Technological University of the Philippines - Manila
College of Science
COMPUTER STUDIES DEPARTMENT

ACTIVITY #2:
"Cloud Computing and Autonomic Computing: Perfect Partners for Digital Transformation"

Submitted by:
Group #3 - BSCS 2CD

Leader:
Calulang, Mary Jane P.

Members:
Barrios, Armand Angelo C.
Oloroso, Andrew R.

Submitted to:
Mr. Peragrino Amador
CS202/CS202L - AppDev Professor

2023

INTRODUCTION

In today's fast-paced digital world, The significance of efficient and secure data management has never been greater. Enter cloud computing, a technology that has transformed how we store, access, and manage data. The cloud has become a buzzword in the IT sector, providing exceptional flexibility, cost-effectiveness, and security to individuals and companies of all kinds.However, as data volume and complexity increase, new challenges emerge. That's where autonomic computing comes in, a new discipline aimed at making cloud computing systems self-managing, self-healing, and self-optimizing.

Cloud computing, at its heart, is a model for distributing computer resources, such as storage, servers, and applications, over the internet. Users can access data and applications through the cloud from any location and on any device without the need for physical infrastructure. This enables businesses to expand their operations to accommodate shifting demand while also lowering costs and enhancing efficiency.

Furthermore, the cloud provides unmatched security with sophisticated encryption, firewalls, and other safeguards to protect sensitive data. This makes it the perfect option for businesses, such those in the healthcare and financial services industries, that have stringent compliance and data security standards. Businesses can concentrate on their core business functions by using the cloud while leaving the

labor-intensive task of managing IT infrastructure to cloud service providers.

In this study, we'll look at the fundamentals of cloud computing, as well as its various forms and advantages. Additionally, we will examine the difficulties and dangers of adopting the cloud, and we'll offer suggestions for businesses that want to make the switch. You will have a thorough understanding of cloud computing and how do you use it in your daily lives.

OBJECTIVES

It might say that given the length of time that has passed, everything has changed. This research paper's goal is to give a thorough grasp of the fundamentals of cloud computing, including its underlying technology, deployment models, and service models. Our objective is to offer a strong foundation for anyone interested in learning about cloud computing and its potential to change how we store, manage, and access data.

The specific aims of our research study are as follows:

1. Define cloud computing and autonomic computing,
2. Explain evolution of cloud computing,
3. Explain three (3) types of cloud deployment models,
4. Describe three (3) Service Models and top cloud providers,

5. Describe the advantages and disadvantages of both technologies,

6. Describe some of the application areas of cloud,

7. Explain how cloud and autonomic computing works in different focus area.

DISCUSSIONS

What is Cloud Computing?

Cloud computing is the delivery of technology services - including compute, storage, databases, networking, software, and many more - over the internet with pay-as-you-go pricing. So, rather than owning your own computing infrastructure or data centers, you can rent access to these different services from a cloud service provider, like Amazon AWS, Microsoft Azure, or Google Cloud Platform.

What is Autonomic Computing?

The term "autonomic computing" describes a computer system's capacity to operate autonomously without constant human supervision. Autonomic computing is the process of creating computer systems that can independently assess their own performance, spot issues before they become serious, diagnose them, and take the necessary corrective action.

Evolution of Cloud Computing

The evolution of cloud computing can be traced back to the dawn of computers and is separated into three major phases: the idea phase, the pre-phase, and the cloud phase.

1. Idea phase: The concept of cloud computing first appeared in the 1960s with the creation of time-sharing systems that allowed numerous users to access a single computer at the same time. During this time, the concept of virtualization, which allowed multiple virtual machines to run on a single physical machine, was also developed.

2. Pre-phase: Grid computing arose in the 1990s, allowing resources to be shared across multiple enterprises. This was a forerunner to cloud computing since it allowed for the larger-scale sharing of computing resources. During this time, utility computing, which allowed computing resources to be provided as a service, also emerged.

3. Cloud phase: With the introduction of Infrastructure as a Service (IaaS) in the mid-2000s, the cloud era began. Companies like Amazon and Google began to offer IaaS, which allowed organizations to rent computing resources from the cloud, such as servers and storage. This was the beginning of cloud computing as we currently understand it. The term "Platform as a Service" (PaaS) first appeared in the late 2000s and early 2010s as a means for companies to create and deploy cloud-based applications. Software as a Service (SaaS), which enables organizations to access software applications over the internet, dominates the present

cloud phase. With providers offering a wide range of applications, from email to corporate resource planning (ERP) systems, SaaS has grown to be the most well-liked cloud computing model.

