Loose Collaborations on the Blockchain: Survey and Challenges

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Abstract. Blockchain technology has emerged as a promising infrastructure for enabling collaboration between mutually distrustful organizations. The enactment of blockchain-based collaborative processes typically requires a profound understanding of the process being executed, limiting support for flexible processes that cannot be fully prespecified at design time. To overcome this limitation, support for looseness, dealing with the configuration and execution of underspecified processes, is essential. In this paper, we conduct a systematic literature review to examine looseness support for blockchain-based collaborative processes from a behavioral and organizational perspective. In addition, we identify open research challenges to pave the way for further research in this area.

Keywords: Collaborative processes · Flexibility · Looseness · Blockchain

1 Introduction

The adoption of blockchain technology in business process management (BPM) opened up new opportunities for the collaborative execution of business processes. Unlike traditional, centralized BPM systems for process orchestration, blockchain technology provides a trusted environment for the decentralized execution of collaborative processes [20]. Most current blockchain-based approaches for process execution require a comprehensive understanding of the process prior to deployment, typically using a model-driven design approach [26]. However, in knowledge-intensive domains, processes are required to support dynamic behavior that cannot be fully anticipated at design time, thus demanding a more flexible execution environment [5]. To support the execution of such dynamic processes on blockchains, support for looseness is required.

The concept of looseness deals with the configuration and execution of underspecified processes. By incorporating looseness support, process specifications can be refined beyond design time [24]. However, due to the immutability of the deployed logic, associated costs, and increased complexity, deferring refinements can pose challenges in a blockchain environment. This survey investigates the support of looseness for the execution of blockchain-based collaborative processes based on the following research questions:

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RQ1: To what extent do model-driven blockchain-based approaches for executing collaborative processes support looseness in existing literature?
RQ2: What are open challenges in supporting looseness in collaborative processes on the blockchain?

To answer the research questions, this paper presents a systematic literature review analyzing looseness support of current approaches for blockchain-based collaborative business process execution from a behavioral and organizational perspective. Based on the results, open research challenges are derived.

In the following, Sect. 2 outlines fundamental concepts such as collaborative process execution using blockchain technology and looseness, as well as related work. Next, Sect. 3 presents the methodology used for the systematic literature review. Section 4 reviews the current looseness support of approaches enabling blockchain-based collaborations based on the selected literature. Finally, Sect. 5 identifies open challenges, and Sect. 6 concludes this paper.

2 Foundation and Related Work

2.1 Blockchain-Based Collaborative Processes

In an interorganizational environment, organizations are entailed to collaborate by bridging their internal workflows to create value that equitably benefits all participants. The collaboration can take different forms according to the desired goal and boundary scope for each organization [19]. Business process management offers a set of methods to design, execute, and optimize business processes to reduce the ambiguity of complex cross-organizational interaction behavior [32]. The literature refers to interacting processes involving multiple participants with different terms, such as process collaboration or choreography. In the context of this paper, we adopt the term *collaborative process* to encompass processes of interorganizational nature [6].

Process-Aware Information Systems (PAIS) ensure that the participants adhere to the execution order of activities by keeping track of the execution state of a process. Centralized PAIS architectures are intended to support the orchestration of internal processes within the boundaries of an organization [21]. However, collaborative processes are decentralized in the sense that they are not controlled by a single authority. To overcome this challenge, traditional PAIS architectures must evolve to support collaborative business processes.

The emergence of blockchain technology, enabling the creation of a secure and distributed ledger among a network of participants without the need for mutual trust, holds great potential as a platform for executing and monitoring collaborative business processes [6,30]. Smart contracts emerged as a viable approach to execute business logic on the blockchain [31]. The development of blockchain-based collaborative processes typically follows a model-driven approach, translating a process model into an executable code embedded in smart contracts. Subsequently, collaborating participants engage with the smart contracts by initiating transactions, thereby advancing the state of the process.

