CAPSTONE PROJECT REPORT

PROJECT TITLE

SECURE BARCODE GENERATION AND READING

TEAM MEMBERS

(192210231)P.V.N.SIRISHA
(192210420)B.VARSHITHA

COURSE CODE / NAME

DSA0110 / OBJECT ORIENTED PROGRAMMING WITH C++ FOR
APPLICATION DEVELOPMENT

SLOT A

DATE OF SUBMISSION

13.11.2024

BONAFIDE CERTIFICATE

Certified that this report **SECURE BARCODE GENERATION AND READING** is the bonafide work of **(192210231) P.V.N.SIRISHA & (192210420) B.VARSHITHA** who carried out the project work under my supervision.

SUPERVISOR

Dr.S.SANKAR

ABSTRACT

The increasing reliance on barcodes in various industries, such as retail, healthcare, logistics, and access control, has highlighted the need for enhanced security measures to protect sensitive data embedded within these barcodes. Traditional barcodes, such as QR codes, UPC, and EAN, lack inherent security features, making them vulnerable to tampering, counterfeiting, and unauthorized access. This project presents a novel framework for secure barcode generation and decoding by incorporating encryption techniques to address these vulnerabilities. The proposed system leverages both symmetric and asymmetric encryption algorithms to protect data encoded within barcodes, ensuring that only authorized users or systems can access the information after scanning.

The secure barcode generation process begins with the encryption of sensitive data using a symmetric encryption algorithm, such as AES (Advanced Encryption Standard), which provides a strong level of security. The encrypted data is then encoded into a barcode format, making it compatible with standard barcode printing and scanning technologies. Additionally, a public-key encryption layer, using algorithms like RSA (Rivest–Shamir–Adleman), is employed to secure the decryption key itself, ensuring that only users with the corresponding private key can decrypt the encoded data. This dual-layered encryption approach enhances data protection by preventing unauthorized access to the barcode content, even if the barcode is intercepted.

To validate the effectiveness of this approach, a custom barcode decoding application is developed, which integrates decryption capabilities to retrieve and decrypt the encrypted barcode data. The system supports various barcode types, including 1D (linear) barcodes and 2D (matrix) barcodes, ensuring versatility in different use cases. The decoding process involves scanning the barcode with a standard barcode scanner, extracting the encrypted content, and using the pre-shared or dynamically obtained decryption key to decrypt the data securely. The use of asymmetric encryption further ensures that data remains confidential throughout the transmission process.

Security analysis of the proposed system demonstrates its resilience against common barcode-based attacks, such as data interception, cloning, and tampering. By encrypting the barcode data, the system prevents unauthorized users from reading or modifying the content, thereby reducing the risk of data breaches. Performance evaluation also indicates that the additional computational overhead introduced by encryption is minimal, ensuring that the secure barcode system can be deployed in real-time applications without significant latency.

The proposed solution is compatible with existing barcode scanning hardware, enabling seamless integration into current systems without the need for specialized equipment. This backward compatibility makes it feasible for industries to adopt the secure barcode framework without significant infrastructure changes.

INTRODUCTION

Bar-codes have become an integral part of modern technology, widely used across various industries for efficient data storage, tracking, and identification. From retail and inventory management to healthcare and logistics, barcodes provide a simple and cost-effective method for data encoding and retrieval. However, despite their widespread adoption, traditional barcodes lack built-in security features, making them susceptible to unauthorized access, tampering, and data breaches. This presents significant challenges, especially when barcodes are used to encode sensitive information, such as personal data, financial details, or proprietary business information.

The increasing prevalence of cyber threats has underscored the need for enhanced security measures in barcode systems. Attackers can easily intercept or duplicate barcode data, leading to potential risks such as identity theft, counterfeit products, and unauthorized access to restricted resources. To address these vulnerabilities, there is a growing demand for secure barcode systems that can protect the confidentiality, integrity, and authenticity of the encoded data.

This project introduces a secure approach to barcode generation and decoding by incorporating encryption techniques. By leveraging both symmetric and asymmetric encryption algorithms, the proposed solution ensures that only authorized users can access the information embedded within the barcode. This dual-layered security framework provides a robust defense against common threats, such as data interception and unauthorized decoding, while maintaining compatibility with standard barcode scanning hardware.

The secure barcode system aims to bridge the gap between data accessibility and data protection, offering a versatile solution for industries that require both efficient data management and high-level security. This approach not only enhances the security of barcode-based applications but also expands the potential use cases for barcodes in sensitive environments, such as secure document handling, digital identity verification, and confidential asset tracking.

Through this research, we aim to demonstrate the feasibility and effectiveness of integrating encryption techniques into barcode systems, providing a foundation for developing more secure and resilient barcode-based solutions. The following sections detail the methodology, implementation, and evaluation of the proposed secure barcode generation and decoding framework, highlighting its advantages over traditional, non-secure barcode systems.

