The Role of Modeling in Blockchain Process Design

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Abstract. Blockchain could introduce a new approach by which organizations view and govern their information and technology projects. Processes involving blockchain are oftentimes transaction-based, decentralized, and require coordinated communization before implementation. This approach may introduce new challenges to conventional modeling techniques. In this study, the role of modeling during the design phase of blockchain processes is explored. This role is described through a theory derived from 30 semi-structured interviews, two case studies, and two focus groups. The results are applied to inter-organizational business process modeling. The role of modeling, the effects on this role caused by the introduction of blockchain, and the shortcomings of current modeling techniques are described. Additionally, the study provides several opportunities for future research.

Keywords: Modeling · Blockchain · Process design

1 Introduction

Blockchain could introduce a new approach by which organizations view and govern their information and technology projects. This approach may introduce new challenges to contemporary modeling techniques. Processes involving blockchain are oftentimes transaction-based, decentralized, and require coordinated communization before implementing [1]. For instance, once a smart contract or consensus algorithm is written, deployed, and enforced its code is final and cannot be changed unless depicted otherwise in the governance [2]. Besides the technological solution, the inter-organizational setting, business processes, and policy & social environment are affected as well: blockchain introduces a transparent, consensus-based, and highly standardized environment where data and processes need to be unified and streamlined. This is in contrast to the current introvert information technology paradigm where most organizations reside in, as these differences force organizations to interact and communicate more with their competition/competing colleagues [3, 4].

Practice suggests that the design phase, with a particular focus on modeling, needs to be adjusted to facilitate the changes blockchain introduces to them [5]. For example, organizations might face unforeseen challenges when attempting to integrate processes incorporating blockchain (hereafter referred to as “blockchain processes”) in their current process architecture due to a lack of interoperability or the inability to incorporate

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them in the current enterprise architecture, as its distributed nature might not be facilitated by contemporary architecture modeling techniques [6]. Besides this, blockchain processes could enable new ways in which organizations collaborate, communicate, and share information because it makes trust less impactful in ecosystems where it was previously lacking, like peer-to-peer money transfers [7]. This could introduce challenges usually not associated with process (re)design or challenges which organizations have not yet faced. For instance, if process control is handed over to participants outside of an organization, data accuracy cannot be validated, obligations cannot be enforced and it is harder to check if conditions are met [8]. Moreover, inter-organizational relationships, collaborations, and communication might be affected by a technological solution, altering the way they are perceived and governed [9, 10].

Current literature on the modeling of blockchain process also suggests a need to facilitate the changes blockchain introduces [5, 6, 11]. The design or engineering phase is often the most important aspect of process (re)design, as this phase requires extensive communication between partners, coordination between data, and process unification [1]. Research triggers found in literature and practice show the need for research regarding the role of modeling in blockchain processes. These research triggers led to the following research question: "*What is the role of modeling during blockchain process design?*"

The next section discusses the current state of the research field. After this, the methodology, together with the data collection and analysis, is described. Next, the results of the research are presented and elaborated. The last section presents the conclusions and discusses the utilized methodology and results of the research, followed by possible directions for future research.

2 Background and Related Work

The current knowledge domain of blockchain modeling is nascent, but not non-existent. Previous internal research included a literature analysis [12]. This research views the literature analysis as current and valid because it was conducted shortly before this study started. However, because the literature analysis encompassed a low amount of literature (five relevant contributions identified in total), they will be discussed separately, and relations or opposite views will be described.

The analysis showed that Porru and Michele [5] suggest that, when dealing with Blockchain-Oriented Software engineering (BOS), many challenges must be responded to. Among these challenges is the need for testing the software of blockchain applications, especially because there are multiple programming languages used during this development. Additionally, smart contracts should be created through software tools to streamline development in specialist languages (e.g. solidity, a language designed for writing smart contracts in Ethereum).

Developing further on the work of Porru and Michele [5], Rocha and Ducasse [11] attempt to create this specialist language to model BOS. Rocha and Ducasse [11] add that modeling is an important part of designing software, therefore developers may struggle to plan their BOS. They attempt to start the discussion on specialized blockchain modeling notations by applying three complementary modeling approaches to a BOS example. Rocha and Ducasse [11] conclude that every approach had its strengths and weaknesses, and that a specialized notation for BOS is needed to properly design it. These weaknesses were shown when attempting to cope with aspects specific to blockchain, e.g. decentralization and consensus.

