InfoWorld

MODERNIZING ENTERPRISE IT

The Private Cloud

The **cloud** meets the **data center**

VIRTUALIZATION HAS OPENED up unimagined potential. Detaching compute, storage, and networking resources from physical hardware not only maximizes infrastructure investment—it enables quicker deployment and scaling of workloads than ever before.

But a virtualized infrastructure demands new tools to enable all those software-defined resources to be properly managed. That's where the private cloud comes in.

In this special digital edition, InfoWorld's editors and contributors explore four different aspects of the private cloud. We begin by breaking down the elements of the private cloud in "Building the next-gen data center," including metering and chargeback systems, automated configuration, and self-service provisioning.

Then, in "The private cloud times three," we take a quick look at the three most important private cloud platforms—from Open-Stack, Microsoft, and VMware. In "Putting the private cloud to work," we tell the stories of several early private cloud adopters to report on their challenges and rewards. And finally, in "Plugging into the public cloud," we cover subscription-based cloud services that enterprises are using to create hybrid cloud environments.

The private cloud is arguably the most important trend in IT, but it's still early days. We hope this special edition may assist you as you develop your own private cloud strategy.

Eric Knorr
Editor in Chief

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THE **PRIVATE CLOUD**

Borrowing from public cloud architecture and technologies, the private cloud weaves a new management layer around virtualized data center systems BY ERIC KNORR

Building the next-gen data center

THE PRIMARY mission of computing has always been to automate business. The secondary mission has been to automate the automation, a quest that grows ever more urgent as data center technology achieves such towering complexity it threatens to collapse under its own weight.

The private cloud is the latest attempt to boost the efficiency and agility of the vast assortment of hardware and software sprawled across data centers. The idea is to pool compute, storage, and network resources and manage them from a central software control point rather than scrambling to provision, monitor, manage, and reconfigure all that infrastructure manually.

Predictably, the organizations with the most experience designing and running shared infrastructure are the public cloud service providers themselves. Amazon, Google, Microsoft, and Salesforce can't manage their data centers the old-fashioned way—with static chunks of infrastructure dedicated to individual application instances—and hope to deliver services to millions of subscribers over the Internet reliably and cost-effectively. These pioneers' experiences running public clouds at scale have yielded the basic models for the private cloud.

Downsizing the cloud

Some are quick to point out that public cloud providers typically offer a few services at massive scale, not the wide diversity of applications at the small or moderate scale characteristic of the typical enterprise. So is the public cloud model applicable to enterprises at all? Isn't "private cloud" just a marketing phrase for virtualization plus a little bit of automation?

Actually, wherever a sizable chunk of server virtualization is in effect, the public cloud model may apply, even if the scale and the details of the implementation may not. Virtualization has become so widespread, we tend to think of pooled resources, particularly VMs spread across a farm of physical hosts, as simply a fact of life. In truth, this consolidation represents a profound transformation in the way we manage computing infrastructure.

That difference emerges in sharp relief when virtualization reaches critical mass. At a certain point, such as reaching hundreds of physical hosts and thousands of VMs, or serving numerous disparate "tenants" who demand instant gratification, managing virtualization becomes a qualitatively different proposition.

For one thing, you need private cloud software to allocate resources and costs back to line-of-business stakeholders. When possible, you want to take advantage of the agility of a virtualized infrastructure by allowing those stakeholders to provision their own resources. Plus, as you converge data and storage networks, you'll want to virtualize storage and network resources along with servers.

The software to accomplish all that and more has already been released in some form by Eucalyptus, VMware, OpenStack, Microsoft, Citrix, and others. These various private cloud software stacks, however, are not intended to replace every lick of infrastructure software in the data center. They provide a framework that interoperates with much of the software already in place and helps admins wrap their arms around the totality of virtualized data center infrastructure.

Elements of the private cloud

The elements of the private cloud form a new management layer across a wide swath of data center func-

[Perhaps the greatest of all efficiencies offered by the private cloud is the ability to tell stakeholders: Here, you do it.

tions. It sounds like a tall order, but keep in mind moving to the private cloud needn't be an all-or-nothing affair. It can be rolled out incrementally. Although a number of hardware and software vendors imply that you need a whole rack of new hardware and an industrial-size barrel of software spaghetti to build a real private cloud, you can usually graft individual cloud features one by one

onto an existing virtualization infrastructure.

