A distributed model for sharing tendering project information in the South African Local Government

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***Abstract*—The South African Local Government uses the tendering system to deliver some of the basic services to the surrounding communities to promote social and industrial or environmental policies. However, this process still relies heavily on a manual process, which requires skilled personnel to deal with the forms and administrations of the entire tendering process. Some of the project information shared by the supplier during the tender bidding process plays a critical role when it comes to awarding a tender project to a particular supplier since it reflects the competency area and project history. Some of the tools used to share this project information are reports, meetings, presentations, and site visits. Therefore, this study proposes a distributed model that might be used to share tendering project information securely and efficiently with all the parties that have an interest in the tendering project. The proposed model seeks to promote the need for sharing project information while eliminating issues that are related to a single point of failure or having an organisation that has central powers over project information. Additionally, the proposed model can also be used to foster collaboration between the public and private sectors by becoming an essential tool that might be used to securely share project information without colluding. The proposed model also incorporates the benefits and promises that come with the adoption of distributed ledger technology (blockchain) as a technology solution.**

Keywords—Tendering system, South African Local Government, Project information sharing, Distributed ledger, Blockchain

I. INTRODUCTION

The South African organs of state have adopted the use of information and communication technologies (ICTs) as a tool that enables them to perform certain tasks. One of the main reasons for these organs of state to adopt the use of ICTs is that some of their tasks require innovations when it comes to issues related to collecting, processing, and analysing digital information. Digital information can be viewed as data that requires electronic devices such as personal computers or laptops to process and manipulate it. However, some of the tasks of these organs of states still rely heavily on a manual process, whereby they still require the use of paperwork to achieve certain tasks. For instance, all the South African organs of the state still require their suppliers to submit documents whenever there is a tender bidding process. Some of the information used within this process is regarded as essential because it can be used as a deciding factor when it comes to awarding a tender project. Tendering can be viewed as an essential procedure for some of the organisational operations as some of these organs of the state rely heavily on this process to procure goods and services. Tendering can also be viewed as the central method used by the organs of state to deliver some of the basic services to the surrounding communities with an aim of promoting social and industrial or environmental policies [1]. However, tendering can only be regarded as an essential tool if the procedures and principles that underpin it are adhered to [2].

The process of sharing tendering project information might raise some security concerns because illegal information might be used to influence the decision of the tendering committee who are tasked to award the tendering project. The tendering committee only relies on the documents submitted by the supplier who seeks to participate in the tender bidding process. Therefore, the use of a referee and other methods such as sending reports, meetings, or presentations using electronic mail as a mechanism to confirm whether the information shared with the tender committee is true or not, might raise data integrity concerns, because the information might be altered for corrupt purposes at any given stage. Hence, the current tendering system (CTS) still relies heavily on manual processes, which require skilled personnel to handle the forms and administer the entire process [3]. The primary problem of this study is the use of conventional methods such as meetings, reports, presentations, site visits, etcetera to share project information with the parties that have an interest in the tendering project since these methods are prone to fraudulent actions.

The remainder of this study is structured as follows: *Section II* provides a brief overview of the background concepts related to the tendering system used by the South African Local Government (SALG). *Section III* details the research method adopted by this study. *Section IV* provides the details that seek to explore the technology description adopted by this study. *Section V* presents the proposed model used to share tendering project information securely and efficiently. Thereafter, the theoretical use-case of the proposed model is presented in *Section VI*. *Section VII* explores details of the related work, which includes comparing them with the proposed model. Finally, the last section, which is *Section VIII* details the conclusion, as well as the future work related to this study.

II. BACKGROUND

The South African Government is comprised of three spheres, namely National, Provincial, and Local Government. The National Government is responsible for overseeing the Provincial Government, while the Provincial Government oversees the Local Government. However, the delineation of this study lies in sharing tendering project information within the Local Government because it is regarded as the smallest sphere used by the South African Government to deliver some of the basic services to their surrounding communities. Some of these basic services or projects have a direct impact on these communities since they might be intended to either develop the surrounding communities or improve the socio-economic standing of that community. The SALG is divided into three types of municipalities, namely Metropolitan (also known as Metro), District, and Local Municipalities as shown in Figure 1. The District and Local municipalities share their responsibilities when it comes to executing some of the projects, while Metros are regarded as standalone municipalities since they report directly to the Provincial government. However, these municipalities use Supply Chain Management (SCM) as a tool that guides the execution of their projects, and the South African National Treasury is responsible for implementing the SCM [4]. The SCM requires these municipalities to have their role players in-place who are responsible for executing these projects to address the issue of

accountability. Additionally, all these processes are bounded by the legislative frameworks and pillars of procurement [5]. Therefore, Figure 1 summarises this section by visualising the concepts that interact with tendering projects.

