International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 2 Issue: 4 770 – 773

Cloud Computing: Issues and Challenges

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Abstract-Network bandwidth and hardware technology are developing rapidly, resulting in the vigorous development of the Internet. A new concept, cloud computing, uses low-power hosts to achieve high reliability. The cloud computing, an Internet-based development in which dynamicallyscalable and often virtualized resources are provided as a service over the Internet has become a significant issues. In this paper, we aim to pinpoint the challenges and issues of Cloud computing. We first discuss two related computing paradigms - Service-Oriented Computing and Grid computing, and their relationships with Cloud computing. We then identify several challenges from the Cloud computing adoption perspective. Last, we will highlight the Cloud interoperability issue that deserves substantial further research and development.

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I. INTRODUCTION

Many believe that Cloud is going to reshape the IT industry as a revolution. So, what is Cloud Computing? How is it different from service-oriented computing and Grid computing? What are those general challenges and issues for both cloud providers and consumers?

In answering these questions, we aim to define key research issues and articulate future research challenges and directions for cloud computing. With the huge infrastructure come problems like machines failure, hard drive crashes, software bugs, etc. in some companies like Microsoft,Google etc. This might be a big headache for such a community. Cloud Computing offers a solution to this situation.cloud computing is

"An emerging computer paradigm where data and services reside in massively scalable data centers in the cloud and can be accessed from any connected devices over the internet" A cloud is a virtualized server pool which can provide the different computing resources of their clients.

Characteristics of Cloud Computing

1. Self Healing

In case of failure of the application, there is always a hot backup of the application ready totake over without disruption. There are multiple copies of the same application - each copy updating itself regularly so that at times of failure there is at least one copy of the application which can take over without even the slightest change in its running state.

2. Multi-tenancy

With cloud computing, any application supports multi-tenancy - that is multiple tenants at the same instant of time. The system allows several customers to share the infrastructure allotted to them without any of them being aware of the sharing. This is done by virtualizing the servers on the available machine pool and then allotting the servers to multiple users. This is done in such a way that the privacy of the users or the security of their data is not compromised.

3. Linearly Scalable

Cloud computing services are linearly scalable. The system is able to break down the workloads into pieces and service it across the infrastructure. An exact idea of linear scalability can be obtained from the fact that if one server is able to process say 1000 transactions persecond, then two servers can process 2000 transactions per second.

4. Service-oriented

Cloud computing systems are all service oriented - i.e. the systems are such that they are created out of other discrete services. Many such Cloud Computing discrete services which are independent of each other are combined together to form this service. This allows re-use of the different services that are available and that are being created. Using the services that were just created, other such services can be created.

5. SLA Driven

Cloud computing services are SLA driven such that when the system experiences peaks of load, it will automatically adjustitself so as to comply with the service-level agreements.The services will create additional instances of the applications on more servers so that the load can be easily managed.

6. Virtualized

The applications in cloud computing are fully decoupled from the underlying hardware. The cloud computing environment is a fully virtualized environment.

7. Flexible

Another feature of the cloud computing services is that they are flexible. They can be used to serve a large variety of workload types - varying from small loads of a small consumer application to very heavy loads of a commercial application.In particular, five essential elements of cloud computing are clearly articulated:

On-demand self-service: A consumer with an instantaneous need at a particular timeslot can avail computing resources (such as CPU time, network storage, software use, and so forth)in an automatic (i.e. convenient, self-serve) fashion without resorting to human interactions with providers of these resources.

Broad network access: These computing resources are delivered over the network (e.g. Internet) and used by various client applications with heterogeneous platforms (such as mobile phones, laptops, and PDAs) situated at a consumer's site.

Resource pooling: A cloud service provider's computing resources are 'pooled' together in an effort to serve multipleconsumers using either the multi-tenancyor the virtualizationmodel, "with different physical and virtual resources dynamically assigned and reassigned according to consumer demand". The motivation for setting up such a pool-based computing paradigm lies in two important factors: economiesof scale and specialization. The result of a pool-based model isthat physical computing resources become 'invisible' to consumers, who in general do not have control or knowledge over the location, formation, and originalities of these resources (e.g. database, CPU, etc.) . For example, consumers are not able to tell where their data is going to be stored in the Cloud.

Measured Service: Although computing resources are pooled and shared by multiple consumers (i.e. multi-tenancy), the cloud infrastructure is able to use appropriate mechanisms.to measure the usage of these resources for each individual consumer through its metering capabilities.In addition to these four essential characteristics, the cloud community has extensively used the following three service models to categories the cloud services:

Software as a Service (SaaS):Cloud consumers release their applications on a hosting environment, which can be accessed through networks from various clients (e.g. web browser, PDA, etc.) by application users. Cloud consumers do not have control over the Cloud infrastructure that often employs a multi-tenancy system architecture, namely, differentcloud consumers' applications are organized in a single logical environment on the SaaS cloud to achieve economies of scale and optimization in terms of speed, security, availability, disaster recovery, and maintenance. Examples of SaaS include SalesForce.com, Google Mail, Google Docs, and so forth.

