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The State Of Cloud Platform Standards, Q4 2016

Standards Bodies And Open Source Foundations Learn To Play Nice

by Lauren E. Nelson
October 14, 2016

Why Read This Report

Infrastructure and operations (I&O) professionals look to cloud computing services to enable flexibility and scalability for agile applications, but many fear vendor lock-in. Without standardization, applications, products, and entire businesses are vulnerable to the success and decisions of a single vendor. Standards development organizations (SDOs), market leaders, and open source solutions are creating de facto standards that together influence overall cloud standards. This report examines the current state of cloud standards as well as future projections so I&O pros can make informed cloud strategy decisions.

Key Takeaways

AWS And OpenStack Remain The Core De Facto Standards
In Q4 2011, Forrester identified Amazon Web Services' (AWS's) compute and storage application programming as a standard. In Q4 2014, OpenStack joined AWS as the only other cloud platform standard.

Microsoft Holds Promise With Azure
As Microsoft's Azure cloud service gains momentum, it has potential to become another de facto standard. The pending release of Azure Stack will likely vault this platform into a true enterprise standard.

SDOs Have Set Several Standards, But Adoption Has Been Limited
In the past two years, SDOs have released several standards, including Cloud Infrastructure Management Interface (CIMI), Cloud Data Management Interface (CDMI), and Organization for the Advancement of Structured Information Standards (OASIS) Topology and Orchestration Specification for Cloud Applications (TOSCA), but adoption has not yet taken off because the release dates were so recent. TOSCA has started to leverage OpenStack to push adoption through Heat templates.

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Forrester interviewed five development organizations and customer councils: Cloud Security Alliance (CSA), Cloud Standards Customer Council (CSCC), Object Management Group (OMG), Organization for the Advancement of Structured Information Standards (OASIS), and Storage Networking Industry Association (SNIA). Forrester also conducted an informational survey among the major standards organizations.

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De Facto Standards And Open Source Shape Cloud Standards

In Q4 2011, Forrester didn't expect to see cloud platform standards until 2015.[1] At that time, SDOs believed that open source wouldn't play a part in standards development. Historically, I&O leaders have waited until standards creation. Conversely, open source communities felt that SDOs were antiquated and too lethargic to effectively get in front of the market and respond to change. But in 2016, these attitudes no longer remain. Today, interest and momentum lie with open source, not SDOs. Momentum requires collaboration. As a result, SDOs embrace open source projects and their communities to accelerate adoption and test the standards' limits more quickly. The leading example is OASIS TOSCA's involvement in OpenStack's orchestration project, Heat.[2] Some theorize that software standards will be a mix of early leaders and open source, whereas SDOs have a greater opportunity to make an impact on hardware standardization and some structural standards.

The Most Popular Standards, AWS And OpenStack, Are De Facto Standards

AWS's compute and storage APIs remain at the front of public cloud market share, with a wide range of related products and services supporting and leveraging these APIs today. Support for AWS's APIs isn't optional — it's a core requirement in the public and private cloud space of cloud-experienced developers across many organizations. Since its inception, organizations have widely used AWS for net-new development. Capital One and General Electric (GE) both announced plans in fall 2015 to migrate existing workloads to AWS.[3] This only amplifies AWS's strong hold on the market and expands potential use cases. OpenStack became a standard in 2014.[4] Since then, the OpenStack Foundation has boldly announced that 50% of all Fortune 100 companies use OpenStack.[5] Together, AWS and OpenStack have become the two platform standards, along with a long list of existing virtualization and management standards, such as VMware vSphere.

SDOs And Standards-Focused Organizations Continue Their Work

The standards world is full of targeted committees, SDOs, and user groups, all working in step to create new standards and drive momentum behind them. The traditional format of SDOs that delivered internet standards is too slow for today's software market. Enterprises rally behind open source initiatives, and SDOs look to more rapidly progress and test standards through the large open source user base. Forrester's breakdown of the standards-focused groups and their latest progress categorizes (see Figure 1):

› **Definitions: NIST and ISO.** Setting definitions is at the very core of any standards creation. The National Institute of Standards and Technology (NIST) has published formal definitions of cloud to standardize the term "cloud" and its core characteristics.[6] The International Standards Organization (ISO) has taken over where NIST left off.[7] Today, ISO/IEC JTC 1/SC38 defines nomenclature and a common reference architecture for each cloud deployment type. SC38 is also planning to define cloud service-level agreements (SLAs), interoperability, and data flow and use standards.

