



Challenges In Migrating Legacy Software Systems To The Cloud—An Empirical Study

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Abstract— The main focus of this research is to perform empirical research on the concept of migrating legacy software systems to the cloud and identify and address frequent problems and suggestions that arise. Several academic and industrial applications of legacy system transfer to the cloud present both obstacles and advantages. We've broken down the current migration techniques into three distinct approaches based on how well they've been studied and how far they've been put into practice. Different migration strategies need additional considerations, and as a result, other responsibilities will be assigned. [1]. There are technical and non-technical resources and obstacles in migrating current legacy systems to cloud platforms. Many cloud computing migration problems may be traced back to a lack of awareness and readiness in organizations. This paper sheds some light on the most challenging aspects of re-engineering legacy systems to run on cloud platforms in this essay.

I. INTRODUCTION

The use of third-party cloud migration services is growing exponentially. The cloud computing sector has witnessed a recent uptick in demand as more companies choose this method of data storage. The demand for services like Infrastructure As A Service (IaaS) and Platform As A Service increases. On-premises applications and software packages that have gotten antiquated or out-of-date over time are referred to as "legacy apps"[2]. These applications include customer relationship management (CRM), sales apps, QuickBooks, and other industry-specific software. Businesses are always looking for new methods to operate and speed up innovation. Cloud migration is becoming increasingly popular as more companies are concerned about increasing digital demand and scalability challenges. A company's I.T. systems must be modernized when they outgrow their present platforms or infrastructure. An upgraded system, such as a cloud-based service, may improve performance and provide organizations an advantage in the marketplace.

Decision-makers must have broad judgment and insight to fully appreciate the options and the set of essential decisions in the direction of cloud adoption due to the examination of many variables such as economics, strategic risks, and technology concerns [1]. It's not easy to move a legacy application to the cloud, and there are various obstacles to overcome. For small and medium businesses hoping to reap the benefits of cloud computing, the

magnitude and complexity of this endeavor might be daunting. [3] Due to rapid advancements in associated technologies, many of the challenges to be addressed remain poorly understood [3]. The cloud is characterized by abundant resources, including memory, CPU, network bandwidth, and storage. Service users may reserve and release these resources based on demand, allowing them to use them better as workloads fluctuate [4]. Cloud-sourcing decision-making still lacks empirical evidence, according to certain studies [5]. Our research on the problems of moving old systems to cloud computing was motivated by this fact.

Keywords: Legacy systems, Cloud systems, Legacy applications, Re-engineering, Cloud migration, Software Migration.

II. RESEARCH PROBLEM

The main problem that this paper will address is the main challenges facing the migration of legacy systems to the cloud. Migrating old systems involves many issues and risks. For example, whether the migration procedure solely entails moving data into a new system or if it also involves moving application functionality as well. Additionally, the type and status of the legacy system that has to be updated affect the problems encountered by a migration project's success. Legacy systems may be a stumbling block for corporate development, as organizations must find the resources needed to upgrade their infrastructure. It will be impossible to invest in infrastructure and resources at each expansion stage if there is no steady flow of funds. Things become more complicated when a company experiences rapid expansion or is no longer tied to a single market. It's not always a simple option to migrate the program. There are situations when moving from an older but still functional software system to a newer one is impractical. To do so may not even be possible with the resources at hand. However, in some instances, it may be a wise option that offers the company an edge over its rivals and helps the company better satisfy the needs of its customers[6].

III. LITERATURE REVIEW

i. What Is a Legacy Application and How Does It Work?

A legacy application is a software program that has been in use by a corporation for an extended period and employs technology that is older than the existing industry standard or has become outdated. Many businesses put a lot of effort and money into developing apps that they anticipate to last for many years. In the past, databases were

stored on minicomputers and mainframes. Most businesses will inevitably conclude that their existing apps no longer provide enough value. As a result, maintaining and updating legacy applications may take up a significant percentage of a software team's time and resources[7].

Making necessary modifications to a legacy program might be challenging if the code is poor quality or the application architecture is insufficient. It may also be challenging to grasp the source if there isn't enough documentation. Regression issues may arise in certain companies due to a lack of automated testing[7]. Businesses might face a range of problems if they continue to utilize an old or obsolete legacy program. Older systems are more prone to problems, including bugs, mistakes, and other concerns. Over time, the system's documentation may become out-of-date or inadequate, resulting in data loss. A legacy program may also contribute to lower business continuity, soaring I.T. maintenance costs, and a lack of overall dependability. New staff may also be unfamiliar with historical apps that are no longer supported.

ii. What Is Cloud Migration?

