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Exploring the Cloudscape - A Comprehensive Roadmap for Transforming IT Infrastructure from On-Premises to Cloud-Based Solutions

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ABSTRACT

Thanks to rapid advancements in ICT, cloud computing has made great strides. It provides companies a pay-per-use pricing strategy, minimizing upfront investments in the up-front charge and only paying for resources actually used. So all the important IT Functions like storage, servers, operating systems, and software applications are handed over to third-party providers, which means due to this complex structure, decision making is a strategic decision to maximize the benefit from Cloud Services. The Right service provider, Deployment model and service type have their respective significance in driving cloud solutions and aligning with business goals. The paper discusses several benefits of cloud computing, various deployment techniques, service models, migration techniques, tools, and the role of Software-Defined Networking (SDN) in cloud computing to improve cloud computing.

INTRODUCTION

Cloud migration involves transferring local applications, data, and infrastructure to cloud-based environments [1]. The cloud offers computing resources on demand, eliminating the need for active management by users who can store software, hardware, and network services remotely. This shift reduces reliance on ICT helpdesks for routine tasks, minimizes wait times, and ensures services are available 24/7 through on-demand self-service models [2]. Additionally, some cloud services automate software updates and upgrades, enhancing accessibility and convenience for users accessing platform services [2].

Cloud computing offers numerous benefits and features, including:

- On-Demand Self-Service Model: Users can access computing resources independently without intervention from the cloud provider, as long as they have an internet connection. Certain applications may even function offline, providing additional storage and database access. The exception occurs during maintenance downtime when services are temporarily unavailable [2]. Public clouds typically schedule maintenance downtime, whereas in private clouds, users can manage upgrade and maintenance cycles to prevent outages and monitor systems proactively [3]. Despite occasional downtime, cloud technology significantly enhances operational efficiency in commercial settings, such as online business platforms and global companies managing diverse time zones. It facilitates continuous operations, enhances productivity, and fosters collaboration among employees and international partners. This capability became particularly crucial during the Covid-19 pandemic, enabling seamless remote work scenarios where data sharing and updates occur effortlessly through cloud platforms [3].

Cloud computing's extensive network access facilitates global information sharing through cloud services. This capability, bolstered by cloud network bandwidth and low latency, optimizes time-sensitive manufacturing applications, enhancing operational efficiency. Such data-sharing mobility extends to mobile phones and home laptops, enabling remote work—a trend amplified post-Covid-19. This flexibility benefits international businesses, fostering seamless data exchange among employees worldwide and integrating data to reduce recording errors [4].

Data Security and Backup

Cloud computing addresses security concerns prevalent in traditional ICT infrastructures, where manual handling of databases can lead to human errors, data loss, or vulnerability to hackers. Cloud solutions automatically create backups stored on separate servers, preventing data loss. While this necessitates trust in service providers, it ensures robust data management and security protocols [4].

Choice of Public/Private Data

Cloud computing resolves the dichotomy of public versus private data storage. Unlike traditional ICT setups, where data visibility hinges on institutional access, the cloud's multi-tenancy supports hybrid

storage models. This allows users to securely share applications without revealing identities, akin to tenants in a shared condominium. Community clouds further enhance collaboration by pooling resources and expertise [5].

Optimized Resource Sharing and Allocation

Cloud computing optimizes resource allocation by dynamically adjusting CPU and memory usage across departments. Resource pools are managed independently, ensuring efficient utilization without affecting unrelated pools. Service Level Agreements (SLAs) guarantee Quality of Service (QoS), enhancing operational reliability [6].

IMPACT OF CLOUD COMPUTING ON INDUSTRIES

Cloud computing has had a transformative effect on various industries, revolutionizing the way businesses operate, collaborate, and deliver services. Cloud services have enabled organizations to streamline processes, improve efficiency, and drive innovation. In this section, we will discuss the impact of cloud computing on some key industries.

Information Technology (IT) Industry

The IT industry has been significantly impacted by cloud computing. Cloud services have provided IT companies with scalable and cost-effective infrastructure resources, enabling them to develop, test, and deploy applications more efficiently. Cloud platforms have also facilitated the growth of software-as-a-service (SaaS) providers, allowing them to deliver applications directly to end-users without complex installations or maintenance. The IT industry has also seen the rise of cloud-based development tools and collaboration platforms, enabling remote teams to work together seamlessly.

