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Supporting ideation and collaborative design with smart contracts

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GeoCoin: Supporting Ideation and Collaborative Design with Smart Contracts

Bettina Nissen[1]
bettina.nissen@ed.ac.uk

Larissa Pschetz[1]
l.pschetz@ed.ac.uk

Dave Murray-Rust[1]
d.murray-rust@ed.ac.uk

Hadi Mehrpouya[2]
h.mehrpouya@abertay.ac.uk

Shaune Oosthuizen[1]
soosthui@ed.ac.uk

Chris Speed[1]
c.speed@ed.ac.uk

[1]Design Informatics, University of Edinburgh, Edinburgh, UK
[2]Abertay Dundee University, Dundee, UK

ABSTRACT
Design and HCI researchers are increasingly working with complex digital infrastructures, such as cryptocurrencies, distributed ledgers and smart contracts. These technologies will have a profound impact on digital systems and their audiences. However, given their emergent nature and technical complexity, involving non-specialists in the design of applications that employ these technologies is challenging. In this paper, we discuss these challenges and present GeoCoin, a location-based platform for embodied learning and speculative ideating with smart contracts. In collaborative workshops with GeoCoin, participants engaged with location-based smart contracts, using the platform to explore digital 'debit' and 'credit' zones in the city. These exercises led to the design of diverse distributed-ledger applications, for time-limited financial unions, participatory budgeting, and humanitarian aid. These results contribute to the HCI community by demonstrating how an experiential prototype can support understanding of the complexities behind new digital infrastructures and facilitate participant engagement in ideation and design processes.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

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Distributed Ledgers, Smart Contracts, Smart City, Geofence, Design and Ideation;

INTRODUCTION
New complex infrastructures such as programmable currencies, distributed ledger technologies and smart contracts are becoming increasingly widespread. These infrastructures often support finance and distribution transactions [40], running in the background of larger applications, away from users' awareness. There is a growing list of applications and proposals to employ blockchain technologies in the context of the Internet of Things [22]. These applications extend from the Smart Home into the Smart City [28, 52] and are bound to result in wide-reaching implications for users, consumers and citizens alike.

Figure 1. Participants setting off and exploring GeoCoin

As such technologies remain in the background of users' experiences, people's awareness of them is often mediated by technological narratives. Although many have now heard of cryptocurrencies and blockchains, public understanding is shaped by partisan narratives of the future, whether utopian or dystopian, decontextualized and echoed in the mainstream media [23]. In media reports, these technologies are ready to replace governments [47], democratize the Internet, or are portrayed as Ponzi schemes designed to scam the gullible and to support illicit activities [35]. The lack of awareness and understanding prevents a more informed conversation around the implications and potential of these infrastructures, particularly when attempting to involve people in the design process – they are constrained by received narratives, and lack the grounding to create their own.

In this paper, we present GeoCoin[1], a platform that aims to facilitate understanding and ideation with location-based smart contracts; self-executing computer protocols that run on dis-

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[1]https://geocoin.site/

tributed ledgers (e.g. Ethereum[2] or Bitcoin Blockchain[3]). GeoCoin provides a grounded experience of smart contract infrastructures, while remaining open for exploration, reuse, and final translation into new deployments, giving participants the grounding to develop their own perspectives not constrained by media portrayals of technological innovations. The use of location-based contracts is intended to contextualise the technology in everyday practices.

GeoCoin was used in a series of workshops, where participants were guided through i) initial understanding aspects of cryptocurrencies, blockchains and smart contracts; ii) experience of using GeoCoin; iii) ideation around potential applications for geolocated smart contracts. This process is synthesised here through insights gained from using this platform in 4 workshops with 69 participants over the course of 10 months. This paper contributes to the very timely discussion of blockchain technologies in HCI. It presents case scenarios of an experiential platform as open, unfinished software, supporting understanding and facilitating engagement in ideation and design with smart contracts and location-based infrastructures for value exchange.

BACKGROUND

Distributed Ledgers and Smart Contracts

The main challenges of communicating the impact and potential of smart contracts is the complexity of the technology involved and the lack of established references to some of its core concepts.

