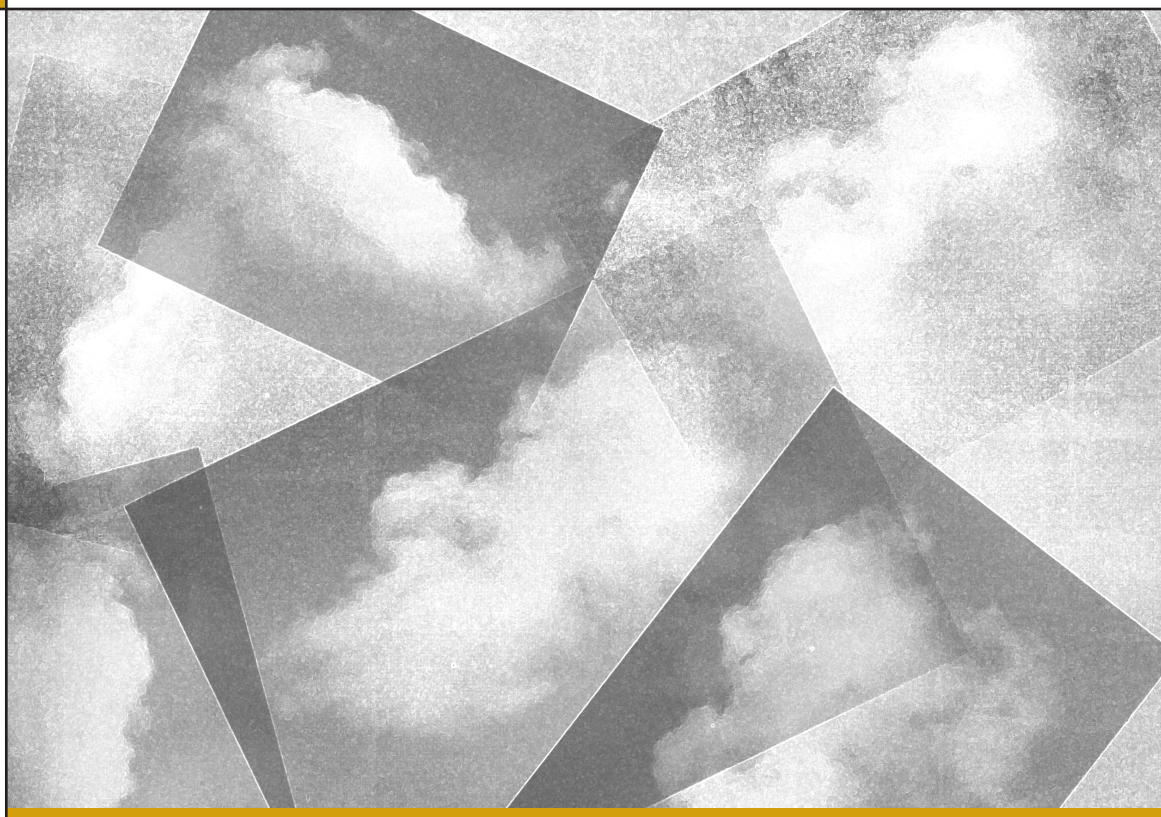
Moving to the Cloud: An Introduction to Cloud Computing in Government



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FOREWORD

On behalf of the IBM Center for the Business of Government, we are pleased to present this report, "Moving to the Cloud: An Introduction to Cloud Computing in Government," by David C. Wyld.

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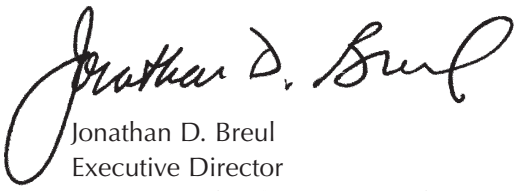
The term "cloud computing" is suddenly everywhere, with government leaders, industry executives, and the press all talking excitedly about this new concept. In this report, Dr. Wyld examines both the interest in and the technology surrounding cloud computing, and why it is receiving such increased attention. The report describes the incremental steps in the evolution of computer systems which enabled cloud computing to emerge. It also examines the current buzz surrounding cloud computing which is increasing our expectations of the role of information technology (IT) in government. Whereas managers have traditionally viewed IT as difficult and expensive, the promise of cloud computing leads many to think that IT will now be easy and cheap, perhaps even free. There are some expectations now that IT should be available on demand, preconfigured, and ready to use, no longer requiring careful planning and integration as in the past.

The reality is that, while cloud computing has simplified some technical aspects of building computer systems, the myriad challenges facing IT executives in government will remain. This report describes many of these challenges. They include government's current one-year budget cycle, the need for IT security, and the need to ensure the development of accurate requirements documentation. There is also still a need for Congress to make it easier for agencies to collaborate on cross-agency initiatives. Cloud computing also raises some new issues around IT security, questions such as the use of information obtained from the scanning of e-mail.

What will be the impact of cloud computing? How can cloud computing deliver on its promise if it can't overcome the challenges discussed above? IBM's recently released 2009 Global Chief Information Officer (CIO) Study sheds some light on this question. The survey found that CIOs add value to their organization through innovation and aligning IT with their organization's mission. Yet, CIOs report spending over 40 percent of their time and 60 percent of their budgets on delivering routine services to their organizations. These routine services are what cloud computing can deliver cheaply and easily.

The Study leads to the conclusion that cloud computing has the potential to transform IT, not necessarily through its impact on an agency's core business systems, but through commoditizing routine services such as e-mail, web servers, and data storage. Cloud computing can also easily deliver services that are common across government, such as accounting, procurement, and collaboration tools. If CIOs can increase their reliance on commodity computing, they will then have more time and resources to focus on the strategic management of IT and provide leadership and value for their agencies.

We hope that this timely and informative report will be useful to professionals and executives across government who are seeking innovative approaches in order to leverage the new technology of cloud computing in their effort to reform and improve IT programs and the delivery of services to both government itself and to citizens.



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EXECUTIVE SUMMARY

What Is Cloud Computing?

Cloud computing is an emerging concept. It has many names, including: grid computing, utility computing, and on-demand computing. Indeed, one of the hindrances to the development and adoption of cloud computing is the lack of understanding of what it is—and isn't—among both private and public sector leaders.

The term "cloud computing" has at its core a single element: computing services are delivered over the Internet, on demand, from a remote location, rather than residing on one's own desktop, laptop, mobile device, or even on an organization's servers. For an organization, this would mean that, for a set or variable, usage-based fee—or even possibly for free—it would contract with a provider to deliver applications, computing power, and storage via the web.

In a nutshell, the basic idea of cloud computing is that computing will become location- and device-independent—meaning that it increasingly will not matter where information is housed *nor* where computation/processing is taking place. This enables computing tasks and information to be available anytime, anywhere from any device—so long as there is access to the Internet. The cloud concept also means that, for individuals and organizations alike, computing will increasingly be viewed as an infinite, not a finite, resource. This is because computing is taking on an on-demand, scalable form, as additional network bandwidth, storage, and computation capacity can be added as needed, much as people simply use—and pay for—more (or less) electricity as their energy needs change. For this reason, many—even in the industry—refer to this as the utility model of computing.

If industry analysts are correct, we are at an inflection point—a true paradigm change—in the evolution of computing. The history of computing consists of a series of such shifts, from the era of the mainframe to the advent of the personal computer (and now, to mobile devices and netbooks), from the client-server model to the networked model, and from the age of isolation to the age of the Internet. While there are many uncertainties regarding the speed and ultimate reach of cloud computing, one thing that does appear very certain is that "business as usual" is soon going to be very different in our work and personal lives because of the advent of cloud computing.

What Are the Benefits of Cloud Computing?

Cloud computing offers a number of benefits, including the potential for:

- Rapid scalability and deployment capabilities (providing just-in-time computing power and infrastructure)
- Decreased maintenance/upgrades
- Improved resource utilization—elasticity, flexibility, efficiencies
- Improved economies of scale
- Improved collaboration capabilities
- Ability to engage in usage-based pricing, making computing a variable expense, rather than a fixed capital cost with high overhead
- Reduced information technology (IT) infrastructure needs—both up-front and support costs
- Capacity for on-demand infrastructure and computational power

- Green-friendly—reduced environmental footprint
- Improved disaster recovery capabilities

All in government IT—and in government itself—need to be aware of cloud computing and consider the possibilities it holds along with the people, technology, procurement, and governance issues raised by its advent. Cloud computing undoubtedly changes how we individually and collectively will approach IT. We already use aspects of cloud computing in our personal lives, and we are migrating to the cloud model in our work lives. The shift to cloud computing will also change how perhaps billions of dollars of IT spending are directed.

The challenge, as the chief information officer (CIO) of the United States, Vivek Kundra, has framed it, is to have the government IT work as well as IT does for ourselves in our own personal lives.

How Is This Report Organized?

This report provides the reader with an introduction to what cloud computing is and how it can—and is—being used by government.

Overview. The first section of this report provides an overview of cloud computing. It begins with a look at how cloud computing has rapidly evolved, examining what cloud computing is and is not, and seeing how the cloud has quickly taken hold as part of our everyday lives and how it is poised to become a major part of IT strategies for all organizations. We examine the notion of computing being "on demand," following in line with other services, such as electricity and telephony, which have become utilities. We see how leadership—from the top, as with new federal CIO Kundra, and from the bottom, from rank-and-file employees, is creating real momentum for implementing cloud computing in the public sector.

Case Studies. The second section of the report looks at specific case studies of how cloud computing is being used presently across the public sector. We focus on developments across several agencies, including cloud projects and initiatives taking place within the General Services Administration, NASA, and the Department of Defense. We also look at interesting ways cloud storage and services are beginning to be used in the education sphere,

Ten Predictions for the Cloud-Enabled Future of Government

1. Cloud computing will take off at the local and state levels through mostly rogue, "under the radar" initiatives over the next few years.
2. At the federal level, there will be a coordinated move to cloud computing, but with inevitable tension between agencies.
3. There will be two to three incidents a year worldwide with potentially massive security breaches, involving much media attention and attendant calls for greater regulation and oversight of cloud providers.
4. There will be much cooperation between private sector firms (seeking to be cloud service providers) and government agencies, with far more data and applications than expected today transitioning to the cloud over the next decade.
5. Budget pressures will continue to drive more and more government IT to hybrid and even public clouds, as more and more former internal IT functions—and assets (hardware, software, data, and support personnel)—are outsourced, with billions in procurement dollars shifting to the cloud.
6. There will be greater use of cloud computing, in everything from health care and education to the military and national security.
7. Free cloud offerings—even beyond the e-mail, storage, and application functions found today—will be a significant part of IT portfolios in most governmental agencies.
8. The spillover effect of government use of cloud computing will include faster agreements among major cloud providers on standards and cloud interoperability protocols.
9. There will be significant legal action arising out of governmental uses of cloud computing, and legislation addressing both IT and business needs and consumer fears and protections will be a major focus over the next decade.
10. The "democratization of technology" brought about by cloud computing will impact the quality of our individual online lives, the growth of businesses, and the pace of innovation, benefiting us all.

including work being done in post-secondary (colleges and universities) and primary and secondary (K-12) schools. Cloud computing efforts internationally are also discussed. Specific focus is given to the ambitious project of the Japanese government, the so-called "Kasumigaseki Cloud," and the "G-Cloud" and the Digital Britain project in the United Kingdom.

Challenges Facing Government Leaders. In the third section of the report, we look at how cloud computing will impact the public sector. We examine the 10 challenges facing government leaders as they work to integrate cloud computing offerings into their IT strategies. These include:

- **Challenge One:** The Need for Scalability
- **Challenge Two:** The Need for High Reliability
- **Challenge Three:** The Need for Securing Data in the Cloud
- **Challenge Four:** The Need for Open Standards and Interoperability
- **Challenge Five:** The Need to Revise Procurement Practices
- **Challenge Six:** The Need to Resolve Potential Legal Issues
- **Challenge Seven:** The Need to Regulate the "Cloud Market"
- **Challenge Eight:** The Need to Redefine the Roles of the IT Workforce
- **Challenge Nine:** The Need to Assess the Return on Investment of Cloud Computing
- **Challenge Ten:** The Need for Government Cloud Coordination

Steps Government Leaders Should Take. The final section of the report concludes with a look at the prospects for cloud computing's development at the federal and state/local levels, as well as abroad. It offers a "cloud migration strategy" for leaders in government IT to follow, which involves:

- **Step 1: Learning.** Both the "techies" and the "non-techies" in policymaking positions need to learn about cloud computing and the potential it holds.
- **Step 2: Organizational Assessment.** Conduct an examination of the organization's real IT utilization and how cloud-based storage, applications, and processing power might replace or supplement present IT capacity.
- **Step 3: Cloud Pilot.** Use one project—perhaps on the edge of the organization—to test how cloud works for your agency and with your existing technology and people.
- **Step 4: Cloud-Readiness Assessment.** Determine where cloud can—and cannot—be used as part of your organization's overall IT portfolio.
- **Step 5: Cloud Rollout Strategy.** Integrate cloud offerings as part of the agency's overall IT strategy and work to gain buy-in to the change effort throughout the organization.
- **Step 6: Continuous Cloud Improvement.** Cloud resources become part of the everyday workings of the agency, and as they do, this will necessitate making decisions as to when and how to best make use of cloud storage and applications.

Many believe cloud computing represents a new era in computing. The cloud model is quickly changing how all of us interact with computing resources and how computing power will be procured and managed. This report addresses the use, challenges, risks, and prospects for cloud computing in government.

An Introduction to Cloud Computing

"As we look forward at government in 2020, we have to fundamentally rethink how technology can be used."

–Vivek Kundra, Federal CIO (quoted in Campbell, 2009)

Cloud Computing 101

Cloud computing has certainly taken on the aura of the "phrase du jour" (Knorr and Gruman, 2008). It is certainly even more confusing and fluid due to the fact that it has become a "perfect marketing buzzword" (Wayner, 2008), or as Weiss (2007) labeled it—"a buzzword almost designed to be vague" (p. 25). Even if unintentional, the broad cloud computing "brand" has been lauded by marketing experts for its simplicity and user appeal, in stark contrast to the acronyms and jargon that characterize much of computing. As Michael Litchfield, who is the creative director at Omnicom Group's technology and financial arm, Doremus, recently observed in the *Wall Street Journal*: "What took them [the information technology (IT) industry] so long? Cloud-based services seem much easier to grasp than 'Application Service Provision.' ASP—who came up with that? The cloud is accessible. It may, in fact, be brilliant" (quoted in Fowler and Worthen, 2009). ASPs are vendors that provide software services that are hosted on their premises for use by client companies.

There is vast disagreement over what cloud computing is—and isn't. Indeed, as Baig (2009) accurately assessed, it is "many things to many people" (p. 4). As of late 2008, one academic study identified at least 22 definitions of cloud computing in common use (Vaquero, et al., 2008). The only real point of agreement today is that cloud computing represents anything beyond traditional computing using one's own data center (D'Auria and Nash, 2009) (see *A Sampling of Cloud Computing Definitions,* p. 10).

Haff (2009) shares the sentiments of many in the field when he suggests that there will likely never be a "canonical definition," for cloud computing, due to the simple fact that there are "too many people (that) have too many different perspectives." And this is complicated by the fact that, as R. Miller (2008a) pointed out, "buzz-chasing marketers' willingness to sprinkle 'cloud dust' over an even broader set of technologies and services." And the definition of cloud computing is indeed likely to evolve over time, as more and different applications shift to the cloud—with more and more companies seeking to provide cloud services and technologies (Hartig, 2009). The lack of a clear definition must be shared by enthusiastic IT buyers and not just the sellers of cloud-based services, for as Bowyer (2009) pointed out, many IT purchasers are willing to "jump on the bandwagon," even if they are unsure precisely what the bandwagon is that they are joining.

R. Miller (2008b) expressed his concern that this clash of terminologies can prove extremely confusing and off-putting to potential buyers of cloud services. And the cloud movement is certainly not without its share of skeptics and detractors (see *The Anti-Cloud Party,* p. 11).

The National Institute of Standards and Technology (NIST) has stepped into the fray, seeking to find a common-ground definition for the cloud computing concept [see *The National Institute of Standards and Technology (NIST) Definition of Cloud Computing,* p. 12]. The NIST definition has been judged to be

A Sampling of Cloud Computing Definitions

Author/Organization	Definition
The *Open Cloud Manifesto* Consortium	The ability to scale and provision computing power dynamically in a cost-efficient way and the ability of the consumer (end user, organization, or IT staff) to make the most of that power without having to manage the underlying complexity of the technology (OpenCloudManifesto.org, 2009, p.2).
The University of California, Berkeley Reliable Adaptive Distributed Systems Laboratory	Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the Data Centers that provide those services. The services themselves have long been referred to as Software as a Service (SaaS), so we use that term. The Data Center hardware and software is what we call a Cloud (Armbrust, et al., 2009).
Gartner	A style of computing where massively scalable IT-related capabilities are provided "as a service" using Internet technologies to connect multiple external customers (Gartner, 2008).
Michael Brown	A data-processing infrastructure in which the application software—and often the data itself—is stored permanently not on your PC but rather a remote server that's connected to the Internet (Brown, 2009).
Jaeger, Lin, Grimes, and Simmons	An emerging model of computing where machines in large data centers can be dynamically provisioned, configured, and reconfigured to deliver services in a scalable manner, for needs ranging from scientific research to video sharing to e–mail (Jaeger, et al., 2009).

one of the best working definitions offered, to date, for the cloud computing concept (Hoover, 2009b). It is especially valuable in that it defines not just the cloud computing concept overall, but spells out the essential characteristics of cloud computing and the various forms it can take in terms of both delivery and deployment models. From the perspective of NIST's Peter Mell, the NIST definition is important in that it is unbiased and expansive. He stated, "We attempted to put our hands around the entire industry doing cloud computing, so we didn't have the bias that any vendor did in their own products. We're scientists, and we weren't content with fuzzy definitions that encompassed anything and everything. We took a taxonomical approach to it that was not always common in definitions, but enabled people to think about cloud computing in a way that got a lot of traction" (quoted in Hoover, 2009b). In this report, we will use the NIST definition.

There are eight fundamental elements that are vital to enabling the cloud concept to not just exist, but to grow to its fullest potential (see Figure 1). From the perspective of Rayport and Heyward (2009, p. 4), it is essential to have the following conditions in the cloud environment:

- *Universal connectivity*—users must have near-ubiquitous access to the Internet.
- *Open access*—users must have fair, non-discriminatory access to the Internet.
- *Reliability*—the cloud must function at levels equal to or better than current stand-alone systems.
- *Interoperability and user choice*—users must be able to move among cloud platforms.
- *Security*—users' data must be safe.
- *Privacy*—users' rights to their data must be clearly defined and protected.
- *Economic value*—the cloud must deliver tangible savings and benefits.
- *Sustainability*—the cloud must raise energy efficiency and reduce ecological impact.

Cloud computing is still an emerging model, and thus, the real challenge, from the perspective of Michael Heath, a professor of computer science at the University of Illinois, is in "making this marriage of substantial processing power, computing resources, and data resources work efficiently, seamlessly, and transparently" (quoted in Borland, 2008).

Why cloud—and why now? According to the results of the 2009 Cloud Computing Survey, surveying

The Anti-Cloud Party

The whole notion of cloud computing is not without its critics and detractors. Richard Stallman, the creator of the GNU computer operating system and founder of the Free Software Foundation, has cautioned that the entire cloud concept is "a trap" for both individuals and organizations alike, as they will increasingly find themselves paying more and more for cloud computing resources over time as they are locked into these proprietary systems. Stallman labeled cloud computing saying, "It's stupidity. It's worse than stupidity: it's a marketing hype campaign" (quoted in Johnson, 2008).

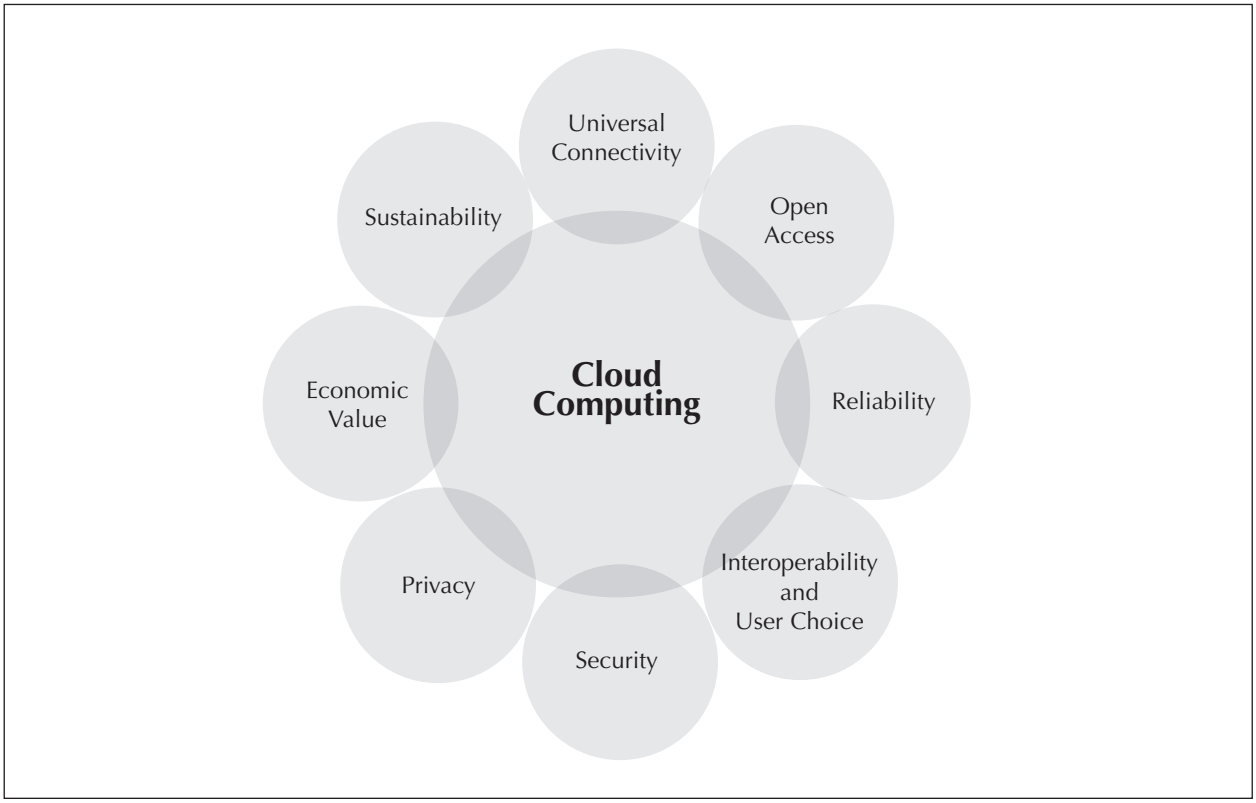
Oracle CEO Larry Ellison famously expressed his frustration with the expansiveness of the cloud concept, stating: "The interesting thing about cloud computing is that we've redefined cloud computing to include everything that we already do. The computer industry is the only industry that is more fashion-driven than women's fashion. Maybe I'm an idiot, but I have no idea what anyone is talking about. What is it? It's complete gibberish. It's insane. When is this idiocy going to stop?" (quoted in Johnson, 2008)

over 500 IT decision makers, the shift to cloud computing can be seen as organizations are increasingly "turning to new technologies to cut costs, rather than cutting back on their technology uptake" (Kelton Research, 2009, p. 1). Cloud computing is also by no means an "all or nothing" proposition. Indeed, it has been seen in practice that cloud involvement often starts when organizations initially use cloud resources for part of their non-mission-critical applications or as resources for test projects (Schwan, 2009).

