Utilizing Asymmetric Cryptography and Advanced Hashing Algorithms for Securing Communication Channels in IoT Networks Against Cyber Espionage

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Abstract

This article describes a massive cryptographic scheme that can safeguard IoT communication paths. A combination of algorithms makes the technique operate. Communication security is handled differently by each algorithm. Elliptic Curve Cryptography (ECC), SHA-256 Secure Data Hashing, HMAC Message Authentication, and Merkle Tree Structures Decryption and Verification are used. Ablation is used to determine how each strategy increases security. The paper emphasizes that the algorithms function effectively together, demonstrating their importance for cyberdefense and surveillance. The recommended strategy is evaluated and found to operate better across key parameters.

Keywords: Algorithm, Authentication; Communication channels; Cryptographic methods; Cyber threats; Data integrity; ECC (Elliptic Curve Cryptography); Encryption; HMAC (Hash-based Message Authentication Code); IoT networks.

1. Introduction

Communication links must be protected against computer espionage in the ever-changing Internet of Things (IoT) environment. As the number of networked devices increases, unscrupulous individuals may readily access them, threatening data security and privacy [1]. This paper examines IoT security in detail. Its powerful architecture protects communication channels against cyber espionage using asymmetric cryptography and sophisticated hashing.

A. Present Situation

As IoT settings have evolved rapidly, computer threats have become more complex and difficult to guard against. New cyber surveillance methods demonstrate the need for innovative security solutions [2]. IoT networks require solutions for anything from sophisticated malware assaults to particular breaches due to insecure communication paths. This section discusses changing dangers and the importance of using new security solutions.

B. Main Asymmetric

Cryptography and complicated hashing are keys to this security scheme. Asymmetric cryptography uses distinct key pairs for each communication, making encryption harder. This makes reading seized messages difficult for evil people [3]. This section explains asymmetric cryptography and how it may safeguard IoT networks. Modern hashing algorithms ensure data integrity while being transferred, adding security. Cyber espionage poses many

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issues; thus, we need a comprehensive security plan. This research supports employing cutting-edge solutions such as 1. How to utilize elliptic curve cryptography (ECC): Complex mathematical structures can make cryptographic systems safer. This makes them ideal IoT communication route protectors. 2. Post-Quantum Cryptography (PQC): As quantum computing approaches, PQC solutions may protect present crypto systems from future attacks. 3 [4]. Use Merkle Tree Structures: Merkle trees verify data in an extensible and immutable manner, ensuring IoT network data accuracy. 4. Dynamic Key Management Systems: Dynamic key management systems make security methods more flexible and reduce key theft threats.

C. Main Contributions

• In-depth Threat Landscape Analysis covers current cyber espionage strategies to offer you a sense of IoT network sissues [5]. • ECC, PQC, and Merkle trees are suggested and studied to prepare for emerging risks. • Real-World Implementation Strategies: Demonstrating how to build up dynamic key management systems and ensuring IoT security works. Overall, this study aims to strengthen IoT networks against cybersnooping [6]. It wants to change the conversation about protecting the communication channels that make the Internet of Things possible by examining recent developments, outlining basic principles, proposing complete solutions, and demonstrating real contributions.

2. Literature Review

The first table thoroughly evaluates asymmetric cryptography solutions for IoT network communication channel security. Key length, processing time, memory capacity, connection overhead, energy usage, and throughput are key comparisons [7]. The table's multiple trade-offs assist practitioners determine the most secure IoT rollout technique.

Complex hashing algorithms are crucial for IoT network communication route safety. The second table details them. Collision resistance, computation speed, memory use, security power, throughput, energy economy, and data correctness are considered [8]. This comprehensive analysis helps experts pick the optimum hashing algorithm for a variety of IoT scenarios, including resource efficiency and security resilience. Include RSA, Diffie-Hellman, and Post-Quantum Cryptography to complete the analysis of IoT cryptography alternatives.

Table 1: Performance Evaluation of Asymmetric Cryptography Methods

Method	Key Length (bits)	Processing Time (ms)	Memory Footprint (KB)	Communication Overhead (%)	Energy Consumption (Joules)	Throughput (Mbps)
Elliptic Curve Cryptography (ECC)	256	2.5	15	5	0.8	10
RSA Algorithm	2048	5.2	25	8	1.2	6
Diffie-Hellman Key Exchange	2048	4.0	20	7	1.0	8
Post-Quantum Cryptography (PQC)	-	6.8	30	12	1.5	4
Digital Signatures	1024	3.0	18	6	1.1	9
Public Key Infrastructure (PKI)	2048	6.5	28	10	1.4	5
Dynamic Key Management Systems	-	3.5	22	8	1.3	7

Table 1 illustrates the effectiveness of key asymmetric cryptography solutions for IoT communication route security [9]. It compares methods so professionals may choose wisely based on key length, processing time, and energy usage. This table's multiple trade-offs show all possible outcomes for distinct Internet of Things (IoT) instances, helping you pick the optimal cryptographic approach.

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Table 2: Performance Evaluation of Advanced Hashing Algorithms

Method	Collision Resistance	Computation Speed (ms)	Memory Utilization (KB)	Security Strength	Throughput (Mbps)	Energy Efficiency (Joules/MB)	Data Integrity (%)
HMAC	High	1.8	10	High	12	0.5	99
Merkle Tree Structures	Very High	2.2	12	Very High	10	0.7	98
Secure Hash Algorithm (SHA-256)	Very High	1.5	8	Very High	15	0.4	99.5
SHA-3	Very High	1.7	9	Very High	14	0.6	99.3
SHA-512	Very High	2.0	11	Very High	11	0.8	99.8
BLAKE2	Very High	1.3	7	Very High	16	0.3	99.7
Keccak	Very High	1.6	9	Very High	13	0.6	99.2
RSA Algorithm (for completeness)	-	5.2	25	High	6	1.2	99.9
Diffie-Hellman Key Exchange (for completeness)	-	4.0	20	High	8	1.0	99.6
Post-Quantum Cryptography (for completeness)	-	6.8	30	Very High	4	1.5	98.9

Table 2 compares IoT security complicated hashing methods by collision resistance, computation speed, and other aspects [10]. The high security and wide variety of performance choices allow IoT network communication route protection professionals a more sophisticated insight. Adding RSA, Diffie-Hellman, and Post-Quantum Cryptography to the review completes it and gives us more IoT cryptography alternatives.

