**Harvard
Business
Review**

THE CIO'S
GUIDE TO CLOUD
COMPUTING

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The Cloud Crossroads

At Oracle, we have had the good fortune to work with thousands of CIOs on their cloud journey. Some started with business applications and others with infrastructure. Wherever they began, ultimately their needs evolved to require greater flexibility, extensibility, and hybrid operations. These CIOs have learned that their enterprise cloud strategy requires a holistic portfolio perspective and a strategic partner like Oracle to help them on their journey.

Companies with a cloud-first strategy have also learned that the cloud's real value comes with being able to delegate the service level agreement (SLA) of an entire solution, from infrastructure to application, instead of components. In the current state of the market, not all cloud providers can step up to that challenge, and that forces companies to manage more than they want to. That's one reason why Jim Fowler, GE CIO, states in this report that "all new systems at GE will be developed on and for cloud services."

Oracle's customers expect the cloud payoff to encompass all enterprise-class technology capabilities on a complete, integrated, open, and secure platform from the infrastructure to the application. It is not new wisdom that recognizes that integrated suites reduce complexity, increase reliability, and cost less—it's just that now, with cloud, the suite includes hardware, security, and operations.

A *complete, integrated, and open* cloud capability is a remarkable accomplishment. Oracle's unique history and leadership across the spectrum of enterprise technology offers enterprises more features, deployment options, and value than any other option in the market.

CIOs are at a crossroads as they make today's investments. Most agree that the cloud paradigm has cost and convenience benefits: availability, speed, agility, and TCO, enabling faster development processes and topping it off with higher reliability and lower risk. So, should they invest in the cloud or continue on premises? What is the next step?

It is the intent of this paper to offer some insight for both strategy *and* action.

- First, strategy. The cloud forces IT to rethink their strategy, structure, and organization. As IT and the business embrace new ways of doing things, now is the time to mitigate the possible risks of cloud proliferation and inefficiency. This report should add to your perspective as you consider new architectures and governance.

- Second, action. Since the cloud offers immediate benefits and multiple starting paths, there's an urgency to act. This report also offers guidance for how to analyze and move your technology portfolio to the cloud.

Your cloud journey has many starting and expansion points. Only Oracle offers a complete and proven portfolio of enterprise cloud services and migration/implementation services to enable you every step of the way.

Oracle has provided industry-leading technology to the world's largest and most demanding customers. Our enduring commitment has helped them transition through every major technology shift—and now to the cloud. While Oracle always builds for the future, we always bridge with the past so that our customers retain the value from their technology investments.

THE CIO'S GUIDE TO CLOUD COMPUTING

Practical steps to building and executing a cloud strategy

The adoption of cloud computing continues apace, with a growing number of high-profile companies making bold moves into the cloud and most organizations using at least some form of cloud services. Over the next three years, cloud services will penetrate deeper into organizations' computing environments at an accelerated rate. Companies that take an ad hoc approach miss out on many of cloud's benefits and experience a variety of pitfalls. In this guide, we will provide a framework for taking a more strategic, planned approach to cloud while still moving quickly. The cloud market and digital technologies in general are rapidly evolving, and there is no single prescription for moving into the cloud. CIOs who are committed to the journey are taking a plan, test and learn approach.

WHY CLOUD?

The shift to digital business is driving the need for change in many dimensions. "Industries have had hardened value chains that were well-defined within their industries," said David Vellante, co-CEO of SiliconANGLE Media and co-founder and chief analyst of The Wikibon Project, an open source IT research community. "Horizontal services are emerging for computing, security, collaboration, social media and data, and cutting across industries as companies digitize their assets. Cloud is the lowest layer of that digital matrix, with companies building their own services out of available services in the cloud."

The benefits of, and rationales for, the different approaches will vary, depending on an organization's profile and goals. For example, a large organization with complex legacy systems and mature IT capabilities will have different needs than a small or midsize business. And enterprises in highly regulated industries, or with extremely sensitive data, will assume a different posture toward public cloud than those handling less sensitive data.

