GeoPact

Citation for published version:
Tallyn, E, Revans, J, Morgan, E & Murray-Rust, D 2020, GeoPact: Engaging publics in location-aware smart contracts through technological assemblies. in *Designing Interactive Systems 2020 conference.* ACM, pp. 799-811, ACM Designing Interactive Systems 2020, Eindhoven, Netherlands, 6/07/20. https://doi.org/10.1145/3357236.3395583

Digital Object Identifier (DOI):
10.1145/3357236.3395583

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Peer reviewed version

Published In:
Designing Interactive Systems 2020 conference

GeoPact: Engaging Publics in Location-aware Smart Contracts through Technological Assemblies

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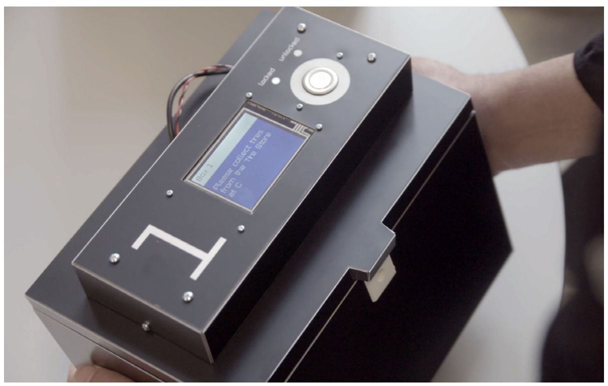


KEYWORDS

Smart contracts, transport, logistics, infrastructure, location data, public engagement, Blockchain, DLT, IoT

DIS '20, July 6–10, 2020, Eindhoven, Netherlands

ACM ISBN 978-1-4503-6974-9/20/07...$15.00
https://doi.org/10.1145/3357236.3395583

ABSTRACT

This paper presents GeoPact, an assembly of technological objects that materialises location-aware smart contracts using internet of things and digital ledger technologies. Such contracts may facilitate the creation of distributed systems and services for transport and logistics that are locally constructed and adaptable, thus supporting specific community needs and sustainable objectives. However the technological infrastructures that underpin these systems are complex, making it difficult to engage publics in design processes. GeoPact grounds infrastructure in relatable physical activities, that are linked with holistic views of the system, and creates new experiences for public engagement. In these activities participants were invited to roleplay as couriers, and to progress through delivery scenarios which were governed by smart contracts. Participants and spectators were then encouraged to discuss their reactions, concerns and ideas. This paper illustrates the GeoPact assembly and reflects on our engagement activities.

INTRODUCTION

Designing with infrastructures

Increasingly human life is governed by infrastructures that are opaque, intangible and whose complex functioning only manifests in small, atomised interactions. These fleeting moments of interaction are the points at which infrastructures meet and are integrated into everyday life. They provide a window from our lives back on to the broader infrastructures, revealing aspects of their workings, making them a useful starting point for design and engagement activities.

The work presented in this paper is motivated by the need to develop new thinking around solutions for transport and logistics. With more people than ever on the move, and the impact of growing volumes of home deliveries on urban logistics [13] this is an area in urgent need of design innovation. However, designing for change in transport and logistics infrastructure to meet both local and national requirements is challenging. These sprawling, complex infrastructures are difficult to fully envisage and are entrenched in incumbent, legacy systems. This makes engaging a broad section of stakeholders in the design process particularly difficult.

We introduce 'location-aware smart contracts', that use location data as part of coded agreements about how objects and people move in space and time. Secured through internet of things (IoT) devices and distributed ledger technology (DLT) these produce new possibilities for location-based transactions. A utopian view is that they may open up access to design within transport and logistics to a broader population. However, there is a technological inscrutability in the combination of IoT and DLT and the frameworks that connect them. Yet much of their value lies in the security provided by their technological structures that are not apparent at surface level.

Data and decentralisation in transport and logistics

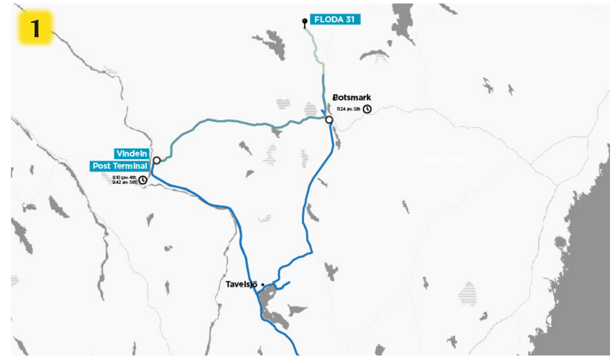
Transport of people and objects is currently being disrupted by emerging data driven approaches. Ridesharing applications e.g. Uber optimise the movement of vehicle fleets through cities, providing users with increased customisation and convenience. Delivery schemes, e.g. Deliveroo, and dock-less bike schemes e.g. Mobike, have also spread quickly. Underpinned by IoT technology, dockless bike schemes have seen particularly rapid roll-out within city centres, followed by an abrupt rejection in some [10,18], resulting from problems of rapid deployment before local, cultural and practical issues have been understood. These systems have been largely successful, offering increased convenience for individuals and new forms of decentralised participation through casual, flexible employment. However, their underlying business models tend to be hyper-centralised [9], and are often antagonistic or disconnected from the planning and transport systems of cities in which the services are deployed. Furthermore, the operations and value of these services flow through opaque algorithms that may leave customers unknowingly disadvantaged [2].

