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HYBRID ALGORITHM FOR DETECTING IOT ATTACKS USING HADOOP BLOCKCHAIN AND MACHINE LEARNING

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ABSTRACT

The extensive utilisation of IoT devices has enabled the collection of various data, however, the storage of this data poses difficulties due to the risk of corruption and undetected data integrity problems. Blockchain technology provides answers for maintaining the integrity of data. However, public blockchains might result in significant transaction expenses when dealing with massive amounts of data. Our research suggests a cost-effective and dependable method for digital forensics, which involves utilising numerous affordable blockchain networks to temporarily store data before completing the verification process on the Ethereum platform. Merkle trees hold event data in a hierarchical structure using hash functions, resulting in reduced costs for Ethereum.

It is crucial to identify compromised IoT devices and gather evidence of their harmful activities. We present an innovative approach that utilises blockchain technology to collect and store digital evidence for forensic purposes. A confidential forensic evidence database holds the proof, while a permissioned blockchain ensures the evidence's security, guaranteeing its effective utilisation in legal procedures. Blockchain technology provides a practical approach for assessing unchangeable IoT records, while integrating it into IoT forensics poses financial and security obstacles.

The IHBF-ML model, developed through our study, is a Cyber-Physical System (CPS) that combines Hadoop, Blockchain, and Machine Learning. It features distributed storage and is designed for forensic analysis. Utilising the Hadoop Distributed File System (HDFS) improves security in the digital realm. IHBF-ML utilises smart contracts to facilitate the transmission of IoT data and employs the Cat Boost classification approach for the purpose of anomaly detection. It employs parallel data processing using the MapReduce Framework, resulting in a 25% reduction in IoT forensic expenses compared to conventional blockchains such as Ethereum and EOS.

Key Words: Internet of Things (IoT), Data Integrity, Blockchain Technology, Digital Forensics Merkle Trees, Ethereum Platform, Transaction Costs, Compromised Gadgets Identification

1. INTRODUCTION

The widespread use of Internet of Things (IoT) devices results in a large amount of data, which presents difficulties for forensic analysts. Communication traffic sources in IoT networks do not have size constraints, hence it is necessary to use appropriate benchmarking methodologies. Solutions frequently depend on identifying departures from typical patterns. The authors suggest a thorough data forensics strategy to guarantee precision and responsiveness. The progress in Internet of Things (IoT) technologies, such as wearable devices and intelligent buildings, brings about security risks. This is because the focus is mostly on enhancing functionality rather than ensuring security, which in turn leads to a rise in cyber-attacks. Novel forensic methodologies are required to ensure the preservation of data integrity. The suggested system employs a third-party server for logging purposes. It takes IoT data and generates alerts for any suspicious activity. Additionally, it utilizes machine learning techniques to detect potential attacks.

What Are Digital Forensics?

Digital Forensics" (DF) is a branch of traditional forensic science. It has to do with finding and analyzing electronic data. DF specialists are in charge of locating, acquiring, recovering, evaluating and archiving digital proof from a variety of electronic gadgets. Forensics Investigation Life Cycle is made up of afore mentioned processes when they are all completed in order. Although different academics split research cycle into phases in slightly different ways, one crucial point should never be overlooked: entire cycle should be carried out using validated equipment and scientifically proved technique. To stay up with developments and ensure accurate and fast data extraction, DF investigators design as well as validate new tools because there are now new platforms based on embedded methods

Cyber Forensics

Digital forensics is the investigation of illicit acts conducted through computer systems. It involves identifying vulnerabilities and adopting solutions to enhance cyber security. Machine learning improves the ability to detect and identify intrusions and viruses. Specialized fields such as memory, disk, cloud, IoT, and network forensics have unique and specific difficulties. These improvements demonstrate the changing nature of digital forensics in countering cyber-attacks.

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Types of Cyber crime

The CIA trinity, consisting of Confidentiality, Integrity, and Availability, plays a vital role in ensuring the security of systems by safeguarding data from unwanted access, change, or deletion (Kumar, 2021). Cybercriminals focus on Internet of Things (IoT) systems to take advantage of weaknesses, employing botnets such as Mirai to carry out Distributed Denial of Service (DDoS) assaults (Yoo et al., 2021). The presence of sophisticated dangers, such as Bricker Bot, emphasizes the necessity for strong security measures in the realm of Internet of Things (IoT).