That said, there are three main drivers for cloud adoption:

• Business transformation (creating new services and business models)

• Agility and flexibility

• Lower costs

Some companies may focus on one of those three benefits over another, but they are interconnected. GE is aggressively pursuing all three in its shift to a "digital industrial" business. To get there it is retiring more than half of its 9,000 applications and moving 60 percent of what's left to the cloud. In the process it will shut down the bulk of its 34 data centers over the next three years. These moves will enable it to offer new services based on software-defined machines (for example, wind turbines that can communicate with each other and adjust what they are doing based on changing conditions) while operating more efficiently.

But many CIOs still have questions about cloud's real costs, reliability and security. In this guide, we will provide a way to work through those concerns.

THE CLOUD MARKET

Most IT and business leaders today understand the **software as a service (SaaS)** model, in which an application (email, expense management, salesforce automation, HR management) is accessed over the internet and usually paid for by subscription. Many also have some experience with **infrastructure as a service (IaaS)**—or at least know that it provides access to processing, storage and other computing resources over the internet, with the customer typically only paying for the actual resources used.

Platform as a service (PaaS) is still an evolving space, with differing definitions. Essentially, it provides the tools and services to operate in a cloud environment. For example, developers can tap PaaS to develop applications over the internet using one or more execution environments supported by the cloud provider. But it's not just for developers; PaaS services include operating systems, database management systems, design tools and hosting capabilities that might be used by systems administrators, analysts, content managers and more. Some cloud providers offer these capabilities—as well as middleware, development, integration and Big Data analytics—as value-added services on top of their IaaS offering, so IT departments don't have to manage these independently or invest heavily while experimenting with entirely new technologies.
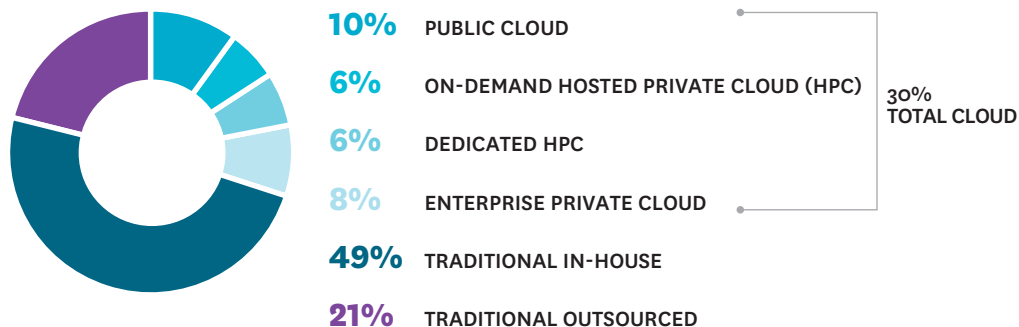
Cloud spending today represents about 30 percent of the overall IT market, according to market-research firm IDC. figure 1 What most people consider to be pure **public cloud** represents only 10 percent. Close to half of the total IT market still exists as traditional IT, owned and managed by the company itself, with another 21 percent in traditional outsourcing arrangements.

When large public companies say they are pushing aggressively into public cloud, what many of them are talking about is really a different category—what IDC defines as **on-demand hosted private cloud** and some refer to as virtual private cloud. In this case, a company's systems and data are indeed running on the same physical machines as other companies'; however, software is used to segregate it virtually, with more controls than are available in the pure public cloud. This gives

FIGURE 1

IT MARKET TODAY

What percentage of your total annual IT budget is allocated to each of these procurement/management models?

10% PUBLIC CLOUD

6% ON-DEMAND HOSTED PRIVATE CLOUD (HPC)