Mendling [13] focusses less on the entirety of BOS, but rather on how Business Process Modeling and Notation (BPMN) can facilitate blockchain processes. Mendling [13] provides seven challenges for blockchain-based process support, two of which imply the role of modeling. The first challenge described the need for an understanding of how business processes can be best innovated using the potentials of blockchain. The second challenge describes new governance models with an overall impact on business strategy. The first challenge is further elaborated upon in Mendling et al. [6], where they reiterate the challenge of understanding how business processes can be best innovated using the potential of blockchain but adds that insights from operations management and organizational science could be informative. Mendling et al. [6] do not suggest the need for a specialized language for BOS, in contrast to Porru and Michele [5]. This suggestion is supported by García-Bañuelos, Ponomarev, Dumas, and Weber [14], who demonstrate a method to compile a BPMN process model into a Solidity smart contract without running into insurmountable obstacles.

3 Research Design

The data for this study is collected over a three-and-a-half-month period, between February 2019 and late-May 2019, through 30 semi-structured interviews, two case studies, and two focus groups. The semi-structured interviews, case studies, and part of the focus groups were used as data collection. For sampling, a combination of convenience sampling and snowballing was utilized.

3.1 Interviews

The first method of this study consists of 30 semi-structured interviews. The goal of the interviews was to let the participants expand on their perspective on modeling during their experience with blockchain processes design. This goal was warranted with a criterion: they should have previous experience with utilizing modeling techniques when conceptualizing blockchain processes. The number of interviews that were conducted is 30, which is adequate for qualitative research [15]. During the interviews, an interview protocol with three sections was used. Section one discussed the participants' background and current occupation. Section two discussed one or multiple blockchain projects the participant was involved with. Section three discussed the role of modeling during those cases. After each subsequent interview, the interview protocol was reviewed and adjusted. Changes made to the interview protocol were meant to improve the data derived from the subsequent interviews. It was not necessary for each participant to answer the same questions, as the goal of the interviews was to extract the participants perspective on modeling during their experience with blockchain process design. In total, 1655 min (27,5 h) of data has been recorded over 30 interviews, averaging 55 min per interview.

Starting from interview 11, the researchers consolidated the interviews and made preliminary conclusions to the research questions. These preliminary conclusions were validated at the end of all interviews following interview 11. After each time the preliminary conclusions were validated, they were reevaluated by the researchers. This helped validate the results and, in some cases, trigger subjects during the interview that were not yet discussed, increasing the richness of the information the participant could convey during the interview.

3.2 Case Studies

If a specific interview had more depth to it than could be covered during the interview, the researchers asked the participant to lend their project for case study analysis. Two criteria were established for a project to be considered for a case study: 1) the existence of documentation for both the processes and technical architecture of the application and 2) a working application. The first criterion allowed the researchers to review the documentation referenced and discussed during the interview. The second criterion meant the project had experience translating the documentation into a working application, completing the design phase, which ensured and grounded their experience of modeling in this phase.

In total, two case studies were conducted. The selection of projects was based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied [16]. During the case study process, a holistic multiple-case design was used, according to Yin's [17] Multiple-Case Study Procedure. A multiple case study design was chosen because the units of analysis were essentially unrelated and thus should not be combined into an embedded case study design [18]. The multiple-case study procedure consisted of three phases: 1) Define and Design, 2) Prepare, Collect, and Analyze, and 3) Analyze and Conclude. During phase one, the theory was developed, the cases selected, and the data collection protocol designed. The second phase consisted of the execution of the case studies themselves. The third phase consisted of the following actions: 1) drawing cross-case conclusions, 2) modifying theory, 3) developing policy implications, and 4) writing cross-case report. As described by Yin [17] and supported by Eilbert and Lafronze [19] and David [20], a Multiple-Case Study with two or more cases is much preferred to a single-case study by providing 1) analytical benefits and 2) the possibility of comparing contrasting situations, leading to further new insights leading to 3) theoretical replication and further generalizability.

3.3 Focus Groups

The results of the interviews and case studies were discussed and validated with two focus groups. Before a focus group was conducted, several aspects were addressed: 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities, and 6) the protocol of the focus group [21].

