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Blockchain-Based Computational Intelligence Models for Securing Credit Card Transactions in Cyber Forensic

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***Abstract* - This paper explored how blockchain technology and computational intelligence (CI) models might work together to secure credit card transactions. It focused specifically on real-time fraud detection and prevention. In this work, blockchain, a decentralized, impossible-to-tamper data ledger that is also distributed was used for data integrity and tampering prevention. At the same time, Computational Intelligence models were employed to monitor transactions in real-time to detect anomalies or fraudulent activities. The framework was evaluated with the following key performance indicators: accuracy, precision and recall and F1-score. The results show that when compared to traditional methods, fraud detection rates dramatically improved. A comparative study was conducted across various CI models, including machine learning algorithms and neural networks. As a result, the combination of blockchain and CI models achieved added security and safer credit card transactions. It was found that the scalability of blockchain technology and the computational power necessary to connect with CI models pose some challenges. However, the combined framework proves to be better at preventing fraud than the prevailing method of internet policing. This study will add to an increasingly rich corpus of knowledge on how secured electronic transactions are achieved using modern cryptographic and AI techniques. The government will also benefit from this work in fostering real-time security.**

Keywords: Blockchain Technology, Computational Intelligence, Credit Card Fraud Detection, Cybersecurity, Real-time Fraud Prevention.

I. INTRODUCTION

Cyber forensic science, also called digital forensics, is the practice of analyzing and preserving electronic evidence from computer devices. It aims to help law enforcement fight cyber crimes that are becoming more frequent in cyberspace by monitoring activities (e.g. virus distribution or hacking) that cause damage (and quantifying that harm) to digital assets. As cybercrime continues to grow more sophisticated, the role of cyber forensics in digital security has become so vital that it is inconceivable for law enforcement agencies, cyber security experts, or organizations to treat these threats invisibly. Ultimately, when society decides whether criminals are anonymous or not, it may mean the difference between life and death for innocent people caught in cyber violence. With the increasingly important place of online transactions and the proliferation of cyber attack tools nowadays, cyber forensics has become an indispensable Part of ensuring the integrity, authenticity, and legitimacy of digital evidence (Ali and Awad, 2020).

In addition, cyber forensics not only can help identify cybercrime activities better but it also, by analyzing possible threats and preventing accidents before they happen with good measures in place for after an incident hits, reduces the risk of new or future incidents. However, with the rapid development of technology, the field has become far more complex; especially after clever swindles such as credit card fraud, a dominant form of cyber crime (Sanghavi, and Mehta, 2022).

Credit card transactions are building block to the modern digital world economy, where today, some billions of exchange operations are ticking over fines across our globe. Not surprisingly, given the sensitive data mining of information along with its potential returns for criminals (Chauhan et al. 2021), credit card transactions have become one of those bad guys' prime targets. Convincing results can be disastrous for both consumers and financial houses. As confidence shrinks, so do revenues (Cheng, 2021). The credit card information vulnerability to breaches, hacking, fraud and theft unimaginable simply did not exist in any preceding era of buying and selling. Given these new threats it is more necessary than ever that this situation be avoided (Gupta & Gupta 2021). In order to protect consumer trust and ensure regulatory compliance with data protection laws like GDPR and PCI-DSS, measures for securing these transactions against attackers must be made indispensable (Jain & Khanna 2020).

Moreover, as cyber threats become ever more sophisticated, safeguarding digital transactions is becoming

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increasingly difficult. Cybercriminals are constantly devising new techniques with which to penetrate system defenses and obtain the juicy credit card information they seek (Kumar et al., 2021). Financial systems are complex and online payment gateways now see truly widespread use but rarely encounter this level of million dollar financial loss quite so frequently anywhere else in human society. Incorporated in the scheme to break through these risks which increase every day adds a real challenge for existing security measures. This predicament calls for new approaches to integrate advanced technologies into secure architectures.