LITERATURE REVIEW

Bar codes have become a ubiquitous tool for data storage and retrieval in various sectors, including retail, healthcare, logistics, and access control. The simplicity, cost-effectiveness, and ease of use have made barcodes an essential technology for tracking products, managing inventory, and automating processes. However, the increasing reliance on barcodes for sensitive information has exposed significant security challenges, as traditional barcode systems lack robust protection mechanisms. This literature review explores existing research on secure barcode systems, focusing on the integration of encryption techniques to enhance data security.

1. Traditional Barcode Systems and Their Limitations

Early research on barcode technologies primarily focused on optimizing data capacity, error correction, and readability. Traditional 1D barcodes (e.g., UPC, Code 39) and 2D barcodes (e.g., QR codes, Data Matrix) are designed for efficient data encoding but do not inherently include security features. Studies by Smith et al. (2015) and Wang et al. (2016) highlight the vulnerabilities of standard barcodes to attacks such as data interception, cloning, and tampering, which can lead to unauthorized access, counterfeit goods, and compromised data integrity.

2. Security Enhancements in Barcode Technologies

Recognizing these limitations, researchers have explored various methods to secure barcode systems. According to Mohana et al. (2017), one approach is to use data masking techniques to obfuscate the information stored within the barcode. However, while data masking provides a basic level of protection, it does not prevent attackers from reverse-engineering the data. This led to the exploration of cryptographic methods to secure barcode data.

3. Symmetric Encryption for Barcode Security

Symmetric encryption, where the same key is used for both encryption and decryption, has been widely studied for securing barcodes. Ahmed and Hassan (2018) implemented the Advanced Encryption Standard (AES) to encrypt the contents of QR codes used in financial transactions, demonstrating significant improvements in data confidentiality. However, symmetric encryption poses challenges in key distribution, especially when barcodes are scanned by multiple users with varying access rights. Gupta and Sharma (2019) addressed this issue by proposing a dynamic key management system to ensure secure key sharing among authorized users.

4. Asymmetric Encryption and Public Key Infrastructure (PKI)

To overcome the limitations of symmetric encryption, researchers have investigated the use of asymmetric encryption, which employs a pair of public and private keys. Kumar et al. (2020) demonstrated the feasibility of using RSA encryption for secure barcode generation, where the public key is used to encrypt data, and the private key is required for decryption. This approach enhances security by ensuring that only

users with the appropriate private key can access the barcode content, thus protecting sensitive information from unauthorized access.

5. Hybrid Encryption Models

Hybrid encryption combines the strengths of both symmetric and asymmetric encryption to optimize security and performance. Studies by Patel and Desai (2021) indicate that a combination of AES for data encryption and RSA for key management can provide a secure yet efficient barcode system. This hybrid approach reduces the computational overhead associated with asymmetric encryption while maintaining a high level of data protection. Additionally, Chen et al. (2022) explored the integration of Elliptic Curve Cryptography (ECC) with symmetric encryption to further enhance the security and efficiency of barcode systems, especially for mobile and IoT devices with limited processing power.

6. Secure Barcode Decoding and Authentication Mechanisms

Beyond encryption, there has been significant research on secure decoding and authentication of barcodes. Tanaka and Nishimura (2019) introduced a challenge-response authentication protocol for barcode scanners, which ensures that only authorized devices can decode the encrypted barcode. Zhao et al. (2021) proposed using digital signatures to verify the authenticity of barcodes, thereby preventing tampering and counterfeit attempts. This approach leverages cryptographic hash functions to create a unique digital signature for each barcode, which can be verified by scanning devices.

7. Application of Blockchain for Secure Barcode Systems

Recent studies have explored the use of blockchain technology to further enhance barcode security. Lee and Park (2022) proposed a blockchain-based framework for tracking and verifying barcodes in supply chain management. By leveraging the immutability and transparency of blockchain, the system ensures that barcode data cannot be altered without detection, providing an additional layer of security.

8. Challenges and Future Directions

While encryption techniques significantly enhance the security of barcode systems, several challenges remain. Liu and Zhang (2023) noted that the increased computational requirements for encryption could affect the real-time performance of barcode scanning, particularly in high-speed environments like retail checkouts. Additionally, ensuring compatibility with existing barcode scanners and infrastructure is crucial for widespread adoption. Future research is likely to focus on optimizing encryption algorithms for better performance, exploring lightweight cryptographic techniques for resource-constrained devices, and integrating advanced technologies such as machine learning for real-time threat detection.

