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CHALLENGES IN THE CLOUD COMPUTING MODEL OF RESOURCE MANAGEMENT ISSUES SUCH AS SERVICE LEVEL AGREEMENTS AND SERVICES MODEL

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Abstract
Cloud computing has recently emerged as a new model for hosting and delivering services over the internet. Cloud computing has many advantages, such as the ability to increase capacity or add capabilities without the need to invest in new infrastructure. It can also fulfill technological requirements in a fast and automated manner. In recent years, cloud computing has changed the IT industry; in fact, it is one of the industry's fastest growing phenomena. However, as more information about people and businesses becomes available in the cloud, concerns about the safety of this environment will increase. In addition, some challenges to the use of this service exist. This paper presents the results of a survey about cloud computing and outlines the main concepts of the technology along with examples of appropriate usage. It also discusses resource management issues such as service level agreements and highlights the challenges faced by users when choosing cloud computing services.

Keywords: Cloud Computing, Service Level Agreements, and Services Model

Introduction
Cloud computing comprises the provision of services, such as shared resources, software, and on-demand information, over the internet. The U.S. National Institute of Standards and Technology (NIST) defines it as a 'model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources, such as networks, servers, storage, applications, and services, that can be fast provisioned and released with minimal management effort or service provider interaction [1]. McKinsey suggests that 'using clouds for computing tasks promises a revolution in IT similar to the birth of the web and e-commerce [2].

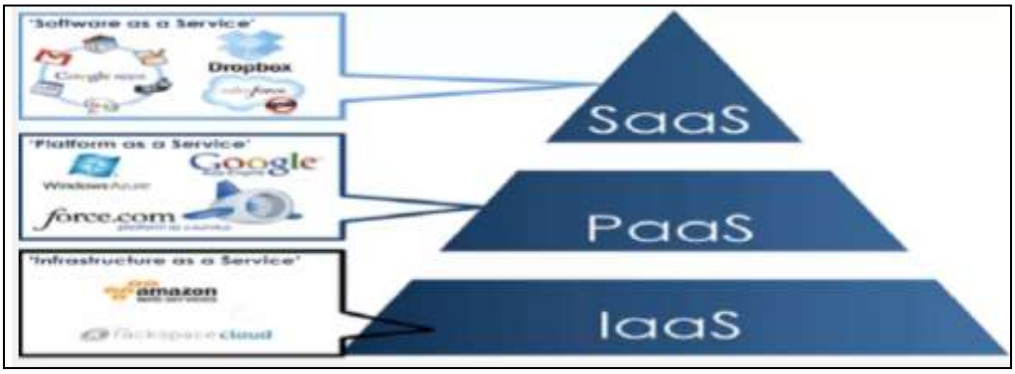

Figure 1. Cloud Computing Services [3]

The worldwide growth of spending on cloud computing services emphasises the significance of the technology and reflects its increased prominence in the field of IT. Nowadays, enterprises are reshaping their business models to benefit from cloud computing and to reduce costs. In addition, decreased operational costs allow for increased innovation. Cloud computing not only reduces the number of employees needed but also provides

other features that make it attractive to business owners [3]. For example, cloud computing uses a pay-as-you-go pricing model, so it requires no up-front investment. Service providers do not need to invest in infrastructure to benefit from cloud computing. In addition, cloud computing lowers operating costs. Resources in a cloud environment can be rapidly allocated and de-allocated on demand, so service providers no longer need to provision capacities according to peak load. This provides great savings since resources can be released to save on operating costs when service demand is low [3].

Related work

The work of Samaher Al-Janabi and Ibrahim Al-Shourbaji [4] is a useful guide to the challenges related to mobile cloud computing. The main issues related to cloud computing on mobile devices include application partitioning and offloading as well as data integrity, service transformation, security, and privacy.

V.K. Saxena and Shashank Pushkar [5] have discussed the concept of cloud computing and the methods available for its implementation. Jingjing Wang et al. [6] have proposed a cloud-based unmanned aerial vehicle (UAV) system. This technology has been widely applied in both military and civilian applications. The cloud-based UAV system would remove computing and data storage from the vehicles and utilise the cloud to process data from the UAVs' sensors and to maintain the stable operation of multi-UAV systems. The necessary resources would be developed as web services. However, UAVs have computational services and physical elements that are affected by the real-world environment.

