BBBlockchain: Blockchain-based Participation in Urban Development

Final Report

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INHALT

1. INTRODUCTION

Transparency is the key to successful urban development and participation processes. To this end, digitalization and blockchains have the potential to improve transparency and trust. The BBBlockchain research project therefore investigates how to support real building projects in Berlin and whether blockchain technologies can improve engagement and transparency in participation processes.

Together with Berlin's housing associations, the Einstein Center for Digital Future (ECDF), and the Technical University Berlin, two interdisciplinary research groups developed BBBlockchain. The research groups Urban Resilience and Digitalisation and Distributed Security Infrastructure reviewed existing participation formats and designed them as blockchain-based use cases. These use cases were then implemented into two building projects in Berlin, Germany, together with degewo and Gewobag.

BBBlockchain started with informational use cases for progress-related news to improve transparency and bring multiple stakeholders onto the same platform. Under real-word conditions, BBBlockchain became part of the ongoing participation process at Kietzer Feld in Köpenick. In addition, BBBlockchain introduced the Consultation use case, where nearby-living residents of the Bülow90 building project in Schöneberg were asked for their opinions and expectations about the future of the building project. The focus was on the collection of opinions and the technical security and transparency of blockchain-based voting.

In close cooperation with Berlin's six state-owned housing associations, the first project phase was completed in 2020. After the project results led to numerous significant research findings, the project was continued by degewo and Gewobag. Therefore, for the last project phase, BBBlockchain studied the potential of blockchain tokens for participation processes. Extending the reach of the consultation through the implementation of token-based incentives, so that residents in the neighborhood get a blockchain token for their participation that they can redeem for a free coffee.

While the focus in the first phase of the project was on providing information, pilot phase two of the project focused on the implementation and testing of another key function of blockchain technologies: the issuance of tokens. Cryptocurrencies or tokens are an integral benefit of blockchains. They are a digital, countable and transferable asset that is managed without centralized entities (e.g., banks). Cryptocurrencies are used when a blockchain is set up specifically for this purpose (the best-known examples are Bitcoin and Ethereum). Tokens, on the other hand, are used when an existing blockchain is used for development. Unlike blockchain cryptocurrencies, tokens can be designed by own programs for the needs of the respective project. In the context of our research project, tokens were introduced as an incentive for citizens to participate in the voting processes. For this purpose, the participating housing associations provide surveys or votes on the design of certain aspects of the pilot projects via the app. Interested residents or tenants install the BBBlockchain app in a first step. After that, they can participate in the respective survey or vote. For this participation, the users are credited with a token via the BBBlockchain app, where it is collected. Users can check their token balance in the app. The tokens are redeemed as discount coupons in a participating café in the pilot project.

Project Milestones:

// 2018 Oct: BBBlockchain project start
// 2018 Dec: Use case studies
// 2019 Apr: User interface design
// 2019 Mar: 1st Advisory Board Meeting
// 2019 Jul: Prototype release
// 2019 Sep: Launch Kietzer Feld: Information
// 2020 Feb: 2nd Advisory Board Meeting
// 2020 Feb: Launch Bülow90: Consultation
// 2020 May: Research Report "Handlungsempfehlungen"
// 2020 Oct: 3rd Advisory Board Meeting
// 2021 May: Official project extension
// 2022 Feb: Launch Kietzer Feld: Consultation
// 2022 May: Launch Bülow90: Tokenization
// 2023 Jan: Final evaluation

Research Milestones:

// 2019:   BBBlockchain Whitepaper
// 2020:   SmartDHX
// 2020:   "Handlungsempfehlungen"
// 2021:   Study on citizens' engagement in urban development through blockchain: a human-centered design approach
// 2021:   Case study: lessons learned for a blockchain-based participation app
// 2021:   Empirical study on the relevance of blockchain-based voting
// 2022:   Study on transparency in digital-citizens interfaces with blockchains
// 2022:   Two studies on blockchain-based authentication mechanisms
// 2023:   Tornado Vote

Academic Milestones:

// 3 Bachelor's theses
// 6 Master's theses and 4 Master's projects
// 1 seminar on blockchain-based authentication
// 1 seminar on privacy and anonymity on the internet
// 2 PhD students and 1 Post-Doc

Main Contributions

// ***BBBlockchain Concept: We conceptually designed blockchain-specific use cases that have the potential to improve citizen participation and transparency.***
We designed the use cases along the established ladder of citizen participation, which reaches from informing citizens to delegating power. We incorporated the opportunities

provided by blockchain technologies and identified tokens as a cross-cutting feature that can augment all layers of participation. The general concept and the use cases served as a template for our project.

// **BBBlockchain Smart Contracts: We implemented the main components (timestamping, voting, and tokens) that build the foundation for our use cases.**
In order to realize BBBlockchain's participation use cases, three major components are necessary: timestamping, voting, and tokens. Timestamping provides a secure sequence of information and enables all users to verify the integrity independently. Voting enables consultation and co-decision use cases. Tokens can be used to augment all use cases by enabling token transfer and incentivization. For the implementation, our focus was an inclusive procedure that does not require special software or hardware.

// **BBBlockchain App: We developed a blockchain-based app to enable transparent multi-stakeholder participation.**
Blockchain technologies are still overly complex and difficult to integrate into existing real-world projects and workflows. For BBBlockchain and its infrastructure, we were able to find reasonable trade-offs to make the technology usable, while maintaining many of the transparency and verifiability features of a blockchain. We have developed a visual design concept that unfolds the complexity involving blockchains step by step to make the BBBlockchain app accessible for users who are not familiar with the concept. At the same time, advanced users can verify all information to the full extent by running the software locally.

// **BBBlockchain Pilot Projects: We successfully accompanied two real-world pilot projects in Berlin.**
We accompanied two urban development projects in Berlin, where we complemented existing (mostly offline) participation with BBBlockchain as a digital offer. We ran and tested different participation formats on different participation layers in the field. We were able to reach and involve a new group of users. In total, more than 3,700 users used the app.

Key Findings

// Introducing blockchains on urban development processes promises more transparency through their immutability and verifiable integrity, but one must also expect negative effects on the willingness of stakeholders to participate on such a binding platform. In particular, we found that the immutability of blockchain significantly changes the communication practices of housing associations, as changes in urban planning have to be communicated as new information. As a result, they were forced to rethink their established communication protocols in favor of a more transparent approach. Therefore, well-defined communication policies and regular engagement are necessary to minimize the negative impact of blockchain. Otherwise, blockchains alone cannot ensure better transparency or increased engagements.

// BBBlockchain has been able to reach new target groups. This positive outcome is, however, not necessarily related to the introduction of blockchain technologies but rather to the benefits of providing an additional digital communication channel instead of completely analogue processes.

// We asked users about their experience with the app and 57% found that BBBlockchain is easy to use. Through a step-by-step navigation concept, we were able to make it possible to use the blockchain without any further technical expertise, even for technically complex blockchain-based voting.

// While we consider blockchains useful for conflict resolution, we have not been able to assess the impact on conflict management, as there have been no major communication conflicts with BBBlockchain. Other external communication conflicts occurred throughout the entire participation process, but were resolved through direct communication with tenants. However, the blockchain showed itself to be ubiquitously helpful in supporting the overall communications concept as well. Nevertheless, we consider that stakeholders were more reluctant to risk conflicts on the BBBlockchain due to the immutability of blockchains. Therefore, blockchains can only be seen as an additional instrument to increase transparency and build accountability.

// To increase citizen participation, BBBlockchain successfully issued crypto tokens as a reward for voting. To this end, 81 participants received their own token, however, only 6% of the participants redeemed the tokens for free coffee. While there are various reasons and ways to improve the process, we conclude that tokens do not necessarily serve as an incentivization mechanism.

Working Plan Comparison

In the following, we compare the working packages (WP) from our research proposal to the completed tasks during the two years of BBBlockchain's second project phase. We completed all of the work packages, except for the implementation of binding co-decision with automatic blockchain execution. Instead, however, we implemented non-binding co-decision making processes to consult tenants on their preferences for the building projects.

WP1: Voting concepts with co-decision.
Together with degewo and Gewobag we developed concepts for votings with BBBlockchain in several workshops. Therefore, we compiled questions from a research perspective (e.g., on the usability of BBBlockchain) and for the building projects (e.g., tenant's preferences on the building progress). We identified legal challenges for the realization of direct co-decision making.

WP2: Further development of the BBBlockchain prototype.
The prototype of the BBBlockchain was extended to allow voting in the Kietzer Field. In addition, a new graphical voting system was implemented based on this experience, with easier usability. Furthermore, the BBBlockchain infrastructure was moved from the Ethereum Testnet Rinkeby to a permissioned network. For this purpose, BBBlockchain was migrated to servers of degewo, Gewobag, and TU Berlin.

WP3 and WP4: Voting and co-decision in the pilot projects.

As envisaged, we continued with both pilot projects, namely Kietzer Feld and Bülow90. In February 2022, a survey was conducted on the neighborhood meeting place in Kietzer Feld. In May 2022, another survey was conducted on the needs and perceptions of the neighborhood to the Bülow90. While we implemented co-decision processes to consult tenants on their preferences, the concept of automatic blockchain-enforced co-decision could not be fully realized, partly due to various legal constraints. Instead, we focused on non-binding blockchain surveys and the transparency and trust that comes with them.

WP5: Trust and decentralization.

New content could now also be stored directly on the blockchain without the need for centralized infrastructures. In addition, residents of the Bülow90 project were asked for their opinions in free text fields. Their answers were stored in cryptographically encrypted form and only released after content checks.

WP6: Information security and privacy.

Information security and privacy was an important priority for the reliability of the votes. Different methods for anonymous voting were tested in the Kietzer Feld and Bülow90 surveys. In addition, two scientific papers were written on the topic of anonymous identity verification and anonymous voting.

WP7: Open votings without (strong) authentication.

To simplify voting and reach nearby living neighbors, a survey was conducted for Bülow90 without authentication. In order to still get reliable results, novel verification methods were implemented, such as hash-matching email addresses and blockchain-based captcha techniques. Ultimately, there was no obvious exploitation of the voting.

WP8: Innovative voting systems with incentive mechanisms.

In order to motivate as many people as possible to participate in the Bülow90 voting, a blockchain-based reward system was developed. After voting, participants received a non-fungible token (NFT) that they could exchange for a cup of coffee.

WP9: Evaluation and final report.

Since the continuation of the project, the research results of BBBlockchain have been evaluated and published in several scientific papers. This report summaries the project output and its contributions.

1^(DE)   EINLEITUNG

Transparenz ist der Schlüssel zu erfolgreichen Stadtentwicklungs- und Beteiligungsprozessen. Digitalisierung und Blockchains bieten dabei das Potenzial, Transparenz und Vertrauen zu verbessern. Das Forschungsprojekt BBBlockchain untersucht daher, wie reale Bauvorhaben in Berlin unterstützt werden können und ob Blockchain-Technologien Engagement und Transparenz in Beteiligungsprozessen verbessern können.

Gemeinsam mit den Berliner Wohnungsbaugesellschaften, dem Einstein Center for Digital Future (ECDF) und der Technischen Universität Berlin haben zwei interdisziplinäre Forschungsgruppen BBBlockchain entwickelt. Die Forschungsgruppen „Urban Resilience and Digitalisation" und „Distributed Security Infrastructure" haben bestehende Beteiligungsformate untersucht und als Blockchain-basierte Anwendungsfälle konzipiert. Diese Anwendungsfälle wurden gemeinsam mit der degewo und der Gewobag in zwei Bauprojekten in Berlin umgesetzt.

BBBlockchain startete mit ausschließlich informativen Anwendungsfällen zur Dokumentation von Baufortschritten und Veröffentlichung von Nachrichten, um die Transparenz zu verbessern und mehrere Beteiligte auf dieselbe Plattform zu bringen. Unter realen Bedingungen wurde BBBlockchain Teil des laufenden Beteiligungsprozesses auf dem Kietzer Feld in Köpenick. Darüber hinaus stellte BBBlockchain den Anwendungsfall Konsultation vor, bei dem Anwohnerinnen und Anwohner des Bauvorhabens Bülow90 in Schöneberg nach ihrer Meinung und ihren Erwartungen an die Zukunft des Bauvorhabens befragt wurden. Der Fokus lag dabei auf dem Einholen von Meinungen sowie der technischen Sicherheit und Transparenz von Blockchain-basierten Abstimmungen.

In enger Zusammenarbeit mit den sechs landeseigenen Berliner Wohnungsbau-gesellschaften wurde die erste Projektphase im Jahr 2020 abgeschlossen. Nachdem die Projektergebnisse zu zahlreichen wichtigen Forschungserkenntnissen führten, wurde das Projekt von der degewo und der Gewobag weitergeführt. In der letzten Projektphase untersuchte BBBlockchain daher das Potenzial von Blockchain-Tokens für Beteiligungsprozesse. Die Reichweite der Befragung wird durch die Implementierung von Token-basierten Anreizen erhöht, so dass die Anwohnerinnen und Anwohner für ihre Teilnahme einen Blockchain-Token erhalten, den sie gegen einen kostenlosen Kaffee eintauschen können.