For this study, the goal of the focus group series is to validate the conclusions of the interviews and case studies and go in-depth into the role of modeling techniques in blockchain processes. The selection of participants should be based on the group of individuals, organizations, information technology, or community that best represent the phenomenon studied [16]. In this study, organizations and individuals that deal with the use of modeling techniques during blockchain process design; examples being project managers or software engineers. The participants were selected based on the same criterion as the participants for the interviews. In total, two focus groups were held. The first focus group had four participants, the second five. Okoli and Pawlowski [22] and Glaser [23] state that the facilitator should be an expert on the topic and familiar with group meeting processes. The selected facilitator has conducted research on the topic before and has experience with interviewing participants on the topic. In addition to the facilitator, the second researcher was always present during the focus groups, thus participating as a 'back-up' facilitator that monitored whether each participant provided equal input, and if necessary, involved specific participants by asking for more in-depth elaboration on the subject. All focus group sessions were audio and video recorded. Each focus group session followed the same protocol, each starting with an introduction and explanation of the purpose and procedures of the session. After the introduction, ideas were generated, shared, discussed, and refined by the participants. This allowed the participants to respond to a statement that represented a specific preliminary conclusion effect. After every focus group session, the researchers analyzed and consolidated the results. Each focus group took about three and a half hours to complete.

4 Data Analysis

After the interviews were conducted, the main findings were summarized by the researchers. All interviews and focus groups were transcribed and analyzed in detail using the qualitative data analysis tool NVivo 12.0 [24]. As established in the introduction, blockchain modeling is a nascent research domain [12]. For nascent research domains, thematic content analysis coding for evidence of constructs is an appropriate method [25]. Thematic content analysis is a descriptive presentation of qualitative data. For thematic content analysis, grounded theory is often used [26]. However, grounded theory insists that theoretical sampling is part of the methodology [16]. Because the method used in this study does not comply with this rule, it will not be considered grounded theory. However, Strauss and Corbin [27] indicate that their guidance for qualitative data analysis can also be useful for research that does not leverage grounded theory. Because of this, Strauss and Corbin's [16] process of 1) open coding, 2) axial coding, and 3) selective coding is used, see Fig. 1, which helps structure the chain of reasoning during the data analysis.

The first cycle was open coding, involving the analysis of sentences and groups of sentences [16]. During the open coding process, the researchers tried to identify what Boyatzis (1998) refers to as "codable observations". Here, the researchers coded the data by identifying sentences in which the role of modeling was discussed. Open coding was followed by the second cycle, axial coding, in which the researchers identified how the participants viewed the role of modeling and why they had this perception [16]. The second cycle started with one interview that was coded separately by both researchers. The coding of this interview was compared and discussed to align the perspective the researchers had on the process. After comparing and discussing a separately coded

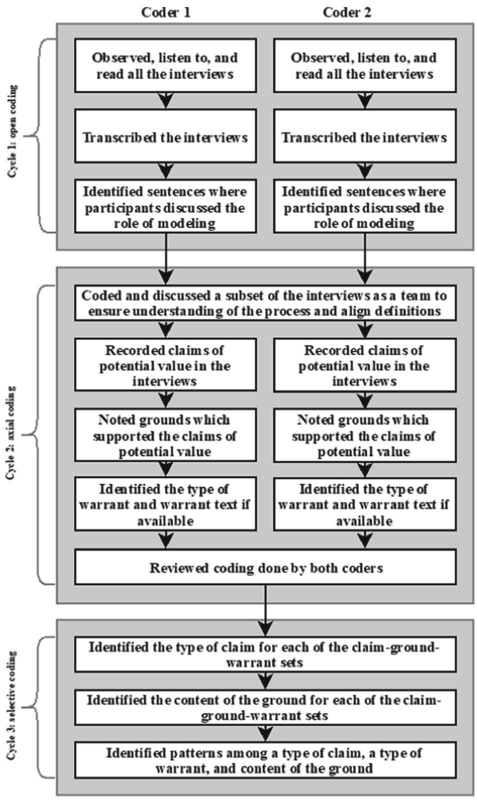

Fig. 1. Coding process

interview, the researchers coded three interviews together to ensure the understanding of the process. This improved reliability of the process [28]. After the process alignment, Toulmin's [29] framework was utilized to code the interviews, which consists of three elements: claim-ground-warrant.

