

Exploring User Experience in Blockchain Interoperability: A Literature Review

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Abstract. *Blockchain interoperability has become a central research topic as the number of blockchain platforms continues to grow. Still, the User Experience (UX) implications of blockchain interoperability solutions seem under-explored. This paper presents a literature review on the intersection between these topics. Selected studies were classified according to six dimensions and our analysis of the selected studies reveals a clear polarization. Further, we identified research gaps, including the treatment of information abstraction as a developer-facing rather than user-facing concern, and the framing of smart contracts almost exclusively as a technical interoperability mechanism rather than a point of user interaction. These results suggest that, among the selected studies, UX research has not addressed interoperability. We conclude by discussing implications for designing user-centered interoperability solutions and outline directions for future research.*

1. Introduction

Blockchain technology has evolved from a single network focused on cryptocurrency (i.e., Bitcoin [Nakamoto 2008]) to a diverse ecosystem with a wide range of uses [Bellotti et al. 2019]. Therefore, a new problem appeared with the proposal of novel and heterogeneous blockchains: how to allow such platforms to interoperate with each other. Several solutions were proposed for the interoperability problem [Belchior et al. 2021]. However, none of the solutions we analyzed tackles the UX aspect, which is important for the adoption of novel solutions when considering user interaction [Partala and Saari 2015].

Although the UX studies we analyzed [Jang and Han 2022, Voskoboynikov et al. 2021, Jang et al. 2020] address blockchain problems, they focus on single-blockchain scenarios, usually addressing wallets and transaction fees as the main difficulties experienced by users. However, it is not clear which characteristics a solution focused on the interoperability of heterogeneous blockchains should present. Thus, applying UX concepts to an interoperability application in a way to make it intuitive enough for users to take advantage of what different blockchains have to offer remains an open challenge.

With this in mind, this paper presents a literature review on UX and blockchain interoperability, focusing on identifying the key research gaps and challenges at their intersection. This paper contributes to the understanding of such an intersection by, (i) providing a classification of selected studies across six dimensions encompassing UX- and interoperability-related aspects; and (ii) identifying and discussing key research gaps at

this intersection, thereby highlighting opportunities for future research toward more user-centered blockchain interoperability solutions.

The remainder of this paper presents the theoretical foundations in Section 2, the methodology in Section 3, the results in Section 4, and concludes with Section 5.

2. Theoretical Foundations

Blockchain technology was first introduced as the underlying mechanism for Bitcoin, a peer-to-peer electronic cash system designed to allow direct payments between two parties without relying on a trusted financial institution [Nakamoto 2008]. The concept has since evolved beyond its original cryptocurrency-focused design. [Belchior et al. 2021], define a blockchain more broadly as a class of distributed system that maintains a shared, replicated ledger across a set of nodes, none of which is individually trusted, but which are collectively trusted as a group due to their number and diversity.

According to [Belchior et al. 2021], the earliest and most established techniques to achieve interoperability between public blockchains, collectively known as *Public Connectors*, with that it can be grouped into three categories:

- **Sidechains and Relays:** a secondary blockchain (i.e., the sidechain) is attached to a main blockchain, enabling assets to be transferred between the two through a two-way peg mechanism. A relay is a client that runs on the target blockchain and verifies transactions from the source blockchain, without necessarily requiring a fully trusted third party.
- **Notary Schemes:** rely on a trusted entity, or a decentralized group of entities, that monitors events on one blockchain and triggers corresponding transactions on another.
- **Hashed Time-Lock Contracts (HTLC):** use a combination of hash locks and timelocks to enforce atomicity in cross-chain exchanges, allowing two parties to swap assets across different blockchains without a trusted intermediary, provided a cryptographic secret is revealed within a defined time window.

In terms of UX, the ISO 9241-210 standard defines UX as the sum of a person's perceptions and reactions resulting from the use, or anticipated use, of a product, system, or service. UX research has expanded well beyond human-computer interaction into fields such as health, marketing, and education, with usability, user acceptance, and user-centered design consistently emerging as central themes across this body of work [Lu et al. 2025].