Smart contracts are enabled by distributed ledger infrastructures such as a blockchain. Distributed ledgers are systems that can computationally verify and store information in a decentralised network without the need for a trusted third party. They allow consensus to be achieved in a distributed system without a central authority. This relatively abstract concept is important for a number of applications that verify and record transactions and other data immutably. The concept was popularised by Bitcoin, which used a blockchain to create a peer-to-peer cryptocurrency [37] supporting many applications focusing on financial trading [40]. Nowadays however, there are other examples of blockchains, and many non-financial applications that range from supply chain provenance[4], securing healthcare records [34], royalty fees in the music industry [44] and new ways of publishing [49].

Complexities of Smart Contracts

The Bitcoin blockchain includes a simple programming language that is used to verify transactions, such as checking that the correct parties have the necessary funds to make a transfer. More recent blockchain systems such as Hyperledger[5] or Ethereum[2], offer a more developed programming language that can be used to create smart contracts: "agreements between two or more parties that can be automatically enforced without the need for an intermediary" [38, p.6]. These contracts are initiated and become autonomous—they do not run on a single computer, and there is no convenient "off" switch. Being autonomous and decentralized, they give a mechanism for carrying out trusted exchange. They are therefore seen as challenging existing models of governance, by replacing centralized sharing platforms [45], or even the entire mechanism of government[6]. Arguably the most famous application of smart contracts is "The DAO", a capital fund organisation that at its peak controlled over $150M of cryptocurrency, with 11000 stakeholders involved in distributed voting on activities and investments [11]. The DAO eventually crashed, when a bug in its code allowed a bad actor to siphon out all of the money invested [14]. This demonstrates some of the challenges of working with smart contracts as well as continuing technical issues around security and concurrency [13, 30].

Smart Contracts in Practice

These technologies are poised to have wide reaching implications for everyday users, yet researchers have found that a small minority employ cryptocurrencies [33] while the broader public — even those that use cryptocurrency – does not fully understand the complexities of the underlying technology [18]. While technical approaches exist to ease development for non-specialists (e.g. Etherscripter[7], a smart contract programming environment based on Scratch[8]), these are only relevant for a relatively technically literate subset of the population, and focus on technical understanding rather than wider implications.

One problem of communicating smart contracts is that they often do not match existing mental or legal models of users. For example, it takes a significant shift in viewpoint to understand how trust can be built up by distributed computers, or that transactions become more trustable with time. Decisions can be validated by the community, which contrasts with existing legal systems. When the DAO crashed, since it controlled a significant fraction of the Ethereum currency on which it was based, the community voted to carry out a "hard fork" and reset many of the transactions that were previously carried out. This kind of rewriting of history is outside the mental models most people have of how currencies function.

In order to understand the effects these technological developments may have on our everyday lives, researchers are looking into ways to render them more accessible and tangible for non-specialist audiences [31, 32]. Other, creative applications and explorations by artists and designers aim to reimagine and critically question future applications or uses of this technology [8]. For example, Lindley's Crypto Heater explored the "distributed peer-to-peer network of so-called 'miners'" [29] while Pschetz and Tallyn's Bitbarista [42] applies blockchain technology to investigate the participant's understanding of data sharing and transparency, and Nissen et al. [39] explore the implications of designing for Distributed Autonomous Systems. These manifestations of blockchain technology in the form of diverse tangible things illustrates an increasing need to understand and think through these complex infrastructures and technologies in accessible ways.

[2] https://www.ethereum.org/
[3] https://blockchain.info/
[4] https://www.provenance.org/
[5] https://www.hyperledger.org/
[6] https://bitnation.co/
[7] https://etherscripter.com
[8] https://scratch.mit.edu/

Implications for the Smart City

One area of growing interest for smart contracts is the smart city, where blockchains offer a possible solution to storing and using data that has been collected securely. Governments and industry are attempting to integrate Internet of Things (IoT) data into citywide information architectures [52]. These are intended to support city services on the one hand [28] and civic engagement on the other [12] with calls for civic activists to "hack the city" [2].

The currently wide-ranging explorations of urban blockchain applications [48] include monitoring environmental sensor data through immutable smart contract logic [25]; integrating a secure infrastructure in the smart city [4]; and using a transparent distributed ledger to offer financial incentive models to urban cyclists [27]. Some of these systems are centralised, while others [22] offer a way for community groups to develop peer-to-peer platform cooperativism [45]. A very recent example in early development is the FOAM protocol[9] which introduces secure storage of a spatial dimension to the blockchain, acting as decentralised geospatial infrastructure.

