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11 Blockchain city

Economic, social and cognitive ledgers

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Introduction

City dashboards are typically representations of a city's accounts, manifest according to values set by the stakeholders. The currency of the data within a dashboard is typically reduced to an assessment of the performance of services (such as traffic flows and crime statistics) largely derived from quantitative sources. Whilst such databases may be useful for mayors to report on the performance of a local government, or to set targets that lead to penalties or bonuses, the city workers and inhabitants that are complicit in the production of data are rarely aware of the nature of how data are collected or the 'ledger' that they are contributing to. As a consequence, dashboards cannot describe many of the transactions that take place between people, nor can they make explicit the values that are brokered between the myriad of city occupants.

This chapter explores different perspectives upon economic and socio/geographical ledgers and the complexity that they involve as they inevitably collide with concepts of chronological time, representation and actions. Three means of approaching the concept and practice of the ledger are discussed: (1) *money, time and the blockchain*: an exploration of how the representation of money shifts from material representation within fiat currencies (i.e. those underpinned by governments or precious metals) to the blockchain, the sealed distributed ledger that supports the Bitcoin cryptocurrency; (2) *city as ledger*: a recovery of the role of time in the production of economic geographies with a focus upon Hägerstrand's approach to time-geography that accounted for personal and group actions within temporal and spatial frames, and inevitably a recovery of Marx and the obfuscation of histories and geographies; and (3) *cognitive and practice-based ledgers*: an introduction of the use of filmic storytelling as a cognitive ledger using the Dardennes' film *Two Days and One Night*.

These three theoretical perspectives on ledgers set the scene for two prototypes utilizing Bitcoin technology that emerged from a design workshop facilitated by the Design Informatics studio, University of Edinburgh. These prototypes begin to explore temporal and social potential for using ledgers within design experiences. By reflecting on the role of ledgers across different forms, this formative chapter establishes the complexity of capturing and producing data across a myriad of social practices using linear systems.

Ledger 1: money, time and the blockchain

There are many elements that make Bitcoin an interesting alternative currency, but critically it is the development and implementation of the blockchain – a distributed ledger that contains all transaction records ever conducted. The Bitcoin blockchain is an encrypted, cumulative ledger composed of 'blocks' of transactions that are verified by miners and which lead back to the first 'Genesis' block whose instance is timed as 18:15:05 GMT, on 3 January 2009, signifying the start of the currency. Blocks can contain the social, economic and geographic information about the senders and receivers of Bitcoin wallets, time of transaction, amount of Bitcoins being transferred, fees and IP addresses from which location can also be identified. Transaction blocks are generated approximately every 10 minutes, a timing that is calibrated by the network – if blocks are completed quicker, the difficulty of the mining is increased, and vice versa. Each new block (and not a huge single list) provides an opportunity for transactions to be verified and thus takes place within a reasonable and anticipated amount of time – in many ways forming both the 'tick' and the check-sum of the platform. This process is verified by miners who compete to complete 'proof of work' functions, that is, computationally intensive algorithms, to check if every block that follows is legitimate (Maurer *et al.* 2013: 264). In addition, each new block essentially concatenates the previous block with the new set of transactions, creating the *chain*, which leads all the way back to the initial Genesis block. Once mined, the block is sealed and, currently, ~~25 Bitcoins are released as a reward to the winning miners~~, thus incentivizing the expensive mining activity and steadily populating the peer network with more currency.

This linear association, connecting one block to the next through the integrity of the encrypted mathematical codes, keeps the chain intact, and, along with the massively distributed, multiple copies of the currency system, helps to prevent fraud. The linear, cumulative nature of this system is of particular interest to the authors, and in particular how this differs from current, centrally controlled, fiat currencies that regulate the release and removal of money in the system (physical and virtual) to attempt to manage the market.