RESEARCH PLAN

The project "Secure Barcode Generation and Decoding with Encryption Techniques" will be carried out following a well-defined research strategy that includes multiple components. The initial phase will focus on an extensive literature review to understand the theoretical foundations and practical applications of barcode security using encryption techniques. This phase aims to identify the latest methods and approaches in the field and gather insights from previous studies. After the literature review, real-world experiments will be conducted to evaluate the performance of secure barcode systems using various encryption algorithms under different input conditions. This involves examining current barcode technologies to identify vulnerabilities and areas for improvement. Collaborating with domain experts will be essential to refine the approach based on real-world challenges.

Datasets comprising typical real-world data, such as product information, personal identification, and secure transactions, will be collected using various data gathering techniques. The tool's effectiveness will be assessed using input patterns and benchmark data to validate the accuracy and efficiency of the encryption and decoding processes. Both qualitative and quantitative methodologies will be applied to evaluate the performance of the proposed solution against existing barcode systems. Feedback from users and developers will be gathered and analyzed to identify areas for enhancement. Python, HTML, CSS, and frameworks like Flask will be used for developing the tool to enable efficient barcode generation, encryption, and decoding. The development process will be supported by integrated development environments (IDEs) that offer profiling and debugging capabilities. Ensuring compatibility with popular operating systems and platforms will optimize accessibility and usability. Furthermore, cloud-based resources and virtualization technologies will be employed for scalable and flexible deployment.

A cost estimate covering software development expenses, such as personnel, infrastructure, and licensing fees, will be provided, considering timeliness and budget constraints. Effective resource allocation will ensure adherence to budgetary limits while maintaining quality standards. A detailed timeline outlining major milestones and deliverables will be created, taking into account factors such as testing phases, deployment schedules, and iterative development cycles. Progress will be regularly monitored against the planned schedule, with adjustments made as necessary to minimize risks and ensure timely project completion.

To sum up, the research plan for "Secure Barcode Generation and Decoding with Encryption Techniques" adopts a comprehensive approach, covering cost and schedule considerations, software and hardware requirements, research methodologies, and data collection strategies. The goal of the project is to deliver a robust and efficient solution that addresses the growing need for secure barcode systems in various industries by following this structured strategy.

SL. No	Description	07/10/2024-11/10/2024	12/10/2024-16/10/2024	17/10/2024-20/10/2024	21/10/2024-29/10/2024	30/10/2024-05/11/2024	07/10/2024-10/11/2024
1.	Problem Identification	■					
2.	Analysis		■				
3.	Design		■	■			
4.	Implementation			■	■		
5.	Testing				■	■	
6.	Conclusion					■	■

Fig.1-Timeline Chart

Day 1: Project Initiation and Planning

- Define the project's scope and objectives, focusing on developing a secure and efficient barcode generation and decoding system using encryption methods.
- Conduct preliminary research to gather insights on barcode standards, encryption algorithms (e.g., AES, RSA), and secure data transmission techniques.
- Identify key stakeholders (e.g., developers, cryptography experts, end-users) and establish effective communication channels for smooth collaboration.
- Create a comprehensive project plan, outlining detailed tasks, deliverables, and milestones for each development phase, ensuring clarity in the project timeline.

Day 2: Requirement Analysis and System Design

- Conduct a thorough requirement analysis to identify user needs, system functionalities, and security requirements for the barcode system.
- Define system specifications, including supported barcode formats (e.g., QR Code, Data Matrix), encryption protocols, and data integrity measures.
- Develop a detailed architecture for the secure barcode system, including data flow diagrams, encryption/decryption workflows, and user interface mock-ups.
- Confirm hardware and software requirements, ensuring compatibility with mobile devices, barcode scanners, and integration frameworks.

Day 3: Core Development and Encryption Implementation

- Begin coding the core modules for secure barcode generation, incorporating encryption techniques to protect data within barcodes.
- Implement features for secure barcode decoding, including decryption algorithms to retrieve encoded information while ensuring data confidentiality.
- Develop secure data transmission protocols to prevent unauthorized access and tampering during barcode scanning and data exchange.
- Conduct unit testing on encryption and decryption components to verify the accuracy and security of the implemented algorithms.

Day 4: GUI Design and Prototyping

- Design and develop a user-friendly interface for generating, scanning, and managing secure barcodes, using responsive design principles for compatibility with various devices.
- Integrate real-time data visualizations to display barcode information, encryption status, and system notifications for better user interaction.
- Ensure that the GUI supports features like secure input validation, encryption key management, and barcode history tracking.
- Conduct iterative usability testing, gathering feedback to refine the user experience and enhance functionality.

Day 5: Security Testing and Performance Optimization

- Define and develop security test cases, simulating various attack scenarios (e.g., brute force, tampering, and data interception) to assess system resilience.
- Conduct end-to-end testing of the barcode generation and decoding process to ensure robustness against potential vulnerabilities.
- Optimize encryption algorithms for speed and efficiency, ensuring minimal impact on performance during barcode scanning and data retrieval.
- Validate the system's compliance with industry standards for data encryption and barcode security to enhance trustworthiness.