› **Security certifications: The Cloud Security Alliance (CSA).** The CSA previously focused almost exclusively on education around security in the cloud through certification and training programs, either online or in person through partners like Hewlett Packard Enterprise (HPE). In 2014, the CSA expanded its focus to include vendor security certifications through its Cloud Controls Matrix lists.[8] Overall, the CSA has made significant strides in the past year and is recognized marketwide for its work in security standardization in the cloud space. Its deliverables thus far have been white papers, the Certificate of Cloud Security Knowledge, CloudAudit, and Cloud Controls Matrix.[9]

› **SDOs: DMTF, ISO, OASIS, and SNIA.** SDOs focus on official standards development but also publish white papers. Distributed Management Task Force's (DMTF's) original virtualization standard, Open Virtualization Format (OVF), carries over to the cloud market and was one of the first established standards.[10] DMTF also released CIMI v2.0, which has published as ISO/IEC 19831:2015, and its CADF standard for event modeling for application security. ISO has officially accepted SNIA's CDMI v1.1.1 as an internationally recognized standard, ISO/IEC 17826.[11] SNIA has developed an automated test via a software-as-a-service (SaaS)-based tool that tests workloads for CDMI compliance.[12] OASIS TOSCA allows applications developers to leverage standard, formatted templates rather than long, nonstandard scripts. Since our Q2 2015 report on cloud platform standards, OASIS has progressed OASIS TOSCA to include new features and expects to complete its second and final public review of its TOSCA simple profile in YAML (v2.0) this fall.[13]

› **Faster-paced SDO projects: OASIS TOSCA and DMTF's Redfish.** More recently, DMTF's Redfish and OASIS TOSCA accelerated their release cycles to better collaborate with open source projects. For The Open Group and OASIS, this is a six-month cadence starting with the next release cycle. DMTF has released the Redfish API for massive simple server management, with releases every three to five months. OASIS TOSCA has worked closely with the OpenStack community for both Heat (application orchestration) and Tacker (network functions virtualization [NFV] orchestration) projects.[14] Recent improvements include life-cycle awareness, Chef and Puppet integration, and greater container support for both Apache Mesos (since 2014) and Kubernetes.

› **Customer councils: OMG's CSCC and TM Forum's ECLC.** Customer councils focus on supporting thought leadership among cloud end users, developing best practices, and identifying key challenges that top cloud customers face. TM Forum's Enterprise Cloud Leadership Council (ECLC) previously partnered with the Open Data Center Alliance (ODCA) to create a white paper on enterprise cloud best practices; the ECLC has since consolidated into the TM Forum's Open Digital Program.[15] Object Management Group's (OMG's) Cloud Standards Customer Council (CSCC) is the only cloud-focused end user customer council and has more than 600 members from companies like AARP, Aetna, AT&T, Boeing, Citigroup, Ford Motor, Lockheed Martin, Lowe's, and State Street.[16] CSCC organizes end user pain points like industry-specific use, privacy, SLAs, and security. Once it organizes these pain points, CSCC uses liaisons to connect with other standards groups, like DMTF, OMG, The Open Group, and OASIS, which then take ownership of addressing some of these challenges through standards, projects, or product creation.[17]

› **Network/telecom-focused groups: ETSI and ITU.** The European Telecommunications Standards Institute (ETSI) shut down its TC Cloud group because it had completed its initial work. Now, ETSI has shifted focus to NFV standardization, such as identifying key network functions for virtualization.[18] The International Telecommunications Union (ITU) supports two projects: 1) Study Group 13 (SG13) finalized its work in 2012 on standards development for next-gen networks (NGNs) and 2) Joint Coordination Activity on Cloud Computing (JCA-Cloud) focuses on coordination with SDOs and white paper creation.[19] The Global Inter-Cloud Technology Forum (GICTF) was previously in this category, but in 2014, it announced its retirement of this work after releasing two specification drafts and a technical-requirements white paper focused on network protocols.[20]

FIGURE 1 Standards-Focused Organizations And Current Projects

Definitions, best practices, and education

- **National Institute of Standards and Technology (NIST):** Core cloud definitions
- **International Organization for Standardization (IOS):** Specific definitions of cloud nomenclature and deployment types

Security certifications

- **Cloud Security Alliance (CSA):** CloudAudit, Certificate of Cloud Security Knowledge, and Cloud Controls Matrix

Customer councils

- **Enterprise Cloud Leadership Council (ECLC):** Best practices with Open Data Center Alliance (ODCA)
- **Cloud Standards Customer Council (CSCC):** Cloud technology pain-point identification

Research groups

- **TM Forum:** Training programs, demos, ECLC, and commercial service-level agreement (SLA) viability
- **Object Management Group (OMG):** Supports CSCC

Network/telecom-focused groups

- **European Telecommunications Standards Institute (ETSI):** TC Cloud and Cloud Standards Coordination (CSC)
- **International Telecommunications Union (ITU):** Study Group 13 (SG13) and Joint Coordination Activity on Cloud Computing (JCA-Cloud)

Fast-paced standards development organizations

- **Organization for the Advancement of Structured Information Standards (OASIS):** Topology and Orchestration Specification for Cloud Applications (TOSCA)

Standards development organizations

- **Distributed Management Task Force (DMTF):** Open Virtualization Format (OVF) and Cloud Infrastructure Management Interface (CIMI)
- **Storage Networking Industry Association (SNIA):** Cloud Data Management Interface (CDMI)

The Open Source World Settles: OpenStack Compatibility Is A Standard

Open source is no longer the small and medium-size business (SMB) workaround to expensive software licenses or a podium to stand upon against vendor lock-in.[21] Open source is driving development within the cloud platform market, and organizations of all sizes are rallying around it.[22] In 2015, 59% of North American and European enterprise software decision-makers from companies that consider cloud-related projects as a high priority said they are also prioritizing increasing their use of open source technology over the next 12 months.[23] When we surveyed North American and European enterprise technology infrastructure decision-makers whose companies have adopted or are planning to adopt private cloud, only 12% said they use a direct open source solution, but a much larger group uses commercial distributions of open source projects (see Figure 2).