Types of Deployment Models

The three (3) main types of cloud deployment models are: private, public, and hybrid cloud.

Private cloud

The private cloud concept is made to be private and is intended only for use by its tenants. This means that in order to connect to a network link and access a private cloud, IT must first set up a specific network access. A business can host its own private cloud infrastructure in-house or through a third party. The infrastructure is created for exclusive usage, which makes the private cloud concept interesting. This provides an organization with direct control over the resources available and the data storage methods. For instance, you can pick the precise hardware and operating system you like. Other models do not offer the same level of versatility as this one. This is especially helpful if there are particular security threats or needs. But compared to the other models, it typically demands a larger time and financial investment. Think about the hardware that needs to be purchased, installed, and maintained, as well as the infrastructure that needs to be created. If the hardware is provided

and maintained by a third party, such as IBM or RackSpace, this decreases. How is this different from on-premise, you might be wondering. The architecture under this paradigm leverages virtualization, which enables on-demand compute resources, and adheres to cloud principles. Off-site private clouds are another option.

Public cloud

Public clouds are the second type. The public can access and use the shared cloud infrastructure. An organization that offers cloud services, such as AWS or Azure, owns and manages the infrastructure. Internet access is available for public clouds. This enables businesses to launch rapidly and for little money. Instead of hosting or committing to an infrastructure, they can choose the services they require from a supplier. Scaling is made simpler by the ability to purchase additional capacity immediately. Public cloud is not a smart option if having direct access to data centers or hardware is crucial. For security concerns, public cloud companies hide the whereabouts of their data centers even from their customers.

Hybrid cloud

Why not both? Enter the third model: hybrid. This is when an organization uses a combination of two or more distinct models. The different models interact with each other via a network link and can share data and services. It's more of a question of where data and services are

physically stored. For example, you could store sensitive patient data on a private cloud for security reasons and use an application on the public cloud, like a business intelligence tool, to process it. Hybrid clouds are useful in the case of cloud bursting. This is when a private cloud is overwhelmed by demand and hits capacity. To avoid disruption of service to users, traffic is moved to a public cloud instance. A classic example of this are seasonal spikes. For example, retail businesses can expect extraordinary traffic during sales periods like Black Friday or Boxing Day. This allows organizations to cost-effectively handle periodic spikes with pay-per-use pricing.

Other deployment models

There are other cloud deployment models to consider including multicloud.The services of various cloud providers are combined in multicloud. An organization might, for instance, use Google Cloud for analytics and Azure for backups and website hosting. A variety of pricing options and service options are available with multicloud. It lessens a company's reliance on a single vendor. This should not be confused with the hybrid model, which combines services with cloud deployment models.

Another model to consider is the community model. This occurs when a single community shares the cloud's infrastructure for their exclusive use. Typically, this community has a shared interest or concern,

such as having the same security requirements or jurisdiction, or sharing a mission. This shared infrastructure facilitates data collaboration and exchange, whether it is research data between universities or government data across agencies. The infrastructure itself can be maintained and hosted within or externally.

Providers

Cloud providers, also known as cloud service providers, refers to third-party IT companies offering various on-demand, scalable computing resources and cloud-based services over the internet. These are well-suited for organizations and individuals alike who do not want the responsibility of installing software, hardware and/or network resources and maintaining them.

Cloud service providers are often categorized by the type of resource they provide:

- **Software as a service (SaaS) providers**

  SaaS providers offer cloud-based software accessed via the internet. They handle everything from infrastructure to data, eliminating the need for businesses to install and maintain software on their servers. SaaS offers applications like CRM, HR, and project management, reducing costs and streamlining operations. Users pay a subscription fee that can be scaled up or down based on their needs.

Notable SaaS providers include Salesforce, Microsoft, Intuit, Veeva Systems, and Oracle.

- **Infrastructure as a service (IaaS) providers**

  IaaS providers offer pay-as-you-go virtualized computing resources, like servers, storage, and networking. These can be customized to meet a business's specific needs, and easily scaled up or down. This flexibility is why IaaS is a popular choice for businesses looking to manage their own infrastructure without physical hardware.