Cloud migration is transferring apps, data, and other business pieces from a local computer to a remote cloud computing environment. Various cloud migrations, such as moving applications from an on-premises data center to a public cloud, are possible for businesses. As part of cloud migrations, it is possible to move apps across cloud providers or platforms. Reverse cloud migration, often known as 'cloud exit,' is the third form of cloud migration. When an application is relocated from the cloud to a local data center, this is what happens. Performance, affordability, and security are all crucial considerations in cloud migration, with the primary aim being to host applications in the most efficient I.T. environment feasible based on these considerations. [7,8] A well-thought-out transition plan may guarantee minimum downtime and interruption of routine company activities while moving to a cloud-based environment.

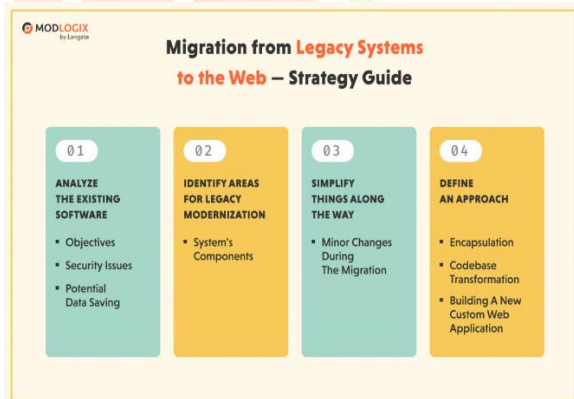


Fig i: Strategies for Legal software systems migration Keeping in mind that not all business applications should exit the data center is critical. Some business-critical applications, such as high throughput, low latency, or stringent geographic constraints, may not need relocation.

iii. Why migrate to the cloud?

The capacity to develop and scale on the cloud is the most significant benefit. Cloud technologies exists as a way to achieve these two aims, which are at the heart of every company's mission. These reasons include, but are not limited to:

a. Cost

The total cost of ownership is increased by establishing and maintaining technological infrastructure. Purchase of components, employment of professionals for system setup, authorization and security measures, interoperability

between the hardware and software, and updating the system are all expenses. If you don't have the time or resources to do this, companies should outsource it to a team of experts or teach the personnel to do it. Any legacy system has these fundamental shortcomings.

When Amazon and Microsoft began delivering cloud services to thousands of users, businesses could instead select infrastructure as a service and pay only when they needed it. Costs have been spread over a vast consumer base, making services more inexpensive.

b. Resources

Businesses must spend on human resources to set up, administer, and maintain legacy systems. Maintenance of the methods is the responsibility of specialized personnel, all of whom must be well-versed in the system's inner workings to keep it compatible and future-proof. It's also worth noting that when businesses use infrastructure and platform services, they receive professional assistance as part of the deal. The service provider handles staffing, training, maintenance, and upgrades. As a result, companies are free to concentrate on what they do best.

c. Security

Businesses are concerned about the security of their data. They and their customers are still worried about it. It was unaffected by the advent of cloud computing platforms. As of late, organizations have spent less time and money on this area because of IaaS, which provides security as part of the total package [9]. Businesses must devote a percentage of their profits to security and threat avoidance when using outdated technology. In addition, they are required to examine their infrastructure regularly to see whether it is vulnerable to new threats and if it can resist them. Many small organizations have challenge deciding how to spend their money since their profits are tiny. However, new ideas like the "shared responsibility model" have entered the market due to the advent of cloud services. AWS, for example, will take care of the hardware, network, and other facilities required to operate the systems while companies are in charge of encryption and authorization [10]. Businesses no longer have to spend money on R&D and infrastructure upkeep. The service providers will bear both the liability and the expense of this. It's more probable that they'll invest in quality and security since their whole business model relies on it. They also have the resources to do so compared to companies that rely on outdated systems.

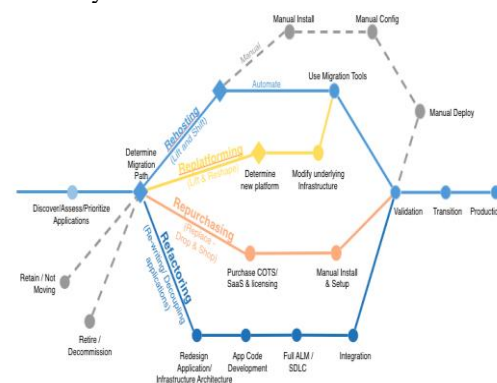


Fig ii: Effective migration strategies

d. Authorization and Easy Access

Data theft and other dangers are more likely to occur on legacy systems since the data is housed on local premises. Anyone who has access to the premises where the information is held may be able to access the data, whether it is encrypted or not. Because of this, organizations have to take additional measures to secure the safety of old systems' data. However, data are saved on a cloud system that is safe and secure. Service providers

often require that the data be encrypted to prevent data leaks. Many features allow for many levels of access, and typically tracking mechanisms are put in place to keep track of who is accessing what.