2.2 Looseness in Business Processes

In knowledge-intensive domains, it is often not possible to fully specify entire business processes in advance due to their unpredictable, non-repeatable and emergent nature [5]. For such situational processes, only certain parts are known a priori. Consequently, the process models used to represent them are typically underspecified. The execution of these processes on a PAIS requires support for *looseness* [2]. Along with *variability*, *adaptation*, and *evolution*, looseness is one of the four flexibility requirements of PAISs that deals with supporting the configuration and execution of underspecified processes [24]. Unlike adaptation and evolution, where changes are made to the prespecified parts of a process, looseness focuses on refining parts that lack specifications in the original model. The need for looseness can be observed from different *process perspectives*. This study focuses specifically on the *behavioral* and *organizational* perspective, which consider execution behavior, i.e., control flow, and the assignment of actors to tasks, respectively. Other perspectives, including operational, functional, informational and temporal aspects, are beyond the scope of this paper.

Achieving looseness in collaborative processes is particularly challenging, since compatibility between all participants must be maintained during refinement. Blockchain technology can address this challenge by providing a decentralized infrastructure that tracks and enforces refinement decisions. Figure 1 illustrates different refinement patterns for loosely specified processes along the lifecycle phases of blockchain-based collaborative processes. The lifecycle is derived from [12] and extended with observations from the literature. In general, we expect the lifecycle to begin with the creation of a model that is compiled into a blockchain-readable format that can then be deployed. Afterward, the process can be instantiated and executed.

According to Fig. 1, processes that do not support looseness follow the *fully prespecified* pattern. This pattern implies that all information needed for process execution is already specified in the modeling phase, and no refinements are required afterward. In contrast, if the model still contains underspecified parts

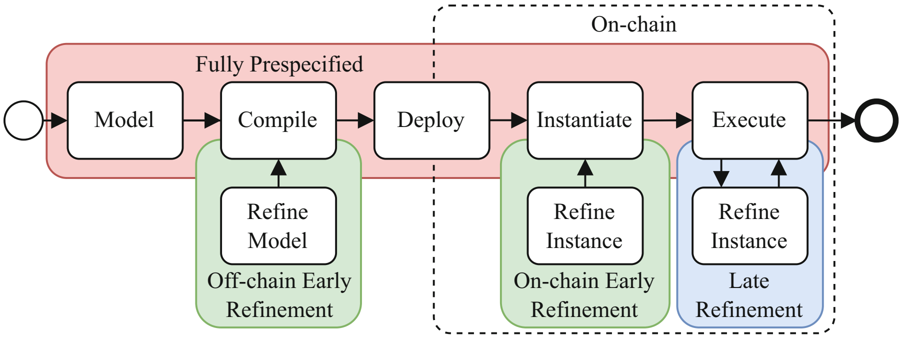

Fig. 1. Looseness patterns applied to the corresponding phases of an extended lifecycle of blockchain-based collaborative process inspired by [12].

after the modeling phase, the *early* or *late refinement* pattern can be applied. The early refinement pattern allows the process to be refined in between the initial modeling phase and the execution phase. Here, the process can be configured according to the needs of a specific instance to be created. In a blockchain setting, we distinguish between *off-chain early refinement*, where additional information is fed to the off-chain compiler to produce the blockchain artifacts required for execution, and *on-chain early refinement*, where the information is provided on-chain during instantiation. Finally, *late refinement* allows for the gradual refinement of collaborative processes during the execution phase.

For a more detailed classification of looseness support, we adopt the *decision deferral taxonomy* proposed by Reichert and Weber [24]. This taxonomy includes, in addition to the process perspective, five dimensions to assess the level of looseness supported by a PAIS: (i) *degree of freedom*, (ii) *planning approach*, (iii) *scope of deferral*, (iv) *degree of automation*, and (v) *decision-making*.

In this context, the degree of freedom refers to the flexibility in choosing the refinement of underspecified parts. The planning approach indicates the degree of prespecification required and the life cycle phase to which refinement decisions can be deferred. The scope of deferral describes the extent to which a process is affected by the need for refinement. The degree of automation reflects the support provided by the underlying information system to automate the refinement of loose specifications. Decision-making determines the primary indicator used to decide on refinements. Table 1 presents the characteristics of each dimension.

