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# How modeling helps in developing self-sovereign identity governance framework: An experience report

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**Abstract**

Digital Identity has become a topic that attracts the attention of researchers due to the enormous number of services that have been provided online recently. Researchers face many obstacles regarding the security, privacy, and utility of digital identity. Self-Sovereign Identity (SSI) ecosystems provide a solution for digital identity, in addition to providing a decentralized human-centric paradigm that enables users to own and control their identity. Governance framework (GF) is a key challenge in building SSI ecosystems for two reasons. First, the GF needs to address various aspects such as user needs, standards, laws, and business requirements in an ecosystem. Second, the ecosystem consists of diverse, dynamic, and distributed groups of stakeholders. This research work adopts a new trend in developing GF by providing a visual view of the SSI ecosystem. In addition, it seeks to highlight the importance of domain-specific modeling in developing GF. It also addresses lessons learned from a real case study and a modeling journey that supported the creation of a GF. We will discuss the advantages and challenges of modeling and the used modeling tool based on the evaluation from the case feedback and conclude with future work.

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## 1. Introduction

**Nomenclature**

| | |
|---|---|
| GF | Governance framework |
| SSI | Self-Sovereign Identity |
| IDSP | Identity Service Provider |
| EGC | Ecosystem Governance Compass |
| PEO | Primary Empirical Observation |

In the last few years, the value of online transactions has increased significantly. This has led to the need for more trustworthiness on digital identity[1]. If users are going to provide personal information online, they need a secure and trustable connection. One solution is a centralized model where authentication is provided by username and password; however, it does not provide enough security. Another solution is a federated model where an identity service provider (known as IDSP) hosts, secures, and stores the user's authentication information. In this model, users can use accounts provided by the IDSP to register for online services, for example, using a Facebook or Google account to register in multiple online services[2]. Whereas these models are more common in online interactions, the decentralized model based on SSI ecosystems is an evolutionary solution. It enables users to authenticate themselves using verifiable credentials (VC) that are managed by the user and saved in their personal digital wallet rather than by the IDSP. Thus, SSI solutions provide more security and enable users to select which information to expose[3].

One of the key challenges in widely adopting SSI-based solutions is establishing the GF for the SSI ecosystem. The GF is a product of lengthy discussions and analyses made by and for multiple stakeholders from various legal, business, technical, and financial perspectives. The Trust Over IP Foundation defines GF as "a set of business, legal, and technical [definitions], [policies], [specifications], and contracts by which the members of the trust community agree to be governed in order to achieve their desired objectives"[4].

Many GF is lengthy, too formal, use legal language, and are hard to understand. Visualizing the ecosystem and its trust community enriches and informs stakeholder discussions while building the GF. Thus, there was an emergent need for modeling to develop the GF. This experience report represents the role of modeling in developing GF, and answers the research question "How does modeling different aspects of the ecosystem help in developing SSI GF?"

This experience report is based on a field study that uses modeling to develop a GF. The first part will represent the recent work related to SSI ecosystems, GF, and real-world examples of SSI GF. The second part will introduce our case study, Yoma, and the modeling language, Ecosystem Governance Compass (EGC). The third part covers the research methodologies, including data collection and model creation. Next, we go through the lessons learned and conclude with a discussion.

## 2. Recent work

### *2.1. Self-sovereign identity (SSI)*

The term Self-Sovereign Identity (SSI) has emerged strongly in the last few years [5]. SSI is described as a form of identity management that allows users to own and manage their digital identity[1]. It could also be seen as a further evolution of non-centric identity management models that give more control of data to users and do not rely on a central trusted authority[6]. That means that service providers do not own the users' identity and can only use it for a specific purpose[7]. SSI ecosystems give users control over the digital copy of their data and let them decide what level of information they want to share[2].

The digital copies of the users' data are called Verifiable Credentials (VC). They could be passports, birth certificates, university certificates, and various types of credentials [8]. VCs are stored in digital wallets, digital wallets could be stored on mobile phones or in a cloud [9]. VCs are exchanged in SSI ecosystems with a digital signature. The digital signatures are protected by public and private cryptographic keys[10].