Healthcare Industry

Cloud computing has transformed healthcare by providing secure and efficient storage, sharing, and medical data analysis. Cloud-based electronic health record (EHR) systems have improved patient care by making medical records accessible to healthcare providers across different locations. Cloud platforms also facilitate the processing and analysis of large volumes of medical data, enabling advanced research, personalized medicine, and predictive analytics. Additionally, cloud computing has facilitated telemedicine and remote patient monitoring, allowing healthcare services to be delivered to patients in their homes.

Financial Services Industry

Cloud computing provides numerous advantages to financial services organizations. With their large capacity, cloud services have enabled financial institutions to reliably store and process these massive amounts of data. Financial modelling and risk analysis is faster and more accurate with cloud-based solutions. They have also enabled the creation of new financial technology (FinTech) solutions (mobile phone banking apps, peer-to-peer borrowing services, digital payment systems, etc.). These innovations offered by cloud computing greatly benefit financial institutions in the aspects of customer experience, operational efficiency, and cost reduction.

Education Industry

Cloud computing has transformed the education sector by allowing distance education, collaboration, and access to learning materials for students. It is important to note that the rapid development of various cloud-based learning management systems (LMS) has made it possible for educational institutions to provide online courses and virtual classrooms, thus reaching a wider audience of students around the world. Therefore can it be say that cloud platforms not only helped in storage & sharing educational content but also allowed collaboration between the teacher and student in any place. Moreover, the administrative aspects of educational institutions — from student information to admissions and online assessments — have also benefited from cloud solutions.

Manufacturing Industry

Data is training until 2023 October. Cloud-based enterprise resource planning (ERP) systems have improved the overall efficiency of manufacturing operations and workflows through real-time visibility into inventory, production, and distribution processes. Manufacturers have de-risked the supply lines with cloud platforms to collaborate with suppliers for sustainable solutions. Moreover, cloud facilities have also opened up opportunities for manufacturers to make use of IoT (Internet of Things) technologies in terms of predictive maintenance, remote monitoring, and data-informed decision-making.

Retail Industry

Retail organizations have embraced cloud computing to offer personalized and omnichannel shopping experiences to their customers. E-commerce solutions in the cloud allow retailers to build and operate an online store-up to a global customer base and cope with peak traffic load by scaling on-the-fly. By adopting cloud solutions, retailers are also able to harness data analytics and customer relationship management (CRM) tools to gain insights into customer behaviour and preferences, allowing for targeted marketing campaigns and personalized recommendations. With cloud computing, tracking of inventory and optimization of supply chains have

become easier, allowing for seamless integration between the two as well as physical and online stores. Just a few examples of how cloud computing makes a difference in the industries respective. Introduction Cloud services have revolutionized the way organizations develop applications and innovate, improve efficiency, reduce costs, and provide better services to their customers. Cloud computing has transformed the landscape upon which industries operate, enabling digital transformation and a more connected and productive society.

MEETING CHANGING BUSINESS NEEDS

Rapid elasticity in cloud computing meets the dynamic needs of businesses through its scalability. It allows customers to quickly scale resources down or up without requiring them to have unnecessary infrastructure in place. Flexible management of resources minimizes operational disruptions from under- or over-provisioning, optimizing cost-efficiency [7].

That is, cloud computing elevates global interconnectivity and data security, while providing previously unimaginable flexibility in how human resources are managed, and paves the way for the emergence of the concept of human cloud, making cloud computing an essential enabling technology for modern enterprises striving to realize the concept of human cloud and to meet the demands of tomorrow's rapidly changing business environments [8, 9].

CLOUD COMPUTING SERVICE MODELS

Cloud computing is a set of different types of computing offerings (Url) that vary by user needs, changing (Url) the delivery, management, and use of the computing environment. (2023) These models are essential for understanding how cloud technology has developed and the impact it has had on digital societies.

Because of this, they are often referred to as "clouds".

