A Framework for Designing Self-sustaining Ecosystems with Blockchain

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Abstract. Blockchain is a foundational technology where the idea of a distributed database and trust is established through mass collaboration and smart contracts. It is being claimed to be the next major socio-technical advancement after the invention of the Internet. In this paper we present a framework that supports experts in designing self-sustaining ecosystems leveraging distributed ledger technology. The critical building blocks of the framework are value exchange mapping, determining an evolutionary distributed ledger technology architecture, governance modelling, and token engineering. The goal of the framework is to establish a Minimum Viable Ecosystem that is self-sustaining in itself while having a positive-sum game as the basis to attain organic network effects. The framework has been evaluated through three case studies of prominent distributed ledger technology projects. The results of the case study were positive and evident of the need for such frameworks to help experts to think strategically, critically and precisely.

Keywords: Distributed Ledger Technology · Blockchain · Token engineering · Self-sustaining ecosystems · Socio-technical system

1 Introduction

Problem Statement: Distributed Ledger Technology (DLT) projects have been easy to bootstrap although when it comes to next steps, for going beyond a proof of concept and scaling up while attaining the network effects, numerous projects have failed or substantially devalued. At times, the reason behind the failure is lack of in-depth understanding of intricacies of blockchain systems coupled with unavailability of right tools to help the projects navigate through the complexities to engineer a technically as well as commercially sound product or service. Nonetheless, many blockchain startups and communities lack a well-defined revenue model which makes it difficult to raise external funding. Moreover, there are also instances, where projects decide to completely discard tokenization as it increases complexity in the system, but it backfires as the project loses an important component which can actually facilitate self-sustenance [3].

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Self-sustaining ecosystems can be defined as being able to operate itself with negligible interference from the outside world. The value is created, distributed, maintained, exchanged and stored within the ecosystem and follows the principles of anti-fragile systems proposed by Taleb and Douady [8]. Moreover, it aims to establish a Schelling Point which is to have an equilibrium in the network with zero communication or coordination. It is a concept of game theory which people tend to use as default solution in the absence of communication because it seems natural, special, or relevant to them.

Aims and Objectives: The problems discussed in the previous section demand to design a framework which can break down the complexity of DLT systems while enabling stakeholders to create self-sustainable ecosystems.

Moreover, it opens up a wide range of possibilities for creating 'fair' marketplaces where digital assets could be traded, exchanged, gifted or even curated without any mandate from any central entity. Therefore, we evaluate the proposed framework by conducting case-studies with multiple DLT projects. *Additionally, to the best of the authors' knowledge, this is the first attempt towards an artefact that is focused on critical elements of blockchain project which assists in carrying out strategic thinking while establishing a precise project roadmap with the aim to attain self-sustenance in the form of a Minimum Viable Ecosystem(MVE).*

Related Work: The most relevant work carried out before in order to propose a framework to facilitate blockchain ecosystems was 'Token Ecosystem Creation' by Dhaliwal et al. [2]. However, it is precisely focused on token engineering while this study focuses on all critical aspects of any blockchain or a DLT system. Secondly, the research by Pelt et al. [7] and Tan [9], provides a blockchain governance and token economics framework, respectively. These important elements while proposing a holistic framework for strategically navigating through any DLT projects.

Research Process: The research design process followed Design Science Research by Hevner and Chatterjee [6]. Further, for the literature study, the study employed Multivocal literature study by Garousi et al. [5] and to evaluate the proposed framework we followed the guidelines by Yin [11] for conducting multiple case studies.

2 Framework

The conceptual model of DLTs resulting from Multivocal Literature Study, served as an input to further curate the framework. *The framework consist of three phases, namely, Discover, Design and Deploy.* Wherever possible, the steps include suggested tools in the form of state-of-the-art conceptual sub-frameworks or other artefacts which were brought together from academic as well as

