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Securing Data Transfer using Parallel Encryption Based on Different Metadata

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ABSTRACT

In the digital age, the security of multimedia data on disk drives is increasingly vital, as data volumes grow rapidly and security threats evolve. Current cryptographic methods, such as RSA-2048, though widely used, present significant limitations. RSA-2048 is computationally intensive, resulting in slow encryption and decryption speeds, which can be impractical for large volumes of multimedia data. Additionally, the RSA-2048 algorithm has vulnerabilities that may allow tampering, posing a threat to data integrity and confidentiality. These shortcomings, combined with the lack of flexibility and constant manual input required from users, make it less suitable for modern applications demanding high efficiency and robust security. The proposed system aims to solve these issues by introducing the XChaCha20 algorithm, a more advanced cryptographic approach. XChaCha20 is known for its high speed, lightweight nature, and ability to handle large-scale data encryption more efficiently. By leveraging parallel encryption and decryption processes, this algorithm significantly reduces the time needed for securing data, making it more suitable for real-time applications. In addition to improving speed, XChaCha20 provides stronger encryption, reducing the risk of tampering and enhancing data confidentiality. Its design allows for better scalability and performance, especially when dealing with the increasing demands of multimedia storage. Overall, the XChaCha20-based system provides a more secure, efficient, and user-friendly alternative to RSA-2048, meeting the demands of modern data security challenges while reducing the computational burden.

Keywords: XChaCha20, RSA-2048, encryption, decryption, efficient, user-friendly.

1. INTRODUCTION

Multimedia information including pictures and videos are gaining primary importance in the society and the amount of data of this type is being hoarded on disk drives and in removable storage media. It is a sad reality that such storage devices, and especially those storing multi-media files are often the victims of security threats and invasions of privacy. This has seen an increased interest in research to create superior protection mechanisms to ensure such sensitive data. Storage encryption is one of the best solutions because it provides multimedia contents with confidentiality and privacy. Nevertheless, the evolution of cryptographic methodologies of the multimedia data is not that simple because of the peculiarities of this data, such as its huge volume, redundancy, and complicated file structure. Moreover, the computational power of cryptographic operations on such data are also a challenge as they are time consuming as well as encrypting and decrypting information.

To address these issues, the current cryptographic file systems have developed to provide more dynamic and efficient solutions to the encryption, decryption and key management. Such systems have the ability to directly integrate with the file systems of the operating system so that cryptographic operations are easily and easily transparent even though they do not need the user's constant attention. There are two major types of cryptographic file systems: those that are implemented in the kernel space and those that are implemented in the user space. Middleware may be implemented at the kernel level, where a single file or a single directory is encrypted but block device layers offer encryption at the storage level, which secures out an entire disk partition.