INTRODUCING GEOCOIN

We developed GeoCoin as an explorative platform for location-based, or geo-fenced currencies to allow researchers and designers to engage wider audiences in understanding and designing with novel infrastructures of smart contracts and cryptocurrencies. Smart contract logic is attached to physical locations, and participants interact with them using a smartphone app that shows the contract instances on a map as the participants move through space. The app maintains a digital currency wallet for each person, so that participants can see changes to their balance in real-time. It currently includes two basic types of smart contract: i) Debit/credit coins which perform a single transaction with the first participant who comes within the radius of the contract; ii) Debit/credit zones which continually add or remove currency from all participants within their radius. Figure 2 shows two versions of the interface that were iteratively developed alongside the workshops. The value of each coin or zone is not visible to users, and only becomes apparent through physical exploration and observing the changes to one's balance. The zones can be easily administered through a web interface (Figure 3), allowing workshop organisers and designers to quickly set up new experiences alongside participants.

GeoCoin and Existing Methods to Support Ideation

With our intention to create an accessible tool for engagement and ideation of smart contract applications, GeoCoin contributes to existing work on methods, approaches and techniques for ideation in general. Existing approaches however are usually focused on idea generation techniques and experimentation with concepts. Several methods have evolved from traditional forms of Brainstorming [16] or Sketching [7], and have been translated into an increasing number of ideation cards and toolkits [17, 21, 26] to name just a few). Some focus

[9] http://foam.space

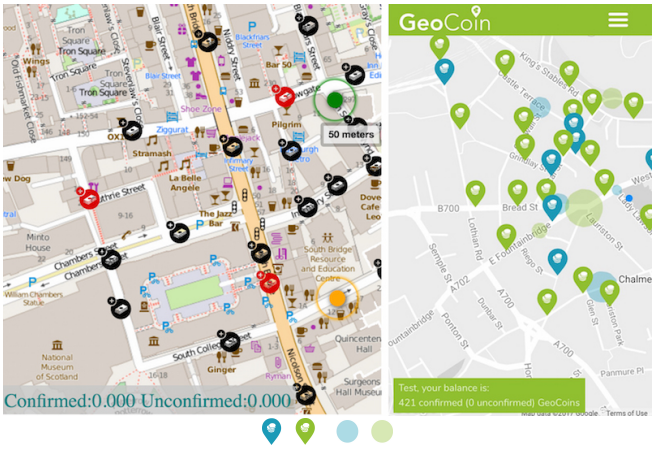


Figure 2. First iteration of GeoCoin (left) and second iteration (right), showing single use transaction pins and continuous transaction zones.

on ideation for designers while others aim to engage participants in the design process [43] as in participatory design approaches [36].

Alongside these tools for ideation, other design tools such as *probes* have been designed to further gain insights from participants and support reflection in relation to specific contexts and concerns. Probes have become increasingly popular to gain nuanced insights into practices and perspectives, as one of the biggest challenges of engaging participants is to reveal their tacit knowledge, things that they often take for granted and therefore do not openly manifest to researchers. Probes vary widely in the level of inclusion of participants in the design process. "Cultural probes" [19] were defined as a way to provoke "inspirational responses" in order to understand participants in an open-ended way, while "Design probes" [51] capture insights from participants through the modification of artefacts that invite expression of subjectivity and intimacy. "Technology probes" can take the form of prototypes that test a particular concept [24] and open up dialogue with potential users. They can also attempt to evoke a context where technology is developed in order to act as a stimulus for understanding larger social practices, such as the way communication patterns evolve [46]. Overall, probes try to strike a balance between having access to participants' knowledge and giving them tools to portray their perspectives in open ended ways.

In the Design and HCI communities, the role and importance of prototypes to gather feedback from participants has been widely acknowledged. In more traditional design approaches, participants are consulted at multiple points in the project, through paper or video prototypes in order to collect feedback from them. *Experience* prototypes are also used [6] with the aim to communicate what it might be like to engage with a product, service or system, and reach a higher level of fidelity towards the final design.

Overall, GeoCoin borrows aspects of these methods but does not strictly follow any of them in particular. GeoCoin incorporates ideas related to participatory design and classic ideation methods. However, these methods have limitations when supporting ideation within more complex technological scenarios.