Während in der ersten Phase des Projekts der Schwerpunkt auf der Bereitstellung von Informationen und der Dokumentation lag, konzentrierte sich die zweite Pilotphase des Projekts auf die Umsetzung und Erprobung einer weiteren Schlüsselfunktion von Blockchain-Technologien: die Ausgabe von Token. Kryptowährungen oder Token sind ein wesentlicher Vorteil von Blockchains. Sie sind ein digitales, zählbares und übertragbares Gut, das ohne zentrale Instanz (z.B. Banken) verwaltet wird. Kryptowährungen werden verwendet, wenn eine Blockchain speziell zu diesem Zweck eingerichtet wird (die bekanntesten Beispiele sind Bitcoin und Ethereum). Token hingegen werden verwendet, wenn eine bestehende Blockchain für die Entwicklung genutzt wird. Im Gegensatz zu Blockchain-Kryptowährungen können Token von eigenen Programmen für die Bedürfnisse des jeweiligen Projekts erstellt werden. In unserem Forschungsprojekt wurden Token als

Anreiz für die Bürgerinnen und Bürger eingeführt, sich an den Abstimmungsprozessen zu beteiligen. Zu diesem Zweck stellen die teilnehmenden Wohnungsbaugesellschaften über die App Umfragen oder Abstimmungen zur Gestaltung bestimmter Aspekte der Pilotprojekte zur Verfügung. Interessierte Anwohnerinnen und Anwohner installieren in einem ersten Schritt die BBBlockchain-App. Anschließend können sie an der jeweiligen Umfrage oder Abstimmung teilnehmen. Für die Teilnahme wird den Nutzern über die BBBlockchain-App ein Token gutgeschrieben, der dort gesammelt wird. In der App können die Nutzerinnen und Nutzer ihr Token-Guthaben überprüfen. Die Token werden in einem der am Pilotprojekt teilnehmenden Cafés als Rabatt-Gutscheine eingelöst.

Projekt Meilenseite:

// 2018 Okt   BBBlockchain Projektstart
// 2018 Dez   Konzeption der Anwendungsfälle
// 2019 Apr   Oberflächen-Design
// 2019 Mai   1. Beiratssitzung
// 2019 Jul   Prototyp Veröffentlichung
// 2019 Sep   Informations Anwendungsfall Start im Kietzer Feld
// 2020 Feb   2. Beiratssitzung
// 2020 Feb   Konsultations Anwendungsfall Start in Bülow90
// 2020 Mai   Forschungsbericht Handlungsempfehlungen
// 2020 Okt   3. Beiratssitzung
// 2021 May   Offizielle Projektverlängerung
// 2021 Feb   Konsultations Anwendungsfall Start im Kietzer Feld
// 2021 Mai   Tokens Anwendungsfall Start in Bülow90
// 2023 Jan   Evaluation

Forschungs-Meileinsteine:

// 2019   BBBlockchain Whitepaper
// 2020   SmartDHX (System für blockchainbasierte Authentifizierung)
// 2020   Forschungsbericht Handlungsempfehlungen
// 2021   Studie zur Bürgerbeteiligung in der Stadtentwicklung durch Blockchain: ein menschzentrierter Design-Ansatz
// 2021   Fallstudie: Erfahrungen mit einer Blockchain-basierten Beteiligungs-App
// 2021   Empirische Studie über die Relevanz von Blockchain-basierten Abstimmungen
// 2022   Studie über die Transparenz von digitalen Bürger-Schnittstellen mit Blockchains
// 2022   Zwei Studien über Blockchain-basierte Authentifizierungsmechanismen
// 2023   Tornado Vote (System für anonymes Voting)

Akademische Meilensteine:

// 3 Bachelor-Arbeiten
// 6 Master-Arbeiten und 4 Master-Projekte
// 1 Seminar über Blockchain-basierte Authentifizierung
// 1 Seminar zum Thema Privatsphäre und Anonymität im Internet
// 2 Doktoranden und 1 Post-Doc

Beiträge

// ***BBBlockchain Konzept: Unser Konzept sieht Blockchain-spezifische Anwendungsfälle vor, die das Potenzial haben, Bürgerbeteiligung und Transparenz zu verbessern.***
Wir haben die Anwendungsfälle entlang der etablierten Leiter der Bürgerbeteiligung entwickelt, die von der Information der Bürgerinnen und Bürger bis zur Übertragung von Macht reicht. Wir haben die Möglichkeiten von Blockchain-Technologien einbezogen und Token als Querschnittsfunktion identifiziert, die alle Ebenen der Beteiligung erweitern kann. Das allgemeine Konzept und die Anwendungsfälle dienten als Vorlage für unser Projekt.

// ***BBBlockchain Smart Contracts: Die implementierten Hauptkomponenten (Zeitstempel, Abstimmung und Token), die die Grundlage für unsere Anwendungsfälle bilden.***
Um die Anwendungsfälle der BBBlockchain zu implementieren, werden drei Hauptkomponenten benötigt: Zeitstempel, Abstimmungen und Token. Zeitstempel bieten eine sichere Sequenz von Informationen und ermöglichen es allen Nutzerinnen und Nutzern, die Integrität unabhängig zu überprüfen. Abstimmungen ermöglichen Konsultationen und Mitentscheidungen. Token können verwendet werden, um alle Anwendungsfälle zu erweitern, indem sie die Übertragung von Token und die Schaffung von Anreizen ermöglichen. Bei der Implementierung haben wir uns auf ein umfassendes Verfahren konzentriert, das keine spezielle Software oder Hardware erfordert.

// ***BBBlockchain-App: Die von uns entwickelte Blockchain-basierte App ermöglicht eine transparente Partizipation aller Beteiligten.***
Blockchain-Technologien sind immer noch sehr komplex und lassen sich nur schwer in bestehende reale Projekte und Arbeitsabläufe integrieren. Für BBBlockchain und die zugehörige Infrastruktur konnten wir geeignete Kompromisse finden, um die Technologie nutzbar zu machen und gleichzeitig viele der Transparenz- und Verifizierungsfunktionen einer Blockchain zu erhalten. Wir haben ein visuelles Designkonzept entwickelt, das die Komplexität von Blockchains Schritt für Schritt entfaltet, um die BBBlockchain-App auch für Nutzerinnen und Nutzer zugänglich zu machen, die mit dem Konzept nicht vertraut sind. Gleichzeitig können fortgeschrittene Benutzerinnen und Benutzer alle Informationen vollständig verifizieren, indem sie die Software lokal ausführen.

// ***BBBlockchain Praxisbetrieb: Erfolgreiche Implementierung von BBBlockchain in zwei Pilotprojekte in Berlin.***
Wir haben zwei Stadtentwicklungsprojekte in Berlin begleitet, bei denen wir die bestehende (meist offline) Beteiligung durch BBBlockchain als digitales Angebot ergänzt haben. Wir haben verschiedene Beteiligungsformate auf unterschiedlichen Beteiligungsebenen vor Ort durchgeführt und erprobt. Dadurch konnten wir neue Nutzergruppen erreichen und einbinden. Insgesamt haben über 3.700 Nutzerinnen und Nutzer die App genutzt.

Erkenntnisse

// Die Einführung von Blockchains in Stadtentwicklungsprozessen verspricht mehr Transparenz durch ihre Unveränderbarkeit und überprüfbare Integrität, aber es ist auch mit negativen Auswirkungen auf die Bereitschaft der Beteiligten zu rechnen, sich an einer solchen verbindlichen Plattform zu beteiligen. Insbesondere haben wir festgestellt, dass die Unveränderbarkeit der Blockchain die Kommunikationspraktiken von Wohnungsbaugesellschaften verändert, da Änderungen in der Stadtplanung als neue Information kommuniziert werden müssen. Infolgedessen mussten sie ihre etablierten Kommunikationsprozesse zugunsten eines transparenteren Ansatzes überdenken. Um die negativen Auswirkungen der Blockchain zu minimieren, sind daher eine klar definierte Kommunikationspolitik und ein regelmäßiges Engagement erforderlich. Andernfalls können Blockchains allein nicht für mehr Transparenz oder Engagement sorgen.

// BBBlockchain ist es gelungen, neue Zielgruppen zu erreichen. Dieses positive Ergebnis ist jedoch nicht unbedingt nur auf die Einführung von Blockchain-Technologien zurückzuführen, sondern vielmehr auf die Vorteile der Bereitstellung eines zusätzlichen digitalen Kommunikationskanals anstelle von vollständig analogen Prozessen.

// Wir haben die Nutzerinnen und Nutzer nach ihren Erfahrungen mit der App befragt und 57% fanden BBBlockchain einfach zu bedienen. Durch ein Schritt-für-Schritt Navigationskonzept konnten wir die Nutzung der Blockchain auch für technisch komplexe Blockchain-basierte Abstimmungen ohne weitere technische Kenntnisse ermöglichen.

// Obwohl wir Blockchains als hilfreich für die Konfliktlösung erachten, können wir die Auswirkungen auf das Konfliktmanagement nicht beurteilen, da es keine größeren Kommunikationskonflikte im Zusammenhang mit BBBlockchain gab. Andere externe Kommunikationskonflikte traten während des gesamten Beteiligungsprozesses auf, konnten aber durch direkte Kommunikation mit den Mieterinnen und Mietern gelöst werden. Die Blockchain hat sich aber auch als sehr hilfreich bei der Unterstützung des gesamten Kommunikationskonzeptes erwiesen. Dennoch gehen wir davon aus, dass die Akteure aufgrund der permanenten Nachverfolgbarkeit von Blockchains eher zurückhaltend waren, Konflikte auf der BBBlockchain zu riskieren. Blockchains können daher nur als zusätzliches Instrument zur Erhöhung von Transparenz und Verantwortlichkeit gesehen werden.

// Um die Beteiligung zu erhöhen, gab BBBlockchain erfolgreich Krypto-Token als Belohnung für die Stimmabgabe aus. Zu diesem Zweck erhielten 81 Teilnehmerinnen und Teilnehmer ihren eigenen Token, aber nur 6% der Teilnehmer tauschten ihre Token gegen einen kostenlosen Kaffee ein. Obwohl es verschiedene Gründe und Möglichkeiten gibt, den Prozess zu verbessern, kommen wir zu dem Schluss, dass Blockchain-Token nicht unbedingt als Anreizmechanismus dienen.

Gegenüberstellung der Arbeitspakete

Im Folgenden vergleichen wir die Arbeitspakete (AP) unseres Forschungsantrags mit den Aufgaben, die in den zwei Jahren der zweiten Projektphase von BBBlockchain abgeschlossen wurden. Wir haben alle AP abgeschlossen, mit Ausnahme der Implementierung der verbindlichen Mitbestimmung mit automatischer Blockchain-Ausführung. Stattdessen haben wir unverbindliche Mitentscheidungsprozesse implementiert, um Mieterinnen und Mieter nach ihren Präferenzen für Bauprojekte zu befragen.

// *AP 1: Konzept für die Durchführung von Wahlen (Mitentscheiden).*
Gemeinsam mit der degewo und der Gewobag haben wir in mehreren Workshops Konzepte für Abstimmungen mit BBBlockchain entwickelt. Dazu haben wir Fragestellungen aus der Forschungsperspektive (z.B. zur Benutzerfreundlichkeit von BBBlockchain) und aus der Bauprojektperspektive (z.B. Präferenzen der Mieterinnen und Mieter zum Baufortschritt) erarbeitet. Wir haben rechtliche Herausforderungen für die Umsetzung direkter Partizipation identifiziert.

// *AP 2: Weiterentwicklung des Prototypen.*
Der Prototyp der BBBlockchain wurde erweitert, um Abstimmungen im Kietzer Feld zu ermöglichen. Außerdem wurde ein neues grafisches Abstimmungssystem implementiert, das auf diesen Erfahrungen aufbaut und einfacher zu bedienen ist. Außerdem wurde die BBBlockchain-Infrastruktur vom Ethereum Testnet Rinkeby auf ein Permissioned-Netzwerk übertragen. Dazu wurde BBBlockchain auf Server der degewo, der Gewobag und der TU Berlin migriert.

// *AP 3 und AP 4: Use Cases 1 und 2.*
Wie geplant haben wir die beiden Pilotprojekte Kietzer Feld und Bülow90 fortgeführt. Im Februar 2022 wurde eine Befragung zum Nachbarschaftstreff im Kietzer Feld durchgeführt. Im Mai 2022 wurde eine weitere Befragung zu den Bedürfnissen und Wahrnehmungen der Nachbarschaft zum Bülow90 durchgeführt. Während wir Partizipationsprozesse implementiert haben, um die Mieterinnen und Mieter nach ihren Präferenzen zu befragen, konnte das Konzept der automatisierten, verbindichen Blockchain-basierten Partizipation zum Teil aufgrund verschiedener rechtlicher Einschränkungen nicht vollständig umgesetzt werden. Stattdessen haben wir uns auf nicht bindende Blockchain-Befragungen und die damit verbundene Transparenz und das Vertrauen konzentriert.