Open Source Cloud Standards Are Shaking Out To Just One Juggernaut

Today, there are four open source infrastructure-as-a-service (IaaS) projects: OpenNebula Project, Eucalyptus, Apache CloudStack, and OpenStack.[24] Each solution substantially differs in its contribution structure, customers, release cycles, ownership, consumption models, design, and functionality. The best solution depends on an adopter's development force, a need for differentiation and customization, and any desire for interoperability with AWS. Of these four projects, OpenStack alone has had sufficient momentum and market presence to set a new de facto standard. Today, OpenStack compatibility is a requirement for all private cloud solutions. The following is a complete update on each major open source project:

› **OpenNebula Project provides full private cloud capabilities.** First released in 2008, OpenNebula Project (the latest version is 5.0) is a European open source project that spans beyond a basic cloud platform by providing a full suite of private cloud capabilities.[25] Its goal is to focus on data center virtualization features rather than creating an alternative to a public cloud platform experience. Since 2012, OpenNebula reports more than 1,000 downloads per month. OpenNebula releases an update once a year, with upgrade and maintenance releases throughout the year. Notable features in OpenNebula include cloud federation, virtual machine (VM) partitioning, multi-VM application deployment, hybrid cloud management, virtual data center (VDC) provisioning, and support for Amazon EC2 APIs. OpenNebula Systems, the company behind OpenNebula Project, provides commercial services such as training and consulting for this solution.[26] Some of its featured users are Activision Publishing, Akamai Technologies, BBC, BlackBerry, Deloitte, ESA, LexisNexis, NASA, and Telefonica. OpenNebula is CDMI-based.

› **Eucalyptus was acquired by HPE.** After losing its original market momentum, Eucalyptus shifted focus to concentrate on a specific use case that was lacking in the market — an AWS private cloud. Moving AWS-native workloads internally to better economics (for that particular workload) or to meet various compliance requirements isn't easy. Typically, this means a complete redesign of all templates and a lack of support for various AWS and ecosystem partner services. Eucalyptus
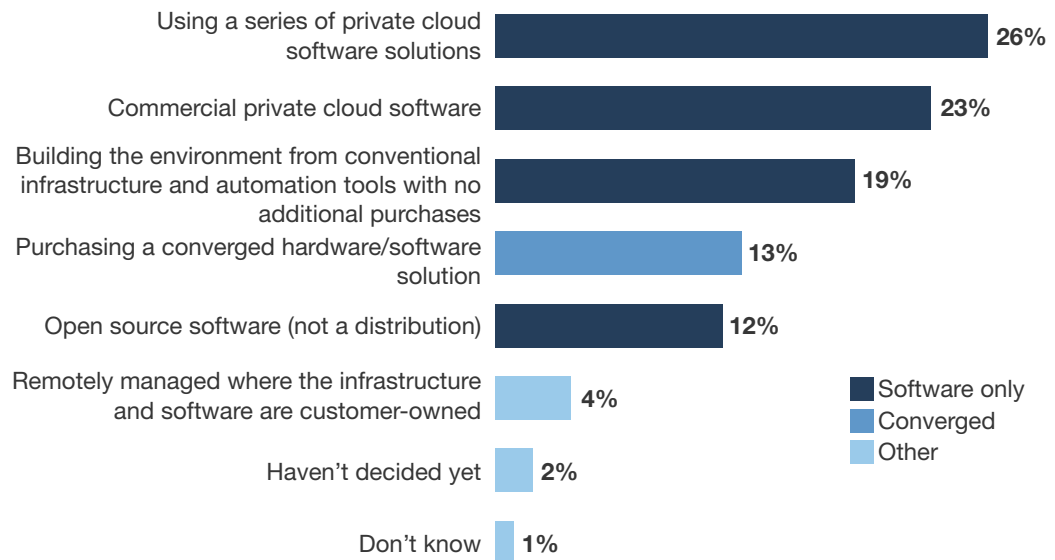
helped customers transition from AWS to an internal solution as seamlessly as possible.[27] In September 2014, HPE acquired Eucalyptus, largely as a talent influx.[28] Today, this solution is still in use but not benefitting from much investment.

