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by Shahriar Khan

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PIXELBAY ONLINE ART MARKETPLACE
DATABASE ARCHITECTURE AND IMPLEMENTATION REPORT
Data storage investigation

Database Systems
Module Code: ACCA7002

Submitted To:
Divya Chidambaram
Lecturer, UWTSD

Submitted By:
Name: Shahriar Khan
Student ID: 2507023

Submission Date: 19 January 2026

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Abstract

Modern World depends on efficient data management to ensure performance, reliability, and scalability. As online marketplaces grow in user base and content volume, the choice of database technology becomes critical. PixelBay in Swansea, Wales, an online art marketplace specializing in digital artwork downloads and streaming, must support complex relationships between users, artists, artworks, and transactions while also maintaining flexibility for future expansion

As the organization scales, selecting an appropriate data storage architecture becomes essential for ensuring performance, flexibility, and long-term maintainability. This report presents a comprehensive academic analysis of encompassing Document, Key-Value, Wide Column, Graph models and detailed implementation demonstration using SQL and MongoDB, supported by an Entity-Relationship Diagram (ERD) and JSON schema diagrams. The findings support a hybrid database architecture that leverages the strengths of both relational and NoSQL systems. The report concludes with a strategic recommendation for PixelBay's future data infrastructure.

Introduction

Customers can explore, buy, and stream digital artworks from a range of artists and studios on PixelBay, which operates within the digital creative economy. The underlying data architecture must accommodate growing amounts of transactional records, customer accounts, and artwork metadata as the platform expands. Choosing a database model that strikes a balance between consistency, scalability, and flexibility is difficult.

NoSQL databases have opened up new options for managing large-scale workloads, semi-structured data, and quickly changing application needs. Four main NoSQL database types—Document, Key-Value, Wide Column, and Graph—are assessed critically in this study and contrasted with relational databases. It looks at their theoretical underpinnings, real-world applications, and appropriateness for the operational environment of PixelBay. Figure 1:



Overview of PixelBay and Database Requirements

PixelBay provides a platform where customers can register accounts, browse digital artwork, make purchases, and manage own content. Artists and studios may upload and manage large collections of artworks. Each transaction must be recorded to ensure accurate ownership and financial tracking.

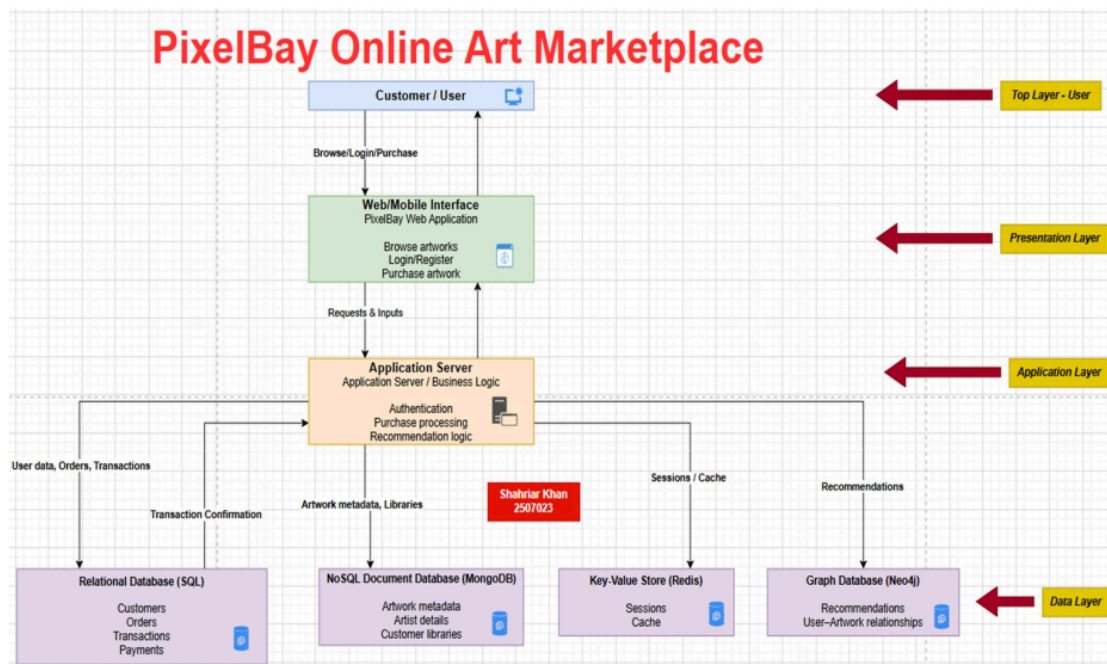
Core Data Entities

- Customers
- Artists / Studios
- Artworks
- Transactions

The database must:

- Maintain data integrity for purchases
- Support scalability as the number of artworks grows
- Allow efficient querying for users and artworks
- Provide flexibility for evolving data requirements

Figure 2: System Diagram



Now, I want to explain my own generated diagram for the overall system diagram of the PixelBay online art marketplace. This system follows a layered design approach that separates user interaction, application logic, and data storage to improve scalability, maintainability, and performance.

At the top level, customers interact with PixelBay through a web or mobile interface, where they can browse artworks, register or log in, and complete purchases. This presentation layer is responsible only for user interaction and does not directly access any databases.

Requests from the interface are processed by the application server, which contains the core business logic of the platform. This includes user authentication, purchase validation, transaction handling, and recommendation processing. The application server acts as an intermediary between the user interface and the data layer, ensuring that all operations follow the platform's rules and security requirements.

The data layer uses a hybrid database architecture. A relational database is used to store structured and transactional data such as customer accounts, orders, and purchase records. This ensures strong data integrity and consistency, which are essential for financial transactions. A NoSQL document database is used to store artwork metadata, artist information, and customer libraries, allowing flexible data structures that can evolve over time. A key-value store is included to manage user sessions and caching, improving system performance. Additionally, a graph database supports recommendation features by modelling relationships between users and artworks.

This architecture aligns with PixelBay's goals by combining the reliability of relational databases with the flexibility and scalability of NoSQL technologies.

COMPARATIVE ANALYSIS

Comparative Analysis of NoSQL Databases

This section provides a detailed academic comparison of relational and NoSQL database models, focusing on their theoretical foundations, operational characteristics, and suitability for PixelBay's requirements. Each subsection includes deeper technical analysis and references to contemporary literature.

➤ Relational Databases

Relational databases, such as MySQL, PostgreSQL, and Oracle Database, organize data into structured tables consisting of rows and columns. Relationships between entities are established using primary keys and foreign keys, and data integrity is enforced through constraints and normalization.

Use Case:

Well suited for transactional systems where data consistency and accuracy are critical, such as managing customer accounts, purchase records, payments, and ownership of digital artworks in an online marketplace like PixelBay.

Strengths:

- Strong data integrity through ACID compliance
- Support for complex queries using Structured Query Language (SQL)
- Clear and well-defined schema that enforces business rules

Weaknesses:

- Limited horizontal scalability compared to NoSQL databases
- Schema changes can be complex and time-consuming as requirements evolve

➤ Document Databases

Document databases, such as MongoDB, store data as flexible JSON-like documents. Each document can contain nested structures and arrays, making them suitable for semi-structured data.

Use Case:

Ideal for content-driven platforms where data schemas may evolve over time, such as user profiles and digital artwork metadata.

Strengths:

- Schema flexibility
- Easy horizontal scaling
- Natural mapping to application objects

Weaknesses:

- Limited support for complex joins
- Data consistency must be handled carefully

➤ **Graph Databases**

Graph databases, such as Neo4j, focus on relationships between entities using nodes and edges.

Use Case:

Useful for recommendation systems, such as suggesting artworks based on user preferences or artist relationships.

Strengths:

- Efficient relationship traversal
- Excellent for interconnected data

Weaknesses:

- Not ideal for simple transactional systems
- Higher learning curve

➤ **Key-Value Databases**

Key-value stores, such as Redis, store data as simple key-value pairs.

Use Case:

Session management, caching user data, or storing frequently accessed information.

Strengths:

- Extremely fast performance
- Simple data model

Weaknesses:

- Limited querying capabilities
- Not suitable for complex datasets

➤ **Wide Column Databases**

Wide column databases, such as Apache Cassandra, store data in tables with flexible columns.

