Cloud Computing

Publication details

Sharon E. Hunt, John G. Mooney, Michael L. Williams
Published online on: 14 May 2014

48.1 Introduction

The concept of cloud computing has received widespread attention since its emergence in about 2007 and has become an important option for the provisioning of IS/IT infrastructure, platform, and applications. In 2012, the U.S. National Institute for Standards and Technology defined cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. (Mell and Grance 2011, p. 2).

Moreover, the NIST definition states that cloud computing, in its purest form, should exhibit the following “essential characteristics”:

- **On-demand self-service**: users can access cloud computing capabilities as needed, without requiring human interaction.
- **Broad network access**: Cloud computing services should be available over the Internet and accessed through standard mechanisms, such as a web browser, which allows use by heterogeneous client devices including smartphones, tablets, laptops, and workstations.
- **Resource pooling**: Cloud computing capabilities are pooled to serve multiple users (a multi-tenancy model) and are assigned dynamically to users according to demand. As a result, users have no control or knowledge of the location of the underlying resources.
• **Rapid elasticity**: Computing capabilities can be instantly provisioned and released, typically automatically, to provide rapid and unlimited upward and downward scaling in response to computational needs.

• **Measured service**: Cloud computing services are metered according to service-appropriate metrics (e.g., storage, processing, bandwidth, number of active user accounts), with automatic monitoring of usage levels, and priced according to use.

While the combination of these characteristics is new, many of the underlying concepts of cloud computing go back to the origins of business computing in the 1950s. Unfortunately, a combination of semantic ambiguities and vendor opportunism has resulted in the term “cloud computing” being used very broadly to describe many variations of computing, storage, and network services across various “off-premise” deployment methods. From the business and user perspectives, cloud computing is an approach in which hardware, software, network, storage, and server resources can be accessed “as a service” from a third party, thereby eliminating the large up-front expense of purchasing the necessary components to build the required technical environment in-house. Additionally, cloud computing can refer to the virtualization of in-house resources, creating an internal infrastructure that maximizes the efficiency of proprietary hardware.

From a technical perspective, cloud computing is a style of computing that employs virtualization methods to create dynamically scalable IT resources. These can be offered to users as a service at a comparably affordable price as a consequence of the economies of scale that cloud service providers can achieve. Taken together, these business and technological perspectives have contributed to the rapid emergence of cloud providers over the past 5 years and the rapid adoption of cloud services. Cloud computing is becoming a computing style of choice by users, a dominant mode of computing within small- and medium-sized businesses, and a key component of the computing portfolio of large enterprises. Based on their extensive survey of cloud adoption practices at over 1000 firms, Willcocks et al. (2011) found that nearly two-third of executives viewed cloud computing as an enabling business service and IT delivery model that was driving innovation in organizations. In short, significant adoption of cloud computing has become inevitable (Seely Brown 2012) and is already well underway.

### 48.2 Underlying Dimensions

The breadth of resources and the variety of deployment models offered by cloud computing vendors contribute to its complexity. The following section lists the major categories of cloud computing commonly offered today with brief descriptions.

#### 48.2.1 Domains of Cloud Computing

**Infrastructure-as-a-Service (IaaS)**: “Infrastructure” typically refers to the tangible hardware components that are required in order to create a computing environment. In order to create computing and storage platforms, companies have traditionally built their own data centers that include the necessary servers, data storage units, power supplies, environmental controls, and other hardware components that provide the foundation for all their computing capabilities. In large companies, these are often large, dedicated centers that require full-time operations personnel and dedicated physical space. In smaller companies, this may simply be a “computer closet.” Either way, infrastructure requires capital investment that must be kept operational and up-to-date in order to support the computing needs of the firm.

IaaS refers to the acquisition of these infrastructure capabilities as a “pay-for-use-service” on a contractual basis from a third party, in accordance with the essential characteristics as defined earlier. This eliminates the need for costly physical assets and operational expenses, as well as the need to hire
experts to configure, operate, and maintain them. With IaaS, a company can host its enterprise applications on virtualized hardware that they never have to see, update, or troubleshoot.

Platform-as-a-Service (PaaS): In order to understand what is meant by PaaS cloud computing, it is first necessary to understand the concept of a computing platform. In software terminology, a platform is the underlying middle-layer code upon which applications and their interfaces are built. For example, the operating system on your laptop (such as Microsoft Windows or Mac OS) is an example of a computing platform. To simplify, we can think of a computing platform as simply an environment upon which software applications are launched and run.