Compute. At the most basic level, in a private cloud, the compute component does pretty much what virtualization management software does: provision, deprovision, start, stop, suspend, clone, and migrate VMs from a central control point. The main difference is that the intent of the private cloud is to enable

you to manage across as much virtual server infrastructure as possible—which in most cases means support for multiple hypervisors.

Storage. Storage management across platforms has been a dream for more than a decade. Most private cloud platforms strive to support object storage and replication, along with block storage and snapshot management, across diverse data center storage systems, although this is still a work in progress. Another essential part of private cloud storage is efficient management of virtual server and virtual disk images.

Networking. Here, private cloud software extends into the cutting-edge realm of software-defined networking. You can create virtual ports, attach VMs, configure virtual switches, and so on. You can provision private networks within the greater network infrastructure, an

essential capability when you're creating a large private cloud to which several different groups of users will have access. In a modern data center with lots of 10G switching and converged data and storage networks, the ability to pool and carve up bandwidth dynamically can be especially powerful.

Metering and chargeback/showback. When infrastructure is shared, you need a way to divide up and meter pooled compute, storage, and networking resources and automatically charge line-of-business accounts—or at least show those charges to the appropriate stakeholders. Without that capability, IT people either get mired in spreadsheets estimating charges or settle for inaccurate or unfair cost allocations that will come back to haunt them.

Self service. Perhaps the greatest of all efficiencies offered by the private cloud is the ability to tell stakeholders: Here, you do it. Developers, for example, can configure and reconfigure their own dev and test environments using a self-service portal. Business units can even "or-

> # The need to isolate multiple tenants in a shared infrastructure makes security both critically important and dauntingly complex.

der" and install applications, which are automatically provisioned and made available without IT necessarily being involved. Naturally, configuring the portal, policy, and automation magic that makes it all work requires time and effort. Also, the standard choices for stakeholders will necessarily be limited. But as the menu expands, the time not spent dealing with requirements, provisioning, configuring, and so on represents huge savings.

Automation and orchestration. For the magic self-service portal to work, you need automation, or basically, a library of scripts that perform common tasks: server provisioning, shared storage setup, network settings for a VLAN, and so on. Orchestration assembles those automated tasks into predefined workflows for specific applications or services, which may require signoffs by gatekeepers. For example, if a developer wants to test a massive application that will require a large chunk of resources and a copy of a live database, the workflow software would automatically fire off an ap-

[Which elements of the private cloud you implement first will depend on the workloads you have in mind.

proval request to management.

Application management and monitoring. Private clouds may extend all the way to managing the application layer. This includes templates for deploying and configuring applications, but also monitoring and reporting on application performance to meet internal SLA requirements, with dashboards to supply admins with the insight they need to deliver on those commitments. At the most advanced level, monitoring may trigger auto-scaling, so that performance levels can be maintained without human intervention.

Security. The need to isolate mul-

tiple tenants in a shared infrastructure makes security both critically important and dauntingly complex. An identity management system that provides multiple levels of authorization according to user group assignments is a key component. It also should be capable of extending granular access controls to external users (such as customers and partners) as well as internal groups.

Which elements of the private cloud you implement first will depend on the workloads you have in mind. If you plan to host partners in your private cloud, the security and network components required to support virtual private clouds could

well be the first order of business. If managing resource allocations for internal dev and test is a top priority, a portal for developers to self-provision (plus the automation and orchestration behind it) might be first in the queue.

On the other hand, it goes without saying that deploying a full-featured private cloud in an environment where business units do not have the scale, interest, or ability to take advantage of its self-service capabilities would be a massive waste of time and money.

