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CLOUD COMPUTING: STATE-OF-THE-ART AND RESEARCH CHALLENGES

I.Umamaheswara Rao*[1], B.Durga Sri[2] & K.Nirosha[3]
[*1]Department of Computer Science and Engineering, St. Martin's Engineering College
[2&3]Department of Information Technology, MLR Institute of Technology

ABSTRACT

Cloud computing in recent times emerged as a latest standard for hosting and delivering services over the Internet. Cloud computing is eye-catching to big business owners as it eliminates the necessity for users to plan in advance for provisioning, and allows enterprises to establish from the initial stage and increase resources only when there is a grow in service demand. On the other hand, in spite of the reality that cloud computing offers very huge opportunities to the IT industry, the growth in cloud computing technology is presently at its early years, with many research issues still to be addressed. In this paper, we present cloud computing, highlighting its key concepts, architectural principles, and research challenges. The aim of this paper is to present a better understanding of the design challenges of cloud computing and recognize essential research directions in this increasingly significant area.

Keywords: *Cloud computing, Big Data, Classification, Knowledge*

I. INTRODUCTION

With the fast development of storage and processing technologies and the accomplishment of the Internet, computing resources have turn into cheaper, more authoritative and more ubiquitously accessible than ever before. This hi-tech trend has enabled the awareness of a novel computing model called cloud computing, in which resources like CPU and storage are provided as wide-ranging utilities that can be leased and released by users through the Internet on-demand approach. In a cloud computing environment, the conventional role of service contributor is separated into two: the infrastructure providers who handle cloud platforms and let resources according to a usage-based pricing model, and service providers, who lease resources from single or numerous infrastructure providers to serve the end users. The emergence of cloud computing has made a marvelous bang on the Information Technology (IT) engineering over the earlier period , where many companies such as Google, Amazon and Microsoft struggle to provide further authoritative, consistent and cost-efficient cloud platforms, and business enterprises exploration to restructure their business models to increase benefit from this innovative paradigm. Definitely, cloud computing provides quite a lot of compelling features that make it striking to business owners, as shown below.

No up-front asset: Cloud computing uses a pay-as you-go pricing model. A service provider does not need to provide in the infrastructure to set up gaining profit from cloud computing. It simply rents resources from the cloud according to its own necessities and pay for the convention.

Lowering operating cost: Resources in a cloud environment can be quickly allocated and de-allocated on insist. Hence, a service provider no longer wants stipulation capacities according to the max out load. This provides enormous savings since resources can be unrestricted to save on operating costs when service order is low.

Highly scalable: Infrastructure providers puddle huge amount of resources from data centers and make them simply available. A service provider can effortlessly spread out its service to large scales in order to handle quick raise in service demands (e.g., flash-crowd effect). This model is also occasionally called as surge computing

Easy access: Services hosted in the cloud are normally web-based. Therefore, they are simply reachable through a selection of devices with Internet connections. These devices not only consist of desktop and laptop computers, but also cell phones and PDAs.

Reducing business risks and maintenance cost: By outsourcing the service infrastructure to the clouds, a service provider shifts its business risks such as hardware failures to infrastructure providers, who often have enhanced

knowledge and are improved set for organization these risks. In addition, a service provider can slice down the hardware maintenance cost and the workers training costs.

On the other hand, although cloud computing has exposed significant opportunities to the IT production company, it also brings a lot of exceptional challenges that need to be carefully addressed. In this paper, we present cloud computing, highlighting its key concepts, architectural principles, state-of-the-art implementations as well as research challenges. Our aim is to offer a superior perceptive of the design challenges of cloud computing and identify significant research directions in this interesting topic. The rest of this paper is structured as follows. In Sect. 2 we provide an overview of cloud computing and compare it with other related technologies. In Sect. 3, we illustrate the cloud computing architecture and present its design principles. The key features and characteristics of cloud computing are exhaustive in Sect. 4. Section 5 Research challenges for cloud computing.. At last, the paper concludes in Sect. 6.