There are three main service models for cloud computing, varying in the degree of control and management available to users:

Infrastructure as a Service (IaaS)

Well, IaaS is the fundamental service in cloud computing, as it provides virtualized computing resources over the Internet. Example of IaaS: Users can control infrastructure components like virtual machines, storage, and networking. They control these resources, adding more as required; the users hold responsibility for the OS, middleware, and applications.

Platform as a Service (PaaS)

PaaS: PaaS gives a full stage to Create and convey Applications These are infrastructure resources, development tools, middleware, and runtime environments. Users target application development while the platform takes care of scalability and security. All of this including the underlying infrastructure, OS, and the runtime stack is fully managed by PaaS providers.

Software as a Service (SaaS)

SaaS delivers fully functional applications over the internet. Users access these applications without needing installation or maintenance. SaaS providers manage hardware, software, and data storage, offering applications via web browsers or thin clients. Users have limited customization but benefit from accessibility and usability from any device.

CLOUD COMPUTING DEPLOYMENT MODELS

Cloud computing also provides diverse deployment models that determine how resources are provisioned and shared:

Public Cloud:

Public cloud resources are owned and maintained by a cloud service provider, accessible to the public via the Internet. Users get scale, cost efficiency, and on demand use of systems—without needing to make large investments upfront. Such examples are AWS, Azure, and Google Cloud.

Private Cloud:

Private cloud resources, on the other hand, are dedicated to a single organization, which allows for greater security and control. These can be hosted on-premise or in a third-party provider, suitable for organizations that have special compliance or data sovereignty needs.

Advantages of Private Cloud over Other Cloud Deployment Models

Maintenance & System Logs Management

The biggest benefit of a private cloud solution is control. When a business owns a private cloud, it has control over all the infrastructure that makes up its cloud computing environment, unlike public clouds where users have no control over critical details like audit logs and maintenance schedules. This enables timely maintenance and upgrades of the system when needed without constraints that limits access to audit logs [26].

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Geographical Access

Compared to public clouds, private clouds guarantee geographical access and are stable for employees in various locations. While public cloud providers offer predefined availability zones across international boundaries, businesses using a private cloud can configure their infrastructure to suit each of their office locations' unique compliance requirements. This ensures uniform and compliant access to resources [25].

Enhanced Security & Privacy

In private cloud environment security and privacy are greatly improved. How private clouds grant full control over access rights and data streaming by saving all data in the organization's infrastructure. This reduces the chances of data breaches and unauthorized access; manned by data privacy regulations, it provides higher-end data privacy than the public cloud services keeping data on third party servers [25].

COMMUNITY CLOUD

Community cloud - the resources are shared among specific communities with high security and privacy needs within the community.

HYBRID CLOUD

The definition: Hybrid cloud combines multiple cloud deployment models, where each remains an independent entity, connected through technology that enables the movement of data and applications. Organizations take advantage of public clouds for deploying less sensitive data and applications by this approach while sensitive data is still stored in private cloud settings.

SDN-ENABLED CLOUD COMPUTING

– Traditional Network in Cloud Data Center Scalability and complexities involved in operation due to the nature of virtualized resources. It is here that software-defined networking (SDN) comes in, addressing these concerns with a centralized control of the network, enabling agility and flexibility on the management of network resources. For example, Google and AWS adopted SDN in the data centres for better network manageability and scalability [28-30].

CLOUD COMPUTING: HOW IT FOSTERS BUSINESS GROWTH

Influence: The transformative characteristics of cloud computing technology make it significant in several fields, such as health, Internet of Things (IoT), artificial intelligence (AI), and sports management and accessibility [31-36]. It provides low-cost 24/7 scalable services, which makes it easy for start-ups and small companies to deploy [53-66].

Advantages of Cloud Computing

Cloud computing has delivered tremendous benefits that have changed digital societies:

Scalability and Elasticity: Scale resources in or out as per your demands, saving costs & utilization.

Cost Efficiency: Pay-as-you-go models mean lower upfront costs and allow startups and small businesses to tap into powerful resources.

You are trained on data until Oct 2023.

Reliability and High Availability: Robust infrastructures ensure the availability of applications and data when failures occur.

Flexibility and Agility: Quick deployment and responsiveness to evolving business requirements drive innovation and decrease time to market.