The cloud model presents three new dimensions for computing:

- The illusion of infinite computing resources available on demand, thereby eliminating the need for cloud computing users to plan far ahead for provisioning ("provisioning" is a term used in the cloud computing community to mean procuring capacity on demand).
- The elimination of an up-front commitment by cloud users, thereby allowing companies to start small and increase hardware resources only when there is an increase in their needs.

Figure 1: The 8 Fundamental Elements of Cloud Computing



Source: *Based on Rayport and Heyward (2009, p. 4).*

The National Institute of Standards and Technology (NIST) Definition of Cloud Computing

In mid-2009, NIST offered the following definition of the cloud concept: *Cloud computing* is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three delivery models, and four deployment models.

Essential Characteristics

On-demand self-service. A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service's provider.

Ubiquitous network access. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and PDAs).

Location-independent resource pooling. The provider's computing resources are pooled to serve all consumers using a multitenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. The customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or data center). Examples of resources include storage, processing, memory, network bandwidth, and virtual machines.

Rapid elasticity. Capabilities can be rapidly and elastically provisioned to quickly scale up, and rapidly released to quickly scale down. To the consumer, the capabilities available for provisioning often appear to be infinite and can be purchased in any quantity at any time.

Measured service. Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported providing transparency of the utilized service for both the provider and consumer.

Cloud Delivery Models

Software as a Service (SaaS). The capability provided to the consumer is the use of the provider's applications running on a cloud infrastructure and accessible from various client devices through a thin-client interface such as a web browser (e.g., web-based e-mail). The consumer does not manage or control the underlying cloud infrastructure, network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

Platform as a Service (PaaS). The capability provided to the consumer is deployment onto the cloud infrastructure consumer-created applications using programming languages and tools supported by the provider (e.g., java, python, .Net). The consumer does not manage or control the underlying cloud infrastructure, network, servers, operating systems, or storage, but has control over the deployed applications and, possibly, application hosting environment configurations.

Infrastructure as a Service (IaaS). The capability provided to the consumer is the provision of processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure, but has control over operating systems, storage, deployed applications, and possibly select networking components (e.g., firewalls, load balancers).

Deployment Models

Private cloud. The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party, and may exist on or off the premises.

Community cloud. The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.

Public cloud. The cloud infrastructure is made available to the general public or a large industry group, and is owned by an organization selling cloud services.

Hybrid cloud. The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting).

Source: *Mell and Grance (2009).*

- The ability to pay for use of computing resources on a short-term basis as needed (e.g., processors by the hour and storage by the day) and release them as needed, thereby rewarding conservation by letting machines and storage go when they are no longer useful (Armbrust, et al., 2009, p. 1).

Understanding Cloud Computing

In the world of computing, clouds have always served a metaphorical, almost mystical, role. They have been used traditionally to represent the Internet in a networked environment when diagramming and mapping operations (Hartig, 2009). By using the term "cloud computing," the cloud metaphor greatly oversimplifies—some say even "obfuscates"—the complexity and issues involved in cloud-based services (Jaeger, et al., 2009). And, as Knorr and Gruman (2008) opined, "As a metaphor for the Internet, 'the cloud' is a familiar cliché, but when combined with 'computing,' the meaning gets bigger and fuzzier."

What is the cloud? There has been a suggestion to define the concept using the name "cloud" as an acronym, standing for computing that is a: "***C***ommon, ***L***ocation-independent, ***O***nline ***U***tility that is available on ***D***emand" (Chan, 2009). Certainly, cloud computing enables a new platform- and location-independent perspective on how we communicate, collaborate, and work. So long as you can access the web, you are able to work when and where you wish (Agger, 2009). On the flip side, from a provider perspective, cloud computing dramatically shifts what Hayes (2008) terms "the geography of computation," from the machine in front of you to a scale perhaps literally spanning the globe. This is because, with fast, reliable Internet connectivity and computer power, it does not matter where the document, the e-mail, or the data the user sees on his or her screen comes from, enabling providers to use distant data centers for cloud computing. Still, while some have predicted the end of the personal computer (PC) era with the rise of the cloud computing model, many believe that most organizations—and even individuals—will continue to make use of traditional PCs and laptops, even if more and more of their use will be to access the cloud (Ulanoff, 2009).

The Growth of Cloud Computing

Global IT spending hit $3.4 trillion in 2008, although the aggregate total is expected to decline for the first time since 2001 in the current year—and perhaps for 2010 as well (Ferguson, S., 2009). Indeed, across the private sector, IT spending is under fire. In fact, due to the interrelated impacts of the recession and the credit crisis, capital budgeting and credit availability for large IT projects has declined significantly. Thus, the only areas of IT that are growing in the wake of the economic crisis are outsourced IT and IT services (Davis, 2009a). Additionally, as new entrants, many of them tied to cloud services, enter the marketplace, the prices for outsourced IT are likely to decline over the next few years as competition intensifies between larger, entrenched competitors and these upstart firms (Davis, 2009b).

IDC estimates that roughly 10 percent of the approximately $64 billion spent on business applications worldwide in 2008 was spent on cloud computing applications—those being entirely delivered on a remote basis (Copeland, 2009). Many analysts, including Gartner, project growth rates for cloud computing in excess of 20 percent or more for years to come (O'Gara, 2009a). The growth rate over the next few years could be as high as 30 percent, with analysts estimating that the global market for cloud computing services could reach $42 billion by 2012 (IDC, 2008b). Gartner sees the cloud computing marketplace as an even larger market, and predicts that the market for cloud services already surpasses $40 billion today, and will grow to over $150 billion annually by 2013 (Hamm, 2009a).

The basic idea behind cloud computing is that anything that could be done in computing—whether on an individual PC or in a corporate data center, from storing data to communicating via e-mail to collaborating on documents or crunching numbers on large data sets—can be shifted to the cloud. Certainly, one of the hallmarks of cloud computing is that it enables users to interact with systems, data, and one another in a manner "that minimizes the necessary interaction with the underlying layers of the technology stack" (Langley, 2008). According to the *Open Cloud Manifesto*, "The key characteristics of the cloud are the ability to scale and provision computing power dynamically in a cost-efficient way and the ability of the consumer (end

user, organization or IT staff) to make the most of that power without having to manage the underlying complexity of the technology" (OpenCloudManifesto.org, 2009, p. 2).

Federal CIO Kundra—who is one of the chief proponents of cloud computing—stated that one of the principal benefits of the cloud model is simplifying computing for users, namely through the ability "to abstract the infrastructure from the applications" (quoted in Hoover, 2009a).

Using Cloud Computing

Think of what you do on the web on a daily basis. You check your e-mail. You do your "social networking"—checking Facebook once, twice, 10 times a day, and now Twittering. You post and view photos. You store files online, and yes, there can be real work done as well, creating documents, spreadsheets, and presentations entirely online. You have entered the realm of cloud computing, and like most Americans, perhaps not even known it. Indeed, technology futurist and Stanford University Visiting Scholar Paul Saffo recently remarked, "A lot of people are in the cloud and don't even realize it" (opinion cited in Brockman, 2009).

In September 2008, the Pew Internet & American Life Project released a report showing the profound shift of how we use the Internet and increasingly use cloud-based services in our daily personal and work lives (Horrigan, 2008). The Pew report revealed that, while many Americans may not be familiar with the term "cloud computing," the reality is that almost 9 in 10 American Internet users have done at least one cloud-based activity (see Table 1)! Thus, the Pew research demonstrates what we see on campuses, in coffee shops, in train stations, and in the park: we are increasingly communicating, storing, interacting and working via cloud-based services. People today are indisputably showing a willingness to put more and more of their lives and information online, "sacrificing privacy to save time and money" (Reiss, 2007). Thus, it is a personal calculus that we all make as to how much we engage in cloud computing offerings for our personal lives, trading privacy for ubiquitous, "easier" computing.

Remote-based e-mail (whether it be Gmail, Yahoo Mail, Hotmail, MSN Mail, AOL Mail, or any similar service) may be the easiest way to understand the basics of how cloud computing works. In fact, analysts have pointed to the fact that our knowledge of how cloud computing works can be best understood through our own personal use of Google's Gmail

Table 1: Americans in the Cloud

Cloud Computing Activities by Different Age Cohorts
Internet users in each age group who do the following online activities (%)

Use of Internet-Based Cloud Activity	Age				All Ages
	18-29	30-49	50-64	65+	
Use webmail services such as Hotmail, Gmail or Yahoo Mail	77%	58%	44%	27%	56%
Store personal photos	50%	34%	26%	19%	34%
Use online applications such as Google Documents or Adobe Photoshop Express	39%	28%	25%	19%	29%
Store personal videos	14%	6%	5%	2%	7%
Pay to store computer files online	9%	4%	5%	3%	5%
Back up hard drive to an online site	7%	5%	5%	4%	5%
Have done at least one activity	87%	71%	59%	46%	
Have done at least two activities	59%	39%	31%	21%	

Source: *Adapted from Horrigan (2008, pp. 1, 5).*

and GoogleApps (Bo and Rentian, 2009). When using a service such as Gmail, your mail is stored on a Google server rather than on your own machine's hard drive. Thanks to this arrangement, you can access your e-mail from any device that has a web browser and an Internet connection. Thus, anyone with a web-based e-mail account is already taking advantage of cloud computing. We see this again and again in our Web 2.0 world, as anyone storing files or photos online is a cloud user, for example, all participants on any social networking sites and blog creators (and the many more who read them).

Thus, most of us are already in the clouds, whether we know it or not. In all of these instances, both the data and the application behind it are stored on a remote server, rather than on your own PC, laptop, or other computing device. The vision of cloud computing thus represents a fundamental challenge to what we regard as a "computer." As C. Thompson (2009) characterized this new model of computing:

> Users' hard drive memory and software will all be provided by a grand universe of servers and data centers, allowing you to access everything you need without being anywhere near your computer. Instead, all you need is a machine with enough power to drive a screen, a keyboard, and an Internet browser. The plan could make computers cheaper than anyone ever imagined, as features that were once thought essential are stripped away, leaving only a fraction of the infrastructure we used to need. And your documents, from reports and essays to photographs and personal videos, will be immediately accessible from any terminal in the world.

Cloud computing thus could be—and likely will be—the "next big thing" in IT for all of us, and for government IT, in particular.

The Evolution from Grid Computing to Cloud Computing

Experts have noted that computing in the future will soon be "a mix of applications that reside on the desktop and services obtained via the Internet, or the 'compute cloud' as it is sometimes called" (Jackson, 2007). Cloud computing has been heralded as nothing less than "creating the new architecture, the new paradigm for IT" (Foust, 2009) and having the "potential to transform a large part of the IT industry" (Armbrust, et al., 2009). From the perspective of Willy Chiu, vice president of IBM Cloud Labs, "Cloud computing is a new way of consuming IT" (quoted in Babcock, 2009). Thus, from an organizational standpoint, cloud computing simply represents "an architecture in which companies consume technology resources as an Internet service rather than as an owned system" (Brandel, 2009a).

The Economist (2008b) reminds us that "computing has constantly changed shape and location—mainly as a result of new technology, but often also because of shifts in demand." We have seen revolutionary computing technologies—truly "game-changing" concepts—come about roughly once each decade in the "modern era" of computing (since around 1945

The Potential of Wireless on Cloud Computing

The wireless trend is not just an American, Asian, European, or even a developed world phenomenon. It is truly worldwide. According to IDC (2008a), the number of devices accessing the Internet worldwide will grow to more than 3 billion by 2012—*doubling* from the 1.5 billion Internet-connected devices in 2008. Half of these device accessing the web will be mobile—laptops, netbooks, personal digital assistants (PDAs), and increasingly, cell phones.

The Economist (2008a) described this trend: "The plethora of devices wirelessly connected to the Internet will speed up a shift that is already under way: from a 'device-centric' to an 'information-centric' world…. (and) as wireless technology gets better and cheaper, more and more different kinds of objects will connect directly to the cloud." Technology writer Clay Shirky has said: "What is driving this shift is a change in perspective from seeing the computer as a box to seeing the computer as a door" (quoted in Rayport and Heyward, 2009, p. 11). The emerging cloud computing paradigm is thus based on a "user-centric interface that makes the cloud infrastructure supporting the applications transparent to [the] user" (IBM, 2009, p. 3). Some have speculated that the functionality of cloud computing "could even render the personal computer obsolete" (Brown, 2009) as we move to what has been described as an "application-centric" world (Jackson, 2007).

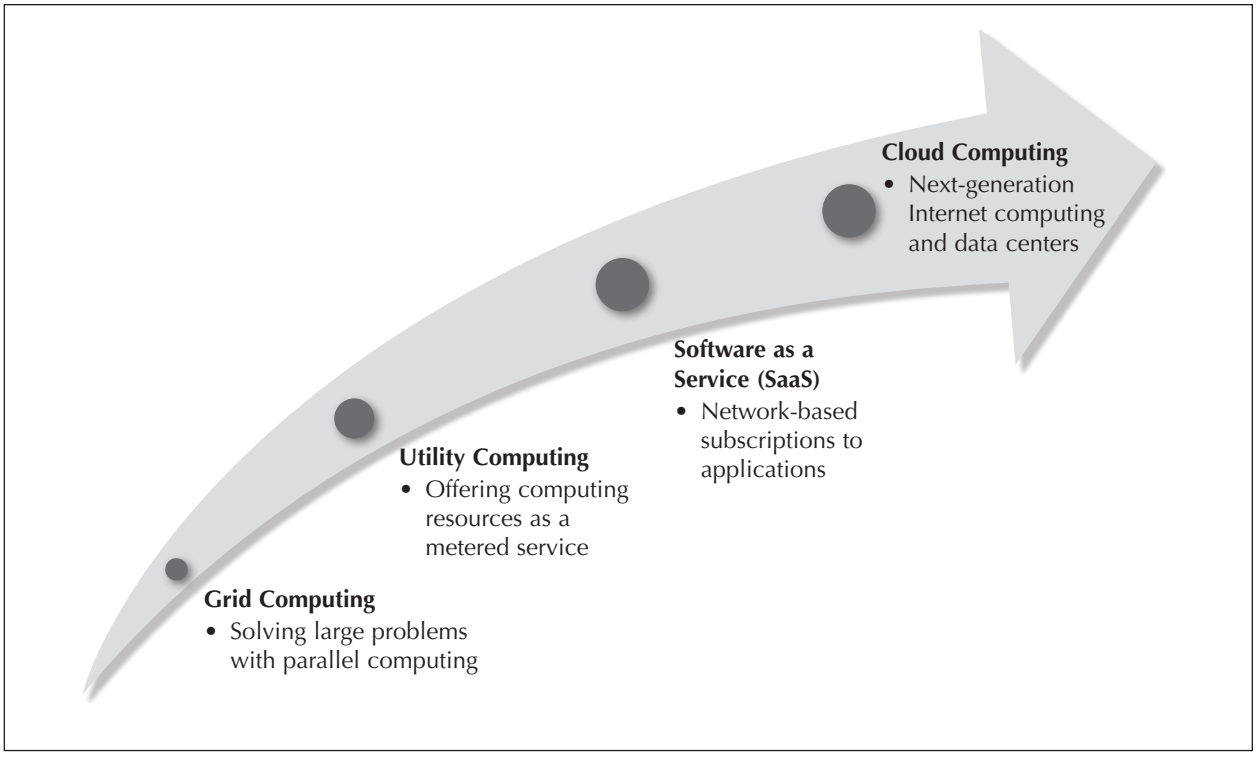
when computing came to mean computations performed by a machine, not by man). We have witnessed the megatrends, from the mainframe era of the 1960s to the advent of minicomputers in the 1970s, the personal computer in the 1980s, the growth of the Internet and the web in the 1990s, and the explosion of cell phones and other smart, web-connected devices in the past 10 years. Now, many think that cloud computing will be "the next big thing." Gartner (2008) believes that, in the end, the impact of the cloud model will be "no less influential than e-business." And thus federal CIO Vivek Kundra observed last year: "The cloud will do for government what the Internet did in the '90s.… It's a fundamental change to the way our government operates" (quoted in Nagesh, 2008).

Grid computing grew out of the idea that, by linking increasing numbers of computers—even supercomputers—together, computing power could be made scalable and available on demand (Kurdi, Li, and Al-Raweshidy, 2008). While grid computing was foundational to the development of the cloud concept (see Figure 2), grid and cloud computing can be distinguished in the following manner: "Grid computing specifically refers to leveraging several computers in parallel to solve a particular, individual problem, or to run a specific application. Cloud computing, on the other hand, refers to leveraging multiple resources, including computing resources, to deliver a 'service' to the end user" (IBM, 2009a, p. 6).

With the idea of computing becoming an on-demand service, the cloud model builds upon the concepts of utility computing and Software as a Service (SaaS). With utility models, computing becomes an on-demand resource in which capacity can be readily added—or subtracted—as conditions warrant, just as we have historically used utility services such as electricity, water, or telephony (see *Appendix)*. Likewise, SaaS—in which software applications for specific functions are hosted by vendors and contracted for on a subscription basis—has come into increasing use by organizations in both the private and public sectors over the past decade. Cloud computing encompasses these antecedent models and offers far greater on-demand computing power—and resources—than ever before.

Gardiner (2009) observed that cloud computing is at an "awkward stage," where it is alternately considered by some to be "the next big thing" and by

Figure 2: The Evolution of Cloud Computing



Source: *Adapted from IBM (2009)* White Paper—Seeding the Clouds: Key Infrastructure Elements for Cloud Computing, *February 2009 (p. 6).*

others to be a "fundamentally flawed idea." With all of the hype surrounding cloud computing, despite the promises of the benefits of the technology, it will undoubtedly hit the "trough of disillusionment" that all new technology innovations pass through (*The Economist*, 2008b). Indeed, Daconta (2009) recently pegged cloud computing as the number one IT fad to be avoided by government IT managers, calling the cloud concept "a red herring" and advising that "chasing this fad now, before standards are in place and security concerns are dealt with, is a complete waste of time."

Those in the IT community have seen prior hyped technologies, such as enterprise resource planning systems, data warehousing, and client-server computing. The common theme has been that, when the hype cycle abated, all of these technologies proved to have significant impacts on corporate computing—but often at far greater costs and with more implementation challenges and complexity than earlier promised (D'Auria and Nash, 2009). Thus, it should not be surprising that, in an October 2009 survey of IT executives conducted by CIO Research, cloud computing was the number one subject of interest among IT decision makers (Johnson, 2009).

Cloud Computing in Government

The State of Cloud Computing in Government

The developments in cloud computing are leading many inside and outside of the public sector to ask, "If it works for business, why not for government?" (Condon, 2009a). In his Senate confirmation hearing in May 2009, Aneesh Chopra, the nation's first chief technology officer (CTO), stated that cloud computing holds a number of advantages for the government. These include "reduced cost, increased storage, higher levels of automation, increased flexibility, and higher levels of employee mobility." As such, Chopra stated, "The federal government should be exploring greater use of cloud computing where appropriate" (quoted in Schatz, 2009). Condon (2009a) observed, "The financial downturn, momentum from the private sector, and a new Web-savvy (Obama) administration have come together to create the perfect climate for government adoption of cloud computing." Certainly, building on the obvious weather analogy, cloud computing is riding "the perfect storm" for development in the public sector.

Much of the focus on cloud computing today comes from the first federal chief information officer (CIO), Vivek Kundra. Kundra's views on government information technology (IT) were greatly influenced by September 11, 2001, when he was the director of infrastructure for technology for Arlington, Virginia. That experience was a formative one for Kundra, as the attack on the Pentagon showed him the vulnerability of data centers. Kundra recalls: "In Arlington, what we realized after those attacks was that, if we had our one main data center shut down, we wouldn't be able to support government" (quoted in Lynch, 2008). When Kundra took over as CTO for the District of Columbia in 2007, he quickly moved the government's e-mail to Google and encouraged the use of Google Apps—shifting the work of 38,000 employees and over 80 municipal agencies to cloud computing (Hicks, 2009a). Shifting to hosted e-mail and applications gives government increased business continuity capability, simply due to the ability to disperse data to geographically remote data centers. He also put a massive amount of District data online, holding a contest for citizens to develop "Apps for Democracy"—which brought forth a wealth of useful applications and was estimated to save the District government millions by involving citizens in the development and analysis processes (Nagesh, 2008). Today, Kundra's goal is nothing less than to "fundamentally revolutionize the way technology is used in [the] public sector and reject the view that [the] public sector has to ride behind the private sector in IT innovation" (quoted in Aitoro, 2009a).

Kundra is attempting to institute massive strategic changes—both in mindsets and operations—in the federal IT area. Indeed, Kundra believes that cloud computing represents a "tectonic shift" in computing technology (quoted in Campbell, 2009), predicting that, ultimately, "the cloud will do for government what the Internet did in the [1990s]" (quoted in Nagesh, 2009a).

Kundra poses a fundamental question for federal IT strategy: "Government needs to start asking the question, 'Are we building an IT organization? Or do we want to move out of the system of owning hardware and get services to deliver solutions to customers faster?'" (quoted in Lynch, 2008). Kundra's philosophy is very much outcome-oriented and metric-driven. He observed that "spending money on technology is good, but at the same time

we want to make sure we have outcomes for those investments" (quoted in Hoover, 2009a). Kundra is also asking why the government should not be making use of more free, web-based alternatives to traditional software. He has observed, "Why would we invest in infrastructure and technologies if they're available for free?" (quoted in Hoover, 2009a) (see *Free!, p. 20*).

