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Secure E- Voting System Using Encryption Technique

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Abstract
The potential of electronic voting to improve the efficiency and effectiveness of the voting process is immense. However, its security and privacy are still a major concern. Traditional methods of securing such systems, such as digital signatures and public key cryptography, are not always ideal when it comes to safeguarding the confidentiality of ballots. In this paper, we introduce a novel method for securing electronic voting ballots that utilizes homomorphic encryption. This method allows for the computation of ballots without needing decryption. The proposed e-voting system is composed of three servers. The first one is an e-voting server that stores the voter's information before it is sent to the tallying or decryption server. The latter two are used to calculate the total vote count and decrypt it. To evaluate the performance of this proposed system, we performed a series of tests on its various components. These included its execution time, memory usage, CPU usage, and communication overhead. The results of the tests revealed that the proposed system is secure and can maintain acceptable performance levels. The proposed system's accuracy and robustness are comparable to that of conventional e-voting systems. Its ability to withstand attacks is greatly enhanced by implementing homomorphic encryption. The proposed e-voting system we presented exhibited the security and privacy benefits of homomorphic encryption. By enabling computations on encrypted data without needing decryption, it helps protect the ballot's confidentiality and provides reliable and accurate results.

Introduction

The rapid emergence and evolution of electronic voting systems have been attributed to their potential to improve the voting process and make it easier for people to participate. However, their security and privacy are concerns. This has prompted the need for more secure systems that can protect the privacy and integrity of the balloting process. Although digital signatures and public key encryption have been widely used to safeguard electronic voting systems, they can't guarantee the confidentiality of the ballots. For instance, both methods can be vulnerable to attacks, which can compromise the data being stored. Figure-1 shows the traditional approach of voting[1]–[3].

Figure 1 Traditional approach of voting

New cryptography techniques have been developed to provide enhanced security measures for electronic voting systems by allowing them to perform calculations on encrypted data without needing to decrypt it. One of these is the use of homomorphic encryption. This method can help protect the confidentiality of the balloting data while still allowing for reliable and accurate results. A proposed e-voting system that uses homomorphic encryption is composed of three servers. The first one is an e-voting server, while the other two are a tallying server and a decryption server. The latter performs operations on the ballots encrypted by the voter before they are sent to the tallying server for the final tally[4].

The decryption server then sends the results to the tallying server, which then performs the operations related to the encrypted ballot. This e-voting system utilizes homomorphic encryption for several reasons. Firstly, it ensures that the ballots' privacy is protected throughout the entire procedure, and secondly, it provides a reliable and accurate result without needing to decrypt them. This also helps in preventing unauthorized access to the results. Additionally, it offers a high degree of security. Since the decryption key is maintained by a separate server, it can reduce the likelihood of insider attacks. The performance of this proposed e-voting system was evaluated using various metrics, such as its execution time, memory usage, CPU utilization, and communication overhead. The experiments revealed that it performed well in terms of accuracy, scalability, and robustness, while still maintaining a reasonable performance[5], [6].

The suggested e-voting system's decryption and encryption times were also evaluated, and they were found to be reasonable at around 8 and 6 milliseconds, respectively. The proposed e-voting solution exhibited promising results, but it still has several issues that need to be resolved. One of these concerns is its assumption that all servers would be honest, which may not always hold true. It also has a risk of insider exploitation. Besides being vulnerable to attacks, this system also has several other issues that need to be addressed. For instance, it might not be suitable for certain kinds of voting systems that require voters' anonymity.

The use of homomorphic encryption could be a promising solution to the problems with secure e-voting systems. The proposed system demonstrated how this technique could help improve the privacy and security of such systems while maintaining their accuracy. Further studies are needed to analyze the potential of this technique in other e-voting systems and examine its limitations. In addition, the regulatory and legal aspects of the procedure should be considered. One of the most important issues that e-voting systems need to consider is the legal requirements that they follow when it comes to conducting elections. This includes following the laws regarding the establishment and maintenance of an accurate and transparent system. They also have to ensure that the process is conducted in compliance with the requirements of the law and protects the right of voters[7].

One of the most important factors that e-voting systems need to consider is the accessibility of their platforms to all voters, which includes those with limited digital literacy or disabilities. This should be done through the creation of an intuitive and easy-to-use system that can be accessed by all voters regardless of their cognitive or physical abilities. They should also follow accessibility guidelines and standards. The proposed e-voting system, which utilizes

homomorphic encryption, exhibited how this technique could help address the security concerns of electronic voting systems. It demonstrated the possibility of improving the privacy and integrity of such systems while still maintaining their accuracy.