› **Apache CloudStack has continued adoption but lacks momentum.** Apache CloudStack, originally Cloud.com, delivers a complete IaaS solution that's ready to use upon download. Vendors that adopt CloudStack can provide an IaaS solution from day 1, letting service providers focus on areas of differentiation and infrastructure. Since CloudStack's inception, it has gained significant service provider adoption. As of September 2016, Apache CloudStack reported at least 584,887 total downloads.[29] And according to our data, 11% of North American and European enterprise infrastructure decision-makers whose companies have adopted or are planning to adopt private cloud reported that they use CloudStack as part of their cloud solution, and 23% stated that they have adopted its major distribution, Citrix CloudPlatform.[30] Citrix sold off this solution to Accelerite in 2016.[31]

› **OpenStack takes off globally.** OpenStack became a private cloud platform standard in Q4 2014. Today, the list of private cloud suites supporting the OpenStack platform includes (but is not limited to) Cisco, HP, IBM, Microsoft, Rackspace, Red Hat, and VMware.[32] Although only 3% of North American and European enterprise infrastructure decision-makers whose companies have adopted or are planning to adopt private cloud recognize the pure OpenStack distribution as part of their private cloud solution, the top six most-adopted vendors all support OpenStack, and many base their own platforms off of their own OpenStack distribution.[33] At its April 2016 Austin summit, the OpenStack Foundation celebrated the 13th release of the platform, code-named Mitaka.[34]Today, half of all Fortune 100 companies use OpenStack.[35]

FIGURE 2 Adoption Of Direct Open Source Is Limited, But It's Widely Used In Specific Deployments

"Which of the following best describes your company's software strategy for how you built/plan to build your internal private cloud?"

Using a series of private cloud software solutions	26%
Commercial private cloud software	23%
Building the environment from conventional infrastructure and automation tools with no additional purchases	19%
Purchasing a converged hardware/software solution	13%
Open source software (not a distribution)	12%
Remotely managed where the infrastructure and software are customer-owned	4%
Haven't decided yet	2%
Don't know	1%

Legend:
- Software only
- Converged
- Other

Base: 555 North American and European technology infrastructure decision-makers whose firms are planning to adopt or have adopted internal private cloud deployment models (1,000+ employees)
Source: Forrester's Global Business Technographics® Infrastructure Survey, 2015

What I&O Pros Need To Know About OpenStack

Forrester has long received inquiries about the viability and readiness of OpenStack, but the frequency of these inquiries has rapidly increased since OpenStack's Havana release in October 2013. Today, organizations generally get OpenStack information through hyped news stories and vendor-speak, making it difficult to get unbiased, basic facts about impact, maturity, interoperability, and the effect of commercialization on open source technology. Some facts about OpenStack are that:

› **OpenStack APIs are a cloud standard.** Today, almost every public, private, and hosted private cloud provider has either already developed or is in the process of developing varying levels of support for the OpenStack APIs. Why? OpenStack's powerful ecosystem, which includes HPE, IBM, Rackspace, Red Hat, and VMware, along with enterprise adoption from Bank of America, Best Buy, BMW Group, Comcast, Disney, Fidelity Investments (FMR), SAP, and Walmart, have driven customer demand for OpenStack API support. The level of API support will vary greatly, with some solutions acting as pure OpenStack offerings, others as distributions that combine their own intellectual property (IP) to OpenStack APIs, and yet others that simply offer compatibility with these APIs.

› **Using OpenStack directly means heavy development investment.** Although large consumer experience-driven organizations like Comcast, eBay, and Fidelity have already kicked off adoption, most enterprises don't have the development resources required to use a direct implementation of OpenStack, which means using a distribution for a hefty price. Why? OpenStack leaves a lot open for customization to fit your scenario. Vendors in the community are able to build their products around this, but for enterprises not going all in, this can mean time-intensive steps with minimal reward. Most enterprises are better off starting from a commercial distribution or managed/hosted solution.

› **OpenStack distributions aren't interoperable — but that's OK.** For better or worse, innovation drives open source projects.[36] Each vendor operates on different versions of OpenStack, chooses a selection of projects, and then differentiates itself from other distributions with its own IP. Each service provider determines its position along this spectrum by its own balance between differentiation from its "co-opetition" (for revenue generation) and contribution back to the community to ensure that its own method becomes the next standard for that particular feature. Complete freedom from lock-in is a myth, but steps have started to get us closer to this vision. All OpenStack-certified solutions must pass an automated test against the core projects of OpenStack.[37]

Keep A Lookout For Tomorrow's Potential Standards

Not a lot has changed over the past year in established cloud standards; however, there's been a significant amount of behind-the-scenes work. Standards groups are changing their release processes and the way they market their work. Vendors have continued to innovate and mold their solutions to fit customer demand, and new open source movements have emerged. Below is Forrester's short list of potential future standards to keep on your radar:

› **Cloud Foundry.** Developer productivity at scale demands user ease, multicloud platform support and consistency, a vibrant ecosystem, and automated application life-cycle management. Platform-agnostic platform-as-a-service (PaaS) offerings such as Cloud Foundry are stepping up to the challenge. Rather than focus on centralizing cloud management, platform-agnostic PaaS centralizes the developer experience and navigates the handoffs and policies necessary to facilitate the full development process. The largest PaaS community to date, Cloud Foundry boasts an impressive list of classic enterprises across a truly diverse range of industries. As with OpenStack, a dedicated foundation runs Cloud Foundry, supported by major technology providers such as Dell, EMC, HPE, IBM, Pivotal Software, and VMware. It's well positioned to become another massive open source endeavor but with a greater ability to bridge across public and private cloud worlds. The greatest threat to Cloud Foundry becoming a standard is a developer preference for containers or cloud native portals.