2.3 Related Work

Existing literature has examined the relevance of process flexibility and its impact on BPM. Cognini et al. [2] present a comprehensive study that discussed the impact of flexibility on different phases of the BPM lifecycle. However, their study does not consider blockchain technology. Mendling et al. [20] focus on the opportunities and challenges of blockchain-based process execution, emphasizing the need for adaptation and evolution. Looseness is not specifically addressed. In [26], Stiehle and Weber investigate the capabilities of blockchain-based collaborative process enactment and identify a lack of support for unpredictable processes. Following on from this, our study aims to provide a more in-depth analysis of looseness. Garcia-Garcia et al. [6] assess the BPM lifecycle support for collaborative BPM on the blockchain. While the study identified a lack of support for adaptation, looseness is not discussed in depth. Moreover, Viriyasitavat et al. [30] provide an overview of blockchain support for BPM, acknowledging the need for looseness. The authors propose declarative approaches or a data-centric paradigm as potential solutions, but do not provide a detailed analysis of their capabilities and challenges. In contrast, our study focuses on addressing the aspect of looseness, exploring different realization options and identifying open challenges in achieving looseness in blockchain-based collaborative processes.

Table 1. Looseness dimension characteristics derived from [24].

Dimension	Character.	Description
Degree of freedom	None	All aspects are prespecified by the model (fully prespecified pattern).
	Selection	The model includes underspecified parts and provides a predefined set of options to complete the business logic of the process.
	Modeling & Composition	The process is loosely composed from known components following predefined constraints.
Planning approach	Plan-driven	After modeling phase, the underspecified parts must be refined before entering the execution phase (early refinement pattern).
	Iterative	After modeling phase, the unspecified parts can be refined during the execution phase (late refinement pattern).
	Ad-hoc	No modeling phase takes place in advance. The process is designed during execution phase.
Scope of deferral	Regional	The process contains prespecified parts. Only certain regions are loosely-specified and require refinements.
	Entirety	The process follows no predefined schema. The need for refinements extends throughout the entire process.
Degree of automation	Manual	Refinements require user intervention. The system does not support the user in deciding on refinement options.
	System-supported	Refinements require user intervention. The system provides the user with information or functionality that supports the refinement process.
	Automated	Refinement decisions are made automatically. No user intervention is required.
Decision-making	Goal-based	Refinement decisions must ensure that predefined goals can be achieved.
	Rule-based	Refinement decisions are constrained by predefined rules.
	Experience-based	Refinement decisions are based on the results of previous executions related to the current execution.
	User-based	Refinement decisions depend only on the end user.

3 Systematic Literature Review Methodology

To address the research questions outlined in Sect. 1, a systematic literature review is conducted. Relevant literature is identified based on three groups of keywords, forming the following search query:

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("Blockchain" OR "Distributed Ledger" OR "Smart Contract") AND
("Business Process" OR "Workflow" OR "Choreography" OR "BPM") AND
("Flexible" OR "Loose" OR "Dynamic" OR "Declarative")
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Table 2. Inclusion and exclusion criteria used for the systematic literature review.

Inclusion Criteria	Exclusion Criteria
1. The study presents or extends a model-driven approach enabling the blockchain-based enactment of collaborative processes. 2. The study discusses concepts linked to behavioral or organizational looseness.	1. The study uses blockchain technology for monitoring purposes only. 2. The study is not primary research, e.g., a literature review, survey, or overview paper. 3. The study does not qualify as a research paper, e.g., patents, technical specifications. 4. The study is not written in English.

Based on the search query, studies are collected from reputable academic databases, including *IEEE Xplore*, *ScienceDirect*, *SpringerLink*, *Wiley Online Library*, and *Google Scholar*. Due to the contemporary nature of the blockchain area, gray literature is considered as well. Initially, the search yielded a total of 2147 studies on 05/09/2023. In a three-step process, the relevance of these studies is assessed based on their title, abstract, and full text. The criteria used to determine their inclusion or exclusion are described in Table 2. In case of the inclusion criteria, it should be noted that studies must not explicitly mention the support of looseness, but may describe concepts that can be mapped to looseness in the corresponding perspectives. In contrast, studies that focused only on process monitoring were excluded, as we focus on execution support for blockchain-based collaborative processes.

After applying the criteria, a total of 24 papers are identified as relevant to the study. They include eight journal articles, 13 conference papers, one workshop paper, one symposium paper, and one gray literature paper, which serve as the basis for the analysis of the research questions in the following sections.