Mariem Jelassi et al. [7] have presented a survey on quality of service (QoS) in cloud computing and the mechanisms and methods used to guarantee QoS in cloud computing services.

Introduction to cloud computing

Since the emergence of the term cloud computing, academics and major IT companies have defined it differently, each approaching the definition from a different angle [8]. Nevertheless, at the core of cloud computing are the connectivity techniques that provide services and applications for business, scientific, and individual use.

Cloud computing can be defined in several ways: Cloud services are shared services that are under virtualised management and are accessible over the internet [9]. Cloud computing is pay-per-use, self-service technology that is delivered over the internet and has standardised capabilities regarding services, software, and infrastructure [10].

Cloud computing is the delivery of computing services over the internet. Cloud services allow individuals and businesses to use software and hardware that are managed by third parties at remote locations (OPC) [9].

With cloud computing, massively scalable IT-related capabilities are provided "as a service" via the internet to multiple external customers [11].As defined by the NIST, the cloud computing model encompasses the process of enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources, such as networks, servers, storage, applications, and services, which can be rapidly provisioned and released with minimal management effort or service provider interaction [1].

Deployment Models

There are three common cloud deployment models (private, public, and hybrid) as well as the community cloud model, which is less common.

Public Cloud
The public cloud is available to anyone wishing to take advantage of its online services. Users can access its resources anywhere. Applications employed in general-purpose computing include Dropbox and Google Drive. These services are provided to users for free, although increased storage must be paid for [12, 13].

Private Cloud
The private cloud is built within a single organisation. It is managed by either the organisation itself or another company specialising in the field of cloud computing [12, 13]

Hybrid Cloud
A hybrid cloud is a merger of two clouds (e.g., a public cloud and a private cloud) that remain unique entities but act together to provide computing resources to the end users [12, 13].

Community Cloud
A community cloud allows several organisations with similar requirements to share common infrastructure. Costs are shared by fewer users than with a public cloud but more users than with a single organisation's private cloud. Figure 2 presents an example of a community cloud shared by several universities [12,14].

Services Model
Service delivery in cloud computing comprises three basic service models, namely infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS), and software-as-a-service (SaaS). Each service model provides layers that are complemented in differing degrees by the end user's layers. The model is presented in Figure 2 [12].

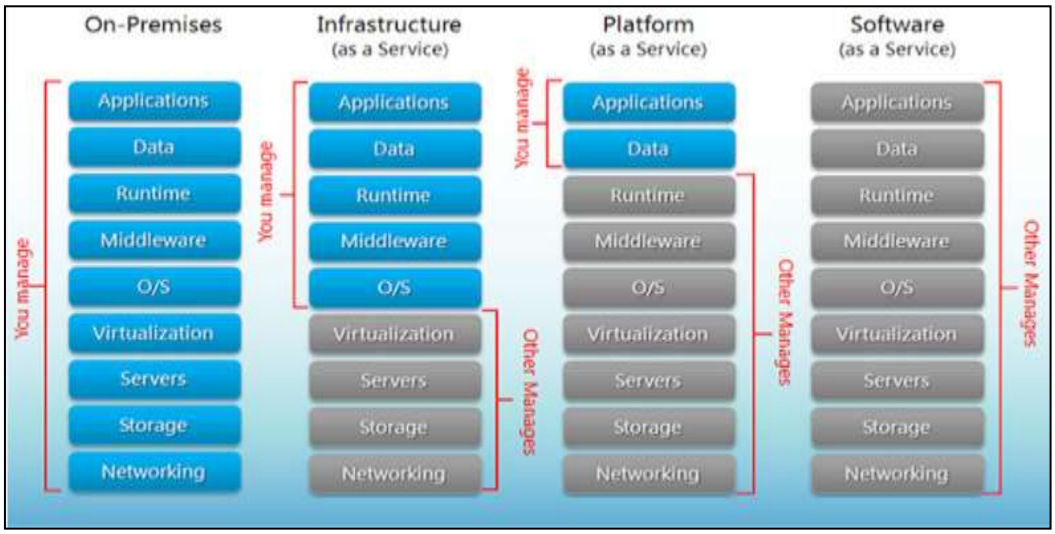

Figure 2. The Architecture of Cloud Services [12]

Software as a service (SaaS)
In the SaaS software distribution model, applications are hosted by the vendor or service provider and made available to customers over a network, typically the internet. The provider delivers software based on a set of common code and data definitions that is consumed in a one-to-many model: all contracted customers can access the service at any time on a pay-per-use basis or via a subscription based on usage metrics[12,15].