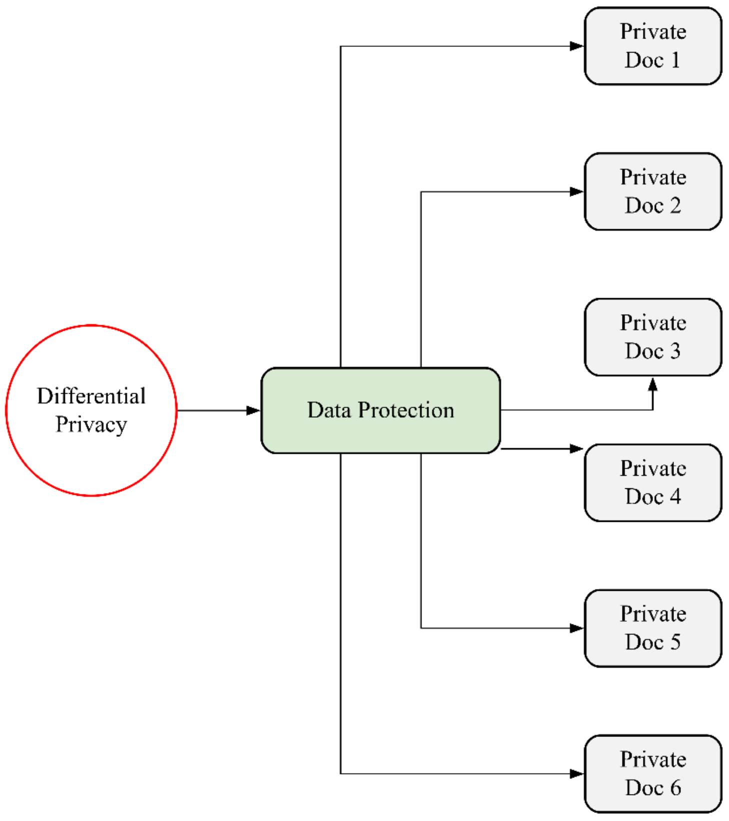

Figure 1: Data Protection Policy

These solutions provide both tremendous security and performance gains to enable them to address a lot of the shortcomings of the traditional encryption applications. XChaCha20 is a sophisticated stream cipher based on ChaCha20 algorithm which was created to be both fast and secure in cryptography. XChaCha20 has a more extended functionality, especially the capability to operate with a bigger nonce size (192 bits) than ChaCha20 with a nonce size of 96 bits, which is more secure in situations where random nonces may overlap. This renders XChaCha20 highly appropriate to the encryption of huge amounts of data, including multimedia files, to minimize the chances of nonce reuse, a weakness that is very disruptive in encryption systems. Similar to its predecessor, XChaCha20 is intended to be fast and efficient across a wide variety of platforms, including low-power devices and modern CPUs. It does not require the complexity of the computations of the traditional cryptographic algorithms such as RSA employing lightweight operations that can be done in parallel thus, speeds up the encryption and decryption processes. This qualifies XChaCha20 as a good solution to secure multimedia data in real-time applications, and ensures high security provisions.

2. RELATED WORKS

Dynamic multimedia encryption using a parallel file system based on multi-core processors [1] osama a. Khashan, nour m. Khafajah [1] securing multimedia data is challenging due to the high computational costs of traditional cryptographic schemes and their limited usability. In response to this, parallelfs was created that is a dynamic and fuse-based encryption file system, and thus uses the parallelism of multi-core processors to improve performance. Through the use of a hybrid encryption algorithm combining the use of symmetric and asymmetric ciphers, parallelfs will have the ability to encrypt, decrypt and manage keys without involving a lot of user intervention. According to experimental findings, parallelfs enhances the reading performance by 35% and the writing performance by 22 percent over sequential encryption mechanisms, and thus it is very effective in storage of multimedia data. [2] A hybrid encryption approach for efficient and secure data transmission in iot devices limin zhang & li wang [2] Security IoT ecosystem is difficult because devices are limited in their resources. This paper will present a hybrid encryption system that will use the Blowfish algorithm to enable the encryption of data and the elliptic curve cryptography (ECC) to ensure the privacy of the key. The scheme maximizes performance through symmetrical and asymmetric encryption, performing at a 15-percent lower time than its counterpart and is overall more effective, thus being suitable in all IoT devices that have minimal effects on processing resources. [3] ENHANCING SECURITY PERFORMANCE WITH PARALLEL CRYPTO OPERATIONS

IN SSL BULK DATA TRANSFER PHASE Hashem mohammed alaidaros; mohd fadlee a. Rasid [3] This paper suggests parallel algorithm of bulk data transfer of Secure Socket Layer (SSL) to enhance its performance without sacrificing its security. The new approach, in contrast to the existing sequential algorithm whereby the first step is the computation of the Message Authentication Code (MAC) and second step is the encryption of the data, uses two processors at once to perform both the encryption and MAC computation through Message Passing Interface (MPI). The process is much faster by 1.74 and 85 percent efficiency simulations over the current sequential method, and yet the process is not compromised in the area of security. [4] Image parallel encryption technology based on sequence generator and chaotic measurement matrix Jiayin Yu, Shiyu Guo, Xiaomeng Song, Yaqin Xie and Erfu Wang [4] The given paper introduces a parallel image encryption transmission algorithm that improves the efficiency with the help of compressed sensing and the security with the help of chaotic cryptography. The aim of compressed sensing is to lower the data sampling and that of chaotic cryptography is to improve encryption with sensitive chaotic signals. Simulations are more efficient in terms of transmission and strong protection against attack. [5] Secure Data Storage And Sharing Techniques For Data Protection In Cloud Environments: A Systematic Review, Analysis, And Future Directions Ishu Gupta, Ashutosh Kumar Singh, Chung-Nan Lee [5] This paper presents an analytical and methodical examination of essential methods of sharing and protecting data safely in the cloud domain, which is the major issue of data protection in the cloud computing environment. Although the cloud has numerous benefits, including scalability and low cost of entry, data security is equally a major issue. The article introduces the review of different existing solutions, their work, potential, and innovations. It entails elaborate descriptions of the workflow, successes, limitations, and future perspectives of each technique and provides information on their efficacy. Standard comparative analysis shows the benefits and limitations of each methodology, gaps in research and ways to investigate it in the future. According to the authors, this work should become the foundation of researchers who are going to develop the data protection in the cloud environment.

3. PREPARATIONS

A. MOTIVATION:

The rapid expansion of the multimedia data and the rising dependence on the digital storage have resulted in the urgent necessity to develop the high-tech encryption methods that can defend the high amount of sensitive information without any waste. RSA-2048 is a commonly used traditional encryption, which is not very effective in addressing the current challenges of speed and performance especially when it comes to encrypting very large data volumes such as multimedia files. As the data volumes grow, the trade-off between security and speed has become increasingly visible, with traditional cryptographic schemes producing huge amount of overhead that slows real-time applications. These constraints are encouraging the pursuit of better encryption methods that could provide the end result of both high security and high performance. XChaCha20 would be a good solution to these problems because it incorporates both high speed encryption and light processing thus it is suitable when securing a large volume of data without impacting on performance.

