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Using Blockchain in Digitalizing Enterprise Legacy Systems: An Experience Report

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Abstract. Blockchain technology and distributed ledger technology (DLT) offer a secure, distributed, and tamper-proof way to store and exchange information. However, apart from standard cryptocurrency-based networks, innovations and process improvements based on the blockchain technology have mostly remained on the conceptualizing stage and have not yet reached mass adoption. There is a high demand for practical experiences from developing blockchain and DLT based systems in various domains outside FinTech. This work seeks to contribute to this gap by presenting real-world experiences from developing a proof of concept for automatizing conditional payments in social benefits and healthcare domains. We found that the key conditions for making these blockchain-based solutions viable are (1) attaining technological maturity and competences, (2) ecosystem thinking and adequate governance of these ecosystems, and finally (3) achieving legal and regulatory predictability. Furthermore, we discuss technological choice, business, and ethical considerations relevant to practitioners and research communities.

Keywords: Blockchain Technology, Distributed Ledger Technology, Smart Contract, Smart Money.

1 Introduction

Blockchain and distributed ledger technology (DLT) are often described as disruptive. They are frequently used synonymously; however, these are separated technologies. DLT presents a solution for creating distributed, peer-to-peer communication and interaction networks that do not have a single central authority [1]. Blockchain technology is one type of DLT that supports the safety of distributing a ledger by enabling an unmodifiable and interconnected list of ledger entries [1]. These technologies have enabled new kinds of innovations and infrastructure changes, most prominently in the financial industry [2, 3].

One of the key features of blockchain technology is that it enables process automation and transparency. This is provided through smart contracts: they are digital contracts that include executable program code lines and are both stored and run on the top of a blockchain [4–6]. Thus, in blockchain, rules for facilitating, verifying, and enforcing conditions on transactions are embedded into code that executes themselves on a condition-based principle.

In a DLT/ blockchain-based ecosystem, information is shared across the network and stored by the actors. Based on the actors' roles and the rules for information sharing, we can divide blockchains into permissionless and permissioned infrastructure [7]. In permissionless blockchains, the actors are unknown to each other and have open access to the data. Trust is built on incentives that positively impact participants' behavior that plays an essential role in reaching consensus [8]. In contrast, in a permissioned ecosystem, the actors are invited and validated before joining the network. Furthermore, the actors are identifiable, and as a consequence, there is more trust among them as compared to the permissionless blockchain protocols with anonymous actors.

While blockchain technology has largely been proven to be eligible to automate processes and provide various benefits, it has not yet reached mass adoption. Some of the reasons behind this are identified lately in the literature (e.g. [2, 9, 10]); however, yet only a few commercial-grade blockchain application exist [11, 12], and we lack technology awareness and practical use case experiences in industries outside of cryptocurrencies (e.g. [11, 13]). These observations could guide the practitioners' possible adoption decisions and help researchers understand the viability of these technologies in a real-world context. Thus, with this study, we aim to bridge the gap between practitioners and academics and present lessons learned from a blockchain adoption experience.

In joint work with an IT services and software company and its partners, we studied the suitability of permissioned blockchain in transferring an asset from one entity to another in a business ecosystem. We developed a proof of concept for blockchain-based conditional payments to eliminate the need for manual issuance and verification of different payment guarantees, such as lunch coupons, vouchers, and bus tickets, among others[1]. In this process, we integrated insights from academic and grey literature and discussions with blockchain practitioners, attended technology-related events, and followed the national and global discussions concerning DLT/blockchain technology development. Furthermore, we considered ethics during development using the guidelines for the development of Trustworthy AI by the European Commission [14].

In this study, we present the key lessons learned during this process with the following main research question in mind: *"What adoption barriers do practitioners meet in real-world settings when digitalizing and automating processes in enterprise legacy systems by utilizing distributed ledger technology and blockchain?"* Besides identifying the barriers, we also aim to answer empirical questions, such as the requirements of a blockchain-based solution and what technological choices have been made and why. In addition to technological perspectives, we also consider business and ethical issues.