Platform as a Service (PaaS): PaaS is a development platform supporting the full "Software Lifecycle" which allows cloud consumers to develop cloud services and applications (e.g. SaaS) directly on the PaaS cloud. Hence the difference between SaaS and PaaS is that SaaS only hosts completed cloud applications whereas PaaS offers a development platform that hosts both completed and in-progress cloud applications. This requires PaaS, in addition to supporting application hosting environment, to possess development infrastructure including programming environment, tools, configuration management, and so forth. An example of PaaS is Google

AppEngine.

Infrastructure as a Service (IaaS): Cloud consumers directly use IT infrastructures (processing, storage, networks, and other fundamental computing resources) provided in the IaaS cloud. Virtualization is extensively used in IaaS cloud in order to integrate/decompose physical resources in an ad-hoc manner to meet growing or shrinking resource demand from cloud consumers. The basic strategy of virtualization is to set up independent virtual machines (VM) that are isolated from both the underlying hardware and other VMs. Notice that this strategy is different from the multi-tenancy model, which aims to transform the application software architecture so that multiple instances (from multiple cloud consumers) can run on a single application (i.e. the same logic machine). An example of IaaS is Amazon's EC2.

Data storage as a Service (DaaS): The delivery of virtualized storage on demand becomes a separate Cloud service - data storage service. Notice that DaaS could be seen as a special type IaaS. The motivation is that on-premise enterprise database systems are often tied in a prohibitive upfront cost in dedicated server, software license, post-delivery services, and in-house IT maintenance. DaaS allows consumers to pay for what they are actually using rather than the site license for the entire database. Examples of this kind of DaaS include Amazon S3, Google BigTable, and Apache HBase, etc.

Deployment Model

More recently, four cloud deployment models have been defined in the Cloud community:

Private cloud. The cloud infrastructure is operated solelywithin a single organization, and managed by the organization or a third party regardless whether it is located premise or off premise. The motivation to setup a private cloud within an organization has several aspects. First, to maximize and optimize the utilization of existing in-house resources. Second, security concerns including data privacy and trust also make Private Cloud an option for many firms. Third, data transfer cost from local IT infrastructure to a Public Cloud is still rather considerable. Fourth, organizations always require full control over mission-critical activities that reside behind their firewalls. Last, academics often build private cloud for researchand teaching purposes.

Community cloud. Several organizations jointly construct and share the same cloud infrastructure as well as policies, requirements, values, and concerns. The cloud infrastructure could be hosted by a third-party vendor or within one of the organizations in the community.

Public cloud. This is the dominant form of current Cloud computing deployment model. The public cloud is used by the general public cloud consumers and the cloud service providerhas the full ownership of the public cloud with its own policy, value, and profit, costing, and chargingmodel. Many popularcloud services are public clouds including Amazon EC2, S3,Google AppEngine, and Force.com.

Hybrid cloud. The cloud infrastructure is a combination of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability.Organizations use the hybrid cloud model in order to optimize their resources to increase their core competencies by margining out peripheral business functions onto the cloud while controlling core activities on-premise through private cloud. Hybrid cloud has raised the issues of standardization and cloud interoperability that will be discussed in later sections.Interestingly, Amazon Web Services (AWS) has recently rolled out a new type of deployment model - Virtual PrivateCloud (VPC), a secure and seamless bridge between anorganization's existing IT infrastructure and the Amazon public cloud. This is positioned as a mixture between Private Cloud and Public Cloud. It is Public because it still uses computingresources pooled by Amazon for the general public. However, it is virtually private for two reasons. Firstly, the connection between IT legacy and the cloud is secured through a virtualprivate network, thereby having the security advantage of Private Cloud.

II. CLOUD ADOPTION CHALLENGES

As Cloud Computing is still in its infancy, current adoption is associated with numerous challenges. Based on a survey conducted by IDC in 2008.

