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VOLUME 3

Cloud Platforms
Private Cloud Deep Dive

Goldman Sachs

Over $300bn in IT spend is at risk of disruption as enterprises pursue "hybrid cloud" strategies. After examining public cloud in Volume 1 of this series, we explore the other half of hybrid cloud: private cloud.

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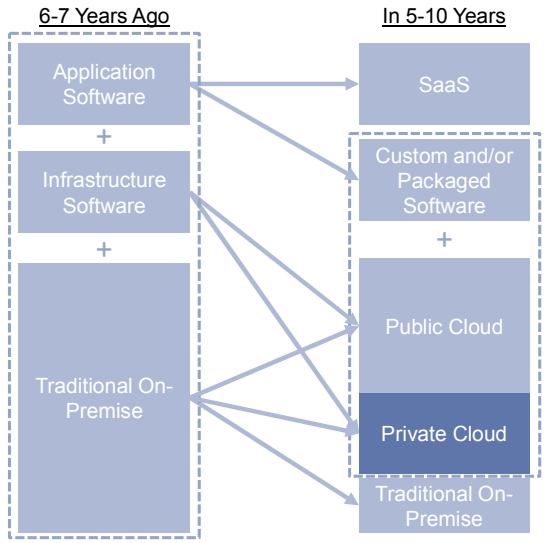
Portfolio manager summary

This report is the third in a multi-part series designed to educate investors about cloud computing platforms. For more detail on the overarching trend and public cloud, please see Cloud Platforms Volume One: Riding the Cloud Computing Wave, published on January 13, 2015

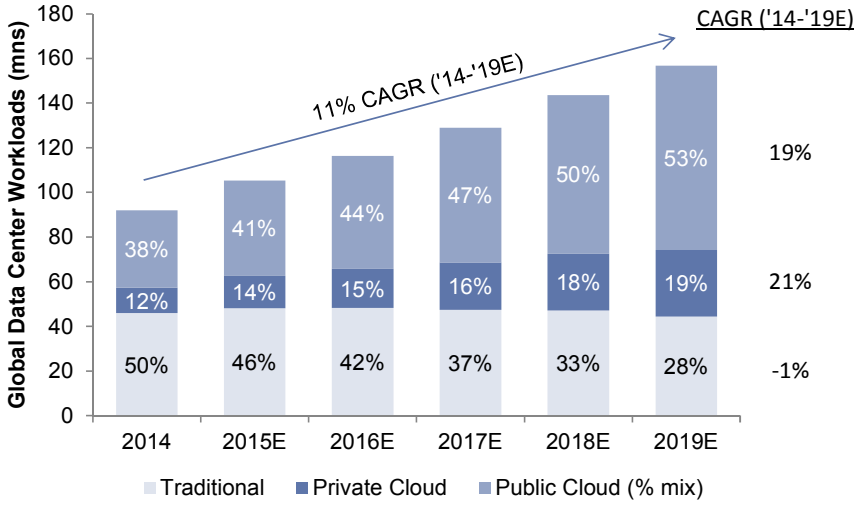
Background – With public cloud disrupting traditional spend, many ask...won't private cloud make up the difference as vendors move to hybrid cloud? This report explores the other half of hybrid cloud, private cloud. We discuss what private cloud is, the foundational technology components behind it (including an in depth look at OpenStack IaaS and Cloud Foundry PaaS), how infrastructure vendors are bulking up their private cloud solutions, and implications for VMware (VMW), Red Hat (RHT), Microsoft (MSFT), Oracle (ORCL), and Rackspace (RAX).

Exhibit 1: Visualization of the next cloud computing cycle



Source: Goldman Sachs Global Investment Research.

Exhibit 2: Workloads by type (Traditional, Private Cloud, Public Cloud)



SaaS excluded in private and public cloud calculations.

Source: Cisco Global Cloud Index, October 2015.

What is private cloud? – Many users describe private cloud as having an Amazon AWS-like environment within their own data center. This is where software developers/engineers can easily and quickly request and receive application infrastructure, just like they can on Amazon AWS. The difference is that the underlying servers, storage and network is wholly owned and dedicated to the organization instead of "rented" through AWS or other public cloud vendors. A private cloud can be within the organization's own physical data center or owned, dedicated (not shared like public cloud) and managed by a third party.

Pages 9-17

Components and vendors of private cloud – Compared to a traditional infrastructure environment, private clouds require five main components: IaaS software (i.e., VMware vCloud, Microsoft System Center, OpenStack), PaaS software (i.e., Cloud Foundry, OpenShift), virtualization software (i.e., VMware vSphere, Microsoft HyperV, Xen, KVM), automation/configuration and orchestration software (i.e., Puppet, Chef, and Ansible which was acquired by Red Hat), and dashboard and management tools (i.e., VMware, IBM, Microsoft). This report details use cases, technology components, vendors' products, and customer benefits of the two of the most popular IaaS and PaaS software technologies, OpenStack and Cloud Foundry.

Pages 18-29

- **OpenStack –** Behind VMware and Microsoft, OpenStack is the third most popular IaaS software technology for private clouds (Exhibit 12). There is strong interest around OpenStack, with 80% of CIOs polled expecting to use OpenStack in three years, up from 60% using the technology today. However, as we mentioned previously, the percentage of workloads running on OpenStack within an organization is low. While there are dozens of OpenStack distributions and multiple ways to deploy and consume OpenStack, we analyze two of the most popular versions, Red Hat OpenStack and VMware Integrated OpenStack.

Pages 30-36

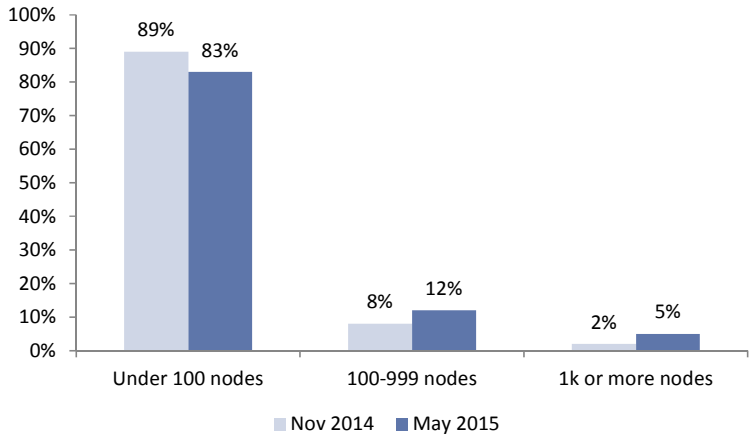
- **Cloud Foundry –** This is one of the most popular PaaS software technologies for private clouds. Cloud Foundry can be deployed across multiple different IaaS platforms, including Amazon AWS, OpenStack and VMware vSphere or vCloud Air. According to data from Gartner, the two most popular commercial versions of Cloud Foundry are Pivotal Cloud Foundry and IBM Bluemix, which we discuss in detail later in this document.

Private cloud is not the same as traditional on-premise environments – Private clouds have five main attributes: self-service, a dedicated environment, cost allocation, speed and uniformity, and scale. This is different from current traditional on-premise environments because software developers can now acquire the infrastructure they need in minutes or hours instead of days or weeks without involving IT. That infrastructure is uniform and can be easily managed and scaled. In addition, the customer has control over how they deploy their workloads and manage their cluster, and can make sure that their environments meet regulatory requirements (i.e., HIPAA or The Health Insurance Portability and Accountability Act of 1996).

Who uses private cloud? – Typically organizations build a private cloud (versus public cloud) due to regulatory concerns or wanting more control over how their cloud runs. Examples of this include AT&T, PayPal, Walmart Labs, Intel, FICO, Volvo, Target, Humana, and Tangerine (Canadian Bank). We profile seven case studies later in this report.

- **Private Cloud use cases –** Similar to public cloud, the most common use cases cited are new applications (web, mobile, IoT) and development and test workloads. Some applications were in production, and some migrated from traditional on-premise to private cloud.
- **OpenStack…small but growing –** We found that for most customers, OpenStack is being used for a minority of workloads. An OpenStack User Community Survey conducted in Spring 2015 showed that the number of OpenStack nodes within an organization is relatively small, but growing, as many are using traditional data center software. Some of the larger OpenStack deployments still do not represent even half of all enterprise workloads, as Target uses OpenStack for a third of their workloads and Volvo uses OpenStack as the underlying infrastructure for just 40 of their 4k apps. However, over time, instances should start to grow. AT&T will likely become the largest OpenStack environment in the world, as they expect to build out their private cloud to 500k nodes (servers) and span across hundreds of data centers.

Exhibit 3: OpenStack User Community Survey: Number of OpenStack compute nodes used



Source: OpenStack User Community Survey, conducted 3/9/15-4/16/15.

How large is this market? – Overall, we expect that the overall spilt between platforms will be roughly 50% public cloud, 20% private cloud and 30% traditional over the next 5-10 years, similar to Cisco's Global Cloud Index forecast (October 2015). This is based on commentary from companies like General Electric, which plans "to move 60% global workload into AWS," Coca-Cola, which expects 50% will run in the public cloud, and Johnson & Johnson, which expects 85% of its workloads will be in a private cloud, and 15% will remain legacy.

Private cloud ROI – We outline the benefits of private cloud by customer, including cost savings on hardware, reducing the time to provision a server, IT headcount savings, increased security and control and avoiding vendor lock in. See pages 19 and 32 for more information.

Trends driving the adoption of private cloud– Besides the move to hybrid cloud, we see three major trends driving the creation of private clouds.

(1) **The Amazon AWS effect –** Similar to the trend over the last decade where enterprises apps have transformed their user interfaces and capabilities to mimic consumer applications (e.g., Facebook, Google search), we believe the adoption of public cloud, most notably Amazon AWS, is transforming traditional on-premise infrastructure, with developers demanding the same ease of use and speed to request and obtain infrastructure as AWS.

(2) **"Move fast and break things" culture –** Adopted by Facebook's engineering culture, enterprises are realizing the benefits of shortening the time it takes to create applications, giving their software developers the infrastructure they need in hours or days instead of weeks or months. This is especially true as enterprises are creating and using software to differentiate their businesses.

(3) **Movement towards DevOps or NoOps –** The code that software developers write is just one portion of all the steps needed to get an application to run. Enterprises are moving towards automating those steps which are usually done by an

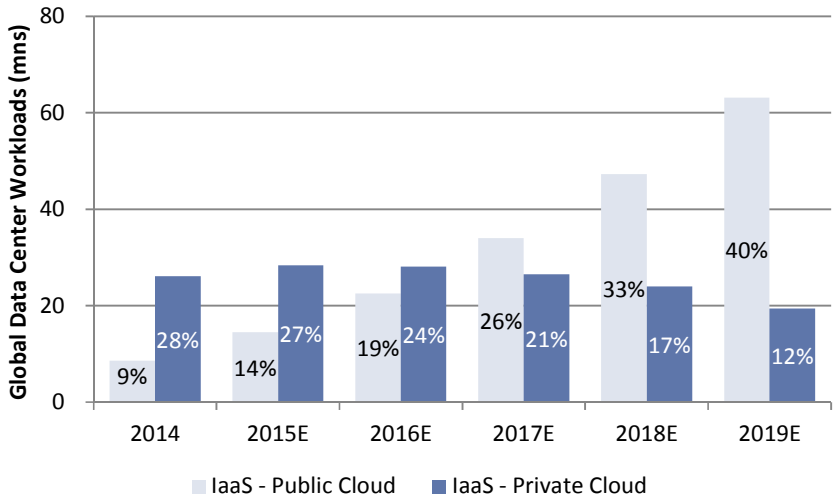
IT operations staff or developers themselves. This is often a frustrating process when there are issues as the application moves from test to production. The automation process can be done through platform as a service (PaaS) software or certain automation and configuration software. With this software, developers are also able to do operations work, either lessening (DevOps) or eliminating (NoOps) the need towards having dedicated operations staff to perform these functions. This has become popularized even more as Docker has become a standard way to package the code with the libraries and other code needed to have the application run in multiple different environments.