  Some known IaaS providers are AWS, Microsoft, and Alibaba.

- **Platform as a service (PaaS) providers**

  PaaS providers offer a comprehensive platform that supports application development, testing, and deployment. They typically provide various development tools, middleware, and operating systems, which are hosted in the cloud and can be accessed via the internet. This approach eliminates the need for businesses to handle the underlying infrastructure, allowing them to concentrate on application development and deployment. Additionally, PaaS providers offer developers a high degree of flexibility in scaling their applications up or down as needed, while only paying for what they use. This makes PaaS a popular choice for businesses looking to develop and deploy applications rapidly, without the additional overhead of infrastructure management.

Some known PaaS providers include Heroku, Red Hat, and Engine Yard.

Currently, the top 3 cloud service providers in the industry are Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP).

Amazon Web Services (AWS)

AWS offers a wide range of cloud computing services including IaaS, PaaS, and SaaS. Some of its most popular services include Amazon EC2 for computing, Amazon S3 for storage, and Amazon RDS for databases.

Microsoft Azure

Microsoft Azure offers similar IaaS, PaaS, and SaaS services as AWS, but with a focus on integrating with Microsoft software and tools. Some of its popular services include Azure Virtual Machines for compute, Azure Storage for storage, and Azure SQL Database for databases

Google Cloud Platform (GCP)

GCP offers IaaS, PaaS, and SaaS services as well, with a focus on machine learning and data analytics capabilities. Some of its

popular services include Compute Engine for compute, Cloud Storage for storage, and BigQuery for data analytics.

Service Models

Many companies face significant challenges in meeting the high expectations of their customers for fast, reliable, and secure services due to an unprecedented burden on their IT infrastructure. Attempting to enhance processing power and storage capabilities can be costly, leading to difficulties in developing and maintaining a robust, scalable, and secure IT infrastructure. Fortunately, cloud computing offers an alternative approach. By leveraging these internet-based services offered by cloud providers, cloud computing thereby allows businesses to move beyond on-premise IT infrastructure.

Cloud computing is offered in various service models with each covering different user and business needs. The three most popular types of cloud computing service most popular types of cloud computing service models are the Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

Software as a Service (SaaS)

Also known as "on-demand software", SaaS is a web-based platform that provides access to cloud computing on a subscription basis, delivering software as a service rather than a one-time product. Users can

access most of the SaaS applications with the help of internet connection and a web browser without any downloads or installations required, making it convenient and accessible to use.

SaaS mostly covers the needs of end-users, as providers of this service typically offer a range of applications that are designed to meet the needs of specific business functions, such as customer relationship management (CRM), human resources (HR), and accounting, which are typically used by end-users.

Characteristics of a SaaS

- Managed from a central location
- Hosted on a remote server
- Accessible over the internet
- Users are not responsible for hardware and software updates. Updates are applied automatically.
- The services are purchased on the pay-as-per-use basis

Common examples of SaaS include Google Workspace, Microsoft 365, Slack, InfinCE and ReachOut Suite among others.

Platform as a Service (PaaS)

PaaS is a web-based platform that provides access to development tools, APIs, and deployment instruments without the need for IT infrastructure, making the development process more efficient and

faster. Users, most typically developers, gain direct, complete access to virtual development environments and Cloud storage, where they can develop, test, run, maintain, and manage such applications.

Characteristics of a PaaS

- Integrates with web services and databases.
- Builds on virtualization technology, so resources can easily be scaled up or down as per the organization's need.
- Support multiple languages and frameworks.
- Provides an ability to "Auto-scale".

Examples of PaaS include AWS Elastic Beanstalk, Windows Azure, Heroku, Google App Engine, Apache Stratos, Magento Commerce Cloud, and OpenShift.

Infrastructure as a Service (IaaS)

IaaS, also known as Hardware as a Service (HaaS), is a cloud service model that provides businesses with cloud-hosted IT infrastructure components that provide compute, storage, network, and virtualization capabilities to the subscriber on an on-demand basis via the Internet. These components include development environments, private networks, virtual storage and networks, and deployment instruments needed for software. IaaS also provides virtualized computing resources and fully

powers the development processes with third-party servers and cloud backup storage.