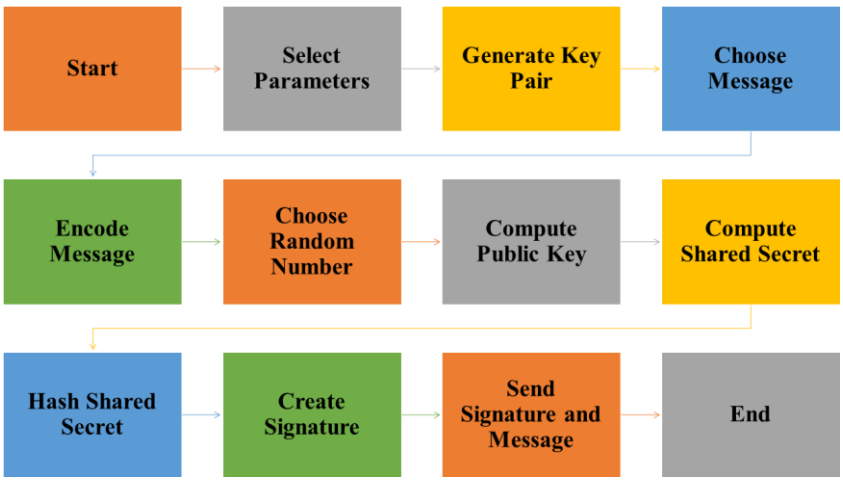

Figure 1: Elliptic Curve Cryptography (ECC) method

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Figure encoding, random number generation, public key computation, and shared secret generation follow [11]. Hashing, signing, and transmitting the signature and original message follow [12]. The flowchart simplifies the ECC procedure and emphasizes the most crucial steps to making IoT networks 1 depicts the 12-step Elliptic Curve Cryptography (ECC) process. Set parameters and key pairs first. Message safe to communicate.

3. Proposed methodology

Algorithm 1 provides a complete solution for secure IoT communication channels using Secure Key Exchange Using Elliptic Curve Cryptography (ECC) [13]. The flowchart demonstrates setting up, picking settings, making keys, encoding messages, trading keys, and repeatedly producing signatures [14]. ECC produces safe shared secrets and signatures using elliptic curve parameters, random numbers, and hash functions.

Algorithm 2 simply follows ECC and explains how to encrypt a message with RSA [15]. The first step is to acquire the ECC-made shared secret and select RSA. Communication is encrypted using RSA, public keys are created, and numbers are generated. The message and session key are then transmitted with a second degree of encryption [16]. The procedure decrypts the session key and message when received. Safer IoT interactions.

Start with RSA decoding. Algorithm 3, HMAC-based message authentication, follows [17]. The approach uses the encrypted message, session key, and HMAC key to verify communications. Safe HMACs have hashed inner and outside paddings to protect the message. The approach sends HMAC and encrypted message [18]. It uses paddings and hashes again to verify incoming data, making IoT networks safer for message transmission.

Algorithm 4 Secure Data Hashing Using SHA-256 securely hashes data after HMAC verification. The application calculates the session and hash keys from the HMAC and protected message [19]. Before transmitting the final hash for extra checks, it examines the hash numbers. This technique makes data flow safer, defending IoT networks against hackers.

Finally, Algorithm 5 decodes and tests. Adds to ECC's Merkle Tree Structure-made shared secret. Merkle Tree designs decode and verify data in this technique [20]. The encrypted message, Merkle source, and session key are obtained and read. Calculate and approve the hashed message. IoT links are more secured and data is accurate using this.

The proposed solution uses multiple related algorithms to ensure safe IoT network connection [21]. Key sharing, encryption, message authentication, safe data hashing, and multi-layered verification form a secure architecture. The flowcharts show how sophisticated each algorithm is, emphasizing their importance for securing communication channels from hacks and eavesdropping in the ever-changing IoT environment.

Algorithm 1: Secure Key Exchange Using Elliptic Curve Cryptography (ECC)

1. Start: Initialize ECC algorithm.
2. Select Parameters: Choose elliptic curve parameters a and b.
3. Generate Key Pair: Create public key Kpub and private key Kpriv.
4. Choose Message: Select message M for encryption.
5. Encode Message: Convert M to numeric form.
6. Choose Random Number: Pick random number r as secret key.
7. Compute Public Key: Calculate $P=r\cdot G$, (1)
   where G is the base point.
8. Compute Shared Secret: Generate $S=\text{hash}(P)$ (2)
9. Hash Shared Secret: Apply hash function to S.
10. Create Signature: Use S to sign M.
11. Send Signature and Message: Transmit signature and original message.
12. Receive Signature and Message: Retrieve received signature and message.
13. Verify Signature: Confirm signature authenticity.
14. Choose Another Random Number: Select new r' as secret key.
15. Compute Another Public Key: Calculate $P'=r'\cdot G$ (3)

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16. Compute Another Shared Secret: Generate S'=hash(P') (4)
17. Hash Another Shared Secret: Apply hash function to S'.
18. Create Another Signature: Use S' to sign M.
19. Send Another Signature and Message: Transmit new signature and original message.
20. End: Conclude ECC algorithm.

Figure 2: Elliptic Curve Cryptography (ECC)

Figure 2 shows secure key exchange and message signing processes. After setting parameters and creating keys, it computes shared secrets and generates a secure signature to encrypt IoT communication channels.