SSI-based ecosystems have some prominent roles. A holder is a person who owns, controls, requests, keeps, and protects the credentials; in some cases, the holder can be an organization. The issuer is an entity that issues and approves credential accuracy. Verifier is the entity that needs assurance about holder credential claims. A governance authority is an organization responsible for publishing the governance framework [11, 12].

Exchanging VCs in an SSI ecosystem starts with the holder asking the issuer to issue credentials. The issuer creates the credentials and signs using a Decentralized Identifier (DID) which is written to a public or private verifiable data registry; the issuer then sends the credentials to the holder to keep them in their digital wallet. When the holder wants to prove something about their identity (a claim), for example, to access a service, they use the credentials to prove the claims in a verifiable presentation to that service provider (the verifier). The verifier can ensure the accuracy and authenticity of the credentials by reading them from the verifiable data registry [1, 2] and without a direct connection to the issuer of the credential.

The SSI ecosystem's primary goal is to build digital trust between different actors within the ecosystem. Many, but not all, SSI ecosystems rely on blockchain or distributed ledger technology. Trust starts from the blockchain network. Each entity on the network has a decentralized identifier (DID) which are unique web addresses that refer to subjects fully controlled by their owner [13]. DID Communication (DIDComm) †is the messaging protocol responsible for generating the DIDs, key pairs, subsequent key rotation, or revocation, and the DID document to provide a more secure transaction for the VCs [14]. DIDs and DIDComm together can provide a secure and private communication method.

### *2.2. Governance frameworks and real-world examples*

There are several governance frameworks (GFs), sometimes called 'trust frameworks,' such as security GF, IT GF, and SSI GF. Security GF defines guidelines and implements controls used as a reference for governing information security in all facets of the organization's information asset environment [15]. IT GF provides guidelines for clarifying decisions, rights, and accountabilities to encourage desirable behavior redeemed for incentives [16]. SSI GF has the same goals as the security and IT GFs that provide guidelines for SSI ecosystems.

Most GF has standard requirements. Firstly, it should be simple and straightforward for stakeholders to understand. For example, the terminology should be clearly explained to educate the reader about the principles. Second, a GF should deliver value by specifying the rules and policies' intended outcomes while considering principles. Third, it should be rigorous auditable, and its outcomes should have the authority and mechanisms to be achieved within its scope [17, 18].

One early example of an SSI identity ecosystem is the Sovrin Foundation GF[‡]. It includes the principles, policies, terminology, and standards that enable different trust communities to define their digital credentials and address their specific needs [17]. The main objective of Sovrin GF is to provide the governance for their ledger to support their mission of being *a global public utility for the identity of all*.

Another example is the Cheqd GF[§]. Cheqd GF core is understanding the acknowledgment of how the system runs to influence decisions. Cheqd defines their view of governance as laws, guidelines, principles, social norms, markets economy, and architecture represented in rules, boundaries, punishments, and rewarding systems. The main objective for Cheqd, another SSI ledger, is to create a new business model for VCs.

Another example case is the Good Health Pass interoperability blueprint (GPH) GF[**]. It is a document delivered and approved by the Interoperability Working Group for Good Health Pass at the Trust over IP Foundation. The document describes that the main goal for the ecosystem is to reopen global travel after the covid pandemic. The document lists the principles and norms that drive the blueprint, in addition to the description of the standards, data models, credential formats, and (technical, issuance, presentation) protocols. The Good Health Pass GF follows the Trust over IP Foundation standards, which are based on Sovrin standards.