IaaS typically covers the needs of Network architects and IT administrators, as this avoids the costs and complexity usually associated with building and maintaining physical infrastructure in an on-premises data center.

Characteristics of an IaaS

- Resources are available as a service
- Services are highly scalable
- Dynamic and flexible
- GUI and API-based access
- Automated administrative tasks

Popular examples of IaaS include the Amazon Elastic Compute Cloud (AWS EC2), Azure IaaS, Google Compute Engine (GCE), Rackspace, and Cisco Metacloud.

Other cloud computing service models include Network as a Service (NaaS), Backup as a Service (BaaS), Database as a Service (DaaS), Communications as a Service (CaaS), Cloud Business Process as a Service (BpAAS), and Storage as a Service (STaaS).

Advantages of Cloud Computing

In today's digital age, the world of computing has undergone a dramatic shift towards the cloud. Cloud computing has revolutionized the way users store, process, and manage data, offering unprecedented levels of flexibility, scalability, and cost-effectiveness. With the ability to access computing resources and applications over the internet, cloud computing has become an essential tool for businesses and individuals looking to streamline their operations and stay ahead of the curve. Listed below are the notable advantages of such.

- **Cost Efficiency**

  Cloud computing provides a flexible and scalable solution that eliminates the need for expensive investments in hardware and software. With on-demand access to computing resources and no requirement for physical installations, capital and operational costs are significantly reduced. The responsibility of maintenance and upgrades lies with the service providers, thereby eliminating the need for in-house IT teams and ongoing upgrades. Additionally, the pay-as-you-go pricing model allows users to optimize resource usage efficiently, resulting in reduced costs.

- **Agile**

  Cloud computing expedites development by providing developers convenient access to an extensive array of computing resources, tools, and services that can be promptly provisioned and

utilized as required. It also enables the adoption of agile development methodologies that facilitate rapid testing and deployment of new features and updates. In addition, cloud providers furnish pre-built templates and tools that enable the swift setup of development, testing, and production environments, furtherly accelerating the development process.

- **Advanced Security**

  Cloud storage providers implement a range of physical and digital security measures conducted and managed by top security experts to safeguard user data. Such physical measures include restricted access to server warehouses, while digital measures involve data encryption, regular security updates, and artificial intelligence (AI) tools to detect potential vulnerabilities. Implementation of built-in firewalls also filter out malicious traffic and prevent malware and viruses from compromising the system. Redundancy practices also ensure data availability in the event of hardware failures or outages. Third-party security testing is also regularly conducted to evaluate the effectiveness of such measures and identify early any unforeseen vulnerabilities.

- **Reliability**

  Cloud computing is a dependable solution that uses backup systems with backup and disaster recovery features to ensure that services always remain available and operational. This means that

in the event of hardware failures, maintenance issues, malicious threat actors, and/or human errors, there is most likely little to no downtime.

- **Accessibility**

  Cloud storage facilitates global data access through distributed data centers, enabling its users to remotely access their data and applications from anywhere in the world with any internet-connected device. Its instant deployment and reduced latency make it an ideal choice for organizations and individuals alike with a global reach. Furthermore, this also introduces convenient accessibility, better collaboration, and cost-effectiveness for businesses of all sizes.

- **Massive Scalability**

  Cloud computing offers the ability to adjust computing resources to meet performance requirements. This ensures efficient use of resources and allows organizations to quickly adapt to changing computing needs and enables them to scale operations without significant upfront investments in hardware and infrastructure.

- **Environmental Sustainability**

  Cloud computing offers an eco-friendlier, more sustainable, and efficient alternative than traditional IT solutions, as businesses

can reduce their energy consumption and carbon footprint by up to 90% through cloud adoption. By using cloud-based services, organizations can access applications and data from any device with internet connectivity, eliminating the need for in-house servers and software and resulting in a smaller environmental impact.

Disadvantages of Cloud Computing

Although cloud computing has many benefits, there are a few drawbacks to take into account. The following are some of the major drawbacks of cloud computing:

- **Security risks** - Data storage on third-party servers may be exposed to hackers, cyberattacks, and illegal access, which can be a security issue. Although the security of the data is the responsibility of the cloud provider, there have been instances where data breaches have led to the leakage of sensitive information.