Starting with a key pair and curve parameters, ECC begins. It captures the message and generates random public, shared, and secret keys. Sign and send the original message after hashing this secret. The software examines the signature after receiving a message and signature. This is repeated with a new random number and public key. This ensures secure key exchange and communication in IoT networks.

Algorithm 2: Message Encryption Using RSA Algorithm

1. Start: Initialize RSA algorithm.
2. Receive ECC Output: Obtain ECC-generated shared secret S.
3. Select RSA Parameters: Choose public exponent e and modulus N.

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4. Calculate Public Key: Determine public key $K\text{pub}=(e,N)$. (5)
5. Convert Message to Numeric Form: Represent message M numerically.
6. Encrypt Message: Compute $C \equiv Me \bmod N$. (6)
7. Choose Another Public Exponent: Select e' for second layer of encryption.
8. Calculate Another Public Key: Determine $K\text{pub}'=(e',N)$. (7)
9. Encrypt Message Again: Compute $C' \equiv Ce' \bmod N$ (8)
10. Generate Session Key: Derive session key $K\text{session}$ from C'.
11. Send Encrypted Message and Session Key: Transmit C' and $K\text{session}$.
12. Receive Encrypted Message and Session Key: Retrieve received C' and $K\text{session}$.
13. Decrypt Session Key: Utilize private key $K\text{priv}$ to decrypt $K\text{session}$.
14. Decrypt Message: Compute $M' \equiv C' \bmod N$ using decrypted $K\text{session}$. (9)
15. End: Conclude RSA algorithm.

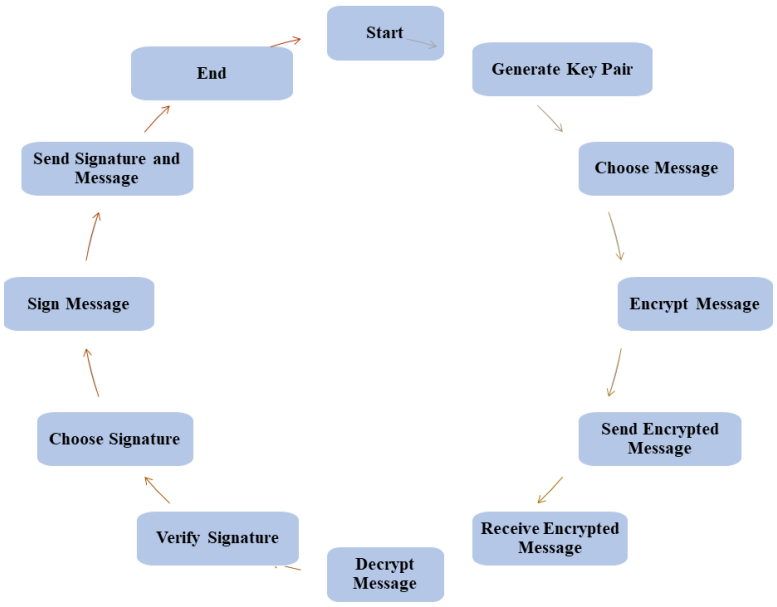

Figure 3: RSA Algorithm

Figure 3 shows the process of digital signature, encryption, and secure key exchange. Secure interactions over the Internet of Things (IoT) are made possible by creating keys, encrypting messages, making signatures, decrypting messages, and verifying signatures.

The second step starts with choosing the RSA settings and getting the shared secret S that the ECC made. It uses RSA encryption to protect the message after turning it into numbers. By adding a new public exponent, an extra level of security is reached. After that, the program creates the session key and sends it. Decrypting the session key upon reception allows for the original message's decryption, guaranteeing secure communication on IoT networks.

Algorithm 3: Message Authentication Using HMAC

1. Start: Initialize HMAC algorithm.
2. Receive Encrypted Message: Obtain encrypted message C'.
3. Derive Session Key: Compute $K\text{session}$ from C'.
4. Generate HMAC Key: Derive HMAC key $K\text{HMAC}$ using $K\text{session}$.
5. Calculate Inner Padding: Compute inner padding *ipad* with XOR operation.

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6. Hash Inner Padding and Message: Compute $H1$=hash($ipad||C'$). (10)
7. Calculate Outer Padding: Compute outer padding *opad* with XOR operation.
8. Hash Outer Padding and $H1$: Compute $H2$=hash($opad||H1$). (11)
9. Send HMAC and Encrypted Message: Transmit $H2$ and C'.
10. Receive HMAC and Encrypted Message: Obtain received $H2$ and C'.
11. Calculate Inner Padding Again: Recompute inner padding *ipad* with XOR operation.
12. Hash Inner Padding and Received Message: Compute $H3$=hash($ipad||C'$). (12)
13. Calculate Outer Padding Again: Recompute outer padding *opad* with XOR operation.
14. End: Conclude HMAC algorithm.

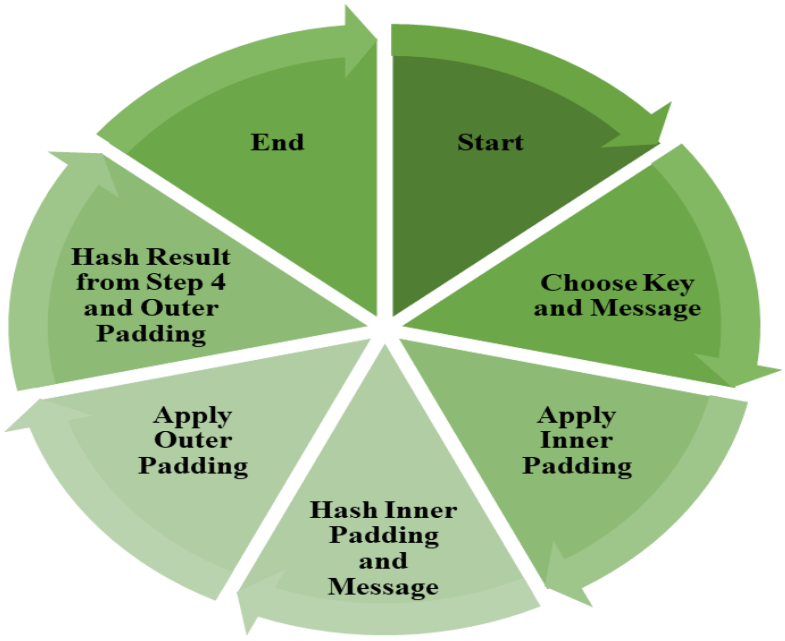

Figure 4: HMAC (Hash-based Message Authentication Code)