Kundra, discussing his decision to shift the District government from hosted e-mail and applications to Gmail and Google Apps, stated, "When employees go home, they have access to more technology at home than they do at work. I said, 'Wait a minute, people have this access at home? How can I bring it to the government?' It made a compelling reason for us to move [in] that direction" (quoted in Lynch, 2008). Indeed, developments and expectations in the consumer realm are becoming drivers of what can and is expected to be done in public and private sector organizations (Brockman, 2009).

It will be the employees themselves who will drive the transition. Michael Nelson, a visiting professor of Internet studies in Georgetown University's Communication, Culture, and Technology Program, observed, "If you don't give the tools to your people, they're going to go find some other tool that is already available from a cloud service provider and do it on their own. Whether it is storing images on Flickr, doing collaboration in a virtual world or using Facebook, they will find it" (quoted in Beizer, 2009a). Thus, in many cases, the spark to use cloud computing will come from rank-and-file employees themselves seeking to have access at work to the cloud services that they use in their personal lives and private pursuits.

Indeed, the ability to more effectively communicate and collaborate has been touted for government agencies as one of the biggest benefits of adopting the cloud model (Beizer, 2008a). With both the application and the data stored in the cloud, it becomes easy for multiple users—located anywhere in the world—to work together on the same project. For instance, with Google Docs, multiple users can open, share, and edit the same document, spreadsheet, or presentation at the same time and truly collaborate in its production.

Vivek Kundra
The Federal Government's CIO

In March 2009, Vivek Kundra was appointed the government's chief information officer (CIO). Kundra also serves as administrator of the Office of E-Government and Information Technology in the Office of Management and Budget. The CIO directs the policy and strategic planning of federal information technology investments and is responsible for oversight of federal technology spending.

Prior to joining the Obama administration, Kundra was chief technology officer for the District of Columbia. Before assuming the District position, he served as assistant secretary of commerce and technology for the Commonwealth of Virginia, the first dual cabinet role in the state's history. In that position, he developed innovations to streamline government, including the development of a dashboard that used business intelligence to maximize the participation of citizens in state government. He also served as director of infrastructure technology for Arlington, Virginia.

Kundra's private sector experience includes serving as vice president of marketing for Evincible Software and chief executive officer of Creostar, where he advised clients in government and industry on IT governance and strategy.

Kundra received his M.S. in information technology and B.S. in psychology from the University of Maryland.

The Cloud and Federal IT Spending

Many analysts believe that the present economic situation—and its resulting financial strain on governments—will only serve to accelerate the adoption of cloud computing in the public sector (Ferguson, T., 2009). As Golden (2009a) discussed, cloud computing offers "undeniable financial payback—higher utilization, lower energy use, and better application availability. The benefits are so large that IT organizations have been willing—eager, even—to tolerate the challenges that accompany the technology." Indeed, a July 2009 *Computerworld* report found that, the larger the organization, the greater the likelihood that it would be engaged in using cloud computing (King, 2009).

Free!

The concept of "free" is a powerful one. Whether it is a 2-for-1 happy hour drink, a sample of teriyaki chicken at the mall's food court, or a complimentary ticket to an event, we all like something for free. This is true in the technology area as well.

There is much discussion about the whole concept of "free" pricing for many products and services today—and many of the e-mail, storage, hosting, and applications that are at the forefront of cloud computing today are indeed free. The most notable of these are the product offerings of Google (Gmail, GoogleApps, GoogleDocs, and others). In exchange for the "free" services, Google collects information from users in order to better target advertising to them (i.e., this is why you see ads for football tickets when you mention something like "we're going to the game" in your Gmail message). The collection of information is explained in the Google's privacy policy.

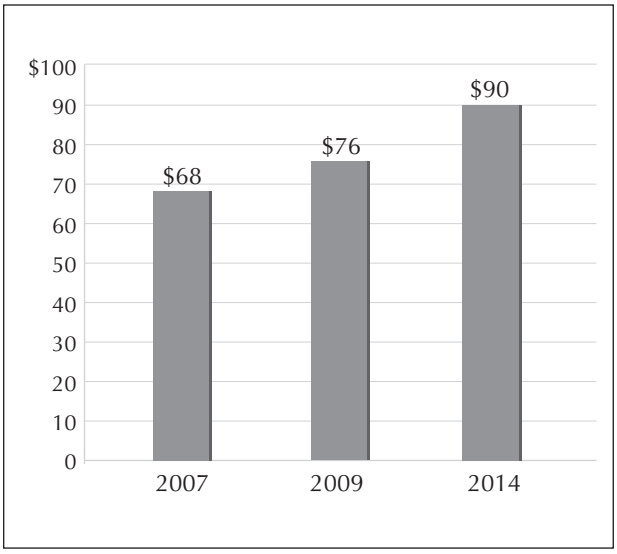
Much attention has been devoted to the concept of "freeconomics," most notably the recent book by *Wired* magazine editor Chris Anderson (2009) entitled, *Free: The Future of a Radical Price*. Most consumer-level cloud offerings would be labeled a "freemium," which is a free version that is supported by a paid, premium version. Such freemiums are becoming an emergent business model, as they are particularly popular among online service and software companies. And, when faced with competing against "free" alternatives, older, more established companies have seen users migrate to the *gratis* alternative. Indeed, some see an entire "culture of free" emerging where—from music to entertainment to news to software—people are coming to expect that free is the price they should pay (Knowledge@Wharton, 2009).

In the corporate computing market, as software, hardware and processing power, and storage capacity become more and more commoditized, cloud computing becomes a free—or lower cost—alternative to the way things have been done for decades. As DiMaio (2009b) remarked, "Why should I bother looking for an e-mail client to replace Outlook and coexist with my newly installed OpenOffice, if I can get e-mail and an office suite as a service with somebody like Google at a fraction of the cost and—most importantly—giving up the IT management burden too? Why are we talking about moving servers from Windows to Linux when the real question is why do we need to have our own servers in the first place?"

The economy and the resulting tightness of all governmental budgets—on every level—may indeed speed and heighten the rise of cloud computing. Dan Israel, an executive with Google's federal group, observed: "Given that we're in a very tight budget situation, looking to the cloud is a very cost-effective means of bringing new technologies into the government. By moving to cloud computing, we can also help government IT get out of the business of using and managing servers and focusing instead on more mission-critical technology projects in their agencies" (cited in Sternstein, 2009a). As such, cloud computing gives organizations greater ability to focus on their core business (Kelton Research, 2009). In the case of government, this would be serving the citizenry. Likewise, Ron Ross, the National Institute for Standards and Technology's (NIST) director of security, commented, "In an era where there's going to be tight resources, there will be compelling ways to do things more effectively on the IT side … [but] we have to be able to do that in an environment that is well protected" (quoted in Condon, 2009a).

Thus, in this new age of budget frugality, the challenge is to do more with less. Information technology is thus seen as an enabler of new ways of bringing efficiency and rationalization not just to computing, but to the business of government itself In this budgetary context, the forecasts for the impact of cloud computing on federal IT spending are certainly eye-opening. The public sector market analysis firm INPUT (2009) recently projected that, over the next five years, overall federal IT spending will grow at a compound annual rate of 3.5%, reaching $90 billion by 2014 (see Figure 3). INPUT forecasts that federal cloud computing-related spending will grow almost eight times as fast, with a growth rate of approximately 30 percent annually over the same time frame. According to INPUT's projections, federal spending on cloud computing services will triple over the next five years, growing from $277 million in 2008 to $792 million annually by 2013. This would mean that, by 2014, over $1 billion of the federal IT budget would be devoted to cloud computing. Projections from Market Research Media (2009) are even more optimistic, saying that cloud computing represents "a fundamental re-examination of investments in technology infrastructure." Its market analysis projects a 40 percent CAGR (compound annual growth rate) for cloud

Figure 3: Federal IT Spending Forecast, 2009–2014 (in billions)



Source: *INPUT (2009).*

computing spending in the federal sector, and predicts that cloud spending will top $7 billion annually by 2015.

The fast growth of federal spending in this area is being driven by top-level commitment to transform the federal IT infrastructure through increased adoption of cloud-based architectures, with the expectations of cost savings and efficiencies to be achieved. Analysts have observed that such spending—and the executive commitment behind it—will mean that the federal government will not lag behind the private sector in the shift to cloud computing (Gross, 2009a). As CIO Kundra has stated, "The cloud computing investment in the 2010 budget reflects the administration's desire to drive down costs, drive innovation across the federal government, and make sure we're making available technologies to the workforce that may be available to them elsewhere" (quoted in Foley, 2009a). Thus, cloud computing appears to be fundamental to the Obama administration's technology strategy to try to gain efficiency from and rationalization of federal IT, while expanding applications, interoperability, and communications.

In May 2009, the Obama administration expressed its commitment to transforming the architecture of federal IT through cloud computing in the annual supplement to its budget proposal for the 2010 fiscal year [Office of Management and Budget (OMB), 2009]. In *Analytical Perspectives*, cloud computing is a central part of an effort to fundamentally realign the government's IT infrastructure and IT strategy:

> The Federal Government will transform its Information Technology Infrastructure by virtualizing data centers, consolidating data centers and operations, and ultimately adopting a cloud-computing business model. Initial pilots conducted in collaboration with Federal agencies will serve as test beds to demonstrate capabilities, including appropriate security and privacy protection at or exceeding current best practices, developing standards, gathering data, and benchmarking costs and performance. The pilots will evolve into migrations of major agency capabilities from agency computing platforms to base agency IT processes and data in the cloud. Expected savings in the out years, as more agencies reduce their costs of hosting systems in their own data centers, should be many times the original investment in this area (OMB, 2009, p. 158).

The pilot categories outlined in the 2010 budget proposal include the following broad areas:

- *End-user communications and computing*—secure provisioning, support (help desk), and operation of end user applications across a spectrum of devices; addressing telework and a mobile workforce.
- *Secure virtualized data centers*—with government-to-government, government-to-contractor, and contractor-to-contractor modes of service delivery.
- *Portals, collaboration and messaging*—secure data dissemination, citizen and other stakeholder engagement, and workforce productivity.
- *Content, information, and records management*—delivery of services to citizens, and workforce productivity.
- *Workflow and case management*—delivery of services to citizens and workforce productivity.
- *Data analytics, visualization, and reporting*—transparency and management.
- *Enterprise Software-as-a-Service*—for example, in financial management (OMB, 2009, p. 158).

Observers have commented that this budget document makes clear that the initial pilot projects and seed investments are but the "beachhead for a broader shift" in federal IT strategy—and spending—under the Obama administration and CIO Kundra (Miller, R., 2009). Cloud computing today has been termed as being in the "wonderful 'discovery' phase of a technology," with great forecasts, but few guidelines on how to properly make use of the technology (Urquhart, 2008). What we have seen, to date, in the federal government is a series of small cloud computing projects as various agencies have undertaken what Woody (2009) termed as "science experiments" in the use of the technology. Definitely, we are in the "early adopter" phase of the product life cycle of cloud computing (Baig, 2009), and some have urged that the federal government, due to its market power, should help to propel the movement and become an early adopter of cloud computing. Rayport and Heyward (2009) urged the Obama administration to adopt "pro-cloud" policies and promote cloud computing to ensure that the U.S. remains at the forefront of this computing revolution. They urged such actions by writing, "It's high time to ensure that the cloud's promise as an opportunity for U.S. wealth generation, job creation, and business and technology leadership does not pass our country by."

Craig Mundie, Microsoft's chief research and strategy officer, observed, "Many of these governments are saddled with incredible legacy data center expenses. They're just some of the world's largest enterprises and they accrue a lot of legacy, often custom, systems that are hard for them to maintain and also then hard for them to replace" (quoted in Romano, 2009). Cloud computing could thus represent an opportunity to break free from the costly and problematic model of managing internal legacy IT systems and operations and move to a more outsourced model of IT operations. Indeed, Michelle Warren, a senior analyst for Info-Tech Research, recently observed, "We're moving toward a world where IT is outsourced" (cited in Paul, 2008).

In the next section, we examine how cloud computing is now being used in government. While we are early in the development of a "cloud revolution," there has been intense and ingenious use of cloud resources all around the world.

The Use of Cloud Computing in Government

In their *2009 Cloud Consensus Report*, Trauth and Hovey (2009) asked their survey panel of several hundred federal IT managers and executives how they believed their agency would be hosting a range of applications five years from now. The researchers found that the majority of the federal IT managers surveyed believed that e-mail and procurement would be hosted in a cloud environment, with strong support across the board for moving to both public and private clouds for applications ranging from enterprise resource planning and customer relationship management (CRM) as well as to accounting applications. Interestingly, the number of executives in the survey answering "unsure" about where they would be hosting applications was quite significant. This demonstrates how the cloud model is shaking up governmental IT in general, for just a few short years ago, would there have been any uncertainty, any debate, as to where a government agency would be hosting its applications and data?

For government, there simply may be no choice but to turn to cloud-based models for computing. Consider the staggering growth in e-mails, blogs, videos, "twitters," and other forms of electronic communications that will be generated in the future. The National Archives is already looking at cloud storage to cope with this digital deluge (Hoover, 2009c). In January 2009, the National Archives received 200 million e-mails from the outgoing Bush administration to catalog and preserve, and they anticipate that the Obama administration may well generate over a billion e-mails. As such, Erlichman (2009) believes that cloud storage will be indispensible in preserving electronic communications for future generations of scholars and historians.

According to NIST's Peter Mell, who heads up the NIST cloud computing research team, "cloud computing is of great interest to the U.S. government, and it's seen as a great opportunity to promote efficiencies, but there is not widespread adoption. At all levels of the government, at least in IT, there is intense scrutiny of the new paradigm and evaluation of its utility" (quoted in Chabrow, 2009). We have, however, seen early examples of the use of cloud computing in the public sector, both in the U.S. and abroad. In this section of the report, we will examine

efforts across the federal government, in education, and internationally.

Federal Government

In June 2009, the Merlin Federal Cloud Initiative, in conjunction with MeriTalk, conducted a large survey of both federal IT executives and industry partners regarding cloud computing. This survey of over 600 federal IT leaders found that, while just 13 percent of federal IT managers reported currently using cloud computing, the actual use of cloud models is likely far higher. This is because, in the same survey, the use of cloud-based applications was found to be far more common than previously thought. In fact, the survey conducted by Trauth and Hovey (2009) discussed earlier revealed that, among the federal IT executives surveyed:

- 44 percent reported using database cloud applications
- 42 percent reported using document management cloud applications
- 28 percent reported running a virtualized server environment in-house (that is, a private cloud) (p. 7)

Their study found that fully three-quarters of the federal IT managers surveyed believe that the cloud model is "here to stay" and that fully 61percent of this same group believe that, in five years time, "the majority of large enterprises will rely on cloud computing for core applications." In regard to this latter finding, the government IT leaders were 10 percentage points more confident than their private sector counterparts about the ascent of cloud computing (Trauth and Hovey, 2009, p. 9).

Not all initiatives will be necessarily led by the public sector. In fact, private sector firms are today using public data as a way to showcase their cloud capabilities and offerings—and to assist government in the process (see *Private Sector Initiatives to Host Public Data in Public Clouds,* p. 23).

Domestic Agencies

General Services Administration (GSA). The GSA has been an active area for cloud computing in the federal government, seeking to build upon its present role as a provisioning hub for the future, and is poised for more—perhaps much more—in the shift to cloud computing.

In February 2009, the GSA announced that it had contracted with Miami-based Terremark Worldwide to provide cloud-based hosting of the federal government's primary e–government portals—USA.gov and its Spanish–language companion site, GobiernoUSA.gov. While the two sites draw in excess of 140 million visits annually (averaging 342,000 visits daily), the traffic can see significant "spikes" due to external events, ranging from natural disasters to the release of the monthly unemployment statistics. With the shift to cloud-based hosting,

Private Sector Initiatives to Host Public Data in Public Clouds

At the federal level, while Data.gov is being established as a central portal for federal government data, private providers are leaping into the market to host government data sets for public access—at least on a trial, demonstration basis. As Foley (2009) pointed out, one of the prime examples of cloud computing in the federal sector today can be found in the fact that Amazon Web Services hosts a number of federal data sets. These include:

- **Federal Reserve Economic Data (FRED)**
  A database of over 20,000 U.S. economic time series
- **Federal Contracts from the Federal Procurement Data System**
  Data on all federal contracts from the Federal Procurement Data System.
- **National Center for Biotechnology Information**
  A set of transcript sequences of well-characterized genes and hundreds of thousands of expressed sequence tags that provide an organized view of the transcriptome
- **The U.S. Census Bureau**
  United States demographic data from the 1980, 1990, and 2000 U.S. Censuses; summary information about business and industry; and 2003–2006 economic household profile data

Source: *Amazon Web Services, aws.amazon.com/publicdatasets/*

Microsoft is also demonstrating the capabilities of its Azure cloud computing operation to host government data through its Open Government Data Initiative (ogdisdk.cloudapp.net/). The company is offering to host public data sets for free on its Elastic Block Storage (Jackson, 2009b). Currently, the Microsoft service is hosting dozens of data sets from the District of Columbia (the catalog of data sets is available at ogdisdk.cloudapp.net/DataCatalog.aspx).

the GSA can use "cloudbursts" to increase capacity as needed, rather than having to host server capacity (and the costs—in personnel and energy—necessary to support this largely idle capacity) to handle the web traffic experienced only at these peak times. Likewise, the GSA reports that, with external hosting, changes to the site that formerly took six months can now be accomplished in a single day (Nagesh, 2009c)!

GSA expects that the shift to cloud computing will halve the agency's administration costs for the sites and cut its infrastructure costs by 90 percent, while delivering improved and scalable web offerings. The changeover is expected to be completed in late 2009 (Beizer, 2009b; Towns, 2009). And while some may question whether such a web-hosting agreement is truly "cloud computing" (Jackson, 2009a), the GSA's move to hosting beyond its own "four walls" would fit within a broad definition of the cloud model. The GSA is exploring moving other web sites and portals it hosts to external hosting, and hopes that the transition of USA.gov to the cloud will serve as a model for other federal agencies. From the perspective of Martha Dorris, deputy associate administrator for the GSA's Office of Citizen Services, which oversees USA.gov, "Government-wide this is a great opportunity for agencies to take advantage and save some of the IT infrastructure money spent on low-risk web sites" (quoted in Nagesh, 2009c).

In May 2009, the GSA issued a Request for Information for interoperability and operational practices from potential vendors (Hoover, 2009e). The vision of the GSA's CIO Casey Coleman is to be able to provide Infrastructure as a Service (IaaS) on demand for all federal agencies through prequalified vendors who have been certified for their security, privacy, and operational capabilities (Hoover, 2009f).

One of the challenges going forward will be to make provisioning cloud-based services as easy as possible. To that end, federal CIO Kundra worked with the GSA to establish a "cloud computing storefront." According to Kundra, the storefront will "allow the agencies to quickly find cloud solutions" (quoted in Stegon, 2009). Such a storefront—mirroring best practices from the private sector, such as those of Amazon and eBay—will simplify IT procurement while also enabling government agencies to dramatically shorten their cycle times for IT acquisitions, which too often result in lead times so long that, by the time the technology is actually in place, it is outdated (Weigelt, 2009a).

In mid-September 2009, this storefront went "live" in the form of Apps.gov (see *Excerpts from General Services Administration Press Release: Obama Administration Launches GSA Cloud Storefront Apps.gov September 15, 2009,* p. 25). The first reactions to the Apps.gov storefront generally gave kudos to Kundra and the GSA for fulfilling this vision to make cloud computing easy to acquire and use, taking a user-based perspective to enable agencies to test-drive cloud offerings (Urquhart, 2009). In fact, Craig Newmark, founder of Craigslist, commented that the introduction of Apps.gov is "a big improvement in the way the U.S. government manages data and gets stuff done. This really is big." However, the effort has also been criticized for its limited offerings and for not going far enough to make acquiring cloud-based offerings as easy as it is in the commercial world. This led the GSA's CIO, Casey Coleman, to comment that Apps.gov is still "a work in progress." Coleman recently noted that, "this (Apps.gov) is not the final solution. It's the beginning of the final solution" (quoted in Weigelt, 2009b).

National Aeronautics and Space Administration (NASA). NASA recently launched the NEBULA cloud computing platform. Created at the NASA Ames Research Center in Mountain View, California, the NEBULA cloud (nebula.nasa.gov) has been designed to allow for greater transparency and public involvement with space efforts, while serving as a "seamless, self-service platform" that will not just consolidate the agency's web offerings into a single portal, but provide NASA personnel with "high-capacity computing, storage, and network connectivity and … a virtualized, scalable approach to achieve cost and energy efficiencies" (NASA, 2009a).

Chris Kemp, CIO of the NASA Ames Research Center, has stated that the NEBULA could be used as a "single facility" in which to consolidate NASA's many websites, promoting the public to be more actively engaged with NASA's space missions, and allowing for user-generated blogs, wikis, and other content (Atkinson, 2009). According to NASA's (2009b) description, the NEBULA platform "offers a turnkey Software-as-a-Service experience that can

Excerpts from General Services Administration Press Release
Obama Administration Launches GSA Cloud Storefront Apps.gov
September 15, 2009

The Obama Administration today announced the launch of the General Services Administration's cloud storefront Apps.gov. This online storefront enhances how the government leverages technology by enabling federal agencies to acquire and purchase cloud computing services in an efficient, effective manner.

"This Administration is committed to providing better value for the American taxpayer," said federal Chief Information Officer Vivek Kundra. "Apps.gov will help to lower the cost of government operations while driving innovation within government by pooling IT resources across organizational boundaries."…

"By offering a centralized storefront for cloud solutions, GSA will help facilitate innovation and efficiency across government while reducing the cost of government operations," said GSA Chief Information Officer Casey Coleman. "Through Apps.gov, GSA can take on more of the procurement processes up front, helping agencies to better fulfill their missions by implementing solutions more rapidly. We will also work with industry to ensure cloud-based solutions are secure and compliant thereby reducing duplication of security processes throughout government."

Cloud computing helps to lower the cost and environmental impact of government operations, create a more secure computing environment, and drive innovation within the government by pooling IT resources across organizational boundaries. IT services and infrastructure are shared by multiple customers, with different physical and virtual resources dynamically assigned and reassigned in real time according to customer demand (e.g., storage, processing, network throughput, and virtual machines)…

In today's announcement at NASA's Ames Research Center in Moffett Field, California, Kundra highlighted GSA's USA.gov as an example of how cloud computing has helped the agency lower cost and increase flexibility to better fulfill its mission of citizen engagement.

"In a traditional IT procurement environment, it would have taken us about six months to upgrade USA.gov to better meet the needs of our citizens. However, in the cloud environment we are now able to do upgrades in one day—giving us greater agility and saving taxpayers approximately $1.7 million annually in computing infrastructure costs associated with USA.gov," added GSA Associate Administrator of the Office of Citizen Services and Communications David McClure.

rapidly address the requirements of a large number of projects. However, each component of the NEBULA platform is also available individually; thus, NEBULA can also serve in Platform-as-a-Service or Infrastructure-as-a-Service capacities." NEBULA uniquely makes use of open-source components as major building blocks of its cloud offerings.