Our differentiated call

(1) **Most net new workloads will likely skip private cloud and go straight to public cloud, limiting the TAM –** Due to the rapid rise of public cloud, we believe many will skip the step of creating their own private cloud and jump straight to public cloud, especially medium to smaller businesses where it is likely more economical and secure than building their own private cloud.

Cisco estimates that while public cloud IaaS and PaaS workloads will accelerate on a number and percentage of overall workloads, private cloud IaaS workloads will decline on a number and percentage of total basis (26mn workloads or 28% of total workloads in CY14 to 19mn or 12% in CY19), while private cloud PaaS workloads will increase slightly on a numbers basis, but decline on a percentage of total basis (9mn or 9% in CY14 to 10mn or 6% in CY19).

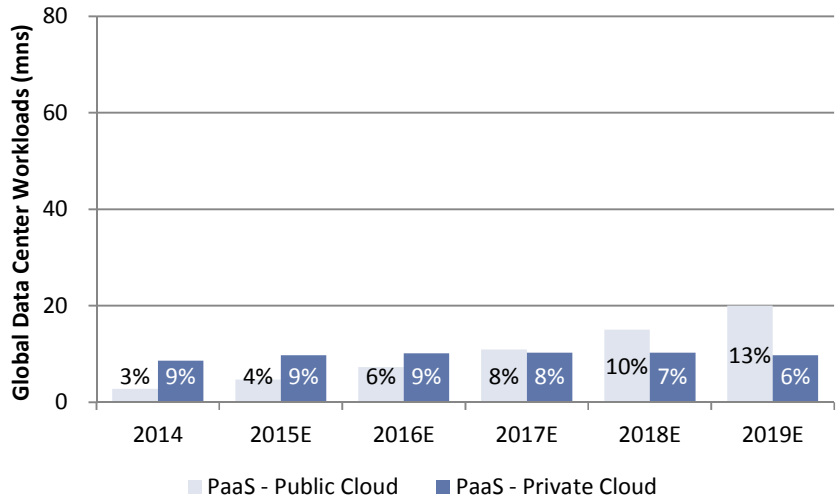
Exhibit 4: IaaS Workloads: Private Cloud declining vs. Public Cloud accelerating



Percentage information reflects Cisco's forecast of the following workloads IaaS – Public Cloud, IaaS – Private Cloud, PaaS – Public Cloud, PaaS – Private Cloud, and Traditional. This forecast excludes Cisco's estimate for SaaS workloads.

Source: Cisco Global Cloud Index, October 2015.

Exhibit 5: PaaS Workloads: Private Cloud up slightly on a number basis (declining on a % of total workloads basis) vs. Public Cloud accelerating



Percentage information reflects Cisco's forecast of the following workloads IaaS – Public Cloud, IaaS – Private Cloud, PaaS – Public Cloud, PaaS – Private Cloud, and Traditional. This forecast excludes Cisco's estimate for SaaS workloads.

Source: Cisco Global Cloud Index, October 2015.

(2) **Private cloud will be used for making traditional more efficient, in addition to new workloads –** However, there is an opportunity for traditional infrastructure to transform into private cloud. Overall we expect that the overall spilt will be 50% public cloud, 30% private cloud and 20% traditional over the next 5-10 years.

(3) **As a vendor offering, managed private clouds should be less profitable than public cloud when both reach scale at peak efficiency –** Many investors ask why Amazon AWS does not offer a managed private cloud (beyond the CIA). Because public clouds are typically more efficient due to extreme scale, we believe large tech vendors are less incentivized to offer a managed private cloud offering. While this is not a perfect comparison since Rackspace mostly offers managed virtualized or traditional environments (rather than private cloud) and public cloud, we note that AWS's CY15 operating margins are 24% versus Rackspace at 10% on a GAAP LTM basis.

(4) **VMware, Red Hat, Oracle and Microsoft's private cloud offerings help preserve their core businesses from moving onto public cloud, and should see some uplift for new products –** For public company private cloud vendors, most private cloud offerings will preserve their core products as many customers will already be on ELAs, and create a slight uplift from new products and associated pull through. This is most relevant to VMware, where they are the market share leader in traditional environments, but the top three public cloud vendors (Amazon AWS, Microsoft Azure, Google Cloud Platform) do not use VMware as their virtualization layer. There is a neutral impact to Red Hat and Oracle as customers can bring their own current license to all major public and private clouds. This is least relevant to Microsoft, as customers can run public cloud workloads on Microsoft Azure.

Impact to our coverage universe

As private cloud workloads are expected to gain 5pts of share to 19% of total workloads in CY19 (Cisco Cloud Index), we view Microsoft, Red Hat, and VMware as best positioned with the most fleshed-out and well-positioned private cloud software stacks. This should help preserve a percentage of the revenue streams of their existing related businesses (Microsoft Server and Tools 25%, Red Hat infrastructure 73%, VMware vSphere 40%), as enterprises can continue to use these products on private cloud rather than risk being displaced if the workload instead migrated to the top three public cloud vendors (Amazon AWS, Microsoft Azure, Google Cloud Platform). Private cloud is expected to be a smaller mix of workloads than public cloud and traditional infrastructure over the next four years, as public cloud is expected to gain 15pts of share to 53% of total workloads in CY19. And beyond their core database and middleware businesses, we see Oracle's private cloud strategy as still evolving and see them focusing more on workload migration to PaaS and SaaS.

- **VMware (VMW, preserves vSphere business (about 40% of revenue or $2.6bn in CY15), attach of vCloud (likely less than 20% of revenue or less than $1.2bn in CY15) plus indirect positive through Pivotal ownership)**
    - Net for net, private cloud has a neutral to slightly negative impact to VMware's core virtualization business (around 40% of revenue).
    - While VMware is the number-one cited vendor for private cloud IaaS (Exhibit 12), we believe most customers will view a VMware private cloud (not overall private cloud) as a way to make their existing infrastructure more efficient, rather than creating a platform for net new applications. And despite our positive view that most VMware private clouds will use VMware's vSphere hypervisor as its virtualization layer (similar to traditional), this implies that IT spend on vSphere for private clouds is unlikely to increase materially because most will likely migrate applications using the same (or perhaps fewer) licenses than what they were using in their traditional environment.

  - Therefore, VMware will need to see a higher attach rate of additional products in order to accelerate from its CY16E revenue growth forecast of 2-5% yoy in constant currency. In private cloud, customers can purchase vCloud Suite (which includes vSphere, vCenter Site Recovery Manager, and vRealize), VMware's management tools, and its software-defined networking solution NSX.
  - VMware also has a minority share in Pivotal, whose Pivotal Cloud Foundry PaaS software is often cited as a top choice for private cloud PaaS. This is net new revenue for Pivotal.
  - In addition, as discussed in our Cloud Platforms Volume 1 report in January 2015 and earlier in this report, VMware is seeing pressure as customers are placing net new workloads onto public clouds, where the top three vendors, Amazon AWS, Microsoft Azure, and Google's Cloud Platform, do not use VMware as their virtualization layer.

- **Red Hat (RHT, preserves their infrastructure businesses (73% of total CY15 revenue), positive impact from OpenStack/OpenShift (likely less than 5% of LTM revenue))**
  - For Red Hat's infrastructure business, which includes Red Hat Enterprise Linux (RHEL, server operating system) and related businesses, we believe Red Hat will see a similar neutral impact as public cloud, where users can use their existing RHEL (Red Hat Enterprise Linux) licenses in a private cloud environment, similar to how they use them in their traditional on premise environment. Many enterprises adopting private cloud are typically larger enterprises with significant traditional onpremise environments who likely already have enterprise agreements with Red Hat, resulting in a neutral impact. However, unlike public cloud, we do not believe that there will be more net new growth than already expected versus public cloud, because public cloud exposes Red Hat to net new customers, mostly SMBs.
  - Red Hat OpenStack (IaaS) and Red Hat OpenShift (PaaS), which is roughly likely less than 5% of Red Hat's revenue, is a positive impact to Red Hat as it is net new revenue, which also helps drag along sales of additional Red Hat products such as RHEL and Red Hat Enterprise Virtualization (RHEV).
- **Oracle (ORCL, preserves database business, roughly 50% of license and maintenance or about 35% of total revenue based on Gartner's DBMS estimate)**
  - Like Red Hat, customers can use Oracle databases on all major public or private clouds. And also similar to Red Hat, most large enterprises who would be interested in creating a private cloud likely already have large enterprise agreements with Oracle. Because customers can use their existing license in their traditional environment on private and public clouds, we see private cloud as having a neutral impact to Oracle.
- **Microsoft (MSFT, preserves Microsoft workloads (Server and Tools was about 25% of CY15 revenue), good for workloads that need to be shifted between on and off premise environments)**
  - Microsoft's private cloud solution is a combination of three pieces of software, Microsoft System Center (IaaS and management software), Windows Server (server operating system) and Hyper-V (virtualization, Hyper-V is free with the purchase of Windows Server 2012 R2). They also offer Azure Pack, software that allows customers to integrate Windows Server, System Center, and SQL Server to create private cloud IaaS, PaaS, and database as a service for no additional cost. Microsoft often discusses its ability to have seamless management and deployments in hybrid cloud environments. Microsoft System Center lets users provision, automate and monitor workloads on private cloud and Windows Azure, in a consistent management environment.

- **Rackspace (RAX, positive impact, private cloud less than 1% of revenue but growing high-double digits)**
  - Rackspace offers four managed private cloud offerings (VMware vCloud, Microsoft Cloud Platform, Rackspace OpenStack or Red Hat Enterprise Linux OpenStack). While Rackspace expects growth in their managed OpenStack public cloud to slow in CY16 (4Q15 earnings call), they are seeing high double digit growth in their managed OpenStack private cloud business. While we view managed private cloud as a growth driver for Rackspace, in our surveys we have found that most users prefer to consume OpenStack as software, not as a fully managed service from a third party (Exhibit 19).