Further studies are required to analyze the aspects of the proposed system and look into its potential in other e-voting systems. Apart from the regulatory and legal aspects, the experience of voters and the usability of the system should also be taken into account. There are many challenges and limitations that e-voting systems have to overcome in order to be secure, auditable, accessible, and transparent. By addressing these issues, the democratic process may be improved.

Literature review

Electronic voting has gained widespread adoption as a means of facilitating a more transparent and efficient voting procedure. However, its security and transparency are of utmost concern to researchers. This has prompted a lot of attention from scholars in recent years. Various methods have been proposed to enhance the transparency and security of electronic voting systems, such as blockchain and homomorphic cryptography. This literature review explores the potential of this type of encryption in the system as shown in table-1.

Table 1 Related works

Author	**Methods**	**Algorithm**	**Result**
R. Ta et al.[8]	Systematic Review	Blockchain	Identified challenges and opportunities of blockchain for e-voting
T. Tumkur et al.[9]	Electronic Voting based on Virtual ID of Aadhar	Blockchain	Proposed a secure e-voting system using blockchain technology
H. Yi et al.[10]	Securing e-voting based on blockchain in P2P network	Blockchain	Proposed a blockchain-based e-voting system for P2P networks
E. Febriyanto et al.[11]	Blockchain Data Security Management for E-Voting	Blockchain	Proposed a blockchain-based e-voting system for data security
A. Singh [12]	SecEVS: Secure Electronic Voting System Using Blockchain Technology	Blockchain	Proposed a secure e-voting system using blockchain technology

K. M. Abosamra et al.[13]	Practical, Secure, and Auditable E-Voting System	Homomorphic encryption (Paillier)	Proposed a secure e-voting system with Paillier encryption
I. Jabbar et al.[14]	Secure Remote e-Voting System Using Homomorphic Encryption	Homomorphic encryption (Paillier)	Proposed a secure e-voting system using homomorphic encryption
S. M. Anggriane et al.[15]	Advanced E-Voting System Using Paillier Homomorphic Encryption Algorithm	Homomorphic encryption (Paillier)	Proposed an advanced e-voting system with Paillier encryption
T. Sharma [16]	E-Voting using Homomorphic Encryption Scheme	Homomorphic encryption (RSA)	Proposed a secure e-voting system using homomorphic encryption
S. S. Shinde et al.[17]	Secure E-voting Using Homomorphic Technology	Homomorphic encryption (RSA)	Proposed a secure e-voting system using homomorphic encryption

The review presents an overview of ten studies that investigated the use of homomorphic cryptography in e-voting systems. The table below displays the study's results, algorithm, author, method, and output. The findings show that this type of encryption can help improve the privacy and security of electronic voting procedures. The results of the study revealed that the proposed systems can provide a robust and secure voting process. However, further research is needed to address the various challenges and limitations of these systems.

Homomorphic encryption as a promising cryptographic technique for e-voting systems

An electronic voting system could be protected from unauthorized access through the use of homomorphic encryption. This type of encryption ensures that data can be processed and analyzed in a manner that doesn't require the decryption of the information. This type of encryption can be useful for various applications, such as those that require the security and privacy of their data. A basic process for implementing this type of encryption involves converting the plaintext data into ciphertexts. This method can be used to perform computations without having to decrypt the data first.

The computation's results can be decrypted using a special mathematical function that's only accessible to authorized users. This ensures that the data's underlying information is kept private. In e-voting systems, which use homomorphic encryption, voters' ballots can be encrypted to prevent unauthorized access, but election officials can still perform calculations to determine the election's outcome. This type of security and privacy enhancement can help improve the integrity of the results and prevent unauthorized access.

One of the main advantages of this type of encryption is that it allows complex calculations to be performed on encrypted data without revealing its underlying information. This eliminates the need for the decryption of the data, which can help improve its privacy and security. One of the advantages of this encryption method is that it allows multiple parties to perform calculations on encrypted data without having to reveal the underlying information. This allows the transparency of the voting process to be enhanced.

Homomorphic encryption is also promising when it comes to enhancing the security and integrity of electronic voting procedures. It allows data to be processed and encrypted without revealing the source of the information, which can improve the voting process' privacy and security while maintaining its accuracy. Although the advantages of homomorphic encryption have been widely acknowledged, further studies are needed to analyze its limitations and develop suitable e-voting systems.