  Keep in mind what happened at Code Space when their AWS EC2 access was hacked, causing data loss and eventually the collapse of the company. Their reliance on remote cloud-based technology forced them to take on the risks related to outsourcing everything.
- **Dependence on internet connectivity** - A reliable and powerful internet connection is necessary for cloud computing. The speed and usability of cloud-based applications and services may be affected if the internet is weak or unavailable.

- **Limited control** - The user's ability to manage the infrastructure, software, and hardware is constrained while using cloud computing. Users are unable to alter the underlying systems or settings in this way, which might be problematic for organizations that have particular demands.

  Clients may be limited in what they may do with their deployments by a cloud provider's management policies and end-user licensing agreement (EULA). Although customers may not have as much control over the infrastructure on the back end, they still have full control over their apps, data, and services.
- **Downtime and outages** - Cloud service providers may encounter outages and downtime, which may affect the accessibility and availability of cloud-based services and applications. Customers may become dissatisfied as a result, along with lost productivity and income.

  An Amazon Web Services outage may have cost publicly traded companies $150 million in 2017. Sadly, no business is immune, especially when it comes to preventing essential business operations. In June and July of 2019, several companies and services, including well-known web services company Cloudflare, Google, Amazon, Shopify, Reddit, Verizon, and Spectrum, experienced outages.
- **Cost** - While cloud computing can be affordable in some circumstances, it can also be costly for companies that need a lot of performance, storage, or processing power. Data transfer,

support, and other services could also come at an additional expense.

- **Vendor lock-in** - When a business relies on a particular cloud provider, switching to a different one or bringing data and apps back in-house might be challenging. This is due to the fact that cloud providers frequently employ exclusive technologies and file formats that are incompatible with those of other providers or on-premise systems.

  To avoid substantial expense and interruption, it might be difficult to move data and apps to another cloud provider or to bring them back in-house. Additionally, it may be difficult or expensive to switch cloud providers due to lengthy contracts or high exit fees. Migration-related flaws or hacks might potentially expose your data to extra security and privacy risks.

Recent Developments of Cloud Computing

The field of cloud computing has seen a number of recent breakthroughs as it is a quickly developing technology. The following are some recent advancements in cloud computing:

- **Multi-Cloud Strategies** - Multi-cloud techniques are being adopted by organizations more often to reduce vendor lock-in and boost resiliency. Multicloud usage is the process through which an organization uses cloud computing services from at least two

different cloud providers to run its applications. Instead of using a single-cloud stack, multicloud configurations frequently incorporate two or more public clouds, two or more private clouds, or any combination of the two.

By being able to create a strategy that uses a variety of suppliers, you may select the features that best suit your particular company needs and lessen vendor lock-in. Multi-cloud strategies and solutions are being used more often by organizations to run apps where they are needed without introducing complexity. Multicloud solutions provide the flexibility and portability required to transfer, construct, and optimize applications across different clouds and computing environments. They are built on open source technologies like Kubernetes. Furthermore, multi-cloud environments are compatible with DevOps practices and other cloud-native application technologies that support portability, such as containers and microservices architecture.

- **Edge Computing** - A distributed computing approach called edge computing puts network, storage, and computation resources closer to the consumer. By processing and analyzing data closer to its source, edge computing lowers latency and boosts speed.Edge computing enables organizations to accelerate the response times of their remote devices and acquire deeper, more immediate insights from device data. Real-time processing is made feasible in areas where it would not otherwise be possible thanks to edge

computing, which removes bottlenecks on the networks and data centers that support edge devices.

Without edge computing, the vast amounts of data that edge devices generate would overwhelm the bulk of current commercial networks, degrading all network operations. IT can get more expensive. Clients who are unsatisfied may choose to do their business elsewhere. Valuable equipment can be harmed or just function less effectively. Most importantly, in industries where sophisticated sensors are used to keep workers safe, those systems may endanger employee security.

- **Serverless Computing** - In a serverless computing architecture, the infrastructure is managed by cloud service providers, who then assign resources to run code automatically. Developers can produce apps more rapidly due to serverless computing, which relieves them of the responsibility of managing infrastructure. In serverless applications, the cloud service provider automatically provisioned, scaled, and managed the infrastructure required to run the code.

  Serverless computing are still responsible for running the code on the server. The term "serverless" describes the idea that infrastructure provisioning and administrative responsibilities be kept out of the developer's view. Using this approach, developers can concentrate more on the business logic and enhance the core functionality of the company. Serverless computing makes it possible for teams to operate more efficiently and to release

products more rapidly. It also enables enterprises to make better use of their resources and to have an innovation-focused attitude.

