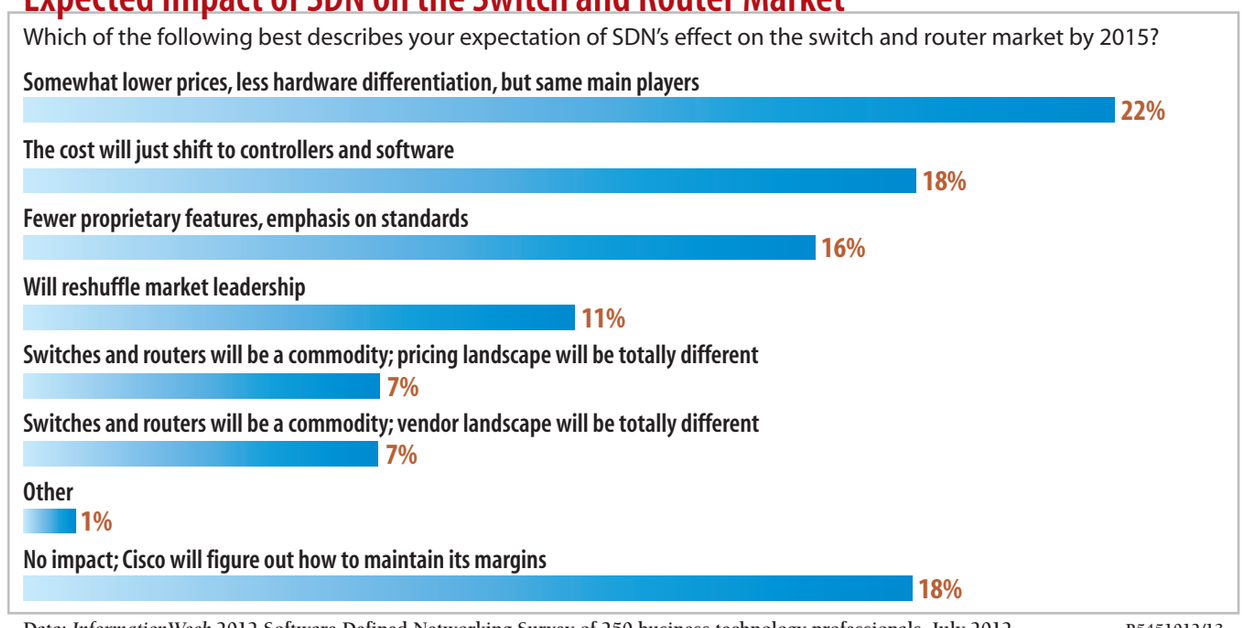
It's also possible that the cost savings of commodity switches will be eaten up by the costs of centralized controllers. In fact, when we asked survey respondents to anticipate the impact of SDN on switch and router markets in 2015, the second-highest response, at

18%, was that costs would simply shift to controllers and software (Figure 12).

In addition, some IT organizations are likely to adopt SDN in a hybrid model, in which some control plane functionality is centralized and the remaining functionality remains distributed within switches. Depending on how much control functionality is centralized, this scenario may not result in switches with significantly less functionality; in fact, this scenario may result in switches that require additional functionality.

The bottom line is that any cost savings that might result from adopting low-cost OpenFlow-enabled devices will take place over a number of years, if at all.

Figure 12



Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012 R5451012/13

Inhibitors to SDN Deployment

IT organizations that are evaluating SDN need to understand the availability and scalability characteristics of the particular designs they are evaluating.

One of the concerns with a controller-based approach to SDN is availability—that is, what happens if the central controller goes down? Another is scalability—how many packets, call setups, processes or flows can one controller support? To respond to those concerns, many vendors, including Big Switch, NEC and Vello, support a clustering of their controllers. While that approach can mitigate availability and scalability concerns, it still leaves open what happens if the network elements somehow lose their ability to communicate with the centralized controller cluster. One network design option that addresses this concern is to implement a redundant link between the controller and each switch.

Another factor that limits the deployment

of SDN is that there is no widely agreed-upon model for how SDN and OpenFlow-enabled networks will interface with existing network management platforms and troubleshooting tools. IT organizations that are evaluating SDN need to have a solid plan for how they'll manage and troubleshoot those networks.