In line with participatory design, Geocoin aims to explore participants' contextual knowledge while they actively engage in the development of new concepts. As such, GeoCoin is strongly influenced by the concept of probes in terms of gaining insights from a specific technology and the context it is situated.

Ideating with Unfinished Software

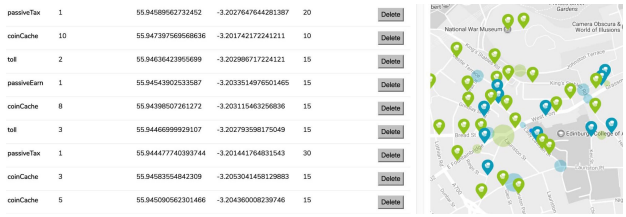
While leaning on these existing design tools, we perceive this novel experiential platform as open, *unfinished software* to support understanding and facilitate engagement in ideation and design processes with smart contracts. Much has been said about the value of unfinishedness in design, from sketching user experiences [7] to ambiguity [20] and open design [50]. Sketches and less finished prototypes can be seen as tools to encourage discussion and intervention, in earlier stages of the design process as they are cheap and easily adaptable [7]. Ambiguity [20] allows artefacts and systems to be open for multiple interpretations [46] and can be useful to express uncertainty in the precision of a system (ambiguity of information), to raise questions about people's perspectives towards practices suggested by technology (ambiguity of context) and to support people in rethinking the roles systems play in their lives (ambiguity of relationship). Open design [50] is still an emergent concept related not only to copyright issues but also the communication and production of tools to support extension, re-use and remix of design projects. Open design is becoming more popular in discussions on digital fabrication processes, but is increasingly discussed in terms of design principles. Architect Alejandro Aravena's half houses [41], is an example of how an open design approach can offer people a functioning basic structure while leaving room for individual expression and further development. Similarly, GeoCoin was intended to provide a functioning experience of a complex technology while leaving a structured space for individual ideation and concept development. This open, experiential platform offers basic technical functionality without prescribing goals and forms the basis of what we perceive as *unfinished software* to support ideation grounded in hands-on learning.

GeoCoin Iterations

With this framing in mind, GeoCoin was developed over the course of 10 months and was tested and deployed throughout this development in several workshops. Learning from initial workshops, GeoCoin went through two major technical and visual iterations, while smaller technical and UI issues were refined over the course of the 10 months.

The first iteration was based on Bitcoin currency, using Electrum[10] "wallets"—applications and services that give cryptocurrencies same affordances as traditional payment systems. Each wallet was initialised with a small, randomised amount of Bitcoin at the start of each workshop. Visually, this iteration was a low-fidelity prototype, using OpenStreetMaps[11]. The user interface showed a relatively busy map with a series of 'coins' and coloured zones, and was intended to engage

[10] https://electrum.org
[11] https://www.openstreetmap.org



passiveTax	1	55.9458956273245 2	-3.2027647644281387	20	Delete
coinCache	10	55.9473975695686 36	-3.201742172241211	10	Delete
toll	2	55.946364239556 99	-3.202986717224121	15	Delete
passiveEarn	1	55.9454390253358 7	-3.2033514976501465	15	Delete
coinCache	8	55.9439850726127 2	-3.203115463256836	15	Delete
toll	3	55.9446699992910 7	-3.202793598175049	15	Delete
passiveTax	1	55.9444777403937 44	-3.201441764831543	30	Delete
coinCache	3	55.9458355484230 9	-3.205304145812988 3	15	Delete
coinCache	5	55.9450905623014 66	-3.204360008239746	15	Delete

Figure 3. GeoCoin admin panel in final iteration.

participants in further thinking through the value and meaning of potential location-based smart contracts.

The second iteration incurred two major changes. First it moved from Bitcoin to Ethereum. Because Bitcoin transactions are not free, a significant proportion of the digital currency was lost to transaction fees in each workshop. The Ethereum platform allows the use of a "test" blockchain, that is free to use and technically compatible with the "real" Ethereum currency. In addition, Ethereum has more support for the kind of smart contracts that we were developing, allowing more of the logic to be handled by the platform. Second, we created a more user-friendly interface that hid most of the complexities of the technology and instead emphasised the coins and zones.