Many large and medium businesses can benefit from the power of the private cloud. The really hard part is getting everyone to agree on the rules, rates, and policies for the automated systems. If you can clear that hurdle, then it's a matter of virtualizing everything you can, prioritizing workloads, and gradually adding more private cloud functionality as you work your way up the stack. ■

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The **private cloud** times three

*Many commercial and open source players are vying
to provide a private cloud foundation for enterprises,
but three contenders stand out*

BY OLIVER RIST

WITH THE PUBLIC cloud, you can choose from thousands of SaaS, PaaS, and IaaS providers, open a trial account, and simply walk away if you don't like what you find. The private cloud, by contrast, is serious business.

In most cases, you need to start by taking a hard look at your own enterprise architecture to determine the breadth and depth of private cloud features you want to adopt. When you start the technology selection cycle, one of the first choices you'll face is a private cloud "operating system"—the software stack to manage virtual servers, storage, and networking, along with access control, monitoring, and chargeback for those resources.

That's a lot of critically important software. Choose the right solution and you'll be rewarded by substantial increases in efficiency and agility. Choose poorly, and you could be punished with all kinds of limitations you never anticipated. You need to feel confident you'll get the capabilities, extensibility, cost-effectiveness, and support you need—

which is going to make your short list pretty darn short.

The private cloud technology landscape is still emerging, with both commercial and open source entrants iterating furiously. Here, we've contrasted four stacks of private cloud software from three different sources: OpenStack, Microsoft, and VMware, with a special emphasis on comparing technology benefits and cost.

Openstack

OpenStack is as much an industry phenomenon as a cloud stack. An open source project built on the collaborative work of NASA and public cloud provider Rackspace, OpenStack has tremendous community momentum, plus the support of key vendors, including Cisco, Dell, HP, IBM, and Red Hat. That's impressive for a project whose first release was in late 2010.

Yet today, few enterprise customers are attempting to deploy OpenStack in a production environment.

OpenStack is similar to the Linux kernel, in that vendors add value around it to make it practical to deploy and maintain. A number of companies, including big players like HP, and startups like Nebula and Piston Cloud, both led by former NASA execs—are doing just that.

Moreover, although OpenStack is already in its fifth version (Essex, released in April 2012), it still has some growing up to do. The network component, Quantum, is not yet part of the stack, and by most accounts, the compute component, Nova, still needs work. OpenStack's proponents say both sticking points will be addressed in the Folsom version of OpenStack due in late 2012.

Meanwhile, many enterprises are downloading OpenStack to check it out. But remember, to make OpenStack work in production, you need to write custom code, buy a commercialized version, or (when available) add the appropriate open source

components. Essex added authentication (Keystone) and monitoring/self-provisioning (Horizon), but key features are still missing. OpenStack currently supports cloud service and delivery on the KVM and Xen hypervisors, and intends to extend its capabilities across any hypervisor on the market. But even using open standards, OpenStack must rely on contributions from hypervisor vendors like Microsoft and VMware to make that happen. The capabilities you get will probably vary depending on which hypervisor you're looking to integrate.

The great strength of OpenStack, and the primary reason for its momentum, is that it's being built from the ground up as a cloud solution based on open source and open standards. It supports the OpenFlow standard for software-defined networking as well as the APIs for Amazon Web Services EC2. VMware, Microsoft, and other commercial vendors build

their private cloud stacks on existing proprietary software, raising the risk of vendor lock-in.

It's difficult to calculate Open-Stack's cost to customers at this early stage. The Essex bits are freely available under an Apache 2 license, which will extend to Folsom and all future releases, but few customers would want to dedicate the internal development resources required to make OpenStack production ready. Eventually, say OpenStack proponents, open source solutions are evolving that should make OpenStack relatively easy to deploy and maintain.

Productized OpenStack versions will vary widely in price; Piston Enterprise OS, for example, runs $3,500 per server. In more conventional open source fashion, Rackspace has a paid support offering called Cloud Builders. HP, IBM, and many other big players provide professional services to help you get OpenStack up and running as your private cloud framework. And Red Hat has announced plans to introduce an enterprise distribution of OpenStack, although no time frame has been set.

For many customers, 2012 will be the year to download and evaluate OpenStack. In 2013, deployments are likely to begin in earnest.

Microsoft

Microsoft's private cloud stack is built mainly around Windows Server and System Center, its server and infrastructure management suite.