When translated to cloud computing terminology, “platform” has been used to describe several different types of computing capabilities and uses, and this definition continues to evolve. PaaS refers to “renting” an operating platform, such as Force.com or Microsoft Azure, on which a firm can build customized software applications to meet its specific needs. Procuring a cloud-based platform also implies that the cloud vendor will be providing the infrastructure necessary to support the platform, so you can think of a cloud platform as the delivery of IaaS with an additional layer of functionality upon which a company can develop or purchase compatible software solutions. Cloud-based platforms are designed with software developers in mind and so provide the tools and support that developers need in order to create agile, scalable applications that typically are also mobile device and social media enabled. PaaS cloud computing remains one of the less developed areas of cloud computing. Over the coming years, its definition will likely evolve and become inclusive of more computing functionalities such as database management, business activity monitoring, and corporate governance (Mitchell Smith et al. 2012).

Software-as-a-Service: Cloud-based software-as-a-service offerings have been around for over a decade and have become the most commonly consumed cloud service genre across consumer and enterprise users. Essentially, SaaS delivers software functionality as a service, rather than as a packaged product that is licensed for use. The functionality is “bundled” with the underlying infrastructure needed to host and run an application and the operating platform on which the application is built. Examples of SaaS solutions in the end-user and consumer markets include web-hosted email providers (such as Gmail or Yahoo! Mail), search engines, Quicken, Pandora, and Netflix. Common enterprise SaaS offerings include Salesforce.com, Workday, and Radian6, an analytics tool used to gauge conversation and sentiment trends via social web conversation analysis. With SaaS, functionality is delivered remotely to registered users over the Internet via a browser. The service is paid for according to the terms of a contract (generally per user per month). Instead of consuming hard drive space and processing power on a native device such as desktop computer or laptop, SaaS solutions are provisioned remotely by a vendor’s virtual infrastructure. Additionally, SaaS solutions are constantly being updated as its developers are fixing bugs and building/releasing new features and functionalities. These improvements to the application are automated for the end user and do not require a new version purchase or lengthy update downloads.

Business Process-as-a-Service: BPaaS remains the least mature, but potentially most business beneficial area of cloud computing. An extension of business process outsourcing (BPO) that incorporates cloud computing principles, BPaaS involves the provisioning of highly standardized end-to-end business processes that are offered through on-demand, pay-per-use, and self-service provisioning models. Currently, the most common process capabilities being sourced via this model include employee productivity, employee source to pay, payroll, customer contact to incident resolution, hire to retire, and order to cash (Karamouzis 2012). The underlying resources and capabilities used to provide the business processes are shared by multiple customers, with possible additional benefits that can emerge from pooling data across these multiple customers. Ried and Kisker (2011) suggest that “BPaaS in many ways represents the culmination of cloud based innovation” (p. 4). It is possible that future innovations in BPaaS services will evolve toward the concept of “Complex Adaptive Business Systems” as articulated by Tanriverdi et al. (2010).
48.2.2 Deployment Methods

Now equipped with a working knowledge of what cloud computing and the general categories of cloud services, the next step in fully understanding cloud technology is to compare and contrast the ways in which these solutions are delivered.

Public Cloud Platforms: The public cloud generally refers to a cloud service that is delivered over the public Internet and is shared by multiple users or "multitenant." Examples include Amazon Web Services, Google Docs, Facebook, and Salesforce.com. Generally, users subscribe to a public cloud service (such as an application or storage space) and then, instead of being supported by an internal virtualization network, users can access that account anywhere from which there is a public Internet connection.

Private Cloud Platforms: The private cloud differs from the public cloud much the same way that an intranet differs from the Internet. Essentially, a private cloud is created with a company’s proprietary resources. However, it uses cloud computing techniques such as virtualization and data center automation in order to achieve the elasticity benefits that are one of the major advantages of public clouds but also the efficiency and productivity benefits associated with cloud-based provisioning. Generally, private clouds provide their owners with greater control over their capabilities and are often cited as providing a higher level of security (Accenture 2010). Companies can either invest in and create this cloud independent of any third-party vendor or utilize third-party services and the “pay-as-you-go” model with private cloud vendors. Examples of such a vendor are EMC’s VMWare, a company that offers enterprise software virtualization products, and Pogoplug that offers products that allow a personal computer to become a web-based file sharing server, pooling storage capacity across all computers within a single company and creating a central location for file access.

The Chief Information Officer (CIO) of a global construction company that was an early adopter of cloud computing shared the view that the biggest difference between a public cloud and a private cloud is whose balance sheet includes the infrastructure asset. The idea behind this statement is that if the technology and capabilities of the cloud are the same or similar internally or externally, then there is no functional difference in regard to business processes (HBR Analytic Services 2011). Although this may be true for a company that does not have the need to create flexibility in its IT operations beyond what can be provided by a cloud vendor, for a company that competes in part through its ability to provide cutting-edge customer service, tracking, supply-chain management, or other functions that rely on increasingly improving IT capabilities, this may be less likely. Private clouds, although generally more expensive to build and maintain than public cloud services, can provide a company with the ability to create their own customized solutions above and beyond what is currently available in the vendor market.