In stark comparison to the blockchain, fiat currencies are released as promissory coins, notes, mortgages or loans according to an assessment of how much money there should be within a society according to the values of that particular economic system. Monetary representation has become increasingly abstracted from the goods and services that it can be used to trade in, and this is central to Marx's concern for how value has become commodified, not in what is needed but what is desired. Since originating in the bartering of actual goods and tools such as animal skins, salt and weapons, for a long time the physical representation or tokenization of a currency corresponded with the goods being purchased.

The form that money takes, and its association with the value of the minerals that it is either made of or is connected to, has become increasingly slippery (Maurer 2006: 27). In 1816, the Bank of England changed the basis of English money from silver to gold through the Great Recoinage and at this point the

value of silver in a silver coin was less than its representational value, and so coin transformed into a token. As global trade required 'modern' organization through the early part of the twentieth century, the Bretton Woods agreement was signed in 1944 by committed countries in order to maintain exchange rates to a fixed value in terms of gold. On its failure in 1971 – due to the dollar's inability to retain value in the light of a global recession – the detachment of monetary value from a mineral ore to a new system of floating exchange rates 'de-materialized' money (Harvey 1990). As the representation of value continues to become further abstracted from goods and services, for example, through electronic BACS transfers and online and mobile banking, we soon arrive at the role of money in society today.

In the abstraction of value from a material representation to a promissory token, both time and identity become obfuscated. Although the jurisdiction of English bills was encoded in such a way to manage the spatiality of economics, it mattered not who the bearer of the coin or note was and when it was exchanged. Once released into a system, the use of individual monies was not monitored or tracked – only the health of the system. In this way, there are significant differences with Bitcoin and its reliance on a blockchain. Given the nature of digital systems, perfect copies of money are conceptually even easier to make than the counterfeiting of physical money. The radical invention of the blockchain uses multiple copies of a single ledger distributed across a network to deal with the 'double spending' potential of digital money, that is, duplicating currency and spending it twice or more, is a central feature to the Bitcoin platform. In fiat currencies, third parties, for example, banks, balance the books at the close of each trading day. In Bitcoin, 'double spend' is prevented by ensuring digital scarcity through the verification of transactions through the mining process and transaction blocks.

These differences represent two entirely different models of time for each form of currency. The inflation and deflation of prices, the savings and overall growth within the system vary according to market values, goods or purchasing power of the currency and trading with foreign currencies. In this case, time is suspended and does not offer a metric through which individual transactions can be recorded.

The 'minting' of the Bitcoin currency is bound to the ledger that records the spend of the currency, resulting in a close relationship between time, value and ultimately power, that is, as time progresses the reward for mining depreciates and demand for more computing power increases. ~~That is,~~ the algorithm knows there is a finite maximum amount of Bitcoins that can be created, a figure of 21 million. These are released at a fixed amount that halves every four years and are issued to winning miners who validate each transaction block. As the computing power has increased in line with the complexity of the maths, the distribution of miners has shifted from a distributed global community toward four mining companies based in China owning almost 70 per cent of the activity. Unlike the anonymous accounting of people spending the same material money over and over again (e.g. coins or notes) in the cash registers of disconnected shops, the spending of Bitcoins is inscribed in the blockchain and forever associated with specific transactions within a distributed network. The sealed, distributed nature of the

blockchain means that the integrity of the currency is reliant on a linear model that looks back, before it generates money forward (DuPont and Maurer 2015). In contrast, fiat currencies project money forward and balance their books retrospectively according to the performance of spending across a system. Compared to the speed of the blockchain in checking the integrity of its system (approximately two hours), it is rumoured that it takes 58 days for the UK civil service to understand its GDP in any given month.

Ledger 2: city as ledger

The introduction of the clock into mediaeval society was connected to the management of land and was closely tied to both the development of the written word and the use of ledgers to account for the production and trade. From an era when 'natural rhythms dictate the pace of life and work and the content of language', and any expectation of a future 'centres on a short lifespan and the imminence of the Day of Judgement' (Thrift 1996: 180), Thrift draws attention to the influence that writing technologies have upon our sense of time. Originating in the technology of the written word, Thrift argued that the linear process of writing and its evidence in the form of texts, revealed a 'consciousness of time past' (Thrift 1996: 180). This in turn informed time present, which became ripe for reorganizing, and consequently daily events became accountable, and inevitably associated with monetary values.