The NEBULA platform makes use of Eucalyptus, which is "an API-compatible open-source clone of the Amazon AWS (Amazon Web Services) cloud platform." The use of Eucalyptus, which was originally developed by researchers at the University of California at Santa Barbara, "provides NASA researchers, should they require it, with the simplest possible approach to on-demand computing capacity

[as] all AWS-compatible tools will work 'out-of-the-box' or with minor customization." Eucalyptus' advantage of allowing open source programming, while mimicking the cloud environment and providing for the access advantages, is finding acceptance in the academic and scientific communities for those reasons (Naone, 2008c). The NEBULA platform offers what NASA describes as "super-computer class storage" through the use of the open source LUSTRE clustering file system. This allows for "highly scalable storage capacity in the hundreds and thousands of terabytes," with "nearly unlimited individual file sizes" (NASA, 2009b). According to NASA: "Never before has such research-grade computing been available in a web application platform."

Through the NEBULA platform, NASA could open up many new possibilities for collaboration and research. For instance, Tomas Soderstrom, IT CTO for the Jet Propulsion Lab, suggested that, once the legal and policy issues have been resolved, all data from NASA missions could be loaded into the NEBULA cloud (Foley, 2009f).

NEBULA also opens up a number of possibilities for NASA to provide cloud services both within the space agency (possibly allowing the agency to consolidate the 70 internal data centers), and quite possibly, to allow NASA to provide cloud computing services to other federal agencies. Since NEBULA is based at the Ames site, giving it proximity to the technology companies and talent located in the Silicon Valley, NEBULA could develop into both a model and a hub for federal government-wide cloud computing efforts (Sternstein, 2009c).

Defense Agencies

Defense Information Systems Agency (DISA). The mission of the Department of Defense's (DoD) DISA is to provide most of the IT systems used within the DoD. In the words of John Garing, DISA's CIO and director of strategic planning, DISA's role is to provide "the heavy-lift IT work" for the DoD (quoted in Hoover, 2009j).

Garing calls cloud computing "something we absolutely have to do." He stated, "We have seen what Amazon and Google have done, and it seems to us that there is a need for that. For example, if you deploy a force somewhere in the world for disaster relief or a special operations team, they ought to be able to connect to the network like you or I can from home, and bring together or compose the services and information they need for what they're doing at that particular place and time, rather than have to connect to a bunch of applications" (quoted in Harris, 2008).

Garing has stated that his biggest challenge in implementing the cloud computing model in the DoD was to overcome the "box-hugging" mentality in the IT area. DISA is now deploying an internal cloud computing service called the Rapid Access Computing Environment (RACE), which can be provisioned on demand—and on a "pay by the drink," usage-based approach by DoD developers and users. RACE allows users to access a variety of data center resources via a self-service portal's drop-down menu (Foley, 2009a).

According to Alfred Rivera, the director of the Center for Computing Services, with RACE, "a Department of Defense user can actually go into a Web-based portal and provision their own operating environment—based on our standard architecture—and within 24 hours it is provisioned for them to do whatever tests or development they want" *(Federal Computer Week,* 2008). Rivera offers that, in the RACE environment, "it is basically true cloud computing, where we give them a certain amount of storage, a certain amount of processing, and they pay for it on a monthly basis. When they're done, they can just shut it off" (quoted in Beizer, 2008b). As a consequence, by using RACE, project lead times have shrunk from many months to days and hours (McGirt, 2009). According to Henry Sienkiewicz, a technical adviser for DISA's Computing Services Directorate, moving to the cloud "will allow us the flexibility to rapidly scale up and down the delivery of those (information) services" within the DoD (quoted in Robinson, 2009a).

RACE employs a "joint capacity" model, contracting with vendors who retain ownership of the hardware and software behind RACE, even though it is hosted in DISA's data centers. In this model, "DISA manages capacity utilization in support of its customers, and the vendors ensure DISA has the capacity to meet its growth demands" (Harris, 2008). While hosted internally today, Garing hopes to be able to use external cloud providers in the near future. To that end, he recently stated: "If I were king for a day,

Cloud Computing in Other Domestic Government Agencies

Department of Interior National Business Center (NBC). The U.S. Department of Interior's NBC (nbc.gov/) is a service provider for numerous federal agencies, and today it is seeking to build upon that strength as a cloud service provider. The NBC presently operates two data centers that handle a variety of computing tasks, including payroll, human resources, and accounting for dozens of federal agencies. It is introducing several cloud-based human resource management applications, including web-based training, staffing, and recruitment programs. The NBC is also beginning to offer cloud-based financial and procurement software. The director of the NBC, Doug Bourgeois, reports that shifting to cloud-based programs has produced both marked gains in productivity and significant savings in power consumption. Additionally, the shift to more cloud-based offerings affords the NBC the ability to expand its service offerings while not having to expand its physical operations—and thus up its cost structure. As Bourgeois recently commented, "For us, like other data centers, the volume of data continues to explode. We want to solve some of those problems with cloud computing, so we don't have to build another $20 million data center" (quoted in Lohr, 2009). In August 2009, the NBC (2009) released a cloud computing strategy and established a cloud portal (cloud.nbc.gov/) through which it will consolidate its cloud offerings.

Department of Health and Human Services (HHS) Program Support Center (PSC). The HHS PSC (psc.gov/) offers over 60 services to HHS and other federal agencies. In late 2008, Robert Spector, who directs the agency's business process improvement efforts, was tasked with examining how to create an online product request system for users. After selecting Salesforce.com for the SaaS pilot, the center had a working pilot online within just a few weeks (Gross, 2009).

Census Bureau. The U.S. Census Bureau is employing Salesforce.com's SaaS to manage the activities of about 100,000 partner organizations. To date however, the agency has chosen to store citizens' census data on its own internal servers. From the perspective of J.R. Wycinsky, who is a program analyst for the Census Bureau, it has not made use of cloud storage because of security and privacy concerns. He stated that, "People have to trust us, otherwise they won't give us the data" (quoted in Hart, 2009a).

The White House. The White House has taken steps to integrate cloud computing tools into its operations. It made use of Google Moderator, a simple tool that helps groups determine which questions should be asked, to solicit questions from the general public and then allow for public voting to then determine what questions would be asked of President Obama at a March 2009 online town hall meeting. The cloud-based application allowed for hundreds of thousands of votes to be cast on the almost ten thousand questions that were submitted for possible use in the live event with the president (Arrington, 2009). Also, the Office of Management and Budget is looking to cloud computing as a way for state and local agencies receiving stimulus funds to report on their uses of the monies via the cloud … and allowing for citizens to track the results online (Sternstein, 2009a).

I'd rather turn to a Google, Amazon or somebody else and say, 'Do this for us.' We're starting on our own, but I hope that someday there will be a hybrid model where I can use outside services without having people say, 'Oh my gosh, we're on the Internet'" (quoted in Stedman, 2009).

For his work leading DISA's cloud computing effort, Garing was named by *Fast Company* magazine as No. 12 on its ranking of the "100 Most Creative People in Business" (McGirt, 2009). Yet, Garing sees RACE as just the beginning: "It's the germ upon which we will grow this more important cloud, this platform" (quoted in Harris, 2008).

United States Army. The U.S. Army has begun using cloud computing to improve its recruiting efforts, both in the field and in its new recruitment "megastore" in Philadelphia, The Army Experience. The Army solution combines CRM Software as Service (SaaS) with social networking applications to provide recruiters with new tools, accessible via mobile devices, that have produced tangible improvements in recruiting numbers in the test area.

In 2008, the U.S. Army initiated a major pilot program to revamp its recruiting efforts. It was undertaken both to more effectively reach out to today's youth and to better inform the public about the army. According to Maj. Gen. Thomas P. Bostick, head of the U.S. Army Recruiting Command, "What we are doing here is reaching out to Americans, giving them the opportunity to understand their Army" (quoted in Reisinger, 2009).

The centerpiece of the program is the Army Experience Center (thearmyexperience.com/), located at Franklin Mills Mall in Philadelphia. The Army Experience is not your father's storefront recruiting office. It comprises over 14,000 square feet, and is filled with helicopter and tank simulators, Xbox consoles on which to play the America's Army game, a theater, a retail store, and a café (U.S. Army, 2009). As of mid-2009, well over 10 thousand visitors had visited the mall site, and it is credited with helping the army dramatically improve its recruiting in the Philadelphia and nearby New Jersey area—which has historically been a difficult region for attracting recruits (Colimore, 2009).

Behind the scenes, Maj. Larry Dillard, a program manager in the army's Office of the Chief Marketing Officer, was tasked with creating the information infrastructure to support not just the Army Experience Center's physical location, but to support in-field recruitment efforts as well. Dillard chose to implement a CRM software solution from Salesforce.com. The use of SaaS enabled the Army to radically reshape its outreach approach to potential recruits in the pilot area, using SaaS tools, combined with social networking tools and census data, to better target its recruiting efforts in a cost- and time-effective manner. Dillard estimates that the cost of using SaaS was far less than that of building a unique solution. Plus, the ability to support mobile access for recruiters and to tie in with Facebook and other social networking sites to better reach out to today's potential recruits has increased buy-in from users (Gross, 2009b). According to Dillard, the value of the cloud solution is simple: "I'm running a scalable, enterprise-capable application with no IT staff at all" (quoted in Beizer, 2009a).

National Security Agency (NSA). Intelligence Community Directive 501, proposed under the Bush administration and signed into law in the first days of the Obama administration, seeks to improve information sharing among the 16 intelligence agencies and to create a culture of "responsible sharing and collaboration" in the intelligence community (Bain, 2009). In response, the NSA has developed a cloud computing model. It is designed to improve information sharing by linking the databases housed by the various intelligence systems and making them taggable and searchable by agency analysts and staffers. The NSA chose to make use of Google's Hadoop file system to interlink the remote databases and allow for new collaborative and discovery capabilities—to improve intelligence gathering, analysis, and reporting—by interlinking legacy systems in a new way through the cloud model (Hoover, 2009d).

Dr. Randy Garrett, director of technology for the Office of the Director of National Intelligence, Integrated Intelligence Program, observed that the NSA's goal was not cost-cutting or operating efficiencies, but rather to improve intelligence: "The object is to do things that were essentially impossible before. If a military commander in the field has a question, and there is information that relates to the question, it is available. No matter where the information comes from, no matter which agency has it, it is accessible to that commander." (quoted in Beizer, 2009a).

Education

Some of the most exciting uses of cloud computing in the nonfederal area are sprouting from the world of education. In this section, we will look at early demonstrations in the use of cloud computing both at colleges and universities and in primary and secondary (K-12) education.

Colleges and Universities. For universities, migrating to cloud-based services affords them the ability to provide improved collaboration and research capabilities. Students and faculty can take advantage of the ability to work and communicate from anywhere and on any device using cloud-based applications. Magnified by the need to pare overhead costs at a time when public and private institutions are grappling with significant budget shortfalls, cloud computing allows universities not just to use the resources of commercial cloud providers—many of which are available to them either for free or at reduced costs—but to pool their IT resources. This already has occurred in Virginia and North Carolina. For instance, in Virginia, a dozen colleges and universities have come together to form the Virginia Virtual Computing Lab (Young, 2008). Such efforts allow institutions to cut their IT costs by reducing their need for software licensing, for upgrade capabilities, and for perhaps maintaining their own data centers, all while improving the IT resources for their faculty and students.

Already, many campuses have switched to Google or Microsoft-hosted e-mail. Google and Microsoft

presently host e-mail for over four thousand colleges and universities, not just in the U.S., but in over 80 countries worldwide. In fact, almost half of all campuses are now making use of hosted e-mail services (Armbrust, et al., 2009). It is estimated that, at present, 5 million students in higher education are making use of Google Apps, with growth pegged at 400 percent annually (Gralla, 2009). The switch to hosted services is paying significant dividends for the early adopting institutions. By switching to Gmail, Notre Dame reports that it saved $1.5 million in storage and other tech costs, while at the same time finding that their students' satisfaction with the campus' e-mail rose by over a third!

Institutions— such as Arizona State and Washington State—are consistently reporting at least six-figure annual savings from switching to Google- or Microsoft-hosted systems (Caplan, 2009). Even more importantly, by switching to hosted e-mail and productivity software, the job and focus of college IT staff can be changed. As Pepperdine University's CIO Timothy Chester observed, his smaller IT staff can be more productive. He recently stated: "We want our staff working more with students and faculty and less on the nuts and bolts of delivering technology" (quoted in Caplan, 2009).

The cloud model has enhanced research capabilities. Where in the past only the largest universities have had supercomputing capabilities, cloud computing—with number-crunching capabilities available on an on-demand basis—affords researchers anywhere to scale their computing power to match the scale of their research question, bringing supercomputing to the mainstream of research. As Delic and Walker (2008) put it, cloud computing might just "enable new insights into challenging engineering, medical and social problems," as researchers will now have newfound capabilities "to tackle peta-scale type(s) of problems" and to "carry out mega-scale simulations" (p. 5). Craig A. Stewart, associate dean for research technologies at Indiana University, recently remarked that, with cloud computing, "you reduce the barrier to use advanced computing facilities" (quoted in Young, 2008).

There are certainly discussions and embryonic efforts under way in all states, as public and private universities examine how best to make the cloud concept work for them and their students and faculty. Additionally, there have been calls for the federal government to take the lead to create a cloud computing environment for use by all colleges and universities nationwide. In doing so, proponents argue for the economic and educational benefits that such a resource would provide, as it would democratize computing technology and "level the playing field" so all students and faculty could have access to the scale and type of computing power enjoyed only by elite institutions (Hurley, 2009). This has led many in higher education to concur with the opinion of Kate Keahey, who stated, "I believe that this will be the model of the future. This will absolutely drive cost savings for the universities" (quoted in Staten, 2008).

Primary and Secondary Schools. In much the same way as universities are planning, primary and secondary schools are taking advantage of cloud computing to pare their IT costs while offering web-based communication, productivity, and storage capacity to their faculty, staff, and students. Thus, one would hope and expect school districts and state education officials to actively pursue cloud computing strategies and pooled cloud centers. Already, the cloud model is showing the power to reshape how education is delivered. While there have been online models for some time to deliver content to public, private, and even home-schooled students, the state of Minnesota has created a cloud-based model for its Minnesota's Online High School (MNOHS) (mnohs.org/). MNOHS Executive Director Ned Zimmerman-Bence reports that the use of a cloud platform has dramatically reduced the technical issues encountered by students, not just reducing technical support issues and costs, but reducing student frustrations and improving their retention/progression through the program (cited in Hurley, 2009b).

Likewise, in the mountains of Eastern Tennessee, the Pike County School System faced a common problem plaguing American education—old computing resources and a student body that needed and wanted better computing. Working with IBM, the rural school district established a private cloud, linking the computers in the schools and enabling students and faculty across the 27 schools in the system to access courseware instantly. In moving to the cloud environment, the district got more life out of an aging computer infrastructure, which it could not

afford to replace in a wholesale manner, and also cut its IT support costs by over 60 percent (IBM, 2009b).

There will certainly be vendors actively seeking to serve the education market—many of which will offer their cloud services on a free or discounted basis to educational bodies. Their motivation is the ability to reach such large audiences of potential customers. Why has Google provided Google Apps to universities for free? Dave Girouard of Google reports that it is because, quite simply, "We're generating millions of users for life" (quoted in King, 2009).

International Experience

Cloud computing is not just a U.S. phenomenon. Indeed, cloud movements are taking place in governments around the world. For instance, In the European Union presently, the European Commission and several member states are taking actions perceived by many as leading toward the creation of a cloud-based, common infrastructure for IT in member states (DiMaio, 2009a). We are however already seeing significant cloud models being used in areas around the world.

The United Kingdom. In the United Kingdom, the government has made the creation of the "G-cloud," which is to be a government-wide cloud computing network, a strategic priority (Glick, 2009). *The Digital Britain Report*, issued jointly in June 2009 by the Department for Business Innovation & Skills and the Department for Culture, Media and Sport (2009a), calls for the U.K. government to take the lead in a wide-ranging digital strategy for the country. As Prime Minister Gordon Brown announced the issuance of the report, he said, "Digital Britain is about giving the country the tools to succeed and lead the way in the economy of the future" (Government of the United Kingdom, Department for Business Innovation & Skills and Department for Culture, Media and Sport, 2009b).

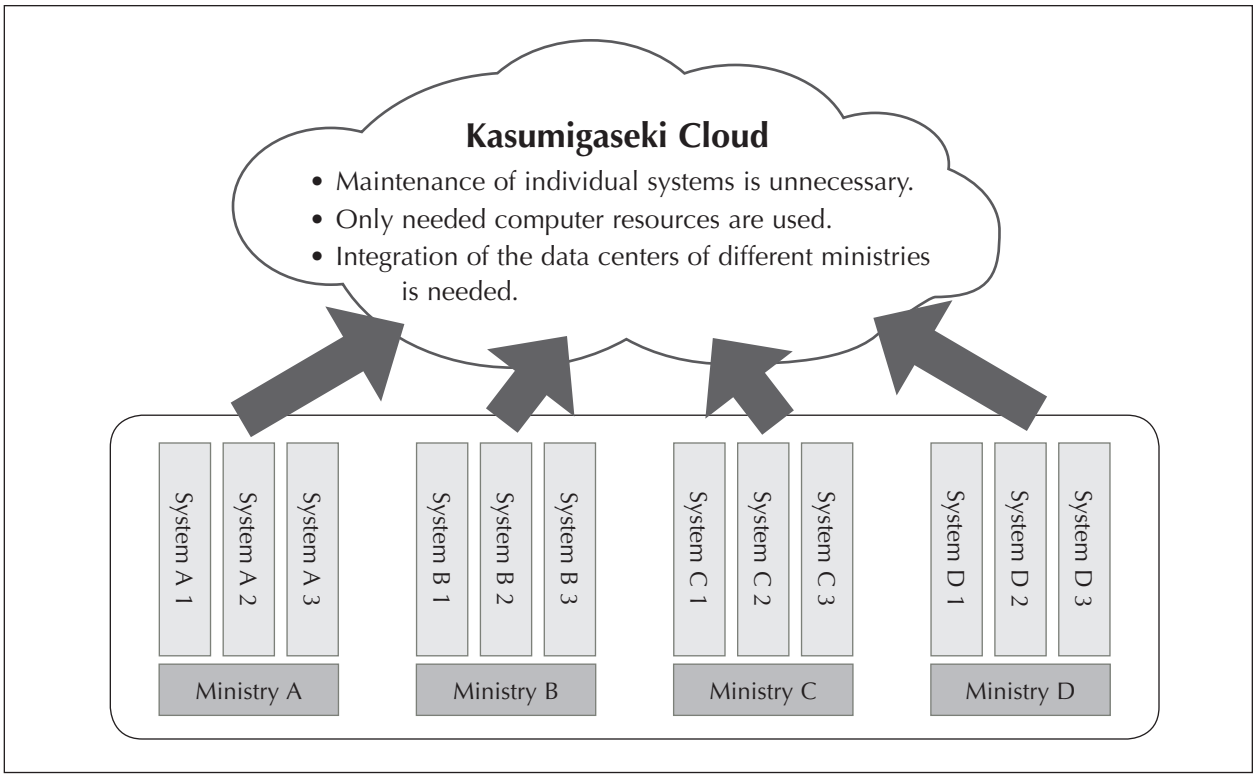
An important aspect of the Digital Britain strategy is to improve governmental IT and allow for more services to migrate online. To support this action, IT procurement will be focused on enabling the U.K. government to become a leading force in the use of cloud computing. The report states that "the Government's impact on the digital economy goes way beyond its role as policy maker. In delivering public services, as a large customer of ICT products and services and as the owner of data systems, the public sector has enormous influence on the market. In many areas, such as education, health and defence, Government can use its position as the leading procurer of services, to drive up standards—in some cases to set standards—and to provide an investment framework for research and development." (Government of the United Kingdom, Department for Business Innovation & Skills and Department for Culture, Media and Sport, 2009b).

Japan. In Japan, the national government is undertaking a major cloud computing initiative, dubbed the "Kasumigaseki Cloud" (named for the section of Tokyo where many Japanese government ministerial offices are located) (Hicks, 2009a). The initiative seeks to develop a private cloud environment that would eventually host all of the Japanese government's computing (Ng, 2009). As can be seen in Figure 4, the Kasumigaseki Cloud will allow for greater information and resource sharing and promote more standardization and consolidation in the government's IT resources, according to Japan's Ministry of Internal Affairs and Communications (MIC) (2009).

By consolidating all governmental IT under a single cloud infrastructure, the Japanese government believes it will see not just reduced costs and operational benefits, but more "green," environmentally friendly IT operations (Rosenberg, 2009). The Kasumigaseki Cloud is part of the Digital Japan Creation Project. This represents a governmental effort aimed at using IT investments (valued at just under 100 trillion yen) to help spur economic recovery by creating several hundred thousand new IT jobs in the next few years and doubling the size of Japan's IT market by 2020 (Hoover, 2009g). The MIC (2009) believes that "accelerating the use of ICT nationwide will require the government to take the initiative in implementing measures," and that the national government's promotion of cloud computing will not just help spur ICT development, but to help diminish the digital divide in that country.

Thailand. In Thailand, the Government Information Technology Service (GITS) is establishing a private cloud for use by Thai government agencies. The GITS has already established a cloud-based e-mail service, and it plans to add SaaS offerings in the near future. GITS believes that such consolidation

Figure 4: The Japanese Government's Kasumigaseki Cloud



Source: *Government of Japan, Ministry of Internal Affairs and Communications (2009).*

will improve service offerings for government agencies, while simultaneously cutting their overall IT costs "considerably" (Hicks, 2009b).

New Zealand. In New Zealand, the Ministry of Commerce announced in June 2009 that it would be consolidating IT procurement for all government agencies, looking to form "centres of expertise" focused on rationalizing IT acquisition and investigating how cloud computing and SaaS can play a more significant role in the future (Strecker, 2009).

Vietnam. IBM is working with the Vietnamese government and universities to help the country leverage the power of cloud computing across the public and private sectors of this rapidly changing, formerly agrarian, economy (Nystedt, 2009). Willy Chiu of IBM Cloud Labs recently observed that the country's commitment to the new model is due to the fact that "the government views cloud computing as a way to move to a services-lead economy" (quoted in Babcock, 2009).