4 Looseness in Collaborations on the Blockchain

In this section, we classify the studies under review based on the decision deferral taxonomy described in Table 1, focusing on the behavioral and organizational process perspectives.

Figure 2 depicts the distribution of the selected literature in terms of its support for looseness in the two process perspectives. The distribution indicates a focus on support for organizational looseness. Furthermore, Fig. 3 shows the looseness patterns applied by the studies for each perspective. In accordance with the descriptions in Sect. 2.2, we examine the characteristics of each study regarding each dimension. The results of this review are presented in Table 3, which provides a comprehensive categorization of the studies. It should be noted that studies with a degree of freedom of 'None' are not further assessed for other dimensions within the same process perspective, as they do not indicate support for looseness from the corresponding perspective. Due to the focus on model-driven approaches, Fig. 4 provides an overview of the modeling languages used by the studies. Consequently, approaches supporting ad-hoc planning are outside the scope of this survey, as they omit any upfront modelling. In the following, we provide a detailed analysis of the results from each process perspective to gain insights into the current support for looseness in model-driven collaborative processes using blockchain to answer RQ1.

4.1 Behavioral Perspective

When examining looseness from a behavioral perspective, we investigate how the selected approaches enact a loosely defined control-flow on the blockchain.

Degree of freedom deals with the flexibility in assigning concrete business logic to unspecified parts, e.g., placeholders. A collaborative process with a fully prespecified activity sequence is generally considered not to retain any aspects of behavioral looseness. The conducted literature review has shown that 14 studies do not support any *degree of freedom* in their process. The aforementioned studies define their collaborative process during the modelling phase and leave no latitude to a loose control-flow. While the studies do not support looseness from a behavioral perspective, they can still support looseness in other process perspectives, such as the organizational perspective (16 studies). Eight studies do implement some *degree of freedom* in their process. Of these, three studies support process refinement through selection, while the remaining five do so through modeling & composition. In the selection strategy, a set of process fragments are predefined during the modelling phase. The fragments are either stored in a repository off-chain [23] or deployed on-chain as individual smart

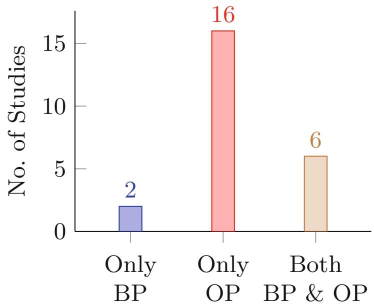

Fig. 2. Looseness support of studies based on process perspectives. Studies can support looseness from only an organizational (OP) or behavioral perspective (BP), or support both.

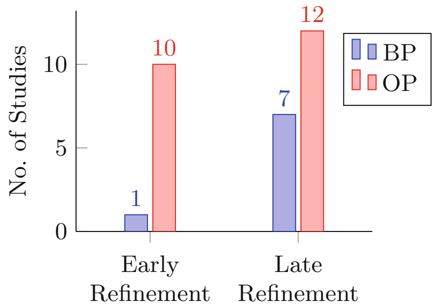

Fig. 3. Refinement patterns employed by studies according to the behavioral (BP) and organizational perspective (OP).

Table 3. Looseness support provided by the selected literature from a behavioral and organizational perspective.

Decision Deferral		Behavioral Perspective		Organizational Perspective	
Dimension	Character.	No.	Reference List	No.	Reference List
Degree of Freedom	None	16	[3,4,8–11,13,14,16,17,22,27–29,31,35]	2	[33,34]
	Selection	3	[15,23,34]	21	[1,3,4,7–11,13–18,23,25,27–29,31,35]
	Mod. & Com.	5	[1,7,18,25,33]	1	[22]
Planning Approach	Plan-driven	1	[23]	10	[1,7,10,11,17,18,23,27,28,31]
	Iterative	7	[1,7,15,18,25,33,34]	12	[3,4,8,9,13–16,22,25,29,35]
	Ad-hoc	0		0	
Scope of Deferral	Regional	3	[15,23,34]	2	[8,29]
	Entirety	5	[1,7,18,25,33]	20	[3,4,7,9–11,13–18,22,23,25,27,28,31,35]
Degree of Automation	Manual	0		14	[1,3,4,7,11,16–18,22,25,27,28,31,35]
	Sys.-sup.	7	[1,7,15,18,25,33,34]	5	[9,10,13–15]
	Automated	1	[23]	3	[8,23,29]
Decision Making	Goal-based	0		1	[23]
	Rule-based	7	[1,7,15,18,23,25,33]	3	[13–15]
	Exp.-based	0		2	[8,29]
	User-based	1	[34]	16	[1,3,4,7,9–11,16–18,22,25,27,28,31,35]