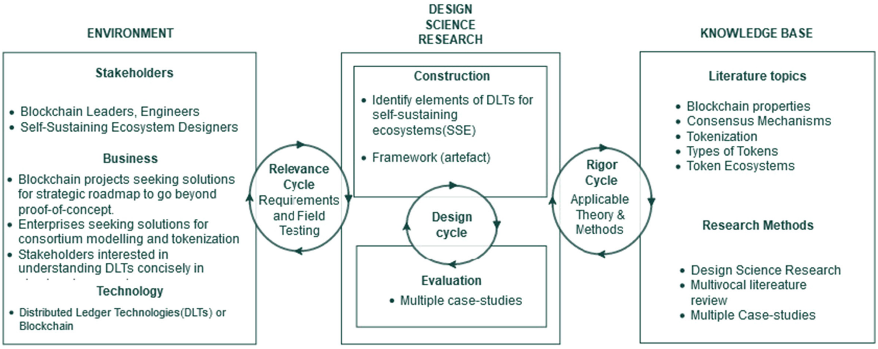

Fig. 1. The design science research framework applied to this study, adapted from [6]

non-academic communities. They were included in the process model to ensure the framework delivers efficacy for DLT projects. *The framework is defined in a manner where governance and token engineering are an integral part of project strategizing.* Moreover, the framework is aligned to our research method of DSR by Hevner and Chatterjee [6], where framework offers a cyclic process for relevance, design, evaluation and rigour as depicted in Fig. 1.

There are two primary requirements for the framework to be operationally feasible and operate at an optimum level, it is assumed that *Self-sovereign identity (SSI)* is integral part of the project and *legal regulations* are being considered at each step of the framework.

It has been observed over the period of time that there is a common practice by experts for approaching DLT projects as starting up a traditional business or startup. But there is more to these projects when approached from the perspective of starting up a new 'country'. The country requires a set of rules (governance) and monetary policies (token economics) to facilitate/attract/retain citizens (network effects) and drive their user behaviour. This approach helps in making the governance, token engineering and network effects as Key Performance Indicators (KPIs) for any Blockchain or DLT project.

The framework (Fig. 2) starts with the '**Discover**' phase which determines the particular characteristics of the ecosystem and the purpose behind the ecosystem followed by **stakeholder mapping** and **value exchange mapping**. The discover phase aims to prepare blockchain leaders with a series of questions while laying out the context, criteria for success, the scope of solution space, and constraints that need to be satisfied. Secondly, **determining DLT architecture** for the project is equally critical as there are key elements to consider such as required level of on-chain transparency, platform access rights, data governance, issuing of digital assets and tokenization. These are a few of the most important considerations required at the beginning of any DLT project. Further, to determine DLT architecture we suggest Decision Support System(DSS) Farshidi et al. [4]. The DSS[1] results in a potential list of possible

[1] https://dss-mcdm.com.

options for DLT architecture as per the initial assumption of the project. The DSS is a useful tool to perform quick initial feasibility check although recommendations are generic and not specific to particular use-case.

The next phase '**Design**' is an emerging concept that consists of building an ecosystem surrounding the market or the business models via use of blockchain or DLTs. It is a complex task, similar to designing and launching a completely new economic system supported by technical infrastructure. It consists of making high-level design choices including governance structures, the token modelling and its parameters. These parameters are needed to be optimized for stakeholders' incentives and the long term sustainability of the associated ecosystem in order to avoid value leakage. The **governance** must be focused on (i) Rules (ii) The collective scope (iii) The decision-making process, and the (iv) Lack of formal control systems. The blockchain governance model curated by van Pelt [10], offers high-level view on the formation and context within the intricacies of blockchain governance. It is divided into five dimensions consisting of roles, incentives, membership, communication and decision making. The next step is the **token engineering**. Token design requires an understanding of the incentives for each participant in the ecosystem, the associated business model, market structure, and network structure. The final model leads to a protocol design that allows the network to sustain itself while prioritizing system security through engineering of optimal incentive and governance mechanisms. *The core elements of token economics are divided into three segments, Market Design, Mechanism Design and Token Design.* **Market design** is the design of the environment which mainly consists of off-chain parameters. **Mechanism design** is the design of the system from off-chain as well as on-chain for optimizing governance, token economy and thereafter, overall ecosystem. **Token design** is the design specific to the token that will be used in the ecosystem ecosystem Tan [9]. Further, the step of '**classifying tokens**' is essential for the token economics and engineering of the tokens. The tokens could be fungible or non-fungible based upon the nature of project. The most critical parameter at the end of Design phase is about '**Analyzing Security Threats**', the research conducted by Debus [1] offers required insights into securing the ecosystem.