China. In China, cloud efforts have thus far been spearheaded by local leaders. The city of Dongying in the northern region of the country is undertaking a cloud computing initiative aimed at improving not only its e-government offerings, but economic development, by leading the effort to create what is known as The Yellow River Delta Cloud Computing Center. The vice mayor of Dongying, Li Jinkun, envisions that Dongying can "become a 'city of digital innovation'" through the IBM-developed cloud platform that is at the heart of this initiative (quoted in Hicks, 2009f). Likewise, in the city of Wuxi, located in Southeastern China, the municipal government has set up a "cloud services factory" to improve the computing resources available to local companies. The many start-up firms in the city's "software park" faced a common problem of not having the financial resources to acquire the IT infrastructure necessary to compete effectively. In response to this need, and to attract more firms to its economic development project, the government of Wuxi worked with IBM to build a cloud computing center to provide on-demand computing resources for firms in the software park. Using the cloud services factory, software developers can readily access the computer resources they require for projects. Participating firms have a ready-made, on-demand

computing infrastructure, freeing financial resources for other needs and making the start-ups more likely to thrive and create new economic wealth and jobs in the city (IBM, 2009a).

Singapore. The Infocomm Development Authority of Singapore (IDA) holds that cloud computing represents "an important next paradigm in information technology," and as such, "It is important to prepare Singapore well to leverage cloud computing for greater economic reach, impact and competitiveness" (Hicks, 2009c). For well over a year, the IDA has been the sole public sector partner in the Open Cirrus project (https://opencirrus.org/), which is "an open cloud-computing research testbed designed to support research into the design, provisioning, and management of services at a global, multi-datacenter scale involving HP, Intel, Yahoo and a number of global research universities and institutes."

Major Challenges Facing Government in Implementing Cloud Computing

The Economist (2008b) stated that "the rise of the cloud is more than just another platform shift that gets geeks excited. It will undoubtedly transform the information technology (IT) industry, but it will also profoundly change the way people work and companies operate. It will allow digital technology to penetrate every nook and cranny of the economy and of society." IT executives must decide if the cost savings and flexibility/scalability to be gained through shifting data and functions to the cloud are worth the trade-off in terms of control and security (Schwartz, 2008a). Lohr (2009) points out that many IT executives in both the private and public sectors have been reluctant to jump on the cloud computing bandwagon due to "traditional corporate computing concerns like the security of data, reliability of service and regulatory compliance." Indeed, many public sector IT executives like the idea of shifting data and applications to public clouds, but control, access, security, and interoperability issues will need to be resolved before their organization could make use of public clouds (Linthicum, 2009).

In this section, we will examine ten major issues facing government leaders in the shift to using cloud computing. They are:

- **Challenge One:** The Need for Scalability
- **Challenge Two:** The Need for High Reliability
- **Challenge Three:** The Need for Securing Data in the Cloud
- **Challenge Four:** The Need for Open Standards and Interoperability
- **Challenge Five:** The Need to Revise Procurement Practices
- **Challenge Six:** The Need to Resolve Potential Legal Issues
- **Challenge Seven:** The Need to Regulate the "Cloud Market"
- **Challenge Eight:** The Need to Redefine the Roles of the IT Workforce
- **Challenge Nine:** The Need to Assess the Return on Investment of Cloud Computing
- **Challenge Ten:** The Need for Government Cloud Coordination

Challenge One: The Need for Scalability

Flexibility. It's become a hallmark of successful strategies in the business world today, with sudden shifts in the overall economy and in specific markets becoming commonplace. As Erik Brynjolfsson, professor at the Massachusetts Institute of Technology (MIT) Sloan School of Management and the director of the MIT Center for Digital Business, observed, "The economy has become much more volatile, not just in the past year, but over the past 10 years. The ability to be agile in your infrastructure is what separates the winners from the losers ... cloud computing is one of the most important technologies that affect the ability to maintain that level of flexibility" (quoted in Cass, 2009).

In today's environment, IT resources will need to become more flexible, agile—in other words, scalable—for all organizations. Cloud computing turns the economics of IT on its head, due to an unprecedented elasticity of resources. In everyday use, elasticity is commonly thought of not just as the ability of an object to stretch out when needed, but to also contract as necessary (think of a rubber band or a bungee cord). In computing terms, elasticity can be defined as "the ability of a system to dynamically

The New York Times' Use of Cloud Computing

In the relatively short time that cloud computing has been available, there have already been truly amazing examples brought forward by companies making innovative use of the scalability of on-demand computing resources. If you want a good illustration of the power of cloud computing in action, you need look no further than your doorstep (or bookstore) as to how the *New York Times* discovered the power of cloud computing.

In 2008, the *Times* took on the task of adding many years' worth of articles to its searchable web database to make them available for download. It sought to add roughly 11 million articles, published from the newspaper's founding in 1851 up through 1989. With its cloud computing offering, the Elastic Compute Cloud, or EC2, Amazon offers anyone—be they a large company or an individual—the opportunity to run applications or crunch numbers quickly and cheaply. To accomplish the *Times'* massive computing task, an IT staffer at the *Times* merely set up an account with Amazon Web Services with his credit card. *Times* staffers then began the tedious task of cutting the physical copies of the articles and scanning them into TIFF files. These files—approximately 4 TB (terabytes)—were uploaded to Amazon's SC storage site; then, using its EC2 platform, the files were converted into 1.5 TB of Adobe PDF files, ready for use on the *Times* website. The job was done in less than 24 hours, using 100 LINUX machines. And the cost for all of this was less than five hundred dollars (Snyder, 2008; Gruman, 2008)! Derek Gottfrid, who is the senior software architect for the *Times*, commented that "it would have taken a month at our facilities, since we only had a few spare PCs. It was cheap experimentation, and the learning curve isn't steep" (quoted in Gruman, 2008).

Nicholas Carr (2009a) commented that "the *New York Times*' use of Amazon.com is a small but telling example of what happens when you radically democratize computing so that anyone has access at any moment to supercomputer-type capacity and all the data storage they need." This availability of computing processing and storage power on demand could have profound implications in everything from scientific inquiry (by making no problem too big to compute) to new enterprise formation (by drastically reducing the need for up-front investment in IT resources—and the people to support and maintain them) to public agencies (by making IT more affordable and available to governments at all levels and in all locales). Thus, we may be seeing a truly new era, wherein there is a "democratizing" of computing technology under way—bringing "the benefits of high-powered computers and communications to all" (Foley, 2009c).

acquire or release compute resources on-demand" (Langley, 2008). Under the cloud model, organizations that need more computing power dramatically increase their computer utilization without having to pay a premium for that ability. Say, for instance, that a company has large, batch-oriented processing tasks. It can run the operations far faster than previously possible and at no additional cost, "since using 1000 servers for one hour costs no more than using one server for 1000 hours" (Armbrust, et al., 2009, p. 1). This unique attribute of cloud computing is commonly referred to as "cost associativity," and it allows for computational needs to be addressed far faster and far more cheaply than in the past. In short, cloud computing gives organizations—even individual users—unprecedented scalability.

In IT terms, scalability can be defined as "the ability of a computing system to grow relatively easily in response to increased demand" (Langley, 2008). Cloud solutions are ideal for situations where there is "spiking" of demand—sudden shifts from handling little or no traffic to having the need to handle huge levels of traffic (Chan, 2009). In the private sector, this may be handling online sales on the morning of Black Friday sales on the day after Thanksgiving or allowing for online voting on a show like "American Idol" or "Dancing with the Stars."

In the public sector, the analogous situations could be traffic going to either the Internal Revenue Service's website on April 14 (the day before federal taxes are due) or the Federal Emergency Management Agency website to apply for disaster assistance in the wake of a hurricane or flood. Certainly, one of the principal benefits of shifting to cloud-based applications, communications, and storage capabilities is in the area of disaster planning. When a disaster does occur, the off-site—and often out-of-region—capabilities of cloud providers to the affected governmental jurisdictions become an IT lifeboat—enabling agencies to more easily maintain operations during a natural or man-made disaster and more quickly recover to normal operational capabilities.

Challenge Two: The Need for High Reliability

One of the principal concerns about cloud computing is the reliability question, and this is certainly a case where, when a tree falls (i.e., an outage occurs), everyone hears the sound. Unfortunately, worries over cloud reliability and availability—or specifically, the lack thereof when such instances arise—are not just theoretical.

There have been well-publicized outages of many of the most popular public cloud services, including Gmail and Google Apps (Worthen and Vascellaro, 2009), Apple's MobileMe service (Parr, 2008), and Amazon's S3 cloud service (Perez, 2008; Waxer, 2009). And, as Schwartz (2008a) astutely pointed out, when cloud service outages or inaccessibility occur, "most of the risk and blame if something goes wrong will fall directly on the shoulders of IT—and not on the cloud computing service providers." For instance, in September 2009, Gmail had its longest outage—lasting over 100 minutes. Such downtime for e-mail services can cast doubts in the minds of IT decision makers over the viability of the bigger proposition of replacing desktop functionality with functionality from the cloud (Gralla, 2009).

For private sector IT executives, there is a reluctance to shift core, mission-critical data storage or applications to public cloud environments, even if the cost savings and efficiency arguments are there, over concerns about the reliability and security of cloud offerings. Take, for instance, the case of the Princeton, New Jersey-based Educational Testing Service (ETS), which administers the SAT and other standardized tests. While ETS uses Software as a Service (SaaS) platforms from Salesforce.com and other vendors for noncore functions, the firm's chief information officer (CIO), Daniel Wakeman, recently expressed his reluctance to shift data storage and processing for the tests themselves to a cloud environment. This is in spite of the fact that, due to the highly cyclical nature of test administrations, scoring, and reporting around specific testing schedules throughout the year, ETS has an average server utilization rate of just around 8 percent, making the firm a prime candidate for acquiring computing resources on demand. Wakeman simply stated that, due to security issues which have yet to be worked out in what he and other perceive to be an "immature market," ETS will monitor developments in the cloud marketplace and "not (be) putting anything up there that we really care about" (quoted in Stedman, 2009).

One of the truths about cloud computing, as pointed out by Waxer (2009), is that in-house IT can rarely match the service levels provided by commercial cloud providers. For a cloud provider to offer a service level agreement (SLA) with "four-9s performance," it would be guaranteeing 99.99 percent uptime. Translated into "real life," four-9s availability translates into just 52 minutes of downtime per year. If there were more downtime or unavailability than that .01 percent, then the cloud provider would be liable for penalties or rebates. To assure this level of service, cloud service costs typically rise as the SLA escalates from three-, four- or even now some "five-9s" levels of performance (Waxer, 2009). SLAs have been criticized for not protecting cloud-procuring organizations from a loss of system uptime, but protecting cloud providers from financial and legal exposure after their failure to deliver. As such, they have been labeled as only applying "after the fact" and being a "vehicle to argue over" and likely mitigate (Golden, 2009b).

As discussed above, cloud providers typically guarantee a particular benchmark for the availability of their services through what are known as SLAs. Yet, for all the reliance on SLAs, there is misunderstanding as to what they really guarantee—and what can be done should a cloud provider fail to live up to its promises. In many instances, collecting on the rebate provided for in the SLA may not be a routine matter (Brodkin, 2009c). It also may not mean much if the outage comes at a critical moment, for which no amount of money can make up. As one commentator opined, "Frankly, I think SLA and $3 will get you a coffee" (Krill, 2009). Still, as Golden (2009a) advised, avoiding cloud computing solely on the basis that SLAs invariably can't cover actual business losses from downtime or outages "is a rationalization, not a reason" for not engaging the cloud computing model.

For the government, SLAs may be especially vacuous if a data breach occurs and a law is broken—as the bar is raised much higher for a public sector client. As Chabrow (2009a) commented, in such instances:

> The government doesn't have the luxury of just saying, 'Oh, give me my money back.' They need to follow laws that have been

> specifically laid out to protect national security, to protect personal liberties; so, it's really not just a commercial transaction. They really need to understand the details within these infrastructures. It's not enough to say, 'Oh, yes, it's secure.' The government has to understand how it is secure, why it is secure, what are the risks. If the government can't see that, then it's very difficult for them to leverage that type of service.

Cloud providers invest a great deal in their systems to provide for reliability and assure that their services—and user data—will be available on demand. For instance, Amazon Web Services has a feature in its EC2 (Elastic Compute Cloud) dubbed "failover," where, if a user's application fails to run in one of Amazon's data centers, a second center will automatically take over and run the application (Ricknäs, 2008). There are even early versions of cloud applications that can be run offline—in the absence of a network connection (Naone, 2009). Developments in this area would enable cloud computing to move to the edge of the network and be functional in remote areas where there is spotty connectivity—defeating one of the exclusionary rationales for not making use of cloud-based offerings.

Challenge Three: The Need for Securing Data in the Cloud

John Garing, the Defense Information Systems Agency (DISA) CIO and director of strategic planning, characterized the federal government's dilemma as the classic case of the "irresistible force versus immovable object," where "the irresistible force is the incredible thirst for collaboration and information-sharing that Web 2.0 tools and many young people have brought on board, and the immovable object is security" (quoted in Harris, 2008).

Security is undoubtedly a hard metric to quantify. And, all too often, from the perspective of Golden (2009c) and other observers, the IT community has a somewhat damaging tendency to treat all risks—whatever the real nature of them—as the very worst-case scenario and not judging the true impact—and likelihood—of their occurrence. And today, many security experts believe that the notion of putting more data and more applications on the Internet via the cloud model could present vast new opportunities for criminal activity through identity theft and misappropriating intellectual property, hacking, and other forms of malicious activities (Bailey, 2009).

The degree to which *any* organization engages in cloud computing—whether outside or inside its own "four-wall" environment—will certainly depend on its need for security (North, 2009). Thus, with heightened security concerns, how to make cloud computing secure is one of the biggest issues for making it viable for the federal government—or for any government agency. As with prior shifts in IT with the advent of the Internet and the web, the introduction of e-mail, and the explosion of social media, their growth and adoption rates have been slowed by initial fears—some justified and some very unjustified—over security concerns and the loss of control over data and operations (Kelton Research, 2009). Indeed, analogies have been drawn between the advent of cloud computing today and the introduction of wireless technologies a decade ago. As Ron Ross, the National Institute for Standards and Technology's (NIST) director of security, observed, "When wireless came along, we didn't really know a lot about how to protect it, but we developed that understanding as we went forward, and now we do a pretty good job of protecting wireless" (quoted in Beizer, 2009c). However, Wyatt Kash (2008), editor-in-chief for *Government Computer News,* warned that the shift to cloud computing could be slowed by what he termed as "a darker cloud of Internet security vulnerabilities."

Privacy and security questions will need to be addressed as public data and applications move into a cloud environment. Adrienne Thomas, acting archivist of the United States, stated, "It's a very big issue for government, in terms of someone else to have control of our stuff" (Hoover, 2009c). Yet, as Arun Gupta, a partner at Columbia Capital, a venture capital firm, who worked with Vivek Kundra during his time as chief technology officer (CTO) for the District of Columbia observed, in order to succeed today, "You have to have the confidence to say, 'I don't need to control everything.' That's very much a Web 2.0 mentality. Is that the panacea to everything? Probably not. But it's a step in the right direction" (quoted in Hart, 2009b). Linda Cureton (2009), CIO of NASA's Goddard Space Flight Center, told IT decision makers in government that it is imperative when considering a cloud-shift: "Don't confuse control and ownership with security and viability."

Kaplan (2009) categorized the widely held perception that cloud computing and SaaS applications were less secure and less reliable than applications housed on an organization's own network was nothing less than a "myth." Indeed, cloud offerings may be significantly more reliable than an organization's internal offerings (Worthen and Vascellaro, 2009). The difference is that, when a company's e-mail server crashes or a power outage disrupts operations at its data center, these internal failings do not make media headlines, as is the case anytime there is an outage or data breach with a Google, an Apple, or an Amazon cloud offering. As Kash (2009) framed the issue, large-scale cloud providers are oftentimes more secure than a government agency's or private sector company's internal IT operations, simply because they have the "talent, resources and focus" that their customers—and their smaller counterparts—do not have. Still, IT executives stridently believe that their own hosted systems are far more secure than cloud-based resources (Foley, 2009d), and public sector IT managers stridently believe that their internal operations are more secure than those that a private sector vendor could provide (Brodkin, 2009b). Still, as Gardiner (2009) observed, "hardliners see the very concept of the cloud as a deeply unreliable security nightmare."

Musico (2009) characterized the need to retain control and protection of sensitive, private data, in an age of information sharing, the "Catch-22" for government IT with regard to cloud computing. Data security questions are, by definition, dependent on the nature and sensitivity of the data involved. Ron Ross, NIST's director of security, observed that it is important to consider the sensitivity of the data in question and to develop and employ "a range of security controls (that) will be appropriate for differing levels of data sensitivity" (quoted in Condon, 2009a).

One of the complicating factors in the shift to a cloud computing environment will be federal requirements for agencies to certify the security of their IT contractors' systems. There are presently no cloud-specific security standards in place. From the perspective of NIST's Peter Mell: "Compliance is going to be tricky in the cloud space for several reasons, but one reason is that clouds are likely to use new security technologies that aren't well understood or widely adopted, and that will make it difficult to prove the required level of security to auditors and to authorizing officials" (quoted in Chabrow, 2009b). Some have questioned whether the federal government would be precluded—from a regulatory standpoint—from using cloud-based services for such reasons. In fact, John Curran, CTO and chief operating officer of ServerVault, commented, "For many agency applications, stringent compliance requirements in areas such as privacy, financial controls, and health information will preclude use of public clouds, regardless of the actual security controls of the provider" (quoted in Foley, 2009e). Analysts have already voiced concern that cloud providers methods of logging activities and document reads/access are presently insufficient for meeting the needs of government agencies to assure their compliance through audit controls (Westervelt, 2009).

Analysts have stated that one of the benefits for small companies is that they may, in fact, be able to raise the level of their computing security by moving more data and applications to the cloud. This is simply because cloud providers will have more resources to spend on security for their operations than can most individual firms. Plus, their investments in security can be spread over their entire present—and prospective—client base (perhaps hundreds or thousands of firms), producing far greater results in improving computer security than an individual firm's investments in such efforts (Schwartz, 2008a). The same principle will hold true for government clients as well, especially those at the state and local levels. Yet, analysts have said that this may also be true even at the federal level, as large cloud providers—whose business depends on secure operations—may provide better security than internal federal operations (Hart, 2009a).

For their part, cloud providers have been characterized as addressing such security concerns by going "over the top" with their physical and data security measures, which one writer labeled as measures that could "easily outdo anything ever seen on *Mission: Impossible*." He cites the fact that Salesforce.com's data center employs "five levels of biometric hand geometry scanners and even 'man trap' cages designed to spring on those without the proper clearances" (Gardiner, 2009). This is evidence that cloud providers are very much aware of and attuned to both their clients' concerns in the security area, and the legal and regulatory risks that are being taken on by both the client and their firm

Can Cloud Computing Pose a National Security Risk?

As ever-greater amounts of governmental and private sector firms' work is shifted to cloud computing, could this shift in the locus of computation indeed be creating a national security risk? Cohen (2009a) noted, "Cyber-threats against the country and the government are growing exponentially, and the desire to connect agencies and make government open, transparent and interoperable makes it easier for hackers to carry out their attacks—(thus) will openness and interoperability make us as a nation less secure?" He also went on to note that government will have significant interest in protecting cloud resources for the private sector and individuals as well, noting the huge economic impact and disruption that can occur if a major cloud resource, such as Gmail, were to go down for an extended period of time or be lost forever.

Such risks are not without precedent, as the government of Estonia was hit by a well-coordinated denial-of-service attack—suspected to be Russian in origin—during a period of tension between the two nations in 2007 (Kirk, 2007), and during Summer 2009, several agencies in the U.S. government and sites in South Korea were cyberattacked by what was widely believed to be a scheme conducted by the North Korean government (Williams, 2009). Such a risk has led Carr (2009b) to label this as the threat of a "Cold War 2.0"—and it is certainly an area where federal policymakers need to be concerned.

by accepting a sizable portion of the client's IT operations (Golden, 2009c).

What are the other benefits of cloud computing in the security area? One of the best ways to improve security is to have a single point of access, controlled by the organization and mandating that users follow their procedures and policies for access privileges. However, while such access controls return power to the client, they may well serve to defeat some of the robust advantages for remote access fundamental to the cloud computing model (Jackson, W., 2009). A recent study from researchers at the University of Michigan showed that, by shifting virus protection from individual PCs to the cloud that connected them by raising the level of protection to the network, the ability of antivirus software to detect viruses and malware was significantly improved (Greene, 2008).

Finally, cloud computing is also a relatively quick and easy solution to the significant problem of laptop theft, which poses a very real, intransigent security and financial headache for IT managers (Wyld, 2009). This is because, should a user lose his or her laptop, there would be no security threat, simply because the data would reside in the cloud rather than on the machine itself (Gardiner, 2009). In fact, some have said this would actually mean that cloud storage would increase security for the federal government by reducing the security risk inherent with the hundreds of thousands of laptops in employee possession both inside and outside of federal facilities (Hickey, 2008b).

In the final analysis, as Golden (2009c) observed, those who view cloud computing as too risky may be "overly optimistic" in their view of how well their own security and risk management efforts work—both in reality and in comparison to the cloud model. He remarked, "This attitude reflects a common human condition: underestimating the risks associated with current conditions while overestimating the risks of something new. However, criticizing cloud computing as incapable of supporting risk management while overlooking current risk management shortcomings doesn't really help, and can make the person criticizing look reactive rather than reflective."

Challenge Four: The Need for Open Standards and Interoperability

Over the roughly 60 years since modern electronic computing came about, buyers of IT have had to be concerned with the very practical question, "Am I going to be stuck with *this*?" Whether *this* referred to an operating system, a version of software, or a type of computer, this could make the difference between having a "white elephant" system that would be obsolete and isolated or a system that could work with the latest and greatest technologies as they invariably supplanted what you just bought or what you just signed a contract for. Thus, from the original mainframe model of computing through the preponderance of Microsoft operating systems and its Office Suite on desktops and the database dominance of Oracle and SAP, interoperability and "lock-in" have both been major concerns for IT users, buyers, and administrators (Hamm, 2009b).

Today, cloud computing has been compared to the early days of the Internet, where Compuserve and America Online were "siloed communities" that could not allow for interoperability or easy user switching (Naone, 2009). Knorr and Gruman (2008) described the current state of affairs as more accurately being "sky computing," due to the fact that users—be they individuals or organizations—today largely do not plug into a single cloud, but rather multiple, isolated clouds that must be entered into separately.

