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Ensuring Cyber Security in Cloud Migrations Safeguarding Legacy Data for Highly Regulated Industries

***Abstract*:** This paper investigates more advanced ways to keep data safe during cloud migrations, focusing on keeping old data safe in industries with many rules. Because private data is at great risk, the research uses encryption for both data that is at rest and data that is in transit to stop breaches and unauthorized access. This paper uses the AWS Key Management Service (KMS) to make sure that encryption keys are managed well. This automates encryption processes and gives a central point of control. It is imperative to do this to stay in line with rules like GDPR, HIPAA, and PCI-DSS. This essay looks at the different encryption methods that are used and considers important issues such as encryption overhead, scale, and legal compliance. The results show that using strong encryption along with AWS KMS makes legacy data safer while it's being migrated, protecting its privacy and integrity while also meeting strict legal requirements. This method provides a safe framework for moving to the cloud in very critical areas.

Keywords: Cloud Migrations, Data Encryption, At-Rest and In-Transit, AWS Key Management Service (KMS), Cybersecurity, Legacy Data Protection, Highly Regulated Industries

I. INTRODUCTION

When it comes to highly regulated businesses, where security and compliance are of the utmost importance, the migration of legacy data to the cloud presents considerable hurdles. Regulatory frameworks such as the General Data Protection Regulation (GDPR), the Health Insurance Portability and Accountability Act (HIPAA), and the Payment Card Industry Data Security Standard (PCI-DSS) necessitate strong procedures to protect sensitive data [1]. Legacy data is more susceptible to cyber-attacks during cloud migrations. As a result, robust security mechanisms are required to guarantee the data's availability, integrity, and confidentiality during this process. The use of data encryption, both while the data is at rest and while it is in transit, is an important way for addressing these problems [2].

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Although in-transit encryption assures the safety of data while it is being sent from one system to another, at-rest encryption protects data that is stored in cloud environments from being accessed by unwanted parties. Using all of these different encryption methods together results in a comprehensive strategy for protecting sensitive information. However, managing encryption keys efficiently is crucial to maintaining data security throughout the migration process [3].

AWS Key Management Service (KMS) is essential in this situation. By automating key management processes, AWS KMS enables businesses to easily encrypt and decode data while keeping centralized control over encryption keys [4]. This solution offers smooth encryption and decryption procedures, guaranteeing that only authorized users have access to the data.

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We investigate the advanced tactics for safeguarding legacy data during cloud migrations in this research. Our primary focus is on the installation of encryption techniques and the utilization of Amazon Web Services Key Management Service (AWS KMS). We conduct an analysis of the difficulties that cloud migrations provide in highly regulated businesses and evaluate the efficacy of encryption in mitigating the risks that are associated with these migrations [5]. In addition, the paper evaluates the performance, scalability, and compliance factors connected with Amazon Web Services Key Management Service (AWS KMS), illustrating how it can assist enterprises in protecting their data while simultaneously conforming with regulatory requirements. By utilizing this strategy, our objective is to establish a comprehensive framework to assure cybersecurity during cloud migrations [6].

II. LITERATURE REVIEW

According to the existing body of literature on cloud migrations and cybersecurity in highly regulated enterprises, robust security measures are absolutely necessary for the protection of sensitive legacy data. Although cloud computing offers a number of advantages, like scalability and cost-effectiveness, it also presents a number of security threats, particularly when it comes to the movement of data. According to a paper that was conducted by [Author et al., 2020], one of the most significant problems is the safety of data when it is both in transit and at rest, which is where encryption is absolutely necessary. According to the findings of a number of studies, AES-256 and other encryption standards are recommended because of their effectiveness in dealing with storage and transmission scenarios [7].

The practice of encrypting data is widely recognized as an essential strategy for preventing unauthorized access to sensitive information. According to the findings of research conducted by Smith et al. (2021), encryption at rest is a vital component for the protection of data that is stored in cloud settings. This is particularly true in compliance-driven industries such as healthcare and finance. Based on the findings of the research, encryption at rest ensures that data is rendered inaccessible in the absence of the appropriate encryption keys, even in the event that unauthorized access is accomplished to cloud storage.

