International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 5 Issue 1, January-2016

Migration and Decision-making in cloud computing environments

Divya Shree

ABSTRACT

Cloud computing now offers organizations more choices regarding how to run infrastructures, save costs, and delegate liabilities to third-party providers. It has become an integral part of technology and business models, and has forced businesses to adapt to new technology strategies. Accordingly, the demand for cloud computing has forced the development of new market offerings, representing various cloud service and delivery models. These models significantly expand the range of available options, and task organizations with dilemmas over which cloud computing model to employ. This paper studied about the available cloud computing models, their use, migration and decision making in cloud computing trends.

Keywords: cloud computing, migration, decision making, environment.

INTRODUCTION

The idea of providing a centralized computing service dates back to the 1960s, when computing services were provided over a network using mainframe time-sharing technology. In 1966, Canadian engineer Douglass Park hill published his book The Challenge of the Computer Utility, in which he describes the idea of computing as a public utility with a centralized computing facility to which many remote users connect over networks. In the 1960s, the mainframe time-sharing mechanism effectively utilized computing resources, and provided acceptable performance to users; however, mainframes were difficult to scale and provision up-front because of increasingly high hardware costs. Accordingly, users didn't have full control over the performance of mainframe applications because it depended on how many users utilized the mainframe at a given moment. As such, with the introduction of personal computers users loved the idea of having full control of their computing resources, even though these resources are not as effectively utilized. With the change in the semiconductor industry, personal computers became affordable, and business abandoned mainframes.

A new challenge was then introduced: how to share the data. Client-server systems were supposed to address this data-sharing challenge by providing centralized data management and processing servers. As business computing needs grew and the Internet became widely adopted, the initially simple client-server architecture transformed into more complex two-tier, three-tier, and four-tier architectures. As a result, the complexity and management costs of IT infrastructure have skyrocketed – even the costs of actual software development in large organizations are typically lower than costs of software and infrastructure maintenance for many enterprises, the long-standing dream has been to background information technology issues and concentrate on core business instead. Although the effect of the cloud computing adoption is yet to be seen, many companies believe that cloud computing may offer feasible alternative model that may reduce costs and complexity while increasing operational efficiency.

Why use Cloud Computing?

Let's consider a few of the most important factors that provide key incentives for organizations to use cloud computing.

Elasticity

The ability to scale computing capacity up or down on-demand is very important. For example, imagine a company that provides software-as-a-service (SaaS) online tax-filling services. Obviously with such a business model, this organization's computing resource demand will peak during tax season – only two to three months each year. Financially, it doesn't make sense to invest up-front knowing that computing infrastructure will remain only partially utilized nine or ten months per year.

Pay-As-You-Grow

Public cloud providers like Amazon allow companies to avoid large up-front infrastructure investment and purchase new computing resources dynamically as needed – companies needn't plan ahead and commit financial resources up-front. This model is particularly feasible for smaller companies and start-ups, which often cannot afford to spend large sums of money at the beginning of their business journey.

In-House Infrastructure Liability and Costs

Running information technology inside the company incurs substantial liability and costs. While some would argue that running infrastructure inside the organization is safer and cheaper, that's not necessarily the case. Depending on a company's IT budget, employee skills, and some other factors, it could worth running infrastructure from a public cloud. Public cloud providers could offer reasonable service-level agreements (SLA) and take care of the liability headaches that company CIOs may face.

RELATED WORK

The related work section will start with a general description of cloud computing together with references to some positioning papers. Next, the reasons for a company to adopt this relatively new paradigm will be described in detail using case studies and best practices. Finally, some frameworks and simulation tools related to the migration of legacy applications to the cloud will be listed. For some years now Cloud Computing has been a promising area for both scientists and professionals. Cloud Computing emerged as a natural evolution of a combination of virtualization, utility computing and distributed computing (Armbrust et al., 2010). Despite the initial mismatch and overabundance of Cloud Computing definitions, an agreement has been reached as to specify Cloud Computing based on the US National Institute of Standards and Technology definition of Cloud Computing (US NIST, 2009). According to their definition, 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.

