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ADAPTIVE TASK FORWARDING FRAMEWORK FOR CLOUDS

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Abstract

Cloud service provider's offers computational services and Virtual Machine (VM) images for information systems. Throughput and cost factors are considered in the service selection process. CloudGenius framework is constructed to handle process migration from web applications into public cloud resources. CloudGenius provides migration support for multi-component web applications. Evolutionary migration process for web application clusters is distributed over multiple locations. A multi-criteria-based selection algorithm on Analytic Hierarchy Process (AHP) is employed in CloudGenius model. Parallel Genetic Algorithm (PGA) is applied to select migration solutions. CumulusGenius is an implementation support for CloudGenius framework. The CloudGenius framework is enhanced to support migration under public and private cloud environment. User selection criteria based migration scheme is integrated with the system. Control flow and data dependency analysis mechanism are integrated with the migration system. Middleware services are adapted to support migration tasks.

1. Introduction

Internet applications have been prosperous in the era of cloud computing, which are usually hosted in virtual machines in geographically distributed data centers. Live migration of Internet applications across data centers is important for different scenarios including load management, power saving, routine server maintenance and quality-of-service [9]. Additionally, Internet applications tend to have dynamically varying workloads that contain long-term variations such as time-of-day effects in different regions. It is desirable to move the interactive/web application to the data center that has better network performance to users for lower response time. Also, workloads can be migrated across different data centers to exploit time-varying electricity pricing. The recent advance of VM live migration techniques is able to relocate a single VM across data centers with acceptable migration cost. Typical Internet applications employ a multi-tier architecture, with each tier providing certain functionality. Specific to multi-tier applications, we need to migrate several tightly-coupled VMs in multi-tiers, instead of a single VM. Previous studies have demonstrated the potential performance penalty of multi-tier applications during migration. In this paper, we investigate whether and how we can reduce the migration cost without suffering application performance degradation.

A typical multi-tier web application consists of three tiers: presentation layer (web tier), business logic layer (App tier) and data access layer (DB tier). Different layers usually run on different VMs and have different memory access patterns. VMs are correlated because only when all VMs of the multi-tiers are migrated to another data center, they can completely and efficiently serve requests in that data center. We call this problem correlated VM migrations. Correlated VM migrations can cause significant performance penalty to multi-tier applications. Consider the following scenario: if the middle tier is first migrated, then the other two tiers must redirect the communication and data access traffic to another data center and wait for the processing results to be sent back. Moreover, because the multi-tier application and migration processes share the same link for data transferring, given the data-intensive nature of multi-tier applications and limited network bandwidth between two data centers, network bandwidth contention may cause significant performance degradation for both applications and VM migrations. While live migration of VMs provides the ability to relocate running VMs from one physical host to another without perceivable service downtime the state-of-theart VM migration techniques mainly target a single VM. These techniques cannot fundamentally solve the correlated VM migrations problem. We need effective and efficient mechanisms to coordinate correlated VM migrations across distributed data centers.

2. Related Work

Over the last years, some works have been intended to evaluate dependability of cloud infrastructures. Wei *et al.* [10] show a hierarchical method based on heterogeneous models, combining RBD and SPN for dependability evaluation of a virtual data center (VDC). In this method, a top-level model based on the RBD defines the VDC infrastructure and a low-level model based on SPN contemplates the components of the VDC in failure and repair state. Dantas *et al.* [1] produce a hierarchical and heterogeneous modeling to depict redundant architectures and compare their availability taking in account computers acquisition costs. In this modeling strategy, a high-level model based on RBD denotes the Eucalyptus platform subsystems and a low-level model based on Markov chains represents the respective subsystems employing warm standby replication. Ram *et al.* [5] investigate the availability of a redundant system through the supplementary variable technique and Laplace transformation.