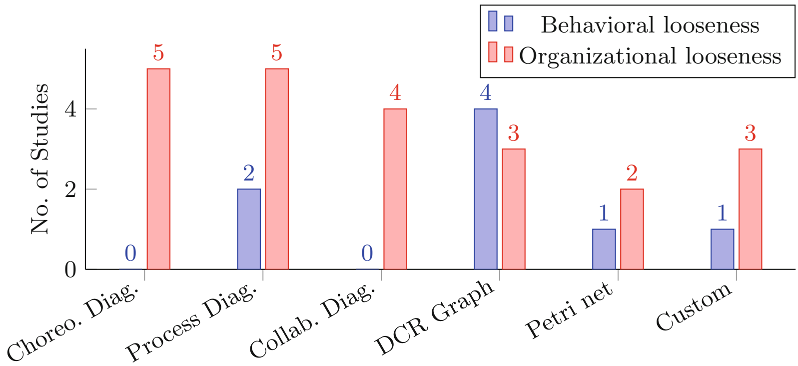

Fig. 4. Modeling languages used by studies related to looseness support based on the perspectives. A study may provide looseness support for both perspectives.

contracts [15,34] ready to be reused during the process refinement. On the other hand, studies adopting modelling & composition follow a fine-grained placeholder refinement by composing fragments using individual activities. Imperative modelling languages like BPMN are not as expressive for such a purpose as declarative approaches. For instance, we find that four studies supporting modelling & composition make use of *dynamic condition response* (DCR) graphs to express the control-flow [1,7,18,33]. Furthermore, [25] adopts *artifact-centric processes*, which provide a declarative approach for specifying the control-flow.

In the *planning approach*, we examine the phases in which the control-flow can be refined in the lifecycle of blockchain-based collaborative processes. In this context, we focus on the phases depicted in Fig. 1. Following a plan-driven strategy, the refinement of the control-flow takes place prior to the execution phase, i.e., early refinement pattern. According to the results, one study–a framework for modelling smart contract control-flow [23]–is compliant with this strategy. The proposed framework makes use of a set of predefined fragments represented as individual smart contracts to generate the workflow of a collaborative process. Since the process of generating the workflow takes place in an off-chain phase, this could be considered as an off-chain early refinement according to the lifecycle in Fig. 1. On the other hand, seven studies adopt an iterative strategy, in which the refinement of a control-flow happens while the process is being executed on-chain. For instance, in [7], the author embeds the DCR execution rules into a smart contract, ensuring the correctness of process refinement at run-time, an example of the late-refinement pattern.

Scope of deferral specifies the loosely defined region of a control-flow. Five studies allow looseness in the entirety of the process [1,7,18,25,33]. These studies rely on declarative process representations, such as DCR graphs and artifact-centric processes. The remaining three studies limit behavioral looseness to a specific region of the control-flow. For instance, in [15,23,34] the main process is prespecified, while certain regions are left to be refined later.

Placeholder assignment can be done through various *degrees of automation*. No approach adopts a manual degree of automation. Since manual refinements can lead to compatibility issues, refinement of collaborative processes can benefit from system support. In the literature, seven studies rely on system support for the refinement of processes. For example, [34] addresses the issue of process state inconsistency that may be a consequence of a control-flow refinement event. The authors employ fragments as individual smart contracts under the name of navigators which are attached to the process instance at run-time, the navigator must fulfill some preconditions before a successful attachment. Only one study [23] adopts fully automated refinement by generating a workflow composed of multiple smart contracts without the intervening of participants.