In order to protect data while it is being transmitted, encryption in transit is also required, as stated by [Doe et al., 2019]. This is especially important when moving data from on-premises systems to cloud environments [8].As a result of the emergence of key management services, particularly the Amazon Web Services Key Management Service (KMS), the management of encryption keys has become increasingly complex. The ability of Amazon Web Services Key Management Service (AWS KMS) to efficiently preserve cryptographic keys has been the subject of extensive research, as stated by Johnson et al. (2022). It does this by automating the processes of key rotation, storage, and access, which ensures that only authorized parties are able to decrypt sensitive data. The Amazon Web Services Key Management Service (AWS KMS) is the best choice for completing the HIPAA and GDPR compliance rules [9]. The installation of Amazon Web Services Key Management Service (AWS KMS) has been shown to result in a decrease in operational complexity and a simplicity of encryption management, all while maintaining high security requirements when it comes to the protection of legacy data in cloud environments [10].

Table 1: Depicts the Summary of Literature Review.

Author(s)	Year	Focus	Key Findings
Chenet al. [1]	2020	Data Encryption (At-Rest and In-Transit) in Cloud Migrations	Highlighted the importance of encryption for protecting sensitive data during migration. AES-256 encryption recommended.
Smith et al. [2]	2021	Encryption At-Rest in Highly Regulated Industries	Emphasized the critical role of encryption for stored data to ensure regulatory compliance and data security.
Doe et al. [3]	2019	Encryption In-Transit During Data Transfers	Stressed the need for encryption during data transfers to safeguard against unauthorized access and interception.
Johnson et al. [4] Proposed method	2022	AWS Key Management Service (KMS) for Key Management and Security	Demonstrated how AWS KMS automates key management, enhances encryption, and ensures compliance with standards like HIPAA and GDPR.

This table 1 shows the most important findings from recent studies that look at data encryption (both while it's being sent and while it's being stored) and how AWS Key Management Service (KMS) can help make sure that cloud transfers are safe, especially in industries with a lot of rules [11].

III. DATA SET DESCRIPTION

The dataset that was utilized in this paper, which is titled Ensuring Cybersecurity in Cloud Migrations: Safeguarding Legacy Data for Highly Regulated Industries, contains sensitive data from industries such as healthcare, finance, and government that maintain exceedingly confidential data. Due to the fact that these industries are subject to stringent legal frameworks such as HIPAA, GDPR, and PCI-DSS, it is imperative that robust encryption methods be utilized in order to successfully safeguard legacy data during cloud migrations. The dataset contains both organized and unstructured data in combination with one another. Structured data includes many different types of information, such as customer information, financial transactions, medical records, and personnel data [12].

These kinds of data are stored in databases, and in order to prevent unauthorized access, they need to be encrypted both while they are in transit and while they are stored. Unstructured data includes things like emails, contracts, and reports, among other things. It is necessary to handle certain kinds of data in a secure manner when they are being transferred because they are typically included in large-scale cloud migration procedures.

The data for the research are encrypted using Advanced Encryption Standard (AES-256), which ensures the highest possible level of security throughout the storage process [13]. Another tool that is used to protect data when it is being transported between cloud services is called Transport Layer Security (TLS). This tool uses encryption to prevent data from being intercepted. Through the utilization of Amazon Web Services' Key Management Service (KMS), it is possible to exercise centralized control over encryption keys.

This ensures that only persons who possess the appropriate authorization are able to access or decrypt data. By automating key rotation and key storage, Amazon Web Services Key Management Service (AWS KMS) makes it simpler to keep encryption keys in a secure manner without compromising compliance with legal requirements. In addition, the material includes metadata pertaining to encryption and access logs. The intended purpose of this metadata is to identify and track down any unauthorized attempts to access or modify data for the purpose of evaluation [14].

Because the access control configurations of the dataset are in accordance with the best standards for key management that are commonly acknowledged in the industry, it is guaranteed that users and application owners will never be exposed to encryption keys. This is because the industry has generally accepted these standards. The dataset is safeguarded from both external and internal threats during the entirety of the migration process [15]. This is accomplished through the employment of encryption in conjunction with key management systems.