Platform as a Service (PaaS)
Platform-as-a-service is defined as a way to rent hardware, operating systems, storage, and network capacity over the internet. The service delivery model allows the customer to rent virtualized servers and associated services for running existing applications or developing and testing new ones. It is a platform for the creation of software, delivered over the web [16].

Infrastructure as a service (IaaS)
Infrastructure-as-a-service is a standardized, highly automated offering, where an organization outsources the equipment used to support operations, including storage, hardware, servers, and networking components, and offers the service to customers on demand. Customers are able to supervise this infrastructure using a web-based interface. An infrastructure API could also be provided as an option [12].

Advantages and Disadvantages of cloud computing
This section starts with the many advantages offered by cloud computing [17].

Advantages
- Lower infrastructure and software costs for users
- Less maintenance of software programs needed
- Software updates and latest versions always available
- Storage capacity availability
- Increased data safety
- Increased computing power
- Improved compatibility between operating systems
- User access to documents from anywhere
- Payment according to users' needs.

Disadvantages
- This approach requires a constant internet connection.
- It does not work well with low-speed connections.
- Stored data might not be secure.
- There is a lack of control over operations and development.
- There is limited integration with other applications and systems.
- A lack of standards can create problems when relocating data to a new supplier or regarding the interactions between different clouds.

Challenges
The adoption of cloud computing technology faces various challenges because some users are sceptical about its abilities. A survey found numerous challenges related to cloud computing, which are outlined in this chapter.

Security
Security is an important factor in whether users accept cloud computing solutions; storing data and running software on a remote hard disk and CPU intimidate many users. Security issues such as data loss, phishing, and boot net can threaten an organisation's data and software. Moreover, the multi-tenancy model and the practice of pooling computing resources in cloud computing have introduced new security challenges that require novel techniques to mitigate. For example, hackers can use the cloud to create boot net, since the cloud often provides reliable infrastructure services at a relatively low price [18].

The Costing Model
When choosing whether to migrate to the cloud, consumers must consider trade-offs in computation, communication, and integration. Although this change can significantly reduce infrastructure costs (i.e., the costs of transferring an organisation's data to and from public and community clouds), the cost per unit of

computing is likely to be higher. This problem is intensified if the consumer uses the hybrid cloud deployment model. In general, on-demand computing can only be justified for CPU-intensive jobs [19].

Service Level Agreements

To fulfil the quickly changing enterprise requirements of cloud computing, existing data centre resource management systems must be enhanced to support service level agreement-orientated (SLA-orientated) resource allocation and to realise cloud and utility computing. No work has been done to integrate customer-driven service management, computational risk management, and autonomic resource management into a market-based resource management system. Resource management issues such as SLAs must be involved in software delivery, since delivering software and services to users via data centres is more complex than distributing software to users to run on their personal computers [20].