II. OVERVIEW OF CLOUD COMPUTING AND A COMPARISON WITH RELATED CONCEPTS

Definition

The word "cloud" has also been used in diverse contexts such as recitation large ATM networks in the 1990s. However, it was after Google's CEO Eric Schmidt used the word to explain the big business model of providing services across the Internet in 2006, that the term actually in progress to gain recognition. The word cloud computing has been used in general as a marketing term in a diversity of context to characterize various extraordinary ideas. Definitely, the lack of a regular definition of cloud computing has generated not only market hypes, but also a large amount of disbelief and uncertainty. For this cause, recently there has been work on standardizing the definition of cloud computing. As an example, the work in [49] compared over 20 different definitions from a diversity of sources to verify a standard definition. In this paper, we adopt the definition of cloud computing given by The National Institute of Standards and Technology (NIST) [36], as it covers, in our view, all the necessary aspects of cloud computing: NIST defines Cloud computing is a model for enabling well-situated, on-demand network access to a common pool of configurable computing resources for e.g., networks, servers, storage, applications, and services, that can be quickly provisioned and unconfined with minimal administration effort or service provider communication. The most important reason for the survival of different perceptions of cloud computing is that cloud computing, unlike other technical terms, is not a latest technology, but rather a new-fangled operational model that brings together a set of existing technologies to run business in a special way. Indeed, the majority of the technologies used by cloud computing, such as virtualization and utility-based pricing, are not novel. The Related technologies of Cloud computing is frequently compared to the subsequent technologies, each one of which shares definite aspects with cloud computing:

Grid Computing: It is a distributed computing pattern that coordinates networked resources to attain a ordinary computational objective. The growth of Grid computing was initially driven by scientific applications which are typically computation-intensive. Cloud computing is similar to Grid computing in that it also employs dispersed resources to accomplish application-level objectives. Conversely, cloud computing takes one step advance by leveraging technologies like virtualization at several levels to understand resource allocation and dynamic resource provisioning.

Utility Computing: It represents the form of providing resources on-demand and changing users based on procedure rather than a horizontal rate. Cloud computing can be supposed as a awareness of utility computing. It adopts a utility-based pricing scheme totally for financial reasons. With on-demand resource provisioning and convenience based pricing, service providers can actually maximize resource utilization and minimize their working costs.

Virtualization: It is a technology that briefs the particulars of substantial hardware and provides virtualized resources for high-level applications. A virtualized server is frequently called a virtual machine (VM). Virtualization forms the base of cloud computing, as it provides the capacity of pooling computing resources from group of servers and vigorously assigning or reassigning effective resources to applications on-demand.

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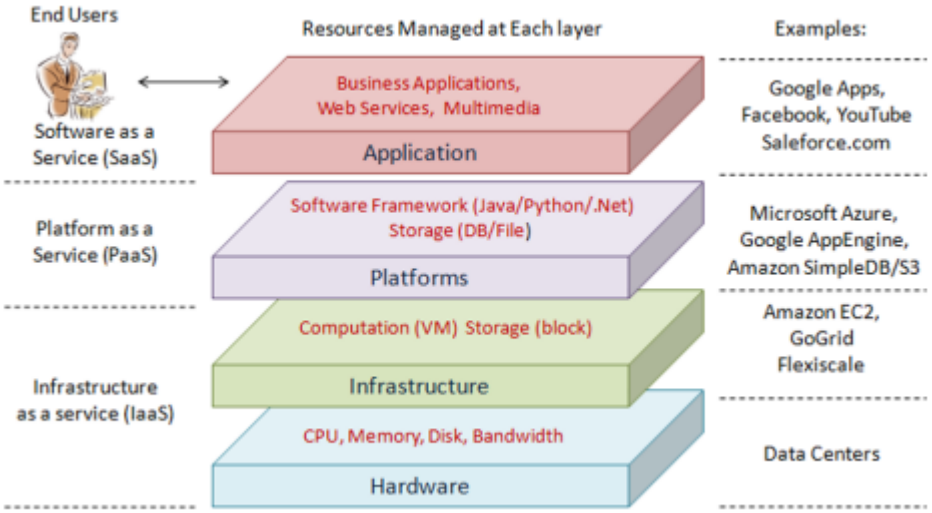
Autonomic Computing: Initially coined by IBM in 2001, autonomic computing goal is to build computing systems accomplished of self-management, i.e. which reacts to internal and external annotations without individual interference. The aim of autonomic computing is to conquer the management difficulty of present computer systems. Even though cloud computing exhibits definite autonomic features such as automatic resource provisioning, its main purpose is to decrease the resource expenditure rather than to reduce system difficulty.

In summing up, cloud computing leverages virtualization technology to accomplish the objective of providing computing resources as a service. It shares definite aspects with grid computing and autonomic computing which differs from them in other aspects. Therefore, it offers exclusive profit and imposes typical challenges to meet its necessities.

III. CLOUD COMPUTING ARCHITECTURE

In general the Cloud computing architecture of a cloud computing environment can be divided into 4 layers: the hardware/datacenter layer, the infrastructure layer, the platform layer and the application layer, as shown in Fig. 1. We describe each of them in detail



The hardware layer: This layer is chargeable for managing the physical resources of the cloud, together with physical servers, routers, switches, power and cooling systems. In observe, the hardware layer is often enforced in information centers. a knowledge center sometimes contains thousands of servers that square measure organized in racks and interconnected through switches, routers or alternative materials. Typical problems at hardware layer embrace hardware configuration, fault tolerance, traffic management, power and cooling resource management.