Community or Virtual Private Cloud Platforms: A community cloud refers to a cloud that is hosted on the public Internet but is not fully multitenant. Rather, it is shared between a restricted community of firms or users, thus addressing the concerns of security and/or verifiability of the geographic location of the data. One major downfall of using a private cloud is the lack of economies of scale that arise from the efficiencies inherent in providing services to the large number of users that tap into public cloud solutions. In industries where similar businesses use private cloud computing capabilities, it is often advantageous to pool these resources in order to achieve some of the economies of scale that are lost in single-firm private clouds. Generally, these community clouds integrate numerous private clouds, using the unallocated resources from user machines to create a virtual data center.

Hybrid Cloud Platforms: Hybrid clouds refer to a type of cloud computing deployment that uses a combination of more than one delivery method, such as private and public cloud services. Typically, firms that are highly concerned with security issues and/or have legacy applications that would be too costly to move to public cloud computing services will maintain a portion of their computing capabilities within a private ecosystem and utilize public software and platform clouds to enable other business processes. Another reason hybrid clouds are popular is that they provide a means...
Cloud Computing

from which enterprises can remove data quickly from a public cloud, in response to either a pending security threat or complications with a vendor.

48.2.3 Location Types

There are three different ways that clouds can be located, each with its own set of capabilities and purposes:

On-site: An on-site cloud is a cloud that is located entirely on the premises of the user. The cloud can either be owned by the company itself or it could be the property of a third-party vendor that installs, maintains, and services the hardware. The latter option allows companies to have the benefits of private cloud computing without the hefty capital expenditure of purchasing the equipment. Hitachi Data Systems is a vendor that originally offered cloud computing services for telecommunication companies in the public cloud. However, having identified and understood the hesitation of executives in the telecommunication industry to move private consumer information into a public cloud, they began offering on-site, private clouds that they locate within the client company’s own firewall.

Dedicated: Like an on-site cloud, a dedicated cloud serves only one client—however, the cloud is located in the provider’s facilities. Companies can obtain dedicated infrastructure for their own use, instead of sharing with other “tenants.” This allows a company to have greater control over the infrastructure—for example, if a company is utilizing a dedicated server to host its portfolio of corporate websites, then it would be able to select what operating system the website will use and what sort of security protection (such as encryption capabilities and firewalls) the server will provide. In general, a dedicated cloud gives the client more ability to customize the machine in accordance with its own needs (Loebbecke et al. 2012).

Shared: Shared clouds are the most commonly used type of cloud. These are located off-site (generally in the vendor’s facilities) and allow multiple clients to utilize the same resources (Loebbecke et al. 2012). There is limited customization with this location method, but it is generally a less expensive option than on-site or dedicated clouds.

48.3 Impact on Business Practice: Applications of Cloud Computing and Their Outcomes

As more companies adopt cloud computing successfully to minimize cost, increase agility and standardization, and bring products to market faster, other firms across the spectrum of size, industry, and globalization are taking interest (Abokhodair et al. 2012). Although the potential benefits of cloud computing are compelling, managers must be aware of what objectives they are trying to accomplish with cloud technologies and develop effective management practices for eliciting and maintaining the intended benefits.

48.3.1 Benefits of Cloud Computing

The most commonly cited benefits offered by cloud computing are significantly reduced IT fixed costs and IT capital assets, increased speed of deployment of IT services, and greater flexibility or “elasticity” of IT services provisioning (Accenture 2012; Harris and Alter 2010; Iyer and Henderson 2012; McAfee 2011). Short-term variable cost reductions may also emerge from reductions in data center operational costs, IT operations, maintenance and support staff, electricity usage, and software licensing fees. Large, established companies can also take advantage of these savings by substituting internally developed or acquired assets with infrastructure, platform, and application services that are hosted in the cloud. Likewise, companies that are just entering new markets can experience decreased barriers to entry due

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Managing and Securing the IT Infrastructure and Systems

to the fact that they have instant access to “world class” computing capabilities at affordable prices. Beyond cost, however, cloud computing offers other important areas of benefit for business organizations. Drawing from their research on early adopter companies, Iyer and Henderson (2012) identified six “benefit patterns” that companies had achieved from leveraging cloud computing capabilities: increased business focus, reusable infrastructure, collective problem solving, business model experimentation, orchestrating business partner dependencies and the “Facebook effect” of leveraging mobile devices, social networking, real-time data, and user-driven content generation. The aggregation of perceived business benefits across a wider range of adopters reveals the following primary areas of impact:

**Flexibility:** Cloud computing can offer flexible resources to companies that experience seasonal or sporadic increases in computing capacity needs. By offering these resources in such a way that is immediately elastic, companies need not invest in extra infrastructure just to support periodic bursts or suffer from overloading due to insufficient resources. These two factors not only add to the potential cost savings of a firm but also help to negate the risk of unsatisfactory service due to a lack of capacity. Due to the nature of cloud computing, new capabilities can be quickly implemented and deployed, increasing the speed in which a firm has access to technologies that assist in creating and delivering products, thereby increasing the speed in which these products get to market.

**Standardization:** Another compelling benefit of cloud computing is the ability for a large corporation to be able to standardize applications across previously segmented and siloed parts of the firm. Oftentimes, the apparent needs of different departments/regional locations within the same company give way to employing multiple legacy applications that are not capable of sharing information with one another, creating silos, communication difficulties, and compromising business intelligence. The task of extracting the data in these applications and moving them over to a new integrated system can be daunting and expensive. Cloud computing offers the possibility of deploying such a shared platform with greater speed, less expense, and less user resistance than creating an internal system.

**Business intelligence and big data:** Business insights and analytics tools powered by public and community clouds are becoming an increasingly popular means to access and analyze the vast datasets now available to business organizations. For example, some cloud analytics vendors create detailed geographic and demographic profiles by analyzing and interpreting the click behavior and interactions of millions of online consumers. By tapping into the resources generated by public clouds, firms are able to attain access to more granular (and therefore accurate) information than they would have otherwise. Some vendors, such as APTARE, leverage a community cloud in order to provide its members with analytical data regarding how well they are optimizing their data storage resources. The company, while keeping each individual community member’s information private, is able to study and compare how well a firm is utilizing its resources compared to other members of the community with an infrastructure of similar size and scope.

Companies that develop their own internal clouds can use these capabilities to offer innovative products and services in addition to their core offerings, gaining a competitive advantage in the marketplace.

**Enabling focus on core business competencies:** In an ideal world, all IT systems would effectively act as enablers of core business functions, creating a more efficient and effective workforce. Too often, however, technology begins to create operational boundaries, limiting the very employees that it was implemented to help. Salespeople in the field are not able to provide customers with immediate information without access to their computers; IT professionals are distracted from their core duties when expanding technological capabilities to a new branch location; customer service agents cannot deliver speedy service when they are required to search through multiple, nonintegrated databases to gather basic information.

Cloud computing can offer solutions to such problems through multi-device access, anywhere anytime access, and standardization across all users. Salespeople can answer customer questions in real
time via mobile cloud software services, branch openings are simplified by utilizing cloud computing vendor capabilities for immediate expansion, and SaaS offerings may provide integrated databases and immediate knowledge-sharing capabilities. In such scenarios, employees are empowered to focus on what matters most to the core business, whether that be customer service, knowledge expertise, or something else (Iyer and Henderson 2010).

### 48.3.2 Management Practices for Achieving Benefits from Cloud Computing

Although the possible business benefits of cloud computing are significant, managers of firms that intend to deploy cloud computing for business benefit must understand that cloud deployment is much like any other IT-enabled business process in that it must be carefully analyzed, planned, deployed, and monitored after implementation. Because cloud computing is an emerging technology with low barriers to adoption, it may be easy to fall into the trap of experimentation and speculation. Before moving to a cloud solution, managers must perform a comprehensive analysis of benefits, costs and risks, vendor due diligence, and develop compelling business cases built on appropriate, verifiable metrics (Herbert and Erickson 2011).

Although there are clear steps that should be taken before any business leader embarks on a journey to the cloud, research shows that managers who have had more than 5 years of experience with cloud computing are convinced that the benefits are greater than the risk (HBR Analytic Services 2011). Experience with cloud computing cultivates effective management capabilities, which in turn engenders confidence. Recent research showed that only 4% of senior managers in companies with more than five years of experience perceive that the risks of cloud computing outweigh the benefits (HBR Analytic Services 2011).

#### 48.3.2.1 Understand the Market and Your Current IT Environment

Before undergoing a switch from traditional to cloud computing solutions, managers must understand thoroughly the rationale for this decision. In what areas does the firm need improvement? Is the market faced with an influx of new entrants that are more agile and more rapidly bringing products to market? Does the company need to standardize its processes in order to increase productivity and minimize the learning curve for cross-functional teams? Are legacy applications outdated and difficult to modernize?