Use Case:

Large-scale distributed systems requiring high write throughput.

Strengths:

- High scalability
- Fault tolerance

Weaknesses:

- Complex data modelling
- Eventual consistency model

Comparative Summary Table:

Figure 3: Comparative Summary of Database Types

Database Type	Strengths	Weaknesses	Best Use Cases	Pixel Bay Application
Relational	ACID transactions, structured schema, strong integrity	Rigid schema, limited scalability	Financial systems, CRM	Orders, payments, customer accounts
Document	Flexible schema, JSON structure, scalable	No joins, denormalization	Catalogs, profiles	Artwork catalog, customer libraries
Key-Value	Extremely fast, scalable	No complex queries	Caching, sessions	Session storage, caching
Wide Column	High throughput, distributed	Complex modelling	Analytics, logs	Usage analytics
Graph	Relationship modelling, recommendations	Not transactional	Social networks, recommendations	Artwork similarity, user preferences

NoSQL vs Relational Databases

NoSQL databases perform well when:

- Data structure is flexible or evolving
- Scalability is a priority
- High-volume, low-latency operations are required

Relational databases are preferable when:

- Data consistency is critical
- Complex queries and joins are required
- Business rules must be strictly enforced

For PixelBay, both approaches provide value depending on the context

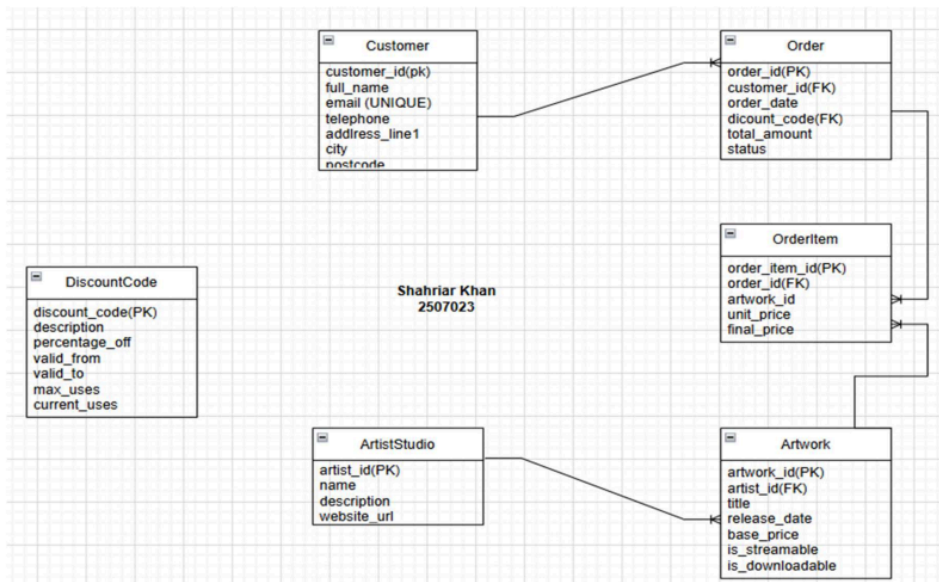
DATABASE IMPLEMENTATION DEMONSTRATION

Implementation Demonstration

Here the relational and NoSQL database technologies can be used to meet PixelBay's data requirements. The objective is to demonstrate the structural consequences, query patterns, and modeling variations of each method. The theoretical analysis previously provided is strengthened by this real comparison, which also gives PixelBay a basis for internal testing.