Digital Forensics

Digital forensics" is a branch of criminalistics that focuses on legal process involved in evaluating and securing digital data. Finding and getting data from many sources is required. After that, the information might be evaluated by employing it in a civil or criminal trial (Shaid and Marof 2014). This method comprises applying scientific as well as technological methodologies to data that various digital objects have generated. The aim of digital forensics is to gather data that Can be utilized to assess the particular details of an incident. The 5WH inquiries refer to the following: who had a role in the incident and where it happened how it occurred and when it occurred—are routinely asked during investigations. Investigators can confirm the incident's validity with the aid of the answers to these questions (Sachdeva and Ali 2022). The digital forensics investigative procedure: According to National Institute of Standards and Technology, four procedures and Procedures utilized in digital forensics process are meant to help organizations understand the significance of their inquiries.

IoT forensics

The Internet of Things (IoT) transforms mobile communication by allowing intelligent tasks to be performed through the use of situational awareness and sensory capabilities (Mottola & Picco, 2021). Although IoT systems offer advantages, they are vulnerable to security risks such as ransomware and DoS attacks. This has led to a demand for IoT forensics to address these issues (Mitra et al., 2006). Nevertheless, the accumulation of extensive amounts of data presents difficulties for data centers, requiring remedies for analytics and security concerns (Mitra et al., 2006). The intricacies of protocols and data formats provide an additional layer of difficulty to the process of retrieving proof from IoT-enabled gadgets, therefore emphasizing the issues faced in the field of IoT forensics (Mitra et al., 2006). Despite the difficulties involved, IoT forensics provides a dependable means of gathering proof, meeting user requirements, and supplying contextual information for analyzing real-life occurrences (Naeem et al., 2022). This represents a significant advancement in the field of digital forensics (Naeem et al., 2022).

2. OBJECTIVES

- To construct an Integrated Hadoop Blockchain Forensic Machine Learning (IHBF- ML) model for security and cost reduction in IoT forensic environment
- To provide cyber trust block chain for detecting malicious activity and store proof regarding such incidents
- Initially, the IHBF-ML model collects data from IoT nodes and data is stored in database. With stored data information is being processed and evaluated to retrieve the information from the node data
- The constructed model comprises the HDFS system integrated with cyberspace. Within the HDFS the node data are stored and processed in a parallel manner with the use of the MapReduce framework. The MapReduce framework model process the distributed files in the network with the conversion of data
- The MapReduce framework model processes the data in a parallel manner with the distributed file management with the smart contract-based Public blockchain model. MapReduce framework performs the translation, extraction and analysis of the feature in the IoT nodes through a parallel process

3. LITERATURE REVIEW

Ahamed and Alshehri (2023) Explored the fusion of Hadoop with blockchain technology to enhance security in the Internet of Things (IoT). They stressed the importance of using a hybrid approach that integrates machine learning and blockchain to effectively handle substantial amounts of data and precisely detect irregularities. The study presented a thorough forensic strategy, guaranteeing both precision and responsiveness in the management of IoT data. By integrating blockchain technology, the system implemented an immutable log, so bolstering the integrity of forensic information. Furthermore, machine learning algorithms were utilized to enhance the capabilities of anomaly detection. This dual strategy successfully tackles the ever-changing nature of IoT threats and improves the effectiveness of forensic analysis. Their research indicates that the integration of these technologies can greatly enhance the security and dependability of IoT systems, rendering it a resilient solution for contemporary cybersecurity issues.

Kebande (2023) research centered on the integration of machine learning and blockchain for enhancing security in the Internet of Things (IoT). The research highlighted the advantages of decentralized data management and the detection

of anomalies. The study employed Hadoop for processing enormous amounts of data and blockchain for storing data securely. Machine learning techniques were utilized to detect trends and anomalies from typical behavior. The hybrid system exhibited enhanced detection rates of IoT assaults, showcasing the possibility of integrating these technologies to bolster IoT security and forensic investigation. The system provides scalability and security by utilizing Hadoop's capacity to manage large volumes of data and blockchain's unchangeable record-keeping. The incorporation of machine learning algorithms significantly improves the system's capacity to accurately identify and promptly address problems. Kebande's study highlights the significance of using a comprehensive approach to tackle the changing risks in IoT environments, providing a strong solution for contemporary cybersecurity concerns.