Exhibit 6: Summary of the impact to our coverage universe
Blue highlight = high market share (if available) or a top private cloud survey result (pages 13-17, 25)

	RHT	VMW	ORCL	MSFT	RAX	Private Companies
Revenue Exposure to Cloud Platforms	73%	40%	35%	25%	<1%	
Private Cloud Software						
IaaS: Private Cloud Software	RHEL OpenStack	vCloud Suite, vRealize, VIO, NSX	OpenStack for Oracle Linux	System Center, Azure Pack	OpenStack Private Cloud	Mirantis
Virtualization	RHEV	vSphere	Oracle Virtual Machine	HyperV		
Automation / Configuration	Ansible	vRealize Automation		System Center		Chef, Puppet, Docker
Dashboard / Management	CloudForms	vRealize Operations, vSOM		System Center, Azure Pack		
PaaS: Private Cloud Software	OpenShift	Pivotal Cloud Foundry		System Center, Azure Pack		Pivotal Cloud Foundry (EMC/VMW)
PaaS: Operating System	RHEL		Oracle Linux	Windows Server		
PaaS: Database			Database	SQL Server		
PaaS: Middleware	JBoss		Fusion Middleware			

Source: Goldman Sachs Investment Research.

What is private cloud?

Many users describe private cloud as having an Amazon AWS-like environment within their data center, automating the request and delivery of infrastructure to developers. This includes requesting compute or virtual machines (packaged to include the servers, storage, networking, and often virtualization software or hypervisor layer), specific operating systems, databases, middleware and more. There are five main attributes most vendors and industry analysts require to characterize the underlying infrastructure as private cloud – self-service, dedicated environment, cost allocation, speed, uniformity, and scale. However, we note that reporters, generalists, and sometimes customers often use the term private cloud and traditional IT infrastructure synonymously, and we suggest readers dig into each reference to make sure it is truly a private cloud environment. We explain each attribute from a user's point of view in Exhibit 7.

Exhibit 7: Private cloud attributes

Attribute	Prior to creating an application, a software developer should be able to:
Self-Service	(1) Request infrastructure needed for the application
Dedicated Environment	(2) The infrastructure must be a closed environment dedicated to the organization
Cost Allocation	(3) Allocate the cost to their department/business unit
Speed & Uniformity	(4) Within minutes or hours (versus days or weeks traditionally), developers receive the infrastructure necessary, which is uniform with what other developers receive, with minimal to no interaction with the operations team
Scale	(5) The infrastructure should be able to scale as the application grows

Source: Goldman Sachs Global Investment Research.

Benefits of private cloud versus public cloud

Public and private clouds share similar benefits, such as scalability, shorter implementation times, and easier future updates and management. However, organizations that choose to build a private cloud mainly do so for control/agility and regulatory or security needs, which we outline in Exhibit 8. For more detail on public cloud benefits, please see our *Cloud Platforms Volume 1* report from January 13, 2015.

Exhibit 8: Benefits of private cloud versus public cloud

Benefit	Example(s)
Regulatory/ Security	• Humana decided to not use public cloud due to HIPAA concerns, which is why they chose to build a private cloud on premise using Cloud Foundry, also giving them the ability to scale internally and have control (Source: Cloud Foundry Summit, May 2015) • General Electric is migrating most of their workloads to Amazon AWS, except for their "secret sauce", which they plan to keep on premise (Amazon re:Invent, October 2015)
Control/ Agility	• FICO decided to build their own private cloud over using a public cloud provider because they would have "control over its destiny and infrastructure direction," plus expand and issue new features while meeting their customers requirements (Source: FICO Blog, June 2014)

Source: Goldman Sachs Global Investment Research.

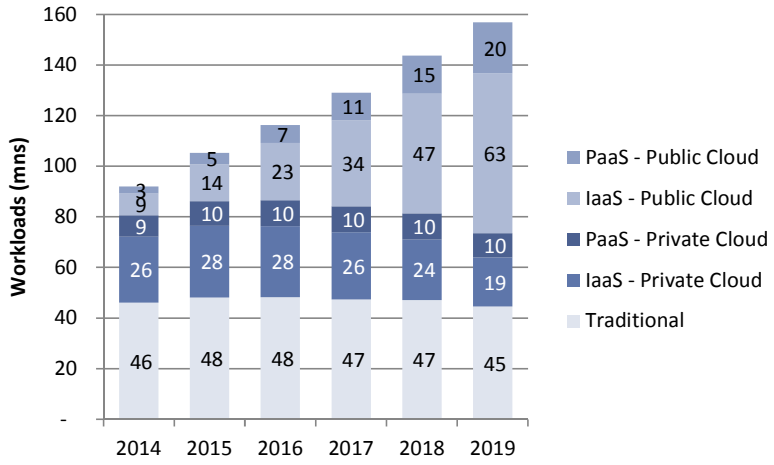
We expect private cloud to be roughly 20% of overall workloads over the next 5-10 years

Many legacy technology vendors have pointed to private cloud as their vehicle for growth the last couple of years. But with enterprises spending more on public cloud, we examine the true potential for private cloud. Overall, we expect that the overall spilt between platforms will be 50% public cloud, 20% private cloud and 30% traditional over the next 5-10 years, similar to Cisco's forecast (Exhibits 9-10). This is also based on commentary from enterprises and technology vendors, including the following:

- Cisco Global Cloud Index forecasts a 53% public cloud / 19% private cloud / 28% traditional split in CY19
- General Electric plans "to move 60% global workload into AWS"
- Coca-Cola expects 50% of workloads will run in the public cloud
- Johnson & Johnson expects 85% of their workloads will be in a private cloud and 15% will remain legacy
- Vendor Mirantis believes 50% will run in the public cloud
- IDC believes that by 2018, at least half of IT spending will be cloud based

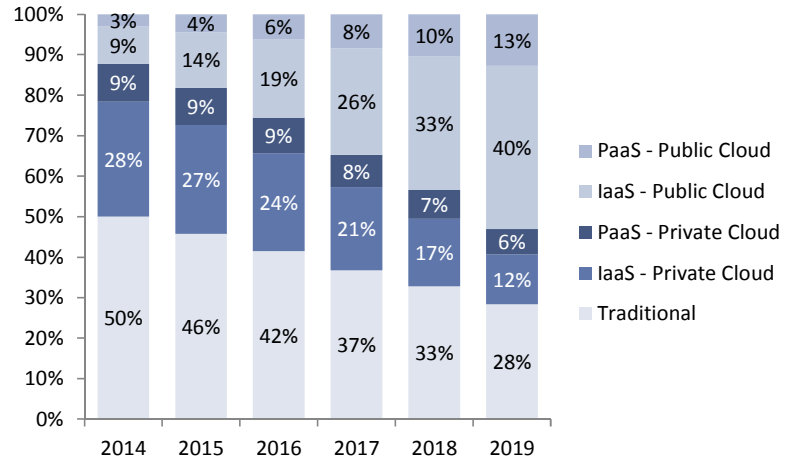
While Gartner and IDC have not released private cloud TAM estimates, we note that IDC expects the hosted private cloud market (a portion of overall private cloud, where vendors like Rackspace sell managed private cloud environments to customers) to grow from $9bn in CY14 to $41bn in CY19.

Exhibit 9: Workloads by type 2014-2019



Source: Cisco Global Cloud Index, October 2015.

Exhibit 10: Mix of workloads 2014-2019

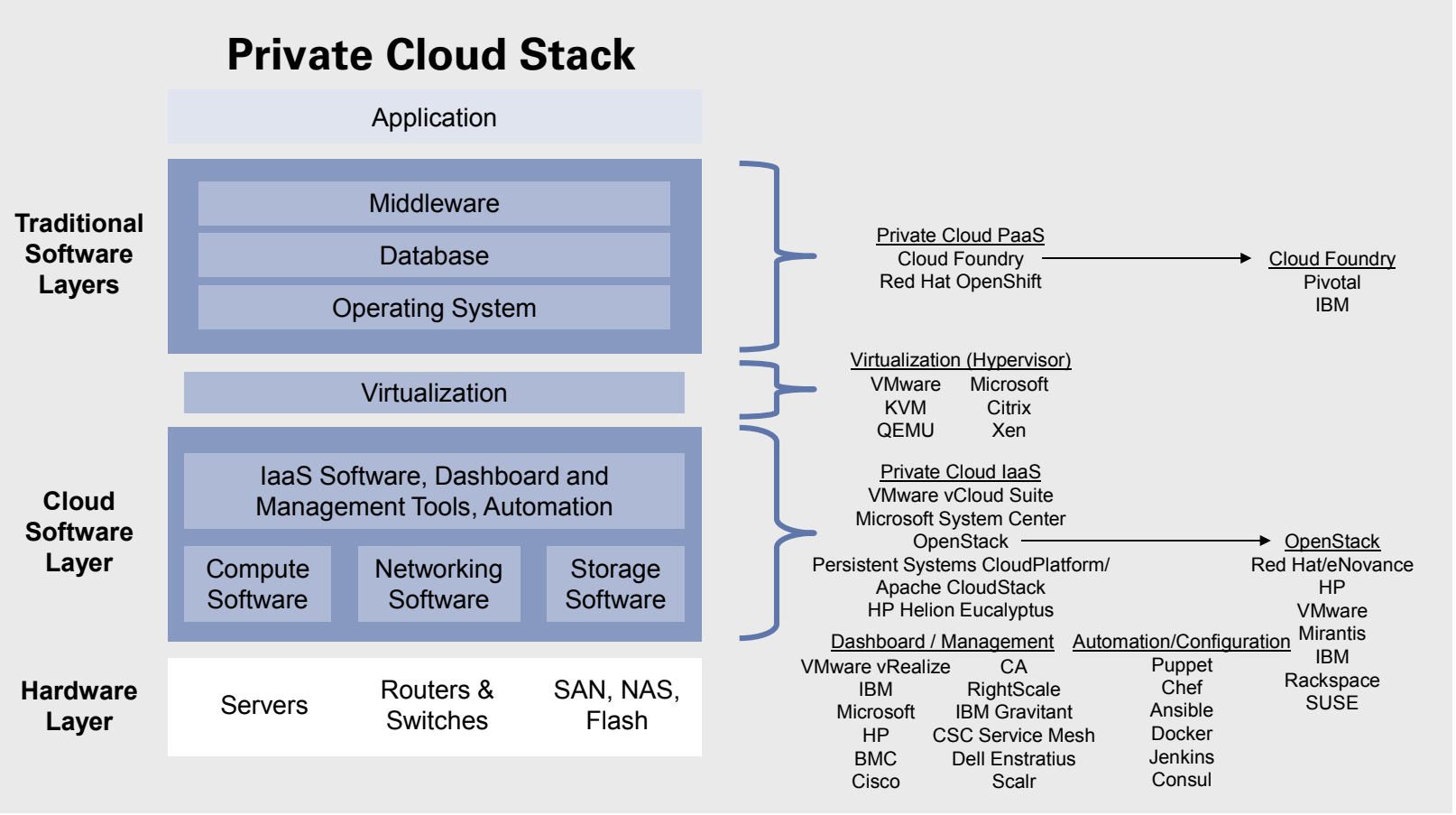


Source: Cisco Global Cloud Index, October 2015.