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[1] https://medium.com/kelalab/distributed-ledger-a-revolution-in-conditional-payments-fa92e6ec4747
https://medium.com/kelalab/experimenting-with-smart-money-f645512aeb8e

Simply put, we aim to provide a realistic picture of the viability of automating and digitalizing enterprise legacy processes.

The structure of this article is as follows. In the next section, we present earlier work on this research domain from academic and grey literature. In the Findings section, we give an overview of the developed proof of concept, the technological choices for its development, and the lessons learned in the form of key experiences. Finally, we discuss the findings and present our conclusions.

2 Recent Work

In this section, we give an overview of recent work. In the first subsection, we overview earlier research on adoption factors of DLT/blockchain technology. In the second subsection, we present two production stage projects whose experiences in value tokenization and conditional payments we used during the development of proof of concept.

2.1 Adoption of DLT/ Blockchain Technology

Extant literature recognizes the technical challenges of DLT/blockchain technology adoption, such as interdependency of the technology features, the importance of system design, and process time for transactions in developing distributed, decentralized systems compared to centralized systems [15, 16]. It was found that choosing the right technological platform and architecture puts emphasis on system design, value creation [9], and needs considering the organization's operating principles, governing protocol, information storage needs, and willingness to share information [1, 3, 11]. The practical side (e.g., maintaining the systems, issues of scalability and interoperability) and the impact of making technical trade-offs from an ethical point of view have also been mentioned in research [1, 3, 8, 17]. The decision to move from centralized legacy systems towards more distributed and decentralized solutions requires some understanding about balancing between costs and benefits, the technology and community involvement [7, 18]. However, there is an imbalance in understanding disruptive new technology's impacts and characteristics [15, 19].

Current research found that cultural norms, practices, industry standards, and many other formal requirements affect the degree of distribution and decentralization that an organization is willing to adopt [1]. Chong et al. [10] found that there is no one-size-fits-all approach and each business model has its challenges that are not yet answered. Early research in the financial industry has shown that even if blockchain technology-based solutions hold potential in transforming processes across multiple industries [8], they preferably will be a complementary technology that enables alternative data and value transactions [2].

Governance related challenges were emphasized both by practitioners and researchers [1, 20]. The discourse of providing accountability using technical means seems to be shifting more to realizing that some level of institutional engagement and coordination is needed, for example, to resolve conflicts and manage risks and costs [7, 20].

2.2 Related Projects

An investigation of grey literature appointed two main research projects in related problem domains of enabling value tokenization and issuing rule-based benefits without centralized intermediaries. First, the Commonwealth Scientific and Industrial Research Organization's (CSIRO) Data 61 and the Commonwealth Bank of Australia in 2018 developed a proof of concept in a similar problem domain and similar product requirements in an example environment of Australia's National Disability Insurance Scheme (NDIS) [21]. In the trial called "Making Money Smart", NDIS provides funding on the blockchain network to people with disabilities to spend according to pre-set rules on support services. The technical solution was built on a permissioned Ethereum network and focused on payment functionality. The project sought to find whether and in what ways blockchain could improve conditional payments. In addition to the technical prototype, they also included user testing, managers, service providers, and experts. [21]

The project demonstrated the potential to deliver economic benefits through efficiency gains and network effects, especially with multiple conditional payment environments. The concept was as seen promising in enhancing public policy programs, empowering users to optimize their budgets, and reducing friction and costs for various stakeholders. However, the report highlighted the need for further research and development on technical performance and confidentiality, and integration with existing systems. Considerations of alternative conditional payment environments, accessibility, and compliance with legislation and regulation were mentioned in the final report. [21]

