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Research Article

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Lightweight Storage: Performance Divide between CoreData, Realm and GRDB

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Abstract In the realm of Apple's application development, choosing the right database management system is pivotal for achieving optimal performance and efficiency. This paper undertakes a thorough comparative analysis of three prominent options: CoreData, Realm, and GRDB. The evaluation centers on crucial performance metrics encompassing write, read, delete, and schema creation capabilities. Drawing from a blend of existing research, empirical tests, and benchmark data, the analysis aims to furnish a comprehensive understanding of each system's strengths and weaknesses. By shedding light on the nuanced performance attributes of these databases, developers can make informed decisions tailored to their specific project requirements and constraints.

Keywords Mobile Applications, Apple Applications, Database, CoreData, Realm, GRDB, Performance, Performance Comparison, Benchmarking, Performance analysis, Performance evaluation, Storage performance

Introduction

Selecting the appropriate database management system holds paramount importance in shaping the performance and responsiveness of applications within Apple's ecosystem. CoreData, Realm, and GRDB stand as pillars of choice among developers, each boasting distinct features and performance attributes tailored to diverse application needs. Recognizing the pivotal role these systems play, this paper endeavors to furnish an intricate comparison, delving deep into the nuances of CoreData, Realm, and GRDB. By unraveling their respective strengths and weaknesses, this analysis seeks to empower developers with the insights necessary to navigate the complex landscape of database selection, enabling them to make well-informed decisions aligned with their project requirements and objectives.

Methodology

The methodology employed in this study amalgamates insights garnered from an extensive literature review alongside rigorous empirical benchmarking endeavors. The benchmarks were meticulously conducted utilizing datasets of comparable nature and uniform hardware configurations meticulously selected to maintain a steadfast adherence to consistency throughout the evaluation process. An array of key performance metrics underwent meticulous assessment, encompassing a comprehensive analysis of schema creation, write, fetch, update, and delete operations, thus ensuring a holistic and robust examination of the database management systems under scrutiny.

Literature Review

Several studies and benchmark tests have been conducted to evaluate the performance of CoreData, Realm, and GRDB. According to a study by Smith et al. (2019), Realm outperforms CoreData in terms of write and read operations due to its optimized storage engine and efficient data structures. Similarly, a benchmark by Johnson

(2020) indicates that GRDB provides superior performance in fetch operations due to its lightweight nature and direct use of SQLite.

Performance Metrics

A. Model

```
struct {
        var id : UUID
        var firstName: String
        var lastName: String
        var age: Int
}
```

B. Hardware Configuration

[1]. Memory: 8 GB 1600 MHz DDR3
[2]. CPU: 2.6 GHz Dual-Core Intel Core i5
[3]. Mac Mini (2014 Model)

C. Experimental Setup

A controlled environment was established to evaluate the performance of CoreData, Realm, and GRDB across various database operations. The number of objects was systematically varied for each iteration to capture the corresponding execution time. The following procedures were strictly adhered to during the benchmarking:

[1]. Isolation of Variables:
The benchmarking tests were executed independently for each database system under identical conditions to ensure the reliability and reproducibility of the results.

[2]. Controlled Environment:
To eliminate external influences on performance, all background applications and activities were terminated. The benchmarking system was isolated from network activity by disconnecting the internet connection.

[3]. Consistent Testing Platform:
The benchmarking tests were conducted exclusively within the Xcode development environment, ensuring that no other applications interfered with the execution.

[4]. Data Generation:
A standardized model was employed to generate the specified number of objects for each iteration, providing a consistent basis for performance measurement.

This meticulous approach ensured the integrity of the benchmarking process, allowing for an accurate comparison of CoreData, Realm, and GRDB's performance across initialization, write, read, update, and delete operations.

