*Research Article / Systems-Computer Engineering*

# Use of Design Research Methodology (DRM) for designing an electoral system applied to the TLÖN project

## Uso de la Metodología de Investigación en Diseño (DRM) para el diseño de un sistema electoral aplicado al proyecto TLÖN

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**ABSTRACT**

The social-inspired computing approach is not so well developed. Electoral systems constitute one of the most important research areas in political science. Within the existing development of social-inspired computing, there is no complete interaction with the political science literature relevant to electoral systems. This article takes as a case study the distributed computing system TLÖN, designed by the group of the same name at the National University of Colombia. TLÖN is an example of social-inspired computing, but its design is more influenced by the political philosophy of Thomas Hobbes and lacks the empirical perspective and the approach to electoral system design from political science. In this study, the Design Research Methodology (DRM) is applied to perform a systematic literature review and design an electoral system module within TLÖN, relying on political science literature on electoral system design. The design was carried out using structured analysis techniques (SADT). The results obtained raise new questions about the possible behavior of the system nodes under this new design.

**Keywords:** Social-inspired computing, Electoral systems, TLÖN, DRM, Orchestration

**RESUMEN**

El enfoque de la computación social-inspirada no está tan desarrollado. Los sistemas electorales constituyen una de las áreas de investigación más importantes en la ciencia política. Dentro del desarrollo existente de la computación social-inspirada, no hay una interacción completa con la literatura de ciencia política relevante a los sistemas electorales. Este artículo toma como caso de estudio el sistema de cómputo distribuido TLÖN, diseñado por el grupo del mismo nombre en la Universidad Nacional de Colombia. TLÖN es un ejemplo de computación social-inspirada, pero su diseño está más influenciado por la filosofía política de Thomas Hobbes y carece de la perspectiva empírica y del enfoque de diseño de sistemas electorales desde la ciencia política. En este estudio, se aplica la Metodología de Investigación en Diseño (DRM) para realizar una revisión sistemática de la literatura y diseñar un módulo de sistema electoral dentro de TLÖN, apoyándose en literatura de la ciencia política sobre el diseño de sistemas electorales. El diseño se llevó a cabo utilizando técnicas de análisis estructurado (SADT). Los resultados obtenidos abren nuevas preguntas sobre el posible comportamiento de los nodos del sistema bajo este nuevo diseño.

**Palabras clave:** Computación social-inspirada, Sistemas electorales, TLÖN, DRM, Orquestación

## Introduction

Unlike bio-inspired systems, which are commonly used for research on distributed artificial intelligence [1], e.g., through swarm behavior of unmanned aerial vehicles (UAVs) [2] or leveraging genetic algorithms for enhancing movie recommendation systems [3]; social-inspired systems haven't been yet thoroughly examined in the subject of engineering. The TLÖN project of the research group with the same name as the National University of Colombia is a case of a social-inspired system, one of its components is an ad-hoc network [4]. A distributed network like the TLÖN project uses social concepts like justice and equity [1] in order to solve the difficulties in QoS that gaps in technical capabilities between nodes generate. This social modeling allows us to understand the network's agents as people, and the network as a community [5].

Due to the social behavior of the system's agents, it's only natural that political processes occur. A political process

of great importance is choosing an electoral system. This is because in any frequently discussed subject that political science studies, like elections and representation, political parties and party systems, or government creation and coalitions; the electoral system plays an important role [6]. In fact, many political scientists consider electoral systems as one of the most influential political institutions and of great importance for governmental matters [7]. That said, governmental matters are not just a relevant subject of study for political scientists. The 80,000 Hours team is an organization that provides research and support for people that want to help solve the world's most pressing

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problems. It argues that improving political systems could serve as a broad intervention with far-reaching effects on various critical global challenges, such as climate policy, biosecurity, and AI regulation [8]. These global issues, says the organization, are incredibly complicated and require an understanding of complex interrelated systems. However, modern governments, the ones that have the ability to solve these global issues, face many challenges in their decision-making, originating in part because of the electoral systems they use [9].

Even though there's plenty of research about decision-making in distributed computing systems, it's commonly done for a unique leader in charge of distributing and assigning resources and tasks [10], [11]. For the current algorithms available, more development in a social-inspired focus is required. Regarding direct research that has been carried out on social-inspired distributed systems like TLÖN, decision-making algorithms have been focused on the question that a node asks itself whether participating or not in the network [5], [12]; however, once the node's already participating, the area of choosing delegates and participating in elections is underdeveloped.