A system offering a Cloud Computing service should present five essential characteristics; namely, on demand self-service, broad network access, resource pooling, rapid elasticity, and measured service. In literature new Cloud-based service models are presented as everybody strives to offer everything as a Service. Nevertheless, only three service models are commonly accepted, namely Software as a Service, Platform as a Service, and Infrastructure as a Service. Nowadays research institutions tend to build upon the NIST definition striving for standardization (Vaquero, Rodero-Merino, Caceres, & Lindner, 2008) (Vouk, 2008). Some of these surveys base their line of argument on companies' reports which aim at providing a global overview of the opportunities for IT Cloud services (IDC, 2010). Those company reports state how Cloud Computing is an appealing topic not only for academia but for enterprises as well.

Enterprises are attracted by the benefits of migrating to a Cloud-based architecture. However, Cloud Computing not only represents a chance to technically improve modern data centres but it also entails an important change in how services are both provisioned and used (Fox & Griffith, 2009). Therefore, professionals have to consider both the benefits and risks of migrating to a Cloud-based deployment. Moreover, more subtle changes have to be considered as well, such as the organizational changes caused once the responsibilities of the IT department are shifted outside of the organization to external companies, e.g. Amazon (Khajeh-Hosseini, Sommerville, et al., 2010). In literature researchers strive to illustrate the real-life implications of the migration of existing applications to the Cloud by performing case studies with different approaches either technically oriented, more business-oriented or something in between. On the one hand, some take a technical approach on how to tackle the challenges related to the carrying out of the actual migration or the implications for the software architecture of planning the migration of an application. Some authors (Babar & Chauhan, 2011) focus on the analysis of the requirements of the application to be migrated in order to identify the architectural modifications needed to Cloud-enable an existing application.

They state that current architecture evaluation methods do not effectively assess the architecture decisions before their implementation as they do not draw attention to Cloud-related quality features such as scalability and accessibility. Likewise, security aspects have to be borne in mind and integrated in the migration process of legacy systems (Rosado, Gómez, Mellado, & Fernández-Medina, 2012). Due to the fact that each service provider has its own identity management system, a user needs to have multiple digital identities. Therefore, they suggest the use of federated identity management in order to uniquely identify users for each of the services accessed (Seung, Lam, Li, & Woo, 2011). On the other hand, some authors stress the economic and operational implications of including Cloud Computing in an organization, yet ignoring the inherent technical challenges (Marston, Li, Bandyopadhyay, Zhang, & Ghalsasi, 2011). Following this trend, (Hajjat et al., 2010) study how the overall migration cost is the result of a complex combined effect of applications characteristics in terms of workload intensity, storage capacity, growth rate, and the cost of software licenses. They conclude that horizontal partitioning between in-house and Cloud deployments can be very beneficial for certain applications. (Khajeh-Hosseini, Greenwood, & Sommerville, 2010) shows a 37% system infrastructure cost reduction. Moreover, they exemplify the operational implications of the migration as approximately 1 out of 5 support calls for the analyzed system were avoided.

The Cloud Genious framework takes into account a large set of heterogeneous criteria and their interdependencies. However, they apply their framework to single-tiered applications. Therefore, they leave out a lot of current enterprise applications which are more complex than that (Menzel & Ranjan, 2011). A similar approach is taken in Cloudward Bound as (Hajjat et al., 2010) present a modelling technique for the migration of enterprise applications to the Cloud. Nevertheless, they forgot to include the socio-technical implications of the migration. As validation, they evaluate their algorithms in the migration of an ERP system to the Cloud. Cloud Motion (CMotion) is another framework devised to help researchers to solve the issues related to the migration of heterogeneous composite applications. The very nature of these applications, which consist of heterogeneous components noncompliant with any specific interface, hinders the migration process. CMotion effectively addresses this problem whereas it does not incorporate enterprise or government policy support into the decision system (Binz, Leymann, & Schumm, 2011).

