Blockchain (not) for Everyone: Design Challenges of Blockchain-based Applications

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ABSTRACT

Upon its arrival, the Ethereum blockchain promised to introduce a new paradigm of Internet-based applications that would revolutionize multiple fields, from finance to IoT to the public sector. Until now, scientific efforts have been primarily focused on theoretical discussions about the implications of the technology and on technical proposals to improve and consolidate the underlying infrastructure, neglecting the experience of people using blockchain-based systems. However, for this technology to permeate the mainstream, blockchain technology should be easily accessible to the general public. This paper reports on evaluations conducted with first-time blockchain users of two Internet-mediated communities using prototype applications built on Ethereum. Results unveil that even users familiar with technology experienced severe difficulties using blockchain-based apps. Also, we saw how blockchain metaphors and transaction-mediated interactions challenge established mental models for modern applications, imposing heavy workloads on users. We conclude the paper by discussing design implications resulting from blockchain's paradigm change.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in collaborative and social computing**; *Human computer interaction (HCI)*;

KEYWORDS

blockchain, decentralized applications, user experience

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1 INTRODUCTION

In 2008, in the context of an economic crisis and a general climate of distrust in formal institutions, a pseudonymized paper presented Bitcoin: the first cryptocurrency based purely on a peer-to-peer system. Five years later and, inspired by the underlying technology that supports the operation of bitcoin—the blockchain—, a group of developers led by Vitalik Buterin released Ethereum: a decentralized and open-source project to develop software solutions using blockchain, with smart contract[1] capabilities. Ethereum has been conceived as the next generation of blockchains offering a general-purpose programmable "Turing-complete" blockchain[2]. The enthusiasm generated by Ethereum raised interest in its application beyond finance and cryptocurrencies, including logistics, energy, healthcare, IoT, and governance [15]. In this sense, the blockchain enables diverse applications since it maintains multiple advantages of the cloud (online web services, externalized computing, shared resources) without the drawbacks of central servers maintenance or trusts in a provider [19]. This has enabled blockchain-based applications for multiple purposes, e.g., software updates in IoT devices [10], improving transparency in supply chain management for perishable products [49], and supporting e-government initiatives, like citizens' digital identities [29]. Over the past five years, billions have been invested in blockchain technology, and players such as Amazon, IBM, and Microsoft are entering the space [7, 12].

While Ethereum practitioners have attempted to revolutionize diverse fields with blockchain, academic efforts have primarily focused on studying the implications of applying the technology and proposing technical improvements to consolidate the infrastructure supporting blockchain's operation. Examples of the former are concerns regarding novel applications of blockchain to various industries [41], dilemmas in the design of blockchain technology for commons [14], or legal code [21], while cases of the latter are to increase the security of protocols [3, 8], improve consensus algorithms [27], or address network latency [34].

However, the experiences of people using blockchain technologies have been under-studied [1, 31]. The few existing studies focus primarily on established users [23, 24]. Also, these studies discuss usability issues without involving end-users in the analysis [48] and primarily report the evaluation of blockchain technology available on the market, such as crypto wallets [38]. There is a consensus

[1]Computer programs that run on the Ethereum network allowing the encoding of clauses in distributed applications signed among different parties, automatically enforcing the rules embedded in their code [52]
[2]Turing complete refers to the Ethereum's ability to run programs of any complexity in a state machine called Ethereum Virtual Machine [4]

in the literature that if the technology is intended to pervade the general public, more attention must be paid to user experience [1, 26, 30].

To tackle this lack of research, this article aims to deepen our understanding of users' experiences with blockchain-based applications. In contrast to previous research endeavors, we did not involve blockchain experts but people proficient in ICT who are new to blockchain. Also, we did not evaluate existing technologies; instead, we implemented and assessed our blockchain-based applications. To this aim, we analyzed data of usability tests from 11 first-time blockchain users, whose sociodemographic characteristics differentiate significantly from the attributes of typical blockchain enthusiasts [47]. We built two decentralized applications implemented using the Ethereum public blockchain to conduct the tests. The applications were tailored to the context of the two case studies explored in this study: an online platform for linguists and a platform cooperative of cultural workers. In sum, we tackled the **research question**: *what challenges do first-time blockchain users face when operating blockchain-based applications?*

The paper is structured as follows: Section 2 presents relevant literature. Section 3 introduces the case studies and discusses details about the prototypes. In Section 4, we present the usability tests conducted to evaluate the prototypes. Section 5 describes the results, Section 6 discusses the limitations. Findings are introduced in Section 7 while Section 8 contains the conclusions and future works.

