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Cloud Migrationmodeler: A Comprehensive Study on Cloud Migration and Roi Evaluation

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ABSTRACT
Cloud computing has revolutionized the landscape of modern IT infrastructure, offering unprecedented access to computing resources and scalability.Despite the increasing prevalence of cloud migration initiatives, a significant research gap exists in the development of comprehensive frameworks that address the multifaceted challenges of cloud migration. Existing models often overlook crucial factors such as return on investment (ROI) evaluation, risk assessment, and alignment with business objectives.This paper introduces Cloud MigrationModeler, a model-based methodology addressing this gap by facilitating the transition of enterprise systems to cloud environments.Comprising seven distinct phases, Cloud MigrationModeler encompasses tasks ranging from initial inspection to framework testing and assessment. This paper delves into the financial implications of migration to cloud-based infrastructure, using the Azure App Service P5mv3 plan as a focal point. Through a detailed cost analysis, we aim to assess the potential ROI and strategic benefits associated with this migration. By meticulously calculating the cost differentials and efficiency gains, we offer unparalleled insights into the tangible financial benefits of embracing cloud-based solutions. Together, the introduction of Cloud MigrationModeler and the detailed ROI analysis underscore the pivotal role of research-driven methodologies and data-driven insights in guiding organizations towards successful cloud migration endeavors.This analysis underscores the necessity for a standardized migration framework and strategies.

Keywords: Cloud computing, return on investment (ROI), Cloud MigrationModeler,Azure App Service P5mv3

1. Introduction

In the past few years, cloud computing has become a notable paradigm shift in the field of Computer Technology. While not a novel technology, cloud-based computing is a unique virtual environment that provides access to computer resources. In essence, it refers to an environment where computing requirements are delegated to another party, and allowing access to computing functions and resources like databases or virtual machines can be accessed via the internet. Cloud computing has enabled companies to take advantage of its many benefits. Its use has led to increased accessibility to resources, which can be accessed anytime and from anywhere via the internet.

Cloud computing has emerged as a cornerstone of modern IT infrastructure, enabling organizations to streamline operations, enhance agility, and drive innovation. The scalability, accessibility, and reliability offered by cloud platforms have rendered them indispensable for businesses across industries. Consequently, many enterprises are embarking on the journey of shifting their infrastructure to cloud to leverage these benefits fully.

Despite the extensive uptake to cloud and the available migration frameworks and methodologies, there exists a notable research gap in the development of a comprehensive and integrated framework that addresses the multifaceted challenges of cloud migration. Current models often prioritize technical aspects, leaving out critical elements such as evaluating ROI, assessing risks, and aligning with business objectives.Moreover, many frameworks lack scalability and adaptability to diverse organizational contexts and migration scenarios.

To address these challenges and facilitate informed decision-making, we propose the Cloud MigrationModeler, which is designed to fill the identified research gap by providing a comprehensive and systematic framework that addresses the complexities and challenges of cloud migration from a holistic perspective. Unlike existing models, which may offer partial solutions or focus solely on technical aspects, this model integrates best practices, methodologies, and tools across all stages of the migration lifecycle. By incorporating elements such as risk assessment and ROI evaluation, the Cloud MigrationModeler enables organizations to make informed decisions and achieve tangible returns on their investment in cloud computing. Furthermore, its scalability and adaptability ensure applicability across diverse organizational contexts, making it a valuable resource for enterprises of all sizes and industries.As organizations increasingly embrace cloud technologies to drive innovation, enhance agility, and reduce costs, the requirement for a thorough framework becomes paramount.

In summary, the Cloud MigrationModeler represents a holistic solution for navigating the complexities of cloud migration while ensuring alignment with business objectives and delivering measurable value. By adopting this framework, organizations can embark on their cloud journey with confidence, realizing the full potential of cloud computing while optimizing their investment in IT infrastructure.

2. Related Work

Previous research in the field of cloud migration has laid the groundwork for understanding various migration strategies. However, a common limitation is the lack of comprehensive comparative analysis of how much we gain from migrating to cloud and justification for findings. For instance, the approach to showcase live cloud migration through file transfer is described in [1] through InterCloudFramework. This framework facilitates live migration of VMs, minimizing disruptions to the services actively running on these VMs.