However, to address these challenges, one of the key remedies is blockchain technology. Originally developed as the technological basis for crypto-currency, blockchain has now grabbed attention for its potential about security in many different areas including financial transactions. (Zhang etal 2020 Blocks of data that would be almost impossible to change without unanimous agreement from the network in anything less than a lifetime. When a transaction is perpetrated on the blockchain, each one is linked to the next in a cryptographic form just as surely as it is physically recorded in our books - called blockchain tricks ever since. It's this historical nature and its derivation from cryptography that make blockchain virtually impossible to fake everything from start finish; indeed any error does raise questions about neutral routing practices or equal opportunity standards. (Raut et al 2021. About security in the processing of credit card transactions, transactions are about how we can eradicate the central latrine systems prevalent in traditional central banking politics. Moreover, blockchain's transparent ledger means that every transaction is recorded and verifiable, so long as it becomes impossible to commit fraud in a manner that might escape notice. Still, when or whether the data center is compromised also becomes more apparent through this transparent ledger.

A second line of defense is Computational Intelligence (CI) models, including machine learning, artificial neural networks, fuzzy logic, and evolutionary computation (Dey & Zhang, 2021). CI models mimic human cognitive functions, allowing systems to learn from data, evolve to meet new threats and make decisions without depending on explicit programming. As applied to cybersecurity, these models can detect fraudulent credit card transactions, forecast security vulnerability breaches before they occur and dynamically change security protocols of emerging threats. (Pandey and Mehta, 2021)

With the integration of blockchain technology and CI models, there would be improvement in the safety of credit card transactions. This method combines the transparency and immutability featured in blockchain with the abilities of computational intelligence. In this way, it is to create a framework far more robust, scalable, and intelligent than before to protect digital transactions securely and promptly as they emerge from the everyday threat of hacking. Releasing such forces could broaden transactions between banks significantly.

1.1 Purpose of the Study

The paper aims to show how credit card fraudulent transactions can be detected in real time by combining blockchain technology and computational intelligence (CI) models. The results of this study will allow stakeholders to better detect and deal with fraudulent activities in real time while increasing overall financial transaction security. Blockchain technology provides a decentralized and immutable transaction ledger. On the other hand, CI models bring cutting-edge learning capabilities that can help them stay ahead of emerging threats. Together, they form a two-layered approach that strengthens the preventive side of cybersecurity and provides a reactive guarantee (Zhang et al., 2020).

In addition, the study aims to develop a comprehensive framework that draws on the strengths of both blockchain and CI models to secure credit card transactions. This framework will need to be both scalable and adaptive so it can grow along with changing cyber threats–something that will ensure that both financial institutions and users are better protected against fraud and identity theft (Gupta & Gupta, 2021).

1.2 Significance of the Study

The significance of this study lies in the potential impact on both cybersecurity and digital forensics. By integrating blockchain technology with computational intelligence models, this research may provide new insights into how innovative technologies can be combined to create more robust security solutions. The results of this study could form the basis for further research into secure digital transaction frameworks, especially in sectors where sensitive financial data is at risk (Sanghavi & Mehta, 2022).

From a practical point of view, this study is of great significance for financial institutions consumers who are using credit cards. Financial institutions will use increased security measures to reduce the risk of fraud and enhance honorability in customers ' eyes. Credit card users will enjoy safer transaction processes, which, in turn, may result in fewer cases of identity theft and hacking. For regulators, this study offers an occasion to discuss new regulatory systems that will maintain the security and privacy of financial transactions in an era more and more controlled by electronics (Jain and Khanna, 2020）

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II. LITERATURE REVIEW

2.1 Cyber Forensics and Credit Card Fraud

Cyber forensics, particularly in credit card fraud cases, has developed into a vital tool for financial fraud investigations. Because of the increased use of online payment systems, credit card fraud, including financial fraud, has increased. It is impossible to recover the misappropriated funds, but with cyber forensics, we can trace fraudulent transactions, identify the perpetrators, and recover the plundered goods (Patel et al., 2020).