When a participant discussed their perspective on the role of modeling during blockchain process design, it was coded as a claim. Each claim had a ground, in which the participant elaborated on the claim. Warrants were not explicitly coded, as they are not explicitly stated by the participant and, therefore, reflected the researcher's assumption. In the end, only one warrant was identified in the data: "Authority – Asserts the reliability or validity of a presumed expert source and their statements (i.e., grounds) expressed [30]." Whenever a participant expressed their opinion that was accompanied by a ground based on assumptions instead of experience, it was not coded as a claim of a warrant, as the researchers could not identify the warrant. After both researchers concluded the coding of their interviews, one interview was randomly picked and coded again to provide a "reality check" [28] for the researchers, making sure the process established at the beginning of this cycle was adhered to until the end of the process. After axial coding, the third cycle, selective coding [16], started. In this cycle, the type of claim and the content of the ground were coded. The types of claims were not predetermined, but rather coded along the theme the researchers interpreted the claim to be part of. This process required inductive reasoning, which was applied to reason from empirical observations (interviews, case studies, and focus groups) to a theory.

After the interviews, the case studies were analyzed. This started with interviewing at least one of the organizations associated with the case, analyzing the documentation, and cross-referencing this documentation with the interview. The interview in which the case study is identified is also considered as the interview conducted in this case study, as the information about the case derived from the participant was considered saturated by the researchers. By analyzing primary and secondary data concerning the same case, inconsistencies in the data collection where identified. To reduce the chance of inconsistency, the participants were asked to elaborate on the secondary data during the interview. Based on this process, no inconsistencies were identified. The last data to be analyzed were the focus groups. The focus groups consisted of data collection and data validation. The data collection part was analyzed using the same method as the interviews. The data validation part was analyzed by both researchers listening to the reactions and discussion of the participants in the video recording and by analyzing the answers they submitted through Socrative; a tool that was utilized to structure the discussion and topics.

The process of how the results are derived from the data should be seen as an extension of the selective coding process and is based on Runeson and Höst's [18] process of deriving a chain of evidence. The first phase consisted of interpreting the results. It started with categorizing themes based on commonalities observed by the researchers. Because blockchain changes the function of trust, the categorization of the results of this paper should encompass inter-organizational aspects as well. Therefore, we apply the results to inter-organizational business process modeling [31] and discuss how it may affect modeling. The second phase consisted of interpreting relationships between the themes and deriving effects on the role of modeling during the design phase of blockchain processes caused by these relationships. These effects simultaneously formed the conclusions drawn from the data. Finally, the conclusions are translated into a theory and structured alongside the categories identified by the researchers.

5 Results

The results are structured along the two facets of inter-organisational business process modeling: the modeling facet and the process facet.

5.1 Inter-organizational Modeling

Two effects that the introduction of blockchain has on the activities and decisions made during inter-organizational modeling are identified: inter-organizational processes and architecture. **Inter-organizational processes** become more complex and inclusive. Because of the collaborative and inter-organizational nature of blockchain, more stakeholders are introduced that have to participate in an ecosystem. This makes the inter-organizational processes more complex because more stakeholders are involved, more communication channels exist between these stakeholders, more power is to be distributed because of on-chain governance aspects like voting power and different consensus mechanisms, and the network effect is more important because more stakeholders are involved. Besides more complex, they also become more inclusive because stakeholders that would normally not be considered for collaboration are now an integral part of the project. For example, one participant noted: "*Construction workers now have to use the same application as everyone else, meaning they have to be aware of how and why the application is used, up until a certain point. This is something they are not used to, as these applications usually only encompass a few big organizations.*" Additionally, processes become compartmentalized, meaning the integral process consists of interchangeable components. This is supported by a, as one participant of the focus groups called it, "information architecture", in which stakeholders standardize definitions. The **inter-organizational architecture** is defined as the 'minimal compliant architecture' of the application. This refers to an application architecture that is compliant up to its weakest link, creating the "minimal compliant architecture". This means that the application architecture is compliant with both general legislation as well as organization-specific legislation, which might apply to external- and internal stakeholders of the ecosystem. During the focus groups, all participants agreed that this effect was magnified by the introduction of the General Data Protection Regulation (GDPR) legislation and had a significant impact on the architecture of blockchain processes. One participant noted: *"Some organizations very strictly adhere to the GDPR legislation, and if you want to collaborate with these organizations you have to adhere to their standard of data privacy."*

