Cloud computing for building effective information systems in Higher Education

# Introduction

In today’s world, most organizations are moving to cloud computing because of the advantages and scalability provided by the service provider. The following document discusses Should higher educational institutes depend on cloud computing to build a cost/security effective Information System.

# Dynamic scalability and its importance

Cloud computing is a distributed computing powered by a number of “abstracted virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet” (Foster et al., 2008). Bouyer & Arasteh (2014) states any organization does not require specialized training or control over the cloud system to dynamically alter resource consumption in order to provide services to the end-users, which makes cloud as the optimal solution for the institutes.

Vulic et al. (2011) state as most organizations are moving to digital and paperless E-learning, so inorder to manage resource demand, the systems can be scaled up quickly using the cloud infrastructure.

Cloud technology and eLearning provide the opportunity for an organization to go beyond the geographic boundaries and provide an opportunity for international students and faculties who are working from all over the world (Bouyer & Arasteh, 2014).

Every educational institution has its customized infrastructure requirement depending on geographic, economic, and social conditions can be managed by leveraging cloud platform provides scalability with its wider selection of services and solutions.

Pardeshi (2014) states, that there has been a decrease in the budget for higher education institutes due to economic downturns, which has also affected the IT budget, resulting in the cloud adaptation by the educational institute for scalability and inbuild security features offered by the cloud vendors.

With the new emerging technology, there is a constant need for change in IT hardware to keep up with the required infrastructure to deliver quality education and support. Pardeshi (2014) states that cloud computing provides the option to scale up the system as required and the computation for the end-user is carried out in the cloud clusters thus the end-users can use their legacy hardware to access the high-end systems without incurring the cost.

# Advantages

The major advantages of cloud computing are as follows:

## Mobility

## The cloud-based learning provides the advantage to learn in transit. The student need not be at the institute campus to access the institute resources rather they can be in any part of the world accessing the resources such as online laboratories, libraries, chat rooms (group discussion), etc. thus providing more freedom to students and faculty members to manage work-study-life balance (Pardeshi, 2014).

## New Services

## Institutes of higher education are offering e-learning and virtual classrooms, cloud provides the opportunity for the institute to upgrade their teaching with the latest cloud services provided (Pardeshi, 2014).

## The latest cloud providers also provide the latest industry-grade applications and platforms, which can be used by the institutes to upgrade their course curriculum and assist students in becoming more industry-ready.

## The leading cloud service providers, provides educational support for the latest technologies such as Artificial intelligence & Machine Learning, Kubernetes Services, Quantum, Devops, Pipeline, IoT, Spares, virtual reality, etc. (Wan et al., 2018).

## Storage

Cloud provides scalable storage opportunity (Azure, 2022.a) for the higher institutes and can be leveraged by the higher education institute for increasing the storage capacity since they require to store enormous data for student information, course work, research material, etc. (Pardeshi, 2014).

## Business Resilience

McKinsey & Company (2022) explains business resilience as the precautionary measures implemented by an organization to handle unforeseen risks. Pardeshi (2014) states data destruction due to natural disaster or failure of any server can lead legacy data to become unrecoverable, but cloud computing provides the opportunity to retrieve data and service since they use replicating techniques to have redundant copies of servers and storage providing an extra layer of business resilience (Azure, 2022.b).

AWS (2022.a) states, that the resiliency service not only brings back the servers and data lost due to attack, failure, natural disaster, etc. but also guarantees the system or data to be back online within the specified Recovery Time Objective as mentioned in the Service Legal Agreement.

## Cost-Benefit

Cloud service providers such as Azure provides free inbuild cost analysis and assist with industry best practices. The system dashboard also provides real-time tracking of resources consumed, assists in limiting resource consumption, analyzes system usage, and provides suggestions to minimize the cost (Winter, 2017).

For example, if any organization has a development instance that consumes 16 GB RAM and 1 TB SSD, but is used infrequently by the users. The Azure analyzer will notify the admins to change the configuration or to shut down the server when not utilized (Winter, 2017).

Combining the Azure Reserved Instances (RIs) and Azure Hybrid Benefits assists end-users to save up to 82% (Winter, 2017).

The cloud hosting platforms even provide their cost-based analysis against their competitors. Winter (2017) states Azure Reserved Instances are 67% more cost-effective than their AWS counterpart for Windows VM.

Following is a comparison, “For the calculation, we are giving servers a 5-year lifetime and an on-premise minimum guaranteed uptime of 99.9% with the following configuration: 14 vCPUs and 72GB of RAM with 1024GB of disk storage” (Azure, 2021).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| On-premise Total Cost |  |  | Cloud Total Cost (monthly) |  |
| Refresh cycle first year | $ 76,267.16 |  | Cloud Servers: | $ 1,421.75 |
| Following years: | $ 16,487.30 |  | Average monthly savings in $: | $ 1,375.52 |
| Average monthly cost: | $ 2,797.27 |  | Average monthly savings in %: | 49% |

Table 1: Cost comparison for Azure (Azure, 2021)

Similarly for AWS, Parthasarathy & Kumar (2016) uses the following case for “Windows operating system and Microsoft SQL server and the storage capacity is considered as 3 TB. The future increase is predicted as 15%” (Parthasarathy & Kumar, 2016)

|  |  |  |  |
| --- | --- | --- | --- |
| Description | On-premise | AWS | Difference |
| Administration | $9,108 | $2,277 | $6,831 |
| Environment | $31,050 | $0 | $31,050 |
| Network | $25,767 | $1,306 | $24,461 |
| Server | $26,240 | $16,382 | $9,858 |
| Storage | $7,280 | $3,443 | $3,837 |
| Total/year | $99,445 | $23,408 | $76,037 |

Table 2: Cost comparison for AWS (Parthasarathy & Kumar, 2016)

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Figure 1: Azure Cost Saving (Winter, 2017)

## Security

### Pardeshi (2014) states the availability of community clouds (discussed in the latter part of the document) which are consumed by multiple organizations of similar categories and are updated according to the latest compliance requirement.