Lessons Learnt from Prototyping with Bitcoin and Ether

A recurring narrative around cryptocurrencies is that they enable micropayments, by being fast and cheap to use. Our prototyping showed that this is often not consistent with current platforms for two reasons:

- First, as mentioned above, transactions through Bitcoin (Electrum) wallets are not free. When performing many small transfers, the transaction costs quickly eclipse the actual transaction amounts, and workshops become expensive to run as money disappears. Additionally, the distribution of fractions of bitcoins in a large number of wallets means that a portion of the funds are not economic to recover under the original architecture.
- Second, transactions are not instantaneous due to block mining times, taking up to 15 minutes to be seen in Electrum wallets. In a real-time, physical experience, transactions that take 15 minutes to "come through on the blockchain" are no longer salient, and the process of discovering mechanisms is disrupted. In response to this, we added a "confirmed" value representing the trusted transaction in the blockchain, and an "unconfirmed" balance that would update instantly (Figure 2).

GEOCOIN WORKSHOPS

In a series of collaborative workshops, we used GeoCoin as a tool for embodied learning and speculative ideation with location-based smart contracts. These workshops were developed not as a stand alone study dedicated to this platform, but as part of a series of associated events to engage different stakeholders and communities in the discussion of these new technologies. As a result, although each workshop was structured similarly, we adjusted details for differences in setting and audience to make it meaningful to them and retain real life impact. Participants included Arts and Humanities researchers,

Figure 4. Participants mapping GeoCoin opportunities and implications.

industry experts, informatics students, community groups, creative industry organisations, artists and designers. Overall, we ran 4 workshops with participant numbers ranging from 8 to 35 with a total number of 69 participants. The national and international workshops ran from half a day and whole day to, in one case, two days (as discussed by Cila et al. [10]). All workshops were documented using post-it notes, audio, video recordings and field notes.

Each workshop roughly followed a similar 3 stage structure:

1. *Overview:* the first stage aimed to give participants an initial understanding of the underlying technological principles and wider concerns in an accessible format through a combination of presentations and a guided BlockExchange[12] session
2. *Exploration:* the second stage consisted of a short introduction to the GeoCoin platform and its use before sending the participants out into the city, where they roamed freely around the streets and parks exploring and interacting with GeoCoin.
3. *Ideation and Design:* A final design and ideation session brought participants back together to explore opportunities, issues and ideas arising from their GeoCoin experience. We asked participants which contexts or situations such location-based platforms could be meaningfully applied to, who would interact with such a system and what rule bases or conditions would be useful. In shorter workshops, the ideation stage was limited to sketching out and presenting idea outlines. In the longer workshops, the participants worked with a developer to turn their ideas into new forms of smart contract applications. After a code sprint, the prototypes were then collectively experienced.

Participants' Projects

The initial GeoCoin experience presented a series of simple smart contracts, i.e. the ability to collect and spend coins in particular geofenced areas. These mechanisms were directly appropriated by participants to create rich distributed applications. The ideas generated in the workshops ranged from abstract, speculative concepts to concrete applications, with an emphasis on bottom up, community building ideas to empower citizens, residents or a wider public which align

[12] http://blockexchange.designinformatics.org/

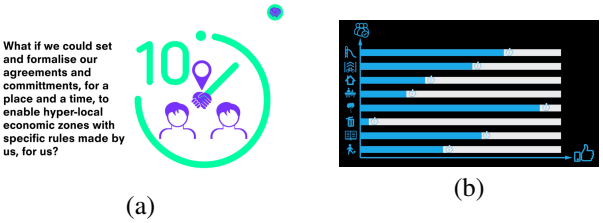


Figure 5. Handfastr (left) and CivicBlocks (right) designs by participants.

with the ethos or promise of distributed ledger technology. Often these included creating novel, cause-specific currencies, gamified incentives and distributed budgeting systems with a playful and creative angle. In general, concepts revolved around 3 main themes: infrastructure, cultural landscape, and socio-economic applications. While we encouraged participants to reflect on one final concept to prototype, many ideas were generated during the process with several overlaps. Final concepts often differed in their level of development.

Overall, 7 concepts were clearly defined and articulated, while other ideas remained at the sketch stage. These concepts included (1) gamifying a city's tourist attractions to alleviate crowded hotspots and increase visits to lesser known cultural venues; (2) counteracting gentrification by offering residents the chance to build community equity; (3) an environmental currency offering financial incentives for low-carbon practices; (4) a cultural currency that could only be spent at cultural events and venues within the community; (5) collaborative financial decision making for temporarily joined funds; (6) a participatory budgeting platform; and (7) distributing humanitarian aid directly to peers. From these 7, we are describing the latter three as most compelling and furthest advanced examples below, which have also been developed into full applications employed in different contexts.