The modeling approach should start with stakeholder identification. Identifying these stakeholders is increasingly important when blockchain is introduced, as stakeholders in a blockchain application are often external stakeholders of each other. One participant noted: *"Blockchain is always with the outside, collaborating with multiple parties."* Which give baring to the statement that external stakeholders are what gives value to blockchain applications. Another participant noted: *"If you want to do something with blockchain, you have to do it with multiple [external] parties, otherwise you do not need a blockchain"*. This is in line with previously reviewed literature which noted that inter-organizational collaboration is key to leveraging blockchain [7]. After the stakeholders have been identified, the business model of the ecosystem is defined. One participant noted that conceptualizing the business model attracted the attention of different professions and expertise. The participant noted that: *"If you change a business model it has an impact on business operations. Chief Financial Officers (CFO's) are often one of the first people to join these meetings. They might not participate in the project, but they for sure are in the engineering."* Modeling is also used for communication and creating a common understanding among stakeholders. This communication is especially difficult when it concerns layman stakeholders, as one participant noted: *"Trying to place yourself in the shoes of a layman is the essence of a good model, I think. Only then can you convey complex models to different groups of people."* However, these models should not only be used to communicate towards layman stakeholders but to all stakeholders, as they convey essential information in a way that is understandable for all. Lastly, the information and minimal compliant architecture with regard to the stakeholders and the ecosystem is created. This entire modeling approach is outwards instead of inwards. Inwards modeling means stakeholders view themselves as the starting point of their perspective and differentiates between internal and external processes. With an outwards modeling perspective, the ecosystem is the starting point of the perspective and the processes modeled are those used by the entire ecosystem (usually crossing organizational borders).

The only shortcoming identified is the difficulty of communicating complex subjects to layman stakeholders. One participant noted: *"Self-explaining models would be a great step forward. Something that already works really well is modeling something as simple as possible, just the essence of what you are trying to say really. Also, visualization in a way that is visually attractive: a video or animation of sorts. But that could just as easily be someone who tells a story while being filmed: a man and a woman who are perceived as experts that explain what is going to happen in an easy and understandable manner."* It should be noted that this is not necessarily a shortcoming to the modeling of blockchain processes. However, blockchain does magnify this shortcoming because more layman stakeholders are involved in the design phase.

5.2 Organizational/Business Processes

Three effects that the introduction of blockchain has on the activities and decisions made in the organizational/business processes design are identified: process architecture, transactional focus, and evolving project roles. **Process architecture** concerns the need for information standards. Stakeholders need to provide data to the application in a standardized manner so that other stakeholders know how to interpret the data. This does not mean that they have to adjust their internal processes of collecting, storing, and using the data in accordance with that same standard. For example, a stakeholder might collect data using XML but when the stakeholders provide the data to Application Programming Interface (API) of the application, it gets stored in a JSON format. This way, all the data in the application is stored in a standardized manner, creating an open standard (a standard that is publicly available but has certain demands for usage). If layman stakeholders are not aware of this difference, it could be solved by letting them provide their data through, for example, a web portal. One participant noted: *"As soon as you cross organizational borders, communication will be a lot stiffer. But another thing that is very important is that if there is no standard for data communication, you add another dimension. Sometimes there is a standard which is open to a lot of interpretation. Sometimes, this causes you to define something a little different than [other stakeholders]. In that case, you need to have to harsh discussion to figure it out together. Right now, we often solve this inter-organizational problem by sending messages. If you place one application in the middle you will not be able to do that, then you all have to adhere to one standard."* In the focus groups, the participants noted that, although they agreed with this effect, this open standard is always subject to the governance of an application. For example, if a majority of the ecosystem wants to change something to the application, they could impose a different standard. **Transactional focus** refers to how the application functions. Blockchain applications are inherently made out of state changes instead of linear processes because they store transactions, not data. This means that an application doesn't necessarily follow a linear process (first activity a, then activity b, etc.) but consists of application states which are altered by transactions. This is done by stakeholders in the ecosystem sending transactions to one another. For example, a patient can go to doctor A to get their bloodwork done. Doctor A will provide the application with the results of this bloodwork, creating the first state. This first state consists of the patient's data and the bloodwork results. The patient can then go to doctor B, who diagnosis his bloodwork results and provides the application with the diagnosis, creating the second state. However, doctor B has to know how to interpret the bloodwork results of doctor A. This effect reiterates the need for an application-wide information standard.