[†] https://identity.foundation/didcomm-messaging/spec/
[‡] https://sovrin.org/library/sovrin-governance-framework
[§] https://docs.cheqd.io/governance/
[**] https://www.goodhealthpass.org/blueprint

## 3. Introduction to the Yoma study case and the Ecosystem Governance Compass

### *3.1. Yoma ecosystem*

Yoma[††] (Youth agency and a marketplace) is a digital platform incubated by UNICEF in Africa, enabling youth participants to create a digital CV and find paths to employment and sustainable livelihoods. The CV is built on VCs. VCs are received for participating in education, impact tasks, or challenges. Yoma rewards youth participation with tokens (ZLTO) that can then be spent in the Yoma marketplace on goods and services such as mobile network airtime or premium education opportunities. Yoma uses artificial intelligence to build personalized learning pathways for youth participants. The Yoma ecosystem has been built using a value-based engineering methodology in which youth defined their core values as privacy, personal self-development, trust, community, fairness, and inclusion. These values serve as a basis for the whole technology and governance design [19].

### *3.2. The Ecosystem Governance Compass (EGC)*

Yoma models were built using a new tool called the Ecosystem Governance Compass (EGC[‡‡]). EGC is amodeling language developed based on domain-specific modeling theory [20]. EGC supports ecosystem practitioners in planning and automatizing GFs. It provides actions, system methods, and processes to make multiple-level decisions for different stakeholders in an ecosystem. EGC is implemented on a model-based development tool called MetaEdit+[21]. EGC has gone through two development phases to date, and the third phase is in process. The Yoma case study evaluated the tool and developed the language further.

The mental model behind EGC is based on a literature review on blockchain governance[22] and consists of four layers: governance, business, technology, and legal and regulatory aspects. The governance layer identifies the main actors in the ecosystem and their roles. It also identifies the rights and responsibilities of each actor/role. It explains the incentives that each actor/ role would gain as an ecosystem participant. The business layer includes the core business activities per actor/role. The business aspects show the revenue models and the costs for each actor/role with business activity. The legal and regulatory aspects layer defines the laws, regulations, legal standards, and technology standards required for compliance. It also identifies the legal agreements and contracts that control the interaction between different actors. The technology layer identifies the technical services, technology components, data objects, and data storage.

## 4. Research methodology

This paper is an experience report that aims to help SSI practitioners develop the GF using modeling. The research was a collaboration between our research team and the Yoma team. We used participant observation methodology; we were responsible for building Yoma models while writing the GF for the ecosystem. The collaboration helped us study the effect of modeling in developing Yoma GF. The feedback and evaluation were based on a discussion with the Yoma Ecosystem Task Force that belongs under Trust Over IP Foundation's Ecosystem Foundry Working Group [§§] and the project manager of the Yoma ecosystem. The discussions focused on how the EGC helped Yoma GF and what key points needed to be developed on EGC to make the GF development more efficient in the future.

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[††] https://www.yoma.africa
[‡‡] JYU Startup Lab / Ecosystem Governance Compass JYU · GitLab
[§§] https://wiki.trustoverip.org/display/HOME/YOMA+Ecosystem+Task+Force

### *4.1. Data collection*

Our research team participated as an active member of the Yoma Ecosystem Task Force between May - September 2021. We relied on observations at stakeholders' meetings. Then, we had meetings with various Yoma teams separately as shown in Table 1. The fieldwork developed EGC in addition to our technical and business skills.

Table 1 Yoma meetings

| Meetings Objective | No. Meetings | Participants |
|---|---|---|
| Introduction EGC and its benefits to Yoma, requirements for the governance model, and evaluating the development of Yoma GF after EGC modeling. | 6 meetings | Yoma Project Manager |
| Discussions with the technical team expectations from EGC, collecting requirements for the technology model. | 2 meetings | Yoma Technical Team |
| Collecting information about Yoma's processes, principles, values, business processes, technology components, agreements, and regulations, presenting regular updates on modeling, collecting feedback, and discussing the risk assessment approaches. | 8 meetings | Trust Over IP Foundation Yoma Ecosystem Task Force |
| Modeling the technical layer, developing the metamodel with, e.g., new objects to fit the study case, addressing and implementing the technical requirement for the model. | 2 meetings | Research Team |
| Ethical value requirement specification workshop YOMA \| Value-based Engineering. | 3 meetings | Yoma Ethical Value Team |
| Legal requirements preparation. | 1 meeting | Yoma Legal Team |
| Discussion about the motivation of each actor to share on Yoma, addressing the revenue model and costs. | 2 meetings | Yoma Product and Innovation Manager |
| Introducing EGC, presenting how it helped to develop Yoma GF. | 1 meeting | DIF Africa Call Audience |

### *4.2. Model Creation*

Model creation took place in four phases accordingly with data collection. Data were extracted from the meeting minutes and the initial document for the GF that was undergoing continuous development during all four phases.