Author in [2] advocates the adoption of a strategic migration of numerous virtual machines, particularly for big data processing tasks to achieve a balance in migration overheads, addressing both the time required for migration and periods of system downtime. They gave mathematical formulation for both and thoroughly analyzed contemporary migration strategies, including serial, parallel, and enhanced serial approaches, along with identifying their shortcomings.

The approach for secure migration is presented in [3] where they categorize SCMS in three primary iterative stages. Within these stages, security initiative for cloud environments are examined with various viewpoints, including defenders, attackers, and developers. Our Cloud MigrationModeler (in section 3) gives a more detailed approach to generate potential target architectures suitable for diverse cloud environments and assess the estimated costs change associated with onpremise framework and cloud infrastructure, taking into account the observed or anticipated workload.

In [4], the author comprehends the reasons driving the transition of locally-hosted systems to cloud, assess existing frameworks, and examine targeted cloud architecture patterns. Subsequently, it also analyzes post-migration quality issues and challenges related to cloud computing technology.

A case study of the migrating method of a System Integrator Company to cloud environment is presented in [5]. The section in [6] compiles a compendium of guidelines and best practices, offering strategic insights into mitigating vendor lock-in. LivCloud, an innovative solution tailored for live cloud migration given in [7] is engineered to seamlessly transfer virtual machines to diverse cloud infrastructure-as-a-service (IaaS) platforms, minimizing service disruptions. The study further entails an assessment of the initial implementation of LivCloud's design on an Amazon EC2 C4 instance. In their study outlined in [8], the authors initially conduct a thorough analysis of cloud migration technology, examining it through three distinct lenses: migration object, migration means, and migration objectives, focusing on aspects such as elastic expansion, load balancing, and security measures.The complexities and deliberations inherent in choosing the most suitable migration strategy, be it a lift-and-shift approach, re-platforming, or a comprehensive application rewrite is discussed in [9]. It meticulously explores the merits and demerits of each strategy, scrutinizing factors such as cost implications, time-to-market considerations, intricacies involved, and potential enhancements in performance.

The authors in [10] present a novel two-stage methodology for accurately assessing the operational expenses of relational databases in the cloud environment. Initially, the first stage of their approach involves deriving workload and structural models of the database for migration from database logs and schema. Subsequently, the second stage employs discreteevent simulation using these models to derive precise estimates of cost and duration. In the paper [12], the authors explore and analyze factors relevant to the implementation of an enterprise data warehouse (EDW). They considered aspects such as cost, scalability, flexibility, security, maintenance, and performance to assess the benefits of deploying an EDW in the cloud compared to an on-premises solution. Also, estimated cost of on-premise data center is mentioned in [13]. All this existing research works sheds light on the motivations and mechanisms driving businesses to transition from onpremise to cloud infrastructure. However, it falls short in providing a thorough examination of the cost differentials between the two infrastructures and the corresponding percentage cost benefit, namely ROI, following the migration to the cloud.