// *AP 5: Vertrauen und Dezentralität der Infrastruktur.*
Neue Inhalte können nun ohne zentrale Infrastruktur direkt auf der Blockchain gespeichert werden. Darüber hinaus wurden die Nachbarinnen und Nachbarn der Bülow90 in Freitextfeldern nach ihrer Meinung gefragt. Die Antworten wurden kryptografisch verschlüsselt gespeichert und erst nach inhaltlicher Prüfung freigegeben.

// *AP 6: Datenschutz und Datensicherheit.*
Informationssicherheit und Schutz der Privatsphäre waren wichtige Prioritäten für die Zuverlässigkeit der Abstimmungen. In den Umfragen von Kietzer Feld und Bülow90 wurden verschiedene Methoden zur anonymen Stimmabgabe getestet. Darüber hinaus

wurden zwei wissenschaftliche Arbeiten zum Thema anonyme Identitätsprüfung und anonyme Stimmabgabe publiziert.

// *AP 7: Offene Wahlen ohne starke Authentifizierung.*

Um die Abstimmung zu vereinfachen und auch Nachbarinnen und Nachbarn in der Nähe zu erreichen, wurde für Bülow90 eine Umfrage ohne Authentifizierung durchgeführt. Um dennoch verlässliche Ergebnisse zu erhalten, wurden innovative Verifizierungsmethoden wie Hash-Matching von E-Mail-Adressen und Blockchain-basierte Captcha-Techniken implementiert und erforscht. Im Ergebnis konnte kein offensichtlicher Missbrauch der Abstimmung festgestellt werden.

// *AP 8: Innovative Wahlverfahren mit Anreizsystemen.*

Um eine möglichst hohe Beteiligung an der offenen Bülow90-Abstimmung zu erreichen, wurde ein Blockchain-basiertes Belohnungssystem entwickelt. Nach der Abstimmung erhielten die Teilnehmerinnen und Teilnehmer einen Blockchain Token (NFT), den sie gegen eine Tasse Kaffee eintauschen konnten.

// *AP 9: Evaluation und Abschlussbericht.*

Seit der Fortführung des Projekts wurden die Forschungsergebnisse von BBBlockchain in mehreren wissenschaftlichen Arbeiten evaluiert und veröffentlicht. Dieser Bericht fasst die Ergebnisse und Beiträge des Projekts zusammen.

2.   RESEARCH STATEMENT

In the past, numerous urban participation processes suffered from a loss of trust. This caused a decline in citizens' participation and trust. However, Blockchain technologies have attracted attention because they promise to be able to ensure trusted processes between untrusted parties.

BBBlockchain studies if and how citizens' engagement and transparency in urban participation processes can be improved with blockchain technologies. For this reason, established participation processes were transformed into blockchain use cases. BBBlockchain implemented these use cases in a blockchain-based mobile App for two building projects in Berlin, Germany. To this end, BBBlockchain has shown how to develop a mobile blockchain app for participation processes and what benefits it brings to established participation use cases.

BBBlockchain used the Arnstein Ladder of Participation as a basis to analyze participation use cases in a bottom-up approach, i.e., in ascending order of influence and power. First, BBBlockchain analyzed the information layer with tamper-proof blockchain communication. Next, BBBlockchain analyzed the consultation layer with secure blockchain voting, to directly involve citizens and gather their opinion on the building project. Finally, BBBlockchain studied the impact of blockchain tokens and how they can incentivize participation. The final evaluation was based on the collection of app usage statistics at the quantitative level, as well as, interviews and surveys at the qualitative level.

It is important to note that the goal of BBBlockchain is not to replace entire participation processes, but to complement them. Therefore, BBBlockchain is not implemented as a fully autonomous participation application, but is controlled in a coordinated manner by the housing associations and accompanying stakeholders.

Ultimately, the research around BBBlockchain focused on whether blockchain is actually necessary to improve transparency and participation.

3.   BBBLOCKCHAIN

3.1 Background

Digital Participation in Urban Planning

In urban planning, citizen participation processes have always been considered an essential element in improving democracy, and today, they have become part of the government's

organizational logic (Monno and Khakee, 2012). However, in practice, planning processes are often influenced by corporate and political actors whose interests differ largely from the democratic values of participatory planning. Distrust and the image of corruption have therefore become the default citizens' perception of urban development projects (Wilson et al., 2019). Lack of trust among the involved stakeholders has led to the need for more transparency. Historically, public participation in urban planning has taken many forms, including dialogue meetings, opinion surveys, panels, consultations, open labs, and so on. Although these methods can be fruitful for obtaining public opinion, they suffer from limited transparency as they tend to limit expressions of conflicting opinions and maintain the status quo (White, 1996). In Berlin, for example, this was demonstrated in the vote on the redevelopment of Tempelhofer Feld or in the opposition to the Google campus in Kreuzberg.

Digitalization offers new possibilities to transform urban participation processes. An increasing number of so-called civic tech platforms provide online participation instruments which try to improve the cooperation between citizens and governmental institutions. The aim is to achieve higher participation rates and a higher diversity of participants. However, current online tools have processes similar to the more established participation processes and, often, only allow minimal participation on the part of citizens. So far, a concurring lack of citizen participation has been associated with platforms' disengaging design, failure to keep citizens' motivation high, citizens' insufficient knowledge of the topics, and lack of trust (Rana et al., 2019).

Generally, these online Participation platforms are summarized under the umbrella term Civic Technology (Civic Tech for short). Civic tech describes online-based methods and platforms that enable better exchange with and between citizens.

Looking at the existing options in citizen participation, in most of them, information flow is generally one-sided, and even if citizens are asked to express their preferences, they are rarely taken into account. An essential aspect for the success of digital participation is the involvement of the political level in order to allow citizens to influence decision-making. To meet this challenge, it is useful to understand the effectiveness of new digital tools, to adapt them to the needs of stakeholders at an early stage, and to find a middle ground that mediates between interest groups.

In 1969, Arnstein introduced the ladder of participation, arguing for an increased and meaningful involvement of civil society in decision-making. For Arnstein, citizen participation can be presented as a ladder with multiple steps which progressively moves from more ''passive'' roles linked to information access and transparency to more ''active'' ones based on consultation, decision-making, and co-creation. A more recent and currently widely used model by governments in planning and reporting on public consultation initiatives is the International Association for Public Participation (IAP2)'s spectrum of public participation (2018). According to the IAP2 model, the definition of participation starts with purely informing the public about ongoing planning processes. The next step is defined as consulting the public by listening to concerns and asking for their input and feedback. The next level is to involve them throughout the planning processes actively. Collaboration refers to the joint development of solutions between the government and citizens. The ultimate is empowerment, where decision-making power is handed over to the public.
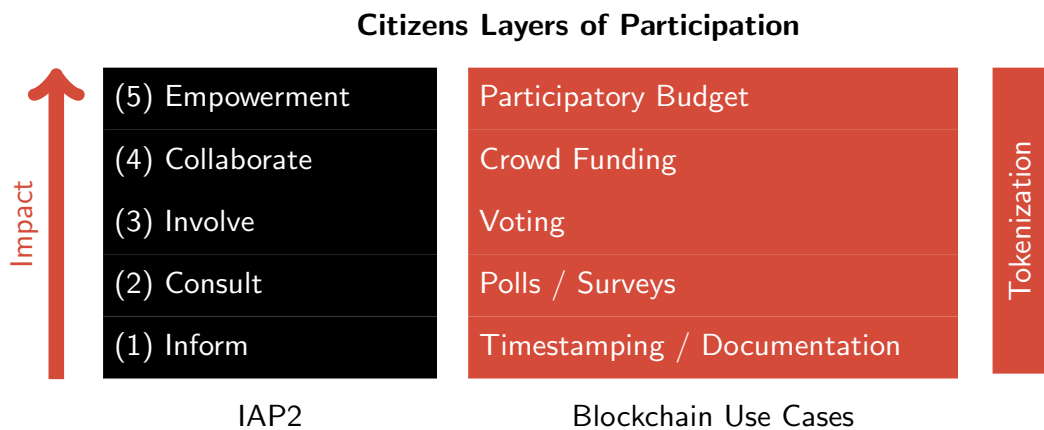
Citizens Layers of Participation

Impact ↑	IAP2	Blockchain Use Cases	Tokenization
	(5) Empowerment	Participatory Budget	
	(4) Collaborate	Crowd Funding	
	(3) Involve	Voting	
	(2) Consult	Polls / Surveys	
	(1) Inform	Timestamping / Documentation	

Figure 1: Citizens' layers of participation and corresponding use cases

Blockchain Technologies

Due to the peculiarities of decentralization, traceability, and immutability, blockchain technologies have recently grabbed governments' attention as an attractive opportunity to improve public engagement in urban planning processes. Although these characteristics have initially sustained cryptocurrencies, they are also relatable to various scenarios in which several stakeholders need a reliable system to manage their interrelationships. Some of the most important blockchain promises include: a move toward decentralized, transparent, and accountable processes through data integrity and immutability; a way to empower citizens through technical means; a vision of cutting out government and third-party middlemen through automatic trust (Benitez-Martinez et al., 2021).

Utilizing blockchain technology could improve the urban planning process's transparency, trust, and accountability in the five layers of the public participation spectrum, including co-decision making and empowerment.

First, blockchain is a distributed ledger technology whose records are very difficult to change retroactively. Such immutable information storage in a sequential and decentralized manner makes blockchain systems reliable in registering and storing information. As all the data in the blockchain are „hashed" and linked to the previous block's hash, even minimal changes in the data will result in significant changes in the hash value. Therefore, as data are unlikely to be manipulated, blockchain can provide good data integrity, which positively impacts information quality by ensuring reliability, hence, transparency.

Since all records are visible to everyone and must be approved by the network to ensure integrity (consensus algorithm), each record is fully traceable. Therefore, citizens and other stakeholders can monitor and verify all information themselves. This makes blockchain useful for tracking urban development processes, preventing corruption, and providing a transparent basis for discussion, especially in situations where government decisions are likely to be lengthy and controversial, thus providing a transparent basis for conflict management (Macintosh and Whyte, 2008). Therefore, traceability becomes an important feature to improve the availability of information, as all transactions remain permanently visible to anyone at any time, and all data can be traced back (Gaggioli et al., 2019; Kitchin, 2014).

Blockchains also eliminate the need for trust between stakeholders, as all completed transactions are recorded in a distributed ledger that is not controlled by a central authority (Le Dantec, 2016). In fact, one of the main arguments that blockchain enthusiasts support is its ability to conduct transactions without relying on trust, as they are executed in a peer-to-peer network, which provides users with technical mechanisms to trust. This means that instead of trusting a centralized computing entity, actors would trust the network to perform transactions in a transparent and immutable manner.

3.2 BBBlockchain conceptualization

BBBlockchain is a blockchain-based civic tech platform aiming to improve trust, transparency, and citizen participation in urban development processes.

Compared to other civic tech platforms, which mostly focus on citizen consultation and co-decision on a supra-regional level, BBBlockchain integrates immutable information from all involved stakeholders in one place to maintain a continuous and reliable exchange of information between stakeholders during the development process and gives citizens real power of co-determination and decision-making. Thanks to blockchain, data manipulation can be detected, leading to regular and transparent multichannel information and increased stakeholders' accountability. Therefore, blockchain technology solves the problem of communication between the stakeholders who do not necessarily trust each other in a decentralized way.

The BBBlockchain app was conceptualized in 2019 and has been tested in two urban development projects (400+ residential units densification) in Berlin, Germany. To this end, BBBlockchain was deployed as a digital participation tool for a real-world urban development project in the second half of 2019.

Technically speaking, BBBlockchain is a decentralized application that verifies the integrity of the blockchain-secured contents on the users' devices through a simple user interface that conveys complex blockchain concepts on a visual level. BBBlockchain provides information strictly chronologically to allow users to view the newest updates in the urban development projects. The app interface therefore revolves around a timeline view, as shown in Figure 2, and it is intended to remind users of a calendar. It also ensures that users are confronted with blockchain details as little as possible. Nonetheless, users can access blockchain details for each entry and utilize cryptographic hash values to verify data integrity. Accordingly, BBBlockchain, by incorporating such verification in the user interface, can ensure information reliability. As urban planning processes are likely to change as they develop, such changes will need to be communicated as new information due to blockchain's immutability.

Several potential benefits of using blockchain technologies for participation processes were identified in a joint analysis by the participating expert groups. These were considered in detail as research questions in the project:

Transparency and Trust. The immutability of blockchains reduces dependence on trust in individuals (authorities, mediators, interest representatives, lobbyists, etc). All information can be accessed and verified at any time. Therefore, everyone can trust that the provided information have not been manipulated once they are published.

Target Group and Reach. Blockchains provide permanent insight into the planning processes. All interested parties can access the information at any time. The advantages are based on the assumption of an idealized blockchain in which there are no majorities that could endanger the integrity of the blockchain. For example, through the association of blockchain participants into so-called mining pools, centralized structures could arise as soon as majorities of more than 50% of the blockchain participants cooperate.

