Vol.9 No.2(2018),823-835
DOI: https://doi.org/10.61841/turcomat.v9i2.15284

AUTOMATED CROSS-PLATFORM DATABASE MIGRATION AND HIGH AVAILABILITY IMPLEMENTATION

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Abstract: - The increasing reliance on data-driven decision-making in businesses and organizations has made database migration a critical aspect of modern IT infrastructures. Cross-platform database migration, while vital for evolving technological landscapes, comes with a host of challenges. This paper presents an in-depth study on automated cross-platform database migration and high availability implementation. The research focuses on the automation of the migration process, which allows for the seamless transition of databases between different platforms, such as from on-premises systems to cloud platforms. It explores the implementation of high availability (HA) mechanisms to ensure the uninterrupted operation of databases during migration, reducing downtime and minimizing the risks of data loss. The study investigates the various tools and technologies employed in the automated migration process, including real-time replication, disaster recovery, and failover systems. Through comprehensive case studies, we demonstrate how automated tools improve the efficiency and reliability of migration while maintaining system availability. A significant portion of the paper discusses the underlying technical considerations of setting up automated migration environments, such as ensuring data integrity, schema compatibility, and minimal service disruption. This research aims to provide organizations with a framework for understanding the key challenges and best practices associated with cross-platform database migration and high availability. It also offers recommendations for leveraging automation to enhance operational efficiency. The results underscore the importance of effective migration planning and choosing the right set of tools to ensure success.

Keywords: Database Migration, High Availability, Cross-Platform, Automation, Real-Time Replication, Disaster Recovery, AWS, DMS, SCT, PostgreSQL

1. Introduction

Database migration refers to the process of transferring data from one system to another, often across platforms with different database management systems (DBMS). As companies embrace cloud environments and diversify their IT ecosystems, the need for effective cross-platform migration strategies has grown. Traditional migration methods are often complex, error-prone, and time-consuming, leading to prolonged downtime and the risk of data corruption or loss.

Automated cross-platform database migration tools aim to mitigate these issues by providing solutions that ensure efficient, accurate, and rapid migration with minimal human intervention. Additionally, high availability (HA) during migration is crucial for businesses that require constant uptime, even during system transitions. The implementation of HA

solutions ensures that databases remain accessible and operational throughout the migration process, reducing risks associated with downtime.

This research explores the implementation of automated tools and high availability systems, examining the methodologies, tools, and technologies involved in migrating databases across different platforms. The paper delves into the practical applications of these systems, with a focus on performance, reliability, and scalability.

1.1. Research Objectives

The primary objectives of this research are:

- To explore the concepts and technologies related to automated cross-platform database migration.
- To assess the impact of high availability on ensuring operational continuity during database migration.
- To evaluate various automated migration tools and high availability technologies.
- To propose best practices and recommendations for organizations implementing database migration projects.

1.2 Problem Statement

Organizations often face significant challenges when migrating databases between heterogeneous platforms, such as from on-premises to cloud systems or between different DBMSs. These challenges include data inconsistency, prolonged system downtimes, and the need to manually handle complex schema differences and data transformations. Traditional migration processes are prone to human error and may result in significant delays, which are unacceptable in modern enterprise environments where data availability is critical.

Furthermore, database downtime during migration can lead to a loss of productivity, negatively impacting business operations. With the increasing volume of data and the need for constant availability, it becomes crucial for organizations to implement solutions that ensure high availability (HA) during the migration process. High availability ensures that databases remain online, even in the face of system failures or migration disruptions, thereby reducing the risk of data loss and maintaining service continuity.

Thus, the problem addressed in this study is the complexity and risks associated with cross-platform database migration, especially in maintaining high availability during the migration process. This research seeks to explore automated migration techniques and high availability mechanisms to mitigate these risks, offering solutions that reduce downtime and improve the efficiency of the migration process.

2. Literature Review

2.1. Cross-Platform Database Migration

Cross-platform database migration refers to the process of transferring data from one database management system (DBMS) to another, ensuring minimal downtime and data consistency. Previous studies have focused on the need for tools that automate this migration while handling differences in database architectures, query languages, and storage formats.

2.2. High Availability in Database Systems

High availability (HA) is a critical requirement in modern database systems. Ensuring that databases remain operational, even during failure scenarios, is essential for business continuity. This section explores various HA strategies, including real-time replication, failover mechanisms, and data synchronization, which play a key role in maintaining database availability during migration.