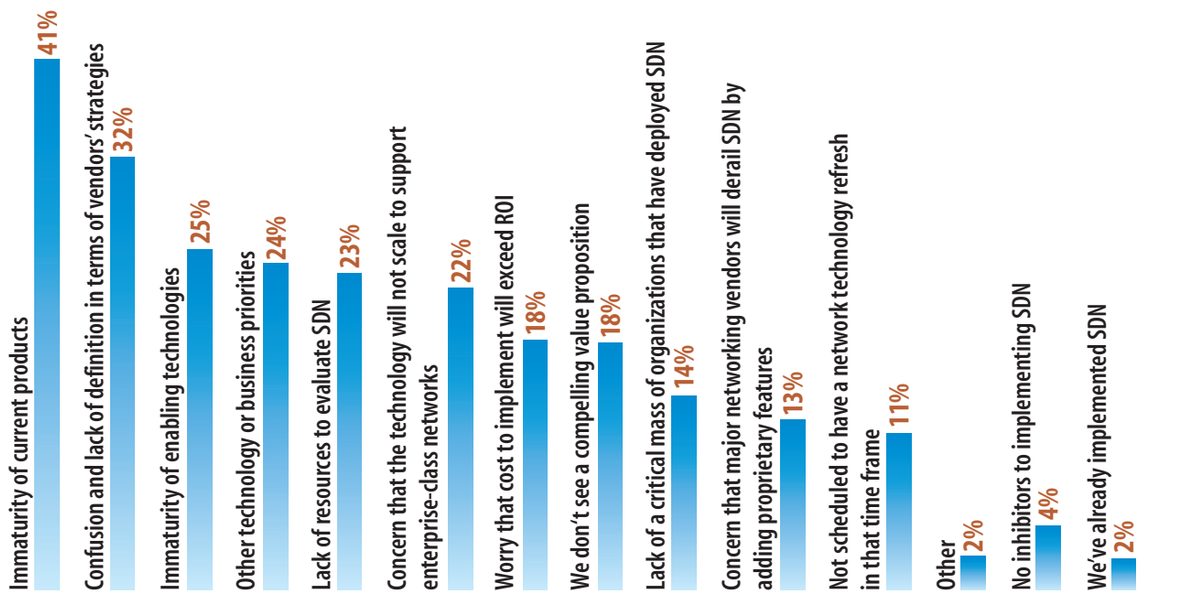
We asked our survey respondents to indicate the primary inhibitors to their company adopting SDN in the next two years. Their top three responses reflect one of the central themes of this report: As is typical of any early-adopter market, the development and implementation of SDN is characterized by immaturity and confusion. The top response, at 41%, was the immaturity of current products (Figure 13). However, the second-highest response, at 32%, was "confusion and lack of definition in terms of vendor strategies." Given that there are several technological approaches that can claim to be software-defined networking despite significant differences among the approaches, such confusion is understandable.

That confusion is echoed in IT organizations.

Figure 13

Barriers to SDN Adoption

Which of the following are the top inhibitors to your company adopting SDN in the next two years?



Note: Three responses allowed R5451012/8
Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012

For instance, the infrastructure architect says the lack of education is a major barrier to the adoption of SDN. "We don't know a lot about SDN and what its benefits are."

Interoperability is also a concern. He says he would like to see some form of certification so that if he were to acquire an SDN controller, he would know what switches, and what code versions, it worked with.

At present, any IT organization that tries to

take an SDN controller and connect it to three or four vendors' OpenFlow switches would either fail or would, at a minimum, spend a lot of time and resources working with the vendors to make those devices work together because the OpenFlow protocol is still so new.

Call to Action

There are relatively few players in the IT industry making the argument that SDN is ready for broad deployment in production networks. As such, SDN is not encumbered by too much hyperbole. However, given the market research presented in this report, it is clear that SDN is shrouded in confusion.

As is typical of any early-adopter market, the development and implementation of SDN is marked by immaturity and confusion.

IT organizations need to disperse this confusion to better understand SDN and to establish a strategy—even if that strategy is to do nothing relative to SDN for the foreseeable future. We offer a set of considerations to help guide you in creating that strategy.

> Start with a firm definition of what SDN means to the organization. This includes taking a position relative to whether or not they want to implement an SDN that features:

>> Direct programmability of switches and routers, which in most cases will be accomplished by leveraging software created by a third party

>> Separation of the control and forwarding planes using OpenFlow for communications between them

>> Separation of the control and forwarding planes using something other than OpenFlow for communications between them

>> An overlay network

>> Other approaches and technologies

> Define the use cases that justify deploying SDN, whether to solve problems or add value. Analyze alternative ways to solve those problems or add that value and recognize that the use cases may change over time.

> Keep an eye on SDN adoption in the market and SDN's technological maturation. This includes analyzing the items mentioned in the preceding section (e.g., the stability of OpenFlow and of the northbound APIs).

> Identify how extensive the implementation of SDN will be, both initially and over the first couple of years. For example, will the implementation just include top-of-rack switches or will it include core switches? Will it include L4 to L7 functionality, such as load balancing or protection against DOS attacks?

> Decide whether any of the control functions that have historically been done in switches and routers will be done in SDN controllers.