Private cloud components

We believe there are five major software components that enable a private cloud: IaaS software, PaaS software, virtualization software, automation and orchestration software, and dashboard and management tools. We describe each on the following pages, and take an in-depth look at the two most popular private cloud IaaS and PaaS technologies, OpenStack and Cloud Foundry. We note that HP Enterprise recently announced that they would exit their public cloud offering on January 31, 2016, and double down on private and managed cloud capabilities.

Exhibit 11: Private cloud components

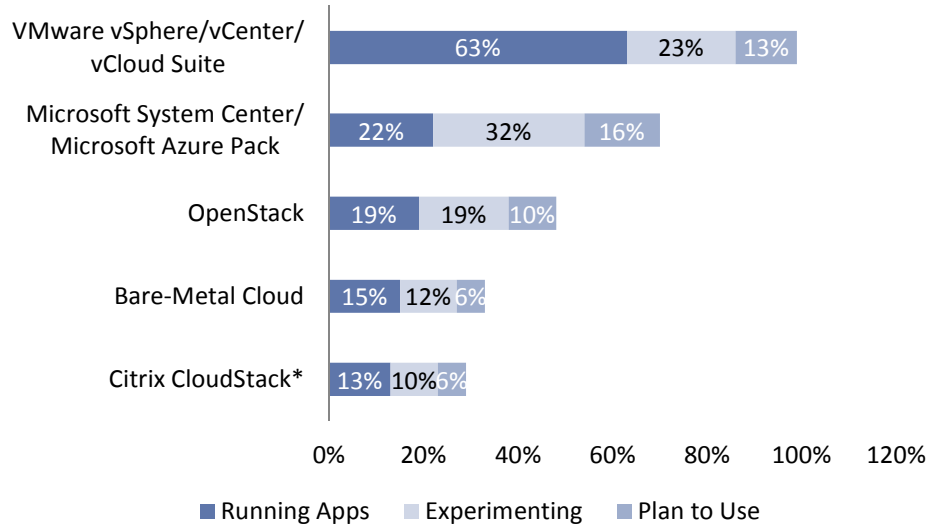


Source: Goldman Sachs Investment Research.

Private cloud IaaS (Infrastructure as a Service) software

This foundational software layer is essentially a control layer for an organization's private cloud. Users are able to control the underlying hardware (compute, networking and storage), for example, spinning up a new virtual machine, or managing the network. This software can be combined with software defined networking software or virtual storage software to create. This software also helps create the self-service web portal where developers can request a virtual machine, database and more. We found that VMware, Microsoft, OpenStack, and Citrix CloudStack (Citrix's CloudPlatform is powered by Apache CloudStack; Citrix announced on January 11, 2016, that CloudPlatform would be acquired by Persistent System's products business, Accelerite) are the most popular products, as evidenced by RightScale's 2016 State of the Cloud Report.

Exhibit 12: Percent of respondents running applications on each type of private cloud



*The paragraph above this exhibit provides further detail on CloudStack and how Citrix's platform was acquired by Persistent Systems.

Source: RightScale State of the Cloud Report, 2016.

Private cloud PaaS (Platform as a Service) software

The private cloud PaaS layer operates similar to public cloud PaaS, where the software sits on top of the IaaS layer and helps automate portions of the application creation, deployment and monitoring processes. It speeds up the time it takes to create an application and lets developers focus on writing code instead of building out the software infrastructure needed for the application to run.

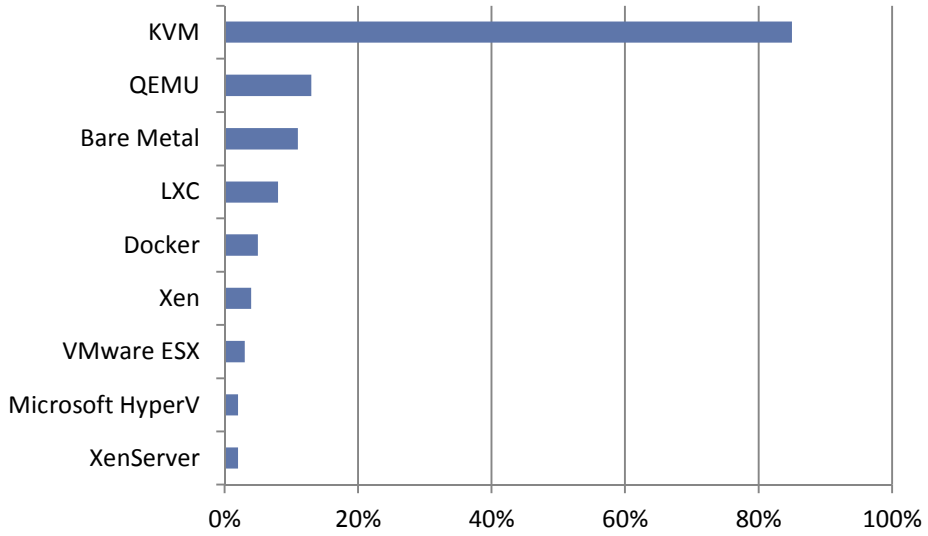
Why do organizations need this additional layer? The code that developers write when creating an application is just one part of the overall process of creating an application. PaaS software would then automatically figure out what language the code was written in (Ruby, Java, PHP, etc.) and package that code up with the additional code needed for the application to execute (runtimes) usually inside of a container. The application then needs to interact with end users, so the PaaS layer helps route the traffic to the correct container. Finally, the PaaS layer monitors applications to make sure they are running properly and have enough resources. Having this software saves developers and operations personnel time making sure all of these components work, especially as the application evolves from test to production.

The two most popular private cloud PaaS layers include Cloud Foundry (according to data from Garnter, the two most popular commercial versions are from Pivotal and IBM) and OpenShift (Red Hat). Popular public cloud PaaS vendors include Amazon AWS's Elastic Beanstalk, salesforce.com's Heroku, and Google App Engine.

Virtualization software

Prior to the emergence of virtualization software, organizations used to run one application or workload per server. With a virtualization layer (hypervisor), organizations can run 11 workloads per server on average (Gartner, December 2014), lowering hardware costs. In the traditional infrastructure world, x86 servers are roughly 75% virtualized (Gartner, July 2015) and VMware has the largest share by installed virtual machines at 70% (Gartner, July 2015). On a shipment basis, IDC estimates that VMware has a 47% share versus Microsoft at 30% (September 2015). In private cloud, organizations using VMware vCloud would also use VMware's hypervisor. However, for the second most popular private cloud IaaS software, OpenStack, the majority of organizations use the free open source virtualization software, KVM.

Exhibit 13: Hypervisor used in production on OpenStack workloads
OpenStack User Committee Survey – Spring 2015



Source: OpenStack User Committee Survey, Spring 2015.

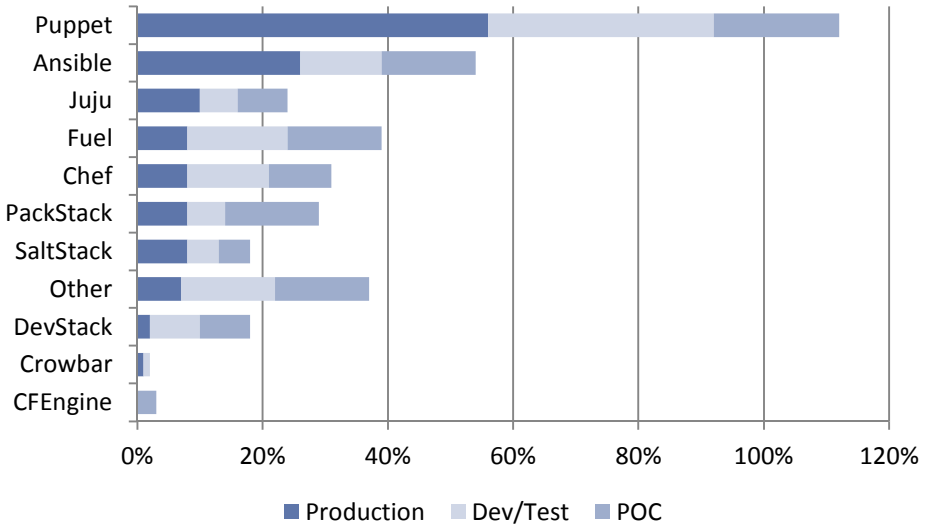
Automation software

Automation, configuration and orchestration tools help automate the process of provisioning servers, storage, and other hardware components, as well as helping to launch new virtual machines in a uniform and automatic manner, instead of manually provisioning every time a new virtual machine or piece of hardware needs to be added. The end result is that it takes hours or days to give a developer the virtual machine they need versus weeks or months in a traditional environment.

This software also helps ensure uniformity within the cluster, where each compute node has the same version of virtualization software, operating system, etc. This is optimal for IT departments, as it is easier to update the cluster when there are security patches or major version upgrades.

According to a survey by the OpenStack User Committee, Puppet and Ansible (Ansible was acquired by Red Hat in October 2015) are top tools used for OpenStack private cloud deployments.

Exhibit 14: What software tools are you using to deploy or configure this OpenStack cluster?
OpenStack User Committee Survey – Spring 2015



Source: OpenStack User Committee Survey, Spring 2015.

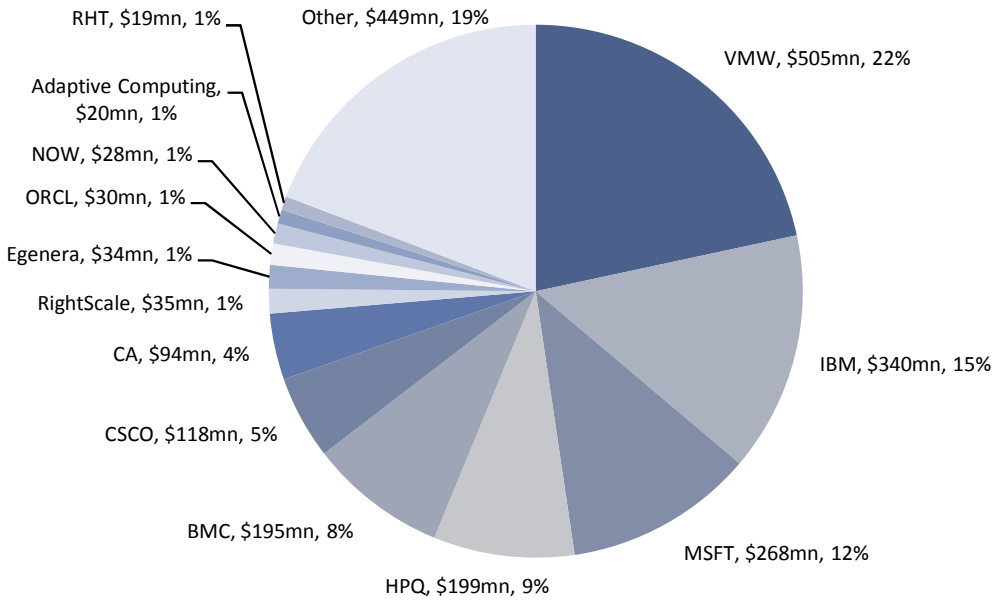
Dashboard and management tools

This layer of software typically refers to software that enables multiple components, including the following.