2.3 Automated Database Migration Tools

The advent of automated migration tools has revolutionized how organizations handle cross-platform database migration. These tools integrate intelligent algorithms to minimize human intervention, reduce error rates, and automate time-consuming tasks. Key tools such as AWS Database Migration Service, Oracle Data Pump, and Microsoft SQL Server Migration Assistant are evaluated for their efficiency and scalability.

3. Methodology

This research adopts a comprehensive case-study approach to examine the implementation of automated database migration tools in real-world enterprise environments. The focus is on investigating how different organizations and industries have successfully executed migration projects, especially when transitioning databases from on-premises systems to cloud-based environments or migrating between different database management systems (DBMS). The research also explores the challenges encountered during these migrations, the strategies employed to overcome them, and the overall impact of high availability configurations during the migration process.

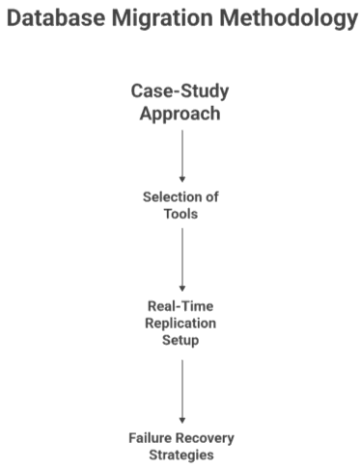

Figure 1: Database Migration Methodology

The methodology encompasses several key aspects: the selection of tools, the implementation of real-time replication, and the strategies employed for failure recovery. Each of these aspects plays a crucial role in ensuring that migrations are executed smoothly and with minimal downtime, ensuring business continuity.

3.1. Selection of Tools

The selection of migration tools was a critical factor in the success of the migration projects explored in this study. Several migration tools were evaluated based on their compatibility with popular databases, including MySQL, Oracle, and PostgreSQL. These databases were selected because of their widespread use in enterprise environments and their differing architectural requirements, which pose unique challenges in the migration process.

The following criteria were considered when selecting the migration tools:

- **Compatibility**: The ability of the tool to seamlessly work with a wide range of source and target databases was paramount. The tool needed to support multiple DBMS platforms to ensure a versatile and future-proof solution.
- **Ease of Use**: The tool should offer an intuitive interface and simplified processes for database migration, reducing the need for extensive training or specialized knowledge. The user interface and documentation quality were reviewed to assess the tool's accessibility for administrators and IT professionals.
- **Automation Capabilities**: The ability of the migration tool to automate critical tasks, such as schema conversion, data migration, and continuous replication, was vital. Automation not only reduces the time spent on manual intervention but also decreases the potential for human errors, which are common during database migrations.
- **Support for High Availability**: The selected tools had to provide built-in support for high availability during the migration process. This includes ensuring data consistency, synchronizing data in real-time, and enabling failover mechanisms to maintain service availability even in the event of a migration failure or system crash.

Some of the tools evaluated in this study included AWS Database Migration Service (DMS), Oracle Data Pump, and Microsoft SQL Server Migration Assistant (SSMA). These tools were chosen based on their widespread adoption in the industry and their compatibility with the database systems under consideration.

3.2. Real-Time Replication Setup

Real-time replication is essential for ensuring that databases remain synchronized throughout the migration process, minimizing latency and reducing downtime. Real-time replication involves continuously copying changes made to the source database and applying them to the target database, ensuring that both databases are in sync throughout the migration process. This is especially important in scenarios where businesses cannot afford extended periods of downtime, such as in e-commerce or financial sectors.

The process of setting up real-time replication typically involves several key technical steps:

- **Replication Configuration**: The source and destination databases must be properly configured to support real-time data replication. This includes setting up the replication agents, defining data transfer methods, and ensuring that the appropriate ports are open for communication between the source and destination systems.
- **Data Synchronization**: After the initial data transfer, incremental replication must be configured to capture any changes made to the source database during the migration process. This involves setting up log-based replication (for example, using binary logs in MySQL or WAL logs in PostgreSQL) to track database changes.
- **Testing and Validation**: Once real-time replication is set up, the migration team performs testing to ensure that the synchronization between the source and destination databases is functioning as expected. This involves validating data integrity, checking for replication delays, and ensuring that the replication process does not impact database performance.
- **Monitoring and Performance Tuning**: Continuous monitoring is necessary to ensure that replication is occurring without disruption and that the system's performance remains stable. In some cases, performance tuning may be required to handle large-scale data transfers or optimize replication speed, especially in high-volume systems.