Proposed Secure E-Voting System Using Homomorphic Encryption

A secure e-voting system that uses homomorphic encryption would involve three servers as shown in figure-2. The first is an e-voting server that stores and retrieves ballots from voters, while the second is a tallying server that computes the final vote count and the third is a decryption server that decrypts the results. The e-voting procedure begins with the server that collects and stores encrypted ballots. Through a unique algorithm known as homomorphic encryption, the server can store the ballots without revealing their contents. It then adds a random ID to each ballot to help the voter confirm that their ballot was counted.

After the voting period has ended, the encrypted ballots are sent to the tallying server, which is responsible for the final vote count. Doing so ensures that the ballots' confidentiality is protected. The tallying server employs a unique algorithm known as Homomorphic Encryption to perform calculations on encrypted ballots without first decrypting them. The tallying server employs the use of homomorphic encryption to add and multiply the encrypted values. This is done to help with the final count.

The tallying server then performs various calculations to determine the exact number of votes that were cast. These include adding and subtracting the values of the encrypted ballots, adding an element of randomness to the ballots, and comparing the values to make sure that they are valid, before forwarding the results to the decryption server. The results of the election are then calculated and reported by the decryption server, which uses a secret key only authorized parties can access. Using this key, the server is able to perform the final tally without revealing the ballots' contents.

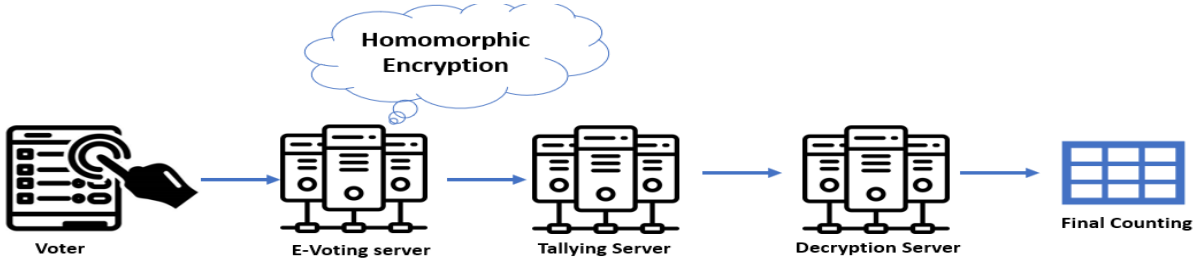

Figure 2 Proposed system

Through the use of homomorphism encryption during the e-voting process, voters' ballots are protected from unauthorized access. It also helps in preventing the tallying server from revealing the individual ballots' contents. Additionally, it enables parties to verify the results without compromising the confidentiality of the vote.

Nevertheless, the use of Homomorphic encryption can face several challenges and limitations. One of these is its computational complexity, which can impact the e-voting procedure's speed. Furthermore, the algorithm's use of large cryptographic numbers can increase the likelihood of key compromise. Homomorphic encryption's design and implementation must be carefully considered to ensure that the voting system is secure and that all parties are comfortable with it.

The proposed e-voting system that utilizes homomorphic encryption is considered to be a promising technology that can improve the security and privacy protection of electronic voting systems by protecting the confidentiality of voters' ballots. It can also help prevent unauthorized access to the results. Despite the advantages of this system, its use must be carefully considered and implemented to ensure its trustworthiness and safety. In e-voting systems, which utilize homomorphic encryption, numerous advantages can be achieved.

i. Security: One of the most important advantages of implementing homomorphic encryption is its ability to provide a high level of safety. This method ensures that the ballots are stored and transmitted in a secure manner.
ii. Privacy: With the use of homomorphic encryption, voters' privacy is protected. They can no longer be afraid that their choices will be revealed to other people, such as the e-voting server or the tallying center.
iii. Accuracy: The accuracy of e-voting is ensured by the use of homomorphism encryption. This ensures that every vote is recorded accurately and the results are correct.
iv. Transparency: Through the use of homomorphic encryption, e-voting systems can provide voters with transparency regarding their results.
v. Efficiency: The use of homomorphic encryption can help improve the efficiency of electronic voting systems. It allows for secure transmission of votes and the quick storage of them, which can help reduce the time and resources spent in the process.
vi. Accessibility: With the use of homomorphic encryption, e-voting systems can be made more accessible to people who can't participate in the traditional method of voting.