A thorough understanding of the ways in which cloud computing is currently being used in your industry is necessary before coming to conclusions regarding how best to incorporate it into your company’s current operations. This process is further aided by mapping out the company’s IT infrastructure, platform, and application ecosystem. What business processes are supported by legacy applications? What is involved with moving these processes to cloud-based solutions? Is the cost of the transition sufficiently outweighed by the expected benefits gained from increased efficiency and productivity? How strong are the data used to support the decision?

Investigating industry best practices with the cloud and how conducive the firm’s current technology management capabilities are to moving to a cloud environment will bring clarity to the adoption decision. Although the possible benefits of cloud computing are numerous, companies will need to have a clear vision for why they are moving to cloud computing and what challenges and/or synergies it will encounter with its current ecosystem.

#### 48.3.2.2 Define and Manage the Intended Outcomes

Because of the extent of hype surrounding cloud computing, it may be easy to assume that moving a company over to cloud solutions will reduce costs and increase agility, but in order to get the most out of cloud-based solutions, managers must be specific regarding the intended processes they intend to improve, cost and revenue metrics, and other business outcomes. Managers cannot simply make the switch to cloud computing because it is trending in the industry or because they expect certain outcomes that are loosely defined. This goes beyond identifying areas of opportunity to creating a road map.
that describes hard objectives with useful measurements, the stakeholders involved, how the change will affect them, and the identification of who in the company will be responsible for ensuring that the objectives come to fruition (Peppard et al. 2007).

Involve stakeholders and stakeholder representatives in the formation of this plan in order to identify and address concerns that may not be apparent. Including those impacted by a change to a cloud computing solution in the decision itself will not only give managers greater clarity regarding the likely consequences of the change, but will also help to create buy-in from different user groups.

48.3.2.3 Define and Manage the Necessary Changes

If the current IT ecosystem is thoroughly understood and if that information aids in the selection of a cloud solution, deployment model, and vendor, then much of the legwork for defining what actual changes need to happen for a successful transition is already done. Examples of such changes could include redefining certain professional roles, training personnel on a new software solution, or redesigning a particular business process to be aligned with standardization goals. Whatever the change, managers must identify it and assign the management of it to a particular owner. These changes should be linked to their intended business outcome and should follow a plan that includes a timeline, milestones, and risk mitigation considerations.

In order to successfully create a realistic timeline and properly put into place mechanisms of risk mitigation, stakeholders must once again be consulted and considered. Who will be affected by this change? What pending projects are reliant on the legacy application that is being eradicated? What technological capabilities will be lost if all data centers are consolidated and an IaaS solution is deployed? What contingency plans are in place to help business processes continue in the event there is a hitch? What long-term cultural and organizational changes will result in this new business model?

48.3.3 Cloud Computing Risks

Although the possible benefits from switching to a business model that incorporates cloud computing has the potential to be dramatic, there are also many risks and challenges involved in the decision, which conscientious managers must address.

48.3.3.1 Confidentiality and Privacy of Data

What managers across the globe are concerned with is the threat of data privacy and confidentiality breaches (Accenture 2010). In addition, global companies may need to contend with differences in privacy laws depending on where they conduct business and prepare for subpoenas, searches, and seizures as permitted by local law. As we progress into the twenty-first century, the laws and regulations surrounding the use of cloud computing services will need to evolve with these developments. Firms will need to ensure that they remain under compliance and are protected. Before entering into new global territories, firms needed to closely scrutinize the liabilities that they may be subject to as users of cloud computing. They will also need to regularly audit their vendors to ensure that they are regularly iterating the development of their security measures to keep up with constantly evolving threats.

48.3.3.2 Market and Vendor Maturity

At this point in time, the cloud computing market is relatively immature, so there are constantly emerging vendors that are vying for market share. Although newer entrants may appear to offer better deals or other benefits, there is inherent value in a vendor that has proven its reliability as a trustworthy business partner. If a company’s day-to-day operations rely on applications, stored data, or other capabilities that are powered by the cloud (as they likely will), then it could be potentially disastrous for that cloud to incur some sort of technical failure.

Relatively young firms and new entrants dominate the market space of cloud computing providers. This is particularly the case with the most innovative cloud service firms, many of which are new
ventures that are dependent upon venture capital for financial stability, whose offerings are relatively new to market and are relatively unproven, and whose customer base is small when compared with the long-established vendors of comprehensive enterprise systems. The overall immaturity of this sector creates greater risks and concerns for adopting firms and will require robust due diligence in vendor evaluation and contracting (Phifer and Heiser 2012).