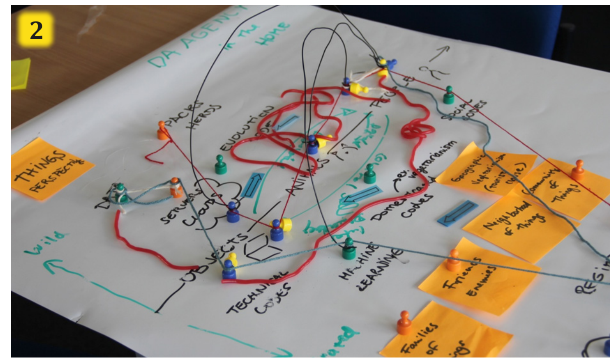
Through trust in distributed structures and cryptographic data processing, distributed ledger technologies such as blockchains conjure imaginaries of true distributed ownership and management of systems, presenting opportunities to develop new systems and services locally and on a smaller scale. Smart contracts have the potential to provide certainty around data and computation, offering a secure, programmatic method to enable people, objects and spaces to transact without the need for trusted third parties. Previous work has clarified the distinguishing features of these technologies in relation to HCI and design, discussing the importance of linking new designs and applications with lived experience [5], and in particular involving publics in civic development [6]. Using a fusion of location-based IoT and DLT to verify and secure location data, the work in this paper explores how people, organisations and existing services could collaborate in providing new services that use location data as part of transactions. Aligned with previous design thinking to support the development of collaborative economies [8] the development of GeoPact is motivated by a vision of technical democratisation, where individuals and communities bring their experience and expertise to participate in designing and running their own services, tailored to fit both personal and local needs. However, to reach this vision, we first need to explore methods which open up these technologies and their transport possibilities to a wider society, to support discussions of reliability, appropriateness, fairness and trust.

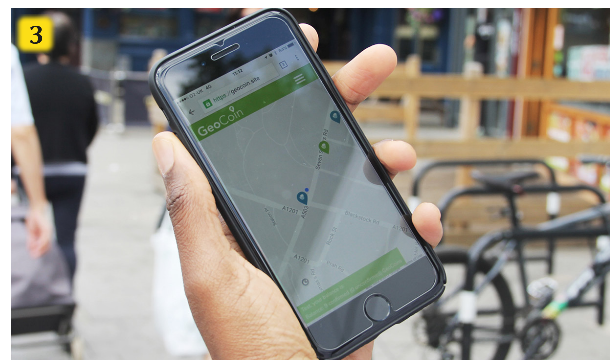
Connecting Blockchains and Transport through Design

Revealing the structures that underlie new technologies in participatory design processes has long been seen as essential to digital civics, enabling citizens to decide what is most important to them [4]. Previous work has explored the activities and processes around existing transport and delivery infrastructures to reveal them through ethnographic studies [1, 14], and deployed design probes that track and visualise activities across logistics infrastructures 1 [3]. In contrast, HCI and design projects that engage people around DLT concepts have worked with abstracted and simplified versions of their structures and applications using tangible assets, such as Lego [11], cards [7], or mixed media 2 [12]. These methods focus thinking on specific aspects and attributes of DLTs and enable participation around high-level thinking, without overloading people with technological concepts. The material qualities of trading coffee [16] and energy [15] supported by DLT have been explored through consumer artefacts, and GeoCoin provides a personal, real-world experience of location-based smart contracts supported by a mobile application 3 [13]. Whilst the smart contracts in GeoCoin were simple, this work demonstrated the importance of roleplay in engaging with smart contracts, and avocated the need for open-ended experiences.

Building on this existing work, we have created GeoPact, a high-fidelity digital and physical system through which we engage publics with location-aware smart contracts. In this paper we illustrate the material and interactive elements of GeoPact through its exhibition at public events, to provide a design exemplar that demonstrates a visual language for articulating smart contracts. We conclude with reflections on our experiences of public engagements and insights into design and engagement practices for transport infrastructure and smart contracts.





