Towards the use of Blockchain Technology in SEI, a Brazilian Electronic Document and Process Management Tool

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"This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001"

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Abstract. *The Sistema Eletrônico de Informação (SEI) is a Brazilian system that manages electronic documents and processes, promoting administrative efficiency and transparency. The SEI is part of the National Electronic Process Initiative (PEN), and its implementation contributes to modernization and efficiency in Brazilian public administration. Blockchain technology with Smart Contracts can help the Brazilian Federal Government avoid security and technology problems. By addressing these challenges and leveraging the inherent benefits of blockchain technology, the Brazilian government can unlock new opportunities for improving the reliability, security, and efficiency of its information management processes within the SEI.*

1. Introduction

The Electronic Information System (SEI) [Silva& Barbosa 2020] is a Brazilian system that manages electronic documents and processes developed by the Federal Regional Court of the 4th Region (TRF4). It was created in 2009 to improve public institutions' administrative efficiency and transparency [Cedro & Duque 2019]. SEI streamlines processes, eliminates paper use, saves on paper and postage costs, and ensures greater transparency to administrative records. It is part of the National Electronic Process (PEN) [de Freitas Nogueira & de Almeida Costa 2017], a joint initiative by public administration bodies to build a public infrastructure of electronic administrative processes and documents. The federal public administration prefers to adopt SEI.

The SEI offers advantages such as monitoring processes in digital media, online signing of documents, increased productivity, reduction in paper consumption, and access by various devices (notebooks, cell phones, tablets). Its implementation contributes to the efficiency of public management and the transparency of work processes. With the launch of "SouGov.br", which aims to integrate several services into a single interface, SEI will be part of this transformation. All activities of other platforms, such as *Sigepe Banco de Talentos* and *Sigesp Gestor*, are expected to be gradually transferred to the new system. The SEI is an essential tool for the modernization and efficiency of the Brazilian public administration, promoting digitalization and improving the management of documents and processes.

Blockchain technology was initially created for use in cryptocurrency applications [Nakamoto 2008]. It operates as a transparent, tamper-resistant digital ledger that is implemented and works in a distributed network of peer-to-peer nodes. Transactions within a blockchain are securely recorded without the need for central approval or a

trusted authority. Each transaction is hashed and stored in blocks, forming an immutable chain of records. Blockchains enable peer-to-peer data exchange without intermediaries, covering various domains like money, contracts, land titles, medical records, and accounting.

Blockchain technology can enhance transparency, accountability, and public trust in SEI by making transactions visible and traceable. It also ensures immutability, preventing data alteration. Blockchain's cryptographic techniques protect against unauthorized access and tampering, and its decentralized architecture reduces reliance on a single point of control. It facilitates secure data sharing across government agencies while maintaining privacy. Additionally, blockchain can enhance the validity and security of digital signatures used in SEI [Lykidis, Drosatos & Rantos 2021]

Smart Contracts [Xavier & Duque 2021] in SEI can automate processes, reducing bureaucracy and enhancing efficiency. Blockchain networks can face scalability issues when handling many transactions, which can be challenging. Migrating SEI to a blockchain-based system requires careful planning [Kuroki Jr & Gottschalg-Duque 2024] and integration; another question is establishing legal norms and regulations for blockchain adoption. Training government officials and users about blockchain technology is essential. This proposal recognizes the potential of blockchain technology to improve government governance. It considers the advantages and disadvantages of implementing blockchain in SEI.

2. Understanding Immutability in Blockchain

Immutability in blockchain technology means that data cannot be modified, deleted, or tampered with without consensus among network participants. When a new transaction is generated within the SEI and stored on the blockchain, it integrates into a block, each holding a cryptographic hash of the preceding block. Once a block is added to the chain, its contents become immutable, making it crucial to achieve agreement among network participants for maintaining immutability in Consensus Mechanisms.

Blockchains can be distinct consensus mechanisms, Proof of Work (PoW), Proof of Stake (PoS) and Proof of Authority (PoA), among other options, ensure that all network nodes unanimously validate transactions. Specifically for the SEI, any alteration to an official record necessitates consensus from most participants, rendering unauthorized modifications practically unfeasible. [Durham 2023] [Fahim, Rahman & Mahmood 2023] [Youn-A 2021].