e. Collaboration

It is possible to collaborate with individuals from all over the globe at the same time on a cloud-based platform. Because of this, businesses can now recruit people from all over the world, which improves production and communication. Locating the right talent locally or at a lower cost may be a problem [11]. Cloud computing has given organizations a solution to these problems.

f. Speed

Cloud platforms are frequently faster and more responsive than traditional systems because they use the newest technology. Many cloud service providers invest significant resources in improving the Platform's performance, interoperability, and uptime via research and development.

iv. Legacy systems migration

Data and users are transferred to the new, more modern system. I'd suggest making sure there's a straightforward way for people to migrate. Before making any further modifications, it's critical to duplicate the underlying data model. Many businesses dread the idea of legacy migration, yet it's a necessary evil for many. A proven and established strategy such as our 6-step approach may avoid some pitfalls. Still, it can also assist companies in transforming the legacy migration process into a profitable endeavor for the organization.

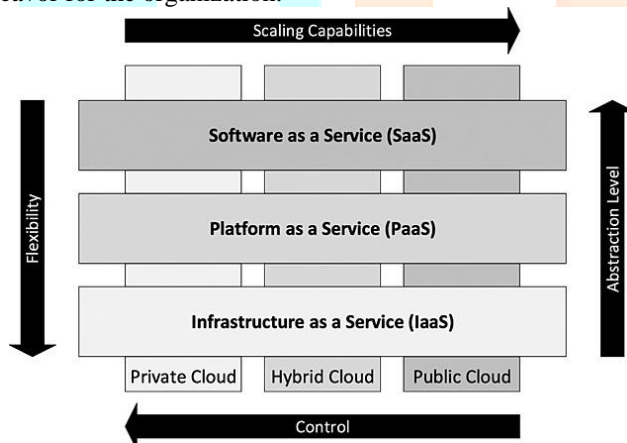


Fig iii: Migrating legacy software to the cloud

a. Migration to IaaS

When using an Infrastructure as a Service solution, the vendor supplies all the hardware, computing, storage, and networking resources necessary for the application to execute (often on a virtual machine). Customers have complete control over the virtual machine (V.M.) they've been given. Based on the mapping, rehost and revise are the two migration methods connected to the migration to IaaS strategy. The IaaS solution may seem to be a quick and straightforward option, but some drawbacks during the migration to cloud [11]. Dynamic resource needs, storage location restrictions, unique hardware device requirements, and the volume of the data stream must be considered by users. Despite the ease and speed with which one might migrate to IaaS, it is imperative to thoroughly examine one's needs before making a final decision. Before migrating an application, companies should think about the associated costs and the system and resource needs. Estimates of migration costs for IaaS and PaaS solutions and the factors that contribute to the expenses of each. Migration to IaaS is less expensive if the number of resources needed can fit within a pre-set service plan[12]. But there may be additional costs incurred by the

installation, training, and administration of the infrastructure resources, which are required since the users must learn how to handle them independently.

b. Migration to PaaS-based architecture

When creating cloud-based solutions and apps, PaaS is a standard tool. As with conventional SOA design, PaaS relies on a variety of standard pre-built services to help developers build their applications. Microsoft® Azure™ is an example of a PaaS that provides a platform for web application hosting and data storage. Web applications are integrated with other services and apps utilizing Azure's service bus [10]. The integration does not need the creation and configuration of virtual machine instances by hand. Software development and delivery more accessible by Platform as Service solutions, which offer the whole cloud I.T. stack, including databases and middleware. It is then used to build up and deliver cloud applications on the cloud. Refactor, revise, and rebuild are the migration methods associated with the Migration to PaaS strategy. PaaS solutions need that the migrated program adhere to particular platform requirements, such as compatible programming languages and databases, middleware and third-party libraries, and any other PaaS-specific requirements. The cost of migrating to a PaaS solution is mostly due to the changes needed to the legacy application to match the limits of the chosen PaaS solution. To put it another way, the cost of migration truly relies on the amount of work required to make the old application's components compatible with the PaaS. Because PaaS operates at a higher level than IaaS, it is not subject to the same hidden administrative costs as IaaS.

v. CHALLENGES OF LEGACY SYSTEM MIGRATION

One of the most difficult aspects of data migration is dealing with data that might be in various states. Evaluating whether or not missing or unclear data sets would negatively impact migration or usage in the old system is one of the most difficult challenges to overcome. Identifying which data sets need to be transferred is also an important challenge; removing data that isn't required might save money, but determining where to make those cuts is difficult. [12] Data scientists and planners may require considerable time and effort to select critical data sets for migration [12].