At the time, power of the controlling the ledger was in the hands of a new generation of literate monks and members of the King's Court who gradually began cataloguing the use of the land as a means of calculating profit and eventually monitoring performance and efficiency. 'Thus, financial accounts may now seem the most obvious way of stating time as money' (Thrift 1996: 184). Clocks were the next step toward a synchronization between the church day and the individual, instead of responding to the church bell, people could be organized in to more specific blocks of time. The term 'organized' is used because the owner of the clock is the one with power, and, as Harvey reveals, 'such time discipline crucially depended upon the construction of distinctive spaces of surveillance' (Harvey 1996: 225). Consequently, it is not long before a recognizable 'modern' system is in place.

In the late sixties and early seventies, Lund University in Sweden established important relationships between time and geography. Amongst many, Hägerstrand worked hard at eroding the 'compositional' view of the world that most social scientists were using to talk about how people make sense of space. Taking a situation as a snapshot, and seeing it as a complex construction of 'objects' that are acting upon one another, Hägerstrand suggested that the compositional view could only deal with context and was constrained by establishing fixed relations between artefacts, preventing the opportunity for movement and change. Whilst it aspired to objectivity, the compositional approach lacked point of view and subjects became items. In contrast, the time-geographic approach attempts 'to capture the complexity of interaction at the scale of the smallest indivisible unit which for human population is, of course, the individual' (Parkes and Thrift 1980: 244).

Much of the time-geography work concentrated upon developing methods of describing people and their journeys through space in time. Inevitably the work identified a linear series of events that make up a person's day, suggesting that the nature of these events (called a project) motivated individuals to move through space to see them fulfilled. The subsequent documentation of these various 'projects' formed a ledger of a group's activities and could be analysed to understand social, spatial and temporal relations.

Criticism of the time-geographic approach has since been targeted at the apparently linear, and indeed Cartesian, approach of conceptualizing time and space, although the Lund school argued that they merely absorbed given models in order to make their point clear. Another problem is the lack of focus that the models show for dealing with a psychological conception of space since the Cartesian parameters dominate the representation of events and places. Finally, and perhaps the most interesting problem with the time-geography model for considering the city as a database, was the participants' honesty (and apparent lack of interest) in what happens when the linear paths cross and cause conflicts in the completion of the tasks. The spatial and temporal ledger of social practices that Hägerstrand constructs provides a valuable insight into personal and group activities, offering a chance to reflect and consider how individual projects are connected to partners, groups and communities.

As databases across the city develop, Hägerstrand's time/space projections of the interweaving of social and material relations is to some extent possible as the potential of machine learning promises to uncover more and more correlations between datasets. A question remains though to the extent to which the city wants to reveal all of its social and geographical relations.

Constructing a form of digital ledger for geographical and social relations, Ian Cook's 'Follow the Things' project provides insight and discussion into the background of consumer products from food items to clothes, and electricals to health and beauty products (http://www.followthethings.com) (Cook 2015). For instance, the collection of reports on celebrity perfumes that was authored by Gethin Chamberlain and originally published in the *Guardian* in 2010.[1] The article primarily focuses upon the poor working conditions and pay of Indian employees of the Pragati company for packaging celebrity branded perfumes including Katie Price and Jade Goody. The financial markups of individual bottles retailed for £19.99 in UK pharmacies, whilst the average take-home for its 7,000 employees was a low as £2.05 per day. Follow The Things therefore becomes a form of socio-geographical ledger for a wide range of products, and supporting discussion and debate to better understand the 'veil' that is placed over desired artefacts that obfuscates their histories and boosts their economic value.

Ledger 3: cognitive and practice-based ledgers

Beyond the various forms of metric ledgers that record financial transactions, citizens, times and space, cultures are underpinned by shared stories told through a series of passages, chapters and accounts. Within literate society, books and

films share a great deal in common with ledgers as they rely upon a linear time base across which a story or an account is experienced by the recipient. Limited to only articulate one line of activity at a time, the author shapes the reader's experience by moving in and out of the activities of characters to reveal and hide circumstances that sustain the narrative.

