

Capstone Project Report

Optimized Virtualized Storage Security: Ensuring Data Integrity and Confidentiality in a Virtualization Environment

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Abstract

The growing adoption of virtualization technologies in data centers and cloud computing environments has revolutionized the way data is stored and managed. In order to ensure data integrity and confidentiality in the face of this paradigm shift, it is essential to have a thorough understanding of the security issues posed by virtualized storage. This report delves into the technical aspects of Optimized Virtualized Storage Security, providing insights into the strategies and mechanisms employed to safeguard critical data within virtualized environments.

The report starts off by explaining the fundamental ideas of virtualization and how it affects storage infrastructure. It highlights the advantages of virtualized storage, like resource optimization, scalability, and flexibility, but it also draws attention to its drawbacks, which include data tampering and unauthorized access.

Data integrity is a paramount concern in virtualized storage. The report delves into techniques like cryptographic hashing and checksums, which provide safeguards against data corruption. Data integrity is examined in relation to virtualization-specific threats, including resource contention and snapshot attacks, and strategies to reduce the risk are explained.

Confidentiality, another critical aspect, is addressed through encryption strategies. The report explores encryption at rest and in transit, highlighting the utilization of encryption algorithms and keys to protect sensitive data. It discusses the challenges of key management in virtualized environments and the deployment of hardware security modules (HSMs) to enhance key security.

Furthermore, the report emphasizes the importance of secure hypervisors and discusses security measures at the hypervisor level, such as access controls and secure boot procedures, to maintain data integrity and confidentiality.

Virtualized storage environments often encompass multi-tenancy, making isolation and access control vital. The report investigates role-based access control (RBAC) and network segmentation to ensure that only authorized users and applications have access to specific data.

The study concludes with a comprehensive overview of best practices and recommendations for implementing a robust security framework in virtualized storage environments. Organizations can achieve a strengthened security posture for their virtualized storage infrastructure by integrating the principles of data integrity and confidentiality, using encryption, and implementing advanced access controls.

Introduction

Virtualization allows organizations to maximize the utilization of hardware resources, streamline management, and enhance flexibility. However, the benefits of virtualization also come with a set of unique security challenges, particularly in the realm of storage security. As data is a critical asset for organizations, ensuring its integrity and confidentiality within virtualized environments is of paramount importance.

This report delves into the technical aspects of optimized virtualized storage security, with a primary focus on safeguarding data integrity and confidentiality within virtualization environments. It explores the key security concerns that arise when leveraging virtualized storage solutions and presents strategies and best practices to mitigate these risks.

1. Virtualization and Its Significance:

Virtualization is the process of abstracting computing resources, such as servers, storage, and networks, from their physical hardware, allowing multiple virtual instances to operate independently on a single physical host. This technology has revolutionized data centers, enabling cost savings, resource optimization, and agility. However, the dynamic and shared nature of virtualized environments introduces new security challenges that must be addressed comprehensively.

2. The Importance of Data Integrity:

Data integrity refers to the accuracy, consistency, and reliability of data over its entire lifecycle. In virtualized storage systems, ensuring data integrity is crucial as virtual machines (VMs) share underlying storage resources. Any unauthorized access, tampering, or corruption of data can lead to severe consequences, including data loss and compromised system functionality.

3. The Imperative of Data Confidentiality:

Data confidentiality is the principle of protecting sensitive information from unauthorized access. In virtualized environments, where multiple VMs share common storage infrastructure, there is a heightened risk of data leakage or exposure. This report explores mechanisms and practices to maintain the confidentiality of data, such as encryption and access controls.

4. Security Challenges in Virtualized Storage:

The report examines various security challenges inherent in virtualized storage environments, including:

- **Data Leakage:** Virtualized storage systems may inadvertently expose sensitive data due to misconfigurations or inadequate access controls.
- **Data at Rest:** Data stored within virtualized environments is susceptible to unauthorized access if not adequately encrypted.
- **Data in Transit:** Data transferred between virtual machines, or between VMs and storage, is at risk during transmission, making secure data transfer a critical concern.
- **Data Backup and Recovery:** Backup and recovery processes must ensure data security to prevent the compromise of historical data.
- **Data Integrity Verification:** Methods for verifying data integrity, such as checksums and cryptographic hashes, are crucial in maintaining data trustworthiness.

5. Mitigation Strategies:

This report provides insights into technical strategies and tools for addressing the challenges mentioned above. Topics include:

- **Encryption:** Implementing encryption mechanisms to protect data at rest and data in transit, ensuring data remains confidential even in shared storage environments.
- **Access Controls:** Defining and enforcing access controls and permissions to restrict unauthorized access to virtualized storage resources.
- **Integrity Verification:** Employing cryptographic techniques to verify data integrity, thus detecting any unauthorized modifications.
- **Virtualization-Aware Security Tools:** Utilizing specialized security solutions designed for virtualized environments to enhance overall security posture.

About our Project

Enhancing the security of virtualized storage systems to guarantee the integrity and confidentiality of data within a virtualized environment is the technical goal of the project "Optimized Virtualized Storage Security: Ensuring Data Integrity and Confidentiality in a Virtualization Environment." This project is essential in addressing the security challenges that arise when using virtualization technologies, as these technologies introduce unique vulnerabilities and risks. The technical aspects of this project can be broken down into several key components:

1. Virtualized Storage Security:

The project starts by addressing the security challenges specific to virtualized storage. Virtualization involves the abstraction of physical storage resources, which can make data more susceptible to unauthorized access and tampering.

2. Encryption and Decryption:

To ensure data confidentiality, the project incorporates encryption techniques. This involves encrypting data at rest and in transit. The project utilizes the Fernet symmetric encryption algorithm for this purpose. The encryption key used in the project, stored as `\verb|key|`, is employed for both encryption and decryption processes.

3. Data at Rest Security:

Data at rest refers to data stored on physical disks. The project provides a mechanism for encrypting data when it is stored using the Fernet encryption key. Users can encrypt and decrypt data using the provided GUI interface.

4. Data in Transit Security:

Data in transit refers to data being transferred over a network. The project provides the capability to send encrypted data over a network connection, ensuring that data remains confidential during transmission. Data is encrypted using the Fernet algorithm before being sent and decrypted upon reception.

5. Data Integrity:

To ensure data integrity, the project calculates and verifies the hash values of data using the Blake2b hash function. The hash values are used to detect any tampering or corruption of the data.

6. User-Friendly GUI:

The project incorporates a Graphical User Interface (GUI) to make it user-friendly. Users have the ability to choose whether they want to work with data at rest or data in transit, select data or files for encryption or decryption, and view the results.

7. Performance and Optimization:

While ensuring security, the project aims for optimal performance. It measures the time taken for data transmission, which is important for assessing the efficiency of the encryption and transmission processes.

8. Error Handling:

The project provides error handling mechanisms to deal with issues such as incorrect keys or file paths. It provides feedback to users in cases of decryption failures and other issues.

9. Data Storage:

The project saves both encrypted and decrypted data to files for reference. This is crucial for preserving data for future analysis, auditing, or other purposes.

10. Networking and Socket Programming:

The project utilizes socket programming to establish network connections between sender and receiver components. This enables the secure transmission of data in a virtualized environment.

11. Security Key Management:

The project assumes that users possess the encryption key, which must be kept confidential. Key management is critical in any encryption-based project, and secure key storage and distribution mechanisms are essential.

12. Result Presentation:

The project offers a result presentation mechanism that opens a new window displaying the original data, encrypted data, hash value, and transmission time. This feature enhances the user experience and facilitates result analysis.

13. User Experience and Interaction:

The GUI components of the project are designed to make it accessible to users who may not have in-depth technical knowledge. Users can choose options, browse files, and visualize results in a user-friendly manner.

Importance

The project is of paramount importance in the realm of IT security and virtualization. Its significance lies in addressing critical technical challenges and vulnerabilities that are increasingly prevalent in modern computing environments. Here's a comprehensive overview of the importance of this project from a technical perspective:

In a virtualized environment, data can be subject to various risks such as corruption, tampering, and unauthorized access. Ensuring data integrity is a fundamental concern to prevent data loss or compromise. The project aims to implement robust mechanisms for data integrity verification, making it a vital component of secure virtualization.

Confidentiality Protection: Data confidentiality is crucial in virtualization, especially when multiple virtual machines share the same physical infrastructure. This project seeks to employ encryption and access control mechanisms to safeguard sensitive data from unauthorized access. Protecting data confidentiality is a critical requirement for industries dealing with sensitive information, such as healthcare and finance.

Virtualization Efficiency: Virtualization offers numerous benefits in terms of resource optimization, scalability, and cost reduction. However, security measures should not compromise these advantages. This project's optimization aspect is vital to striking the right balance between security and performance. Efficient security measures are essential for a smooth and responsive virtualized environment.

Reducing Attack Surfaces: Malicious actors can frequently take advantage of the new attack surfaces and vectors that virtualized storage systems frequently introduce. Understanding and minimizing these vulnerabilities is crucial. The project helps in identifying and mitigating these risks, thereby reducing the potential points of failure and entry for cyberattacks.

Business Continuity and Disaster Recovery: Data loss or system compromises can lead to business disruptions and financial losses. The project's emphasis on data integrity and security contributes to robust disaster recovery and business continuity planning. This is particularly important in mission-critical environments.

