

A SECURE DATA PERSISTENCE STRATEGY USING ENTITY FRAMEWORK CORE WITH DYNAMIC ENCRYPTION IN ENTERPRISE .NET SYSTEMS

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Abstract - In modern enterprise .NET applications, data persistence frameworks such as Entity Framework Core (EF Core) are widely adopted for efficient database interaction and rapid development. However, EF Core primarily focuses on simplifying Object-Relational Mapping (ORM) operations and lacks built-in mechanisms for securing sensitive data at the application level. This limitation exposes critical enterprise information to potential security threats, including unauthorized access, data breaches, and insider attacks. To address this challenge, this research proposes a secure data persistence strategy that integrates dynamic encryption techniques within the EF Core data access pipeline. The proposed approach introduces an encryption module that automatically encrypts sensitive data fields before database storage and decrypts them during retrieval, ensuring data confidentiality without altering application logic. The framework leverages EF Core features such as value converters and interceptors to seamlessly embed encryption into persistence operations. A prototype enterprise application is developed using ASP.NET Core and EF Core to validate the feasibility of the proposed model. Experimental evaluation demonstrates that the proposed strategy significantly enhances data security while maintaining acceptable performance overhead. Comparative analysis with traditional and static encryption approaches highlights improved flexibility and stronger protection. The findings suggest that integrating dynamic encryption within ORM frameworks provides an effective solution for secure data persistence in enterprise environments.

Key Words: Entity Framework Core, Dynamic Encryption, Secure Data Persistence, ORM Security, Enterprise .NET Systems, Data Protection

1. INTRODUCTION

1.1 Background

1.1.1 Evolution of Enterprise Architectures (Monolithic → Microservices)

Enterprise software systems have undergone a significant transformation over the past few decades, evolving from tightly coupled monolithic architectures to highly modular and distributed microservices-based systems. Traditional monolithic applications integrated all functionalities—such as user interface, business logic, and data access—within a

single codebase, making them easier to develop initially but difficult to scale and maintain over time. With the rise of cloud computing and distributed systems, organizations have shifted toward microservices architectures, where applications are decomposed into independent, loosely coupled services that communicate via APIs. This evolution has improved scalability, flexibility, and deployment efficiency, enabling enterprises to respond rapidly to changing business requirements (Newman, 2015).

1.1.2 Importance of Data-Driven Systems and Persistence

Modern enterprise applications are fundamentally data-driven, relying on persistent storage systems to manage large volumes of critical information such as customer records, financial transactions, and operational data. Data persistence ensures that information remains durable and accessible across application lifecycles, supporting business continuity and decision-making processes. As organizations increasingly depend on real-time analytics and intelligent systems, the role of efficient and secure data persistence mechanisms has become crucial. Persistent storage frameworks, particularly those integrated with ORM technologies, enable seamless interaction between applications and databases while maintaining data integrity and availability (Silberschatz, Korth and Sudarshan, 2019).

1.2 Problem Statement

1.2.1 Lack of Field-Level Encryption in EF Core

Despite its widespread adoption in enterprise .NET applications, Entity Framework Core (EF Core) does not provide built-in support for field-level encryption of sensitive data. While it simplifies database interactions through abstraction and automation, its default configurations prioritize developer productivity over security. As a result, sensitive fields such as personal identifiers, credentials, and financial data are often stored in plaintext unless additional security mechanisms are implemented manually (Lerman, 2020).

1.2.2 Exposure of Sensitive Enterprise Data

The absence of integrated encryption mechanisms in ORM frameworks increases the risk of data exposure in enterprise

systems. Databases often become prime targets for cyberattacks, including SQL injection, unauthorized access, and insider threats. If sensitive information is stored without encryption, attackers who gain access to the database can easily exploit such data, leading to financial losses, reputational damage, and regulatory violations (Whitman and Mattord, 2018).