2 RELATED WORKS

Although the primary focus in academia has been the technical and conceptual perspective (e.g., [14, 18, 34, 44]) and practical applications of blockchain (e.g., [13, 20, 36, 39, 50]), some attention has been paid to human factors of the blockchain, which are decisive in the adoption of the technology [1, 31, 48].

In this sense, a group of studies explored issues and challenges of user experience (UX) in blockchain technologies using Bitcoin crypto wallets as the case study and interviews, focus groups, and usability testing as the research methods [1, 17, 25, 28, 31, 32, 38]. Design strategies and recommendations to improve UX are proposed to complement the results in these studies. Others conducted similar studies but at a system level (Bitcoin) investigating barriers of adoption as well as issues like security, privacy, trust, energy demand, and transparency from an end-user perspective and providing insightful reflections on the design implications of the findings [6, 26, 35, 42, 46]. Content analysis of online opinions and documents was employed to analyze the topology of blockchain applications, learn about trust development in Bitcoin communities, and pinpoint UX problems of crypto wallets, respectively [16, 33, 51]. Finally, frameworks that serve various purposes, from designing onboarding mechanisms to crypto wallets [22] to evaluating blockchain services [30], examining the level of trust [45] and understanding mental models of blockchain users [37] were also introduced after carrying out user studies and reviews of the literature on Bitcoin.

Our work contributes to the incipient efforts of the CHI community to shed light on the implications of blockchain from an HCI perspective. In particular, this article distinguishes itself from the existing literature in several ways. Most of the previous HCI research in blockchain examines Bitcoin at the system level and crypto wallets at the application level, while our investigation focused on Ethereum and general-purpose blockchain-based applications powered by smart contracts. All of the reviewed literature reported user studies on existing technology (mobile- and desktop-based crypto wallets), while we conducted our analysis on in-house prototypes with the challenges that represent the integration and interoperability of various technologies, some of them still in their infancy, thus unstable and immature. We also draw not on a single test but on two different case studies, which allows us to complement and enrich the findings. Moreover, we evaluated with ordinary Internet users with no experience with crypto technologies rather than with people from blockchain communities. This attempts to understand to what extent decentralized applications are ready to be employed by ordinary people.

3 CASE STUDIES

3.1 Amara on Demand

Our first case study is a collaboration with Amara of Demand (AOD), an Internet-based service for the on-demand creation of video subtitles and translations [2]. Over the past years, AOD moved from a few linguists to a large community of more than 900 at the time of writing. The work of linguists in AOD is remunerated, and they are organized on a per-language direction basis, in which English operates as the master language. To join AOD, linguists are required to submit a resume, two examples of captioned or translated work, and pass an online interview and a test.

Through a research process that included a variety of qualitative methods (e.g., interviews, documentary analysis, focus groups), we worked with linguists of the Portuguese-Brazilian language direction of AOD on task distribution mechanisms and blockchain-enabled governance models. As one of the first steps in this collaboration, we implemented a decentralized task distribution application, which is presented next.

3.1.1 Task distribution prototype. We have implemented a blockchain-based application that lists the available translation and subtitling tasks or assignments (from here, we use tasks or assignments interchangeably), see Figure 1 (a). It lets the linguists choose the task they want to work with on a First-Come, First-Served basis. The prototype[3] was deployed on the Ethereum test network Rinkedby and implemented using the frameworks React and Material-UI for the front-end. The programming language Solidity was employed to develop the smart contracts in the back-end. As show in Figure 1 (a) available translation and subtitling assignments are represented using card widgets that provide, among others, a thumbnail of the video to be translated together with its duration and required translation language, the team in charge of the task, title and language of the video, and the assignment due date.