Rose et al. (2023) investigated the utilization of machine learning and blockchain technology in the processing of Internet of Things (IoT) forensic data. Their research suggested a framework in which Internet of Things (IoT) data is recorded on a blockchain to guarantee its integrity, while machine learning algorithms examine this data for any irregularities. They employed Hadoop to oversee the vast amount of data produced by IoT devices. The findings demonstrated that this combination method was successful in detecting and reducing risks associated with IoT, offering a strong structure for forensic analysts. The technology improves the security and dependability of IoT environments by using blockchain to ensure data integrity and machine learning for anomaly detection. The incorporation of these technologies provides a flexible and protected resolution for contemporary IoT forensic difficulties, showcasing substantial promise in enhancing the rates of identification and the speed of response to IoT risks.

Siddique et al. (2023) investigated the amalgamation of blockchain and machine learning with the purpose of augmenting the security of IoT. The organization adopted Hadoop to manage the huge volumes of IoT data and utilized blockchain for secure and unalterable logging. Subsequently, machine learning techniques were employed to identify irregularities and potential risks. This complete strategy secured the consistency and reliability of data and enhanced the precision of identifying potential risks, demonstrating its effectiveness in protecting IoT environments. The solution exhibited substantial enhancements in detecting and mitigating Internet of Things (IoT) hazards by utilizing the unique capabilities of each technology: Hadoop for efficient data processing, blockchain for secure data storage, and machine learning for intelligent analysis. Their research emphasizes the capacity of this combination approach to offer a strong and reliable security structure, effectively tackling the many obstacles encountered in IoT contexts.

Bilal et al. (2022) investigated a hybrid methodology that integrates blockchain and machine learning techniques to enhance the security of IoT environments. Their study utilized Hadoop to handle extensive datasets and blockchain for ensuring safe data logging. The data was processed by machine learning algorithms to identify anomalies, resulting in a substantial enhancement of threat detection rates. The suggested approach exhibited significant efficacy in detecting IoT threats, highlighting the possibility of merging these technologies for resilient IoT security and forensic investigation. The system provides a comprehensive answer to IoT security concerns by leveraging Hadoop's capacity for processing massive amounts of data, blockchain's ability to create unchangeable logs, and machine learning's excellent anomaly detection. This integration emphasizes the improved capability to identify, examine, and address possible dangers, hence strengthening the security structure inside IoT ecosystems.

Huang, Wei, and Wang (2022) conducted a study on the application of blockchain and machine learning in the field of IoT forensic investigation. They employed Hadoop for the purpose of data processing and applied blockchain to guarantee the integrity of the data. Machine learning algorithms were utilized to identify irregularities in the Internet of Things (IoT) data. Their research emphasized the heightened security and effectiveness of this hybrid system in detecting Internet of Things (IoT) risks, providing useful knowledge on the incorporation of these technologies to boost forensic capabilities. The system achieved a notable enhancement in the accuracy and speed of threat identification by integrating Hadoop's strong data processing capabilities, blockchain's secure logging, and machine learning's superior anomaly detection. The study highlights the need of employing a comprehensive strategy to strengthen IoT security, offering a scalable and dependable framework for forensic analysts to efficiently handle and examine extensive volumes of IoT data.

Mak and Zhu (2022) introduced a forensic framework that integrates blockchain and machine learning to enhance security in the context of Internet of Things (IoT). Hadoop was employed to manage the substantial amount of Internet of Things (IoT) data, while blockchain was utilized for the purpose of recording data in an unchangeable manner. Abnormal patterns were detected using machine learning techniques. The study shown that the utilization of this hybrid approach might significantly bolster IoT security and offer a dependable technique for forensic investigation. The system showcased substantial enhancements in identifying and managing IoT threats by utilizing Hadoop's vast data management, blockchain's secure and tamper-proof logging, and machine learning's advanced anomaly detection. This integration provides a strong and effective solution to the complicated security issues in IoT environments, guaranteeing the accuracy of data integrity and improved detection of threats. The results emphasize the possibility of integrating

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these technologies to establish a scalable and effective forensic framework for contemporary IoT environments.