The social nature of a social-inspired system and the importance of electoral systems make their study pertinent, given that they're very related to each other. Therefore, advancing in their study can give us an improvement not only in the studies of ad-hoc networks, but also in the understanding of political systems. In this paper we take the TLÖN project as an example of a social-inspired distributed computing system, where we analyze its structure in order to design appropriate electoral systems within it.

## Methodology

The chosen framework for developing the designs is the Design Research Methodology (DRM), as described by Blessing [13]. This is because using DRM as a project methodology allows iterative development work, on which improvements can be done without requiring a total completion of the system [14, p. 139, Recomendaciones].

The goal of this paper is to produce designs but not to produce prototypes for the intended system; therefore, according to the DRM typology, the type of research done is Research Type 2, i.e., Research Clarification as a Review-Based Study, Descriptive Study I as a Comprehensive Study and Prescriptive Study as an Initial Study.

### Research Clarification

In the Research Clarification step, major bibliography pertaining to the current designs of the TLÖN system was consulted, mainly the Ph.D. Thesis of Zárate-Ceballos [1] and the Master Thesis of Molano [14], but also some papers from Vega [15] among others.

More literature review was conducted, mainly from several books on Electoral Systems and Comparative Politics as well as The New International IDEA Handbook for Electoral System Design. From the designs of the TLÖN works, some relevant aspects in its Virtualization layer were identified, these particular designs make the Initial Reference Model, building upon them is this paper's contribution.

### Descriptive Study I

A more in-depth review on the designs of interest identified in the Research Clarification step was conducted in the Descriptive Study I step. The parts to be changed in the Virtualization layer were described in order to match the design techniques of the previous works. In this step, more information about the social-inspired concepts related to the TLÖN Pseudo-State was reviewed.

### Prescriptive Study

In the Prescriptive Study step, designs addressing the desired changes in the previous steps were carried on using the Structured analysis and design technique (SADT).

## Results

### Research Clarification

#### Literature review

Historically, electoral systems are rarely designed, but are actually born out of a messy compromise between factions fighting for survival [6]. Despite this hard-to-deny reality, there are multiple efforts by political scientists to give advice to those interested in reforming a given electoral system or to design from scratch a new electoral system suited to a newly created democracy [6], [7]. In political science, there is research on the classification and comparison of different electoral systems, which are analyzed through a comparative political and historical approach of different key states that are used as a case study [6]. Within the main electoral systems, the advantages, and disadvantages are investigated, as well as their impact on representativeness and the reasons that political actors may have for reforming them [6], [7].

The project of the Research Group on Dynamic Telecommunications Networks & Distributed Programming Languages TLÖN, proposes a computing scheme inspired by social models [4]. In the particular case of the TLÖN system, there is research related to the decision-making of a node, with a focus on deciding whether the node participates in an ad hoc network depending on the resources offered to it. This research also considers that the node decides how many resources it will contribute to the network [5], [12]. Another decision-making model investigated for this system is one based on the sociability of the nodes [16]. There is also research into achieving emergent cooperation at nodes through coalition games and genetic algorithms, modeled with social concepts of sympathy and commitment [15].

In general computing, there is algorithmic research in distributed systems on leader election, which in this context is the election of a single process to manage a task distributed across multiple nodes [10], [11]. There is also research on the intersection of computing with social processes: Specifically, economic processes such as auctions [17], wisdom of the crowds [18] or prediction markets [8], [19]; as well as social phenomena like social trust, social incentives, and group-based social behavior in technologies such as fog networks on cloud datacenters [20].

Broadly, as described by Zárate-Ceballos [1], Kumar [21] devised a classification system for algorithms inspired

by nature, in this classification, Kumar mentions the subcategory of Social / Cultural Algorithm, such as the algorithm category based on Socio-Political Ideologies like the Ideology Algorithm, the Election Algorithm and the Election Campaign Algorithm. However, in the classification of Kumar these algorithms are encased as a subcategory of bio-inspired algorithms focused on the issue of optimization [21] instead of a direct application on a social-inspired system like TLÖN, whom, its designers consider it as a superior abstraction to bio-inspired systems.