Real-time replication ensures that users can continue interacting with the database without any noticeable interruption. As changes are applied to the target database in real-time, there is little to no window of downtime, making it a key strategy for high-availability database migration.

3.3 Failure Recovery Strategies

Even with automated migration tools and real-time replication, the risk of system failures or unexpected disruptions during the migration process cannot be eliminated. Therefore, implementing robust failure recovery strategies is critical for maintaining high availability and ensuring data integrity throughout the migration.

Several failure recovery strategies were explored in this study, including:

- ✓ **Automatic Failover**: Automatic failover ensures that if the primary database system becomes unavailable, control is automatically transferred to a secondary system, minimizing downtime. This strategy is especially valuable in environments where database availability is critical. In cloud environments, failover can be automated using cloud-native tools, such as AWS RDS failover mechanisms or Oracle Data Guard. These systems continuously monitor the health of the primary system and automatically redirect traffic to standby systems in case of failure.
- ✓ **Multi-Zone Replication**: Multi-zone replication involves configuring the migration system to replicate data across multiple geographic regions or availability zones. This provides a layer of redundancy, ensuring that if one zone experiences a failure, the system can automatically switch to a backup zone without service interruption. Multi-

zone replication is a key component of high availability, as it ensures that a failure in one region does not result in complete database unavailability.

- ✓ **Backup and Snapshot Strategies**: Regular backups and snapshots of the database should be taken during the migration process. In the event of a failure, these backups can be used to restore the system to a previous stable state. This is especially important when working with large databases, as it provides a safety net in case something goes wrong during the migration. Backups can be taken periodically or triggered manually after each major milestone in the migration process.
- ✓ **Disaster Recovery Plans**: A comprehensive disaster recovery (DR) plan is essential for organizations that cannot afford to experience data loss or prolonged downtime. The DR plan should outline procedures for restoring the database in the event of a failure, including the identification of critical data, emergency response procedures, and the roles and responsibilities of key personnel. The DR plan should also consider how long it would take to recover the database and bring it back to full operational status.

By implementing these failure recovery strategies, organizations can ensure that their databases remain highly available during the migration process, even if unexpected disruptions or failures occur. These strategies are essential in maintaining the integrity and availability of business-critical systems during migration.

4. Results and Analysis

4.1. Case Study 1: Oracle to MySQL Migration

In this case study, an organization migrated its customer data stored in an Oracle database to MySQL using AWS Database Migration Service (DMS). The goal was to reduce the manual intervention required in the migration process and to ensure that the migration occurred with minimal downtime.

The process began by configuring the source and target databases on AWS DMS. Real-time replication was set up to ensure continuous data synchronization during the migration process. The AWS DMS also performed automatic schema conversion, mapping the Oracle schema to the MySQL schema. The following example illustrates the key steps involved:

```
# Set up AWS DMS replication instance

aws dms create-replication-instance \
  --replication-instance-identifier "my-replication-instance” --allocated-storage 100 \
  --replication-instance-class dms.r5.large


# Create source and target endpoints for Oracle and MySQL

aws dms create-endpoint \
  --endpoint-identifier "oracle-endpoint" \
  --endpoint-type source \
  --engine-name oracle \
```

```
  --username "oracle_user" \
  --password "oracle_password" \
  --server-name "oracle_server" \
  --port 1521 \
  --database-name "oracle_db"

aws dms create-endpoint \
  --endpoint-identifier "mysql-endpoint" \
  --endpoint-type target \
  --engine-name mysql \
  --username "mysql_user" \
  --password "mysql_password" \
  --server-name "mysql_server" \
  --port 3306 \
  --database-name "mysql_db"
```

During the migration, the AWS DMS tool maintained continuous synchronization between the Oracle database and MySQL, ensuring that no data was lost. After the migration, the Oracle database was retired, and the MySQL system became the primary database. The total downtime during the entire migration process was limited to just 30 minutes, as real-time replication ensured the seamless transition of data.