Cloud MIG is a framework which automates parts of the migration process, such as the extraction of application requirements, the selection of a Cloud-provider and finally the generation of the target architecture (Frey & Hassel bring, 2010). However, they still have to improve their framework to enable it to evaluate migrated applications. Following the same trend, Cloud Flex focuses on the technical issues related to the migration of a typical three-tiered enterprise application. Cloud Flex uses load balancing to solve problems related to dynamic performance bottlenecks which appear after the migration but disregards the socio-technical effects of the migration (Seung et al., 2011). The different frameworks explained are often validated using ad-hoc validation methods. In an attempt at facilitating these tasks, some researchers have presented their own framework for modeling, simulation, and experimentation.

With the aim of assisting researchers in the evaluation of the performance of Cloud provisioning policies, application workload models and resources performance, there have been some attempts to develop simulators of Cloud Computing architectures. CloudSim (Calheiros et al., 2011) models VM allocation, network and data centre energy consumption but they focus on a lower level of abstraction, the Infrastructure as a service (IaaS) level. On the other hand, the presented approach works on the Software as a Service (SaaS) level.

MIGRATION STRATEGY

With regard to the migration classification, there exist different classification cases in different literature. Binz et al. classified the migration into three types: Standardized Format Migration, Component Format Migration and Holistic Migration. The component implemented in standardized, self-contained format is migrated in Standardized Format Migration such as VMware or Open Virtualization is Format images. The format of the respective component transformed into another format in the second type, for example, transforming a virtual machine image or enabling the execution of scripting languages on PaaS. Holistic migration aims to realize migration to complete application built out of multiple components by migrating each component separately. According to the holistic migration, the authors proposed the cloud motion framework that could leverage existing application models and provide support to migrate composite applications to cloud.

Identified four migration types that could cloud-enable applications by adaptation

The first type replaces components with cloud offerings, which is the least invasive type of migration. The second describes the case that migrates some of the application functionality to the cloud. The third is the classic migration case where the whole software stack of the application is migrated to the cloud. The last is complete migration of the application, which requires the migration of data and business logic for the cloud. While Gartner suggests information technology (IT) organizations consider the following five options when they seek to move legacy systems to the cloud: rehost on infrastructure as a service, refactor for platform as a service, revise for IaaS or PaaS, rebuild on PaaS and replace with software as service. However, Cisco considers three application migration options including SaaS, PaaS and IaaS in white paper for migration of enterprise application to the cloud.

They think the migration to SaaS is no longer an application migration but more of a replacement of the existing application with a SaaS. Migration to PaaS is an option for migrating business applications that are based on standard application server software such as JavaEE or .net platforms. Migration to IaaS involves deploying the application on the cloud service provider s servers. In addition, the criteria that are used for considering every application migration are discussed. Similarly, Solentive software proposed three main approaches for migrating legacy system to the cloud in a white paper, namely Iaas, PaaS and SaaS. The white paper looks at these approaches in detail and analyzes the benefits and disadvantages of each.

Through comparing and analyzing, we can categorize the migration into three strategies integrally: migration to IaaS, migration to PaaS and migration to SaaS. The first strategy implements migration only by porting legacy system to the cloud by using IaaS. The legacy system will be migrated to the cloud by system refactoring according to the platform of PaaS in the second strategy. As to the migration to SaaS, it can be divided into three sub-strategies concretely, namely replacing by SaaS, revising based on SaaS and reengineering to SaaS. To the first sub-strategy, legacy systems will be completely replaced by commercial software delivered as a cloud service. Based on the second sub-strategy, some functionality of legacy systems will be replaced by cloud service. To the third sub-strategy, legacy systems will be reengineered to cloud service. In reality, enterprises often migrate their legacy systems to cloud platform by adopting the first strategy.