Xue and Wang (2022) examined the utilization of blockchain and machine learning in the field of IoT forensic analysis. Their study entailed employing Hadoop for the handling of extensive amounts of data and utilizing blockchain for the purpose of secure logging. Machine learning techniques were employed to identify anomalies in IoT data. The results suggested that this combination system has the potential to greatly enhance the precision and effectiveness of detecting threats in the Internet of Things (IoT), particularly in the context of forensic applications. The technology showcased improved abilities in detecting and addressing security issues in the Internet of Things (IoT) by combining Hadoop's powerful data processing features, blockchain's unchangeable record-keeping, and machine learning's superior anomaly detection approaches. This research provides useful insights into the integration of different technologies, presenting a scalable and efficient approach for forensic investigation in IoT contexts.

4. METHODOLOGY

Proposed Integrated framework

The suggested architecture comprises two components: one for the preservation of digital evidence and another for the utilization of blockchain technology to identify and mitigate cyber threats. It pertains to Security Incident Management (SIM), which involves the identification of security incidents and the implementation of procedures to address them in accordance with broken security requirements. Data acquisition is managed by a server that is not directly involved in the process. This server redirects IoT traffic to a monitoring server, which then creates logs and alarms for further analysis of the data. The forensic analysis process consists of four steps: data gathering, inspection, analysis, and reporting. To overcome the limitations of IoT, the system employs a logging server to identify attacks. Machine learning enables the automation of threat detection, while Security Onion offers comprehensive analysis. This framework improves the process of IoT forensic investigations by assisting in the identification of attackers and providing a comprehensive picture of the entire attack scenario.