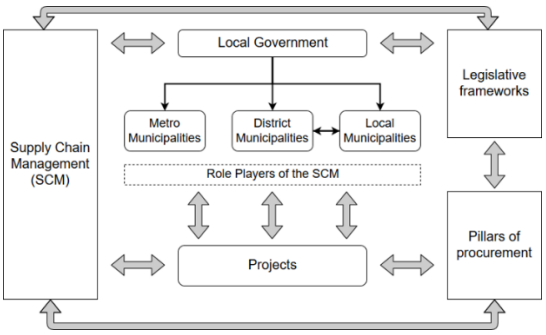

FIGURE 1: LOCAL GOVERNMENT TENDERING PROJECT CONCEPT

The following items seek to provide a high-level overview of the concepts highlighted within Figure 1.

- *SCM*: this is the process that seeks to manage all the activities associated with the procurement process [6]. Note that the procurement process requires suppliers to share some of their information in relation to their competency area and project history when they bid for tendering projects. Additionally, the information shared by the supplier is also used for decision-making purposes, especially when it comes to awarding a specific tender project to a particular supplier.
- *Legislative frameworks*: these are the legislations that seek to govern the procurement processes used by the SALG. The legislation that seeks to govern the procurement processes are *Constitution* [7], *Preferential Procurement Policy Framework Act* [8], and *Municipal Finance Management Act of 2003* [9].
- *Pillars of procurement*: all the procurement legislation are incorporated with the core pillars of procurement to ensure that all the procurement processes are adhered to. The South African Government, through the Public Finance Management Act of 1999 has identified five pillars that need to be considered during the procurement process. These pillars are "*value of money"*, "*open & effective competition"*, "*ethics and fair dealings"*, "*accounting & reporting"*, and "*equity"* [4] [10].
- *Role players of the SCM*: these are the individuals accountable for the procurement processes executed by their municipality and these role players are the Municipal Council, Account Officer, and the Municipal SCM Unit [9] [11].

The section introduced the concepts associated with the tendering project within the SALG. The following section explores an overview of the CTS used by the SALG with the aim of visualising how various stakeholders interact with the project information of their interest.

A. SALG current tendering system overview

The CTS used by the SALG requires all the municipalities to share some of their project information with the affected parties, such as communities and investigators. Communities act as the beneficiaries of some of these projects, while the investigators are responsible for investigating irregularities that might occur during the execution of some of these projects. Additionally, these municipalities are also required to share their financial reports of these projects with their auditors because they are responsible for overseeing how these municipalities use public funds. The communication channel used by these municipalities to share project information is structured in a centralised manner whereby municipalities are seen as the centre that distributes project information to all the parties that have an interest in the project information as shown in Figure 2. Furthermore, this communication channel relies heavily on paperwork to share project information, even though some of this information is used for decision-making purposes, especially when it comes to awarding a tender to a particular supplier. Figure 2 seeks to summarise the concept discussed within this section by visualising how the current project information-sharing concept works.

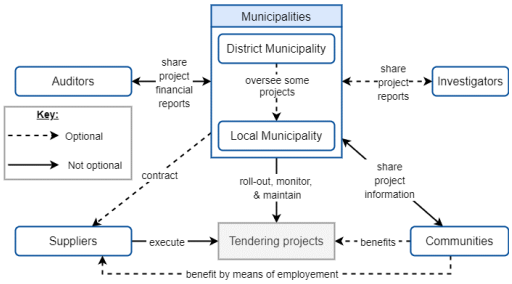

FIGURE 2: CURRENT PROJECT INFORMATION-SHARING CONCEPT

B. The importance of monitoring tendering projects

Tender projects play an important role in stimulating the development of many countries since some of these projects are designed to improve their infrastructure while also empowering the surrounding communities. As indicated in the previous section, the government uses tender projects to deliver some of its services and it also invests a huge amount of money to fund such projects. Therefore, having the legislations, pillars, and role players in place to govern the procurement processes does not ensure the successful implementation of these projects. However, there are some aspects that need to be considered that contribute to getting the best benefits and value for money out of these projects. These aspects are monitoring and assessment of projects. Otieno [12] distinguishes these aspects as follows: Monitoring of projects is "the process that provides the necessary information and ensures the use of such information by management to assess the effects or impact of the projects". Assessment of projects is drawn from "the use of data generated by the monitoring systems to analyse the impact of the project trends" [12].

