Elements of Cloud Adoption

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Sharing experiences in transitioning from traditional computing paradigms to the cloud can provide a blueprint for organizations to gauge the depth and breadth of cloud-enabled technologies.

Cloud computing, a mainstream of research over the last decade, is expected to revolutionize the information and communication technology (ICT) sector. The cloud offers everything as a service (XaaS) on a pay-per-use model. Among the main incentives to adopt the cloud computing paradigm are easy and pervasive (anytime, anywhere) access to data and applications and cost effectiveness.

Significant savings in initial capital expenditures and operational expenses inspire enterprises and businesses to adopt cloud services for their computing demands. Enterprises using the cloud don't need an enormous budget to deploy a computing infrastructure. Moreover, by implementing a cloud-based system, they can reduce running/operational costs by reducing the IT staff, relieving data security and backup concerns, and lowering energy bills. Employees can access cloud-based services anywhere and anytime using handheld devices. Moreover, pervasive and convenient access to enterprise data and applications augment employees' productivity. Furthermore, cloud computing makes computing and storage resources available when required on the fly. Enterprises can procure and release cloud resources for short-term needs based on the "pay per use" policy.

According to the US National Institute of Standards and Technology (NIST),

> Cloud computing is 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.[1]

As an IT buzz word, cloud computing has been defined in a variety of ways,[2,3] yet most definitions include on-demand, pay-per-use, and elastic services provisioning; and access to virtually unlimited shared resources. From a system engineer's perspective, cloud computing is software implemented on a shared pool of interconnected resources in a large-scale datacenter to deliver various cloud services. Such a viewpoint ignites a debate that perhaps the

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cloud was available as early as the 1990s, with Web mail as the prime example.

These conflicting and sometimes ambiguous definitions and interpretations mandate the need for a forum in which to share successes (and lessons learned) from cloud experiences and adoption. Such a forum will not only help us understand what works and what doesn't but also help move academia and industry toward this game-changing technology. Here, I describe some of the elements of cloud adoption to set the tone for the types of articles that will be of interest under the emblem of "Cloud Experiences and Adoption."

Growth Areas

In a "Market Trends" report, Gartner estimates that the cloud-based business services and software-as-a-service (SaaS) markets will increase from US$13.4 billion in 2011 to $32.2 billion in 2016.[4] Similarly, the infrastructure-as-a-service (IaaS) and platform-as-a-service (PaaS) markets are estimated to grow from $7.6 billion in 2011 to $35.5 billion in 2016.[4] In addition to supporting various operations in the business and enterprise sector, cloud computing is transforming many aspects of our social and personal lives. For instance, social networking has minimized the communication gap by helping users connect seamlessly through the cloud. The cloud also facilitates the downloading and updating of various mobile applications and allows people to easily share pictures, videos, files, and product reviews. Moreover, cloud gaming lets users play state-of-the-art online games on low-performance endpoints, such as smartphones. Not only do players have a rich set of online competitors to choose from, but all of the game processing and rendering is performed in the cloud for a real-time gaming experience.

The business sector is overwhelmingly adopting cloud computing. An IBM Institute of Business Value and Economist Intelligence Unit survey of 572 technology and business executives across the globe revealed that around three-fourths of the surveyed companies are using the cloud.[5] Moreover, 90 percent of these surveyed executives are expected to adopt the cloud paradigm within the next three years[5] The benefits offered by cloud computing, such as unlimited resources at nominal prices, are motivating enterprises and research organizations to use the cloud for their computation and data storage requirements. Cloud computing is also being used widely in e-commerce, agriculture, nuclear science, healthcare, smart grids, and scientific applications.[6] For example, pharmaceutical company Eli Lilly executed a complex bioinformatics workload on a 64-machine cluster within a cloud with a price tag of $6.40.[7]

Government agencies are also envisioning the cloud as a cost-effective and unified paradigm. In September 2009, the US government announced the *Federal Government's Cloud Computing Initiative*.[8] The US government spends more than $76 billion annually on IT,[8] an amount it expects to reduce with the adoption of cloud computing. In 2010, Recovery.gov became the first government-wide system to migrate to the public cloud. The system used the Amazon Elastic Compute Cloud (EC2) infrastructure to provide added security. According to a government report, moving Recovery.gov to the cloud saved $334,800 in 2010 and $420,000 in 2011.[8] In collaboration with RightNow solutions, the US Air Force implemented an SaaS-based solution for knowledge management, case tracking, contact center tracking, and customer survey mission needs.[8] The cloud-based system empowered the Air Force to reduce manpower and save around $4 million annually. It also led to an overwhelming increase in queries to the knowledge base to around 2 million per week, raising customer engagement to 70 percent.