Voting and Co-decision. Voting and co-decision processes are implemented as smart contracts of varying effectiveness. Therefore, smart contracts map co-decision processes in a binding way without mediating instances. These added values of the blockchain are offset by the costs and effort required to implement the technology. In order to obtain a basis for decision-making on the use of the BBBlockchain, the economic efficiency of the BBBlockchain was also examined in more detail, and the costs incurred were quantified.

BBBlockchain aims to overcome the underlying problems in participation processes and mediate between the interest groups. The conception of the research project and the design of the two pilot projects are explained in the next section.
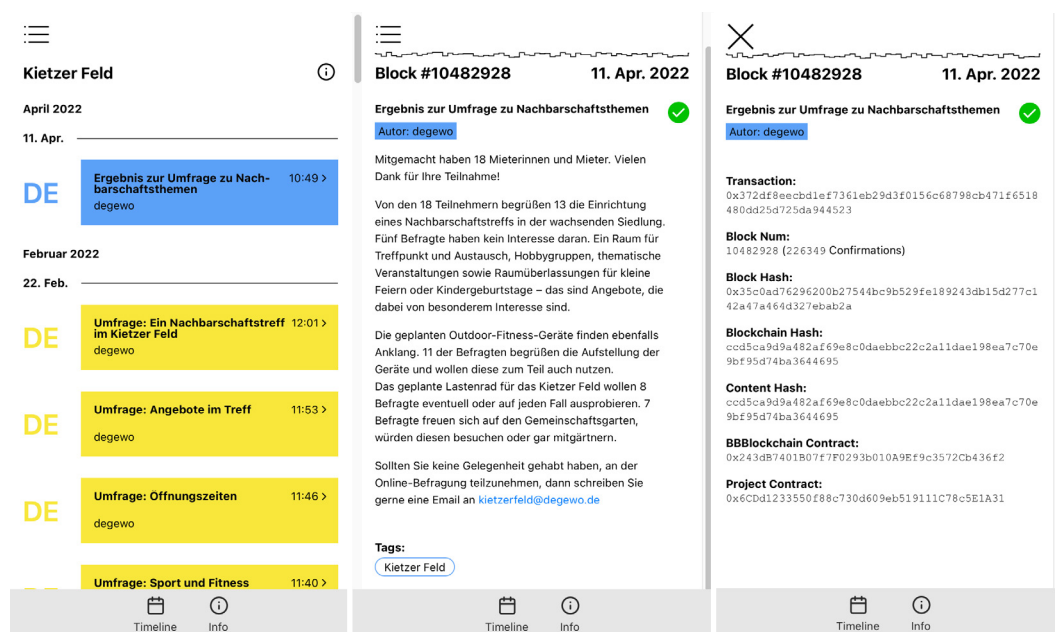

Figure 2: Screenshots of the BBBlockchain interface

3.3 Technical Design

BBBlockchain was initially designed as Ethereum DApp for mobile devices (i.e., Android and iOS) and desktop browsers. All features of the app were implemented as smart contracts, which can store program logic and arbitrary information on the blockchain. We provide additional technical infrastructure for better usability and inclusivity, but using it is optional. Our infrastructure allows users to access BBBlockchain just like a standard mobile app. There is no need to install a blockchain client software and to set up a wallet.

For the pilot phase, the BBBlockchain was hosted on the Ethereum test network Rinkeby and used a centralized web server file storage, a web API for the apps, and an admin interface. At first, we decided to use a test network as it has no monetary exchange value to its cryptocurrency, unlike the Ethereum Mainnet. The test network allowed us to experiment without financial pressure during the initial development phase. However, launching the pilot project on a network did not significantly influence our trust assumptions because we could not control or manipulate the blockchain ourselves. Instead, Rinkeby is operated by a closed group of miners who did not have any intention to give up the blockchain's principles to manipulate BBBlockchain. Therefore, it had comparable trust properties for our use cases as the Mainnet, except for the value of its cryptocurrency. Hence, BBBlockchain's transactions could not be manipulated unnoticed by us or any other stakeholder. While on Rinkeby, we still monitored the network for unexpected behavior that would defeat our assumptions.

Nevertheless, in 2020, we forked Rinkeby as the test network became unstable, e.g., no free test coins were available anymore. Since it was also foreseeable that the test network would officially shut down, as officially announced later in 2022, we decided to set up our own blockchain. Since BBBlockchain would automatically detect changes to the underlying blockchain as manipulation, we copied the existing Rinkeby blockchain and continued with our own miners. Therefore, we have copied all existing contents on the blockchain and can now add new contents and blocks ourselves. However, we have not seized all the mining power but have distributed it among the stakeholders: one miner run by the researcher teams and two by the HAs. Therefore, only the three nodes can produce new blocks, however, a 2 out of 3 majority would be required to manipulate past blocks.

Figure 3 shows the basic technical infrastructure of BBBlockchain and underlying technologies. With the next-generation Web3 in mind, we developed all program logic for participation in a smart contract. Thus, BBBlockchain can be used directly by any user, e.g., with Metamask. However, less technical experienced users may be discouraged, which is why we also offer an optional graphical user interface on an external server.
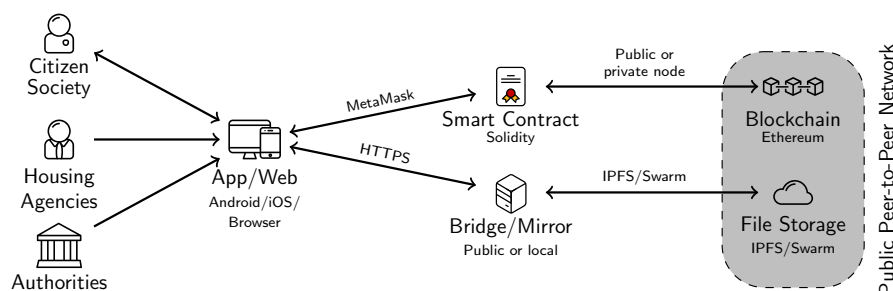

Figure 3: BBBlockchain technical infrastructure

The append-only policy of blockchains makes storing data expensive since once added data cannot be deleted anymore. So, with respect to data storage, BBBlockchain currently stores rich media contents (e.g., images or files) at an external storage provider to reduce blockchain storage and transaction fees. Unfortunately, network failures or server maintenance during the pilot phase resulted in synchronization failures in our app, and (supposedly) manipulations were temporarily indicated. Therefore, we are in the process of replacing the centralized file storage provider with recent promising peer-to-peer data networks, such as the Interplanetary File System (IPFS) or Ethereum Swarm. Both allow hosting files in a decentralized network that everyone is free to join. Everyone can access all files and mirror them on their own infrastructure. Unlike a centralized storage provider, the files become available from multiple servers; if one server becomes unavailable, the files are still accessible on other servers. Hence, network failures and maintenance issues would no longer affect the verification of BBBlockchain entries.

Processing the blockchain requires high CPU resources and storage (about 1,2 TB for syncing Ethereum Mainnet with Geth at the time of writing). Therefore, running fully synchronized blockchain clients on mobile devices for everyday usage is not practical for most users. For the pilot phase, we therefore installed our own Ethereum node and provided access for BBBlockchain users via a public server with an API. However, smartphones and recent blockchain technologies enable direct access to the blockchain with light client implementations, which do not process all transactions but rely on public or self-hosted fully synchronized clients.

The blockchain nodes, which store and execute the smart contracts, are mirrored into an API interface that allows the stakeholders with writing rights to directly publish content on the App without the need to know blockchain frameworks. The participating housing associations (HAs), local authorities, and residents' representatives are given access to publishing contents on BBBlockchain. Nonetheless, as the content created through the editor is added to the blockchain by an external monitoring tool (oracle), data integrity is still retained as changes to the planning project need to be uploaded as new information. Anyone can also verify data integrity through the hash values, which are visualized on the App to convey a secure information transfer in a comprehensible manner.

From a user interface design perspective, BBBlockchain provides information in a strictly chronological order to allow users to catch up with the newest updates in an urban development project. The app interface therefore evolves around a so-called timeline view. It is intended to remind users of a calendar app, which provides a chronological, color-coded overview of all published entries by the participating stakeholders (e.g., news articles or official announcements). Users are confronted with blockchain details as little as possible initially but can investigate all details if desired.

With recent posts at the top, the app also follows the concept of a social media feed that lists titles and shortened contents. While the timeline view is the starting point, opening a timeline post shows the corresponding content, including rich media entries (e.g., with pictures and file attachments). Lastly, users can review blockchain details for each entry's transaction, enabling technically experienced users to verify the contents without the BBBlockchain app. For instance, the transaction hash can be used for inspecting blockchain details with an external blockchain explorer.

For a consistent look-and-feel of a mobile app, the navigation between the timeline, posts, and further details, follows the well-established concept of a navigation stack that allows users to go back step-by-step by swiping on their mobile phones (or using the back button). Additionally, the app header displays navigation information at the same positions and shows the authors' names and specific colors in further navigation levels as a recognizable orientation marker.

In order to visualize the blockchain functionality, we added the key concept of integrity verification. Cryptographic hash values represent arbitrary data as numbers. They are mathematically designed as one-way functions, so it is easy to calculate them, but it is computationally very hard to reverse, i.e., to find the corresponding data for a given hash value. Blockchains utilize this concept for verifying the integrity of all stored data. We therefore use the integrity verification process as part of our visualizations to convey a secured information transfer in a comprehensible manner. Once all contents are downloaded, the app calculates the corresponding hash value locally. While this verification could happen hidden in the background of the app back-end, our visualization approach aims to support technically inexperienced users to understand the cryptographical concepts of hash verification. Hence, visualizing is not necessary to improve the technical security but helps users to gain trust into the verification process.

We developed a plotting algorithm for this visualization, as visually demonstrated in Figure 4. The upper plot line represents the immutable hash value of the original contents on the blockchain when the content was uploaded. At the bottom, it shows the hash value of the corresponding contents downloaded to the user's device. Now, users can visually check if the lines match or not. Additionally, a check mark indicates whether the hash values match or not. A green check mark intuitively confirms the integrity of all data; a red cross appears if the contents have been manipulated or deleted after they were published. Users are immediately aware of the integrity regardless of whether they are familiar with underlying cryptographic concepts.
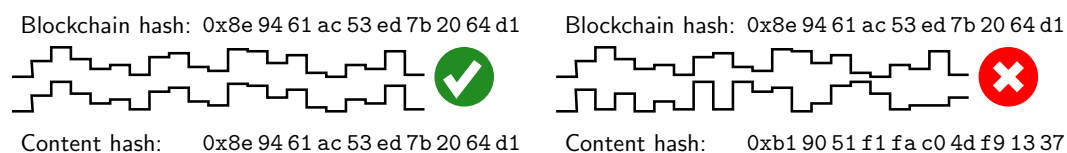

Figure 4: Hash value visualization and comparison

3.4 Use Cases

Based on the participation levels (see Fig. 1), various possible use cases of blockchain application were developed. Such use cases are based on the added value of blockchain in urban planning. Here we present a small selection of all the use cases that we developed as part of the research project. A comprehensive overview of all the use cases and other possible applications can be found in the BBBlockchain whitepaper[1].

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1   https://bbblockchain.de/wp-content/uploads/2019/07/BBBlockchain.pdf

Information Use Case

The information use case focuses on the IAP2 first layer of participation, with the corresponding functions of timestamping and document management. Specifically, BBBlockchain provides an ongoing overview of the urban development process through the management and secured storage of various documents, such as land-use plans, approval processes, contracts, and general building information.

Because of the underlying data structure, blockchain technologies can increase the reliability and accountability of those public institutions that use it for record keeping. The consensus mechanism validates and registers all the transactions in a consistent way, identifying possible errors or manipulation attempts. By recording information on a public distributed ledger, which is open to everyone, we can ensure the integrity of their historical transactions' records. The ledger can be updated in an append-only manner and link current entries with previous transactions. This implies that the history of documents transitions between different states of the ledger is integral, accurate, and fully auditable. Therefore, users are able to report potential data alteration or manipulation of, e.g., official announcements and documents. This characteristic becomes particularly relevant for urban development projects as they are inherently subject to changes. Changes during the urban development project have to be communicated as new entries on the app. Stakeholders, therefore, are required to report on a regular basis the development project progress and potential deviations to plans. This should improve the transparency per se and enable the provision of a more transparent basis for conflict management, as past statements and information can be traced back and compared. Furthermore, by providing the cryptographic hash value verification into the user interface, BBBlockchain also ensures information reliability.

Voting Use Case

The BBBlockchain voting use case focuses on the third and fourth layers of the IAP2 ladder of participation, which are co-design and co-decision. Blockchain technologies can, in fact, enhance the legitimacy of voting processes by allowing voters to play a more significant role in controlling and monitoring the process and the way their votes are cast. During the pilot projects, citizens were involved in various development or design options through three voting processes.