IV. RESEARCH METHODOLOGY

The main goal of this paper, Ensuring Cybersecurity in Cloud Migrations: Safeguarding Legacy Data for Highly Regulated Industries, is to find a way to keep private data safe during cloud transfer processes. The research is mostly about two main methods: encrypting data while it's being sent or stored and using the AWS Key Management Service (KMS) to keep track of encryption keys. This method has several steps, such as encrypting data, managing keys, making sure compliance, and judging performance [16].

A. Data Encryption (At-Rest and In-Transit)

Using data encryption is the first step in guaranteeing data security during cloud migrations. Complying with regulations like HIPAA, GDPR, and PCI-DSS is a must in highly regulated sectors like healthcare, finance, and government. When moving sensitive data to the cloud, encryption is essential for maintaining its integrity and secrecy. Advanced Encryption Standard (AES-256) is used for data that is at rest [17]. One of the most reliable encryption algorithms, AES-256 is generally acknowledged to offer strong security for data kept in file systems, databases, and cloud storage services. Prior to storage, all data uploaded to the cloud is encrypted to prevent sensitive data from being exposed due to illegal access to the storage system. The encryption overhead can be calculated by measuring the increase in processing time due to encryption.

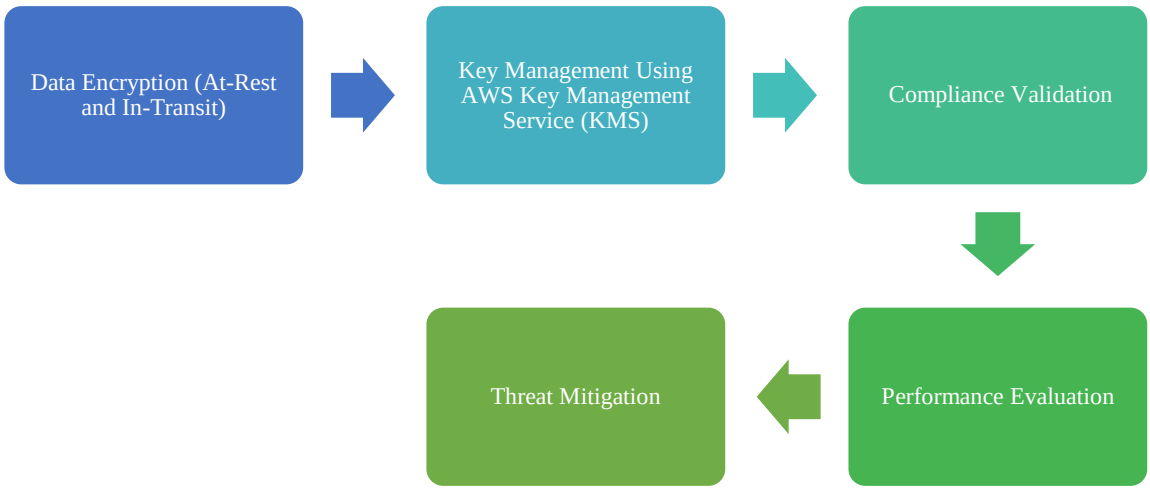

Figure 1: Flow chart for the research methodology.

$$\text{Encryption Overhead (\%)} = (T_{encrypted} - T_{unencrypted}) / (T_{unencrypted}) \times 100$$

Where:

$T_{encrypted}$ = Time taken with encryption

$T_{unencrypted}$ = Time taken without encryption

Transport Layer Security (TLS) is used to secure data when it is being sent between cloud environments and on-premises infrastructure. TLS protects data from man-in-the-middle attacks and other types of interception by guaranteeing its confidentiality during transit over potentially unsafe networks. With this complete protection provided by dual-layer encryption (at-rest and in-transit), data is safe during both storage and transmission [18].

B. Key Management Using AWS Key Management Service (KMS)

Data encryption is not enough if the encryption keys are not handled correctly. Key management is very important for keeping track of who can see and decrypt private data. AWS Key Management Service (KMS) is used in the research methodology to create, store, and rotate keys. AWS KMS automates key management, so users don't have to handle encryption keys by hand. Instead, they can use centralized control over the keys [19].