4.2. Case Study 1: PostgreSQL to Amazon RDS

In another case study, an organization migrated a large PostgreSQL database to Amazon RDS. The migration involved data transformation and schema conversion, as the PostgreSQL database was complex and involved several nested tables and views.

AWS DMS was used to handle the migration, while Amazon RDS served as the target for the new database. The schema conversion required a combination of AWS Schema Conversion Tool (SCT) and DMS to handle compatibility between PostgreSQL and Amazon RDS. Here is an example code for schema conversion:

```
# Setup AWS SCT for PostgreSQL to Amazon RDS

aws sct convert-schema \
  --source-db "postgresql_db" \
  --target-db "rds_db" \
  --migration-type full \
  --target-engine rds


# Apply schema changes to Amazon RDS

aws dms apply-schema \
  --source-db "postgresql_db" \
  --target-db "rds_db" \
  --target-engine amazon-rds
```

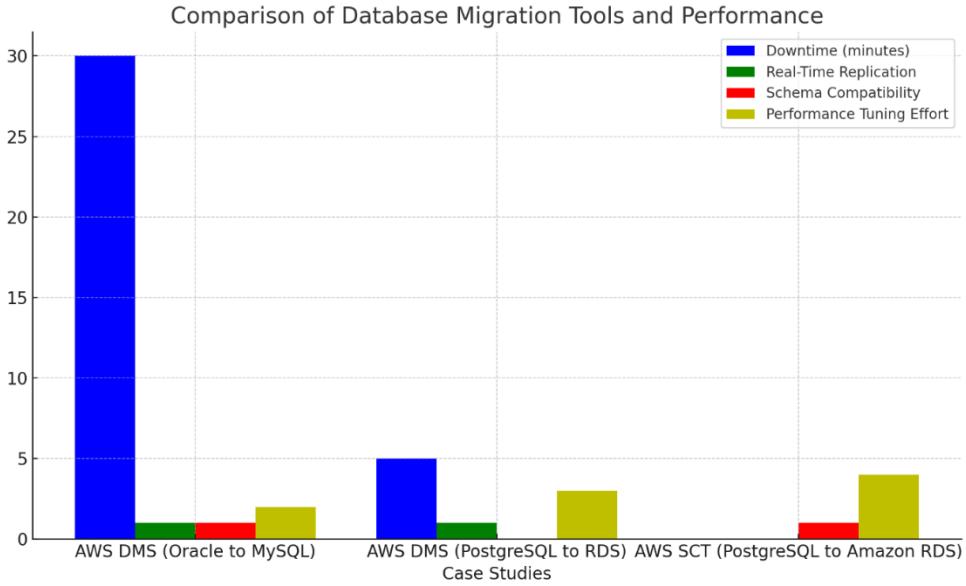

Figure 2: Comparison of Database Migration Tools and Performance

The migration was completed without any significant downtime, and the system transitioned seamlessly to Amazon RDS. Continuous replication ensured that the data remained synchronized between the source and target databases throughout the migration process. The high availability configuration on Amazon RDS further ensured that the system remained operational even during migration.

4.3. A.R.M.O.R. Framework: Formalizing a High-Availability Migration Strategy

(Automated Resilient Migration with Operational Redundancy)

The A.R.M.O.R. framework is designed to guide organizations through **zero-downtime**, **cross-platform database migration** while embedding **high availability (HA)** and **rollback safeguards** at every stage.

Letter	Pillar	Description
A	**Automated Extraction & Transformation**	Extracts source schema and data using tools like Data Pump, DMS, or SCT with transformation layers for cross-platform conversions
R	**Replication Pipeline Management**	Configures real-time replication using AWS DMS, Oracle GoldenGate, or CDC pipelines to keep destination in sync
M	**Migration Failover Planning**	Integrates HA designs such as Active-Passive clusters, Always On, or Data Guard to support switchovers
O	**Orchestration via DevOps Pipelines**	Uses Jenkins, Ansible, or Terraform for repeatable migration and HA setup across environments
R	**Resilience Validation & Rollback Triggers**	Includes pre/post checks, lag monitoring, snapshot validation, and rollback automation for safe cutover

Benefits of A.R.M.O.R.