However, the reading of a book or watching of a film constructs a 'cognitive ledger' in the mind of the reader who navigates the narrative to develop an individual understanding of the meaning and consequences of each of the interactions. In the case of a film taking place over a 90 to 120-minute period, the management of the director and the skill of the editor can offer a highly compelling experience whereby the audience moves through a visual ledger that suspends reality and invests them the actions and affairs of the onscreen characters.

One explicit manifestation of such a cognitive ledger (and perhaps closer to our theme) is the 2014 film *Two Days, One Night* by the Dardenne brothers. The film follows Sandra Bya, a working mother who returns to work on a Friday following a nervous breakdown to find that her 16 workmates have voted to take a €1,000 bonus in place of her job. Supported by her husband and her workmate Juliette, she lobbies her boss to ballot the workers again on Monday morning. Successful in her appeal, she has the weekend to canvass each of the workers at their homes in an attempt to persuade them to change their mind. Following 16 meetings on door steps, back gardens, launderettes and street corners, Sandra returns to work on Monday morning for the new ballot to understand her fate.

The film plays out as a ledger of interactions in which the audience develops a running balance of those who would prefer to keep Sandra, and those who would prefer to take the money. However, the brief insights into each co-worker's lives describe complex personal circumstances which in the mind of the viewer complicates the running total as to whether Sandra deserves to keep her job. However, Sandra's activities between negotiations are as interesting as the co-workers' lives and values that are represented through their partners, children and living conditions. Dominated through acts of consumption, we develop an understanding of Sandra and her family's economic disposition through her drinking of bottled water, take-away pizzas, eating of ice creams and purchase of artisan bread, whilst her mental state is portrayed through an attempted suicide as her encounters (positive and negative) all challenge her sense of identity. In the end, the audience is left divided according to how they balance the books between the welfare of Sandra and her co-workers, alongside wider politics of fairness.

In an interview with Larry Rohter for the *New York Times* (2014), the directors discuss the influence of a study by Michel Pialoux that became part of Pierre Bourdieu's edited book *The Weight of the World: Social Suffering in Contemporary Society* (1999). The book, a collection of studies that read like short stories, provides insight into the lives of a range of people whose lifestyles were affected and disrupted through the inequalities, politics and determinism of late twentieth-century economics. The Pialoux study, entitled 'The old worker and the new plant', reflects on a conversation between the author and two

employees of the Sochaux Peugeot plant in Haute-Saône, a French department of the Franche-Comté region. For the Jean-Pierre Dardenne, the experiences of Gérard and Christophe became of particular interest: 'The book had probably 15 case studies and 15 analyses, and one of these stories was a worker cast aside because of the influence of managers, who got the other workers to agree to push him aside. This worker was probably a little less productive at his job, and therefore that team was never getting its bonuses.'

In many ways, the workers' experiences are situated in a particular epoch of transition for the automobile industry as linear car production began to struggle, and companies looked to Japan for a solution. The result was a move from Henry Ford's never-ending production line as a linear production ledger to the Toyota model in which production contained a reflexivity much closer how we might understand the blockchain; that is, how people become part of these systems and could develop practices within them.

In 1970, Toyota launched the Toyota Production System (TPS), a method that managed car manufacture and employees more effectively than the failing Fordist model, which had struggled in 1950s and 1960s in Japan. 'Just-In-Time' was the title of the manufacturing and conveyance model that informed the demand of car parts in terms of which part was needed, when it was needed, and how many were required. Just-In-Time used a Toyota model for time 'Takt-Time' that was used to monitor the production time against the volume required (Ohno 1995: 29). Coupled with 'Jidoka', a term referring to the ability to quickly stop and modify production lines if problems arise, TPS became a prime example of post-Fordist production models, and one that enabled Toyota to respond to consumer demands. Through TPS, both supply and quality were monitored constantly and allowed the company to build cars in such a way that consumers felt they had more control and individual choice, as colours and specifications could be relayed from the showroom to the factory (Ohno 1995: 30).