Upon placeholder activity enablement, numerous decisions have to be taken in order to proceed with the process execution. *Decision-making* can be based on rules governing how the control-flow is allowed to behave. Seven of the selected studies support rule-based decision-making. Most notably, [15] introduces agreement policies, which restrict how participants can refine control-flow elements. Furthermore, the request to refine the control-flow has to be endorsed by participants during runtime through a voting process embedded in a smart contract. The *decision-making* can also be taken *by participants*. For instance, in [34], a specific participant, namely the process coordinator, is responsible for control-flow changes. While [34] provides rules for process refinement, they only assure consistency rather than restricting the reasoning behind a refinement. Goal-based *decision-making* is not present in any of the studies, as none of the approaches rely on goal specifications to achieve control-flow refinement.

In response to RQ1, the study found that the concept of looseness, particularly in terms of behavioral looseness, has received limited attention in existing literature. For instance, no wide support for automated process refinement could be observed. In addition, the literature lacks a discussion of experience-based approaches, where the transaction log is used to make optimal control flow refinement decisions, and goal-based approaches.

4.2 Organizational Perspective

Organizational looseness refers to the refinement options available for managing resources after the modeling phase. In collaborative processes, this primarily concerns the assignment of participants to tasks [24]. In the following, we distinguish between the terms *actor* and *role*. An actor represents an actual entity involved in a collaboration, e.g., a specific organization, while a role serves as a descriptive placeholder that can be associated with one or more actors.

The *degree of freedom* determines the flexibility in assigning actors to tasks. A degree of freedom of none implies that the assignment of actors to tasks is predetermined by the model. Although no predetermined assignments were observed in the literature reviewed, two studies lacked sufficient insight into resource management to determine the presence of organizational looseness [33,34]. A degree of freedom of selection can be achieved by linking tasks to roles in the model instead of assigning actors directly. Thus, any actor associated with the corresponding role can be selected for the task. Since most of the process modelling languages used in the selected literature inherently include roles, such as BPMN collaboration [9,10,27] or choreography diagrams [3,4,11,16,31] (Fig. 4), selection is supported by the majority of studies. Modelling & composition can be achieved by omitting roles and allowing to select an actor freely for each task from a pool of known actors. In the literature reviewed, one study supports modelling and composition from an organizational perspective [22]: Actors that have completed a part of the choreography can transfer execution control to the next actor via a blockchain transaction. The selection of the next actor is left freely to the actor currently in control of the execution.

Regarding the *planning approach*, both plan-driven and iterative strategies are similarly represented in the selected literature. Plan-driven approaches bind actors to tasks prior to the execution phase, thus following an early refinement pattern. Two studies adopt an off-chain early refinement pattern [1,23], while eight studies use on-chain early refinement [7,10,11,17,18,27,28,31]. In contrast, iterative strategies allow late refinement by binding actors to tasks during the execution phase. While five iterative approaches allow late binding of actors only once [3,4,8,29,35], eight approaches also support rebinding actors during execution [9,10,13–16,22,25]. In addition, two studies allow specifying mandatory and optional roles [3,4], where the former must be refined at the instantiation phase and the latter can be selected during the execution phase.

Considering the *scope of deferral*, most approaches allow a loose binding for the entire process, implying that no actor is prespecified. However, two studies indicate a regional approach by focusing on binding only specific service providers [8,29]. While two studies distinguish between mandatory and optional roles [3,4], since both types of roles can be loosely specified using either early or late refinement, looseness is still provided for the entire process.

The *degree of automation* shows a preference for the manual binding of actors in the selected literature. However, five studies provide system support for refinement decisions. This includes voting smart contracts, which allow to collectively decide on the binding of actors on-chain [9,10]. Three studies use smart contracts to enforce policies that specify the conditions to be considered when binding actors [13–15]. In addition, one study offers a fully automated selection of actors required to execute an order [23], and two studies allow the automatic selection of service providers based on predefined criteria [8,29].

In terms of *decision-making*, most studies provide end-users with full control over actor binding. Rule-based approaches are employed by three studies, using predefined policies to restrict actor bindings [13–15]. Experience-based decision-making relies on previous executions and is supported by two studies [8,29]: The approaches select a service provider based on quality of service ratings from past executions stored on the blockchain. The most appropriate service provider can be selected at runtime using predefined filtering and sorting criteria. Finally, one study demonstrates goal-based *decision-making*, where collaboration participants are selected based on an incoming order to form a supply chain [23].