The voting processes were developed as a smart contract in a way that eligible voters could directly submit their votes on the BBBlockchain mobile and web App. As each vote is saved on the blockchain, citizens can directly verify that votes were correctly counted by checking the transactions on the blockchain. BBBlockchain, therefore, guarantees the integrity and validity of the information and prevents any stakeholder from exercising dominance over the voting process.

In order to ensure the authenticity of the voter (identification), the voter verification must be executed on-chain. Therefore, it is important that the voting transaction does not contain any personal identifiable information of the voter to maintain the privacy requirements. In terms of GDPR regulation, this might present a problem as sensitive information might become accessible to unauthorized blockchain nodes and immutably anchored on-chain

for an unknown period of time. The GDPR regulations on the "right to be forgotten" (Art. 17) states that data should be erasable. The broad principle underpinning this right is to enable an individual to request the deletion or removal of personal data. In a blockchain context, erasure is technically impossible because the system is designed to prevent it. Therefore, BBBlockchain faced the issue of implementing voters' verification while preserving privacy requirements by retaining the voter anonymity. Although the impossibility of deleting data cannot be solved, it can be partially solved by using proper technology solutions that make the data practically inaccessible. For example, cryptographic hash functions can transform personal data to anonymous data.

In fact, on a technical level, BBBlockchain implemented a procedure of smart contract-based verification of anonymous credentials by asking voters to submit their email address which is then saved on the blockchain with a corresponding hash value (pseudonymization). Pseudonymization prevents the traceability of a vote to a voter's identifying credentials. Nonetheless, although only the email's hash values are stored on the blockchain and access to the actual email address is not possible, this might still represent an issue under GDPR law compliance. What constitutes "erasure", is currently under debate and it remains an open question. While some data protection authorities have found that irreversible encryption can be considered as erasure, others argue that data encryption on the blockchain is something different than data deletion in the strict sense and that GDPR regulation only accepts a mechanical deletion of the data where a physical erasure must occur.

However, with this approach, the problem of ensuring voting reliability still persists as voters with multiple email addresses are able to vote more than once. In order to minimize the problem of multiple voting, a non-blockchain governance solution of including terms and conditions where voters are instructed to only vote once were discussed. Nonetheless, we believe that the risk that people would exploit this mechanism would not be very high and the problem should not be over engineered even without any form of proof of authentication.

In order to ensure that only eligible individuals could vote, in the first two voting processes of BBBlockchain, citizens eligibility was initially implemented through the creation of unique codes which were sent via mail to the tenants of the two residential areas of the pilot projects. Codes have multiple advantages as, firstly, they ensure voting eligibility, as only citizens directly impacted by the development project will receive one code which entitles them to vote. Secondly, codes can also prevent the problem of double voting and system manipulation through automation. However, although codes can ensure voting reliability and preserve voters anonymity, this approach was eventually discarded because of the very small percentage of citizens participation in the voting process and because, overall, the process was considered inefficient by the two HAs since, as public entities, they had to go through a public tender process to outsource the codes mail out and they had to deal with multiple inquiries from voters about how to perform the whole process (receive the code, open the website, insert the code, fill the survey) which, in the end, it was deduced to be too overwhelming and complicated to perform for citizens.

Eventually, it was decided to adopt a verification measure via email addresses and compromise on the reliability and eligibility of the voting process as multiple voting and participation from citizens not directly impacted could not be prevented.

Tokens Use Case

The third voting process was combined with the testing of the functionality of tokens as incentives to boost participation. Tokens are digital, countable and transferable assets that are managed without centralized entities (e.g., banks).

A token is created in a smart contract, which assigns a personal credit to all users. These tokens are then collected and made available using the BBBlockchain app. As soon as a token is redeemed, its code can be verified on the blockchain and blocked if necessary. To ensure security for participants, tokens were created as so-called non-fungible tokens (NFTs). These are unique, indivisible, and not exchangeable for other tokens; each token has an individual code - unlike many prominent NFT projects, our tokens are not tied to any digital or existing asset, but can be generated by us at any time. However, it should be noted that tokens in the research project only serve to incentivize and motivate participation. The exchange for a discount does not pursue the goal of creating a monetary currency, but rather to motivate people to visit the pilot projects in person. The technical implementation thus focuses more on user-friendliness than on the billing security of the tokens. The tokens are comparable to a discount coupon in a newspaper.

The participating housing associations release surveys or votes on the design of certain aspects of the pilot projects via the app. Interested residents or tenants install the BBBlockchain app in a first step. After that, they can participate in the respective survey. Once voted and left an email address, the users are credited with a token via the BBBlockchain app, where it is collected. Users can check their token balance in the app. The tokens are redeemed in the respective local participation projects and neighborhood meeting points; one token serves as a discount coupon in a participating café in the pilot project.

Tokens can also be used to map a concept similar to a participatory budget. For this purpose, the participating housing associations could define a budget for use in the pilot projects in advance and define possible purposes of use. These are stored as a vote in BBBlockchain. The interested neighbors or tenants can participate in turn after downloading BBBlockchain. All participants are allocated a certain token budget that can be distributed to the predefined usage purposes according to their own preferences. This allows a ranking of projects to be defined for implementation.

Although the function was conceptualized as feasible on a technical level, it was discarded as some issues at organizational level emerged, such the project being too small. Giving to the token a real exchange value would have raised a number of issues in relation to money laundering law and exchange speculating on the value of the token.

From a legal perspective, the issuance of tokens has also raised issues in terms of taxation, especially how the issuing of NFTs is regulated in terms of turnover tax, if tokens create added-value, who pays sales tax and what kind of exchange value does the token have.

The issuance of tokens also requires setting up some security measures to prevent the system from being hacked to get the monetary value of the tokens. Dealing with security incidents requires organizing an operational IT strategy to prevent them from happening, as they would also give the project a bad reputation that would eventually put an end to everything.

4.   PILOT PROJECTS

The BBBlockchain was tested in two pilot projects of two housing associations in Berlin. The selection was made mainly on the basis of time criteria; (i) which construction project best overlaps with the duration of the research project; (ii) at what stage of development is the building project. As a result, we selected "Kietzer Feld" in Köpenick by degewo and "Bülow90" in Schöneberg by Gewobag as pilot projects.

BBBlockchain was developed together with an Advisory Board, which brings together members from a wide range of disciplines[2], which provided valuable insights during the conceptualization phase.

It is important to distinguish between the pilot projects and the use cases at the level of the research project; since the BBBlockchain is used in real construction projects of the housing associations. The feasibility of the building projects must be ensured; the pilot projects therefore have more limited functions in coordination with the housing associations than the consideration of the use cases within the framework of the research project.

In the following part, we give a general overview of both the pilot projects.

	KIETZER FELD	BÜLOW90
DEVELOPER	degewo Kietzer Feld 12557 Berlin	Gewobag Bülowstrasse 90 10783 Berlin
PROJECT DESCRIPTION	New construction of approx. 300 flats; examination of adding another storey to all existing buildings; construction of an underground car park and day care center for approx. 85 children.	Pilot project to test sustainable models for living, working in practice; focus is on shared spaces, coworking and co-living.
PROJECT DURATION	2019-2023	2019-2023
RESEARCH PROJECT DURATION	10.2019 - 04.2023	02.2020 - 04.2023
INTERNAL DESIGNATION	Pilot project 1	Pilot project 2
USE CASES	Information	Voting, Tokenization

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2   Prof. Dr. Steffen Augsberg (University of Gießen), Thomas Felgenhauer (Howoge), Dr. Martin Florian (Weizenbaum Institute), Dr. Angela Jain (Nexus), Anne Keilholz (Stadt und Land), Ralf Schulze (BMI), Prof. Dr. Gesine Schwan (Humboldt-Viadrina), Sandra Wehrmann (degewo).

FUNCTIONALITIES	Providing and reading information on the construction process	Surveys and votes on the design of the Bülow90, issuing of tokens as rewards for voting
INVOLVED STAKEHOLDERS	degewo; Tenants' Council; District of Treptow- Köpenick (urban planning office), tenants.	Gewobag, tenants, neighborhood
COMMUNICATION	Information to all residents of the Kietzer Feld through information events on the construction process and notices in the hallways.	Mailings to all Gewobag tenants within 1 km radius of the Bülow90 and advertising on nebenan.de to reach more residents in the neighborhoods around the Bülow90.

Table 1: Overview of the BBBlockchain pilot projects

4.2 Pilot Project #1: Kietzer Feld

In two construction phases starting in late 2020, 301 apartments are being built in Kietzer Feld. An underground parking garage and a daycare center for approximately 85 children are also planned.

Starting with the first official introduction meeting on February 1, 2019, we jointly decided that Kietzer Feld is a great first pilot project for BBBlockchain. With the pilot project starting for Kietzer Feld, we introduced BBBlockchain during the first official kick-off meeting for the tenants on July 4, 2019. Together with URD and degewo, we demonstrated the first prototype with its first graphical user interface and timestamped news articles. Since then, there have been other official demonstration dates, such as the Köpenick municipal building department on November 11, 2019 and the tenants' council on November 20, 2019.

Table 2 summarizes the type of content of the entries, according to its corresponding category and publishing stakeholder group. It emerges that most of the entries (13) concerned administrative information, like time and location of physical events, invitations, welcomes, etc. and they were mostly posted by the HAs. Seven entries posted by the HAs discussed the future development steps of the project, including a timeline from the beginning till completion and maps of the construction plan. Nine entries were about decisions already made such as the appointment of a new contractor, trees cutting, permits, etc. Finally, eight entries involved citizens by asking their preferences for the potential establishment of facilities such as a roof garden, an outdoor fitness area, a meeting room and a bike shop. Nonetheless, it was not made clear how their contribution would have been used. Overall, degewo was the most active participating stakeholder group with a total of 39 entries. Municipalities and Tenant Council contribution to the content platform was more limited, with only 2 entries each.

We have archived all timestamped articles and files on Github to preserve all contents,

even without blockchains.[3] The stakeholders in the project are divided into degewo (housing association), the tenants' council, and the district's urban planning office (Treptow-Köpenick).

Type of Content	Housing Association (degewo)	Municipalities	Tenant Council	Research Team
Administrative information (physical events location, how to, etc..)	12 entries	1 entry		
Future planning steps	7 entries			
Steps of the planning process already accomplished	10 entries			
Tenants FAQ	1 entry	1 entry		
General Opinion on the planning	1 entry		2 entries	
Tenants Voting/ Surveys	8 entries			
Research Collaboration enquiries				2 entries

Table 2: Summary of content of BBBlockchain

4.3 Pilot Project #2: Bülow90

Bülow90 is a building project in Schöneberg, Berlin, by Gewobag. It is designed to experiment with sustainable, user-centered and transferable models for living and working together in practice. Schöneberg, Berlin. In the coming years, Gewobag wants to test sustainable, user-centered and transferrable models for living and working together in the building at Bülowstraße 90. They also want to involve tenants and residents of the neighborhood . A pilot project that relies on learning and trying things out together and whose DNA will be continuous change. There will be new apartments with common areas. But also common rooms for working as well as educational, training and cultural offers. A kindergarten, a

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3 https://github.com/ecdf-bbblockchain/bbblockchain-archive/blob/main/archive Kietzer%20Feld.md

neighborhood café and an open workshop are also planned. The building at Bülow90 will be a hub for lively urban development.

Because of the unique characteristics of the project, the involved stakeholders are Gewobag (housing association), tenants and the residents of the neighborhood within a one-kilometer radius.

In close cooperation between URD, DSI and Gewobag, we held several creative workshops to jointly work out different possibilities and potentials for the use of blockchains in 2019, on February 21, March 1, April 26, and May 21. For the launch of BBBlockchain, we had an information booth at the official Info Tag event for all nearby living residents on May 25, 2019. In the following, we conducted two BBBlockchain votes: First, from February 14, 2020, we asked all known Gewobag tenants living nearby about their future wishes for the Bülow90. Next, we asked about future offerings and blockchain experiences publicly, without any voter restrictions, from May 16, 2022. To that end, we also implemented a participation incentive token that could be redeemed for a coffee in the ground floor café.

Table 3 summarizes the type of content of the entries, according to its corresponding category and publishing stakeholder group. Seven eight entries involved citizens by asking their opinions or votes for the potential establishment of facilities and two entries were made by the research group. Specifically, citizens were consulted about the establishment of the following facilities: workshops, a laundry room, a bicycles parking space, a roof garden, a parcel station and the sale of alcohol and cigarettes.

Type of Content	Housing Association (Gewobag)	Research Team
Tenants Voting/Surveys	7 entries	
Research Collaboration enquiries		2 entries

Table 3: Summary of content of BBBlockchain

4.5 Survey Results

In May 2022 we conducted a survey on the user experience of BBBlockchain in the Bülow90 pilot project, as shown in Figure 5.[4] The scope of the survey was to gain a more in-depth understanding on what tenants thought about their experience in using the App. Out of the 81 participants, the 40% were aged between 18-34 years old and the 28% between 34-50 years old. Only 28% of the respondents were over 50. Such results confirm that young/adult demographics are more prone to the use of digital technologies for participating in urban development. 88% of the respondents never used BBBlockchain, and the 60% never heard

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4   https://github.com/ecdf-bbblockchain/bbblockchain-archive/blob/main/voting/
         B%C3%BClow90.md#haben-sie-bbblockchain-schon-einmal-
         benutzt-2022-05-16

of it before. Overall, 57% of the respondents found the App easy and intuitive to use, but only 33% felt that their participation was taken into account.