The transition from the traditional Fordist production lines to those influenced by TPS has not been easy for many Western manufacturers. Intrinsic differences including the role of unions and the speed of technological change made it difficult to change from old methods to new practices. Returning to the worker experiences at Peugeot, there is a genuine conflict in the power relations within the new teams that developed as the plant adapted to new manufacturing models.

Whilst the Dardennes' screenplay uses cinema to construct a cognitive ledger in the mind of the viewer, Pialoux's study of the worker experiences at the Peugeot plant describe the impact of more complex models of car manufacture as the production becomes part of a ledger of actions and check sums. TPS revolutionized Toyota, and subsequently other car manufacturers such as Peugeot and GM, and the empowerment of the teams within production areas to strive for quality over quantity has constructed a form of blockchain, as the control over the production line acts as a calibration within the system to ensure that mistakes are not passed on down the line.

Designing with ledgers: a design case study

In April 2016 the authors and the Centre for Design Informatics were invited to develop a 48-hour workshop for Martyn de Waal's 'Design & The City' programme in Amsterdam. The workshop entitled 'Blockchain City' was intended to expose 'contemporary design methodologies, and their relationship with living labs and smart cities'. A software platform was developed to enable design solutions from participants' exposure to the principles of ledgers as trust platforms, and programmable money such as Bitcoin. The simple premise was that whilst blockchain and the functions of Bitcoin remain abstract for many people, developing a platform to allow physical engagement would actualize characteristics of the technology, as well as lead to critical applications for social and or urban contexts.

In its own words, 'Design & The City' explored citizen-centred design approaches for the smart city. Central themes were the role of design to create opportunities and practices for citizens, (social) entrepreneurs and policymakers towards more liveable, sustainable and sociable urban futures. The workshop was located along the Amsterdam Knowledge Mile that runs from the Amstelplein to the Nieuwmarkt. The mile represents Amsterdam's digital economic initiative involving 'universities of applied sciences, citizens, municipality, organizations and companies to form an applied research ecosystem to develop, test and display smart solutions for metropolitan challenges in the area'. In this way, the social and economic context in which the lab was located was intended to stimulate ideas and reflections within the workshop. Physically located within the commercial Student Hotel, previously home to the editorial offices of some of the country's most important newspapers, Blockchain City aimed to engage participants with a location-based software platform that encouraged them to associate acts of trust in the local community with Bitcoin transactions.

A key stage in scaffolding the participants' ability to design new social economic experiences was the development of a piece of software called 'GeoCoin' that served as an introduction to what programmable currencies could offer in a technical sense, but also allow participants to test them in an urban context to support the development of their own ideas. 'GeoCoin' was a mobile application run from a web browser that used location information to pinpoint the participant within a map of Nieuwmarkt area of Amsterdam. Using the Bitcoin client Electrum, we were able to associate geofences (GPS locations) with transactional functions. On the map the participant was also able to see three types of icons: small bags of money scattered across the area, red hot spots and green hot spots (see Figure 11.1). In the bottom left corner of the screen two numerical amounts appeared preceded by the terms: Confirmed and Unconfirmed. Without further information, participants were asked to leave the workshop studio and venture out in to the surrounding area to discover what the three icons and the numerical values would do as they approached them.

Day 1: The structure of day 1 of the workshop was very simple, consisting of an introductory talk followed by a participatory exercise 'Block Exchange'

that was developed by the Centre for Design Informatics that uses Lego to introduce the principles of the blockchain. More importantly however, it serves to dismantle cultural expectations between the representation of value, and the values that currency can potentially represent if we consider the role of a distributed ledger. Following a conversation over lunch regarding what the Lego activity had revealed we introduced the beta version of the GeoCoin software that would become the starting point for participants to redirect its purpose. Aware that designing applications that use a new representation of value (Bitcoin) is rather challenging, our software provided participants with a head-start toward designing critical applications based upon insights from the Block Exchange exercise. Introducing the software meant going outside and experiencing its functionality; following this, participants spent the remainder of the afternoon coming up with new applications of the software. At the end of first day the software was adapted overnight ready for testing on the second day.