These definitions emphasise that the assessment of projects depends on the monitoring tool since it aimed on ensuring whether the desired objectives have been achieved or not. Therefore, this section focuses on the monitoring of projects because this study aimed at sharing project information which falls under the provision of the necessary information for decision-making purposes. Monitoring of projects can also be viewed as a project management tool that focuses on providing continuous feedback on the project implementations. Some of the reasons behind using this aspect as a project management tool include: the assessment of the project understanding by stakeholders, minimising the risk of project failure, promoting project management, and assessing the progress of the project implementation [12]. The commonly used tools for monitoring tendering projects are verbal communication, meetings, reports, and diary notes. However, all these tools have their own limitations, and they are also vulnerable to data integrity, transparency, and accountability. Project monitoring tools act as mechanisms that lubricate the progress of the project with an aim of achieving the desired objectives [12]. Therefore, it is important to adopt an appropriate monitoring tool that will provide the maximum benefits out of the tendering project.

This section has provided the background details of the concepts that are related to the tendering system as part of trying to examine the tendering system used by the SALG. Additionally, the section provided the importance of monitoring these tendering projects to achieve the desired objectives. Therefore, the following section focuses on the research method adopted in this study.

III. Research Method

This study has adopted the following research methods to achieve the desired objectives, namely literature review and modelling methodology. A brief literature study on how the tendering system work in the SALG context was conducted, which includes the details of the adopted technology. Note that the literature covered by this study uses a wide range of materials gathered from various sources such as the South African legislation, Government documents or publications, articles, journals, textbooks, conference papers, as well as content sourced from the internet. After obtaining a holistic idea of how the tendering system work, then this study proposes a model that might be used to share project information securely and efficiently with all the parties that have an interest in it. Hence, the modelling methodology was adopted to model the proposed solution. Thereafter, a theoretical use-case was used to expand the idea behind the proposed model, which is based on a fictional use-case scenario. Lastly, the proposed model was also compared with other related work.

IV. Technology Description

There are various technologies that can be adopted to achieve the desired objective of this study. These technologies can be classified based on how they use their ledger systems to either store or share information. These ledger systems have evolved significantly over the past years from a centralised system to where it has now become distributed. Figure 3 depicts the classifications of the three main evolution stages of the ledger systems, which are centralised, decentralised, and distributed. However, this study adopts the distributed ledger system (DLS) because it does not have issues related to a single point of failure. Additionally, it also seeks to share project information among all the parties that have an interest in the project or its information.

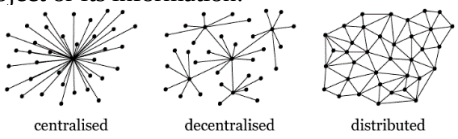

Figure 3: Evolution of ledger systems [13]

ASTRI [14] defined distributed ledger technology (DLT) as a "technology protocol that can be used for developing a replicated and shared ledger system that stores a wide range of assets and transactions in a distributed manner". This implies that a DLS is regarded as a shared ledger system since its records of transactions are maintained across several locations or among multiple nodes, regardless of their geographical location [15]. Basically, this means that all the nodes that are found within that network have the same copy of the ledger. Hence, a DLS does not consist of a central repository or a single point of failure like a centralised ledger system. However, every time when a specific node in a DLS has made some valid changes on the ledger, those changes are propagated automatically and shared with other nodes that form part of the network. Additionally, this mechanism of sharing information is also aimed at maintaining data integrity across all the nodes within that network.

Note that the DLT has become more prevalent in 2008, after the circulation of a white paper titled "Bitcoin: A Peer-to-Peer Electronic Cash System" authored by Satoshi Nakamoto [16]. The white paper proposed a solution for the financial industry that addresses the issue of double-spending and eliminating the norm of using intermediaries. However, the ideology of the proposed solution existed theoretically [19, 20], until 2009 when the first DLT implementation (Bitcoin system) emerged by Satoshi Nakamoto [16]. The underlying technology used by Satoshi Nakamoto to implement the Bitcoin system was termed "Blockchain" technology. Blockchain refers to the ways in which the proposed system stores and organises its information. The word "Blockchain" is a combination of two words namely "block" and "chain". Therefore, DLTs use blocks to store their information, and these blocks are linked together to form a chain-like data structure, hence "Blockchain". As time progresses, similar ways of organising and storing information emerged which led to the term DLTs as a broad term used to categorise such technologies [15].