Phase one: Governance models. We modeled the key actors and their roles in the ecosystem, then linked each actor/role to their rights, responsibilities, and incentives gained from being part of the ecosystem. We took into consideration that each actor could have only one role or multiple roles; for example, Education Opportunity Provider had two roles: the first is Youth Credential Issuer, and the second is a Yoma Organizational Member.

Phase two: Modeling business aspects. The primary concern was the business activities for each actor/role. We linked each actor/role to their revenue model and to the expected costs, including cost type (fixed or variable).

Phase Three: Technology model. The technology model represents Yoma's services, for example, Employment Provider Onboarding, Notifications, and Credentialing. It also represents technology components, for example, the Yoma platform, framework, applications, and middleware. Lastly, data objects and data storage, Indy ledger, Aries wallet, and different data storage components.

Phase four: Legal and regulatory aspects. The legal and regulatory model represents all the agreements that control actors'/roles' interactions. It also represents all relevant standards for the ecosystem, for example, GDPR, VC, DID, DIDComm.

## 5. Findings

Our findings from the case study with the Yoma ecosystem confirmed the significant role that modeling could play in developing GF for SSI-based ecosystems. In addition, it identified the need to develop the EGC. In this section, we present Yoma models and explain their content. We communicate our critical lessons learned and present them in the form of Primary Empirical Observations (PEO). Lastly, we state possibilities for future development. More information and pictures for Yoma models can be found.

### *5.1. Models*

The governance model's primary concern is to list the actors participating in the Yoma ecosystem. The actor is an entity that is capable of performing behaviors or activities in Yoma. The governance model attaches a role for each actor. The role is the characteristic set of behaviors or activities undertaken by Yoma actors. Multiple actors can share the same role if they perform the same activities. For example, Guardian and Youth are sharing the role as educational credential holders. Social Impact Organization, Education Opportunity Provider, and Youth Credential Verifier also share the same role as Yoma Organizational Member. The governance model presents actors/roles essential details like the rights, responsibilities, rules, and incentives. Rights are a privilege to perform a particular behavior or activity. Responsibility is a behavior or action that actors or roles can be held accountable for. The rule is a regulation or principle that governs conduct in Yoma. The incentives are the motivational factor of the actors or roles to take action. Fig. 1 Yoma Governance Model.

Fig. 1 Yoma Governance Model

The business model concerns the business aspects in Yoma. It represents the activities and financial aspects of the actors/roles. Business activities are a collection of business behavior that an actor or role can perform to create and capture value. The financial aspects show the money flow in the Yoma; it includes the revenue model and the costs. The revenue model is the incoming money stream and the related pricing elements through which an actor or a role captures value, and the costs are a financial representation of a cost incurred due to an asset, resource, activity, or service necessary for value creation or capture. Fig. 2 shows Yoma's business model.