Security in Cloud Environments: As more organizations move their workloads to the cloud, ensuring data security and integrity becomes even more complex. This project is essential for developing secure virtualized storage solutions that work seamlessly in cloud environments, addressing the unique challenges posed by cloud-based architectures.

Resource Optimization: While focusing on security, the project also strives to optimize the use of resources like CPU, memory, and storage. Resource efficiency is vital for reducing operational costs and ensuring that virtualization remains a cost-effective solution.

Implementation

Data at rest

In the Sender machine, i.e, Kali Linux we run our python code -

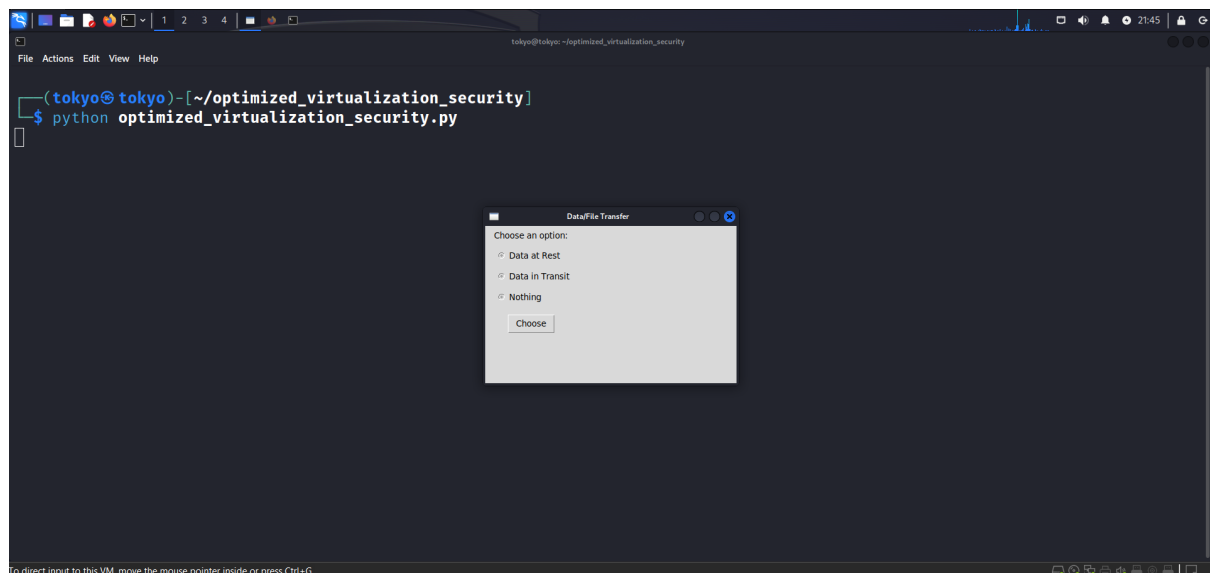


Fig.01 - GUI

One GUI will prompt, which asks whether you want to use it for data at rest or data in transit. You have to select data at rest.

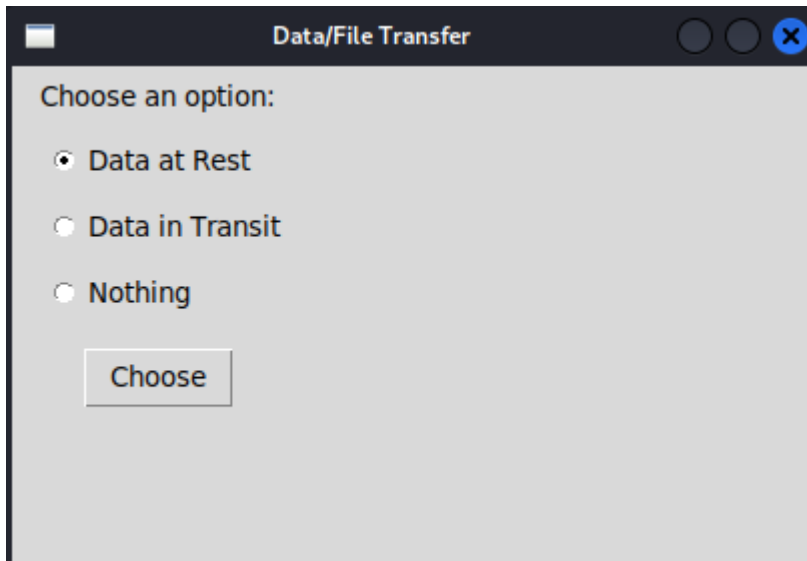


Fig.02 - Data/FileTransfer

After that, complete options will be visible in the GUI.

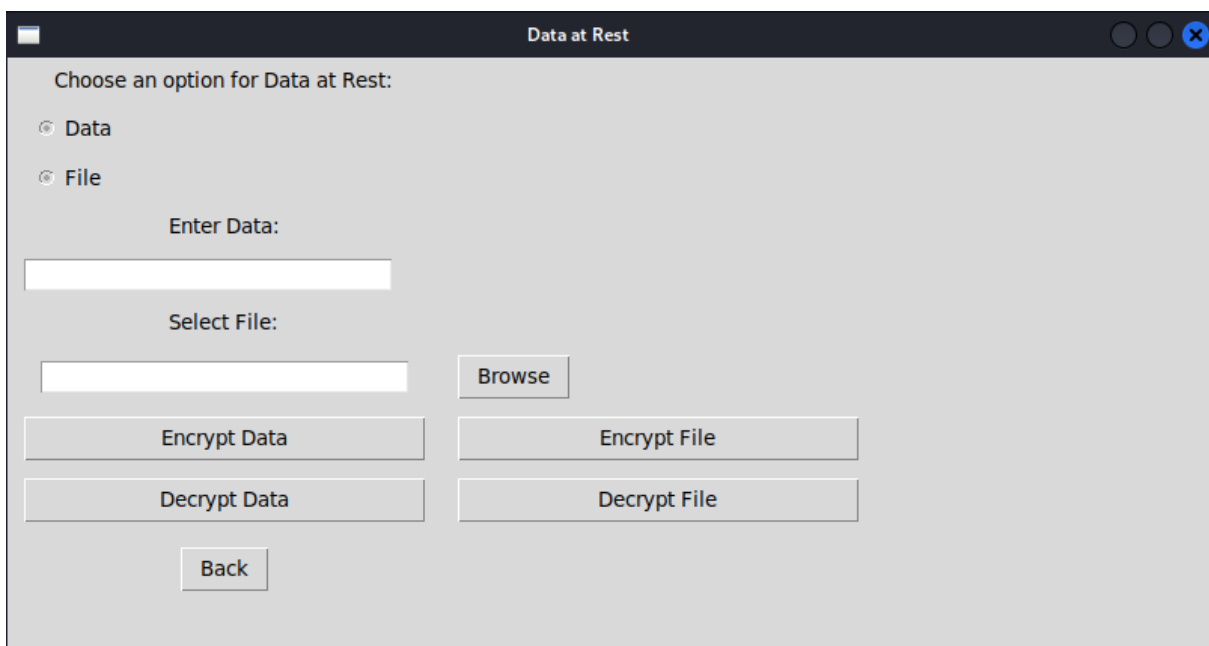


Fig.03 - Data at Rest

Firstly, we will encrypt the data, then file. In the Enter Data field, we have to write the text that we want to encrypt, "I'm sensitive data," and click on Encrypt Data.

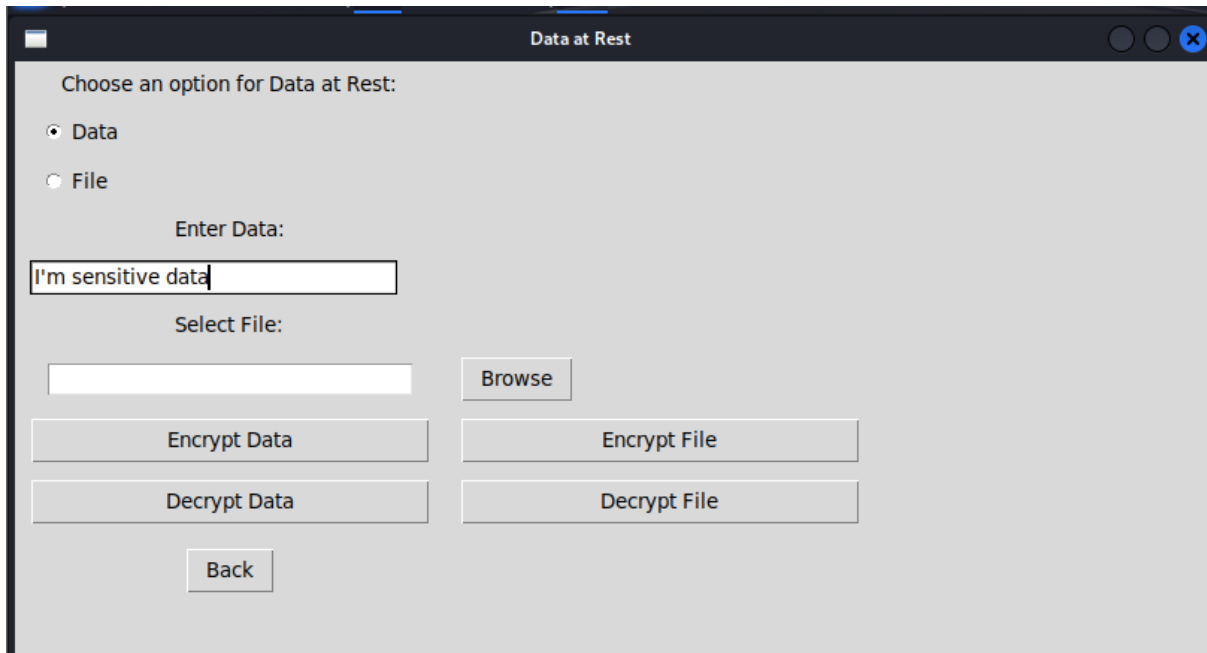


Fig.04 - Data at Rest

Our text was successfully encrypted. Now we will try to decrypt the same hash.