48.3.3.3 Integration with Existing On-Premise Systems
A significant challenge for many firms relates to the necessity to integrate data between traditional on-premise systems and cloud-based services in order to provide for data standardization and process coordination. One of the key benefits of tightly integrated enterprise resource planning (ERP) systems was their embedded support for data integration and master data management. The potential shift from, or augmentation of, these integrated ERP systems with specialized SaaS services creates potential risks of data silos and data inconsistencies (Radcliff 2012).

48.3.3.4 Low Maturity and Consistency of Local and Global Regulations
Another potential challenge for the adoption of cloud computing is the immaturity of regulations that govern various critical aspects of cloud computing services including vendor responsibilities, service-loss accountabilities, data loss prevention, and privacy protection. This sphere is further complicated by differences and inconsistencies in the prevailing policies and regulations across major regions of the world.

48.3.3.5 Reduced Control over IT Demand
Another potential risk associated with the availability of apparently more affordable, on-demand, direct access by users to unlimited computing resources is that demand and consumption of these services can grow exponentially, resulting in significant increases in overall computing costs. Contrast the likely behaviors when users must operate within a fixed storage allocation (e.g., mailbox, file share, or data archive quota) versus behaviors when offered apparently unlimited storage as a service. Combine this with the ability of business unit executives to independently contract for cloud services directly with cloud providers, and the potential for rapid escalation of demand and consumption of IT services emerges. For better or worse, IT units and traditional IT management approaches played a “demand management” role that served to control rising demand and consumption of IT services.

48.3.3.6 Vendor Reliability and Long-Term Viability
Any company that is considering moving critical computing capabilities to the cloud must thoroughly consider the risks of vendor failure. The disaster recovery and business contingency measures that a company should take to protect itself against possible vendor outages are not unlike those it would take to protect against failure of “on-premise” computing infrastructure. Data centers built internally are not immune to risk and must include contingency plans in the event of an unexpected interruption, whether it be from a natural disaster, faulty equipment, malevolent interruptions, or some other occurrence.

However, because of the media attention that cloud computing outages have received in the last couple of years, the actual risks associated with cloud computing reliability have been somewhat exaggerated. A cloud vendor’s reputation and long-term viability are highly dependent on its reliability, and so cloud vendors have a strong motivation to ensure that their services are backed by robust technologies, processes, and management practices. Although there are certainly examples of large failures such as Amazon E2C’s 3 day outage in 2011, there is also evidence of solutions that have thus far proven to be more reliable than their in-house counterparts. For example, Google’s Gmail-enabled email services achieved 99.984% uptime in 2010—making it approximately 32 times more reliable than the average enterprise email system (McAfee 2011).

This is not to say that a loss of service is not a serious threat for companies that rely on cloud computing capabilities. However, proper steps can and should be taken to mitigate the potential consequences...
of a system failure. Netflix is an example of a company that understands this principle and has truly integrated it into the DNA of its operations. When Amazon’s cloud services famously went down in the spring of 2011, Netflix was able to continue to serve its customers uninterrupted because it had tested its systems for this contingency using an internal interference system it had built dubbed “Chaos Monkey.” The system was designed to randomly attack subsets of the company’s technology environment. These built-in attacks required all of Netflix’s operative processes to develop adequate and immediate contingency plans, ensuring that the company was thoroughly prepared for an outside threat (McAfee 2011).

Beyond temporary services outages, a greater concern for cloud adopters is the long-term financial security and viability of highly innovative cloud service providers, many of which remain at the “early stage venture” of the business lifecycle, dependent upon investment funds for operating capital, and desperately striving to achieve the level of market success to ensure their survival and prosperity. Cloud adopters will need to conduct diligent analysis of the financial security and long-term viability of these highly innovative but immature cloud service providers.

48.3.3.7 Security
Skeptics of cloud computing often refer to the risks associated with off-premise cloud computing vendors maintaining the levels of security necessary to protect critical capabilities and proprietary data. These critics maintain that on-site data centers are superior in this regard due to the fact that the company itself controls them. This logic, however, is questionable at best. Cloud service providers are aware that their long-term viability is dependent on mitigating security breaches and consequently will typically dedicate far more resources and expertise to establishing and maintaining a highly secure environment than a typical client company would independently. That said, firms that have adopted cloud computing must manage the business risks associated with that decision and develop business continuity plans (backup plans) in the event the cloud service is inaccessible, or data are compromised, and develop appropriate data recovery processes. These plans should be reexamined periodically to ensure that the considerations remain relevant and complete.