In addition, companies may encounter challenges when automating and integrating data manually. Data input may create a variety of challenges, not the least of which is securing the necessary manpower to complete the data entry process. Project implementation employees may be required to manually code portions of architecture in addition to manually inputting data for migration [12].

The "containers" or systems that manage the data provide additional issues. Legacy software transfer may provide several challenges, some of which comes from a lack of knowledge of the system's original design. A common theme amongst experts discussing legacy conversion initiatives is the presence of issues related to proprietary systems and nonstandard tools or code. For planners to be successful, they must have a thorough understanding of how existing systems work and how they may be adapted to a new platform or context.

These projects also have their own set of intrinsic challenges, such as the details required to prepare for them. Scheduling and resource allocation are two of the most often raised concerns by I.T. professionals. The whole project suffers if a critical phase is not given adequate time. As a result of these and other factors, experts advise offices to prepare a comprehensive legacy migration strategy in advance [13]. The term "data governance rules" or

"organisation structure" is used by others to describe how certain resources are delegated to others. All of this forethought contributes to a seamless and successful move in the long run. Before migrating huge amounts of workload to the cloud from an on-site data center and infrastructure, there must be meticulous preparation. Features such as these should be kept in mind.

a. Compatibility with the Cloud

A cloud environment may not be compatible with certain older apps. Existing applications must be re-architected or refactored to make them cloud-ready for businesses. For big systems, such a migration may be time-consuming and costly, and the choice to move relies on the kind of application and its influence on the organization's business capabilities.

b. Adaptation and customization.

There is a lot of change involved in moving to the cloud, which may interrupt daily operations and cause short-term productivity losses. Before relocating any data, establish which components of the program rely on one another and then move these groups together to prevent this problem. In terms of a successful move, individuals are generally the largest obstacle. Change might be difficult for people to accept [13,14]. There is also a lot of change and disruption with a cloud migration—often with new systems, procedures, and even leadership. The bottom line is that a successful move will be difficult to perform if the human factor is not properly controlled.

c. A lack of skills

A shortage of qualified personnel may hamper cloud migration projects. As a result, companies need to track down a reputable service provider with experience migrating old apps and capable staff to carry it out. Despite the numerous advantages of cloud computing, many organizations are turned off by the challenge of transitioning. There is a major challenge in finding personnel who can effectively manage a move. A growing number of businesses are looking to migrate to the cloud, which has led to a rise in demand for cloud migration professionals. Because of this, there is a shortage of cloud professionals (at least for now). According to a McAfee study, the cybersecurity skills gap is preventing 40 percent of I.T. employees from moving to the cloud. That's a major issue for companies seeking to stay competitive[14].

d. Cost

In the near term, the cost of upgrading may outweigh the benefits to a company's bottom line, so it opts to keep what it has. However, modernization brings corporate value by boosting scalability and dependability and reducing operational expenses in the long term. The long-term benefits of cloud migration include higher efficiency, decreased administrative expenses, and a more efficient work environment. It's still an (expensive) uphill struggle to get there[15]. Concerns about one's financial well-being permeate practically every aspect of the relocation process. Before companies consider the potential long-term financial consequences of poor or sluggish adoption and training after the relocation, companies have to consider the immediate costs of moving.

The following are the most expensive aspects of cloud migration:

- Rewriting application design for the cloud
- Investing in the people and resources necessary to migrate
- Training users effectively on the new systems
- Performance concerns such as latency, interoperability, dependency on non-cloud applications, and downtime
- Bandwidth expenses.

Despite the lengthy and daunting list above, it is feasible to migrate to the cloud successfully and affordably.

e. Risks

Many migrations fail, their costs exceed the budgeted amount, and they take considerably longer than anticipated. Such failures occur because of a lack of a well-thought-out strategy and limited project assessment competence. Based on regular evaluations of the present technology stack and the company's capacity to successfully migrate, companies should develop a modernization strategy.