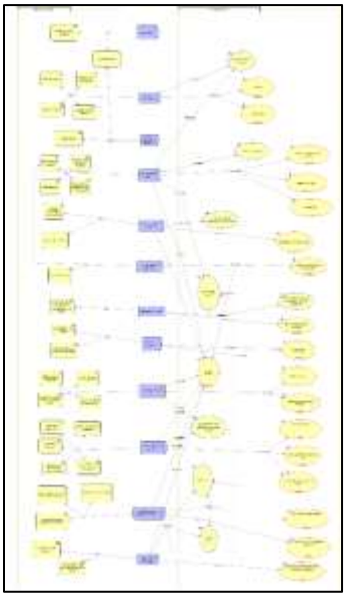

Fig. 2 Yoma Business Model

The technology model represents the technologies used and applied in Yoma. Technology elements can be categorized into three main categories: technology architecture and infrastructure, services and, data. The technology architecture comprises platforms, applications, frameworks, software, and middleware. Platform refers to tools, libraries, and reusable components that facilitate value creation. Applications encapsulate the Yoma web application. Frameworks are software libraries (components, interfaces, and tools) that enable the development of a technological solution. Middleware is software that facilitates the integration of different components within a unified interface, such as the integration of different Yoma components. Services in the Yoma context are user notifications, educational and job onboarding, and a trustful connection. Data do not include the collected information only but also present different varieties for data storage (database, Indy ledgers, user wallets). Fig. 3 shows the Yoma technology model.

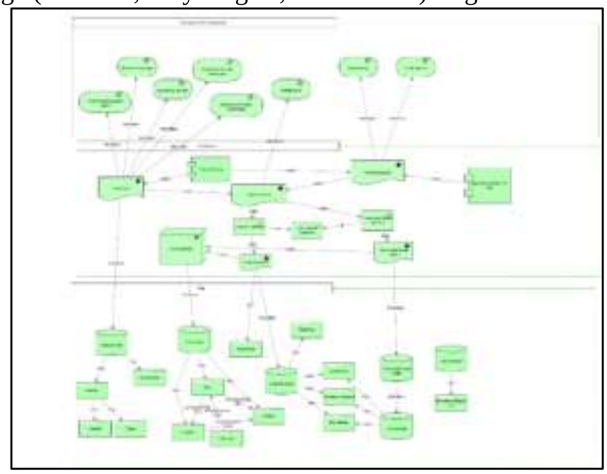

Fig. 3 Yoma Technology Model

The legal and regulatory model is concerned with the agreements between Yoma actors, the standards Yoma follows, and the laws acts and regulations Yoma complies with. Yoma laws acts, and regulations are not modeled as Yoma will operate in multiple African countries, so they would differ from one country to another. Agreements comprise the agreements' parties' terms, conditions, rights, and obligations. The standers refer to the technological and business standers that Yoma needs to follow to ensure compatibility, safety, and quality. Fig 4 shows Yoma's legal and regulatory model.

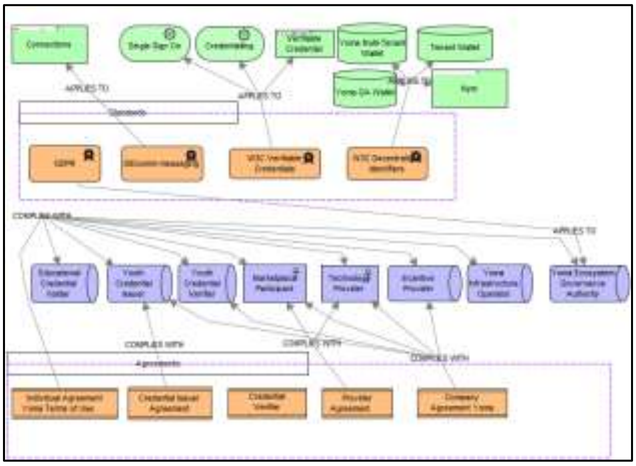

Fig 4. Yoma legal and Regulatory Model

*5.2. Advantages of modeling*

PEO1 [Uniting different viewpoints] Visual, understandable modeling tool brought different stakeholders together to discuss the GF. The different points of view enriched the depth of information in the models and in the GF.

PEO2 [Depth of details] Modeling helped the stakeholders to have more informative discussions about details from different viewpoints. For example, the governance layer helped stakeholders decide the primary responsibilities for each actor and role in the ecosystem as they had to discuss actors and their motivation to share in the ecosystem. They were able to see how each decision would reflect on other parts of the ecosystem based on how the model changes. The Yoma project manager said, "Models helped filter out the extra bits because we were forced to specify things and answer questions and see its reflections on Yoma."

PEO3 [Systematic, structured base] Modeling provided a systematic, structured base for developing a GF. The modeling language has predefined layers represented as a model. Each model describes an ecosystem layer (governance, business, technology, legal and regulatory aspects) and predefined objects representing the ecosystem components. The predefined items provided systemization and a structured base for the GF.