Microsoft introduced its private cloud with Windows Server 2008 R2 and with the various applications under the System Center 2007/2010 umbrella. The company has been pushing its private cloud much harder with the imminent arrival of Windows Server 2012 and System Center 2012, consolidating System Center into a single application and engineering cloud-specific features into both platforms.

Windows Server 2012 has made a splash with significant improvements in Hyper-V, with an increase in VM resource and performance muscle, virtualized storage, and

virtualized networking. Such features have helped move Windows Server much closer to feature parity with VMware's vSphere. Windows Server's overall security and remote access capabilities have also been cloud-optimized, including an easier and more flexible remote access configuration and support for network or cloud multitenancy.

VMware can say that its virtualization hypervisor has vast market share, but Microsoft can say the same thing about Windows Server. Of course, that doesn't mean Hyper-V is being used by all those customers, but it usually does mean that Active Directory is being used, and that's a key weapon for Microsoft. Integrated identity management is a key requirement for private cloud service delivery, and few customers may want to go to the trouble of altering their Active Directory infrastructure in favor of something else.

But for Microsoft, System Center is the beating heart of its private cloud. System Center 2012 has evolved from a loosely connected suite of products into a single, inte-

grated toolset that combines management consoles into consolidated views aimed specifically at managing highly virtualized data centers and private clouds.

System Center really differentiates itself in its cloud service and deployment model. Microsoft doesn't just serve up IaaS resources and individual applications as services, it uses data center orchestration and workflow technologies to let IT pros design services and combinations of services as resource packages. In one swoop you could deploy point-of-sale, CRM, and inventory applications preconfigured to work together based on both business and IT policy.

Although Microsoft's cloud sophistication sounds good, the fact is both System Center 2012 and Windows Server 2012 have yet to be released. This stack will need to prove itself before customers embrace it as a private cloud solution.

Cost could be an attraction. If you're thinking about creating a Microsoft private cloud, you're probably already running Windows Server and perhaps System Center, too, so

it's really just a matter of upgrading to the latest versions. In addition, the Windows Server Datacenter SKU provides unlimited virtualization rights, so VM density isn't a cost issue. Plus, an enterprise-specific incentive program dubbed Enrollment in Core Infrastructure (ECI) gives customers as much as a 20 percent discount on licenses of System Center with a certain minimum purchase of Windows Server.

How many Windows Server customers are really using Hyper-V? Among those that aren't, are they willing to switch virtualization platforms—and very likely add licenses for System Center, which has a much smaller market share relative to Windows Server? No doubt anticipating these objections, System Center 2012 will manage multiple hypervisors and accept management data from a broad swath of competing management tools. Microsoft wants to position System Center as an umbrella management package that sits above your existing data center architecture and implements a private cloud without requiring

you to rip and replace. We'll soon see how that plays out.

VMware

VMware leads in server virtualization market share, but there's more to the private cloud than virtualization. Primarily through acquisition, VMware has built out its private cloud stack to offer one of the most mature commercial offerings.

The company covers all the private cloud bases, including virtualized resource pooling, workload-level self-service, and even PaaS (in the form of Cloud Foundry)—all riding on top of its virtualization platform, vSphere.

The past couple of years have seen VMware integrate many acquired technologies into a coherent whole – work that's still going on. In 2009, VMware bought Integrien as an application performance analysis offering, SpringSource for cloud application development, and TriCipher for authentication. The vSphere virtualization stack got its private cloud

chops with the vCloud Director fabric in mid-2010. That package was updated with the last private cloud requirement – self-service – via an update only a few months later. In July 2012, it added a vital piece of the puzzle by acquiring Nicira, a pioneer in software-defined networking and primary creator of the OpenFlow standard.

Although VMware has an answer for almost every element expected in a private cloud, customers can expect to see numerous changes as its various acquisitions get integrated and consolidated. VMware also needs to evolve these pieces to maintain a competitive edge. For example, its service delivery and deployment model has strong roots in IaaS self-service, but it's still developing at the application layer.