The Defense Information Systems Agency (DISA) launched the Forge.mil project to deliver a software development platform for reusing software code. Through Forge.mil, DISA provides the tools and services necessary for rapid development, testing, and deployment of new software and systems to the entire Department of Defense. By using this cloud-based collaborative environment and open development platform, DISA avoided large start-up costs and increased its return on investment (ROI) through software reuse. DISA saves an estimated $200,000 to $500,000 per project using the Forge.mil environment.[8] Moreover, the agency saves $15 million through software reusability and collaborative development.

Open Issues

Round-the-clock service availability is integral to cloud-based organizations. However, these automated systems are error prone. Regardless of safety measures and infrastructure robustness, many organizations have faced failures. In the cloud, downtime and failures have a huge effect. Organizations pay an average of approximately $5,600 per minute of the datacenter downtime.[9] For a datacenter outage having a recovery time of 134 minutes, the average loss is around $680,000.[9]

Data privacy and security are among the foremost concerns pertaining to cloud computing. In addition to malicious threats, cloud providers receive information disclosure requests from government

agencies and courts across the globe. Google received approximately 27,477 requests for user data as of December 2013.[10] US government agencies submitted 10,574 data requests, and Google provided data for 83 percent of them, specifying 18,254 user accounts.[10] Amazon Web Services (AWS) states in its service-level agreement (SLA) that, "AWS reserves the right to refuse service, terminate accounts, remove or edit content in its sole discretion" (https://aws.amazon.com/terms). A UK-based insurance provider claimed to have accessed the medical records of 47 million patients to determine insurance premiums.[11]

However, lawmaking agencies are suggesting various laws and opinions to protect user privacy (see http://epic.org/privacy/cloudcomputing). The Article 29 Working Party, a privacy agency representing European Union countries, states that cloud providers must abide by the "EU Data Protection Directive." In the US, NIST released a draft of the *Guidelines on Security and Privacy in Public Cloud Computing* for public comment. The US federal government is vigilant about establishing security standards to secure cloud environments.[8] Cloud providers are using state-of-the-art security measures to protect and secure user data from unintentional access and use.

Cloud computing is poised to penetrate—and, to a certain extent, has already penetrated (or replaced)—mainstream computing paradigms. We must therefore share as much information as possible about our experiences pertaining to the transition from traditional computing paradigms to the cloud. Such information dissemination will act as a blueprint for academia, industries, governments, and funding agencies to gauge the depth and breadth of cloud-enabled technologies. Moreover, it will help clarify ambiguities pertaining to the definition of cloud computing and related technologies.

I strongly encourage you to consider submissions that highlight various aspects of cloud experiences and adoption. Such write-ups could be deep technical articles, surveys, cloud competitive technology articles, or position papers. Together, as we will learn more about the cloud computing technology, I would encourage you to consider submitting to Cloud Computing magazine to share your experiences with the rest of the scientific and industrial communities.

References

1. P. Mell and T. Grance, "The NIST Definition of Cloud Computing," National Institute of Standards and Technology, NIST Special Publication 800-145, Sep. 2011, http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf.
2. L. Wang et al., "Scientific Cloud Computing: Early Definition and Experience," *Proc. IEEE Int'l High Performance Computing and Comm.* (HPCC 08), vol. 8, 2008, pp. 825–830.
3. I. Foster et al., "Cloud Computing and Grid Computing 360-Degree Compared," *Proc. Grid Computing Environments Workshop* (GCE 08), 2008, pp. 1–10.
4. L. Columbus, "Cloud Computing and Enterprise Software Forecast Update, 2012," *Forbes*, 8 Nov. 2012; www.forbes.com/sites/louiscolumbus/2012/11/08/cloud-computing-and-enterprise-software-forecast-update-2012.
5. IBM Institute of Business Value, *The Power of Cloud: Driving Business Model Innovation*, IBM, 2012.
6. K. Bilal et al., "A Taxonomy and Survey on Green Datacenter Networks," to be published in *Future Generation Computer Systems*, July 2014; http://dx.doi.org/10.1016/j.future.2013.07.006.
7. M. Bockrath, *Cloud Computing and Pharma: A Prescription for Success*, Kelly Outsourcing and Consulting Group, 2011.
8. V. Kundra, *State of Public Sector Cloud Computing*, CIO Council, 2010.
9. "Unplanned IT Outages Cost More Than $5,000 Per Minute: Report," Channel Insider; www.channelinsider.com/c/a/Spotlight/Unplanned-IT-Outages-Cost-More-than-5000-per-Minute-Report-105393.
10. Google, *Transparency Report,* 2014; www.google.com/transparencyreport/userdatarequests.
11. A. Keeley, "The Society Which Used Data on Every NHS Patient—and Used It to Guide Insurance Companies on Premiums," *Daily Mail*, 23 Feb. 2014; www.dailymail.co.uk/news/article-2566397/The-insurance-firms-buy-data-NHS-patient.html#ixzz2uRHBCYib.

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