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Exploring Cloud Computing

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Abstract: *Cloud computing has reached maturity since Amazon introduced the pioneering cloud services in 2006. Hong Kong, with its vast daily data processing needs across various sectors, is poised to embrace cloud services extensively, despite a gradual uptake initially. Cloud computing now dominates research agendas in computer science due to its profound implications across multiple computing sectors, particularly in managing big data, where it's indispensable. The establishment of a major cloud R&D centre in Hong Kong by Lenovo in January 2015 underscores this trend.*

Cloud computing, fulfilling the long-standing vision of computing as a utility, possesses the capability to revolutionize a significant portion of the IT industry. It enhances the attractiveness of software as a service and influences the design and procurement of IT hardware. For developers with innovative ideas for new Internet services, the need for substantial capital investment in hardware deployment or ongoing operational expenses is eliminated. Concerns about overprovisioning, which wastes resources, or under provisioning, which can lead to missed opportunities, are alleviated. Additionally, companies with extensive batch-oriented tasks can achieve results at unprecedented speeds, as the scalability of programs allows for efficient utilization of resources without incurring additional costs. This elasticity of resources, where utilizing 1,000 servers for one hour costs the same as using one server for 1,000 hours, represents a significant departure from traditional IT models.

Keywords: Cloud computing, Amazon Web Services (AWS), Data processing, big data

I. INTRODUCTION

In the 1960s, Joseph Carl Robnett Licklider pioneered the concept of cloud computing through his contributions to ARPANET, aiming to enable seamless interaction between individuals and data regardless of location or time constraints. By 1983, CompuServe introduced a novel feature, offering its users a modest allocation of disk space for storing files of their choice, marking a step towards the realization of Licklider's vision.

In simple terms, cloud computing involves providing computing services over the internet, encompassing servers, databases, networking, storage, software, analytics, and intelligence. It offers advantages like faster innovation, flexible resources, and economies of scale. Cloud computing differs from traditional on-premises data centers by delivering these services remotely via the internet.

Another major benefit of cloud computing is the mobility it offers, catering to both individual users and businesses alike. Many people are already familiar with various cloud computing services such as Google Docs and email platforms. Some of the most widely used cloud computing products include AWS Elastic Compute, Google Cloud Engine, and AWS Lambda.

Among the leading cloud computing services are Amazon Web Services, Google Cloud Platform, and Microsoft Azure. Cloud computing offers flexibility, particularly suited for businesses with fluctuating or growing bandwidth needs. Scaling up your cloud capacity in response to increased requirements is straightforward, as it involves tapping into the resources of the service's remote servers.

Accessibility:

Cloud computing streamlines access to applications and data from anywhere globally, using any internet-connected device.

Cost efficiency:

Cloud computing provides businesses with readily available computing resources, thus reducing costs associated with acquisition and maintenance. Examples of cloud computing include Dropbox, Facebook and Gmail, which can be utilized for file storage, as well as applications in banking and financial services.

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Consumers entrust their financial information to cloud computing service providers across various sectors such as healthcare, education, government, big data analytics, communication, and business processes. Cloud computing offers three primary distribution models: public, private, and hybrid clouds, allowing businesses to choose the most suitable option based on their specific needs.

Cloud computing encompasses both the delivery of applications as services over the internet and the underlying hardware and system software housed in data centres to support these services. These services are often categorized as Software as a Service (SaaS). While some vendors use terms like Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) to describe their offerings, we avoid these distinctions due to the lack of universally accepted definitions. The distinction between "low-level" infrastructure and a "higher-level" platform is not always clear-cut, and we consider them to be more similar than different, analysing them collectively. Additionally, the term "grid computing" from the high-performance computing community refers to protocols for sharing computation and storage over long distances but did not result in a software environment that extended beyond its original community.