The infrastructure layer: It is also known as the virtualization layer, the infrastructure layer creates a pool of storage and computing resources by partitioning the physical resources using virtualization technologies like Xen [55], KVM [30] and VMware [52]. This layer is an necessary module of cloud computing, since various key features, such as dynamic resource assignment, are only made accessible through virtualization technologies. The platform layer: This layer builts on top of the infrastructure layer, it consists of operating systems and application frameworks. The function of the this layer is to reduce the trouble of deploying applications straight into VM containers. For example, Google App Engine operates at the platform layer to grant API support for implementing storage, database and business logic of representative web applications.

The application layer: The application layer is at the highest level of the hierarchy, it consists of the actual cloud applications. which is different from conventional applications, cloud applications can leverage the automatic-scaling quality to attain enhanced performance, accessibility and lower operating cost.

Business model

Cloud computing employs a service-driven business model. In other words, hardware and platform-level resources are provided as services on an on-demand bases. Theoretically, each and every layer of the architecture described in the earlier segment can be implemented as a service to the layer beyond. On the other hand, every layer can be supposed as a client of the layer lower. However, in practice, clouds offer services that can be grouped into three types: software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS)

1. Infrastructure as a Service: This service refers to on-demand provisioning of infrastructural resources, typically in
   provisions of VMs. The cloud vendor who offers IaaS is called an IaaS provider
2. Platform as a Service: This service refers for providing platform layer resources, together with operating system
   support and software development frameworks.
3. Software as a Service: This service refers for providing on-demand applications over the Internet.

Types of clouds

There are numerous issues to consider when moving an venture application to the cloud environment. For example, some service providers are typically involved in lower operation cost, while others may prefer high consistency and safety. Accordingly, there are different types of clouds, each with its own advantages and disadvantages:

Public clouds*:* A cloud in which service providers offer their resources as services to the common public. Public clouds offer numerous key benefits to service providers, including no early capital asset on infrastructure and shifting of risks to infrastructure providers. However, public clouds lack fine-grained control over data, network and security settings, which hampers their efficiency in many business scenarios.

Private clouds*:* It is also known as internal clouds, private clouds are designed for exclusive use by a single organization. It may be built and managed by the organization or by external providers. It offers the maximum degree of control over performance, reliability and security. However, they are often criticized for being parallel to conventional proprietary server farms and do not provide benefits such as no up-front capital costs.

Hybrid clouds*:* A hybrid cloud is a mixture of public and private cloud models that tries to address the limitations of each approach. In a hybrid cloud, part of the service infrastructure runs in private clouds while the remaining part runs in public clouds. It offer more elasticity than Previous two clouds. Exclusively, they offer tighter control and security over application data compared to public clouds, while still facilitating on-demand service development and tightening. On the down side, designing a it requires suspiciously determining the greatest divide between public and private cloud mechanism.

Virtual Private Cloud*:* An substitute solution to addressing the restrictions of both public and private clouds is called Virtual Private Cloud (VPC). A VPC is basically a platform running on top of public clouds. The major divergence is that a VPC leverages virtual private network (VPN) technology that allows service providers to design their own topology and security settings such as firewall rules. VPC is fundamentally a further holistic design since it not only virtualizes servers and applications, but also the original communication network as well. Additionally, for most companies, VPC provides faultless transition from a proprietary service infrastructure to a cloud-based infrastructure, owing to the virtualized network layer.

IV. CLOUD COMPUTING CHARACTERISTICS

Cloud computing provides numerous significant features that are unlike from conventional service computing, which we summarize below:

Multi-tenancy: In a cloud environment, services owned by many providers are co-located in a single data center. The presentation and management issues of these services are common among service providers and the infrastructure provider. The layered architecture of cloud computing provides a natural separation of tasks: the owner of each layer only needs to focus on the specific objectives associated with this layer. However, multi-

tenancy also introduces difficulties in understanding and managing the communications among different stakeholders.

Shared resource pooling: The infrastructure provider offers a pool of computing resources that can be vigorously assigned to various resource clients. Such active resource project capacity provides much elasticity to infrastructure providers for managing their own resource usage and operating costs. For example, an IaaS provider can leverage VM migration technology to attain a high degree of server consolidation, hence maximizing resource consumption while minimizing price such as power consumption and cooling.

Geo-distribution and ubiquitous network access: Clouds are usually easy to get through the Internet and use the Internet as a service release network. Hence several devices with Internet connectivity, like a mobile phone, a PDA or a laptop, is able to access cloud services. Furthermore, to achieve high network performance and localization, various clouds currently consist of data centers situated at various locations around the world. A service provider can effortlessly leverage geo-diversity to accomplish greatest service utility.