The last phase is '**Deploy**'. The '**Testing**' needs to be an integral part of any ecosystem design process to build an optimal feedback loop that helps govern and monitor the system. This deploy phase consists of iteratively testing until all parameters have been optimized with respect to their constraints. The deployment process involves using a combination of mathematical, computer science and engineering principles to fully understand the interactions in our network and its failure points. It is important to note that optimization and testing are present throughout the entire lifecycle in an iterative process, that is, in practice, governance and token models should be continuously optimized for parameters, variable ranges at all stages. There are various methods to test and optimize the network, for instance, regression learning could be used to validate the input selection stage for identifing the variables and parameters of the objective function. Similarly, Monte Carlo simulations and Markov chains that allow quantifying outputs of token gravity to calculate the velocity of the token and its value. Additionally, agent-based modelling and evolutionary algorithms allow for the model to capture possible future interaction of different use cases and users come on the network. The feedback loop created in this process should relay information to deep learning models comprising neural networks, this can assist in optimizing the network and maximize the objective function of the network. The end goal of the proposed framework (Fig. 2) is to achieve *Minimum Viable Ecosystem* that is self-sustaining in itself.

The process from Discover to Design is suggested to be a single way approach as projects are expected to have concrete assumptions and reasoning before starting the Design phase because it is likely to get lost in the hall of mirrors. Although, the Design and Deploy phase are cyclic to keep room for continuous testing and optimization of ecosystem.

3 Case Studies

The case-study partners were selected on the basis of satisfying these criteria: (i) the blockchain project is relevant to the characteristics of SSE (ii) the blockchain project involves a requirement for token engineering. The Table 1 summarizes the case study partner, their field of work, nature of their project along with identifiers. The identifiers were further used in Table 2 to link the case study partner with their prominent comments. Please note that some amendments were made to the framework after these evaluations. These amendments are left out for reasons of brevity.

Table 1. An overview of the conducted evaluation multiple case-studies

Case study	Field of work	Type of project	Identifier
Eclesia	Startup	Digital Collectables	IE-1
Lisk Casino	Community driven	Online Casino (Gambling)	IE-2
SecureSECO	Academic Project	Self-Sustaining Software Ecosystem	IE-3

Table 2. The most prominent comments from the case participants about their experiences with the framework along the five quality dimensions.

Evaluation Characteristics	Rating	Prominent Comments
Operational Feasibility	IE-1: 5/5	IE-1: "The framework could be used by every other DLT project and is relevant to the LeanStack Startup Innovation Framework"
	IE-2: 5/5	IE-2: "It makes you think of all other feasibility aspects"
	IE-3: 5/5	IE-3: "Would be willing to come back to this framework for future DLT projects"

(contniued)

Table 2. *(contniued)*

Evaluation Characteristics	Rating	Prominent Comments
Ease of Use	IE-1: 4/5	IE-1: "Well structured framework which assists in clear thinking about concrete critical steps"
	IE-2: 5/5	IE-2: "DLT ecosystems are complex and this framework helps in breaking down those complexities"
	IE-3: 2/5	IE-3: "Framework is helpful, but DLTs are complex and therefore it gets overwhelming to consider all aspects"
Usefulness	IE-1: 5/5	IE-1: "It helps in thinking about DLT elements that are essential for scaling up"
	IE-2: 4/5	IE-2: "It is a tangible artifacts for blockchain projects"
	IE-3: 5/5	IE-3: "It helps rethinking how blockchain projects operate"
Completeness	IE-1: 4/5	IE-1: "The discover and design phases are accurate and complete although deploy can still be improved"
	IE-2: 5/5	IE-2: "The framework is complete and covers all major aspects"
	IE-3: 5/5	IE-3: "The framework is complete"
Effectiveness	IE-1: 4/5	IE-1: "The framework is relevant to the needs of DLT projects but it can be improved"
	IE-2: 4/5	IE-2: "The aspects discussed in the case study are effective and helps in thinking beyond the proof of concept"
	IE-3: 5/5	IE-3: "It helps in asking the right questions that are crucial for the success of a project"