IV. FUTURE IN THE U.S.

American legacy systems are being modernized to address new challenges. By 2023, 65% of organizations plan to invest in new technology platforms to replace aging legacy systems [16]. By 2023, IDC projects that expenditure on digital transformation would rise from 36 percent to 53 percent of total ICT investment, a significant increase. An enterprise's investment strategy will significantly impact the amount of money it can save in the long run. These ten most essential government legacy systems, some dating back to the 1970s, have just been recognized by the U.S. Government Accountability Office (GAO). However, a total of 65 systems were submitted for consideration. Many of them are based on out-of-date programming languages such as COBOL, have hardware or software maintenance concerns, and are vulnerable to security attacks [17]. During the next 10-20 years, the utilization of mainframes will decline as multi-cloud computing continues to grow rapidly. Financial sector organizations have been using a "legacy modernization" method to upgrade technology for several years, but 2020 has sped things up significantly.

Social isolation and lockdown limitations in many regions of the United States have compelled consumers to utilize digital channels to make purchases. It's possible to create a virtual server on Amazon Web Services, Microsoft, or Google, but it requires manual resource allocation from a mainframe provider. While Microsoft Azure and Google Cloud Platform each accounted for 18% and 8%, Amazon Web Services accounted for 32% of the market [17]. Maintaining long-term infrastructure for legacy systems may raise the total cost of ownership, making legacy application modernization a need. Keeping organizations safe from cyberattacks, malware, data breaches, and other security threats requires modernizing outdated systems. There is a greater chance for creativity with current systems since they are simpler to integrate. The company's ability to compete in the market will improve if the outdated systems are modernized.

It is estimated that in 2019, the United States Federal Government spent 80% of its I.T. expenditure on Operations and Maintenance. A large proportion of this money is put on old, inefficient, and vulnerable legacy systems. For perspective, just 20% of the I.T. budget was earmarked for the development and enhancements of the I.T. infrastructure.

V. ECONOMIC BENEFITS IN THE UNITED STATES

There are huge economic benefits of legacy software systems in the United States. Customer demand for services based on real-time data has not been addressed since fundamental banking systems are updated once a day rather than immediately, according to an Ernst & Young research from 2019. However, FinTech businesses and BigTechs such as Amazon and Apple use real-time data that is baked into their systems to make their decisions. Across all industries, companies like Maersk and merchants like

Amazon are taking a big step forward in modernizing their outdated systems [18].

Conclusion: There are many reasons why I.T. managers want to keep their momentum going when their staff can work from home successfully. There are fewer one-size-fits-all SaaS solutions, so architects and developer leaders must make more difficult choices about lifting and shifting and what to rearchitect for the cloud with these business applications. Legacy ERP systems are being phased out in favor of cloud-based alternatives in today's quickly evolving corporate landscape. Small and medium-sized companies (SMBs) now have the same benefits as their bigger counterparts, who have the bandwidth and resources to support such I.T. initiatives. Gartner projects that the cloud services industry will increase by 17.3% in 2019 to reach \$206.2 billion[18]. More and more organizations realize that there is no legitimate reason to continue supporting outdated, legacy desktop and local network systems. In-house applications and well-known software that has been tailored to meet the demands of a particular business are both examples of legacy applications.

VI. CONCLUSION

This paper did an empirical study on the Challenges of migrating legacy software systems to the cloud. System migration preparations might take a long time. Most of the time, the solution is envisioned to be a multi-year project, including creating new systems and extensive data transfer. There are several advantages to moving legacy apps to the cloud, which are critical to businesses. However, a cloud migration specialist may be required to design and execute the conversion. In particular, organizations with limited resources to safeguard and manage data on-premises would benefit from the cloud, as will workers who want remote access to legacy legacy software systems from various devices. Migration of legacy systems to cloud infrastructure improves the flexibility and cost-effectiveness of software application testing with dynamic application code testing that identifies problems in operating applications even while they are being tested. It is anticipated that software development teams will have an easier time producing code and real-time project coordination on the cloud because of this flexibility in testing. Businesses must invest in cloud storage that can be accessed by remote workers who are writing code from various places, as well as those in the same company. For a long time to come, there will be a lack of skilled workers. Most companies can't employ and onboard a new cloud engineering staff simultaneously as the labor market catches up. They may, however, benefit from a cloud partner who can assist in guaranteeing a seamless transfer of their legacy systems and optimize cloud operations for long-term success at a fraction of the cost compared to adding large internal manpower. With the right strategy in place, companies can turn their legacy systems into newer, more efficient systems that will help you stay ahead of the competition. Start by looking for an existing system that requires replacing or a new system that relies on information only available in the legacy systems for logic or data.

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