➤ Relational Database Implementation

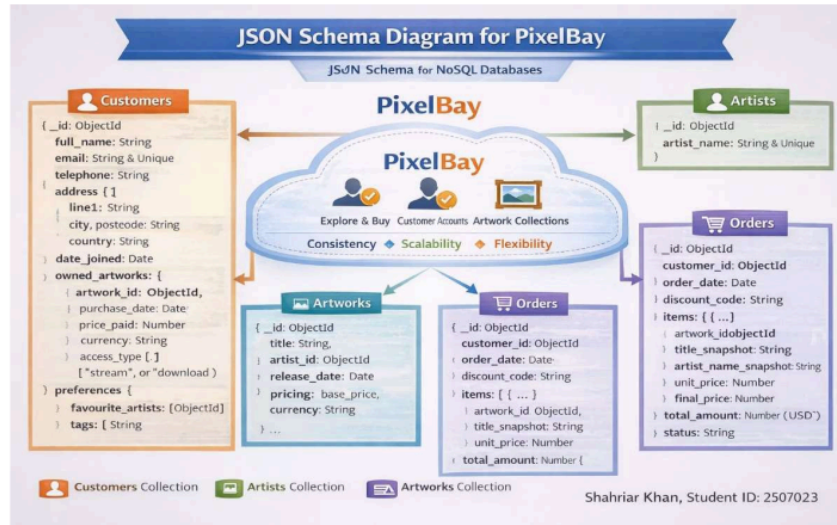
Figure 4: Relational Database ERD



Notes: The provided SQL and MongoDB scripts were developed for structural demonstration purposes and were tested using MySQL and MongoDB Compass respectively.

➤ NoSQL Implementation (MongoDB)

Figure 5: JSON Schema Diagram



CustomersCollection Schema:

```
{
  _id: ObjectId,
  full_name: String,
  email: String,
  telephone: String,
  address: {
    line1: String,
    line2: String,
    city: String,
    postcode: String,
    country: String
  },
  date_joined: Date,
  owned_artworks: [
    {
      artwork_id: ObjectId,
      purchase_date: Date,
```

```
    price_paid: Number,
    currency: String,
    access_type: [ "stream", "download" ]
  }
],
preferences: {
  favourite_artists: [ ObjectId ],
  tags: [ String ]
}
}
```

Artworks Collection Schema:

```
{
  _id: ObjectId,
  title: String,
  artist_id: ObjectId,
  release_date: Date,
  pricing: {
    base_price: Number,
    currency: String,
    discounts: [
      {
        code: String,
        percentage_off: Number,
        valid_from: Date,
        valid_to: Date
      }
    ]
  },
  media: {
    streaming: {
      available: Boolean,
      bitrates: [ String ]
    },
    download: {
      available: Boolean,
      formats: [ String ]
    }
  }
},
```

```
tags: [ String ],
studio_metadata: {
  taitharts: {
    collection: String,
    commission_available: Boolean
  }
}
}
```

Orders Collection Schema:

```
{
  _id: ObjectId,
  customer_id: ObjectId,
  order_date: Date,
  discount_code: String,
  items: [
    {
      artwork_id: ObjectId,
      title_snapshot: String,
      artist_name_snapshot: String,
      unit_price: Number,
      final_price: Number
    }
  ],
  total_amount: Number,
  currency: String,
  status: String
}
```

Example MongoDB Queries

Insert a new customer:

```
db.customers.insertOne({
  full_name: "Shahriar Khan",
  email: "Shahriar.khan@gmail.com",
  telephone: "+44 07909344521",
  address: {
    line1: "186 Corporation Road",
```

```
    city: "Newport",
    postcode: "NP19 0DQ",
    country: "UK"
  },
  date_joined: new Date(),
  owned_artworks: [],
  preferences: { favourite_artists: [], tags: [] }
});
```

Retrieve artworks by tag:

```
db.artworks.find({ tags: "neon" }).sort({ release_date: -1 });
```

Add an owned artwork to a customer:

```
db.customers.updateOne(
  { email: "Shahriar.khan@gmail.com" },
  {
    $push: {
      owned_artworks: {
        artwork_id: ObjectId("..."),
        purchase_date: new Date(),
        price_paid: 7.99,
        currency: "GBP",
        access_type: ["stream", "download"]
      }
    }
  }
);
```



Script & Output:

OneCompiler

2507023_Shahriar_Khan

AI NEW MONGODB RUN

script.js

```
1 //Shahriar Khan
2 //2507023
3
4
5 //Insert a Customer
6
7 db.customers.insertOne({
8   full_name: "Shahriar Khan",
9   email: "shahriar.khan@gmail.com",
10  telephone: "+44 7909344521",
11  address: {
12    line1: "186 Corporation Road",
13    city: "Newport",
14    postcode: "NP19 00Q",
15    country: "UK"
16  },
17  date_joined: new Date(),
18  owned_artworks: [],
19  preferences: {
20    favourite_artists: [],
21    tags: []
22  }
23 });
24
25
26 //Insert an Artwork
27
28 db.artworks.insertOne({
29   title: "Neon Dreams",
30   artist_id: ObjectId("65a123456789abcdef012345"),
31   release_date: new Date("2024-02-01"),
32   pricing: {
33     base_price: 7.99,
34     currency: "GBP",
35     discounts: []
36   },
37   media: {
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Evaluation of PixelBay's Needs

PixelBay requires both transactional reliability and scalability. A relational database ensures accurate purchase records, while NoSQL supports flexible content storage and future growth.

Deployment Strategies

A hybrid deployment strategy is recommended:

- Relational database for transactions and payments
- NoSQL database for artwork metadata and user profiles

Cloud-based solutions such as AWS or Azure provide scalability and reliability.

Data Security and Backup Considerations

Security measures include:

- Role-based access control
- Encryption at rest and in transit
- Regular automated backups

These measures protect user data and digital assets.

DISCUSSION, CONCLUSION & REFERENCES

Discussion: Technical and Organizational Implications

➤ Technical Implications

When deciding between relational and NoSQL databases, PixelBay must consider future scalability, changing business models, and the requirement to accommodate a variety of data types in addition to its existing functional requirements.

Data Modelling Complexity

Relational databases impose are advantageous for transactional integrity but constrictive for dynamic domains like the metadata of digital artwork. Features including resolution, file format, licensing terms, tags, and studio-specific metadata may be present in PixelBay's artworks.

In contrast, document databases enable the inclusion of distinct fields in every artwork document. This adaptability facilitates quick feature development and lessens the need for schema migrations. Denormalization, however, increases the possibility of data duplication, necessitating cautious update techniques.

Performance and Scalability

Because relational databases are usually more powerful hardware is needed to improve performance. Sharding is supported by modern RDBMSs, however its implementation and upkeep are difficult.

NoSQL databases are made to scale horizontally over dispersed clusters, especially document and wide column stores. Because of this, they can handle a lot of read-intensive tasks like collecting customer libraries or perusing artwork catalogs.

Consistency Requirements

Strong consistency is necessary for PixelBay's transactional procedures, which include purchases and discount code validation. Financial activities are dependable and auditable because of relational databases' ACID guarantees.

The BASE paradigm, which provides eventual consistency, is frequently used by NoSQL systems. It is inappropriate for financial transactions but appropriate for non-critical data like artwork metadata or analytics.

Query Patterns

Relational databases excel at complex joins and aggregations, making them ideal for reporting tasks such as:

- Revenue per artist
- Sales per artwork
- Customer purchase history

Document databases optimize hierarchical or nested data retrieval, reducing the need for joins but limiting cross-document queries.

Graph databases provide unparalleled performance for relationship-heavy queries, such as recommendations and similarity detection.

➤ Organizational Implications

Development Agility

A document database enables PixelBay's development team to iterate quickly, adding new artwork attributes or customer preferences without schema migrations. This agility supports innovation and rapid feature deployment.

Operational Complexity

Operational complexity is increased by hybrid architecture, necessitating knowledge of both relational and NoSQL systems. However, the advantages in terms of performance and flexibility make this complexity worthwhile.

Cost Considerations

NoSQL systems frequently use commodity hardware to grow horizontally, which may lower costs. However, these reductions might be outweighed by operational expenses and the requirement for specialized expertise.

Future-Proofing

Global expansion, sophisticated recommendation systems, and extensive analytics are all part of PixelBay's long-term goals. As the platform develops, hybrid architecture has the ability to incorporate graph or wide-column databases.

Conclusion and Recommendation