1.2.3 Limitations of Traditional/Static Encryption

Traditional encryption approaches, particularly static encryption methods, apply fixed encryption mechanisms that lack adaptability to dynamic system requirements. These methods often require manual integration, increasing development complexity and limiting scalability. Furthermore, static encryption may not effectively address runtime security needs or varying data sensitivity levels, making it less suitable for modern enterprise applications that demand flexible and efficient security solutions (Stallings, 2017).

1.3 Research Objectives

1.3.1 Analyze ORM Security Issues

This research aims to critically examine the security limitations inherent in ORM frameworks, particularly focusing on EF Core. The analysis includes identifying vulnerabilities related to data storage, access control, and lack of built-in encryption mechanisms, thereby establishing the need for enhanced security integration (Fowler, 2018).

1.3.2 Design Dynamic Encryption Model

A key objective of this study is to design a dynamic encryption model that adapts to runtime conditions and selectively encrypts sensitive data fields. This model seeks to balance security and performance by applying encryption only where necessary, improving efficiency in enterprise systems (Green and Smith, 2016).

1.3.3 Integrate with EF Core

The research further aims to integrate the proposed encryption model seamlessly within the EF Core persistence pipeline. By leveraging EF Core features such as value converters and interceptors, the study ensures that encryption and decryption processes occur transparently without disrupting application logic (Microsoft, 2023).

1.3.4 Evaluate Performance and Security

Another important objective is to evaluate the effectiveness of the proposed approach in terms of both security enhancement and performance impact. Experimental analysis is conducted to measure encryption overhead, query execution time, and resistance to data breaches, ensuring practical applicability in enterprise environments.

1.4 Research Questions

1.4.1 How to Integrate Encryption in EF Core?

This research investigates how encryption mechanisms can be embedded within the EF Core data access workflow without requiring extensive modifications to application architecture. It explores techniques such as value converters, middleware, and custom encryption services to achieve seamless integration.

1.4.2 What is the Performance-Security Tradeoff?

Another key research question examines the tradeoff between enhanced data security and system performance. While encryption improves confidentiality, it introduces computational overhead. This study evaluates whether the proposed dynamic encryption approach maintains an optimal balance between these two critical factors (Katz and Lindell, 2020).

2. LITERATURE REVIEW

2.1 Data Persistence in Enterprise Systems

2.1.1 Traditional vs Modern Persistence

Data persistence has long been a foundational component of enterprise systems, enabling the storage and retrieval of critical business information. Traditional persistence approaches primarily relied on file systems and relational database management systems (RDBMS), where developers manually interacted with structured query languages (SQL) to manage data operations. While these methods provided strong data consistency and transactional integrity, they often resulted in increased development complexity and limited scalability. In contrast, modern persistence mechanisms leverage abstraction layers, distributed databases, and cloud-native architectures to improve scalability, flexibility, and maintainability. Technologies such as Object-Relational Mapping (ORM) frameworks and microservices-based storage solutions allow seamless interaction with databases while supporting high-volume, real-time data processing. This evolution reflects the growing demand for efficient and scalable data management in enterprise environments (Elmasri and Navathe, 2016).

2.2 ORM Frameworks and Security

2.2.1 ORM Abstraction Benefits & Risks

Object-Relational Mapping (ORM) frameworks have significantly simplified database interaction by abstracting the complexity of SQL-based operations and enabling developers to work with object-oriented paradigms. This abstraction improves productivity, reduces boilerplate code, and enhances maintainability of enterprise applications. However, the abstraction layer also introduces certain security risks. Developers may rely heavily on ORM-

generated queries without fully understanding their underlying behavior, potentially leading to inefficient queries or vulnerabilities such as improper data validation. Additionally, ORM frameworks often lack built-in mechanisms for securing sensitive data at the field level, making them susceptible to data exposure if additional security measures are not implemented. Thus, while ORM frameworks offer substantial development benefits, they require careful configuration and integration with security practices to ensure robust data protection (Fowler, 2018).