Service oriented: As mentioned earlier, cloud computing adopts a service-driven in service model. Hence it places a well-built prominence on service management. In a cloud, all service provider offers its service according to the Service Level Agreement (SLA) negotiated with its clients. SLA guarantees therefore a significant purpose of all providers.

Dynamic resource provisioning: The most important features of cloud computing is that computing resources can be obtained and freed on the fly. Compared to the conventional model that necessities resources according to hit the highest point demands, dynamic resource provisioning allows service providers to obtain assets based on the present demand, which can significantly lower the in service cost.

Utility-based pricing: Cloud computing employs a paper-use pricing model. The accurate pricing scheme may differ from service to service. For instance, a SaaS provider may lease a virtual machine from an IaaS provider on a per-hour basis. On the other hand, a SaaS provider that provides on-demand customer relationship management (CRM) may charge its customers based on the number of clients it serves (e.g., Salesforce). It lowers service in service cost as it charges clients on a per-use basis. However, it also introduces complexities in scheming the in service cost

V. RESEARCH CHALLENGES

Even though cloud computing has been broadly adopted by the industry, the research on cloud computing is still at an initial stage. A lot of accessible issues have not been entirely addressed, while latest challenges keep rising from industry applications. In the following section, we summarize various challenging research issues in cloud computing.

Automated service provisioning:
The important features of cloud computing is the capacity of acquiring and releasing resources on-demand. The purpose of a service provider in this case is to assign and de-allocate resources from the cloud to assure its service level objectives (SLOs), while minimizing its equipped cost. However, it is not noticeable how a service provider can attain this purpose. In particular, it is not simple to decide how to plan SLOs such as QoS requirements to low-level resource requirement such as CPU and memory requirements. Moreover, to attain high liveliness and respond to quick demand fluctuations such as in flash swarm effect, the resource provisioning decisions must be made online

Virtual machine migration:
Virtualization can provide considerable benefits in cloud computing by enabling virtual machine relocation to stability load across the data center. In addition, virtual machine relocation enables vigorous and extremely receptive provisioning in data centers. The main benefits of VM migration is to keep away from hotspots; yet, this is not uncomplicated. At present, detecting workload hotspots and initiating a relocation lacks the ability to take action to sudden workload changes. Moreover, the in memory state should be transferred time after time and efficiently, with included deliberation of resources for applications and physical servers.

Server consolidation:
It is an efficient approach to maximize resource consumption while minimizing energy utilization in a cloud computing environment. Live VM migration technology is frequently worn to combine VMs residing on several under-utilized servers onto a solitary server, so that the remaining servers can be placed to an energy-saving state. The problem of optimally consolidating servers in a data center is often formulated as a modification of the vector bin-packing problem [11], which is an NP-hard optimization problem

Energy management
Improving energy effectiveness is a different main issue in cloud computing. It has been estimated that the price of powering and cooling accounts for 53% of the total prepared costs of data centers [26]. In 2006, data centers in the US addicted more than 1.5% of the whole energy generated in that year, and the percentage is expected to grow 18% yearly [33]. Hence infrastructure providers are under huge stress to decrease energy utilization. The aim is not only to cut down energy expenditure in data centers, but also to meet government policy and environmental principles.

Traffic management and analysis
Analysis of data traffic is significant for present data centers. For example, numerous web applications rely on analysis of traffic data to optimize client experiences. Network operators also need to know how traffic flows all the way through the network in order to make various management and planning decisions. On the other hand, there are numerous challenges for accessible traffic quantity and analysis methods in Internet Service Providers (ISPs) networks and venture to extend to data. Initially, the thickness of links is much superior than that in ISPs or enterprise networks, which makes the most terrible case situation for accessible methods. Secondly, most accessible methods can calculate traffic matrices between a few hundred end hosts, but even a modular data center can have several thousand servers. Finally, accessible methods frequently suppose some flow patterns that are sensible in Internet and enterprises networks, but the applications deployed on data centers, such as Map Reduce jobs, considerably alter the traffic pattern. Further, there is tighter coupling in application's use of network, computing, and storage resources, than what is seen in other settings.

VI. CONCLUSION

Cloud computing has recently emerged as a compelling standard for organization and delivering services over the Internet. The increase of cloud computing is quickly changing the landscape of information technology, and eventually spinning the long-held promise of utility computing into a actuality. However, despite the important benefits offered by cloud computing, the existing technologies are not developed sufficient to realize its full potential. Many key challenges in this domain, including automatic resource provisioning, power management and security management, are only preliminary to obtain attention from the research community. Therefore, we consider there is still fabulous opening for researchers to make innovative contributions in this field, and bring important impact to their development in the industry. In this paper, we have covered its necessary concepts, architectural designs, famous characteristics, important technologies as well as research directions. As the development of cloud computing technology is still at an premature stage, we expect our work will provide a enhanced understanding of the design challenges of cloud computing, and pave the way for additional research in this area.

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