V. A Proposed Distributed Model for Sharing Tender Project Information

The proposed model aimed at sharing project information securely and efficiently among various parties that have an interest in the tendering project. Therefore, to achieve this objective, the proposed model must incorporate the following components namely: *actors*, *gateway*, and *Blockchain network*. These components are explored in detail in later sections, however, for the convenience of the reader to understand the basics of the logic behind the proposed mode, the components are briefly explained below:

- *Actors*: are the role players of the proposed model and may for example consist of various organisations and their members.
- *Gateway*: allows actors to interact with the Blockchain network of the proposed model, including the policing mechanism.
- *Blockchain network* stores and distributes project information among all the actors that have an interest in the tendering project.

Figure 4 depicts an overview of how these components (*actors*, *gateway*, and *Blockchain network*) interact with each other.

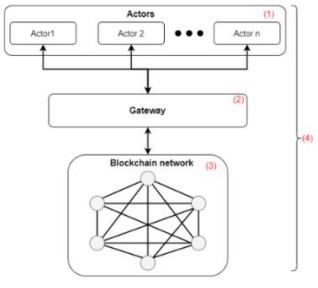

Figure 4: ShareTendPro model overview

As highlighted in Figure 4, this study adopts the following approach to explore how these components work in the proposed model.

1. Identify the actors of the proposed model.

2. Establishing the gateway that will be used to identify and authorise actors as they interact with project information.

3. Establishing the Blockchain network that can be used by the proposed model to securely store and share project information.

4. Defining the ShareTendPro model, which is the integration of steps 1–3 above.

All these steps are discussed in detail in the following subsections to outline the details of this approach.

A. Identifying actors

They are number of actors that might have an interest in the tendering project information and these actors can be classified into two categories namely: *main actors* and *additional actors*. The following items explore the details of these two categories.

1. Main actors: are all the actors that have a direct interaction with the tendering project information and these actors includes:

a) District Municipalities (DMs): they are responsible for rolling out, monitoring, and maintaining tender projects that fall under their mandate, including overseeing some of the projects executed by their Local Municipalities (LMs). Hence, their role within the proposed model will be creating a tendering project, sharing project information, and accessing project information of other municipalities.

b) Local Municipalities: their roles are almost the same as the roles explored within the DM, besides the role of overseeing other projects. Hence, their role within the proposed model is also the same as the roles assigned to the DMs.

c) Communities: they are the beneficiaries and stakeholders of some of these projects. Hence, the municipalities are required to share some of their project information with these communities at some point. Therefore, their role within the proposed model is to access and share project information.

d) Suppliers: these are organisations that seek to render certain services on behalf of these municipalities (i.e., DMs or LMs). Hence, all these Suppliers report directly to the municipality which awarded them the tender. Therefore, their role within the proposed solution is to create or share project information.

2. Additional actors: are all the actors that have an indirect interaction with the tendering project information and these actors are:

a) Auditors: are responsible for ensuring that municipalities account for their actions by auditing their financial expenditures to check for irregularities and misuse of public funds. Hence, their role within the proposed model is to access project reports and share their audit reports.

b) Investigators: are responsible for gathering all the possible evidence that identifies the occurrence of illegal activities within a tendering project. Hence, their role within the proposed model is to access project information related to their investigations.

Figure 5 depicts the interaction of the following actors with the tendering project information: DM, LMs, Auditors, Investigators, Communities, and Suppliers.

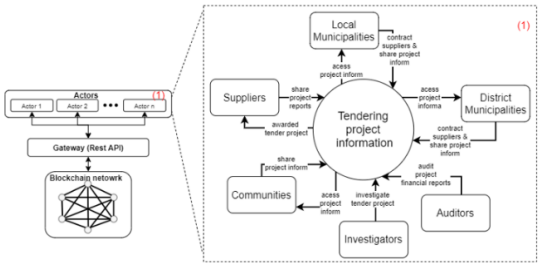

FIGURE 5: ACTOR COMPONENT

The following section explores the gateway component as used by these actors to interact with the tendering project information stored within the proposed model.

B. Establishing the gateway

The Blockchain technology uses a gateway component to separate the role played by various actors within the network. However, some of the Blockchain frameworks achieve this by using the following mechanisms:

- *REST-API:* allows various actors to use an application programming interface (API) to interact with the Blockchain network. In other words, this process exposes the deployed network as a REST-API that allows authenticated actors to interact with the Blockchain data using queries. All the transactions submitted through the REST-API are assigned an HTTP request operation which either creates, reads, updates, or deletes data stored within the network. In addition, all these transactions will also be assigned a digital certificate to preserve non-repudiation.
- *Access control list (ACL):* manages the access rights of all the authorised actors as they interact with the Blockchain data. These access rights can be categorised into two namely read and write access rights. For instance, communities, suppliers, auditors, and investigators are not allowed to write or create tendering project information, however, they are allowed to read or view some of the details contained within it.
- *Secure communication channels:* allow a specific group of actors to secretly share project information. For instance, a channel might be created for certain LMs that fall under a specific District to share project information since some of their tendering projects are overseen by a particular DM.