The most significant strength of it is its capability to deal with encryption concurrently, which can be the key in a situation that requires processing data quickly. The advantage of this parallelism is that it decreases the time required to access large files, in addition to enabling the scalability of the system as data loads increase. With the increase in the volume and significance of multimedia data, encryption algorithms such as XChaCha20 that are capable of keeping pace with these demands become necessary. In addition, XChaCha20 has greater encryption strength than most traditional algorithms such as RSA-2048 and offers greater protection against manipulation and unauthorized access. The advanced cryptographic design of the algorithm also makes sure that the sensitive data is not disclosed, even against high technology attacks. This level of security is vital in the modern world of the internet where cyber threats grow increasingly sophisticated and common. Using XChaCha20, a better level of security can be gained, without sacrificing the flexibility and efficiency of encryption and decryption of real-time data.

B. PRELIMINARY:

The initial research concerning XChaCha20 algorithm implementation with parallel encryption is aimed at improving the security of the data and the speed of the encryption. An extended variant of the ChaCha20 cipher, called XChaCha20, is more secure as it uses a nonce with a 192-bit length, which resists nonce reuse attacks more effectively. XChaCha20 is used in a parallel encryption structure in this system, then data is separated into small pieces, and each piece is computed in parallel over multiple threads or cores. This is an efficient way of minimizing the time of encryption as compared to the traditional sequential encryption techniques and is also very secure. The parallel processing feature of the system indeed fits just the large datasets and real-time encryption requirement and hence, both efficiency and strong security of sensitive multimedia or disk-based stored data is achieved.

C. Weighted Concept Hierarchy:

The XChaCha20 Weighted Concept Hierarchy with parallel encryption offers a systematic hierarchy to streamline the encryption procedure by arranging the information in hierarchical layers in accordance to their relative importance or frequency of use. Over the anti-licensing scheme XChaCha20, a fast-encryption stream cipher, this hierarchy enables prioritization of sensitive data blocks during parallel encryption. With an approach based on a weight, the more important data may be encrypted first or with higher computational resources, and less important information may be processed with a lower priority.

This type of parallel encryption, which is driven by the nature of the XChaCha20 speed and security, can not only offer efficient data protection, but also better performance when processing large amount of data, which is the case in multimedia or real-life application. The Weighted Concept Hierarchy therefore has a balance in data sensitivity and encryption performance and results in a faster and more secure encryption process.

D. CHACHA20 BLOCK FUNCTION:

ChaCha20 operates on a 512-bit (64-byte) block, which is derived from:

$$\mathrm{ChaCha20}_{\mathrm{Block}} = \mathrm{ChaCha20}(\mathrm{key}, \mathrm{nonce}, \mathrm{block\_counter}) \quad (1)$$

The chaCha20 block processing algorithm operates on a 512-bit state, which is a 256-bit key, a 96-bit nonce, a 32-bit block counter and a fixed constant. It works with the input several times (20 rounds of mathematical operations additions, XORs, bitwise rotations) to produce a 512-bit output, which serves as a keystream. The plaintext is XORed with this keystream to get the ciphertext to be encrypted. The process guarantees quickness, ease and safety in encrypting and decrypting.

E. XCHACHA20 INITIALIZATION:

The ChaCha20 cipher is extended to a more secure 192-bit long nonce, preventing nonce reuse. The initial stage is the key setup during which a 256-bit key is multiplied with a 192-bit nonce and a constant. XChaCha20, unlike ChaCha20, uses a longer nonce by executing a subkey generation step through HChaCha20, which generates a 256-bit subkey based on the initial key and the first 128 bits of the nonce. The subkey together with the rest of the 64 bits of the nonce is then used in the initiation of the ChaCha20 block function. It makes the process better encrypted with increased weakness of nonce vulnerabilities.

F. HCHACHA20 FUNCTION:

The HChaCha20 function is based on the ChaCha20 block function but operates on a 128-bit nonce instead of the regular 96-bit nonce:

$$\mathrm{HChaCha20}(\mathrm{key}, \mathrm{nonce}) \rightarrow Subkey \quad (2)$$

HChaCha20 generates a 256-bit subkey which is then applied to the ChaCha20 block function with the second portion of nonce. HChaCha20 is a cryptographic hash which is based on the ChaCha20 stream cipher, which generates a subkey using a key and nonce. It uses the inputs of a 256-bit key and a 128-bit nonce and processes the ChaCha20 block function in such a way that the output is 256-bit wide. This result is used as the subkey to the further encryption or authentication procedure. The HChaCha20 routine undergoes several stages of operation and involves repetitions of a certain number of rounds of permutation and mixing steps that add to the diffusion and security of the subkey generated. HChaCha20 helps give the XChaCha20 cipher the overall robustness the key reuse property of HChaCha20 is that even reusing the same key the subkeys generated will be unique and secure.