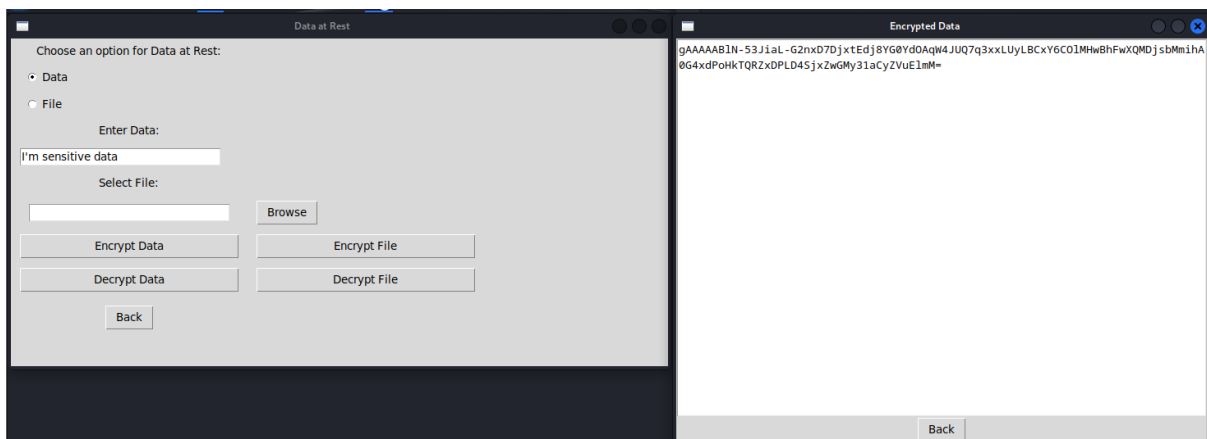


Fig.05 - Data at Rest/Encrypted Data

We copied the hash, pasted it into the input field, and clicked on Decrypt Data.

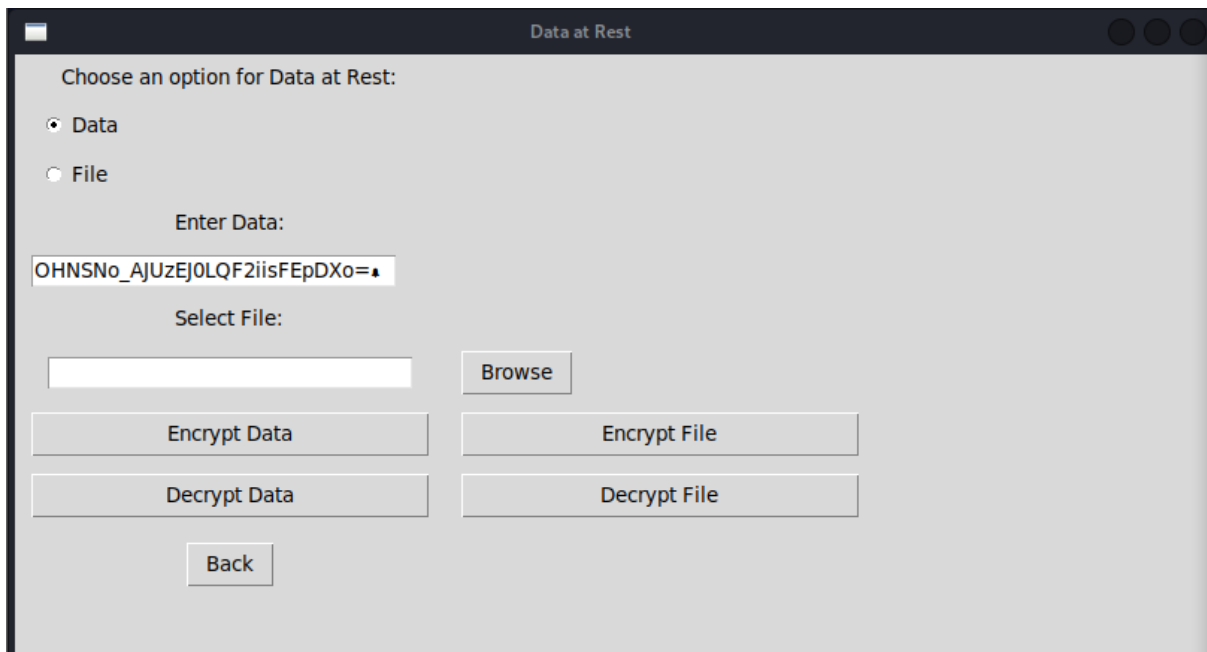


Fig.06 - Data at Rest

Our content was successfully decrypted.

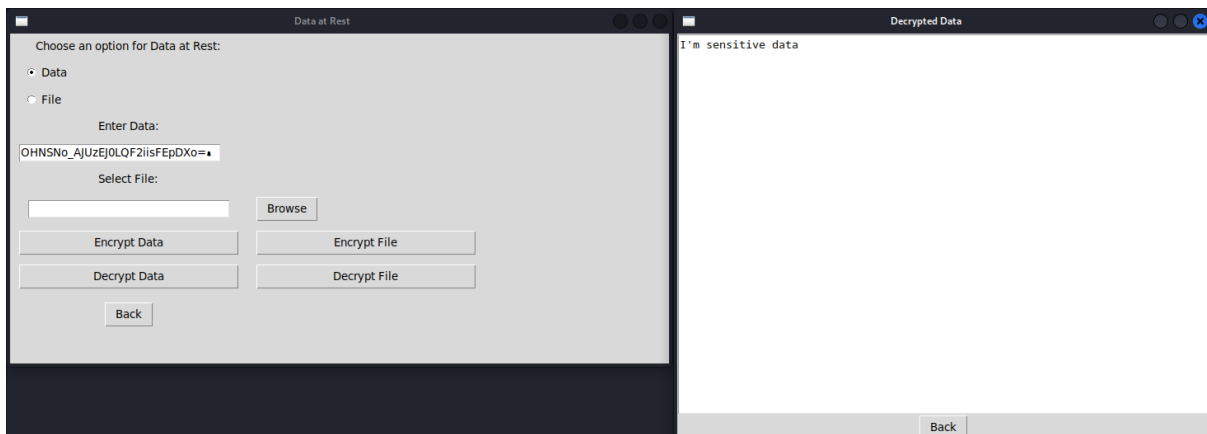


Fig.07 - Data at Rest/Decrypted Data

Now, instead of data, we will choose a file and click on browse.

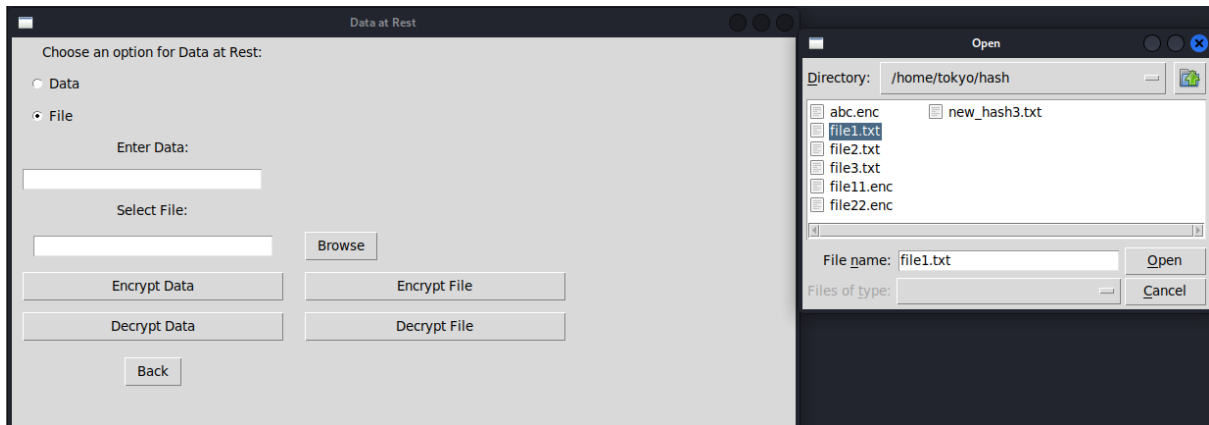


Fig.08 - File selection for encryption

Here, we will select the file that we want to encrypt and click on Encrypt File.