Other works conceive the cost evaluation of cloud infrastructures. Martens *et al.* [11] show that the analysis of relevant cost types and factors of cloud computing services is an important pillar of decision-making in cloud computing management. In this way, such paper presents a total cost of ownership (TCO) approach for cloud computing services. Li *et al.* provide metrics and equations for calculating the cloud TCO and utilization cost, considering the elastic feature of cloud infrastructure and the adopted virtualization technology. That paper provides a foundation for evaluating economic efficiency of cloud computing and it provides indications for cost optimization of cloud computing infrastructures. Differently from previous studies [2], this paper proposes a modeling strategy based on a hierarchical and heterogeneous modeling for cloud infrastructure planning. This work also provides dependability and cost models for representing cloud infrastructures. The modeling strategy allows the selection of cloud infrastructures according to dependability and cost requirements. This modeling strategy is implemented through the SMG4CIP.

3. Automating the Migration Of Web Application Clusters To Public Clouds

A web application is a computer software application, which interacts with users through a frontend programmed using browser-based language. Web applications are typically accessed by million of users over the internet via a common web browser software.

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Common web applications include webmail, online retail sales, online auctions, wikis and the like.

In the traditional web application hosting model, hardware needs to be provisioned for handling peak load. Uncertain traffic periods and unexpected variations in workload patterns may result in low utilization rates of expensive hardware. Therefore, the traditional approach of provisioning for peak workloads leads to unused or wasted computing cycles when traffic is low. With the advent of cloud computing, it is expected that more and more web applications will be hosted using cloud-based, virtualized services. Cloud computing provides an elastic Information Communication Technology (ICT) infrastructure for the most demanding and dynamic web applications. Clouds provide an infrastructure that can match ICT cost with workload patterns in real-time. Cloud1 service types can be abstracted into three layers: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) [3].

Cloud computing is a disruptive technology and an adoption brings along risks and obstacles. Risks can turn into effective problems or disadvantages for organizations that may decide to move web applications to the cloud. Such a decision depends on many factors, from risks and costs to security issues, service level and QoS expectations. A migration from an organization-owned data center to a cloud infrastructure service implies more than few trivial steps. Steps of a migration to PaaS offerings, such as Google App Engine, would differ in several regards. The following steps outline a migration of an organization's web application to an equivalent on a IaaS such as Amazon Web Services (AWS) EC2, GoGrid, Rackspace and the like.

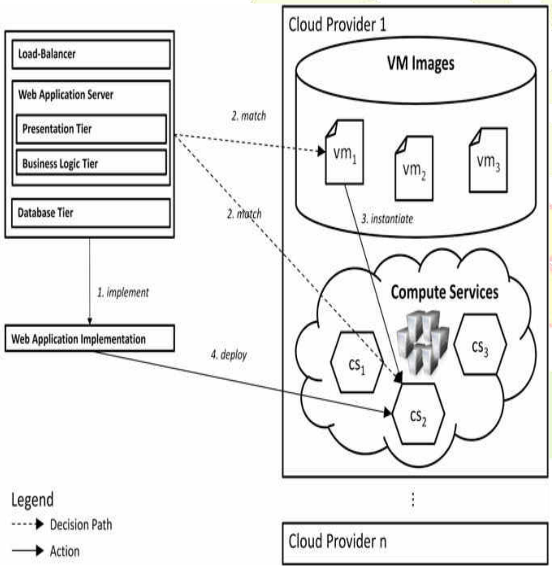

Fig. 3.1. Example of a VM Image (PaaS) and Compute (IaaS) Service Selection.

First, an appropriate cloud infrastructure service, or IaaS offering, is selected. This demands a well-thought decision to be made that considers all relevant factors, such as price, Service Level Agreement (SLA) level, network latency, data center location, availability and support quality. The basis of a selection is data and QoS measurements regarding each factor that describe the quality and make service options comparable. For instance, a low-end

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Compute service of Microsoft Azure is 30 percent more expensive than the comparable AWS EC2 Compute service, but Azure can process application workload twice as quickly.

Second, the existing web application and its execution platform, i.e., a web/application server, a load-balancer, and a database, are transferred from the local data center to the selected cloud infrastructure service. Therefore, the web application and server must be converted into a form expected by a cloud infrastructure service [4]. Typically, in this step, the whole web application is bundled as a VM image that consists of a software stack, from operating system and software platforms to the software containing the business logic. It is often unachievable to convert an existing web application and its server directly to a VM image format compatible with a certain cloud infrastructure service. Therefore, an adequate existing VM image offered by the cloud provider can be chosen and customized. For example, one can select existing VM images provided by bitnami or thecloudmarket.com to cloudify an existing web application system component. Additionally, markets for cloudVM images exist, such as the AWS marketplace [6].