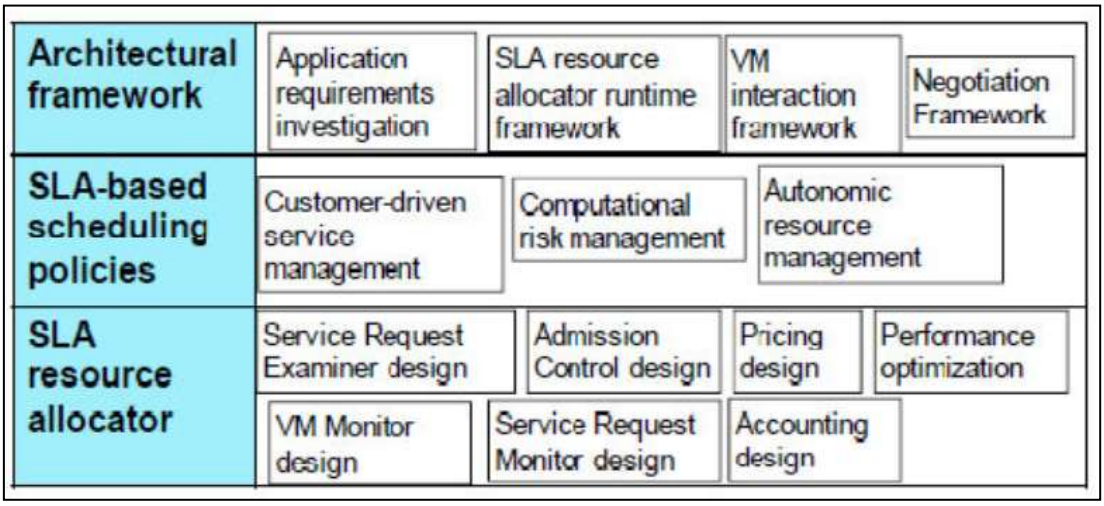

Figure 3: Challenges in SLA-Based Resource Allocation [20]

However, Aneka proposed that Rajkumar Buyya act as a market-orientated cloud platform that allows building and scheduling of applications, provisioning and monitoring of resources with facilities such as pricing, accounting, and QoS and SLA services in private and public cloud environments [20].

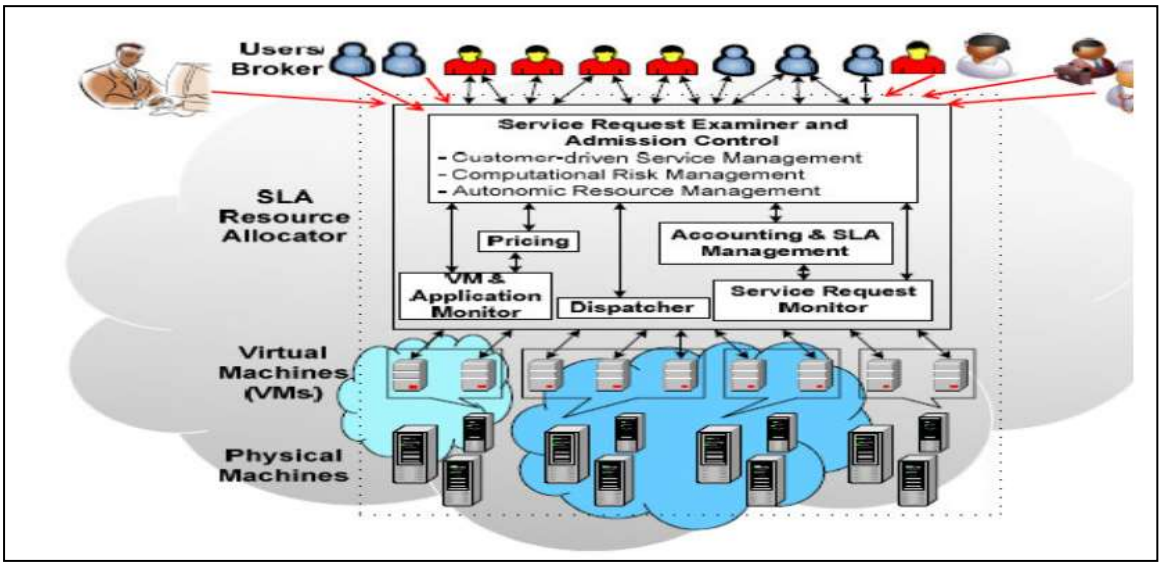

Figure 4. High-Level System Architectural Framework [20]

External Users and Brokers
Users interact with cloud management systems through automatic systems such as brokers who submit users' service requests to the cloud to be processed. An SLA resource allocator is the interface between the cloud computing infrastructure and external users and brokers. It requires the communication of several mechanisms to support SLA-orientated resource management [20].

Service Request Examiner and Admission Control Mechanism
A user's service request is first reviewed by the service request examiner and admission control mechanism, which makes a determination based on QoS requirements whether to accept the request. This mechanism ensures that no SLA violations occur. It connects with both the virtual machine (VM) monitor mechanism (to receive the latest status information concerning resource availability) and the service request monitor mechanism (to assess workload processing). It then assigns requests to VMs and determines resource authorisations for allocated VMs [20].

Autonomic Resource Management
Autonomic resource management is a key mechanism that ensures that cloud providers can serve large numbers of requests without violating SLA terms. It dynamically manages resources by using VM migration and integration [20].

Pricing
The pricing mechanism manages service orders in the cloud. Its goal is to maximise profits for the cloud provider. Requests can be charged based on submission time (peak or off-peak), pricing rates (fixed or changing), or the availability of resources (supply and demand)[20].