[3]The code of the application is open source and is available to anyone to use, extend, and modify at the following Github repository https://github.com/P2PModels/task-allocation-app

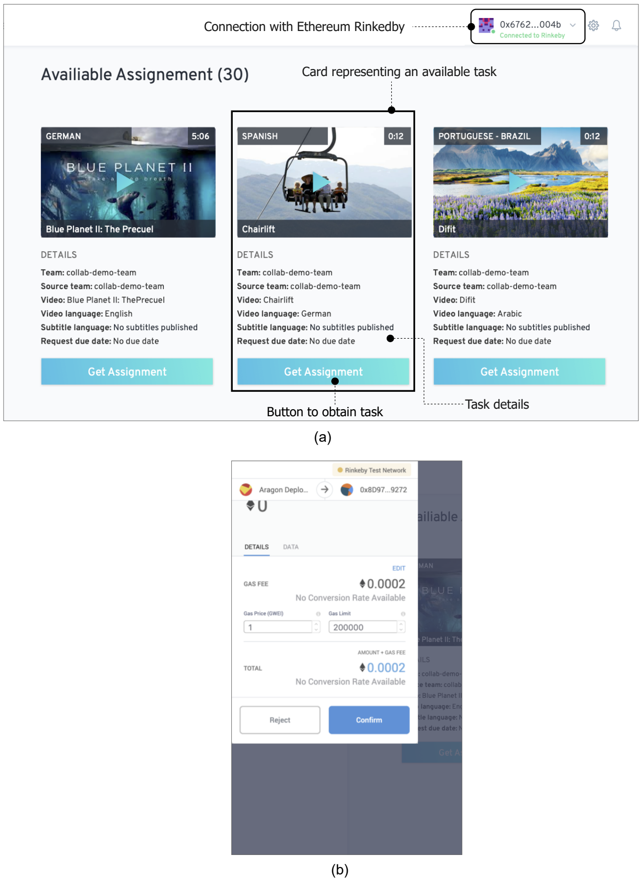

Figure 1: Task distribution prototype. (a) List of the available tasks to be selected. (b) Transaction floating window.

The prototype is integrated with Metamask[4] to manage the interaction with the Ethereum blockchain. Before using the application, the user is required to have installed the Metamask extension for the browser, set up an Ethereum account, and connect the created account to the prototype. Then, when an assignment is selected, a floating window of Metamask opens automatically, displaying information about the account linked to the application, the credit available in Ethers, and details of the transaction cost (gas fee and total), see Figure 1 (b). After the user confirms the transaction, a smart contract is invoked, running the corresponding functions to associate the selected task with the user.

The use of blockchain for such a basic prototype might be questionable at this point. However, we make this prototype an opportunity to experiment and learn with blockchain development tools since part of our future plans with AOD is to experiment with decentralized governance mechanisms, enabling groups of linguists to autonomously decide about the task distribution mechanisms and parameters that best fit their needs.

[4]Metamask (https://metamask.io) is a self-managed crypto wallet employed to manage users' private and public keys, allowing them to interact with Ethereum. It provides a safe and simple way to interact with the blockchain and is one of the leading self-custodial wallets in the market.

3.2 Smart Ibérica

The second case study corresponds to a collaboration with Smart Ibérica (SI), a Spanish cooperative that is part of Smart (Société Mutuelle pour Artistes), a non-profit organization that aims to simplify and support the professional paths of creative and cultural workers [40]. SI offers to its 4,500 members multiple services such as information, training, legal advice, professional networking, co-working spaces, etc.

As part of our collaboration with Smart, we discovered that blockchain has the potential to increase transparency in the cooperative's processes, guaranteeing that data stored using this technology can remain unalterable, incorruptible, and publicly accessible, without a central server/service. As a proof-of-concept and only for experimentation purposes, we agreed with SI to implement a basic blockchain-based version of their member registration system[5].

3.2.1 Member registration prototype. We strived to implement a simple, user-friendly, and self-explanatory tool that allows SI's employees to create, update, and locate member records in a decentralized way. The aim was to make an application that is usable for people who lacked familiarity with blockchain technology. To use the tool, users must, first, connect the prototype to Metamask, which has to be installed in the web browser. By connecting the prototype to Metamask, users can sign and approve the transactions required to operate the application. Once establishing a connection to Metamask, users can add a new member or search for registered members (see Figure 2 (a)).

Figure 2 (b) illustrates the form used to register new members. When entering a record, users have to fill in a form with information about the new member, such as their national identification number, name, email, and nationality. Once completed, users submit the form triggering a transaction that needs to be confirmed using Metamask. After the transaction has been successfully verified, a notification is displayed to the users. React was used together with Semantic UI in the front-end while the smart contracts that support the operation of the application in the back-end were written in Solidity. Similar to Amara, the prototype was deployed on Rinkedby, one of the Ethereum test networks.