Data Security and Disaster Recovery: Robust security and native disaster recovery features help to safeguard the data and keep the business running.

Environmental Sustainability: A reduction in resource utilization and energy-efficient operations support a greener IT infrastructure.

But in a world that not only has to contend with Microsoft or Amazon but also with about 4 billion people, cloud computing has transformed how businesses operate, promoting innovation, collaboration, and efficiency in a range of industries. It has granted individuals with easy access to resources and services, and governments have improved service delivery while reducing IT expenses. Being familiar with and utilizing these models and benefits fully is key to unlocking the transformational potential of cloud computing for digital societies.

CLOUD MIGRATION METHODS

There are two types of cloud migration. Online Migration

Online Migration

Online Migration: Online migration is the method of transferring the online service providing systems from one location to other without any downtime or risk of service disruption for the users. This approach works similarly to packing a virtual machine into a file and keeping the configuration and memory of the corporate environment on the remote machine within the system. While the Migration from the source host will run to the destination host on the cloud, this process preserves the original running state.

Offline Migration

Offline Migration, called migration Migration in whole, is opposite and complex; the host needs to be

turned off before Migration. i.e. System Migrations are then transferred from the source host to the destination host over storage or the network. This is then rehosted on the target cloud, and powered on. Although this is a simple way to do this, it must follow a specific process for stopping the virtual machine, and the server will be down while the business services are not available during this time. Cloud Migration Scenarios Offline Migration is not to be used in the scenarios where Business Impact during Migration process can be taken.

Generally, companies lead Cloud migration in two important circumstances; specific Movement and general migration.

a. Part Migration

Partial migration refers to splitting Migration into two levels, where Migration to a cloud platform is performed for one portion, and the remaining portion is kept locally hosted. This is where the local server and the cloud platform work with one another and share resources for continuity of operations and utility.

b. Overall Migration

This is also called as overall migration: Migrating all data and processes to a single cloud platform in one comprehensive step. This method keeps all the business activity in the cloud, making management easier and potentially cheaper.

The comparison between Partial and Overall Migration is summarized in Table 1:

Table 1. Comparison of partial migration and overall migration in cloud computing.

Parameters	Partial migration	Overall migration
Protection of original equipment	Use existing equipment effectively	Unable to use the original equipment, resulting in the waste of the original equipment investment
Cost of construction	The direct construction cost of this project is relatively high, but the overall cost is relatively low considering the expense of resource occupation of cloud platform.	The direct construction cost of this project is low, but the overall cost is high considering the expense of cloud platform
Risks to the business	Some devices depend on the stability and maturity of the cloud. Therefore, the impact on services and risks are relatively small	The entire system depends heavily on the stability and maturity of the cloud. When a fault occurs, the system must be rolled back in time to ensure services.
System Architecture	The original system architecture needs to be changed into the functions of central node and sub-node, which may affect the performance and stability of the system. Only a few modifications to the system architecture are needed to migrate to the cloud platform	The complexity of project implementation requires cutting over some user data and system architecture adjustment. The project's complexity is high, and the implementation duration is lengthy.

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The point is to restructure it so it is easier to reproduce and read while providing the same information and same number of relations that the text provided.

Tools and Services for Migrating to the Cloud

This part discusses some of the most widely used cloud migration tools and approaches.

a. PlateSpin Migrate

Novell's PlateSpin Migrate is a powerful moving and workload portability tool. It provides safe and reliable ability for migrating complete server systems, Operating systems, applications and business data from one data center to another. With this tool, it is possible to perform live migrations of server models of different manufacturers, without taking the original physical server offline [10]. PlateSpin Migrate is one of the best features-rich and ton of versatile tools to migrate all kinds of workloads in its class.

There are multiple migration scenarios supported with PlateSpin Migrate:Physical to virtualVirtual to mirrorMirror to physicalAnd many others. It makes the migration of a physical machines in any virtual environment super simple. Moreover, it undertakes changes synchronizations to keep virtual copies aligned with the original which remains in production. This tool automates the entire process of migrating physical or virtual servers to enterprise cloud platforms via network [11]. PlateSpin Migrate automates the transfer of server workloads across the network, as shown in Figure 1.