4. SCHEME DESCRIPTION

A. Index building:

Index building is a very important process in database management systems which makes data retrieval operations to be faster and efficient. It consists of the development of an indexing system that enables more rapid searches of large data volumes. B-trees, hash indexes, and inverted indexes are the most common indexes. Although the exact equation that represents the index building may depend on the kind of index employed, a rough example can be explained in the example of a B-tree index, one of the most common types of indexing mechanisms:

1. **Node Splitting**: When a node exceeds its capacity, it splits into two nodes, and the median key is promoted to the parent node. The operation can be represented as:

$$\mathrm{Split}(\mathrm{X}) \rightarrow \mathrm{Y}, \mathrm{Z} \text{ where Y and Z are new nodes} \quad (3)$$

2. **Searching**: The time complexity for searching in a balanced B-tree is:

$$\mathrm{O}(\log_{\mathrm{b}}(n)\ ) \quad (4)$$

Where b is the branching factor (the maximum number of children per node) and nnn is the number of keys in the tree.

3. **Insertion**: The process of inserting a new key involves finding the appropriate leaf node and possibly splitting it, which can be represented as:

$$\mathrm{Insert}(\mathrm{k}, \mathrm{T}) \rightarrow T' \quad (5)$$

4. **Deletion**: Deleting a key may involve merging nodes or redistributing keys, which can be depicted as:

$$\text{Delete}\ (\text{K}, \text{T}') \rightarrow \text{T}'\,where\ k\ is\ the\ key\ to\ delete \tag{6}$$

Index building significantly improves query performance by allowing the database system to quickly locate the desired records. By utilizing structures like B-trees, the efficiency of search, insertion, and deletion operations is greatly enhanced, making it a fundamental aspect of database optimization.

B. GENERATING A TRAPDOOR:

The issuance of a trapdoor in the case of XChaCha20 is associated with the safe key management and encryption mechanism that it uses. XChaCha20 is a stream cipher derived from ChaCha20 algorithm and it uses an uncommon initialisation including formation of a 256-bit subkey with the help of HChaCha20 function. This is done to maintain the fact that even when the same key is used in many of the different sessions the extended length of the nonce (192 bits) will improve the security since the stream of the key will be different each time the encryption is being performed. Here, the trapdoor concept can refer to the challenge of recovering the original plaintext using the ciphertext through the knowledge of neither the key nor nonce. In particular, it is easy to compute the subkey, but it is only possible to reverse the encryption, hence by XORing the plaintext with the ciphertext of the key stream that is built using the subkey, the first key and nonce are required, and so, by incurring a safe trapdoor, goes the protection against unprotected decryption and the preservation of data confidentiality.

Table 1: Index Vector of a Sub-Server

Node	a	b	c	d	e	f	g	h	i	j	k	l	m	n	p	q
S	1	0	1	0	0	1	0									

Table 2: Index Vector of a Document

Node	a	b	c	d	e	f	g	h	i	j	k	l	m	n	p	q
D_1	0	0	0	0	0	1	0	0	0	**TF_i**	**TF_j**	0	0	0	0	0
D_2	0	0	0	0	0	0	**CW_i**									

Table 3: Index Vector of a Trapdoor

Node	a	b	c	d	e	f	g	h	i	j	k	l	m	n	p	q
Q	0	0	0	0	0	0	0									

C. Encryption using XCHACHA20:

XChaCha20 encrypts data by XORing the plaintext with the key stream.

$$\text{Ciphertext} = \text{Plaintext}\ \oplus \text{Keystream} \tag{7}$$

The encryption with XChaCha20 has been designed to be a combination of the benefits of the ChaCha20 cipher and the length of the nonce, which is more secure and open to numerous possibilities. The encryption starts with the initialisation of the XChaCha20 state with a key of 256 bits and a nonce of 192 bits, compared to the nonce size in ChaCha20 that is 32. This long nonce supports more distinct initialization vectors, mitigating nonce reuse risks in applications that encrypt multiple messages using the same key. The XChaCha20 function is used to create a keystream used during the encryption process: multiple applications of the ChaCha20 block function. This key stream is XORed with the plaintext information to come up with the ciphertext. XChaCha20 is efficient and secure in its output and can be used in a wide range of applications, such as communications and file encryption that are secure and it is resistant to known cryptographic attacks.