In the absence of effective guarantees about service and compensatory damages from suppliers, and the absence of legal precedent in these areas, some firms have addressed the potential loss, risk and liability issues by taking out cyber-liability insurance (HBR Analytic Services 2011). Users can also manage this risk by dealing with well-established vendors, avoiding new vendors that have not yet proven reputations in the market. A clearly defined exit path should be developed to prepare for an event in which the vendor suffers some unexpected loss, i.e., bankruptcy or a natural disaster (Stroh 2009).

48.3.3.8 Vendor Lock-In
Firms need to pay special attention to the construction of their clouds, not just in the interest of building the most relevant and cost-effective solution, but also to mitigate the threat of too much vendor control. Vendor lock-in can come in a variety of forms: lengthy and binding service contracts, applications built with proprietary Application Programming Interfaces (APIs), voluminous data storage costs, and hefty switching costs resulting from an ecosystem dominated by one vendor. However, as the cloud computing market grows, firms have an ever-increasing pool of vendors to choose from and should leverage their buyer power to create flexible solutions to minimize these threats.

The first step for any firm that is considering deploying a cloud solution is to build a blueprint of the desired ecosystem. This blueprint should consider what services are necessary, required storage capacity, operating requirements, where user training would be needed, and what elements of design are required for enabling seamless portability of public or community cloud data to the private cloud (and vice versa). Once a firm has a holistic picture of its service needs, it should consider how best to transition from existing assets and resources to the proposed cloud platform.

After taking a comprehensive examination of how the firm intends to use the cloud to satisfy its immediate and longer-term needs, it will be prepared with the right set of questions to present to vendors. For example, if the firm intends to build custom applications, it should consider whether or not
Cloud Computing

its PaaS vendor offers APIs that allow for app transfer to a new platform. In 2011, Google’s App Engine enacted a sudden price increase, but because the applications built using this platform could not run anywhere else, firms had to weigh the cost of redevelopment against the cost of continuing to stay with App Engine. Users of PaaS offerings should also consider the type of code used to build applications, since some code is less expensive to alter than others (Gigaom 2011).

Considerable time should also be given to the negotiation of contracts, service agreements, and termination clauses. Of particular concern are the agreements around data portability. If possible, firms should diversify their cloud environment enough to limit reliability on any one vendor. Cloud vendors should be required to be transparent with their own ecosystem to ensure that customers are not unknowingly using third-party vendors that have not been appropriately vetted. As the market goes through a familiar pattern of mergers and acquisitions in the coming years, firms will need to dig deeper to uncover potentially problematic interdependencies in their proposed cloud ecosystems; otherwise, the diversification of vendors will not have the intended effect (White et al. 2010). By performing due diligence in this regard and leveraging buyer power to obtain preferential contracts, firms can hedge against multiple varieties of vendor lock-in.

48.3.3.9 Uncertainty around Return on Investment

It might be easy to get swept away in the hype around cloud computing. But like any major business decision, detailed analysis must precede any decision-making. First and foremost, there must be clearly defined benefits that are the intended outcome of the cloud migration. Without understanding exactly why a firm is considering a move to the cloud, a proper analysis (including opportunity costs and alternative options) cannot be performed. Once these intended benefits are articulated and included in the business case, however, firms should still rely as much as possible on hard metrics instead of speculative hunches. Tangible costs of the current environment should be compared with a holistic assessment of the costs of transition to cloud-based alternatives, including training, losses from temporary lapses in efficiencies, potential client attrition during the early stages, the added expense of hiring personnel to maintain vendor relationships, and the cost of the vendors themselves.

Depending on how a firm intends to use the cloud and the business benefits it hopes to gain, it will most likely need to develop hypotheses for the financial impact of these benefits. Where hard data do not exist, the hypotheses should be tested in microexperiments in order to avoid making larger, faulty assumptions. For example, if an insurance company believes that moving its customer data to the cloud would improve accessibility for its adjusters and therefore boost the speed of claim resolution and overall customer satisfaction, it could conduct a geographic experiment wherein a small subset of its covered locations are shifted to the cloud. This hypothesis could then be tested and proved (or disproved) before making a significant, company-wide transition (Harris and Alter 2010).

As hinted at in the previous example, return-on-investment, although a popular metric, may not be the best lens through which to view a cloud transition. For example, if one of the intended benefits is to improve employee collaboration or to become more agile in an increasingly dynamic marketplace, attaching a realistic Return on Investment (ROI) number may prove futile. However, the business impact of these improvements may be significant and should not be overlooked when making a case for cloud initiatives. Once again, experimentation and hypothesis testing can be very valuable for evaluating these assumptions and avoiding misguided or lofty predictions.