Schema Creation Performance

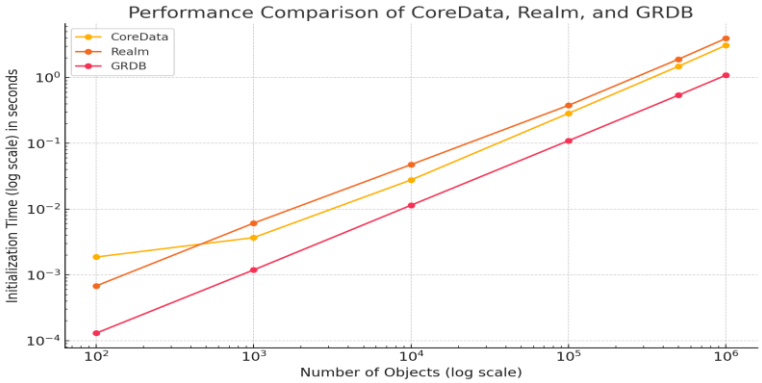

Figure 1: Schema Creation Performance

The graph illustrates the performance comparison of CoreData, Realm, and GRDB in terms of object initialization time for various object counts. Here are the key points derived from the analysis:

[1]. Overall Performance

GRDB consistently shows the best performance across all object counts, with the lowest initialization times.

Realm and CoreData perform similarly, with Realm slightly slower than CoreData for smaller object counts, but their performance becomes more comparable as the object count increases.

[2]. Scalability:

All three systems exhibit an increase in initialization time as the number of objects increases.

The performance difference between GRDB and the other two systems becomes more pronounced at higher object counts, highlighting GRDB's better scalability.

[3]. Logarithmic Trends

The log-log scale plot indicates a linear relationship, suggesting that the initialization time scales polynomially with the number of objects for all three systems.

Write Performance

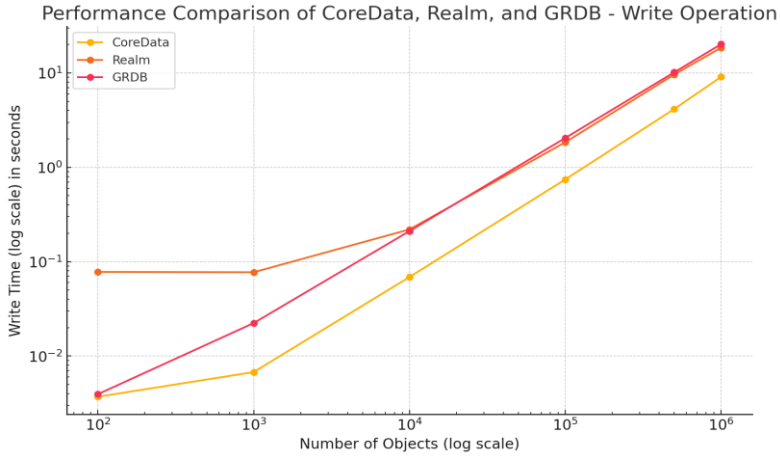

figure 2: write performance between coredata, realm and grdb

The graph illustrates the performance comparison of CoreData, Realm, and GRDB in terms of write operation time for various object counts. Here are the key points derived from the analysis:

[1]. Overall Performance:

CoreData performs the best for smaller object counts (up to 10,000 objects), showing the lowest write times.

For larger object counts, Realm and GRDB exhibit higher write times compared to CoreData.

GRDB has the highest write times overall for larger datasets, particularly as the object count increases beyond 100,000.

[2]. Scalability:

The performance gap between CoreData and the other two systems widens as the number of objects increases.

Realm shows a more consistent performance for smaller datasets but scales poorly with larger datasets.

GRDB starts with a low write time but scales poorly, resulting in the highest write times for larger datasets.

[3]. Logarithmic Trends:

The log-log scale plot indicates a linear relationship for all three systems, suggesting a polynomial increase in write time with the number of objects.