Even though the TLÖN system also considers the "TLÖN Pseudo-State", inspired in the Hobbesian concept of State as shown in Figures 1 and 2, as a changing entity, subject to an optimization game where the question is what's the element to optimize, the difference is that the previously mentioned algorithms try to answer the optimization problem outside the social-inspiration, instead as part of the deployment of the distributed computing system by itself.
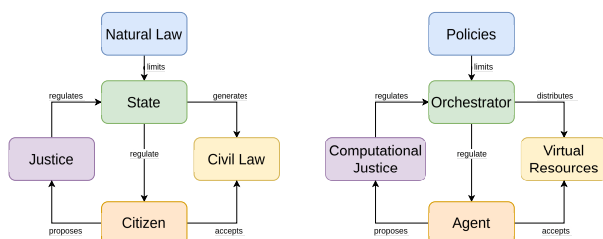


**Figure 1.** Hobbes' State as social-inspired model for the TLÖN project
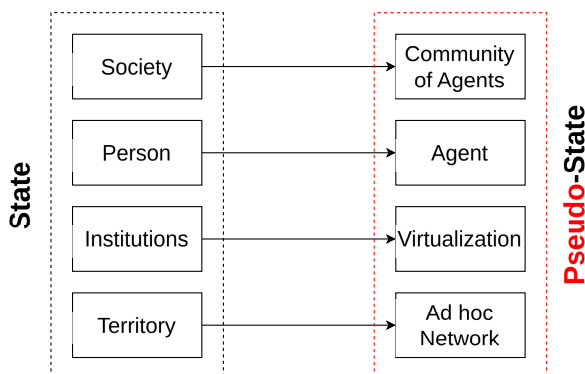**Source:** Adapted from [1]



**Figure 2.** Structure of a State and a TLÖN Pseudo-State
**Source:** Adapted from [1]

In particular, the Election Algorithm [22] tries to mimic the political elections comprising the electoral parties, the candidates, and the voters. It uses a presidential election as the inspiration; however, this design limits the behavior of the systems, as the characteristics might seem more appropriate to use another election that doesn't consider a presidentialist paradigm.

The work of Molano describes different types of trust between nodes that are relevant for the study of a potential electoral system, Vega et al. [15] expand this idea establishing a trust model for the TLÖN system.

Molano also drafts an initial pseudo-constitution for the TLÖN system. Arend Lijphart, as cited in [23], says "The most important choice facing constitution writers is that of a legislative electoral system". In the same book Clark uses Cox's [24] definition of electoral system as

a set of laws and regulations that govern the electoral competition between candidates or parties or both. Political scientists usually categorize electoral systems in three main families based on the electoral formula used to translate votes into representational seats. These families are the majoritarian mechanisms, proportional mechanisms, and mixed mechanisms. Other authors [6] classify them instead in the plurality family, majority family, List Proportional Representation or List PR family and mixed family. Each family has different effects on things like proportionality, ethnic accommodation, accountability, or minority representation. First-past-the-post, The Two Round System, D'Hondt are very common implementations of each family in modern States and are widely studied in comparative analyses [6], [7], [23].

*Initial Reference Model*

As per Zárate-Ceballos [1], the best way to show the dimensions of the TLÖN system is through a layers view as shown in Figure 3.
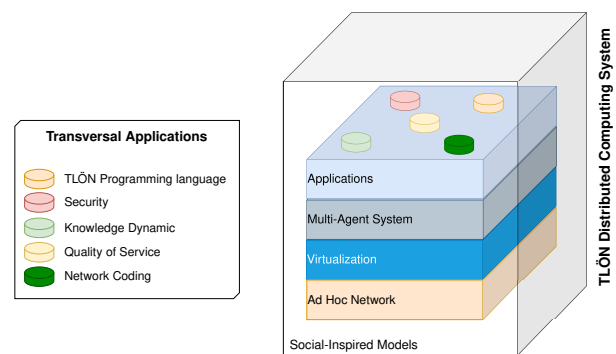


**Figure 3.** TLÖN System
**Source:** Adapted from [1]

**Ad hoc network** Related to the Physical, Data-Link and Network Layers of the OSI Reference Model [25], this is where the devices reside. It is a Mobile Ad Hoc Network (MANET)

**Virtualization** Deployed through containers, it's related to the Operating System and the resource management via the Orchestrator of TLÖN