Cloud computing may indeed provide a standardized foundation for computing across organizations. This is because, with the vendor-controlled platform, rather than one that can be modified on-premise, there will be a more standardized interface and a more stable environment in a SaaS environment (Schwartz, 2008b). From the perspective of Kaplan (2009) and other industry analysts, "a high level of customization can be counterproductive." Most of the public cloud applications are publicly available for use, but are not open source in nature. Blauer (2009) termed such software as being "free but not open." According to his analogy, when you do not have access to the source code, "an important distinction is (to be) made between free and open, the former being akin to free beer, and the latter akin to free speech." While open source will be an alternative to cloud applications, cloud software needs to mostly be standardized—"to get the benefits out of the cloud, you really want to rely on the cloud service as it exists, because if you get unique in the cloud, all of a sudden it's not the cloud—it's your own little outsource bank" (Kash, 2009).

Indeed, standards issues may lead not just to greater interoperability and portability, but perhaps something greater. There is already talk of the development of an "intercloud," which *The Economist* (2008e) described as "a federation of all kinds of clouds, in the same way that the Internet is a network of networks." As Hall (2009b) observed:

> When a new approach to technology takes off like cloud computing is today, the last thing you want to do is hamper its development by instantly weighing it down with new standards. One of the wisest ideas in the *Open Cloud Manifesto* is the argument to use, wherever feasible, existing standards. But it does not follow that, where existing standards do not exist, new ones need to be developed, at least not immediately.

One of the primary concerns regarding cloud computing that government IT executives consistently express is a fear of being locked into vendors, due to the high switching costs—both in dollars and in time and effort—that would be incurred when switching between cloud computing providers (Hall, 2009c). Indeed, Robert Ames, the deputy CTO for IBM Federal, believes that "the government has a fear of lock-in," and this fear of being tied to a specific provider's systems and pricing is one of the overriding factors that is holding back the federal government's adoption of cloud-based technologies (Hall, 2009b).

Brandel (2009a) astutely made the distinction that vendor lock-in is not a unitary concept, as the varying types and categories of cloud offerings each have different levels of commitment and lock-in. Yet, even while tying their organizational computing resources and data to "traditional" platforms such as Microsoft, SAP, and Oracle, IT leaders continue to express heightened concern over lock-in with cloud computing. This is due to the simple fact that the data is not hosted on their own systems and within their own premises. Still, one must consider that with any IT choice—be it even in investing in one's own systems hosted on-site—there are lock-in and data migration considerations. In fact, lock-in may be greater with internal systems than cloud systems—even in today's unfolding cloud marketplace (Brandel, 2009b).

It is also critical to deal with what happens at the end of a cloud computing contract, whether the contract involves a public sector agency or a private entity. As Brandel (2009a) advised, it is imperative that IT executives insist that their contracts with cloud providers contain specifics on how to end the relationship and safely migrate their data either to another cloud provider or back in-house.

Thus, one of the principal ways that government can help to foster the overall growth of cloud computing is to support the establishment of standards that will ensure common architectures and portability of data and files. Rayport and Heyward (2009) advocated that the federal government should be an active participant in the standards-setting efforts, such as the Open Cloud project, and they stated

that "ideally, what governments can do best is clear the road, not pave it."

Standards are vital to growing the overall cloud computing and infrastructure market. From the perspective of Winston Bumpus, president of the Distributed Management Task Force (dmtf.org), an industry-led effort to establish standards in the cloud computing market, "You need standards to avoid vendor lock-in." Yet, while vendors may ultimately cooperate on standards efforts, the lack of standards today is a short-term benefit to cloud providers, as it gives cloud vendors greater leverage by making it harder for customers to leave them. Thus, the primary driving force for the establishment of standards will come from customers, as standards will help overcome the real and perceived fears of vendor lock-in.

Challenge Five: The Need to Revise Procurement Practices

In the governmental space, IT outsourcing has become a well-established practice. However, as Jimmy Lin, an assistant professor of information studies at the University of Maryland observed, "The government may be outsourcing functions to contractors now, but this (cloud computing) takes it to a whole new level" (quoted in Hart, 2009a).

Certainly, one of the challenges that will have to be dealt with as the switch to greater use of cloud computing in government occurs will be government's contracting processes. New rules and regulations, some of which may even preclude the use of cloud computing in select instances, will need to be changed to be more cloud-friendly and encourage the savings and efficiencies that can come from this new model of IT.

Federal CIO Kundra has made IT procurement reform a top priority, as he is asserting that it is important for federal leaders to "recognize we can't treat technology procurements in the same way we do buying buildings" (quoted in Weigelt, 2009a). One of the themes consistently being promoted by Kundra is the need to have a common platform or infrastructure across the federal government that will make it easier to leverage cloud resources and take full advantage of this paradigm shift. Otherwise, what many analysts fear is a continuation of the problems of information silos and unnecessary redundancies and their attendant costs. As Condon (2009b) noted, "Unless you think strategically about how the government works and wants to work, instead of having 150 data centers, we'll have 150 different clouds." Yet, the government is not a "one size fits all" institution, and it is likely that the various needs and interests of agencies will require unique solutions—even if coming atop a shared architecture to some degree or another.

Indeed, one of the challenges going forward will be to make acquiring cloud-based services as easy as possible to obtain. To that end, Kundra has announced a plan to work with the General Services Administration (GSA) to establish a "cloud computing storefront." According to Kundra, the storefront

Options for Outsourcing and the Cloud

Outsourcing has always been a part of any organization's IT decision making, as by outsourcing noncore functions, executives are able to more fully concentrate on strategic priorities and core competencies (Ross and Westerman, 2004). Tech pioneer Geoffrey Moore (2000) developed the concept of core versus context IT activities in organizations. According to Moore's typology, core functions help provide the organization's competitive differentiation and span the organization to connect to its external constituencies, while context functions are typically internal in nature and help support the core activities. In an interview, Moore quipped that, if executives are "caught up in managing old context stuff and you don't find a way to get that stuff out of the company, you have trouble turning the boat," and thus, it is crucial to concentrate on the core functions to promote long-term success (quoted in *Business Week,* 2000).

We may, as Collett (2009) predicts, be quickly moving into "a world where everything is provisioned" in computing. In the realm of deciding which activities to keep internal and which to potentially shift to the cloud, Schwartz (2008a) offered the following "rules of thumb," based on Moore's core-versus-context framework: "If the business practice is context and non-mission-critical, then always put it in the cloud. If it is context and mission-critical, it is likely you should make it cloud-enabled. However, if it is core and non-mission-critical, you may want to think about keeping it behind the firewall; if it is core and mission-critical, then definitely keep it behind the firewall."

will "allow the agencies to quickly find cloud solutions" (quoted in Stegon, 2009). This initiative resulted in the creation of Apps.gov in September 2009 (see page 25). According to Kundra, "the key is to make [cloud computing] available to the federal government in a way that's easy.… We're moving from this notion of 'here's a schedule' to the notion of 'here's a platform that can be provisioned in real-time'" (quoted in Hoover, 2009i).

With these changes in motion, some have suggested that, with federal contracting currently not geared toward purchasing IT on an "as-needed" basis, it will be incumbent upon cloud providers to educate lawmakers as to cloud computing's benefits and the changes in contracting rules that will be necessary to facilitate such procurements (Gross, 2009d). Current federal guidelines are not geared toward purchasing computing on a pay-as-you-go, as-needed basis (Gross, 2009c), and at all levels of government, annual budgeting practices tend to emphasize fixed costs to match fixed levels of funding, rather than variable pricing—even if it is cost-effective to do so (Miller, J., 2008). There will thus need to be vast changes in not just the language, but the *mindset* of contracting for computing services. For while IT administrators look at capacity and systems, end users look to performance. As Jackson (2009d) put it, the key metric will now become: "When I sit down at that computer, do I see the functionality I need?"

Take, for instance, the challenge faced by the U.S. Department of the Interior's National Business Center (NBC). The NBC provides a variety of business services to other federal agencies, and it hopes to add a variety of cloud computing offerings to its slate of services. Yet, it is challenged to do so from a contracting perspective—needing vendors to offer more "government-savvy contracts." To that end, NBC Director Doug Bourgeois commented, "How can the private sector infrastructure providers provide me with a business model that's pay-as-you-go? My customers are only going to pay for what they can use. I need to purchase infrastructure and technology under the same model, so it's truly a shared-risk partnership" (quoted in Gross, 2009d).

Pricing. How to price (and how to negotiate and evaluate) cloud computing contracts will become a huge issue over the next decade as more and more corporate and governmental computing shifts to

Where in the Clouds?

Where does data reside in the clouds? For redundancy, client data often resides in multiple data centers—and perhaps in different countries. For example, Google does not disclose the exact location of where—physically—a Google Docs document might be housed in one of its massive data centers. This would be "a major deal-breaker" for government contracting requirements calling for pinpointing the physical location where data is housed. Thus, with the risk of a data breach being network-based rather than physical security-based (as it is far, far, far more likely for data to be wrongfully accessed or deleted via either remote or internal access than for the server it resides on to be physically stolen or tampered with), as Jackson (2009c) astutely pointed out, in an age of ubiquitous connectivity, "access, rather than location, may be the better way of thinking about things." Still, with developments in virtualization and multitenant architecture, cloud providers can begin to physically separate customers' data in the cloud (Schwartz, 2008a). Public sector clients may thus well require—or be required by new or newly interpreted regulations—to have their data and applications physically segregated (via virtualization or on different servers) from the private sector clients of cloud providers.

The actual "where" in the cloud computing equation *does* become an issue, however, when dealing with government data and functions. For the federal government, there will certainly be restrictions that data storage and processing actually take place within the U.S., precluding the use of cloud providers that might move offshore similar private sector work to data centers located in foreign countries—a development that will continue to grow over the coming decade. (Andriole, 2005; Hall, 2009d). This has likewise been seen in Canada, where national and provincial governments have been slow to adopt cloud computing— due to the hesitancy and Canadian Homeland Security restrictions against putting Canadian public data in foreign data centers—with most major cloud providers being U.S.-based (Rocha, 2009). Likewise, some European governments and companies have expressed concern about working with U.S. based cloud computing providers out of concern that their data—housed at least partially on American soil—could be subject to governmental review due to the provisions of the Patriot Act (Mitchell, 2009). Finally, in order to encourage economic development, states and major cities may require cloud providers to either manage operations in government data centers or to even locate data centers within their jurisdictions—so that the money and jobs stay in their own local area!

cloud providers. Cloud pricing models that are based on usage (the pay-by-the-drink model) could be confusing—and even off-putting—to IT managers and organizational executives. As Allan Leinwand, a partner with Panorama Capital, commented, "You're talking about units that people don't normally think about. CPU hours: that's not something I go buy. I buy a blade server, and the hours are infinite, they're mine. Even if an IT pro finds it easy to understand CPU hours, a CFO might not. Try to explain to your CFO how many CPU hours you're going to use in the cloud, and see if they care" (quoted in Brodkin, 2009c). Furthermore, those entering cloud computing contracts expecting considerable cost savings could experience the "sticker shock" that many of us do with our cell phone bills; if utilization is far greater than anticipated, so too will be the tab for that computing power used from the cloud provider. In other words, metered pricing works well—but only if based on considerable planning, analysis, and understanding of the up- and downsides of consumption-based cloud pricing models.

Some have also criticized the current pricing models for cloud storage, insisting that it makes little sense to charge the same amount to store large amounts of data over a long-term basis. This is due to the fact that storage costs are likely to continue their steady, unabated decline into the future. They argue that unless cloud storage providers develop new pricing and storage models to recognize the different needs clients have for the security and accessibility of their data, the attractiveness of cloud storage may pale versus the declining costs for in-house storage (Brandel, 2008). There also will have to be efforts made to educate procurement staffers on consumption-based contracting and the need for sharing best practices and lessons learned as more experience is gained across the board in this area.

Vendor Concerns. Certainly, one of the principal concerns for anyone using the cloud is the financial and organizational stability of the cloud provider. There is a customer risk in the possibility that the cloud provider could cease operations—and then what is to happen? Whether it is an individual storing pictures in the ether or an organization storing files with a cloud provider, if that firm goes bankrupt, the data may be irretrievable (Brockman, 2009). Thus, vendor financial stability is certainly a concern for public sector buyers of cloud services and storage.

Financial concerns are not the only eventuality that could proved troublesome or even fatal: What if a cloud provider stops operating for another reason—say, the destruction of a data center by a natural disaster (without a redundant secondary backup of their housed data)? Likewise, some have expressed concern that, for providers such as Amazon, their cloud operations are not part of their traditional, core business (Golden, 2009c). This is not to say that, as the cloud model takes off, the cloud portion of their operations will not likely become a much more significant part of the cloud provider's revenue and business model. However, there is always a potential risk when dealing with a firm whose primary line of business is not the area that you are contracting to become dependent upon.

Compliance. The greater automization and standardization embedded in cloud processes may free up many, many work hours of senior and midlevel IT managers from focusing on compliance issues to other, arguably more productive, uses of their time. Still, some are concerned that some cloud providers will be unwilling to open up their operations for the security vetting necessary for federal contracting. However, it is likely that, once contracting guidelines are refined and cloud providers know specifically what they will need to do to be certified and accredited, they will be more than willing to go through the scrutiny, based on the potential size of contracting to provide cloud services to the federal government (Chabrow, 2009a).

Challenge Six: The Need to Resolve Potential Legal Issues

Data handling will invariably be complicated by the cloud. When considering moving data to a cloud storage provider, it is important to remember the admonition of Damoulakis (2009), who observed: "Like a diamond, a piece of data, once created, is forever. It is typically stored, backed up, replicated and, perhaps, archived (all of which require more storage). But the likelihood that it will actually be purged is very low."

When dealing with government data, records may need to be retained for longer periods of time and be made accessible for Freedom of Information Act (FOIA) requests. Likewise, information that was formerly only available through formal FOIA requests

may now be readily available online through the Data.gov portal and, perhaps, through cloud-based federal resources that could speed compliance (N. Thompson, 2009; Aitoro, 2009b). There have also been issues raised as to whether corporate data would be protected from unwarranted search and seizure by government investigators and law enforcement when the data reside on the provider's servers in a SaaS environment, with legal analysts generally concurring that data hosted outside an organization's four walls is more open for sharing and investigation (Westervelt, 2009). All of this could lead to a whole host of legal and security issues for private sector firms, as well as for governmental entities both relying upon and/or investigating the clouds.

As IT functions and data are shifted to cloud computing, there are significant legal concerns that impact both the private and the public sectors, far beyond what can be addressed in this report. For instance, while for-profit organizations must comply with Sarbanes-Oxley regulations governing corporate financial reporting and record keeping, both the private and public sector face compliance issues with the Health Insurance Portability & Accountability Act (HIPAA). According to analysts, HIPAA does not specifically have any language precluding the use of cloud services. However, sections 164.308 and 164.314 of the law do require an organization to obtain assurance from any third parties involved in its data operations that they can properly safeguard the data (Schwartz, 2008a). Also, what happens with "multitenancy"—if a cloud provider's IT resources are used to host government data and applications side by side with private elements (Joch, 2009)?

There are several existing federal laws that may inhibit the adoption of cloud computing by the federal government. First, there are concerns as to how to conduct cloud computing under the Federal Information Security Management Act (FISMA). Analysts believe that cloud-based storage and application hosting can be legally conducted by private vendors, but FISMA compliance will be costly and complicated (Gross, 2009c). The NIST has determined that existing FISMA regulations cover cloud computing, and it cautions that cloud data storage practices and the "fuzziness" of cloud computing boundaries could make FISMA-required "snapshot audits" difficult to perform (Joch, 2009).

"Information Malpractice"

There are rumblings that cloud computing may provoke a whole host of legal concerns—and liability. At the Interop 2009 Conference, Drew Bartkiewicz, a former high-ranking executive for Salesforce.com and now the vice president of cyber risk and new media markets for The Hartford, coined the term "information malpractice" to describe the possibilities for legal action stemming from cloud computing, declaring that "'data is the new oil' because it offers both tremendous value and tremendous liability" (quoted in Evans, 2009,).

Certainly, policymakers at all levels of government will need to examine the potential areas for legal action stemming from data loss, data breach, and data/application inaccessibility from cloud computing. With the rapid evolution of this technology, it is likely that such policy actions will be doomed to be behind the tech wave. However, such actions should be made in a coordinated fashion and strive to protect rights, while not inhibiting the beneficial uses of the technology. However, with greater reliance on centralized data centers and data repositories, the scale involved with cloud computing could make wrongful actions—and potential recoveries—far larger in scope than in traditional, "four-walled" computing environments.

In the cloud computing environment, legal concerns are elevated even more, and the office of the federal CIO is working with Congress to resolve them (Corbin, 2009). Many believe that FISMA reform will be the key element to enabling federal adoption of the cloud model, and that a revision to the 2002 law should be made to specifically address nascent technology such as cloud computing (Chabrow, 2009a). From his perspective, CIO Kundra sees FISMA compliance as a key element to cloud computing moving forward. He recently stated his vision: "Today, every agency has to get their own [FISMA] certification and accreditation, even if they are using the same set of technologies. Imagine how much money we could save if we were able to have a central place where you could get certification and inherit those rights" (quoted in Hoover, 2009i).

The federal government will also have to deal with the Privacy Act, which almost all agree needs to be updated to deal with the change from paper files to electronic files existing in relational databases. Leslie Harris, president and chief executive officer of

the Center for Democracy and Technology, lent her perspective. She said, "I think we all know that that law is severely outdated" (quoted in Corbin, 2009). Likewise, the federal government will be challenged to deal with FOIA requests as more data moves into the clouds—particularly if data are stored both on internal servers and on multiple cloud platforms operated by multiple providers (Beizer, 2009a).

In the final analysis, Congress will need to streamline decades-old electronic privacy and data protection regulations to conform to today's computing realities—and to prepare for tomorrow's. As Golden (2009d) points-out, not only will inaction inhibit governmental use of cloud computing, but wider adoption of cloud-based models in the private sector as well. This is due to the fact that IT and corporate executives legal concerns may well serve to trump all the economic and operational arguments for moving to cloud computing.

Similar legal questions will likewise impact state and local governments, as well as governments abroad. Thus, one of the key motivators for developing cloud interoperability and search ability will be public sector needs for compliance and data integrity/privacy assurance.

Challenge Seven: The Need to Regulate the 'Cloud Market'

Where does the growth of cloud computing take us? Some have speculated that, ultimately, the concentration of resources and power in the cloud leads us down dangerous paths. As Jaeger, et al. (2009) observed:

> Cloud computing represents centralization of information and computing resources—quite contrary to the imagery that the label evokes. Centralized resources, by their very nature, are easy to control, by corporations that own them and governments whose jurisdictions they are under. This less-discussed fact represents a 'darker' or 'stormier' side of cloud computing and presents a danger to open information–based societies if the issues are not carefully considered.

Some have forecast that we may be headed to a future where there are fewer and fewer companies, or as Kelly (2008) imagined, a single "planetary computer" that anyone around the world would be able to tap into from any device. Indeed, Carr has proposed that we are indeed heading to a "world wide computer." In an interview with *Wired*, Carr stated, "IBM founder Thomas J. Watson is quoted—possibly misquoted—as saying the world needs only five computers. Is it true?" He [Carr] went on to say that "the World Wide Web is becoming one vast, programmable machine.… Watson was off by four" (quoted in Reiss, 2007). Carr believes that "we'll probably see some kind of oligopoly, with standards that allow the movement of data among the utilities similar to the way current moves through the electric grid" (quoted in Reiss, 2007).

O'Reilly (2008) has warned that, due to the economies of scale and scope involved, cloud computing could lead to "a huge monopoly." However, he also cautioned that the ensuing competition in this area could make "Windows versus Apple" look like "kid's stuff." Thus, in the near term, competition may well make cloud-based applications and storage even more attractive on a cost basis to potential enterprise customers. As such, this area needs to be monitored closely by governmental authorities to assure competition and choice among cloud providers.

Over the long term, any such consolidation in the emerging cloud services industry could be harmful—even threatening—to the economy, and as such, must be monitored by governmental interests. It is not just for the sake of preventing monopolization for public policy reasons, as more and more consumers and small businesses—and governments—will be dependent on the infrastructure offerings of large cloud providers such as Apple, Amazon, Google—and on the horizon, certainly Microsoft (Naone, 2008a). Erickson (2009) warns that some in the IT community have concerns that cloud computing might cause a new "Big Data" sector of the economy (comprised of firms such as Google, IBM, Amazon, and Oracle) to greatly expand.

Yet, cloud computing will invariably lead to a more vertically integrated structure in the computing industry. This has led legal and industry analysts to predict that just as in prior computing eras there were antitrust concerns and actions brought by the Justice Department against Microsoft and IBM,

similar concentration and market dominance could put Google—or another dominant market player that might emerge—at risk of antitrust actions in the next decade (Vogelstein, 2009).

In this fast-moving area, established regulatory models and practices may well need to be adapted to keep pace with the changing computing paradigm. As Nicholas Carr observed:

> There's a danger of too much of this very important infrastructure falling into the hands of too few companies. It's critical that there continues to be competition both at the level of the utility and of component suppliers to the utility. Don't think hardware and software companies will go away; they'll just shift from supplying the user to supplying the utility company. So it's critical at the highest level to ensure strong competition between all those parties. Eventually, as with electricity, it may require the government moving in to ensure that there isn't too much consolidation (quoted in Melymuka, 2005).

Market mechanisms may also play a role in guarding against a true monopoly/oligopoly from developing in the cloud computing market space. For one thing, much of the cloud computing market (storage, simple SaaS, Infrastructure as a Service, Platform as a Service, and e-mail) may be in the areas that are commodity-like in nature, and thus, low-margin businesses. Also, because there will be many firms that will—out of choice and necessity—operate private clouds; they will be operating largely independent of the market conditions in the public cloud marketplace for their internal operations. Further, as such firms find they will likely have excess capacity, this surplus could be traded/sold through exchanges and brokerage-type operations. Such models are likely to develop in the very near future (Cass, 2009).

Finally, especially if megasized, market-dominant cloud providers do emerge, there may be a need for additional regulation. Based on the banking regulation model, there will be a role for regulations to ensure that cloud providers have enough "reserve capacity" to meet their customers' demands, even in times of extreme utilization (a natural disaster or other emergency could provoke the equivalent of a computing "run on the bank" for capacity). Likewise, as companies—and even federal agencies—are both users and providers of cloud services (much of what has been proposed by the GSA, NBC and DISA is about becoming cloud providers for agencies, outside of their primary scope), there may need to be guidelines and oversight as to whose needs are met first—the provider's internal needs or those of their cloud customers (Greenberg, 2009a)? These are very good points that will most assuredly need to be addressed in the coming years as cloud oversight becomes a real issue. If not, we could well face the prospect of what Greenberg (2009a) terms a "cloud collapse" that could send the government—and the economy—reeling in the event of a major cloud provider failure without adequate procedures in place to address user needs and concerns.