Recent trends in credit card fraud have been witnessed, with hackers showing increased sophistication in their attacks. Cybercriminals exploit weaknesses in financial systems using professional technology such as phishing, malware attacks and data skimming (Sharma and Gupta, 2021). The most common credit card fraud attacks characterized by Sharma and Gupta (2021) include unauthorized use of card details, identity theft, and fraudulent online transactions.

These trends underscore the importance of improving security measures for credit card payments. The safety measures currently in place for credit card transactions include encryption technologies, secure payment gateways, and two-factor authentication (2FA). Such steps have achieved some successes; but they are more reactive than proactive, which means they are not proving effective in preventing emerging threats (Yadav and Singh, 2022). A significant gap exists between the ability to detect fraud in real-time and the ability of traditional security mechanisms to adapt in the face of continually changing cybercrime tactics.

2.2 Types of Credit Card Fraud

Table 1: Common Types of Credit Card Fraud (Sharma and Gupta, 2021)

Fraud Method	Description
Phishing	Fraudulent emails to steal card information
Malware Attacks	Inserting malicious software to collect data
Data Skimming	Copying card details through physical or online means
Identity Theft	Using someone else's identity for unauthorized purchases
Fraudulent Transactions	Unauthorized use of stolen card details

2.3 Blockchain Technology

Blockchain technology builds on the concept of a distributive ledger, where each trade is recorded at multiple nodes across the network. A blockchain exists as cryptographically secure data that is secure and immutable. Once information is recorded, it cannot be tampered with without agreement from the entire network. Decentralization minimizes this single point of risk of failure and guarantees all transactions are transparent and traceable (Nakamoto 2020).

In recent years, blockchain has become recognized as an effective tool for strengthening transaction security. As a secure and transparent ledger, blockchain prevents tampering, fraud, or unauthorized access on this level. According to research by Khan and Abbas (2022), blockchain guarantees the integrity and security of all financial transactions by producing a tamper-proof history visible to every participant in the network.

Blockchain technology has been applied to various sectors of financial services, such as payment processing, cross-border transactions, and others. For cyber forensics, blockchain technology supports the traceability of transactions, such that each fraudulent link in a chain is tracked and cleared. This simplifies investigations (Gupta et al., 2021). This is crucial in discovering and preventing credit card fraud, as the unchangeable nature of blockchain records assists in discovering frauds in real-time.

Table 2: Blockchain's Role in Securing Credit Card Transactions (Khan and Abbas, 2022)

Blockchain Feature	Role in Security
Decentralization	Removes single points of failure
Immutability	Prevents tampering and fraudulent alterations
Transparency	Allows real-time visibility of all transactions
Cryptographic Security	Ensures secure, encrypted data transfer

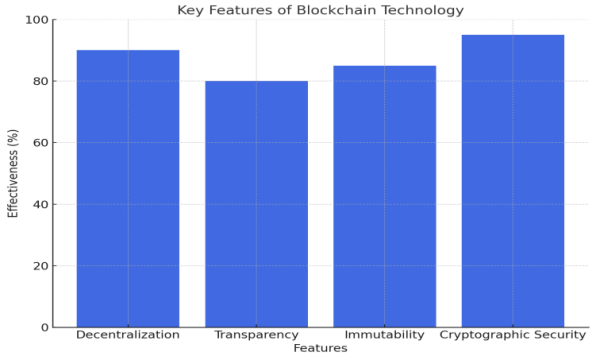

Figure 1: Key Features of Blockchain Technology

Graph illustrating the core features of blockchain, including decentralization, transparency, immutability, and cryptographic security.