There are three particularly compelling scenarios where utility computing offers advantages over traditional hosting. First, when demand for a service fluctuates over time, such as the need to provision a data centre for peak loads experienced only a few days per month, cloud computing enables companies to pay for computing resources on an hourly basis. This approach can result in cost savings, even if the hourly rate for renting from a cloud provider is higher than the cost of owning a machine. Second, utility computing is beneficial when demand is unpredictable. For instance, a web startup may experience sudden spikes in traffic as it gains popularity, followed by periods of reduced activity. Lastly, businesses engaged in batch analytics can leverage the cost efficiency of cloud computing to complete computations more quickly. For example, using 1,000 EC2 machines for one hour costs the same as using a single machine for 1,000 hours, offering flexibility and cost effectiveness.

Although the economic appeal of cloud computing is often described as "shifting capital expenses to operating expenses" (CapEx to OpEx), we believe the term "pay as you go" more accurately captures the buyer's economic advantage. With cloud computing, hours purchased can be used non-uniformly over time, allowing for flexible distribution (e.g., using 100 server-hours today and none tomorrow, yet still paying only for 100). This approach to selling bandwidth is known as usage-based pricing in the networking community. Moreover, the absence of upfront capital expenses enables capital to be redirected towards core business investments. Therefore, even if Amazon's pay-as-you-go pricing appears more expensive compared to purchasing and depreciating a similar server over the same period, we argue that the cost is outweighed by the significant economic advantages of cloud computing, such as elasticity and risk transfer. These advantages mitigate the risks associated with overprovisioning (underutilization) and under provisioning (saturation).

Let's begin with the concept of elasticity. A critical aspect of cloud computing is its ability to add or remove resources with precision, such as adding or removing servers individually with EC2, and doing so within minutes rather than weeks. This capability allows for a much closer alignment of resources with workload demands. Real-world data suggests that typical server utilization in data centres ranges from 5% to 20%. While this may seem surprisingly low, it reflects the fact that peak workloads for many services can exceed the average by factors of 2 to 10. As most user's provision for the expected peak, resources often remain idle during non-peak times, leading to significant waste, especially with larger variations in workload.

For a simplified example, consider a hypothetical website with two user classes: active users (regular visitors) and defectors (those who abandon the site due to poor performance). Suppose that 10% of active users who experience poor service become permanent defectors. Initially, the site is provisioned to handle an expected peak of 400,000 users (1,000 users per server × 400 servers). However, unexpected positive publicity drives 500,000 users to the site in the first hour. Of the 100,000 users who are turned away or experience poor service, according to our assumption, 10,000 become permanent defectors. This leaves an active user base of 390,000. In the following hour, an additional 250,000 unique users access the site.

From a perspective of hardware provisioning and pricing, cloud computing introduces three significant aspects:

1. The availability of unlimited computing resources on demand, capable of rapidly scaling to accommodate load surges. This eliminates the need for users to extensively plan for resource provisioning.

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2. The elimination of upfront commitments by cloud users, allowing companies to start with minimal resources and scale up only as needed.
3. The ability to pay for computing resources on a short-term basis as required (e.g., processors by the hour, storage by the day), and release them when no longer needed, promoting resource conservation.

For those deploying software in the cloud, adaptability is crucial. This entails efficiently managing resources to ensure smooth operation as user numbers increase. It involves handling numerous concurrent requests and coordinating information from various sources, which may not all be within the same organization's control.

On the other end of the cloud computing spectrum, the browser-based user interface presents its own challenges. Replicating the intricate functionality of traditional operating systems within a web browser environment is complex. Moreover, developers face limitations in available programming languages, code libraries, and application frameworks compared to desktop application development.

Moving applications to the cloud also entails mastering multiple languages and operating environments. Backend processes often rely on relational databases, leading to code written in SQL or other query languages. Client-side logic is typically executed in JavaScript embedded within HTML documents, while server-side applications may use scripting languages like PHP, Java, or Python. Data exchange between layers often involves encoding in various XML formats.

Despite the shift towards remote computing, which may seem reminiscent of the 1980s "liberation" movement that granted individual users control over programs and data, control doesn't necessarily revert entirely to corporate IT managers.

Cloud computing poses a significant competitive challenge to vendors of shrink-wrap software as it becomes more successful. Ironically, the open-source movement may also struggle to adapt to this new computing model. While creating and distributing open-source software to compete with traditional applications like Microsoft Word is feasible, it is less clear how a consortium of volunteers could develop a web service to rival Google Docs.