PEO4 [Visual aids] In addition to enabling visualization of the models separately, modeling also provided a holistic view of all the models together or each layer separately. Visualization supported understanding of the relationships between the ecosystem components in different layers. It also opened a way for discussion, brainstorming, and development.

PEO5 [Distinguishable ecosystem layers] Modeling helped distinguish between different layers' objectives on the ecosystem. Each layer has a different color aiding the viewer in recognizing its essential elements as well as differentiating which elements could be used as assistance from other layers. Each model represents only one ecosystem layer and describes its main components, the main actors participating in this layer, and its role in the GF. Ability to distinguish layers helped to focus on details of ecosystem layers and the interplay between them.

PEO6 [Support for output reports] Each model had clear and detailed information regarding each ecosystem layer. These details could be translated into output reports. Reports provided an informative summary of the ecosystem and were helpful for people who joined the GF creation process later. They were able to find a clear definition for each item, the main actors, roles, incentives, business activities, technology, and many other details. For example, the age limitation for youth was discussed in the early sessions for Yoma task force meetings, and later people were able to find descriptive details about the age limitation in the EGC governance model.

PEO7 [Flexibility and ability to customize] EGC is a flexible and customizable language. Yoma task force was able to customize the EGC to fit its purposes and needs. Instead of diverse ecosystems sticking to the available objects, new objects could be added to EGC at any project phase. For example, new object "Risk," new relationships, and new properties for many objects were added to the language in later modeling phases.

PEO8 [Establishing new relations] EGC represents the actors/roles and their incentives in the models, but the motive behind incentives could not be understood. We then discovered a need for creating a new object called "Objective" which helped justify the incentives for each separate actor/role in the Yoma Ecosystem. Objectives could be categorized as primary and secondary objectives.

Table 2. Summary of the PEOs.

| PEO | Key Experience |
| --- | --- |
| GOVERNANCE FRAMEWORK PERSPECTIVE | |
| Depth of details | Deeper details create a better understanding of the governance framework and help to formulate better. |
| Uniting different viewpoints | Different stakeholders have different views on the ecosystem. Modeling made different views as one united view on the GF. |
| Systematic, structured base | Governance frameworks need a systematic base to produce a comprehensive framework. |
| Visual aids | Visualization helps to have a holistic view of the Governance Framework |
| MODELING LANGUAGE PERSPECTIVE | |
| Distinguishable ecosystem layers | Distinguishing layers makes it easy to understand how they are related and what elements link layers together. |
| Support for output reports | Models can give details about the ecosystem elements and relationships in the form of reports. |
| Flexibility and ability to customize | Modeling language flexibility help to cover all the aspects of the domain and the organizations' specific requirements |
| Establishing new relations | Actors' incentives need to be justified with the actors' objectives |

### *5.3. Future development*

EGC evaluation drew the research team's attention to three future developments needed. First, the Yoma model's view was not perceived to be simple enough. In the ecosystem layers, there were too many details for practical application. Adding all the details resulted in congested models. More efficient data categorization would provide a simpler view for the produced models. Second, the output reports would need a different structure to make it easier to identify relevant details. Third, there is a need for a trust assurance document that shows the GF compliance with the standards, e.g., GDPR, security standards, and technical standards. Models' simplicity, restructured reports, and implementing trust assurance documents would add more value to the EGC and make it more efficient.

## 6. Discussion

This paper aims to highlight how modeling can help develop the GFs for SSI-based ecosystems that are decentralized and distributed in their nature. Modeling provides simplified visual models to aid in GF development. Our study used a domain-specific modeling language (EGC) developed explicitly for SSI ecosystems. The findings from our research describe how modeling made the development process of Yoma GF more accessible and helped focus on the deep discussions between different stakeholder groups. The stakeholders' groups presented different views of the ecosystem working processes, motivations, expectations, and other details.