To this strategy, the migration is relatively easy to implement and has good cost benefit. But the migration could not take full advantage of cloud platform. To the second strategy, legacy systems need to be adapted according to the target platform, which can bring disadvantages include missing capabilities, transitive risk, and framework lock-in. To the SaaS related strategy, if legacy system is replaced by commercial software delivered as a service, the migration effort will be reduced greatly and reengineering is unnecessary. When replacing some business logic with existing cloud service, the adaption to the legacy system is necessary. But to reengineer legacy system to cloud service, the related work will be very challenging, and may require reverse engineering, structure redesign, service generation, and so on. After comparing and analyzing, we map the migration methods mentioned above to these five specific strategies.

CLOUD ENERGY MANAGEMENT

There are large amount of prior techniques on energy management in cloud data centers. The reduction of energy consumption leads as well to the reduction of operational electricity costs. As was mentioned in the Section 2 the most common idea is automatic load balancing of VM resources using sophisticated scheduling and further replacement between hosts. The section will overview recently proposed state-of-the-art techniques in this field of study.

One example of such energy-aware approach was proposed in by Beloglazov et al. The authors emphasize on huge amount of electrical energy consumed by data centers that leads also to high operational costs and therefore propose a Green Cloud solution that allows not only to minimize operational costs but also to reduce environmental impact. Figure 1 presents four following main entities defined in the paper that involved in a Green Cloud computing infrastructure supported energy-aware resource allocation: Consumers/Brokers, Green Service Allocator, VMs, Physical Machines. Among all parts of a Physical Machine, such as CPU, memory, disk storage and network interfaces, CPU consumes the main part of energy. Additionally, on average an idle host consumes about 70% of the power consumed by the host running at full CPU speed. Therefore the main focus of the work is applied to power consumption and energy usage of physical machines. This approach divides the problem of VM placement in two: selection and admission of newly created VMs and further optimization of their allocation.

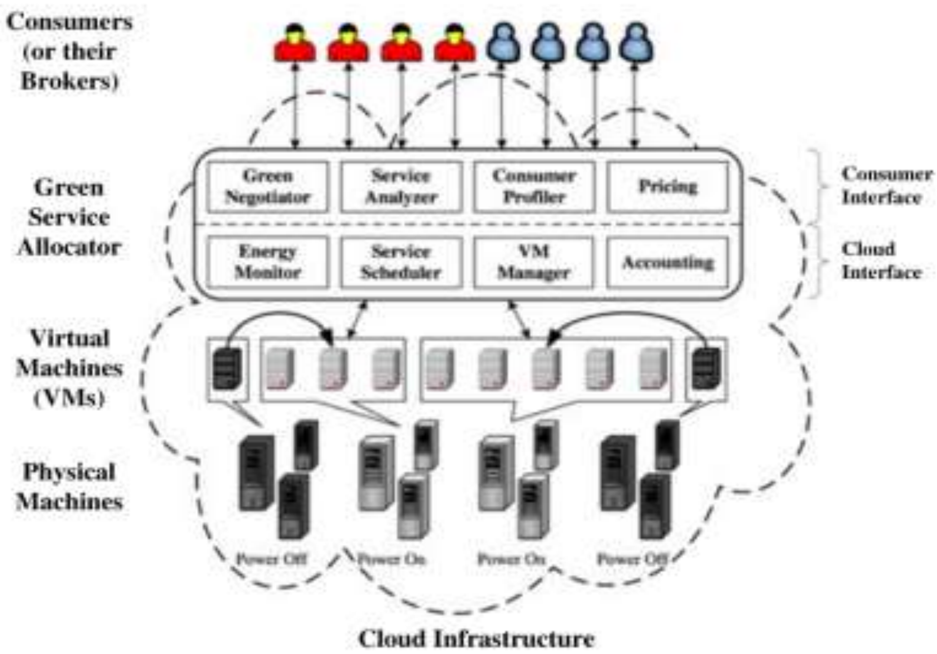

Fig.1: The high-level system architecture of a Cloud infrastructure supported energy-aware resource allocation