VM and Application Monitor
Depending on the services provided, resource management systems must track the performance and status of resources at different levels. The VM monitor mechanism keeps track of the availability of VMs and of their resource entitlements. Cloud providers sometimes offer the same services at different pricing models and QoS levels (posted pricing and spot market)[20].

Dispatcher
The dispatcher deploys the application on a suitable virtual resource. It also takes responsibility for creating VM images and initiating them on selected physical hosts [20].

Service Request Monitor
The service request monitor tracks the progress of the execution of service requests [20].

VMs
Multiple VMs can be started and stopped dynamically to meet accepted service requests [20].

Physical Machines
Data centres contain multiple computing servers that provide resources to meet service demands.
In other words, it is vital for consumers to obtain guarantees from providers on service delivery. The very first issue is the definition of SLA specifications in such a way that has an appropriate level of granularity, namely the trade-offs between expressiveness and complicatedness, so that they can cover most of the consumer expectations and is relatively simple to be weighted, verified, evaluated, and enforced by the resource allocation mechanism in the cloud. In addition, different cloud offerings (IaaS, PaaS, and SaaS) will need to define different SLA met specifications. This also raises a number of implementation problems for the cloud providers. Furthermore, advanced SLA mechanisms need to constantly incorporate user feedback and customisation features into the SLA evaluation framework [20].

Cloud Interoperability Issues
Currently, users interact with the cloud differently in each type of cloud system, which leads to the hazy cloud phenomenon. This impedes the development of cloud ecosystems by forcing vendor locking, which prohibits users who wish to optimise different resources at different levels within an organisation from choosing from alternative vendors simultaneously. More importantly, the use of proprietary cloud APIs hinders the integration of cloud services with an organisation's existing systems. The primary goal of interoperability is to realise the seamless flow of data across clouds and between a cloud and local applications. Interoperability is essential for cloud computing at many levels. First, organisations often need to retain in-house IT assets and capabilities relating to core competencies while outsourcing marginal functions and activities (e.g., the human resources system) to the cloud to optimise resources. Second, organisations may need to outsource some marginal functions to different vendors offering cloud services. Standardisation can address the interoperability issue. However, as cloud computing increases in popularity, the interoperability problem is not being addressed by major industry cloud vendors [21].

Acceptance of Change
In addition, some organisations are not yet ready to accept changes or are very slow to implement these changes. In such cases the support of top management is necessary to implement the required changes [23].

Data Portability and integration
It can be difficult to integrate data stored in a company's internal data centre with data located in the cloud. Organisations employing the hybrid cloud model, where data are spread across both private and public clouds, may face data integration problems and security issues related to data governance and network connectivity. These problems may involve the inability to support transactions across clouds (transaction integrity), difficulties in handling large data volumes, a lack of mechanisms to detect changes to data, data quality control issues, and the inability to determine the origins of data [22].

Performance
Most cloud provider SLA agreements cover only infrastructure availability, not performance. If customer applications have specific performance-related requirements, the customer must generally discuss the requirements with the provider and confirm that they can be met. It is standard practice to negotiate the SLA contact with the cloud service provider and to include performance-related requirements in the contract. It is

generally the responsibility of the customer to monitor cloud performance and ensure that it is compliant with requirements and SLAs, which is usually done by performing a continuous performance metrics analysis. If cloud-hosted applications are used globally, it is important to monitor performance parameters such as network latency across all major customer locations [22].

Most of the obstacles to the adoption and growth of cloud computing are related to basic performance aspects, such as availability, performance, capacity, or scalability. Table 2 presents details relating to obstacles and opportunities.

Conclusion

Information technology companies and academic researchers offer different definitions of cloud computing, with individuals defining cloud computing from different angles. Cloud computing is more than the internet; it is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources, such as networks, servers, storage, applications, and services. Moreover, cloud computing offers benefits for organisations and individuals. However, there are also privacy and security concerns. When considering a cloud service, users should think about how their personal information and that of their customers can best be protected. Users should carefully review the terms of service or contracts and challenge the provider to meet their needs. For organisations looking to move to cloud computing, it is important to understand the different aspects of the technology and to decide which solutions are appropriate for their unique needs. Since cloud computing is not always an appropriate solution, users should study and evaluate its requirements before adopting this technology.

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