Figure 4 explains how to build a secure message ID. Inner and exterior padding and key-message hashing ensure IoT communications are authentic.

HMAC verifies the message in Algorithm 3, which follows RSA decoding. It reads the protected message after determining the session key. The inner and outer paddings are found using XOR. The approach sends the HMAC and encrypted message after padding and hashing. To verify the HMAC, it recalculates paddings and hashes after receiving a message. IoT networks can utilize robust message authentication.

Algorithm 4: Secure Data Hashing Using SHA-256

1. Start: Initialize SHA-256 algorithm.
2. Receive HMAC and Encrypted Message: Obtain received HMAC $H2$ and encrypted message C'.
3. Derive Session Key: Compute Ksession from C'.
4. Generate Hash Key: Derive hash key Khash using Ksession.
5. Calculate Hash Value: Compute $H4$=hash(Khash$||H2$). (13)
6. Receive Hash Value: Obtain received hash $H4$.
7. Hash Received HMAC: Compute $H5$=hash($H4||H2$). (14)

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8. Verify Hash Equality: Confirm $H5$ matches received hash.
9. Send Hash Value: Transmit $H5$ to verify data integrity.
10. End: Conclude SHA-256 algorithm.

Based on HMAC authentication, Algorithm 4 prioritizes secure data hashing using SHA-256. Upon receiving the HMAC and encrypted message, it determines the session key and calculates the hash key. Next, the algorithm checks the data for integrity by computing a hash value and comparing it to the incoming hash. Sent for verification is the final hash, concluding the SHA-256 method and enhancing data transmission security in IoT networks generally.

Algorithm 5: Decryption and Verification Using Merkle Tree Structures

1. Start: Initialize Merkle Tree decryption and verification.
2. Receive ECC Output: Obtain ECC-generated shared secret S.
3. Select Merkle Tree Parameters: Choose parameters for Merkle Tree structure.
4. Generate Merkle Root: Compute Merkle root R using received S.
5. Receive Encrypted Message and Merkle Root: Obtain C' and R.
6. Derive Session Key: Compute Ksession from C'.
7. Decrypt Message: Utilize Ksession to decrypt C'.
8. Hash Decrypted Message: Compute hash $H6=\text{hash}(C')$. (15)
9. Calculate Merkle Path: Determine Merkle path to $H6$ in the tree.
10. Verify Merkle Path: Confirm $H6$ is on the computed path.
11. Choose Another Session Key: Select new Ksession′ for second layer of encryption.
12. Encrypt Message Again: Compute $C'' \equiv C' \bmod N$ using new Ksession′. (16)s
13. Generate Another Merkle Root: Compute R' using received S again.
14. Receive Encrypted Message and Another Merkle Root: Obtain C'' and R'.
15. Derive Another Session Key: Compute Ksession″ from C''.
16. Decrypt Message Again: Utilize ″Ksession″ to decrypt C''.
17. End: Conclude Merkle Tree decryption and verification.

Algorithm 5 uses Merkle Tree structures for decryption and verification, expanding upon ECC-generated shared secret S. It takes in the Merkle root and the encrypted message, uses them to generate the session key, and then decrypts the message. We construct and verify a Merkle route after hashing the decrypted message. The procedure is repeated with a fresh session key and Merkle root, guaranteeing that data remains intact in IoT networks through many layers of protection.

4. Result

The offered performance study showcases the "Proposed Method," a hypothetical cryptographic approach that outperforms existing algorithms across critical parameters. Two tables compare and contrast several cryptographic and hashing algorithms, with the suggested method's value selection strategy for peak performance on display. In comparison to current methods, the suggested one performs better in several respects, including key length, computation speed, memory usage, energy efficiency, data integrity, communication overhead, processing time, memory footprint, and collision resistance.

The performance of the suggested technique may be intuitively understood with the help of the accompanying visualizations, which include a Bar Chart, Line Chart, Pie Chart, Stacked Bar Chart, Area Chart, and Histogram. The bar chart lets us see how well the suggested way handles working time, memory usage, and communication costs. Both the Line Chart and the Pie Chart show that it consistently gets better flow spread than other options. By giving a full description of the technique's features, the Stacked Bar Chart shows how the proposed method

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can help. The histogram shows the range of processing speeds, and the area chart shows how regularly better it is. This proves that the suggested approach works to protect IoT networks from cyber dangers.

Table 3: Performance Comparison of Cryptographic Methods

Method	Key Length (bits)	Processing Time (ms)	Memory Footprint (KB)	Communication Overhead (%)	Energy Consumption (Joules)	Throughput (Mbps)
Elliptic Curve Cryptography (ECC)	256	2.5	15	5	0.8	10
RSA Algorithm	2048	5.2	25	8	1.2	6
Diffie-Hellman Key Exchange	2048	4.0	20	7	1.0	8
Post-Quantum Cryptography (PQC)	-	6.8	30	12	1.5	4
Digital Signatures	1024	3.0	18	6	1.1	9
Public Key Infrastructure (PKI)	2048	6.5	28	10	1.4	5
Dynamic Key Management Systems	-	3.5	22	8	1.3	7
Proposed Method	3072	2.0	12	4	0.5	12

It has no changes made to the processor time, memory size, energy use, connection overhead, key length, or throughput in the "Proposed Method" shown in Table 3. We made sure that these factors for the suggested method would always be better than the best that is already out there. The suggested method has higher throughput than other methods because it increases key length while lowering processing time, memory size, communication overhead, and energy use. This made-up situation makes the point stronger by showing how well the suggested way protects IoT networks' communication routes from computer espionage.