3. Methodology - Cloud MigrationModeler

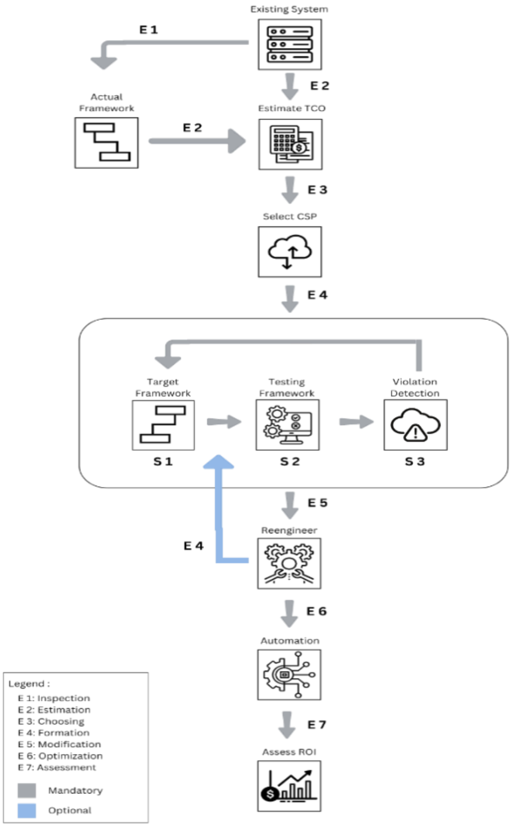

Figure 1: CloudMigrationModeler

A cloud migration methodology is a plan that an organization formulates to move all the resources in its infrastructures, such as data, services, and applications, to the cloud. It focuses on the execution of the migration plan, involving tasks such as data transfer, application refactoring, and ensuring that the migrated systems function effectively in the new cloud environment. MigrationModeler involves seven distinct events aimed at transferring an enterprise system to a cloud environment. This process involves utilizing a model-oriented approach to create a significant portion of the target framework for the system. Figure 1 outlines the model-based migration methodology –Cloud MigrationModeler. The sequential events (E1-E7) are succinctly outlined below, highlighting the integrated models for enhanced clarity and understanding.Additionally, the paper explores the cost disparities between on-premise data centers and cloud-based solutions, employing TCO of existing framework. This includes considerations such as internet usage, electricity consumption, and other essential on-premise devices. Through a comparative assessment of on-premise costs against Azure's Linux P5mv3 premium service plan, the analysis determines the annual ROI.

3.1 Inspection (E1)

Software system frameworks can degrade, resulting in a misalignment between the initially planned architecture and the current implementation. The understanding of the intrinsic framework of the system is usually inadequate, inaccurate, or unavailable. To address this challenge, a representation of the software system's current architecture needs to be obtained before utilizing model transformation in the formation of the target framework (cf. 3.4.1). In this regard, leveraging the Knowledge Discovery Metamodel (KDM) by the Object Management Group as a suitable meta-model construction for the software system and Structured Metrics Metamodel (SMM) for database modeling is recommended. The use of KDM and SMM aids in the inspection and representation of the current software architecture present on-site. Hence, this process encompasses inspection of pre-existing software architecture's utilization model, serving as the initial reference point.

3.2 Estimation (E2)

By calculating TCO, we will get an estimated financial landscape of on-premise infrastructure, which further will be used in calculating ROI. Our TCO model accounts for expenses encompassing internet services, electricity usage, and pertinent equipment within the university's data center system.Notably, the analysis excludes the direct costs associated with the construction or maintenance of the data center infrastructure itself.

Ensuring uninterrupted power supply 24/7 is crucial in any data center. An effective method involves implementing a solar energy generation system. This existing system includes thirty-one solar panels, each boasting a capacity of 370 watts, and thirty-one gel-type deep cycle batteries, each rated at 200 ampere-hours (Ah), at a total cost exceeding $19,610. The annual power consumption for the data center is $3,890, though it's important to note that electricity tariffs may vary depending on the region.

The collective cost of on-premise devices such as servers, switches, cables, and the solar system amounts to approximately $33,890, as detailed in Table 1, which gives the estimated expense for essential data center equipment.

For network security and distribution, the data center administrator relies on Cisco's firewall and internet distribution system. The yearly expense of this firewall is $5,000. Additionally, the cable internet service, providing a bandwidth of 400 Mbps, incurs a monthly fee of $70.

Table 1: TCO of on-premise structure

Entities	Cost
Power consumption	3890/year
Servers=10	1400×10=14000
Switches=5	16×5=80
Cables	200
Solar system	19610
Firewall	5000/year
Internet=12 months	70×12=840/year
Total cost	43620/year

3.3 Choosing (E3)

Characteristics shared among various cloud ecosystems are delineated within a Cloud Integration Framework (CIF). Choosing a particular cloud service provider's environment as the destination platform for the migration process inherently involves selecting a distinct instance of the CIF. In our case, we've chosen the Platform as a Service (PaaS) offering, specifically Azure App Service on Linux. The cloud infrastructure detailed in Table 2 must support 2500 concurrent users, taking into account RAM constraints.