D. Decryption using XChaCha20:

Decryption in XChaCha20 is the inverse of encryption, done by XORing the ciphertext with the key stream.

$$\text{Plaintext} = \ \text{Ciphertext} \oplus \text{Keystream} \tag{8}$$

To encrypt the data with the help of XChaCha20, it is necessary to start with the creation of a subkey 256 bits in length with the help of the HChaCha20 function that requires the original key and the first 128 bits of the nonce. This subkey is essential to the following steps, where the security of the process of encryption is guaranteed. Then, a sequence of keystream is produced by applying the ChaCha20 algorithm using the new subkey, the rest of the nonce, and a block counter. This key stream is then XORed against the plaintext giving the ciphertext. In decryption, on the other hand, the keystream is XORed with the ciphertext to recover the original plaintext. XChaCha20 has been improved by using a longer nonce, thus greatly lowering the threat of nonce reuse attacks with the speed and simplicity of the initial ChaCha20 algorithm. This combination renders XChaCha20 a solid encryption option in an encryption secure application.

5. SECURITY ANALYSIS

a. Confidentiality of Documents and Concepts:

XChaCha20 ensures confidentiality which secures sensitive documents and ideas. This stream cipher employs a secret key together with a nonce (number used once) to produce key stream when encrypting a particular plaintext to ensure that the same ciphertexts are not processed on the same plaintext. This method can be used to conceal the patterns that may be used by attackers.

XChaCha20 provides stronger security by computing a 256-bit subkey with the HChaCha20 function, which is applied with the original key and the first 128-bits of the nonce. This permits longer nonces, which lessens vulnerabilities of nonce reuse, which is a typical drawback in encryption techniques. In the encryption process the plaintext is XORed with the key stream generated and the ciphertext can only be decrypted with the correct key and nonce. This is done to keep the original documents safe and hence XChaCha20 can be used in numerous applications such as in secure communications and file encryption and focus on confidentiality and data integrity.

b. Index and Trapdoor Privacy:

Index and trapdoor privacy are essential terms in the secure data retrieval system and especially so with encryption algorithms such as XChaCha20. An index is a systematic demonstration of encrypted data, which can be searched and accessed effectively and the data remains secret. Trapdoor facility is used in such systems to support secure queries. The trapdoor is a fragment of information that allows a user to access particular information to the index without exposing the plaintext.

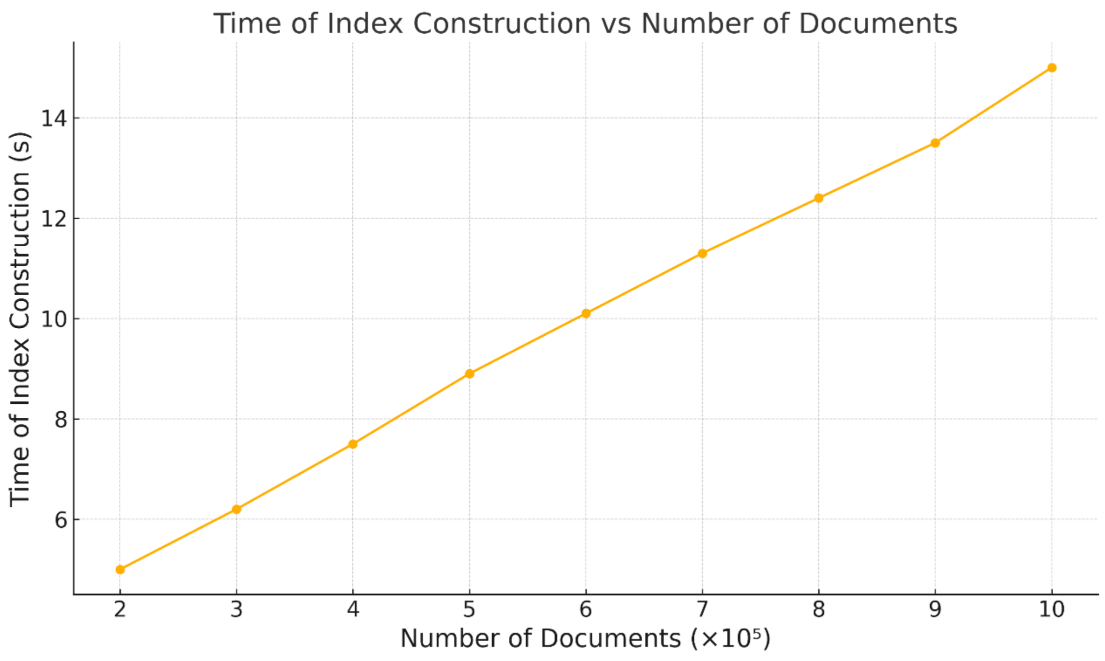

Figure 2: Time of Index Construction vs Number of Documents

Upon a query, the system makes use of the trapdoor to produce a search key which can be compared with the encrypted index. This prevents exposures to the index whilst data is safely stored within a trapdoor such that the contents of the index are not deciphered by the unauthorized users. Through the merits of XChaCha20 that gives high encryption and resistant to several attacks, index and trapdoor privacy can greatly promote the security of data retrieval systems to make sure that sensitive data would be accessed safely and efficiently.

c. QUERY GENERATION:

The problem of query generation when retrieving encrypted data is how to formulate search queries such that the information stored in an encrypted database will be accessed and retrieved in an effective manner without violating the security of the underlying information.