› **Kubernetes.** Kubernetes isn't a cloud platform. It's a container orchestration technology designed by Google and has since been open sourced. Although nobody knows which container technology will become standard, Kubernetes is quickly establishing itself as the container orchestration technology of choice. Container projects intertwine with hybrid cloud strategies and are central to the conversation around cloud workload portability.

› **Microsoft Azure.** Amazon is still ahead.[38] However, Microsoft has quickly become the second major player in the public cloud market. As cloud management tools add support to more platforms, Azure has become the obvious next choice. Whether it's a .NET heritage, discounts on other Microsoft licenses, state-level government certifications, or knowledge of traditional Microsoft apps, Microsoft Azure has become a common provider in the enterprise public cloud mix. AWS still sets expectations for functionality, but Azure API compatibility is quickly becoming a must-have for others in the space.

Portability Of Workloads Is The Next Standards Question

The CSCC defines portability as the ability to move a cloud-based workload to another cloud environment.[39] The good news is that for basic usage, you have options. Today, your cloud provider can move your basic compute, network, and storage resources from major cloud solutions to its cloud platform. The current approach isn't a simple click of a button, but the one-way migration is available if you have to move. However, in this move, you'll lose the additional services that surround your application.[40] It's a simple tradeoff — use a provider's high-value service with the knowledge that only it offers that service. Despite this rather apparent unstated agreement between provider and adopter, the concept of vendor lock-in has garnered significant attention. No agreed-upon method for facilitating portability yet exists. Today, the main conversations around mitigating vendor lock-in to enable greater portability include:

› **OASIS TOSCA.** As mentioned in the standards section, OASIS has created a standard that specifies a format that application and infrastructure templates should have so they're readable from one provider to another. It doesn't dictate that each provider handle each command identically, but it does enable readability of templates from one provider to another. Those using multiple platforms today through a single portal must keep a template library for each provider. TOSCA is the first step toward standardizing these across providers.

› **Vendor-neutral templates.** Several of the cloud management vendors have invested in creating templates that work across several providers. Early efforts identified the inflection points where one provider differs from others to take a vendor-agnostic approach that is compatible across platforms. The challenge is that the resulting template creates an uninteresting application. More-recent developments are massive templates that include code for all major providers. Depending on where you're running the template, it will run that particular code. These templates are still in their early stages, and it remains unclear how the vendors will sustain them over time and contain the resulting management nightmare.

› **Containers.** Interest for container technology has risen dramatically in the past few years. Docker entered the market by making containers easy, compact, and without the bloat or hefty license costs associated with hypervisors. I&O pros are testing several container technologies for test/dev Linux workloads. The container phase is only beginning. As with any new technology, significant complaints arise around security. Additionally, the container approach doesn't solve for vendor-specific services. Users would need to design services from scratch or leverage a user community to get true portability with containers. Others are concerned about application context and the ability to apply policies to created containers.

› **Platform-agnostic PaaS.** Part of the lock-in challenge isn't the services or the platform itself but rather the user experience and centering an entire development practice on a single provider. Platform-agnostic PaaS offerings abstract the platform so the developer is developing without a knowledge of the platform that sits beneath it. For technical developers or those heavily leveraging cloud services, this approach isn't the ideal way to interact with a platform. But ultimately, it does make developers less dependent on a single vendor.[41]

› **Abstracting tools from the platform.** Eucalyptus allowed AWS users to leverage AWS services while running the majority of their compute on-premises. To date, it has been the only example of AWS allowing this level of API usage from another provider. Some providers are working to enable this type of abstraction of services from the platform itself without violating cloud provider terms. This approach is still in its early days, and its success is uncertain.

Recommendations

It's Time To Start Advocating For Cloud Standards

Don't wait for cloud standards — start advocating for service provider adoption. More than half of North American and European enterprise infrastructure decision-makers are focusing on cloud, with 63% prioritizing building a private cloud and 57% prioritizing adopting public cloud from a service provider.[42] You can't delay cloud adoption, because your competition has already begun to take advantage of cloud services to increase agility — and waiting will only put you further behind. For I&O pros who've already adopted cloud, it's time to start advocating for cloud standards. The early standards have been released (OVF, CDMI, CIMI, and TOSCA), and OpenStack is reaching high adoption and greater maturity. Ask your cloud vendors about their adoption of standards and support of OpenStack. In the meantime, minimize the risk of vendor lock-in and future rework by following our recommendations:

› **Join the CSCC.** Even those not passionate about standards development can gain significant value from joining the CSCC and its more than 600 peer member organizations. This organization can serve as a peer-to-peer source among cloud adopters. This not only includes executives and tech management pros but also leverages business users within the organization to ensure that this research is grounded in reality. For example, the CSCC consulted subject-matter experts to

create its report "Impact of Cloud Computing on Healthcare."[43] At a minimum, use CSCC's many white papers as a resource in shaping your cloud strategy. One of its latest papers is on migrating applications to the cloud.[44]

› **Stick with safer bets on solutions from AWS and OpenStack.** AWS is the current de facto standard, and most competitive market solutions (management tools, platforms, etc.) write to AWS's APIs and ensure interoperability. The combination of its ecosystem, technology, and market share makes AWS a likely influencer of future cloud standards. OpenStack-based solutions have already started to proliferate in the market and will also dictate API standards. Outside these solutions, look to early supporters of existing standards.