Cost weighs in any VMware decision. VMware's virtualization solution is both expensive and feature-rich, and there's little reason to believe a full private cloud stack would be different. Your mileage may vary: VMware has a fairly complex licensing model, licensing

vSphere on a per-processor basis, vCenter Server on a per-instance basis, and tacking on another licensing charge for VMs running vCloud Director, vCenter Operations, vShield, and vCenter SRM.

On the other hand, customers that have invested in VMware already have some private cloud building blocks in place. Moreover, one place where VMware is clearly doing better than most is in chargeback – the ability to see who is using what resources and for how long. That's key to budget, cost analysis, and TCO. VMware's vCenter Chargeback is not only integrated but comprehensive and detailed.

Chargeback may not sound like a huge deal, but in fact it's critical—the cloud is all about pooling resources, so you need an automated way to allocate costs to stakeholders. Given how quickly the private cloud is evolving, however, this VMware advantage may not last long. ▪

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Putting the
private cloud
to work

While most early private cloud adopters take one step at a time, some leap in and never look back
BY DAN TYNAN

T WAS APRIL 2011, and the clock was ticking at Medimmune. The 3,500-person biotech firm, a division of pharmaceutical giant AstraZeneca, had decided to drop its longtime IT service provider and move everything in house to a private cloud.

That meant replacing a ton of aging iron, building out a new data center, tripling the IT staff, and migrating more than 370 enterprise apps, all while continuing to pump out products 24/7 and stay in compliance with strict federal regulations.

And Medimmune had exactly one year to get it all done, says Mary Patry, senior director for IS strategic programs. "The big challenge right at the beginning was convincing the business this could be done," says Patry. "Once we got management to buy in, the question became 'OK, now how do we do this?'"

They started by partnering with Acumen Solutions, which helped map the architecture of the cloud and create a strategy for migrating

A key to Medimmune's success was making sure members of its information assurance team were involved from the very beginning, she adds. That helped ensure that the team met its quality, compliance, and security goals as it evaluated which apps to migrate. Ultimately, some 934 servers were moved to the private cloud.

Another big challenge: hiring enough bodies to manage the infra-structure. "We went from a staff of

> # You can't simply take your applications, throw them onto a bunch of virtual machines in the cloud and hope it works.
>
> – **Jason Domina**, director of technical operations for Cafe Press

apps to the new environment, then stayed on to help with implementa-tion and execution, Patry says.

40 to 140 in just four months," she says. "About half of them were senior engineers and architects, the rest are

labor staffed via a unique contract agreement where we retain account-ability for service levels. Having the people who define the architecture and are responsible for the outcome as full-time employees makes a big difference. We hold the keys to the kingdom."

By replacing its aging infrastruc-ture and moving to a private cloud, Medimmune solved a lot of prob-lems at once, says Patry.

"We went from having dozens of high-impact outages each month to less than a handful," she says. "Our enterprise apps now perform notice-ably better. And the improvement in customer service is amazing. It used to take months for us to provi-sion new servers; now we can do it in hours. The private cloud has brought agility back to our business."

Atmospheric pressure

For Medimmune, the decision to go private was driven in large part by regulatory issues, says Patry. Like companies in finance and other heavily regulated industries, the bio-tech firm was wary of using a public

cloud provider due to concerns about security and control of sensitive data.

"We've explored the public cloud for sandbox projects and quick de-velopment environments, but we'd never put our crown jewels there without a lot more scrutiny." she says.

For Cafe Press, moving to a private cloud is less about protecting sensi-tive data and more about maintain-ing control and cutting costs, says Jason Domina, director of technical operations for the custom clothing manufacturer.

"We still think there's a lot of value to controlling one's own des-tiny," he says. "Another reason is you can't simply take your applications, throw them onto a bunch of virtual machines in the cloud and hope it works. You need to architect around the things that can fail in the public cloud, and that takes time."

Working with its co-location host, Cbeyond, the 200-person company is implementing a private cloud us-ing Cisco Unified Communications Platform, and hopes to have it online by October. Domina says a primary benefit will be ease of management.

"The days of a sys admin flying in and manually configuring stuff are pretty much over," he says. "Over the last 18 months we've been using a home-baked automation platform to spin up virtual machines. Moving that onto the UCS platform will make that a lot easier to do."