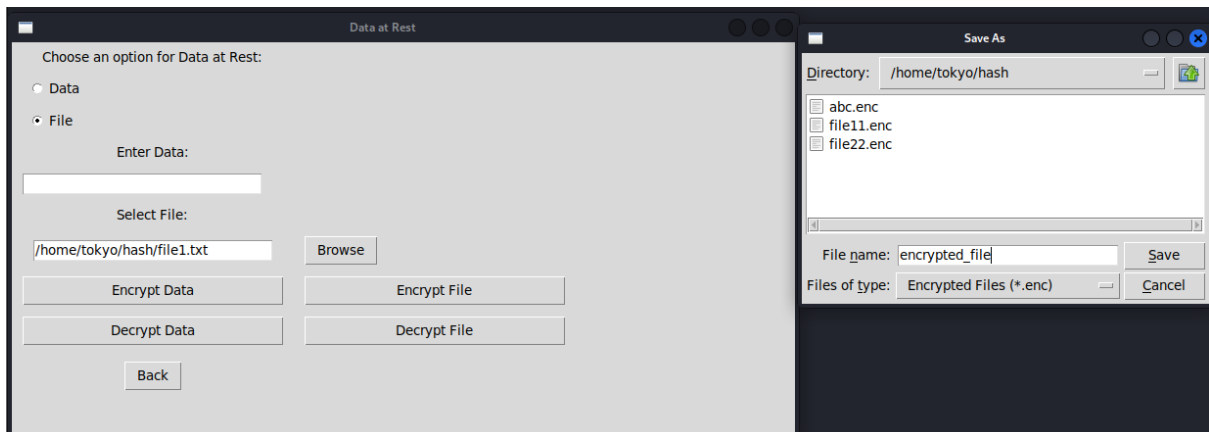


Fig.09 - Save as

As you can see, the content of the file successfully got encrypted, and the encrypted file was also saved with the .enc extension.

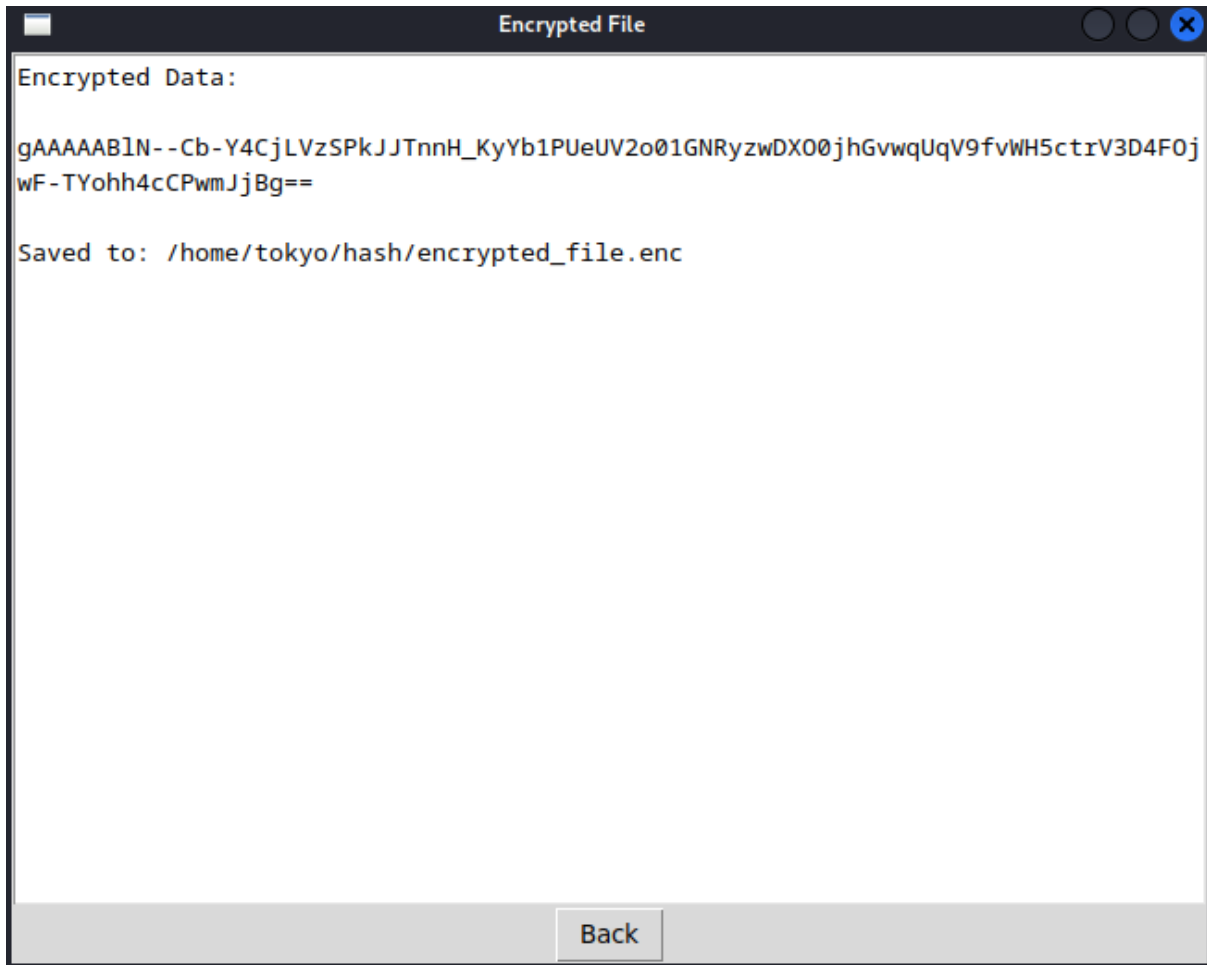


Fig.10 - Encrypted File

Now we will decrypt the same file, choose the browse option, and select the encrypted file.

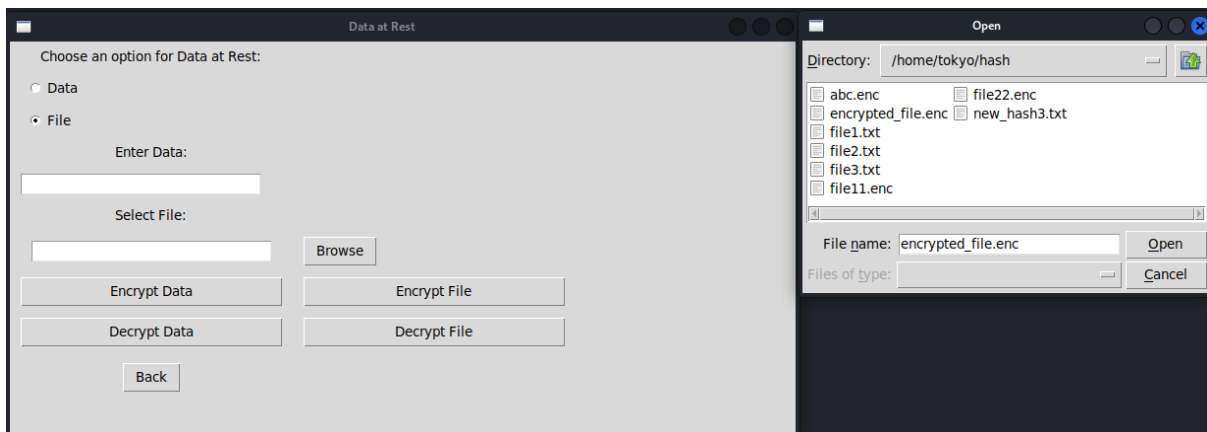


Fig.11 - File Selection for Decryption

Hurray! Our file was successfully decrypted.

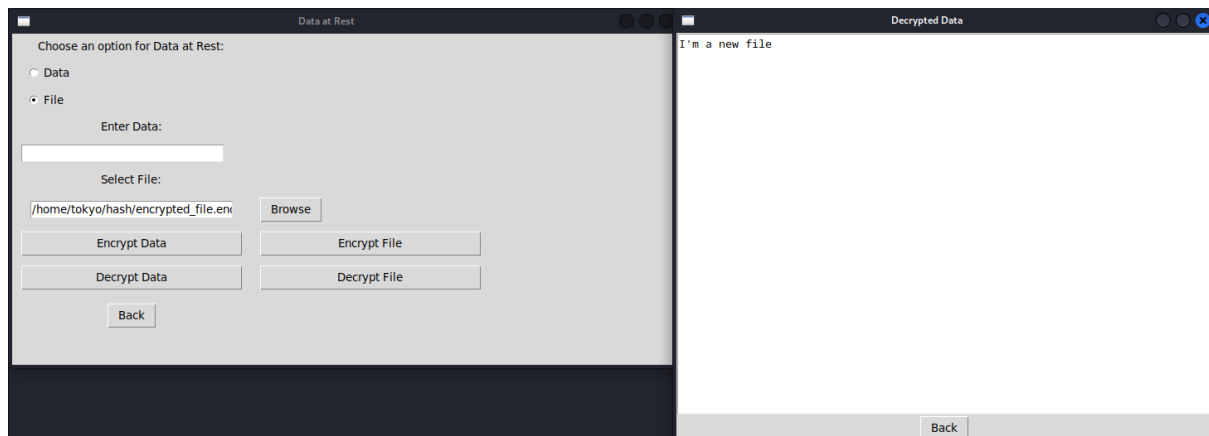


Fig.12 - Decrypted File

Data in Transit

Now we will go back from the Data at Rest menu to the main menu and select Data in Transit.