2.3 Entity Framework Core

2.3.1 Architecture (DbContext, DbSet, LINQ)

Entity Framework Core (EF Core) is a modern ORM framework designed for the .NET ecosystem, providing a structured approach to data access and persistence. Its architecture is centered around key components such as DbContext, which acts as the primary interface between the application and the database, managing connections and tracking changes to entities. The DbSet component represents collections of entities mapped to database tables, enabling CRUD (Create, Read, Update, Delete) operations. Additionally, EF Core utilizes Language Integrated Query (LINQ) to allow developers to write database queries using programming language syntax, thereby improving code readability and type safety. These architectural features collectively streamline database operations and support efficient development of enterprise applications (Lerman, 2020).

2.3.2 Limitations in Security

Despite its architectural strengths, EF Core has notable limitations in terms of data security. The framework does not inherently provide field-level encryption for sensitive data, leaving critical information vulnerable if not explicitly protected. While it supports secure connection protocols and basic authentication mechanisms, it relies on developers to implement advanced security features such as encryption and access control. This limitation becomes particularly significant in enterprise environments where large volumes of sensitive data are processed and stored. Consequently, additional mechanisms must be integrated into the EF Core pipeline to ensure comprehensive data protection (Hoffman, 2019).

2.4 Database Security Techniques

2.4.1 Encryption at Rest, in Transit, Field-Level

Database security techniques are essential for protecting sensitive information from unauthorized access and cyber threats. Encryption at rest ensures that data stored in databases or storage systems remains encrypted, preventing unauthorized users from interpreting it even if they gain access to the storage medium. Encryption in transit secures

data as it moves between applications, servers, and databases, protecting it from interception during communication. Field-level encryption provides an additional layer of protection by encrypting specific sensitive attributes, such as personal identifiers or financial data, within database records. Together, these techniques form a multi-layered security approach that enhances data confidentiality and integrity in enterprise systems (Stallings, 2017).

2.5 Encryption Techniques

2.5.1 Symmetric (AES), Asymmetric (RSA)

Encryption techniques are fundamental to securing enterprise data. Symmetric encryption algorithms, such as the Advanced Encryption Standard (AES), use a single secret key for both encryption and decryption, offering high performance and efficiency for large-scale data processing. In contrast, asymmetric encryption algorithms, such as RSA, use a pair of keys—a public key for encryption and a private key for decryption—providing enhanced security for key exchange and communication. While symmetric encryption is faster and suitable for bulk data encryption, asymmetric encryption is typically used for secure key distribution and authentication processes. Combining both approaches is a common practice in enterprise systems to achieve optimal security and performance (Katz and Lindell, 2020).

2.5.2 Static vs Dynamic Encryption

Traditional static encryption methods apply a fixed encryption mechanism to data, regardless of context or usage patterns. While this approach ensures a baseline level of security, it lacks flexibility and may introduce unnecessary computational overhead. Dynamic encryption, on the other hand, adapts encryption processes based on runtime conditions, data sensitivity, or access requirements. This selective encryption approach enhances efficiency by protecting only critical data while maintaining system performance. Dynamic encryption is particularly suitable for modern enterprise applications that require both strong security and high scalability (Green and Smith, 2016).

2.6 Research Gap

2.6.1 No Integrated Dynamic Encryption within EF Core Pipeline

Existing research and enterprise practices reveal a significant gap in integrating dynamic encryption mechanisms directly within ORM frameworks such as EF Core. While various studies have explored database-level encryption and application-level security techniques, there is limited work on embedding encryption seamlessly within the ORM data persistence pipeline. This lack of integration results in fragmented security implementations and increased development complexity.

2.6.2 Lack of Performance-Aware Secure Persistence Frameworks

Another critical gap lies in the absence of performance-aware secure persistence frameworks that balance data security with system efficiency. Many existing solutions focus primarily on enhancing security without adequately considering the performance overhead introduced by encryption processes. Consequently, there is a need for a comprehensive framework that not only secures data but also evaluates and optimizes the tradeoff between encryption overhead and application performance. Addressing these gaps forms the primary motivation for the proposed research.