50% of the respondents felt unsure if they could get direct benefits from using the App as well as if they felt their information were safe on BBBlockchain (See Figure 8). Respectively, only the 21% and 22% of the respondents considered the App would provide them with direct benefits and felt their information were safe.

In July 2022, during the LNDW night, we asked the attendees of the event to test the App and then conduct a short survey on their experience in using BBBlockchain.[5] Participants would then receive a token which could be used to redeem a freebie at our desk. Overall 31 people participated and redeemed their tokens. 80% of the respondents found BBBlockchain easy to use and 84% would consider using it to get information about urban development. 74% of the respondents thought that blockchain technologies' unique characteristics can provide added-value to citizen engagement in urban development.
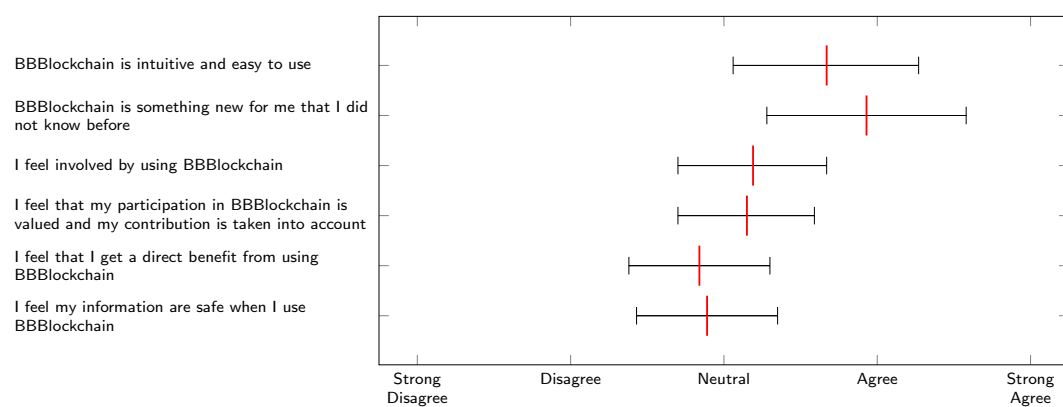

Figure 5: Analysis of the survey results regarding the user experience with BBBlockchain, showing the average vote for each question and the corresponding standard deviation.

4.6 Twitter Incident

BBBlockchain has been successfully conducting the first surveys since 2019. In February 2022, the consultation use case was also implemented in Kietzer Feld. Since the first surveys only addressed residents in the Kietzer Feld, notification letters with access codes were sent out. This ensured that only residents could vote, and only once at a time.

Such a notification was published on Twitter by a local resident on 20.02.2022. The resident was surprised and confused by the use of a blockchain in the participation process:

> „Yesterday I got mail from degewo and thought they want to fool me (I still think). Our neighborhood is undergoing new construction and restocking & now the progress as well as the participation of the residents should be enabled. How do you ask - well with bLocKchAiN of course." (Translated from German to English)

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5   https://github.com/ecdf-bbblockchain/bbblockchain-archive/blob/main/voting/ LNDW%202022.md

402 likes, 60 retweets, 40 quotes, and 71 replies picked up the criticism. In particular, members and fellows of the Chaos Computer Club (CCC) have voiced strong criticism.

Much of the criticism has been unfounded, as critics have failed to address the goals and implementation of BBBlockchain. In summary, the criticism related mainly to the following subjects:

// *"Blockchains waste energy"*
No unnecessary energy is wasted as BBBlockchain does not currently implement proof-of-work (which wastes computational resources on solving cryptographic puzzles). Instead, BBBlockchain runs on a network with proof-of-authority, and once it runs on the Ethereum mainnet, it would run proof-of-stake. Both PoA and PoS do not waste energy.

// *"Urban participation cannot be replaced with an app"*
BBBlockchain was never about replacing entire participation processes or rolling out nationwide. BBBlockchain is an additional building block to improve participation processes.

// *"Blockchain research wastes public money"*
BBBlockchain is a research project that explores the possibilities and limitations of a blockchain in participation use cases. Our research findings and insights extend beyond the individual pilot projects.

The BBBlockchain application, infrastructure, and underlying blockchain have been analyzed and actively attacked by various technical experts. Found vulnerabilities have been publicly discussed on Twitter. Meanwhile, critics have even filed a Freedom of Information Act request.

Ultimately, BBBlockchain has proven that the platform is secure, as attackers have not been able to manipulate content on it. The use of blockchains is often discussed controversially, but usually without addressing the actual facts. In summary, the usefulness of blockchains has been questioned while ignoring the spirit of a research project and without further addressing the potential benefits of BBBlockchain. After all, the research project benefited from the critical debate. The white paper was downloaded more than 600 times that day, more than ever before.

Original Tweet:
https://twitter.com/fabnie/status/1495391788386897921

Technical discussions:
https://twitter.com/thomasmechen/status/1495462509138124805

General critics:
https://twitter.com/LilithWittmann/status/1495557898616852481

FragDenStaat Request:
https://fragdenstaat.de/anfrage/fordergelder-zum-bbblockchain-projekt

5. PROJECT OUTPUT

5.1 Research Papers

The team co-authored 5 papers in the field of smart cities and government digital transformation. Specifically, BBBlockchain was used as a real case study to investigate to what extent blockchain technologies can be implemented in more human-centered ways to make cities digital transformation more sustainable by increasing government transparency and citizens' involvement in urban planning decisions.

Overall, we found that, in order to develop more human-centered blockchain solutions for citizens' engagement, stakeholders values such as transparency, inclusivity, and confidentiality should be taken into account during the design and implementation processes. However, since blockchain technologies do not always have a positive impact on the respect of such values, governance trade-offs solutions are needed to overcome possible values' tensions. For example, in relation to transparency, tensions between citizens' need of transparency and the government's need of confidentiality can be addressed through the establishment of "rules of games" that clearly set what information should be shared, how often and by whom.

Furthermore, the development and operation of BBBlockchain contributed to several technical research papers. In particular, the focus on active participation has led to three papers on blockchain-based voting. First, an empirical study on existing blockchain-based voting applications. Second, a novel anonymous voting system to implement fair blockchain-based decision-making processes. Third, a research paper on secure and anonymous user identification with anonymous credentials for reliable voter identification. Furthermore, the development of BBBlockchain has led to a paper on secure key exchange protocol for secure communication channels.

[IPR+23] Ietto B., Pascucci F., Rabe J., Bartoloni S., Blockchain Civic Tech for smarter cities: Governance challenges from a multi-stakeholder ecosystem perspective, submitted at the conference **„Digital Transformation for Smart Cities and Beyond: Projects are Shaping Society"**, April 2023 at the Kaunas University of Technology in Kaunas, Lithuania.

[IRM+23] Ietto B., Rabe J., Muth R., Pascucci F., **"Blockchain for citizens participation in urban planning: the case of the city of Berlin. A value sensitive design approach."** Cities (under submission, first minor revisions).

[MIE+22] Muth R., Ietto B., Eisenhut K., Rabe J., Tschorsch F., (2022), **"Lessons Learned: Transparency in Urban Participation Utilizing Blockchains"**, presented at the 41st EBES Conference October 12-14 2022, Berlin, Germany.

[IEM+22] Ietto B., Eisenhut K., Muth R., Rabe J., Tschorsch F. (2022), **„Transparency in Digital-Citizens Interfaces through Blockchain Technology: BBBlockchain for Participation Processes in Urban planning"**, Conference 2022 IEEE EUROPEAN TECHNOLOGY &

ENGINEERING MANAGEMENT SUMMIT, March 2022.

[RIM+21] Rabe J., Ietto B., Muth R., Eisenhut K. and Pascucci F., **„Citizens' engagement in urban development through blockchain: a human-centered design approach,"** 2021 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD), 2021, pp. 1-6, doi: 10.1109/ICTMOD52902.2021.9739434.

[MT23] Muth R. and Tschorsch F., **"Tornado Vote: Anonymous Blockchain-based Voting"**, 2023 IEEE International Conference on Blockchain and Cryptocurrency (under review).

[MGH+21] Muth R., Galal T., Heiss J. and Tschorsch F., **"Towards Smart Contract-based Verification of Anonymous Credentials"**, 2021 Financial Cryptography Workshop on Trusted Smart Contracts

[MT21] Muth R. and Tschorsch F. **"Empirical Analysis of On-Chain Voting with Smart Contracts"**, 2021, Financial Cryptography Workshop on Trusted Smart Contracts

[MT20] Muth R. and Tschorsch F. **"SmartDHX: Diffie-Hellman Key Exchange with Smart Contracts"**, 2020, IEEE International Conference on Decentralized Applications and Infrastructures (DAPPS).

[Mut+19] Muth R., Eisenhut K., Rabe J. and Tschorsch F. **"BBBlockchain: Blockchain-Based Participation in Urban Development"**, 2019, IEEE International Conference on eScience.

5.2 Demo and Installation

For demonstration purposes, the following video shows how new content is added to the BBBlockchain app. The individual contributions can be written freely and are then secured using the cryptographic concepts of the blockchain. Once submitted, they become part of a chain and cannot be changed or deleted unnoticed. Furthermore, other activities become part of the same chain, e.g., votes, so citizens can monitor the integrity of all activities at once.

The graphical interface is designed to help non-technical users directly assess blockchain trust. Therefore, complex blockchain concepts are initially presented graphically. However, advanced users can navigate to more advanced screens to analyze all technical details, if they wish to.

Source: https://youtu.be/QPSnEi2UkPk
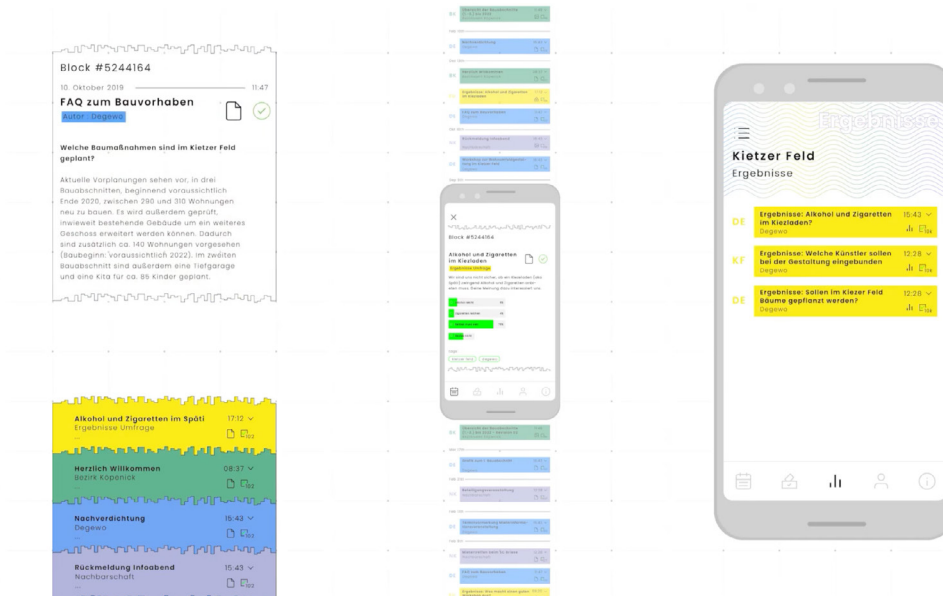
5.3 Outreach and Presentations

We participated in a number of events and presented BBBlockchain. First and foremost, this includes a series of academic and conference talks, where we presented our research results. This includes the following conferences:

// 41st EBES Conference October 12-14 2022, Berlin, Germany.
// Financial Cryptography Workshop on Trusted Smart Contracts, 2022, May 6, St. Georges, Grenada
// 2022 IEEE European Technology & Engineering Management Summit, 09-11 March 2022, Bilbao, Spain.
// 2021 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD), 24-26 Nov. 2021, Lisbon, Portugal.
// Financial Cryptography Workshop on Trusted Smart Contracts, 2021, March 5, Remote
// IEEE International Conference on Decentralized Applications and Infrastructures, April 13-16, Oxford, UK
// International Conference on Networked Systems, 2019, March 18-21, Technical University Munich
// IEEE eScience 2019, September 24 - 27, San Diego, California, USA

In addition, we had the opportunity to present BBBlockchain at numerous networking events, including the following events.

Lange Nacht der Wissenschaften (LNDW), Berlin, 2022. In July 2022, we presented BBBlockchain at the Berlin LNDW event at the Einstein Center Digital Future. During the event, participants were introduced to the App and could ask questions to our team. Participants had also the opportunity to test the App and, in exchange of a reward, fill a short questionnaire on their experience. This experience gave us the opportunity to test the tokens' functionality looking at the entire process from the issuing of the token to its redemption.