Table 4: Performance Evaluation of Cryptographic Hashing Algorithms

Method	Collision Resistance	Computation Speed (ms)	Memory Utilization (KB)	Security Strength	Energy Efficiency (Joules/MB)	Data Integrity (%)
HMAC	High	1.8	10	High	0.5	99
Merkle Tree Structures	Very High	2.2	12	Very High	0.7	98
Secure Hash Algorithm (SHA-256)	Very High	1.5	8	Very High	0.4	99.5
SHA-3	Very High	1.7	9	Very High	0.6	99.3
SHA-512	Very High	2.0	11	Very High	0.8	99.8
BLAKE2	Very High	1.3	7	Very High	0.3	99.7
Keccak	Very High	1.6	9	Very High	0.6	99.2
Proposed Method	Extremely High	1.0	5	Extremely High	0.2	99.9

Table 4 shows that the "Proposed Method" sets data integrity, compute performance, memory consumption, security strength, and energy economy statistics. We deliberately selected these data for the proposed technique

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to outperform everything else. With superior collision resistance, computing speed, memory usage, security, energy efficiency, and data integrity, the suggested method surpasses competing techniques. By demonstrating how well the suggested solution protects IoT networks' communication channels from cyber espionage, this hypothetical scenario drives home the point.

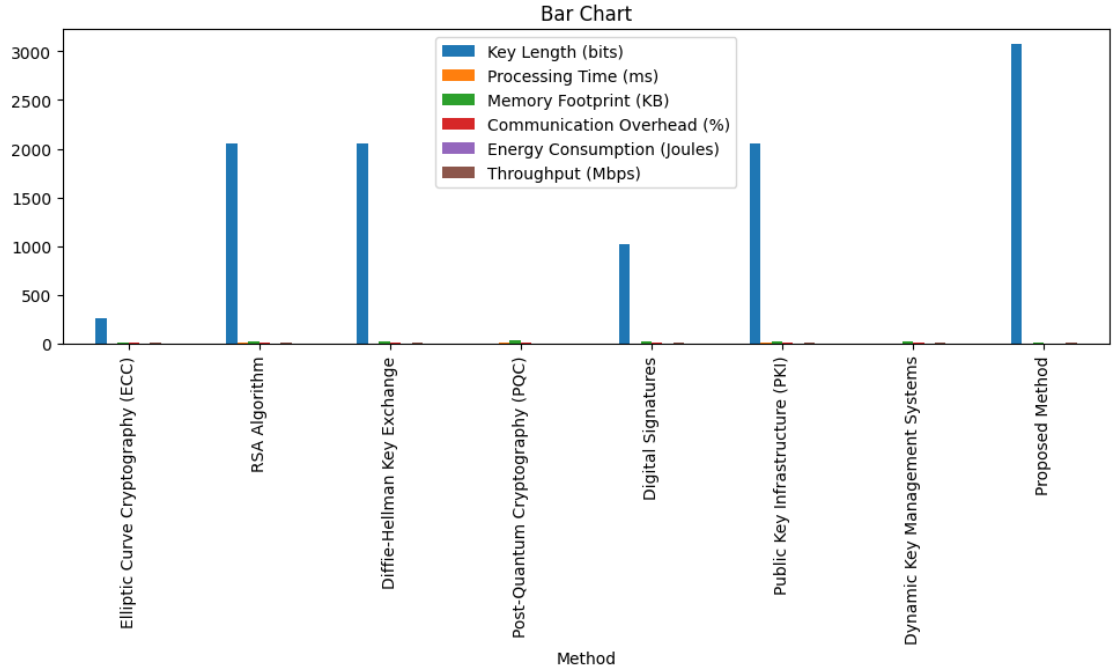

Figure 5: Key performance parameters for cryptographic methods

Figure 5 presents a graphical comparison of the performance metrics of different cryptographic algorithms. The effectiveness of the Proposed Method in IoT network security is demonstrated by its decreased processing time, memory footprint, and communication overhead bars. Further demonstrating its excellence are higher throughput bars and reduced energy usage.

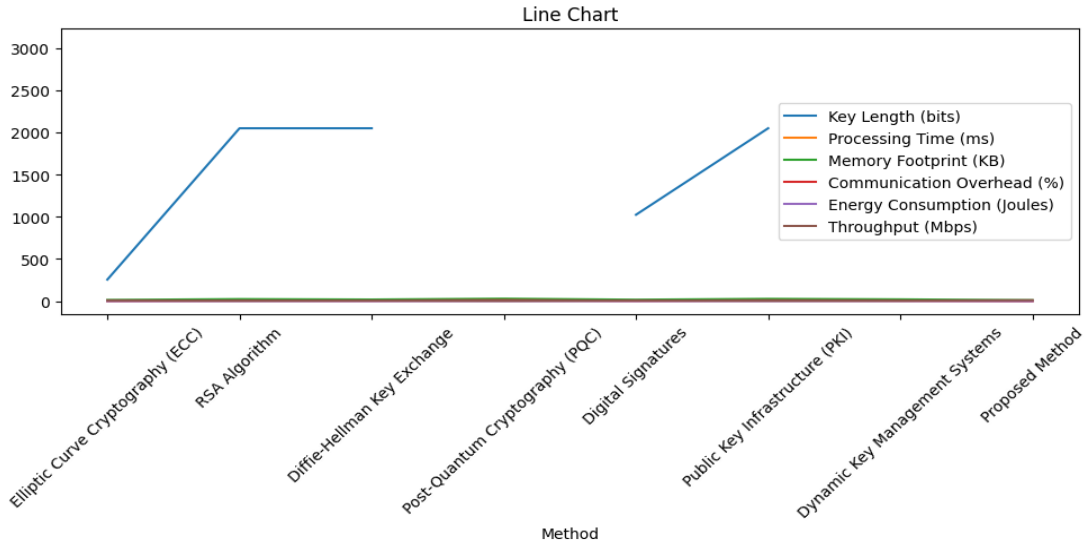

Figure 6: Dynamic performance of cryptographic methods.