Our research describes building the models as a new trend in the GF creation process. It is observed that modeling was not only capable of fulfilling the general requirements of GF in Yoma's case, but it also extended new processes to achieve these requirements and to increase its level of efficiency.

Recent work states that GF needs to address the general requirements like guidelines, specifications, definitions, and contracts to make the GF clearer, usable, and more understandable. In this study, GF general requirements were achieved in a better way using modeling (PEO1 [Uniting different viewpoints], PEO2 [Depth of details]). The EGC provides a systematic and structured base for creating a GF, and thus, the creators can ensure that all the ecosystem details are in their discussions and in GF. In addition, decisions related to the ecosystem are taken in the presence of various stakeholder groups as creating the models needs stakeholders' cooperation.

This study reveals advantages of modeling that existing literature has not identified yet. Modeling provides a systematic and structured base that ensures that all the needed information will be included in the GF (PEO3 [Systematic, structured base]). Furthermore, it provides a visual view of the ecosystem elements and relatedness (PEO4 [Visual aids]). Visualization provided stakeholders and GF creators a better understanding of how the ecosystem operates and how ecosystem elements affect each other, as seen from the model pictures. The layer elements were always described in GF in a long text, which can sometimes be confusing and lead to the missing of information. Modeling assisted in distinguishing layers by using color codes, among other visual hints, such as grouping and separation (PEO5 [Distinguishable ecosystem layers]). Further, it provided clear and adaptable reports (PEO6 [Support for output reports]). Without modeling, it was not possible to list specific elements or describe particular layers of the ecosystem; instead, readers had to read the whole GF to collect the needed information. Now users can use various reports. Furthermore, the flexibility and the possibility of customization has been seen as an advantage of EGC as compared to most modeling languages that have predefined items (PEO7 [Flexibility and ability to customize]). A user could add new elements or objects to the EGC language while working on an ecosystem. Finally, we found a need to justify "incentives" with a new element "objective" during the modeling that emphasizes the need for establishing new relations (PEO8 [Establishing new relations]). We could not find information about PEOs 3–8 in the previous literature and thus consider them original ways to develop the GF. Their originality comes from using EGC as its features support a new process for GF development.

## 7. Conclusions and limitations

GF documents support SSI practitioners to observe and interpret more about ecosystems that are built around promising identity technology. A GF includes information about the ecosystem, its principles, legal agreements, standards, policies, values, norms, and terminology and, thus, is essential in building SSI ecosystem with a decentralized human-centric paradigm. However, practitioners and researchers face two main problems regarding GF. First, the produced GF can be very long and have guidelines from multiple disciplines that would confuse readers with less technical capabilities. Second, readers might miss information or significant details that are pertinent to them.

Our research focused on the role of modeling in developing GF for SSI ecosystems, and we suggest utilizing modeling as a tool to overcome these two key problems. First, visual models allowed anyone with domain knowledge to read the content of each ecosystem layer even with less technical capabilities. Second, providing visual models for Yoma during the development of their GF supported creating clearer and more systematic GF. This modeling experience helped our team to use and develop EGC further in the existing GF development process. It also supported adopting a new, lean approach to governance while creating a GF.

Using EGC has its limitations. First, the modeling language was implemented on a licensed tool called MetaEdit+. Thus, modeling and updating the models were only available for specific resources with the license that caused time delays and complexity, limiting the utility of EGC. This disadvantage could be overcome if EGC was implemented in an open-source environment. Second, Yoma was guided by the European Self-Sovereign Identity Framework Lab (eSSIF-Lab)*** mental models, whereas the EGC's definitions were extracted from the blockchain literature. This led to conflicting terminology and confusion.

We see that EGC could be useful also in other stages in the ecosystem life cycle, for example, in operating the ecosystem, revising, or extending the GF as needed. Additionally, the tool supports extracting, updating, customizing, and changing the format of reports upon any change in the ecosystem. As with any tool, it matters how it is used (the method) and why it is used (the methodology). Additional research work and tight collaboration with SSI practitioners are still required, especially in the areas of operating ecosystems and extending GFs further to develop the tool, the method, and the methodology.

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