6% DEDICATED HPC

8% ENTERPRISE PRIVATE CLOUD

49% TRADITIONAL IN-HOUSE

21% TRADITIONAL OUTSOURCED

3O% TOTAL CLOUD

N=11,350
SOURCE IDC CLOUDVIEW 2016

companies the benefits of tapping into a shared pool of resources (for lower costs and the ability to scale up and down easily) while ensuring they can apply the security, policies and governance they need. Indeed, Rob Alexander, the CIO of financial services company Capital One, has publically declared that they are able to operate even more securely in the public cloud than in their own data centers. That is an extraordinary statement, and one that should make all CIOs reconsider their understanding of the viability of the cloud.
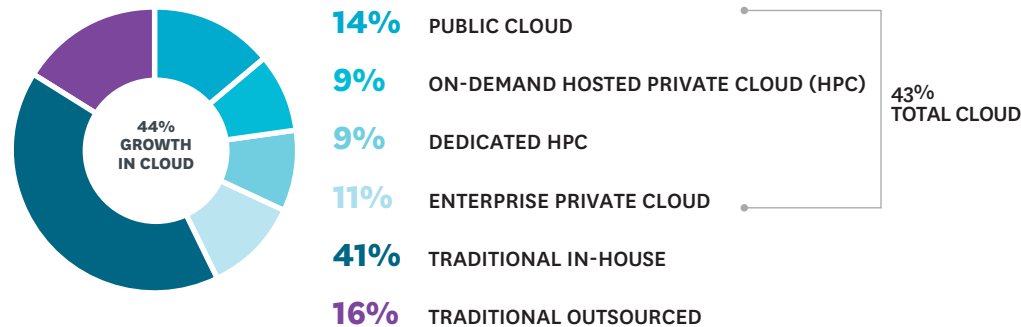
There are two other options for those not yet willing to take the plunge into a shared environment: **dedicated hosted private cloud**, in which a company's systems are physically separated from other companies' systems and data while being hosted at the provider's site, and **enterprise private cloud**, where those physical resources are kept on the customer company's own premises but managed as a service by the cloud provider.

The cloud market is growing quickly. IDC forecasts that within the next two years, cloud will go from 30 percent of the market to 43 percent. figure 2 This is being led by SaaS, which accounted for well over half of cloud spending in 2015 at $50.9 billion. figure 3 IaaS, which grew by 31 percent in 2015 to reach $11 billion, will reach $27.8 billion by 2019. PaaS, while a smaller market overall, is growing even faster. IDC predicts the PaaS market will grow from about $6 billion in 2014 to around $22 billion in 2019.

Not only is the market growing quickly, but providers' portfolios are maturing rapidly as well, thanks to the breakneck pace of development and innovation among cloud service, SaaS and independent software providers and individual contributors via open source initiatives, according to Joe Weinman, author of *Cloudonomics* and *Digital Disciplines*. Moreover, "the co-evolution of customer experience and provider offerings is leading to enhanced reliability from a process, technology, architecture and business perspective," he said. Weinman cites the Netflix Christmas Eve 2012 outage, which caused both Netflix and its provider to change how they do things, leading to more reliable architecture residing on a more reliable service. "Outages are opportunities for learning," said Weinman, and clouds are being built in a "plan, do, check, act approach; it's about fast iteration."

FIGURE 2

IT MARKET IN TWO YEARS: GROWTH IN ALL TYPES OF CLOUD

What percentage of your total annual IT budget will be allocated to each of these procurement/management models in two years??
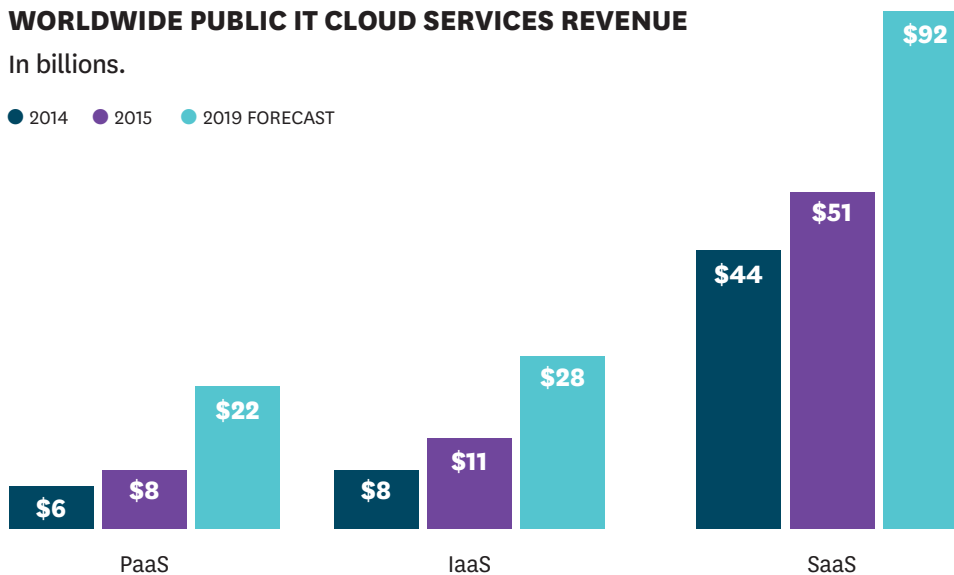