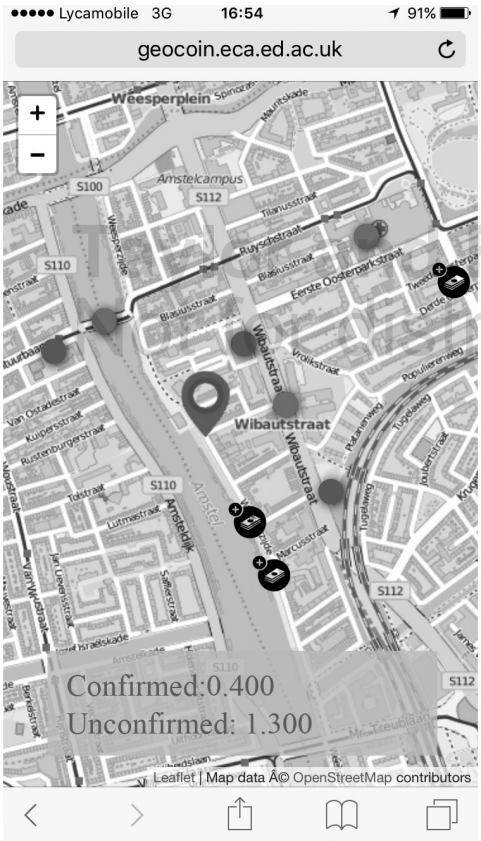

Figure 11.1 Smartphone screenshot of the GeoCoins software featuring bags of coins, and red and green GPS hotspots

Day 2: Whilst Hadi (remote project software developer) continued to develop the two iterations of the platform on the morning of the second day, participants self-organized into two teams and were asked to develop very short explanatory videos that introduced, contextualized and demonstrated their new applications. By early afternoon the teams were able to test and refine the software with Hadi remaining online to troubleshoot bugs. The teams presented their videos during a short presentation and summary of the Blockchain City Lab during a reflective evening event.

Once outside, it became relatively clear to people that the small bags of money would disappear when a participant's location correlated with the GPS coordinates of an icon, and within moments the unconfirmed number would increase on their screen. On returning to the studio participants described their interpretations of how the red and green hot spots worked, and why Unconfirmed and Confirmed numbers fluctuated. Many had guessed that we had used a digital currency such as Bitcoin and distributed fractions of them across the landscape. Less easy to understand, because there was no instant feedback from the icons (unlike the bags of money that disappeared as you walked over them), the group began to realize that if their location corresponded with the GPS coordinates of a red hotspot then their Unconfirmed numbers would decrease, and that if they stood on a green hotspot their Unconfirmed numbers would increase. Whilst these elements were relatively easy to understand, the question of why numbers across the Unconfirmed and Confirmed lines fluctuated was less comprehensible. The difference in the two variables was explained as being the time it took for the blockchain to ratify a transaction within a block. At this point the value of experiencing the time between Unconfirmed and Confirmed transactions began to expose some of the characteristics of a currency that requires confirmation through an entire digital network. Body storming (Schleicher *et al.* 2010) the type of transactions that a programmable currency such as Bitcoin offers was an important step in supporting participants towards the design of their own derivations of the software, and based upon the results, the ability to perform economic software within an urban landscape informed both the conceptual development of ideas but also the representations of their work.