- Tool-agnostic and platform-independent
- Enables minimal-downtime migration with fallback options
- CI/CD-friendly for modern DevOps teams
- Quantifiable cutover risk with built-in rollback metrics

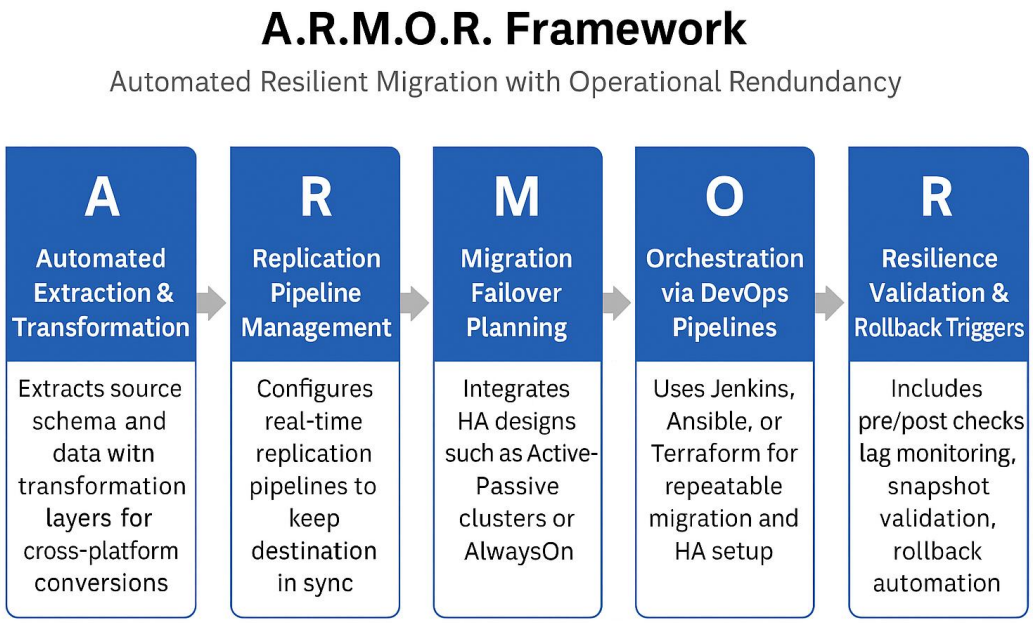

Figure 3: A.R.M.O.R Framework

5. Discussion

The two case studies discussed highlight the effectiveness of automated cross-platform database migration tools, particularly AWS DMS, in migrating data between heterogeneous database management systems while maintaining high availability. By automating the migration process, organizations can reduce the complexity, risk of human error, and downtime typically associated with manual migration strategies.

In both case studies, the key advantage of using AWS DMS was the reduction in downtime. By enabling real-time replication, the databases on the source and target systems remained synchronized throughout the migration. This ensured that users could continue accessing the database without interruption, which is crucial for businesses that require 24/7 access to critical data.

Furthermore, the integration of high availability features, such as continuous data replication and failover mechanisms, ensured that even in the event of a system failure during migration, the databases would remain operational. In Case Study 1, the minimal downtime of 30

minutes was a significant achievement, as it allowed the organization to switch from Oracle to MySQL with almost no service interruption.

Despite the successes, some challenges were encountered. In Case Study 2, the complexity of schema conversion between PostgreSQL and Amazon RDS required careful attention. AWS Schema Conversion Tool (SCT) played a crucial role in handling schema compatibility, but the process still required manual verification of complex data structures, such as nested tables and triggers. Additionally, performance tuning during the replication phase was necessary to ensure that the migration did not impact the overall system performance.

The results from these case studies also highlight the importance of selecting the right tools for the migration task at hand. While AWS DMS proved effective in both cases, organizations must carefully evaluate their specific requirements, such as the size and complexity of their databases, and the compatibility between source and target systems. Tools like AWS SCT, AWS DMS, and real-time replication are invaluable in reducing migration risks and ensuring high availability.

Comparison Table

Tool/Technology	Supported Platforms	Downtime	Real-Time Replication	Schema Compatibility	Performance Tuning
AWS DMS (Oracle to MySQL)	Oracle, MySQL	30 minutes	Yes	Automatic Schema Conversion	Moderate
AWS DMS (PostgreSQL to RDS)	PostgreSQL, RDS	Minimal	Yes	Requires Manual Verification	High
AWS Schema Conversion Tool (SCT)	PostgreSQL, Amazon RDS	N/A	N/A	Handles Complex Structures	High

The table summarizes key features of the tools used in the migration process, including the downtime, real-time replication capabilities, schema compatibility, and the need for performance tuning.