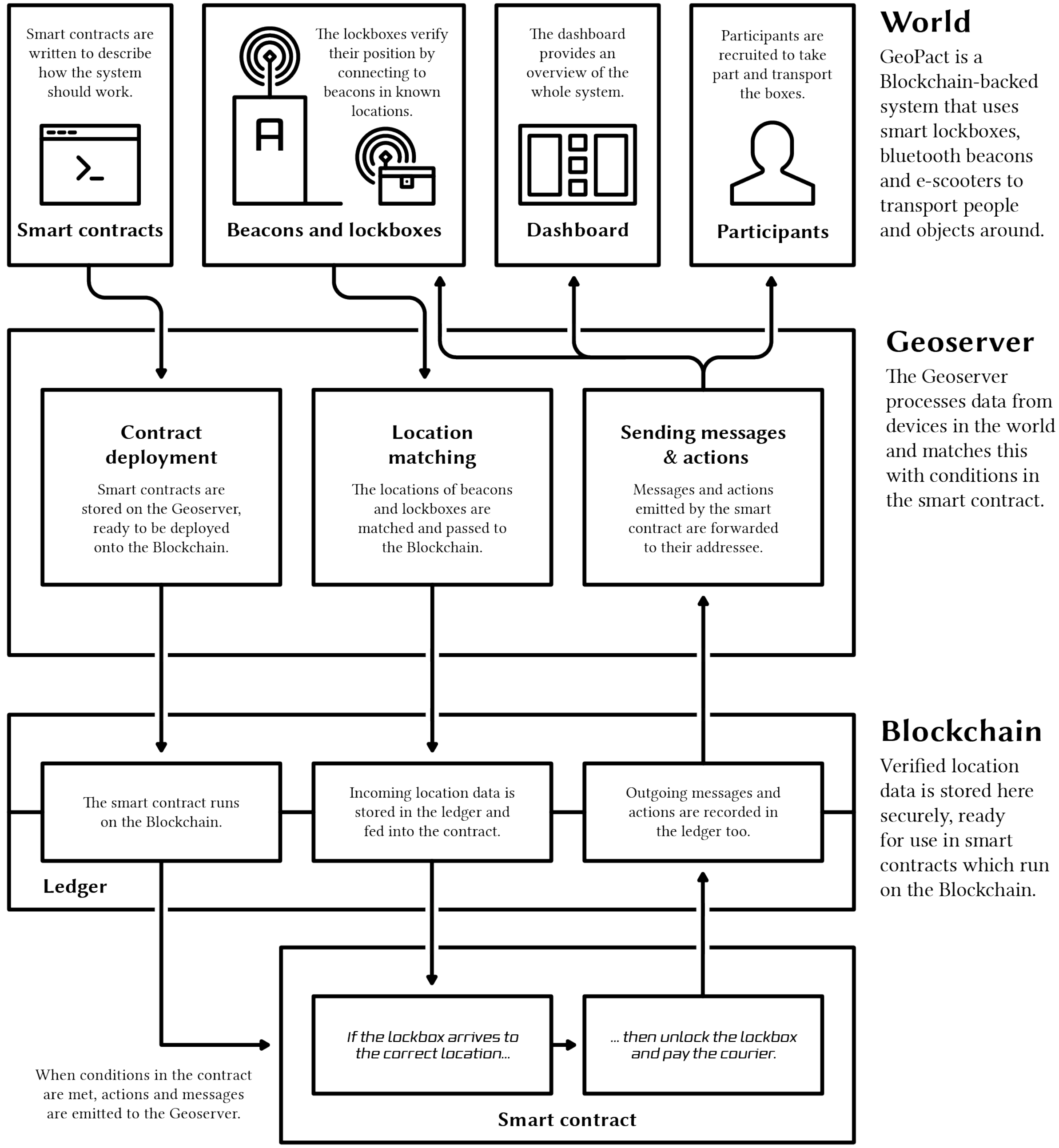


Above: Design approaches to understanding complex systems, from the global overview of visualising transport infrastructures 1 [3] to a relational look at organisations on the blockchain 2 [12] to an unfinished software approach that gives personal experience of participation in the system 3 [13].

GEOPACT SYSTEM OVERVIEW

The GeoPact system enables people and things to transact and interact through secure, location-aware smart contracts. To engage publics in these technologies we aimed to provide a holistic view of the concepts underpinning the smart contract system (broadening that window into the infrastructural), while representing them through relatable, transport activities (connecting them into real-life). When using GeoPact, participants go step by step through examples of functioning location-aware smart contracts, enabling them to experience some of the possible different transactions a user might have whilst using the system, and in the process reducing some of the current mystery around these technologies. To produce these functioning and tangible experiences an extensive assembly of physical and digital artefacts needed to be designed, produced and coordinated.

The technological architecture of GeoPact shown here is comprised of IoT technologies (LoRa, Bluetooth) integrated with an Ethereum blockchain. Bluetooth beacons communicate across local networks using location data to confirm the identity and location of smart objects, then encrypt