Handfastr – Making Commitments Wherever You Are

What if we could set and formalise our agreements and commitments, for a place and a time, to enable hyper-local economic zones with specific rules made by us, for us? A group of 3 participants used smart contracts as the jumping off point to question conventional legal aspects of marriage, by creating location-aware, time-limited financial group partnerships (Figure 5a). The example of marriage was chosen for its common resource-sharing characterization, which is traditionally relatively fixed. This was updated into a flexible, mobile digital smart contract. The resulting application allowed groups of people to join finances for a specific purpose over a flexible period of time. The team designed their app allowing participants to create a temporary social economic contract, or Handfastr, by tapping a marriage button on their phone whilst being within proximity to one or several partners. Sealing a romantic, social or communal agreement in the blockchain, the partners could then join holiday or business finances for the duration of a few days or as long as the members agree. For the duration of this bond, the participants are only able to spend coins when in close proximity with one another.

Civic Blocks – Participatory Budgeting with Bitcoin

How can we use new technologies to create a more democratic city? How can we involve citizens in decisions about

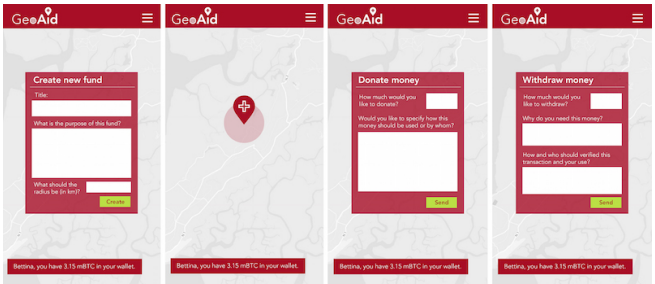


Figure 6. GeoAid iteration of GeoCoin by researchers.

their neighbourhood? The idea of CivicBlocks is the use of blockchain as a decentralised public ledger of votes for civic developments and community projects. A government would release a percentage of their annual budget in equal amounts to local citizens as cryptocurrency. Each resident has the option to create a new zone for a specific civic project, e.g. a new recycling centre, community school and playground. When residents are physically present in one of such zones they can allocate a share of their cryptocurrency to the specific cause or project. The council can then develop and build the next community project or civic development based on community preference (Figure 5b). The system empowers local residents to actively take part in shaping their civic community, while creating a transparent and fair platform for public spending.

GeoAid - Distributing Humanitarian Aid Directly

Can blockchain technologies support the redistribution of humanitarian aid without the need for middlemen/organisations? How could you directly donate to a small village or individual farmer in need? GeoAid set out to use smart contracts to address humanitarian aid distribution. Rather than pay money to a charity without knowing how or where one's donation is allocated, people could set up a fund for a stated purpose in a particular location. The public could then donate money to these local funds from anywhere in the world, setting constraints on how they intended their contribution to be used. Located within the specified radius of the fund (depending on each fund's initial setup and purpose), beneficiaries could then withdraw money from the fund, showing how they were using it. An initial prototype of this system was built (Figure 6) to highlight and critically debate issues surrounding accessibility, verification, control and power over such localised wallets, in particular in less developed or disaster struck parts of the world.

INSIGHTS FROM GEOCOIN WORKSHOPS

In this section we highlight how GeoCoin has supported ideation and collaborative design processes.

Probing the Edges of the Platform

Despite being rough and ready, the concrete implementation of the technology supported participants' understanding of its issues and potential opportunities. For example, seeing how slowly balances changed helped participants interrogate the way that trust is built up on blockchains. Working with the idiosyncrasies of the real system was crucial to helping demystify the black box.

The implementation also allowed participants to probe the edges of these technologies. For example, we observed strategies like standing in the center of a credit and debit zone to try and confuse the system; attempting to sprint through a debit zone trying to avoid collecting debt; and gaming the system more intentionally by turning on and off the phone's GPS to avoid payments. These responses would not have been sensible with a less infrastructurally grounded platform.