Second, the United Nations World Food Programme (WFP) developed a blockchain-based solution to make beneficiary cash transfers more efficient, secure, and transparent in refugee camps. The program strives to enable more choices and more control for refugees over their cash assistance [22]. The goal of developing the solution was to make direct transactions without a possible insufficient or unreliable financial intermediary. The first pilot for blockchain-related was launched by WPF in 2017 when the organization initiated a proof of concept project in Pakistan for authenticating and registering beneficiary transactions. Next blockchain-based technologies were used to deliver food assistance to Syrian refugees in Jordan. WFP has announced its interests in exploring the technology's possibilities in, e.g., supply chain tracking and digital identity management for refugees [23]. The Building Blocks were built on a private, permissioned blockchain Parity Ethereum by Ethereum Foundation [24]. It was integrated with biometric authentication technology, and it has been currently being used in refugee camps in Jordan. The network started with a single authority but has since grown to include other UN Women [24]. This expansion further has resulted in improved security and accountability through two organizations validating each other's transactions and holds the potential to reduce costs and risks [25].

3 Experience Collection Mechanisms

To gather empirical data and experiences in real-world settings, we co-developed a technical proof of concept for smart contracts using DLT/blockchain technologies in collaboration with a company and its partner organizations. We assessed the existing literature, current industry practices, as well as the needs of the stakeholders even-handed. Observations were gathered from meeting memos, notes, project and version control documentations, code repositories, project management documentations (e.g., Scrum agile development method and Kanban lean management method documents) and other forms of sources available online. The team actively followed national and international discussions, projects, pilots, and, for example, the development of legislation related to blockchain-based technologies. Furthermore, the research team participated in discussions with other companies interested in utilizing the DLT/blockchain technology for their use cases or offering services related to their customer' technologies. Additionally, we collaborated with another research team whose primary goal was studying how blockchain technology can be made trustworthy [19]. This research team offered us a new, ethical perspective to develop blockchain-based systems and a practical tool to implement the idea of an ethical, lawful, and robust system.

In the design and development phase, we created a proof of concept in several iterations. The iterations included several consultative and workshop meetings with the partner company and its partners as checkpoints of the work direction and shared understanding of the objectives. An overview of the events is presented in Table 1.

Table 1. Empirical data collection sources

Events	Quantity/ length	External participants
Project meeting with the partner company	10 instances	Partner company representatives, possibly an external expert
Consultative meeting with the partner company	10 days	Developer; partner company representatives
Proof of concept workshop meetings	2 instances	Developer; partner company representatives, project partner representatives
Research conference	5 days	Technically aligned research group representatives (hosted by a research center)
Technical event	1 day	Developer representatives interested in DLT/blockchain technology or using it
Business event	4 days	Business representatives interested in DLT/blockchain technology or using it
Technical training program	2 instances	External technical instructors
Ethical research meeting	8 instances	Collaborating research team
Ethical research interview	2 instances	Collaborating research team representative
Technology-related lecture	3 days	External lecturers (hosted by universities)
Proof of concept technical meeting	2 instances	Project partner technical developers

This paper describes the lessons learned in this study based on active participation and careful documentation of the development process. For these purposes, we used the data collected from various empirical sources and analyzed them iteratively. First, we grouped the relevant information into experiences using post-it notes. Second, we analyzed the notes and grouped the key experiences into categories. We describe the resulting findings in section 4 in the form of Primary empirical observations (PEOs).

4 Findings

In this section, we give an overview of the lessons learned in our work. In the next subsection, we describe the requirements of the proof of concept solution. In the second subsection, we justify our technological choices. In the third subsection, we communicate our key experiences in the form of Primary Empirical Observations (PEOs).

4.1 The Requirements for Proof of Concept

As a case study, we focused on designing and developing a technical prototype Smart Money, a distributed business network for conditional payment guarantees. The concept could be used across various use cases enabling businesses to issue funds in the form of rule-based digital tokens. The network services allow dynamic rule validation and reliable near real-time transaction data. We chose to concentrate on implementing the concept in the domain of social welfare benefits. It presented us with several challenges, such as a highly regulated environment, a high number of transactions, and a comprehensive and broad end-user base. Thus, we expected to face possible barriers in technical, market, and institutional dimensions. We were primarily interested in the efficiency gains that the technologies enable by removing the need for intermediated data-synchronization and concurrency control. However, we noticed that practitioners faced similar issues in utilizing DLT/blockchain technologies in various use cases.