Networking Event „Transforming Communities", Berlin Open Lab, 2022. In May 2022 we had the opportunity to present BBBlockchain at the Networking Event Transforming Communities at the Universität der Künste of Berlin. Together with other research projects from the ECDF and the DFKI, BBBlockchain was presented to an audience of experts. This gave us the opportunity to collect opinions and impressions on BBBlockchain and exchange ideas in an informal context.

ECDF Projects Demos for T-Labs at Universität der Künste, Berlin. In July 2022, Dr. Alex Jinsung Choi and the management of Telekom Innovation Laboratories had a demonstration of the ECDF projects at the UdK open lab. We presented BBBlockchain and its token concept. To that end, we openly discussed the technological potentials to improve participation processes and the role of blockchain tokens for such use cases.

Blockchain Nights, Weizenbaum Institute. In May 2019, we discussed the potential of empowerment with smart contracts as part of the so-called Blockchain Nights series #BCN013 at the Weizenbaum Institute, Berlin. We were invited to present BBBlockchain and discuss the potential of tokens on a panel.

ECDF Evaluation. In March 2019, for the evaluation of the ECDF, all research activities were presented and reviewed. BBBlockchain was featured in this evaluation as an ECDF project and presented during a poster session. BBBlockchain particularly convinced with its strong interdisciplinary focus and its future-oriented approach.

Kietzer Feld info event: In 2019, we introduced BBBlockchain and presented the first prototype of the BBBlockchain app to tenants at a local participation event, along with the official presentation of the future building project plans.

Open House Bülow90. For the open house day in May 2019, nearby residents and interested visitors were invited to see the Bülow90 construction project in person. We presented our app to nearly 200 guests and introduced the concept of blockchain-supported building participation processes.

Humboldt-Viadrina Governance Platform. In May 2019, we presented our concept of a blockchain-based participation platform to the Humboldt-Viadrina Governance Platform. Together with Prof. Dr. Gesine Schwan and her team, we discussed the role and potential of blockchains in society.

6. DISCUSSION

6.1 Methodology

The analysis was conducted through an exploratory qualitative research approach as it provides a more in-depth, comprehensive, and realistic understanding of phenomena which are not well understood yet (Yin, 2009). In our context, the case study methodology was particularly suitable since it allowed us to ground the findings in the empirical evidence from BBBlockchain. The data used for the analysis were collected from four different sources: in-depth interviews with direct and indirect stakeholders, recordings of direct stakeholders' meetings and the content published on BBBlockchain. Finally three surveys were also conducted; one during pilot phase one (25 respondents), the other one during pilot phase two (81 respondents) and the third one during the LNDW night at the ECDF. Table 4, 5 and 6 provide a summary of all the data used for the analysis. Such a variety of data sources can provide greater reliability, less dependency on a particular context, and better generalizability of the findings (Zheng et al., 2018). Following a grounded approach (Gioia et al., 2008), the data were entered into NVivo12 software and inductively coded from empirical to conceptual so that related concepts could be merged into more abstract themes following the subjective interpretation of the researcher.

Type of Informant	Role in the project	Rationale
Expert - Co-founder of digital tools for spatial planning		
Expert – CEO of Funding Program to develop open-source applications in the areas of Civic Tech		
Expert – Founder of Non-profit organization developing innovative solutions for more democratic decision making	Express opinion on the added value of blockchain technologies for citizens participation in urban development	Provide general opinion on BBBlockchain potential benefits for citizens participation in urban development.
Expert – Founder of Open-source software firm developing solutions for agile administration		
Expert – Executive Director of urban development firm		
Expert – Executive Director and partner of urban development firm		

CEO of Housing Association	Managerial decision on project viability	
CEO of Housing Association	Finance the project	
Member of Housing Association	Set the project purpose and objectives	Get insights into their values and preferences, objectives they want to achieve with the project
	Liaise with tenants and tenants representatives	
	Marketing and communication	
	Upload content on the platform	
Design studio of promotional strategy of Housing Association	Understand how BBBlockchain could be integrated on Housing association promotional strategy	
Member of BBBlockchain Advisory Board	Provide feedback on BBBlockchain design and objectives during the conceptualisation phase	To understand the most important values and features that BBBlockchain should deliver
Developer of BBBlockchain	Develop technical infrastructure and design features, maintenance of the platform	To understand what values informed the project team and get insights into to what extent other stakeholders' requirements were taken into account for the technical and infrastructural features
Project Coordinator of BBBlockchain	Manage and coordinate the project planning, coordinate interaction among stakeholders	
BBBlockchain designer	Designed the App interface and user experience	Understand how blockchain characteristics were communicated through design features
Tenants' Representative	Intermediary between citizens and Housing Associations	Understand citizens' perception of BBBlockchain

Table 4: Summary of in-depth interviews

Date	Meeting Objectives
11th Nov 2022	Brainstorming on challenges and successes of BBBlockchain
24th Oct 2022	Report on the current technical status of tokens Voting procedures
14th Oct 2022	Voters' identification procedures
16th Sep 2022	Voting survey content Token redemption procedure
11th July 2022	Discussion on the hacking attack and app security
13TH May 2022	Current status of testing of voting
8th Apr 2022	Procedure for redeeming tokens
4th Feb 2022	User Journey for the voting Security of the tokens
16th Dec 2021	Data privacy compliance and money laundering laws to be considered during implementation
27th Nov 2021	Token Workshop

Table 5: Summary of Stakeholder meetings

	Number of Respondents	Purpose of the Survey
Survey nr. 1	25	Understanding citizens level of engagement (sense of inclusiveness, perception of information quality and accessibility)
Survey nr. 2	81	Understanding BBBlockchain user experience (ease of use, innovativeness, inclusiveness, safety)
Survey nr. 3	31	Understand BBBlockchain user experience (ease of use, usefulness)

Table 6: Summary of citizen surveys

6.3 BBBlockchain and Transparency

The first research question of the project is to investigate to what extent blockchain technologies can improve the transparency of urban planning processes. Based on a

multidimensional model on the concept of transparency that we have developed (Figure 6), here below we summarize our key findings (for the full analysis see Ietto et al., 2022).
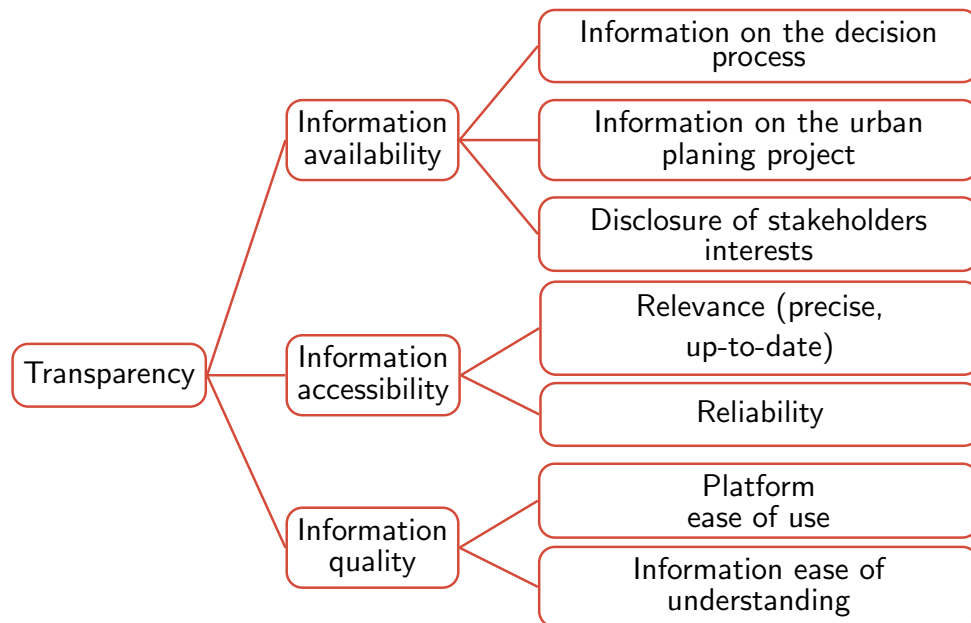

Figure 6: Conceptualization of Transparency

Our findings confirmed that blockchain technologies can have a positive impact on information availability and, therefore, increase government accountability. However, such increase in accountability might produce undesirable effects on the very same information availability which is supposed to enhance by reducing information comprehensiveness, as stakeholders might limit the publishing of information for fear of increased accountability.

In relation to information quality, blockchain can improve information reliability by ensuring information integrity but it has no impact on the quality of the data (garbage in - garbage out).

In the case of information accessibility, blockchain has a positive impact because its public network structure allows anyone to access information. However, its technical complexity might constitute a barrier to accessibility for non-expert users. Nonetheless, BBBlockchain interface design keeps blockchain details hidden through an API so that users are confronted with technical detail as little as possible.

Finally, a trade-off between transparency and the need to protect some stakeholders' more sensitive and confidential information, can be found by establishing an "adequate level of transparency". Such a solution takes into account the need of government confidentiality, public officials' fear of overexposure and citizens' need of open access. For example, "rules of games" could be established for a clear communication on what information should be shared, how often and by whom.

Therefore, we can conclude that blockchain has some important positive (information immutability and integrity) and negative effects (stakeholders accountability, accessibility of information), on the levels of transparency of urban development processes and repercussions on stakeholders' engagement. Nonetheless, blockchain alone cannot support transparency as there are some dimensions which are beyond its influence.

The advantages of the underlying blockchain integration would primarily become visible when conflicts arise between the involved stakeholders. In this case, past statements could be traced back through the blockchain integration, thus, providing a transparent basis for conflict management. Obviously, this only applies to conflicting parties committed to reason and cannot avoid discussions deliberately deploying misinformation beyond the BBBlockchain.

QUOTES

„Transparency to me means communicating content but also processes in an understandable way" (E4)

"I don't think that 100% transparency is important or even right in every step and that a certain level of secrecy in some points is not wrong and is also important to protect the stakeholders"

"Communication of the limits of transparency is important; what do I publish and what not"

"It is important to find a good balance between transparency and still allowing all parties to contribute without coming under pressure, because you also have to look at who is exposing themselves".

6.5 BBBlockchain and citizen engagement

6.5.1 Reach and Target Groups

As traditional channels of participation (ex: workshops to collect ideas) are no longer sufficient for citizens' involvement and do not allow a continuous share of information with residents, blockchain technologies were considered as a complementary approach to reach more diverse target groups.

Specifically, both the Housing Associations expressed their willingness to participate in the BBBlockchain project to demonstrate government engagement with digital innovation, achieve open government and increase citizens involvement in urban planning decisions.

In terms of reach, the evaluation of the pilot projects showed that at least 3.712 people accessed BBBlockchain until February 2023. Figure 7 shows that most visitors used BBBlockchain between 9 am and 10 pm. Broken down by pilot projects, there were 1,836 visits to the Kietzer Feld and 1,019 visits to Bülow90. In comparison, more than 500 people were at the on-site participation in Kietzer Feld during the survey period. Unfortunately, the access numbers are not accurate because they represent only the minimum. As part of the user tracking regulations, all users were asked if they would agree to be included in the statistics. It is reasonable to assume that a significant proportion of users declined the user tracking.
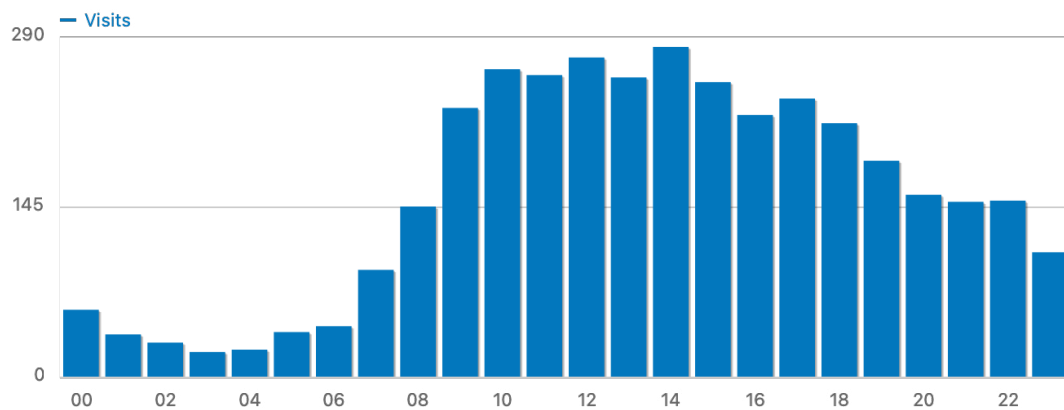
Figure 7: Access times

The survey results have shown that the new mobile form of participation was well received and reached a new user group. Overall, the residents have welcomed the additional digital offer within reach of the pilot urban development projects. The preliminary results showed that 70 percent of survey participants had never participated in participation processes before. Furthermore, the user survey indicates that the participants were evenly distributed across all age groups; 50 percent of the voters at Kietzer Feld were 50 or older, while the majority of voters at Bülow90 were between 18 and 34 years old.