14%	PUBLIC CLOUD
9%	ON-DEMAND HOSTED PRIVATE CLOUD (HPC)
9%	DEDICATED HPC
11%	ENTERPRISE PRIVATE CLOUD
41%	TRADITIONAL IN-HOUSE
16%	TRADITIONAL OUTSOURCED

44% GROWTH IN CLOUD

43% TOTAL CLOUD

N=11,350

SOURCE IDC CLOUDVIEW 2016

WORLDWIDE PUBLIC IT CLOUD SERVICES REVENUE

In billions.

● 2014　● 2015　● 2019 FORECAST

SOURCE IDC WORLDWIDE PUBLIC IT CLOUD SERVICES FORECAST 2015–2019

Now that large enterprises are making serious moves to cloud, providers are working with them to meet their unique needs (such as Capital One's need for security) and then applying what they've developed to make all of their offerings better. This will open the market to even the most conservative organizations.

"HYBRID" CLOUD AND THE SINGLE PANE OF GLASS

When people talk about hybrid cloud, they're not really talking about another deployment model but rather a way to manage across multiple clouds and/or across public and private computing environments. Private clouds will never match public clouds for potential cost savings and flexibility. At the same time, for the foreseeable future there will be systems and data that aren't appropriate for any cloud at all. For most organizations, "100 percent cloud" is an aspiration, not a literal goal. This is where the hybrid cloud comes in. In a hybrid model, an organization is able to connect together cloud and on-site systems and even connect cloud to cloud, with the ability to manage across those different environments.

Good governance needs to be designed into any approach to cloud. As hosting sites increase, release cycles, operational management and support become more complex. Transparency and control across hosting sites (multi-cloud and on-site) are necessary for governance and smooth operations.

However, most experts agree that cloud providers are unlikely to come up with universal standards that would make this inherently easy. Vellante goes further, saying, "That's never going to happen." To manage in a multi-vendor cloud environment, CIOs will have to "create an abstraction layer though APIs that allows them to govern their application portfolio," he said. This abstraction layer enables what is often referred to as a "single pane of glass," allowing CIOs to control things like governance, security and corporate policies programmatically. "So if you're going to provision some storage with [one provider] and some compute from [another], you're programmatically

applying your corporate policies to those infrastructure components" automatically through code. "Without that it's just helter-skelter, run-amok cloud," Vellante said.

This hybrid cloud management capability is an emerging offering in the market. Managed service providers (MSPs) are starting to offer this as a management layer to all of their customers' assets, whether cloud, on-site or hosted by the MSP. Risk mitigation requires visibility, access and planning across all platforms. SLAs should focus on business process throughout and that should span on-site systems and cloud or even multiple clouds.

MOVING TO THE CLOUD

While every organization must make its own decisions about what to move to the cloud based on its unique business needs, the following offers a framework for making those decisions.

Discover: The first step is to find out what you have: for large, complex organizations, this is not an easy thing to do. Even smaller organizations are plagued by renegade applications and servers under desks. But it's a necessary first step.

Categorize: Once you know what's out there, according to Bernard Golden, author of *Amazon Web Services for Dummies* and CEO of Navica—a consulting firm focused on cloud computing and DevOps—you should sort your applications into the following categories:

1. OLD/OUTDATED SYSTEMS OF LIMITED VALUE These should be ruthlessly eliminated. However, it will require CEO authority as well as CIO influence to pry pet applications out of some business users' hands. CIOs now have some good models to hold up as examples with GE, Motorola Solutions, AstraZeneca, Telefonica and more.

2. NECESSARY BUT NON-DIFFERENTIATING SERVICES Services like email, office productivity, salesforce automation and conventional enterprise applications should migrate to SaaS. This provides businesses with modern innovations as they emerge—for example, new employee productivity features such as social processing, mobile workforce extensions, or increased analytics—and lets CIOs focus their teams' efforts on things that make a competitive difference. Patrick Benson, CIO of ClubCorp—a Dallas-based operator of over 200 golf, country, sports and business clubs—is basing his cloud strategy on SaaS and managed services wherever possible. "Part of cloud's value prop is the rapid release of new features that become available," he said, noting that with custom development, CIOs are going to have to deliver that rapid release of new features themselves. "There's got to be some overwhelming competitive advantage for us to undergo the expense, pain and time to redevelop something so it works in the cloud."