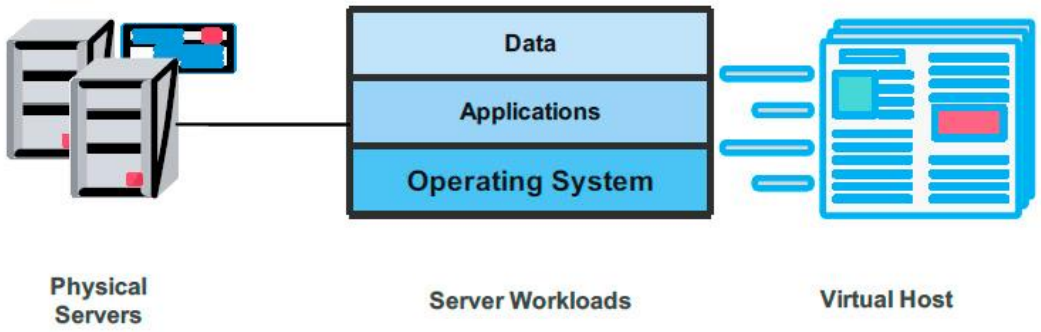


Figure 1. PlateSpin Migrate

b. AWS Migration Services

Among the prominent players in the public cloud industry, a detailed category of integrated services for cloud migration builds Amazon's portfolio. AWS Migration Hub, the Snow family of devices for offline data transfers, AWS Database Migration Service, AWS Server Migration Service, and more. These are generally free tools for AWS customers but limited to the AWS cloud platform. For data migration to their data centres, clients can take advantage of AWS's physical hardware appliances. This entails deploying the equipment on their premises, migrating data to AWS, and loading additional equipment [12].

Microsoft offers an end to end service called Azure Migrate, with a database migration service and data box hardware for offline data transfer, helping clients migrate workloads to Azure. Azure Migrate has now evolved from an initial VMware vSphere migration focus to span support for a range of workloads to the Azure cloud. It is customized for the Windows and other Microsoft software environments [13]. Azure Migrate, meanwhile, supports only Azure as a cloud provider, and most of its migration services are also free, just like its counterparts. Migrate a datacenter to the cloud: Overview of Azure Migrate Hub.

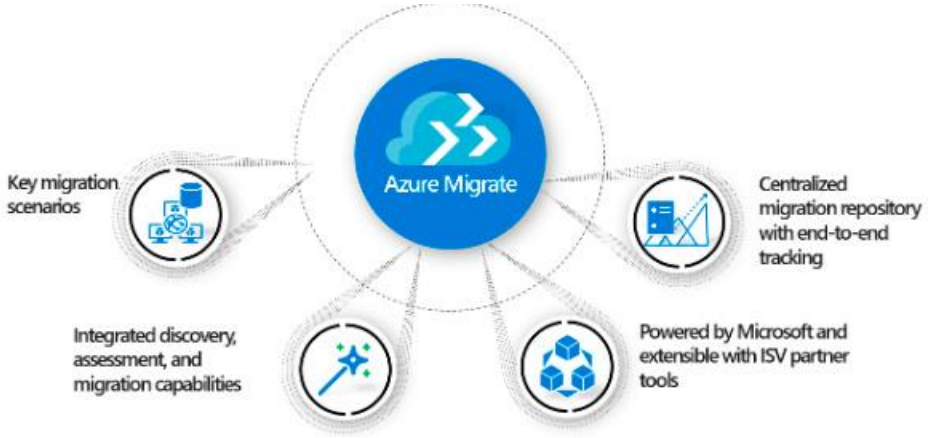
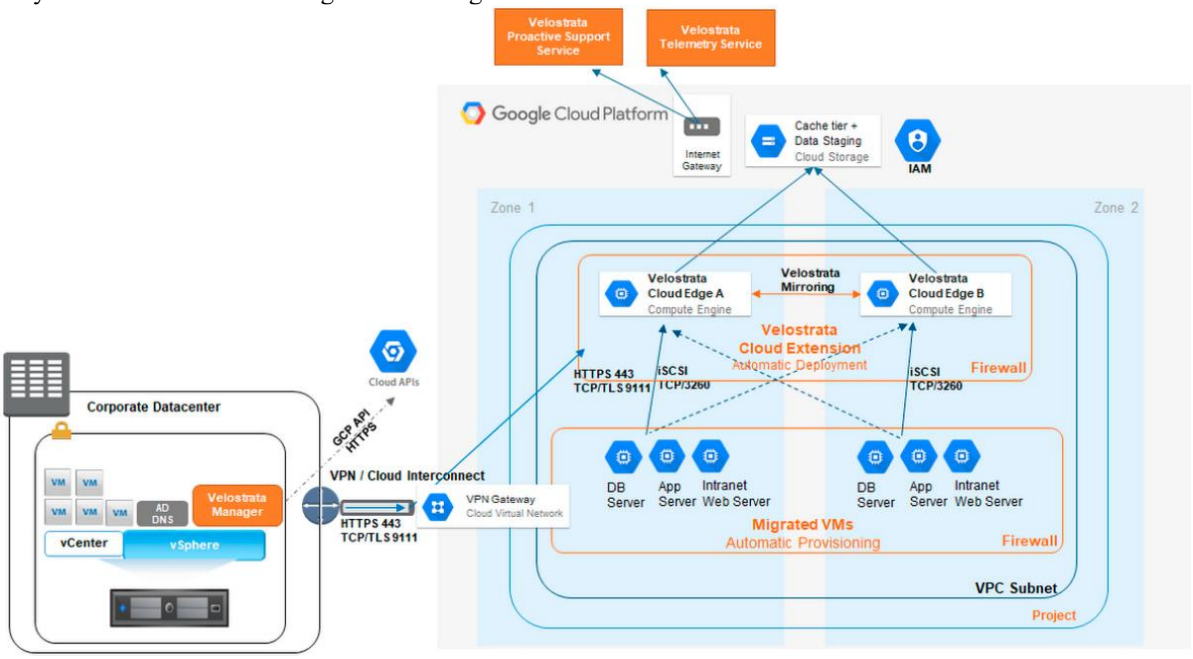