the data and resulting processing, storing it on the tamperproof Ethereum blockchain. The stored data can be verified and accessed by distributed networks and used within smart contracts. In GeoPact, we materialise the infrastructures – IoT beacons, smart contracts and blockchain data – as well as the smart objects that participants interact with.



ASSEMBLIES

The GeoPact assembly is comprised of smart lockboxes 1 used to securely transport items by electric scooters, 2 which help imagine possibilities around future intelligent transport systems. Bluetooth beacons 3 provide location detection, whilst the Geoserver and Ethereum blockchain network provide the backend operations. A set of pre-coded location-aware smart contracts, which allow simple logic statements to be chained together (such as: 'if this box and this person are in the same place, the box will unlock'), govern events that must take place for the contract to complete. A dashboard 4 displays an entire, active smart contract broken down into its constituent steps, along with a view of the generated data being written to the blockchain.

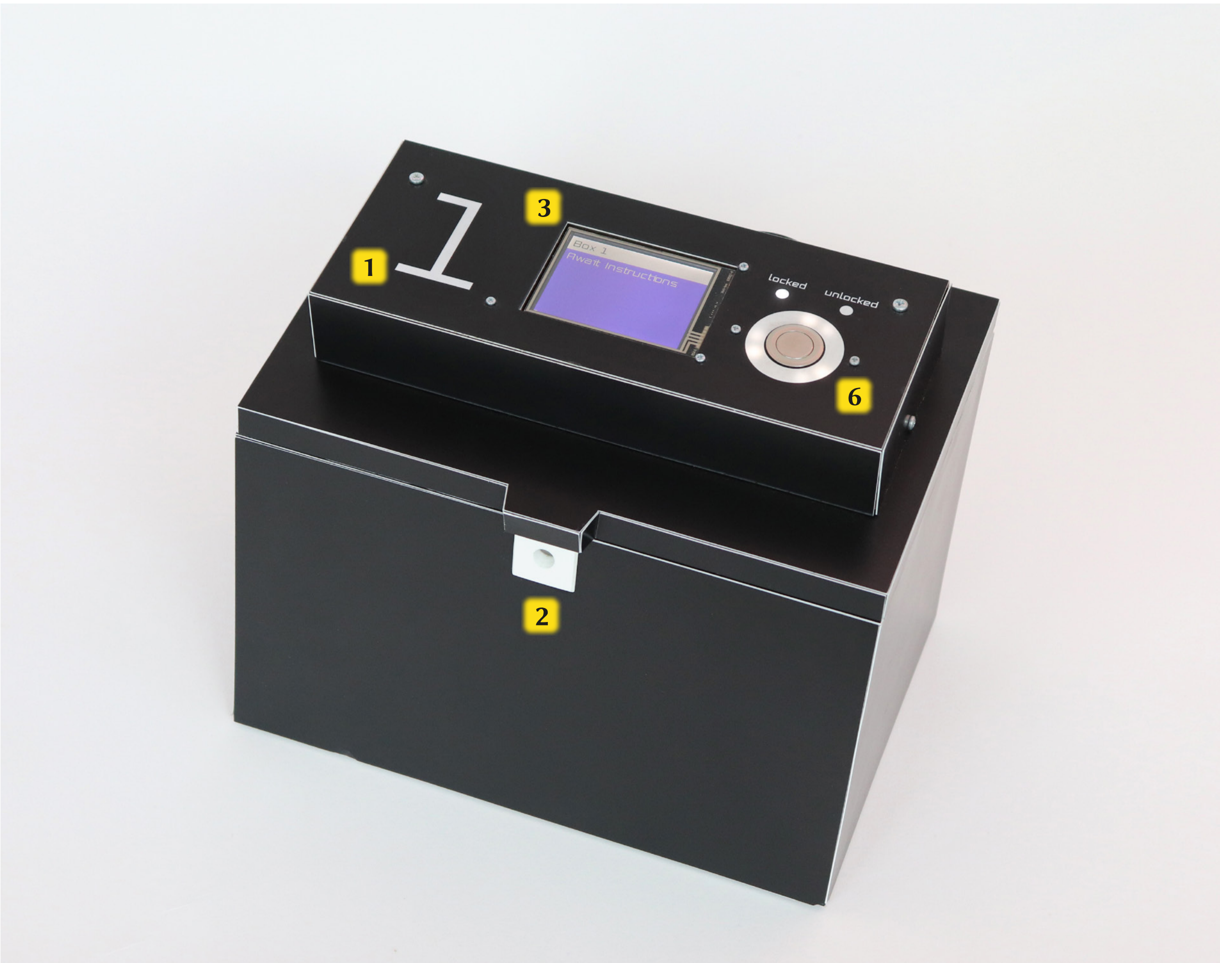
Because the elements of the assembly, in particular the beacons, were spread across a large space, and sometimes spanning indoor and outdoor spaces, visual consistency across the elements was important. We employed strong colours and clear signage for the beacons and the dashboard, and made them physically large enough to be easily visible at a distance.