3. Methodology

This study consists of a literature review of three stages: definition of the research questions, search and selection of studies, and construction of a classification scheme.

3.1. Research Questions (RQ)

The two RQs that guide this study were defined to structure the literature review and identify opportunities to contribute to the state-of-the-art at the intersection of user experience and blockchain interoperability. The first RQ investigates whether and how user experience has been addressed in the context of blockchain interoperability, while the second focuses on the main challenges and research gaps. They are as follows:

- **RQ1:** Has user experience been addressed in the context of blockchain interoperability? If so, which aspects have been considered?
- **RQ2:** What are the main challenges and research gaps concerning user experience in blockchain interoperability?

3.2. Search and Selection Criteria

We conducted a systematic search of the literature to identify studies addressing user experience and blockchain interoperability. The search was conducted manually using Google Scholar as the search interface. The keywords used to build the search terms were *blockchain*, *interoperability*, *user experience*, and *blockchain interoperability*. Two queries were used to cover the two thematic axes of this study, each restricted to the three publisher sources considered relevant to this work, IEEE, ACM, and Elsevier (ScienceDirect), using the `source :` operator provided by Google Scholar, and further restricted to the period from 2019 to 2026 using Google Scholar’s custom date range filter.

Within the period considered, these queries returned approximately 21,300 and 17,200 results for the user experience and interoperability axes, respectively. Secondary studies, such as surveys, systematic literature reviews, and mapping studies, were then excluded using the following terms: *-survey* - *“systematic review”* - *“systematic literature review”* - *“mapping study”* - *“literature review”* - *“state of the art”*. After this exclusion, approximately 12,400 and 4,360 results remained, respectively. Given that these numbers remained too large for an exhaustive manual screening, results were ordered by Google Scholar’s default relevance ranking, and titles and abstracts were screened following this order until reaching thematic saturation, i.e., until subsequent results consistently failed to meet the inclusion criteria. This screening prioritized primary studies that presented a direct contribution, such as a proposed solution, architecture, or evaluation. Studies focused on application-specific verticals unrelated to the paper’s scope (*e.g.*, healthcare) were also excluded at this stage. Google Scholar’s result counts are internal estimates and may vary between executions of the same query. Lastly, the theoretical basis of this work [Scheid et al. 2019] was added by snowballing, totaling 11 studies.

Standards fall outside the scholarly search and were not part of the classification; we note the existence of [IEEE 2023], which specifies protocols for data authentication and communication between blockchains, as context for the interoperability dimension.

3.3. Classification Scheme

To analyze the selected studies, we defined dimensions covering user experience and blockchain interoperability. Each study was classified according to the following six dimensions, marked as present (✓) or absent (✗):

- **Wallet solutions:** proposes implementation and/or UX solutions for wallets;
- **User feedback:** discusses mechanisms for providing feedback to users;
- **Information abstraction:** proposes abstracting technical complexity from end users;
- **Error communication:** discusses mechanisms for communicating errors to users;
- **Smart contracts:** addresses smart contracts from a UX, interoperability, or developer experience perspective;
- **Interoperability:** discusses mechanisms for interoperability between blockchains.

4. Results and Analysis

Table 1 presents an overview of the works identified through the literature review and classified according to the dimensions defined in the methodology.

Table 1. Classification of Selected Studies

Reference	Year	Wallet Solutions	User Feedback	Info. Abstr.	Error Comm.	Smart Contracts	Interoperability
<i>UX-oriented studies</i>							
[Jang et al. 2020]	2020	✓	✓	✓	✓	✗	✗
[Jang and Han 2022]	2022	✓	✓	✓	✓	✗	✗
[Voskoboynikov et al. 2021]	2021	✓	✓	✓	✓	✗	✗
<i>Interoperability-oriented studies</i>							
[Lafourcade and Lombard-Platet 2020]	2020	✗	✗	✗	✗	Interop.	✓
[Darshan et al. 2023]	2023	✗	✗	✗	✗	Interop.	✓
[Bigiotti et al. 2026]	2026	✗	✗	✗	✗	Interop.	✓
[Gurunath et al. 2026]	2026	✗	✗	✗	✗	Interop.	✓
[Mukhandi et al. 2025]	2025	✗	✗	✗	✗	Interop.	✓
[Mohamed et al. 2026]	2026	✗	✗	✗	✗	Interop.	✓
[Ruzza et al. 2026]	2026	✗	✗	✗	✗	Interop.	✓
<i>Hybrid case</i>							
[Scheid et al. 2019]	2019	✗	✗	✓	✗	✓	✓