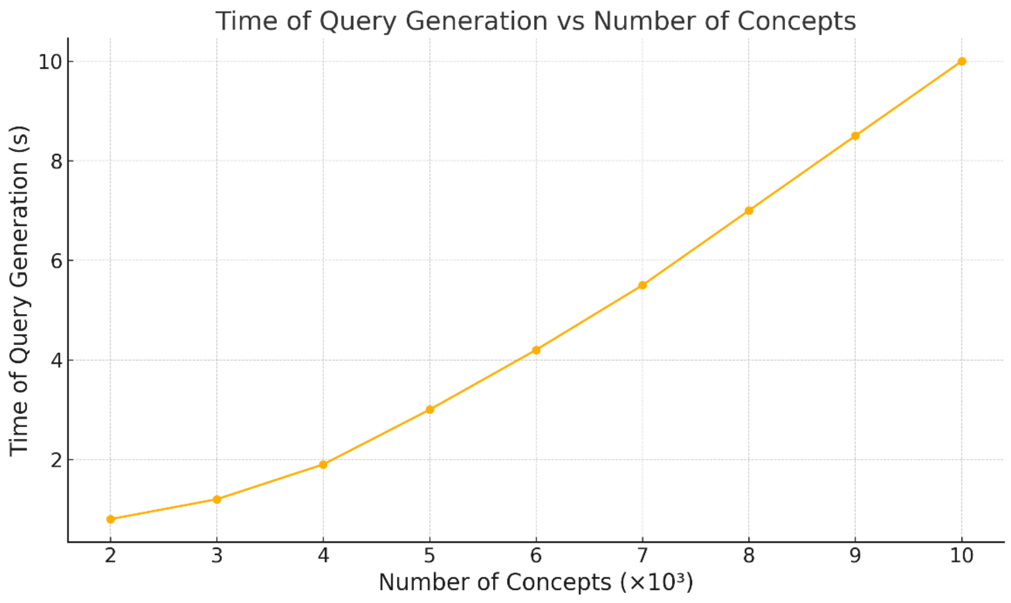

Figure 3: Time of Query Generation Vs Number of Concepts

In the case of applying encryption algorithms such as XChaCha20, the method would usually start with the request of a user to obtain certain information that is processed into a structured query. This query is then joined to a trapdoor which is a bit of information to enable authorized users to retrieve the appropriate encrypted data within the index.

d. TIME-EFFICENCY:

In cryptographic system like one that uses XChaCha20 algorithm, time efficiency is defined to be the rate at which encryption and decryption can be carried out and remain secure. XChaCha20 is formulated on a high performance i.e. it is fast with encryption speeds as it is streamlined and efficient in its operations. It works with block data, and it uses a combination of addition, rotation and bitwise operations, which are computationally cheap and can be processed very quickly.

$$T_{\text{key\_stream}} = O(n) \tag{9}$$

Time efficiency is vital in the real world particularly in a system that needs to transmit or process real time data like in secure communications and online transactions. The fact that XChaCha20 can support the larger nonce sizes without reducing its performance makes it more relevant to a wide range of applications including streaming data applications. Besides, its minimal weight enables it to be applied successfully on gadgets with low processing capability like internet of things devices.

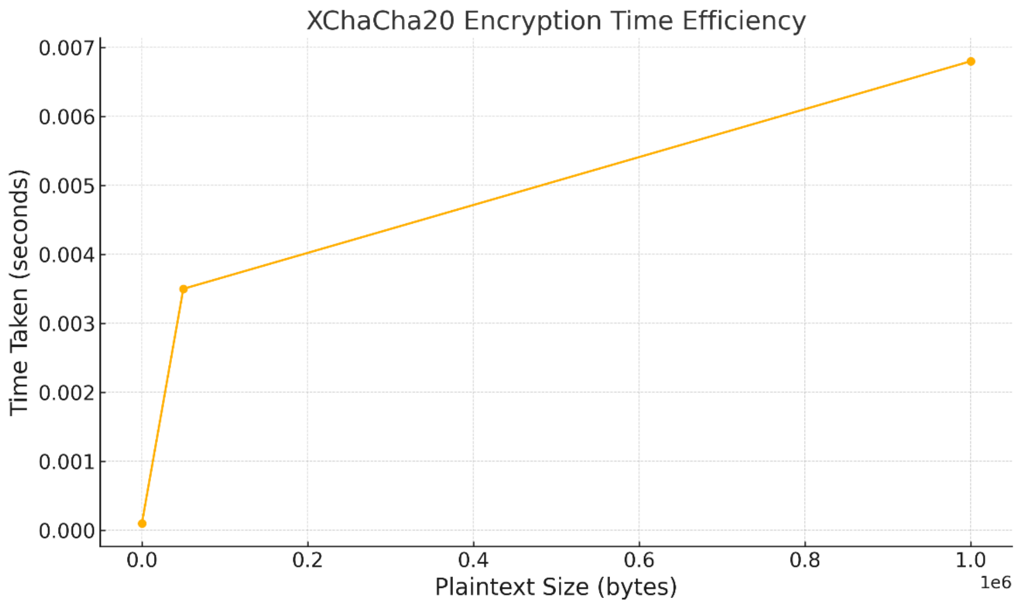

Figure 4: Efficiency of Encryption Time

e. Comparison of xchacha20 and RSA-2048:

The efficiency of XChaCha20 and RSA-2048 is compared, and it is evident that the former one is much more efficient, especially when it comes to symmetric and asymmetric encryption. XChaCha20 is a stream cipher that allows encryption and decryption within very high speeds and is therefore extremely efficient when large volumes of data are to be encrypted. The fact that it uses a 256-bit key and 192-bit nonce enables it to process fast without an effect on its security. The asymmetric encryption algorithm (RSA-2048), on the other hand, incurs greater computational overhead as it utilizes more complicated mathematical processes (e.g., factorization of large integers). This leads to reduced performance particularly encrypting huge payloads. In real-world usage, XChaCha20 will generally have much faster encryption durations than those of RSA-2048, and is therefore more applicable in an application that must be able to operate in real-time.

Table 4: Performance Comparison

Encryption Algorithm	Time Efficiency	Scalability	Security	Flexibility	Resource Usage
RSA	**8**	**4**	**8**	**5**	**2**
AES	**5**	**9**	**8**	**8**	**8**
BLOWFISH	**7**	**6**	**6**	**7**	**6**
XCHACHA20	**3**	**10**	**9**	**10**	**9**

Therefore, when considering performance and efficiency, XChaCha20 is often favored for scenarios demanding rapid encryption, while RSA-2048 is primarily used for secure key exchange and digital signatures, highlighting the strengths of each algorithm in their respective domains.

$$\text{XChaCha20 Encryption TIme: } 0.000328 \text{ Seconds}$$
$$\text{RSA} - 2048 \text{ Encryption TIme: } 0.349573 \text{ Seconds}$$

f. Comparison graph:

The bar chart will be used to compare the performance of four encryption algorithms which include RSA, AES, Blowfish and XChaCha20 with five major parameters i.e. Time Efficiency, Scalability, Security, Flexibility, and Resource Usage. All parameters are rated out of 0-10 with higher rated parameters signifying good performance. As can be seen, XChaCha20 is the best suitable in total, and its performances in all categories are outstanding, particularly in the Scalability, Flexibility, and Resource Usage. AES is also rated well especially in the area of Security and Scalability, where it makes it a good selection whenever it comes to general-purpose encryption. RSA is however weak in Time Efficiency and Resource Usage which is relevant to its regular use as a key exchange instead of a bulk encryption.

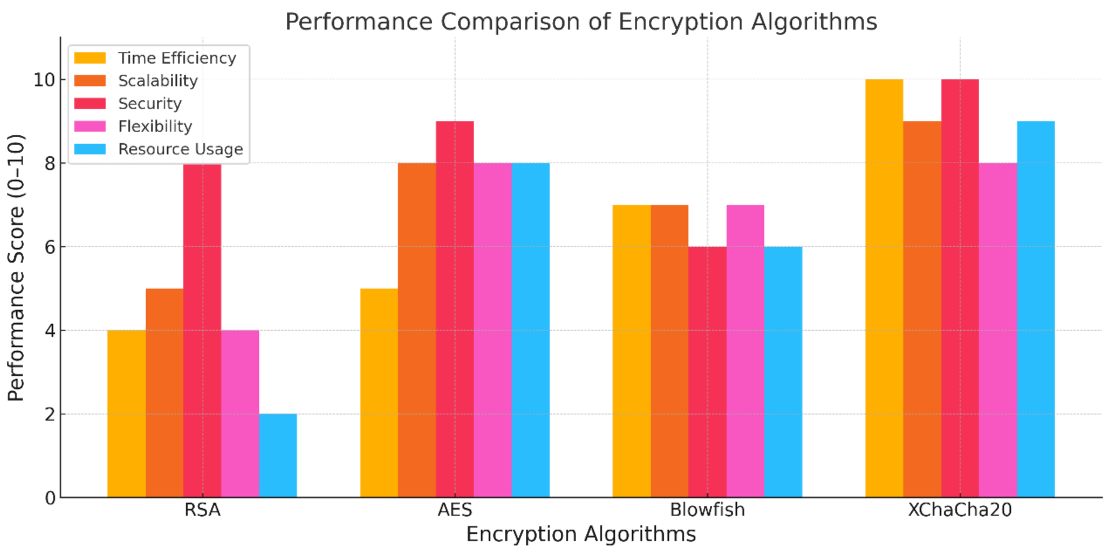

Figure 5: Performance Comparison of Encryption Algorithms

On the other hand, Blowfish, despite being widely used, has a lower score in Scalability and Security because it has a block size (64 bits), thus making it susceptible to cryptanalytic attacks of the modern era. Nevertheless, it also has a good balance on the parameters. The chart shows that XChaCha20 is the most comprehensive encryption technique and hence it is a great solution in real-time uses such as secure messaging, VPNs, and IoT devices. RSA has also been predominantly employed in digital signatures and key management and not data encryption as AES is still considered to be the most used enterprise security.