**Multi-agent system** It's where the agent communities operate

**Applications** High level services offered by the TLÖN system.

*Descriptive Study I*

A social-inspired system made by Long [26] through principles of political realism for multiagent reinforcement learning considers the Majoritarian Voting Mechanism. However, the selection of this mechanism by Long is a result out of Hobbes' political philosophy of the natural condition of mankind, which, while fundamental for this system, mandates that the nodes will "form a political union under a Sovereign with sufficient power". This might not be appropriate for the TLÖN system. An explanation for this is that, as Molano pointed out, Long's system doesn't have a distributed property, i.e., Long's system's nodes

aren't heterogeneous. The TLÖN system nodes do have this heterogeneous property in the sense that they can't offer the same amount of computational resources, therefore, the system doesn't only consider Hobbes' concept of State, but it also incorporates other political concepts, like Rawls' Second Principle of Justice, the Distributive Justice, in which "social and economic inequalities are to be arranged so that they are both (a) reasonably expected to be to everyones advantage, and (b) attached to positions and offices open to all" [27].

As said before, Long's system is grounded in political philosophy, its voting system is shaped by the political views of Hobbes, this approach is descriptive or explanatory in nature. According to Heywood this is due to the question of political authority and legitimacy that preoccupied the social contract tradition, this question dominated early modern political thought [28]. It probably fits the historical problem of electoral systems in the sense that it is not designed, but rather a product of the circumstances [6]. To complement the expanded social-inspiration of the TLÖN system, a more practical approach, one informed by political science handbooks [7] and frameworks designed for governance that build upon the philosophical accounts but also from empirical experiences in real world States, might be more suitable.

Despite these limitations, it seems as if the TLÖN system works similarly, as identified by Molano, where this Hobbesian Sovereign is the Orchestrator of the TLÖN system [14]. Molano points out the Orchestrator fulfills the role of the monarch and recognizes the limitations in the TLÖN system, explaining that throughout history many other political thinkers like Rousseau or Locke have proposed alternative social contracts. The initial preference for the Hobbesian State inspiration is that it allows for less autonomy in the agent nodes, this proves easier to model than other social contracts.

Furthermore, Molano designed an information security module for the TLÖN system. His social-inspired solution took an institutional approach [14]. As influenced by the definition of Hobbes, he suggests a pseudo-constitution composed of 14 articles; among them, we highlight the following articles.

**Article 3** Rules in the TLÖN State are statements that delimit the actions of the designers of the TLÖN computing system and the actions of its implementation.

**Article 9** An Institution is a body of the TLÖN Pseudo-State designed for the purpose of implementing a feature of the TLÖN Pseudo-State and regulating its behavior.

**Article 10** An institution will describe a social interaction within the TLÖN Pseudo-State. It will provide a normative dimension that allows for the mapping of roles to obligations, restrictions, or permissions.

**Article 11** The institutions of the TLÖN Pseudo-State must be regulated by the TLÖN pseudo-constitution.

**Article 14** There shall be an institution dedicated to safeguarding the integrity of information in the TLÖN Pseudo-State. This institution shall control the specific policies for managing the integrity of information in the TLÖN Pseudo-State.

This approach is related to the concept of formal and informal institutions of O'Neil, as a guiding concept for comparative politics since the 1950s. In the view of O'Neil [29], institutions "are organizations or patterns of activity that are self-perpetuating and valued for their own sake", vary from country to country, and embody norms or values that are considered central to people's lives.

Moreover, most political regimes, democratic or not, establish a number of political institutions [30], for example in the executive branch of government, that carry out the laws and policies of a given State. This branch is typically organized into ministries or secretariats, each overseeing a specific domain of governance such as education, defense or foreign relations. In this sense, Molano's information security module functions analogously to an executive ministry or secretariat responsible for defense.

The Virtualization layer is of special interest for this paper; it includes the Orchestrator, which is, as previously mentioned, the equivalent of the Hobbesian Sovereign. It also includes the Operating System, which is designed based on the concept of institutionality, the designers call it SOVORA [1].

The Virtualization layer of the TLÖN system is done through the concept of containers, they're similar to virtual machines but only use the resources necessary for the deployment of their application. A Container is an instance of an application. They are one of the principal components of lightweight virtualization [1]. In this context is where the concept of orchestration emerges. Zárate-Ceballos defines an orchestrator as an instance or agent that manages all the interactions of a cluster and formalizes the Orchestrator of the TLÖN Pseudo-State as the predictive management scheme, it allows for auto-adaptation and distributed task management. While the current designs for the TLÖN system take into account the orchestration approach to resource management, the designers mention other alternatives such as self-managed or emergent [1].