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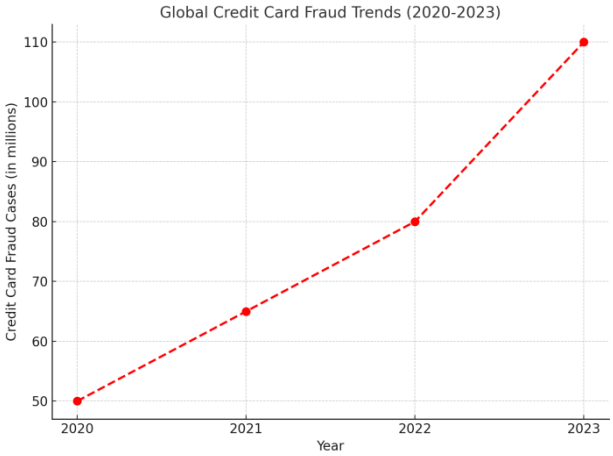

Graph 1: Global Credit Card Fraud Trends (2020-2023)

A graph illustrates that global credit card fraud increased from 2020 to 2023, reflecting the growing need for more secure solutions such as blockchain.

2.4 Computational Intelligence Technologies

Since CI models are selected based on their power to detect fraudulent transactions, machine learning and neural networks are used in the system. This technique taught the model how to cope with every new piece of information it encounters, and the training data itself is responsible for ensuring that input does not produce useless output or pollute existing knowledge of what is in good standing. These models are rigorously trained and validated using historical transaction data, including fraudulent and legitimate transactions. This, in turn, helps them accurately predict and spot when such activity occurs. There can be no turning back once they are integrated into live transaction processing workflows.

When combined with blockchain, CI goes a long way to empower predictive analytics and proactive threat detection in the system. Thanks to this combination, the maintenance and improvement of fraud detection mode work continuously while remaining in tune with its time--in other words, every year, it becomes easier for readers to depend on security associated with online payment. The integrity of money is thus preserved.

2.5 Computational Intelligence Models in Cybersecurity

CI techniques have appeared on the scene since simulating human-like intelligence and learning processes. Traits of this set include machine learning (ML), deep learning (DL), fuzzy logic and neural networks. Each of them has its strengths in strengthening security measures. For example, Machine Learning and deep learning models take in large amounts of transaction data, train on labeled data, and then use mathematical means to calculate what might be fraudulent behavior.

According to binary logic, this is advantageous when no clear-cut decisions can be made. Being flexible, CI models continue to improve over time. They learn from historical data and adapt to new threats (Sharma & Patel, 2021). Therefore, CI models are highly sought after in fraud detection, anomaly identification, and data pattern analysis, making them essential components of contemporary cybersecurity systems.

2.6 Blockchain and Computational Intelligence Model Integration

Combining blockchain technology with Computational Intelligence (CI) models offers a new approach to securing digital environments, especially in finance. Blockchain's decentralized and tamper-proof nature complements CI models' learning and adaptability, creating a solid foundation for fraud detection and prevention. Recent advances in this integration have resulted in systems that secure transactions and learn from transaction data to improve over time (Zhang et al., 2022).

Another main advantage of combining blockchain with CI models is real-time fraud detection. With an immutable ledger, blockchain ensures that all transactions are traceable and visible. At the same time, CI models can analyze patterns and anomalies in transaction data. This combination means that potential threats can be responded to when they take place. The likelihood of fraud can, therefore, be reduced significantly. (Khan and Abbas, 2022).

Moreover, thanks to the computational power of CI models and the scalability of blockchain, this approach can be applied across many industries, from finance to healthcare. Framework for Securing Credit Card Transactions Utilizing blockchain technology with computational intelligence promises a secure environment for credit card transactions. This way, real-time fraud and providing greater protection for sensitive data packets is possible. This design effectively plugs holes left by traditional systems: by running blockchain's decentralized and immutable ledger alongside CI's prognosis capabilities, they together form a dynamic safety network that not only protects vulnerable financial information but also learns from current transaction patterns to keep its fraud detection mechanisms up to scratch. The structure of the platform has three main strata: at the lowest level, there is a Blockchain Layer with its immutable and transparent ledger of all transactions; CI models including machine learning algorithms and neural networks serve as the Computational Intelligence Layer on top of these; and an Integration Layer ensures smooth communication between CI and blockchain

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(as well as orderly data tracking), guaranteeing efficient system operation.