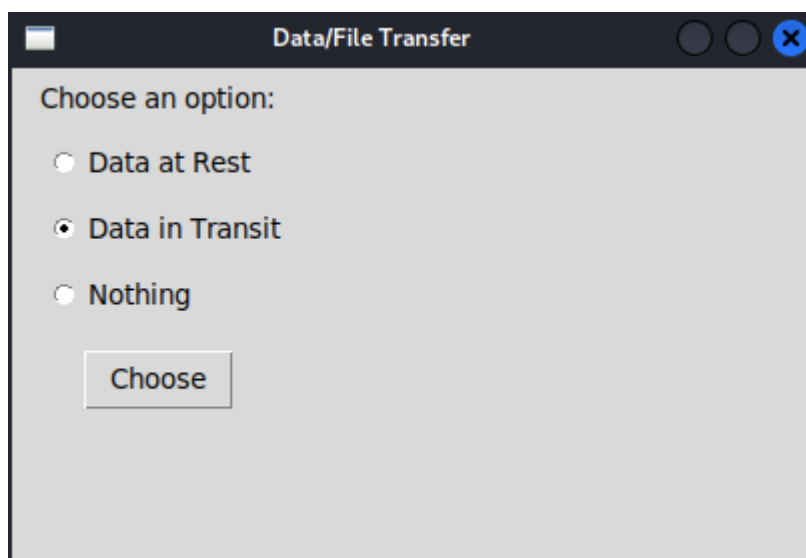


Fig.13 - Data in Transit

And run the receiver Python code on another virtual or host machine; in my case, it is a Windows machine. Click on receive data and it will start receiving data or a file from the remotely connected machine

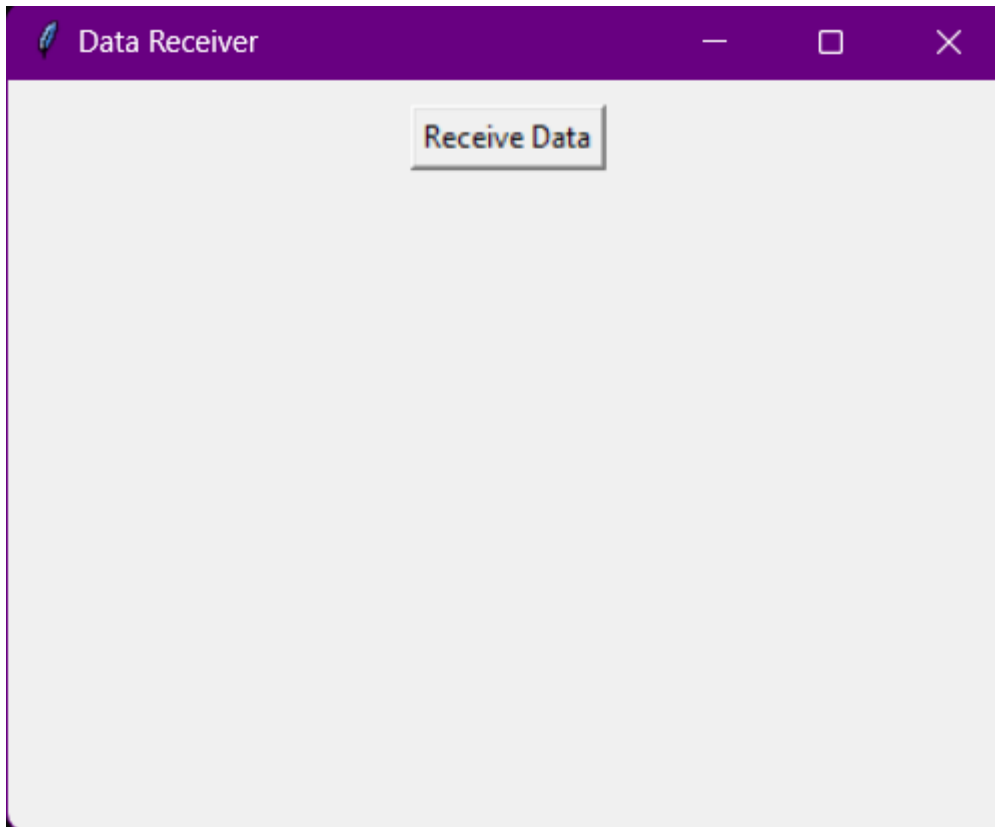


Fig.14 - Data Receiver

Then, in the sender machine, in the same way, write the data “I’m a data” and click on send data. As we can see, our data was successfully sent with the encrypted data, hash value, and transmission time.

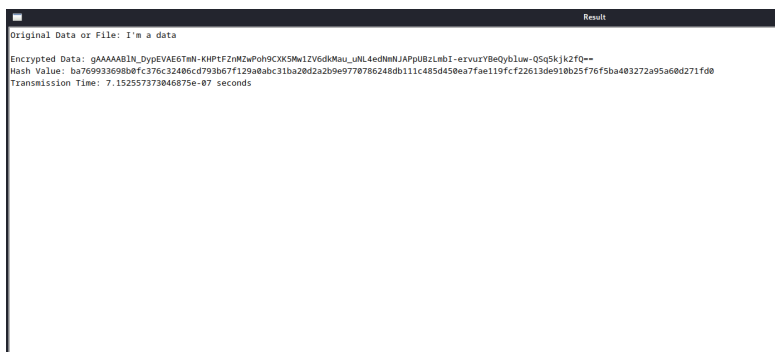


Fig.15 - Sending Data

Here in the receiver machine, it successfully received the encrypted data as well as the decrypted data, so the hash of the data and the total time taken to receive the data are used to check the integrity of the data. The results are also automatically saved on the local server.

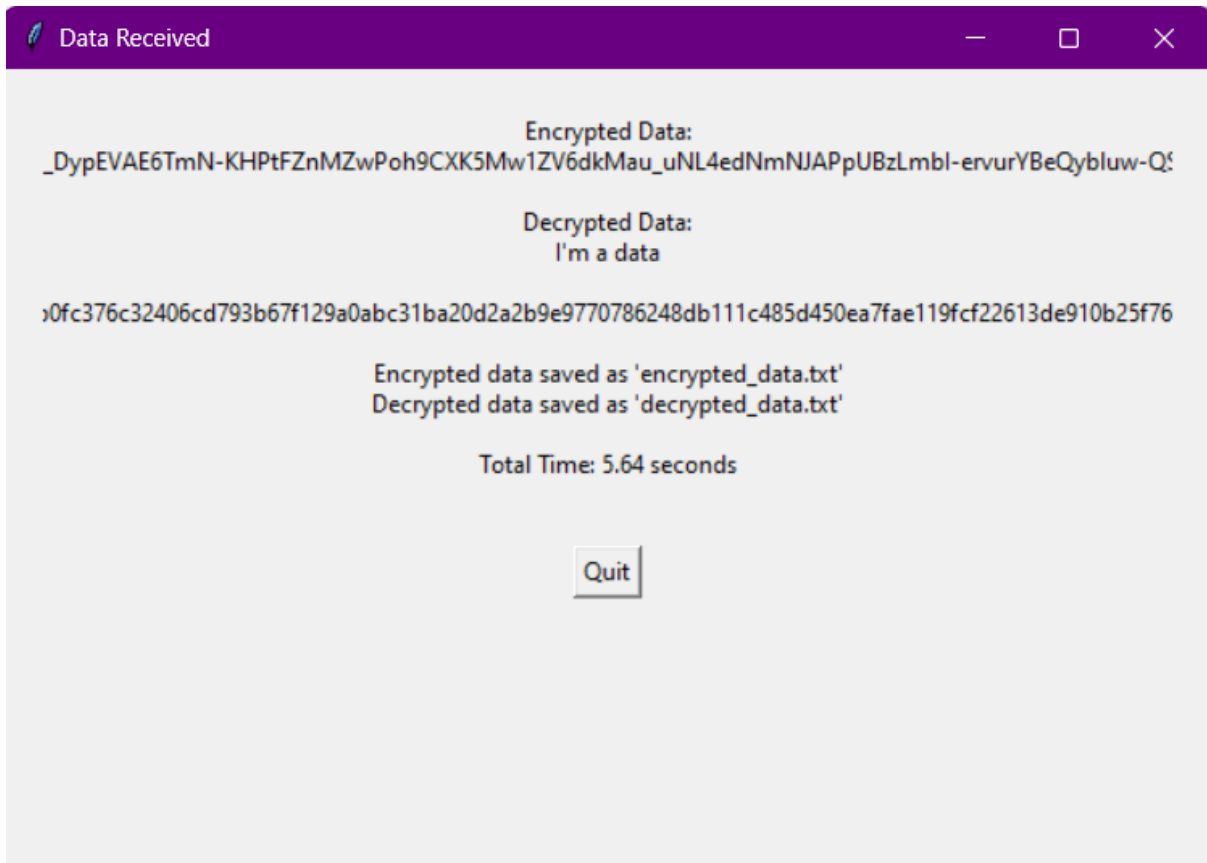


Fig.16 - Receiving Data

I will now try to transfer the file to the receiver machine.