2.1 Benefits for SEI

The SEI manages crucial government documents, encompassing contracts, legal rulings, and administrative communications. Leveraging the immutability of blockchain, SEI ensures the integrity of these records. Once a document is recorded on the blockchain, it remains unaltered, establishing a dependable historical trail. In traditional systems, authorized and unauthorized users can alter or delete records. However, with blockchain technology, unauthorized modifications are virtually eradicated. Any attempt to tamper with data would necessitate altering subsequent blocks—a computationally infeasible task due to the cryptographic interconnections between blocks. The immutability of records within the SEI ensures both transparency and auditability. If access to the

blockchain, it can verify the complete history of a document, fostering trust among stakeholders—including citizens, government officials, and external auditors. But, the public employees' and users' resistance to adopting blockchain is a severe problem that cannot be ignored; despite the advantages in adopt new technology [Tanniru et ali 2021].

3. Understanding Smart Contracts

Smart contracts are an application of blockchain technology that can significantly improve the functionality of self-executing immutable systems (S-EIS). These contracts are encoded on the blockchain, allowing for automated actions based on predefined conditions. Smart Contracts can speed up administrative tasks and workflows, such as document routing, approvals, notifications, and reminders. By automating these processes, smart contracts eliminate the need for manual intervention and ensure consistency. Secure automation is particularly useful in government document processes such as creation, review, approval, and archiving.

Smart contracts streamline document lifecycles by initiating workflows, triggering approvals, and automatically archiving documents. They enforce approval hierarchies across multiple levels, halting progression if rejected. They can send notifications and reminders to relevant parties, assign reviewers when due, and escalate notifications to higher authorities if deadlines are missed, ensuring timely action and accountability.

Blockchain technology enables governments to integrate smart contracts into their operations, providing an immutable audit trail of document lifecycles, approvals, and notifications. This transparent and tamper-proof record allows auditors and stakeholders to verify events, fostering trust and accountability. By integrating smart contracts into SEI, governments can streamline administrative processes, ensure compliance with approval workflows, and maintain a transparent record of all actions.

4. Smart Contracts in SEI

The power of smart contracts within a self-executing immutable system (S-EIS) becomes evident when considering the lifecycle of a government contract. From inception to execution, smart contracts can streamline and automate the entire process, ensuring efficiency, transparency, and compliance. It starts with creating a new contract drafted and uploaded to the SEI platform. Upon submission, a smart contract is automatically initialized, assigning appropriate reviewers and setting deadlines for each stage of the review process. This automated workflow management eliminates manual coordination and ensures the contract progresses through the necessary channels without delay.

Designated reviewers can access the document within the SEI system as the contract enters the review and approval phase. Each reviewer thoroughly evaluates the contract's terms and conditions, providing feedback, approval, or rejection. The smart contract monitors this process, and when all reviewers have approved the contract, it automatically triggers the final approval stage. However, if any reviewer rejects the contract, the smart contract halts further progression and notifies the relevant parties, ensuring that no unapproved or non-compliant contracts move forward.

Once the contract has successfully navigated the review and approval process, the smart contract automatically archives the final version, creating an immutable record on the blockchain. This permanent and tamper-proof record is a valuable reference for future audits or disputes. Furthermore, the smart contract takes care of notifying all relevant stakeholders about the successful completion of the contract. For instance, it can notify the legal department for record-keeping purposes, ensuring the contract is appropriately cataloged and accessible for future reference.

Additionally, it can notify the finance department to initiate payment processing, ensuring that the contractual obligations are fulfilled promptly and accurately. By leveraging the power of smart contracts within SEI, government agencies can streamline the entire contract lifecycle, from creation to execution. This automated and transparent process enhances efficiency, promotes accountability, reduces the risk of errors or omissions, and fosters trust among all parties involved.