The Smart Money blockchain-based solution could improve the current system of social and welfare benefits by reducing administrative burden and costs as well as simplifying and automating processes. It allows an Issuer to create and transfer a token with predefined rulesets to a Customer's digital wallet (shown in Figure 2) who spends them according to the spending rules on products or services. Merchants accept tokens.

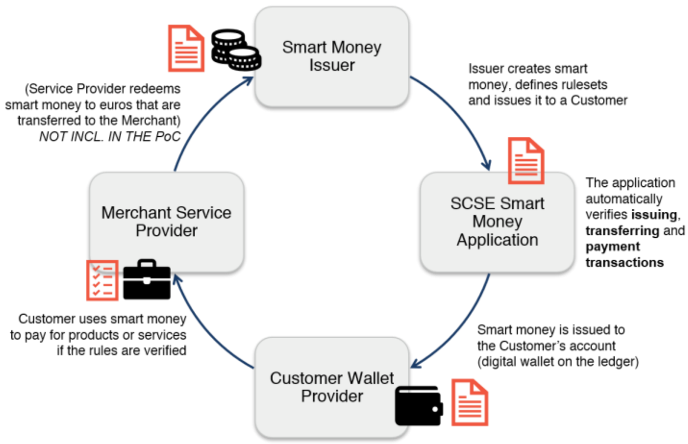

Fig. 1. Smart Money token lifecycle in the proof of concept trial.

The Customers and Merchants access the network through their Service Providers, who are network nodes alongside with the Issuer. The application enables a fund issuer to define customized spending rules on a token before sending it to a recipient's account. After receiving the token, the recipient can use it to buy products and services if and only if the pre-set rules are met. The rules could include price-caps, lists of approved service providers, and expiration dates, among others. See Table 2 for details related to designing and implemented high-level functionalities. The application was developed with an enterprise-level blockchain platform Corda (release version 4.1) by a software company R3.

Table 2. Functionalities implemented in the Smart Money proof of concept.

Functionality	Design criteria	Implementation and constraints
Creating Smart Money accounts	Using and interacting with the system should be easy and not require knowledge about the technology. Users connect to the network through their role-based service providers.	In the time of the development, Corda did not have an account feature. We chose to use a Corda-based third-party software called Cordite by Cordite Foundation.
Creating Token ruleset	Tokens could be used as vouchers or cash; they should be generalized enough for scalable use. The Token rulesets should be easily updatable by the Issuer when laws, regulations or standards change.	Updating rules require node hosts to implement changes. One-time-use vouchers are clearer than divisible cash as changing token type rulesets affect every consumer with the same type of tokens. In our scope, the operator's rights are comparable to a centralized system.
Issuing Token on an Account	The system should promote human oversight control and intervention if necessary. The Issuer should be permissioned to modify the expiry of the Smart Money Tokens or state them worthless. The origin of the allowance should be traceable but protect the Customers' privacy.	The scope does not include updating the transaction after Issuance. The ledger hosts e.g., public service provider credentials, but all confidential data is maintained outside of the ledger. The allowance origin can be tracked to the Issuer without revealing additional Customer data.
Transacting a payment	Spending allowance should promote efficiency and simplify the process to the Customers and Merchants. The system should be resilient to misuse and potential attacks and its mechanisms, constraints, and decisions should be transparent and auditable.	With limited resources we did not concentrate on exception management. The unwanted use of the system was evaluated to belong to managing participants rights and access rules outside the system.

Additionally, we considered long-term requirements such as redeeming tokens for payment, digital identity management, keeping track of transactions, validating payments with smart contracts, and token type-specific rules. Furthermore, we implemented ethical requirements into the proof of concept development process through a practical tool that supported raising ethical awareness and discussion. We followed the guidelines for Trustworthy AI by the European Commission [14] that state that a trustworthy system should be lawful, ethical, and robust. The objectives are realized with seven key requirements: 1) human agency and oversight, 2) technical robustness and safety, 3) privacy and data governance, 4) transparency, 5) diversity, non-discrimination and fairness, 6) societal and environmental well-being, and 7) accountability [14].