Domina also plans to deploy an open source tool, Opscode Chef, to make imaging virtual servers even more push-button simple.

"With Chef you create a 'recipe' for a particular kind of server or app. When you spin up a new server, Chef takes care of imaging it, installing the correct applications and account information. Provisioning time shrinks from days to minutes. That's the world we're moving into, that's what this technology is unlocking for us."

Headed for the stratosphere

By all accounts, cloud computing is booming. Forrester Research projects that the private cloud market will grow from roughly $8 billion in 2011 to nearly double that by 2020. The market for virtual private

> **We'd like the business areas to realize the cost of the goods and processes they've procured. Being able to weigh the cost versus the value drives better business decisions.**
>
> – **MARY PATRY**, senior director for IS strategic programs.

clouds, where an enterprise's dedicated cloud infrastructure is hosted and maintained by a third party, is projected to reach $66 billion in the same time frame. And that is dwarfed by the public cloud market, which is expected to hit nearly $160 billion within eight years.

Even though many enterprises are embracing private clouds, it's still relatively rare to find one that's gone all in the way Medimmune has. Enterprises that migrate to a private cloud usually start slow and gradually get more ambitious, says Myriam Blázquez, cloud director at Indra, a $3.3 billion global IT services firm that provides virtual private cloud services for companies in more than 100 countries.

"At the beginning, most of our contracts are small," she says. "Customers start by moving just development into the cloud, or side applications from specific depart-

ments. After about a year they see how it works and how easy it is to increase or decrease services, and they start to move their core systems into it."

Organizations looking to adopt private clouds still face some formidable hurdles. One challenge is making sure the enterprise has the necessary skills in house to manage and provision cloud services, says Mark White, CTO for Deloitte Consulting LLP's Technology practice.

"If you're focused on building a private cloud, your IT group is going to need the talent to do fairly sophisticated operations and application automation, as well as server provisioning and de-provisioning, and service management," he says.

Another question enterprises must answer is how to account for the value the cloud services are providing to the business. Patry says Medimmune is
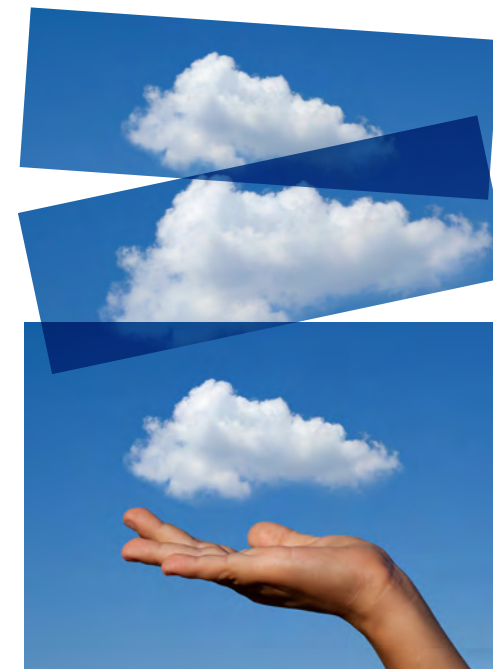
still allocating costs to each business unit; it plans to move to a chargeback model once it finishes defining the cost of the resources consumed by its users.

"We'd like the business areas to realize the cost of the goods and processes they've procured," she says.

> # Configuration and patch management are simple concepts, but when you get into the cloud they become very complex."
>
> — **DAVE SHACKLEFORD**, founder and principal consultant for Voodoo Security

"Being able to weigh the cost versus the value drives better business decisions. And it's always easier to ask for something if you don't know the true cost."

Many enterprises may opt for pri-

vate clouds because of the added security they seem to provide, but securing a virtualized environment comes with its own set of unique challenges, notes Dave Shackleford, founder and principal consultant for Voodoo Security.

Security best practices like separation of duties are harder to implement in a virtual environment where one team manages the entire infrastructure, says Shackleford, who teaches courses on cloud security at the

SANS Institute. If any member of the team goes rogue or makes a mistake, the whole house of cards can come tumbling down, he says.