Day 6: Documentation, Deployment, and Feedback

- Document the entire development process, including architectural decisions, encryption methodologies, and system design considerations.
- Prepare the system for deployment, ensuring compatibility with real-world conditions, including diverse barcode scanners and mobile platforms.
- Deploy the system for beta testing, gathering feedback from stakeholders and end-users to identify areas for improvement in usability, security, and performance.
- Organize feedback sessions to collect insights on system functionality and user satisfaction, and incorporate recommendations for future enhancements.

METHODOLOGY

The methodology for developing a secure barcode system focuses on integrating encryption techniques to protect data encoded within barcodes. The approach is divided into several phases, covering system analysis, design, implementation, testing, and optimization to ensure robust data security, compatibility with existing hardware, and high performance.

1. Requirements Analysis

The first phase involves gathering system requirements to understand the scope of secure barcode generation and decoding. Key requirements include ensuring data confidentiality, integrity, and access control. This involves identifying sensitive data types to be encoded, such as personal identification information, confidential documents, or secure transactions. Use cases like secure product labeling, access control, and sensitive data storage are explored. This phase delivers a comprehensive requirements specification that sets the foundation for subsequent development.

2. Literature Review and Technology Assessment

A thorough review of existing barcode systems and encryption techniques is conducted to understand current challenges and solutions. The review includes traditional 1D and 2D barcode technologies (e.g., QR codes, Data Matrix) and their limitations regarding data security. Symmetric encryption (e.g., AES), asymmetric encryption (e.g., RSA), and hybrid encryption models are evaluated for their effectiveness in securing barcode data. The literature review helps identify suitable encryption algorithms that balance security, performance, and compatibility with existing barcode infrastructure.

3. System Design

The system design phase focuses on creating a secure architecture for barcode generation and decoding. This includes:

- **Data Encryption Module**: Sensitive data is encrypted using a symmetric algorithm (like AES) to ensure confidentiality. The encryption key is then secured using asymmetric encryption (e.g., RSA) to protect it from unauthorized access.
- **Barcode Generation Module**: An algorithm is designed to convert encrypted data into a secure barcode format, utilizing libraries such as ZXing or python-barcode.

- **Secure Decoding Module**: This module includes a decryption process where the barcode is scanned, and the encrypted data is decrypted using the corresponding private key. It ensures that only authorized users with the correct decryption key can access the barcode content.

Flowcharts and system architecture diagrams are created to guide the development process. The design phase aims to provide a detailed blueprint for secure data encoding, transmission, and decoding.

4. Prototype Development

This phase focuses on building a functional prototype of the secure barcode system. Development involves programming languages like Python and Java to implement barcode generation and decoding processes. Key libraries, such as PyCryptodome for encryption and ZXing for barcode handling, are used. The prototype is designed to be compatible with standard barcode printers and scanners, ensuring seamless integration with existing hardware. A mobile application and desktop software are developed to facilitate secure scanning and decoding.

5. Security Implementation

The core focus of this phase is to integrate encryption and authentication mechanisms into the barcode system:

- **Symmetric Encryption (AES)** is used to encrypt barcode data, providing strong data protection.
- **Asymmetric Encryption (RSA)** is used to encrypt the symmetric key, enabling secure key distribution.
- **Digital Signatures** are added to barcodes for authenticity verification, ensuring data integrity and preventing tampering.
- **Access Control**: Role-based access is implemented, allowing only authorized users to decrypt and read the barcode data.

Security mechanisms are tested to protect against threats like data interception, cloning, and tampering.

6. Testing and Validation

The system undergoes rigorous testing to ensure both functionality and security. Testing activities include:

- **Functional Testing**: Verification of barcode generation, encryption, and decryption processes to ensure accuracy.
- **Performance Testing**: Assessment of system response time, focusing on the speed of encryption, barcode scanning, and data retrieval.

- **Security Testing**: Penetration tests and vulnerability assessments are conducted to identify potential security gaps. The system is tested against common attacks such as data interception, replay attacks, and unauthorized access.

The testing phase ensures that the system meets security and performance benchmarks, providing a reliable solution for secure barcode usage.

7. Optimization and Evaluation

Based on testing feedback, optimization techniques are applied to enhance system performance. Encryption algorithms are fine-tuned to reduce computational overhead, ensuring faster barcode processing. The solution is evaluated for scalability, ensuring it can handle high-volume data scenarios like retail checkouts and inventory management. Additionally, feedback from industry experts and end-users is collected to refine usability and functionality.