> Analyze how the deployment of SDN fits in with your existing infrastructure as well as with other IT initiatives in progress.

> Review vendors' SDN strategies and offerings and identify one or more viable SDN design. This includes understanding the risks and rewards of acquiring pieces of SDN from disparate vendors vs. trying to acquire all or most of the system from a single vendor.

> Determine whether the IT organization will write applications itself to take advantage of SDN. If so, what has to happen within

the organization to enable that capability?

> **Identify and analyze commercially available applications** that take advantage of SDN.

> **Evaluate the availability and scalability characteristics** of the particular SDN designs that are under consideration.

> **Understand how your IT organization can provide a sufficient level of security** for the controllers.

> **Assuming that your IT organization is interested in OpenFlow,** decide whether to implement OpenFlow-only switches or hybrid switches that support OpenFlow and traditional networking.

> **Understand how the IT organization will manage** and troubleshoot its SDN deployment.

> **Evaluate publicly available reports on interoperability testing.**

> **Test the SDN designs and use cases that are under consideration.**

> **Analyze how the intended implementation of SDN** would impact the current networks.

> **Draft a plan for how your IT organization** will minimize and mitigate the risks associated with implementing SDN.

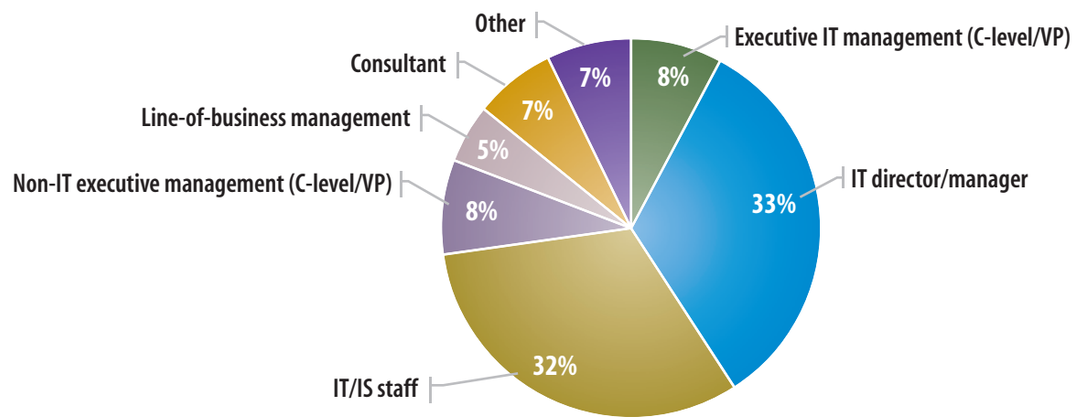
> **Develop a program to get management buy-in.** This includes getting funding as well as the buy-in from any other organization that will be directly impacted by the deployment of SDN.

APPENDIX

Figure 14

Job Title

Which of the following best describes your job title?