Both prototypes were the result of months of co-design research with members of the communities of AOD and Smart in which qualitative methods such as surveys, interviews, focus groups, and participant observations were conducted to tailor the prototypes to the communities' needs [43]. Also, the design of the user experience was carefully led by a UX expert, who is one of the co-authors of the article, and the implementation was based on established design systems, like Material Desing [9], which facilitated the effective application of today's best practices and standard paradigms of interface design.

4 METHOD

We conducted two series of cognitive walkthrough usability tests [17, 38], one for each case study. In AOD, we performed a usability test with linguists from the Portuguese-Brazilian language direction. We chose this group of linguists due to its complex organizational

[5]Recognizing the serious data privacy concerns with storing personal information in a public blockchain, we evaluated the prototype using exclusively mock data

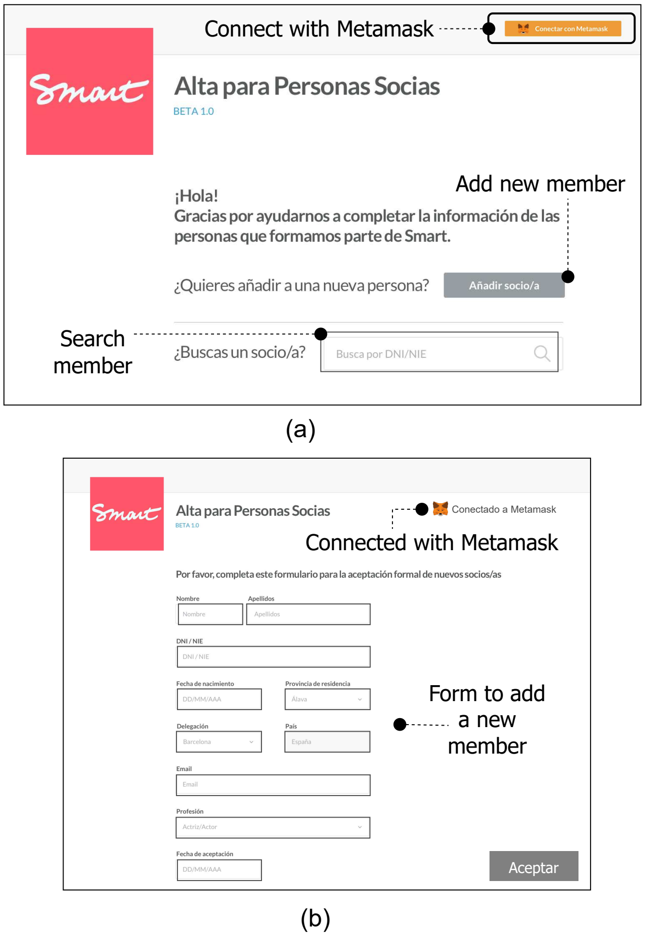

Figure 2: Member registration prototype. (a) Prototype landing page, including search feature. (b) Member registration form.

structure, which was considered crucial for our long-term research goal of experimenting with decentralized blockchain-based governance models. Recruiting was facilitated by core members of AOD, who conducted a dissemination campaign among members of the Portuguese-Brazilian group. Seven people showed interest in participating in the tests, and five were selected by the research team. The selection was based on expertise level and degree of engagement in AOD, aiming to have a variety of backgrounds. Three of the linguists were female, while the remaining two were male. Four reported being between 18 and 35 years old, while one was older than 35 but younger than 50. The participants reported scarce familiarity with blockchain technology. None had previous experience with cryptocurrencies, wallets, or related technology. However, they all recognized the term and related it with Bitcoin and cryptocurrencies. This participant's profile differentiates significantly from the typical blockchain users, who are primarily young white and wealthy males with high levels of domain-specific knowledge [47]. Table 1 shows detailed information about the participants.

For the Smart case study, members of the core team of the cooperative participated in the sessions. Invites were sent to the 10 members of the core team, six of whom accepted. In this case all participants were female since the core team of Smart Ibérica is composed solely of women. Most participants were between 30 and 39 years old. Half of the participants in this case study vaguely recognized the term blockchain, while the others had never heard it before. The six participants did not have any experience with blockchain. Refer to Table 1 for more information.