Finally, firms should ensure to carefully consider the various pricing models of the proposed vendors and evaluate the implications of these in the event of anticipated business growth and broader strategic goals. A thorough examination of available vendors should consider not only capabilities and lock-in potential, but whether or not their pricing models are aligned with the company’s strategy (Stroh 2009).

48.3.3.10 Resistance from Executives, IT Managers, and Users

A thorough business case analysis should incorporate securing executive team support for moving critical capabilities to the cloud. However, studies show that IT professionals and business professionals tend
to view the risks and benefits associated with moving to the cloud quite differently, and so the same pitch may not be effective across the board (Willcocks et al. 2011). Namely, IT professionals tend to see the threat of lock-in as much more looming than their business counterparts, who in turn are more skeptical of the potentially negative impacts of not moving to the cloud. In addition, IT managers tend to be much more conservative regarding the expected benefits of the cloud and the time horizon necessary for attaining these benefits. The gaps in risk perception and expectations between business and IT staff members can potentially cause tension during the shift to the cloud, causing undue strain on the transition (Willcocks et al. 2011).

An effective way to manage this likely divergence of views is to build a cloud strategy team that is cross-functional, including members from the executive team and multi-department managers, including business and IT representatives. Additional valued members of this team would include law experts, innovation specialists, and managers adept at instituting new processes. Such cross-functional teams can do much in terms of bridging the gaps between the business and technology sides of the firm, creating a holistic and realistic cloud strategy, and earning buy-in from key company players (Harris and Alter 2010).

48.4 Future Research Issues and Challenges

Given its recent emergence and relative maturity as an important alternative approach for the provisioning and consumption of computing resources, there is relatively little published academic IS research on cloud computing to date. However, a review of the research papers included within the leading IS academic conferences in 2012 (e.g., the 2012 European Conference on IS, 2012 Pacific-Asia Conference on IS and the 2012 Americas Conference on IS) clearly shows that much research on cloud computing is in process. That said, it is also clear that many opportunities for comprehensive academic and applied research studies on the technological, business, and managerial opportunities and challenges associated with cloud computing remain. The levels of adoption of cloud computing motivate a need to reevaluate much of the prevailing wisdom about computing across almost every chapter in this volume. Critical areas for which new insights will be needed include application services development and deployment methods for cloud computing environments; models and approaches for effective data management within distributed cloud-based systems; global regulations for data protection and data discovery, and management practices for adhering to these; enterprise architecture in the context of cloud-based services; services versioning and pricing; collaboration and collective intelligence in massively online cloud computing contexts; security and data privacy management; effective governance practices for cloud computing; and management practices for realizing value from cloud computing. Other areas of great importance are the implications of cloud computing for internal IT units and their requisite skills and capabilities for a model of business computing in which the dominant traditional competencies of design, development, and operation will be overshadowed by competencies in services architecture, brokering, and integration and in which users can assume much greater independence and control over their computing needs.

48.5 Summary

Cloud computing has emerged to offer important capabilities for corporate computing. For small- and medium-sized enterprises, the affordability, scalability, and simplicity of deployment of cloud computing are driving rapid adoption. Within these small- and medium-sized businesses, cloud computing is becoming the dominant approach for providing infrastructure services, application functionality, and business process capabilities. Cloud computing is diminishing many of the barriers to “enterprise-class computing resources” that have been previously available only to large firms with extensive financial resources and comprehensive internal IT management capabilities, and thus leveling the field for all players in the digital economy.
Cloud Computing

For large enterprises, cloud computing is providing compelling features and capabilities that augment and extend the accumulated portfolio of IT infrastructure and applications. Cloud-based approaches have been especially valuable for supporting the incorporation of social media interfaces, social network applications, tablet and smart phone devices, computing-intensive “deep analytics,” and storage-intensive “big data” opportunities. For users, cloud computing has offered the opportunity to “untether” from desktops and embrace mobile computing devices with access to powerful on-demand applications and interactive information services.

Of great significance for the future of computing are the realities that almost all venture capital for software start-ups is being directed toward ventures that are embracing a cloud-based distribution model and that most established enterprise software companies are actively developing and executing a cloud strategy for their products. While some features of cloud computing are new, enabled by recent technology innovations, it also has to be realized that the emergence of cloud computing is entirely consistent with the evolving pattern of business computing and information systems provisioning that has been developing for the past 70 years. Fortunately, much of the knowledge about effective approaches for realizing value from computing that has been accumulated over this period is immediately applicable to cloud computing. However, consistent application of this knowledge to guide management practices remains a perennial challenge.

Further Information

Cantara, M. 2012. BPM is critical for the adoption of applications and business processes in the cloud, Gartner Research Report.


**References**


Cloud Computing