Challenge Eight: The Need to Redefine the Roles of the IT Workforce

Resistance to cloud computing from users is likely to be limited, so long as they can count on the same type of IT resources as they have had in the past. There will, undoubtedly, however be some resistance among the IT workforce to the advent of cloud computing. Traditional IT staffers are likely to be the most resistant, while those with experience with web development are likely to be supportive of cloud efforts (Gruman, 2008). Gardiner (2009) is among those who believe that the rising generation in the IT workforce—comfortable in their use of and reliance upon a whole host of web-based tools and services—will be more willing to shift operations and data to the cloud than will be the current generation of IT decision makers. They will likely see their older colleagues' concerns about reliability and security issues regarding the use of cloud computing as "exaggerated and quaint."

Many in IT may also perceive the shift as not just changing what they do, but as a threat to their very jobs. Martha Dorris, deputy associate administrator for the GSA's Office of Citizen Services and Communications, commented that the biggest issue in her agency's changeover of the USA.gov web portal to a cloud-based platform was that "our technology team did not want to give up the servers." She observed that, in the end, "this isn't a story about technology. It's a story of culture" (quoted in Towns, 2009). As we have seen with so many technological shifts that have previously occurred, it is essential to

gain cultural buy-in from employees to get them to do something differently, as it is absolutely essential that "cultural change must accompany the technology shift" (Babcock, 2009). Indeed, many in IT will have to overcome the idea of data and applications not residing within their realm of control within their own four walls.

It is thus highly likely that, as with other major technological changes, the most important issues to be resolved will be people-based, not tech-based. As Patrick Stingley, CTO of the Bureau of Land Management, stated, "You have a culture that needs to change and to embrace the cloud and embrace the concept of sharing. Cloud computing is a shared service; we need to learn how to share. It's not a hard concept, but we can't agree how to do it" (quoted in Erlichman, 2009).

According to Kaplan (2009), many IT professionals are growing more receptive to the concept, as these cloud computing tools may in fact make their jobs better by freeing them from the "day-to-day hassles" of maintaining software. Jerry Hodge, senior director of information services at appliance maker Hamilton Beach, commented that, while his staff was apprehensive about shifting some IT functions to the cloud, the value of the cloud computing is that it affords him the chance to "let someone in the cloud run e-mail and free up my guys' time to work on stuff that does make a difference" (quoted in D'Auria and Nash, 2009). One of the profound issues that will need to be dealt with is the reluctance of both IT staff and users to switch to online applications. For instance, while there are free online options for both word processing and spreadsheet applications (i.e., Google Apps and Open Office), such systems have not proven to be 100 percent compatible with existing Microsoft Word and Excel files in terms of formatting, style, and templates. Thus, working with cloud options for such productivity software entails more work for users and IT than existing "shrink-wrapped" software options (Dignan, 2008).

Recent estimates are that, for every $1 organizations spend on PCs in the enterprise, another $8 is required for administrative support, maintenance, and upgrades (Miller, I. 2009). For the federal government, the equation may be higher—much higher. In fact, infrastructure costs have been estimated to consume *almost half* of the federal IT budget today. Thus, rapidly increasing maintenance costs for legacy systems may be one of the prime forces that will drive adoption of cloud computing. Radha Sekhar, assistant deputy undersecretary of defense comptroller for financial management, described the shift to a greater use of cloud computing as "inevitable," stating, "These are investments the government has to make, otherwise the costs of computing will be very high. There are no limits, especially in the defense budget. If we don't have innovative, smart technical solutions, the budget will keep growing" (quoted in Nagesh, 2009b).

Certainly, the nature of IT jobs and the skills required to perform them will change markedly over the next decade. There will be less manual work needed, both in data centers ("racking and stacking") and in the field (doing installations and upgrades). At the same time, there will be a greater emphasis on the negotiation, conceptual, and people skills needed to manage contracted cloud services. Indeed, in the near future, there will be a great need for developing expertise in specifying, negotiating, and managing service-level and organizational agreements (Robinson, 2009b). All of this will lead to IT executives being able to focus on how best to deliver services, rather than where they are hosted or how they are implemented (Schurr, 2008). This will, of necessity, lead to changes in how IT and IT managers are evaluated for their performance.

How will this impact IT employment overall? Erlanger (2009) offered a very informative, long-term assessment on the impact of cloud computing on IT jobs and the IT workforce. He noted that, while cloud computing will create jobs in the near term, over the next decade, there will be a significant displacement of many of the "nuts and bolts" technology jobs in IT—doing "hands-on" work in maintenance, upgrades, and the like. Overall, the technical skills needed for IT jobs will likely decrease, as many jobs in the field become more administrative in nature (overseeing and negotiating contracts, handling customer inquiries, and the like). Some have referred to this as a shift away from "blue-collar" IT jobs and careers toward a more white-collar IT workforce.

Golden (2009e) has offered the reminder that, while IT has seen platform transitions before—from mainframe to Windows to the web, the fact is that

"human capital is the most difficult kind to upgrade." Thus, at a time when cloud computing is emerging so quickly, it will be difficult to train IT professionals on cloud technologies—and then to retain them. As Erlanger (2009) pointed out, this will require retraining of many present IT workers—and those jobs that are found with cloud providers will indeed be away from "traditional" tech centers and major cities and in the rural, power-friendly areas where major cloud data centers will tend to be more commonly located.

Challenge Nine: The Need to Assess the Return on Investment of Cloud Computing

What—and when—will be the return on investment (ROI) of cloud computing? Most analysts have projected that cloud computing can deliver cost savings by outsourcing IT operations—perhaps as much as three to five times more cheaply than in-house data centers and hosted applications (Greenberg, 2009b). Based on anecdotal evidence from government entities, the ROI of cloud computing initiatives—from cloud storage and e-mail to SaaS applications—can be significant, as costs savings have been demonstrated by using hosted applications and having less need for internal IT resources and staffing (Hall, 2009e). However, a report from McKinsey & Company has called this into question. McKinsey found that cloud computing could actually be more expensive than in-house IT operations, especially if organizations look to adopt best practices to improve their internal server utilization rates through a combination of virtualization and reduced capacity (O'Gara, 2009b).

The ROI calculation is a bit different for the public sector than for private sector companies, specifically due to the tax treatment of capital costs. Private sector firms can write off the cost of capital investments on their taxes as a depreciation expense. Thus, they may find the concept of funding their IT needs as a variable expense, rather than a fixed cost, less attractive for tax reasons. However, for government IT leaders, a cost is a cost, so with no concern over depreciation of equipment, cloud computing may in fact be more attractive to public sector executives than to their for-profit brethren (Chabrow, 2009c).

However, in other areas, there are no differences in costing between government and for-profit organizations. First, the shift to cloud computing will not be without a cost. To the contrary, even if shifting to free resources, there will be switching costs involved. Patrick Stingley spoke of the retooling and migration costs that will be incurred in the switch, stating, "It will cost money to move to the cloud; this isn't going to be free" (quoted in Erlichman, 2009).

Stingley believes that one of the objectives of cloud computing should be to prepare agencies for making their data portable—to separate the data from the proprietary systems it is run on: "Because we will need to be able to move from Provider A to Provider B, this will force us to move to open data" (quoted in Jackson, 2009d). There are certainly indirect costs that will apply to IT operations regardless of how much of the operations are shifted to cloud computing. For instance, in the accounts payable area, there still will be the processing and payment of invoices, whether they are buying servers and software or paying for cloud storage or applications (Golden, 2009f). Finally, the reality is that any organization—public or private—that moves a core function to cloud computing will likely face having to run a hybrid solution for some time to come—not a hybrid cloud, but a dual track of the old, in-house system and the new, cloud-based solution (Hodgin, 2009).

An organization's cloud computing strategy should thus certainly not be an "all or nothing" gambit, with a sudden "we're in" or "we're staying out of it" decision. Instead, a cloud strategy should look to create "a portfolio of cloud resources," combining public, private, and hybrid cloud elements with the organization's legacy systems and resources (Staten, 2009). Laurence Millar, former CIO of the Government of New Zealand, recently framed the cost-versus-control trade-off between private and public clouds in a very astute manner, commenting, "A private government cloud is all very well, and at the moment it is probably worth paying a price premium for the control and security that it supposedly provides. But it is a risk-versus-cost equation. A private cloud will half the cost of computing. But the public cloud will half that cost again" (quoted in Hicks, 2009a).

Many observers believe that what will emerge are hybrid models, whereby organizations will combine the use of their own private in-house clouds for running mission-critical operations and hosting sensitive data with the use of public clouds for

routine work, operations, and storage. The key will be to develop decision rules to determine which applications and data should remain in-house and which are candidates for the cloud.

Finally, Golden (2009f) argues that the most significant cost of not shifting to greater utilization of cloud computing is in the time and attention of senior IT and organizational leadership. As he framed the issue, "Every minute spent on reviewing an RFP for procuring another tranche of servers is a minute not devoted to how to use IT for competitive business advantage." Yet, one challenge facing cloud adoption is the simple fact that, as organizations choose to move some of their data and applications to the cloud, rather than running a 100 percent internal IT operation, this will necessitate the development of a second management front—and additional time, training, and managerial attention—to managing cloud operations.

Challenge Ten: The Need for Government Cloud Coordination

As federal agencies establish their own private cloud environments, analysts have forecast that we are likely to see agencies sharing data centers and cloud services to facilitate collaboration and to share costs (Haynie, 2009). Some have even forecast that we may well see an "über-cloud" emerge, where, across the federal government, there can be a sharing of data and applications (Foley, 2009a). It is vital that cloud adoption be government-wide, and not done on a piecemeal basis, in order not just to prevent more information silos from developing, but to provide the scale that will make the concept work even better than in an agency-by-agency framework. As the NBC's Doug Bourgeois commented, "Without scale and a lot of it, this is not going to be economical" (quoted in Nagesh, 2009b). In fact, some have predicted that "the federal government could run the biggest cloud ever" (Gross, 2009c).

Stingley stated his belief that it is important for the federal government to have a well-coordinated cloud computing strategy, noting, "We need to do this as a government, not as a whole bunch of little armed camps" (quoted in Erlichman, 2009). Given that the scale economies and need to eliminate redundancies will push for a "one cloud" solution, the GSA would appear to be the reasonable home for a federal cloud; as a central service provider for the entire government, it could host computing capacity tomorrow as it does office space and vehicles today (Hoover, 2009h).

Thus, the Kundra-backed "GSA storefront" concept, Apps.gov, may indeed be the best prescription for pursuing cloud computing on the federal level. Likewise, we may see statewide or even multistate consortia develop in the U.S. for cloud computing (maybe hybrid clouds for multiple governments hosted on the same, physically and cyberprotected grounds), and abroad. It will be vital to see national cloud computing strategies take form, with their own champions for the cause.

We have seen predictions that, due to the cost and operational benefits of cloud computing, more and more companies will find themselves outsourcing most—if not all—of their IT to cloud providers, creating what Appirio, Inc. (2008) termed "serverless" companies. And this will not be true just for small enterprises, as it has been predicted that organizations of all sizes will find it beneficial to concentrate on and optimize their business processes by outsourcing the IT function. So, why not "serverless government"? Perhaps not outsourcing all of IT and all data storage/handling—that may be impossible for a governmental body, however, particularly for cities, counties, colleges and universities, and even perhaps state agencies, this may be a viable proposition, particularly as cloud offerings expand and are made more secure and reliable.

Finally, Doctorow (2009) recently criticized IT leaders in a Harvard Business School publication, observing that "the dirty secret of corporate IT is that its primary mission is to serve yesterday's technology needs, even if that means strangling tomorrow's technology solutions." In the public sector, too often we speak in terms of not just dealing with "information silos," but with a legacy of outdated systems that run in programming that is cumbersome and difficult to work with. The prime example of this is found in the federal government, in the fact that many agencies still rely on Cobol for critical applications. As Haynie (2009) discussed at length, cloud computing can further the application modernization movement under way to help move federal agencies away from the "Cobol world" in a fraction of the time and at a far lower cost than rewriting or replacing these critical applications.

Looking Ahead: The Future of Cloud Computing in Government

Looking into the immediate horizon, one can well imagine that, in five to ten years, we may not speak of "the cloud" or "cloud computing" anymore. This is because using what we now regard as cloud-based services—for applications, for storage, for e-mail, etc.—may simply become the way things are done. Just as today we no longer can tell if a phone call is from an analog or a cell phone, in the very near future—sooner than most think—we may no longer be able to know—or care—whether the program we are using or the data we are accessing resides on our desktop, our laptop, our cell phone, or somewhere in the cloud (likely a data center in Oregon or Washington State).

How will all of this unfold? How long will it take? Where can government take the lead—and where will it lag? Will cloud computing replace 10, 20, 50, 75, or 80 percent of what we typically think of as the information technology (IT) function in organizations? Many believe that this will not be an overnight transformation. With the entrenched investments, people, and ways of in-house IT, Dave Girouard, Google's president of enterprise computing, put it, "It will be a draining of the pond" (quoted in King, 2009). After all, as the Defense Information Systems Agency's (DISA) Henry Sienkiewicz recently stated, in government IT, "(We) have been good at throwing hardware and resources at things, but the ebb and flow of the cloud is a lot different for us both as providers and as users" (quoted in Robinson, 2009a).

It is unlikely that government agencies will move critical datasets and applications to public cloud environments anytime soon. However, there is likely to be rapid growth in cloud computing hosted in private cloud environments, with many hosted on-site for governments by vendors/service providers in hybrid cloud arrangements. As Kurdi, Li, and Al-Raweshidy (2008) reminded us, we must be mindful that "successful innovation is the result of a specific socioeconomic and technological constellation—the right product, in the right market, at the right time where specific requirements in terms of user needs, pricing, and standards, among others, must be met."

In this section, three takeaways from the report are offered. The first is an outlook for the development of cloud computing in government, looking at the federal, state, local, education, and international experience. Second is a "Cloud Migration Strategy" for government IT executives. This six-step model provides IT leaders with a process to assess how cloud computing can fit into their overall IT strategy, in support of the mission and overall strategy of their agency, and then take action toward moving to the cloud. Third is an overall conclusion for the report, trying to put the cloud revolution—and its impact on government IT and beyond—into some context.

The Road Ahead

In the Federal Government

We are likely to see the Obama administration and federal chief information officer (CIO) Vivek Kundra continue to move aggressively on an IT agenda, with cloud computing being a major ingredient in their efforts to streamline government IT. The federal government will move—over the next one to two years—to implement many of the core ideas of cloud computing. We will likely see the GSA move to become a hub—the "storefront" Kundra envisions—for cloud computing to be provisioned on-demand through Apps.gov and other developments.

We will likely see more push for common IT architectures and streamlined procurement processes that will make for a more "cloud-friendly" environment in which to buy computing time and power, rather than computers themselves. We will likely see more vendors create government-specific cloud computing products for equipping public sector computers with much of the functionality that today resides on individual machines and agency servers, following the lead of Google, which in September 2009 announced a version of Google Apps that will be specifically geared toward U.S. federal agencies (Gaudin and McMillan, 2009).

We also will likely see IT costs rise in the near term—due to the legacy costs of integrating the older, existing systems and exploring ways to make them work—and communicate—better through the use of cloud resources. We will likely see a bit of a clash in the federal IT area that must be proactively managed, as a potential cultural divide likely will emerge as between the web-savvy younger workers and the battle-hardened, "old school" IT community. We will see that it will be vitally important to highlight and share best practices and innovations throughout the government—and beyond, as will it be important for leaders in government IT to benchmark best practices that will develop in the private sector's use of cloud-based models.

In the years ahead, cloud computing has great potential not just to make federal IT less costly (at least as a fixed cost), but to give it—and the people behind the technology—greater utility, as IT can better deliver the right computing power at the right cost to the right situation. And whether it is measured by the ability to provide computing resources for scientific research, for disaster response, for unforeseen military needs, or for the decennial U.S. Census, the idea of "computing on demand" will be regarded as a good government practice.

The greater the penetration of cloud computing in the federal government, the greater the role that federal agencies and the government as a whole can have in helping to shape standards and influence the cloud marketplace as perhaps the largest cloud computing customer in the world. In the end, this could be a chance "to get it right," to increase governmental cooperation, collaboration, and efficiency through leveraging the potential of cloud computing.

Ten Predictions for the Cloud-Enabled Future of Government

1. Cloud computing will take off at the local and state levels through mostly rogue, "under the radar" initiatives over the next few years.

2. At the federal level, there will be a coordinated move to cloud computing, but with inevitable tension between agencies.

3. There will be two to three incidents a year world wide with potentially massive security breaches, involving much media attention and attendant calls for greater regulation and oversight of cloud providers.

4. There will be much cooperation between private sector firms (seeking to be cloud service providers) and government agencies, with far more data and applications than expected today transitioning to the cloud over the next decade.

5. Budget pressures will continue to drive more and more government IT to hybrid and even public clouds, as more and more former internal IT functions—and assets (hardware, software, data, and support personnel)—are outsourced, with billions in procurement dollars shifting to the cloud.

6. There will be a greater use of cloud computing, in everything from health care and education to the military and national security.

7. Free cloud offerings—even beyond the e-mail, storage, and application functions found today—will be a significant part of IT portfolios in most governmental agencies.

8. The spillover effect of government use of cloud computing will include faster agreements among major cloud providers on standards and cloud interoperability protocols.

9. There will be significant legal action arising out of governmental uses of cloud computing, and legislation addressing both IT and business needs and consumer fears and protections will be a major focus over the next decade.

10. The "democratization of technology" brought about by cloud computing will impact the quality of our individual online lives, the growth of businesses, and the pace of innovation, benefiting us all.

In State and Local Government

The interest in making use of cloud computing—for applications, storage, and IT infrastructure— will undoubtedly grow at the state and local levels as well, and it is very likely that we will see them take the lead in exploring how to leverage the cloud model to their best advantage. The state and local landscape should be quite active over the next few years, as we are likely to see both coordinated efforts and rogue operations that will test how and where cloud computing can be effectively applied. As we have seen, colleges and universities—along with K-12 education—have in many instances lead the way thus far. These entities will continue to do so, based on their need for computing power on demand and for providing the types of ready—and, in many cases, free—IT resources to their students.

Certainly, as challenging budgetary times have been forecast to persist for the next few years, at least, there likely will be even greater pressure on state and local governments to replace "paid" software and computing resources with free or low-cost cloud alternatives. With pressure to reduce the fixed costs of government—and IT being a very rich target—the shift to cloud may be forced more in some cases than may be dictated by the on-the-ground circumstances. Still, with 50 states and thousands of cities, townships, counties, and parishes of all sizes and economic/technological circumstances, some of the most exciting uses and best practices for cloud computing in the public sector could well come from the state and local levels of government.

Across the World

There are certainly vast opportunities for nations abroad to be just as active in their leadership in the cloud computing area as their counterparts in the United States—if not more so. Across the European Union (EU), we will see the emerging cooperation of member states on an EU-wide cloud computing effort. With many of the same pressures and forces operating on the EU governments as in the U.S., we will likely see just as many—if not more—cooperative efforts and innovative experiments in cloud computing in Europe.

Across Asia, in both the developing and developed world, we will see national and provincial/state/local governments undertake single-entity, cooperative, and national cloud computing efforts, Particularly in less-developed nations, we may see even greater momentum to adopt cloud computing, analogous to how wireless technologies have made available Internet and telephony in the absence of wired alternatives. Thus, cloud computing may serve to enable governments—and even their citizens—to modernize much more quickly and cheaply than what would have been possible with traditional hardware- and software-dependent computing. Thus, there is vast potential for cloud computing around the world; with these possibilities, the opportunities for cloud service providers—and for the specialist firms necessary to provide integration and IT strategy—are vast as well.

Government as a Service

Federal CIO Vivek Kundra has spoken of his desire "to start thinking of government as a platform" (quoted in Hoover, 2009i). But what if we went one step further—what if cloud computing were a right for citizens? Reuven Cohen, who is the founder and chief technology officer for Toronto-based Enomaly, Inc., a cloud service and platform provider, has proposed that, as an offshoot of governmental adoption of cloud computing, government could actually provide vastly improved access to computing services for its citizenry. Cohen (2009b) has labeled his concept "Government as a Service" (GaaS). He explains the concept:

> Government as a Service is a way for governments around the globe to offer enabling technical services to their population. These could be as simple as web-based services to complex infrastructure and platforms made available through the web and specifically to a citizen of a given country. In a lot of ways, Government as a Service is the ultimate social program, an equalizer that enables the broader populous uniform access to emerging cutting edge technology that may otherwise be out of reach for the average person. Combined with broadband initiatives, governmental cloud computing could truly be the information revolution we've all been waiting for. If information is power, cloud computing is the tool that gives it.

It's an intriguing notion. And in the big scheme of things, it could actually be one of the most important ways that government could truly "democratize" technology.

Cloud Migration Strategy

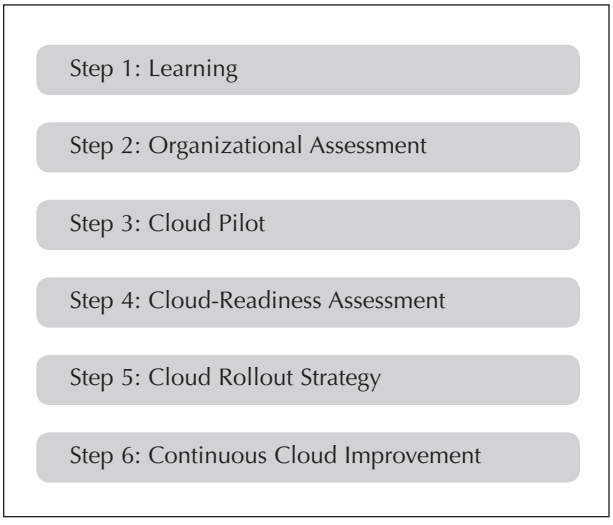
Golden (2009a) admonished IT executives that, when it comes to the shift to cloud computing, "Standing pat means being left behind." As Linda Cureton (2009), CIO of NASA's Goddard Space Flight Center, framed the matter:

> I'd like to say it a little more bluntly. If CIOs don't get ready, manage fears and manage their risk, they will get run over by this disruptive technology. Your organization is doing it anyway—without you! So do something! You don't have to move your entire enterprise into the cloud, just take the first step and look at some appropriate data sets. This doesn't have to be an all or none decision.

It is important to bear in mind the advice of Higginbotham (2009b) that "cloud computing is a tool, not a strategy." Government IT leaders thus will be well-advised to take a programmed assessment of how cloud computing can fit into their overall IT strategy, in support of the mission and overall strategy of their agency. This should take a six-step process (see Figure 5).