Even basic sys admin chores can quickly get complicated. "Configuration and patch management are simple concepts, but when you get into the cloud they become very complex," he says. "If you're a VMware shop you need to get VMware patches and use VMware tools to install them. The same goes for Microsoft and Citrix. Ninety percent of all penetration tests are successful because of the simple stuff, like missing patches or silly configuration mistakes. Those are only exacerbated in the cloud environment."

Cloud forecast: Bright
The biggest barrier to successful cloud adoption may be psychological, says Agatha Poon, research manager for global cloud computing at 451 Research.

"The biggest inhibitor to the cloud is still the mentality of the people running IT," she says. "That has to

change if they want to implement new technology. Even if the IT people aspire to use the cloud, they aren't necessarily communicating what that really means to different units at the corporate level. Without collaboration and cooperation from the business side, any cloud effort is doomed to fail."

When it's successful, though, the accolades come pouring in from all directions, notes Patry. And that creates a new problem, though one most tech execs would probably like to have: How to do even better next time.

"That was truly one of the most rewarding outcomes we've ever had," she says. "It lead me to really believe in the concept of managing your own destiny in the form of a private cloud. Now we're looking at what else we can deliver on this platform. This migration was such a huge leap forward, we'll have to work really hard to make it continually better."

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Plugging into the **public cloud**

If it's impractical to run a workload in your private cloud,
you have plenty of public cloud options

BY SERDAR YEGULALP

THE **PRIVATE CLOUD** can transform IT, since it can yield a qualitative jump in your data center's efficiency and agility. But that doesn't mean every workload belongs on the private cloud. You may be better off letting some workloads continue running on legacy systems, while others may make

more sense as public cloud services you pay for by subscription.

Everyone talks about the hybrid cloud, which simply refers to any IT operation that runs a combination of private and public cloud workloads. But an interesting parallel approach is shaping up as well: Most public cloud IaaS providers also have private cloud counterparts with API compatibility, which can yield tighter integration and management across public/private clouds.

When you think about it, what you want from any cloud is the ability to scale and allocate pooled resources as smoothly as possible, with all due security and transparency. Many workloads, particularly those that don't require complex integration, can find a suitable home on a public cloud service. Here's a quick rundown of what's out there and how you may wish to take advantage of it.

Infrastructure on demand
The cloud began with AWS (Amazon Web Services) nearly a decade ago. Back then you had a storage service (S3) and a compute service

(EC2), period. Together they enabled you to upload virtual machine images and data and use Amazon's data center infrastructure as if it were your own. Hence the acronym IaaS for "infrastructure as a service."

Since then AWS has added doz-

> **The public cloud allows a company to spin up on-the-spot computing power for short but intense computational workloads.**

ens of services from databases to a content delivery network (hundreds if you include services offered by partners). Along the way, an independent open source project called Eucalyptus emerged, which was API-compatible with S3 and EC2 and offered a similar user interface. The idea was to enable customers

to manage their own in-house virtualized infrastructure in the same simple fashion as they managed the public AWS cloud.

But this public/private cloud compatibility cuts both ways. If you adopt Eucalyptus for your private cloud, you may be more likely to stick with AWS as the other half of your hybrid cloud. Perhaps that's why in March 2012, for the first time, Amazon gave its official blessing to Eucalyptus.

With its 2012 versions of Windows Server and System Center, Microsoft is apparently thinking along the same lines: Build your private cloud around

those two products and for interoperability reasons you may be more inclined to choose Windows Azure for your public cloud. VMware, on the other hand, is taking a partnership approach in hopes that customers who have invested heavily in the VMware private cloud will choose a VMware public cloud, such as that offered by Verizon subsidiary Terremark.

The OpenStack open source project has perhaps the grandest ambitions. Over the long haul, the idea is that many, many customers and public cloud providers will adopt OpenStack, creating a vast ecosystem with broad interoperability that will reduce the risk of lock-in. Today, HP offers— and Rackspace will soon offer—a public cloud based on the OpenStack cloud operating system. If the OpenStack private cloud catches fire with customers, you can bet that a host of providers will jump into offering public OpenStack IaaS services.