Table 1: Participants' main characteristics

ID	Case Study	Gender	Age Range	Professional Background
P1	AOD	F	30-39	Civil Engineer
P2	AOD	M	40-49	Lawyer, Sociologist
P3	AOD	M	21-29	Civil Engineer, Professional Translator
P4	AOD	F	21-29	Mathematician
P5	AOD	F	30-39	Lawyer, Professional Translator
P6	Smart	F	40-49	Cultural Management
P7	Smart	F	40-49	Art-History Specialist
P8	Smart	F	30-39	Psychologist
P9	Smart	F	30-39	Psychologist
P10*	Smart	F	——	——
P11	Smart	F	30-39	Business Administrator

Note. * We could not obtain the participant's age and professional background

Sessions were running online using Whereby[6]. The session started with a welcome message from the research team, who explained the goals of the test, asked permission to record the participant's screen, and described the participant's role during the test. Then, the actual usability test was carried out (see Table 2 and Table 3 for tasks). In the third part, we required verbal feedback from the participant using the System Usability Scale (SUS) questionnaire [11] as well as questions about the overall experience using the prototype. Entire sessions lasted, on average, between 30 to 45 minutes and were videotaped for posterior analysis. The participants did not receive training on blockchain technology before the test. At the beginning of the session, the participants were asked to access the prototype after receiving the website URL through Whereby. Once there, they had to follow the instructions to perform the test. Participants signed an informed consent form and received monetary compensation according to their organizations' hourly rates.

Field notes were taken during tests and videos recorded during sessions were informally analyzed, annotating task completion times, blocking and confusing situations, and critical usability and experience issues that emerged.

5 RESULTS

5.1 Experience with Metamask and Ethereum

In general, more than 70% of the total time of the test was spent with participants dealing with Metamask and Ethereum (tasks 4 to 7 in Table 2 and tasks 3 to 6 in Table 3). At this stage, the participants' experience installing Metamask and creating an Ethereum account was primarily characterized by blocking and confusing moments.

At the beginning of Metamask installation (task 4 in Table 2 and task 3 in Table 3), participants struggled when they were asked to

[6]https://whereby.com

Table 2: List of tasks proposed to evaluate the AOD prototype

No.	Task	Explanation
1	Access instructions	Access instructions received by email before the session
2	Login into translation platform	Login into the translation platform with a testing credential provided in the instructions
3	Access the prototype	Use a web browser to access the URL of the prototype
4	Install Metamask	Click on the Metamask button located on the prototype's website to install the browser extension of Metamask
5	Create an Ethereum account	Use Metamask to create an Ethereum account
6	Change the Ethereum network	Open Metamask by clicking on the icon of the extension and change the Ethereum network of the account from the Main net to Rinkeby. The prototype was deployed on Rinkeby
7	Send Ethereum address to get funds	Share with researchers through the chat of Whereby the address of Ethereum account
8	Connect Metamask with the prototype	Use the button Connect with Metamask located at the top right corner of the prototype's website to connect Metamask with the prototype
9	Select a translation assignment	Navigate through the list of available assignments and choose a translation assignment
10	Open translation platform	Click on the button Translate of the assignment to access the AOD translation platform

Table 3: List of tasks proposed to evaluate the Smart prototype

No.	Task	Explanation
1	Get into the prototype	Use a web browser to access the URL of the prototype
2	Access instructions	Click on a link on the landing page of the prototype to download the pdf with the instructions to install Metamask
3	Install Metamask	Follow instructions on the pdf to install the browser extension of Metamask
4	Create an Ethereum account	Use Metamask to create an Ethereum account
5	Change the Ethereum network	Open Metamask by clicking on the icon of the extension and change the Ethereum network of the account from the Main net to Rinkeby. The prototype was deployed on Rinkeby
6	Send Ethereum address to access funds	Share the address of the Ethereum account with researchers through the chat on Whereby
7	Connect Metamask with the prototype	Use the button Connect with Metamask located at the top right corner of the prototype's website to connect Metamask with the prototype
8	Register a new member	Click on the button to access the form to register a new member. Fill out the form with fake data and submit the new register
9	Search member	Use the search function of the prototype to find information about the recently created member

decide whether to create a new wallet or restore an existing one. For outsiders of the crypto ecosystem, the terms used at this step were unfamiliar and created uncertainty about the action to take. In our case, 6 out of the 11 participants (55%) were confused at this point, not knowing which option to select. Some went back to the instructions, while others followed their intuition to move forward. Next in the installation of Metamask participants were invited to confirm a sequence of mnemonic code words provided by the wallet to secure backup and retrieval of the private key. Most participants (6 out of 11) skipped this part even when Metamask emphasized the importance of confirming the code. Out of the rest who tried to confirm the mnemonic, one of them struggled trying to confirm the 12 words of the code by memory while the remaining showed to be overwhelmed by the amount of information given by Metamask at this step, including the recommendations, instructions, and warnings.