Evolving project roles means that certain professions and expertise is used in different phases and/or have different activities. Because the need for projects to be privacy- and compliant by design, the data model has to be as well before going into production. For example, whether a data model contains personal data or not could impact the compliance of a model to legislation such as the GDPR [32]. To get a model privacy- and compliant by design, lawyers are often involved in the project from an early phase. Instead of lawyers saying what is not compliant, they help by figuring out how it can be changed to be compliant. One participant noted*: "At some point, people just learn that is it not ideal to involve legal afterwards. [GDPR] enhanced that need because we have to be more careful with personal data. Because this became more important legal got more tools and methods to control and observe where personal data is stored and where people can access this data."* Additionally, other project roles considered to have increased in importance in blockchain projects, as named by participants, include procurement, marketing, communication, and risk management.

During the design process, the function of an application is visualized or conceptualized. Standardized modeling techniques like BPMN and UML and other techniques like PowerPoint and wireframes are utilized. For example, PowerPoint can be used to digitize decision made in a meeting between stakeholders about what features the application must include. This PowerPoint document will then be translated into wireframes, visualizing how the interface of the application could look. After that, state diagrams (a behavioral diagram in UML [33] can be used to show transactions between stakeholders and BPMN 2.0 [34] can be used to make a visualization of the integral process in the ecosystem. Participants noted that they use modeling techniques in three degrees: 1) no adherence to standardized modeling techniques, 2) their interpretation of standardized modeling techniques allowing them to navigate aspects of blockchain process design they thought were not supported by the techniques, and 3) adhering completely to the standardized modeling technique. On the subject of not adhering to standardized techniques, one focus group participant noted*: "We do not use standardized modeling tools because they want to know things we are not even thinking about in these stages. They require too much detail to be used in this stage."* Another participant, when asked how they differentiated which data is stored on the blockchain and which is not, noted: *"With color, we denoted which data is stored in the blockchain and the changes of a transaction."* On the subject of adhering completely to the standardized modeling technique, one participant noted: *"Blockchain, in the end, is just a database that can alter process flows. You are no longer looking at your individual databases but at a shared database. I do not see how contemporary modeling techniques are not sufficient. We do* *not need a completely new modeling technique for this, current techniques really are sufficient."* One participant argued that even though contemporary modeling techniques are sufficient for blockchain process design, they could benefit from updates to their standards to better facilitate certain aspects of blockchain. Participants also experienced difficulty modeling which data is stored on the blockchain, facilitating their processes with a transactional-based application, how stakeholders reach consensus, and how the consensus was reached (or was not reached) by the application.

Four effects that the introduction of blockchain has on the technology solution are identified: blockchain type, on-chain governance, transactional focus, and psychical location. **1) Blockchain type** refers to the nature of a blockchain being public or private. If a blockchain is public, it means that everybody can join the ecosystem. In private blockchains, stakeholders have to be validated before they can join the ecosystem. In a public blockchain, transactions are only processed if consensus is reached by the miners. This means that once a blockchain or smart contract goes into production, it gets increasingly difficult to make changes to the application as more stakeholders join the ecosystem. This leads to projects wanting to be sure the application is correct before putting it in production, adhering to the first-time-right principle. This leads to a greater need for testing, which is in line with literature [5]. During development, the application has to be tested more thorough because once it is placed in production it is hard to correct mistakes. Because of this, the design phase gets more attention, making it a more structured project. In the focus group, one participant added that even though the project is more structured than other information system projects, the development can still be iterative. Before the focus groups, it was presumed that this effect was only applicable to public blockchains. However, the participants of the focus groups disagreed and noted that this would also apply to private blockchains because it depended on the governance structure. Even once an application is live in a public blockchain, it can still be altered through various governance mechanisms. **2) On-chain** governance enables incentivized applications and causes applications to be structured in a transactional manner. This affects the technical architecture of an application because it has to support state transitions and a form of cryptocurrency. **3) Transactional focus** means that processes get compartmentalized. this effect means that the technical architecture of the application needs to be based on state changes instead of a linear process. **4) Psychical location** of the data is also an important decision. Because of the privacy- and compliance by design principle, projects need to know where their data is stored because the psychical location of the data dictates to which legislation the project has to adhere.