Figure 6 represents the above mechanisms, i.e., *REST-API*, *ACL*, and *secure communication channels*, used by the proposed model to manage the identities of various actors, including providing access to the Blockchain network.

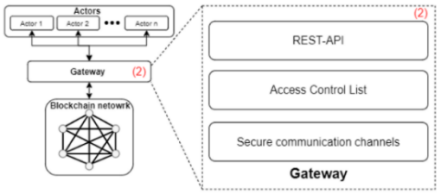

FIGURE 6: GATEWAY COMPONENT

The following section explores how the Blockchain network component works, including how project information is distributed among various actors or nodes within the network.

C. ShareTendPro model as a Blockchain network

This component focuses on the operational concept or logic behind storing and sharing project information with all the actors that have an interest in the tendering project. This component achieves this by allowing all the authorised actors to submit project information as transactions. However, all

these transactions should meet specific requirements associated with it. Hence, the Blockchain network makes use of the smart contract (SC) to govern all the transactions within the network. The SC consists of predefined conditions associated with each transaction and all the transactions that do not meet such requirements are discarded or declared as rejected by the network.

All the accepted transactions are forwarded to the ordering service for ordering. The ordering service collects all the accepted transactions and groups them into blocks, which are then distributed among all the nodes within the network. The Blockchain network component achieves this by using a DLS that allows it to distribute these blocks of transactions to various nodes. However, each node will then make use of the SC to verify these ordered transactions before appending them to the ledger. Once this process is complete and all the nodes have appended the new transactions to their ledger, then all the actors who have an interest in that tendering project will now have access to the updated project information. Figure 7 depicts how the Blockchain network component distributes project information among various nodes or actors. Part A of Figure 7 represents the information flow, while part B represents the distributed nature of the nodes or actors as they share project information.

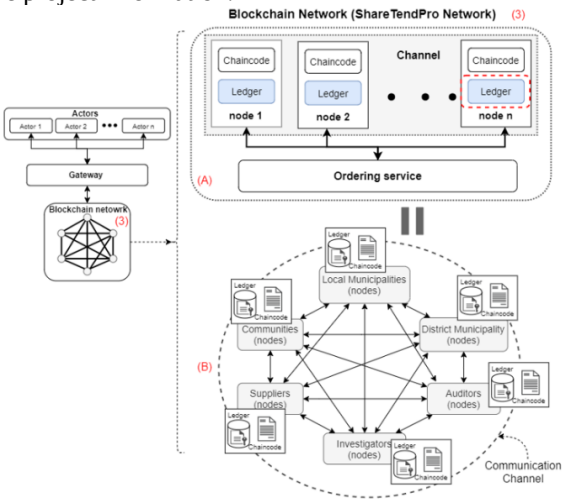

FIGURE 7: BLOCKCHAIN NETWORK COMPONENT

The following section seeks to integrate all these components (*actors*, *gateway*, and *Blockchain network*) to generate the final step labelled number 4 as shown in Figure 4.

D. ShareTendPro model as an integrated whole

This section integrates the components discussed in Figure 4 to generate a ShareTendPro model as our last step. Therefore, Figure 8 depicts a graphical representation of the ShareTendPro model as an integral of these components (*actors*, *gateway*, and *blockchain network*). It also reflects the flow of the project information as it passes through various components and objects. The numbers labelled 1-3 represent the three respective components, while number 4 can be viewed as the approach used by this study to explore how the proposed model integrates. The ShareTendPro model allows various actors to share tendering project information securely and efficiently. The Blockchain network component is one of the main key components that allow the ShareTendPro model to achieve its objectives because it is responsible for storing and sharing project information securely and efficiently.