3. PROPOSED METHODOLOGY

3.1 Research Design

3.1.1 Design Science Research (DSR) Approach

This research adopts the Design Science Research (DSR) methodology, which is widely used in information systems and software engineering to develop and evaluate innovative technological solutions. The DSR approach focuses on creating a functional artefact—in this case, a secure data persistence framework—that addresses a specific problem identified in enterprise systems. The methodology follows a structured process consisting of problem identification, objective definition, artefact design, development, demonstration, and evaluation. In the context of this study, the problem of inadequate data security in EF Core persistence is addressed by designing a dynamic encryption-integrated framework. The artefact is implemented as a prototype enterprise application and evaluated through experimental analysis to validate its effectiveness in improving data security while maintaining acceptable performance levels.

3.2 System Overview

3.2.1 Secure Persistence Framework Integrating EF Core, Encryption Module, and Key Management

The proposed system introduces a secure persistence framework that integrates three primary components: Entity Framework Core (EF Core), an encryption module, and a key management system. EF Core serves as the data access layer, enabling object-oriented interaction with relational databases. The encryption module is responsible for automatically encrypting sensitive data before storage and decrypting it upon retrieval, ensuring data confidentiality throughout the data lifecycle. The key management component handles the generation, storage, and rotation of cryptographic keys, ensuring secure and reliable encryption operations. By combining these components, the framework provides a seamless and automated approach to securing

sensitive enterprise data without requiring significant modifications to application logic or database structures.

3.3 Architecture Design

3.3.1 Multi-Layer Architecture

The proposed framework is designed using a multi-layer architecture to ensure modularity, scalability, and separation of concerns. This architectural approach divides the system into distinct layers, each responsible for specific functionalities within the data persistence process.

Application Layer

The application layer represents the topmost layer of the system and is responsible for handling user interactions, business logic, and request processing. It communicates with the data access layer to perform database operations while remaining independent of underlying encryption mechanisms. This separation ensures that security enhancements do not disrupt application functionality.

Data Access Layer (EF Core)

The data access layer is implemented using EF Core, which acts as the intermediary between the application and the database. It manages entity tracking, query generation, and transaction handling. EF Core abstracts database interactions, allowing developers to work with strongly typed objects instead of raw SQL queries. Within the proposed framework, this layer also interacts with the encryption module to ensure secure data persistence.

Encryption Layer

The encryption layer is a dedicated component responsible for applying cryptographic operations to sensitive data. It performs encryption before data is stored in the database and decryption when data is retrieved. This layer ensures that sensitive information is never stored in plaintext, thereby enhancing data confidentiality and protecting against unauthorized access.

Database Layer

The database layer represents the persistent storage system, typically implemented using relational database management systems such as SQL Server or PostgreSQL. In the proposed architecture, the database stores only encrypted data, ensuring that even if unauthorized access occurs, the stored information remains protected and unreadable without proper decryption keys.

3.4 Dynamic Encryption Model

3.4.1 Runtime Encryption/Decryption

The dynamic encryption model operates at runtime, automatically applying encryption and decryption processes during data operations. When data is inserted or updated, the encryption module encrypts sensitive fields before they are persisted in the database. Similarly, when data is retrieved, the module decrypts the encrypted fields to provide readable information to the application. This runtime approach ensures seamless integration of security mechanisms without requiring manual intervention from developers.

3.4.2 Selective Field-Level Encryption

Unlike traditional approaches that encrypt entire datasets, the proposed model implements selective field-level encryption, targeting only sensitive attributes such as personal identifiers, credentials, and financial data. This selective approach reduces computational overhead while maintaining strong security for critical data. It also provides flexibility by allowing developers to define which fields require encryption based on application requirements and security policies.

3.5 Integration with EF Core

3.5.1 Value Converters

Value converters in EF Core are used to transform entity property values during database operations. In this framework, value converters are utilized to automatically encrypt data before it is stored in the database and decrypt it when retrieved. This approach allows encryption logic to be embedded directly within the entity model, ensuring transparency and minimal impact on application code.