Another blocking situation occurred when the participants were required to change the Ethereum network from Mainnet to Rinkedby (task 6 in Table 2 and 5 in Table 3)[7]. Here, a participant attempted to change their wifi network, while the others either did not find the Metamask UI widget that displays the list of available networks, or the number of options in the list and their unusual names complicated the selection.

A serious obstacle was locating the Ethereum address (task 7 in Table 2 and 6 in Table 3). Five participants (45%) struggled to understand this address and where to locate it within the UI of Metamask. Some participants incorrectly sent the prototype URL and the Metamask website URL, while the rest recognized they did not know where to find it. For the participants, it was unclear that the alpha-numeric sequence displayed by the Metamask UI below the account name represents the wallet address. Not being able to locate and share the wallet address blocked the participants, preventing them from receiving the Ethers necessary to use the prototype.

5.2 Experience with the prototypes

The operation of the prototypes was generally more straightforward than the Metamask installation and Ethereum setup. Yet, the experience helped to unveil a few minor issues with their UIs, such as the button to connect the AOD prototype with Metamask being complicated to locate for some participants or the search feature in the Smart prototype supporting only case-sensitive searches. Besides these situations, one of the biggest hurdles when operating the prototypes was understanding how to start working with them after completing Metamask installation. Almost half of the participants (5 out of 11) struggled at this point mainly because of not understanding the relationship with Metamask. The impression is confirmed by the following comments from P1 *"What I struggled with was understanding, why I had to login into the mask app?, why did I have to download it?"* We saw that this happened because the installation occurred on Metamask's website, which decontextualized the participants by taking them out of the prototype. At the end of the installation, the participants remained at the Metamask installation site without knowing how to navigate from there to the prototype. This situation generated frustration, which was verbalized using phrases like *"I don't get the Metamask thing"* (P5), *"The Metamask thing can confuse a lot of people [...] is not well integrated with the rest of the prototype"* (P5), *"[It] added too many steps to an already complicated process"* (P3).

However, the most confusing part when operating the prototypes and which represented for the participants a novel paradigm in the use of web-based applications, was the requirement to create and confirm transactions for almost every interaction. The wording and terms used in the transaction window (e.g., gas fee, gas price, gas limit) were found to be over-complicated by people with limited experience with blockchain technology. One of the participants verbalized this confusion by asking, *"what do you mean by transaction?"* (P5). Along this line, the use of virtual money (ETH) in transactions confused the participants, asking about the role of the ether (*"is*

[7]As mentioned before prototypes were not deployed on the Mainnet of Ethereum but on the test-net Rinkedby

[Ether] like a security thing?", P1) or *"where does the money to confirm transactions come from?"* (P8). Another participant stated that the use of virtual money might be detrimental for adoption, saying that *"people are [usually] scared of jumping into technologies that involve the use of money or payment"* (P2). Participant P1 expressed concerns regarding the change of paradigm fostered by blockchain technology, which imposed users to pay for interactions with the platform.

5.3 Systematic (SUS) feedback

After concluding the tasks, the participants were asked to provide a more systematic and formal assessment of their experience. Participants rated the prototypes with scores of 45 to 90 on a scale of 0 to 100—which does not represent percentages. The average score was 60 (std = 17.41). Our interpretation of the SUS results is based on the general guidelines presented by [5], who found that the target average SUS score for web-based interfaces is 68.05. With this in mind, we can see that the prototypes rated below the target score, indicating severe usability issues to be addressed.

6 LIMITATIONS

This study has several limitations. First, results cannot be generalized given the small sample size and the particular demographic characteristic of the participants, although the findings are consistent with previous investigations focused on cryptocurrencies (e.g., [1, 25, 32, 37]). Second, using immature and unreliable technology, like blockchain development tools, may have affected the participants' behavior when seldom technical errors suddenly appeared in the middle of the test. Third, the quality of the video analysis might have been improved by employing a more formal content analysis methodology to study the footage.

