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Case Study on Data Leakage Prevention File System (DLPFS)

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Abstract - *Data Leakage Prevention (DLP) is a crucial technique used by organizations to safeguard sensitive or confidential data. A core component of DLP is the de-identification of Personally Identifiable Information (PII) before sharing it with third parties or stakeholders. Techniques such as masking and replacement are employed to conceal or anonymize PII. Masking involves substituting specific elements, like names or addresses, with generic placeholders such as "<PERSON>" or "*". Replacement substitutes sensitive data with similar but fictitious values, for instance, replacing the name "Aman" with "Rishi". Beyond de-identification, DLP systems incorporate access control mechanisms for uploading and reviewing files, ensuring that only authorized personnel can access the data. Additionally, DLP systems encrypt stored data to prevent breaches, rendering the data inaccessible without the appropriate decryption key, even in the event of theft. As organizations increasingly need to share information with multiple parties, the adoption of DLP technology is essential for maintaining the privacy and security of sensitive information while enabling secure data sharing with relevant stakeholders.*

Keywords*: *De-identification, Extraction, Encryption, Pseudonymization, anonymization

1.INTRODUCTION

Data breaches are frequently attributed to human error, such as misconfigurations or inadequate data governance, rather than external hacking attempts. Misconfigured applications and software bugs pose a constant risk to the confidentiality of sensitive information. Common examples of data leakage include log files that inadvertently store sensitive details like usernames and passwords, as well as stack traces or core dumps from crashed applications that expose private data.

Traditional data protection strategies, such as access control and encryption, are often insufficient to address all potential data leakage scenarios. Data leakage can occur when data is shared among multiple users or systems, or when it must be accessible for purposes like auditing or debugging. The widely practiced approach of creating multiple versions of datasets for different purposes is costly and impractical, especially for large-scale data handling.

1.1 DLP File System

The Data Leakage Prevention File System (DLPFS) introduces an innovative approach to secure data sharing across applications and systems. By leveraging advanced data type identification and de-identification technologies, DLPFS provides robust data protection. It integrates seamlessly into existing infrastructures by exposing a POSIX file system API, enabling applications to access protected data subtrees without significant modifications.

DLPFS enables users to share data securely and maintain privacy across multiple systems without the need to generate custom copies of data for different applications. Additionally, it supports legacy applications by allowing them to operate on de-identified data in real-time, eliminating the need for modifications to the applications themselves.

1.2 Transitioning DLPFS to a Web-Based Application

While the original DLPFS was designed to secure data within POSIX-compliant file systems, its architecture is inherently tied to file-based operations, limiting its applicability in modern, web-based environments. In response to the growing need for privacy-preserving data handling in distributed and dynamic web systems, this project reimagines DLPFS as a **web-based application**, addressing the challenges of real-time data sharing over HTTP protocols.

The adapted system retains the core principles of DLPFS, such as sensitive data detection, de-identification, and robust access control, while extending its functionality to meet the demands of web-based workflows. By replacing the POSIX file system API with a scalable web architecture, this project integrates state-of-the-art data masking, redaction, and anonymization techniques into a middleware solution that operates seamlessly across distributed systems.

3.2 Features and Modules

For Data Identification - sensitive data patterns are defined using regex rules stored in the Knowledge Base. Key patterns include

```
[
    {
        type:'Email',
        reg: /\b[A-Z0-9._%+-]+@[A-Z0-9.-]+\.[A-Z]{2,4}\b/gi,
        redact:'<EMAIL_ID>'
    },
    {
        //add formate checker
       type:'Phone_Number',
        reg:/(\+\d{1,2}\s)?\(?\d{3}\)?[/\s.-]?\d{3}[/\s.-]?\d{4}/g,
        redact:'<PHONE_NUMBER>'
    },
   {
       type:'SSN',
        reg:/\d{3}-?\d{2}-?\d{4}/g,
        redact:'<SSN>'
    },
]
```

Fig -1: Example of PII Type

For Data Transformation - Detected sensitive data undergoes transformation based on configurable rules:

- Redaction: Replaces sensitive data with asterisks (e.g., john.doe@example.com → ********).
- Masking: Substitutes sensitive data with syntactically similar but fictional values.
- Anonymization: Applies differential privacy techniques to numerical data.

These transformations are applied in compliance with user-defined configurations.

For file Read and Write - The system intercepts file uploads and processes them in the following steps:

- Upload: The user uploads a file through the web interface.
- Inspection: The backend scans the file for sensitive data patterns.
- Transformation: Detected patterns are transformed based on Knowledge Base rules.
- Storage: Transformed files are securely stored, and the original files are discarded.

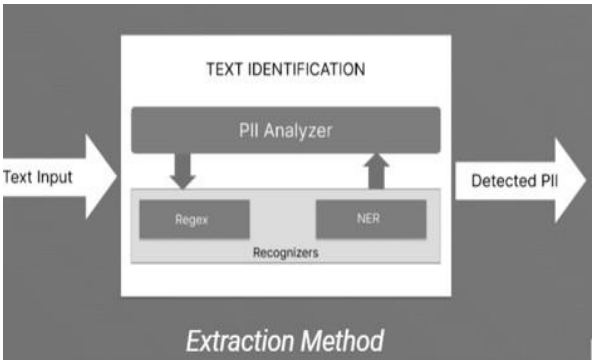

Fig-2: Processing of Text Identification

The above diagram illustrates the process of PII (Personally Identifiable Information) Detection and Extraction. It begins with the input of text, which is then processed by a PII Analyzer. This analyzer employs two

primary methods: Regex (Regular Expressions) and NER (Named Entity Recognition). Regex identifies PII based on predefined patterns, while NER leverages machine learning models to recognize entities like names, addresses, and social security numbers. The detected PII isthen outputted as the final result.

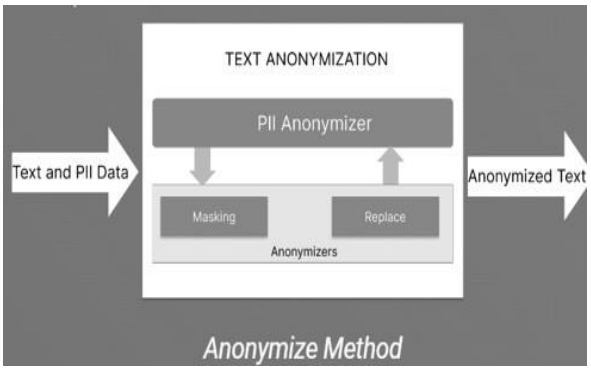

Fig -3: Processing of Text Anonymization

The above diagram illustrates the process of Text Anonymization. It begins with the input of text containing PII (Personally Identifiable Information). This text is fed into the PII Anonymizer, which employs two anonymization methods: Masking and Replace. The Masking method obscures PII by replacing sensitive characters with special characters, while the Replace method substitutes PII with generic or placeholder values. The anonymized text, devoid of sensitive information, is then outputted as the final result.

5. CONCLUSIONS

Data Leakage Prevention File System extracts the PII data efficiently and Masks or Replace PII data based on users choice to store or share with 3rd parties and stakeholders. Extraction of Address is still one of the issues which we need to work on. In conclusion, a data leakage file system is a critical element in ensuring the security of sensitive organizational information. It allows organizations to regulate access to information and control who has access to specific data. A well-designed data leakage file system should allow for easy administration, real-time monitoring, and a robust audit trail system. This will help in identifying any unauthorized access to sensitive data and respond to such incidents promptly. Overall, organizations should invest in a robust data leakage file system as part of their overall security strategy to prevent data breaches and data loss.

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