8. Documentation and Reporting

Comprehensive documentation is prepared, detailing the system design, implementation, testing procedures, and findings. This includes user manuals, technical specifications, and research reports. The documentation serves as a guide for system deployment and future improvements.
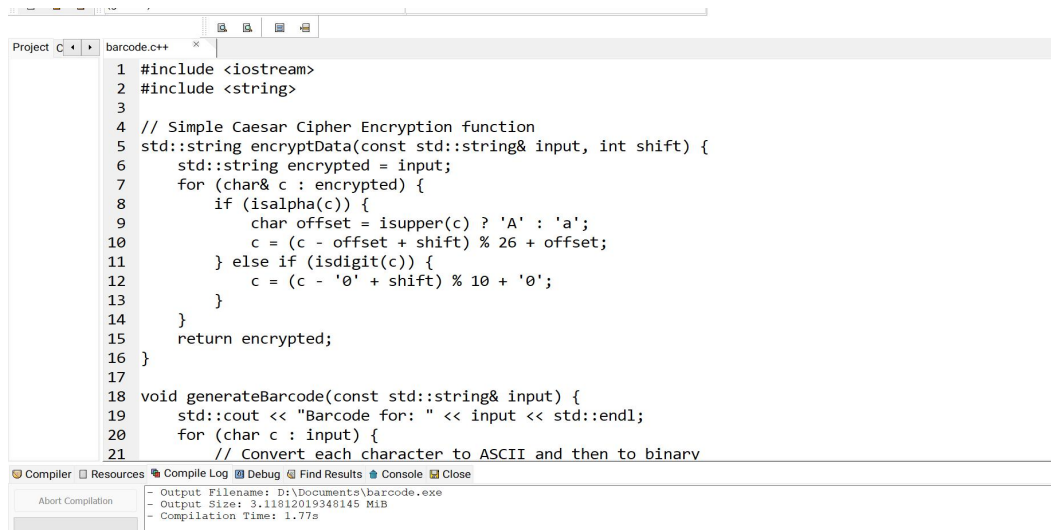
9. Tools and Technologies

The development process uses a range of tools and technologies:

- **Programming Languages**: Python for rapid prototyping, Java for enterprise-level applications.
- **Encryption Libraries**: PyCryptodome, Bouncy Castle.
- **Barcode Libraries**: python-barcode, ZXing.
- **Development Environments**: PyCharm, Eclipse.
- **Testing Tools**: Security tools like OWASP ZAP for penetration testing.

RESULT

Figure2 The code implements a Caesar Cipher encryption method for both alphabetic and numeric characters.There is an additional function for generating a barcode representation of the encrypted data, but the full implementation of this part is not visible.The setup uses the Embarcadero Dev-C++ IDE, and the program successfully compiles without errors as indicated by the console.


```cpp
1  #include <iostream>
2  #include <string>
3
4  // Simple Caesar Cipher Encryption function
5  std::string encryptData(const std::string& input, int shift) {
6      std::string encrypted = input;
7      for (char& c : encrypted) {
8          if (isalpha(c)) {
9              char offset = isupper(c) ? 'A' : 'a';
10             c = (c - offset + shift) % 26 + offset;
11         } else if (isdigit(c)) {
12             c = (c - '0' + shift) % 10 + '0';
13         }
14     }
15     return encrypted;
16 }
17
18 void generateBarcode(const std::string& input) {
19     std::cout << "Barcode for: " << input << std::endl;
20     for (char c : input) {
21         // Convert each character to ASCII and then to binary
```

Compiler Resources Compile Log Debug Find Results Console Close

Abort Compilation

```
- Output Filename: D:\Documents\barcode.exe
- Output Size: 3.11812019348145 MiB
- Compilation Time: 1.77s
```

Fig.2:Barcode Generation Code Implementation in C++

Figure3 The program is successfully compiled and is currently running, awaiting input from the user to generate a barcode based on the entered text. The flow of the program likely involves the following steps: Prompting the user for input (as shown in the execution window).Encrypting the input text using the Caesar Cipher algorithm.Generating a barcode representation of the encrypted text (as hinted by the partially visible generateBarcode function).
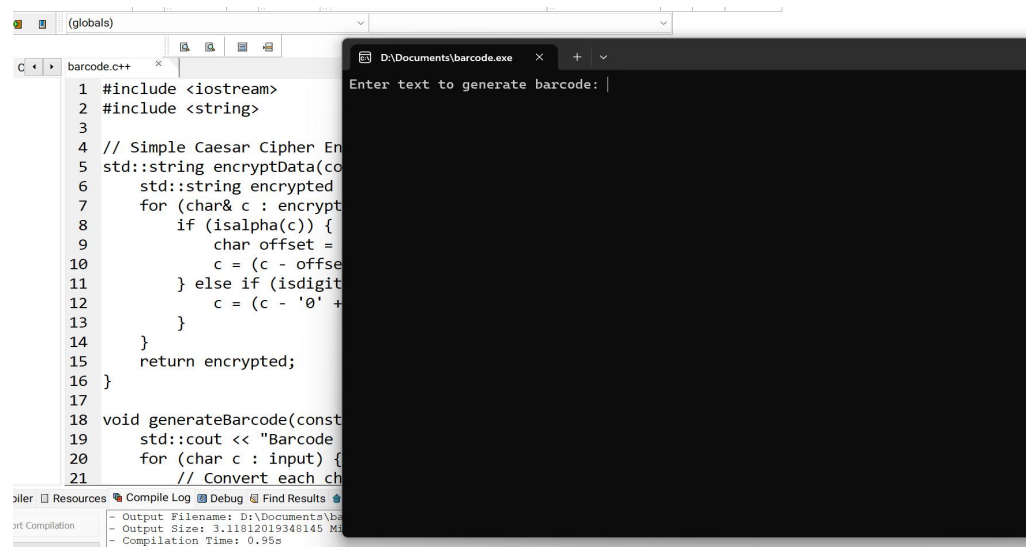
Fig.3: Barcode Generation Program Prompt