› **Manage your deployments through a cloud management software tool.** Management tools fill the gaps in functionality and interoperability before the arrival of standards. Take advantage of these solutions by managing your cloud portfolio through a single platform such as RightScale for security, monitoring, and cloud life-cycle management. These tools shield you from potential API incompatibilities and changes.[45]

› **Use internet, management, virtualization, and web services standards when possible.** In lieu of cloud standards, leverage internet, management, virtualization, and web service standards in your cloud implementations. Cloud standards will likely draw from these existing standards for consistency among markets. For example, when evaluating networking monitoring and analytics, look for standard monitoring methods, data-center-to-data-center protocols, and policy controls that are consistent with existing networking standards.

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Supplemental Material

Survey Methodology

Forrester's Global Business Technographics® Infrastructure Survey, 2015, was fielded to 3,592 business and technology decision-makers located in Australia, Brazil, Canada, China, France, Germany, India, New Zealand, the UK, and the US from companies with two or more employees. This survey is part of Forrester's Business Technographics and was fielded from May 2015 to June 2015. ResearchNow fielded this survey on behalf of Forrester. Survey respondent incentives include points redeemable for gift certificates. We have provided exact sample sizes in this report on a question-by-question basis.

Forrester's Business Technographics provides demand-side insight into the priorities, investments, and customer journeys of business and technology decision-makers and the workforce across the globe. Forrester collects data insights from qualified respondents in 10 countries spanning the Americas, Europe, and Asia. Business Technographics uses only superior data sources and advanced data-

cleaning techniques to ensure the highest data quality. We have illustrated only a portion of the survey results in this document. To inquire about receiving full data results for an additional fee, please contact data@forrester.com or your Forrester account manager.

Companies Interviewed For This Report

Cloud Security Alliance (CSA)

Cloud Standards Customer Council (CSCC)

Object Management Group (OMG)

Organization for the Advancement of Structured Information Standards (OASIS)

Storage Networking Industry Association (SNIA)

Endnotes

[1] In 2011, Forrester published this report describing the (then) current state of cloud standards and featured predictions of future trends and possibilities. See the "The State Of Infrastructure-As-A-Service Cloud Standards" Forrester report.

[2] For more information on the OpenStack Heat orchestration project, read the official Wiki. Source: "Heat," OpenStack (https://wiki.openstack.org/wiki/Heat).

[3] Source: "AWS re:Invent 2015 Keynote, Jim Fowler, CIO, GE," YouTube video, October 13, 2015 (https://www.youtube.com/watch?v=i1yW6vWCpgk).

[4] The open source cloud-computing project OpenStack has come a long way since NASA and Rackspace launched it in 2010. Backed by leading technology infrastructure providers, including Cisco, Dell, EMC, HP, IBM, Intel, and VMware, OpenStack underpins significant workloads at an increasingly diverse set of organizations, including BMW, CERN, Comcast, eBay, and Walmart. For more information, see the "Brief: OpenStack Is Now Ready For Business" Forrester report.

[5] Source: "OpenStack Powers Demanding Production Workloads Worldwide." OpenStack (https://www.openstack.org/user-stories/).

[6] The NIST defines cloud computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." Source: Peter Mell and Timothy Grance, "The NIST Definition of Cloud Computing," National Institute of Standards and Technology, September 2011 (http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf).

[7] ISO both reviews standards put forth by other standards groups and establishes its own standards/references as needed. ISO has created standards on nomenclature and reference architectures (in collaboration with NIST), and, more recently, has written standards on public cloud security and privacy (ISO/IEC 27017 and 27018). Source: "ISO/IEC 27017:2015," ISO, December 15, 2015 (http://www.iso.org/iso/catalogue_detail?csnumber=43757) and "ISO/IEC 27018:2014," ISO, August 1, 2014 (http://www.iso.org/iso/catalogue_detail.htm?csnumber=61498).

[8] CSA has a three-tiered STAR (Security, Trust, and Assurance Registry) cloud matrix system. To qualify for tier 1, the group must take a self-assessment on its security practices, which more than 100 groups have successfully done today. Thirty percent of this group are enterprises rather than cloud vendors. Tier 1 qualifiers include AWS, Atos, China Mobile, Citrix, HPE, Microsoft, Salesforce, and T-Systems. To achieve tier 2, vendors must undergo a third-party audit to meet ISO27001 and SOC2, scoped for cloud. Today, 15 companies have met this requirement. The CSA is currently working on a tier 3 iteration of this program and hopes to have this set by midyear. For more information, please visit the CSA page dedicated to the STAR program. Source: "CSA STAR: The Future of Cloud Trust and Assurance," Cloud Security Alliance (https://cloudsecurityalliance.org/star/).

For a list of STAR-qualifying companies, please visit this CSA page. Source: "CSA Security, Trust & Assurance Registry (STAR)," Cloud Security Alliance (https://cloudsecurityalliance.org/star/#_registry).