EXHIBITIONS

The GeoPact demonstration was exhibited at three different locations in the spring of 2019: The Tate Exchange at the Tate Modern, the Piazza at The University of Warwick, and the Bayes courtyard at The University of Edinburgh. These were walk-in events, open to the public and advertised via websites and social media. For these events we created an experience that people could engage with in limited space and time. Both the Warwick Piazza and the Bayes Courtyard are off-street, outdoor spaces, where the use of electric scooters was possible, but at the Tate the demonstration was inside a gallery space where scooting was not permitted.

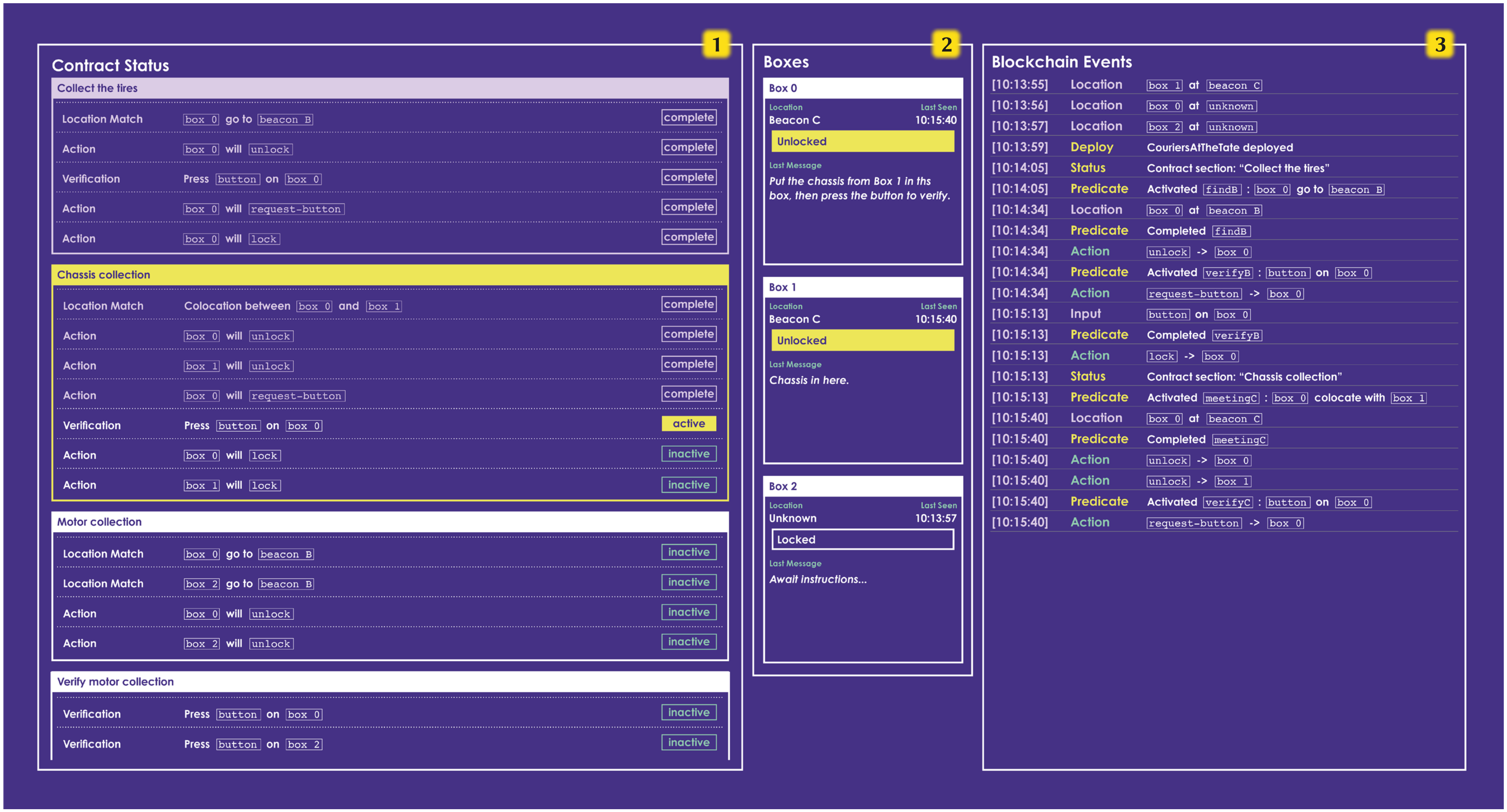
LOCKBOXES

Participant interactions centre around 'lockboxes', used to transport items - although small, conceptually these boxes represent containers of any size. Each box, labelled with an ID 1, locks and unlocks in response to instructions from a smart contract, e.g. 'Box 1 will unlock when it is near both Beacon B and Box 2'. These simple interactions – based on co-location between beacons and boxes – have enabled us to create a number of interesting, example transactions. The locking mechanism 2 provides clear physical states 'locked' and 'unlocked', which are easy for people to register, and have strong symbolic links to privacy and security. The box display 3 shows its current state and instructions for participant action, emitted from smart contracts. Instructions could include, for example, 'take the box to Beacon D' 4, 'open the box' 5, 'press the verification button' 6. The subsequent participant actions then produce data which is shared with the smart contract. The contract checks this data and steps of the contract then execute.



DASHBOARD

The dashboard is split into three sections: the left pane containing the current smart contract **1** ; the smaller central pane showing the state of the boxes involved in the smart contract with the contract message currently displayed on the box **2** ; and the right pane showing a live listing of the sequential stream of detailed data coming from the boxes, beacons and smart contract actions that is permanently stored in the Ethereum blockchain **3** . Together these panes of information provide a holistic view of the system. The representation of the smart contract in the right pane is particularly important as part of the GeoPact experience, because it shows the actions that need to take place for the contract to complete. In particular it shows the actions the participants should take, and the status of each action: inactive and pending, active, or complete (see the icons to the right of each listed step). Once initiated the smart contract checks to see if certain conditions in the active step have been met. When these conditions are true, the step of the contract will execute, and the contract activates subsequent steps. For example, if the contract is waiting for a box to come into proximity with another box, when it receives data confirming this, the current active step in the contract will complete and the next pending step will become active.



REPRESENTING SMART CONTRACTS

Location aware smart-contracts connect real-life actions to the IoT and blockchain technologies, tying events together to ensure things happen in a specified way. This provides contractual certainty around events that should take place and is the central value of smart contracts. With GeoPact we can create different smart contracts specifying a wide range of terms and models of operation using location data. For the GeoPact exhibitions we created two pre-set contracts, one simple and one more complex. Participants were eased into the experience with the simple contract, which we call 'Getting Started'. This is comprised of the basic interactions this system offers: the participant is instructed to move a box to a beacon, when a box is in proximity with the beacon it unlocks, participants are instructed to open the box and take something from it, and then verify they have done this. While in some respects this is a simple interaction, in the GeoPact assembly it has several layers for participants to make sense of as they link the physical events to the infrastructure. On the left **1** we describe real-world actions and interactions between the staff, participants and system. Next are the steps of the smart contract **2** shown on the dashboard. At **3** we show the instructions emitted by the contract and shown on the box display. These are seen by participants one at a time as the contract unfolds. The blockchain record of contract actions and data from the world shown on the dashboard are at **4** and these are more detailed than the contract actions shown at **2**. Finally at **5** we show diagrams of the real-world transactions that the contract facilitates. These were printed on flashcards, and used as part of post-experience reflection activities.

Getting Started contract

Description 1

The vistor is introduced to the project by a member of staff. They are given a lockbox and are told to follow the instructions on the box.

The visitor is asked to go to beacon A. Once they arrive their box colocates with the beacon and their box unlocks. Inside the box are sweets, which they receive as a reward. They verify the collection of their reward and the box re-locks.

Dashboard view 2

Contract Started

Action	box will request-button
Verification	verify button on box
Location Match	box go to beacon A
Action	box will unlock
Action	box will request-button
Verification	verify button on box
Action	box will lock

Contract Ended

Box messages 3

Press the button to start the demo.

Put this box on bracket at A.

Take what's in the box then press the button to verify.

Good job on completing your first smart contract.

Blockchain events 4

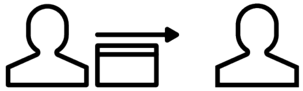
Deploy	Contract deployed
Status	Contract section: "Demonstration Contract"
Action	[request-button] -> [box]
Predicate	Activated [start]: [button] on [box]
Input	[button] on [box]
Predicate	Completed [start]

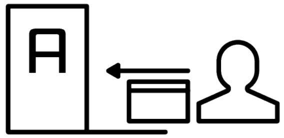
Predicate	Activated [foundA]: [box] at [beacon A]
Location	[box] at [beacon A]
Predicate	Completed [foundA]
Action	[unlock] -> [box]
Action	[request-button] -> [box]
Predicate	Activated [end]: [button] on [box]
Input	[button] on [box]
Predicate	Completed [end]

Action	[lock] -> [box]

Status	"Contract Ended"