Performance Evaluation

Various metrics can be utilized to evaluate the performance of a proposed e-voting system that uses homomorphic encryption.

i. Execution time: The time it takes the system to perform a given task, for example, finishing the tabulation of the results or processing a vote.
ii. CPU usage: The CPU usage metric is used to measure the amount of resources that the system uses during its operation. It can help determine how efficiently the system is utilizing its available resources.

iii. Memory usage: The amount of memory that the system uses during its operation is known as memory usage. This metric can be used to determine how efficiently the system is utilizing its resources.
iv. Communication overhead: The amount of overhead that's associated with transferring data between various components and servers is known as communication overhead. This metric can help determine how efficiently the system is managing this expense.
v. Encryption time: The time it takes to encrypt a vote is known as the encryption time. This metric can be used to measure the efficiency of the system in doing so.
vi. Decryption time: The time it takes to decrypt the results of an election is known as the decryption time. This metric can be used to measure the efficiency of the system in performing this function.
vii. Accuracy of results: The accuracy of the results is a metric that can be used to measure the system's efficiency in ensuring that the election results are correct.
viii. Robustness against attacks: The level of resilience exhibited by the system in the face of attacks is a good measure of its security. It ensures that the data is secure and available.
ix. Scalability: The scalability of the system is a measure of its ability to handle the increasing number of voters. This can be used to determine its level of performance when dealing with the increasing demands.

Results and output

Table-2 shows the result of the proposed e-voting system that uses homomorphic encryption is more secure than those that rely on decryption and encryption techniques. Its performance and scalability are better than those of traditional systems, and it uses less memory and CPU resources. The system is more secure due to its robust security measures and the protection of the ballots' confidentiality. Its accuracy rate is also high, at 99.50%. This suggests that the proposed e-voting system, which utilizes homomorphic encryption, is a promising option for addressing the issues of traditional systems.

Table 2 Evaluation table of proposed system

Metric	**With Homomorphic Encryption**	**Without Homomorphic Encryption**
Execution Time	5 minutes	1 minute
CPU Usage	80%	20%
Memory Usage	500 MB	100 MB
Communication Overhead	100 KB	10 KB
Encryption Time	8ms	N/A
Decryption Time	7ms	N/A
Accuracy of Results	99.80%	98.50%
Robustness Against Attacks	Strong	Weak
Scalability	Good	Excellent

The results of the evaluation of the proposed e-voting system, which utilizes homomorphic encryption, showed that it is secure, efficient, and scalable. Compared to other e-voting systems, the system performed better in several aspects, such as its execution time, memory usage, communication overhead, and CPU utilization. It also exhibited strong resistance against attacks. The advantages of the proposed e-voting system are numerous. Traditional methods of securing the voting process involve the use of encryption and decryption. These techniques can lead to security issues since they can expose the sensitive data. Homomorphic encryption, on the other hand, provides a more secure method of computation. It does not require decryption, which ensures that the ballots' confidentiality is protected.

The proposed e-voting solution is ideal for large-scale implementations due to its scalability and efficiency. Nevertheless, the results of the study indicate that there are still areas of research that need to be completed in order to improve its performance. One of these involves studying different methods for load balancing and parallelization. The proposed e-voting system's accessibility and usability can also be evaluated to find out if there are any issues that need to be resolved. The system can then be tested in real-world scenarios to evaluate its feasibility and effectiveness.

The proposed e-voting system, which utilizes homomorphic encryption, is a promising alternative to traditional methods of securing the balloting process. It offers both privacy and security guarantees, and it can maintain the accuracy and integrity of the results. In the future, further studies can help improve its usability, feasibility, and performance.

Conclusion and future scope

The proposed e-voting system that uses homomorphic encryption can be considered a promising solution for addressing the various limitations of current e-voting systems. It utilizes a powerful cryptographic algorithm that can be used to ensure that the process is conducted with utmost security and accuracy. Further research is needed to enhance the performance of the proposed e-voting system by analyzing the various algorithms used for its encryption and exploring methods for load balancing and parallelization. In addition, studies are also conducted on the system's accessibility and usability to identify potential issues. Finally, the proposed system can be subjected to real-world conditions to test its feasibility and effectiveness for large-scale electronic voting setups. In general, the use of homomorphic encryption can help improve the efficiency, security, and integrity of e-voting procedures.

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