- Cost allocation/chargeback – when developers request new virtual machines, databases, more storage, or other options, costs can be allocated by department
- Monitoring – dashboard software that monitors consumption and the health of components of the cluster
- Alerting – users can set up alerts to warn them if elements of the cluster hit certain limits, for example, if storage for a specific application is almost at the total amount allocated
- Predictive capabilities – the software attempts to anticipate and warn users of upcoming issues (i.e., warns users of under-provisioned resources)

IDC released their market share forecast for top cloud systems management software, which showed VMware as the top share leader with $505mn in revenue or 22% share, followed by IBM at $340mn or 15% share, and in third was Microsoft with $268mn and 12% share (Exhibit 15)

Exhibit 15: Cloud Systems Management market share, 2014



Source: IDC, June 2015.

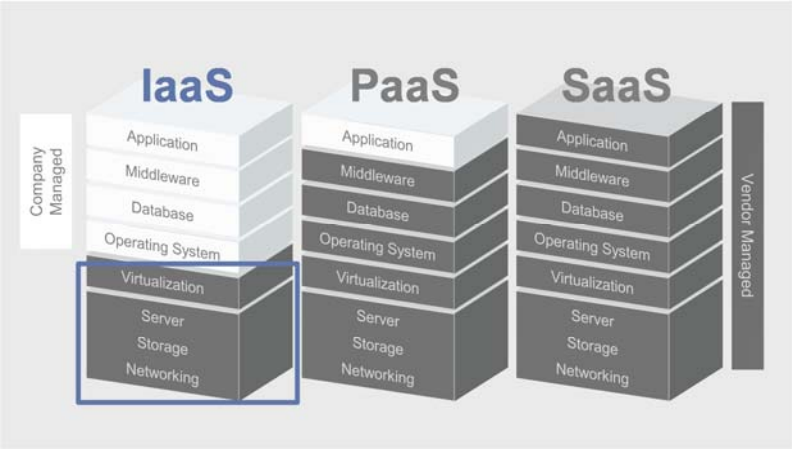
OpenStack 101

OpenStack is free, open source infrastructure software that is mainly used to create a private cloud. OpenStack started as a technology project co-founded by Rackspace Hosting and NASA in 2010. Since then, it has grown to encompass a global community of 28k developers and users in the OpenStack Foundation. The foundation governs the technical direction of the code, as well as promoting the adoption of OpenStack.

OpenStack is IaaS software, and an indirect alternative to Amazon AWS

In our report, *Cloud Platforms – Volume 1: Riding the Cloud Computing Wave*, we detail the three main types of cloud architectures, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). OpenStack is a type of IaaS, and is a software layer that is primarily used to manage the foundational components of a private or public cloud – compute, storage, and networking.

Exhibit 16: Infrastructure as a Service



Source: Goldman Sachs Investment Research.

ROI for OpenStack deployments

Cost savings on hardware

- AT&T believes they can save double digit billions in capex and opex by moving to private cloud. This includes lower hardware costs, where the company can use commodity boxes instead of proprietary Cisco hardware
- With OpenStack, Walmart Labs uses new servers that are 50% cheaper than what they typically invest in and are 2x more powerful
- With Red Hat OpenStack, Dualtec saw a 25% cost reduction in hardware in addition to efficiency gains

Reducing the time to provision a server and other infrastructure

- PayPal developers can log into a dashboard and get the compute, load balancer, database, all within minutes when they need it
- Walmart Labs lowered their turnaround time (to provision servers/infrastructure) from 90 days to provision one server from 19 machines provisioned per minute
- Intel was able to reduce the time to provision a server/compute from 120 days to under one hour
- For Volvo it now takes seconds to add a new virtual machine versus minutes or days on VMware or Microsoft HyperV

Cost savings on IT headcount

- Intel was able to increase the ratio of servers to engineers who support them
- FICO was able to reduce staff by 20%

Increased security and control

- FICO is able to stay PCI compliant for their hardware, and keep sensitive data secure. And with more control, FICO is able to expand whenever customers need it

Avoiding vendor lock in

- TD Bank chose Rackspace's OpenStack private cloud because it gave them flexibility and freedom from vendor lock in

We profile seven companies that use OpenStack

AT&T

Used For: AT&T will likely become the largest OpenStack environment in the world, as they expect to build out their private cloud to 500k nodes (servers) and span across hundreds of data centers. AT&T hopes to run every call through its OpenStack infrastructure by 2020. They expect to have the first 60 data centers up and running by the end of 2015.

Benefits: The company believes they can take out double digit billions in capex and opex from moving to private cloud as they can use commodity pizza boxes instead of proprietary Cisco boxes. This saves billions in capex. This also saves opex because the entire infrastructure will be automated, helping AT&T operate at a faster pace and bring in new services, which is easier to do when they are software based.

Technology used: Mirantis. AT&T evaluated Red Hat, VMware and HP, but eventually the decision came between Mirantis and Red Hat. Ericsson is going to be Mirantis' systems integration partner (SDX Central, August 2015).

eBay and PayPal

Used for: By March 2015, all of PayPal's front and mid-tier was running on OpenStack, and 20% of eBay.com was running on OpenStack. In addition, 100% of development and test work is done on OpenStack

Penetration: eBay and PayPal have grown their OpenStack nodes from 300 in 2012 to roughly 12k in spring of 2015 (as of May 2015). While we do not have the exact percentage of eBay's and PayPal's total infrastructure, we note that InformationWeek in March 2015 reported that PayPal had 4k servers on OpenStack and while OpenStack represents 100% of their "traffic serving, Web/API applications, and mid-tier services at PayPal…[they were] careful to note that a few legacy systems remain in place."

Benefits: Their developers like OpenStack because there is no wall between developers and the infrastructure. They can log into a dashboard and get the compute, a load balancer, and/or a database, all within minutes when they need it.

Challenges: They noted that OpenStack is not a cloud in a box, it is cloud controller software. They realized that they needed to add automation at scale, so they could keep thousands of hypervisors in sync with one another (same setup, same version, same patching, etc).

Technology used: We note that the PayPal switch from VMware to Mirantis OpenStack has been widely publicized since Forbes reported that this migration might occur back in March 2013.

Walmart Labs

Used for: OpenStack was used as the underlying infrastructure for Walmart.com during Black Friday and Cyber Monday in 2014. It handled 1.5bn page views with zero downtime. Walmart Labs needed a more agile way to deploy infrastructure, improve their automation, and make their IT more self-service.

Penetration: OpenStack is running in six data centers on 555 hypervisors.

Benefits: (1) hardware savings – using new servers that were 50% cheaper than what they typically invest in and are 2x more powerful, (2) fast turnaround times to provision servers/infrastructure – they lowered the 90 day turnaround time to provision one server down to 19 machines provisioned per minute, (3) chargeback model adds accountability – developers can use capacity without general downward pressure on usage.

Challenges: IT had become comfortable not knowing exactly where everything is running (e.g., what server their app is running on).

Technology used: WalMart Labs has not disclosed if they use a commercial version of OpenStack that they manage themselves, or a commercial vendor like Red Hat or Mirantis. They use CentOS, Ubuntu and Red Hat Enterprise Linux as their operating systems. Walmart Labs acquired OneOps in 2013 and use it as their PaaS layer. They had previously used Chef, Puppet, Ansible, and SaltStack as configuration and automation tools.

Intel

Used for: Intel uses OpenStack as the control plane software for their private cloud to host new applications (mix of development and production workloads). They noted that they are not migrating any applications that are running today.

Penetration: They estimate 60% of their workloads are transient, or workloads prior to production. They realized that they did not need to run these workloads on their most expensive infrastructure, and some of it can be used on OpenStack. The other 40% are multi-year, stable workloads. By the end of 2016, they plan to have fully automated architecture, with instant fulfillment of 90% of service requests.

Benefits: (1) Intel is able to leverage OpenStack to reduce vendor lock in, (2) they reduced time to provision a server/compute from 120 days to under one hour, and (3) are able to increase the ratio of servers to engineers who support them.

Challenges: Change in type of IT staff needed - Intel noted that it was challenging to transform the workforce from those who had specific skills on proprietary hardware and tools to general large scale systems management and software engineering.

Technology used: They started using OpenStack with VMware's hypervisor, EMC VNX storage and SDN software for networking; they then expanded using KVM as their hypervisor, EMC VNX and Red Hat Inktank Ceph for storage, and SDN for networking. In August 2015, Intel Capital led Mirantis's latest $100mn funding round.

FICO

Benefits: (1) Reduced costs and increased sales–reduced staff by 20%, and drove more than $10mn in sales. (2) Security – FICO is able to stay PCI compliant for their hardware, and keep sensitive data secure. (3) Control – FICO is able to expand when customers need it.

Technology used: Red Hat Enterprise Linux OpenStack.

Volvo

Used for: A total of 40 new and migrated apps. They chose applications that could easily move to the cloud across different segments of the company. WirelessCar joint venture's web based call center tool, mobile apps, connected truck services, fleet management software.

Penetration: Uses OpenStack for 1% of their applications (40 of 4k).

Benefits: Seconds to add a new virtual machine versus minutes or days on VMware or Microsoft HyperV.

Challenges: Restricts some of the developers' flexibility in how they want to write their apps.

Future: Over time they plan to expand their Amazon AWS plus OpenStack environment to half of workloads.

Technology used: Uses a combination of open source plus Red Hat OpenStack for its private cloud, Amazon AWS for public cloud, VMware for their core on-premise infrastructure, Red Hat Enterprise Virtualization for their hypervisor, and Red Hat OpenShift and Docker for their Platform as a Service layer. They also use Puppet, Jenkins, and HashiCorp Packer for configuration and automation, and AlgoSec for network security policy management.

Target

Used for: Mostly non-production workloads (also production workloads) on bare metal.

Penetration: The company has two main data centers, roughly one third of each is OpenStack.

OpenStack Alternative: If they were not using OpenStack, they would have run the workload on Microsoft HyperV.