4.2 Technological Considerations

One of the most critical decisions is related to choosing the best fitting blockchain protocol. Enterprise blockchains differ from traditional permissionless, public blockchain designs, e.g., in areas of identity, privacy, and transaction scalability [7, 26]. Thus, there were multiple discussions concerning the advantages and disadvantages of different alternatives. In Table 3, we describe the three most promising alternatives (Corda, Fabric, and Enterprise Ethereum). Based on various decision criteria presented in the table, the Corda platform was chosen. Corda is an open-source, enterprise-level blockchain that provides a platform for recording and managing contracts between designated parties in a transaction and deals with network sharing, data, business logic, and the current state of shared facts [26].

Table 3. Enterprise Blockchain comparison considering network and transaction features as presented by R3 in Q3/2019 [27].

Feature	Corda by R3	Fabric by IBM	Enterprise Ethereum by several companies
Real-world identity	Legally valid and unique	Certificate-based (not assured)	No inherent notion
Scalability	Scalable as not every node handling all transactions	Limited by channels architecture (increases with participants)	Low due to complex zero-knowledge proof privacy calculations
Method to guarantee uniqueness	Pools of known notaries	An ordering service	Validation nodes (most of the time)
Privacy	Only participants to a transaction have access to the data	Channels architecture allow private transactions	Private deployment of Ethereum has a viable privacy model
Conclusiveness	The completed transaction cannot be reversed	The completed transaction cannot be reversed	Small possibility completed transaction can be reverser

We chose the Corda platform for different reasons. First, Corda's consensus mechanism requires transaction validity and uniqueness [26, 28]. Second, the platform is mature related to different issues, such as data privacy, identity, emphasis on legal agreements, regulator/public sector collaboration, and interoperability/integration and is actively developed [29]. Third, the Corda platform also has higher scalability than some of the other enterprise-level blockchains (e.g., Fabric and enterprise Ethereum) as each node in the network does not handle all transactions [28]. Finally, in the Corda platform, each business network defines its membership criteria, and only those who participate in a transaction have access to its data, which further enhances the platform's privacy [26].

However, despite Corda's advantages over other alternatives, performance, confidentiality, and system integration raised concerns among practitioners and partners in our use case study. First, there is a concern related to the adequacy of the open-source version of Corda. Open Source Corda has some limitations related to its scalability and capacity of handling massive amounts of transactions [28] after the solution is taken into real use. It indeed needs to be noted that any larger-scale trials should be run on Enterprise Corda. Second, transaction privacy between Corda nodes is secured, but this confidentiality does not apply to the account level. Finally, some concerns were raised related to integrability to legacy systems.

4.3 Lessons Learned

Designing a blockchain-based solution requires many different activities. First, it requires developing a technical solution. Second, besides providing an architecture, the providers should promote the adoption and build a whole ecosystem with its actors and interactions among them. Third, the ecosystem resides in a legal and regulatory context where ethical concerns should be considered as well. In what follows, we describe our key experiences in the form of Primary empirical observations (PEOs) related to these three aspects, as shown in Table 4.

Table 4. Key experiences in the form of Primary empirical observations (PEOs).

Activity	Key experience
Technical development	
PEO 1 Developer Community	The leading enterprise blockchain protocols have attracted an active, considerably stable, and frequently pushing developer community.
PEO 2 Immaturity of the Technology	Despite high interest across industries, blockchain technology is still in its maturing phase.
PEO 3 Interoperability	Compatibility with existing IT systems and interoperability between blockchain networks are critical aspects of incorporating blockchain technology into existing systems.
PEO 4 Technological Trade-offs	Many of the DLT/blockchain technology attributes are interdependent; thus, all blockchain technology features cannot be integrated as such, but there is a need to make trade-offs and choose the essential features
Building an ecosystem	
PEO 5 Governance	When developing decentralized systems, a key issue that needs special attention is governance: actors, incentives, access, and control rules.
PEO 6 Business Goals	One of the key challenges of blockchain technology adoption is complying with different business requirements in decentralized settings.
PEO 7 Technology Acceptance	There is an increasing interest and higher trust in the potential of DLT/blockchain technology in redesigning already existing services of various industries.
PEO 8 Information Asymmetry	There is information asymmetry related to DLT/blockchain technology.
Ethical and legal considerations	
PEO 9 Ethical Considerations	Blockchain-based solutions should be designed and developed with ethical considerations in mind; however, blockchain technology's ethical aspects are still underdeveloped and need further research.
PEO 10 Legal Aspects	Legal predictability is a prerequisite for larger scale blockchain deployment. Lack of legal recognition is one of the most important non-technical limitation of block-chain-related technologies.