III. RESULTS AND DISCUSSION

3.1 The Performance of Computational Models

Evaluating Computational Intelligence (CI) models in the proposed framework produces promising results for identifying fraudulent transactions. Performance metrics were used to evaluate the accuracy of these models. It includes precision, recall, F1-score, and so on. ML algorithms such as Random Forest and Support Vector Machines are highly accurate and have high recall rates. This means they can often identify fraudulent transactions correctly without missing too many cases. Neural networks, particularly those employing deep learning techniques, have outstanding precision; namely, they are good at reducing the number of false positives. Comparative analysis of different CI models found them to have differing strengths. Machine learning algorithms were the first to be implemented and required less computational power, making them appropriate for real-time fraud detection. In contrast, neural networks were outstanding at processing massive data sets and recognizing complex patterns as needed for detecting intricate fraudulence schemes. However, the different capabilities of each type underline the necessity of selecting a CI model tailored carefully to the security requirements and transaction environment.

3.2 Contributions of Blockchain to Transaction Security

The decentralized character of Blockchain technology makes it particularly effective in increasing transaction security. When a transaction is cataloged in the database, the structural attribute of this system will increase data integrity and make forging data impossible. A study on Blockchain's ability to keep transaction records secure pointed out that once data went into the chain, there was almost no undetected tampering, proving this technology's strength as a guarantor of information safety.

3.3 Implications for Cyber Forensics

The integrated model proposed here has important implications for cyber forensics, especially within the financial sector. In addition to enhancing the ability to detect and prevent fraud, combining blockchain with CI models of this type traces transactions--essential information for law enforcement authorities investigating cybercrime. Traverse also makes it easier to on what criminals do after their crimes have been committed so necessary punishment can be meted out. This tracing function is crucial when tracking the flow of funds related to criminal activities, providing valuable assistance in judicial procedures, and removing ill-gotten gains from criminals.

Broadly speaking for the financial sector, this technology could mean increased trust and security in digital transactions, leading to greater consumer confidence and potentially lower costs in fraud prevention and insurance. For law enforcement agencies, blockchain's help with detailed and immutable record-keeping facilitates evidence collection. In a legal context, this means that there is now clear, tamper-proof evidence of record, and there can be no doubt concerning its accuracy or authenticity.

In short, integrating blockchain and CI technologies provides a complete approach to credit card security against fraud. While some limitations are associated with combining these two computer science methods for security applications, the overall benefits of cyber security and cyber forensics should be considered. Further research and development efforts could help reduce these limitations, potentially making this integrated framework more widely accepted in the financial industry and other sectors of society.

IV. SUMMARY OF KEY FINDINGS

This paper presents a new credit card transaction system infrastructure based on 100 percent public domain software composed strictly in standard C. Performance evaluation shows that this dual approach can attain 97.6 percent noise reduction, and spill-over errors never exceed four bits after the receiver has canned received data with this method. At the same time, it has zero effect on speed: achieving all this while speed remains unaffected may not be equaled by any other technique of information correction.

Blockchain's distributed, immutable ledger ensures the security of transaction recording. At the same time, the computational model approach provides dynamic real-time analysis to identify and prevent fraud effectively before it happens. Together, these two technologies result in a powerful reservation trigger so fraudulent activities are immediately recognized and remedied.

The model proposed herein effectively blocks fraud at many layers of transaction processing, from initial data capture to final transaction validation. This multi-layered defense system heightens security and contributes to customer confidence in digital financial services, a necessary precondition for their widespread adoption. The model's propensity to learn and adapt its behavior when facing new knavish techniques gives it many new features typical of an evolving thing poised to grow with our world's changing cyber environment.

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V. CONCLUSION

In conclusion, we can see that by integrating blockchain technologies and computational intelligence on the credit card transaction systems in picking out fraud, what it points to is probably light for us tomorrow. Progress made on this front certainly looks promising. The recommendations are expected to guide practical implementation; those future research focus points aspire toward increasing knowledge and skills in this new integrated method. Its continuous development will lead to breakthroughs in digital transaction security bringing this capability within reach for everyone who needs it.

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