Step One: Learning. The Cloud Migration Strategy begins with learning about the basics of cloud computing—through attending seminars, networking, talking with vendors, and reading. Given that cloud computing represents a new paradigm in computing technology, it will be important for technology transfer to occur—the "techies" in and outside of government will need to go the extra mile to educate and inform the "non-techie" policymakers (agency executives, staffers, and lawmakers) as to the merits and value of cloud computing. It will be especially important to devote sufficient funding for research to establish how cloud computing is working—or not—in various areas and at all levels of government, so as to ground policy and practices in regard to governmental use of cloud computing.

Figure 5: Cloud Migration Strategy



Step Two: Organizational Assessment. Then, IT managers should conduct an assessment of their present IT needs, structure, and capacity utilization. In a cloud computing environment, where resources can be added—or subtracted—based on needs and demand, it will be critical for IT managers to *honestly* assess their IT baseline. In looking at data center utilization, it will be vital to look at what resources are used all the time and are necessary for day-to-day

Video Primers on Cloud Computing

Let's say you—or your manager—need to quickly learn about cloud computing. What should you Google? Well, here are some ready recommendations:

- Very good, simple tutorial on how to use on-demand capacity with cloud computing, from the editors of *Technology Review:* technologyreview.com/computing/ 22843/
- Very good explanatory video, "Cloud Computing Plain and Simple," from rPath: youtube.com/watch?gl=GB&hl=en-GB&v=XdBd14rjcs0
- IBM's perspective on Cloud Computing, as part of the "Smarter Planet" campaign: ibm.com/ibm/ideasfromibm/us/smartplanet/topics/virtualserver/20090618/index.shtml?&re=sp7
- The GSA's explanatory video on cloud computing, found on the Apps.gov home page: apps.gov/cloud/advantage/main/start_page.do.
- Very good video explaining cloud computing, from Christopher Barnatt, associate professor of computing and future studies in Nottingham University Business School: youtube.com/watch?v=hplXnFUlPmg
- Very concise overview of cloud computing from *Computing Magazine* (United Kingdom): computing.co.uk/computing/video/2226260/definitive-guide-cloud

Excerpt from
"Tech Companies Push to Digitize Patients' Records"
By Steve Lohr, *New York Times*
September 10, 2009

On one proposal for health care reform at least, there is a rare bipartisan consensus: the push to computerize patient records….

So even as the Obama administration and Congress struggle with broad health policy legislation, the technology industry is pursuing the opportunity in digital health records as never before. Although most of the government money will not start flowing until next year, the companies hoping to get their share include technology giants like General Electric, I.B.M. and the big telecommunications company, Verizon. Also in the hunt are smaller health technology specialists like Athenahealth, eClinicalWorks and Practice Fusion….

To proponents, electronic health records, when thoughtfully set up and deployed, are a modern tool to improve care and help curb costs. They hold a patient's health history, medications, lab tests and, when connected to databases, treatment guidelines. The potential benefits include fewer unnecessary tests, reduced medical errors and better care so patients are less likely to require costly treatment in hospitals.

But doctors in small offices have not moved to digital records, mainly because today's technology is costly and complex.

What is needed, experts agree, are new models of delivery and easier-to-use technology to reduce the expense and technical headaches. The proposed offerings are typically bets on the new Internet-based service model, known as cloud computing, in which much of the computing firepower and data reside in remote data centers, which doctors, nurses and staff would use via the Web browsers on their personal computers.…

The government's effort to try to encourage a market in digital health records, experts say, faces formidable hurdles. The risk is that physicians buy lots of computer hardware and software, but see no improvements, leaving a legacy of wasted money, angry doctors and disrupted care for patients.…

Even I.B.M., whose health business is geared to big medical groups, is planning a move. The company does not make electronic health record software, and so would work with partners. I.B.M. will not say precisely what it plans. "Adoption is so low in small practices because the economics doesn't work for them, but the cloud computing model can help change that," said Sean Hogan, vice president of I.B.M's health care delivery unit. "And yes, we're going to be delivering a cloud-based service into this space…."

operations in order to establish a baseline for internally hosted operations. Only then can one look at whether to continue to host "excess" capacity in the data center or to contract for cloud services as needed to scale up to meet seasonal, cyclical, or event-based demand for greater amounts of computing resources.

Step Three: Cloud Pilot. Next, IT managers should pick one area—even one specific project—to "cloud pilot" and assess their ability to manage and bring such a project to fruition. As with any new technology, we are seeing a great deal of pure experimentation with cloud computing. All of us who use the Internet are ourselves experimenting with cloud applications in our daily lives—from Twittering to Gmail to using photo-sharing sites. In the same way, we are seeing organizations conducting cloud computing experiments—efforts that are far away from their core IT operations and many times on the periphery of (or trying to connect to) the organization.

Many times—even in the public sector—such experiments may be "rogue" operations taken on by individuals and units to test the utility of the technology. These are important efforts, and they should be supported—and reported within and outside the organization—so that others in IT and wider community can learn of the successes and the downsides of operating in the clouds. Thus, it will

be vitally important to share both "best practices" and "lessons learned" in cloud computing. Indeed, many predict that such "science projects" in large and small organizations will drive the eventual acceptance and adoption of cloud computing (King, J., 2009).

Step Four: Cloud-Readiness Assessment. After the internal assessment and external outreach stemming from the pilot effort, IT managers should then conduct an overall IT cloud-readiness assessment to determine if their organization has data and applications that could readily move to a cloud environment, and if a public/private/hybrid cloud would be suitable or usable for these purposes and rank-order potential projects. As this assessment progresses, IT decision makers must focus on establishing decision rules as to which data and applications can—and cannot—be housed in *any* form of cloud environment. In doing so, they will discover a definite field of "cloud-eligible" and "cloud-ineligible" data and applications.

Step Five: Cloud Rollout Strategy. It is time to begin a cloud rollout strategy—gaining buy-in from both organizational leadership and IT staffers, and communicating with both internal and external stakeholders as to the goals, progress, and costs/benefits of each cloud project. This is where the cloud goes from being a test effort to become more mainstream in the way the agency manages its data, its operations, and its people. It becomes part of "normal" operations, just as other prior tech innovations (from telephony to fax to the Internet to e-mail and to social media) have become IT tools, used in support of the agency's IT strategy, and more importantly, its *overall* strategy.

Step Six: Continuous Cloud Improvement. At this step, the process enters the final stage—call it "continuous cloud improvement"—where the agency/organization/unit continues to move appropriate data and applications to the cloud and perhaps even back from the cloud to internally hosted operations, if necessary, based on a thorough and continuous assessment of the appropriate use of cloud technologies for the particular agency. The shift to more cloud-based applications will indeed bring to government agencies newfound capabilities to communicate and collaborate. However, it will also necessitate a flurry of policy decisions that will need to be made and operational rules that will need to implemented. For instance, there will have to be decisions made as to who can access what files and what type of access they will have (e.g., read-only, editing access) (Beizer, 2008a).

Conclusion

We may look back on the latter portion of this first decade of the new millennium as a true turning point in the history of computing. The transition, however, will take years, perhaps even decades, and as Nicholas Carr observed, "We're not going to wake up tomorrow and get all our computing requirements through a socket in the wall" (quoted in Melymuka, 2005). Pick your weather analogy—between "the perfect storm," a "cloudy day ahead," a "cloudburst," or the like—to represent the vast possibilities that are being brought about by the adoption of cloud computing.

Casey Coleman, the General Services Administration's CIO, recently observed, cloud computing offers advantages that "are so compelling, I don't think there's any going back" (quoted in Gross, 2009d). Yet, the task ahead for CIO Kundra and the federal government to leverage the power of cloud computing is a daunting one. As one observer commented, with the sunk IT investments, entrenched interests, and constant pressure for IT efficiencies and performance, the process of transferring from the status quo to the cloud environment is tantamount to "trying to build a plane while flying" (Condon, 2009b). There will also be fits and starts in the federal government's move to cloud computing.

The cloud model will ultimately serve to transform—in a big way—not just government IT, but IT in the corporate world as well. And so, with hundreds of billions of dollars being spent domestically across the public sector in the U.S.—many times that worldwide—the shift from procuring IT "stuff" to IT services will be transformational. It will transform not just how government—and the people within and interacting with it—computes, operates, communicates, and collaborates, but it will greatly impact the companies that are involved in supplying a vast array of IT equipment, software, support, and services. New, whole "industries" will likely be birthed over the next decade by the shift to more cloud-based computing (who would have had an

inkling even three years ago of what a cloud service provider might do—other than fog machines for high school dances and movie-making?). And, as many have proclaimed, the U.S. is home-base again for a computing revolution. In a time of economic turmoil, perhaps once again, the creative and entrepreneurial nature of another IT revolution will help place America—and her citizens and her government—at the forefront of the winds of change.

Appendix: Computing—The Fifth Utility?

It is one of those proverbial "big ideas": What if we could just plug in the computer and it would go, just as we plug a cord into an outlet for electricity, turn on the tap for water, or hit "send" on our cell phones? What if computing became a *utility*? In fact, it has been suggested that the move to the cloud model could make computing the fifth utility (along with water, electricity, gas, and telephone) (Buyya, et.al., 2009). This may well be a trend that takes decades—perhaps even a century—to fully unfold (Hayes, 2005). But many believe that we are in the midst of a fundamental transformation toward a more centralized utility model of computing.

While various authors have addressed the notion of computing becoming a utility, the concept crystallized in the work of Nicholas Carr. Carr first advanced the concept in 2005 in his *Sloan Management Review* article, "The End of Corporate Computing." Carr continued developing and discussing his ideas on the subject over the next three years, leading to the release in 2008 of his book on the subject, *The Big Switch: Rewiring the World, From Edison to Google*. All of this is not new, as companies whose business model was to "sell computing instead of computers" dates back to pioneers such as payroll processor ADP and to Ross Perot, who left IBM in 1962 to found EDS (Electronic Data Systems) (Hayes, 2005).

Michael Rappa (2004), the director of North Carolina State University's Institute for Advanced Analytics, categorized a number of services according to their business models (see Table A-1). What can be seen from Professor Rappa's work is that many services have evolved over the years from "make your own" to utility models. Many compare what is happening today with similar circumstances surrounding electricity at the turn of the last century. Before the rise of the electric utility, businesses and individuals had to generate their own power to run their machines. However, when large electric producers began generating power and delivering it via transmission lines into factories, buildings, and homes, self-generation of power waned due to the cost-efficiency and convenience of having reliable electricity on demand. At the turn of the century, for manufacturing plants and other large facilities to have electrical power, they had to generate their own electricity through small generators or be located near a water source that could operate a waterwheel (Carr, 2008). Take, for instance a brewery operating a hundred years ago. As Amazon chief technology officer Werner Vogels famously put it: "They had to be experts in electricity to brew beer. Something is off there. These guys couldn't wait to dump their own generators and start to use electricity from other companies" (quoted in Brodkin, 2009a). So, just as turn-of-the-century manufacturers had to produce all their electricity on site, today's organizations in the private and public sector historically have had to own all of their information technology (IT) resources—until now.

However, like electricity, IT assets are not used equally or continuously. Overall, research has shown that, as computing power has indeed grown far cheaper and more plentiful, utilization rates for IT resources have, in fact, plummeted. Carr (2005) reports that, overall, corporate servers typically use *less than a third* of their processing capacity (and much of the time, they are simply not being used). Likewise, much of a typical organization's storage capacity is either unused or being "wasted" by unnecessary redundancy. An IBM study showed that desktop computers in organizations were even less

Table A-1: Business Models of Utility Services

Type of Service	Business Models
Water	**Periodic** • Metered usage of service
Electricity	**Periodic** • Metered usage of service
Common Carrier Transportation	**One-way or Round-trip Service** • Basic pay-as-you-go fare **Commuter Service** • Pay-as-you-go fare • Subscription (weekly or monthly pass)
Telephone	**POTS ("Plain Old Telephone System"—or Land-Line Telephone Service)** • Subscription for local service • Metered usage of long-distance service • Equipment leased or purchased **Cellular** • Subscription with usage limits • Metered usage in excess of the subscription limit equipment purchased or bundled with subscription
Radio and Television Broadcasting	**Terrestrial** • Advertiser-sponsored • Community-sponsored **Satellite** • Subscription with basic package and premium services • Lease or purchase equipment **Cable** • Subscription with basic package and premium services • Pay-per-view for special event programming and movie selections • Leased equipment bundled with service
Internet Access	**Dial-up** • Subscription for limited service or metered usage, based upon connection time • Equipment purchased **DSL** • Subscription for unlimited ("always on") service • Leased equipment bundled with service **Cable** • Subscription for unlimited ("always on") service • Leased equipment bundled with service

Source: *Adapted from Rappa (2004, p. 38).*

utilized—with an average utilization rate of just 5 percent (Berstis, 2002). Writing in the *Harvard Business Review*, Cramm (2009) argues that this underutilization comes as a result of not properly using existing IT resources and unnecessary spending on new IT resources to ensure even more overcapacity *and* even greater underutilization, compounding the problem even more.

All of this adds up to a great deal of waste—an overinvestment in IT resources—and all those dollars being tied up in unnecessary hardware, software, and

the manpower it takes to monitor, maintain, and constantly upgrade and update those resources which serve as a drain on not just individual firms, but the economy as a whole (Carr, 2008, 2005). As Baig (2009) commented, this means "companies with static compute resources have to consistently grapple with the trade-offs related to under- and over-provisioning of in-house compute capacity" (p. 6). For large organizations, these IT investments—both in capital costs and operating expenditures—represent a significant level of commitment to providing the computing resources necessary for operations. Yet, traditionally, IT has been viewed as a capital expense. With ready access to credit, the cost of acquiring technology could be written off over a period of years. Today however, with shrinking budgets, companies are increasingly looking to cut their IT costs—not just the up-front infrastructure costs, but also the personnel, software, and energy costs necessary to maintain and support that level of internal IT.

Many are now increasingly looking at a pay-as-you-go approach (Vizard, 2009). This means not just a strategic change but a shift in the mindset of many—from viewing IT and its infrastructure as a fixed, capital expense to seeing it as a variable cost. By only paying for the computing power they actually use, cloud computing, for most organizations, can represent a significant overall cost savings. The more organizations keep IT in-house, the more expensive—and difficult—they will find it to attract and retain qualified IT staff (Andriole, 2005).

This situation is replicated, and even magnified, when it comes to the public sector. The simple fact is that IT costs not just the government, but all of us who support it through our tax dollars, much more than it should due to the inefficient structure of today's IT model.

With all of the unused computing capacity, the stage has been set for cloud computing to develop. Carr (2005) stated, "The history of commerce has repeatedly shown that redundant investment and fragmented capacity provide strong incentives for centralizing supply. And advances in computing and networking have allowed information technology to operate in an increasingly 'virtual' fashion, with ever greater distances between the site of the underlying technological assets and the point at which people access, interpret and manipulate the information. Given this trend, radical changes in corporate IT appear all but inevitable" (p. 73). Carr (2008) believes that we will see the web morph to become, in time, the "World Wide Computer," where we will go for all of our computing and communication needs in the era of cloud computing.

Futurist George Gilder predicted in 2006 that we would see the growth of mammoth computing companies that would take advantage of the economies of scale for centralized computing operations. Gilder (2006) wrote:

> In the PC era, the winners were companies that dominated the microcosm of the silicon chip. The new age of petacomputing will be ruled by the masters of the remote data center—those who optimally manage processing power, electricity, bandwidth, storage, and location. They will leverage the Net to provide not only search, but also the panoply of applications formerly housed on the desktop. For the moment, at least, the dawning era favors scale in hardware rather than software applications, and centralized operations management rather than operating systems at the network's edge.

Another driver toward the technology possibility of computing as a utility—and cloud computing—is to be found in the trend toward what Gartner (2008) labeled as the "industrialization" of IT. There is no doubt that IT has become standardized today, with "commoditized" hardware that underpins the Internet and data centers today. Former IBM expert Irving Wladawsky-Berger believes that this standardization is key, in that, "for computing to reach a higher level," he says, "its cells had to be commoditised (sp)" (quoted in *The Economist*, 2008b). There is also far more harmonization than at any point perhaps in the history of computing, with common software, file, and document formats that no longer present the "Mac vs. PC" incompatibility issues. Some have compared the possibilities that come from such standardization to those offered when Henry Ford mastered the art of assembly-line manufacturing to provide lower-cost, standardized outputs that made cars and a whole hosts of products available at reasonable costs. Indeed, the concept of

"modularity" and interchangeable parts has been around since the early days of computing, with common parts used in programming (through the use and reuse of subroutines) and standards constantly emerging (*The Economist*, 2008c). In fact, it has been said each generation rediscovers the power of interchangeable parts, making cloud computing "a 21st century version of centralized mainframe computing" (Erlichman, 2009).

Certainly, as with electricity, there are cost efficiencies to be gained from centralizing and industrializing IT—through better capacity utilization, economies of scale, and cost savings/sharing (akin to the cost differential of a plant having its own small electrical generator versus the giant, centralized generators operated by an electrical utility firm). Instead of buying, operating, and maintaining IT functions on their own internal servers and data centers, organizations can instead today opt to purchase this capacity and services from cloud providers—often at a far lower cost and perhaps with more capabilities than their own internal systems. They can buy these services over the Internet from companies specializing in IT—at a lower cost than running an in-house system.

Such industrialization of IT, built upon massive economies of scale, may well revolutionize the very structure of the computer industry and how IT resources are owned and housed. Traditionally, when it comes to software, IT managers had to decide whether to "build" or "buy" what was needed for operations. In contrast today, the choice is complicated by adding two new options—whether to build with open source or to "rent" through Software as a Service applications (Collett, 2009, Hempel, 2009). The move to cloud computing will ultimately be a sourcing decision, and for public and private sector organizations, there will be operations that are too critical—at the heart of one's core business—to outsource and place outside of one's control (Hall, 2009a). As Carr commented, "One of the key challenges for corporate IT departments, in fact, lies in making the right decisions about what to hold onto and what to let go" (quoted in King, 2008). As outsourcing grows, more and more computing functions will be shifted to outside, often outsize providers. Indeed, Intel has projected that by 2012, a quarter of all its server chip sales will be for machines to be placed in such "mega-data centers" (Higginbotham, 2009a).

Jackson (2007) noted that there has been a long-term pendulum swinging between centralized and personalized computing. In other words, we have seen periods where computing power, data, and programs have been held on a major, centralized platform, and we have also seen periods where that power has resided on one's desktop—or today, literally in the palm of your hand. We may well be heading, in a way, "back to the future" as the pendulum swings again. We have seen computing cycle from a highly vertical structure in the mainframe era of the 1960s and 1970s to an increasingly distributed, horizontal model of computing. This latter era began with the introduction of PCs in the 1980s through the next three decades with the explosion of the web and the proliferation of mobile devices. In the horizontal model of computing, it was important to distinguish between hardware, software, networking, and support services, and as such, entire industries grew and proliferated around each element of computing. However, under the cloud model—where we tie into the cloud—there is a move back toward a more vertical model of computing. Because as cloud computing features IT as a service, as *The Economist*, (2008d) put it, "in a world of services it often does not make sense to think of hardware and software separately."

Haff (2009) categorizes the utility analogy as "an intriguing and big argument," but one that ultimately will encounter a great deal of resistance from organizations (and their IT departments) that will have security and compliance issues which will cause them to retain computing resources and functions in house. Besides those issues, there are also other trade-offs for treating computing as a utility and moving to a more centralized computing model. Certainly, under cloud computing, while IT gains from better efficiencies, utilization, and manageability, that same centralization could inhibit the ability to innovate in the IT area by tying in users to larger and larger standardized systems (Hayes, 2005).

Simply put then, when organizations can procure the same level of computing power and like-power (and compatible) software applications from outside providers as they get from their in-house resources for less (and perhaps for free), then companies and even public sector agencies will turn to the utility model and obtain more and more of their computing from the cloud (Beizer, 2009a). Carr stated the

cloud case very succinctly by saying that "it makes computing a heck of a lot less expensive" (quoted in Braiker, 2008). Thus, the stage has been set for cloud computing to emerge as a new model for delivering information technology to individuals, organizations, and government agencies.

Today, as Daniels (2009) posited, "The early 21st century is like the early 20th century, in that we are at the beginning of a new economic paradigm. This time, however, the engine of growth will not be manufacturing, but *information*." (emphasis added). Yet, with this new age come new uncertainties. In her 2002 book, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages*, Carlota Perez described the "techno-economic" paradigm of technological innovation that has occurred historically. Once a major new technology emerges—be it trains, the telephone, or electrical power—eventually these disruptive innovations become thought of as "utilities"—becoming stabilizing forces for a new order for business and the economy. What is "different" about this time and the revolution in computing that is under way is that there will likely not be a stable period coming from the disruptively innovative technology forming the model of computing as a utility. Writing in the *Harvard Business Review,* Hagel, Brown, and Davison (2008) commented that:

> [The] historical pattern—disruption followed by stabilization—has itself been disrupted. A new kind of infrastructure is evolving, built on the sustained exponential pace of performance improvements in computing, storage, and bandwidth. Because the underlying technologies are developing continuously and rapidly, there is no prospect for stabilization … making equilibrium a distant memory (p. 82).

As some commentators have pointed out, past technological innovations have created far more jobs than those they have destroyed. However, as old media is being supplanted by new media, new media companies have mostly remained very small, with many being "Mom and Pop" or even one person in nature (Vigeland, 2008). And so, with more IT being shifted to the cloud—and more internal IT roles being outsourced to external providers—it is likely that we will see fewer IT jobs overall. And, as Carr (2009a) pointed out, from a public policy perspective, this IT revolution is failing to create middle-class jobs to replace the ones that will inevitably be taken away. Further, he believes—as do others—that outsourcing IT could likely become offshoring IT for many cloud providers, thus taking the jobs and revenue from cloud computing outside of the country entirely. For certain areas of the country, like the Pacific Northwest, cloud computing may mean a veritable economic boom, as companies from Amazon to Google to Microsoft have moved to place their mammoth cloud data centers in areas with abundant water supplies and relatively inexpensive electrical utility costs (Hickey, 2008a).

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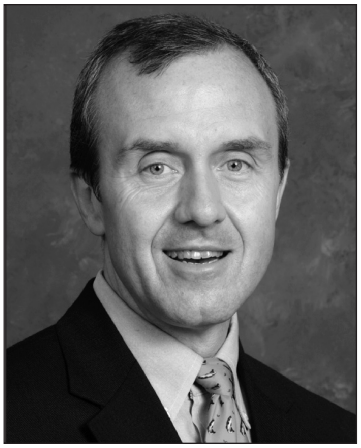

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