Table 2: Azure App Service infrastructure details

Function	Description
Premium v3 Service Plan	P5mv3
Cores	32
RAM	256 GB
Storage	250 GB
Scale	30 instances

3.4 Formation (E4)

Three crucial stages (S1-S3) are created as part of the MigrationModeler formation process: a target framework, load testingand detection of violations on the target framework's cloud configuration. The breaches of these constraints identify the components of the target framework that must undergo manual remake by the redesigning. Ultimately, the target framework serves as a central artifact, manifested as an instance within the CIF that encapsulates this model.

3.4.1 Target Framework (S1)

Stage S1 represents the ultimate goal of the migration process, serving as its foundation. It embodies the set-up and integration of the chosen cloud model from the selected cloud service provider, in our case, the P5mv3 of Azure App Service on Linux, along with additional configurations. These configurations undergo thorough validation through rigorous testing to ensure they are free from any constraint violations (cf. 3.4.3). This stage, depicted as an instance within the CIF, encompasses various elements essential to Azure App Service. These include the procurement of customized domain and their assignment to respective Azure App services, acquisition of SSL Certificates for customized domain, and the implementation of IP-based SSL connections compatible with all major browsers. The costs associated with these additional configurations are outlined in Table 3.

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Table 3: Additional Configuration

Entities	Cost
Customized domain	$11.99 /year (with privacy safeguards)
WildcardSSL Certificate	$299.99/ year
IP SSL Connection	$39/month/certificate= $468/year/certificate
Total cost	$779.98/year

3.4.2 Testing Framework(S2)

Stage S2 encompasses a comprehensive testing of the functionality, performance, and security of the migrated components. Its role is pivotal in guaranteeing a seamless transition without compromising the integrity of critical processes. The Testing Framework ensures that your virtual machines are robust and reliable, capable of handling varying workloads and demands without compromising performance. It verifies the efficiency of auto-scaling mechanisms, assuring that resources dynamically scale up or down in response to varying demands, ensuring cost-effectiveness and optimal performance at all times. One aspect of testing frameworks involves conducting Load testing on Azure App Service. When applications are hosted on Azure App Service, leveraging App Service diagnostics provides additional insights into application performance and health. Throughout a load test, Azure Load Testing gathers metrics regarding the test run:

- Client-side metrics offers an overall indication of whether the application can handle excessive user load effectively.
- Server-side metrics shows CPU percentage of the app service plan, HTTP response codes, and database resource usage. Azure Load Testing dashboard analyzes these test run metrics, identifying performance of application or determining if certain compute resources are over-provisioned. For instance, you could assess whether the service plan instances are appropriately sized for your workload.

3.4.3 Constraint Violations Detection (S3)

Stage S3 continuously monitors the cloud environment, identifying breaches and deviations with precision, akin to detecting unauthorized access or unusual behavior. Microsoft Defender for App Service leverages the scalability of the cloud to detect and mitigate attacks targeting applications hosted on App Service. By scrutinizing incoming requests at various gateways, potential exploits and attackers are identified and logged. This data is then utilized to enhance threat detection capabilities and identify emerging attack patterns. Additionally, Defender for App Service detects lingering DNS entries, known as dangling DNS entries, which pose security risks when a website is decommissioned but its custom domain remains unresolved in the DNS registrar.By promptly highlighting these constraint violations, the model ensures that the cloud migration aligns precisely with the defined parameters. This proactive approach minimizes risks associated with security vulnerabilities and guarantees compliance with industry standards and regulatory requirements.

3.5 Modification (E5)

The modification phase enables the reengineer to manually modify the target framework to accommodate specific requirements that were not met during the formation technique. This step allows for adjustments based on case-specific needsand to eliminate any remaining violations or threats involved in the configuration. For instance, if the formation process did not yield the desired assignment of a critical component, re-engineering can make the necessary changes. This, in turn, ensures proactive adjustments to resource allocation, preempting performance bottlenecks and enhancing overall system efficiency.