- **Containerization** - Containerization is the process of packing software code and dependencies into separate containers. Containerization allows programs to execute reliably across diverse computer environments, making cloud deployment and management easier.

  Software packages called containers provide everything needed to run in any environment. Containers virtualize the operating system and let it run on any device, be it a developer's laptop, a public cloud, or a private data center. Google operates all of its services in containers, including Gmail, YouTube, and Search.

  Some benefits of containerization are portability, without having to rewrite the program code, it may deploy programs in many settings. Scalability, software components that are lightweight perform well. Fault tolerance, containerized microservices run in divided user areas, thus a single defective container has no effect on the others. Agility, developers may debug and modify application code without interacting with the operating system, hardware, or other application services.

- **Hybrid Cloud** - The term "hybrid cloud" refers to a cloud computing platform that blends public and private cloud environments. The hybrid cloud enables businesses to profit from the benefits of both public and private clouds while keeping control over sensitive data.

A hybrid cloud strategy is one of the most used infrastructure setups currently. Cloud migrations usually result in hybrid cloud setups because enterprises must constantly migrate apps and data carefully and deliberately. Hybrid cloud solutions allow you to continue using on-premises services while also taking use of the flexible storage and access options offered by public cloud providers such as Google Cloud. When computing and processing demand exceeds the capabilities of an on-premises datacenter, enterprises may utilize the cloud to immediately scale capacity up or down to accommodate extra capacity. It also saves organizations the time and money associated with acquiring, deploying, and maintaining new servers that they may not always require.

- **Artificial intelligence and Machine learning** - As it offers the necessary scalability, flexibility, and compute resources required for data processing and analysis, cloud computing provides an ideal platform for the deployment of machine learning and artificial intelligence models.

  Business organizations now have new chances to take use of the power of data and analytics due to the combination of machine learning and artificial intelligence with cloud computing. Machine learning and artificial intelligence may be used in the cloud for applications like predictive maintenance, fraud detection, and natural language processing. A variety of machine learning and artificial intelligence services are available from cloud providers

including Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP), including Amazon SageMaker, Azure Machine Learning, and Google Cloud AI Platform. For data scientists and developers to create, train, and deploy machine learning models without the requirement for a complex infrastructure setup, these services offer pre-built algorithms and tools.

Relation to Autonomic Computing

Cloud computing and autonomous computing are closely linked ideas with numerous commonalities. Both technologies aim to automate computing resource management and improve system performance.

Autonomic computing is a computer paradigm in which systems may manage and optimize themselves. It entails the creation of systems that can monitor and respond to changes in the environment without the need for human involvement. Autonomic computing is commonly utilized in large-scale systems like data centers and cloud environments to increase system efficiency and save operating expenses. In contrast, cloud computing is a methodology for giving on-demand access to computer resources over the internet. Infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS), and software-as-a-service (SaaS) are all services provided by cloud computing companies. Cloud computing

allows businesses to scale their computer resources up and down as required, paying only for what they use.

Cloud computing and autonomic computing are related in that cloud computing providers frequently utilize autonomic computing approaches to manage their computer resources. Autonomic computing is used by cloud providers to monitor and optimize resource use, identify and respond to security issues, and control overall system performance. Autonomic computing is an important component of cloud computing because it enables providers to provide their clients with dependable, high-performance services.

Autonomic computing and cloud computing are technologies that work together to automate the administration of computing resources. In cloud settings, autonomic computing approaches are frequently utilized to enhance system performance and decrease operating expenses.

SUMMARY

As a result of offering an economical and effective means to store, manage, and access data and applications, cloud computing has fundamentally changed the way organizations function. Cloud computing has various advantages, including scalability, flexibility, accessibility, and lower infrastructure costs. However, cloud computing,

like any other technology, has its challenges and drawbacks, such as security concerns, vendor lock-in, and reliance on internet connectivity. The idea of autonomous computing has developed as a solution to these problems and as a means of enhancing cloud computing's capabilities. Self-governing systems that can adjust to user demands and changing settings are a key component of autonomous computing. Autonomic computing strives to provide more effective, dependable, and self-healing cloud systems by using artificial intelligence and machine learning.