Regarding design techniques in the TLÖN system, both Zárate-Ceballos and Molano use the Structured analysis and design technique (SADT), they said this language has already been established as a standard for the TLÖN system [14] since it allows for joining different layers and relationships between layers [1]. On top of that, Clements provides guidance called Views and Beyond for assembling a package of effective, usable documentation for a software architecture, while also giving a chapter beyond the intended use compliant with the ISO/IEC 42010 [31], [32]. The initial SADT diagrams, shown in Figure 4, this paper focus on are related to the Orchestrator, the Local Agent (the container) and the Virtualization.
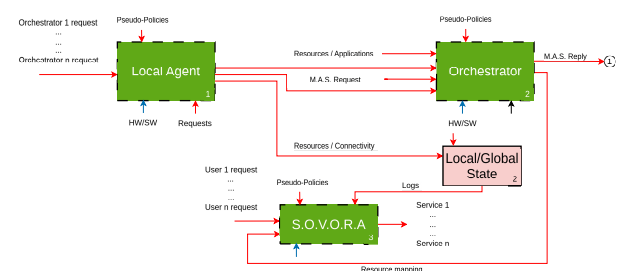


**Figure 4.** Initial Virtualization Model
**Source:** Adapted from [1]

*Prescriptive Study*

As previously mentioned, this work makes use of the Electoral System Design Handbook [7]. The handbook provides several advice points for electoral system designers inspired by major historical drawbacks faced in electoral reform processes, as a result, it generated a checklist. Some checkpoints the handbook provides are:

- ☐ Are the mechanisms for future reform clear?

- ☐ Will the system help to alleviate conflict rather than exacerbate it?

- ☐ Will the election results be seen as legitimate?

- ☐ Are unusual contingencies taken into account?

Using a different way of resource management could benefit from using emergence or self-managed, but this won't be taken into account, considering it might be needed to redesign many parts of the TLÖN system. Instead, while still using an Orchestrator, this work takes a different approach than that of Zárate-Ceballos; this work designs a different behavior for the Virtualization layer that dissociates itself from the monarchy inspiration Molano pointed out.

Regarding the unusual contingencies the handbook warns about, it means events like massive voter abstention, a tie between candidates, not having a winner under the proposed system, agents not voting for their preferred candidate [7]. This calls into attention the issue of political participation in the TLÖN system. Some political scientists have developed models of voting participation based on resources. The model of Brady and Verba [33], as cited by Castillo [34], has three components: time, money, and civic skills.

In respect to the question about alleviating conflict rather than exacerbate it, this possible political inequality previously mentioned deserves a careful analysis to avoid that more autonomy in the local agents might break the idealization of the TLÖN system. This is because political participation is very important in the field of Distributive Justice [27], [35]. Rawls himself wrote extensively about political inequality; he said, "Perhaps the most obvious political inequality is the violation of the precept one person one vote" [27].

*Designs*

The desired impact we want to achieve is to expand the Virtualization layer by adding the Election Module as seen in Figure 5. This module, shown in Figure 6, exists in order to regulate the voting mechanism used for the elections, as well as any disallowed action, or the disqualifying conditions of candidates from participating in elections. As well as the frequency and duration of an election and the set of candidates that are the available alternatives. As previously mentioned by Clark [23], a voting mechanism is an electoral formula that translates votes into a winner. Therefore, choosing a specific electoral formula pertains more to the implementation of the Virtualization layer than the design. Nonetheless, the structure we're proposing implies that we can discard mechanisms that are focused for legislative elections which give the winner status to multiple candidates.

Furthermore, we give the Local Agent (citizen) the capacity to raise his opinion in the form of a vote. We want the Local Agent to have a preferred policy. The Local Agent must be in capacity to agree or disagree with the current distribution of resources and tasks that the Orchestrator is overseeing regarding the whole computing system. As well as the general objective of the system, and it's reason to exist. In a more detailed perspective this could be modeled with a utility function. As shown in Figure 5, each Local Agent communicates its vote to the Electoral Module, which in its turn communicates the winner set of policies that will now rule the behavior of the Orchestrator.

**Proposed Articles for the TLÖN Pseudo-State's pseudo-constitution regarding an Electoral Module**

**Article X** There shall be an institution dedicated to overseeing the integrity and administration of elections in the TLÖN Pseudo-State. This institution shall establish and enforce specific policies for ensuring appropriate electoral processes within the TLÖN Pseudo-State according to the social principles it's based on.