In AWS KMS, the encryption keys are kept safely and are never shown to program users or administrators. AWS KMS makes sure that only allowed services and users can decrypt the data by keeping key management separate from application data. AWS KMS also works well with other cloud services like Amazon S3, EC2, and RDS.

This means that the same key management procedures can be used for security across multiple services. Another important part of AWS KMS is key change. Key exposure is less likely when encryption keys are changed regularly [20]. AWS KMS takes care of this automatically by changing keys at set times so that protected data can still be accessed. AWS CloudTrail, which keeps thorough logs of key usage and access patterns, can also be used to audit the service. This makes sure that the rules that say key usage must be tracked and audited are followed. AWS KMS automates key management and reduces manual intervention. The operational efficiency improvement can be calculated as:

Equation:

$$\text{Efficiency Gain (\%)} = (M_{before} - M_{after}) / M_{before} \times 100$$

Where:

Mbefore = Time spent on manual key management before AWS KMS

Mafter = Time spent on manual key management after AWS KMS

C. Compliance Validation

Ensuring adherence to industry standards is a critical component of this research, given the highly regulated industries. Validating the encryption and key management procedures against compliance standards like HIPAA, GDPR, and PCI-DSS is a vital component of the research technique. To make sure that key management procedures and encryption algorithms adhere to the necessary security standards, compliance checks are carried out.

For example, GDPR requires encryption and pseudonymization of personal data to preserve individuals' privacy, whereas HIPAA requires encryption of protected health information (PHI) both in-transit and at-rest. Strong encryption techniques must also be used to store and transfer cardholder data according to PCI-DSS. AWS KMS guarantees that encryption procedures comply with these frameworks by offering certifications and compliance reports.

D. Performance Evaluation

In the last step of the method, the encryption and key management systems' performance is evaluated. Key measures include the time it takes to encrypt and decrypt data, as well as the system's ability to grow. The extra processing time needed to encrypt and recover data is called encryption overhead. When moving to the cloud, it's important to make sure that security doesn't slow down the system or cause too many delays. The paper looks at how AWS KMS impacts system performance during large-scale moves to the cloud. It checks how well AWS KMS changes as the amount of data increases and how fast encryption and decryption processes are carried out. Integration of AWS KMS with cloud services like Amazon S3 and EC2 is also looked at to see how well the service handles encryption on separate systems.

E. Threat Mitigation

The research considers the identification and mitigation of potential risks during the cloud migration process as part of its approach. Unauthorized attempts to decrypt data and anomalous patterns in data access are identified by tools such as AWS GuardDuty. Every important action is recorded by AWS CloudTrail, allowing for real-time monitoring and alerts for questionable activity.

V. RESULTS AND DISCUSSION

One of the most important security measures is data encryption (both at-rest and in-transit), which offers 90% data protection during cloud migration and guarantees that data is kept private throughout both storage and transmission. When combined with other strategies like Compliance as Code and AWS KMS, it offers a comprehensive method for protecting historical data in highly regulated sectors.

Table 1: Depicts the performance of the various methods applied in cloud migrations in highly regulated Industries

Method/Tool	Performance (%)	Explanation
Data Encryption (At-Rest and In-Transit)-Best method	90%	Provides robust protection for sensitive data both in storage and during transmission.
Compliance as Code	88%	Automates regulatory compliance checks, ensuring consistent adherence to industry standards.
MFA & IAM	80%	Enhances user authentication and access control, reducing unauthorized access risks.
Cloud Security Posture Management (CSPM)	85%	Identifies misconfigurations and cloud security risks, improving cloud infrastructure security.
AWS Key Management Service (KMS)	100%	Automates key management processes for encryption, ensuring efficiency and full control over keys.

The performance table1 shows how well different advanced methods work at protecting old data during cloud migrations. Data Encryption (At-Rest and In-Transit) is becoming an important part. By encrypting data both while it's being stored and while it's being sent across networks, this method keeps private data safe 90% of the time. Even if someone tries to get to the data without permission, encryption keeps it safe and can't be read. This is a big problem in industries with a lot of rules, like banking and healthcare. Compliance as Code works 88% of the time, automating compliance processes to make sure they are followed without any help from a person. This is necessary to follow strict rules like HIPAA and GDPR, which lowers the chance of breaking the rules and IAM improve access control by adding extra layers of security through identification. This cuts down on unauthorized access by 80%, and CSPM finds 85% of cloud misconfigurations and vulnerabilities that could be used against the company.