Given how quickly technology is developing and how much demand there is for digital transformation, the future of cloud computing seems bright. Businesses are increasingly implementing multi-cloud and hybrid cloud strategies to benefit from the advantages of various cloud providers and architectures. In the upcoming years, it is anticipated that the fusion of cloud computing with cutting-edge technologies like the Internet of Things (IoT), edge computing, and blockchain will lead to fresh uses and applications. However, as cloud computing spreads, it is critical for businesses to address the difficulties and dangers posed by the technology, including data privacy, compliance, and vendor lock-in. Businesses must carefully examine their cloud strategy, provider, and security measures in order to fully benefit from cloud computing. They must also make sure they have the knowledge and resources required to maintain their cloud environment.

In conclusion, cloud computing has revolutionized company operations and evolved into a crucial facilitator of digital transformation. The capabilities of cloud computing are growing as autonomic computing takes off, resulting in cloud systems that are more effective and self-managing. While cloud computing has a promising future, businesses must be on guard and adopt a strategic approach to its adoption and management if they are to fully capitalize on its advantages.

Reference/s:

Introduction & What is Cloud Computing

- Introduction To Cloud Computing - javatpoint. (n.d.). Www.javatpoint.com. https://www.javatpoint.com/introduction-to-cloud-computing
- Glass, E. (2020, October 15). A General Introduction to Cloud Computing. DigitalOcean. https://www.digitalocean.com/community/tutorials/a-general-introduction-to-cloud-computing
- Introduction to Cloud Computing - Apprenda. (2012). Apprenda. https://apprenda.com/library/cloud/introduction-to-cloud-computing/

Evolution

- Evolution of Cloud Computing. (n.d.). Www.tutorialspoint.com. Retrieved May 3, 2023, from https://www.tutorialspoint.com/evolution-of-cloud-computing

Deployment Models

- Peterson, R. (2020, January 8). Cloud Deployment Models. Www.guru99.com. https://www.guru99.com/cloud-deployment-models.html#:~:text=Four%20most%20important%20cloud%20deployment

Providers

- What are cloud service providers? (n.d.). https://www.redhat.com/en/topics/cloud-computing/what-are-cloud-providers
- What are cloud service providers? (n.d.). https://www.redhat.com/en/topics/cloud-computing/what-are-cloud-providers
- *What is a Cloud Service Provider? | Google Cloud*. (n.d.). Google Cloud. https://cloud.google.com/learn/what-is-a-cloud-service-provider
- Techopedia. (2022, July 11). *What is a Cloud Provider? - Definition from Techopedia*. https://www.techopedia.com/definition/133/cloud-provider
- Virtana. (2022, March 6). *What are cloud providers*. https://www.virtana.com/glossary/what-are-cloud-providers/

Service Models

- Carrero, L. (2023, February 23). Main cloud service models: IaaS, PaaS and SaaS | Stackscale. Stackscale. https://www.stackscale.com/blog/cloud-service-models/
- Cloud Service Models - javatpoint. (n.d.). www.javatpoint.com. https://www.javatpoint.com/cloud-service-models
- Expert, C. (n.d.). The Top 3 Cloud Computing Service Models. CDW.com. https://www.cdw.com/content/cdw/en/articles/cloud/top-3-cloud-computing-service-models.html
- IaaS vs. PaaS vs. SaaS | IBM. (n.d.). https://www.ibm.com/topics/iaas-paas-saas
- Kumar, A. (2023, April 26). Top 3 Cloud Computing Service Models. SaaS | PaaS | IaaS. https://k21academy.com/amazon-web-services/aws-solutions-architect/cloud-service-models/
- Marketer. (2023, February 28). Different Types of Cloud Service Models. Jelvix. https://jelvix.com/blog/cloud-service-models
- Munevar, C. (2022). The three service models of Cloud Computing. Open International. https://www.openintl.com/the-three-service-models-of-cloud-computing/
- Saratchandran, V. (2023). Cloud Service Models Saas, IaaS, Paas – Choose the Right One for Your Business. Fingent Technology. https://www.fingent.com/blog/cloud-service-models-saas-iaas-paas-choose-the-right-one-for-your-business/