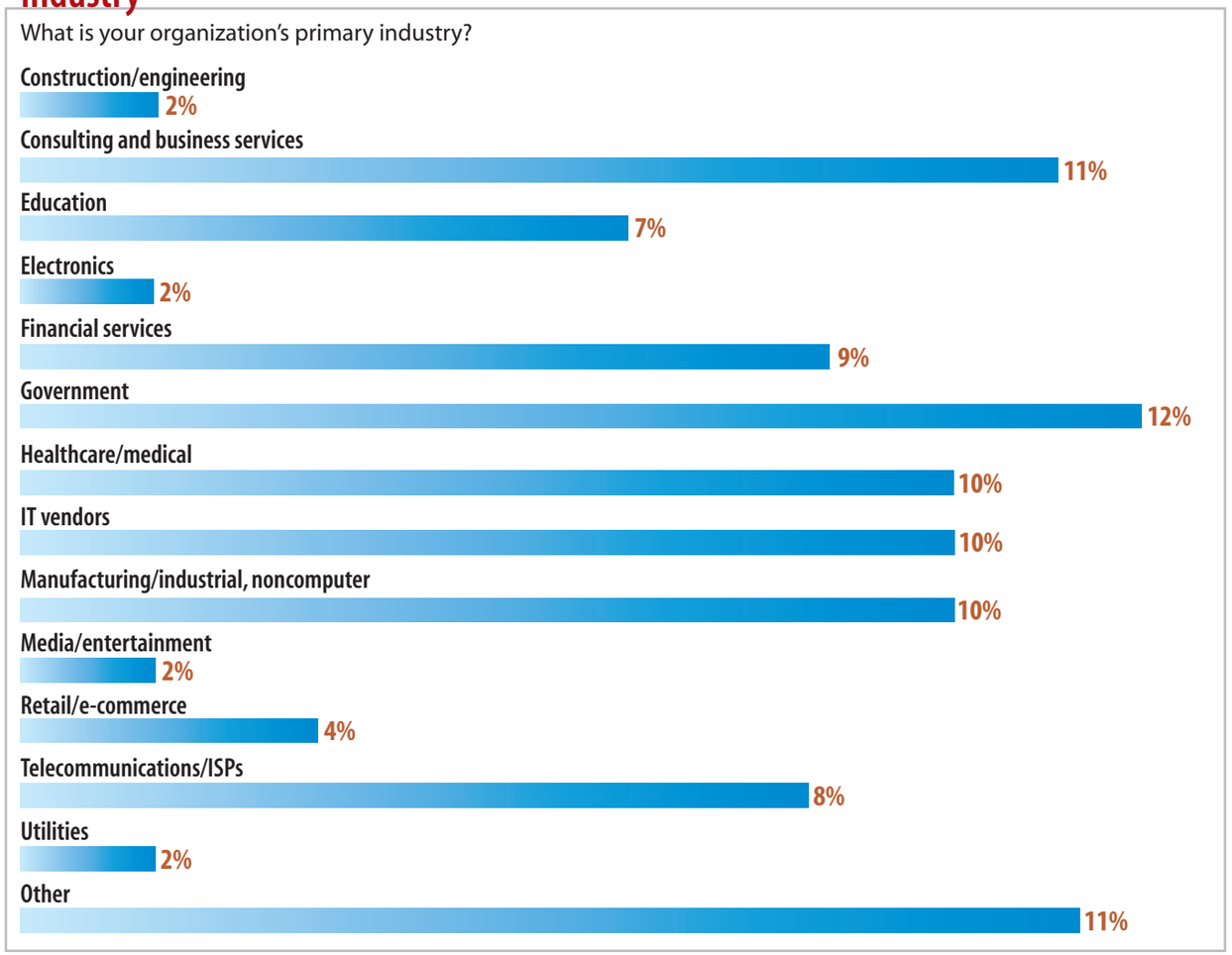


Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012 R5451012/24

Figure 15

Industry

What is your organization's primary industry?

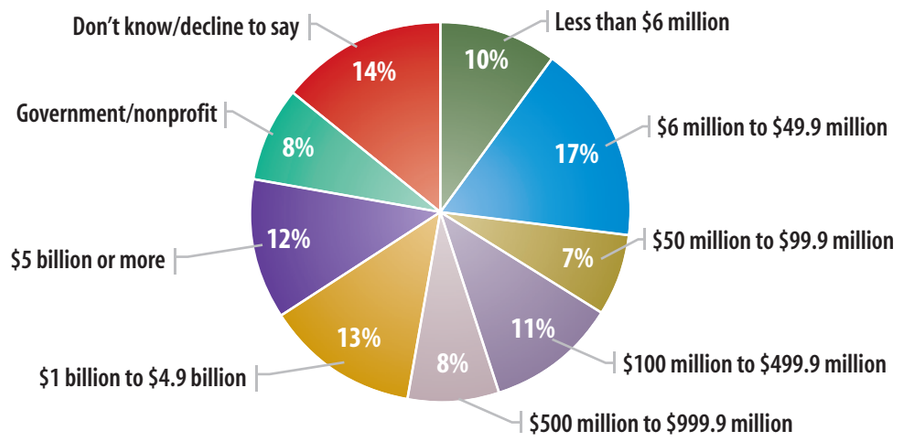


Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012 R5451012/25

Figure 16

Revenue

Which of the following dollar ranges includes the annual revenue of your entire organization?

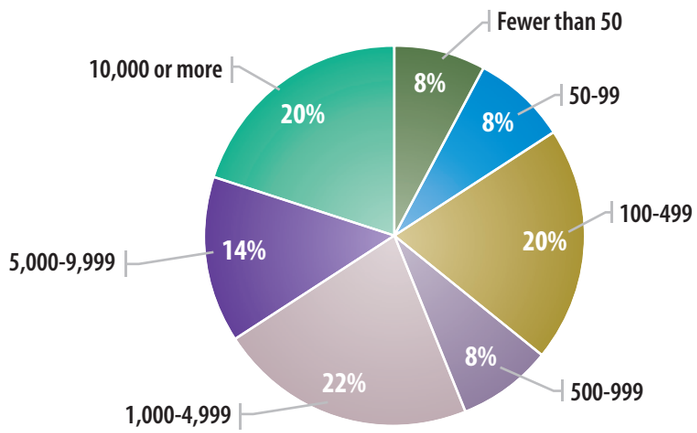


Data: *InformationWeek* 2012 Software-Defined Networking Survey of 250 business technology professionals, July 2012 R5451012/26

Figure 17

Company Size

Approximately how many employees are in your organization?



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