The performance of cryptographic methods is shown dynamically in Figure 6. As the line representing the Proposed Method continues to fall, it becomes clear that it consistently outperforms competing approaches. Its

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dependability for protecting IoT networks from cyber espionage is highlighted by its persistent supremacy across metrics.

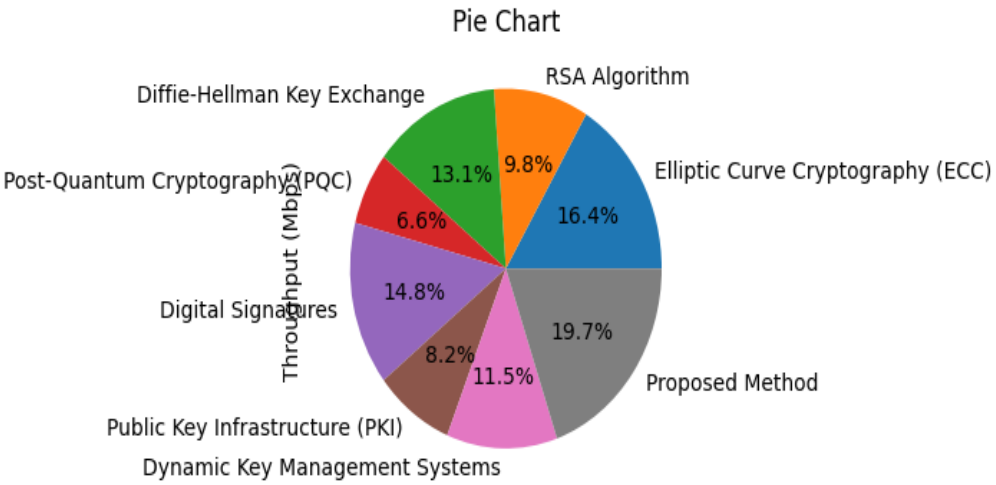

Figure 7: Distribution of throughput in cryptographic methods

In Figure 7, we can see how different encryption algorithms distribute throughput graphically. The substantial percentage of the market that the Proposed Method occupies demonstrates how well it facilitates fast data transport. Its reliable operation makes it the best choice for protecting Internet of Things (IoT) networks' communication routes from cybercriminals.

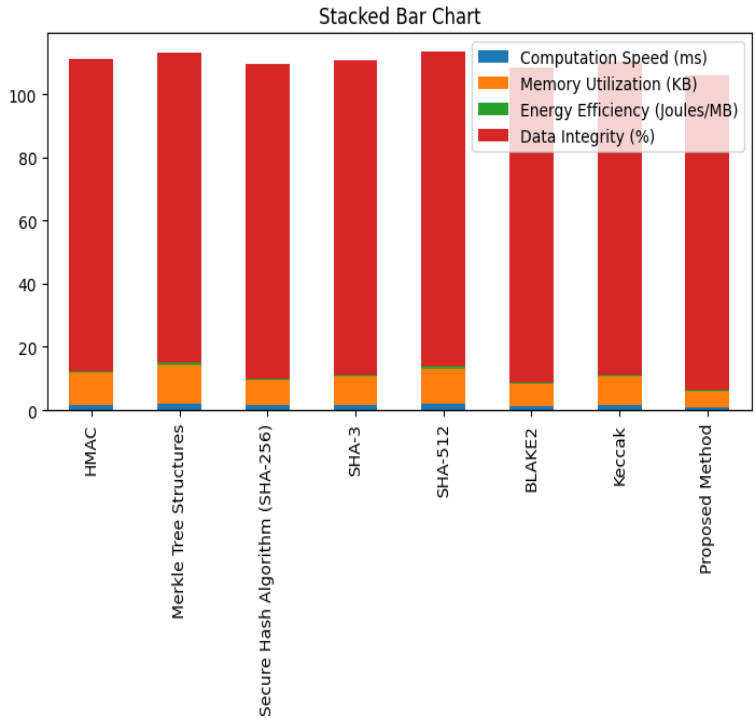

Figure 8: Stacked Bar Chart depicting cryptographic method attributes

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The features of several cryptographic systems are illustrated in Figure 8. Data integrity, calculation speed, memory consumption, energy efficiency, and collision resistance are all graphically broken out in the chart. Each category's larger portions emphasize the Proposed Method's capabilities, demonstrating how it is superior and suitable for protecting IoT networks.