To do this we define a candidate as a set of suggested priorities in the way of policies. The local agents can participate in the election process according to the related policy defined by the Electoral Module.
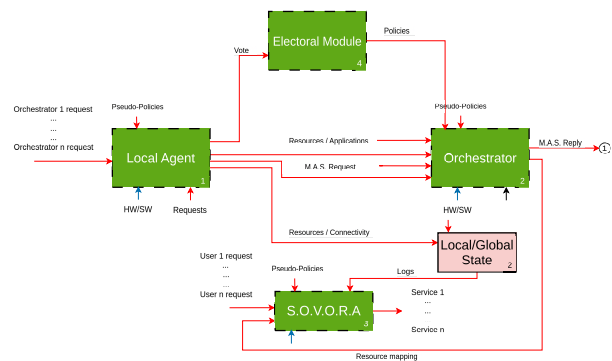


**Figure 5.** New Virtualization Model
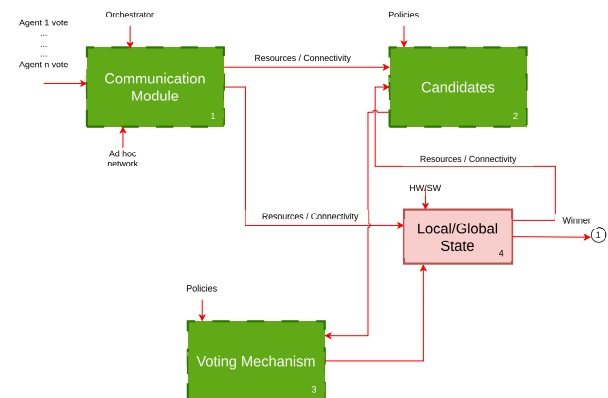**Source:** Designed based on [1], [14]



**Figure 6.** Electoral Module
**Source:** Designed based on [1], [14]

## Conclusions

Even though there's much to learn from more technical and specialized works on political science like the electoral system design handbook, using this kind of pragmatic literature to complement the social-inspired model calls for looking more closely at the proposed idealization of the TLÖN system. The reason for this is the emphasis the manual puts in thinking about unusual contingencies that might impact the idealization of the system.

The designs refrain from completely ending the role of the Orchestrator, since the proposed guides and handbooks are from a point of view of reforming an existing electoral system. Furthermore, this might require adopting different social contracts instead of the Hobbesian one, which might require looking closely at all parts of the TLÖN system models in order to see if each part needs reforming or not.

## Future Work

This work can be complemented by deepening the design of the Election Module for the TLÖN system, not unlike the way Molano did with the Information Security Module, this means performing research of higher DRM typology. Including, among other things, specifying the organizational structure of the module and clarifying the mechanism for electoral reform, this is, the policies that the Electoral Module enforces.

Further research is needed regarding other aspects of social phenomena that occur in societies, like the economy of the TLÖN system or International Relations (interaction between two TLÖN-like systems).

Elections serve both as regime change and as a measurement of legitimacy, this opens the question of modeling and incorporation of election legitimacy into the current trust model of the TLÖN system.

The political science literature base of this work tends to take by default the modern view of western liberal democracy. Nonetheless, a scenario where not all the local agents participate, effectively other kinds of government like aristocracy or anarchy, weren't developed in this work. Further research in this regard is needed, as well as investigating a possible relationship with the alternative methods for resource management and task distribution in a cluster that Zárate-Ceballos mentioned, like self-managed or emergent.

Only the Orchestrator was investigated, the TLÖN system has other kinds of institutions that weren't analyzed and might benefit from an electoral mechanism. Further research in this regard is needed.

## CRediT author statement

Conceptualization, Data curation, Formal analysis and Writing: J. P. Delgado-Cárcamo. Supervision: J. E. Ortiz-Triviño. Writing - review and editing: J. P. Delgado-Cárcamo and J. E. Ortiz-Triviño. Resources: J. E. Ortiz-Triviño.

## Conflicts of interest

The authors declare that they have no significant competing interests, including financial, non-financial, professional, or personal interests, that could influence the objectivity and integrity of the research presented in this manuscript.

## Statement on Artificial Intelligence (AI)

During the elaboration of this work, the author(s) used LanguageTool with the aim to refine and double check grammar and wording. After using this tool/service, the author(s) reviewed and edited the content as necessary and take full responsibility for the content of the publication.

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