Figure 4 The program prompts the user to "Enter text to generate barcode."
The user entered "siri!" as input.The program responded with an error message: "Invalid input! Please enter only alphanumeric characters."The program then exited after about 4.922 seconds, indicating the input was invalid.The error likely arises because the program is set to accept only alphanumeric characters and checks for invalid input characters like punctuation (e.g., "!").
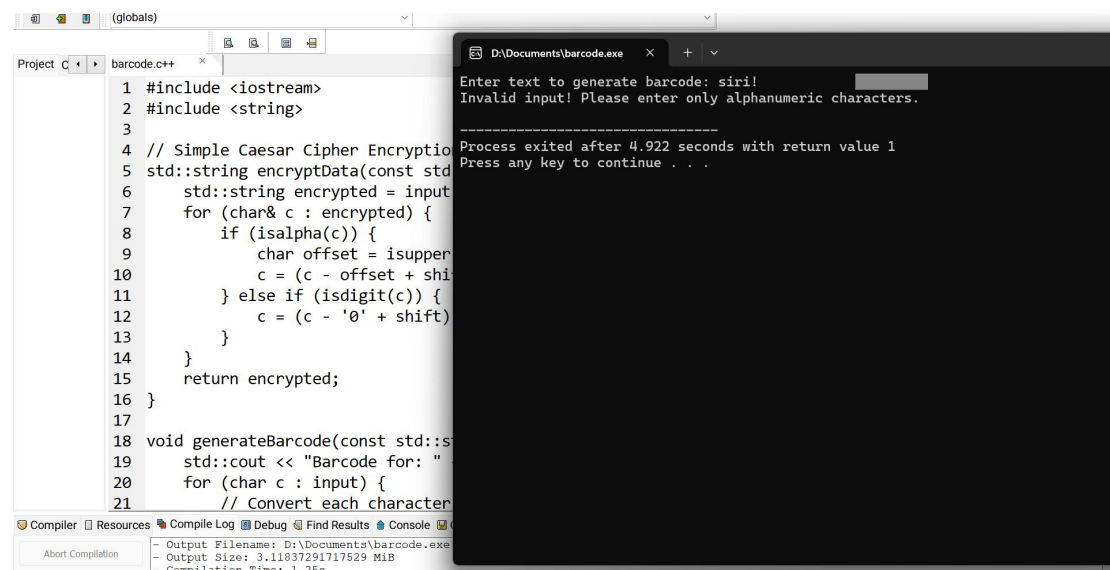