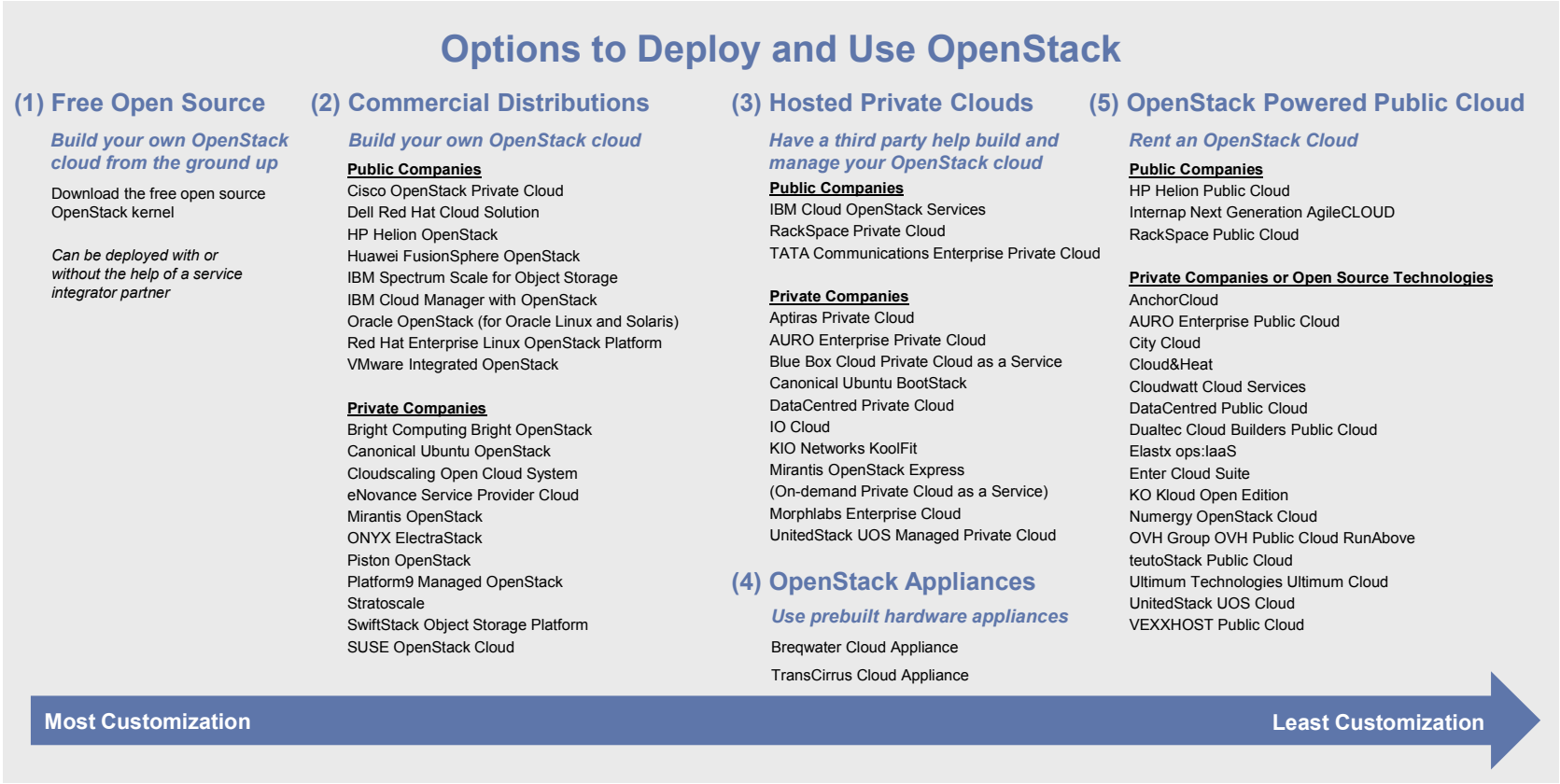
Challenges: The company noted that VMware is excellent when a server goes down because it automatically re-distributes the load among other servers, which does not happen on OpenStack. Therefore developers are forced to write that into the application. They said that with workloads on the public cloud, it is better that they start to write it into the app, because the company does not have 100% certainty whether the public cloud vendor will automatically re-distribute the load.

Technology used: Red Hat Enterprise Linux OpenStack.

Options to deploy and use OpenStack

Users can get started using OpenStack in five ways: (1) download the source code (kernel) for free, (2) use a commercial distribution of OpenStack (Commercial versions of OpenStack have the free open source OpenStack kernel at its core. Vendors then add components to make it their own, for example, adding code to make the distribution more stable, more secure, and fixing any bugs they find. Some will swap out components, such as storage or networking with their own software, (3) work with a company that can manage and host an OpenStack private cloud for the company, (4) use OpenStack appliances, (5) if users want to use OpenStack but do not want to be responsible for the hardware, software and networking, users could use an OpenStack powered public cloud. The difference between the five options is the degree of customization and control over their OpenStack cloud.

Exhibit 17: OpenStack distributions and hosted private clouds



We include HP Enterprise Helion OpenStack in this exhibit. While HPE is ceasing their public cloud products, they are continuing to invest in their private cloud products, like Helion OpenStack.

Source: OpenStack Marketplace website as of 8/20/15 and Goldman Sachs Investment Research.

Major components of OpenStack

Users can use one or all of each OpenStack project. We discuss the five most popular components of OpenStack – dashboard, compute, networking, object storage, and block storage.

Exhibit 18: Popular OpenStack components

Type of Software/ OpenStack Project	Description	Public Cloud Alternative / Partner
Dashboard / Horizon	A web portal developers can access to launch an instance	For public cloud vendors, this is included in Amazon AWS, Microsoft Azure and Google's Cloud Platform
Compute / Nova	Software is used to create, schedule and decommission virtual machines. This can be used on bare metal or on a hypervisor (virtualization layer)	The public cloud alternative is Amazon AWS EC2, Microsoft Azure Compute, and Google Compute Engine
Networking / Neutron	An API for software defined networking (SDN) software. Users can configure and manage a network based on the underlying SDN software.	Neutron is complementary to SDN software vendors such as Cisco Application-Centric Infrastructure (Cisco ACI) and VMware NSX (acquired Nicira)
Object Storage/ Swift	Similar to a file system, this software controls how data is stored and accessed. It can scale out to 100's of petabytes, and is designed for massive concurrency. Users can use inexpensive physical storage	The public cloud alternative is Amazon AWS S3
Block Storage / Cinder	Users can connect Cinder to a Nova virtual machine and Cinder acts as an attached hard drive. Compared to Swift, Cinder has lower latency and can be used as a data store for a database.	Cinder can be used with software and hardware such as Red Hat Inktank (Ceph) and SolidFire.

Source: Goldman Sachs Global Investment Research and OpenStack Summit.

Our survey shows that 60% of CIOs polled are using OpenStack today, and 80% expect to use OpenStack in three years

We surveyed 100 CIOs in August 2015 about their use of OpenStack. We asked which company's product respondents are currently using and which vendors they plan to use three years from now. There were four main takeaways.

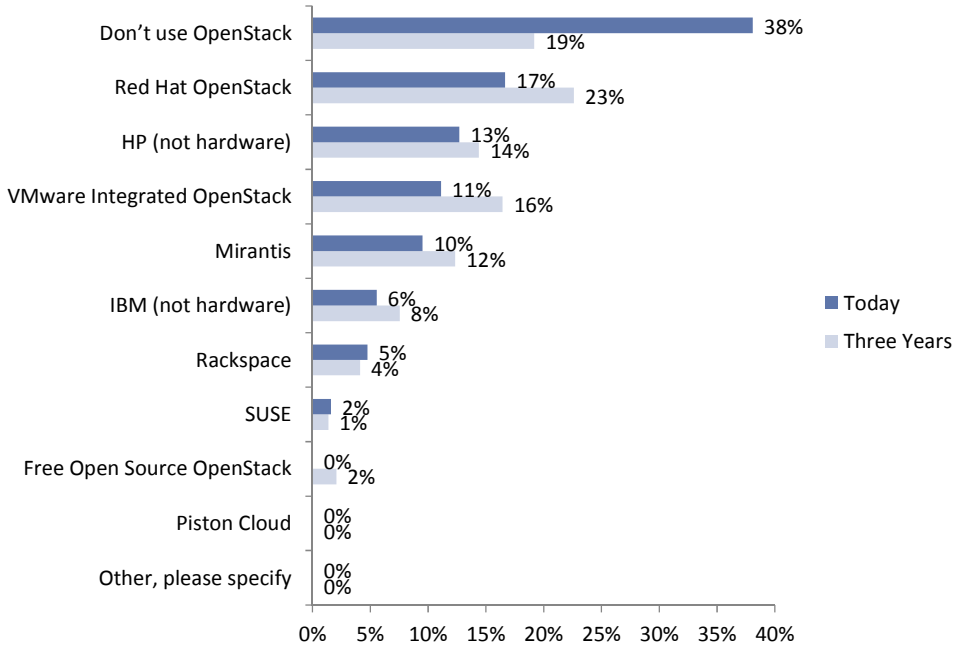
(1) While 38% of respondents are not currently using OpenStack, only 19% expect this to still be the case three years from now.

(2) The vast majority of CIOs using OpenStack opt for a commercial version instead of the free, open source version.

(3) Red Hat's OpenStack offerings are currently the most popular OpenStack deployment in use with 17% of responses today (Red Hat OpenStack plus their acquisition of eNovance), and 23% expect to use Red Hat over the next three years (19% Red Hat OpenStack plus 4% eNovance).

(4) The only vendor expected to see a larger share gain is VMware, whose share of responses is expected to increase 500bps from 11% today to 16% in three years. This is surprising since VMware's 1.0 version became generally available just 5 months ago (3/16/15). This compares to Red Hat Enterprise Linux OpenStack which became generally available on July 2013.

Exhibit 19: Which OpenStack vendor(s) are you using today for software and services, and which vendor will you use in three years?



Source: Goldman Sachs Global Investment Research CIO Survey August 2015.

We compare the most popular commercial OpenStack distributions

We compare the five most popular distributions of OpenStack below.

Red Hat Enterprise Linux OpenStack Platform

Management believes OpenStack and OpenShift are hitting a tipping point in 2015, as early adopters start to move from testing to production environments. Red Hat's version has been available for over two years now (generally available on July 10, 2013).

Customers: FICO, Volvo (40 apps), Target (about one third of workloads).

Differentiators: Management believes that there is significant value in closely pairing OpenStack with the operating system, and the virtualization layer, differentiating themselves from competitors. For example, if there was a security vulnerability in the Linux operating system, like the ghost bug in early 2015, a customer using OpenStack alone would not be able to fix the issue, but if they used both Red Hat OpenStack and RHEL, Red Hat would be able to quickly identify and patch the issue.

Dedicated OpenStack Engineers: Red Hat has several thousand certified OpenStack engineers, and anticipated ending 2015 with 10k (this compares to 70k total Red Hat certified engineers), as the lack of qualified OpenStack talent has been an inhibitor to adoption of the technology. Red Hat is focused on making OpenStack easier to consume and is devoting 100 engineers to work on just the configuration portion.

Pricing model: The annual subscription cost for RHEL OpenStack Platform Standard is $3,449/socket-pair/year (Premium is $4,499/socket-pair/year).

Competition: In April 2015, Red Hat believed their biggest competitor for OpenStack is HP, mostly due to its size. HP has since decided to cease operations of its public cloud but to double down on its private and managed cloud in November 2015.

Partners: CSC has a Big Data PaaS that bundles Red Hat Enterprise Linux OpenStack with commodity hardware. Dell and Red Hat are collaborating to offer an integrated OpenStack offering for private cloud deployments. In January, Google announced they would support Red Hat's OpenShift. Google started supporting Red Hat Enterprise Linux in December 2013.

Hewlett-Packard Enterprise (HPE) Helion OpenStack Private Cloud

On October 22, 2015, HP announced it would cease HP Helion Public Cloud on January 31, 2016, as customers state that the "lines between all the different cloud manifestations are blurring." HP is starting to partner with public cloud vendors like Microsoft Azure (December 1, 2015), and is instead doubling down on private and managed cloud. HP OpenStack is one of those private cloud offerings. In in September 2014, HP acquired Eucalyptus, which offered a private cloud for Amazon AWS.