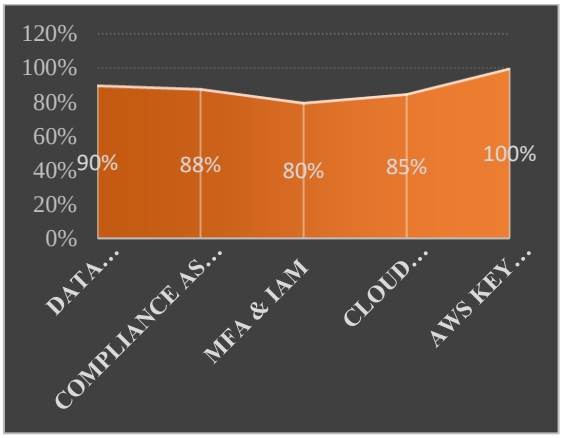

Figure 2 shows a clear visual representation of the performance of different methods used to secure legacy data in cloud migrations.

Finally, the AWS Key Management Service (KMS) is a key part of handling the management of encryption keys, which works perfectly every time. KMS makes sure that encryption processes go easily by getting rid of the chance of making mistakes when handling keys by hand. This improves overall security during cloud migrations. These methods work together to make a complete defence plan. Encrypting data is one of the most important parts of this plan. Highly regulated industries AWS KMS automates the management of encryption keys, ensuring encryption and decryption processes are handled securely 100% key management efficiency with minimal operational overhead. The combination of these methods provides a strong framework for securing legacy data during cloud migrations. The advanced techniques ensure data protection, regulatory compliance, and enhanced access control while minimizing performance overhead and improving operational efficiency.

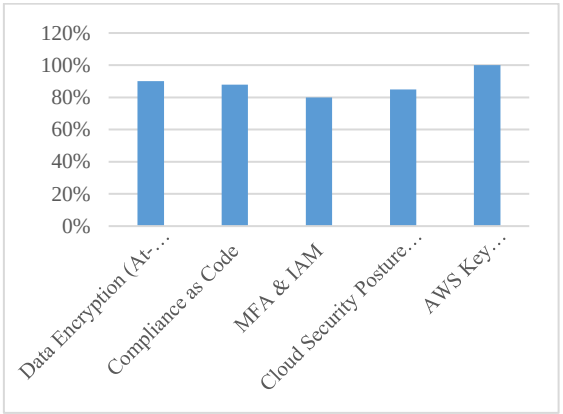

Figure 3: Shows comparison of cybersecurity methods in cloud migrations in highly regulated industries

This figure 3 illustrates how these methods, particularly when integrated with AWS KMS, provide a robust cybersecurity framework for cloud migrations in highly regulated industries. The graph above highlights Data Encryption (At-Rest and In-Transit) as the best-performing method in ensuring cybersecurity in cloud migrations for highly regulated industries. The orange bar represents Data Encryption with a performance value of 90%, showcasing its importance in safeguarding sensitive data.

VI. CONCLUSION

This paper shows how very important it is to make sure that cybersecurity is maintained during cloud migrations, especially in businesses with a lot of rules. Companies can keep private old data safe from hackers and other bad people during the migration process by encrypting it both at rest and while it's being sent. AWS Key Management Service (KMS) is a key part of handling encryption keys, rotating keys automatically, and making sure that regulations like HIPAA, GDPR, and PCI-DSS are followed. AWS KMS improves security even more by centrally controlling who can access and use keys. This lowers the chance of making mistakes when keys are handled by hand. When you combine advanced encryption methods with AWS KMS, you get a very safe framework for moving to the cloud. This framework makes operations more efficient while protecting data security and privacy. As more and more people use the cloud, these cybersecurity best practices will still be necessary to keep sensitive data safe in heavily controlled areas.

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