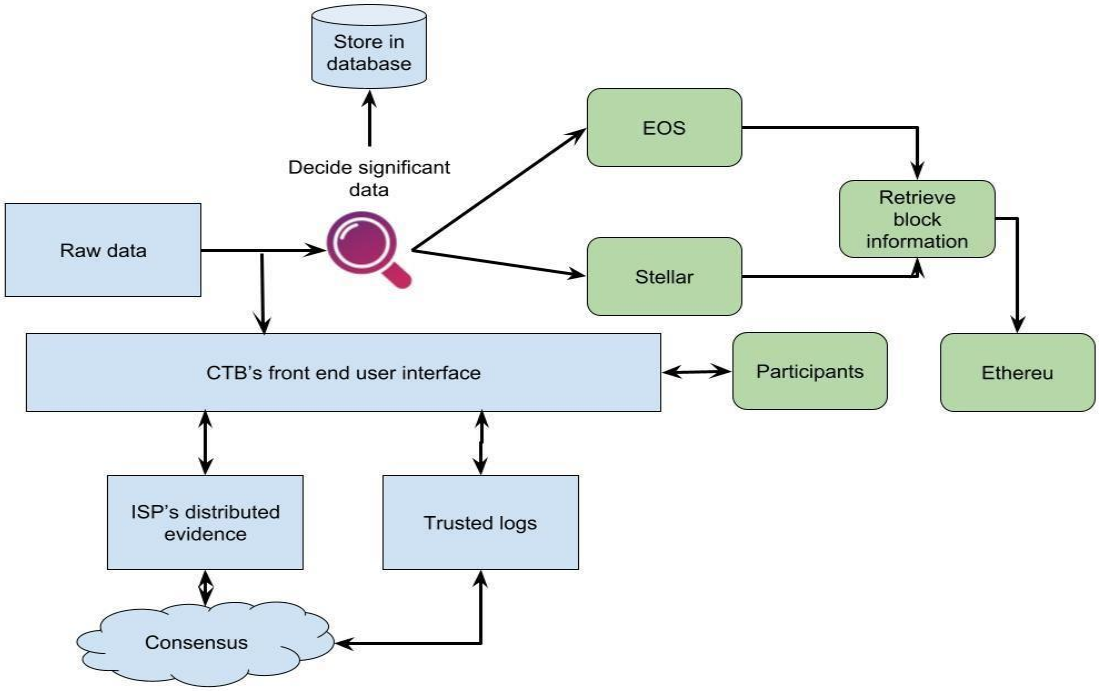

Fig. 4.1 Architecture of Integrative Forensics framework

Low-Cost Forensic framework

The architecture we propose utilizes public blockchain technology to establish a trustless environment. Because of the exorbitant expenses and concerns over privacy associated with keeping data on public blockchains, we opt for more cost-effective alternatives such as Stellar and EOS. Additionally, we integrate Bitcoin and Ethereum to enhance robustness. All of these platforms utilize smart contracts to facilitate smooth communication. Hash functions and Merkle trees are used to decrease the amount of data. The procedure commences with an IoT edge device relaying a cryptographic hash of IoT data to a multi-chain network. Stellar and EOS receive valuable data hashes on a daily basis. At the end of each day, the rental company's data center performs synchronization, retrieval of confirmed transactions, and evaluation of Merkle roots. These Merkle roots are subsequently transferred to Ethereum and stored locally for forensic purposes. This guarantees the protection and affordability of data integrity and resilience. Table 4.1 Cost comparisons of different Block chains

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Approach	Total Cost in dollars
Multi chain (Steller+EoS+Etherreum)	443
Ethereum Only (fun call)	13140
Ethereum Only	69350

The Table 4.1 compares the costs of various Procedures to ours. As can be seen, the Ethereum- only strategy is rather costly, costing roughly 70K dollars. The bike firm will not be interested in deploying it, despite the fact that it is exceedingly secure and dependable. The alternative Ethereum approach, which uses function calls, is significantly more inexpensive, costing roughly 13K dollars. The reason for this is that the agreement's installation price is a singular charge, and hashes are consistently recorded in the terms of the agreement. Nonetheless, this is still a lot more costly than 443 dollars. Our method saves a lot of money and may be highly appealing to a corporation to use. In future If we use Beacon Chain which is the heart of the Ethereum 2.0 system chain the processing time and Processing cost will reduce much more.

Cyber-Trusts blockchain

The objective of Cyber-Trust is to identify compromised networks and components, enabling the implementation of corrective measures. Intrusion detection technologies gather and analyze evidence from multiple sources to identify and track unauthorized access attempts. Crucial Internet of Things (IoT) data is securely kept on a blockchain to protect against hackers and simplify the process of collecting evidence. The Smart Gateway Agent (SGA) gathers network data, monitors the state of the network, analyzes the behavior of IoT devices, and establishes connections with ISP layer systems. The SGA employs fingerprinting to identify new devices, utilizes a basic Intrusion Detection System (IDS) to search for abnormal behavior, and directs potentially suspect network traffic for thorough analysis through deep packet inspection.

Process for Verifying Integrity

When a conflict emerges, the proposed framework examines and substantiates what transpired. Once the data integrity has been confirmed, it is possible to determine the party responsible. The investigator obtains forensic data from the data centre, collects transactions containing hashed data from primary blockchains, and gets pertinent Merkle root values and paths. Miners operating on multiple chains and extended Proof of Work (PoW) durations serve to confirm the presence of transactions on the blockchain.

We have created protocols for conducting partial forensic examinations, separating evidence, selectively collecting data, and performing digital forensic triage using parallel computing for the processing of cloud forensic data. The algorithm we have developed is capable of identifying virtual environments during digital forensics. It effectively classifies attack datasets by utilizing distinct filters to locate disguised virtual computers. The indexing capabilities of traditional digital forensic tools are insufficient to handle the increasing bulk of digital content, particularly virtual disks on cloud systems.

5. RESULT

We employed two separate digital forensic tools to examine what data could be recovered I used the Amazon Echo Dot to investigate the privacy concerns related to IoT gadgets and to verify that no confidential information had been stored on the gadgets. We then Contrasted the test findings to evaluate which tool worked better. The Sleuth Kit, an open-source forensic tool, is used as the first digital forensic tool and is used to extract data from raw image files and mobile gadgets. Paraben E3:DS, a commercial forensic tool, is used as the second digital forensic tool. Next, we set up a laptop as a wireless access point. We could have complete control over the network traffic in the environment if the laptop served as a router. The laptop was then used to connect the gadgets to the internet. In order to closely study every detail of what is occurring on the network, we installed the Wireshark network analyzer. This made it possible for us to record network traffic flowing from Amazon Echo Dot through set-up laptop to internet, remote servers and other way around.