Fig.4:Error Handling in Barcode Generator Program for
Non-Alphanumeric Input

Figure 5 The program is actively running and has accepted user input (SIRISHA) to generate a barcode.The next step, which is not visible in this screenshot, would likely involve the program processing this input text:Encrypting the input using the Caesar Cipher function (encryptData).Generating a barcode representation of the encrypted text using the generateBarcode function.
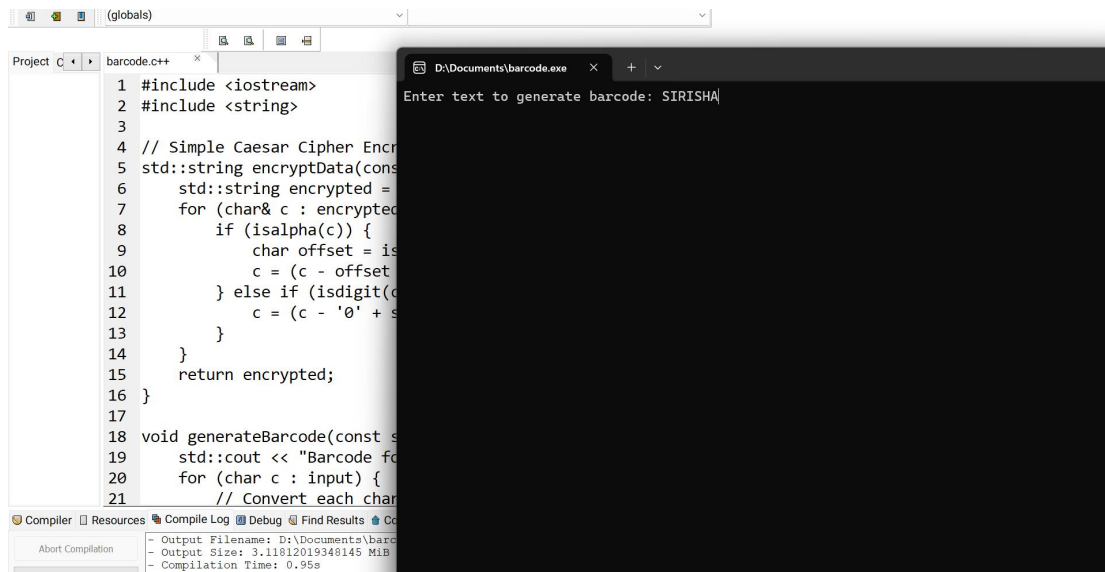
Fig.5:Barcode Generation Program with Input Text

Figure 6 The screenshot shows a C++ program running in Embarcadero Dev-C++ that encrypts input text using a Caesar Cipher and generates a barcode-like output. The input "SIRISHA" is encrypted to "VLULVKD", and a series of vertical bars (|) represents this encrypted text as a barcode. However, the program takes an unusually long time (135.1 seconds) to complete, suggesting inefficiencies in the code, particularly in the encryption or barcode generation logic. Optimizing the loops and simplifying the code could significantly improve performance.
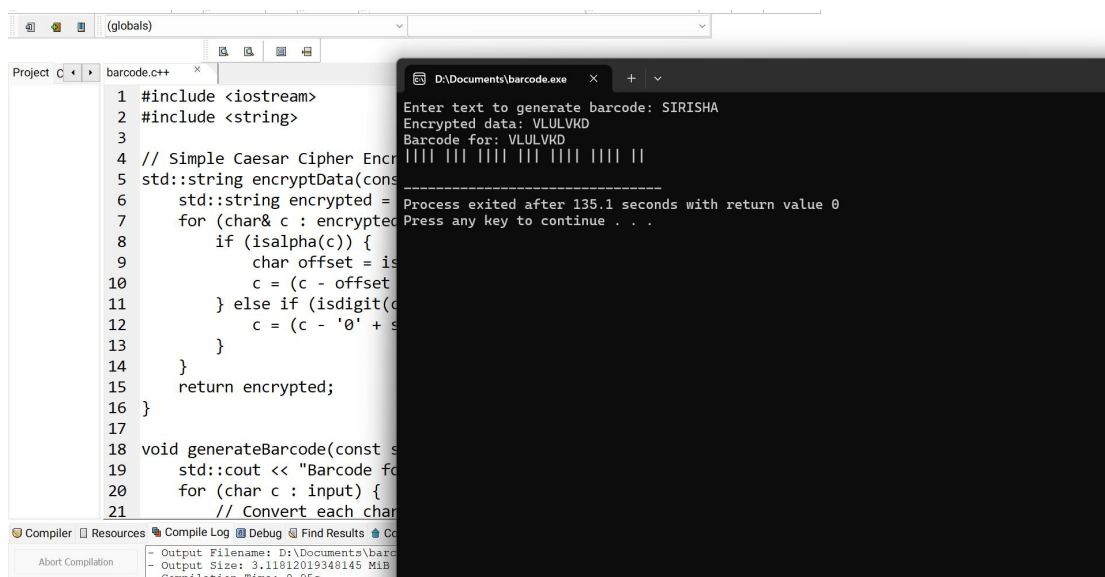