7 DISCUSSION

7.1 Confusing financial-related terms and deficient integration

We saw that when blockchain is applied outside the financial domain the terms associated with its operation mislead users, who are not familiar with the crypto ecosystem. This is even more notorious when the design of the UI resembles traditional web 2.0 apps, but their operation do not necessarily correspond to typical web-based applications, creating inconsistencies, misconceptions, and operational errors. For example, to start with web 2.0 applications users are required to carry out a well-established process, which generally requires filling in a brief registration form. In contrast, the steps to begin with blockchain-based applications demand users to carry out a lengthy and tedious procedure that involve an almost insurmountable learning curve, especially for first-time users, who must learn to operate unfamiliar tools and understand complicated concepts. Even if users successfully complete this process, the deficient integration between crypto wallets and applications negatively impacts their experiences.

Our findings suggest that significantly more efforts need to be conducted in the design of general-purpose blockchain-based technology. The sole inclusion of buttons to connect applications with the blockchain showed to be insufficient, requiring alternative design mechanisms to be incorporated to reduce language, terms, and concept barriers and to promote a more seamless integration. For example, a mitigation alternative is the use of onboarding mechanisms [22] to illustrate the sequence of installation steps, outlining how users can continue operating the application after its setup.

Alternatively and inspired by the approach of custodial wallets [51], the onboarding can be streamlined by promoting a more transparent use and set up of the crypto wallets. In this sense, blockchain-based applications can manage users' public and private keys, making interaction with the blockchain transparent. Moreover, transparency can be implemented at different levels, allowing more expert users to use their wallets if they already have one or have experience creating them. Also, transparency can be achieved by enabling users to manage transactions, leaving key management to the application. Transparency can also avoid taking users outside the application context, improving integration and not affecting users' task flow.

7.2 Transaction-mediated interactions: a paradigm shift in user experience

We have seen that working with blockchain technology requires users to adapt to a new paradigm of interactions with web-based services and applications. In this regard, Alshamsi and Andras claim that using blockchain requires developing a "new way of thinking," adjusting users' mental models to new forms, terms, and concepts [1]. Ideally, user's mental model should somehow align with the system's conceptual model. Here, we see that blockchain introduces a paradigm shift that requires people to adapt their mental models when using web applications.

Interactions on typical web applications are interrupted, although gradually less frequently, by pop-up alerts containing, in general, short instructions or simple confirmation messages. In the blockchain, "writing" actions (e.g., select an item from a list) typically trigger a transaction window, which is a pop-up full of specialized technical language (e.g., gas fee, gas limit, transaction cost) that resembles web-banking operations rather than interactions with general-purpose web applications. Users are requested to confirm transactions to continue operating the application without fully understanding what is happening, generating uncertainty, confusion, and caution. We saw how this situation impacted the attitude of the participants in the study, who did not understand why money transactions were needed to be confirmed to complete actions on a non-finance-related application. Also, the participants were somewhat insecure and particularly cautious about making mistakes, similar to what was found in [23]. Moreover, the heavy burden imposed by the number of clicks users need to perform to approve transactions for almost every "writing" action in the application damaged the overall experience.

Although some low-level interactions with the blockchain might be made transparent to final users like how custodial wallets take control of managing users' public and private keys, transactions introduce an unprecedented change of paradigm in web applications. As noted by the participants, the user experience of blockchain applications is significantly modified by the need to pay for actions. This situation revolutionizes how users interact and conceive the operation of the web. Our study found that the participants were concerned about having to "pay to work," in contrast to what happens today when they are economically compensated for their professional contributions, without any prior micro-payment. It is worth noting it would be feasible to use middle layers (e.g. a server) to better isolate the blockchain experience from users and avoid them "pay to work." This would make sense in hybrid systems, but not as much in those that, following blockchain proponents, want to popularize decentralized server-less applications.

8 CONCLUSIONS

A key topic that emerged during the test yet was initially discussed here is the change of paradigm introduced by decentralized technologies. There is ample room for further studies about the transition from web 2.0 to web3 models and the potential adjustment to this paradigm shift. It remains to be seen how this paradigm change impacts the adoption of blockchain-based technology besides the unresolved user experience limitations (e.g., inadequate integration, interruptions by almost every interaction). Future works can deep dive into the implications of this change for the design of general-purpose blockchain technology, exploring questions like how users value paying for interacting with applications? Can current user experience constraints be solved without undermining disintermediation?

Finally, enthusiasts promise that, sooner rather than later, blockchain will pervade every aspect of our day-to-day life, revolutionizing areas such as democracy, industry, medicine, education, and law; however, this study empirically demonstrates that this future remains further away. Until the user experience is significantly improved, the adoption of this technology might continue to be limited to specific niches, despite promises.

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