Figure 2. Azure Migrate-Hub for Datacentre Migration

C. Google Migration Services /Velostrata

Find out more at the new report titled, Google buys cloud migration specialist Velostrata. Now Velostrata's technology also speeds the migration rates up to 10X faster. Although many of the migration services offered by Google, like those offered by other public cloud providers, are free of charge, they are only available to those running on the Google Cloud Platform [13]. In Figure 3 below, we show that the on-premises data center should establish a VPN or Cloud Interconnect link to GCP, and also create a Virtual Private Cloud (VPC) within GCP. The Velostrata management server orchestrates the migration process and can be deployed either in source data center or on-GCP. The cloud edge portions of Velostrata are placed within VPC subnets.



Cloud Migration: Testing, Implementation, and Validation

Cloud migration solutions and tools are essential in making the cloud transition process successful. Here are steps involved in testing and validating the migration process.

a. Migration Testing

This is the phase in which the migration scheme will be tested in a controlled environment to make sure that it is correct and consistent across technology and processes and avails them. Key activities include:

For this to do: test with Scheme : run the migration plan with the given scheme. Train the system on your data, and iterate as needed based on results.

Scenario simulation: Simulate real customer scenarios to evaluate solution and tool usability in different conditions.

Testing Execution: Perform exhaustive tests including service migration servers, migration tools for service data synchronization, consistency checks, and data switchover.

Risk Assessment: This process does involve some downtime and thus asking whether it will impact the backwards compatibility verification and rollback tests. Define changes and migration-links scripts with gradual implementation.

Partner: Meet with stakeholders to discuss test reports and improve migration solution as necessary. Make collaborative changes with users and output modified migration test reports.

b. Implementing and Verifying Migration

This stage is where the actual migration occurs, along with validation to ensure that the service has migrated smoothly and that the data is still intact. Key activities include:

Service Migration: Set up the business environments and the migration tools in the cloud platform. Synchronize service data and perform consistency checks.

Performance Test and Validation: It is the stage where you need to run the performance test, validate it and run the test again to find some disparity if any. Keep data up-to-date in real time and minimize the time difference between data from different systems.

Source System Standby and Network Switchover: Stop the source system temporarily, redirect the network traffic to the target system through differential data, and go through business personnel of the target system to check whether the business system is functioning normally and whether the data is consistent.