Uncovering Unequal Infrastructure

As a GPS driven, networked web app, GeoCoin's performance is influenced by each individual's device and service provider. Newer phones could geolocate more quickly and more accurately, allowing them to claim coins before older models in the same place—in one workshop, the most coins were collected by the owner of the newest smartphone. This accidental hierarchy challenged participants to consider these implications on a more global and community scale than solely their interactions, triggering debates about how digital technology accidentally reconstructs social inequalities and wealth accumulation. Such issues of power were discussed and future real-world scenarios considered, such as 'state-issued devices' to support economic equality and what implications this may have if a location-based economic model became reality.

Evolving GeoCoin Factors into Smart Contract Conditions

Participants also looked at different conditions for smart contracts. Environmental or temporal factors led to weather-dependant or day/night time dependant scenarios—parks that charge more in the sunshine, or public transport that becomes cheaper when it rains. Several participants wanted to modify behaviour, for example rewarding environmentally friendly or community building activities vs. penalising anti-social actions. From considering such factors participants quickly imagined them as smart contract conditions or algorithmic rules that could be described as "If This Then That" style scripts. For example, if a person cycled to a shop instead of driving, the price of groceries could be reduced or carbon coins could be earned. Although these services do not really require a geolocated currency, the platform opened up discussion on the usage of smart contracts in these contexts.

Influencing Behaviour

The platform helped participants to engage with critical issues of location-based smart contracts. Some participants considered jaywalking to collect coins in the middle of a street, leading them to decree that dangerous acts such as jaywalking should not be rewarded. Other participants crossed streets to avoid debit coins or walked back the same way they came because other directions were 'blocked' by debit coins or zones. One participant chose a cafe in a credit zone in order to accumulate money while drinking coffee. This raised discussions of the implications for businesses when citizens' economic decision making processes are influenced by geo-located smart contracts. At other times, participants found it very easy to be unaware of the digital results of their actions—several people, especially towards the beginning of the exercise found that they had accrued a lot of debt without realising it.

Looking inward, GeoCoin honed participant's self-awareness towards their smartphone usage and behaviour during the exercise, in particular staring at and following their phones. If on one hand GeoCoin was seen as distracting from real-life experiences, it equally led to serendipitous explorations of new areas. Participants described constructed relationships between the digital objects and their real-world surroundings. For example, multiple coins were placed in an area home to several charity shops. Although not planned, this brought up debates about power, control and meaning, as participants questioned how the coins were located, and who by—a faster version of the recently documented gradual public understanding of the sociological implications of playing Pokemon Go [1].

DISCUSSION

Value of Ideating with GeoCoin

The use of the GeoCoin app to engage participants in a series of workshops offered opportunities to imagine, speculate and ideate with complex infrastructures through an accessible and open ended format. As identified by Elsden et al. [15], one key aim for future HCI research is to engage participants in novel blockchain designs through speculative and experiential methods. A crucial factor to achieve this is the use of smart contracts 'in the wild' [9], raising real-world concerns and drawing connections to broader societal issues.

GeoCoin draws from a number of existing methods and techniques, from probes and experience prototyping to participatory design. It borrows elements of probes, as it offers an open-ended experience for participants. While experience prototypes and probes are often focused on gaining understanding of participants' perceptions, GeoCoin attempts to provide an informed experience of smart contracts and invite participants to intervene in or extend the system. Instead of evaluating participants' experience [6] or collecting data [19, 24, 51], the aim was to mediate learning so that participants would feel empowered to apply smart contracts creatively. This invitation for creative thinking and appropriation also goes beyond the definition as experience prototypes [6]. In this sense, GeoCoin differs from these approaches in terms of intention, delivery and outcomes. While GeoCoin invites intervention and re-use, the open-ended nature of the outcomes stand in contrast with participatory or co-design methods, which often aim to involve stakeholders to solve a particular problem.

Through the experience, appropriation, design, modification, and testing of their own concepts, participants were able to learn and express new understandings about their environments, social contexts, and economic and political concerns in relation to smart contracts. Although participants' ideation with GeoCoin may relate to aspects of Speculative Design [3] and Design Fictions [5] in their creative applications and speculative narratives, the platform itself is not understood as such. In the resulting projects, even though future impact of these technologies were considered, participants tested ideas with technologies and infrastructures that are already available to them. By being programmed on an actual Bitcoin or Ethereum platform, the real nature of such monetary transactions grounded this prototype in a very real and present interaction experience.