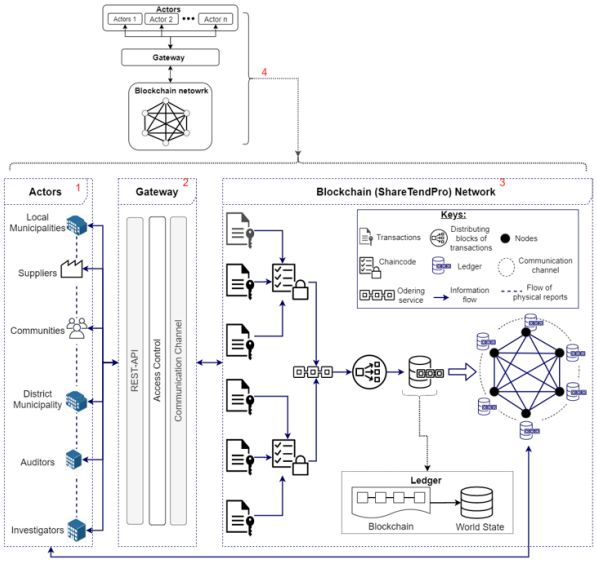

FIGURE 8: SHARETENDPRO MODEL

VI. THEORETICAL USE CASE SCENARIO

This section explores the scenario that could be addressed by the proposed solution. Therefore, the following items present the process that takes place within the scenario as shown in Figure 9.

1. *Step 1:* the LM opens tendering project X for bidding.
2. *Step 2:* various suppliers apply for tender project X by submitting tender documents to the LM.
3. *Step 3:* the tendering committee assigned by the LM assesses all the suppliers who applied for project X and submits the results of the assessment to the LM.
4. *Step 4:* the LM awards project X to supplier S based on the outcomes presented by the tendering committee.
5. *Step 5:* the LM assigns Peter to manage project X. Thereafter, Peter uses computer LM_N0 (which stands for Local Municipality node 0) to issue a progress report for project X as part of his responsibilities which seeks to portray the following progress "so far, 20% of project X was completed within four months".
6. *Step 6:* Peter shared this report with John from the Auditor's Firm who was tasked to audit the financial expenditure of tendering project X. Hence, the report acts as proof of payments associated with the work that was completed by supplier S.
7. *Step 7:* Peter also shared this report with David from the Investigator's Firm (IF) who was tasked to investigate allegations of corruption in the tendering project X. The report acts as proof of work completed by supplier S.
8. *Step 8:* later on, the DM opens tender project Y for bidding. Assume that project Y is similar to project X.
9. *Step 9:* assume that supplier S decided to collude with Peter when it comes to falsifying the report of project X to portray the following progress "50% of project X was completed within four months".
10. *Step 10:* various suppliers apply for project Y, including supplier S. Assume that supplier S has included a falsified progress report of project X when applying or bidding for project Y and included Peter as a referee who can provide more clarifications regarding project *X*.

11. Step 11: the DM assigns Martha from the tendering committee of project Y a task to request a progress report of project X from Peter as part of trying to confirm whether Supplier S managed to complete 50% of the project within four months or not. Note that Martha used computer DM_N0 (which stands for District Municipality node 0) to send an electronic mail (email) to Peter when requesting the progress report of project X.

12. Step 12: Peter submitted a falsified progress report of project X to Martha (DM_N0) at the DM.

13. Step 13: The tendering committee of the DM assesses all the suppliers who applied for project Y and submits the results of the assessment to the DM.

14. Step 14: the DM awards tendering project Y to Supplier S based on the outcome of the assessment which was motivated by the information provided by the supplier and confirmed by Peter who works at the LM.

The main objective of this scenario was to depict a loophole that might be used to tamper with the project information in such a way that it can be used to influence the decision of other projects offered by a different municipality. For instance, in the scenario, a falsified report of project X was used to influence the decision when it comes to awarding project Y offered by the DM. Figure 9 seeks to visualise this scenario as various people in different organisations interact with either a falsified or a legit report of project X. Assume that the communication mechanism used to share the report of project X was an email. Hence, Figure 9 depicted the computers used by various people in different organisations as they interact with an electronic report of project X.

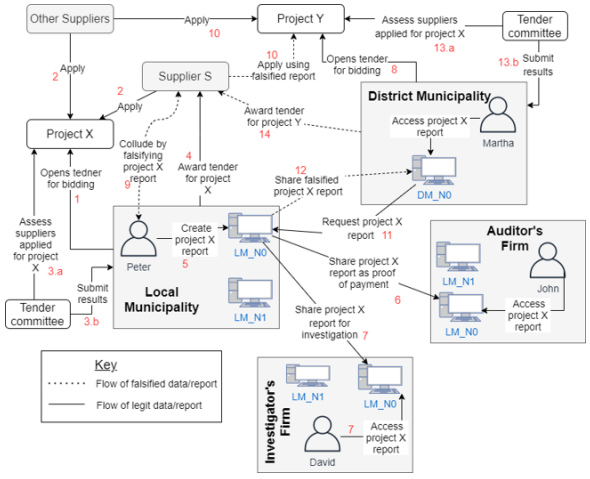

FIGURE 9: SCENARIO

To support the CTS, this study proposed a distributed model, instead of conventional email, that seeks to connect all the computers of various organisations that have an interest in the tendering project. For instance, the computers that have an interest in project X are LM_N0, DM_N0, IF_N0 (Investigator's Firm node 0), and AF_N0 (Auditor's Firm node 0) as shown in Figure 9. Therefore, the proposed model would be used as a tool that replaces email when it comes to sharing project information with all the people that have an interest in the tendering project. Additionally, the establishment of the Blockchain network also allows these computers to share project information securely while preserving the integrity of the information. The establishment of the ShareTendPro network as a solution is also aimed at enforcing trust and transparency among various organisations that have an interest in the tendering project.