Legend: ✓ dimension explicitly addressed; ✗ dimension not addressed; *Interop.* = smart contracts discussed from an interoperability/cross-chain perspective

Regarding UX in the context of blockchain interoperability, our analysis reveals a clear polarization in the analyzed studies. As shown in Table 1, only the three UX-oriented studies [Jang et al. 2020, Jang and Han 2022, Voskoboynikov et al. 2021] address wallet solutions, user feedback, information abstraction, and error communication. However, these same studies address single-blockchain settings, mainly wallets and individual blockchain services, without extending their findings to interoperability scenarios. In contrast, the remaining seven interoperability-oriented studies [Lafourcade and Lombard-Platet 2020, Darshan et al. 2023, Bigiotti et al. 2026, Gurunath et al. 2026, Mukhandi et al. 2025, Mohamed et al. 2026, Ruzza et al. 2026] and the project taken as the theoretical basis for this work [Scheid et al. 2019], propose solutions that go well beyond wallets and cryptocurrency, addressing domains such as smart cities [Darshan et al. 2023], supply chain traceability [Mohamed et al. 2026], and cross-domain authorization [Mukhandi et al. 2025]. Yet none of them consider the end-user side of these interactions. Answering RQ1, then, among the analyzed studies, UX is addressed through wallet solutions, user feedback, information abstraction, and error communication but not within the context of interoperability.

Building on this finding, two main challenges emerge from this analysis. First, when information abstraction is addressed in an interoperability context, as in the theoretical base [Scheid et al. 2019], it targets developers integrating multiple blockchains rather than the end users of the resulting applications. Second, smart contracts are mostly treated as a technical interoperability mechanism across the analyzed studies [Gurunath et al. 2026, Mukhandi et al. 2025, Mohamed et al. 2026], and never as a point of direct interaction between the user and the underlying protocol.

Answering RQ2, the central challenge is the absence, in the analyzed studies, of a concrete approach to designing UX around interoperability solutions: while numerous technical solutions have been proposed, none of them addresses how end users should perceive or interact with them. [Voskoboynikov et al. 2021] proposes that future wallet

solutions mimic traditional payment systems and that user support be present both before and during use, but this guidance, while valuable, remains limited to the wallet domain. Thus, the analyzed studies leave unclear how interoperability solutions should be presented to end users. What we do know, from [Jang et al. 2020], is that such applications should not attempt to explain their technical value directly to users; instead, they should be designed so that users can intuitively discover the advantages of distributed applications through use.

5. Summary, Conclusion and Future Work

This paper reviewed 11 studies on UX and blockchain interoperability, classified along six dimensions. In the analyzed sample, UX-oriented studies remain confined to single-chain scenarios, while interoperability-oriented studies rarely consider the end user, which answers RQ1. For RQ2, the gaps are the treatment of information abstraction as a developer-facing concern and of smart contracts almost exclusively as a technical mechanism. Interoperability should thus be addressed not only as a technical challenge, but also as a user-facing concern.

Future works consider (i) the implementation of an application that intuitively shows the advantages of distributed applications while fulfilling all six of the dimensions presented in this paper and (ii) the development of an interoperability solution that integrates the end-user as well as heterogeneous blockchains.

Use of Artificial Intelligence Tools

Generative Artificial Intelligence (AI) tools were used during the preparation of this study to support brainstorming activities, language refinement, and the organization of ideas. The authors assume full responsibility for the content, conclusions, and scientific contributions presented in this work.

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