Instead of a probe, experience prototype or co-design method we propose to refer to GeoCoin as an *unfinished software*, an open system that invites appropriation and translation of complex technologies into participants' own ideations.

Engaging with Smart Contracts in the City

Working with smart contracts allowed workshop participants to interrogate values by viewing them through practical yet disruptive lenses. It would have been challenging to immediately jump into redefining marriage, or supporting more transparent aid distribution, without the technological infrastructure to ideate around. The workshops led to a number of smart contract ideas that ranged in their applicability and validity, from highly feasible to more speculative designs. These ideas addressed many social, cultural and economic concerns, and were critically debated regarding wider social, environmental and political implications.

There was an understandable bias towards applications that engaged with the city and it's inhabitants. Most projects focused on the promise of the blockchain to democratise resources and services via grassroots, community-based peer-to-peer systems. Generally, most participants took a more critical position than seen in mainstream development of the smart cities. For example, while UNICEF is looking to deploy Ethereum for transparency in aid, the GeoAid project aimed to critically explore how such technology could bring different stakeholders together to investigate issues around current aid distribution.

The way these ideas developed throughout the process, and the discussion surrounding them, demonstrates how a practical experience with *unfinished software* can support an informed ideation process without stifling creativity. Without this support, ideation can sometimes lead to an idealisation of technology, where participants model the infrastructure to work 'perfectly'. It can also lead to designs that simply follow mainstream media narratives of technology. By implementing and testing these ideas, however, participants experienced the gap between mental models and the world, and between promises and delivery of these technologies. Some unexpected findings – such as the scenario where a faster phone would collect more coins – pushed the participants to consider social and ethical questions that they would not have otherwise engaged with. By facilitating participant engagement, tools such as GeoCoin lead to a more varied range of applications, manifesting concerns of a more diverse set of stakeholders, and challenging the dominant narratives of technological solutionism.

Design for Unfinishedness

With GeoCoin, we worked on two dimensions of unfinishedness: a) the platform, particularly in its first version, was somewhat rough and ready, lacking controls and presenting an interface that was unpolished enough that people could imagine modifying it. While there is much literature about the impact of the level of finish on inviting criticism and change (e.g. [7]), the refinement of GeoCoin in the second iteration of the prototype had little impact on ideas generated by participants. b) the experience provided by the application was somehow a sketch, with minimal functionality and a system

that was solid enough to provide the experience of using a technology that triggers smart contracts. We did not give explicit reasons or goals for the existence of contracts in particular places, instead leaving it open for the participants to debate what might be intended.

GeoCoin trod a path between being plausible and rich enough to engage people, but leaving enough rough edges and space in the experience so that participants were comfortable and even compelled to change the system. The open-ended application helped people think through issues as well as benefits, letting them extend out to ideating for smart contracts, smart cities and completely different contexts.

The system explored ambiguity of relation [20], leaving room to imagine alternative interpretations, leading on to developing their own responses. The unfinished state of GeoCoin allowed participants to imagine, design, develop and own the applications developed on top of it. Similarly to Aravena's houses, a finished software would focus on people's practices, an unfinished one would focus on triggering their imagination.

IN SUMMARY

In this paper, we have introduced GeoCoin, an example of *unfinished software* aimed at creating a shared environment for speculative ideating and collaborative designing with location-based smart contracts. We contribute to the HCI community by developing the concept of *unfinished software*. In particular, we have used it to:

- *Make smart contracts experientially accessible to non-specialists.* We have discussed how this experiential prototype can support non-specialists in understanding complex technological systems such as smart contracts.
- *Explore values and concerns of smart contracts for smart cities.* We have discussed insights from a series of GeoCoin workshops with a number of audiences ranging from arts organisations, artists, designers to academics, industry and blockchain experts.
- *Allow participants to ideate with smart contracts.* We have presented a series of design ideas emerging from the workshops which shows how GeoCoin facilitated participant engagement in ideation and design processes, through the concept of open, unfinished software.

GeoCoin.site is freely available to HCI researchers as a web platform for creating open geo-located smart contract experiences. More generally, we demonstrate how employing unfinished software platforms can engage non-specialist audiences in location-based value exchange and peer-to-peer systems in a way that is meaningful and empowering to them.

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