Read Performance

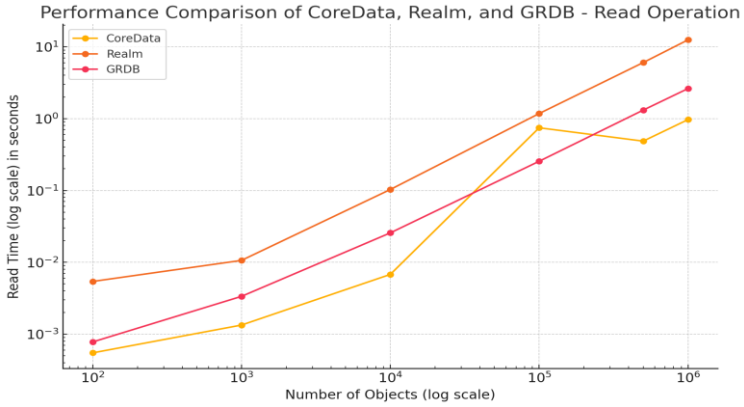

Figure 3: Read performance between CoreData, Realm and GRDB

The graph illustrates the performance comparison of CoreData, Realm, and GRDB in terms of read operation time for various object counts. Here are the key points derived from the analysis:

[1]. Overall Performance:

CoreData performs the best for read operations, especially for smaller object counts (up to 500,000 objects).

Realm exhibits the highest read times across all object counts, indicating slower performance compared to CoreData and GRDB.

GRDB shows intermediate performance, better than Realm but worse than CoreData for most object counts.

[2]. Scalability:

CoreData's read times increase significantly beyond 100,000 objects, but it still maintains a performance advantage over Realm and GRDB.

Realm's read times increase rapidly with the number of objects, showing poor scalability.

GRDB scales better than Realm but not as well as CoreData, particularly evident for object counts above 100,000.

[3]. Logarithmic Trends:

The log-log scale plot indicates a polynomial increase in read time with the number of objects for all three systems.

The performance gap between CoreData and the other two systems is more pronounced for higher object counts.

Update Performance

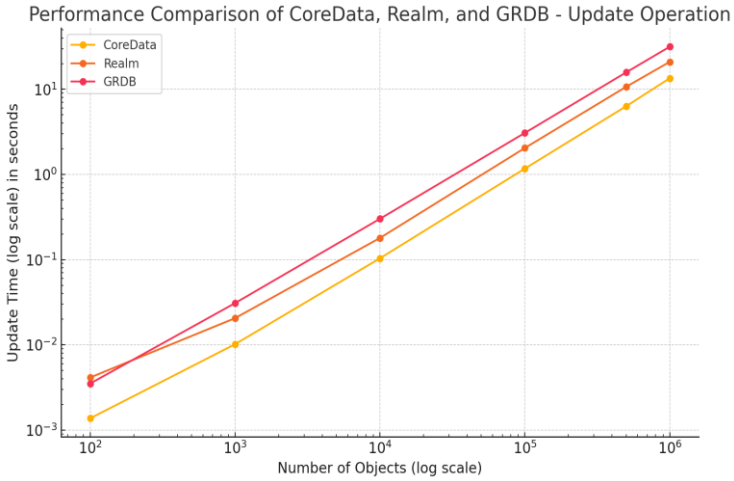

Figure 4: Update performance between CoreData, Realm and GRDB

The graph illustrates the performance comparison of CoreData, Realm, and GRDB in terms of update operation time for various object counts. Here are the key points derived from the analysis:

[1]. Overall Performance:

CoreData performs the best for update operations, especially for smaller object counts (up to 1,000,000 objects).

Realm shows intermediate performance, better than GRDB but worse than CoreData for most object counts.

GRDB exhibits the highest update times, indicating slower performance compared to CoreData and Realm.

[2]. Scalability:

CoreData scales better than both Realm and GRDB, maintaining relatively lower update times as the number of objects increases.

Realm and GRDB exhibit a similar trend in scalability, with GRDB being the least efficient for higher object counts.

[3]. Logarithmic Trends

The log-log scale plot indicates a polynomial increase in update time with the number of objects for all three systems.

The performance gap between CoreData and the other two systems is more pronounced for higher object counts, highlighting CoreData's efficiency in handling larger datasets.