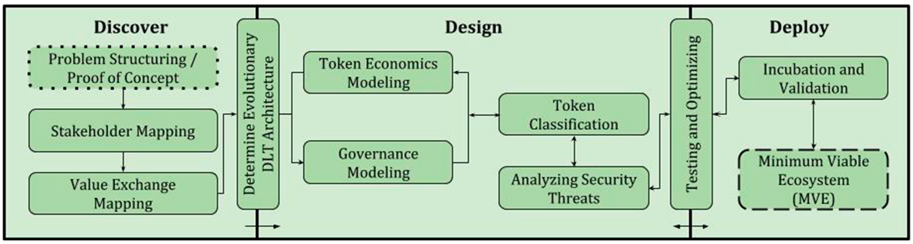

Fig. 2. Revised framework for designing self-sustaining ecosystems

4 Discussion

There was a researched assumption that the DLT community lacks a structured approach while working on a DLT project. Moreover, the aspects such as governance and token economics are rarely considered at the early stage of any DLT project due to their complexity, although these elements determine key design decisions in order to build a Minimum Viable Ecosystem. At the beginning of this research, token engineering was the sole topic to focus on but while progressing and getting a better perception of the range of the topics and gaps in the community, it was decided to further scope our research and propose a holistic framework which is complete in itself while aiming for self-sustenance.

Strengths of Framework: The goal of the framework was to assist DLT projects to efficiently strategize and implement their solutions which includes governance and token engineering as integral part of the process. The case-studies made it evident that the framework is a required tool and important for projects to scale-up. The step for '*value exchange mapping*' was the most discussed element of all the case-studies. The overall results of the case-study received high confidence on the framework in terms of operational feasibility, completeness, effectiveness and usefulness. The framework provides scope for experimentation and exploration throughout the process while aiming for Minimum Viable Ecosystem. Moreover, it fills in the gap for the projects that have already achieved a Proof of Concept for, and are struggling to further scale it up. Here, the framework could be leveraged to attain network effects and scope for new business models. The element such as value exchange mapping which was the most discussed element of the case-study, could benefit from a defined framework which can make value mapping efficient.

Limitations of Framework: During the case-studies, the framework was sometimes perceived as a bit complex but that was also because of the nature of DLT projects. The case-study reference material included all sub-category frameworks regarding governance, token economics, classification of digital assets etc. which can guide the projects but it did add complexity to the main framework. Moreover, the case-studies were conducted with only three partners and results were promising. Although, it is insufficient to derive a thorough conclusion from just three case-studies. To reach a concrete conclusion there needs to be more case-studies. Also, it is expected that the framework will evolve along with the results from case-studies as well as with progress in the DLT space. Furthermore, there could be efforts in making the framework more easy to perceive. On the other hand, the evaluation of the deploy phase was limited as none of the projects were at that stage and also, it requires state-of-the-art agent simulations to get precise results but that in itself is a research and development challenge. Lastly, the framework works as a guiding principle which extensively helps in answering 'why', 'who', 'what', 'when' for the project but has limitations while answering 'how'.

Impacts of Framework: One of the most evident impacts of the framework, during the course of case-studies was that each partner experienced some new territories within the DLTs which were critical for their projects. It enabled rethinking and reconsideration of elements crucial for engineering of DLT projects. Moreover, the framework was received as a complete artefact covering all the required DLT elements for the project. The effectiveness of the framework for each of the project was impeccable as it enabled them to think about every dimension in a DLT project. Each of the partners stated that they would use the framework for their existing work and would be willing to come back to it, in any other future DLT endeavours. Lastly, the framework is critical for the DLT projects which are struggling to move beyond a proof of concept or a minimum viable product.

5 Conclusion

Hence, the framework was curated while studying the intricacies of DLTs and identifying the key elements of DLTs which dictate the design decisions to achieve self-sustenance. These key elements were further structured into three phases of Discover, Design and Deploy. The Design and Deploy are the iterative phases. Furthermore, the framework was rigorously evaluated with ongoing DLT projects as a part of multiple case studies. The results affirmed the need for such artefacts which can help in strategizing the engineering decisions of next-generation socio-technical ecosystems while making them commercially viable.

Future Work: The case studies were limited to three in this study, although more case studies would provide concrete insights along with upgrading the framework itself. The framework was perceived as bit complex and overwhelming so future could be in attempt to make it simpler and concise. Other interesting future work would be modelling of token economics through agent based simulations which would allow designers to bypass any theoretical limitations and model the agents as per the assumptions directly while taking into account every possible constraint.

Acknowledgement. This research is inspired from the work of Dhaliwal et al. [2] and Tan [9].

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