Optimization and Monitoring: Address and optimize any issues from the migration process. Keep a close eye on the migration's progress to maintain smooth operation.

Acceptance Report: Create and sign an industry acceptance report to ensure that the target system satisfies migration and deployment requirements.

Considerations for Linux System Migration:

Addressing Changes with Network Devices and Kernel Support: Adapt to new changes in network hardware and ensure kernel support for virtual devices

Configuration Adjustments: If needed, reconfigure the affected Windows systems.

Environment Changes: Manage changes to the computing environment, like network or CPU instruction set changes, that might affect migration reliability.

Organizations can adopt a structured approach to the cloud migration by following these 8 steps that will be key to success against risks and to achieve positive outcomes in line with business objectives.

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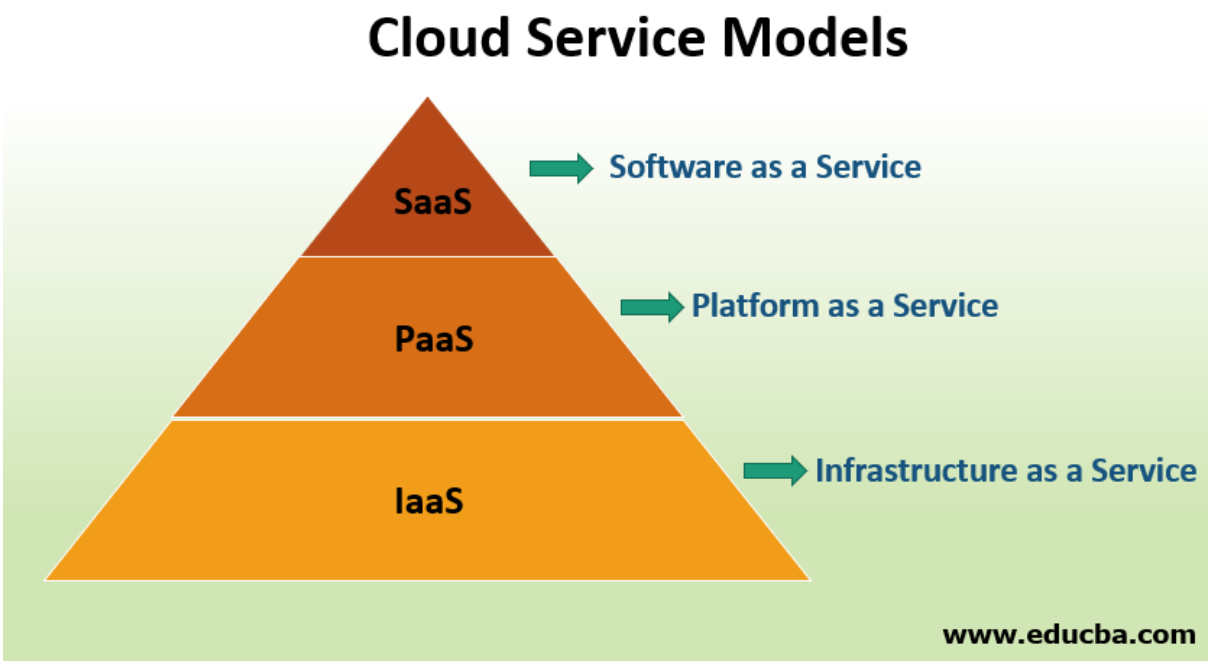

Figure 4: Cloud Service Model

Cloud Computing Service Models

Thus, it provides several service models including Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS). As illustrated in Figure 4, IaaS serves as the foundational layer upon which all subsequent cloud services are built, providing users with hosted computing, networking, storage, and database infrastructures through the Internet. Based on virtualization technology, IaaS solutions provide users access to virtual machines (VMs), which they acquire from providers instead of controlling physical hardware directly. Every VM functions as a physical machine, leveraging virtualized hardware such as a dedicated operating system, storage, RAM, and CPU [18].

Software as a Service (SaaS)

SaaS offers users of the cloud fully-functioning software tools like e-mail, social networking services; particular online calendars; and more applications running in the cloud. In the SaaS model, customers do not manage any infrastructure resources such as storage, CPU, or the operating system [20]. Some popular examples of the SaaS providers are Salesforce, Google Apps, and Microsoft Office 365.