Following their forays into the local area surrounding the student hotel, the six participants formed two groups of three people, and began developing responses to both the Block Exchange Lego workshop and their experiences of the GeoCoin software. The two ideas that emerged corresponded to the ideas and values evoked during the Block Exchange workshop. During the final round of the Lego workshop participants are invited to trade anything that they desire as long as it can be valued by somebody else and written down on to the ledger. As facilitators we wrote down the subject of these exchanges because they tended to follow a pattern of participants realizing that they can trade anything as long as the ledger is trusted. The pattern follows that people begin with trading material goods, then they realize that they can trade services which tend to become increasingly outlandish, before settling down to trade services that are for the common good. This workshop was no exception with the teams moving from trading pens (that were vital to write transactions into the ledger and were

therefore rare assets), through providing service such as kisses, singing songs for people, before finishing with Lego blocks that are required by everybody and finally a common fund. This pattern from materialist desires toward social projects reoccurs as participants place increasing faith in the trusted ledger, and for the two groups it provided the stimulus for two distinct iterations of the GeoCoin software.

Civic Blocks (Project Team: Dorota Kamrowska-Zaluska, Hanna Obracht-Prondzynska, Eileen Wagner)

Civic Blocks transposed the value of a fraction of a Bitcoin into a vote for how a City Council should spend a proportion of its budget. The team suggested that a City Council could convert a proportion of its capital resource budget into Bitcoin, perhaps 10 per cent. Using the unique capabilities of Bitcoins to divide them into

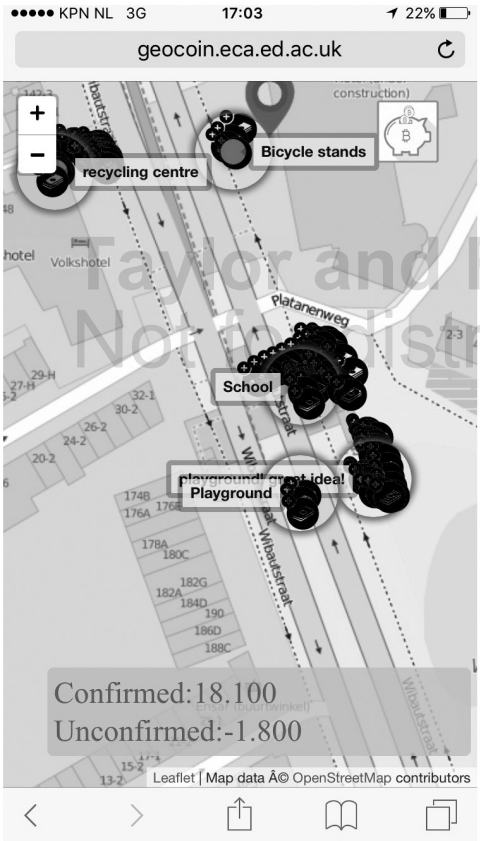

Figure 11.2 Screenshot taken from smartphone displaying the Civic Blocks software in use. The position of the user is denoted by the red marker who is spending their vote/coins on a bicycle rack project

fractions, 10 per cent of the budget would be distributed to all citizens of a city that are eligible to vote. Citizens are then invited to spend their vote/coins by dropping them at locations generated by fellow residents including proposals for spending council monies on schools, parks and roads, or they can choose to generate their own spending project by creating a new geofence and naming it with their own cause. With the GPS coordinates, name of the project and the value of accumulated coins/votes inscribed in to the blockchain, council monies are locked into particular projects. Through the technical support of Hadi, the team were able to design a fully working prototype that allowed workshop attendees to spend their votes on social projects in the local area (see Figure 11.2). The team also produced a short video explaining the principles of the platform: https://vimeo.com/163760240.

HandFastr (Project Team: Corina Angheloiu, Max Dovey, James Stewart)

The second group became very interested in the potential for the blockchain to record smart contracts that could reconfigure social pledges and transform spending powers. Adopting marriage as a social contract, the team designed a mechanism to support social economic bonds in the form of temporary mobile agreements using smartphones. As explained by Max Dovey, a member of the team:

> Marriage, with all its connotations, can be whittled down to one of the oldest forms of contract that binds two people from two families to create financial security. Arranged marriages, short-term fixed marriages or visa weddings all utilize the contract to secure wealth, security or freedom between different parties. We adapted the practical and functional aspects of marriage into the GeoCoin platform to enable impromptu financial commitments between people in public space.