HP's OpenStack Cloud has been generally available since October 2014. We also note that HP Enterprise also has a cloud foundry solution named HPE Helion Stackato.

Customers: DreamWorks, Ormuco.

Differentiators: Customers can use HPE across private, hybrid, managed and public clouds and leverage HPE's professional services staff.

Pricing model: $1,200 per year per server with 9 hours a day, 5 days a week support, $2,200 per year per server with 24x7 support. The OpenStack Community edition is free to download and use, but customers can purchase support for $900 per year per server.

VMware Integrated OpenStack (VIO)

VMware is quickly gaining traction, almost one year after VMware's Integrated OpenStack 1.0 version became generally available in March 2015 (Exhibit 19 provides more detail about our recent survey). Customers have commended VMware on VIO's relative ease of use, some saying they had tried implementing OpenStack for nine months with nothing to show for it, and three weeks after implementing VIO they had a working environment.

Customers: Adobe, Cox Automotive, Nike, Wells Fargo.

Differentiators: (1) VMware customers using vSphere are able to run VIO on their existing vSphere environment. With one of the largest enterprise customer bases at 500k, and a 70% share of the virtualization market (Gartner, December 2014), VMware should be able to leverage their existing relationships to further penetrate this market. (2) VIO is free for VMware vSphere Enterprise plus customers. (2) Users like the ability to use and troubleshoot in familiar VMware tools. (3) Users can also use VMware's software defined networking software (NSX) or VMware's virtual SAN products with VIO.

Pricing model: VIO is free for vSphere Enterprise Plus customers (vSphere Enterprise Plus's list license price is $3.5k per CPU). However, VMware charges $200 per CPU for support. There is a minimum support size of 50 CPUs.

Mirantis OpenStack

Mirantis is a pure play OpenStack company that was founded in 2005. The private company has raised $220mn in funding, with the latest $100mn Series C round raised in August 2015.

Customers: Over 100 OpenStack customers, including AT&T (up to 500k nodes), Verizon, Overture (101-500 nodes), Thales (20-100 nodes), Stratus Technologies (20-100 nodes), Ericsson.

Financials: Mirantis generated $57mn in bookings YTD as of October 2015, up from $34mn in CY14.

Differentiators: Mirantis points to its ability to scale to large deployments and the company's pure-play focus (AT&T's OpenStack deployment is expected to build out to 500k nodes). Mirantis has 800 engineers all devoted to OpenStack, which Mirantis states is more than the competition and has helped to keep Mirantis' tech edge.

Cloud Foundry connection: Mirantis joined the Cloud Foundry foundation in April 2015, but has no plans to build its own Cloud Foundry distribution. Mirantis is instead re-selling Pivotal Cloud Foundry. Cloud Foundry can be used on OpenStack.

IBM Cloud Manager with OpenStack

IBM has evolved their offering to include cloud platform capabilities with their OpenStack distribution, including provisioning and automation, a self-service portal and metering. Customers can also add on IBM's Cloud Orchestrator, to enhance their private cloud deployment. Cloud Orchestrator helps customers coordinate workflows to manage and deploy apps.

Rackspace OpenStack Private Cloud

Rackspace invented OpenStack with NASA in 2010. Unlike the other vendors mentioned above, Rackspace chose to offer OpenStack private clouds as a service, rather than sell OpenStack as a software only distribution. As described earlier in this report, customers can purchase four types of private clouds, including two types of OpenStack private clouds (Rackspace Private Cloud and Red Hat Enterprise Linux OpenStack Private Cloud). The company has 100 managed Rackspace OpenStack private cloud customers (last disclosed June 2014).

As noted earlier in this report, Rackspace's OpenStack private cloud business grew high-double digits yoy in 4Q15 despite management's expectations that their OpenStack public cloud will slow in CY16.

OpenStack Limitations

While OpenStack is starting to hit a tipping point with AT&T deciding to deploy 500k OpenStack nodes, we discuss some of the limitations that are keeping OpenStack from being adopted widely today.

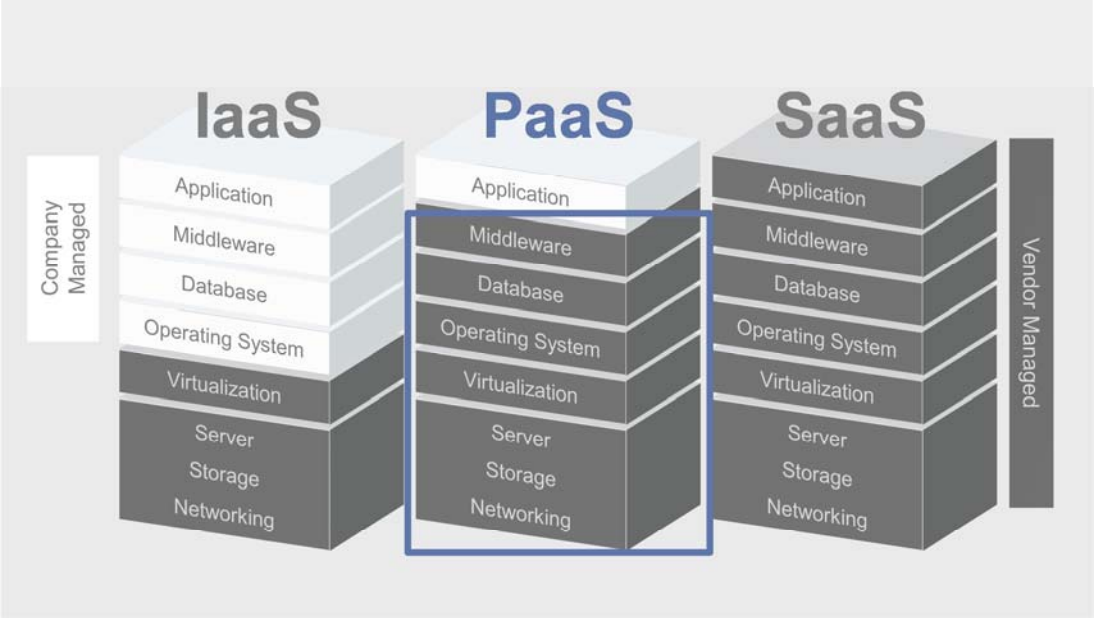
- **Does not work out of the box –** The biggest misconception Red Hat sees from customers is that they expect the free open source version of OpenStack to work out of the box. For example, telcos and other early adopters have found out that when they download a version of OpenStack, make changes to it, and put the workload into production, that it does not always work. Another example is Target. When Target compared OpenStack to VMware, they discussed features that are available in VMware but not OpenStack – for example, when a server goes down, VMware automatically re-distributes the load among other servers, which does not occur on OpenStack. Therefore developers are forced to write that into the application.
- **Ease of deployment –**There is no right (or most often used) way to deploy OpenStack, with an unlimited number of deployment configurations possible.
- **With the exception of AT&T, most deployments have been small –** As discussed earlier in this report, we found that for most customers, OpenStack is being used for a minority of workloads. An OpenStack User Community Survey conducted in Spring 2015 showed that the number of OpenStack nodes within an organization is relatively small, but growing, as many are using traditional data center software. Some of the larger OpenStack deployments still do not represent even half of all enterprise workloads, as Target uses OpenStack for a third of their workloads and Volvo uses OpenStack as the underlying infrastructure for just 40 of their 4k apps.
- **Pace of updates may be too rapid for enterprises running production workloads –** There is a new major OpenStack release every six months, which is often too rapid for enterprise customers to securely update their systems.
- **Updates are difficult, requiring two instances –** There is no easy way to migrate to new versions of OpenStack. Today customers have to deploy both instances side by side and use a migration tool.
- **Patching requires manual coding**– Currently this is done manually through writing code and rebooting, rather than a quick download or a live update.
- **Stability at scale –** There have been complaints that this is still an issue, especially in the networking layer.
- **The rise of public cloud as an alternative –** Public cloud, especially Amazon AWS and Microsoft Azure have gained significant traction in usage, revenue, migrations, and production use cases faster than OpenStack
- **Keep up with the pace of innovation versus Amazon AWS –** OpenStack leverages the community to keep up with Amazon's rapid pace of innovation, as AWS continues to flesh out its platform.
- **A bug in the operating system layer can impact the entire cluster –** Red Hat believes that there is significant value in closely pairing OpenStack with the operating system, and the virtualization layer. For example, if there was a new virus similar to the ghost bug (security vulnerability in the Linux operating system), a customer using OpenStack alone would not be able to fix the issue, but if they used both Red Hat OpenStack and RHEL, Red Hat would be able to quickly identify and patch the issue.

Cloud Foundry 101

Cloud Foundry is open source Platform as a Service (PaaS) software that can be used as a layer on top of IaaS infrastructure. The Cloud Foundry project started at VMware and was launched in April 2011. Similar to OpenStack, the development of Cloud Foundry is governed by a third-party organization, the Cloud Foundry Foundation. Cloud Foundry can be deployed across multiple different IaaS platforms, including Amazon AWS, OpenStack, and VMware vSphere or vCloud Air. According to data from Gartner, the two most popular commercial versions of Cloud Foundry are Pivotal Cloud Foundry and IBM Bluemix.

Prior to Cloud Foundry and other PaaS software options, for a developer to take the code they wrote and turn it into a live application, it took weeks and sometimes months. For example, let us say a developer wrote a web and mobile retail application for a new brand. Beyond asking for the IaaS layer, the developer would have to ask the database team for a database to keep the order information (i.e., SKU, price, customer name, address). The database team would respond by needing to know the type of database, version, how large the database should be, how large it could reach at peak times, etc. The developer may not know since this is a new brand, so they then have to coordinate schedules and work with the database team to figure this out before it is provisioned. The same steps happen for middleware, and the virtualization and operating system layers if the IaaS team does not handle it. This compares to PaaS, where a developer in hours can point and click in a common web interface and provision those layers which automatically scale up and down.

Exhibit 20: Platform as a Service



Source: Goldman Sachs Investment Research.

Major software components of Cloud Foundry

We outline key components of Cloud Foundry:

Exhibit 21: Major components of Cloud Foundry

Component	Description	Example
Cloud Controller	Keeps track of the desired state of the private cloud cluster, including application code, versions, the desired number of instances, and upgrades	After a developer writes an application, he or she sends the files to the Cloud Controller to deploy it. But instead of sending all the files, the Cloud Controller can look at them, determine which are net new, and only upload the incremental files.
Droplet Execution Agent (DEA)	This is the staging layer where applications get packaged and are run/executed	Developers don't write all of the code needed to run an application. The DEA takes the bits of code uploaded by the developer, identifies the type of application (e.g., Java, Ruby), downloads the appropriate runtimes required (often called libraries, which is code needed to translate the code written by the developer into a machine language that the operating system and other components understand), compiles and runs the complete application in its own container. Then the DEA starts up additional copies, if needed
Router	This software component is responsible for routing application traffic	While the DEA runs applications, the end user cannot access the application through a web browser without the router directing traffic to the right instance on the DEA.
Health Manager (HM9000)	This component tells IT when there are differences in the expected and actual state of applications	The Health manager monitors applications to make sure that the actual state (from monitoring the message bus) is the same as its expected state (within the cloud controller) and notifies the cloud controller when there is a discrepancy
Other Components	(1) Elastic runtime keeps instances running, scaling up/down, serving traffic, (2) Cloud Foundry gem is the command line interface, and (3) BOSH allows users to make changes to the entire cluster. Finally, Cloud Foundry Services takes stateless runtime layers and add state to it (add a database), which could be Redis, Mongo, Cassandra, or others.	