A. Security

It is clear that the security issue has played the most important role in hindering Cloud computing. Without doubt, putting your data, running your software at someone else's harddisk using someone else's CPU appears daunting to many. Well-known security issues such as data loss, phishing, botnet (running remotely on a collection of machines) pose serious threats to organization's data and software. Moreover, the Simultaneously in order to optimize resources at different levels within an organization. More importantly, proprietary cloud APIs make it very difficult to integrate cloud services with an organization's own existing legacy systems.The scope of interoperability here refers both to the links amongst different clouds and the connection between a cloud and an organization's local systems. The primary goal ofinteroperability is to realize the seamless fluid data across clouds and between cloud and local applications. There are a number of levels that interoperability is essential for cloud computing. First, to optimize the IT asset and computing resources, an organization often needs to keepin-house IT

multi-tenancy model and the pooled computing resources in cloud computing has introduced new security challengesthat require novel techniques to tackle with. For example, hackers are planning to use Cloud to organize botnet as Cloud often provides more reliable infrastructure services at aSource: IDC Enterprise Panel, August 2008 n=244

Availability

The multi-tenancy model has at least created two new\security issues. First, shared resources (hard disk, data, VM) onthe same physical machine invites unexpected side channelsbetween a malicious resource and a regular resource. Second,reputation of many good Cloud "citizens" who happen to,unfortunately, share the computing resources with their fellowtenant - a notorious user with a criminal mind. Since they may share the same network address, any bad conduct will beattributed to all the users without differentiating real subverters from normal users.

B. Costing Model

Cloud consumers must consider the tradeoffs amongst computation, communication, and integration. While migrating to the Cloud can significantly reduce the infrastructure cost, itdoes raise the cost of data communication, i.e. the cost oftransferring an organization's data to and from the public and community Cloud and the cost per unit (e.g. a VM) of computing resource used is likely to be higher. This problem is particularly prominent if the consumer uses the hybrid cloud deployment model where the organization's data is distributed amongst a number of public/private community clouds. The argument made by Gray that "Put the computation near the data" still applies in cloud computing. Intuitively, on-demand computing makes sense only for CPUintensive jobs.

III. CLOUD INTEROPERABIOLITY ISSUE

Currently, each cloud offering has its own way on how cloud clients/applications/users interact with the cloud, leading to the "Hazy Cloud" phenomenon. This severely hindersthe development of cloud ecosystems by forcing vendor lock-in, which prohibits the ability of users to choose from alternative vendors/offering .

assets and capabilities associated with their core competencies while outsourcing marginal functions andactivities (e.g. the human resource system) on to the cloud. Poorinteroperability such as proprietary APIs and overly complex or ambiguous data structures used by a HR cloud SaaS will dramatically increase the integration difficulties, putting the IT department into a difficult situation. Second, more often than not, for the purpose of optimization, an organization may need to outsource a number of marginal functions to cloud services offered by different vendors. For example, it is highly likely that an SME may use Gmail for the email services and

SalesForce.com for the HR service. This means that the many features (e.g. address book, calendar, appointment booking, etc.) in the email system must connect to the HR employee directory residing in the HR system.

SaaS and PaaS Interoperability

While the aforementioned solutions generally tackle with IaaS interoperability problems, few studies have focused on other service deployment models. SaaS interoperability often involves different application domains such as ERP, CRM, etc. A domain that is of particular interest to our research group at DEBII is the data mining research community. In the recent KDD09 panel discussion, a group of experts in the field of data mining raise the issue of establishing a data mining standard on the cloud, with a particular focus on "the practicaluse of statistical algorithms, reliable production deployment of models and the integration of predictive analytics" across different data mining-based SaaS clouds. Promising progress inthis direction is the development of the Predictive Model Markup Language (PMML), a gradually accepted standard that allows users to exchange predictive models among varioussoftware tools. To the best of our knowledge, we have not yet discovered considerable efforts made in providing PaaS interoperability.Since PaaS involves the entire software development lifecycle on the cloud, it would be more difficult to reach the uniformity with regards to the way consumers develop and deploy cloud applications.

Standard

Standardization appears to be a good solution to address the interoperability issue. However, as cloud computing just starts to take off, the interoperability problem has not appeared on thepressing agenda of major industry cloud vendors. For example, neither Microsoft nor Amazon supports the Unified CloudInterface(UCI) Project proposed by the Cloud Computing Interoperability Forum (CCIF) [13]. The standardization process will be very difficult to progress when these big players do not come forward to reach consensus. A widely used cloud

API within the academia is the Eucalyptus project [14], which mirrors the well-known proprietary Amazon EC2 API for cloud operation. Although an Eucalyptus IaaS cloud consumercan easily connect to the EC2 cloud without substantial redevelopment, it cannot solve the general interoperability issue that requires an open API complied with by different types ofCloud providers.

CONSLUSION

This paper discussed the challenges and issues of Cloud computing. We articulated the relationships amongst Cloud computing, Service-Oriented Computing, and Grid computing.We analyzed a few challenges on the way towards adopting Cloud computing. The interoperability issue was highlighted and a number of solutions are discussed thereafter for different cloud service deployment models.

IV. AKNOWLEDGEMENT

I am thankful to all the teachers and principal sir for their valuable guidance. I would like to thank Prof. Karuna Bagde, whose knowledgeable guidance helped me to make this paper more descriptive. At last I would like to thank my parents and friends for their support.

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