On average, respondents voted four times and spent two minutes on BBBlockchain App. Most votes took place around 3 pm. This indicates that participation via the app is quick and uncomplicated.

Device	Visits
Smart Phone	65 %
Tablet	4 %
Desktop	28 %
Unknown/Others	3 %

Table 7: Users' devices

The participants were also equally male and female. Interestingly, the majority of users accessed the app via smart phones (65 percent), rather than via desktop web browsers (see Table 7). We hence conclude that introducing the BBBlockchain app offers the potential to reach a broader audience in participation processes, which is a key ambition of all urban participation projects. However, we would like to stress that BBBlockchain is not designed to replace analogue participation methods, rather to offer a hybrid option. It is important to acknowledge that the reach of a broader audience indeed represents a positive outcome in relation to the accessibility of urban planning processes by a group of citizens that was previously not reached through more traditional analog participation processes.

Therefore, although not directly related to blockchain technologies, we can conclude that BBBlockchain reached a broader audience.

In terms of inclusivity, currently BBBlockchain does not give citizens and tenants the opportunity to openly express their opinions as writing rights are only granted to the housing association, the municipalities and tenants representatives. In the case of giving citizens and tenants an equal writing access, we recommend clearly articulating in advance "rule of games" so that platform abuse can be prevented. Non-anonymous entries could be a solution for this.

Nonetheless, the surveys' results showed that 57% of the respondents considered the App easy and intuitive to use, 45% see themselves as better involved in the planning and construction process thanks to BBBlockchain, and around 50% now have a more positive attitude towards the respective housing association (see voting results[6]).

Therefore, we can conclude that BBBlockchain was successfully designed with a simple and familiar design and information were easy to understand, by using a clear and simple language. We can also conclude that blockchain technologies positively impacted on inclusivity thanks to the traceability and immutability of the information and its public nature with smart contracts stored open-source.

QUOTES

"As a HA, for us it's important to involve citizens, hear their opinions, questions, interact with them at an early stage of the development project. We want to empower people to make decisions which directly impact their living. For us it is important to assess how blockchain can support this kind of interaction" (M-1, HA).

6.5.2 Voting

For the use case of voting, we successfully tested on both pilot projects that voting processes can be enabled through the smart contract functionality (see section 3.4). Votes were successfully sent through our infrastructure and the results could be confirmed with the help of blockchain. Table 8 summarizes the overall participation on both pilot projects.

Date of Voting	Bülow90	KF
Feb 2020	78 Votes	
Feb 2022		13 Votes
May 2022	81 Votes	

Table 8: Summary of voting processes participants

BBBlockchain was developed in such a way that eligible voters could successfully submit their votes directly on BBBlockchain and verify themselves that the App counted them correctly.

Overall, we were able to prove that blockchain-based voting is technically possible as an

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6   https://github.com/ecdf-bbblockchain/bbblockchain-archive/blob/main/voting/ B%C3%BClow90.md#bbblockchain-ist-intuitiv-und-einfach-zu- bedienen-2022-05-16

option that complements traditional voting processes and that blockchain can minimize the potential for arbitrary voting and improve the transparency of the process.

Nonetheless, during the implementation phase, we faced a number of challenges including how to enable a voting process which is reliable, transparent and also retains user anonymity. Although privacy, reliability, and eligibility are all fundamental obligations of a voting system, in BBBlockchain it was necessary to find a trade-off by adopting a verification measure via email addresses which, however, cannot guarantee voting reliability and eligibility. Specifically, challenges emerged in relation to the definition of authorized voters (see section 3.4). Nonetheless, the mechanisms implemented to protect the privacy of voters successfully ensured voter anonymity through pseudonymisation.

Overall, we proved that the currently available blockchain infrastructure cannot fully comply with the requirements of an online voting system. Although blockchain technology has a real potential in developing a secure and inexpensive voting system, there are still many practical issues that have to be dealt with before the technology will be accepted. At the moment, voting processes which are reliable, transparent and anonymous are not feasible because of a number of issues presented by the intrinsic nature of blockchain technologies which include the complexity of the technology, an uncertain legislative context, public stakeholders needs, citizens and institutional resistance. At its current stage of development, blockchain-based voting has the potential to be viable, but primarily in non-binding participatory modes (For the full findings see Ietto et al., 2023).

6.5.3 Tokens

The issuing of tokens represent a unique blockchain feature that we were able to conceptually develop and empirically implement to incentivise citizens participation in voting. As discussed in section 3.4, we were able to develop Non-Fungible-Tokens (NFTs) and assign to each token an individual code so that they could be redeemed only once. Once redeemed as a coupon, the token is checked and locked on the blockchain.

In order for the residents to redeem their token they need to follow the following steps:

// Installation of the BBBlockchain app
// Participation in the respective survey or vote
// Receipt of a token/multiple tokens
// Users can check the balance of tokens in the app
// Redeeming the tokens in the Bülow90

Overall, 81 participants received their own token, however, only 6% of the citizens participating in the voting process redeemed the tokens. The reasons of such a low number might be due to:

// The reward might have not been attractive enough to go through the voting process which some might have found cumbersome (down the app, fill the survey, leave email address, download the token, redeem the token)

// The process of token redemption was not made clear enough (Ex: once the token was displayed, it did not say where it could be redeemed, explanation was on the flyer).

It was suggested that the process should have been accompanied by clear written instructions. That would have also prevented HAs dealing with phone calls and citizens enquiries about the process.

// Technological barriers of the users – older demographics might find the process too difficult and prefer analogue participation formats. HAs must consider to also have offline voting possibility (problem of double voting).

// Email verification might hinder participation as participants might be reluctant in leaving their email addresses.

6.6 Lessons Learned

The scope of the project BBBlockchain was to test if and to what extent citizens' engagement and transparency in urban participation processes can be improved with blockchain technologies. For this scope, three main use cases (information, voting and tokens) were developed and tested in a blockchain-based mobile App for two building projects in Berlin, Germany.

Overall, we can conclude that blockchain technologies only play a partial role in improving citizens' engagement and transparency. There are several other aspects that also need to be considered in addition to the development of the technology.

First of all, on a conceptual level, BBBlockchain technological infrastructure was successfully tested as feasible to improve transparency and citizens engagement.

We were able to create a reliable and stable infrastructure for the three main building blocks of timestamping, voting and tokens. BBBlockchain always ensured the integrity of the content and smart contract processes. There were no integrity errors or detected attacks on the internal access and rights management of the BBBlockchain smart contracts. The voting use case was also successfully developed so that votes went directly on BBBlockchain and voters could verify themselves that the App counted votes correctly. The mechanisms implemented also ensured voter anonymity through pseudonymisation.

Nonetheless, on a more empirical real-life level, we could not find a strong evidence to support BBBlockchain potential to solve transparency and engagement issues.

First of all, blockchain-based platforms still suffer from an unclear legal and regulatory support in relation to many aspects including stakeholders' responsibilities, dispute resolution, enforcement and so on. Therefore, there are still many uncertainties that will need to be addressed as the technology becomes more mature.

The purpose of achieving maximum transparency could not be achieved because of a number of factors. First of all, blockchain technologies are implemented within existing legal frameworks of urban planning, therefore, for legal reasons, information such as copyrighted material, personal data, licensed material, communication logs and recordings cannot be disclosed without the permission of the involved parties.

Nonetheless, we were able to partially address such tension through an on-chain protocol design which is public but permissioned and runs on a private network whose three main nodes are represented by the stakeholders with writing rights. Such trade-off between achieving maximum levels of transparency and controlling the decision-making process of BBBlockchain has helped to reduce the housing associations' fear of losing control over the content published on the platform.

Alternatively, we can also recommend addressing this problem through an a-priori establishment of standards about the expected level of transparency and corresponding monitoring processes. In this case, it is important to develop "rules of participation" which clearly define in advance what information will be shared by whom and how often. In fact, the analysis seemed to suggest that the optimum level of transparency to maximize the engagement of all the involved stakeholders does not necessarily correspond to its maximum level. This should be supported by proper mechanisms that ensure stakeholders' compliance to it.

A further benefit of blockchain for transparency that we wanted to test is in relation to conflict management among stakeholders. Blockchain is conceptually resistant to data manipulation and allows users, including non-expert users, to check the integrity of the data. This enables all involved stakeholders, citizens in particular, to openly monitor how urban planning projects unfold and to what extent they deviate to what was previously decided and agreed upon. Therefore, in case of conflicts among the interested parties, the immutable historical record stored on the blockchain, could represent a reliable and transparent basis to manage the conflict. However, as we did not observe any significant conflicts, at this stage, we cannot report any experiences. Nonetheless, some considerations can be made. Blockchain technologies make urban planning projects more transparent. They, however, do not produce accountability by default; they only represent a means for accountability by providing transparency. For conflicts to be properly managed, the involved parties must be aware of the existing avenues of accountability and how to use the available information. Currently, it remains unclear to what extent citizens are legally empowered to monitor urban planning project integrity. Therefore, it is important to clearly articulate how each party can be held accountable, by whom and how. For blockchain technologies to properly function for conflict management in a transparent way, they should be integrated within governance structures and procedures with consistent approaches to address accountability. Citizens should also understand how to proceed and understand what information and course of actions are available to them. This requires efforts by the government to raise awareness on new and existing accountability structures, as well as ensuring that information are accessible and understandable by all the involved stakeholders. Therefore, blockchain should be seen as an approach to use transparency to build up accountability and, eventually, to contribute to the trust held between citizens and their government. The full potential of blockchain technologies for handling conflicts transparently cannot be realized in the absence of a clear procedural framework and effective stakeholders engagement and monitoring.

As for blockchain to improve citizens' engagement, we can conclude that, on a conceptual level, they do have some positive impact especially if the platform has a permissionless and public infrastructure and the smart contracts are stored open source. However, on an empirical level we were not able to strongly support such evidence.

Our results confirmed that BBBlockchain was successful in terms of citizens engagement as 70% of users had never taken part in participation processes before and 57% of users considered the App easy and intuitive to use. However such results are regardless of the fact that our App was built on blockchain.

Besides the blockchain argument, our results confirmed the importance of creating platforms which are easy and intuitive to use, using simple language and retaining a design similar to other Apps which conveys a sense of familiarity. Yet, how to design a blockchain-based platform to best present blockchain features is an area of research that, so far, has not been sufficiently investigated. Currently, there are no clear guidelines on how to design the platform based on the context of application.

The analysis also showed that, for a more inclusive process, all the stakeholders' groups, including the affected citizens, should be included into the process to a greater extent. In the pilot phases, writing access was granted only to a selected group of stakeholders and residents' opinions were voiced by tenants' representatives. Granting writing rights only to key stakeholders was necessary to prevent misuse of the platform or the publication of illegal content as it was shown that arbitrary content can be written to the blockchain. Nonetheless, limiting access is a form of control and discrimination as it affects the openness of the platform and therefore its accessibility. Therefore, future developments should envisage designing the app and its underlying infrastructure in a way that all affected stakeholders groups are granted writing access. This however requires ways to mitigate misuse, for example, by incorporating means of anonymous authentication.

Finally, we would like to emphasize the importance of having measurable goals to clearly assess the success of each use case. Table 9 summarizes the most suitable metrics to be used for each developed use case.

Use Cases	Metrics	
	Citizens and Tenants	Housing Associations and Government
Information	Traffic/Access	Amount of information posted on the platform
	Return visits	
	Clicks and views	Frequency of posting
	Number of participants at offline events	Amount of feedback given to citizens questions
Voting	Nr. of votes	Nr. of questions asked
Tokens	Nr. of redeemed tokens	Amount of participatory budget allocated

Table 9: BBBlockchain Metrics

7.   CONCLUSION

The aim of the research project was to use BBBlockchain to develop a new, digital solution for the participatory challenges in urban development processes. The characteristics of blockchain technologies were considered helpful for this purpose. This includes, in particular, regular and transparent multichannel information in construction processes. The contributions of BBBlockchain were to develop an unchangeable information platform, to maintain a continuous reliable exchange between stakeholders during the development process and to motivate citizens to participate as well as to give them the opportunity to express their opinions and preferences through voting. However, BBBlockchain could not give citizens real co-determination and decision-making power. This means that the use of all BBBlockchain functionalities is only possible to a limited extent.

 Although we were able to test the benefits of blockchain on a conceptual level and develop the technological infrastructure behind each use case, currently we do not have strong evidence to make statements about the added values of blockchain technologies in participation processes.

One of the key advantages of blockchain lies with no doubts in resolving conflicts, as all statements can be traced back. However, since no conflicts emerged during our testing phases, we were not able to gather empirical evidence to support this.

One visible impact was that the use of the blockchain had a disruptive effect and moved the participants to rethink their usual communication protocol. As a result, the BBBlockchain platform was little used by all stakeholder groups involved. In particular, the immutability of the entries in the blockchain has raised major concerns as an appropriate communication culture among the stakeholders is still missing. Willingness to communicate as well as to open up participation are both essential aspects for the success of digital participation. However, this is a general cultural problem in urban development and is not limited to our application.

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