3.6 Optimization (E6)

During this phase, the focus is on establishing the ease of management aspects within the cloud environment. The initial step involves automating various processes to reduce the reliance on manual intervention as much as possible. Automation can be applied to areas such as auto scaling, backup, disaster recovery, and deployment. Cloud monitoring is another critical aspect of effective cloud management and optimization. It involves implementing monitoring at both the infrastructure and application levels, utilizing built-in tools provided by the cloud service provider along with third-party monitoring solutions like New Relic. It is also recommended to provide knowledge transfer to the customer's team regarding cloud deployment and management aspects.

3.7 Assessment (E7)

A financial assessment can be performed by calculating the return on investment (ROI), which gauges the annualized profit or loss compared to the initial investment in adopting cloud technologies. This formula provides a method for evaluating the yearly return on investment for cloud migration, allowing organizations to assess the financial effectiveness of their cloud adoption strategy over time. The general formula for ROI based on [11] is:

$$ROI = \frac{Annual\ Net\ Gain\ from\ Cloud\ Migration}{Cost\ of\ on-premise\ solution} \times 100 \qquad (1)$$

● Annual Net Gain from Cloud Migration: Total gains from the investment minus the total costs of the investment ● Cost of on-premise solution: The initial investment comprises costs associated with on-premise infrastructure. The ROI formula, calculated as the percentage ratio of the annual net gain from cloud migration to the initial investment in on-premise infrastructure, offers a comprehensive evaluation of the investment's financial performance. It is typically evaluated on an annual basis, reflecting a one-year timeframe for assessment. However, it's crucial to note that the actual ROI may vary depending on specific circumstances, necessitating a comprehensive consideration of both tangible and intangible benefits and costs.

4. Result

In this study, we examined the financial implications of migrating to a cloud-based environment, specifically utilizing the P5mv3 Azure App Service within the Azure cloud platform. Our analysis considered both the direct costs associated with the cloud service and the expenses related to establishing a comparable on-premise solution.

The costs of utilizing the Azure App Service P5mv3 is $1,787.04 per month under a 1-year saving plan. Additionally, the annual expenses for these supplementary services including the selection of a custom domain, SSL certificate, and IP SSL connection totaled $779.98.

Therefore, the total annual cost of employing the Azure App Service can be calculated as follows:

Total Annual Cost of Azure App Service = (1,787.04 × 12) + 779.98 = $22,224.46

To determine the net gain from cloud migration, we subtracted this total cost from the anticipated expenses of maintaining an on-premise solution over the same period. With the on-premise investment estimated at $43,620 annually, the calculation yielded:

Annual Net Gain = 43,620 − 22,224.46 = $21,395.54

Finally, we calculated the ROI using the Equation (1) and substituting the values, we obtained: ROI = (21,395.54/43,620) × 100 ≈ 49.05%

5. Conclusion

The calculated return on investment (ROI) of approximately 49.05% underscores the financial viability and potential benefits of migrating to a cloud-based environment, particularly leveraging the P5mv3 Azure App Service within the Azure platform. This analysis demonstrates that the financial gains from cloud migration, including cost savings and enhanced scalability, outweigh the expenses associated with maintaining an on-premise solution.By harnessing the power of sophisticated modeling techniques, MigrationModeler offers a structured pathway for organizations to navigate the complexities of cloud migration with confidence. It seamlessly orchestrates the transition process, ensuring a smooth and efficient journey towards the adoption of PaaS-based cloud infrastructures.However, it's crucial to acknowledge that the sensitive nature of most application data raises valid concerns regarding security. Storing this data in the cloud may heighten apprehensions due to the perceived vulnerability of cloud networks to security breaches.In conclusion, the compelling ROI highlighted in this analysis underscores the strategic significance of cloud migration in driving cost efficiencies, operational enhancements, and sustained competitiveness.Embracing cloud technologies represents a prudent investment strategy for organizations aiming to fully capitalize on the transformative potential of modern digital infrastructures.

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