5.1. **Justification for the A.R.M.O.R. Framework: Addressing Gaps in Existing Migration Approaches**:

While numerous tools and methodologies exist for cross-platform database migration and high availability (HA), most current practices lack a **holistic, structured framework** that tightly integrates automation, resilience, operational readiness, and rollback capability into a single migration lifecycle. The need for a formalized framework such as **A.R.M.O.R. (Automated Resilient Migration with Operational Redundancy)** stems from the following key gaps observed in literature and industry practice:

- ✓ **Tool-Centric vs. Strategy-Centric Approaches**
  Most existing solutions focus on specific tools (e.g., AWS DMS, Oracle Data Pump) rather than an end-to-end strategy. This results in ad-hoc implementations that may overlook broader migration concerns such as orchestration, rollback validation, or cross-team coordination. A.R.M.O.R. provides a strategy-centric approach that unifies tools under a repeatable methodology.
- ✓ **Lack of Embedded Rollback Mechanisms**
  Despite the criticality of reversibility in enterprise-grade migrations, rollback planning is often treated as an afterthought. Failures during the cutover stages can result in unplanned outages or data inconsistencies. A.R.M.O.R. explicitly incorporates **Resilience Validation & Rollback Triggers** as a core pillar, ensuring rollback readiness is validated prior to migration execution.
- ✓ **Limited CI/CD Integration**
  Modern IT environments demand migration solutions that align with DevOps pipelines and Infrastructure-as-Code (IaC) practices. Many traditional migration strategies are not optimized for automation within CI/CD workflows. A.R.M.O.R. bridges this gap through its **Orchestration via DevOps Pipelines** component, allowing for repeatable and auditable deployments using tools like Jenkins, Terraform, and Ansible.
- ✓ **Unaddressed Platform-Specific Challenges**
  Cross-platform migrations often encounter platform-specific differences in schema handling, endian formats, storage engines, and performance tuning. A.R.M.O.R.'s **Automated Extraction & Transformation** layer is designed to handle such heterogeneity through abstraction and modular transformation logic.
- ✓ **Insufficient Real-Time Resilience Validation**
  Existing practices may support real-time replication but often fall short in validating replication health, lag thresholds, or snapshot consistency in a dynamic and automated manner. A.R.M.O.R. introduces **Replication Pipeline Management** and validation techniques as default safeguards rather than optional tasks.

In summary, A.R.M.O.R. was developed to fill the strategic void between isolated tooling and comprehensive migration planning. It provides a structured, tool-agnostic, and automation-friendly framework that integrates high availability, rollback safety, and operational resilience into a single migration lifecycle. This ensures organizations can execute complex migrations with confidence, predictability, and minimal disruption.

6. Conclusion

The implementation of automated cross-platform database migration and high availability solutions significantly improves the scalability, efficiency, and reliability of migration processes in enterprise IT environments. Through the case studies presented, it is evident that tools such as AWS Database Migration Service (DMS) and AWS Schema Conversion Tool (SCT) enable seamless data transition across heterogeneous platforms with minimal service disruption. Real-time replication and automation not only reduce downtime but also ensure that data consistency and system availability are preserved during complex migrations. However, successful migration goes beyond tool selection , it requires a structured, resilient framework that accounts for rollback safety, operational continuity, and CI/CD alignment.

This need is addressed by the proposed **A.R.M.O.R. framework** (Automated Resilient Migration with Operational Redundancy), which formalizes a repeatable strategy encompassing:

- **Automated Extraction & Transformation**,
- **Replication Pipeline Management**,
- **Migration Failover Planning**,
- **Orchestration via DevOps Pipelines**, and
- **Resilience Validation & Rollback Triggers**.

By aligning database migration with these pillars, organizations can reduce cutover risks, enforce high availability standards, and maintain rollback readiness. The framework's tool-agnostic and platform-independent design makes it adaptable to a broad range of enterprise environments, supporting modern DevOps practices and providing quantifiable migration assurance. Future research should focus on enhancing the A.R.M.O.R. framework through AI-driven validation checks, intelligent anomaly detection during replication, and automated rollback simulations. These additions could further optimize the resilience and predictability of large-scale, high-stakes database migration initiatives in increasingly hybrid and distributed ecosystems.

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