Key Experiences from the Technical Development

PEO 1. [Developer Community]. The leading enterprise blockchain protocols have attracted an active, considerably stable, and frequently pushing developer community. We made our technological choice based on several objective decision criteria (see subsection 4.2); however, one very important success criteria is the developer community's activity behind the platform. The enterprise blockchain Corda platform built and maintained by R3 differs from the other leading enterprise protocols in having been purpose-built and not originating from a traditional technology organization. Partly due to the active developers, by the end of year 2019, Corda was one of the leading enterprise blockchain protocols having the highest total activity and total pushes compared to Linux Foundation's Hyperledger projects Fabric, Sawtooth and Besu, as well as to Quorum (a fork of Ethereum) and MultiChain (a fork of Bitcoin, Coin Sciences).

PEO 2. [Immaturity of the Technology]. Despite high interest across industries, blockchain technology is still in its maturing phase.
Even though blockchain technology has gained much interest across industries, its adoption is still on an experimental stage, and the platforms themselves are under development. We faced different challenges related to upgrades from the Corda platform version 3 to 4 and lack of some technological features introduced to the platform in later releases during our proof of concept development. Not having the needed features, we ended up using third-party application components, which raised questions about safety, reliability, and maintainability of the system.

PEO 3. [Interoperability]. Compatibility with existing IT systems and interoperability between blockchain networks are critical aspects of blockchain adoption.
The Corda platform offers integrability with legacy systems and functional information flow between different applications on the same platform and between different blockchain platforms. However, these features (e.g., database support, hardware security module, and technology enabling secure deployment inside corporate data centers) are not yet available open-source but are additional features of Corda Enterprise. As a rising number of organizations is adopting Corda commercially, the platform faces novel requirements. R3, in line with other technology providers, displays willingness to promote simplicity, flexibility, and connectivity of their platform to encourage adoption.

PEO 4. [Technological Trade-offs]. Many of the DLT/blockchain technology attributes are interdependent; thus, all blockchain technology features cannot be integrated as such, but there is a need to make trade-offs and choose the essential features.
Blockchain protocols vary significantly in their configurations related to, e.g., the level of permission, data access, transaction consensus, modularity, scalability, interoperability, centralization, and anonymity. The technology level makes use of various technologies such as distributed ledgers, identification, and cryptography. Many of the attributes enabling each of these features are interdependent, and bending con-

ditions in one of the dimensions could be disadvantageous to another area. Thus, designing a blockchain-based distributed system leads to making technological trade-offs such as sacrificing the system's decentralization or integrity for better scalability.

Building an Ecosystem

PEO 5. [Governance]. When developing decentralized systems, a key issue that needs special attention is governance: actors, incentives, access, and control rules.
Developing a distributed system compared to a centralized requires considering additional questions, e.g. who should have access to the information within the system and how open the system management should be. Managing stakeholders and their rights is even more emphasized in permissioned enterprise blockchain platforms compared to public networks in which every participant is equal in their restrictions and rights. Furthermore, communicating the advantages of the blockchain solution and providing incentives to the stakeholders is a crucial task in system design and development.