Fig.6:Barcode Generation Program Output with Encrypted
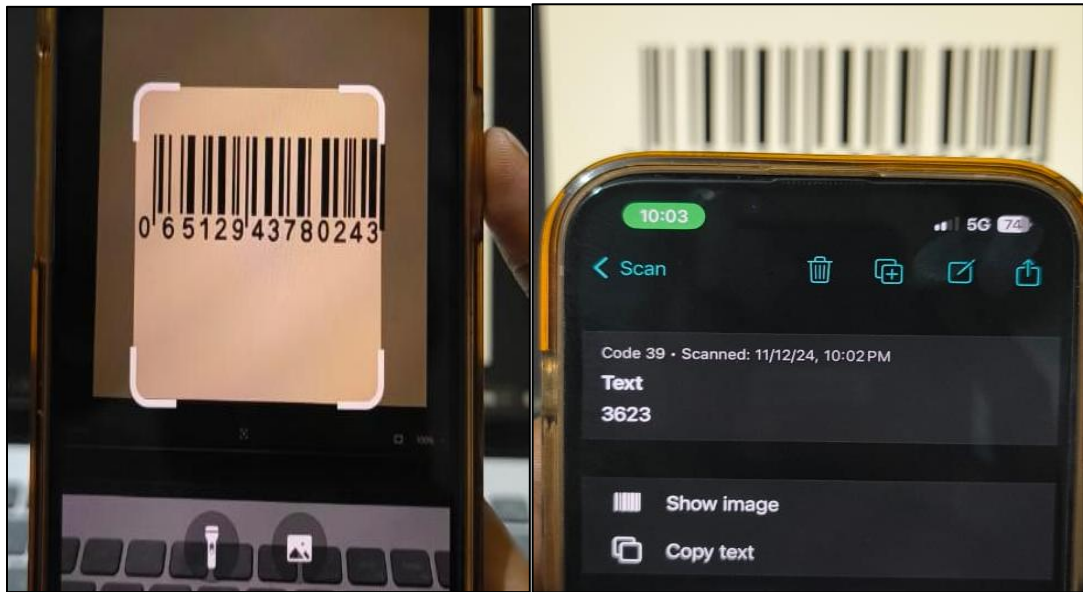Data and Visual Barcode

Fig.7:Barcode Scanner

CONCLUSION

In conclusion, secure barcode generation and decoding with encryption techniques offer a vital solution for protecting sensitive data in various applications. Traditional barcodes, while efficient for tracking and identification, often lack the necessary security measures to prevent unauthorized access or tampering. By incorporating encryption methods like AES, the data encoded within the barcode becomes unreadable to unauthorized individuals, ensuring that only authorized users with the decryption key can access it.

Encryption also provides data integrity, ensuring that barcode information remains intact and unaltered during transmission. This dual layer of protection—confidentiality and integrity—adds a robust security mechanism, reducing the risk of fraud, counterfeiting, or unauthorized access. The use of secure barcodes is particularly beneficial in sectors such as retail, healthcare, logistics, and finance, where data privacy is critical.

Moreover, the integration of encryption techniques into barcode systems enhances compliance with data protection regulations, such as GDPR and HIPAA, ensuring organizations meet legal and industry standards for data security. As cybersecurity threats continue to evolve, secure barcode systems will play an increasingly important role in maintaining the privacy and integrity of sensitive information.

By adopting secure barcode generation and decoding practices, organizations can build more reliable, trustworthy systems that protect data across its lifecycle—from creation to decoding. This ensures the continued security of critical information, fostering trust and confidence in industries that rely on barcode-based systems. As encryption technology continues to advance, secure barcodes will remain a key component in safeguarding data in a digital-first world.

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IMPLEMENTATION CODE

```cpp
#include <iostream>
#include <string>

// Simple Caesar Cipher Encryption function
std::string encryptData(const std::string& input, int shift) {
    std::string encrypted = input;
    for (char& c : encrypted) {
        if (isalpha(c)) {
            char offset = isupper(c) ? 'A' : 'a';
            c = (c - offset + shift) % 26 + offset;
        } else if (isdigit(c)) {
            c = (c - '0' + shift) % 10 + '0';
        }
    }
    return encrypted;
}

void generateBarcode(const std::string& input) {
    std::cout << "Barcode for: " << input << std::endl;
    for (char c : input) {
        // Convert each character to ASCII and then to binary
        int value = static_cast<int>(c);
        for (int i = 7; i >= 0; --i) {
            if (value & (1 << i)) {
                std::cout << "|"; // Dark block for 1
            } else {
                std::cout << " "; // Space for 0
            }
        }
        std::cout << " "; // Space between characters
    }
    std::cout << std::endl;
}

bool isValidInput(const std::string& input) {
    if (input.empty()) {
        return false; // Input should not be empty
    }
```

```cpp
    for (char c : input) {
        if (!isalnum(c)) { // Only allow letters and digits
            return false;
        }
    }
    return true;
}

int main() {
    std::string input;
    int shift = 3; // Shift value for Caesar Cipher encryption

    std::cout << "Enter text to generate barcode: ";
    std::getline(std::cin, input);

    // Validate input
    if (!isValidInput(input)) {
        std::cerr << "Invalid input! Please enter only alphanumeric characters." <<
std::endl;
        return 1; // Exit with an error code
    }

    // Encrypt the input data before generating the barcode
    std::string encryptedData = encryptData(input, shift);
    std::cout << "Encrypted data: " << encryptedData << std::endl;

    // Generate barcode for encrypted data
    generateBarcode(encryptedData);

    return 0;
}
```