Addressing RQ1, organizational looseness has received extensive support in the selected literature. Given its widespread acceptance as a fundamental modeling concept, 21 studies used roles to allow loose binding of actors. 12 studies support late refinement to enhance runtime flexibility. However, 14 studies rely on manual and user-driven decision-making, thus providing no decision support.

5 Research Challenges

During our analysis, we identified several challenges that need to be considered when supporting looseness in blockchain-based collaborative processes. In this section, we aim to address RQ2 by exploring the challenges and discussing how to overcome them.

Refinement Support. Determining the authority responsible for refining underspecified parts in collaborative processes is challenging, as each collaborator may pursue their own interests. Especially from an organizational perspective, current approaches often follow manual and user-based decision-making, leaving refinement decisions to individual users. However, this strategy does not necessarily reflect the collective interests or ensure optimal outcomes. Lopez-Pintado et al. [13–15] introduce on-chain policies to control the refinement as a promising first step to address this challenge. In addition, Viriyasitavat et al. [29] and Henry et al. [8] use on-chain information from previous executions to guide organizational refinement. However, experience-based and goal-based behavioral refinement is not extensively studied, making them topics worthy of investigation. While initial approaches employ system-supported decision-making, automated decision-making remains largely unexplored. Therefore, looseness support can be enhanced by further research on blockchain-based process refinement support.

Cost Optimization. Introducing looseness support for processes executed on public blockchains can lead to additional costs, for example, due to the need to verify declarative rules for each task execution. Furthermore, looseness can be exploited as an attack vector, as adversarial actors can add refinements that force other parties to bear higher transaction costs [18]. Hence, it is essential to carefully weigh the benefits of looseness against added costs. In particular, the development of hybrid approaches that combine loose and structured specifications, allowing looseness only in certain areas, needs further investigation. Furthermore, to enable fair collaboration, cost-sharing approaches need to be explored. As a first step in this direction, Klinger et al. [9,10] propose a fair cost distribution mechanism for the deployment of new instances in their approach.

Loose Modeling Support. Model-driven development shows potential for designing and implementing collaborative processes using blockchain technology, as evidenced by its widespread adoption [26]. Since the existing literature focuses on highly structured modeling languages (Fig. 4), there is a notable lack of research on loose modeling languages for developing blockchain-based collaborations. While initial studies use DCR graphs to achieve behavioral looseness [1,7,18,33], additional languages need to be explored to enable the selection of the most appropriate modeling language for a given business case. In addition, the integration of blockchain-specific concepts [11] into these languages can foster model-driven development of loose blockchain-based collaborative processes.

Loose Implementation Patterns. Implementing loose collaborative processes on the blockchain is challenging due to the increased complexity compared to fully prespecified processes. To gain a comprehensive overview of how to effectively leverage blockchain properties to achieve looseness, a detailed analysis of blockchain implementation patterns is essential. The findings can serve as the basis for designing a guideline that facilitates the development of loose collaborations on the blockchain, eventually leading to more reliable applications.

In summary, to answer RQ2, there are several challenges to supporting looseness in blockchain-based collaborative processes. These challenges include support for refinement decisions, optimizing the costs associated with looseness, and developing appropriate modelling concepts as well as implementation patterns. Overcoming these challenges is critical to successfully realizing the benefits of looseness in blockchain-based collaborative processes.

6 Conclusion

This paper explores the current support (RQ1) and challenges (RQ2) in enabling looseness for blockchain-based collaborative business process executions, considering both behavioral and organizational perspectives. To this end, a systematic literature review is conducted to classify model-driven approaches providing looseness support. The selected studies are analyzed using the decision deferral taxonomy [24], which allows the assessment of their level of looseness support. The results indicate that current approaches already largely support organizational looseness, but lack support for behavioral looseness. Based on the findings, challenges related to refinement support, cost optimization, modeling support, and implementation patterns are identified that require further investigation to advance looseness support for blockchain-based collaborative processes.

Since RQ1 is only examined from an organizational and behavioral perspective, future work can explore looseness support from additional process perspectives mentioned in Sect. 2.2. Moreover, investigating the relationships between different blockchain implementation patterns and support for looseness dimensions could contribute to a comprehensive understanding of looseness-enabling patterns for collaborative business processes using blockchain technology.

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