### While Hybrid clouds are provisioned with security in collaboration with vendors and consumers. While the other cloud platforms except for private are secured using the latest security patches and updates. In the case of the private cloud, end-end security is handled by the organization (Pardeshi, 2014).

### A cloud service provider such as Azure provides the following security measures (Azure, 2022.c):

### Unify security management

### Microsoft defender for cloud protects the multi-cloud environment and assists in improving overall security by updating security configuration to the industry best practice, managing compliance by enforcing controls to maintain industry and regulatory standards, enabling threat protection for cloud (both Azure and other vendors), and on-premise systems, and detecting vulnerabilities in the hybrid workload against cyber threats (Azure, 2022.d).

### Key Vault

### Azure Key Vault Increase security and control over keys and passwords by creating and importing keys and implementing FIPS 140-2 to validate HSM (Azure, 2022.e).

### Distributed Denial of Service (DDoS) Protection

### Azure DDoS protection uses adaptive threat intelligence, DDoS mitigation at the network, and Full details of DDoS attack and mitigation plans to safeguard applications (Azure, 2022.f).

### Azure Information Protection

### Control and help secure email, documents, and sensitive data that you share outside your company by classifying data based on sensitivity and adding controls accordingly (Azure, 2022.g).

### Built-in web application firewall

### Protects applications from common web vulnerabilities and exploits (Azure, 2022.h).

### Microsoft Azure Attestation

### The service provides trust attestation service to validate multiple Environments (Azure, 2022.i).

### Azure confidential ledger

### “Store unstructured data that is completely tamper-proof and can be cryptographically verified” (Azure, 2022.c).

# Type of services

Pardeshi (2014) states, the cloud service providers offers Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and oftware as a Service (SaaS).

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Figure 2: Service Hierarchy (Azure, 2020.j)

## IaaS

Pardeshi (2014) & Azure (2022.j) states IaaS as the service offering essential computing components such as processor, RAM, Storage, and Networking device.

## PaaS

Pardeshi (2014) & Azure (2022.k) states PaaS as the service offering permitting customers to create and host their own application.

## SaaS

Pardeshi (2014) & Azure (2022.l) states SaaS as the service offering permitting customers to create and host their own application, and also provides computing essentials such as RAM, Storage, and Networking device.

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Figure 3: “Service models for Cloud. Blue indicates as level owned and operated by the organization, and red indicates levels run and operated by the service provider” (Pardeshi, 2014).

# Cloud Deployment Models

The cloud service providers provides different types of cloud models which will help the customers to achieve their end goals.

## Private Cloud

The infrastructure is provided exclusively for a single customer (Pardeshi,2014).

## Community Cloud

The infrastructure is created to support the similar type of customers, for example, a cloud-based network is created for healthcare organizations and a similar configuration will be used to support other healthcare customers. This type of cloud comes with pre-defined compliance and controls (Pardeshi,2014).

## Public Cloud

The public cloud is provided with inbuilt security, this has more generic configuration and are compliant with the laws of the local authority (Pardeshi, 2014).

## Hybrid Cloud

The hybrid cloud is a combination of local IT system along with one or more cloud vendors (Pardeshi, 2014).

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Figure 4: Cloud Environment Architecture (Pardeshi, 2014)

# Data Privacy

Sabi et al. (2016) & Pardeshi (2014) discusses the compliance requirements which includes Data Privacy thus the cloud service providers are implementing the solutions in accord to the laws of the customer country of origin.

“AWS customers can use all AWS services to process personal data (as defined in the GDPR) that is uploaded to the AWS services under their AWS accounts (customer data) in compliance with the GDPR. In addition to our own compliance, AWS is committed to offering services and resources to our customers to help them comply with the GDPR requirements that may apply to their activities. New features are launched regularly, and AWS has 500+ features and services focused on security and compliance.” (AWS, 2020.b).

Nair (2018) states the details of compliance policy implementation in Azure using the Azure Data Subject Requests for the GDPR, Azure Policy, Compliance Manager, Azure Information Protection, Azure Security Center, and Azure Security and Compliance GDPR Blueprint.

(Barati et al., 2022) discuss the growing challenge due to the shared resource pool used for cloud computing as it increases challenge for the IT and data flow auditing. The authors suggests using block chain smart contract to track the data flow and make sure the data flow are compliant with the data protection laws.

# Conclusion

As discussed by Bouyer & Arasteh (2014) and Pardeshi (2014) also signifies the importance of e-Learning which has seen an increase in the number of students in recent years. This also provides an opportunity for people who had dropped off earlier to continue their studies due to the ease and availability of resources without visiting the university campus at cheaper tuition fees.

Sabi et al. (2016), Bouyer & Arasteh (2014), and Pardeshi (2014) argue in favor of using cloud computing in the higher studies due to the inherent benefits such as scalability, cost-effectiveness, security, and inbuild risk management.

As mentioned by (Barati et al., 2022) smart contracts can be used to tackle challenges regarding the data flow and the data flow can be easily tracked which provides additional assurance to the compliance perspective.

Also, after cross-checking with the leading cloud service providers such as Azure and AWS this can be concluded, that a cloud-based approach will be beneficial for higher education institutes as it concludes the same inference.

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