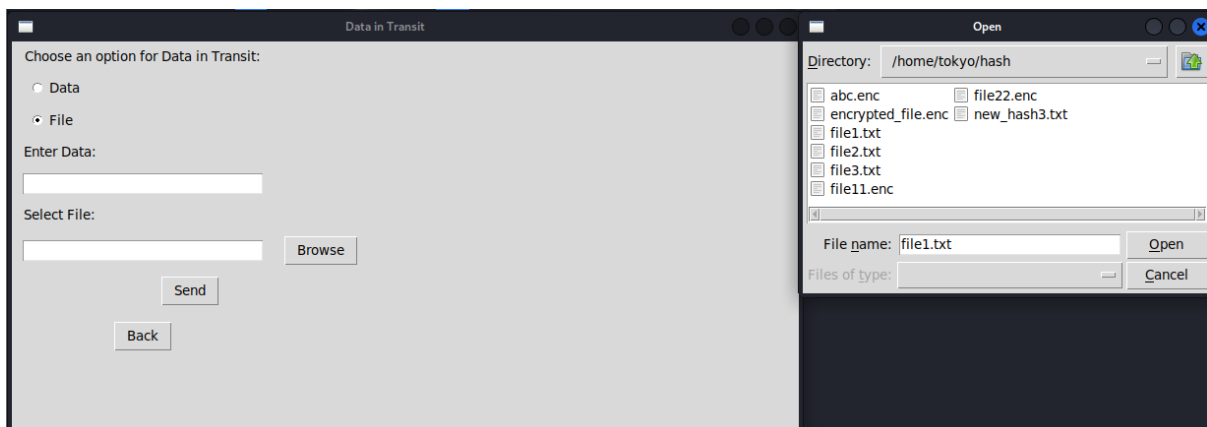


Fig.17 - Selecting file to send

Click on the browse button and select the file you want to send. Click on Send.

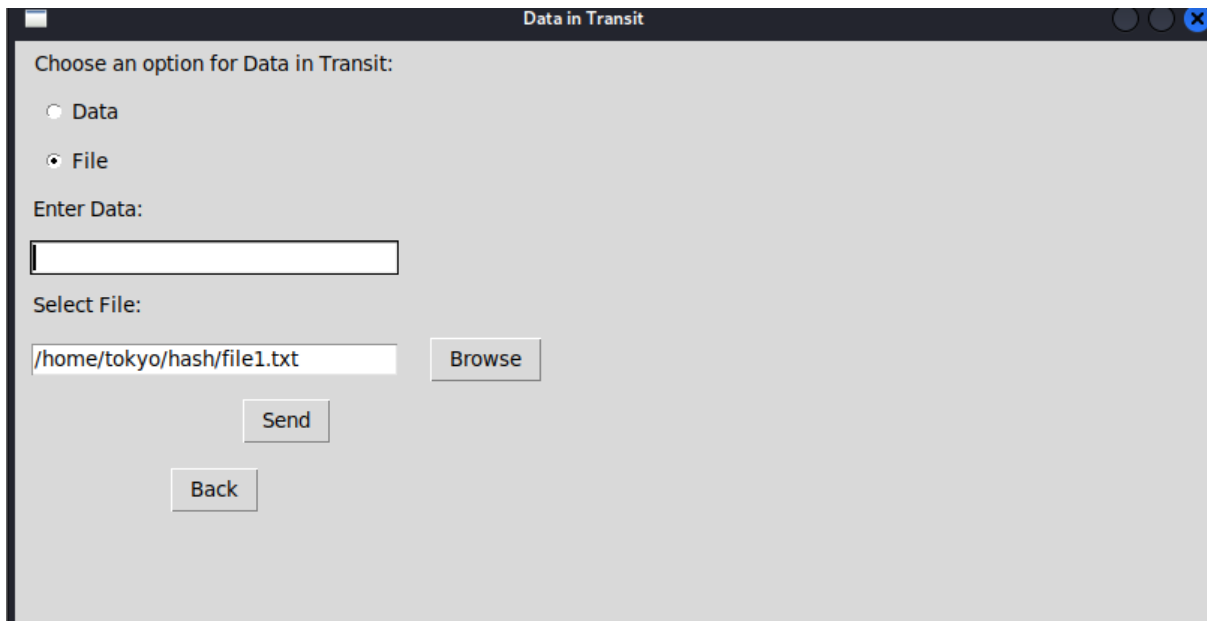


Fig.18 - Sending file

Our file was successfully sent to the receiver machine. Let's check on the receiver machine to see if it was received or not.

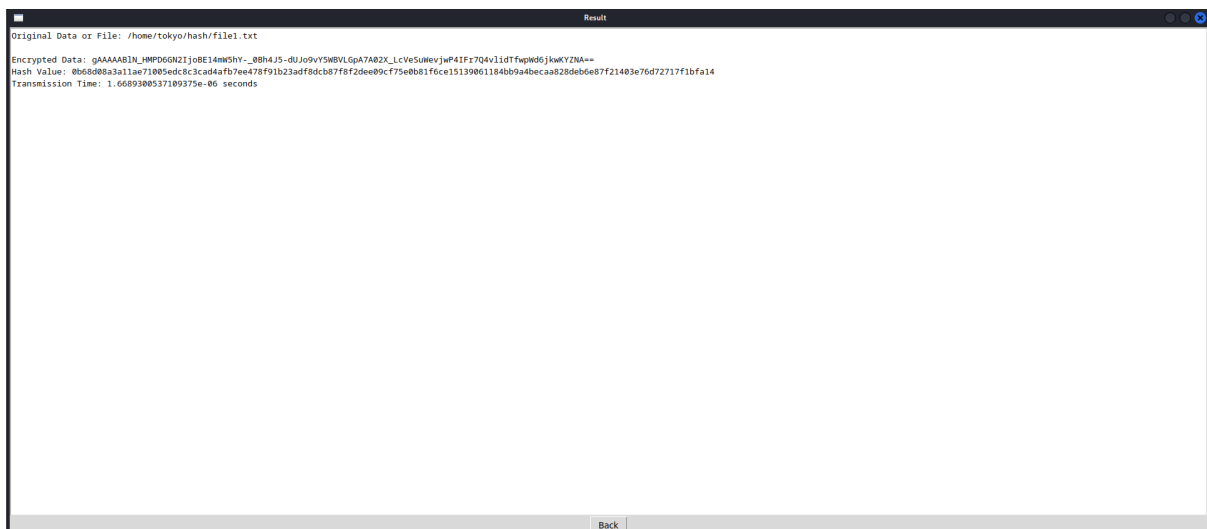


Fig.19 - File sent

Here we can see we received both encrypted and decrypted data with a hash value of the data in the file. Now we will check whether the encrypted and decrypted files were saved on the local server or not.

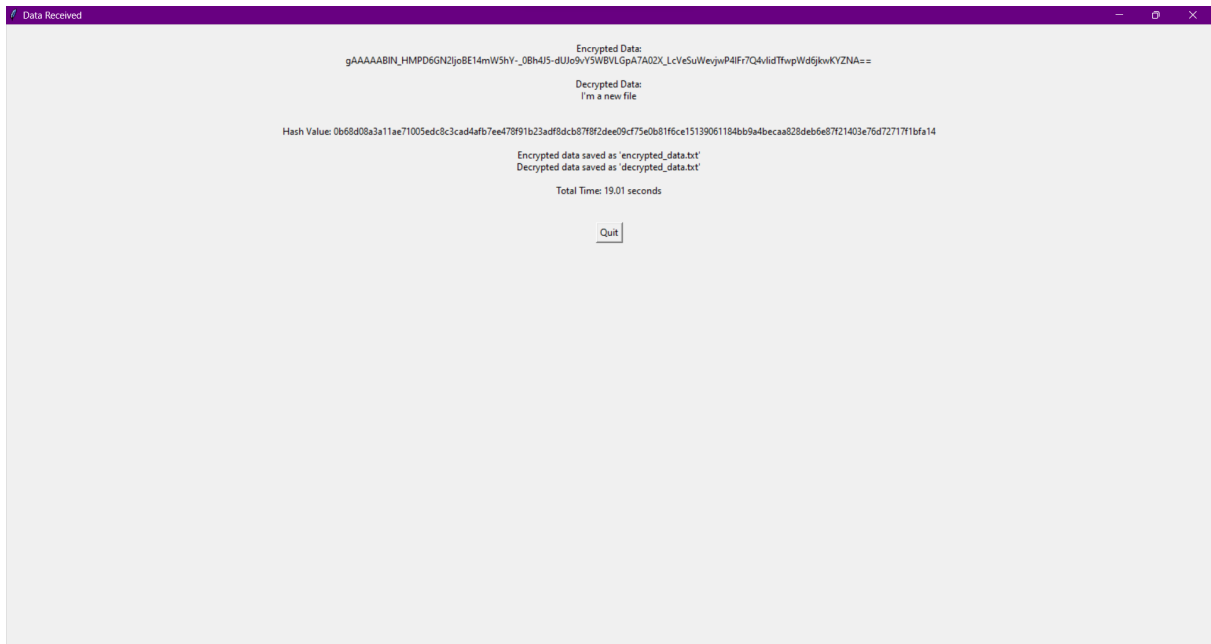


Fig.20 - File received

Hurray! Our files were successfully saved.




	decrypted_data	24-10-2023 10:03 PM	Text Document	1 KB
	encrypted_data	24-10-2023 10:03 PM	Text Document	1 KB
	receivedata	18-10-2023 12:26 AM	Application	11,147 KB

Fig.21 - Saved on the local server

If we neither want to use Data at Rest nor Data in Transit then we will choose the Nothing option to close it.