Here I will discuss relational and NoSQL databases, which assess appropriateness for PixelBay's strategic and operational needs. Relational databases are perfect for PixelBay's transactional core, which includes customer accounts, orders, and discount code administration, since they provide robust ACID guarantees, structured schemas, and strong query capabilities.

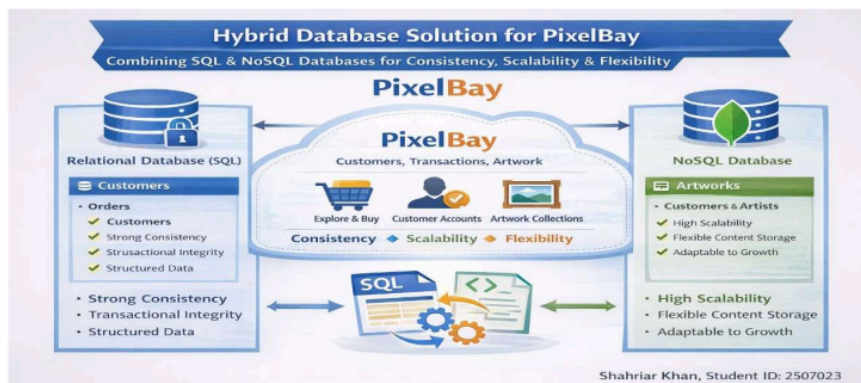
NoSQL databases, especially document stores, offer the scalability and schema flexibility needed for PixelBay's customer libraries and artwork collection. The dynamic nature of digital artwork attributes is in line with their capacity to store varied metadata without requiring schema upgrades. Additional advantages for caching, analytics, and recommendation systems are provided by key-value stores, wide column databases, and graph databases.

The practical distinctions between relational and NoSQL architectures are demonstrated using SQL and MongoDB. While the example queries show how each system supports various access patterns, the ERD and JSON schema diagrams emphasize opposing approaches to data modeling.

A hybrid database architecture is the suggested strategy for PixelBay based on the analysis:

- Relational databases for reporting and transactional integrity, such as PostgreSQL
- Document databases (like MongoDB) for customer libraries and adaptable artwork metadata
- A key-value store for session management and caching, such as Redis
- Wide-column databases or graphs as potential future improvements

This **hybrid database approach** is the most suitable solution for PixelBay. Relational databases provide strong consistency and transactional integrity, while NoSQL databases offer scalability and flexibility. This combination aligns with PixelBay's goal of expanding its online presence while maintaining data reliability.



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FINAL GRADE

GENERAL COMMENTS

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 **Comment 1** |  **Practical Application(40)**

Task 1 (Comparative Analysis): Partially done. Descriptions are provided, but the contrast with relational databases is not sufficiently detailed.

Task 2 (NoSQL vs Relational): Partially done. General discussion is present but lacks depth and specific examples.

PAGE 14



The report includes an abstract, table of contents, and headings. However, several required sections from the specification are absent or only briefly mentioned, including a detailed outline of deployment strategies and a dedicated discussion on data security and backup. The report structure is acceptable but lacks completeness. Referencing, as noted, does not follow the specified IEEE in-text citation format.

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GRADING FORM: DC-DBS_CW2

SHAHRIAR KHAN

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ENGAGEMENT WITH LITERATURE(25)



Engagement with literature is noted through the inclusion of a reference list. However, critical engagement with academic sources is not demonstrated within the main body of the report. In-text citations following the IEEE style are absent; sources listed in the reference list are not referenced within the text to support comparisons or recommendations. The use of sources is limited to a list, without interrogation or discussion of their content in relation to the analysis. Current trends and debates are mentioned but are not supported by references to contemporary literature.

12

KNOWLEDGE & UNDERSTANDING(15)



An understanding of different database types is shown through descriptive summaries. Relational database principles and their contrast with NoSQL approaches are outlined. Theoretical knowledge is applied to the PixelBay scenario at a general level. Data modelling principles are acknowledged, as seen in the provided diagrams, but the discussion remains at a surface level without detailed examination of design choices.

12

COGNITIVE & INTELLECTUAL (10)



Analytical thinking is shown through the comparison table and some discussion of technologies. Justification for the hybrid recommendation is provided, though the reasoning could be more detailed. The database needs of PixelBay are interpreted in terms of structure and scalability. Synthesis of research, implementation, and platform needs to form a recommendation is attempted but would benefit from a more detailed connection between these elements.

14

PRACTICAL APPLICATION(40)



While an Entity-Relationship Diagram is presented, the accompanying SQL code for table structures, constraints, performance enhancements, in detail. A NoSQL schema and example queries are demonstrated in the report. Therefore, the implementation tasks are only partially completed

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TRANSFERABLE SKILLS(10)



Report Structure: Partially complete. Required sections on deployment strategies and data security/backup are not fully developed.

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