PEO 6. [Business Goals]. One of the key challenges of blockchain technology adoption is complying with different business requirements in decentralized settings.
Centralized enterprise legacy systems naturally emphasize security and privacy, whereas distributed and decentralized solutions gain an advantage in sharing services and resources among multiple participants. Privately operated DLT/blockchain technology solutions might be an appealing alternative compared to more open or public blockchain protocols that still fulfill the enterprise business requirements. However, private blockchains do not fully undertake the traditional blockchain technology's ideology and its most distinctive features, such as decentralization and censorship-resistance. Consequently, private blockchains are distributed ledgers that function like closed, secure, cryptography-based databases, and therefore, they introduce new challenges besides their benefits.

PEO 7. [Technology Acceptance]. There is an increasing interest and higher trust in the potential of DLT/blockchain technology in redesigning already existing services of various industries.
DLT/blockchain technology managed to gain traction by its success in re-implementing financial services and enabling both secure transactions and innovation in the financial services industry. As enterprise blockchains have already reached some level of stability, there seems to be a keen commercial interest in transforming processes across various industries beyond the initial fintech applications and currency markets. There are, however, not yet many commercial applications that would offer lessons learned or best practices to encourage wider adoption.

PEO 8. [Information Asymmetry]. There is information asymmetry related to DLT/blockchain technology.
The current state of knowledge related to DLT/blockchain technology is still significantly unequal between those who provide blockchain-related services and those who

use these systems. Even though technology providers are reporting an increase in understanding among customers, the research team encountered different concerns related to, among others, the potential benefits of distributed systems as compared to centralized legacy systems, data privacy, and the viability of the business and technology aspects. Moreover, a few technology company representatives emphasized that blockchain technology knowledge and interest are very scattered and mostly concentrated in their financial units.

Ethical and Legal Considerations

PEO 9. [Ethical Considerations]. Blockchain-based solutions should be designed and developed with ethical considerations in mind; however, blockchain technology's ethical aspects are still underdeveloped and need further research.
One of the key conditions for making blockchain-based solutions viable is related to the ethical aspects, such as transparency, accountability, responsibility, and fairness, among others. However, researchers and practitioners concurred that currently, the ethical questions related to blockchain technology are generally unthought and unstructured. Besides privacy and some domain-specific concerns (e.g., medical, finance, insurance), also other important ethical issues (e.g., the ethical impact of technological choices or accessibility), were thought to be distant.

PEO 10. [Legal Aspects]. Legal predictability is a prerequisite for larger-scale blockchain deployment. Lack of legal recognition is a major barrier in adopting blockchain-related technologies.
Blockchain adoption is ready to take a leap from proofs-of-concept to commercial implementations; however, the required laws, regulations, policies, and standards are still under development. There are currently different initiatives to overcome these obstacles in different parts of the world where different actors (e.g., authorities, enterprises, developer communities) are working to promote legal certainty. The current immaturity in laws, regulations, and standards and the uncertainty thereof leads to putting the project on hold until regulatory concerns are cleared.

5 Discussion

The findings of this paper emphasize the need for additional research on the barriers to blockchain adoption. Many of the barriers described in our lessons learned were recured among practitioners in various domains and were to some extent identified in the extant literature but did not yet have comprehensive, comprehensively agreed solutions. Thus, even though the number of academic publications on different aspects of blockchain technology rose significantly [8, 9], our experiences show that further research is needed to bridge the gap between researchers and practitioners.

We categorized our key experiences in three dimensions that should be considered when utilizing blockchain-related technologies: 1) technical development, 2) building an ecosystem, and 3) ethical and legal considerations. Related to the technical challenges of DLT/blockchain technology adoption (PEO 4), we are in line with recent work that identified the interdependency of DLT/blockchain technology features as a barrier and accentuated the importance of system design in developing distributed, decentralized systems compared to centralized systems [15, 16, 18]. Our results contribute to these findings by finding that the lack of conscious design and development choices could diminish transparency, fairness, safety, and auditability (PEO 9). Our findings further revealed that pragmatic use cases are also needed in blockchain initiatives as a means to provide guidelines, usability, and technical competencies (PEO 7). In the design and development phase of our proof of concept solution, we had concerns about scalability and system maintenance (PEO 2). Furthermore, we found that the developer community behind the chosen technology platform is of key importance (PEO 1). We lacked some of the chosen platform features, which raised security concerns if the prototype would be developed further (PEO 2). Besides, we had interoperability issues that we could not anticipate in advance (PEO 3). Finally, we also had to make technical trade-offs from an ethical perspective (PEO 4).