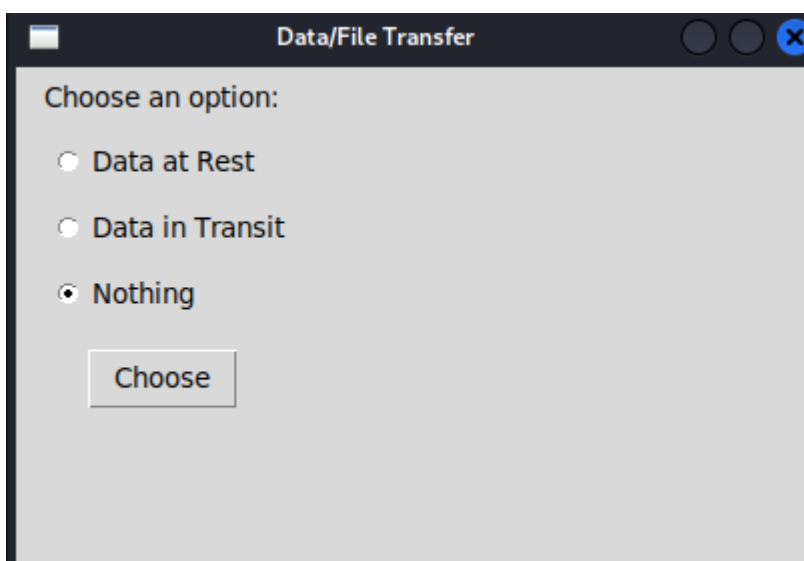


Fig.22 - Exit

Design

Design for the Sender Component :

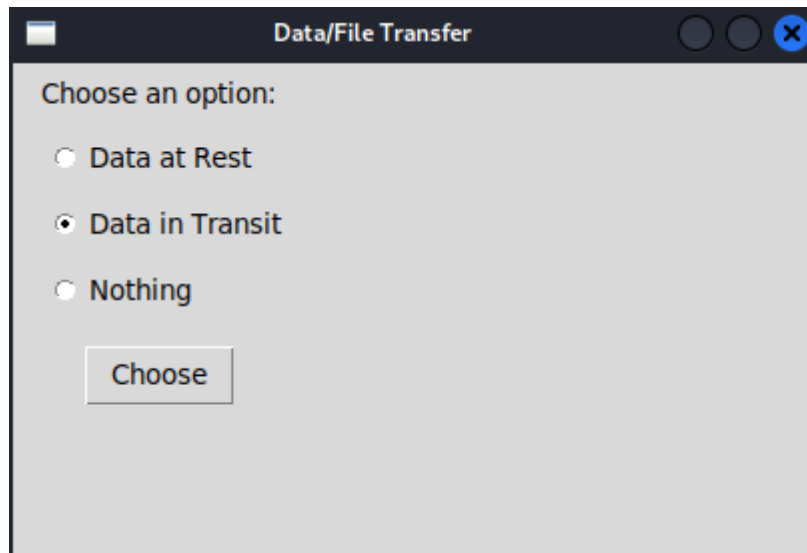


Fig.23 - GUI for Sender

Encryption and Hashing:

1. The sender program utilizes the Fernet symmetric encryption algorithm from the cryptography library to encrypt the data. Fernet is a secure encryption algorithm that provides confidentiality.
2. After encryption, a BLAKE2b hash is calculated for the encrypted data. Hashing helps ensure data integrity and is a critical aspect of data security.

Transmission Time:

3. The code also calculates the transmission time, which is essential for measuring the efficiency and performance of the data transfer process. Monitoring transmission time is crucial in virtualized environments where optimized resource allocation is key.

Choice of Data Type:

4. The sender program allows the user to choose between sending raw data or files. This flexibility is important in a virtualized storage environment, where data can be stored in various formats.

User Interface (GUI):

5. The sender program offers a graphical user interface (GUI) using the Tkinter library. This user-friendly interface allows users to select their options easily.

Design for the Receiver Component :

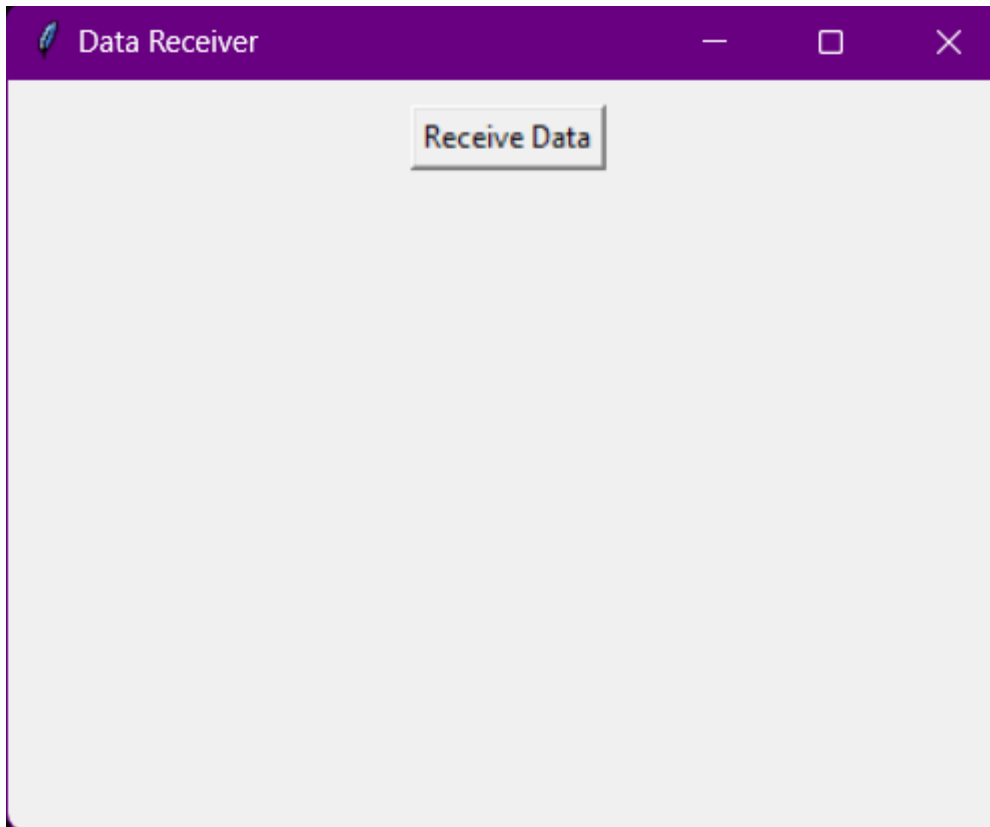


Fig.24 - GUI for Receiver

Encryption and Decryption:

1. The receiver program receives the encrypted data and uses the same Fernet encryption algorithm to decrypt it. This ensures that only authorized parties can access the data, thus maintaining confidentiality.

Hash Verification:

2. It calculates the BLAKE2b hash of the received data and verifies it against the received hash. This step ensures data integrity and guards against tampering during transmission, which is crucial in a virtualized storage security context.

Result Presentation:

3. The receiver program presents the decrypted data, hash value, and other relevant information in a GUI window. This provides an easy way to verify the received data's integrity and confidentiality.

Optimized Virtualized Storage:

4. While not explicitly stated in the code, optimizing virtualized storage security would involve implementing the sender and receiver in a virtualized environment. This would include securing the virtual machines (VMs), managing access controls, and ensuring data encryption and integrity at the virtualized storage layer.

Efficiency:

5. The program tracks and displays the total time taken for the data transfer. In a virtualized environment, this information can help assess the efficiency of the data transfer process and optimize resource allocation.

User Interface (GUI):

6. The receiver program also uses a GUI (created with Tkinter) to present the results. GUIs can simplify the process of data verification and enhance the user experience in a virtualized storage setting.

Installation

To run the code provided, you'll need to have Python, the `cryptography` library, and the necessary dependencies for socket communication. Here are the installation and setup instructions:

Prerequisites:

For Both Sender and Receiver:

Python:

Ensure that Python is installed on the sender machine. You can download Python from the official website <https://www.python.org/> and follow the installation instructions specific to your operating system.

Python Libraries:

Install the necessary Python libraries using pip, which are not included in the Python standard library. Open a terminal or command prompt and run the following commands:

```
"pip install cryptography"
```

Installation Steps for Sender:

1. Download or clone the sender code onto the sender's machine.
2. Open a terminal or command prompt and navigate to the directory where the sender code is located.
3. Run the sender code using Python:

```
"python sender.py"
```

4. The sender's GUI will appear, allowing you to choose between the "Data at Rest" and "Data in Transit" options. Follow the instructions in the GUI to proceed with data encryption and transmission.

Installation Steps for the Receiver:

1. Download or clone the receiver code onto the receiver's machine.
2. Open a terminal or command prompt and navigate to the directory where the receiver code is located.
3. Run the receiver code using Python:

```
"python receiver.py"
```

4. The receiver's GUI will appear with a "Receive Data" button. Click on this button to initiate the data reception process

Note: The sender and receiver components of the code need to be executed on different machines. The sender's IP address (in this case, '192.168.79.1') should be set to the actual IP address of the sender machine, and the receiver code should be run on a machine with network access to the sender. Additionally, the provided encryption key ('key') should be shared securely between the sender and receiver.