While a simpler choice than rewriting an application, moving to SaaS "is not as simple as you stop using one and start using another," said an IT leader with over a decade of cloud experience. First you have to be clear with the users of the system that the chosen service will define the process. This may require some negotiation. You have to populate and map the data, and ensure you are able to audit access to it. Finally, the users of the system must be retrained in the new process.

3. NECESSARY AND DIFFERENTIATING APPLICATIONS This is the most challenging group to sort out. Systems that are unique, homegrown or heavily customized are not good candidates for SaaS, but they may be for PaaS or IaaS. Deciding how to handle them requires sorting through many considerations such as the complexity of the code base, portfolio dependencies, network latency issues, whether or not demand is consistent or variable, data residency requirements for the countries in which you operate, and security, privacy and compliance concerns.

There are four basic options for how to approach these systems:

- **Lift and shift:** In this model, existing applications are moved to cloud infrastructure without being rewritten. It's a good option for organizations that have excessive infrastructure costs, and for applications where the data is tightly coupled to the application logic. Motorola Solutions, which had been heavily outsourced for infrastructure and application management, took this approach with a lot of its portfolio to increase reliability and availability and quickly lower costs. Virtualized workloads, such as VMWare, are easier to lift and shift and can be re-hosted unchanged on supported platforms. However, if your infrastructure costs are already good, lift and shift won't gain you much, as your application will not be able to take advantage of some of the primary benefits of cloud infrastructure, such as its scalability. And this is *not* a good choice for resource-intensive applications, which will likely cost more to run in the cloud and may suffer from performance and latency issues as well.

- **Containers** provide a "wrapper" around existing code to enable portability from one environment to another. The best known and most widely adopted of these is the Docker open-source standard. Containers provide access to more of the benefits of cloud than does the lift-and-shift model but without assuming the burden of having to rewrite the application itself. Containers are also useful for new development, enabling you to develop in one environment, test in another and run in a third, said Weinman. But as with much of the cloud space, containers are still evolving. It's a great tool and one that has many CIOs excited, but it may not be right for every application. Try it with a few complex but non-critical applications and learn from the experience.

- **Rewrite** applications (or refactor, changing the code but none of the functionality) to achieve full cloud-native capabilities where greater responsiveness to business needs is important—e.g., in areas that are rapidly changing and would benefit from faster release cycles, or for mobile applications. Rewriting increases developer productivity in the long run and makes it easier and faster to roll out new versions, as applications are based on components or microservices. It can provide higher performance and responsiveness, often at a lower cost.

  Of course, large organizations are likely to have a lot of these, and rewriting can be expensive and time-consuming, so it's essential to understand how the application addresses your business needs and what risk factors are involved. A good place to start is with applications where you'll see the biggest business lift from an agility/business benefit standpoint and where the risks are low in terms of the application or data. Systems that are poorly designed to begin with are also good candidates, because these will "consume cloud resources inefficiently [in a lift-and-shift arrangement], thus generating a much higher public cloud bill, and may even create performance and stability problems," according to David Linthicum, senior vice president at Cloud Technology Partners.[1]

- **Leave it alone.** Some complex legacy systems are fine as they are—at least for now. If the demand on the system is steady and the system is working well, there may be no immediate reason to move it to the cloud. On the other hand, if only a few people really understand and can work on the system, that's a risk factor. CIOs are weighing the pros and cons of maintaining these systems, managing the costs and complexity of data centers, and shifting their investments from CapEx to OpEx. This will be a continuous process over the next five to 10 years.

New capabilities: As the economy continues to evolve, organizations in all industries need to develop new capabilities—to capitalize on new opportunities and to fend off threats. It is becoming accepted wisdom that any new applications should be cloud-based, with SaaS as the first option (will an existing service fill your needs?), and with custom-developed applications written to be cloud native. GE CIO Jim Fowler has said that all new systems at GE will be developed on and for cloud services.