3.5.2 Interceptors

Interceptors provide a mechanism to intercept and modify database operations within the EF Core pipeline. They enable the implementation of cross-cutting concerns such as logging, validation, and security. In the proposed framework, interceptors are used to enforce encryption policies dynamically by intercepting database commands and applying encryption or decryption processes as required.

3.5.3 Middleware Security Layer

The middleware security layer acts as an additional abstraction within the application pipeline, ensuring consistent enforcement of security policies across all data operations. It integrates with the application's request-response cycle and works alongside EF Core to manage encryption processes. This layer enhances the flexibility and scalability of the framework by centralizing security logic,

reducing redundancy, and ensuring uniform protection of sensitive data across the system.

4. SYSTEM IMPLEMENTATION

4.1 Development Environment

4.1.1 ASP.NET Core

The implementation of the proposed secure persistence framework is carried out using ASP.NET Core as the primary application development platform. ASP.NET Core provides a robust and scalable environment for building enterprise-grade web applications and APIs. It supports modular architecture, middleware integration, and cross-platform deployment, making it suitable for implementing secure data-driven systems. Within this research, ASP.NET Core is used to handle user requests, business logic, and interaction with the data access layer, ensuring seamless integration with security components.

4.1.2 Entity Framework Core (EF Core)

Entity Framework Core is utilized as the Object-Relational Mapping (ORM) framework for managing database operations. EF Core simplifies data access by mapping application objects to relational database tables and supporting features such as change tracking, migrations, and LINQ-based queries. In this implementation, EF Core plays a central role in integrating the encryption mechanisms within the persistence layer, allowing secure handling of sensitive data without modifying the core business logic.

4.1.3 SQL Server / PostgreSQL

The database layer is implemented using relational database management systems such as SQL Server or PostgreSQL. These databases provide reliable data storage, transaction management, and scalability required for enterprise applications. In the proposed framework, the database stores encrypted data, ensuring that sensitive information remains protected even in the event of unauthorized access to the database system.

4.2 Encryption Module Implementation

4.2.1 AES-Based Encryption

The encryption module is implemented using the Advanced Encryption Standard (AES), a widely adopted symmetric encryption algorithm known for its strong security and computational efficiency. AES is used to encrypt sensitive data fields before they are persisted in the database. Its high performance makes it suitable for enterprise systems that handle large volumes of data, ensuring minimal impact on system performance while maintaining strong data protection.

4.2.2 Key Management Strategy

A secure key management strategy is essential for ensuring the effectiveness of the encryption process. In this framework, cryptographic keys are generated using secure algorithms and stored in protected environments such as configuration stores or secure vaults. Key rotation mechanisms are implemented to periodically update encryption keys, reducing the risk of key compromise. Proper key lifecycle management ensures that encryption remains secure and compliant with enterprise security standards.

4.3 Secure Data Flow

4.3.1 Data Input → Encryption → Database Storage

The secure data flow begins when a user submits data through the application interface. This data is processed by the application layer and passed to the data access layer managed by EF Core. Before the data is stored in the database, the encryption module automatically encrypts sensitive fields using the configured encryption algorithm. The encrypted data is then persisted in the database, ensuring that no sensitive information is stored in plaintext.

4.3.2 Data Retrieval → Decryption → Application

When data is retrieved from the database, EF Core fetches the encrypted records and passes them through the encryption module. The module decrypts the relevant fields before returning the data to the application layer. This ensures that the application operates on readable data while maintaining secure storage practices. The entire process is transparent to the user and does not require manual handling of encryption or decryption operations.

4.4 Prototype Design

4.4.1 Entity Model with Encrypted Fields

The prototype system is designed using entity models that represent database tables within the application. Sensitive attributes within these models, such as personal identifiers and confidential records, are configured for encryption using EF Core mechanisms. By integrating encryption at the entity level, the framework ensures that security is embedded directly into the data model, providing a consistent and scalable approach to protecting sensitive information.

4.4.2 Secure Repository Pattern

The repository pattern is implemented to manage data access operations in a structured and secure manner. This pattern abstracts database interactions and centralizes data handling logic, allowing the integration of security mechanisms such as encryption and access control. By using a secure repository pattern, the system ensures that all data operations adhere to predefined security policies, improving

maintainability and reducing the risk of inconsistent security implementations.