The proposed algorithm for the first part is a modification of the Best-Fit-Decreasing (MBFD) algorithm that "sorts all VMs in decreasing order of their current CPU utilizations, and then allocates each VM to a host that provides the least increase of power consumption due to this allocation". Thereby it tries to allocate a VM to the most power-efficient nodes first. The second step, the optimization of the current VM allocation, is performed as follows: first, the approach identifies VMs that should be migrated, second, applies MBFD algorithm to place them to the hosts. The proposed idea of VM selection is to define lower and upper thresholds of host energy utilization and to keep total host utilization between them. For these purposes three following policies were defined.

- The minimization of migrations policy selects the minimum number of VMs that have to be migrated in order to decrease CPU utilization below the upper threshold if it is violated.
- The highest potential growth policy is applied in the case if upper threshold is violated. It migrates VMs with the lowest CPU usage to reduce the potential growth of the power utilization and prevent possible SLA violation.
- The random choice policy defines a random selection of a number of VMS for decreasing of the CPU utilization by a certain host below the upper threshold.

DECISION MAKING USING DATA MINING APPROACH

Time series is a data mining approach to identify any regular pattern of data relative to the past in order to make predictions for future periods. Models for this approach investigate data characterized by a temporal dynamics to predict the value of the target variable for one or more future periods. By this way, the methods based on combinations of predictive models and the general criteria underlying the choice of a forecasting method are quite effective in practice. Association rule is second mining approach to be used when the dataset of interest does not include a target attribute. They derive association rules the aim of which is to identify regular patterns and recurrences within a large set of transactions. Clustering is another mining approach to subdivide the records of a dataset into homogeneous groups of clusters, so that attributes belonging to one group are similar to one another and dissimilar from those contained in other groups. Clustering techniques are therefore able to segment heterogeneous members into a given number of subgroups composed of attributes that share similar characteristics; attributes included in different clusters have distinctive features. Some knowledge should be identified:

- The main features of clustering models;
- The most popular measures of distance between pairs of characters, in relation to the nature of the attributes contained in the dataset;
- Partition methods, in particular focusing on K-means and K-medoids algorithms;
- Agglomerative and divisive hierarchical methods;
- Some indicators of the quality of clustering models;

Majority of enterprises use ERP software to manage daily work. ERP software's databases contain large amount of data which can be provided to business intelligence. Enterprise resource system covers the production, supply chain, customer relations, human resources, finance, office, e-commerce, and all other business processes, the data islands are serious drawbacks, different computing requirements , and the data processes have the burst character, and the reliability requirement, all these required a powerful and reliable data server to guarantee its objective. The cloud computing is such a solution to efficiently overcome the above problems.

Cloud computing platforms provide highly reliable data center architecture, they can achieve load balancing, real-time backup, and remote disaster recovery. By the technical infrastructure support of SaaS (Software-as-a-Service), PaaS (Platform-as-a-Service) or IaaS (Infrastructure-as-a-Service), the large server clusters, high reliability and high availability platform, the cloud computing ERP system can efficiently segment each user's transaction into grain tasks on multiple nodes, which can provide customers with the fastest speed solutions.

CONCLUSIONS

The paper discussed about the requirement of decision support system, then presented a cloud-based infrastructure to solve the above problems, it can not only provide multiple business applications services together, and dynamically adjust the computing availability on demand, but also minimize their capital expenditures. Cloud Computing is a disruptive methodology that is rapidly changing how computing is done. When mass adoption of cloud computing services began in 2005 and 2006, several cloud providers achieved an early market lead. Then the market started to boom around these cloud services, and many companies saw potential and entered the market. Currently, although a few major players lead the market, none of them holds a market lock in terms of technology standards and features. Other mechanisms are rule-based approaches, heuristics, and many more. An interesting project could combine these approaches and try to build a system that can choose an appropriate and good decision-making mechanism especially in the context of addressing trade-offs in Cloud Computing and related environments.

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