[9] For more information on the CSA and its ongoing projects and research, go to its website. Source: Cloud Security Alliance (https://cloudsecurityalliance.org/).

[10] Recently, OVF has become ANSI INCITS 469-2010, ISO/IEC DIS 17203:2011, and an official DMTF standard. Source: "Open Virtualization Format," DMTF (https://www.dmtf.org/standards/ovf).

[11] For more information on ISO/IEC 17826:2012, visit the following website. Source: "ISO/IEC 17826:2012," ISO, November 15, 2012 (http://www.iso.org/iso/catalogue_detail.htm?csnumber=60617).

[12] SNIA's automated tool has more than 300 end users registered. Neither OpenStack Swift nor Amazon S3 has an automated compatibility test available for users. Source: SNIA.

[13] This report examines the current state of cloud standards as well as future projections so I&O professionals can make informed decisions when it comes to their cloud strategy. See the "The State Of Cloud Platform Standards: Q2 2015" Forrester report.

[14] For more information on the OpenStack Heat orchestration project and the OpenStack Tacker NFV orchestration project, read the official Wiki. Source: "Heat," OpenStack (https://wiki.openstack.org/wiki/Heat) and "Tacker," OpenStack (https://wiki.openstack.org/wiki/Tacker).

[15] For more information on TM Forum and its published white papers, visit its website. Source: TM Forum (https://www.tmforum.org/resources/?filter_document-type=2241).

[16] For more information on the CSCC, visit its website. Source: Cloud Standards Customer Council (http://cloud-council.org/).

[17] For a list of white papers from the CSCC, visit the following website. Source: "Resource Hub," Cloud Standards Customer Council (http://cloud-council.org/resource-hub.htm).

[18] ETSI also continues its work through its Cloud Standards Coordination (CSC) to understand how existing standards work comes together to avoid redundancy or conflicting standards.

[19] For more information on ITU's Study Group 13, visit its website. Source: "Study Group 13 at a glance," ITU (http://www.itu.int/en/ITU-T/about/groups/Pages/sg13.aspx). This website has additional information on ITU's Joint Coordination Activity on Cloud Computing. Source: "Joint Coordination Activity on Cloud Computing (JCA-Cloud)," ITU (http://www.itu.int/en/ITU-T/jca/Cloud/Pages/default.aspx).

[20] Source: Jeff Hilland, "2014 Year in Review with DMTF President Jeff Hilland," DMTF Newsletter, December 2014 (http://createsend.com/t/y-D67A270702F387E9).

[21] Open source is not of interest to just researchers, startups, or small businesses. The modern enterprise embraces open source capabilities to accelerate its digital transformation efforts, and open source components increasingly underpin today's major technology markets. CIOs must consider open source technologies as part of their broader business technology strategies. For more information on the evolution of open source and highlights on its importance to enterprise strategy moving forward, see the "Open Source Powers Enterprise Digital Transformation" Forrester report.

[22] For a deeper dive into the evolution of open-source-based private cloud solutions over the past few years, see the "State Of Cloud Platform Standards: Q1 2014" Forrester report.

[23] Source: Forrester's Global Business Technographics Software Survey, 2015.

[24] For a detailed overview of the top software-only private IaaS solutions in the market today, see the "Vendor Landscape: Private Cloud Software Solutions, Q2 2016" Forrester report.

[25] In November 2013, we published a Forrester Wave™ that evaluated the top software-only private infrastructure-as-a-service solutions in the market. Since then, there's been demand for a portrait of the entire private cloud software market — not just the leaders. See the "The Forrester Wave™: Private Cloud Solutions, Q4 2013" Forrester report.

The following report provides I&O professionals with a high-level overview of more than 30 software-only private cloud service providers and is the second in a series of three reports that detail the vendor landscape and segmentations of the private cloud market. See the "Vendor Landscape: Private Cloud Software Solutions, Q2 2016" Forrester report.

[26] Source: Ben Kepes, "EMC Acquires Cloudscaling. The Expected Rationalization Continues," Forbes, October 13, 2014 (http://www.forbes.com/sites/benkepes/2014/10/13/emc-acquires-cloudscaling-the-expected-rationalization-continues/).

[27] Before HP acquired it, Eucalyptus made compatibility with AWS workloads the focus of its private cloud platform; specifically, it set out to make transferring workloads from an AWS public cloud environment to Eucalyptus' private cloud environment as easy as possible. To find out more information about Eucalyptus' platform as well as nine other private cloud software vendors, see the "Applying The Forrester Wave™: Private Cloud Solutions, Q4 2013" Forrester report.

[28] On September 11, 2014, HP announced that it is acquiring Eucalyptus Systems, an open source cloud platform founded in 2009. This was an unexpected move, as HP was committed to a separate open source cloud platform (OpenStack). At face value, HP's acquisition of Eucalyptus appears to be a second-guessing of HP's OpenStack commitment, but we think this interpretation misses the mark. For Forrester's perspective on the reasoning behind the acquisition, see the "Quick Take: HP Acquires Eucalyptus Systems" Forrester report.