Enterprise apps in the cloud
Salesforce is the most familiar name in SaaS. The company established the SaaS model more than a decade

ago: Instead of buying enterprise apps and deploying them on your own hardware, you simply fire up a browser, open an account, and begin using a Web application running on the provider's infrastructure. That model was followed by NetSuite, which now offers the most robust ERP solution in the cloud. But lately, many traditional creators of enterprise apps are making their software available in SaaS form.

The big news is that Oracle, arguably the biggest name in enterprise software, dove headfirst into SaaS in June 2012 (though some consider Oracle's delivery model closer to hosting than to SaaS). For starters, the Oracle Cloud consists of three enterprise applications: CRM, human capital management, and enterprise social networking, plus cloud versions of WebLogic and Oracle Database itself. All told, Oracle claims that more than 100 applications will be available, including ERP eventually.

In a similar vein, SAP offers its OnDemand-branded CRM and financial software as SaaS solu-

tions, although both target small and medium businesses rather than large enterprises. Microsoft offers cloud-based versions of Exchange, SharePoint, and Lync, plus, with the forthcoming Office 2013, Office Web Apps with greater functionality than what was delivered with Office 2010.

Is there any special interoperability between locally installed applications and SaaS offerings from the same vendor? It depends on the vendor and product. With Microsoft, that's the main value proposition: The company will run Exchange, SharePoint, and Lync servers for you, while Office stays locally installed on PCs. Oracle claims close integration between local and cloud software versions, but at this point it's not entirely clear what that integration may entail.

Whether or not you go with a given SaaS solution depends on your switching costs, security concerns, integration requirements, and more. One thing is clear: More and more enterprise applications are moving to the cloud and those

apps get richer with each iteration. And SaaS, unlike IaaS, saves you the administration associated with setting up and maintaining remote infrastructure.

Develop, test, and deploy

Once upon a time, an organization's IT department typically set aside a complement of physical machines for dev-and-test work. Then, as virtualization evolved into a practical tool, it became easier to use VMs as test beds. Why re-image a whole physical system (slow) when you could just revert a VM to a previous snapshot (fast)?

Moving dev-and-test work to the public cloud allows for that sort of flexibility and much more besides. The biggest immediate advantage: the ability to spin up and reconfigure test environments in a flash and scale capacity as needed. AWS has been ground zero for this sort of activity from the beginning and many of its key services, particularly database services, have been crafted with dev and test in mind.

Conventionally, once dev and test

on a public cloud is done, customers deploy finished applications on their own server. But that's changing, thanks the proliferation of PaaS (platform as a service), which caters to developers who want to develop, test, and deploy in a fully provisioned cloud environment they control. Force.com, Google App Engine, and Windows Azure are three of the oldest and best-known PaaS offerings—the latter catering primarily to Microsoft developers—but VMware's Cloud Foundry and Salesforce's Heroku are coming on strong.

The fact is, at this point, there are almost too many PaaS offerings to count, many of which center on one or two specific languages. Want a Node.js cloud? Joyent has a solution for you. Are your developers itching to spin up Ruby Web apps? Try Engine Yard or Heroku. Cloud Foundry, which supports Java, Node.js and Ruby development, is offered as both a public cloud service and as a locally installable environment. Take your pick. There's no more prolific area of the cloud than PaaS.

Big data and business intelligence

Before cloud computing, you had to either manually build large arrays of computing power for major number crunching, or rent someone else's systems at an inflated cost. Today, the public cloud allows a company to spin up on-the-spot computing power for short but intense computational workloads—the kinds of data sifting businesses are turning towards for an operational advantage over their competitors.

Such instant access to reams of CPU and memory makes it that much easier to use the newest tools designed for just such work. To wit: Hadoop, a distributed processing system for working with terabytes (or more) of data. It still requires a knowing hand at the controls, but the number of cloud providers who offer Hadoop as a service in some form make it far easier to plug data into it and get results.

Another advantage the cloud brings here is automatic workload scaling. Instead of being stuck with the physical limitations of the iron you've purchased, you can spin up that many more CPUs or add that much more memory on the spot—helpful if you're trying to complete an analysis in time for a critical deadline, and at far less cost than provisioning the same amount of local server power to handle the job. ∎

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