Our lessons-learned revealed that one of the biggest challenges is related to building an ecosystem around blockchain technology. Even though there are an increasing interest and higher trust in the potential of the technology (PEO 7), there is also information asymmetry between the different stakeholders (PEO 8). However, this uncertainty can be mitigated through negotiations and education. In line with earlier research (e.g. [1–3, 20]), one of the key issues is related to governance: establishing incentives, accountability, access, and control rules among stakeholders (PEO 5). Achieving business goals in decentralized settings need careful strategy and actions (PEO 6). The unsolved governance issues found in our research highlight the need for additional research in this area.

Related to the reluctance of truly utilizing the distributed nature of DLT/blockchain technology in automating and digitalizing legacy systems, we found that rethinking preexisting business practices and implementing novel technical approaches are challenging (PEO 6). However, at the same time, expectations for the technologies' performance are increasing (PEO 7). We highlight the importance of ecosystem thinking: understanding how different stakeholders can jointly create and capture value as well as convincing these stakeholders about this value is crucial in building meaningful DLT/blockchain technology-based business applications (PEO 5). We concur with Chong et al. [10] that there is no one-size-fits-all approach and each blockchain-inspired business model has its own challenges that are not yet answered.

During our research, it became clear that creating effective and fair governance, regulation, and management requires a thorough understanding of the technology PEO 4, PEO 8, PEO 9, in line with [1, 11, 20]). We recognized the immaturity of legal and regulatory context needed for mass adoption (PEO 10). We also found that ethical issues in the development and use of DLT/blockchain technology are not appropriately addressed in earlier research and need additional work (PEO 9).

6 Conclusions

This study presents the findings of a research process during which we designed and developed a proof of concept of a blockchain-based solution for conditional payments using smart contracts and DLT/blockchain technology. These observations can be used to guide decisions on future research topics and discussions in industry practices in different ways. First, our experiences related to the proof of concept requirements and the decision criteria in choosing a suitable blockchain platform could be used by practitioners. Second, our key experiences on the viability of the business solution could be used by both researchers and practitioners for further work.

Our study identified key adoption barriers from the lessons learned that are presented in this experience report. The barriers are divided into three activities that have utter importance in utilizing blockchain-related technologies. First, despite the high interest in the DLT/blockchain technology, the adoption of blockchain is still in its experimental stage, and the platforms keep maturing; thus, further development of technological components is of key importance. Second, the cost and risk of blockchain adoption and implementation quickly can be very high; thus, ecosystem thinking is needed to promote blockchain adoption and enable viable and pragmatic solutions. Third, the immature legal and regulatory context and the unstructured ethical discussions related to DLT/blockchain technology need to be addressed before the blockchain deployment can leap from proof of concepts to commercial implementations. As businesses are eager to move from experimenting with the technology towards commercial deployment of DLT/blockchain technology, we expect these topics described above to gain closer attention.

Despite the growing body of knowledge by academics and practitioners, there are still notable challenges and knowledge gaps related to the development and use of DLT/blockchain technology-related solutions. Some of the adoption barriers, such as legal predictability, require national and international collaboration and cannot solely be addressed by researchers or industry practitioners. Even if research shows that distributed and decentralized solutions gain an advantage over centralized systems in sharing services and resources among multiple participants [18], it is not yet happening in practice. Companies experimenting with the DLT/blockchain technology are currently building solutions for individual use cases instead of establishing blockchain-based infrastructures. As the situation stands, the future deployment and the significance of these technologies can only be speculated until further adoption.

This research has some limitations. The findings are based on the development of one technical proof of concept and limited discussions with practitioners, and thus, further research is needed to make these observations more generalizable. Further-more, additional work is required in the research areas discussed in this paper, such as technological immaturity, ecosystem governance, redesigning business processes and models as well as legal uncertainty and ethical issues.

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