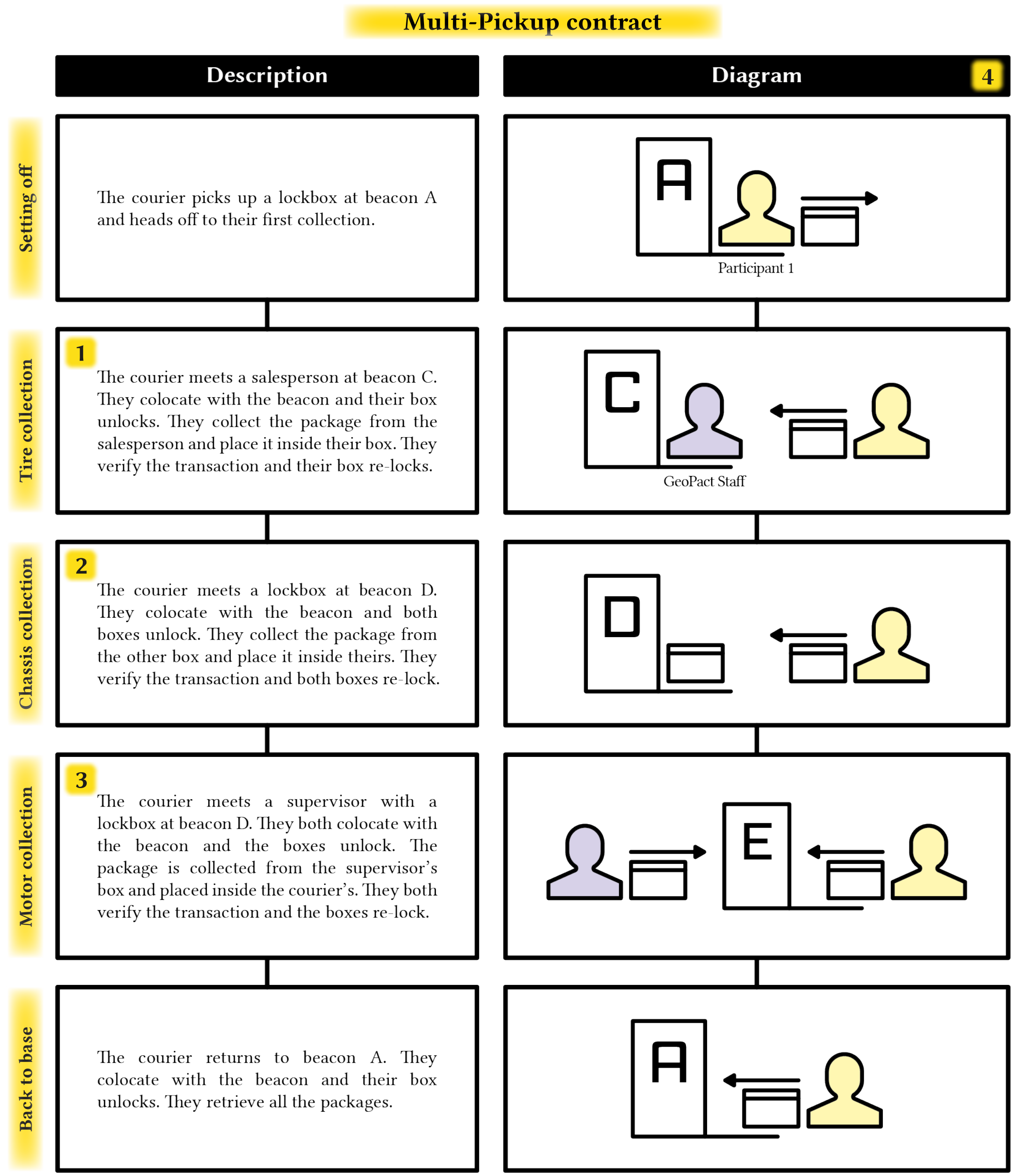
Diagrams 5





ROLEPLAY WITH SMART CONTRACTS

After completing the Getting Started contract participants were encourage to try a more complex one, which we call the 'Multi-Pickup' contract. This has multiple stages in which the participant collects various items. It provides a more developed scenario which we hoped would enable participants to make more connections to real-life activities, and through this stimulate new ideas for potential uses. Before starting on this contract we gave participants a brief backstory to motivate their interactions and bring the experience to life. We asked participants to take the role of a courier – perhaps as a side-hustle, or freelance job – picking up parts of an electric car (tires, chassis and motor) for a client. The car parts varied in nature and value, leading to different terms and conditions around their collection: the tires were handed over to the courier by a sales-person 1, the chassis collection was mediated solely by the GeoPact assembly 2, and pick-up of the motor was mediated by GeoPact and verified by a sales-supervisor 3. The sales-person and supervisor were role-played by us, the researchers, and the car parts were mocked up with Lego and packaged with flash cards showing the representative transaction diagram, similar to those shown here 4 (shown on Page 11).



CONNECTING THROUGH ACTION

Participation in the Multi-Pickup contract was captured in a video made during our Edinburgh event. Using stills pulled from the footage, we reveal the detail of two contract collections, which illustrate variations on these transactions and show the interactive events that connect the physical and the infrastructural. In the tire collection 1 at the tire store (Beacon C), proof is provided through the location of the box at the store and verification of the collection by the courier here. In the motor collection 2 proof is bolstered by the arrival of a second lockbox which must also co-locate in the correct location (Beacon E), and verification is provided by both the courier and the sales-supervisor.

Roleplaying alongside the participants allowed us to witness experiences and discuss emerging questions, ideas and concerns with participants as they arose. This enabled us to encourage participants to consider the impact and potential future uses of the technology in similar, everyday life situations, as the experience unfolded.

Tire collection 1

Courier arrives at the tire store, box unlocks and displays new message

Message prompts courier to expect staff, who then arrive with the tires

Sales staff take tires from store and hand over to courier

Courier put tires in the box, for secure transport

Courier verifies tires have been packed in the lockbox at the tire store

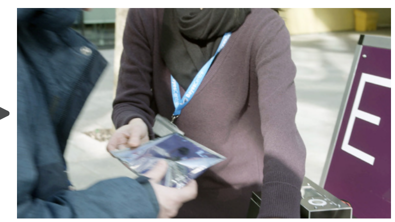
Box locks and contract confirms tire collection is complete

Motor collection 2

Courier waits while supervisor arrives with additional box

Both boxes agree on co-location at motor store and both boxes unlock

Message instructs supervisor to retrieve motor from box for handover



Supervisor hands the motor to the courier

Courier places the motor in their box and closes the lid

Both courier and supervisor verify that the exchange has taken place

Both boxes re-lock, confirm collection completed, and send new instructions

Couriers fit box to electric scooter for next journey

OBSERVING AND PARTICIPATING

The GeoPact exhibitions offered different starting points, where participants could either begin with the physical through actions, or with the infrastructural through exploring the dashboard or the boxes.