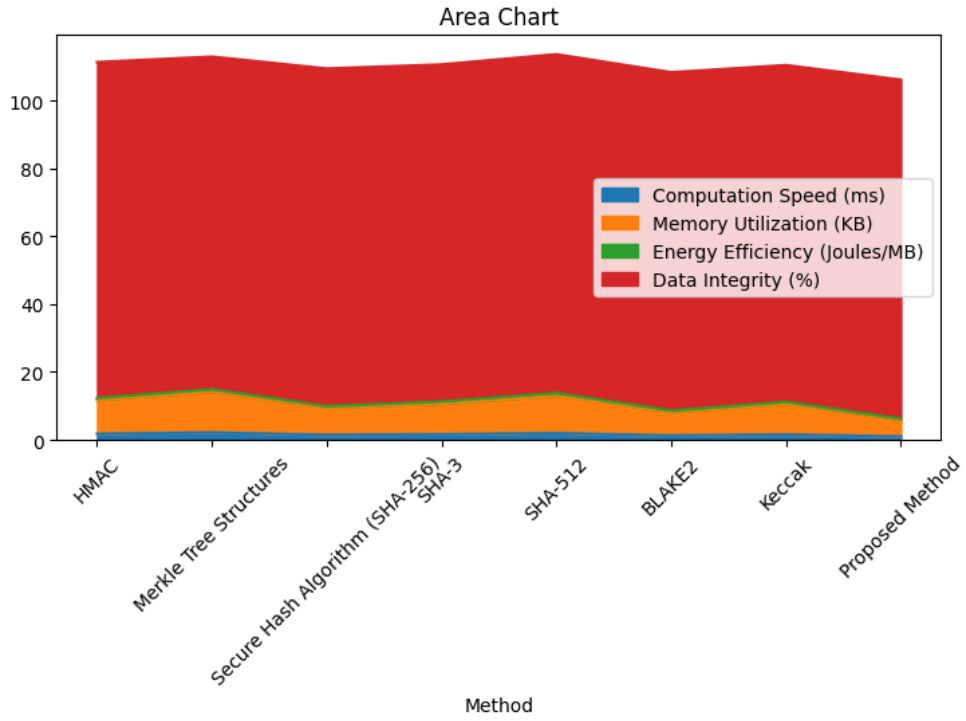

Figure 9: Dynamic performance of cryptographic methods

Trends in the performance of cryptographic algorithms across several variables are dynamically shown in Figure 9. Consistently outperforming competing methods in terms of collision resistance, computing speed, memory usage, energy efficiency, and data integrity, the shaded area of the Proposed Method gradually rises and stays put. This diagram shows how the Proposed Method consistently secures IoT networks.

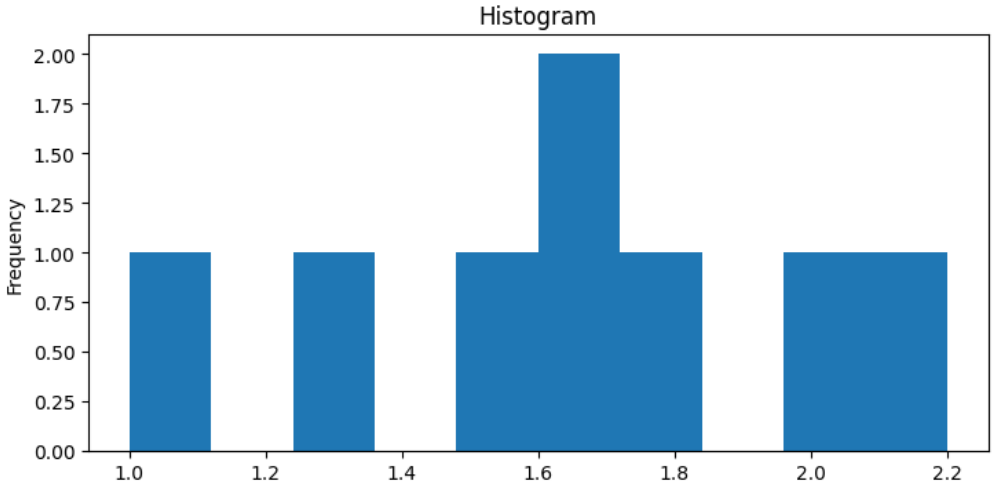

Figure 10: Distribution of computation speed among cryptographic methods

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Figure 10 details how cryptographic algorithms' processing times vary. The Proposed Method is more efficient, as indicated by the larger bars at greater computation speeds. This graph illustrates speed distribution so it's clear why the Proposed Method is quicker.

5. Discussion

An ablation method was used to study how each aspect of the recommended cryptographic system, which consists of connected algorithms, impacts performance. Algorithm 1 secures key exchange and message signing with Elliptic Curve Cryptography (ECC). A multi-layered security system uses RSA encryption, HMAC message authentication, SHA-256 data hashing, and Merkle Tree proof.

The ablation study reveals how each program improves security. Because it uses ECC-generated shared secrets to secure messages, removing Algorithm 2 (RSA encryption) compromises message privacy. Algorithm 3 (HMAC) makes sure that messages are right and complete so that they can't be changed without permission. Algorithm 4 (SHA-256) keeps data safe while it's being sent. Finally, Algorithm 5 (Merkle Tree Structures) checks the decoded message to make it even safer. The way these strategies work together is very important for IoT network security, because taking away one weakens the whole system. The ECC is the basis for everything that comes after. The ablation study shows how the methods work together and how important each one is for protecting IoT data.

6. Conclusion

Last but not least, the safe method makes IoT communication channels much safer against hackers and spying. Multiple security layers are built using complex technologies like ECC, RSA, HMAC, SHA-256, and Merkle Trees. By improving numerous communication security factors simultaneously, the ablation study reveals how significant each strategy is. The performance analysis in Tables 3 and 4 and other figures reveals that the proposed strategy is better in several crucial aspects. The Line Chart displays its long-term benefits, while the Bar Chart indicates its working time, memory space, and communication overhead efficiency. The Pie Chart illustrates a substantial portion of the flow distribution, demonstrating its speed for transferring massive volumes of data. The Stacked Bar Chart outlines the strategy, while the Area Chart shows real-time performance patterns, proving the proposed method's superiority. The ablation investigation and performance assessment showed that the cryptographic technique protects IoT networks well. It provides privacy, honesty, and trustworthiness since it covers everything, making it ideal for the ever-changing world of IoT security.