5. EXPERIMENTAL SETUP

5.1 Evaluation Metrics

5.1.1 Execution Time

Execution time is measured to evaluate the overall system performance, particularly the time required to complete database operations such as insertion, retrieval, and updates. This metric helps determine the impact of encryption on application responsiveness and efficiency.

5.1.2 Query Performance

Query performance analysis focuses on the speed and efficiency of database queries executed through EF Core. It examines how encryption affects query execution time and database interaction, ensuring that the proposed framework maintains acceptable performance levels in enterprise environments.

5.1.3 Encryption Overhead

Encryption overhead refers to the additional computational cost introduced by encryption and decryption processes. This metric is critical for assessing the feasibility of the proposed approach, as excessive overhead may negatively impact system scalability and performance.

5.1.4 Security Strength

Security strength is evaluated based on the framework's ability to protect sensitive data from unauthorized access. This includes assessing data confidentiality, resistance to data breaches, and effectiveness of encryption mechanisms in safeguarding stored information.

5.2 Dataset and Test Environment

5.2.1 Enterprise-Like Simulated Dataset

The experimental evaluation is conducted using a simulated dataset that reflects real-world enterprise scenarios. The dataset includes various types of sensitive and non-sensitive data, such as user information, transaction records, and operational data. This realistic dataset allows for accurate assessment of the framework's performance and security capabilities under practical conditions.

5.3 Comparative Models

5.3.1 EF Core (Without Encryption)

The baseline model consists of a standard EF Core implementation without any encryption mechanisms. This model is used to measure the default performance and

highlight the security limitations of unprotected data persistence.

5.3.2 EF Core with Static Encryption

The second model incorporates static encryption, where data is encrypted using a fixed approach without dynamic adaptation. This model provides a comparison point to evaluate the limitations of traditional encryption methods in terms of flexibility and performance.

5.3.3 Proposed Dynamic Encryption Model

The final model represents the proposed framework, which integrates dynamic encryption within the EF Core persistence pipeline. This model is evaluated against the baseline and static encryption approaches to demonstrate improvements in data security, flexibility, and overall system performance.

6. RESULTS AND ANALYSIS

6.1 Performance Analysis

6.1.1 Query Latency Comparison

The performance of the proposed secure persistence framework is evaluated by analyzing query latency across different models. Query latency refers to the time taken by the system to execute database operations such as insert, update, and retrieval. The baseline EF Core model without encryption demonstrates the lowest latency due to the absence of additional processing overhead. In contrast, the static encryption model introduces moderate latency because encryption and decryption operations are applied uniformly to all data. The proposed dynamic encryption model shows slightly higher latency than the baseline but performs better than static encryption due to its selective encryption strategy, which targets only sensitive fields. This optimization ensures that unnecessary encryption operations are avoided, thereby maintaining acceptable system responsiveness.

6.1.2 Encryption Overhead Impact

Encryption overhead represents the additional computational cost introduced by cryptographic operations during data persistence. The static encryption model incurs higher overhead as it encrypts all data fields regardless of sensitivity. In comparison, the proposed dynamic encryption model reduces overhead by applying encryption selectively at runtime. Experimental observations indicate that while there is a measurable increase in processing time compared to the baseline, the overhead remains within acceptable limits for enterprise applications. This demonstrates that the proposed approach effectively balances security requirements with performance constraints.

6.2 Security Evaluation

6.2.1 Data Confidentiality Improvement

The proposed dynamic encryption framework significantly enhances data confidentiality by ensuring that sensitive information is encrypted before being stored in the database. Unlike the default EF Core model, where data is stored in plaintext, the encrypted storage mechanism prevents unauthorized users from interpreting sensitive information even if database access is compromised. The selective field-level encryption further ensures that critical data elements receive stronger protection while maintaining system efficiency.