Examining and spectating

GeoPact exhibits offered a number of ways for people to approach the experience, and begin to make connections between the physical activity through participation, and the infrastructures that are behind it. Participants often began by examining the smart boxes and with staff explanation they could get a sense of the types of interactions GeoPact enables. Observing the activities of other participants was a particularly important learning experience. By watching contracts execute on the dashboard as participants progress, they could view the contract events in conjunction with the physical activity, so people could get an overview of how the components of the assembly link and work together. This was useful both before participation, to get an idea of what will happen but also after, where it provides a summary of the most recent sequence of events, which supports reflection.

Participating and discussing

Taking part in working through a smart contract provided a close-up experience of the interactions GeoPact supports. The contracts lead participants through the process with the messages displayed on the box screen. This experiential perspective was important in encouraging participants to think about how they might feel about using such a system, with particular regard to issues such as trust and reliability. Many participants took part in pairs or small groups, and worked through contracts collaboratively with lots of discussion. Others were keen to explore the experience alone. We encouraged solo interaction with the system, and in particular without staff, by placing beacon D, where the courier would collect the chassis directly from another box, away from the GeoPact hub. The intention was to enhance the experience of performing a fully automated transaction, without the influence of another person.

Examining the boxes and discussing the possibilities with staff was a popular starting point.

Many potential particpants began by watching others' action as they worked through the smart contract.

On the dashboard spectators could observe contracts executing as participants completed steps and this provided a way for spectators to connect the digital steps in the contract to the physical activity.

The majority of participants worked through the contracts in small visitor groups. This provided a good opportunity for discussion about what was happening and why, as the experience progressed.

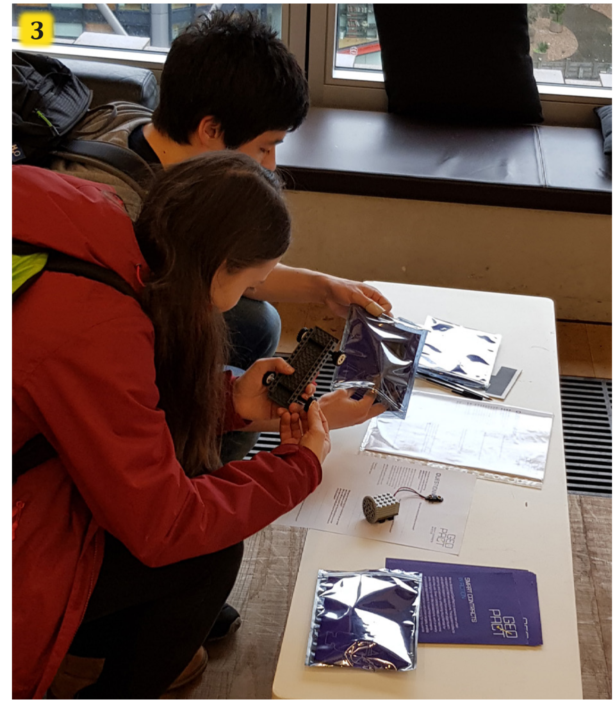
In Multi-Pickup contract participants could experience interactions with the research team who role-played sales-staff and supervisors. This provided an opportunity to use the system with someone they did not know, which may have produced a different sense of trust and fairness.

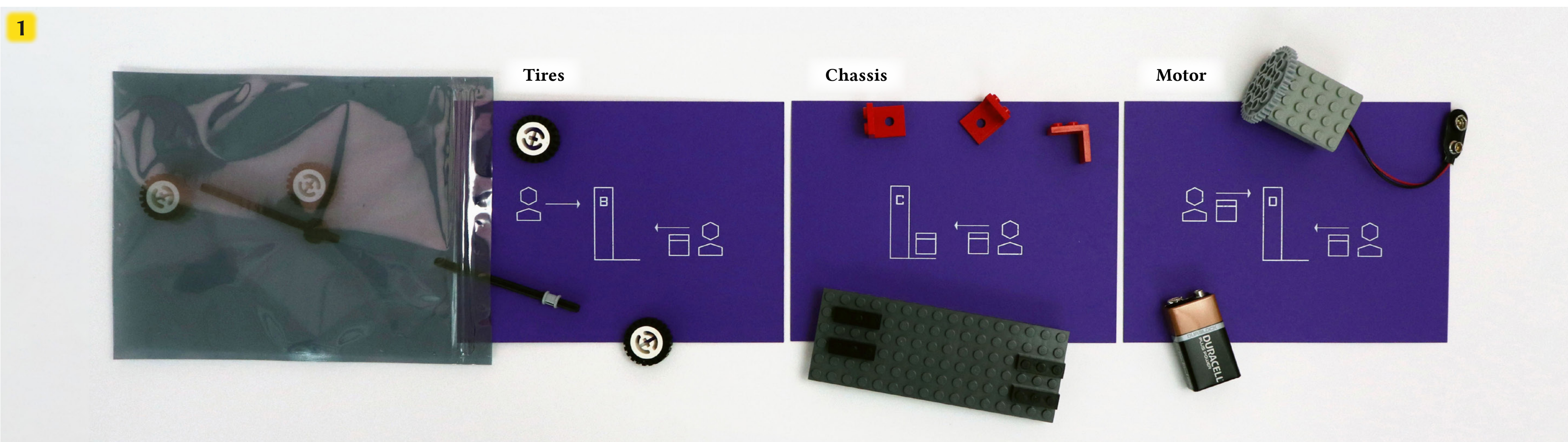
The collection of the chassis was fully automated, which meant that often participants would experience this interaction alone. Here a participant would arrive at an unstaffed beacon (D) to find another lockbox that contained the chassis, which they collected directly from the box.