Existing images vary in many aspects, such as underlying operating system, software inside the software stack, or software versions. Therefore, selecting a functionally correct VM image becomes a complex task. Besides, choosing a comprehensive VM image helps to minimize the effort of installing a software stack on a basic image. The resulting VM image should reflect the original application server and at least replace it in a sufficing manner. Next, a migration strategy needs to be defined and applied to make the transition from the local data center to the cloud infrastructure service. A migration strategy defines procedures and the course of action to transition a system and its data to the target state. In case data must be incorporated in the web application migration, all data on the original machine must be transferred to the new system in the cloud. Moreover, all configurations and settings must be applied on the new web server in the cloud to finish creating an appropriate equivalent.

Optimal web application serverQoS in cloud environments demands appropriate configuration for both VM images and cloud infrastructure services. However, no detailed comprehensive cost, as well as performance or feature comparison of cloud services exists. The key problem in mapping web application server components to cloud data centers, as depicted in Fig. 1, is selecting the best collection of VM images and compute services to ensure that a system's QoS targets are met. Furthermore, another challenge is to satisfy conflicting selection criteria related to software and computer services. Additionally, components might be placed at different locations or providers to prevent outages and generate costs for the Internet connectivity.

4. Problem Statement

Cloud service provider's offers computational services and Virtual Machine (VM) images for information systems. Throughput and cost factors are considered in the service selection process. CloudGenius framework is constructed to handle process migration from web applications into public cloud resources. CloudGenius provides migration support for multi-component web applications. Evolutionary migration process for web application clusters is distributed over multiple locations. A multi-criteria-based selection algorithm on Analytic Hierarchy Process (AHP) is employed in CloudGenius model. Parallel Genetic Algorithm (PGA) is applied to select migration solutions. CumulusGenius is an implementation support for CloudGenius framework. The following drawbacks are identified from the existing system.

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- Hybrid cloud architecture is not supported
- Migration cycles delay is high
- Provider Customization is not supported
- Control and data flow dependencies are not considered

5. Adaptive Task Forwarding Framework

Public and private cloud resources are provided for the cloud workloads. Web application tasks are transferred into the cloud environment. Workload migration process is supported to manage resource failures. The system is divided into four major modules. They are Cloud Services, Workload Submission, Scheduling Process and Workload Migration.

The cloud services module is designed to provide cloud resources. Workload submission module is used to submit workloads to the cloud environment. Resource allocation performed under the scheduling process. Fault tolerance is managed under the workload migration process.

5.1. Cloud Services

Cloud services are provided to execute functional components. Service provider allocates the services for the users. Computational and data resources are shared with cloud services. Web applications are constructed with cloud service support.

5.2. Workload Submission

Workloads are submitted by the cloud users. Workloads are initiated with resource and service information. Data requirements are considered in the workload submission process. Workload results are passed to the cloud users.

5.3. Scheduling Process

Service components are assigned in the scheduling process. Cloud resources are provided for the selected service components. CloudGenius middleware handles the scheduling process. Public and private cloud resources are provided under the scheduling process.

5.4. Workload Migration

Resource failures are monitored by the middleware framework. Workload migration is initiated with reference to the fault levels. Deadline factors are also considered in the workload migration process. Data dependency factors are integrated with the workload migration process.

6. Conclusion

Cloud services are deployed to provide resources and service components. CloudGenius framework is adapted to handle workload migration for web applications. CloudGenius is enhanced to support migration under hybrid cloud environment. Component dependency analysis, customization and middleware service integration features are added to the system. The web application migration scheme is adapted for the public and private cloud environment. Control flow and data dependencies are analyzed in the migration process. Customization features are adapted in the CloudGenius framework. Workload performances are increased with minimum cost and time.

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