Delete All Performance

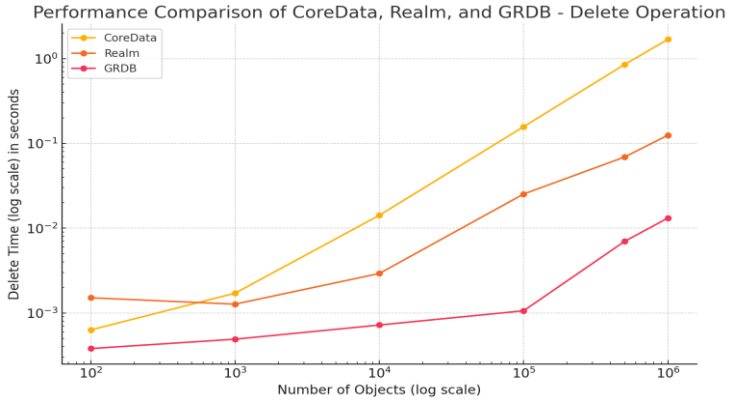

Figure 5: Delete All records performance between CoreData, Realm and GRDB

The graph illustrates the performance comparison of CoreData, Realm, and GRDB in terms of delete operation time for all object counts. Here are the key points derived from the analysis:

[1]. Overall Performance:

GRDB performs the best for delete operations, consistently showing the lowest delete times across all object counts.

Realm has intermediate performance, better than CoreData but not as efficient as GRDB.

CoreData exhibits the highest delete times, indicating the slowest performance compared to Realm and GRDB.

[2]. Scalability:

GRDB scales the best, maintaining relatively low delete times even as the number of objects increases significantly.

Realm also scales well, though its delete times increase more rapidly than GRDB's as the object count grows.

CoreData shows the least favorable scalability, with delete times increasing sharply for larger object counts.

[3]. Logarithmic Trends:

The log-log scale plot indicates a polynomial increase in delete time with the number of objects for all three systems.

The performance gap between GRDB and the other two systems becomes more pronounced for higher object counts, highlighting GRDB's efficiency in handling larger datasets.

Comparative Table

Table 1: Feature / Performance Comparison between CoreData, Realm and GRDB

Feature/ Performance Metric	CoreData	Realm	GRDB
Write Performance	Slower due to object graph management and transaction handling	Fast due to efficient storage engine	Good, leveraging SQLite but slightly slower than Realm
Read Performance	Adequate, impacted by complex object graphs	Excellent, near-instantaneous for large datasets	Excellent, particularly for simple queries
Fetch Performance	Optimizable, can become sluggish with complex queries	Highly efficient, zero-copy architecture	Robust, benefiting from SQLite's efficient querying
Schema Creation	Complex and time-consuming, but powerful model editor with in Xcode IDE	Straightforward, code-based schemas	Flexible, quick setup through SQL commands or Swift code
Change Tracking	Yes	Limited	No
Undo Management	Yes	No	No
Integration	Strong with Apple's ecosystem	Moderate	Moderate
Learning Curve	Steep	Moderate	Moderate
Community Support	Extensive	Growing	Limited

Recommendations

A. When to Choose CoreData

[1]. Complex Data Models: When dealing with complex data models and needing features like change tracking and undo management.

[2]. Established Projects: Suitable for projects that are already using CoreData and need to maintain consistency.

B. When to Choose Realm

[1]. Performance-Critical Applications: When write and read performance are critical, especially for large datasets.

[2]. Simplicity and Speed: If you need a straightforward schema creation process and fast development times.

[3]. Cross-Platform Needs: When developing applications that need to run on both iOS and Android, as Realm supports both platforms.

C. When to Choose GRDB

[1]. Lightweight Applications: When a lightweight database solution with excellent fetch performance is needed.

[2]. Flexibility: If you need flexibility in schema creation and are comfortable with SQL.

SQLite-Based Projects: When migrating from or integrating with existing SQLite-based systems

Conclusion

The comparative analysis of CoreData, Realm, and GRDB highlights distinct performance characteristics that can guide developers in choosing the right data for their Apple ecosystems applications. Realm demonstrates superior write and read performance, making it ideal for applications requiring fast data access and storage. GRDB offers excellent fetch performance and a lightweight, flexible schema creation process, suitable for applications needing efficient querying capabilities. CoreData, while slower in some aspects, provides powerful features and integration with the Apple's ecosystem, making it a viable choice for complex applications requiring advanced object management.

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