Table 5.1 IoT nodes credentials for experiment

Node	Public Key	Private Key
1	0xB0908B6e032fF8F79524292E9B 017 5bD713F6aeD	f399ae6ed4c92851a28f179ac9bc7140ceb4f0 3b6d30635af5bdfc0701e7876c
2	0x25E1DED38B2ec0839ccE678722 5e 8Cc41bE8Bb97	5da19b4ddf3775714826a4eb28f01e8cf5e57 85875116928bb4f4811c385bb6b
3	0x784b5cbA80069059EDE9cCF5a7d4 c0F9001D0Aaf	c7b8656b422aace74586da37d7372431fe14d cbc67030047a64b239b7c0835f9

4	0x1a702009E32F7435d5cc95dD172 a4 F54DEe1dcC7	059b3c037d9db76f7a46f166c32b48612b 6ca 6758cf73ffdd9a847f2eacc4ea6
5	C5bEc83028Ad3BFcbF4767Ad1 d831a6011749	90d93f804064e8b877c090f6acf7acb32e522e 95bdf2e980717f98b33395a514
6	0xe9d7e06Ef1Be5F1336090550909 729 A64dA74599	28a66f08f7aede7a78b1107db6c18a9785193 503b9be9b5531acfd8618a2232e

Table 5.2 Token exchange set parameters

Node in Cluster	EnergyLevel	Number ofHops	ResidualEnergy	ThresholdLevel
5	1Joules	3	> 1 J	0.5

In the simulation of the data exchange among the nodes are stored in the cyber space enabled Hadoop distributed file system. The HDFS enabled public blockchain model for the IoT forensic activities uses the transaction details within the space as presented in Table 5.3. The generated model uses the 50 Ethers for the transaction in the balanced state. The exchange token among the nodes is evaluated with the periodic maintenance for the nodes and service billing process.

With IHBF-ML model network traffic are monitored with increase in network size for the increase in the system with increases in same ration with the maximal utilization of the available resources and maintains the constant values. The obtained values focused in the security and cost-effectiveness for the attached number of nodes ad replica of the HDFS input or output. The processing time is evaluated within the cyber space either it increases or decreases the replica number with the increase in Data Nodes. The classification performance is presented in Table 5.3

Table 5.3 Classification Performance Analysis

Class	Accuracy	Precision	Recall	F -Score
Malicious	0.9956	0.9946	0.9956	0.9946
Non - Malicious	0.9972	0.9973	0.9957	0.9937