CIOs and cloud experts agree that the best place to start the cloud journey is with systems that will be relatively easy to implement with the lowest risk surrounding the application or data. Many are gaining their public cloud experience with development and testing (see box above) before moving on to production systems.

NEED FOR STRONG IT LEADERSHIP AND CLOUD SKILLS

Whatever model you pursue, moving to and operating in a cloud environment requires strong IT leadership and cloud skills. Even organizations that work with an MSP need to develop internal cloud management capabilities. While the basics are considered "managed," the CIO will drive the overall strategy and planning. Internal IT will define policies, monitor and manage service level agreements, and oversee capacity planning, compliance, troubleshooting and security. Different vendors offer different services, and that's changing all the time as the market matures. Business processes that span deployments, such as SaaS to SaaS and SaaS to on-site, need to be coordinated.

Cloud changes the skills you need in-house—and it affects almost every role. "Architects, developers, operations—long term, everyone has to learn new things," said Golden. Helen Sun, vice president of cloud computing, information and architecture at Motorola Solutions, agrees, using the example of a systems administrator: "Instead of configuring and implementing large packages, that skill set has to shift to scripting, development, programming and automation," she said. Jonathan Feldman, CIO at the City of Asheville, NC, changed a recent job posting from infrastructure analyst to infrastructure developer because "we got so many people who do cut-and-paste, 'Fisher-Price-control' systems administration who applied…. The future of infrastructure is automation and scripting. If you can't do that, we wish you luck elsewhere."

IT shops that are moving to more of a SaaS model might need a different skill set too. "I don't need developers who like to tinker," said ClubCorp's Benson, who is relying on his vendor to do much of the integration and coordination. Instead, he said, he needs more business analysts who can help match business needs to service offerings.

These shifts are taking place across IT organizations, and companies that venture into the cloud without the appropriate knowledge and skills do so at their peril. A $7 billion home-products company had its system hacked in the cloud. The company has since brought its system back in-house until it can develop the internal cloud management and security skills to do it right.

SECURITY IN THE CLOUD

The conversation around security in the cloud is often polarized, with many fearing their data will be less secure in the cloud and others thinking their own security will never match that of the big cloud providers. The truth, of course, is not so absolute. However great your provider's security measures are, you will always be responsible for your own organization's security. The first step is to do the due diligence to find out exactly what security the cloud company will provide (in IaaS deployments, that's often the physical infrastructure and network virtualization) and what your team will still need to do (e.g., security for the operating system, applications, data and service configuration)—and to clearly define that division of labor. Given how rapidly the market is evolving, cloud-committed CIOs are working closely with their providers to develop new models that fit their needs. For example, financial services has long been seen as an industry that would never use public cloud for anything critical. But Capital One has been working with its cloud provider to develop a security model that CIO Rob Alexander says will be more secure than Capital One's own data centers. As a result, they have been able to develop and deploy their new mobile banking app in the cloud.

There are some great vendor-agnostic resources available to help you navigate all this. For instance, the member-driven Cloud Security Alliance[2] provides a host of resources and best practices, including a list of questions to ask your cloud provider.

Cloud is not a panacea, and each company will draw its own line for what should go to public cloud and what should stay on-site (or be hosted by an MSP), depending on its unique business needs and organizational readiness. Even companies that are making huge investments in cloud, like GE, are retaining some of their own infrastructure—at least for now.

To get started, business and IT leaders should focus first on their business goals: Is this part of a major business transformation, as it is for GE? Or is your goal more about being able to respond more quickly to changing market conditions, or lower costs? This will help determine the approach you take and how fast you move, and ensure that as CIO, you're not going it alone.

Next, create a road map based on the framework above. Start with workloads that are easy to move and low-risk, and learn as you go.

Finally, move fast—but not too fast. Cloud is a necessary requirement for competing effectively in the digital economy, but there's a lot about it that's new. Make sure you understand how cloud is different, that line of business leaders are engaged in the decision process, that your team has the knowledge and skills to operate effectively, and that end users are supported as things shift. Just don't sit by while your competitors increase their agility by moving to the cloud.

ENDNOTE

1 http://www.cloudtp.com/2015/12/04/refactor-vs-lift-and-shift-vs-containers/

2 https://cloudsecurityalliance.org/