5. Implementation and Challenges

Implementing blockchain technology within the SEI requires careful consideration of the technical aspects, particularly selecting an appropriate blockchain platform. This choice will significantly influence the system's performance, scalability, security, and compatibility with existing frameworks. There are many possibilities, but we will focus on two technologies, Ethereum and Hyperledger, because of their characteristics:

Ethereum (2015) is a popular option due to its mature ecosystem and widespread adoption. By leveraging Ethereum, SEI could benefit from the platform's existing developer tools, libraries, and a vast community support network. However, it is crucial to acknowledge Ethereum's scalability challenges, such as high gas fees and network congestion, which may impact SEI's performance and efficiency.

Another approach is Hyperledger Fabric (2016), a permissioned and modular blockchain framework. Fabric offers fine-grained control over access permissions and consensus mechanisms, allowing SEI to tailor the system's security and governance models to specific requirements. Fabric's enterprise-grade features and flexibility are advantageous for SEI's implementation, enabling seamless integration with existing systems and processes.

An alternative approach is Hyperledger Besu (2019), an open-source Ethereum client developed under the Apache 2.0 license and written in Java. It runs on public networks (such as Ethereum Mainnet and public testnets like Goerli and Sepolia) and private permissioned networks.

Each platform offers unique advantages and trade-offs, and a comprehensive assessment will be necessary to determine the best fit for SEI's implementation. Regardless of the chosen platform, integrating blockchain technology can revolutionize government operations, enhancing the system's transparency, efficiency, and accountability.

Data storage and encryption strategies necessitate careful consideration when implementing blockchain in SEI to ensure the system's efficiency, security, and privacy. Effectual data management is decisive for maintaining the integrity and confidentiality

of sensitive information while leveraging the benefits of decentralized, immutable ledgers. The implementation's success depends on its seamless interoperability with existing infrastructure and components, such as legacy databases and APIs, critical to SEI's operations. Ensuring compatibility and interoperability between these systems and new blockchain-based components is crucial for a smooth transition and uninterrupted service delivery.

Using a Hyperledger Besu to create a permissioned Consortium Blockchain, this new proposed SEI module permits the responsible for creating and distributing the contracts in traditional SEI to create the Smart Contracts in the new module, the alternative net. SEI users know that the security problem at SEI is constant and causes losses to institutions. Constant attacks, like hacker activities, invasions, fraud, and deletion of files, whether due to sabotage or malpractice, are realities that cannot be ignored. Blockchain and smart contracts can mitigate such actions, which are harmful to governments and institutions today.

6. Discussion and Conclusion

Integrating blockchain technology into the SEI can significantly enhance transparency, efficiency, and data integrity within the Brazilian government's information management processes. The case studies and real-world applications have highlighted the key benefits of blockchain, including improved transparency and trust, increased workflow efficiency through automation, and enhanced data security and integrity. However, the successful adoption of blockchain in the SEI also faces several limitations and challenges, such as scalability, interoperability, regulatory compliance, and user resistance to change.

Addressing these issues cited previously satisfactorily requires a multimodal strategy, including developing scalable and high-performance blockchain solutions, establishing interoperability standards, creating regulatory and governance frameworks, and implementing user-centered design and education strategies. Scalability is one of the main limitations of blockchain technology, which becomes crucial as the adoption and usage of the SEI continue to grow. As the volume of documents and the number of users within the government ecosystem increase, the blockchain network must handle the growing demand without compromising performance and efficiency.

There are at least three possibilities to solve the scalability problem: Sharding, Layer-2 Solutions, and Parallelized Execution, and a combination of these solutions is possible, too. High performance can be solved using Consensus mechanism improvements; also, using Sharding and Layer-2, the interoperability problem can be solved, or part of it, using these techniques: Bridging: Exchanging tokens and data between networks using digital bridges; Certificate Creation: Verifiable data across networks; Parachains: Sharded chains connecting applications through foundational layers; Cross-Chain Messaging Protocols: Read/write data between blockchains, enabling cross-chain dApps.

Smart contracts can be used to solve regulatory compliance. Education and awareness can solve the user's resistance to change. By addressing these challenges and leveraging the inherent benefits of blockchain technology, the Brazilian government can unlock new opportunities for improving the reliability, security, and efficiency of its

information management processes within the SEI. Continued research, cross-agency collaboration, and the implementation of pilot projects will be crucial in driving the widespread adoption of blockchain in the government sector and shaping the future of this transformative technology.

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