Figure 11.3 Still from the Handfastr video developed by participants to describe how their prototype software allows people to form temporary smart contracts for shared banking and spending

Through negotiation with Hadi, a platform was developed that placed geofences in the vicinity of the workshop that when consenting participants agreed to 'get married', the software would transfer Bitcoins that were previously held in separate wallets, into a conjoined wallet. As long as the partners (can be any number) remained married, they could only spend the currency when they were in the same GPS location. The team also produced a short video to introduce the platform: https://vimeo.com/163565402 (see Figure 11.3).

Conclusion

The database city is entirely based upon a multitude of ledgers – all owned by different parties, and all constructed to account for different transactions. Registering a database is as easy as buying a book, from signing up for Facebook to installing the MySQL databases that sit behind our personal blogs and local government Customer Relationship Management systems. All of them provide an account of social, spatial and economic interactions. However, rarely do they describe the city – that complex, messy, contested environment that is completed every night for some participants, and falls apart for others. It is impossible to escape the ledger as we are entangled in the accounting of ourselves, our friends and strangers. This chapter has set out to explore the experiences of being in a culture in which the ledger has become an intrinsic, if generally unrecognized, part of the data city. Not new, but now networked, ledgers offer to some extent the potential to resolve the cities greatest problems of complexity – prediction and instability. By looking for patterns within databases and building feedback loops to support public involvement in managing the city, the ledger is the history and the future of the city.

The chapter used three perspectives on the historical use of ledgers in the accounting, mediating and representation of value in order to better understand how the linear inscription of transactions forms is a habitual characteristic of social and economic practices. Through an introduction to the workings of the digital currency Bitcoin and the nature of the blockchain, the chapter explored the relationship between time and money. In particular, attention was drawn to the intrinsic and immutable association between bitcoins and the transactions that they are written into the blockchain, unlike material coins that become a proxy for value, and remain independent of the accounts that describe what they were used to purchase.

The growth of writing through the church, and in particular the accounting of labour and goods was used to demonstrate the close association between the documentation of time and the space. Hägerstrand's time-geography explicitly used temporal and spatial ledgers to map the simultaneous activities of individuals within groups. The disaggregation of individual practices that are carried out through 'projects' within time and space reveal the social, economic and environmental constraints in which members of a group operate. The difference between members' responsibility, mobility and freedom are laid bare in the time-geography ledgers to hint at levels of agency. As temporal, spatial and material data become increasingly associated with goods and products as they

move through the value chains of production, distribution and consumption, projects such as Follow the Things extends the role of the ledger to involve not only humans, but the things that we buy.

In the third section, a dispute in a Peugeot factory that provided the inspiration for the Dardenne brothers' film *Two Days, One Night*, offered an opportunity to explore the tensions between established Fordist methods of car production in which the speed of production led to a ledger of poorly assembled cars, to the influence of the reflexive Toyota model that involved workers in the quality control of each car. Introduced as cognitive ledgers, the engagement of the individual to be involved in the evaluation of each transaction, whether it was the cinema audience who tried to retain a ledger of Sandra's interactions with her co-workers, or GM and Toyota employees that could halt the assembly line to rectify errors, the examples reminded us of how we enact ledgers.

At the time of writing, applications of distributed ledger technologies were still being developed and trialled within different sectors. As the technology finds its niche we can be confident that platforms that offer trust will support and encourage its members to trade any imaginable commodity. To illustrate, the authors used a case study to explore what designers would chose to exchange when they are given software that allows them to associate values to Bitcoin transactions in an urban context.

In summary, as the virtues and limitations of the blockchain and DLT technology begin to become part of the architectures of an internet in which trust is a key characteristic, the chapter reveals the complex relationship that we have between trusted lists, temporality and situated practices. Involving people in the co-authorship of a ledger suggests that we have an opportunity to understand the values that they intended to represent. Whatever form the city dashboard of the future takes, their function as visualizations of complex social, economic and environmental systems valued by all parties will require trusted methods for the capture and representation of values.

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Note

1 http://www.followthethings.com/celebrityperfumes.shtml.

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