[29] Apache tracks downloads from only two of its four download options. This data shows downloads from 2014 to 2016 and was provided by the Apache Software Foundation.

[30] Source: Forrester's Global Business Technographics Infrastructure Survey, 2015.

[31] Source: Steve Wilson, "A New Home: Accelerite to Acquire CloudPlatform." Citrix blog, January 11, 2016 (https://www.citrix.com/blogs/2016/01/11/a-new-home-accelerite-to-acquire-cloudplatform/).

[32] For a list of more vendors offering platform support for OpenStack, visit the OpenStack Marketplace website. Source: "Marketplace," OpenStack (https://www.openstack.org/marketplace/).

[33] Source: Forrester's Global Business Technographics Infrastructure Survey, 2015.

[34] At its Paris summit, the OpenStack Foundation celebrated the 10th release of the platform (code name: Juno). What stood out about this latest iteration and the progress of its ever-growing ecosystem of vendors, users, and service providers was the lack of excitement that comes with maturity. The Juno release addressed many challenges holding back enterprise adoption to this point and showed signs that 2015 may be the year its use shifted over from mostly test and development to mainstream production deployments. For more information, see the "Quick Take: OpenStack Summit, Q4 2014" Forrester report.

[35] The OpenStack Foundation kicked off its semiannual release summit with powerful data points for its enterprise audience: Half of all Fortune 100 companies use OpenStack, and 65% of users reportedly run production workloads in their OpenStack environments. For more information, see the "Quick Take: OpenStack Summit, Q2 2016" Forrester report.

[36] In this YouTube video, Boris Renski, cofounder and CMO of Mirantis, discusses "co-opetition" and how open-source innovation drives itself. Source: "Keynote: OpenStack CoOpetition, A View from Within," YouTube video, April 4, 2014 (https://www.youtube.com/watch?v=i7HXu2abNj0).

[37] The OpenStack Foundation determines core projects. For information on which solutions are certified, visit the OpenStack Marketplace website. Source: "Marketplace," OpenStack (https://www.openstack.org/marketplace/).

38 In our 34-criteria evaluation of global public cloud platform providers for enterprise developers, we identified the eight most significant ones — Amazon Web Services (AWS), CenturyLink, Google, IBM, Microsoft, Oracle, Salesforce, and SAP — and researched, analyzed, and scored them. This evaluation shows how each provider measures up to enterprise software development requirements to balance application platforms with infrastructure control to help application development and delivery (AD&D) professionals select the right public cloud platform partner. See the "The Forrester Wave™: Global Public Cloud Platforms For Enterprise Developers, Q3 2016" Forrester report.

39 Source: "Interoperability and Portability for Cloud Computing: A Guide," Cloud Standards Customer Council, November 2014 (http://www.cloud-council.org/CSCC-Cloud-Interoperability-and-Portability.pdf).

40 There are many mobile and customer-facing apps and built-on public cloud platforms, and more will come as the age of the customer progresses. Customer-facing apps are different: They elastically scale on cloud platforms, are composed of services, and are delivered and improved through continuous delivery. Shifting to this model is difficult with on-premises web platforms but can be easy on the right public cloud platforms. This report details the tools and services for application development and delivery pros provided by 22 public cloud platforms. See the "Which Public Cloud Platforms Have The Right Developer Tools And Services?" Forrester report.

41 Enterprise private cloud strategies are shifting to focus on developers — not optimized infrastructure. Developer productivity at scale demands user ease, multicloud platform support and consistency, a vibrant ecosystem, and automated application life-cycle management. Change is on the horizon for enterprise developers. Private PaaS offerings such as Cloud Foundry are stepping up to the challenge. At its Santa Clara summit, Cloud Foundry featured its enterprise users, along with other updates on penetration. For more information, see the "Quick Take: Cloud Foundry Summit, Q2 2016" Forrester report.

42 These respondents selected "high priority" or "critical priority." Source: Forrester's Global Business Technographics Infrastructure Survey, 2015.

43 Source: "Impact of Cloud Computing on Healthcare," Cloud Standards Customer Council, 2012 (http://www.cloud-council.org/deliverables/CSCC-Impact-of-Cloud-Computing-on-Healthcare.pdf).

44 Source: "Interoperability and Portability for Cloud Computing: A Guide," Cloud Standards Customer Council, 2014 (http://www.cloud-council.org/deliverables/CSCC-Interoperability-and-Portability-for-Cloud-Computing-A-Guide.pdf) and "Migrating Applications to the Cloud: Assessing Performance and Response Time Requirements," Cloud Standards Customer Council, 2014 (http://www.cloud-council.org/deliverables/CSCC-Migrating-Applications-to-the-Cloud-Assessing-Performance-and-Response-Time-Requirements.pdf).

Other recently published deliverables are listed on the CSCC website. Source: "Resource Hub," Cloud Standards Customer Council (http://www.cloud-council.org/resource-hub.htm).

45 Having the right cloud management tool for your cloud deployment is essential; the capabilities of the platform need to match the use cases and demands from your enterprise users and developers. For more information on the range of private cloud management tools in the market, see the "Vendor Landscape: Private Cloud Software Solutions, Q2 2016" Forrester report.

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