Advantages of Cloud Computing

- Advantages Of Cloud Computing | Google Cloud. (n.d.). Google Cloud. https://cloud.google.com/learn/advantages-of-cloud-computing#:~:text=Cloud%20storage%20enables%20you%20to,they%20have%20an%20internet%20connection.
- Cloud Security: How Secure is Cloud Data? (n.d.). Norton. https://us.norton.com/blog/privacy/cloud-data-security#:~:text=What%20makes%20cloud%20storage%20so,harder%20for%20cybercriminals%20to%20access.
- DeClute, D. (2022). Top 11 benefits of cloud computing. Cloud Computing. https://www.techtarget.com/searchcloudcomputing/tip/Top-11-benefits-of-cloud-computing
- GeeksforGeeks. (2020). Advantages and Disadvantages of Cloud Security. GeeksforGeeks. https://www.geeksforgeeks.org/advantages-and-disadvantages-of-cloud-security/

- Naveen. (2023). Advantages and Disadvantages of Cloud Computing. Intellipaat Blog. https://intellipaat.com/blog/tutorial/amazon-web-services-aws-tutorial/advantages-and-disadvantages-of-cloud-computing/
- Peterson, R. (2023). Advantages and Disadvantages of Cloud Computing. Guru99. https://www.guru99.com/advantages-disadvantages-cloud-computing.html
- Simplilearn. (2023). What is Cloud Scalability? Simplilearn.com. https://www.simplilearn.com/what-is-cloud-scalability-article
- Top 10 Benefits of Cloud Computing. (n.d.). https://www.oracle.com/cloud/what-is-cloud-computing/top-10-benefits-cloud-computing/

Disadvantages of Cloud Computing

- Larkin, A. (2022, October 10). Disadvantages of cloud computing. Cloud Academy from https://cloudacademy.com/blog/disadvantages-of-cloud-computing/
- What's cloud computing? the advantages and disadvantages. Microsoft. (n.d.) from https://www.microsoft.com/en-gb/microsoft-365/business-insights-ideas/resources/whats-cloud-computing-the-advantages-and-disadvantages
- Venezia, T. D. E. B. P., & Venezia, P. (2014, June 23). Murder in the amazon cloud. InfoWorld from https://www.infoworld.com/article/2608076/murder-in-the-amazon-cloud.html
- Hersher, R. (2017, March 3). Amazon and the $150 Million typo. NPR from https://www.npr.org/sections/thetwo-way/2017/03/03/518322734/amazon-and-the-150-million-typo?t=1529930367722

Recent Developments of Cloud Computing

- Google. (n.d.). What is Multicloud? definition and benefits | google cloud. Google from https://cloud.google.com/learn/what-is-multicloud
- Google. (n.d.). Multicloud Solutions | google cloud. Google from https://cloud.google.com/multicloud
- Google. (n.d.). What is kubernetes? | google cloud. Google from https://cloud.google.com/learn/what-is-kubernetes
- What is edge computing?: Microsoft Azure. What Is Edge Computing? | Microsoft Azure. (n.d.) from

https://azure.microsoft.com/en-us/resources/cloud-computing-dictionary/what-is-edge-computing/

- Serverless Computing and Applications: Microsoft Azure. Serverless computing and applications | Microsoft Azure. (n.d.) from https://azure.microsoft.com/en-us/resources/cloud-computing-dictionary/what-is-serverless-computing/
- Google. (n.d.). What are containers? | google cloud. Google from https://cloud.google.com/learn/what-are-containers
- The University. (1978). What is Containerization? Amazon from https://aws.amazon.com/what-is/containerization/
- Google. (n.d.). What is a hybrid cloud? - google cloud. Google from https://cloud.google.com/learn/what-is-hybrid-cloud
- Azure, M. (n.d.). What is a hybrid cloud?: . What is a Hybrid Cloud? | Microsoft Azure from https://azure.microsoft.com/en-us/resources/cloud-computing-dictionary/what-is-hybrid-cloud-computing/

Relation to Autonomic Computing

- Sobers Smiles David, G., Ramkumar, K., Shanmugavadivu, P., & Eliahim Jeevaraj, P. S. (1970, January 1). Autonomic computing in cloud: Model and applications. SpringerLink from https://link.springer.com/chapter/10.1007/978-3-030-71756-8_3
- GeeksforGeeks. (2020, September 2). What is autonomic computing? GeeksforGeeks. from https://www.geeksforgeeks.org/what-is-autonomic-computing/