Figure 10 depicts how this study addresses the identified problem within the scenario by introducing the ShareTendPro network as a solution. A more detailed discussion of the ShareTendPro solution as shown in Figure 10 follows next to solve the problem shown in Figure 9.

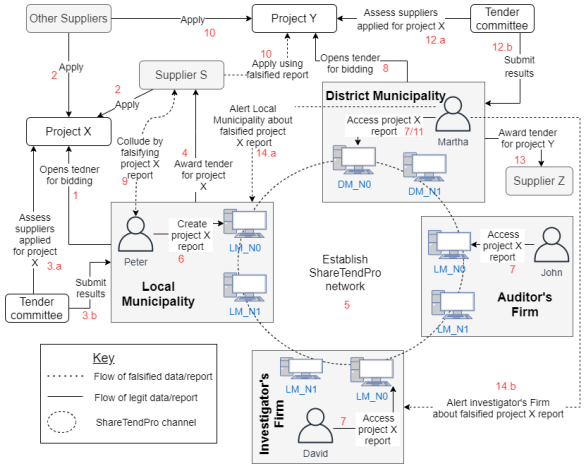

FIGURE 10: SHARETENDPRO SOLUTION

The process taking place within the ShareTendPro model is as follows:

1. Steps 1-4: these steps are similar to steps 1-4 as discussed in the scenario of Figure *9*.

5. Step 5: represents the establishment of the ShareTendPro network that would be used to share project information securely while preserving the integrity of the information.

6. Step 6: depicts Peter using computer LM_N0 to create a progress report of project X. Note that computer LM_N0 is one of the computers of the LM that has joined the ShareTendPro network – hence, the report created by Peter would be stored within the blockchain of the ShareTendPro network.

7. Step 7: depicts various computers accessing the report of project X that was created using computer LM_N0. Note that this step is automatically activated when computer LM_N0 submits the report of project X to the Blockchain network of the ShareTendPro model, whereby the ShareTendPro network distributes it to all the computers that have joined the communication channel, due to the inner workings of the Blockchain.

8. Step 8: depicts the DM opening project Y for bidding. This step is similar to step 8 of Figure *9*.

9. Step 9: depicts Supplier S and Peter colluding by falsifying the report of project X. This step is similar to step 9 of Figure 9. Later (in step 12) it will become clear how this falsification is detected.

10. Step 10: depicts various suppliers applying for tendering project Y offered by the DM, including Supplier S. This step is similar to step 10 of Figure *9*. Assume that Supplier S has included the falsified report on the tendering documents when bidding for project Y.

11. Step 11: represents Martha who was tasked by the tendering committee of project Y to confirm the progress report submitted by Supplier S within the ShareTendPro network. Note that Martha at node DM_N0 did not request the report of project X as compared to the scenario depicted

in step 11 of Figure *9* because the report is now available in the ShareTendPro network (Blockchain) as she can access it directly.

12. Step 12: depicts the tendering committee of the DM assessing all the suppliers that have applied for project Y and submitting the results of the assessment to the DM. However, the tendering committee realised that the report (i.e. document) of project X submitted by Supplier S contradicts the actual details (i.e. the report) stored within the blockchain of the ShareTendPro network. Due to this discrepancy, Supplier S is removed from the bidding process of project Y with consequences, and another supplier will need to be appointed.

13. Step 13: depicts the DM awarding tender project Y to Supplier Z. Note that this was achieved after penalising Supplier S since the information or report provided by the supplier does not correspond with the actual report stored within the ShareTendPro network.

14. Step 14: represents Martha who is part of the tendering committee of project Y alerting the LM and IF about the falsified report of project X for further investigations. The LM will conduct an internal investigation to discipline Peter, while the IF will conduct corruption-related activities or investigations between Peter and Supplier S which include acts of bribery. This, however, is out of the scope of this research and will not be shown further.