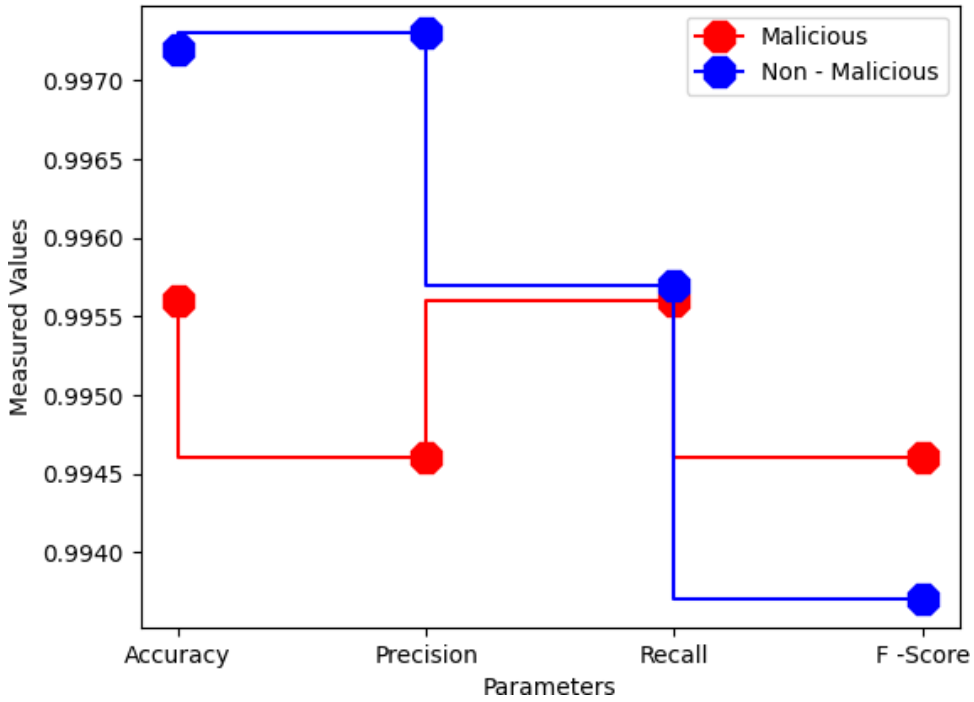

Fig. 5.1 Measured Machine Learning Model for Security

Table 5.4 Comparison of Cost

Blockchain Technology	Annual Cost
EOS	$ 29,000,000.
Steller	$ 23,000,000.
IHBF-ML (Ethereum)	$18,000,000

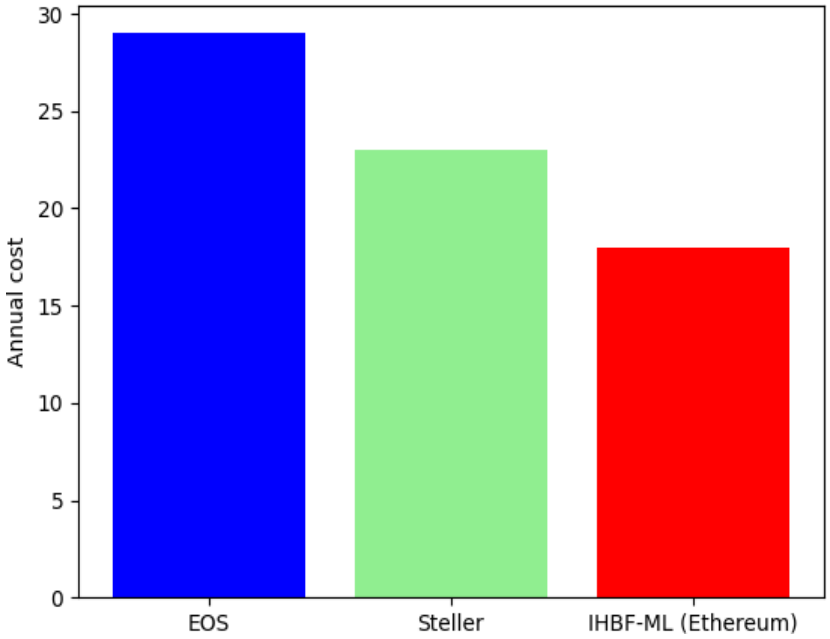

Fig. 5.2 Comparison of Blockchain

6. CONCLUSION

The digital forensics sector is impacted by issues in IoT technology, including key management and the absence of appropriate forensic tools. Despite the progress made in technology, forensic professionals have not fully harnessed these capabilities. Cloud storage can resolve storage limitations, but it is crucial for the tools to be flexible and easy to use. Investigations related to the Internet of Things (IoT) are inherently more intricate than typical investigations, necessitating the use of specialist instruments. The forensic architecture we propose utilizes numerous blockchain networks to authenticate the integrity of data from IoT devices. By integrating blockchains, we provide a system that is both safe and resistant to tampering, while also being cost-effective. The IHBF-ML paradigm combines Hadoop, MapReduce, Ethereum smart contracts, and the Cat Boost algorithm to enable parallel processing and detect anomalies. This approach effectively minimizes expenses and enhances productivity, attaining an exceptional anomaly detection rate of 99% while incurring a total expenditure of $18,000,000. The framework we present showcases the cost-effectiveness and resilience of our solution for IoT forensic investigations. We do this by utilizing blockchain technology and machine learning algorithms to boost security and minimize costs.

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