Public Cloud:

A public cloud environment, managed by an outsourced provider, is accessible to multiple businesses over the internet on a pay-per-use basis. This model offers cost savings on IT operational expenses, with the cloud provider responsible for resource provisioning and security. Public clouds are typically suited for small to medium-sized businesses with limited budgets, offering easy scalability, cost-effectiveness, reliability, and ease of management. However, they may not be the safest option for sensitive data.

Private Cloud:

In contrast, a private cloud is a customized infrastructure maintained by a single business, offering a dedicated environment where access to IT resources is centralized within the organization. While private clouds provide enhanced security and control, they require significant expertise and investment. Hybrid Cloud:

For businesses seeking benefits from both private and public cloud models, a hybrid cloud environment combines the two, offering a tailored IT solution that meets specific business needs. Hybrid clouds provide high flexibility, cost-effectiveness, and enhanced security, though network communication challenges may arise.

Cloud Services:

The three main service models of cloud computing are Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). Each model offers unique features in terms of storage, foundation building, and collaboration, allowing businesses to leverage different aspects of cloud computing based on their requirements.

Infrastructure as a Service (IaaS):

This service model offers virtual servers, networking, operating systems, and storage drives, providing flexibility, reliability, and scalability without the need for on-premises hardware. It is suitable for small to medium-sized businesses looking for a cost-effective IT solution and is available in public, private, or hybrid configurations.

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In cloud computing, a provider manages both the infrastructure and the software framework, allowing businesses to scale and deploy their own applications rapidly and efficiently. Platform as a Service (PaaS) enables web applications to be developed quickly and easily, making it suitable for environments with multiple developers working on a single project or were leveraging an existing database, such as a CRM tool, is necessary.

Software as a Service (SaaS) delivers software over the internet to multiple businesses through subscription or pay-per-use models. It is particularly useful for applications requiring extensive web or mobile functionality, such as mobile sales organization software, as it eliminates the need for businesses to maintain the software themselves and is ideal for short-term projects.

Advantages of Cloud Computing:

1. Backup and data recovery: Data stored in the cloud can be easily backed up and recovered.
2. Enhanced collaboration: Cloud applications facilitate collaboration by enabling teams to share information easily via shared storage.
3. Increased accessibility: Cloud computing allows for quick and easy access to stored data from anywhere in the world with an internet connection, boosting productivity and efficiency.
4. Reduced maintenance costs: Cloud computing reduces both hardware and software maintenance costs for organizations.
5. Mobility: Cloud computing enables access to cloud data via mobile devices.
6. Unlimited storage capacity: Cloud computing offers vast storage capacity for storing various types of data in one location.
7. Data security: Cloud computing provides advanced security features to ensure that data is securely stored and accessed.

Disadvantages of Cloud Computing:

1. Internet connectivity: Accessing data stored in the cloud requires a stable internet connection.
2. Vendor lock-in: Switching between cloud providers may be challenging due to differences in platforms.
3. Limited control: Cloud infrastructure is managed by the provider, limiting the user's control over the platform and services.
4. Security risks: While cloud service providers implement stringent security measures, there is a risk of data breaches or unauthorized access.

Scope of Cloud Computing:

The potential of cloud computing is promising, with the market expected to grow rapidly. In India, the cloud computing market is currently valued at around $2 billion and is projected to grow at an annual rate of 30%.

By 2024, the cloud computing market in India is expected to reach $8 billion and create a significant number of jobs in the country. Roles specific to this field, such as Cloud Operations Engineer, Cloud Architect, Cloud Solution Architect, and Cloud Software Developer, are in high demand according to reports.

II. CONCLUSION

Cloud computing represents the beginning of a new era in the field of information and communication technology, introducing a development paradigm with the potential to revolutionize computing practices. While users are still becoming acquainted with this technology, a gradual shift from traditional computing to cloud computing is anticipated. Thanks to this technology, developers with innovative ideas for internet services will no longer need to invest large sums of money in building their own infrastructure and tools.

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