6.2.2 Resistance to Data Breaches

The framework improves resistance to data breaches by integrating encryption directly within the persistence layer. In the event of unauthorized database access, attackers are unable to retrieve meaningful information due to the encrypted format of stored data. Additionally, the use of secure key management practices enhances protection against key compromise. Compared to static encryption, the dynamic encryption model provides improved resilience by adapting encryption strategies based on data sensitivity and operational context, thereby strengthening overall system security.

Table-1: Model Comparison

Model	Security Level	Performance	Flexibility
EF Core Default	Low	High	Low
Static Encryption	Medium	Medium	Low
Proposed Dynamic Model	High	Medium-High	High

6.3.2 Interpretation of Comparative Results

The comparative analysis highlights the strengths and limitations of each model. The default EF Core model offers high performance but lacks adequate security, making it unsuitable for handling sensitive enterprise data. The static encryption model improves security but introduces higher computational overhead and lacks flexibility due to its rigid encryption approach. The proposed dynamic encryption model achieves the best balance by providing high security, improved flexibility, and acceptable performance. Its ability to selectively encrypt sensitive fields makes it more efficient and adaptable to real-world enterprise requirements.

6.4 Discussion

6.4.1 Trade-off Between Security and Performance

The results clearly demonstrate the inherent trade-off between data security and system performance. While encryption enhances data protection, it introduces additional computational overhead that can impact system efficiency. The proposed dynamic encryption model addresses this challenge by optimizing encryption operations through selective application, thereby reducing unnecessary processing. This approach ensures that security enhancements do not significantly degrade performance, making it a practical solution for enterprise environments.

6.4.2 Practical Feasibility in Enterprise Systems

From an implementation perspective, the proposed framework is highly feasible for real-world enterprise applications. It integrates seamlessly with existing EF Core workflows and does not require major architectural changes. The use of built-in EF Core features such as value converters and interceptors simplifies adoption, while the modular design ensures scalability and maintainability. Overall, the results indicate that the proposed secure persistence strategy can be effectively deployed in enterprise systems to enhance data security without compromising operational efficiency.

7. CONCLUSION

This research presents a secure data persistence strategy for enterprise .NET applications by integrating dynamic encryption within the Entity Framework Core (EF Core) data access pipeline. The study addresses a critical limitation of modern ORM frameworks, which primarily focus on simplifying database operations but lack built-in mechanisms for protecting sensitive data at the application level. By introducing a dynamic encryption model, the proposed framework ensures that sensitive data fields are automatically encrypted before storage and decrypted during retrieval, thereby enhancing data confidentiality without disrupting application functionality.

The implementation of the framework using ASP.NET Core and EF Core demonstrates its practical feasibility in real-world enterprise environments. Experimental evaluation highlights that the proposed approach significantly improves data security compared to default EF Core and static encryption models. Although encryption introduces additional computational overhead, the selective field-level encryption strategy effectively minimizes performance degradation, maintaining acceptable system efficiency. Furthermore, the integration of encryption mechanisms using EF Core features such as value converters and interceptors ensures seamless adoption without requiring major architectural modifications.

Overall, the research successfully establishes a balanced approach to secure data persistence by addressing both security and performance considerations. The findings contribute to the advancement of secure software engineering practices and provide a practical framework for protecting sensitive enterprise data in modern .NET-based applications.

8. FUTURE SCOPE

Future research can extend the proposed framework by incorporating advanced and adaptive encryption techniques, such as AI-driven or context-aware encryption mechanisms that dynamically adjust security levels based on data sensitivity and usage patterns. Integration with cloud-based key management services, such as secure key vaults, can further enhance scalability and security in distributed environments. Additionally, exploring the applicability of the proposed approach in NoSQL databases and microservices architectures would broaden its usability across diverse enterprise systems. Performance optimization techniques, including hardware acceleration and parallel encryption methods, can be investigated to further reduce computational overhead. Finally, incorporating blockchain-based data integrity verification and zero-trust security models could strengthen the overall robustness and trustworthiness of secure data persistence frameworks in future enterprise applications.

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