VII. RELATED WORK

There are several related works that can be associated with this study. However, some of them tend to focus more on the procurement processes, which include processes such as applying for a tender, submitting tender documents, tender bidding, and awarding of tenders [17, 18, 19, 20], including managing tender contracts or construction projects [21, 22, 23]. For instance, the following studies [18, 24, 25] can be associated with the procurement processes because they contain some of the elements that are related to tender bidding.

The framework presented by [22] focused on how the Blockchain can be used to facilitate data integrity within the document management for construction projects, while the study done by [26] also proposes a model that focuses on managing tendering contracts. The Mexican Government also implemented a similar tool that seeks to manage the contract of their procurement processes [27]. This study has noted that most of these proposed concepts or prototypes make use of the Ethereum platform to achieve their desired objectives, while some of them use a deprecated tool called Hyperledger-composer (HLC). The Ethereum platform relies on miners to add new transactions to the network, and it also uses the native cryptocurrency called Ether [28]. The HLC tool is regarded as a deprecated tool because none of its maintainers are actively providing support or developing new features on it [29].

All these studies tend to share tendering project information with a limited number of parties, especially parties that are involved in the procurement processes. A study done by [22] presented an open government concept that seeks to promote transparency within the procurement processes and the importance of sharing project information with various parties that have an interest in it. The following study [23] proposed a framework that might be adopted by the South African government to reduce corruption and other issues that emanates from managing procurement contracts. However, this study took a slightly different approach since it proposes a concept that can be used to monitor the tendering project, including sharing project information securely and efficiently among various parties that have an interest in the tendering project. Therefore, Table 1 depicts the comparison of the related works and the ShareTendPro model. Note that the comparison is based on the features or potential benefits offered by the adopted technology solution.

Table 1: compares related work with the ShareTendPro

Related work	Support private Blockchain	Support smart contract	Share tender information	Does not use deprecated tool	Does not use cryptocurrency	Not used for tender bidding	Does not use mining
[17, 18, 19, 20, 21, 22, 25, 30, 31]		√	√	√			
[23]	√	√	√	√			
[24]	√	√	√		√		√
[26]		√	√			√	
ShareTendPro	√	√	√	√	√	√	√

As indicated in Table 1, the ShareTendPro model met all the features or potential benefits offered by the adopted technology solution. However, only two of the related work support the configuration of a private Blockchain network, which implies that others are configured for either public Blockchain or public-permissioned Blockchain. Note that a public Blockchain network enables anyone to join and participate in the network, while a private Blockchain allows only selected actors to participate in it. All the related work supports the use of SC as a mechanism that seeks to govern their transactions to securely share project information. Two of the related work rely on a deprecated tool, which is HLC. One of the related works does not rely on either cryptocurrency or mining algorithms to add new transactions to the network. Lastly, one of the related works does not support tender bidding processes since it focuses on managing tender contracts as indicated earlier on.

This study acknowledges that a full experimental evaluation of the CTS and the proposed solution was not conducted due to time constraints. Hence, the security comparison of the existing system and the proposed solution were not fully detailed. However, this study makes use of the potential benefits associated with the adopted technology solution to determine the security aspects of the proposed solution. For instance, the proposed solution is more secured since its data is distributed in multiple locations or different organisations that use different security mechanisms to secure their data, unlike the existing systems whereby a particular organisation is responsible for securing its data. Additionally, this mechanism of sharing data makes it difficult for unauthorised parties to compromise the project information once it has been stored within the network since it requires them to simultaneously hack all the organisations that form part of the network to compromise or access the data stored in it. Furthermore, the proposed solution is more secured because it uses various security mechanisms such as cryptography, timestamp, and distributed ledger, as well as having immutable data.

One of the main foreseeable shortcomings that might arise is the lack of political will to adopt the proposed solution because most of the high-ranking positions within these institutions are influenced by politics. Hence, they might exist

some reluctance when it comes to adopting a solution that seeks to reduce issues that emanate from corruption within the tendering system.

VIII. Conclusion

The proposed model demonstrates how DLT can be used to share project information securely and efficiently with all the parties that have an interest in the tendering project. Some of the information security mechanisms used by the adopted technology are DLS, cryptographic encryption techniques, and having immutable data or transactions. The proposed model seeks to promote the need for sharing project information while eliminating issues that are related to a single point of failure or having an organisation that has central powers over project information. Additionally, the adoption of DLT incorporates the benefits and promises that come with this new technology. The SALG uses tendering projects to promote collaboration between public and private sectors, therefore, the proposed model becomes an essential platform that can be used to securely share project information without colluding.

In the future, this research will focus on the design and implementation of the proposed model as part of trying to come up with the proof of concept related to sharing of project information among all the parties that have an interest in it.

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