Source: Goldman Sachs Investment Research and Pivotal at the Cloud Foundry Conference 2013.

ROI for Cloud Foundry deployments

Reduction in deployment times

- "Now, with Cloud Foundry and Pivotal, operations that used to take weeks can take minutes or less." – Philips with Pivotal Cloud Foundry
- "Reduce deployment times from 14 hours to 14 minutes." – Axel Springer with Pivotal Cloud Foundry
- "Deployment timeframes have been reduced by 75 percent, accelerating deployments from a month to a week." – EMC Enterprise Content Division, Pivotal Cloud Foundry
- "If a developer wanted a server for application development, it could take one to three months just to get an application development platform. Now, it can take just hours to get a server." – EMC, Pivotal Cloud Foundry
- "Complete a mobile application for our business development team in 10 weeks. Something that would have taken us conservatively 9 months to do before." – Lockheed Martin, Pivotal Cloud Foundry
- "It takes us sometimes 2 months to provision servers…to actually deliver a product to everyone in 5 weeks really is for us revolutionary…Pivotal Cloud Foundry is the heart of what's enabled these fast deliveries." – Humana, Pivotal Cloud Foundry
- "From 100 days to minutes, that's what Pivotal Cloud Foundry gives us." – Allstate, Pivotal Cloud Foundry
- "There was a 40% improvement in development time." – SilverHook Powerboats, IBM Bluemix
- "By integrating with Bluemix and SoftLayer, we can cut development times significantly, and we no longer need to care about issues like scaling." – Diabetizer, IBM Bluemix

Reduce costs

- "One goal was to consolidate 700+ applications down to approximately 300 to reduce maintenance costs and decrease data redundancy." – CoreLogic, Pivotal Cloud Foundry

Lower server to admin ratio

- "90% reduction in infrastructure operating costs and a dramatic increase in server-to-admin ratios." – Rakuten with Pivotal Cloud Foundry

Cloud Foundry use cases

Intel

Used for: Intel expects most applications that use PaaS will be new. The company is using PaaS for specific types of applications – small to medium sized custom apps with a cloud-hosted component. This includes Intel.com public applications, Intel's SaaS apps for customers, temporary apps for marketing campaigns and department level and B2B apps.

Technology used: Intel started using open source Cloud Foundry over three years ago.

Benefits: Intel (1) enhanced agility by automating tasks and processes (Intel noted that a typical application lifecycle has 75 steps, with only 9% automated), (2) reduced complexity by abstracting the infrastructure, middleware, and configuration steps, (3) now has greater standardization and extensibility, which allows for better reusability of code, standard disaster recovery and monitoring, and (4) improved resource utilization by creating multi-tenant virtual machines instead of a full virtual machine for each application, reducing CPU cycles, memory and disk required. Intel also outlined the benefits they have seen from idea to production.

Exhibit 22: Intel's benefits from implementing PaaS

Development Team Task	PaaS Improvements	Result
Provision server and services	• Virtual machines pre-provisioned with platform • Abstracted infrastructure • Single-click deployment	Days to hours
Load and install new code	• Single-click deployment	Hours to minutes
Respond to problems	• High availability of PaaS. Application designed for failure • Restart on fatal error • Fast rebuild and application redeployment	Hours to minutes
Initiate hosting	• Developer-controlled deployment • Abstracted infrastructure management	Developer self-service
Manage application capacity	• Resource consumption data • Tools to add/remove additional application instances and components, such as a front-end web server	Elasticity
Improve asset utilization	• Consolidated platform across applications • Fewer idle preproduction environments • Metering	IaaS + PaaS resource efficency

Source: Intel white paper "Extending Intel's Enterprise Private Cloud with Platform as a Service" June 2012, Goldman Sachs Investment Research.

Humana

Used for: The first app they put on Cloud Foundry was Humana's My Health app that lets consumers enter their weight and blood pressure to received personalized health content. It is focused on diabetes, hypertension and congestive heart failure.

Technology used: Pivotal Cloud Foundry. Humana took an approach to not use public cloud due to HIPAA concerns, which is why they thought Cloud Foundry on premise was going to give them the ability to scale internally and have control.

Benefits: With Pivotal Cloud Foundry on the back end of Humana's My Health app, the creation of the application only took 2.5 months. By using Pivotal Cloud Foundry, they were able to deploy APIs much faster. They also repurposed employees into more value added roles, for example employees that would have spent time moving files before would be in charge of managing Cloud Foundry Ops Manager.

Tangerine (Canadian Bank)

Used for: mobile applications for customers, including an onboarding application where consumers can become clients in 10 minutes.

Technology used: IBM Bluemix. Tangerine integrated IBM Blumix's Mobile Quality Assurance product within their app, and within days they were able to let clients give them feedback by shaking the phone. Within a week they received over 1k feedback items.

Benefits: They were able to implement IBM Blumix's Mobile Quality Assurance within days instead of weeks, cutting down implementation times by 90-95%. By not focusing on infrastructure, they were able to take those resources and dollars and repurpose them into areas that are more impactful to Humana.

Products

Pivotal Cloud Foundry

The overarching Cloud Foundry project started at VMware and was launched in April 2011. The project was subsequently spun out into VMware's subsidiary, Pivotal, in spring 2013 (Pivotal is owned by EMC (62%), VMware (28%) and GE (10%)). And in November 2013, Pivotal released Pivotal CF based on open source Cloud Foundry.

Customers: Allstate Insurance, Philips, CenturyLink, NTT, CoreLogic, Axel Springer, CITIC Securities, NTT and investors EMC and General Electric.

Differentiators: Pivotal Cloud Foundry is de-coupled from the IaaS layer, unlike IBM Bluemix, so customers are able to run Pivotal Cloud Foundry on multiple public and private clouds, including Amazon AWS, OpenStack and VMware.

Metrics: In the June 2015 quarter, Pivotal saw a triple digit increase in subscription orders for Pivotal CF, and continued to expand the number of customers adopting Pivotal Cloud Foundry.

Pricing model: Subscription based. EMC's 10-K noted that Pivotal's product revenue decreased 3% to $65mn (total revenue of $227mn in CY14 increased 27% yoy) due to an increase in order of Pivotal Cloud Foundry and Big Data Suite, which have subscription-based ratable revenue recognition instead of upfront license revenue recognition.

IaaS the software runs on: Amazon AWS, OpenStack, VMware vSphere and vCloud Air, and more.

Standard Runtimes/Buildpacks supported: Java, Ruby, Node.js, PHP, Python.

Standard databases supported: MySQL, Redis, Riak.

IBM Bluemix

IBM committed over $1bn to build out their PaaS platform, Bluemix, investing to drive innovation and geo expansion. IBM's PaaS platform became generally available in June 2014, over six months after Pivotal CF. IBM originally made an aggressive move into this market with the purchase of IaaS software, SoftLayer for $2bn, which closed in July 2013.

Customers: Capgemini, Citi, GameStop, Avnet, AnswerHub, Bernhardt Furniture, BP3, BYTE restaurant, Datkota State University, DataSkill, InXero, Jibes, King Mongkut's University, Kiwi Wearables, Mesa Technology, SilverHook Powerboats, Tangerine Bank, Technical University of Denmark, Verdafero.

Differentiators: The CTO of Vivocha, a customer interaction software startup, stated in September 2014 that mobile was a differentiator "Mobile is super important for us and it's not that well supported on computing platforms, that's something that we found in Bluemix."

Metrics: In July 2015, IBM said they were onboarding 10k new users each week, have over 100 new services and runtimes, and is available in two regions. IBM expects profit margin to expand as the cloud platform scales.

Pricing model: pricing is based on the number of instances and memory required. IBM estimated costs for three different types of organizations. We summarize them in Exhibit 23. In addition, virtual machines are still in beta and customers will not be charged for them until they become generally available. Bluemix Local is available on a subscription and allocation model, dependent on the size of the environment.

Exhibit 23: IBM Bluemix pricing examples

	Startup	Medium Business	Large Enterprise
Language	Java for IBM	NodeJS	Ruby Sinatra
Memory	256MB	512MB	1GB
Instances	1	2	4
User(s)	<100	<8,000	200,000+
HTTP Requests	<300/second	<600/second	>10k/second
Cost per month	Free	$24	$175

Source: IBM Bluemix website.

IaaS the software runs on: IBM Softlayer. However, with Bluemix Local (introduced on 10/1/15), it should allow customers to run Bluemix on VMware or OpenStack.

Standard Runtimes/Buildpacks supported: Java, Ruby, Node.js, PHP, Python, Go.

Standard databases supported: Cloudant NoSQL, IBM DB2, MongoDB by Compose, PostgreSQL by Compose, Redis by Compose, ClearDB MySQL database, MongoLab, Redis Cloud.

Private Cloud M&A Transactions

There have been a number of acquisitions in this space, including:

- In November 2015, IBM announced it would acquire cloud management software vendor Gravitant.
- In October 2015, Red Hat announced it would acquire automation software vendor Ansible for $100mn.
- In February 2014, IBM announced it would acquire Cloudant, to let developers easily create mobile and web apps.
- In October 2014, EMC acquired Cloudscaling, a provider of OpenStack powered IaaS for private and hybrid cloud solutions.
- In June 2014, Red Hat announced it would acquire OpenStack IaaS software vendor eNovance for €70mn.
- In May 2013, Walmart Labs announced that it would acquire PaaS vendor OneOps.
- In April 2014, Red Hat announced it would acquire Inktank for $175mn, a provider of open source storage systems based on Ceph.
- In October 2013, CSC acquired cloud management company ServiceMesh.
- In May 2013, Dell acquired Enstratius, which provided cloud management software and consulting services.

While there has been a number of sales and shutdowns of related businesses

- **OpenStack startup shuts down –** In April 2015, Nebula, a startup that productized OpenStack, stating that the market will take "another several years to mature." It has been reported that Oracle hired the engineering talent from Nebula after it shut down.
- **Citrix sells its cloud management platform as part of its streamlining –** In January 2016, Citrix noted in its blog that they sold their CloudPlatform and CloudPortal Business Manager product lines to Accelerite, the products business of Persistent Systems, which is based in India. CloudPlatform was powered by Apache CloudStack.
- **Telcos selling data center assets –** There has also been a recent reversal of strategy by telcos as they now look to divest their data center assets (AT&T, CenturyLink, Windstream), after the space saw heavy consolidation in 2011 (Verizon acquired Terremark, CenturyLink acquired Savvis).
- **HP and Verizon ceasing public cloud offerings, shifting the focus to private cloud –** Over the last six months, two major vendors, HP Enterprise (10/22/15) and Verizon (2/11/16) announced they would cease their public cloud products, and focus on private cloud instead.

Disclosure Appendix

Reg AC

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