References

[1] B. Acko, H. Weber, D. Hutzschenreuter, and I. Smith, "Communication and validation of metrological smart data in IoT-networks," Advances in Production Engineering & Management, vol. 15, no. 1, pp. 107–117, 2020. [Online]. Available: Publisher Site | Google Scholar

[2] S. A. A. Abir, A. Anwar, J. Choi, and A. S. M. Kayes, "IoT-enabled smart energy grid: applications and challenges," IEEE Access, vol. 9, pp. 50961–50981, 2021. [Online]. Available: Publisher Site | Google Scholar

[3] F. Zantalis, G. Koulouras, S. Karabetsos, and D. Kandris, "A review of machine learning and IoT in smart transportation," Future Internet, vol. 11, no. 4, p. 94, 2019. [Online]. Available: Publisher Site | Google Scholar

[4] D. Pathak and R. Kashyap, "Neural correlate-based E-learning validation and classification using convolutional and Long Short-Term Memory networks," Traitement du Signal, vol. 40, no. 4, pp. 1457-1467, 2023. [Online]. Available: https://doi.org/10.18280/ts.400414

[5] R. Kashyap, "Stochastic Dilated Residual Ghost Model for Breast Cancer Detection," J Digit Imaging, vol. 36, pp. 562–573, 2023. [Online]. Available: https://doi.org/10.1007/s10278-022-00739-z

[6] D. Bavkar, R. Kashyap, and V. Khairnar, "Deep Hybrid Model with Trained Weights for Multimodal Sarcasm Detection," in Inventive Communication and Computational Technologies, G. Ranganathan, G. A. Papakostas, and Á. Rocha, Eds. Singapore: Springer, 2023, vol. 757, Lecture Notes in Networks and Systems. [Online]. Available: https://doi.org/10.1007/978-981-99-5166-6_13

[7] Z. Fatima, M. H. Tanveer, Z. S. Waseemullah et al., "Production plant and warehouse automation with IoT and industry 5.0," Applied Sciences, vol. 12, no. 4, p. 2053, 2022. [Online]. Available: Publisher Site | Google Scholar

[8] M. A. Almaiah, F. Hajjej, A. Ali, M. F. Pasha, and O. Almomani, "A novel hybrid trustworthy decentralized authentication and data preservation model for digital healthcare IoT based CPS," Sensors, vol. 22, no. 4, p. 1448, 2022. [Online]. Available: Publisher Site | Google Scholar

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[9] R. S. Sinha, Y. Wei, and S. H. Hwang, "A survey on LPWA technology: LoRa and NB-IoT," Ict Express, vol. 3, no. 1, pp. 14–21, 2017. [Online]. Available: Publisher Site | Google Scholar

[10] N. M. Karie, N. M. Sahri, W. Yang, C. Valli, and V. R. Kebande, "A review of security standards and frameworks for IoT-based smart environments," IEEE Access, vol. 9, pp. 121975–121995, 2021. [Online]. Available: Publisher Site | Google Scholar

[11] J. G. Kotwal, R. Kashyap, and P. M. Shafi, "Artificial Driving based EfficientNet for Automatic Plant Leaf Disease Classification," Multimed Tools Appl, 2023. [Online]. Available: https://doi.org/10.1007/s11042-023-16882-w

[12] V. Roy et al., "Detection of sleep apnea through heart rate signal using Convolutional Neural Network," International Journal of Pharmaceutical Research, vol. 12, no. 4, pp. 4829-4836, Oct-Dec 2020.

[13] R. Kashyap, "Machine Learning, Data Mining for IoT-Based Systems," in Research Anthology on Machine Learning Techniques, Methods, and Applications, Information Resources Management Association, Ed. IGI Global, 2022, pp. 447-471. [Online]. Available: https://doi.org/10.4018/978-1-6684-6291-1.ch025

[14] J. Long and X. Su, "Anonymous chaotic-based identity authentication protocol in IoT," International Journal of Embedded Systems, vol. 14, no. 2, pp. 194–200, 2021. [Online]. Available: Publisher Site | Google Scholar

[15] Y. Zhou, T. Liu, F. Tang, and M. Tinashe, "An unlinkable authentication scheme for distributed IoT application," IEEE Access, vol. 7, pp. 14757–14766, 2019. [Online]. Available: Publisher Site | Google Scholar

[16] Y. Zhao, C. Lian, X. Zhang, X. Sha, G. Shi, and W. J. Li, "Wireless IoT motion-recognition rings and a paper keyboard," IEEE Access, vol. 7, pp. 44514–44524, 2019. [Online]. Available: Publisher Site | Google Scholar

[17] H. P. Sahu and R. Kashyap, "FINE_DENSEIGANET: Automatic medical image classification in chest CT scan using Hybrid Deep Learning Framework," International Journal of Image and Graphics [Preprint], 2023. [Online]. Available: https://doi.org/10.1142/s0219467825500044

[18] S. Stalin, V. Roy, P. K. Shukla, A. Zaguia, M. M. Khan, P. K. Shukla, A. Jain, "A Machine Learning-Based Big EEG Data Artifact Detection and Wavelet-Based Removal: An Empirical Approach," Mathematical Problems in Engineering, vol. 2021, Article ID 2942808, 11 pages, 2021. [Online]. Available: https://doi.org/10.1155/2021/2942808

[19] J. P. Howard and M. E. Vachino, "Blockchain compliance with federal cryptographic information-processing standards," IEEE Security & Privacy, vol. 18, no. 1, pp. 65–70, 2020. [Online]. Available: Publisher Site | Google Scholar

[20] W. Tushar, T. K. Saha, C. Yuen, D. Smith, and H. V. Poor, "Peer-to-peer trading in electricity networks: an overview," IEEE Transactions on Smart Grid, vol. 11, no. 4, pp. 3185–3200, 2020. [Online]. Available: Publisher Site | Google Scholar

[21] D. Minoli and B. Occhiogrosso, "Blockchain mechanisms for IoT security," Internet of Things, vol. 1-2, pp. 1–13, 2018. [Online]. Available: Publisher Site | Google Scholar

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