The role of modeling also involves the technical descriptions of the applications. According to the focus groups, this is done more detailed than in other information system projects. One participant explained that because of the difficulty of changing features after the application has gone in production, they spend more attention on how they described the application. By spending more attention on the description, all stakeholders got a better idea of how the application will function once in production and could identify mistakes beforehand. This made the project more structured. The participants of the focus groups added that even though the project is more structured, the development was still done iteratively. The application was coded based on the functional specifications made while designing the business/organizational processes. Participants noted that programming a blockchain application is similar to other information systems and did not encounter any shortcomings while programming the application. On the subject of the progression of innovation in blockchain application programming, one person noted: *"When we started with blockchain there was no tooling to create the business network, it was manual labour and coding. Now we can just model it. You model which stakeholders are in your network, which assets they exchange, whether they go through some kind of lifecycle etc. You model transactions, and when you have modelled that (it takes a while as you have to really think about it) you just generate the network, all the API's, a dummy User Interface (UI), and you can continue."* This means that low-coding environments for blockchain applications might be available in the near-future, lowering the abstracting level of blockchain development, making modeling a more important aspect of blockchain process projects.

One participant noted an interesting approach to modeling smart contracts during the interview: *"If there is a mistake in the hardware, for example in the chips, you have to throw away all those chips. It is the same in the blockchain. If we upload twenty faulty smart contracts and put them in circulation you cannot just have a small vote and get them off the blockchain because they are online and just continue operating."* The participant continued by detailing how a smart contract is developed, from a policy written on paper to coding specification. The participant started in a room filled with lawyers who had to translate these policies to logic which can be modelled. They used the Decision Model and Notation (DMN) for this [35]. After the policies had been translated into DMN, they translated the DMN models into First Order Logic (FOL) (the symbolization of reasoning in which each sentence, or statement, is broken down into a subject and a predicate [36]), which would then be coded into a smart contract. By using DMN and FOL, the smart contract was logically sound, reducing the threat of a smart contract being hacked once it was put in production. This does not mean that the smart contract is un-hackable because a smart contract consists of both logic and code. The code could still be hacked.

6 Conclusion and Discussion

In this paper, we aimed to find an answer to the following research question: "What is the role of modeling during blockchain process design?" To answer this question, 30 semi-structured interviews, two case studies, and two focus groups were conducted in a study that, to the knowledge of the authors, has not been conducted before in this research domain. The role of modeling stays consistent with the definition of having at least four purposes: 1) supporting communication between developers and users, 2) helping analysts understand a domain, 3) providing input for the design process, and 4) documenting for future reference [37, 38]. However, the data identified 11 effects blockchain has on the role of modeling. The 11 effects identified should be taken into account when conceptualizing blockchain processes. From a theoretical perspective, our results are mapped to aspects of inter-organizational business process modeling [31]. The gained insights provide knowledge to better understand the role of modeling during blockchain process design. From a practical perspective, this research provides insight into how blockchain affects the role of modeling. This insight should be used as foresight into the role of modeling when initiating a blockchain project. Additionally, organizations who concerns themselves with blockchain should learn from the insights presented and start developing best practices, concepts, and methods as this could guide them to better facilitate the effects the introduction of blockchain has.

This research has several limitations. Considering our sampling and sample size, all research participants in the sample had a Dutch nationality, and most of them (apart from one) worked at Dutch organizations. This might make the sample less generalizable to projects at foreign organizations and countries. Additionally, most participants only had experience in relatively small projects, therefore limiting the insights of these participants to smaller projects. Future research should focus on generalizing towards international organizations. Especially because of the inter-organizational nature of blockchain processes. This same argument also holds as a basis for future research into implementation challenges experienced in other countries. Such research could identify research patterns which can form best practices, concepts, or methods to model blockchain processes. With regards to the sample size, while 30 interview participants, two case studies, and two focus groups is a sufficient sample to conduct explorative research on the role of modeling during blockchain process design, future research should also focus on including more participants, preferably in conjunction with the aforementioned future research directions.

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