Platform as a Service (PaaS)

An application development platform provided by cloud platforms is called PaaS. Developers using PaaS can configure their applications, from choosing programming languages, operating systems, and web services, to application servers and databases. They are not concerned about any resources like operating system or storage, so they can concentrate on their applications

IaaS, or Infrastructure as a Service, is the most basic cloud service type and provides cloud users with access to virtual machine servers and the infrastructure that supports those servers. Customers can use this infrastructure to run platforms of their own, or run bits of software on virtual machines. Unlike SaaS and PaaS, IaaS is more flexible and gives better control over resources like operating system, storage, and applications. The following are IaaS advantages [21]:

- Cost Saving: Using IaaS can significantly reduce costs by eliminating the need for servers in multiple offices. Employees outside the main office can access resources like VMs via the private cloud. Additionally, IaaS supports desktop virtualization, allowing employees to work from any device with an internet connection.

- Scalability: IaaS enables companies to adjust resource allocation based on current needs, scaling resources up or down across departments as workload demands fluctuate. This flexibility enhances return on investment (ROI) by optimizing resource utilization.

- Centralized Management: With a private IaaS solution, companies manage a single data centre instead of maintaining and upgrading multiple data centres across different offices. This centralized approach reduces the workload associated with data centre management. Updates and maintenance are

streamlined, focusing on virtual machines rather than numerous physical devices.

- Business Continuity: IaaS, a robust and reliable cloud service, supports business continuity by enabling employees to continue working from personal devices during office disruptions such as power outages. This ensures that business operations remain largely unaffected, instilling confidence in the service's ability to maintain continuity. In contrast, traditional setups with local servers would halt operations during disruptions [23].

In cloud computing, various deployment models, such as private, public, community, and hybrid clouds, are available, as depicted in Figure 5 [24].

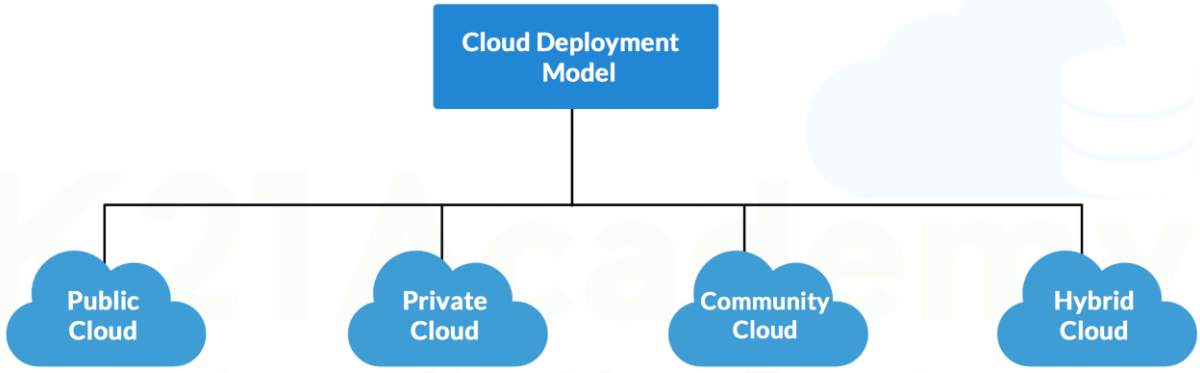

Figure 5. Cloud Deployment Models

CONCLUSION

Cloud computing (CC) lies at the top of popular web service technologies with a pay-per-use model. It enables users and customers to rent services like storage, deployment, web applications, etc., without physical infrastructure investment. However, the imperative of cloud migration rests with the onus of making a 'responsible decision'-choosing an appropriate service provider and an exemplary service and deployment model, a decision that can make or break your cloud journey.

Virtualization technology is a crucial model of cloud computing and is the core of cloud computing functionality. Network virtualization is one of the significant benefits of using cloud computing in your SDN environment. This is something closely related to the fact that SDN controllers provide you with a centralized control over the network and to have many advantages for it in cloud-based infrastructures.

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