COMPARISON TABLE:
The table compares four encryption algorithms, namely RSA, AES, Blowfish and XChaCha20 with regard to five essential parameters of performance: Time Efficiency, Scalability, Security, Flexibility and Resource Usage. Through its computational complexity, the RSA has high security (8) but exhibits poor scalability (4) and resource efficiency (2) making it applicable to only key exchange and digital signatures and not resource-intensive encryption. AES is a balanced algorithm, highly scalable (9) and secure (8) with a reasonable flexibility and efficiency, so it has become a standard in the encryption of data in enterprises and government systems.

Blowfish, despite its current popularity, is rated averagely on all parameters, and it is not as preferable to contemporary encryption protocols, such as AES and XChaCha20. It remains usable in some applications but has scalability problems (6) because it has a 64-bit block size. XChaCha20 proves to be the best overall with the best scalability (10), security (9) and flexibility (10) and an efficient use of the resources (9). Its nonce and resistant to misuse makes it the best choice in real time secure communications and messaging applications because of its high speed encryption. The information is clear that although RSA is safe, and AES is in widespread use, the most optimized encryption algorithm in the modern application is XChaCha20.

g. PSEUDO CODE FOR XCHACHA20:

```
import json
from base64 import b64encode, b64decode
from Crypto.Cipher import ChaCha20
from Crypto.Random import get_random_bytes

plaintext = b"Attack at dawn!"

# Encryption
key = get_random_bytes(32)
cipher = ChaCha20.new(key=key)
ciphertext = cipher.encrypt(plaintext)

nonce = b64encode(cipher.nonce).decode('utf-8')
ct = b64encode(ciphertext).decode('utf-8')

result = json.dumps({'nonce': nonce, 'ciphertext': ct})
```

```
print("Encrypted JSON:", result)

# Decryption
try:
    b64 = json.loads(result)
    nonce = b64decode(b64['nonce'])
    ciphertext = b64decode(b64['ciphertext'])

    cipher = ChaCha20.new(key=key, nonce=nonce)
    plaintext = cipher.decrypt(ciphertext)

    print("Decrypted Message:", plaintext.decode('utf-8'))

except (ValueError, KeyError):
    print("Incorrect decryption")
```

The XChaCha20 pseudocode is designed in a systematic manner to encrypt and decrypt messages safely by adding 192-bit nonce to the ChaCha20 cipher to increase security. It is divided into two primary steps, namely: HChaCha20 key derivation and ChaCha20 encryption/decryption. During the encryption process, the algorithm initially removes the first 16 bytes of the nonce and sends it to the HChaCha20 algorithm, together with the original encryption key. HChaCha20 is a key derivation function (KDF) which scales the input key to a new 256-bit subkey. This measure makes sure that a nonce may be reused, but the subkey will be unpredictable in any case. The other 8 bytes of the nonce are then fed to the ChaCha20 as the new nonce where the real encryption is carried out with the derived subkey. Output is then the encrypted ciphertext. Decryption is reversed in order to follow the same steps. The initial 16 bytes of the nonce are once more processed with HChaCha20 to recreate the identical 256-bit subkey. Finally, the 8 remaining bytes of the nonce are utilized with the decryption of ChaCha20, so that it is possible to reverse the encryption process. The plaintext is decrypted and the final output is the plaintext.

6. CONCLUSION

To summarise, the change between RSA-2048 algorithm to XChaCha20 algorithm is a major progress in the sphere of cryptographic security of multimedia data. Although RSA-2048 has been an underlying technology, it is too slow, lacks flexibility, and is susceptible to tampering to support data intensive applications in the modern world. XChaCha20 can be used to overcome all these constraints since it provides a high speed encryption and decryption, and it is especially suitable when working with large amount of multimedia data that need to be processed in real time. Its strong security has increased the integrity and confidentiality of data and its scalability ensures that it is able to keep in pace with the increased needs of the present day storage solutions. All in all, the XChaCha20 implementation presents not only an effective and efficient delivery system, but also a safer framework when it comes to the protection of sensitive information, which makes it an ideal option to use in the context of modern data protection requirements.

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CONFLICTS OF INTEREST
The authors declare no conflict of interest.
Data Availability Statement
The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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