SUPPORTING REFLECTIONS

At each transaction within the Multi-Pickup smart contract, participants collected Lego pieces representing car parts. These were packed inside bags with flash cards showing the diagrammatic representation of the type of transaction that took place to collect the part 1. After the experience we encouraged participants to unpack these bags and consider the different types of transaction that took place, and the car parts they collected 2. The dashboard also provided a useful prompt to aid reflection, as it showed a summary of the sequence of events and provided more detail on the individual transactions than the diagrams, enabling participants to refer back to the events and consider the infrastructural processes behind them. These prompts also provided participants with a point of reference in conversations with research staff, in which participants discussed their thoughts and feelings about both the specifc transactions and the experience as a whole. In particular, they helped to support conversations around potential applications and services in which different types of transactions might be particularly useful or appropriate.

Finally, participants could also build the electric Lego car which acts as a fun reward for participation (the car works!) and closure for the experience 3.





CONNECTING ACTIONS AND INFRASTRUCTURES

Conversations with publics

Discussing concepts and ideas with the visiting publics was integral to the GeoPact experience. In order to offer flexibility to exhibition visitors, these conversation were informal and varied considerably in length. Some particpants asked a couple of key questions, whilst others wanted longer, indepth discussions to learn more about the technology and share their opinions. This fluidity meant that we sacrificed gathering formal results from these participants in favour of providing maximum value to them. In terms of the GeoPact experience itself we found that few participants reported usability issues with the dashboard, boxes or smart contract messages. We tested these in a pilot trial to iron out such issues prior to exhibition. In particular we had given considerable attention to the wording of the contract messages, which required many re-writes, for example where there might be ambiguity around which box to attend to. Through the informal conversations at the exhibitions would typically explore questions around the nature, construction and use of location-aware smart contracts, and focussed on subjects such as: incorporation into everyday life, trust and control, use in transport and delivery services and other novel application areas. Common themes emerged from the discussions in the exhibitions. People often applied the concepts to familiar situations, possible in an effort to further ground them in real-life. In particular we discussed situations where current systems and services regularly create problems, such as in train travel (which has had many problems in the United Kingdom in recent years). Many people discussed this example, where perhaps smart contracts could hold failing train companies to account if services were running late. Examples involving large companies often led to considering the power balance in the construction of smart contracts. Who would write them, and in particular who would benefit from them? People typically considered fairness to be important. Many were excited by the idea that this technology could be a way to address the current status quo in which terms and conditions are dictated by large companies. However, few had much faith that they would be able to get involved in defining the terms of smart contracts, and felt it likely that this would be controlled by large companies who would write contracts which benefit the company first. In considering the complexity of everyday actions, and how well people normally accommodate changes in circumstances, participants questioned how such pre-defined contracts would integrate with messy, everyday life. In particular people asked about the consequences of not following the contract's instructions, which might happen for a variety of unintended, good reasons, whilst not wishing to break the contract or be penalised for this.

Reflections

Previous design methods that engage non-experts in smart contracts and DLTs have tended to present and work with concepts at a high and abstract level [7,11,12]. The work of GeoCoin [13] was a precursor to GeoPact, in beginning to move away from abstraction and provide grounded physcial experiences. In GeoCoin this was achieved through simpler smart contracts and presented at a lower level of fidelity than in GeoPact. GeoCoin ultimately led to the idea of open-ended experiences, that left room for interpretation. With GeoPact we found that participants needed a clearly described scenerio in order to grasp the complexity of the technology that was driving it. In the pilot study participants reported that leaving the scenario open made it difficult to make sense of the experience. Instead providing the relatable (albeit futuristic) scenerio helped to show how it might be part of a real-life activities and therefore demystified the abstract concepts. Focussing participants on a pre-defined, guided set of interactions may seem likely to close down the process of creative thinking. However, we found that it enabled participants to scrutinise the details of each step in the interactions, often by discussing reactions and thoughts with others as they emerged. GeoPact also differs from previous work in moving away from attempts to explain the complex workings of DLTs or their special qualities, by instead showing an example of how they might be used. Experiencing a fully functional example of a DLT seemed to provide participants with confidence to comment on the potential real-world impact of the types of new applications DLTs might support.

Through the elements of the GeoPact assembly we have begun to develop a visual language and process to articulate location-based smart contracts and their operations. We have found it particularly effective to provide two different views into the system, an overview via the dashboard that enabled participants to spectate and get a sense of the experience as a whole, and immersion in the physical process of the delivery task with the boxes, interacting directly with the smart contracts, providing an experiential handle to connect real-life to the workings of smart contracts. We have seen how the concretisation of smart contracts through a delivery scenario has helped to demystify their working and connect them into everyday transport activities, and how abstract smart contracts have provided a way of articulating and reflecting on the design of transport infrastructure. Participants' growing understanding of how location-aware smart contracts might become part of every-day life led to discussion of some of the difficult questions in this area. Many of our conversations about GeoPact came back to the subject of how these smart contracts come into existence, not only who writes them, but how, and who ultimately has control? GeoPact provides a visual and material starting point for engaging publics in smart contracts and their operations. Taking this forward, exploring ways to compose or assemble smart contracts in different contexts, might be a fruitful area for future work, in particular through encouraging the design of local and sustainable transport systems.

Acknowledgements

We would like to thank Sigrid Schmeisser for her contribution to graphical elements of the GeoPact assembly, and Eleonora Muller for her work on developing smart contracts as part of the B-IoT project. We would also like to thank photographers Chris Scott, Chih-Peng Lucas Kao and Dan Weill for capturing our engagement activities for us. Finally we would like to thank all of the willing people that came by to take part in GeoPact. This work was part of the B-IoT and TRaM projects funded by the UK Engineering and Physical Sciences Research Council project: PETRAS (EPN02334X1). It was also part of BLING an Interreg project supported by the North Sea Programme of the European Regional Development Fund of the European Union.

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