Future Implementations

Enhanced Data Security with the Present Algorithm

The present code implements data transmission and storage security using the Fernet encryption scheme to ensure data integrity and confidentiality in a virtualized environment. However, as the landscape of cybersecurity and encryption algorithms is continuously evolving, it is imperative to explore potential enhancements and adaptations to stay ahead of emerging threats and address specific needs for virtualized storage security. One promising avenue for future implementation is the integration of the present algorithm, which can offer improved security and efficiency in the context of virtualized storage environments.

Present Algorithm Overview

The Present algorithm, which stands for "The block cipher PRESENT," is a lightweight and highly secure symmetric key block cipher. It was designed to be compact and efficient, making it a suitable choice for resource-constrained environments such as embedded systems and virtualized storage infrastructures. Its key features include:

Lightweight: Present has a minimal code footprint and low computational overhead, making it well-suited for virtualized storage systems where resource utilization is a critical consideration.

Strong Security: The algorithm is known for its strong security guarantees, offering resistance against various cryptographic attacks.

Efficiency: The present's computational efficiency ensures that it can operate quickly, which is vital for processing data in real-time storage and retrieval scenarios.

Use Cases

Use Case 1: Data Encryption and Decryption

In a virtualized storage environment, one essential use case is the encryption and decryption of data. This ensures data confidentiality and protects sensitive information from unauthorized access. Here's how this use case works:

Scenario: When data is stored in a virtualized storage system, it needs to be encrypted to prevent unauthorized access, even if the storage infrastructure is compromised.

Technical Implementation:

- Data is encrypted using strong encryption algorithms such as AES.
- A secure encryption key (e.g., Fernet key) is used to protect the encryption/decryption process.
- The encrypted data is stored within the virtualized storage system.

Benefits:

- Even if an attacker gains access to the storage system, the data remains encrypted and unreadable without the decryption key.
- Sensitive data is protected from insider threats and data breaches.

Use Case 2: Data Integrity Verification

Another critical aspect of virtualized storage security is ensuring data integrity. This use case focuses on verifying that data has not been tampered with during storage or transmission.

Scenario: When data is stored in a virtualized storage system or transferred over a network, it's essential to confirm that the data hasn't been altered, corrupted, or tampered with.

Technical Implementation:

- Hash functions like Blake2b are used to generate checksums or hash values for the stored data.
- Periodic integrity checks are performed on the data by recalculating hash values and comparing them with the original values.

Benefits:

- Ensures that data remains unchanged and reliable throughout its lifecycle in the virtualized storage environment.
- Provides early detection of data corruption or tampering.

Use Case 3: Secure Data Transmission

In a virtualized storage environment, data often needs to be transmitted securely between different components. This use case focuses on ensuring the confidentiality and integrity of data during transmission.

Scenario: Data must be securely transmitted between virtual machines, storage devices, and other components within the virtualized environment.

Technical Implementation:

- Data is encrypted before transmission using secure encryption protocols like TLS or VPNs.
- Secure channels are established for data transfer, and encryption keys are exchanged securely.

Benefits:

- Protects data during transit, preventing eavesdropping and man-in-the-middle attacks.
- Ensures that data remains confidential and unaltered while in motion.

Use Case 4: Secure Key Management

Secure key management is crucial for maintaining the security of the virtualized storage environment.

Scenario: Encryption keys are central to data security. Proper key management is vital to prevent unauthorized access.

Technical Implementation:

- Use hardware security modules (HSMs) or secure key management systems to store and manage encryption keys.
- Implement key rotation and access control policies.

Benefits:

- Ensures that encryption keys are well-protected and not vulnerable to theft or compromise.
- Facilitates secure and controlled access to data.

Use Case 5: Data Backup and Recovery

In a virtualized storage environment, data backup and recovery are essential for business continuity.

Scenario: Data loss or hardware failures can occur. Therefore, data backup and recovery mechanisms must be in place.

Technical Implementation:

- Regular data backups are created, and these backups are also encrypted.
- Automated recovery procedures allow for quick data restoration in cases of data loss.

Benefits:

- Ensures data availability and business continuity.
- Protected backups prevent data breaches, even if they are stored off-site.

Conclusion

Finally, the "Optimized Virtualized Storage Security: Ensuring Data Integrity and Confidentiality in a Virtualization Environment" project has produced significant technical insights and solutions to improve data security in virtualized storage systems.

Throughout the project, a robust focus on data encryption and decryption was maintained, emphasizing the necessity of safeguarding data at rest and in transit. By employing strong encryption algorithms, such as the Fernet encryption method, we have showcased the pivotal role encryption plays in preserving data confidentiality, even in the face of unauthorized access.

Furthermore, the project introduced a critical element in data security—data integrity. Through the use of hash functions, particularly the BLAKE2b hash, the project highlighted the significance of hash values in validating data integrity. This not only detects any potential tampering but also ensures data reliability, a crucial aspect of data security.

The project delved into the realm of data transmission security. By encrypting data prior to transmission, the project established a robust defense against eavesdropping and ensured that data remained confidential during transfer. The computation of transmission durations has facilitated the understanding of performance factors and tactics to enhance data transfer in virtualized storage setups.

User interaction and user-friendliness were key considerations. The incorporation of a user-friendly graphical user interface (GUI) allowed users to easily select data protection options, promoting secure practices and facilitating interaction.

Handling both data and files was another pivotal aspect of the project. The ability to store encrypted data in files and include file encryption and decryption processes improves how well data is managed in virtualized storage systems.

Moreover, the project presented a comprehensive result reporting mechanism. It offers transparency regarding the security operations performed on data. Users gain detailed information on encrypted and decrypted data, hash values, and the time taken for transmission or operations, allowing them to make informed decisions about their data.

Efficiency and performance optimization were also at the forefront of the project. The project made clear the significance of striking a balance between data security and performance, a crucial consideration in virtualized environments, by taking transmission times and the choice of encryption algorithms into account.

Lastly, the project's platform independence means it can be readily deployed across various platforms, making it a versatile and adaptable solution for different virtualization environments.

References

- [1] Sharma, S., Soni, S., Sengar, S., (2012) Security in cloud computing National Conf. on Security Issues in Network Technologies, 1-6.
- [2] Sen, J., (2013) Security and privacy issues in cloud computing Retrieved from arxiv.org/pdf/1303.4814. International Conference on AI and Big Data Application (AIBDA 2019)IOP Conf. Series: Materials Science and Engineering 806 (2020) 012027IOP Publishingdoi:10.1088/1757-899X/806/1/0120275
- [3] Khurana, S., Verma, A.G., (2013) Comparisons of cloud computing service model: SaaS, PaaS, IaaS International Journal of Electronics Communication Technology (IJECT), 4 3 29-32.
- [4] Ashraf, I., (2014) An overview of service model of cloud computing Int. J. of Multidisciplinary and Current Research 2, 779-783.
- [5] Zhang, T., Lee, R.B., (2016) Monitoring and Attestation of Virtual Machine Security Health in Cloud Computing [J]. IEEE Micro, 36(5): 28-37.
- [6] Shukla, A., Hedao, D., Chandak, M.B., Veena Prakash and Raipurkar, A., 2017. A Novel Approach: Cloud Based Real Time Electronic Notice Board. International Conference On Smart Technologies For Smart Nation (SmartTechCon), August.
- [7] Artiochani and Dongre, N., 2017. Security Issues in Cloud Computing. 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), February.
- [8] Grosse, E. and Upadhyay, M., 2013. Authentication at scale. IEEE Security and Privacy, 11(1), pp.15–22.
- [9] Fylaktopoulos, G., Goumas, G., Skolarikis, M., Sotiropoulos, A. and Maglogian-

nis, I., 2016. An Overview of Platforms for Cloud Based Development. Greece, Springerplus. Vol. 5, pp. 1–13.

[10] Rouskas, G.N., 2012. Network Virtualization: A Tutorial. IEEE Conference on OFC/NFOEC, March.

[11] Ge. J.-W., Deng, Y.-L. and Fang, Y.-L., 2010. Research on Storage Virtualization in Cloud Storage Environment. International Conference on Multimedia Technology, October

[12] Jin, H., 2008. Desktop Virtualization Techniques and Applications. Third International Conference on Pervasive Computing and Applications, October.

[13] B. Li, J. Shu, and W. Zheng, ♦Design and implementation of a storage virtualization system based on scsi target simulator in san,” Tsinghua Science Technology, vol. 10, no. 1, pp. 122-127, 2005.

[14] J. Guo-song and H. Xiao-ling, ♦Design and implementation of iscsi out-of-band storage virtualization,” in Intelligence Science and Information Engineering (ISIE), 2011 International Conference on, pp. 378-381, IEEE, 2011.

[15] Z. Qiang, C. Dong, W. Yunlong, and D. Zhuang, “The out-of-band virtualization model of network storage based on trusted computing,” in Natural Computation (ICNC), 2010 Sixth International Conference on, vol. 8, pp. 4354-4357, IEEE, 2010.

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